Plenary I: AEESP Lecture

Particle Resuspension: From Indoor and Outdoor Sources to the Human Receptor. ANDREA FERRO, *Clarkson University*

Particle resuspension is a major contributor to both indoor and outdoor aerosols. While we benefit from decades of research in this field, there has recently been more attention on particle resuspension due to its role in exposure to bioaerosols that impact human health. This presentation will address particle resuspension from source to receptor, including adhesion and detachment mechanisms, primary factors affecting resuspension, and the role of resuspension in human exposure to aerosols. Current models for resuspension, validated by both wind tunnel and bulk air experiments, will be discussed along with best estimates for resuspension source emission terms and intake fractions for inhalation exposure. The work has many applications, including controlling particle adhesion and removal in the manufacturing processes for the semiconductor, xerographic, and pharmaceutical industries, understanding residential exposures to pollutants associated with indoor dust from resuspension via human activity, and protecting soldiers in the field from exposure to chemical and biological agents.

Plenary II

Numerical Modelling of Titania Nanoparticles from Flame Synthesis. MARKUS KRAFT, *University of Cambridge*

Titanium dioxide, also known as titania, nanoparticle is one of the most studied materials for its wide-ranging applications with high commercial importance including photocatalysis and solar cells. The properties of nanoparticles, including size, crystallinity and morphology, have been shown to critically affect the performance of the material in these applications. The main challenge lies in controlling these properties during manufacturing process as required for specific applications. Among various possible routes, flame synthesis is one of the most preferred manufacturing options offering a direct, continuous synthesis with high throughput and versatility, increasingly becoming the standard in industry and laboratory experiments. Despite recent advances in research community, a comprehensive understanding of chemistry and particle formation involved in titania synthesis remains lacking. Computational modelling provides attractive capabilities to study such system with aims to gain further understanding of the underlying chemical and physical mechanism and to optimize the process. Following the success with soot, detailed population balance model has been applied for titania system, with titanium tetraisopropoxide (TTIP) and titanium tetrachloride (TiCl4) as starting precursors. The model, combined with detailed kinetic mechanism developed from quantum chemistry calculation, has been used to describe the particle dynamics in both laboratory and industrial conditions with good predictive power. Coupled with experimental characterizations of lab-scale configurations such as premixed stagnation and diffusion flames, the model can be validated and further refined. Moreover, further insights into complex mechanism of phase transformation and doping of titania nanoparticles in flame can be gained to extend the predictive power of the model. The model can subsequently be used to optimize the synthesis process to produce tinania nanoparticles with specifically tailored properties for use in applications such as photocatalytic water splitting for hydrogen evolution.

Plenary III

Towards a Molecular Understanding of Biogenic Organic Aerosol: From New Particle Formation and Growth to Multi-phase Aging. JOEL A. THORNTON, *University of Washington*

Organic carbonaceous material is a ubiquitous and often significant fraction of atmospheric submicron aerosol mass, and can be responsible for driving the growth of ultrafine particles to cloud condensation nuclei sizes. Development of a molecular-level understanding of the processes governing the evolution of organic aerosol mass has been a long running challenge. I will present new insights into the formation and growth of aerosol due to the chemistry of biogenic hydrocarbons, using both in situ observations as well as controlled simulation chamber studies. An underlying theme is the role novel instrumentation techniques have had recently in allowing direct observation and quantification of the molecules and chemical processes contributing to organic aerosol mass formation and properties such as volatility. Example systems will include constraints on the molecules driving growth of recently nucleated particles in the boreal forest, the contribution of isoprene to secondary organic aerosol (SOA) mass, and the role of anthropogenic nitrogen oxides in the conversion of terpenes to SOA.

Plenary IV: Friedlander Lecture

Toward a Greater Understanding of the Chemistry and Impacts of Mineral Dust and Sea Spray Aerosols. VICKI GRASSIAN, *University of California San Diego*

Mineral dust and sea spray aerosols represent the largest quantity of aerosol mass present in the Earth’s atmosphere. This talk will focus on understanding molecular processes and transformations of mineral dust and sea spray aerosols through laboratory studies. These studies combine and integrate a broad range of measurements including single particle analysis so as to better determine how mineral dust and sea spray aerosols impact atmospheric chemistry, climate, and human health.

1AC.1

Properties and Evolution of Biomass Burning Organic Aerosol from Wildfires in the Western U.S. Shan Zhou, Sonya Collier, Timothy Onasch, Daniel Jaffe, Lawrence Kleinman, Arthur J. Sedlacek, QI ZHANG, *University of California, Davis*

Wildfires are a large source of primary organic aerosol (POA) and volatile organic compounds (VOCs) that can be oxidized to form secondary organic aerosol (SOA). However, the chemical properties and the formation and atmospheric aging of these organic aerosols (OA) are still poorly understood and constrained. In this study, a suite of real-time instruments, including high-resolution aerosol mass spectrometers, were deployed at the Mt. Bachelor Observatory (2763 m a.s.l.) – a high-altitude ground site located in Central Oregon – and onboard the Gulfstream-1 aircraft during the DOE-sponsored Biomass Burning Observation Period (BBOP). Our goal was to study the emissions and atmospheric aging of BB particles from wildfires in the western US. Well-defined smoke plumes that span a range of transport time (1 – 45 h) were identified based on MODIS fire hotspot information and HYSPLIT trajectory. The cumulative solar radiation (CSR) that each smoke plume was exposed to over the course of transport was estimated and used as an indicator for photochemical aging. We found that the enhancement ratios of OA relative to CO (ΔOA/ΔCO) were independent of CSR, indicating negligible net photochemical production of OA in wildfire plumes observed in this study. However, the enhancement ratios of AMS tracer ion for levoglucosan, $C_2H_4O_2^+$, ($\Delta C_2H_4O_2^+/\Delta CO$) and the fresh BBOA component ($\Delta BBOA_f/\Delta CO$) decreased with CSR, while that of the aged BBOA components ($\Delta BBOA_a/\Delta CO$) increased with CSR. In addition, our thermodenuder measurements indicate that the fresh BBOA was more volatile than the aged BBOA. These results indicate that volatilization, photooxidation, and secondary formation of BBOA occurred simultaneously in wildfire plumes after emission and that atmospheric aging and oxidation significantly changes the chemical composition of BBOA. These processes likely influence both the properties and the lifetime of BB particles, and therefore their effects on climate and health.

1AC.2

Molecular Characterization of Water-Soluble Organic Carbon (WSOC) from Biomass Burning of Wildland Fuels Using Ultrahigh Resolution Orbitrap Elite Mass Spectrometry. Elena Kirillova, Vera Samburova, Chiranjivi Bhattarai, Deep Sengupta, Hans Moosmuller, Andrey Khlystov, LYNN MAZZOLENI, *Michigan Tech*

Wildland biomass burning is an important source of water-soluble organic carbon (WSOC) to the atmosphere contributing to climate change, reductions in visibility, and adverse human health affects. In this study, we focused on five globally important fuels: Alaskan, Russian, and Florida swamp peat, cheatgrass, and Ponderosa Pine needles. Aerosol from laboratory controlled combustion experiments was collected on filters and extracted in HPLC grade water. Ultrahigh resolution electrospray ionization mass spectrometry and light absorption measurements were performed after sequential solid-phase extraction (SPE) using Strata-X and HyperSep Hypercarb SPE cartridges. This was done to remove inorganic components and to pre-concentrate acidified WSOC components. The SPE cartridges were eluted twice: first, with methanol and water (90:10); second, with methanol containing 1% of aqueous ammonia. Over 2000 molecular formulas were assigned in the negative ion mass spectra of WSOC from each fuel. CHO compounds were dominant followed by CHNO, CHOS, and CHNOS compounds. In all cases, the reversed phase Strata-X cartridges retained the majority of the organic anions; the greater part of which was eluted during the first elution, while the larger, less oxidized, more aromatic molecules with lower average O/C and H/C ratios were eluted with the alkaline methanol elution. Only 25-36% of the assigned formulas were common for both elutions. We observed Absorption Ångström Exponents (AAE) of 10.4-15.2 for the first elution and 6.7-8.8 for the second elution, indicating clear differences in the light absorbing properties of WSOC in the two Strata-X elutions. The Hypercarb SPE cartridge retained the smaller, more polar and non-light absorbing molecules not captured by the Strata-X cartridge. Overall, most of the assigned molecular formulas demonstrated low O/C ratio (< 1) typical for fresh biomass combustion aerosols. Larger similarity was observed in peat burning aerosol samples compared to aerosol of other fuel types.

1AC.3

The Impact of Biomass Burning on Fine Aerosol Acidity, Water Content and Nitrogen Partitioning. Aikaterini Bougiatioti, Despina Paraskevopoulou, Iasonas Stavroulas, Stelios Myriokefalitakis, Nikos Daskalakis, Rodney J. Weber, Maria Kanakidou, Nikolaos Mihalopoulos, ATHANASIOS NENES, *Georgia Institute of Technology*

Biomass burning is an important source of regional and global pollution, contributing 44% of the total $PM_{2.5}$ emissions in the EU. During BB episodes considerable amounts of ammonia, NOx, organics, variable amounts of K^+, Na^+, C^{l-} and minor amounts of sulfate are emitted into the atmosphere. All these species can impact on the aerosol liquid water content as well as the particle pH, but to an extent that is currently not known. Motivated by this, we analyze composition measurements conducted in Athens (Greece) during winter 2013, to evaluate the impact of BB on aerosol water and acidity (pH). Acidity and liquid water is obtained by thermodynamic analysis of the observations with the ISORROPIA-II model.

From our analysis we find that BB contributes significantly to the increased organic aerosol loadings, BCwb, particulate nitrates, chloride, and potassium. These increased concentrations strongly impact on fine aerosol water, with Winorg having an average concentration of 11±14 μg m^{-3} and Worg constituting almost 38% of the total submicron aerosol water content. Particle pH was generally found to be acidic, with average pH during strong BB influence of 2.8±0.5, value similar to the pH observed for regional aerosol influenced by BB episodes at a remote background site (Crete).

During cleaner days without BB influence, submicron aerosol was found to be more acidic, with a pH that was lower by about 1 unit. The reduced acidity of aerosol during BB periods is attributed to the presence of non-volatile cations and co-condensation of nitrate and ammonium. The reduced acidity predisposes the inorganic nitrate and chloride tends to reside in the aerosol. Global model simulations confirm that this is an effect seen in regional and global scales, therefore carrying important implications for public health, climate and ecosystems.

1AC.4

Chlorine Activation and Speciation during Nocturnal Processing of Authentic Biomass Burning Aerosol. LYDIA JAHL, Lexie Goldberger, Adam Ahern, Joel A. Thornton, Ryan Sullivan, *Carnegie Mellon University*

Nitryl chloride ($ClNO_2$) is a nighttime reservoir of NO_x that is formed from the uptake of dinitrogen pentoxide (N_2O_5) into particles containing chloride. $ClNO_2$ was thought to be formed only in the presence of chloride from sea spray aerosol, but its recent detection in areas far from the ocean has raised the possibility that other unrecognized particulate chloride sources make important contributions to chlorine activation chemistry. $ClNO_2$ is photolyzed each morning to produce the chlorine radical and recycle NO_x, thereby increasing the atmospheric oxidant budget. The formation of $ClNO_2$ from the heterogeneous reactions of N_2O_5(g) with authentic biomass burning aerosol has not previously been studied. We observed the rapid production of N_2O_5 and then $ClNO_2$ from a variety of fuels using a smog chamber at Carnegie Mellon University. Iodide adduct chemical ionization mass spectrometry was used to measure gas phase $ClNO_2$ and N_2O_5 and acetate chemical ionization mass spectrometry was used to measure gaseous HCl and other compounds, while a soot particle aerosol mass spectrometer measured changes in aerosol composition. Upon the addition of ozone to biomass burning smoke, N_2O_5 was consistently rapidly formed and $ClNO_2$ was subsequently detected in the gas phase. During experiments at high relative humidity, we observed decreases in particulate chloride and increases in particulate nitrate which we believe are due to acid displacement of HCl(g) by HNO_3 since no additional $ClNO_2$ was produced in the gas phase. The reactive uptake probability of N_2O_5 on authentic biomass burning aerosol and the yield of $ClNO_2$ were determined for the first time using smog chamber experiments on smoke from biomass fuels including sawgrass, palmetto leaves, and ponderosa pine. These experiments confirm the formation of N_2O_5 and $ClNO_2$ in biomass burning emissions and suggest that biomass burning is a likely source of continental $ClNO_2$.

1AC.5

Low Temperature Chemistry of Biomass Burning Markers. VIKRAM PRATAP, Aditya Kiran Srikakulapu, Qijing Bian, Jeffrey R. Pierce, Philip K Hopke, Shunsuke Nakao, *Clarkson University*

Chemistry of biomass burning markers, such as levoglucosan, has been studied for summertime conditions in the context of wildfires and prescribed fire. However, studies under low temperature conditions are very limited despite significant contributions of residential wood combustion to air pollution during wintertime. Low temperatures during winter are expected to impact gas-particle partitioning and reaction kinetics. The impact of lower temperature on quantitative interpretation of biomass markers is not well understood. In this study, we have conducted wood smoke experiments using real wood smoke in an outdoor 6-m3 Teflon smog chamber. Ambient temperatures (native to Potsdam NY winter conditions) have been used to study the chemistry. The lifetime of levoglucosan and other secondary markers was evaluated in this work. Additionally, an aerosol microphysics model was utilized to compare the experimental results with the model predictions considering particle and vapor wall loss within a Teflon chamber. Preliminary experimental results indicate a significant increase in the lifetime of levoglucosan below 10 °C. Finally, the applicability of wood smoke markers will be assessed for source apportionment studies for winter conditions.

1AC.6

Impact of Wildfire Emissions on Chloride and Bromide Depletion in Marine Aerosol Particles. RACHEL BRAUN, Hossein Dadashazar, Alex MacDonald, Aldhaif Abdulamonam, Lindsay Maudlin, Ewan Crosbie, Mojtaba Aghdam, Ali Mardi, Armin Sorooshian, *University of Arizona*

This presentation will report on findings related to particulate chloride (Cl^-) and bromide (Br^-) depletion in marine aerosol particles influenced by wildfires at a coastal California site in the summers of 2013 and 2016. Novelties of this work include: (i) presentation of rare data for size-resolved aerosol composition at a coastal site impacted by wildfires from two source regions in separate summers; (ii) contrasting size-resolved characteristics of Cl^- and Br^- concentrations and their degree of depletion between non-fire and fire periods; and (iii) quantification of species most responsible for Cl^- depletion during non-fire and fire periods.

Chloride exhibited a dominant coarse mode due to sea salt influence, with substantially diminished concentrations during fire periods as compared to non-fire periods. Bromide exhibited a peak in the submicrometer range during fire and non-fire periods, with an additional supermicrometer peak in the latter periods. Chloride and Br^- depletions were enhanced during fire periods as compared to non-fire periods. The highest observed %Cl^- depletion occurs in the submicrometer range, with maximum values of 98.9% (0.32 – 0.56 µm) and 85.6% (0.56 – 1 µm) during fire and non-fire periods, respectively. The highest %Br^- depletion occurred in the supermicrometer range during fire and non-fire periods with peak depletion between 1.8 – 3.2 µm (78.8% and 58.6%, respectively). When accounting for the neutralization of sulfate and nitrate by ammonium, organic acid particles showed the greatest influence on Cl^- depletion in the submicrometer range.

As wildfire research is growing in importance, the results of this work highlight the need for considering how aerosol properties and effects, such as hygroscopicity and radiative forcing, can be modified as a result of acidic species depleting Cl^- and Br^- in sea salt particles.

1AC.7

Effects of Atmospheric Aging on Light Absorptivity and Oxidative Potential of Biomass Burning Organic Aerosols.

JENNY P.S. WONG, Nikolaos Mihalopoulos, Maria Tsagaraki, Kalloipi Violaki, Maria Kanakidou, Athanasios Nenes, Rodney J. Weber, *Georgia Institute of Technology*

Away from sources, organic aerosols (OA) are continually subjected to further physical and chemical processing ("aging"), that can transform the particulate physiochemical properties, which are important for climate, air quality, and human health. While the effects of aging on the mass, chemical composition, and hygroscopicity of OA are becoming better understood, the corresponding impacts on their direct radiative forcing and adverse health effects remain unclear. Through a combination of laboratory experiments and field observations, the objective of this work is to investigate the effects of atmospheric aging on the light absorptivity and oxidative potential (ability to generate Reactive Oxygen Species, ROS) of biomass burning organic aerosols (BBOA). In the laboratory, changes in the light absorptivity of molecular weight separated BBOA due to photolytic aging were systemically examined. Results suggest that the extent to which photo-bleaching and photo-enhancement occurs is dependent on the molecular weight fraction of BBOA. The effects of atmospheric aging on ambient BBOA, using filter samples collected in Crete, Greece, were also investigated. Focusing on samples that transition from freshly emitted to highly aged BBOA, results suggest that light absorbing large molecular weight compounds can be long-lived components in atmospheric aerosols, thus more likely to have a larger impact on the direct radiative forcing of OA. To better understand the health impacts of BBOA, preliminary results elucidating the role of atmospheric aging on their oxidative potential will also be presented.

1AP.1

Single Scattering Albedo of Homogeneous, Spherical Particles in the Small and Large Particle Limit.

HANS MOOSMULLER, Chris Sorensen, *Desert Research Institute*

The aerosol single scattering albedo (SSA) is the dominant intensive particle parameters determining the aerosols radiative forcing in the earth's atmosphere. Here, we use Mie theory to examine the behavior of SSA as a function of size parameter x and complex refractive index m for homogeneous spherical particles. We focus on the limiting cases of the small particle limit ($x << 1$) and the large particle limit ($x >> 1$), where we compare Mie theory with Rayleigh and geometric optics plus diffraction approximations. We show how the SSA in the small particle limit depends on size parameter x and complex refractive m and in the large particle limit on m and how Mie theory results converge to Rayleigh and geometric optics plus diffraction approximations.

1AP.2

Solving the Inverse Problem for Coarse-mode Aerosol Morphology. MATTHEW BERG, Yuli W. Heinson, Osku Kemppinen, Stephen Holler, *Kansas State Univeristy*

Coarse mode atmospheric aerosol particles are abundant in agricultural, desert, and urban environments. The accurate characterization of these particles' morphology is an important need in scientific and applied contexts, especially to advance our understanding for how such aerosols influence the solar radiative forcing of the atmosphere. Light scattering is the standard method used to study aerosol particles in a contact-free manner, wherein measured scattering patterns are interpreted to infer particle morphology. Due to the absence of wave-phase information in such measurements, the inference is not unique, which in part, is the essence of the inverse problem. An alternative approach is digital holography where wave-phase information is encoded in the measurements. We will show that digital holography and spatial filtering can solve the inverse problem for free-flowing particles in the sense that a measured scattering pattern can be uniquely associated with the particle size, shape, and orientation producing it. We will also show how the total cross sections are obtained as well and discuss the implementation of this work in a field instrument currently under construction.

1AP.3

Optical and Microphysical Properties of Aerosols Emitted from a Marine Engine Using Different Fuels and Engine Loads. ROYA BAHREINI, Justin Dingle, Yu Jiang, Kent Johnson, Wayne Miller, Stephanie Gagne, Kevin Thomson, Tak Chan, Yue Lin, Heejung Jung, Xinze Peng, Paul Van Rooy, David R. Cocker III, Gavin McMeeking, Bob Cary, *University of California, Riverside*

Marine vessels are a large source of atmospheric particles regionally (i.e., in coastal regions) and globally. Limited studies have been carried out on direct microphysical characterization of aerosols emitted from marine vessels. Here, we present results from laboratory-based emission tests with a diesel marine engine, as a function of fuel type and engine load. The tests were carried out at University of California, College of Engineering- Center for Environmental Research and Technology's Heavy-Duty Engine Dynamometer Test Facility. A large suite of instruments, including photoacoustic (PAX-375 and MSS), laser-induced incandescence (SP2 and LII), and thermal/optical (semi-continuous and offline OC-EC) techniques, was used to measure various optical and microphysical properties of the emitted aerosols, under different operating conditions of the engine. Additionally, instruments alternated between sampling the non-conditioned and conditioned (i.e., downstream of a catalytic stripper/sulfur adsorber) exhaust stream to understand the influence of co-emitted pollutants on the apparent aerosol characteristics. In this presentation, we report on single scattering albedo (SSA) and mass absorption coefficient (MAC) of exhaust aerosols, using different fuel types, engine loads, and exhaust conditioning. We examine how different estimates of MAC are, depending on the instrument used to measure aerosol mass. Variations in SSA and MAC with exhaust aerosol size distributions are also explored.

1AP.4

Generic Numerical Solutions to Aerosol General Dynamic Equation for Constant Rate Aerosol Reactors. Peter H. McMurry, CHENXI LI, *University of Minnesota*

Generic dimensionless solutions to the aerosol general dynamic equation are described for a system in which a condensable species is produced by chemical reaction at a constant rate. Solutions account for wall deposition, loss to preexisting aerosols, and dilution that may occur when samples withdrawn from a reactor are replenished with particle-free air. Also, two different mechanisms for vapor evaporation from clusters are included, including classical evaporation modeled with the Kelvin equation, and evaporation that occurs when chemical nucleation is occurring by acid-base reactions. Dimensionless parameters are defined to account for each of these processes. The dimensionless parameters are the natural variables for the nucleating system, and incorporate dependencies on aerosol physical/chemical properties (vapor pressure, molecular weight, particle density and surface tension, etc.) as well as system thermodynamic properties (e.g., temperature, pressure, etc.). The solutions provide numerically accurate and realistic descriptions of aerosol dynamics in systems, such as smog chambers, that satisfy certain simplifying constraints.

1AP.5

Single Airborne Aerosol Particle Raman And Cavity Ringdown Spectroscopy. CHUJI WANG, Zhiyong Gong, Yong-Le Pan, Gorden Videen, *Mississippi State University*

Due to the physical and chemical complexity of aerosol particles and the interdisciplinary nature of aerosol science that involves physics, chemistry, and biology, our knowledge of aerosol particles is rather incomplete; our current understanding of aerosol particles is limited by averaged (over size, composition, shape, and orientation) and/or ensemble (over time, size, and multi-particles) measurements. Physically, single aerosol particles are the fundamental units of any large aerosol ensembles. Chemically, single aerosol particles carry individual chemical components (properties and constituents) in particle ensemble processes. Therefore, study of single aerosol particles can bridge the gap between aerosol ensembles and bulk/surface properties and provide a hierarchical progression from a simple benchmark single component system to a mixed phase multicomponent system. Latest technological advances provide exciting new opportunities to study single aerosol particles and to further develop single aerosol particle instrumentation. We present updates on our recent studies of single airborne aerosol particles optically trapped in air using the optical-trap Raman and cavity ringdown spectroscopy.

1AP.6

Measuring Interfacial Tensions and Viscosities of Aqueous Aerosol Droplet Systems with Microfluidics. SHWETA NARAYAN, Archit Dani, Hallie Boyer, Cari Dutcher, *University of Minnesota*

Measurements of viscosity as well as surface and interfacial tensions of micron-sized aerosol droplets provide valuable information about the dynamic processes in these complex micro-environments. For liquid-liquid phase partitioning, thermodynamically favorable morphologies can be predicted with measurable quantities such as surface and interfacial tensions. In addition, the viscosity of aqueous aerosols is also important for determining particle mixing states, as the droplets may range from low viscosity dilute solutions to ultrahigh viscosity glassy states, depending on ambient conditions and solute concentrations. This work presents microfluidic techniques for measuring the viscosities and interfacial tensions of aqueous aerosol mimics using a microfluidic contraction-expansion geometry.

In the first part of this talk, biphasic micro-scale flows in PDMS devices are used to measure interfacial tensions of atmospheric aqueous aerosol mimics. Measurements are made at contracting microfluidic channels, which deform droplets of the aqueous phase by imposing an extensional flow field. Deformations are captured in videos by a high-speed camera and a force-balance equation is applied to the deforming droplet to calculate the interfacial tension. In the second part of this talk, viscosity is measured by studying droplet relaxation when these droplets emerge from the channel contraction in a microfluidic device and deform in a direction perpendicular to the flow. The relaxation is governed by the viscosity of the droplet. Low viscosity systems undergo periodic oscillations, whereas high viscosity systems relax to a spherical shape in an aperiodic manner. This shape relaxation is imaged, and the viscosity of the droplet calculated using existing theory for normal mode oscillations of a viscous liquid drop. Additionally, microfluidic hydrodynamic trapping, which can be used to confine single droplets generated on-chip, is demonstrated to measure the viscosity of the aqueous phase by inducing droplet oscillations.

1AP.7

Vapor Pressure Measurements Using Aerosols of Low-Volatile Materials. MATTHEW B. HART, Vasanthi Sivaprakasam, Jay D. Eversole, *Naval Research Laboratory*

We have previously described an experimental arrangement for studying aerosols that permits measurements of individual droplet evaporation rates with high precision and relative ease. This capability provides a means for obtaining fundamental molecular properties of different compounds of interest under varying environmental conditions.

The fundamental description of droplet evaporation includes the product of the vapor pressure and the diffusion coefficient of the vaporized material into the surrounding atmosphere [1, 2]. In this presentation, we describe implementation of our experimental technique, which follows a previously demonstrated approach [3], to determine both the vapor pressure and the vapor-gas diffusion coefficient of the droplet material. This is achieved by comparing evaporation rates of liquid aerosols that are electrodynamically levitated in different surrounding gas species and temperatures. In many cases, these specific thermodynamic properties have proven difficult to accurately measure using more conventional methods with bulk materials. Consequently, there is a need for data for many compounds of interest, and while estimates can be made using statistical mechanical relationships, there is a large gap of experimental validation and verification for a range of realistic environmental conditions. Our measurement method provides a high level of precision, and can yield reliable and accurate values from low volatility compounds with vapor pressures less than 10 8 Torr (10-6 Pa). We will discuss results of applying this technique on single, low-volatile droplets levitated in different pure atmospheres of: helium, nitrogen and argon.

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1BA.1

Vertical Distributions of Bioaerosol Over the Eastern U.S.

ANNE PERRING, Ellis Shipley Robinson, Shang Liu, Joshua P. Schwarz, Ru-Shan Gao, *NOAA ESRL*

The prevalence of bioaerosol in the atmosphere is relevant to atmospheric chemistry, microbial ecology, and climate. Bioaerosol can act as effective cloud condensation nuclei and ice nuclei, representing a potential feedback between vegetation and precipitation. They often comprise a significant fraction of supermicron aerosol near the surface, and may contribute substantially to total aerosol mass in a variety of environments. Very few measurements are available, however, to constrain loadings of bioaerosol in the free troposphere, thus impeding assessment of their overall importance. Here we present vertical profiles of fluorescent aerosol concentration (a common proxy for bioaerosol) spanning particle sizes from 0.8 to 10 µm, observed over the eastern U.S. during the summer of 2016 using a Wide Band Integrated Bioaerosol Sensor (WIBS). The instrument was installed aboard a NOAA Twin Otter research aircraft which was also equipped with a Printed Optical Particle Sensor (POPS) that measured the concentration and optical size of particles in between 14 nm and 3000 nm. The airspeed and inlet configuration were optimized for efficient sampling of aerosol with diameters up to 10 µm, and vertical profiles extended from 1000’ to 17,500’ AGL, spanning a temperature range relevant to ice formation. 100 hours of data were obtained that cover a latitude range from 30N to 46N and target a variety of potential bioaerosol source regions including forests, croplands, the Gulf of Mexico, and Lake Michigan. Vertical distributions, which showed large day-to-day variability in bioaerosol loadings above the boundary layer, are analyzed in the context of ecological region, meteorology and long-range transport. Bioaerosol mass loadings and number and mass size distributions are compared to those of total aerosol observed with the POPS. Finally, observed vertical profiles are compared to current model parameterizations and implications are discussed.

1BA.2

Biosurfactants Produced by Cloud Micro-Organisms: Potential Impact on Cloud Droplet Formation.

ANNE-MARIE DELORT, Isabelle Canet, Pascal Renard, Martine Sancelme, Laurent Deguillaume, Nolwenn Wirgot, *Université Clermont Auvergne, France*

480 microorganisms collected from 39 clouds sampled at the puy de Dôme station (alt. 1465 m, 45°46'19"N, 2°57'52"E, Massif Central, France) were isolated and identified.[1] This unique collection was screened for biosurfactant (surfactants of microbial origin) production by measuring the surface tension (σ) of crude extracts consisting of the supernatants of the pure cultures by the pendant drop technique.[2] 41% of the tested strains are active producers (σ-1), 7% being extremely active (σ-1). The most efficient biosurfactant producers (σ-1) belong to a few bacterial genera (*Pseudomonas* and *Xanthomonas*) from the Y-Proteobacteria phylum (78%), and yeast genera (*Cryptococcus* and *Dioszegia*) from the Basidiomycota phylum (11%). Some *Bacillus* strains from the Firmicutes phylum are also active but represent a very small fraction of the total population. Strains from the Actinobacteria phylum are mainly present in the group with a moderate biosurfactant production (45<σStatistical analyses showed some positive correlations between the origin of air masses and chemical composition of cloud waters[3] with the presence of biosurfactant-producing microorganisms in clouds, suggesting a “biogeography” of this production.
Finally we discuss the potential impact of the production of biosurfactants by cloud microorganisms on atmospheric processes.

Acknowledgements
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1BA.3

Observations of Fluorescent Aerosol and Ice Nucleating Particle Concentrations during Wintertime at a Pacific Coastal Site. MARKUS PETTERS, Hans Taylor, Thomas Hill, Paul DeMott, Samuel Atwood, Christina S. McCluskey, Sonia Kreidenweis, Nicholas Rothfuss, Kimberly Prather, Gavin Cornwell, Andrew Martin, *North Carolina State University*

We report observations of the aerosol characteristics observed at Bodega Bay Marine Laboratory between January and March 2015. These include size- and supersaturation resolved cloud condensation nuclei (CCN), ice nucleating particles (INPs) measured from aerosol-into-liquid and aerosol-filter sampling, as well as fluorescent particles measured with an optical particle counter (WIBS-4A). The directly measured CCN supersaturation spectrum could be predicted based on the aerosol size distribution and the associated measured kappa values. INP concentrations were determined using two different cold-stage methods that differed by particle collection technique, drop volume, and cold-stage implementation. Results from these techniques are intercompared against an online technique. Technical details associated with sample handling required for cold-stage measurement of ambient INP concentrations are discussed. The fluorescent particle concentration followed a regular diel cycle. Two multi-day time periods with enhanced fluorescent particle concentration following mesoscale precipitation events were observed. Fluorescent particles were grouped together by characteristic excitation–emission profiles. INP concentrations at T > -20 degree C from both instruments correlated well with two of these groupings. These data add to an emerging body of literature that suggests the presence of a significant terrestrial biological source for warm INPs.

1BA.4

Bioaerosols in the Eastern Mediterranean: Seasonal Variability and Nutrient Supply. ARNALDO NEGRON-MARTY, Chara Almpani, Giorgos Kouvarakis, Iordanis Magiopoulos, Paraskevi Pitta, Kostas Konstantinidis, Maria Kanakidou, Nikolaos Mihalopoulos, Athanasios Nenes, *Georgia Institute of Technology*

Primary biological atmospheric particles (PBAP), also called bioaerosols, are ubiquitous in the atmosphere and potentially contribute to cloud formation [1], affect the hydrological cycle [2], public health [3], and nutrient supply to ocean ecosystems [4,5]. Critical towards understanding the role of PBAP on clouds and ecosystems is the quantitative understanding of their concentration and size. Little is known however about their prevalence and seasonal variability in part due to challenges in available techniques for PBAP detection [6,7]. Our study aims to speciate and quantify the concentration of coarse-mode PBAP at a remote marine ground site in the Eastern Mediterranean to help understand their importance as a supply of phosphorus (P) into the oligotrophic sea. Sampling took place twice a week over a year (May, 2016 – May, 2017) at the ACTRIS site of Finokalia, Crete and the University of Crete campus outside Heraklion, Crete. PBAP samples were collected with a modified wet-walled cyclone high volume bioaerosol sampler, SpinCon-II, which was operated for 8 hours per sample. During sampling, all PBAP above roughly 500nm diameter were collected in PBS, fixed in formalin, and subsequently analyzed using flow cytometry (FCM) and epifluorescence microscopy (EPM) using protocols developed by Negron et al., 2017 [8]. FCM results show PBAP concentrations up to 10^6 m^{-3} associated with African dust events, and around 10^5 m^{-3} associated with European air masses. Moreover, Heraklion FCM results shows consistently that daytime PBAP are up to tenfold higher than nighttime PBAP concentrations, suggesting that PBAP is introduced into the boundary layer from aloft, which is most effective during midday, and is lost continuously from dry deposition to the sea surface. The effect of environmental conditions (humidity, UV radiation levels, temperature) on the relative amounts of PBAP (bacteria, fungi, pollen, biological debris) and resulting nutrient (P) flux to the East Mediterranean Sea is computed and compared against model estimates [4].

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1BA.5

Fluorescent Biological Aerosol Particle Emissions Caused by Human Activities. YILIN TIAN, Yingjun Liu, Pawel Misztal, Jianyin Xiong, Caleb Arata, Allen H. Goldstein, William Nazaroff, *University of California, Berkeley*

Fluorescent biological aerosol particles (FBAP) emissions caused by human activities were studied via observational monitoring campaigns and manipulation experiments. Two multi-week observational monitoring campaigns (summer 2016 and winter 2017) were conducted in a single-family residence with two occupants in northern California. An ultraviolet aerodynamic particle sizer was used to measure size-resolved FBAP and total particles in real-time. For observational monitoring periods, the UVAPS was located in the kitchen. Information regarding occupant activities, including breakfast, making applesauce, and vacuuming, was obtained from occupant-maintained logs. Wireless environmental monitors, motion sensors, and optical particle counters were distributed throughout the house. For manipulation experiments, the UVAPS was located in the master bedroom, where scripted activities (showering and bed making) were performed. A single-compartment mass balance model was used to estimate FBAP emission rates. Size-resolved adjustment factors, defined as the kitchen total particle concentration to the house average particle concentration ratio, were used to adjust FBAP concentrations measured in the kitchen. Human activities strongly influenced indoor FBAP concentrations. FBAP emission rates (1-10 micrometer diameter) were found to vary from 10^7 to 10^8 particles h^{-1}. FBAP emission rates were influenced by particle size and type of activity.

1BA.6

Diversity and Ice Nucleation Activity of Microorganisms collected with a Small Unmanned Aircraft System (sUAS) in France and the United States. Regina Hanlon, Craig Powers, Celia Jimenez-Sanchez, Cindy E. Morris, DAVID SCHMALE, *Virginia Tech*

Many microbes relevant to crops, domestic animals, and humans are transported over long distances through the atmosphere. Some of these atmospheric microbes catalyze the freezing of water at higher temperatures and facilitate the onset of precipitation. We collected microbes from the lower atmosphere in France and the United States with a small unmanned aircraft system (sUAS). Fifty-five sampling missions were conducted at two locations in France in 2014 (an airfield in Pujaut, and the top of Puy de Dome), and three locations in the U.S. in 2015 (a farm in Blacksburg, Virginia, and a farm and a lake in Baton Rouge, Louisiana). The sUAS was a fixed-wing electric pusher platform equipped with a remote-operated sampling device that was opened once the aircraft reached the desired sampling altitude (40 to 50 meters above ground level). Samples were collected on agar media (TSA, CLA, R4A, R2A, and CA) with and without the fungicide cycloheximide. Over 4,000 colonies were recovered across the 55 sUAS sampling missions. A droplet freezing assay was used to screen nearly 2,000 colonies for ice nucleation activity, and 15 colonies were ice nucleation active at temperatures warmer than -8 degrees Celsius. Colonies are being identified based on DNA sequences of portions of the 16S rDNA gene. Future work aims to understand the potential origin of the atmospheric microbial assemblages collected with sUAS, and their association with mesoscale atmospheric processes.

1BA.7

Atmospheric Sampling of Microorganisms above a Freshwater Lake with an Unmanned Surface Vehicle (USV).

CRAIG POWERS, Regina Hanlon, Linsey Marr, David Schmale, *Virginia Tech*

Ice-nucleating microorganisms, such as the bacterium *Pseudomonas syringae*, are ubiquitous in aquatic environments and may influence cloud formation and precipitation processes. Little is known about the aerosolization and transport of microbes from aquatic environments. We designed and deployed a bioaerosol-sampling system onboard an unmanned surface vehicle (USV, a remotely-operated boat) to collect microbes and monitor particle sizes in the atmosphere above a large freshwater lake in Virginia, USA. The bioaerosol-sampling system included a 3D-printed impinger, optical particle counters, and a weather station. This system was deployed on a USV over the course of several days in May of 2017 at Claytor Lake, Virginia, USA. Samples were then processed and plated on selective media to estimate concentrations of culturable bacteria 1m above the surface of the lake. Cultured microbes are being identified based on DNA sequences of portions of the 16S rDNA gene. Future work aims to understand the distribution of microbes within and above freshwater aquatic environments, and their potential association with cloud formation and precipitation processes.

1IA.1

The Failure (and Promise) of Residential Filtration.

JEFFREY SIEGEL, *University of Toronto*

Approximately three quarters of American homes have forced air heating and/or cooling systems. Most of those systems, which primarily recirculate indoor air and serve no ventilation function, employ a filter to remove particulate matter from indoor air. A substantial fraction of homes use filters that are predominantly intended to remove very large particles, largely to protect the HVAC equipment rather than improve health. However, recent years have seen an increased emphasis on higher efficiency filters, which are intended to remove health-relevant particles. However, there is a broader question about whether high efficiency filters can actually protect human health. There are many barriers to filter efficacy including the fundamental limitation that most systems only use their fan when there is need for heating or cooling. In periods of time when the weather is moderate, systems do not operate and air is not filtered. Even in more extreme weather conditions, many systems operate much less than half of the time. A second set of issues arises from system design, installation, and operation. Air volumetric flow rates vary considerably between homes and conditioning modes and, in many homes, there may be insufficient air flow through the filter to result in measurable cleaning. Many American homes also locate ducts outside of the conditioned space and ducts often leak. This results in the entrainment of air from buffer zones such as attics and crawlspaces as well as increased infiltration of outdoor air because of the resulting pressure differences. Even in well-designed and properly installed systems, the filter itself often does not perform as anticipated. Filter bypass (air that goes around the filter) and filter efficiency degradation are ubiquitous. If these challenges are addressed, filtration can offer indoor air quality benefits in residential environments where we spend over 65% of our time. This presentation takes a fundamental view of aerosol removal to filters and a systems view of residential recirculating systems and utilizes data from over 10,0000 North American homes to demonstrate both the current impact of filtration and the potential impact that could be realized if system operation was optimized.

1IA.2

Assessment of Indoor Air Quality in Low-Income Residential Homes of Colorado during Wildfire Seasons.

PRATEEK SHRESTHA, Shelly Miller, *University of Colorado Boulder*

In this study we are assessing home tightness and indoor air quality in low-income communities in the Denver-Boulder area of Colorado during the 2016 and 2017 fire seasons. Through a combination of direct air sample measurements, questionnaires and air exchange rate measurements, we are investigating the level of protection offered by small-scale residential building shell structures against elevated outdoor pollutant levels during the events of wildfires. Home ventilation rates are measured using multi-point depressurization blower door tests and gas-phase air pollution measurements are taken using low-cost instruments developed at the University of Colorado Boulder. PM 2.5 is measured using low-cost optical particle counters: the Dylos 1700 Air Monitors. Both indoor and outdoor measurements are taken and compared in five homes at a time for three to five days in the areas affected by wildfire plumes. In addition to air quality monitoring using instrumentation, participants of the study are also asked to fill out a time activity diary to keep track of human activities such as cooking and opening windows that might affect the indoor air pollutant levels. Outcomes of this study will provide guidance on weatherization activities that reduce air exchange rates in homes while still providing a healthy indoor environment.

1IA.3

The Application of Low-cost Air Quality Sensors to Monitor Portable Air Filtration Device Performance and Personal Exposure in Beijing, China.

KAROLINE JOHNSON, Michael Bergin, Christina Norris, Junfeng Zhang, Yinping Zhang, James Schauer, *Duke University*

Portable air filtration devices are popular in China due to the severe air quality problems that exist in many urban areas. However, the effectiveness of these devices is largely unknown, without any standardized measurement methods available to monitor indoor air quality. Low cost, light scattering PM sensors are one possible solution. Twenty-three real-time sensor packages were deployed at homes and base stations around Beijing, China during a 3-week study. These air quality sensor packages were designed at Duke University and included a Plantower $PM_{2.5}$ sensor, temperature and relative humidity sensors, and a number of gas phase sensors. Seven participants were recruited from around Beijing. Participants randomly received true filtration in their homes for 1 week and sham filtration for the other week of this study. Each home had an indoor and outdoor sensor and the participant carried a personal sensor for 48 hours to determine the effects of indoor filtration on personal exposure. Calibrations were generated for the sensors by locating them on a roof a few kilometers from the US embassy and by comparing sensor data to the embassy $PM_{2.5}$ data. Indoor, outdoor, personal, and base station measurements were also evaluated against Teflon filters samples with good correlation (R^2 =0.8). Preliminary analysis shows that when windows were kept closed, the portable air filtration devices were effective at dropping indoor $PM_{2.5}$ concentrations by 75% on average as compared to the sham period. During sham periods, indoor concentrations were on average 75% of outdoor concentrations. During true filtration, indoor concentrations were only 20% of outdoor concentrations. The performance of these sensors during this pilot study indicates they are effective both as personal exposure monitors and for monitoring the performance of air purifiers.

1IA.4

The Role of Outdoor Atmospheric Pollutants on Secondary Organic Aerosol in Indoor Environments. MICHAEL WALKER, Claire Fortenberry, Arun Loka, Audrey Dang, Gauri Date, Karolina Cysneiros de Carvalho, Glenn Morrison, Brent Williams, *Washington University in St. Louis*

Characterizing the chemical composition and evolution of organic aerosol (OA) in indoor environments has remained challenging despite significant advances in measurement techniques. Human activity continuously alters indoor air composition, providing sources of temporal and chemical complexity that makes general characterization difficult. For example, natural ventilation (e.g. opening windows to regulate temperature) may play a key role in altering indoor OA chemistry by increasing the infiltration of outdoor pollutants.

The Air Composition and Reactivity from Outdoor aNd Indoor Mixing (ACRONIM) campaign was conducted in a single-family home in St. Louis, Missouri during the summer of 2016. To better understand the impacts of natural ventilation, measurements were taken outside and inside the unoccupied home with periods of both closed and opened windows. Volatile organic compounds (VOCs) were quantified by gas-chromatography mass spectrometry (GC-MS) analysis of sorption tubes, and a thermal desorption aerosol gas chromatograph (TAG) provided hourly, speciated OA measurements.

The use of a recently developed chromatographic binning technique with positive matrix factorization (PMF) allows for the analysis of full sets of TAG chromatograms, providing a more complete understanding of the chemical composition of OA. Factors corresponding to both primary and secondary organic aerosol (POA and SOA, respectively) have been identified across the indoor and outdoor samples. Additionally, a factor corresponding to SOA from monoterpene ozonolysis has been identified based on comparisons to laboratory-generated SOA from a Potential Aerosol Mass (PAM) reactor. The abundance of this class of SOA within the home increased moderately with window opening, which also corresponded to increased levels of ozone in the indoor environment.

1IA.5

Aerosol-Phase Effects of Occupants in a Wintertime Classroom. ANITA AVERY, Michael Waring, Peter DeCarlo, *Drexel University*

Humans can impact the composition of indoor air via heterogeneous reactions of gas-phase oxidants with skin constituents on a person, or skin that has been shed (desquamation), as well as by direct emissions from people themselves (bioeffluents) and the personal care products they use. However, separating the influence of the many emissions and oxidation products from those of outdoor influence has been a challenge. This work aims to identify and quantify the aerosol-phase impact of human occupants on the indoor environment. Real-time indoor and outdoor aerosols were measured simultaneously at high time resolution with a high-resolution time of flight aerosol mass spectrometer (HR-ToF-AMS) in a classroom with regular student occupants in Philadelphia. In this way, the influence of outdoor aerosols was assessed separately from that of emissions from occupants. Individual hydrocarbon mass fragments consistent with squalene fragmentation of $C_5H_9^+$, $C_6H_9^+$, and $C_7H_9^+$ were significantly enhanced with room occupancy as determined by high indoor CO_2 concentrations. Additionally, fragment $C_8H_{13}O^+$, which is associated with the oxidation product of squalene and ozone of 4-MHO, increased by 22% in high versus low CO_2 events. Fragment emission rates were quantified by relation to number of occupants. Ozone outdoors was observed in a typical diurnal pattern, while indoor ozone varied very little over time, resulting in a large calculated beta value during occupied times compared with unoccupied times. While these fragments contributed little to the overall aerosol mass in the classroom, they represented an exposure route for organic aerosol in poorly ventilated and/or highly occupied classrooms.

1IA.6

Time-resolved Exposure Level to Heavy Metal Aerosols at the Underground Platform of a Subway Station in Seoul, Korea.

SEUNG-BOK LEE, Chang Hyeok Kim, Hyungjin Lim, Jihoon Seo, Jin Young Kim, Gwi Nam Bae, *Korea Institute of Science and Technology*

Higher exposure level to particulate matters especially heavy metal aerosols at the subway stations for passengers were reported by using personal sampling methods, and daily averaged or subway operating-hour averaged concentrations of heavy metal components have been found to be significantly higher than ambient pollution level. However, time-resolved concentrations exposed to passengers are needed to evaluate health risk assessment for consideration of time-activity patterns and floating population by demographic groups. In this study, gaseous and particulate hazardous air pollutants including heavy metal aerosols were intensively measured at the underground platform of a subway station in urban area of Seoul, Korea, for one week in December 2016. Four mini-volume samplers were used for PM10 sampling for six hours from 0-6 a.m., 6-12 p.m., 12-18 p.m., 18-24 p.m., respectively. The highest concentration of iron during rush hours was about thirty times higher than ambient annual average. The concentrations of iron, manganese, copper, chromium showed a good positive correlation with the number of subway trains operated. This correlation equation can be used to estimate time-resolved concentrations exposed to heavy metal aerosols at the subway platforms for detailed health risk assessment.

1IA.7

Aerosol Sampling Experiment on the International Space Station Part I: Overview and Findings.

MARIT MEYER, Gary Casuccio, *NASA Glenn Research Center*

The International Space Station (ISS) gives a 6-member astronaut crew the ability to live and work in low earth orbit. It is a unique indoor environment which has served as both home and workplace to over 200 people in 53 increments since the year 2000. In its existence, virtually the same volume of air has been conditioned and 'revitalized,' including the removal of particles by filtration. While gaseous constituents of ISS air are monitored meticulously, sparse data exists on indoor aerosols. The quantity and types of airborne debris have recently been investigated in the Aerosol Sampling Experiment funded by NASA's Life Support Systems Program. Sampling began in late November 2016, continued through January 2017 and samples were returned to Earth in March 2017. Both active and passive samplers were placed in U.S. segments of the ISS, including the Lab where experiments take place, Node 1 where meals are enjoyed, Node 2 where cargo vehicles dock and are unpacked, Node 3 where exercising and crew hygiene takes place, as well as in a storage area. The custom-designed Passive Samplers were placed over vents and filters in the path of incoming dirty air and collected larger particles, whereas the Active Samplers were specially adapted TPS100 Personal Nanoparticle Samplers from RJ Lee Group which collected smaller particles by thermophoresis. Fibers, biological and metal particles were observed in the initial evaluation, with fibers predominant on Passive Samplers as expected. An overview of the results will be presented along with actions taken within NASA's Life Support community as a result of the new data.

1IM.1

Laboratory Characterization of the Exhale Breath Collector (EBC) for High Collection Efficiency of Particles Down to 10nm. ARANTZAZU EIGUREN FERNANDEZ, Gregory Lewis, Susanne Hering, *Aerosol Dynamics Inc*

The Exhaled Breath Collector (EBC) was developed for efficient collection of exhaled particles and proteins. The EBC system consist of six laminar-flow growth tubes (24” long) maintained at 1^{o}C. The outcoming flow is joined in one single delivery nozzle and impacted onto ice. Particles down to 10nm contained in the vapor-saturated exhaled breath grow to above 1µm, while the excess water vapor condenses on the wick walls and is removed. Impaction on an ice surface preserves the integrity of proteins exhaled during breathing, while eliminating particle bounce. The EBC runs at a flow rate of 12 lpm and the condensationally enlarged particles are collected into approximately 2mL for a 30 min sampling time. Using analytical techniques such as PCR, immunoassays and proteomics, proteins present in the collected sample can be quickly identified, allowing diagnosis of lung infections in less than an hour.

Characterization and optimization of sampling conditions for high collection efficiency of the EBC was conducted in our laboratory, using both laboratory generated ammonium sulfate particles and ambient particles. The effect of the relative humidity (RH) of the incoming air, particle size (Dp) and number concentration (#/cc) on the collection efficiency was evaluated and the parameters optimized.

The RH of the incoming flow was the most important parameter. Collection efficiencies were <50% for low RH values, rapidly increasing after the RH reached 70%. Optimum collection efficiency (>90%) was achieved when the RH was >85%. Collection efficiency didn’t vary with particle sizes between 10nm and 250nm when run at RH >85%. For particles smaller than 10nm, collection efficiency decreased, with 80% efficiency for 8nm particles. The EBC was also tested for particle number concentrations varying between $0.5x10^3$ and $1.2x10^4$ particles/cc. Collection efficiencies above 95% were obtained for all sizes and concentrations.

1IM.2

Scanning Flow Isothermal CCN Analysis (SFICA): A New Method for Measuring CCN. MARY KACARAB, Tomi Raatikainen, Greg Kok, Athanasios Nenes, *Georgia Institute of Technology*

The ability of atmospheric aerosols to act as cloud condensation nuclei (CCN) plays a complex and important role in aerosol-cloud interactions and their effect on the global climate (IPCC 2014). Currently, CCN activity is most often evaluated using a continuous-flow streamwise thermal gradient CCN counter (CFSTGC) in either a constant flow regime utilizing different temperature gradients along the column to generate different supersaturation conditions or a constant temperature gradient utilizing scanning flow CCN analysis (SFCA) methods to achieve a higher time resolution through ranges of supersaturations. This work presents a novel method to generate supersaturation environments within the column without the need for a temperature gradient, solely through manipulation of the pressure drop across the instrument column. This method is first demonstrated and evaluated on the full-size commercial CFSTGC instrument both in the laboratory and in the field during the 2016 NASA ORACLES campaign. The zero temperature gradient method is further applied to a lightweight, miniaturized isothermal instrument. The decreased size and isothermal column allows for a substantial reduction in the cost of the instrument and furthermore opens up possibilities for measuring CCN on unmanned aerial vehicles (UAVs). This work opens up a significant opportunity for establishing a network of low-cost and highly accurate CCN measurements, which are critical for an increased understanding of the radiative and hydrological impacts of regional aerosols on clouds.

1IM.3

A Study of Alternative Working Fluids and Corresponding Effects for Condensation Nuclei Counters Applied on Automotive Exhaust. MARTIN KUPPER, Martin Kraft, Tristan Reinisch, Alexander Bergmann, *CTR Carinthian Tech Research, Villach, 9524, Austria*

Introduction An established measurement device for particle number (PN) concentrations in automotive exhaust gases in scientific as well as for industrial applications are condensation nuclei counters (CNC), which typically use butanol as a working fluid. With the inauguration of partly biogenic fuels some new effects like strong system drifts and shortened lifetimes of wicks occurred. These effects can partly be related to carboxylic acid butanol ester chains resulting from the imperfect burning of biogenic components of the fuel and can be avoided by the use of a suitable working fluid instead of butanol.

Methods A pre-selection of 88 working fluids was done considering critical parameters as e.g. diffusivity, kelvin diameter, dielectric constant, vapour pressure, etc. and supported by CFD simulations and practical tests under laboratory conditions n-decane and n-dodecane were selected as most suitable candidates. Based on literature research regarding capillary condensation, a theoretical model was set up to describe the processes during the nucleation event in a CNC for vapours of different fluids.

Results Tests with a CNC using n-decane in comparison to one using butanol showed at least comparable, or even superior counting efficiency for the decane CNC using soot as condensation nuclei. Theoretical considerations reveal until now a strong dependence of the kelvin diameter to the morphology of the particle but on the other hand suggest no or just a weak dependency of the working fluid.

1IM.4

Design and Performance of an Indirect Ionization Soft X-ray Charge Conditioner. DEREK OBERREIT, Siqin He, *Kanomax FMT, Inc.*

Aerosol measurements using electrical-based instruments such as Faraday cup electrometers and electrical mobility classifiers require corrections to account for charge probability distribution within the population of aerosol particles. Often this is accomplished by exposing the aerosol to ionizing radiation (light, radioactive, x-ray), where gas molecules within the aerosol are ionized and, through collisions with the aerosol particles, achieve a known charge probability distribution. Exposing the aerosol to this ionizing energy can result in new particle formation by the radiolytically excited gas vapors within the aerosol, as well as directly ionization the particles. The radiolytically generated particles may be indistinguishable from the particles within the sampled aerosol, leading to measurement errors. Additionally, using these methods does not allow for controlled chemical ionization, where the ionizing molecule is chosen for its specific properties. Finally, in special cases, it is possible to alter the properties of the particles themselves by exposing them to high levels of electromagnetic radiation (e.g. particle heating from a photoionization process).

A novel indirect ionization device has been developed to allow for controlled chemical ionization of aerosol particles without exposing the aerosol to relevant levels of ionizing energy. The principle of operation and performance of the device are presented, including size-dependent charge distribution measurements for different ionizing gases.

1IM.5

Characterization of a Condensation Particle Counter to Rapidly Measure Sub 3 Nanometer Atmospheric Clusters through Pulse Height Analysis. CHONGAI KUANG, *Brookhaven National Laboratory*

Atmospheric particle nucleation is an important environmental nano-scale process, with field measurements and modeling studies indicating that freshly nucleated particles can contribute significantly to the global population of aerosol and cloud condensation nuclei. Our understanding of atmospheric nucleation and its influence on climate, however, is limited, as few ambient measurements have been made of either the nucleation rate or the chemical composition of the freshly formed clusters, both of which are necessary to gain process-level understanding.

Recent advances in the development of condensation particle counters (CPCs) have enabled the detection of gas-phase single molecules and molecular clusters down to 1 nanometer diameter and below through the use of new working fluids and/or varying operating conditions. This new capability has enabled the direct measurement of aerosol nucleation from trace-gas precursors in both laboratory experiments and the ambient environment, providing information necessary to understand and constrain the nucleation mechanism.

While there have been an increasing number of atmospheric cluster measurements from surface-based platforms, there have been very few measurements of the vertically-resolved ambient cluster size distribution from aerial platforms, which are needed to connect atmospheric nucleation with large-scale boundary layer transport processes. To address this measurement need, a commercial CPC has been has been adapted to rapidly measure (~ 1 Hz sampling time resolution) the cluster size distribution (< 3 nm) through pulse height analysis. Characterizations of the CPC size-dependent counting efficiency and analysis of the resulting droplet size spectra to recover the sampled aerosol size distribution will be presented using electrical mobility classified ammonium sulfate aerosol and ambient aerosol.

1IM.6

A Compact, "MAGIC" Water Condensation Particle Counter. STEVEN SPIELMAN, Gregory Lewis, Arantzazu Eiguren Fernandez, Jocelyn Bale-Glickman, David Delew, Susanne Hering, *Aerosol Dynamics Inc.*

A fully integrated, self-sustaining, water-based condensation particle counter has been developed and validated. Called MAGIC, for moderated aerosol growth with internal water cycling, this instrument obtains the water needed for condensational growth through a combination of capture of water vapor from the sampled air, and internal recapture of water vapor after particle activation. Recent efforts have focused on refining and testing a fully integrated system, with the aim to provide a robust system. A Nafion-based sample stream humidifier has been added to partially humidify the incoming air stream so as to guarantee sufficient water vapor to sustain operation over multiple weeks of operation. System temperatures are adjusted based on the measured temperature and relative humidity at the growth tube inlet, which enables stable multi-week operation. A new optical detector has been designed that uses a longer focusing path, a wider beam waist and a larger diameter focusing nozzle to reduce the sensitivity to accumulated debris in the nozzle or slight misalignment of optics. Calibrations were done with reference to the versatile water-based condensation particle counter (Hering et al, 2017), which is independently calibrated against an aerosol electrometer. Laboratory-generated sulfate and sucrose aerosols show that the lower threshold for particle detection is below 7 nm. It has a rather gentle response curve, rising to 80% detection efficiency at 14 nm, 90% detection at 28 nm, and above 95% for particles larger than 40 nm. The measured response is linear with concentration up to the highest levels tested which were 10^5/cm^3.

1IM.7

A Method to Estimate the Bipolar Ion Mobility Ratio and Charge Fractions of Submicron Particles in an Aerosol Neutralizer. XIAOTONG CHEN, Jingkun Jiang, *Tsinghua University*

Electrical mobility size spectrometer is widely used in aerosol science. Among its three key components (i.e., bipolar charger (neutralizer), electrical mobility classifier, and detector), more attention has been given to the latter two in recent years and good progress was made. Progress in understanding and reducing the measurement uncertainties caused by the charger is slow. Recent studies revealed that trace species in the carrying gas can lead to significant variations in the mobility of ions produced in the charger. Accordingly, aerosol charge fractions after the neutralizer may deviate from values predicted by a widely used formula. In this study, we proposed a method to estimate the mobility ratio of positive and negative ions produced by a neutralizer based on measured positively and negatively charged particles by an electrical mobility size spectrometer. A modified equation from Gunn and Woessner (1956) was used to calculate aerosol charge fractions from the ion mobility ratio. The estimated charge fractions can then be used in data inversion to achieve more accurate measurement of aerosol size distributions. This method was evaluated using simulated aerosols and laboratory-generated aerosols.

1RA.1

Marine Aerosol Organic Composition and Sea Spray Production Processes. LYNN RUSSELL, Raghu Betha, Savannah Lewis, Jun Liu, Patricia Quinn, Timothy Bates, *Scripps Institution of Oceanography*

Organic functional group composition of marine aerosol particles associated with sea spray were measured for submicron particles during five open ocean research cruises: one in the northeastern Pacific and four in the northwestern Atlantic. Fourier transform infrared spectroscopy provides information about the functional group composition that represents the marine organic fraction more completely than is possible with techniques that measure non-refractory mass. Primary biogenic marine particles have measured compositions in these ocean regions that include approximately 50-70% hydroxyl groups and 10-20% alkane groups. The organic composition of atmospheric primary marine (ocean-derived) aerosol particles is nearly identical to model generated primary marine aerosol particles from bubbled seawater. This study evaluates the processes that link the organic composition to sea spray production using ambient measurements.

1RA.2

Aerosol Properties over the Remote North Atlantic Ocean: Quantifying the Burden of Marine Emissions and Long-Range Transport. LUKE ZIEMBA, Matthew Brown, Ewan Crosbie, Richard Moore, Michael Shook, Kenneth Thornhill, Edward Winstead, Bruce Anderson, *NASA*

The climate impact of marine biogenic aerosols is tied directly to effects on overlying cloud properties. Phytoplankton blooms are a potential source of particles in the North Atlantic Ocean basin, both through primary emissions of sea-spray aerosol and secondary oxidation of dimethyl sulfide. This environment is observationally challenging as concentrations are low and pervasive clouds make relating aerosol and ocean properties from satellites especially uncertain. Additionally, long-range transport of continental and biomass burning air masses often overwhelms any biogenic response. The NASA NAAMES (North Atlantic Aerosol and Marine Ecosystem Study) mission was designed, in part, to address this issue by utilizing a synergy of complex ship-based measurements of ocean properties, airborne in-situ and remote-sensing observations, and a seasonal sampling strategy. Here, we present aerosol observations made aboard the NASA C-130 during flights in November-2015 and May-2016. Our analysis will highlight differences in particle size distribution, chemical composition, and number concentration to quantify the relative burden attributed to phytoplankton bloom emissions and transported biomass burning particles. Vertical profiles are used to constrain inputs to the marine boundary layer through entrainment as well as emissions from the sea surface. We will also highlight the role of secondary sulfur chemistry with respect to accumulation-mode mass and new particle formation.

1RA.3

Linking Barbados Mineral Dust Aerosols to North African Sources Using Elemental Composition and Radiogenic Sr, Nd, and Pb Isotope Signatures. AYSE BOZLAKER, Joseph M. Prospero, Jim Price, Shankar Chellam, *Texas A&M University*

Arid and semi-arid regions of North Africa are the largest source of mineral material to the global atmosphere. Large quantities of dust uplifted from the Sahara-Sahel region are carried across the Atlantic to the Caribbean Basin and southern United States where it plays an important role in the biogeochemistry of soils and waters and in air quality. The elemental and isotopic composition of this dust was comprehensively characterized in Barbados during the summers of 2013 and 2014, the season of maximum dust transport. Total suspended particulates (TSP) mass concentrations during high-dust days (HDD) averaged $22.6\pm9.9 \mu g/m^3$ in 2013, ~4 times the low-dust days (LDD) value ($5.4\pm3.1 \mu g/m^3$). Although HDD concentrations approximately doubled in 2014 ($40.8\pm25.1 \mu g/m^3$) compared to 2013, the abundances (µg element/g TSP) of 50 elements were similar. Predictably, mineral and marine aerosol tracers such as Na, Mg, Al, Si, K, Ca, Ti, and Fe were the most abundant constituents of Barbados aerosols. Aerosols in HDD and LDD were regularly enriched in Na, Cu, Zn, As, Se, Mo, Cd, Sn, Sb, and W relative to the upper continental crust. Enrichment of these elements, many of which are anthropogenically emitted, was significantly reduced during HDD attributed to mixing and dilution with desert dust over source regions. Generally, Ti/Al, Si/Al, Ca/Al, Ti/Fe, Si/Fe, and Ca/Fe ratios in HDD differed from their respective values in North African source regions. Ca/Al, K/Al, Ca/Fe, and K/Fe ratios were also significantly different between LDD and HDD. Nd isotope composition expressed as ε_{Nd} was relatively invariant for LDD and HDD periods. In contrast, HDD-aerosols were more radiogenic with higher $^{87}Sr/^{86}Sr$, $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$ ratios compared to LDD periods. Our results demonstrate that summertime Barbados aerosols, both during and between large dust events, are dominated by a mixture of particles originating from different Sahara-Sahel regions.

1RA.4

Molecular Characteristics of Long-range Transported Organic Aerosol at the Pico Mountain Observatory (PMO).

SIMEON SCHUM, Bo Zhang, Katja Dzepina, Paulo Fialho, Claudio Mazzoleni, Lynn Mazzoleni, *Michigan Technological University*

The properties of remote free tropospheric aerosol are impacted by the continental outflow of pollutants, their chemical transformation, and removal mechanisms. To investigate this, we determined the molecular characteristics of long-range transported aerosol from North America collected at the Pico Mountain Observatory (PMO, 38.47°N, 28.40°W, 2225 m above sea level). PMO is located within the marine free troposphere on Pico Island in the Azores archipelago and is an ideal location to sample aged free tropospheric aerosols, as it is far from large orographic systems and is primarily above the marine boundary layer. Aerosol samples from pollution events in the summers of 2013, 2014, and 2015 were selected for ultrahigh resolution ESI-FT-ICR MS characterization of water-soluble organic carbon. Thousands of molecular formulas were identified in all the samples, ~60% contained only carbon, hydrogen, and oxygen, ~30% contained nitrogen, and ~10% contained sulfur. FLEXPART back trajectory analysis was performed for the three sample periods and indicated that two of the samples were primarily transported above the marine boundary layer, while the third was primarily transported within the marine boundary layer. Differences in the transport patterns are reflected in the molecular characteristics of the aerosol, with the two free troposphere transported samples having lower average O/C ratios (0.46 & 0.47) and OS_c values (-0.411 & -0.348) compared to the boundary layer transported sample (O/C = 0.55 & OS_c = -0.279). This difference in apparent oxidation for aerosol transported in the boundary layer versus in the free troposphere has not been previously described and is the focus of this presentation.

1RA.5

Seasonal Cycles in Particle Number Fluxes over a Pine Forest.

HOLLY DEBOLT, Ryan Fulgham, John Ortega, Delphine Farmer, *Colorado State University*

The ability of global climate models to accurately reflect global warming and cooling processes is limited by our understanding of the physical mechanisms underlying these predictions and our ability to directly observe and accurately quantify the relevant measurements. The area of greatest uncertainty in predictive models is the magnitude of radiative forcing due to aerosol effects which may potentially mask a significant amount of warming due to anthropogenic greenhouse gas emissions. Underlying this uncertainty is a lack of observational study of the factors governing aerosol emission and removal mechanisms in various types of terrain. Measurements of relatively simple, smooth terrain such as grasslands have been shown to agree with predictive modeling of exchange velocities, However, predictions over rough surfaces, such as forests, have failed to match observed measurements. To improve these parameterizations, accurate quantification of particle flux and deposition velocity is needed.

The Manitou Experimental Forest Observatory (MEFO) in Colorado provides the surface-to-atmosphere interface for our study during a year-long deployment covering all four seasons. We have obtained fast (10 Hz), size-resolved (80-100nm) measurements of particle number concentrations with an Ultra High Sensitivity Aerosol Spectrometer (UHSAS) and calculated particle fluxes using the Eddy Covariance micrometeorological method. Deposition fluxes were observed through the daylight hours in each season with occasional upward fluxes occurring in the morning, corresponding to the breakup of the nocturnal boundary layer. An inter-seasonal comparison of particle fluxes shows differentiation of flux magnitude among the seasons with summer having the highest magnitude deposition flux, winter having the lowest, and with spring and fall fluxes falling in between. This observed trend is correlated with the observed particle number concentrations recorded in each respective season. These initial results provide a basis for further investigating the seasonal parameters that influence aerosol dry deposition processes over the forested surface-to-atmosphere interface.

1RA.6

Chemical and Physical Properties of Aerosols in Regional Air Masses and the Free Troposphere over the Western U.S.

SHAN ZHOU, Sonya Collier, Daniel Jaffe, Qi Zhang, *University of California, Davis*

Understanding the properties and lifecycle processes of aerosols in regional air masses and the free troposphere (FT) is crucial for constraining the climate impacts of aerosols on a global scale. In this study, characteristics of regional and FT aerosols in the western US were studied using a high-resolution time-of-flight aerosol mass spectrometer deployed at the Mount Bachelor Observatory (MBO; 2763 m a.s.l.) in central Oregon in summer 2013. In the absence of wildfire influence, the average (± 1σ) concentration of non-refractory submicrometer aerosol (NR-PM_1) at MBO was 2.8 (± 2.8) μg m^{-3} and 84% of the mass was organic. Organic aerosols (OA) showed clear diurnal variations driven by the boundary layer (BL) dynamics with significantly higher concentrations occurring during daytime, upslope conditions. NR-PM1 contained a higher mass fraction of sulfate and was frequently acidic at night when MBO resided in the FT. OA in the FT was highly oxidized (O/C ~ 1.17) with low volatility. In contrast, OA associated with BL air masses had an average O/C of 0.67 and appeared to be semivolatile. The significant compositional and physical differences observed between FT and BL aerosols may have important implications for understanding the climate effects of regional background aerosols.

1RA.7

Towards Understanding the Physical Conditions Governing the Relationship between Aerosol Optical Depth and Surface PM2.5 Mass in the Western U.S.

SANDRA-MARCELA LORÍA-SALAZAR, Anna Panorska, W. Patrick Arnott, James Barnard, Cesunica Ivey, Jayne Boehmler, Heather Holmes, *University of Nevada, Reno*

Monitoring surface PM2.5 using satellite retrievals is desired because of the improvement in spatial resolution of the sampling with respect to ground-based monitoring stations. Data fusion models based on statistical techniques aim to create relationships that rely on columnar aerosol optical depth (AOD) from satellite retrievals as a spatial surrogate of surface PM2.5. Those models show optimistic results in the eastern U.S. because of the strong correlation between AOD and PM2.5. However, data fusion models based on purely statistical approaches are not able to represent surface concentrations of aerosol pollution in the western U.S. because they are challenged by complex atmospheric physics (e.g planetary boundary layer mixing, transport of aerosol pollution), air pollution sources, and uncertainty of satellite retrievals due to instrument calibration and non-ideal model parametrizations and assumptions. Therefore, data fusion or exposure models based on purely statistical relationships may not be able to capture the physical conditions governing the relationship between AOD and PM2.5 in the western U.S. Thereby requiring an intensive examination of the atmospheric conditions to improve surface estimates of PM2.5. The main goals of this investigation are: 1) Study the atmospheric processes that impact the complex relationship between AOD and PM2.5 using ground-based sunphotometry as "ground-truth" and 2) investigate the atmospheric and aerosol pollution scenarios under which AOD from satellite retrievals can be used as spatial predictors of surface PM2.5. Future aims include using the results of this investigation to help identify atmospheric variables that will improve results from data fusion models that estimate near surface PM2.5.

2AC.1

Formation of Secondary Organic Aerosols from Gas–Phase Emissions of Heated Cooking Oils. Tengyu Liu, Zijun Li, Man Nin Chan, CHAK K. CHAN, *City University of Hong Kong*

Cooking emissions can potentially contribute to secondary organic aerosol (SOA) but remain poorly understood. In this study, the formation of SOA from gas-phase emissions of five heated vegetable oils (i.e. corn, canola, sunflower, peanut and olive oils) was investigated in a potential aerosol mass (PAM) chamber. Experiments were conducted at 19-20ºC and 65-70% RH. The characterization instruments included a scanning mobility particle sizer (SMPS) and a high-resolution time-of-flight aerosol mass spectrometer (HR-TOF-AMS). The efficiency of SOA production, in ascending order, was peanut oil, olive oil, canola oil, corn oil and sunflower oil. The major SOA precursors from heated cooking oils were related to the content of mono-unsaturated fat and omega-6 fatty acids in cooking oils. The average production rate of SOA, after aging at an OH exposure of 1.7×10^{11} molecules cm^{-3} s, was 1.35 ± 0.30 $\mu g\ min^{-1}$, three orders of magnitude lower compared with emission rates of fine particulate matter ($PM_{2.5}$) from heated cooking oils in previous studies. The mass spectra of cooking SOA highly resemble field-derived COA (cooking-related organic aerosol) in ambient air, with R^2 ranging from 0.74 to 0.88. The average carbon oxidation state (OSc) of SOA was -1.51 – -0.81, falling in the range between ambient hydrocarbon-like organic aerosol (HOA) and semi-volatile oxygenated organic aerosol (SV-OOA), indicating that SOA in these experiments was lightly oxidized.

2AC.2

Modeling the Formation of Secondary Organic Aerosol Precursors from Isoprene. KELVIN BATES, John Seinfeld, Paul Wennberg, *California Institute of Technology*

Isoprene, a volatile hydrocarbon emitted by plants, represents the single most abundant source of non-methane organic carbon to the atmosphere. After its rapid oxidation by OH radicals in the troposphere, isoprene may follow any of a number of complex reaction mechanisms to form more highly functionalized products, depending in large part on the relative abundance of reactive radicals such as HO_2 and NO; some of these products can be sufficiently water-soluble, non-volatile, and/or reactive to partition into atmospheric particles and contribute to the creation of secondary organic aerosol (SOA). In this work, a comprehensive mechanism of isoprene oxidation is incorporated into GEOS-Chem, a global chemical transport model, to investigate the formation of SOA precursors such as isoprene epoxydiols (IEPOX), methacryloyl peroxynitrate (MPAN), and tetrafunctionalized species including dihydroxy-dihydroperoxides and dihydroxy-nitrates. We explore the spatial and temporal distribution of these products, and find that upwards of 180 Tg y^{-1} of IEPOX, 30 Tg y^{-1} of MPAN, and 40 Tg y^{-1} of tetrafunctional species are produced in the atmosphere, representing a significant source of SOA mass globally. We further investigate various methods of parameterizing SOA formation from these precursors for incorporation into models.

2AC.3

Spatial Differences in Summertime Enhancement of Aerosol Optical Thickness: Organic Carbon Fractionation and Particle Size. AMY CHRISTIANSEN, Annmarie Carlton, *University of California, Irvine*

Summertime aerosol optical thickness (AOT) over the United States is strongly enhanced in the Southeast, and not elsewhere. Proposed explanations for this phenomenon in the literature include seasonal patterns in aerosol liquid water (ALW), height of the planetary boundary layer, and formation of biogenic secondary organic aerosol (SOA). Although geospatial patterns and seasonality in total particle organic mass measurements at the surface are inconsistent with satellite AOT, aloft formation of biogenic SOA and seasonal differences in particle organic chemical speciation remain plausible explanations. Here we explore: 1.) seasonal differences in organic mass speciation, specifically organic carbon (OC) fractions OC1, OC2, OC3, and OC4 as defined and reported at Interagency Monitoring of PROtected Visual Environments (IMPROVE) monitoring locations across the continental US, and 2.) seasonal estimates of particle size that include ALW. This is done in the context of spatial and temporal differences in Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)-measured AOT. In the area of strongest CALIPSO AOT summertime enhancement, OC2 and OC3 fractions show summer/winter differences of several percent by mass concentration. This is contrasted to OC1 and OC4 fractions, in which there is little seasonal difference in mass concentration. Additionally, there is seasonality in particle size and, through Mie scattering calculations, we explore the potential to explain the seasonality in satellite AOT measurements. The chemical composition for individual species or functional groups responsible for differences in OC categories is a topic for future study.

2AC.4

Fog Enhances Toxicity of Ambient Particulate Matter. Stefano Decesari, MOHAMMAD SOWLAT, Sina Hasheminassab, Silvia Sandrini, Stefania Gilardoni, M. Cristina Facchini, Sandro Fuzzi, Constantinos Sioutas, *University of Southern California*

Numerous studies have demonstrated that outdoor exposure to atmospheric particulate matter (PM) is associated with adverse health effects. However, it should be pointed out that the actual chemical species responsible for PM toxicological properties remain a subject of investigation. Carbonaceous species and transition metals have been clearly identified as triggers of PM toxicity in urban environments, however little is known for background continental sites. We provide here reactive oxygen species (ROS) activity data for PM samples collected at a rural site in the Po Valley, Italy, during the fog season (i.e., November-March). We show that the intrinsic ROS activity of Po Valley PM, which is mainly composed of biomass burning and secondary aerosols, is comparable to that of traffic-related particles in urban areas. The airborne concentration of PM components responsible for the ROS activity decreases in fog conditions, when water-soluble species are scavenged within the droplets, and the intrinsic ROS activity of fog droplets is even greater than that of the PM on which droplets are formed, indicating that redox-active compounds are not only scavenged from the particulate phase, but are also produced within the droplets. Therefore, even if fog formation exerts a scavenging effect on PM mass and redox-active compounds, the aqueous-phase formation of reactive secondary organic compounds can eventually enhance ROS activity of PM when fog evaporates. These findings demonstrate that a significant portion of airborne toxicity in the Po Valley is largely produced by environmental conditions (fog formation and fog processing) and not simply by the emission and transport of pollutants.

2AC.5

Investigating the Formation of Quinonic Compounds from Aqueous-phase Reactions of Phenols. WENQING JIANG, Lu Yu, Shan Zhou, Alexander Laskin, Cort Anastasio, Qi Zhang, *University of California, Davis*

Quinones are a class of oxygenated derivatives formed from aromatic hydrocarbons such as polycyclic aromatic hydrocarbons (PAHs) and phenols. Quinones contain two carbonyl groups in a fully conjugated cyclic dione structure and are effective light-absorbing compounds. Quinonic compounds are also a concern for human health due to their ability to generate reactive oxygen species (ROS). Because of their low volatilities, quinonic compounds tend to exist in the particle phase, where they can affect the optical and toxicological properties of particles. Previous studies have observed the presence of quinones in wood smoke, which is a large source of phenolic compounds. In this study, we investigate the production of quinones through aqueous-phase oxidation of phenol and two methoxyphenols using high resolution time-of-flight aerosol mass spectrometry (HR-ToF-AMS) and nanospray desorption electrospray ionization mass spectrometry (nano-DESI MS). Formation of quinonic compounds was observed in the secondary organic aerosols formed through the aqueous reactions (aqSOA) of phenol, guaiacol, and syringol with the triplet excited state of an aromatic carbonyl (3C*) and the hydroxyl radical (·OH). Several HR-ToF-AMS tracer ions that can potentially represent quinones (e.g. $C_6H_4O_2^+$ and $C_{12}H_8O_6^+$ in phenol aqSOA and $C_6H_4O_2^+$, $C_{14}H_{12}O_7^+$ and $C_{14}H_{12}O_8^+$ in guaiacol aqSOA) have been identified in this study, allowing us to track the changes of quinonic concentrations during the course of the aqueous reactions. The relative abundances of quinones increase significantly in the first two hours of aqueous-phase photochemical oxidation, and then plateau or slightly decrease in the later hours. Although previous studies of our group find that fragmentation eventually dominates over oligomerization and functionalization in the photochemical evolution of phenolic aqSOA, our results here suggest that quinones may still play an important role even in the late periods of photochemical oxidation.

2AC.6

The Effect of Short-chain Alcohols on Secondary Organic Aerosol Mimicking Solutions Containing Glyoxal and Ammonium Sulfate. ANDREW BERKE, Tara Bhat, Claire Keller, Kim Lu, Hunter Myers, Lily Timpane, *Smith College*

The reaction between glyoxal and ammonium sulfate represents an important model system with which to study the non-oxidative production of light absorbing compounds in secondary organic aerosols (SOAs). SOA particles have access to hundreds or thousands of airborne chemicals as they age, and each of these chemicals have the potential to affect particle growth and the production of light-absorbing compounds, such as imidazoles. These compounds can affect particle size, and thereby influence a particles climatic and human health effects.

Our research seeks to elucidate the effect short-chain alcohols have on laboratory-based, bulk-phase SOA chemistry. The kinetics of product formation for compounds, predominantly imidazoles, absorbing near 280 nm are monitored via UV-Vis for aqueous mixtures of glyoxal, ammonium sulfate, and varying concentrations of alcohols. Results will be presented for methanol, ethanol, 1- and 2-propanol, and t-butyl alcohol that show a dependence on both alcohol species and concentration. Reasons for the observed differences in alcohol-mediated reactivity are also explored.

2AC.7

Effect of the Urban Heat Island on Aerosol pH. MICHAEL BATTAGLIA JR., Sarah Douglas, Christopher Hennigan, *University of Maryland, Baltimore County*

The urban heat island (UHI) is a widely observed phenomenon whereby urban environments have higher temperature and lower relative humidity than surrounding suburban and rural areas. Temperature (T) and relative humidity (RH) are critical factors that affect the partitioning of semi-volatile species found in the atmosphere, such as nitric acid and ammonia. These species are inherently tied to aerosol pH, which is a key parameter driving some atmospheric chemical processes and environmental effects of aerosols. In this study, we characterized the effect of the UHI on aerosol pH in Baltimore, MD. The T and RH differences that define the UHI lead to substantial differences in aerosol liquid water (ALW) content for the same aerosol chemical composition. The ALW differences result in urban aerosol pH that is systematically lower (more acidic) than rural aerosol pH for identical aerosol composition. The UHI in Baltimore is most intense during the summer and at night, with differences of up to 1 pH unit predicted during these times. The UHI has been observed in cities of all sizes, so these results likely have broad implications for chemistry occurring in and around urban atmospheres globally.

2AC.8

Photocatalyzed Autoxidation of Polycyclic Aromatic Hydrocarbons in the Production of Humic-like Substances. JOHN HAYNES, Keith Miller, Brian Majestic, *University of Denver*

This study evaluates the possibility of humic-like substance (HULIS) production by oxidation of aqueous suspensions of polycyclic aromatic hydrocarbons (PAH) with exposure to sunlight. HULIS material is presented as a collective of compounds, each containing significant aromatic and carboxylic acid character. They are found to be a major component of brown carbon and are implicated with radiative forcing in the atmosphere. PAH and HULIS are commonly observed in particles sourced from pyrogenic processes, e.g. biomass burning and vehicle exhaust. The extended atmospheric lifetimes of PAH lend themselves to longer exposure times to sunlight and oxidants, potentially producing other branched and oxidized PAH (oxPAH) products such as anthraquinone and naphthol, which then may act as intermediates for larger structures, e.g. HULIS. Particle surfaces containing PAH may use ultraviolet radiation as a catalyst in an electron transfer interaction with elemental oxygen or water molecules to produce radicals, such as superoxide or hydroxyl radicals. These radicals are highly reactive oxidation agents and may initiate several oxidizing pathways, resulting in the production of HULIS via oxPAH.

Reaction conditions use varying light exposure, sample composition, and duration. Analytical techniques, including HPLC, SPE, GCMS, FTIR, UV-vis, and pH, are used to elucidate the number and character of these products. Initial PAH data include many new HPLC peaks during and following light exposure periods, which indicate the production of several species of oxPAH. This array of products is emblematic of HULIS materials. The growth of peaks at specific retention times throughout the reaction demonstrates the evolution of explicit reaction pathways toward predictable products. Evaluating the formation of products from dissolved and suspended PAH solutions with photo-reactions conducted within purified water, formate buffer, and suspended soil allows for the determination of specific reaction mechanisms.

2AC.9

Secondary Organic Aerosol Formation from 3-Methylfuran Oxidation. TAEKYU JOO, Masayuki Takeuchi, Nga Lee Ng, *Georgia Institute of Technology*

Biomass burning (BB) is an important source of both primary and secondary organic aerosol (SOA). Recent studies suggested that nontraditional precursors such as phenols or furans can contribute to SOA formation from BB considerably. Methylfurans are one of major furan alkyl-derivatives from BB. 3-methylfuran (3MF) is an isomeric compound of the methylfurans which originates not only from BB but also from oxidation of isoprene. Here, we investigate SOA formation from 3MF under various reaction conditions at the Georgia Tech Environmental Chamber (GTEC) facility. Different oxidants were injected into the chamber to compare day and nighttime oxidations of 3MF under dry and humid conditions. In the case of photooxidation by OH radical, reaction was carried out under different NO_x conditions where different RO_2 fates dominate. N_2O_5 was injected into the chamber to study nighttime 3MF + NO_3 chemistry. Gas- and particle-phase composition were monitored using a Filter Inlet for Gases and AEROsols coupled with time-of-flight chemical ionization mass spectrometer (FIGAERO-ToF-CIMS) and a High Resolution-Time of Flight-Aerosol Mass Spectrometer (HR-ToF-AMS). Decay of 3MF was monitored with a Gas Chromatography Flame Ionization Detector (GC-FID) and volume of aerosol was detected using a Scanning Mobility Particle Sizer (SMPS). Differences in SOA yields under experimental conditions and their respective chemical composition will be discussed.

2AC.10

Chemical Characterization of 2016 Alberta Wildfire Smoke and Its Long-term Health Impact. Meng Meng, Shunyao Wang, Lukas Kohl, ARTHUR W. H. CHAN, *University of Toronto*

The wildfires near Fort McMurray, Alberta, Canada was the costliest disaster in Canadian history, burning over 2000 homes in Fort McMurray and over 1.5 million acres of forest land. Since wildfire smoke has been shown to induce pulmonary oxidative stress and contain gene mutagens, there are significant concerns over the long term health impacts of exposure to wildfire smoke and residual ash. In this work, we characterize the chemical composition (including organic compounds and metals) of the smoke generated from Alberta wildfire. Both fire smoke particulate matter and ash samples were collected in the area. Synchronized Hybrid Ambient Real-time Particulate (SHARP) monitors that remained in operation provide filter samples of PM2.5 directly emitted from the fires. Ash samples were also collected after the wildfire in urban and rural areas. Gas chromatography-mass spectrometry (GC/MS) with in-situ derivatization was used to characterize the organic composition, and the metal content was analyzed using Inductively Coupled Plasma Mass Spectrometer (ICP-MS). Preliminary results show that many semi-volatile organic compounds such as alkanes, alkanoic acids, polycyclic aromatic hydrocarbons and their derivatives were found to be significantly elevated in the samples during the fire. Measurements of oxidative potential (OP) by the dithiothreitol (DTT) assay show that OPs were also elevated in locations not directly affected by fire, suggesting the role of atmospheric transport of fire smoke. Ash collected in urban areas show a different profile in metal concentrations from ash collected in rural areas, which may indicate different long-term health impacts. The spatial profile of organic and metallic chemical compositions of PM2.5 and fire ash samples will be discussed.

2AC.12

Characterization of Highly Oxidized Multifunctional Species (HOM) Generated from the Oxidation of α-pinene Using High-resolution Time-of-Flight Chemical Ionization Mass Spectrometry (HR-ToF-CIMS). PENGLIN YE, Andrew Lambe, Chao Yan, Wei Nei, Paola Massoli, Manjula Canagaratna, John Jayne, Douglas Worsnop, *Aerodyne Research, Inc.*

Highly oxidized multifunctional (HOM) species that are generated in the gas phase from the oxidation of biogenic and anthropogenic precursors play an important role in new particle formation and growth. However, the relative contribution to HOMs formation from different oxidation pathways remains poorly understood. Using α-pinene as a biogenic surrogate species, we characterize the chemical compositions and relative yields of HOMs along with other oxidation products that are formed following oxidation initiated by O3, hydroxyl (OH) radicals or nitrate (NO3) radicals in a Potential Aerosol Mass (PAM) oxidation flow reactor. We use a high-resolution time-of-flight chemical-ionization mass spectrometer with I- as the primary reagent ion coupled to a filter inlet for gases and aerosols (FIGAERO I-CIMS) to measure the elemental composition of HOM molecules in both vapor and particle phases. A subset of these CIMS measurements are also conducted with NO3- as the reagent ion to further characterize more oxidized gas-phase HOMs. PAM reactor operating conditions are systematically varied in order to characterize HOM signatures as a function of integrated oxidant exposure and ratio of nitric oxide (NO) to hydroperoxyl (HO2) radical. We additionally compare laboratory CIMS signatures with ambient CIMS measurements obtained in a boreal forest.

2AC.13

Modeling Peroxy Chemistry and VOC Evolution in Oxidation Flow Reactors. ZHE PENG, Julia Lee-Taylor, Marie Camredon, Bernard Aumont, Alma Hodzic, Sasha Madronich, Jose-Luis Jimenez, *CIRES, University of Colorado*

The use of oxidation flow reactors (OFRs) is very rapidly increasing in atmospheric aerosol chemistry, especially in secondary organic aerosol (SOA) studies. The fate of peroxy radicals (RO_2) is a critical step in the oxidation of organics and formation of SOA in the atmosphere. It is critical to characterize the degree to which OFRs and other experimental systems mimic RO_2 fates in the atmosphere. The bimolecular fate of most RO_2 in standard (“low-NO”) OFR is mainly RO_2+HO_2, similar to the troposphere. For acylperoxys, their in-OFR loss by RO_2+RO_2 is not as important as in the troposphere. RO_2+NO reactions can dominate for certain “high-NO” modes of operation, although just adding high NO levels at the OFR inlet generally does not work. RO_2+OH reactions may be as important in the OFR as they are in the atmosphere, since HO_2:OH ratios in OFRs are close to ambient values, but we note the dearth of rate coefficient measurements for this class of reactions. Under typical low-NO conditions, the short residence times of OFRs prevent slower RO_2 isomerization ($k\sim0.1\ s^{-1}$) from proceeding to a similar extent as in the low-NO troposphere. Fast isomerization ($k>1\ s^{-1}$) is much less affected, since it dominates corresponding RO_2 fate in both the atmosphere and OFRs under typical low-NO conditions. The similarities and differences of the fate of different VOCs among OFRs, typical experiments in large environmental chambers, and the atmosphere are explored with the fully explicit GECKO-A model. OFRs and chambers can reproduce many aspects of atmospheric OH oxidation, but may differ from the atmosphere in several respects, e.g., relative importance of photolysis and RO_2 self/cross-reactions. Most importantly, careful attention to OFR input concentrations and operating conditions is needed, as many commonly-used conditions can lead to chemistry strongly deviating from the atmosphere.

2AC.14

Contrasting the Oxidation Behavior of Aerosols in Urban and Rural Locations. RISHABH SHAH, Kalliopi Florou, Albert A. Presto, *Carnegie Mellon University*

We present direct and oxidized measurements of atmospheric aerosol in a rural and an urban case location. The rural case location is the remote village of Finokalia on Crete island, Greece. Finokalia is characterized by highly oxidized and stable organic aerosol, with air masses coming from different sources (dust from Sahara Desert, marine aerosol over the Mediterranean Sea, urban pollution from mainland Europe).

An oxidative flow reactor (OFR) is used for simulating oxidation of sampled aerosol. Size distribution and chemical composition of ambient and OFR-oxidized aerosol particles are measured using a scanning mobility particle sizer (SMPS) and high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). Using National Oceanic and Atmospheric Administration's Lagrangian trajectory model (HYSPLIT), we estimate the source of air parcels received in Finokalia during sampling. We find that (a) ambient aerosol on all days of sampling is highly oxidized (indicated by elemental O:C=0.9 and H:C=1.5 ratios); (b) irrespective of whether air parcels come from mainland Europe or simply over the sea, several days' worth of simulated aging in the OFR only yields mass enhancements as high as 1.6; (c) when the air parcels are received from mainland Europe, the oxidation state of particles increases upon processing in the OFR – a behavior not observed when air parcels are transported completely from marine environments.

The next stage of our project is to conduct similar experiments in an urban case location (Pittsburgh, PA) in May-June, 2017. Sampling locations selected within the city will include areas influenced by different emission sources e.g., near-road, industry and suburban background. We believe that contrasting the results obtained in Pittsburgh against those from Finokalia will inform on the oxidation mechanisms of urban and semi-urban aerosol in the atmosphere.

2AC.16

Kinetic Process Models for Growth, Evaporation and Multiphase Chemistry of Organic Aerosols. THOMAS BERKEMEIER, Masayuki Takeuchi, Gamze Eris, Ulrich Pöschl, Manabu Shiraiwa, Nga Lee Ng, *Georgia Institute of Technology*

Heterogeneous reactions, gas-particle partitioning and other multiphase processes are important pathways in the formation and processing of atmospheric organic aerosols, but the effects of particle phase state on reaction and condensation kinetics are still not fully elucidated and can often not be described by classical models assuming a homogeneous condensed phase. This presentation outlines how kinetic modelling can be used to gain insight into the coupling of mass transport, phase changes, and chemical reactions in complex multiphase reaction systems.

We apply the kinetic multi-layer model KM-GAP, which explicitly resolves gas adsorption, evaporation, condensed-phase diffusion and condensed-phase chemistry and the Monte-Carlo Genetic Algorithm (MCGA), a novel method that enables automated and unbiased global optimization of model parameters such as reaction rate coefficients, diffusion coefficients and Henry's law solubility. We show how moisture-induced phase changes can affect the gas uptake and chemical transformation of organic matter by applying the kinetic multi-layer model to a comprehensive experimental data set of ozone uptake by shikimic acid. We find that slow diffusion and ozone destruction can effectively shield reactive organic molecules in the particle bulk from degradation.

Online coupling of kinetic multi-layer models to mechanisms of gas-phase chemistry such as the Master Chemical Mechanism (MCM) allows for depth-resolved tracking of concentrations during formation and growth of secondary organic aerosol (SOA) particles. In this work, formation, condensation and evaporation of SOA upon change in temperature were investigated in an environmental chamber for several different SOA precursors, leading to an estimation of diffusion coefficients in secondary organic matter.

2AC.17

Temperature Dependence of Vapor Wall Deposition: A Case Study with Levoglucosan. ADITYA KIRAN SRIKAKULAPU, Vikram Pratap, Qijing Bian, Jeffrey R. Pierce, Philip K Hopke, Shunsuke Nakao, *Clarkson University*

Recent studies have shown that wall deposition of semi-volatile organics significantly affects the interpretation of smog chamber experiments. None of the previous studies, however, focused on low temperature conditions that may be relevant to wintertime atmosphere. Temperature is expected to significantly affect vapor wall deposition primarily through reduction in saturation pressure. In this study, we investigated the role of temperature in vapor wall loss in a Teflon chamber over a wide temperature range including sub-zero °C for the first time. We used levoglucosan as an example semivolatile molecular marker to investigate vapor wall loss in an outdoor 6 m^3 Teflon smog chamber located in Potsdam, NY. The outdoor set up allowed us to perform chamber experiments in warm conditions in summer and cold conditions in winter. Preliminary analysis of aerosol size distribution data based on an aerosol microphysics model showed that under warm temperatures, the majority of levoglucosan resided in the wall, whereas under sub-zero °C, levoglucosan vapor wall loss was negligible due to kinetically limited evaporation from the particle phase. This study confirmed the key role of saturation pressure in vapor wall loss within a Teflon chamber.

2AC.18

Secondary Organic Aerosol (SOA) and Ozone Formation from Low NOx Photo-oxidation of Select Intermediate-Volatility Organic Compounds (IVOCs) and Consumer Products Containing Them in the Presence of a Surrogate Mixture. WEIHUA LI, Lijie Li, Chia-Li Chen, Mary Kacarab, Peng Weihan, David R. Cocker III, *University of California, Riverside*

Organic compounds with vapor pressure216 °C are distinguished as low vapor pressure-volatile organic compounds (LVP-VOCs) and are provided ozone exemptions by regulating agencies due to low evaporation rates. LVP-VOCs studied in this work, however, fall in the IVOC range. Therefore, we evaluated atmospheric availability of select IVOCs and found that these IVOCs have great potential to enter the atmosphere and contribute to SOA and ozone formation at ambient conditions after extended period of time. We also studied SOA and ozone formation from the select individual IVOCs and IVOC-containing generic consumer products under low-NOx conditions using H2O2 as the OH radical source as needed in the presence of a surrogate mixture in the advanced environmental smog chamber facility housed at the College of Engineering, Center for Environmental Research and Technology at UC Riverside. Our study showed that half of the select IVOCs did not form noticeable SOA, which contradicts our expectation that the select IVOCs would form significant SOA due to their high boiling points and low vapor pressures. Only three select IVOCs have yields greater than 0.1 without added H2O2 and only n-Heptadecane have very high yields relative to common VOC precursors. Although ozone formations from several individual IVOCs were suppressed, because of different sensitivities to effects on radical levels, NOx concentrations, and other factors, the effects on ozone in the experiments is not exactly the same as their effects on ozone in the atmosphere. The addition of lab created generic consumer products had a weak influence on ozone formation from the surrogate mixture but strongly affected SOA formation. The overall SOA and ozone formation of the generic consumer product could not be explained solely by the results of the pure IVOC experiments.

2AC.19

Chemical Thermodynamics of Aqueous Atmospheric Aerosols: Modeling and Microfluidic Measurements.

LUCY NANDY, Cari Dutcher, *University of Minnesota*

Accurate predictions of gas-liquid-solid equilibrium phase partitioning of atmospheric aerosols by thermodynamic modeling and measurements is critical for determining particle composition and internal structure at conditions relevant to the atmosphere. Organic acids that originate from biomass burning, and direct biogenic emission make up a significant fraction of the organic mass in atmospheric aerosol particles. In addition, inorganic compounds like ammonium sulfate and sea salt also exist in atmospheric aerosols, that results in a mixture of single, double or triple charged ions, and non-dissociated and partially dissociated organic acids. Statistical mechanics based on a multilayer adsorption isotherm model can be applied to these complex aqueous environments for predictions of thermodynamic properties.

In this work, thermodynamic analytic predictive models are developed for multicomponent aqueous solutions (consisting of partially dissociating organic and inorganic acids, fully dissociating symmetric and asymmetric electrolytes, and neutral organic compounds) over the entire relative humidity range, that represent a significant advancement towards a fully predictive model. In addition to the modeling approach, water loss of multicomponent aerosol particles is measured by microfluidic experiments to parameterize and validate the model. In the experimental microfluidic measurements, atmospheric aerosol droplet chemical mimics are generated in microfluidic channels and stored and imaged in passive traps until dehydration to study the influence of relative humidity and water loss on phase behavior.

2AC.20

Characterization of Winter Organic Aerosol in Zurich Using Extractive Electrospray Ionization Time-Of-Flight Mass Spectrometry (Eesi-Tof).

LU QI, Giulia Stefenelli, Veronika Pospisilova, Tianning Zhao, Samuel Brown, Yandong Tong, Christoph Hueglin, Martin Rigler, Mindong Chen, Xinlei Ge, Urs Baltensperger, Andre S.H. Prévôt, Jay G. Slowik, *Paul Scherrer Institute*

Organic aerosol (OA) has significant but highly uncertain effects on climate and human health. Online aerosol mass spectrometry (AMS), combined with statistical methods such as positive matrix factorization (PMF), has greatly advanced the quantification of primary organic aerosol (POA) sources and total secondary organic aerosol (SOA) mass. However, thermal vaporization and electron ionization yields extensive thermal decomposition and ionization-induced fragmentation, destroying chemical information important for SOA source apportionment and mechanistic studies. The new extractive electrospray ionization time-of-flight mass spectrometer (EESI-TOF), which provides online organic aerosol mass spectra with a linear response to mass but without fragmentation or thermal decomposition, is a promising tool for SOA characterization and source apportionment.

EESI-TOF and AMS instruments were deployed for four weeks during winter 2017 at an urban site in Zurich, Switzerland. The deployment of AMS provided complementary information on major OA sources while constraining the total OA mass and atomic ratios. PMF analysis of EESI-TOF data resolved both primary OA sources such as traffic, cooking, and biomass burning, as well as SOA factors distinguished by organic nitrate content and atomic H:C ratio. The retrieved factor mass spectra are compared to spectra generated from smog chamber aging of emissions from real-world sources, and contextualized by comparison to source apportionment results from a full year of filter samples analyzed offline by EESI-TOF and AMS.

2AC.21

Measurement of Aerosol Acidity Using Colorimetry Integrated with a Portable Miniature UV-Visible Spectrometer. RYAN WINSLOW, Myoseon Jang, *University of Florida*

Atmospheric aerosol acidity is an important characteristic of inorganic aqueous salts. It influences the health effects of particulates due to metal solubility, and is also a kinetic model parameter that processes acid-catalytic reactions of atmospheric organics to increase secondary organic aerosols. Despite numerous usages, the conventional measurement of aerosol acidity is limited to indirect estimations using a thermodynamic model and the compositions of ionic species originating from ion chromatography. In this study, a method for measuring aerosol acidity has been developed using colorimetry integrated with reflective UV-visible spectrometry (C-RUV). In order to assemble a portable device in the field, we use a miniature spectrometer that is self-contained and deployable. The C-RUV system operates by passing an air sample through a filter infused with an indicator (metanil yellow), which changes color in response to acidity changes. The optical probe transfers both the source beam from the spectrometer to the filter surface via optical fiber, and the reflected beam from the filter to the detector in the spectrometer. The C-RUV method has been applied to measure the proton concentration of inorganic aerosols comprised of ammonium and sulfate under various humidity conditions. Inorganic aerosols were introduced into a flow tube from an atomizer, and collected on the colorimetric filter. The color change of the particle sample was measured in situ by exposing the filter to the optical probe at different humidities, which were controlled using a water bubbler and dry air. The humidity effect on the equilibrium thermodynamics of the indicator (protonated vs. unprotonated) in response to aerosol acidity at different ionic strengths was theoretically described by the inclusion of excess acidity (X) in the calibration curve. The feasibility of this method and the resulting calibration curve was also demonstrated by measuring the acidity of ambient particles.

2AC.22

The Gap between Short and Long Timescales in Vapor-Wall Interaction in Laboratory Chambers. YUANLONG HUANG, Ran Zhao, Sophia Charan, Christopher Kenseth, John Seinfeld, *California Institute of Technology*

Vapor wall deposition can play a significant role in lowering secondary organic aerosol yields in environmental chamber studies. Two key mass transport steps control the vapor-wall interaction in chamber studies: bulk phase boundary layer diffusion and interfacial vapor accommodation. Recent studies reveal conflicting conclusions about the rate-limiting step in vapor wall uptake. The discrepancy arises from several possible aspects: 1. “memory effects” from sampling lines and the instrumental inlet; 2. the chemical system itself; and 3. unresolved vapor-polymer film interaction mechanisms. In this study, the “memory effect” is examined experimentally and is interpreted theoretically by an adsorption model. Wall deposition of in situ oxidation products in both low- and high-NOx environments are investigated under a range of relative humidities to assess the effect of differing chemical systems on wall deposition. A two-stage sorption model is proposed to explain short and long vapor-wall interaction timescales.

2AC.23

Predicting the Glass Transition Temperature and Viscosity of Secondary Organic Aerosols Using Molecular Composition. WING-SY WONG DERIEUX, Ying Li, Mallory Hinks, Peng Lin, Julia Laskin, Alexander Laskin, Sergey Nizkorodov, Manabu Shiraiwa, *University of California, Irvine*

Secondary organic aerosols (SOA) account for a large fraction of submicron particles in the atmosphere. Traditionally, SOA particles have been assumed to be homogeneous and well-mixed liquids. Recent laboratory experiments as well as atmospheric measurements, however, have demonstrated that they can occur in amorphous solid or semi-solid phase states depending on chemical composition, relative humidity and temperature. The particle phase state is crucial for various atmospheric gas–particle interactions, including SOA formation and partitioning, heterogeneous and multiphase reactions and ice nucleation. It is important to know the SOA phase state in multicomponent atmospheric particles for better quantification of aerosol effects on climate and air quality. The glass transition temperature (T_g) characterizes the non-equilibrium phase change from a glassy solid state to a more pliable semi-solid state as the temperature increases. Recently, we have developed a method to estimate T_g of SOA oxidation products using their elemental composition. In this study, kinetic fragility values from literature have been compiled and analyzed to identify trends related to molar mass and O:C ratio. As molar mass increases, we find that the fragility strength parameter (D) approaches a lower limit of ~10 (+/- 1.7). A weak correlation between fragility and molecular O:C ratio is observed. Using the estimated T_g and the fragility parameter, we have predicted viscosity of α-pinene and isoprene SOA as a function of RH, which matches with experimental measurements well. The effect of varying T_g, fragility, hygroscopicity and Gordon-Taylor constant on viscosity is explored. We also have estimated T_g and viscosity of toluene SOA using the elemental composition measured by high-resolution mass spectrometry.

2AC.24

Molecular Composition and Phase Partitioning of Indoor Organic Aerosol Measured during the Atmospheric Composition and Reactivity from Outdoor aNd Indoor Mixing (ACRONIM) Study. CLAIRE FORTENBERRY, Michael Walker, Audrey Dang, Arun Loka, Gauri Date, Karolina Cysneiros de Carvalho, Glenn Morrison, Brent Williams, *Washington University in St Louis*

Although the average person spends most of his/her time indoors, relatively little information exists on the chemical composition, transport, and fate of organic aerosol (OA) present in indoor air. Volatile organic compounds (VOCs) emitted from paint, varnishes, cleaning products, and other common household items can undergo oxidation and subsequent partitioning into the particle phase, driving formation of OA that can deposit in the airways and lungs. Knowledge of the chemical composition and oxidative evolution of indoor OA is therefore critical for informing exposure estimations and future building and ventilation standards.

The Atmospheric Composition and Reactivity from Outdoor aNd Indoor Mixing (ACRONIM) Study was conducted during the summer of 2016 to investigate the impacts of natural ventilation (i.e. window opening and closing) and human activities (i.e. cooking, cleaning) on the chemistry of indoor particles and gases within a typical single-family residence. The suite of instruments deployed during this campaign include a Thermal desorption Aerosol Gas chromatograph (TAG), sorption tubes for offline gas chromatographic analysis of VOCs, a Scanning Mobility Particle Sizer (SMPS), and online gas monitors for evaluation of O3, NOx, and CO concentrations. Measurements were taken alternately indoors and outdoors to evaluate key differences between indoor and outdoor aerosol composition.

We present results obtained during the ACRONIM study, with special emphasis on chemical speciation data provided by the TAG. Phase partitioning of indoor and outdoor OA components, many of which are semi- and intermediately volatile, are approximated using the TAG denuder difference method. Finally, changes in chemical speciation are evaluated in the context of current knowledge of indoor OA reaction pathways.

2AC.25

Mixing Times of Organic Molecules within Secondary Organic Aerosol Particles: A Global Planetary Boundary Layer Perspective.

ADRIAN MACLEAN, Christopher Butenhoff, James Grayson, Kelley Barsanti, Jose-Luis Jimenez, Allan Bertram, *University of British Columbia*

When simulating the formation and life cycle of secondary organic aerosol (SOA) with chemical transport models, it is often assumed that organic molecules are well mixed within SOA particles on the time scale of 1 h. While this assumption has been debated vigorously in the literature, the issue remains unresolved in part due to a lack of information on the mixing times within SOA particles as a function of both temperature and relative humidity. Using laboratory data, meteorological fields and a chemical transport model, we determine how often mixing times are < 1 h within biogenic SOA in the planetary boundary layer (the region of the atmosphere where SOA concentrations are on average the highest). Based on laboratory viscosity measurements, we show that the mixing times are < 1 h most of the time (> 93 % of the occurrences) when the SOA concentrations are significant. In addition, we show that a reasonable upper limit to the mixing time for most locations is 30 min. Additional measurements are needed to explore further the effect of oxidation level, oxidation type, and gas-phase precursor on the viscosity and diffusion within biogenic SOA; nevertheless, based on the available laboratory data, the assumption of well mixed SOA in chemical transport models seems reasonable for biogenic SOA in most locations in the planetary boundary layer. On the other hand, slow diffusion in biogenic SOA may still be important in the PBL for heterogeneous chemistry. Slow diffusion in biogenic SOA will also be more important in the free troposphere where both the temperature and RH are lower than in the PBL. Mixing times within anthropogenic SOA can be longer than mixing times within biogenic SOA, at least a room temperature, but additional studies of viscosities or diffusion rates of organic molecules within anthropogenic SOA as a function of both temperature and RH are needed to better constrain how often mixing times are > 1 h within anthropogenic SOA in the PBL.

2AC.26

Effects of Hydroperoxyl-Radical-to-NO Ratio on SOA Formation from Aromatic Hydrocarbons in a Controlled Reactivity Urban Atmosphere.

PENG WEIHAN, Mary Kacarab, William P. L. Carter, David R. Cocker III, *University of California, Riverside*

Secondary Organic Aerosol (SOA) formation from hydrocarbon precursors is typically predicted by using either two-product model or volatile basis set (VBS). Both models use two sets of aerosol yield parameters, low NOx and high NOx, which are estimated from environmental chamber studies. Given the fact that NO has significant effects on SOA, two scenarios of NO conditions are not sufficient to accurately represent the sensitivity of SOA to different NO levels. Thus, this work explores aerosol yield potential with a better resolution of NO concentration. Absolute NO condition or NO/VOC ratio is typically used as the index of oxidation level in environmental chamber; however, the relative level of NO to HO_2 largely impacts SOA formation. The reactions of RO_2 with both NO and HO_2 are two important pathways of SOA formation with the gas-phase products from the RO_2+HO_2 pathway generally have lower volatility than that from RO_2+NO reaction for aromatic hydrocarbon system. The ratio of NO to HO_2 controls the branching ratio of these two reactions and thus determines secondary gas-phase products and their ability to partition to aerosol-phase. This work, instead of performing traditional single precursor chamber study, investigates the effects of NO and HO_2 on SOA formation from m-xylene and 1, 2, 4 - TrimethylBenzene in a controlled reactivity system by adding a surrogate reactive organic gas mixture. All aromatic experiments were conducted in 90 m^3 UCR/CECERT dual environmental reactors. HO_2 is predicted using the SAPRC chemical mechanism. The correlation between SOA yield and HO_2/NO is presented along with bulk SOA chemical composition via HR-ToF-AMS as a function of HO_2/NO.

2AC.29

Chemical Characterization of Organic Aerosol in a Northern Michigan Forest: Investigating Oxidation Products and Pathways.

JENNA DITTO, Emily Barnes, Masayuki Takeuchi, Gamze Eris, Peeyush Khare, Nga Lee Ng, Drew Gentner, *Yale University*

Highly functionalized biogenic organic compounds are known to be a major component of organic aerosol in both remote and urban environments. However, little is known about the identity of many of these compounds, and their impact on local and regional air quality is poorly understood. In this study, we chemically speciate a variety of PM10 organic aerosols collected in July 2016 at the PROPHET field site in Northern Michigan. Oxidation products of varying volatility were analyzed via liquid chromatography coupled with electrospray ionization and quadrupole time-of-flight mass spectrometry (both MS and MS/MS analysis), as well as by gas chromatography coupled with electron ionization mass spectrometry. While the majority of detected compounds have an oxygen-to-carbon ratio (O/C) ranging from 0.2-0.5, compounds with O/C ratios ranging from 0.5 to greater than 1.0 were also observed. We characterize and propose chemical structures for a diverse set of functionalized compounds formed in this forested environment, including highly oxygenated organics, organic nitrates, and organic sulfates. Products observed during the day and at night are contrasted, and we examine possible formation pathways for these compound classes based on elemental ratios and proposed structures. In addition, we compare ambient aerosol products from the PROPHET campaign to chamber oxidation experiments, with a focus on nitrate radical oxidation of alpha- and beta-pinene. Similarity between many organic nitrate compounds observed in chamber experiments and those observed in ambient air suggests the prominence of nitrate radical oxidation at the PROPHET field site. Many nitrated products were observed at night, when nitrate radical oxidation is expected, as well as during the day, suggesting sufficient stability of certain products to persist into the daylight hours as well as additional daytime formation through NO_x-dependent pathways.

2AC.30

Utilizing Outdoor Chambers to Quantify Secondary Organic Aerosol Formation from Evaporative Emissions of Commercial Fuels and Aromatics.

TERRY LATHEM, Jeff Bean, Shaokai Gao, John Gingerich, *Phillips 66*

A large fraction of ambient particulate matter (PM) is comprised of secondary organic aerosol (SOA), which is formed in the atmosphere through oxidation of natural and anthropogenic volatile organic compounds (VOCs). To ensure cost effective and efficient regulatory compliance for PM, detailed understanding of the formation and evolution of SOA is required. Photochemical models, such as the Community Multi-scale Air Quality Model (CMAQ) and Comprehensive Air Quality Model with Extensions (CAMx), are continuously being advanced to predict SOA yields. However, these models are still challenged with accurately representing the SOA measured in the atmosphere for the wide range of ambient conditions observed.

This presentation will discuss the current challenges and uncertainties in quantifying and measuring SOA originating from commercial fuel sources, with an emphasis on measuring and modeling the SOA formation observed under real-world conditions. Outdoor chamber experiments using sunlight were used to quantify the SOA formation from the photo-oxidation of evaporative emissions of fuels and aromatics under varying environmental conditions. The outdoor chamber experiments were simulated with the SAPRC box model, utilizing the SAPRC-07 gas-phase chemical mechanism and the AERO6 SOA mechanism. Comparison of measured vs. model predicted SOA yields will be presented and the impact of varying environmental conditions will be discussed.

2AC.31

Identification of Organic Hydroperoxides and Organic Peroxyacids from α-pinene Secondary Organic Aerosol.

SHOUMING ZHOU, Jean Rivera-Rios, Frank Keutsch, Jonathan Abbatt, *University of Toronto, Toronto, Canada*

Previous studies have shown that organic peroxides (including organic hydroperoxides and peroxyacids, ROOH) could account for a significant fraction of the secondary organic aerosol (SOA) generated from atmospheric oxidation of biogenic volatile organic compounds (VOCs). Moreover, it has been proposed that ROOH compounds are involved in oligomer formation and aerosol aging processes. However, due to the unstable nature of ROOH species, studies on their identification and quantification are very limited.

In this work, we report an experimental study of an off-line method for the identification of ROOH products from ozonolysis of α-pinene. SOA was generated in a 1 m3 Teflon chamber, collected on a filter, and then extracted with methanol. The solution was directly infused into the ionization source utilizing positive-ion atmospheric pressure chemical ionization (APCI) of a tandem mass spectrometer (MS/MS, Thermo Endura). A characteristic neutral loss of 51 Da (arising from loss of NH3+H2O2) in the MS/MS analysis of commercially available ROOH was also observed in a series of products in α-pinene SOA, indicating the formation of ROOH. The possible identities and formation mechanisms of these ROOH products in the ozonolysis of α-pinene will be discussed.

2AC.32

Particle Acidity Effects on SOA Formation from Toluene Oxidation in the Presence of NOx under Dry and Humid Conditions.

DAO HUANG, Yunle Chen, Steve Kim, Nga Lee Ng, *Zhejiang University*

Toluene is estimated to be one of the most important precursors of SOA in urban areas and some rural areas due to its relatively high concentration and SOA yields. Particle acidity is considered to be an important factor in aerosol formation as it may affect SOA yield and composition. For toluene SOA formation, the particle acidity effect is under debate although most studies tend to support that particle acidity has little impact on aromatic SOA formation. Furthermore, little is known about toluene SOA composition in the presence of seeds of different acidity. In this study, ammonium sulfate seeds and ammonium sulfate+sulfuric acid seeds were used in the photo-oxidation of toluene in the presence of NO_x under dry and humid conditions. A high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) and a high-resolution chemical ionization time-of-flight mass spectrometer coupled with a filter inlet for gas and aerosol (FIGAERO-CIMS) were used to measure the particle composition under different conditions. Our experimental results indicate that particle acidity have insignificant impact on toluene SOA yields. We also compared particle-phase compositions in the presence of seeds of different acidity.

2AC.34

Phase Separation, Morphology, and Diffusivity of Secondary Organic Matter Determined using Aerosol Optical Tweezers.

KYLE GORKOWSKI, Neil Donahue, Ryan Sullivan, *Carnegie Mellon University*

Atmospheric aerosols contain a wide variety of organic and inorganic components and can phase-separate into distinct liquid phases, resulting in either a core-shell or a partial-shell particle morphology. Understanding and predicting when each of these morphologies forms is critical to understanding gas-particle interactions and climate-forcing properties. We conducted experiments exploring phase-separation of droplets suspended using aerosol optical tweezers (AOT). The droplet levitation and the surface resonant whispering gallery modes (WGMs), retrieved in the cavity-enhanced Raman spectrum, provide a direct and real-time assessment of the droplet's morphology. Analysis of the Raman spectra using our new algorithm allows us to independently observed changes in the size and refractive index of both the core and shell phases in core-shell droplet morphologies.

We performed the first optical tweezers experiment on droplets to which secondary organic matter (SOM) was added through in situ precursor ozonolysis directly in the tweezing chamber. The alpha-pinene SOM formed a composite droplet with separate phases when added to an aqueous salt or a squalane droplet, producing a shell of secondary organic matter. Using spreading coefficients, we can bound the surface tension of alpha-pinene SOM and conclude that the air-liquid surface tension of alpha-pinene SOM is less than or equal to that of squalane, 28 mN/m. This, in turn, helps to constrain the Kelvin diameter for condensation of alpha-pinene SOM onto ultrafine particles soon after nucleation in the atmosphere. On aqueous cores, we observed that the coating of SOM does not impede water equilibration timescales. We also observe a humidity-dependent phase separation of glycerol and alpha-pinene SOM, which is supported by the Hansen solubility parameterization.

2AC.35

Experimental Characterization and Lung Cytotoxicity of Secondary Aerosol from D5 Cyclic Siloxane Oxidation.

NATHAN JANECHEK, Benjamin King, Nathan Bryngelson, Rachel Marek, Andrea Adamcakova-Dodd, Traci Lersch, Kristin Bunker, Gary Casuccio, William Brune, Peter Thorne, Keri Hornbuckle, Jennifer Fiegel, Charles Stanier, *University of Iowa*

Cyclic volatile methyl siloxanes are anthropogenic chemicals present in personal care products such as antiperspirants and lotions. These are volatile chemicals that are readily released into the atmosphere by product use. Due to their emission and relatively slow kinetics of their major transformation pathway (reaction with hydroxyl radicals (OH)), these compounds are present in high concentrations in indoor environments and widespread in outdoor environments. While the parent compounds have been well-studied, the oxidation products have received much less attention, with almost no ambient measurements or experimental physical property data. We report physical properties of aerosols generated by reacting the cyclic siloxane D5 with OH using a Potential Aerosol Mass (PAM) photochemical chamber. The particles were characterized by SMPS, imaging and elemental analysis using both Scanning Electron Microscopy and Transmission Electron Microscopy Energy Dispersive X-ray Spectroscopy (SEM-EDS and TEM-EDS), volatility measurements using Volatility Tandem Differential Mobility Analyzer (V-TDMA), and hygroscopicity measurements using a Droplet Measurement Technologies Cloud Condensation Nuclei Counter (DMT-CCN). Aerosol yield sensitivity to D5 and OH concentrations, residence time, and seed aerosols were analyzed. SEM-EDS and TEM-EDS analysis show spherical particle morphology with elemental composition consistent with aerosols derived from cyclic siloxane sources. Measured aerosol yields were 20-50% with typical aerosol concentrations 300,000 particles cm^{-3}, up to 200 $\mu g\ m^{-3}$, and diameters of 30-90 nm. Particles experienced little diameter change after heating up to 200°C suggesting low volatility, while particle activation was retarded compared to ammonium sulfate suggesting moderate hygroscopicity in line with other secondary organics. Cellular toxicity was tested by exposing A549 lung epithelial cells to the generated aerosols using an *in vitro* air-liquid interface exposure system. No significant difference in cell viability could be attributed exclusively to the aerosol species. No increases were observed in biomarkers of inflammation and oxidative stress.

2AC.36

Evaluation of Organic Aerosol Production and Chemical Aging Modeling Schemes against Ground and Airborne PEGASOS Campaign Measurements. ELENI KARNEZI, Benjamin Murphy, Spyros Pandis, *Carnegie Mellon University*

We simulate the atmospheric organic aerosol (OA) using its volatility-oxygen content distribution (2D-VBS) during the two PEGASOS campaigns in the Po Valley in Italy during 2012 and Hyytiälä, Finland during 2013. Extensive measurements were performed both at the ground and aloft with a Zeppelin. Po Valley has major air quality problems due to industrial and agricultural sources and Hyytiälä is characterized by high biogenic secondary OA (SOA) levels. Seven aging schemes with different assumptions about functionalization, biogenic SOA aging, and fragmentation were found to reproduce well the ground and Zeppelin O:C and OA measurements. In the Po Valley, anthropogenic SOA from VOCs was predicted to contribute between 15 and 25% of the total OA and SOA from the oxidation of intermediate volatility compounds oxidation between 20 and 35%. The contribution of biogenic SOA varied from 15 to 45%, depending on the parameterization scheme. Primary OA (POA) was around 5%, the OA from long range transport varied from 6 to 8% and the SOA from evaporation of the primary and subsequent oxidation from 7 to 11%. These results are encouraging because despite the uncertainty introduced by the different schemes, their predictions about source contributions are relatively robust. Assuming significant later generation net bSOA production resulted in overpredictions of the OA. There was also surprising low sensitivity of predicted OA concentration and O:C to enthalpy of vaporization.

Despite the very different environment, the performance of all seven parameterizations was surprisingly similar in the boreal forest atmosphere. Despite their differences, the seven schemes predicted once more similar OA composition: 40-63% biogenic SOA, 11-18% SOA from anthropogenic VOCs, 14-27% SOA from IVOCs, 4% POA, 4-6% SOA from evaporated POA, and 5-6% from long range transport. This agreement is encouraging about our ability to constrain the SOA sources.

2AC.37

Nighttime Secondary Organic Aerosol Formation from Biodiesel and Ultra-Low Sulfur Diesel Blends. SHAOKAI GAO, Jennifer L. Murphy, *Phillips 66 Research Center*

The Renewable Fuel Standard requires oil refiners to blend biofuels, such as ethanol and biodiesel, into transportation fuels. Since the approval of this Standard in 2007, biodiesel use has been increasing in the United States. However, the impact of use of biodiesel on air quality has been difficult to assess as photochemical models lack parameters for predicting secondary pollutant formation (e.g. ozone and secondary organic aerosol (SOA)) from biodiesel volatile organic compound precursors.

The goal of this study is to investigate effect of biodiesel on nighttime SOA formation behavior when blended with petroleum diesel. Three biodiesel samples obtained from different feedstocks, including soybean, corn oil, and canola oil were blended with an ultra-low sulfur diesel (ULSD) at different volume ratios (B0, B5, B10, B15, and B20). A comparison of SOA mass loadings and composition from the four biodiesel blends and ULSD will be presented. The results will help in quantitatively understanding the role of intermediate volatile organic compounds (IVOC) in the SOA formation chemistry, which will help in improving accuracy of photochemical models used for development of future particulate matter regulations.

2AC.38

The Role of Day- and Night-time Aging on the Evolution and Composition of Organic Aerosol from Wildfire Emissions. SHANTANU JATHAR, Ali Akherati, Shiva Tarun, Liam Lewane, Abril Galang, Timothy Onasch, Scott Herndon, Joseph Roscioli, Tara Yacovitch, Edward Fortner, Philip Croteau, , Conner Daube, Berk Knighton, Benjamin Werden, Ezra Wood, *Colorado State University*

Wildfires are the largest combustion-related source of carbonaceous emissions to the atmosphere; these include direct emissions of black carbon (BC), primary organic aerosol (POA) and semi-volatile, intermediate-volatility, and volatile organic compounds (SVOCs, IVOCs, and VOCs). However, there are large uncertainties surrounding the evolution of these carbonaceous emissions as they are physically and chemically transformed in the atmosphere. To understand these transformations, we performed sixteen experiments using an environmental chamber to simulate day- and night-time chemistry of gas- and aerosol-phase emissions from 7 different fuel types at the Fire Laboratory in Missoula, MT. Across the test matrix, the experiments simulated 2 to 8 hours of equivalent day-time aging (with the hydroxyl radical and ozone) or several hours of night-time aging (with the nitrate radical). Aging resulted in an average organic aerosol (OA) mass enhancement of 28% although the full range of OA mass enhancements varied between -10% and 254%. These enhancement findings were consistent with chamber and flow reactor experiments performed at the Fire Laboratory in 2010 and 2012 but, similar to previous studies, offered no evidence to link the OA mass enhancement to fuel type or oxidant exposure. Experiments simulating night-time aging resulted in an average OA mass enhancement of 10% and subsequent day-time aging resulted in a decrease in OA mass of 8%. While small, for the first time, these experiments highlighted the continuous nature of the OA evolution as the wildfire smoke cycled through night- and day-time processes. Ongoing work is focused on (i) quantifying bulk compositional changes in OA, (ii) comparing the near-field aging simulated in this work with far-field aging simulated during the same campaign (via a mini chamber and flow tube) and (iii) integrating wildfire smoke aging datasets over the past decade to examine the relationship between OA mass enhancement ratios, modified combustion efficiency, initial aerosol concentrations and composition, aerosol size, oxidant exposure, VOC:NOx ratios, and emissions and speciation of SOA precursors.

2AC.39

Biological Impacts on Carbon Speciation and Morphology of Laboratory Generated Sea Spray Aerosols. Don Pham, Rachel O'Brien, Matthew Fraund, Daniel Bonanno, Olga Laskina, Charlotte Beall, Kathryn Moore, Sara Forestieri, Xiaofei Wang, Chris Lee, Camille Sultana, Vicki Grassian, Christopher Cappa, Kimberly Prather, RYAN MOFFET, *University of the Pacific*

An isolated wave channel facility was used to generate sea spray aerosol during a one month mesocosm study. Two consecutive phytoplankton blooms occurred and sea spray aerosol were sampled throughout. Scanning Transmission X-Ray Microscopy coupled with Near Edge X-Ray Absorption Fine Structure (SXTM-NEXAFS) spectroscopy was used to determine spatially resolved molecular information for carbon within individual particles. Morphological changes and organic enrichment in the emitted particles occurred during two blooms. The extent of organic enrichment correlates with the occurrence of aliphatic-rich organic species as detected by an intense $C1s \rightarrow \sigma(C\text{-}H)^*$ excitation. These aliphatic-rich species had a strong association with graphitic carbon, detected by a $C1s \rightarrow \sigma^*$ exciton excitation. This enrichment was unique to particles collected in the aerodynamic size range 0.18-0.32 µm and corresponded with the decrease in hygroscopicity. Aliphatic organics can significantly suppress the particle hygroscopicity when they replace salt, thus influencing the effect sea spray aerosol particles have on light scattering and cloud formation.

2AC.40

Fe(II) and H2O2 Production in the Presence of Soot. JUAN RODRIGUEZ, Stephen Bradford, Hector Casique, Dan Hinz, Ashleen Reddy, Justin Rodriguez, Anne Johansen, *Central Washington University*

Combustion of fuels leads to the emission of carbonaceous soot particles that may contain black carbon, organic molecules and trace metals. Despite the fact that ferrous iron, Fe(II), and quinone-like structures seem to contribute to soot toxicity, not much is known about (i) how these compounds are produced during combustion and after emission into the atmosphere, and (ii) how they impact the environment and human health. The purpose of this research is to study model iron-soot systems under conditions encountered in the tail pipe, the environment, and cellular systems, in order to increase our understanding of the iron redox processes that control iron speciation and soot reactivity. Wet-chemical and spectroscopic techniques are used to determine iron speciation, H_2O_2 production and soot characteristics in a variety of settings. Results show that soot contributes to the reduction of Fe(III) to Fe(II) and increases the production of H_2O_2 in the presence of biologically and environmentally relevant organic electron donors. Parameters that control the degree of reactivity between various soot types are under investigation. Observed mechanisms may play a significant role in the toxicity of soot through the related Fenton reaction that produces the highly oxidizing hydroxyl radical in reaction of Fe(II) with H_2O_2.

2AC.41

Role of Oleic Acid Coating in the Heterogeneous Uptake of Dimethylamine by Ammonium Sulfate Particles. Yangxi Chu, CHAK K. CHAN, *City University of Hong Kong*

Reactive uptake by ammonium (NH_4^+) salts is one of the major pathways for the gas-to-particle partitioning of short-chain alkyl amines. Recent studies using particles of individual ammonium salts and mixtures with hydrophilic organics have revealed that the degree of amine uptake depends on the phase state of ammonium salts, the particulate water contents and the particle viscosity. The role of hydrophobic organics, another important category of particulate organics commonly detected in the ambient atmosphere, in amine uptake remains unknown. In this study, we investigated the reactive uptake of dimethylamine (DMA) by ammonium sulfate particles coated with fresh or ozone-aged bulk oleic acid (OA) at 60%, 30% and <5% relative humidities (RHs) using an electrodynamic balance coupled with Raman spectroscopy. OA and DMA were selected to represent hydrophobic organics and alkyl amines, respectively. Over 74% of the original NH_4^+ ions were displaced due to DMA uptake, except for those experiments performed at <5% RH. On the other hand, the fresh or aged bulk OA coating retarded DMA uptake by preventing the particle surface from effectively accommodating gaseous DMA molecules. Judging from the estimated DMA uptake coefficients, the retardation gradually intensified as the weight percentage of coating increased before levelling off, likely when the particle surface was completely covered by fresh or aged bulk OA. We propose that the accommodation of DMA at the gas-particle interface is the rate-limiting step of overall DMA uptake. Intensive aging of the bulk OA coating had little effect on the equilibrium particle-phase compositions but retarded DMA uptake.

2AC.42

Atmospheric Mineral Aerosol Reaction (AMAR) Model for Simulation of Heterogeneous Photooxidation of SO2.
ZECHEN YU, Myoseon Jang, Jiyeon Park, *University of Florida*

The photocatalytic uptake of SO_2 corresponding to sulfate production on mineral dust particles is known to be much higher than that in the dark but is not fully considered by current models. In this study, the Atmospheric Mineral Aerosol Reaction (AMAR) model was developed to predict sulfate formation in the presence of airborne mineral dust particles under various environments. The SO_2 oxidation reactions in three phases, including the gas phase, the inorganic salt aqueous phase, and the dust phase, are taken into account in this model. The kinetics of the dust chemistry is described as gas-particle partitioning process followed by surface reactions. The SO_2 photooxidation is promoted by surface oxidants (e.g., OH radicals) that generated by the photoactive semiconducting metal oxides in dust particles (electron and hole theory). The photoactivation factor of dust particles to produce surface radicals was derived from the integration of the combination product of the dust absorbance spectrum and actinic flux of light sources. The kinetic parameters of dust chemistry were then leveraged using indoor chamber data for two different mineral dust particles, Arizona Test Dust (ATD) and Gobi Desert Dust (GDD). The AMAR model was evaluated using UF-APHOR chamber data, which was operated with ambient temperature and humidity under natural sunlight. After seven consecutive hours of photooxidation of SO_2 in an outdoor chamber, the sulfate formation from dust phase was attributed to ~70% of total sulfate (60 ppb SO_2, 290 $\mu g\ m^{-3}$ ATD, and NO_x less than 5 ppb). At high NO_x concentration (>50 ppb of NO_x), sulfate formation was suppressed by the competition between NO_2 and SO_2 that both consume the surface oxidants. The model derived in this study will provide a platform for the prediction of sulfate formation from the surface photochemistry of air-suspended mineral dust particles.

2AC.43

Sources of PM2.5 during Haze Episodes in Winter 2016 in Beijing. MEI ZHENG, Caiqing Yan, Tian Zhou, Yue Liu, Xuhui Cai, Jie Li, *Peking University*

Beijing has implemented various emission controls especially in the past several years. However, Beijing and some other cities in the North China Plain experienced more severe haze episodes in November and December 2016, when higher average PM2.5 concentration was found than the previous year. High-time resolution (1-h) measurements of PM2.5 composition were performed continuously from November to December 2016, including PM2.5 mass by TEOM, EC and OC by Sunset semi-continuous OC/EC analyzer, major ions by in-situ Gas and Aerosol Compositions Monitor (IGAC), and multiple metals by Xact. The detailed chemical speciation data were integrated with meteorological data such as wind speed and direction as well as footprint results to identify regional transport and potential source regions of fine particles measured in Beijing. Our results indicated that there was a clear cycle of PM2.5 concentrations with a period of about a few days (less than 10 days). The lowest concentrations were all occurred during a strong cold front from northwest, with very similar chemical composition (sulfate accounting for about 40% of PM2.5 and the relative abundance of Ca higher than other periods). During the later stage of haze, higher secondary inorganic species dominated PM2.5 in Beijing, with both local and regional contributions. During the most severe and longest episode during the study period, carbonaceous aerosol and trace metals did not exhibit increase while secondary inorganics continued to increase. Sources of PM2.5 were identified with receptor models using positive matrix factorization (PMF). It was found that poorer dispersion conditions in winter 2016 also contributed to higher PM2.5 concentrations compared to winter 2015. This study combined high-time resolution chemical speciation data with footprint results and meteorological information to explain major source types and regions that contributed to high PM2.5 measured in Beijing.

2AC.44

Biologically Mediated Control of Marine Cloud Condensation Nuclei Concentrations. XIAOFEI WANG, Kathryn Mayer, Mitchell Santander, Jon Sauer, Camille Sultana, Kimberly Prather, *University of California, San Diego*

Previous field studies suggest that cloud formation in the marine atmosphere may be linked to biological activity in seawater. Two types of marine cloud condensation nuclei (CCN) are nascent sea spray aerosol (SSA), produced by breaking waves, and secondary marine aerosol (SMA), produced when semi or low volatile gas phase compounds from the oceans partition onto particles. It has been hypothesized that particle composition can be modulated by biological activity in seawater. However, it is still unclear to what extent biological activity plays a role in affecting SSA composition. To elucidate this question, we studied both SSA and SMA production during a mesocosm experiment. We initiated a phytoplankton bloom in 2,400 liter of natural seawater. Nascent SSA were produced using a plunging waterfall in a marine aerosol reference tank (MART). SMA were produced by oxidizing the gaseous emissions from the seawater in an oxidative flow reactor (potential aerosol mass flow reactor, PAM). The production flux and hygroscopicity parameter (κ) of SSA were measured and the relative contribution to CCN was calculated. In addition, we also studied the mass yield, chemical composition, and hygroscopicity parameter (κ) of SMA from the oxidative flow reactor. Our result suggests that marine biological activity can play an important role in modulating marine cloud properties through secondary reaction processes that lead to SMA.

2AC.45

Profiling of Polycyclic Aromatic Compounds in Ambient Air Samples Collected in the Athabasca Oil Sands Region (Canada) from 2011 to 2015. ANDRZEJ WNOROWSKI, Jasmin Schuster, Tom Harner, Yayne Aklilu, Jean-Pierre Charland, *Environment and Climate Change Canada*

We report on a study of the temporal and spatial distributions of 110 polycyclic aromatic compounds (PACs) monitored in ambient air in proximity of oil sands exploitation and bitumen processing. Composite gas- (GP) and particle-phase (PM) samples were collected for 24 hours every six days between December 2010 and December 2015 from three monitoring sites. PACs in these samples were characterized as a function of distance to oil sands exploration, concentration levels, ratio of PAC subclasses (parent polycyclic aromatic hydrocarbons (PAHs), alkylated-PAHs (alk-PAHs) and dibenzothiophenes (DBTs)) and seasonal variations. The results indicated that alk-PAHs represent the majority of the PACs determined and their correlation with parent PAHs confirmed common emission sources. Individual PACs exhibited variations in their spatial and seasonal profiles. Their concentrations declined over distance from a Reference Point at the arbitrary geographic centre of the Athabasca Oil Sands Region. The rate of concentration decay changed with the volatility of the PACs studied, affecting the shape of the PAC fingerprint with distance from the Reference Point. The median air concentration levels for alk-PAHs were highest in the summer (100 ng/m3) and lowest in the winter (86 ng/m3), while parent PAHs exhibited opposite trend with highest median concentrations in the winter (12 ng/m3) and lowest in the summer (7 ng/m3). Correlations of PAC levels with production factors (bitumen extraction, crude oil production, diluent naphtha, sulphur, petcoke) provided indications on the contributions of oil sands exploration processes to the PAC profiles. Annual PAC concentration levels did not correlate with increasing bitumen processing in the Athabasca Region. In comparison, results from the farthest monitoring site located 15 km from the Reference Point indicated that PAC levels were in general lower than at the nearest urban site. This comprehensive study provides first insights on multiyear active air sampling for PACs in the oil sands region.

2AC.46

Condensational Kinetics of Viscous Amorphous Organic Aerosol. NICHOLAS ROTHFUSS, Aleksandra Marsh, Grazia Rovelli, Markus Petters, Jonathan P. Reid, *North Carolina State University*

Accurate representation of aerosol hygroscopic growth is relevant to model the global radiation budget, precipitation processes, and visibility. As viscosity modulates bulk diffusion, it has been suggested that at high viscosities the penetration of water molecules into the particle bulk will be retarded, resulting in kinetic limitations to hygroscopic growth. Condensational kinetics for a series of micron-sized sugar solution droplets (sucrose, glucose, raffinose, trehalose) were investigated at temperatures between -7.5 °C and 20 °C using a comparative kinetics measurement applied in a cylindrical electrodynamic balance (EDB). Near-instantaneous relative humidity (RH) switching was achieved by switching gas flows (~20-80% RH) between the top and the bottom of the EDB chamber. During the RH switching the confined particle viscosity changed from a value characteristic of high equilibrium solution viscosity (10^4 Pa·s to $\geq 10^{12}$ Pa·s) to an RH characteristic of low equilibrium solution viscosity ($\leq 10^0$ Pa·s). Similar experiments were performed for aqueous sodium nitrate and tetraethylene glycol, which are less viscous than the sugar solutions ($\leq 10^0$ Pa·s at 20% RH). Condensational timescales were derived from fitting the collected time-dependent measurements of droplet radius to a Kohlrausch-Williams-Watts-style equation. Typical timescales for the sugars were ~1 order of magnitude slower than timescales predicted using a diffusional growth model that accounts only for mass and heat flux to and from the particle surface, suggesting that low particle viscosity retarded the hygroscopic growth. However, these timescales were also fast enough relative to atmospheric timescales to argue that at high RH moderately hygroscopic particles will plasticize from water uptake sufficiently quickly such that kinetic limitations arising from high viscosity do not affect warm-cloud microphysical processes.

2AC.47

Chemical Compositions of Outdoor and Indoor PM2.5 in Downtown Shanghai, China: Based on 1-Year Field Measurements. Jianbang Xiang, Jingjing Shi, Fengkui Duan, Zhuohui Zhao, Jinhan Mo, Haidong Kan, Yinping Zhang, *9411*

Numerous epidemiological and toxicological studies have demonstrated that acute/chronic exposure to $PM_{2.5}$ has adverse health impacts, being associated with increased morbidity and mortality. The degree of PM-related toxicity depends on the composition of the particles, which comprise inorganic elements, water-soluble inorganic ions (WSIIs), organic carbon (OC), elemental carbon (EC) and organic compounds such as polycyclic aromatic hydrocarbons (PAHs). Both outdoor and indoor $PM_{2.5}$ pollution are quite severe in present day China, especially in economically developed cities. However, there are limited studies on characteristics of chemical composition of $PM_{2.5}$. The aim of this study is to investigate the characteristics of indoor/outdoor $PM_{2.5}$ and chemical composition in downtown areas of Shanghai, China. Both indoor and outdoor $PM_{2.5}$ samplings were collected simultaneously twice a month from May 2015 to May 2016 in one residence, one office, one dorm and one kindergarten. Outdoor $PM_{2.5}$ was sampled by two mini-volume portable pumps (Airmetrics, USA) with a $PM_{2.5}$ cyclone operating with flow rates of 5L/min for continuous 48h, while indoor $PM_{2.5}$ was sampled by two pumps (SKC, USA) with a $PM_{2.5}$ cyclone operating with flow rates of 2L/min for continuous 48h. The samples were collected on teflon and quartz filters, respectively. Elements, WSIIs, OC/EC and PAHs in the samples were analysed based on standard methods. Preliminary results indicate that the I/O ratio of $PM_{2.5}$ - heavy metal elements (Cr/As/Cd/Pb) was greater than 1 in the residence, which means there existed indoor source of heavy metal elements. The annual mean indoor $PM_{2.5}$– PAHs concentrations were 2-8 times that of outdoors's in all the four type of buildings, which indicates there were indoor sources of PAHs. More results are under analysis and will be presented in the conference.

2AC.48

Development of a Laser-Induced Breakdown Spectroscopy (LIBS) System with Timed Ablation to Increase Detection Efficiency of a Single Particle. HYUNOK MAENG, Hoseung Chae, Heesung Lee, Gibaek Kim, Haebum Lee, Kyoungtae Kim, Jihyun Kwak, Gangnam Cho, Kihong Park, *Gwangju Institute of Scinece and Technology(GIST)*

Elemental composition of ambient aerosols has been commonly determined using filter-based techniques such as atomic absorption spectroscopy (AAS) and inductively coupled plasma-mass spectrometry (ICP-MS). However, these techniques usually require a long sampling time (12-24 hours) and a series of sample pre-treatments. In addition, elemental variation among particles and their mixing state cannot be determined by filter-based method. On the other hand, the laser-induced breakdown spectroscopy (LIBS) technique can be used to determine elemental composition in real-time because it is a useful tool for the rapid detection. However, hitting efficiency (%) and hitting rate (hits/min) are significantly low under the constant firing mode of pulse laser when particle concentration is low. Thus, this study focused on developing the LIBS system with timed ablation to improve detection efficiency of a single particle by employing a continuous wave (CW) laser in front of the pulse laser as a trigger source. The evaluation of this system was conducted using laboratory-generated particles ($CaCl_2$, $MgCl_2$, NaCl and KCl) at various sizes (200-600 nm) and number concentration (100-100,000 particle/cm^3) range. As a result, hitting efficiency (%) was improved significantly by more than 26 times at 1,000 particles/cm^3. Lower detection limits, in terms of particle size (~200 nm) and number concentration (<100 particles/cm^3), were also achieved compared to those obtained under the constant firing mode of pulse laser. Lastly, the hitting rate (hits/min) increased around 15 times. In conclusion, this study suggests that the developed LIBS system with timed ablation significantly improves the determination of elemental composition of a single particle under low concentration in real-time.

2AC.49

New Explorations into the Atmospheric Auto-oxidation of Volatile Organic Compounds. S. MANI SARATHY, Zhandong Wang, Matti Rissanen, Mikael Ehn, *KAUST*

The auto-oxidation of volatile organic compounds (VOCs) is of central importance to atmospheric chemistry. In the troposphere, the chemistry of alkylperoxy radicals and their derivatives determines the fate of VOCs. Several studies have shown that auto-oxidation of VOCs under low-NOx conditions leads to the formation of extremely low volatility organic compounds (ELVOCs) that ultimately impact air quality and climate. The mechanistic pathways leading to formation of highly oxidized multifunctional molecules (HOMs), which are the building blocks for ELVOCs, are not well understood. A detailed investigation of the structure of HOMs, their reaction mechanisms, and corresponding kinetics can help develop models to predict the distribution of HOMs and ELVOCs in the atmosphere. We find there are synergies in hydrocarbon auto-oxidation chemistry studied in combustion systems and analogous processes occurring in the atmosphere. These areas are the focus of this proposed exploratory research. We have conducted well-controlled reactor experiments with advanced analytical chemistry diagnostics to study the structure of HOMs produced during the auto-oxidation of various VOCs (alkanes, alkenes, naphthenes, aromatics, etc.). The experiments help us understand the effects of VOC source, temperature, and residence time on the concentration and chemical nature of HOMs that are produced. The results of these studies have enabled us to develop reaction mechanisms that describe the initial destruction of VOCs and subsequent formation of HOMs.

2AC.50

Feedbacks between Atmospheric Aerosol Microphysics and Photochemistry of Iron Complexes. PABLO CORRAL ARROYO, Peter Aaron Alpert, Jing Dou, Beiping Luo, Ulrich Krieger, Markus Ammann, *Paul Scherrer Institut*

Physical and chemical transformations of atmospheric particles, known as aerosol aging, are key to understand their impact on climate, air quality and health. Photochemistry is one aging process in which chromophores in aerosol particles act as photocatalysts inducing oxidation of non-absorbing molecules. Iron (Fe(III)) carboxylate complexes absorb light below about 500nm, followed by ligand to metal charge transfer (LMCT). This results in the reduction to Fe(II) and oxidation of the carboxylate ligands, which represents an important sink of organic acids in the troposphere, and in the production of reactive oxygen species, HO_2, H_2O_2 and organic peroxides. We investigate the turnover of these photocatalytic processes as it responds to changes in relative humidity, which drives kinetic limitations through the plasticizing effect of water in viscous highly oxidized organic particles. To achieve this scope we study the internal structure and oxidation spatial gradient within single aerosol particles before and after irradiation with UV light (370nm) by using an X-ray microspectroscopic method (Scanning Transmission X-Ray Microspectroscopy, STXM). We use the spatially resolved Fe(II) fraction as an observable for transport limitations of reactants and intermediates as a function of relative humidity. We also measure HO_2 radical production and VOC production from irradiated macroscopic films of similar composition in Coated Wall Flow Tube (CWFT) experiments to obtain further information on the chemical mechanism and yields. Additional information comes from experiments in an Electrodynamic Balance (EDB), in which the overall mass loss and radius decrease is measured as a function of the same environmental variables as in the other techniques. A numerical model which includes chemical equilibria, reactions and diffusivities was created to analyze our data for different relative humidities. These data will be used to better understand aerosol chemical/structural evolution due to photochemical oxidation and quantify mechanisms and degradation kinetics under varying environmental conditions.

2AC.51

Application of Three Dimensional Source Contribution Function (3d-Pscf) for Air Pollutants from Biomass Fuel Burning Affecting the Air Quality in Seoul. IN SUN KIM, Dae Hyun Wee, Yong Pyo Kim, *Ewha Womans University*

The conventional potential source contribution function (2D-PSCF) cannot consider the emission and transport height of air pollutants. That missing information might be critical because injection height varies depending on the source type, such as with biomass burning. Kim et al. (2016) developed a simple algorithm to account for the height of trajectories with high concentrations and combined it with the 2D-PSCF to devise three-dimensional potential source contribution function (3D-PSCF).
In this study, 3D-PSCF was conducted to determine the possible source areas of air pollutants from biomass fuel burning that were affecting the air quality in Seoul. 3D-PSCF was applied for concentrations at Seoul between 2006 and 2014.

This work would support the research for quantifying the impact of air pollutants emitted from biomass fuel burning in China and North Korea to air quality in Seoul.

2AC.52

ICARUS: An Online, Open-access, and Searchable Database for Atmospheric Chamber Research in the United States. TRAN NGUYEN, William P. L. Carter, David R. Cocker III, Neil Donahue, Lea Hildebrandt Ruiz, Jose-Luis Jimenez, Ajith Kaduwela, Nga Lee Ng, Sergey Nizkorodov, John Orlando, Spyros Pandis, Allen Robinson, John Seinfeld, Geoffrey Tyndall, Paul Ziemann, *UC Davis*

Atmospheric simulation chambers (also known as smog chambers or environmental chambers) have facilitated atmospheric chemistry research for over 50 years. The fundamental data obtained from chamber studies are routinely used as empirical inputs and constraints in atmospheric models. Yet, despite their importance and growing number, the data from atmospheric chambers are not centrally archived or made openly accessible to the scientific community and the public.

The National Science Foundation (NSF) has funded the development of first online, open-access, searchable, database for atmospheric chamber research data in the United States called ICARUS (Index of Chamber Atmospheric Research in the United States). ICARUS is partnering with EUROCHAMP, an equivalent atmospheric chamber database in Europe that, to enhance the efficiency of the initial database development process and increase the global reach of the project. The specific objectives of the project are to (1) provide a searchable public index of the chamber experiments from each participating research group; (2) archive past chamber data from each participating group under their indexed chamber experiment; (3) standardize chamber data reporting formats; (4) provide a uniform template for chamber metadata; and (5) streamline future data submissions. The overarching goal is to create a sustainable web-based infrastructure for storing, sharing, and using atmospheric chamber data that will synergistically facilitate atmospheric chemistry research in the U.S.

After initial development, ICARUS will integrate with databases at the National Center for Atmospheric Research (NCAR) for long-term sustainability. At this point, any research group in the United States performing chamber research can use ICARUS as a data management tool to increase the visibility of their research and to better comply with the data policy of government funding agencies. This poster will outline the proposed plans of action for ICARUS and ways it can serve the community. We invite discussion on any topic, including: data stewardship, utilizing data for model evaluations, shared approaches to chamber research, data mining, collaborations, and more.

2AC.53

Evolution of Brown Carbon Aerosol Optical Properties Induced by Heterogeneous OH Oxidation. ELIJAH G. SCHNITZLER, Jonathan Abbatt, *University of Toronto*

Heterogeneous OH oxidation of a brown carbon (BrC) surrogate was investigated in a series of photooxidation chamber experiments. The BrC surrogate was generated from aqueous 1,3-dihydroxybenzene (10 mM) and H_2O_2 (10 mM) exposed to >300 nm radiation, atomized, passed through a series of trace gas denuders, and injected into the chamber. Following aerosol injection, H_2O_2 was continuously bubbled into the chamber; an hour later, the chamber was irradiated with black-lights (UV-B) to produce OH. Before irradiation, aerosol absorption and scattering at 405 nm, measured using a photoacoustic spectrometer, decreased due only to deposition and dilution, and single scattering albedo (SSA) was steady. In the presence of gas-phase OH, absorption first briefly increased, despite continued particle losses, and SSA decreased. Subsequently, absorption decreased faster than scattering, and SSA increased uniformly. No particle growth occurred, because trace gases were removed before particle injection, and the evolution of the BrC optical properties cannot be attributed to the size-dependence of Mie scattering and absorption. Consequently, this evolution reflects changes in the imaginary part of the refractive index of the aerosol. Furthermore, heterogeneous OH oxidation of a large azo dye (Reactive Yellow 2) results in colour loss without the initial colour enhancement observed for BrC. Colour enhancement followed by colour loss is consistent with the photochemical evolution of other BrC surrogates in the bulk aqueous phase and likely corresponds, chemically, to functionalization followed by fragmentation.

2AC.54

A Steady State Continuous Flow Chamber for the Study of Daytime and Nighttime Chemistry at Atmospherically Relevant NO Levels. XUAN ZHANG, John Ortega, Yuanlong Huang, Geoffrey Tyndall, John Orlando, *National Center for Atmospheric Research*

Understanding of fundamental kinetics and mechanisms in atmospheric chemistry has been derived largely from experiments performed in laboratory chambers. Two chemical regimes, classified by ‘high-NO’ versus ‘NOx-free’ conditions, have been extensively studied in previous chamber experiments. Results derived from these two chemical scenarios are widely parameterized in chemical transport models to represent key atmospheric processes in urban and pristine environments. As the anthropogenic NOx emissions in the United States have decreased remarkably in the past few decades, the classic ‘high-NO’ and ‘NO_x-free’ conditions are no longer applicable to many regions in the world that constantly intercept both polluted and background air masses. We present here the development and characterization of the NCAR Atmospheric Simulation Chamber, which is operated in steady state continuous flow mode for the study of atmospheric chemistry under ‘intermediate NO’ conditions. This particular chemical regime is characterized by constant sub-ppb levels of NO in the well-mixed chamber and is created by precise control of the inflow NO concentration and the ratio of chamber mixing to residence timescales. Under such conditions, the peroxy radicals (RO_2), a key intermediate from the atmospheric degradation of volatile organic compounds (VOCs), are expected to survive up to minutes and undergo a diversity of reaction pathways instead of combining with NO and HO_2 as predominantly observed in classic ‘high-NO’ and ‘NO_x-free’ chamber experiments. Characterization experiments under photolytic and dark conditions were performed and, in conjunction with model predictions, provide a basis for interpretation of prevailing atmospheric processes in environments with alternated biogenic and anthropogenic activities. We demonstrate the proof of concept of the steady state chamber operation method through measurements of major first-generation products, methacrolein (MACR) and methyl vinyl ketone (MVK), from OH- and NO_3-initiated oxidation of isoprene.

2AC.55

Trends in the Oxidation and Relative Volatility of Chamber-Generated Secondary Organic Aerosols. KENNETH DOCHERTY, Eric Corse, Mohammed Jaoui, John Offenberg, Tad Kleindienst, Jonathan Krug, Theran Riedel, Michael Lewandowski, *EPA/ORD/NERL*

The relationship between the oxidation and relative volatility of chamber-generated secondary organic aerosol (SOA) generated from reaction of a number of different hydrocarbons is investigated using a fast-stepping, scanning thermodenuder (TD) interfaced with a high resolution time-of-flight aerosol mass spectrometer (AMS). With respect to a particular parent hydrocarbon, SOA oxidation obtained from replicate experiments is relatively stable and unit-resolution (UR) indicators (f43, f44) are consistent with literature values. Oxidation, however, is highly variable of among different parent hydrocarbons based on both UR indicators and ratios obtained from elemental analysis (EA) of high-resolution spectra. Linear regression of H:C vs O:C obtained both from parameterization of f43 and f44 and from EA in Van Krevelen space suggest that oxidation across different SOA types occurs via carboxylation with subsequent fragmentation consistent with recent analyses. Similar regression of ratios obtained from a subset of toluene photooxidation reactions with different integrated OH exposures provides similar results. Relative volatility shows the same trends, being fairly stable within reactions of a particular hydrocarbon or hydrocarbon class but exhibiting a large degree of variability among different hydrocarbons. Across the wide range of SOA types investigated relative volatility of both SOA and total chamber aerosol is proportional to and highly correlated with carbon oxidation state (OSc).

2AC.57

In-Situ Surface Tension Measurements of CVOC Uptake onto Hanging Aerosol Mimic Droplets. Thomas Beier, JOSEPH WOO, *Lafayette College*

Carbonyl-containing volatile organic compounds (e.g. acetaldehyde, glyoxal, methylgloxal, etc.) are known to form surface-active SOA products upon uptake into aqueous aerosols, followed by subsequent aerosol-phase reactions. As aerosol surface tension is participatory in several indirect radiative forcing effects, accurate representation of how surface tensions shifts throughout a droplet's lifetime is paramount to properly characterizing the effects of a given VOC on aerosol properties. Here, we measure surface tension dynamics of hanging ammonium sulfate droplets when exposed to controlled organic concentration and RH gas flows. By using small (<25µL) volumes, the relative surface area to volume ratios are more representative of aerosols than bulk mimic solutions; conversely, single drops are easier to control and can be directly observed as opposed to aerosol chamber studies that necessitate filter collection or similar aggregate measurements. Observed surface tension is compared to S-L estimations via GAMMA, a 0-dimensional computational box model; the discrepancy between inferred bulk concentration via observed surface tension and inferred bulk concentration via aerosol uptake and processing is explored.

2AC.58

The Role of Nonvolatile Cations on Aerosol Ammonium-Sulfate Molar Ratios and Aerosol pH. RODNEY J. WEBER, Hongyu Guo, Athanasios Nenes, *Georgia Institute of Technology*

Overprediction of fine-particle ammonium-sulfate molar ratios (R) by thermodynamic models is suggested as evidence for an organic film that selectively inhibits the equilibration of only gas-phase ammonia (but not water or nitric acid) with aerosol sulfate and questions the equilibrium assumption long thought to apply for submicron aerosol. The ubiquity of such organic films would imply significant impacts on aerosol chemistry. We test the organic film hypothesis by analyzing ambient observations and find that R and ammonia partitioning can be accurately reproduced when small amounts of nonvolatile cations (NVC), consistent with observations, are considered in the thermodynamic analysis. Exclusion of NVCs results in predicted R consistently near 2. The error in R is positively correlated with NVC and not organic aerosol mass fraction or concentration. These results strongly challenge the postulated ability of organic films to perturb aerosol acidity or prevent ammonia from achieving gas-particle equilibrium for the conditions considered.

2AC.59

O3- and NO3-Initiated Aging of Toluene Secondary Organic Aerosol. SATHIYAMURTHI RAMASAMY, Tomoki Nakayama, Takashi Imamura, Kei Sato, *National Institute for Environmental Studies, Japan*

Formation of secondary organic aerosol (SOA) and aging by OH radicals are covered in the widely-used volatility-basis set (VBS) model. However, night time aging of SOA by NO_3 radicals and O_3 is excluded in this model. We examined the aging of aerosol formed from OH oxidation of toluene by NO_3 radicals and O_3. Laboratory experiments were carried out in a 6 m^3 smog chamber. OH radicals required for toluene oxidation were generated either by the photolysis of H_2O_2 or by the ozonolysis of tetramethylethylene (TME). N_2O_5, O_3 and NO_2 were injected in dark condition after the level of formed SOA became stable to study the aging. From N_2O_5 injection NO_3 radicals was produced along with NO_2. During experiments, FT-IR spectrometer and proton transfer quadrupole ion guide time-of-flight mass spectrometer (PTR-QiTOF) were used to measure gaseous reactants and products in real time. AMS and SMPS were used to monitor the SOA formation. Our results showed that only after the injection of N_2O_5, SOA and nitrate aerosol increased. Similar results were obtained in both H_2O_2 photolysis and TME ozonolysis experiments. PTR-QiTOF result showed that cresol was degraded completely after the injection of N_2O_5 and gaseous methylbenzoquinones and nitorocresols were produced. No clear increase was observed in SOA concentration after the injection of ozone or NO_2. From these results, it is obvious that night time aging by NO_3 radical is important for toluene oxidation.

2AC.60

Overview Of TANGENT (Tandem Aerosol Nucleation and Growth ENvironment Tube) 2017 IOP Study. LEE TISZENKEL, Qi Ouyang, Chris Stangl, Justin Krasnomowitz, Shanhu Lee, Murray Johnston, *University of Alabama Huntsville*

New particle formation consists of two steps: nucleation and growth of nucleated particles. However, most laboratory studies have been conducted under conditions where these two processes are convoluted together, thereby hampering detailed understanding of the effect of chemical species and atmospheric conditions on two processes. The objective of the Tandem Aerosol Nucleation and Growth ENvironment Tube (TANGENT) laboratory study is to investigate aerosol nucleation and growth properties independently by observing these processes in two different flow tubes. This research is a collaboration between the University of Alabama in Huntsville and the University of Delaware. In this poster we will present the experimental setup of TANGENT and summarize the key results from the first IOP (intense observation period) experiments undertaken during Summer 2017. Nucleation takes place in a temperature- and RH-controlled fast flow reactor (FT-1) where sulfuric acid forms from OH radicals and sulfur dioxide. Sulfuric acid and impurity base compounds are detected with chemical ionization mass spectrometers (CIMS). Particle sizes and number concentrations of newly nucleated particles are measured with a scanning mobility particle sizer (SMPS) and particle size magnifier (PSM), providing concentrations of particles between 1-100 nm. Nucleated particles are transferred directly to the growth tube (FT-2) where oxidants and biogenic organic precursors are added to grow nucleated nanoparticles. Sizes of particles after growth are analyzed with an additional SMPS and elemental chemical composition of >50 nm particles is detected with a nano-aerosol mass spectrometer (NAMS). TANGENT provides the unique ability to conduct experiments that can monitor and control reactant concentrations, aerosol size and aerosol chemical composition during nucleation and growth. Experiments during this first IOP study have elucidated the effects of sulfur dioxide, particle size, relative humidity, temperature, oxidants and biogenic organics on nanoparticle formation and growth. In another 3 companion posters, we will discuss these results in detail.

2AC.61

Laboratory Studies of Temperature and Relative Humidity Dependence of Aerosol Nucleation during the TANGENT 2017 IOP Study. QI OUYANG, Lee Tiszenkel, Justin Krasnomowitz, Chris Stangl, Murray Johnston, Shanhu Lee, *University of Alabama in Huntsville*

In this poster, we will present recent measurements of temperature and relative humidity dependence of aerosol nucleation of sulfuric acid under the conditions representative of the ground level to the free troposphere. Aerosol nucleation is critically dependent on temperature, but the current global aerosol models use nucleation algorithms that are independent of temperature and relative humidity due to the lack of experimental data. Thus, these models fail to simulate nucleation in a wide range of altitude and latitude conditions. We are currently conducting the Tandem Aerosol Nucleation and Growth Environment Tube (TANGENT) the intense observation period (IOP) experiments to investigate the aerosol nucleation and growth properties independently, during nucleation and growth. Nucleation takes place from sulfuric acid, water and some base compounds in a fast flow nucleation tube (FT-1) where temperature and relative humidity is controlled. Nucleation precursors are detected with two chemical ionization mass spectrometers (CIMS) and newly nucleated particles are measured with a particle size magnifier (PSM) and a scanning mobility particle sizers (SMPS). Then these particles grow further in the second flow tube (FT-2) in the presence of oxidants of biogenic organic compounds. Chemical compositions of grown particles are further analyzed with a nano-aerosol mass spectrometer (NAMS). Our experimental results will provide a robust algorithm for aerosol nucleation and growth rates as a function of temperature and relative humidity.

2AC.62

Temporal Variation of PAHs and n-Alkanes Concentrations in Atmospheric PM2.5 of a Background Site in South Korea: Evaluation of Fossil Fuel Combustion Contribution. KI AE KIM, Soo Bin Hong, Jong Sik Lee, Eun Sil Kim, Yong Pyo Kim, Chang Hoon Jung, Ji Yi Lee, *Chosun University*

PAHs and n–alkanes in atmospheric $PM_{2.5}$ samples measured every 6th day during one year (from June 2015 to May 2016) at Anmyeon Island, a background site of South Korea were determined using GC–MS to evaluate contribution of fossil fuel combustion. PAHs are products of incomplete combustion, mainly from anthropogenic sources, while, n–alkanes are emitted by both anthropogenic and biogenic sources. Therefore, the source of organic aerosol in $PM_{2.5}$ can be classified as fossil fuel combustion vs biogenic emission through the diagnostic ratios of PAHs and carbon number distribution of n–alkanes. Average concentration of PAHs was 2.83±3.44 ng/m^3. While, n–alkanes concentrations ranged from 1.77 to 47.65 ng/m^3 with an average of 14.02±10.26 ng/m^3. The PAHs concentration was about one over higher in winter than summer, however, the difference of n–alkanes concentration was not large (about 3 times higher in winter). It might be due to the contribution of biogenic emission without seasonal variation. The Carbon Preference Index (CPI) values of n-alkane was ranged from 1.13 to 8.31. The CPI values showed close to unity during heating period, while, the CPI values in non–heating period showed higher than heating period. The contribution of mixture of biomass burning and coal burning smoke were found through diagnostic ratios of PAHs (Flt/Pyr, BaP/BeP and IcdP/BghiP) with a good linear relationship ($R^2 \geq 0.58$) between PAHs and fossil fuel derived n–alkanes, demonstrating that mixture of coal and biomass burning is the main contribution sources in the background site during heating period. The contribution of coal and biomass burning was approximately 35.8% of total variance in the PCA (Principle Component Analysis) and this contribution was evaluated as the influence of long range transport from outside the Anmyeon Island rather than impact of local emission based on the meteorological data and backward trajectory of air parcel analysis.

2AC.63

Nanoparticle Formation in a Tandem Flow Tube Apparatus (TANGENT). CHRIS STANGL, Justin Krasnomowitz, Qi Ouyang, Lee Tiszenkel, Shanhu Lee, Murray Johnston, *University of Delaware*

Atmospheric aerosols are well known to impact radiative forcing through both direct and indirect effects, however discrepancies between modeled and measured aerosol yields in the atmosphere remain a critical deficit in our ability to accurately predict future changes in climate. In this work, a Tandem Aerosol Nucleation and Growth ENvironment Tube (TANGENT) apparatus is used to study particle formation and growth. In the experiments described here, nanoparticles are generated by sulfuric acid-water nucleation in flow tube #1 (FT-1) using sulfur dioxide oxidation by OH as the source of sulfuric acid. Aerosol from FT-1 is sent into a second flow tube (FT-2) where it is mixed with α-pinene and ozone. Initial experiments were performed with mixing ratios in FT-2 on the order of 400 ppbv sulfur dioxide, 14 ppbv α-pinene and 10-400 ppbv ozone. Under these conditions, we find that both nucleation and growth occur in FT-2, and both processes depend strongly on the extent of sulfur dioxide oxidation by OH and/or the Criegee intermediate that are produced by α-pinene ozonolysis. The results give insight into the role of sulfur dioxide for enhancing ambient nanoparticle formation in plumes.

2AC.64

Nanoparticle Growth in a Tandem Flow Tube Apparatus (TANGENT). JUSTIN KRASNOMOWITZ, Chris Stangl, Lee Tiszenkel, Qi Ouyang, Shanhu Lee, Murray Johnston, *University of Delaware*

This work uses a Tandem Aerosol Nucleation and Growth ENvironment Tube (TANGENT) apparatus to study particle growth. Freshly nucleated particles from a nucleation tube (FT-1) are sent into a growth tube (FT-2) with longer resonance time in order to study growth under varying conditions. The goal of these experiments is to elucidate mechanisms of particle growth by measuring size distributions and chemical composition of particles exiting FT-2. In our initial experiments, FT-2 is conditioned with constant mixing ratios of a-pinene (14 ppbv), sulfur dioxide (400 ppbv) and ammonia (between 160 pptv and 2 ppbv depending on the experiment), while ozone is increased in a stepwise manner over time from 10-400 ppbv. Each increment of the ozone mixing-ratio creates additional low volatility species that lead to particle growth. Elemental composition of individual nanoparticles is done using a modified version of the Nano Aerosol Mass Spectrometer (NAMS) that utilizes an aerodynamic lens assembly to focus particles in the size range of 40-100 nm. These focused particles are then intercepted by a pulsed laser and undergo Laser Induced Plasma Ionization (LIPI) to created positive multiply charged elemental ions that can then be detected using a time-of-flight mass analyzer. Information provided from NAMS gives measure of the relative importance of sulfuric acid and secondary organics in the particle growth observed. Bases such as ammonia are also present in these experiments. Analysis by NAMS allows both the degree of sulfuric acid neutralization and the relative contributions of sulfuric acid and organics to be determined. Size distributions measured by SMPS throughout the experiments aid in the determination of diameter growth rates and how they depend on the amount of a-pinene reacted.

2AC.65

Multi-generation Chemical Aging of Secondary Organic Aerosol Components.

NINGXIN WANG, Neil Donahue, Spyros Pandis, *Carnegie Mellon University*

Secondary organic aerosol (SOA) formation from volatile organic compounds in the atmosphere can be thought of as a succession of oxidation steps. The production of later-generation SOA via continued oxidation of the first-generation products is defined as chemical aging. The first part of this study investigated aging in a well-constrained system through smog chamber experiments. The first-generation α-pinene ozonolysis products were allowed to react further with hydroxyl radicals (OH) formed via HONO photo-dissociation under either low-NO_x or high-NO_x initial conditions. The SOA was characterized by a High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS). Attenuated total reflectance (ATR-FTIR) was also employed to identify and quantify organonitrate functional groups for experiments with high-NO_x initial conditions. A kinetics box model was deployed to monitor gas-phase species and shed light on the reaction mechanisms under high-NO_x conditions. A 20-40 % increase in OA mass and a more oxygenated product distribution were observed after aging with an equivalent of 2-4 days of typical atmospheric oxidation conditions. Relative humidity did not have a significant effect on the additional SOA production. The high-NO_xexperiments suggested that the second-generation SOA formation was similar in magnitude or higher to that of the low-NO_x case. Organonitrates accounted for about 20-40 % of the SOA formed.

The second part of this work investigated aging of ambient air through field perturbation experiments conducted in a portable dual-chamber facility. First experiments performed at a remote sampling site in Crete, Greece suggested significant SOA formation after exposing ambient air to additional OH.

2AC.66

Product Identification of Reactions Between Small Atmospheric Carbonyls and Ammonium Sulfate.

MELISSA GALLOWAY, Daisy Grace, Jessica Ackendorf, Rachael Holappa, *Lafayette College*

The chemical composition of atmospheric aerosol is complex and poorly understood. Aqueous reactions of aldehydes with amines or ammonium salts have been implicated in atmospheric brown carbon formation processes. Recent work has started to identify the products of these reactions, especially those responsible for visible light absorbance. However, few studies have looked at the reaction products of ammonium with a mixture of aldehydes. A variety of techniques, including NMR spectroscopy and ESI-MS, are used to identify the reaction products of mixture of small, water soluble carbonyls (e.g. glyoxal, methylglyoxal, and glycolaldehyde) with ammonium sulfate. We present structural and mass comparisons between products formed from the reaction of a single aldehyde with ammonium and a mixture of aldehydes and ammonium sulfate. The results of these studies will allow us to better understand the aqueous chemistry occurring in atmospheric aerosol droplets.

2AC.67

Understanding Missing Sources of Fine Particulate Organosulfur Compounds in the Southeastern US: Implications from Ambient Measurements and Laboratory Experiments. YUZHI CHEN, Matthieu Riva, Karsten Baumann, Tianqu Cui, Mike Fort, Eric Edgerton, Lindsay Yee, Weiwei Hu, Sri Hapsari Budisulistiorini, Caitlin Rose, Zhenfa Zhang, Allen H. Goldstein, Jose-Luis Jimenez, Stephanie L. Shaw, Avram Gold, Jason Surratt, *University of North Carolina at Chapel Hill*

Organosulfates (OSs) can contribute a substantial mass fraction of total organic aerosol (OA), and presumably, fine particulate organosulfur. Multiphase chemical processes have been demonstrated to form OSs, such as from the reactive uptake of certain oxidation products from biogenic volatile organic compounds (BVOCs) onto acidic sulfate aerosols. As sulfate over continental regions is generally of anthropogenic origin, it is important to assess its influence on biogenic secondary organic aerosol formation. Chemical analyses were performed on PM2.5 collected during the 2013 Southeast Oxidant and Aerosol Study at the SEARCH Centreville, Alabama ground site. OSs and methanesulfonic acid (MSA) were characterized and quantified by ultra-performance liquid chromatography interfaced to electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry (UPLC/ESI-HR-QTOFMS). Total organosulfur mass was determined by isotope ratio inductively coupled plasma mass spectrometry. While the sum of 33 OSs and MSA contributes to 8% of total OA, it only explains 50% of the total organosulfur mass, suggesting significant missing organosulfur sources. We hypothesized that the multiphase chemistry of BVOC oxidation products with acidic sulfate aerosols produces previously unidentified oligomers containing sulfate. Aiming to investigate the missing sources, follow-up chamber experiments were conducted using acidic sulfate aerosols to generate isoprene-derived SOA. Inorganic and organic sulfates were characterized and quantified by a particle-into-liquid sampler coupled to offline ion chromatography and UPLC/ESI-HR-QTOFMS. Real-time measurement techniques were also used to track the reaction dynamics in both gas and particle phase. If sulfur mass closure can be achieved for the chamber experiments, it will help us interpret our findings on ambient organosulfur. Results from this study will direct future investigations to achieve mass closure for ambient organosulfur, helping to improve model predictions of PM2.5 in the southeastern US.

2AE.1

Exposure to PM during Different Sport Activities in a Sport Center in Astana, Kazakhstan. Mehdi Amouei Torkmahalleh, MERUYET BAZHANOVA, Karakat Kabay, *Chemical Engineering Department, Nazarbayev University*

Physical activities at sport centers are becoming more popular in Kazakhstan, and thus, it is crucial to measure the exposure level of the participants to PM. Present study investigated the exposure of teenagers, adults, and students to PM at two sport facilities of Nazarbayev University, a Gymnastics Hall and a Multi-Purpose Hall located in Astana, Kazakhstan during two weeks measurement campaign. Mass concentration of five fractions of particulate matter (PM1, PM2.5, PM4, PM10 and PMtotal) were measured using a DustTrak Aerosol Monitor DRX model 8533, TSI. A Condensation Particle Counter (CPC) Model 3007, TSI and a low-cost particle counter, Dylos DC1700, were deployed to measure the number concentration of the particles. Two types of instruments including TSI IAQ Meter, and a Low-cost humidity pSense Portable CO2 Meter were used to identify CO2 concentration and comfort parameters including temperature and relative humidity. The average concentrations of 0.0073 mg/m3 for PM1, 0.0077 mg/m3 for PM2.5, 0.0079 mg/m3 for PM4, 0.0099 mg/m3 for PM10, and 0.0241 mg/m3 for PMtotal in Gymnastics Hall were observed. In the Multifunctional Hall, the average concentrations were found to be 0.0078 mg/m3 for PM1, 0.0083 mg/m3 for PM2.5, 0.0083 mg/m3 for PM4, 0.0093 mg/m3 for PM10, and 0.013 mg/m3 for PMtotal. The average PM2.5 and PM10 concentrations in the sport center were found to be lower than the limit value set by WHO. Higher particle number concentration was registered for Multifunctional Hall (peak value 19147 pt/cm3) compared to the Gymnastic Hall (peak value 10238 pt/cm3). It was found that training ball-based sports including indoor soccer, basketball and volleyball, provided higher PM concentration compared to the sports conducted with no balls, because of the dust resuspension. Number of participants and intense indoor activities greatly influenced PM concentration. For example, during Judo and Boxing classes simultaneously conducted with total of 30 people, the peak values for PM1, PM2.5, PM4 were 0.045 mg/m3, and for PM10 it was 0.070 mg/m3 in the Gymnastics Hall. The reliability of the low-cost instrument Dylos data showed in average PM>0.5µm to be 23.7 times higher than PM>2.5µm. A relationship between particle number concentration counted by Dylos and particle mass concentration estimated by DustTrak DRX will be presented. However, Dylos DC1700 Air quality monitor requires future assessment.

2AE.2

Quantifying the Sensitivity of Mortality Calculations to Household-level, Ambient-level, and Combined Exposure to PM2.5 from Solid-fuel Combustion.

JACK KODROS, John Volckens, Michael Brauer, Ellison Carter, Kelsey Bilsback, Christian L'Orange, Michael Johnson, Jeffrey R. Pierce, *Colorado State University*

Many studies have estimated the burden of human disease due to $PM_{2.5}$ exposure from household combustion of solid fuel. Central estimates of mortality from this exposure source range from 2.9 to 4.3 million deaths for 2012, globally. While it is clear that residential solid-fuel combustion poses a substantial health burden, the sensitivity of estimated mortality to uncertainties in individual input parameters (such as $PM_{2.5}$ concentration, baseline mortality rate, or concentration-response functions) has not been quantified. We perform a variance-based sensitivity analysis on mortality due to exposure to $PM_{2.5}$ from solid-fuel combustion at the ambient level and household level. We also consider the mortalities attributable to solid-fuel use from the combined effect of exposure to $PM_{2.5}$ from solid-fuel combustion and $PM_{2.5}$ from ambient sources. When considering the combined effect of ambient- and household-level exposure, we estimate 300,000 fewer deaths per year attributable to solid-fuel use than when only household-level exposure is considered. This is likely attributable to the log-linear health-response to $PM_{2.5}$ exposure. Exposure to $PM_{2.5}$ from solid-fuel combustion in regions with already high (>40 $\mu g\ m^{-3}$) concentrations of $PM_{2.5}$ from other anthropogenic sources does not proportionately increase disease burden. We find that concentration-response functions contribute the most to the variance in mortality (50-60% across Asia and 40-50% in South America and Africa) with the fraction of the population using solid fuel for energy the next largest contributor (15-30%). Conversely, the ambient and household $PM_{2.5}$ exposure contributes very little to the estimated variance in mortality estimates (1-7%). This suggests that in order to reduce uncertainty in mortality calculations at the ambient- and household-level exposures, future studies should focus on more precise quantification of exposure-response relationships to $PM_{2.5}$.

2AE.3

Aerosol Deposition in Upper Respiratory Tract for Different Inhalation Patterns and Effective Flow Inlet Area: Computational Fluid Dynamics Study.

MAHDI ASGARI, Arkadiusz Kuczaj, *Philip Morris International R&D*

Pulmonary aerosol deposition depends on a variety of factors ranging from the complex airflow in a respiratory tract to the evolving physical and chemical aerosol properties. Although sophisticated computational aerosol transport models have improved our understanding of the aerosol inhalation in the human airways; there are still many scientific aspects to be explored. Among those, the importance of the breathing flow pattern and effective mouth flow inlet area for the aerosol transport and deposition has been emphasized with conducted in-vitro lung cast experiments. This is of particular importance for estimation of realistic aerosol doses for buccal/epithelial tissues exposed in in-vitro exposure systems.

In this computational study, we employ our Eulerian internally mixed aerosol model to predict the aerosol transport and deposition in a realistic geometry of the human upper respiratory tract. In order to capture the size dependent behavior of the polydisperse non-evolving aerosol, our model relies on the sectional discretization of the droplet size distribution function. This implementation allows us to evaluate the occurring aerosol deposition due to inertial impaction, gravitational sedimentation and diffusion. With a well resolved computational mesh near the walls, our simulation show a good agreement with the available experimental data for monodisperse aerosol transport. We investigate the impact of the breathing pattern and effective flow inlet area on the size-dependent regional aerosol deposition.

2AE.4

Interplay of Mobile Air Monitoring and Distributed Samplers to Study Intracity Spatiotemporal Variation.

HUGH LI, Peishi Gu, Qing Ye, Naomi Zimmerman, Ellis Shipley Robinson, Joshua Apte, Allen Robinson, Albert A. Presto, *Carnegie Mellon University*

Long-term exposure to particulate matter (PM) is the major contributor to air pollution related death in 21st century. Intracity exposure patterns can be more complex than intercity ones because of local traffic, land use, and industrial facilities. We use a hybrid sampling network to characterize spatiotemporal variations of multiple pollutants in Pittsburgh, PA. This network incorporates a mobile sampling platform, supersite, and distributed sampling together to investigate a wide range of pollutants (CO, NO, NO2, VOCs, O3, PM2.5 mass and composition, and ultrafine particles UFP). The 1st key question to address is the effective mobile sample size to generate representative long-term averages. We randomly subsample from the mobile data, and compare it to the stationary site data. We compare mobile and stationary data collected in the same 30m (or 100m) grid box so that we get a "true" comparison of the two sampling methods at the same point in space. A mobile sampling size of 20 measurements inside a 30m grid box has such statistical power to estimate long-term trends for most target pollutants. Pollutants such as NO, BC and UFP have significant intracity spatial variation after removing within day and day to day temporal variability.

Second finding focuses on spatial representativeness of long-term distributed monitors. Locations closer to monitors are more likely correlated with monitor measurements. We first use a 20% deviation criteria to define measurements agreement between two sampling platforms (mobile V.S. stationary) and identify cutoff distance for target pollutants across various types of site. And then we use the geospatial approach -- semivariogram to find the same correlation distance threshold. The final product will be correlation distance for different gas and particle pollutants, and possible metric (traffic density, dispersion characteristics) to describe the spatial range informed by stationary monitors.

2AE.5

Health Effects Investigation of Nebulizing Alternaria Extracts and Nanosilica Particulate Matter using a Mouse Chamber.

XINZE PENG, David R. Cocker III, David Lo, *University of California, Riverside*

A whole-body exposure chamber is established and characterized for studying the exposure of mice to multiple air contaminants. This design is a result of a collaboration between the UC Riverside School of Medicine, CE-CERT, and plant/botany sciences. Alternaria, which is known as a common fungus to Southern California that has been shown to increase the risk of developing asthma when inhaled chronically, was used as a bioactive material for a five-day health study. Alternaria extracts diluted in water were nebulized into the chamber to generate a particle size distribution with a mode of 100 nm. Preliminary data using mice indicates an increase in both lung inflammation (e.g., elevated eosinophil levels) and brain inflammation (e.g., TLR2 induction) following a continuous five-day exposure. Silica Nanospheres in water solution were also nebulized into the chamber to generate a size distribution with a mode of 100 nm to serve as comparison study of non-bioactive nanoparticles. The research purpose of this study is to determine whether the health effects were caused by bioactive materials or by simple inhalation of nanoparticles.

2AE.6

An Enhanced Children's MicroPEM for Household Air Pollution Personal Exposure Measurements.

Ryan Chartier, Mukesh Dherani, KATHLEEN OWEN, *RTI International*

Three billion of the world's poorest people rely on solid fuels (wood, crop wastes, dung, charcoal and coal) and simple open fires and stoves for their everyday cooking needs. This results in high levels of exposure to smoke pollution among family members, including young children. These exposures to household air pollution (HAP) have been linked to numerous adverse health outcomes.

The RTI MicroPEM (240g) has been used to measure personal exposure to particulate matter (PM) in numerous HAP exposure studies. The MicroPEM has been validated as a personal exposure monitor and deployed in field studies with adult and school-aged children. However, this device can be burdensome for small children (< 5 years). Therefore, RTI developed a smaller version of the MicroPEM, the Enhanced Children's MicroPEM (ECM). The ECM is 47% smaller and weighs 90g less than the MicroPEM. This decrease in size and weight reduces the physical burden on the child while the existing performance MicroPEM is maintained or improved.
The ECMs were deployed in a small pilot effort (N=50) in rural Malawi. ECMs were worn by children falling into one of 5 age groups (0-1, 1-2, 2-3, 3-4, and 4+ years of age). The youngest children were found to have the highest mean exposure levels (58.6 $\mu g/m^3$), and exposures decreased with age, reaching a minimum in the 3-4 year group (29.2 $\mu g/m^3$). Additionally, the ratio of the mother's $PM_{2.5}$ exposure, measured using the MicroPEM, to that of her child increased from a minimum at age 0-1 year (1.9) to a maximum at age 3+ (5.6). These data indicate children likely spend more time away from their mother, and therefore the cookstove, as they become older. Forty-nine of the 50 mothers indicated they would be willing to have their children wear the ECM for exposure measurements again.

2AE.8

On-Line Aerosol Characterization within Exposure Systems Using Soft Ionization Time of Flight Mass Spectroscopy.

Sandro Steiner, Shoaib Majeed, ARKADIUSZ KUCZAJ, Stefan Frentzel, Julia Hoeng, *Philip Morris Products S.A., Switzerland*

Three dimensional organotypic models of the human respiratory tract epithelia are the most advanced biological test systems in in-vitro inhalation toxicology. They enable the exposures to be conducted with the cell cultures in direct contact with the test atmospheres, i.e., at the air-liquid interface. As the test atmosphere may change its physicochemical properties within aerosol exposure systems (e.g., due to dilution and liquid-vapor partitioning), methods for monitoring chemical aerosol composition in close proximity to the exposure chambers are required.

We present a method using soft photon ionization time-of-flight mass spectroscopy (SPI-TOFMS) to measure the chemical composition of test aerosols in real-time within the Vitrocell 24/48 aerosol exposure system (Vitrocell GmbH, Germany). The SPI-TOFMS (Photonion GmbH, Germany) was connected to the Vitrocell system one centimeter upstream from the quartz crystal microbalance chamber, which is structurally and functionally equivalent to sampling directly upstream to the cell culture exposure chambers. Cigarette smoke (3R4F research cigarettes) and aerosols representative of commercially available electronic cigarettes (generated in a collision nebulizer) were delivered to the system as during regular exposures of organotypic tissue cultures, and mass spectra were acquired continuously.

The applicability of the method is demonstrated via reproducible high-resolution monitoring of the chemical composition of the smoke/aerosol and its time-profile (the puffing). Furthermore, the quantification of representative constituents was in agreement with extrapolated results of established off-line methods, indicating that non-representative aerosol sampling and co-localization of mass peaks of different compounds or their fragments does not pose a major limitation of the proposed measurement method.

2AE.9

Population Exposure to Ultrafine Airborne Particle Number and Mass Concentrations in California. XIN YU, Melissa Venecek, Anikender Kumar, Abhishek Dhiman, Michael Kleeman, *University of California, Davis*

Numerous epidemiological studies have identified positive correlations between exposure to ambient particulate matter (PM) and increased risk of respiratory and cardiovascular diseases, premature mortality and hospitalization. Some toxicity studies have suggested that ultrafine particles (UFPs; $Dp<0.1\mu m$) may be especially dangerous to human health since they have higher toxicity per unit mass and can penetrate the lungs and enter the bloodstream and secondary organs. These preliminary toxicology results are suggestive but more epidemiological evidence is required before the need for new regulations on UFPs can be fully assessed.

In this work, exposure fields are calculated for ultrafine particle mass concentration (PM0.1) and ultrafine particle number concentration (PNC0.1) in California with 4km spatial resolution and hourly time resolution for the year 2010-2016. Concentrations are predicted with a regional chemical transport model that includes explicit size-resolved emissions information for all major sources of ultrafine particles and all major atmospheric transformation processes. Predictions for PNC0.1 and PM0.1 concentrations are compared to available measurements to evaluate the accuracy of simulations. Predicted source contributions to primary PM0.1 and PNC0.1 are compared to the analysis results from receptor-based Chemical Mass Balance (CMB) model and Positive Matrix Factorization (PMF) model. The contributions from most significant sources of PM0.1 and PNC0.1 are assessed over the entire state. The results provide detailed spatial and temporal variations and enhanced source apportionment information for epidemiological studies to examine the relationship between health effects and concentrations of PM0.1 and PNC0.1 in California.

2AE.10

Wintertime Submicron Particulate Matter in Logan, UT as Measured by SMPS and EPC. JONATHAN KRUG, John Offenberg, Maribel Colon, Kenneth Docherty, Bruce Habel, Russell Long, *EPA/ORD/NERL*

Submicron particulate matter (PM) in the atmosphere is typically emitted directly or formed through secondary processes such as condensation and nucleation of semivolatile compounds, little submicron PM is generated by natural processes such as wind-blown dust. Submicron PM is not currently regulated by the EPA beyond inclusion with the PM2.5 standard on a mass basis. There is significant interest in measurement of submicron PM for understanding exposure risks and potential health effects related to exposure. Because individual submicron particles have relatively little mass, particle number concentration could be the most relevant metric in health effects studies. Due to wintertime atmospheric inversions, Logan UT frequently experiences exceedances in PM2.5. To better understand the local submicron PM, concentrations were monitored by Scanning Mobility Particle Sizer (SMPS) and by Environmental Particle Counter (EPC) during January and February of 2017 at a field site located in Logan UT. Daily median particle diameter is reported as well as particle number concentrations as measured by the SMPS and EPC. Trends are examined for correlation of submicron PM concentration to local atmospheric inversion events.

Disclaimer: Although this work was reviewed by EPA and approved for presentation, it may not necessarily reflect official Agency policy.

2AE.11

Exposure Assessment of Market Products Including Nanomaterial in General Use and Disposal Process. YASUTO MATSUI, Shigeru Kimoto, Minoru Yoneda, *Kyoto University*

The purpose of this study is measuring the amount of the nanoparticle generated from the product including nanomaterial by crushing and combustion or in the popular use situation.

Nanoparticles from the products including the nanomaterial were measured in the noble chamber we developed. The distribution was well controlled in each sampling sixteen points on a side wall. We selected the filter which is a part of air purification system and coating spray including titanium dioxide. Over 1.6×105 number/mL particles were detected by FMPS after spray and the concentration decreased to the same concentration of chamber background in 2.5 hours. However, there was little particle concentration during fractured wasting. Ti was detected in each sampling filters by ICP/MS. These results indicate that Ti using for product artificially was be able to detect and separate between them and particles with other materials secondarily.

We developed a new electrostatic sampling instrument for detecting in a tiny area with electron microscope, X-ray fluorescence or synchrotron micro beam.

2AE.12

Aerosol and Gaseous Pollutants Emission from a Desktop Laser Cutter and Engraver. JUN WANG, Kevin O'Neill, *University of Oklahoma*

The emission of laser generated airborne contaminants (particles in respirable fraction mass and sub-532 nm fraction numbers, VOCs, and CO) were examined in this study. The experimental matrix comprised of four different materials (cardboard, wood, plastic, and glass) and three different currents. The efficiency of exhaust ventilation was evaluated. Particle emission in the respirable fraction and the ultrafine fraction is particularly a concern for nanotoxicity and potential user exposure. A large percentage of the experiment resulted an overexposure to respirable particulate mass comparing to OSHA PEL of 5 mg/m^3 despite the short period of sampling time. Cardboard consistently produced highest respirable particulate mass (0.37 mg), high emission rate of particles smaller than 532 nm (2.37 × 1010 #/min) with the smallest geometric mean diameter (82.1 nm without ventilation). This hints that cutting cardboard should be exercised cautiously. On the contrary, glass was very robust and resist to thermal cut and less amount of respirable particulate mass (0.12 mg, in some cases below LOD), with a close to the background level of particle size distribution in the sub-532 nm range. Wood and plastic were in between cardboard (high) and glass (low) in terms of respirable and ultrafine particle production. Materials with relative higher carbon content were able to generate more VOCs and CO such as wood and cardboard. Plastic cutting emitted more VOCs while CO was absent. Glass was very inert to gas emission and no VOC or CO was observed when engraving glass. Ventilation control was able to mitigate all aspects of emission to certain scales. It can effectively reduce respirable particulates mass by averaging 61%, and decrease ultrafine particle emission rate by magnitudes. Ventilation was able to completely remove all gaseous contaminants generated. Therefore, it is highly recommended to implement ventilation while conducting laser cutting/engraving.

2AE.13

Condensation Particle Growth for Improved Delivery of Nanoaerosols to Air-Liquid Interface Cell Culture.

TREVOR TILLY, Jiva Luthra, Sarah Robinson, Arantzazu Eiguren Fernandez, Gregory Lewis, Saber Hussain, Tara Sabo-Attwood, Chang-Yu Wu, *University of Florida*

An efficient particle delivery system has been designed for the characterization of submicron particles. Using water-based condensational growth technology, particles as small as 10 nm are amplified to droplets greater than 3 µm allowing them to be counted by optical measures. Furthermore, this technology has been transitioned as an efficient means for collecting viable virus and bacteria aerosols in a sampler known as a growth tube collector (GTC). The temperature, 37 ºC, and humid environment used by the GTC for particle collection makes the sampler ideal for delivering particle aerosols to air-liquid interface cell cultures for toxicity evaluation. 3D printing was used to adapt the GTC to support air-liquid interface cell culture; in this design, four wells can be simultaneously exposed to evaluate variations and obtain statistically relevant results. Particle deposition efficiency, and intra- and inter-well variability was determined by aerosolizing fluorescein and quantifying the amount deposited in each well using fluorometry. Three fluorescein aerosol particle concentrations of 60,000, 150,000, 210,000 #/cm^3 were used to test the controllability in depositing particles for sampling periods varying between 5 and 20 minutes. Each sampling condition was run in triplicate. The standard deviation of the deposited dose was below 0.01 for each of the exposure conditions and their triplicate trials, with 9 of the 12 timepoints of the three conditions being below 0.005. Testing results showed that the delivered dose of fluorescein to the cell membranes was linearly related to exposure concentration and time. The high efficiency of the GTC for delivering particles to cells results in dosing concentrations ranging from 177 ng/cm^2 to 2.93 µg/cm^2 in under 20 minutes. Therefore, particle deposition to cells can be carefully controlled in the GTC to provide a flexible method to evaluate the toxicity of aerosol exposures.

2AE.14

In Vitro Aerosol Exposure of Nanoaerosols: From Laboratory to Field Toxicity Testing.

TREVOR TILLY, M. Tyler Nelson, Christin Grabinski, David Mattie, Chang-Yu Wu, Saber Hussain, *Air Force Research Laboratory*

Exposure to nanoaerosols (NAs) is inevitable, whether incidental or intentional, and its impact requires robust toxicological assessment. Advanced in vitro models which consist of culture cells at the air-liquid interface (ALI) have made direct delivery of nanoparticles onto cells possible to allow researchers to assess the toxicity of NAs as they occur. Despite these developments, operational and environmental toxicity assessments to date mainly collect particles exposed in the field and then conduct toxicity assessment in the laboratory. A custom designed aerosol exposure chamber (AEC) was tested on its ability to assess the toxicity of three NAs comprised of CuO, NiO, and ZnO exposed to A549 lung epithelial cells cultured at the ALI in comparison to traditional toxicity screening with submerged cell culture. Then the AEC was taken to the firing range, and the same cell line was exposed to NAs emitted by a 9 mm pistol and a semi-automatic rifle. The cell viability was assessed using lactate dehydrogenase and alamarBlue and the inflammation response was determined using IL-8 ELISA. A dose dependent toxicity response from cells exposed to the laboratory NAs was observed, with the ALI cell models being more resilient against higher particle exposure concentrations than submerged culture. In agreement with published literature, the CuO and ZnO reduced the cellular viability greatest by ~60% at concentrations of 1.87 and 24.1 µg/cm^2, respectively, and a delivered dosage of NiO at 8.09 µg/cm^2 reduced the cellular viability by just over 30%. NA exposure from rifle fire reduced cell viability greater than that of a pistol, while the pistol stimulated inflammatory cytokine release of IL-8, which is likely due to the lethal exposure to the cells exposed to rifle exhaust caused by overloading of cells with Cu, Fe, and Ni particles, making them unable to secrete IL-8.

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2AP.1

Evaluation of Particle Release Map using Selected Turbulence Models on the T Junction for Cohesive Wall Treatment. YUKI TSUZUKI, Ralph Aldredge, *University of California, Davis*

The purpose of this research is to evaluate the discrepancies in the fate of the particles using the particle release map (PRM) under the treatment of cohesive particle to wall treatment in the T junction pipe using three selected turbulence models: Launder-Sharma k-epsilon, k-omega SST, and SSG Reynolds Stress Model (RSM). The results obtained from the particle laden flow in branched pipe systems plays a key role in a gas pipeline system such as transferring aerosolized sealants for sealing leaks or sedimentation of non-cohesive particles in the branched pipes. Current research provides in-depth particle analysis using depositional velocity and concentrations of particles distribution; however, the consequences of particle transfer rates to branched system from various turbulence models is not clear. This research is going to utilize the selected turbulence models to analyze the particle response under the T-junction pipe systems.

In this paper, the CFD simulation is conducted using the open-source software OpenFOAM, using the Lagrangian particle method. Observing parameters are particle distribution, particle diameter and T junction location with all under cohesive particle-wall interactions. The post processing comparison of the particle distribution is analyzed using PRM, which provides the connection between pre-branched to post-branched particle profile.

The computational results comparing the turbulent kinetic energy (TKE) associated with three models show differences from the DNS, seen in Hedlund et al. [1], where the peak of the TKE at near the wall, and TKE at the centre of the pipe can differ up to ~90% and ~40% respectively. This discrepancy will directly influence the particle distribution and alter the particle entering the daughter branches. Further research will be directed toward conducting and analyzing the effect of these models on the T-Junction geometry using PRM.

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2AP.2

Heterogeneous Nucleation of CO2 on n-Alkane Nanodroplets. YENSIL PARK, Barbara Wyslouzil, *The Ohio State University*

In earlier work (Tanimura et al. 2015) we investigated the heterogeneous nucleation of CO_2 on small ice particles. Heterogeneous nucleation depended on the size of the particles, but never required supersaturations beyond those defined by of the extrapolated supercooled liquid CO_2 line. Here we extend this work to consider heterogeneous nucleation of CO_2 on liquid n-pentane droplets and solid n-hexane particles. All experiments are conducted in a supersonic nozzle using pressure trace measurements (PTM), Small Angle X-ray Scattering (SAXS), and Fourier Transform Infrared Spectroscopy (FTIR) to characterize the phase transitions. In both cases, we considered three n-alkane mass fractions and 12% of CO_2 in the inlet flow. This talk will summarize how the nature and state of the alkane determines the conditions for the onset of CO_2 condensation as well as the final particle structure. In all cases, CO_2 condensation onto the n-alkanes required significantly higher supersaturations than CO_2 condensation onto water ice.

Reference:
Tanimura et al. (2015) *RSC Adv.*, 5, 105537-105550.

2AP.3

DMA-MS based Examination of Organic Vapor Uptake by Nanometer Scale Clusters. CHENXI LI, Christopher Hogan Jr., *University of Minnesota*

Condensational growth of sub 2 nm particles in a supersaturated environment (CPCs) has been found to be dependent on particle material, polarity and vapor species. Vapor uptake is the first step of such processes and therefore influences subsequent particle growth. However, uptake is not well understood in the nanometer size range. In this study we utilized a differential mobility analyzer coupled with a time-of-flight mass spectrometer to examine the uptake of organic vapor molecules by nanometer scale sodium chloride cluster ions ($(NaCl)_x(Na^+)_z$ and $(NaCl)_x(Cl^-)_z$). Chemically related (1-butanol, ethanol) and distinct (methyl ethyl ketone (MEK), toluene) vapor species were selected to observe their influence on the inverse mobility of the cluster ions. For each vapor, a similar pressure range (from 0 to several hundred Pascals) was tested. Butanol uptake results in shifts of inverse mobility of both positive and negative cluster ions by more than a factor of two. Ethanol uptake led to inverse mobility shifts that are qualitatively similar to that of butanol, though smaller at the same vapor pressure. MEK uptake led to shifts for positively charged cluster ions upwards of a factor of 1.5, while MEK exposure led to negative ion inverse mobility shifts less than a factor of 1.3. Toluene, lacking strongly polar functional groups in its molecular structure, led to shifts in inverse mobility below a factor of 1.2. In total, relative inverse mobility shifts were found to be strongly influenced by vapor molecular structure and cluster ion charge polarity. Kelvin effect based models are found inadequate to explain the observed mobility shifts, and we instead used a site-specific, Langmuir type model to fit the vapor uptake behavior by the cluster ions.

2AP.4

Experimental Determination of Optical Losses due to Absorbing and Non-Absorbing Particles Deposited onto Solar Cells. LAURA LLANZA, Patricio Piedra, Hans Moosmuller, *Desert Research Institute*

Industrial solar energy production is rapidly expanding; however, the efficiency of solar cells decreases when mineral dust deposits onto their surface. We conducted an experimental study suspending absorbing or non-absorbing mineral dust in a deposition chamber. Glass slides were placed at the bottom of this chamber, simulating the solar cell with the entrained dust being allowed to gravitationally settle onto the slides. Once these glass slides acquired a desired deposited dust mass density, we removed them from the deposition chamber and measured their forward hemispheric scattering coefficient and direct beam light transmission with an integrating sphere spectrophotometer. This experiment allowed us to determine the optical losses of solar cells due to mineral dust deposition as a function of aerosol type, deposited mass density, and optical depth. Results will be presented for both strongly absorbing hematite and non-absorbing lake-bed deposits.

2AP.5

Scattering by Wavelength-scale Spheroidal Particles. JEHAN SENEVIRATNE, Matthew Berg, *Mississippi State University*

Aerosol particles are of different shapes and sizes. While many scattering models approximate the particles are spherical in shape, it is important to understand that the scattering by small particles heavily depend on the shape and orientation of the particle. We present our work on scattering by wavelength-scale spheroidal particles and discuss how the shape, size, and orientation of the aerosol particles affect the forward and back scattering.

2AP.6

Dynamic Modeling of Wall Loss in a Teflon Atmospheric Smog Chamber. MEREDITH SCHERVISH, Neil Donahue, *Carnegie Mellon University*

Suspended phase organics constitute a large fraction of atmospheric pollutants. These aerosols heavily impact the environment making the determination of their formation and growth critical to our understanding of the atmosphere. Smog chambers provide a controlled experimental environment to probe suspended phase dynamics. Modeling these experiments is crucial to understanding how chamber yields are impacted by the walls of the chamber. While particle deposition has been studied extensively leading to knowledge on the timescale and size dependence of this phenomenon, the vapor wall loss picture remains less clear. Experimental evidence has shown the walls of the chamber can provide a continuous sink for vapors or a phase to which vapors can reversibly partition depending on the compound and the chamber conditions. Due to the current infeasibility of measuring vapors in the walls, we present a model to dynamically partition mass between the suspended and vapor phase as well as the chamber walls using a specified “wall region” to track vapors interacting both with particles deposited on the walls and the Teflon itself. We find that compounds with low volatilities ($C^{*}< 100\ \mu g/m^3$), will reside entirely in the Teflon at equilibrium, however compounds with higher volatilities remain in appreciable amounts in the vapor phase. In addition, we see deposited particles still playing a significant role in the system, evaporating suspended organics once vapor concentrations are low with respect to the compound’s volatility. This model will allow incorporation of wall partitioning into larger more chemically rigorous models for more accurate chamber models.

2AP.7

Applying Extended Kirkwood-Riseman Theory to Rotating Fractal Aggregates in the Transition Regime. JAMES CORSON, George Mulholland, Michael Zachariah, *University of Maryland*

There is comparatively little focus on the rotational friction or diffusion coefficients, which affects particle alignment in an external field or from the flow field and relaxation time from an aligned state to a fully random state. Inclusion of rotational dynamics is also important when considering particle coagulation rates in Brownian motion simulations. We apply our extended Kirkwood-Riseman method to calculate the torque and rotational friction coefficient for fractal aggregates in the transition flow regime. For these calculations, we neglect hydrodynamic interactions due to rotation and translation-rotation coupling and consider only translational interactions between spheres due to their linear velocities. EKR results for DLCA aggregates are in good agreement with rotational friction coefficients computed using more rigorous Kirkwood-Riseman-based methods in the continuum regime – where the friction coefficient is proportional to the number of primary spheres to the power of approximately 1.6 – and a Monte Carlo method in the free molecule regime – where the friction coefficient is proportional to the number of spheres squared. This suggests that our EKR method is well-suited for studying the rotational behavior of DLCA aggregates in the transition regime. Our results also suggest that there is a universal relationship between the aggregate slip correction factor, defined as the ratio of the continuum rotational friction coefficient to the Knudsen-number-dependent friction coefficient, and an aggregate Knudsen number, defined as the ratio of continuum to free molecule friction coefficients. This result is analogous to the adjusted sphere method of Dahneke (1973) and Zhang et al. (2012) for the translational friction coefficient.

2AP.8

Solving the General Dynamic Equation for Nucleation, Surface Growth, and Coagulation, using the Nodal Method. JAMES CORSON, George Mulholland, Michael Zachariah, *University of Maryland*

We present a MATLAB-based code for solving the general dynamic equation using the nodal method, where particles exist at discrete size nodes instead of in bins, as in the sectional method. The MATLAB version of NGDE is based on an earlier version of the code written in C but includes several notable improvements. These improvements include a dynamic timestep that significantly decreases code execution time and enhances numerical stability, a more modular structure whereby the various physics packages are consolidated in subroutines (as opposed to appearing multiple times in different sections of the code) to simplify code maintenance, and a post-processing feature that generates static figures as well as animations that show changes in the particle size distribution in time. The post-processing tool also incorporates a Mie scattering calculation to illustrate changes in the extinction and scattering coefficients with the changes in size distribution. Results for the particle size distribution are in excellent agreement with exact solutions (where available) and with the previous iteration of the code. This MATLAB-based NGDE code and post-processing routine can be a useful teaching tool because the code is relatively simple, yet it incorporates the important physics of particle nucleation, surface growth, and coagulation. The following examples will be given: coagulation of an initially monodisperse aerosol, surface growth of a monodisperse aerosol, and the full GDE (nucleation, surface growth, and coagulation) for condensing aluminum vapor.

2AP.9

The Light Scattering Internal Coupling Parameter for Aggregates of Particles. CHRIS SORENSEN, *Kansas State University*

It is often found that scattering and absorption of light by aggregates of particles is well (but not perfectly) described by the diffraction, or Rayleigh-Debye-Gans (RDG), limit. This can be understood qualitatively by the fact that aggregates can have considerable free volume within their rough perimeters, thus “diluting” the refractive nature of the material. Our group has recently introduced the internal coupling parameter which is successful in parameterizing light scattering by non-aggregate particles of arbitrary shape including spheres. Here we describe an extension of this parameter to aggregates, both fractal and non-fractal, that successfully parameterizes the scattering and indicates when deviations for RDG will occur. For uniform, non-fractal aggregates this approach limits to the Maxwell–Garnett mixing theory description.

2AP.10

Homogeneous Nucleation of Carbon Dioxide in a Supersonic Laval Nozzle. KAYANE DINGILIAN, Yensil Park, Kyaw Hpone Myint, Barbara Wyslouzil, *The Ohio State University*

Understanding the nucleation of carbon dioxide (CO_2) on a molecular level has significant implications on the future of assessing and countering climate change. In this work, we intend to study the homogeneous nucleation of carbon dioxide in a supersonic Laval nozzle. Results from previous experiments in the laboratory focusing on heterogeneous nucleation of CO_2 indicated the presence of unexpected homogeneous CO_2 nucleation. The nozzles used in this experiment are designed to reach temperatures of ~ 90-100 K when argon is the carrier gas. Pressure trace measurements (PTM) along the length of the nozzle provide the data for flow calculations determining nucleation rate, residence time, and other physical properties. Further analysis with Fourier transform infrared spectroscopy (FTIR) and small angle x-ray scattering (SAXS) are used to confirm nucleation and calculate nucleation rate. Preliminary data from two nozzles have shown that carbon dioxide nucleation rates are on the order of 10^{15} particles per centimeter cubed per second. Experimental results will also be compared to classical nucleation theory and other models to help mend the gaps between predictive methods and reality.

2AP.11

Aerosol Emission from Seawater Contaminated by Crude Oil and Crude Oil-Dispersant Slicks due to Bubble Bursting. NIMA AFSHAR-MOHAJER, Kaushik Sampath, Ana Rule, Joseph Katz, Kirsten Koehler, *Johns Hopkins University*

Bubble bursting observed in oceanic whitecaps is a well-known mechanism of marine aerosol generation from seawater surfaces. Although spills of crude oil occur frequently in the ocean, the emission of oily marine aerosols ejected to the atmosphere due to bubble bursting has not been detailed. The use of chemical dispersants as a treatment strategy for oil spills significantly reduces the oil-water interfacial tension, thereby altering the size distribution of the aerosolized particles. The purpose of this study is to characterize particles aerosolized from an oil slick due to the bubble bursting, with and without the use of chemical dispersants. A mechanical shear based nozzle is used to generate a controlled bubble cloud that is injected into a vertical seawater column (0.6 m diameter, 1.8 m high). The bubbles rise to the oil-contaminated water surface and eventually burst. The resulting concentration of aerosolized droplets is measured by an aerodynamic particle sizer (APS) covering 0.5-20 µm and a scanning mobility particle sizer (SMPS) covering 10-370 nm particles. Planar bubble fluorescence imaging is used to measure subsurface bubble size and velocity distributions. Measurements are performed at the same air injection rate for varying bubble diameters (0.18, 0.4 and 1.4 mm), slick thicknesses (0.1 and 0.5 mm) and interfacial tensions (crude oil, and crude oil premixed with the dispersant Corexit 9500A (Nalco) at dispersant to oil ratios of 1:100 and 1:25). Results show that there is a considerable increase in the number concentration of micron-sized droplets (particle mode size of 2-5 µm) for all cases after bubble bursting. The number concentration increases with a decrease in bubble diameter, and a decrease in slick thickness. These findings help provide evidence on aerosol size distributions and their emission rate needed for the evaluation of health concerns and risks associated with the inhalation of oil and dispersant particles.

2AP.12

Fractal Scaling of Soot Packing Density across Five Size Decades. PAI LIU, William Heinson, Rajan Chakrabarty, *Washington University in St. Louis*

Fractal aggregates in nature grow with a scaling dimensionality less than the spatial dimension. This results in their packing density (θ_f, solid matter volume fraction) to decrease with increasing size R_g/a (aggregate radius of gyration normalized by average radius of monomers (repeating subunits)). Fundamental questions remain regarding the scaling laws and physical mechanisms controlling the evolution of θ_f, especially after the onset of gelation. In this work, we experimentally map the scaling of θ_f for soot aggregates across five orders of magnitude of R_g/a. The θ_f-R_g/a scaling relationship evolves through three successive regimes with distinct power-law exponents of -1.20±0.01, -0.58±0.06, and -1.31±0.14. The first cross-over agrees with the classical aerosol-to-gel transition theory. This agreement, however, breaks down at the second cross-over point, where a late-stage cluster-cluster aggregation of aerosol gels takes over.

2AP.13

An Experimental Comparison of Aerodynamic and Optical Particle Sensing for Indoor Aerosols. PARICHEHR SALIMIFARD, Donghyun Rim, James Freihaut, *The Pennsylvania State University*

Particle size is one of the most influential factors in particle transport and human exposure. A number of studies have investigated the relationship between optical and aerodynamic particle size. However existing literature is inconclusive due to limited available data on particles with varying size distribution, shape, density, and optical characteristics. The objective of this study is to experimentally investigate the relationship between optical and aerodynamic sizing techniques for a wide range of biological and monodisperse particles.

Biological particles included cat fur, dog fur, Bacillus thuringiensis spore, pollen, dust mite and monodisperse particles involved silica, melamine resin, and methyl methacrylate in the range of 1- 10 µm. In addition, NIST indoor reference dust, quartz, and aluminum oxide particles were used as reference particles. Each particle was dispersed into a dispersion chamber (76×76×42cm) with a computer-controlled syringe injection system. Particle sizes and concentrations were simultaneously measured by aerodynamic particle sizer (APS3321, TSI) and optical particle counter (AeroTrak OPC, TSI).

Comparison between APS and OPC results showed that the relationship between optical and aerodynamic diameters strongly depends on the particle size itself for all tested particles with varying shape factors, density, and refractive indices. Generally, OPC measures a higher number count compared to APS in smaller size bins whereas as size bin increases this relationship is reversed. The cut point at which the inverse proportion of OPC and APS is happening increases from about 1 to 3 µm with respect to size of the tested particle. This study further discusses effects of density, shape and optical properties causing coincidence errors in aerodynamic and optical sensing -for each combination of the tested particles- resulting in disagreement between optical and aerodynamic size distributions. This finding implies that researchers should avoid interchangeable use of aerodynamic and optical particle sizing technique results without providing optical and aerodynamic parameters.

2AP.14

The Effect of Polydispersity of Ultrafine Aerosol Particles on Electrical Charge Measurements in Low-cost Sensors. ROBERT NISHIDA, Nene Yamasaki, Adam M Boies, Simone Hochgreb, *University of Cambridge*

Electrical charging of particles and subsequent electrical current measurement is commonly used in low-cost ultrafine particle sensors. The devices are experimentally calibrated with controlled aerosol sources to provide metrics such as mean particle size and total concentration from one or more electrical current measurements. However, a polydisperse aerosol with a large standard deviation will provide a significantly different signal from a monodisperse aerosol with the same mean particle size. Therefore, further understanding of effect of polydispersity on integrated electrical current signal is required to improve the accuracy of low-cost sensors. In this work, we solve the conservation equations for particle/ion charging and transport (convection, diffusion and electrical transport) for a laminar, steady-state, incompressible flow along a cylindrical geometry. The particle charging method is direct ultraviolet photoionization, currently used in the development of a low-cost environmental sensor. The polydisperse particle size distributions are represented by multiple size bins, each with multiple charge levels. Results are presented for integrated electrical current from lognormal distributions of varying mean particle size, concentration, standard deviation and electric field strength. The results show that there are significant differences in signal between monodisperse and lognormal particle distributions, and that these differences increase with standard deviation.

2BA.1
A Realizable Fast Way to Measure Biological Airborne Particles via Adenosine Triphosphate Detection. HYEONG RAE KIM, Ji-Woon Park, Ki Young Yoon, Jeong Hoon Byeon, Jungho Hwang, *Yonsei University, Korea*

In this study, we introduced a fast methodology to measure biological airborne particles which could cause adverse health effect for human and livestock. We sampled biological airborne particles of indoor environments on a swab using a lab-made portable air sampler (5 x 5 x 5.5 cm). For the feasibility test in a laboratory, we generated bacteria particles (*Staphylococcus aureus*) and sampled the bacteria on the swab using our sampler. The swab was returned back into the kit tube and let the cotton swab react with reagent for ATP bioluminescence. Then we put the swab kit into the luminometer which measures bioluminescence intensity proportional to the number of biological air particles. For the quantification, we sampled the bacteria on the agar plates using a single stage viable impactor and counted the colony number after incubation. And we also measured the concentration of bacteria using APS simultaneously. We correlated the bioluminescence intensity values, colony number, and concentration of the bacteria represented as RLU/m^3, CFU/m^3, and #/cm^3, respectively. After the bacterial feasibility test in the laboratory, we sampled biological air particles in an office, a restroom, a lobby, a cafeteria, and a classroom of the university using our sampler and impactor simultaneously. The results of the feasibility test showed that 1 RLU corresponded to 0.89 ± 0.43 CFU and 1587 ± 261 # for *S. aureus* cells. However, 1 RLU corresponded to 0.15 ± 0.06 CFU for the indoor biological air particles which is different with the correlation data of the bacterial test in the laboratory. Viable but non culturable (VBNC) biological airborne particles and the fungal spores which have more ATP than that of bacteria might be the reason of the discrepancy of the laboratory and field tests.

2BA.2
Sampling of Bacterial Aerosols using a Personal Electrostatic Particle Concentrator. SEONGKYEOL HONG, Myeong-Woo Kim, Jaesung Jang, *Ulsan National Institute of Science and Technology, Korea*

Bioaerosols including fungi, bacteria, and viruses can cause allergies, infectious diseases, and other adverse health effects. Since the exposure to bioaerosols is usually assessed using air sampling and subsequent analyses, the sampler is required to provide highly concentrated samples without damaging the bio-particles' physical and biological states in the air. We previously developed a personal electrostatic particle concentrator (EPC) for gentle sampling of submicrometer airborne virus particles, and the concentration of infectious T3 phage was 1682 times higher in the EPC than in the SKC BioSampler. In the current study, bacterial aerosols were sampled with the EPC and compared with the BioSampler. The physical collection efficiency and biological recovery were examined varying the collection media, applied voltages, and sampling flow rates. The influence of electrolytes of the collection media on the viability of the collected bacteria will be discussed. For the sampling of *Pseudomonas fluorescens* aerosols, the physical collection efficiencies based on the bacterial cells collected in the collection medium were 53.3% and 77.3% in the EPC (1.2 L/min) and the BioSampler (12.5 L/min) respectively. In spite of the lower collection efficiency and the sampling flow rate, the total bacterial concentration was 2.6 times higher in the EPC than the BioSampler. In addition, the biological recovery rate was 1.9 times higher in the EPC than the BioSampler. Owing to the high sample concentration in the EPC, it can be potentially used for rapid detection of bioaerosols in conjunction with biosensors.

2BA.3

Anti-Bacterial and Anti-Viral Performance Test of Silver Nanowire Coated Nanofiber Filter. KYUHYUN PARK, Jungho Hwang, *Yonsei University, Republic of Korea*

Particle filtration field has been growing up together as airborne microorganism occurs problem as SARS or MERS. Therefore, various filters have been developed and invented for figuring out problems of airborne microorganism. Electrospinning and electrospraying method were used for fabricating and coating the filter. Silver nanowire coated nanofiber filter's filtration efficiency and pressure drop were measured to evaluate performance test. Aerosolizing prepared bacteria which were bacillus cereus, staphylococcus aureus, and micrococcus luteus and virus which was MS2 bacteriophage carried out for performance test of silver nanowire coated nanofiber filter. Filtration efficiency of prepared nanofiber filters was measured upstream and downstream of the particle concentrations by aerosolizing prepared bacteria and virus. The concentration of bacteria and virus was measured by using an aerodynamic particle sizer (APS) and a scanning mobility particle sizer (SMPS). By using a differential pressure gauge, the pressure drop was measured between upstream and downstream. For anti-microorganism test, pristine nanofiber filter and silver nanowire coated filter were used for comparison. Colony counting method and plaque counting method were used to get anti-bacterial efficiency and anti-viral efficiency. These efficiencies show a similar tendency which anti-microorganism was increased with increase of silver nanowire's coating time. Filtration performance test of silver nanowire coated electrospun nanofiber filter was evaluated by using APS and SMPS. Anti-bacterial and anti-viral ability of the filter were also evaluated. The silver nanowire coated electrospun nanofiber filter was evaluated to prove increase of the filtration efficiency and antimicrobial ability with increase of coating time of silver nanowire and steadiness of pressure drop.

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2BA.4

Measurements of Airborne Influenza Viruses using a Personal Electrostatic Particle Concentrator and Vertical Flow Assay based Electrochemical Paper Sensors. Jyoti Bhardwaj, MYEONG-WOO KIM, Seongkyeol Hong, Jaesung Jang, *Ulsan National Institute of Science and Technology, S. Korea*

Airborne influenza viruses can cause serious respiratory diseases and they are one of the biggest threats to human health. To monitor the threats effectively, we previously developed a personal electrostatic particle concentrator (EPC) for gentle sampling of submicrometer airborne virus particles, and the concentration of infectious T3 phage collected was 1682 times higher in the EPC than in the SKC BioSampler. In the present study, a portable vertical flow assay (VFA) based electrochemical immunosensor was used to detect the airborne influenza virus particles captured in the EPC. The capture antibody specific to the influenza virus was immobilized on the gold electrode; antibody-peroxidase conjugate (detection antibody) was immobilized on the conjugate pad. An asymmetrical membrane prepared by attaching the nylon membrane (pore size 0.45 μm) on the lower side of Whatman filter paper (pore size 11 μm) was used as a sample pad. This sample pad acted as a filter membrane which allows the smaller particles (<0.45 μm) to pass through it and retains the large particles (dust particles etc.) on the upper side of the membrane. The measurements were conducted by varying the collection time with constant applied voltage (5kV) and sampling flow rate (1.2 L/min). After collecting, the media containing the virus particles was transferred to the sample holes of the immunosensors. The immunosensor showed 512 PFU/mL within 16 min including 10 min sampling time. The concentration of the virus particles increased with increase in sampling time (10–30 min). These results were independently confirmed by commercialized ELISA Kits. This combination can provide a simple and cost-effective monitoring system for bioaerosols.

2BA.5

Hydrogen Peroxide Modulates the Energetic Metabolism of the Cloud Microbiome. ANNE-MARIE DELORT, Nolwenn Wirgot, Virginie Vinatier, Martine Sancelme, Laurent Deguillaume, *Université Clermont Auvergne, France*

Hydrogen peroxide plays a central role in atmospheric chemistry as a precursor of $HO^{\bullet}$ radicals and determines the oxidant capacity of the liquid phase [1]. In cloud water, H_2O_2 is also in direct interaction with microorganisms which are metabolically active and can have a significant impact on the oxidant capacity [2]. In this context, the present work highlights the interactions between $H_2O_2$and cloud microorganisms.

First, experiments were performed with model strains isolated from clouds in microcosms designed to mimic the cloud environment, including the presence of light and iron. The most important result was that H_2O_2 strongly impacted the microbial energetic state as shown by ATP measurements in the presence and absence of H_2O_2. This ATP depletion was not related to the loss of cell viability.

Secondly, correlation studies were done based on real cloud measurements from 37 clouds samples collected at the puy de Dôme station (1465 m., France). The results supported a strong correlation between ATP and H_2O_2 concentrations and confirmed that H_2O_2 modulates the energetic metabolism of the cloud microbiome. This modulation could impact cloud chemistry.

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2BA.6

Siderophores in Cloud Waters and Potential Impact on Atmospheric Chemistry. Virginie Vinatier, Monica Passananti, Nolwenn Wirgot, Muriel Joly, Martine Sancelme, Laurent Deguillaume, Gilles Mailhot, Marcello Brigante, ANNE-MARIE DELORT, *Université Clermont Auvergne, France*

One of the major sources of OH radical in atmospheric water has been attributed to iron species. However, iron chemistry in aqueous solution is a very complex process due to the existence and the stability of numerous iron species. Given the insolubility of ferric oxyhydroxides and oxides under natural waters conditions, the concentration of iron in equilibrium with these solids is very low and insufficient to drive substantial change in iron speciation or oxidant capacity of the medium. However, the concentration of dissolved iron can substantially increase by the presence of strong complexing agents as siderophores. The so formed iron complexes may absorb solar light and undergo a redox process leading to the reduction of Fe(III) and the formation of oxidant species . The presence of organic Fe-complexing ligands with high stability constants comparable to siderophores ones ($K>10^{20}-10^{22}$) has been shown in rainwaters[1]. Our hypothesis is that iron could be also complexed by siderophore synthestized by microorgtanisms in cloud waters. To test our hypothesis 450 strains isolated from cloud water at the puy de Dôme station (1465m, France) were identified and screened for siderophore production[2]. Under our conditions 42% of strains were able to produce siderophores. The most frequently encountered genus *Pseudomonas* was also the most active. A mixture of pyoverdins produced by bacteria isolated from clouds was used to determine the photoreactivity of Fe(III) pyoverdine complexes under simulated cloud conditions. The photolysis of these complexes led to the generation of Fe(II) and hydroxyle formation. Acetate formation was also observed suggesting a fragmentation following ligand-to-metal charge transfer[3]. Finally the presence of pyoverdine in cloud water could impact the composition and oxidative capacity of this environment.

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2BA.7

Diversity and Abundance of Microorganisms in Individual Raindrops Isolated from Natural Precipitation Events.

REGINA HANLON, Ellen Garcia, Osman Karatum, Linsey Marr, David Schmale, *Virginia Tech*

Precipitation samples collected at or near the surface of the earth are usually composite samples of many different raindrops. Little is known about the abiotic and biotic components found within individual raindrops. We used a liquid nitrogen bath to collect and isolate individual raindrops from a series of natural rain events. The raindrops fell into the bath, froze instantaneously, and were recovered in a sterile colander placed at the bottom of the bath. The mean droplet volume observed across all of the natural rain events was 7.6 µL (+/- 0.41). Twenty eight percent (40/143) of the natural raindrops isolated contained culturable microbes. Cell counts with an ImageStream® Mark II flow cytometer showed that a single raindrop (10 µl) contained over 1600 fluorescent objects, many of which were bioaerosols. Our ongoing work aims to elucidate the diversity and abundance of microorganisms in natural rain events. By isolating and studying individual raindrops, we hope to increase our understanding of the specific bioaerosols that may be drivers of precipitation processes.

2BA.8

Effect of Airborne Ion Emissions on Microbial Viability and Culturability.

NIRMALA THOMAS, Taewon Han, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

A personal electrostatic bioaerosol sampler (PEBS) has been recently developed at Rutgers University to assess exposure to airborne microorganisms. The key features of PEBS are the wire-to-wire charging section and a removable, superhydrophobic, dual-sided collection plate. This study evaluated the effect of airborne radioactive ions and ions produced during charging process on airborne microbial viability and culturability when sampled by PEBS. Airborne gram-positive bacteria Bacillus atrophaeus and fungal spores Penicillium chrysogenum were aerosolized and collected by PEBS under three conditions: 1) particles were charge-neutralized by a radioactive Po-210 source, and then those that retained any amount of charge were collected, 2) aerosolized particles were allowed to retain charge imparted by aerosolization and then collected , and 3) particles were neutralized, imparted positive ions and then collected. Total bacteria and fungi were counted by epifluorescence microscope and hemocytometer chamber. Viable bioaerosols were detected using bioluminescence of Adenosine Triphosphate and Thiazole Orange/Propidium Iodide cell viability assays. Culturable bacteria and fungi were determined by plating aliquots on nutrient agar and malt extract agar plates, respectively.

The bacteria collected by PEBS had a viability of 64% in the absence of any ions, while the viability decreased to 52% when the bacteria were charge-neutralized; the viability was 58% when bacteria were charge-neutralized and then charged by positive ions. The culturability was higher in the absence of ions but not statistically different to the other conditions ($p>0.05$). For fungi, the viability and culturability were not different in the three conditions ($p>0.05$).

These results suggest that the airborne ion emissions from PEBS do not affect fungal spores but might have a small effect on the viability of sensitive bacteria. Future tests will include extended sampling time and outdoor testing with Button Sampler and BioSampler at instrument standard flow rates.

2BA.10

Wind Tunnel Experiment of Bacillus Spores Resuspension.

JING QIAN, Babak Nasr, Meilu He, Kavindra Kumaragama, Matthew Brown, Morgan Minyard, Andrea R. Ferro, Goodarz Ahmadi, Suresh Dhaniyala, *Clarkson University*

Quantitative understanding for accurate modeling of real-world outdoor biological particle resuspension processes is lacking. The current experimental study quantifies particle resuspension for a range of substrates and particle types in a wind tunnel designed and fabricated to operate at high flow rates and variable humidity. The detachment of particles as a function of shear velocity for each set of conditions is measured. The experimental methodology for spore preparation, deposition, resuspension and detection are described. Results include resuspension rate vs shear velocity for the detachment of Bacillus spores as compared with glass spheres and PSL particles from glass and stainless steel substrates under various flow rates and two different RH conditions are presented. Approved for public release, distribution is unlimited.

2BA.12

Collection of Air Samples for Improved Detection of Microbes onboard the International Space Station.

Andrew Page, DAVID ALBURTY, Michael Hornback, Stephanie Cantrell, *InnovaPrep LLC*

Protecting the ISS crew from microbial contaminants is of great importance. Bacterial and fungal contamination of air has the potential to cause sickness and to impact onboard experiments. The development of a rapid way to determine when microbial contamination events occur through the use of low-power, high-efficiency bioaerosol sampling is presented here. Preliminary work in a ground-based bioaerosol laboratory compared high volume dry gelatin filters and low volume electret filters, and demonstrated that the low volume electret filters in combination with rapid elution using a carbonated surfactant buffer provided comparable effectiveness to the gelatin filters. The effectiveness of low volume electret bioaerosol sampling in this study was the improved viability of aerosolized *E. coli*, with an average overall efficiency of 37% viability following a 5 minute collection at 14 liters per minute. Elution resulted in average sample volumes of 4.9 mL, resulting in a concentration factor of 5.4 (CFU/mL)/(CFU/L_{air}). The gelatin filters preserved an average of 11% viability at 100 LPM, and were dissolved in 10 mL of water, giving a concentration factor of 5.6.

2BA.13

Development of A High Volume Portable Bioaerosol Concentrating Sampler.

HAOXUAN CHEN, Maosheng Yao, *Peking University*

Bioaerosols exposure can cause many adverse health effects even death when deadly pathogens involved. Existing bioaerosol samplers either have low sampling flow rate or have higher impaction stress (resulting in low concentration or injuries to the cells) such that further analysis of the samplers is often is a great challenge. Here, we have developed a portable high volume bioaerosol sampler (1200 L/min) that was powered using a battery and optimized to have an impaction velocity of around 10 m/s. The sampler was shown to not only have relatively higher physical collection efficiencies of ambient air particles with a cutoff size of 2 μm, but also resulted in greater diversity of bacterial cells compared to the Andersen type sampler as revealed from gene sequence analysis. In addition, the HighBioTrap sampler was also shown to be able to concentrate large volume of air into small amount of liquids at a rate of about 2 millions/min. The collected air samples can be easily analyzed using loop-mediated isothermal amplification (LAMP) for low level pathogen detection.

2BA.14

Detecting Breath-borne Pathogens Using a New Device Together with LAMP.

YUNHAO ZHENG, Haoxuan Chen, Maosheng Yao, Li Xiaoguang, Xu Jie, *Peking University*

Respiratory infection causes a tremendous toll on humans worldwide every year. It is very important for patients to be diagnosed accurately and rapidly as they need effective and appropriate medications. However, point-of-care diagnostic methods are significantly lacking at the bedside. Here, we investigated a rapid and non-invasive pathogen diagnosis method using Loop Mediated Isothermal Amplification (LAMP) to multiplexing detection of common respiratory pathogens from human exhaled breath samples and also throat swabs. And the collected samples were subjected to LAMP analysis for potential human pathogens. Exhaled breath condensates were collected using a commercialized exhaled breath collection device (eBioCollect) from human subjects with respiratory infection symptoms at Peking University 3rd Hospital. The pathogens included Streptococcus pneumoniae, Staphylococcus aureus, Methicillin-resistant Stphylococcus aureus, E. coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii, Stenotrophomonas maltophilia, Haemophilus influenzae, Legionella pneumophila, M. Pneumonia, Chlamydia pneumonia, and M. tuberculosis.

Results showed that LAMP can be used together with the eBioCollect for detecting breath-borne pathogens. For four out of fifteen patients, E. coli and P. aeruginosa were detected, while for one subject both MRSA and E. coli were detected from the exhaled breath samples. For throat swabs samples, we have detected pathogens from 25 out of total 69 samples, and the dominant pathogen was H. influenzae, which accounted for about 50% of the infections. Here, depending on the initial pathogen load in the sample, the entire procedure only takes 20-60 min to complete for a respiratory infection diagnosis for both type of samples. The eBioColect device for exhaled breath samples was shown to be able to collect 30 uL exhaled breath condensate samples within 3 mins. This work provides evidence that human bacterial pathogens can be exhaled out into the air while developing a rapid and non-invasive respiratory infection diagnosis protocol for the clinical settings.

2BA.15

Use of Automobile Filter Samples for Profiling Global Bioaerosols. JING LI, Maosheng Yao, *Peking University*

Bioaerosols in theory are all generated from the ground and could vary greatly across locations. In this work, we employed a previously established automobile filter method to obtain air samples from 15 cities of 10 countries under 8 different climate zones. Total 117 auto filter samples were obtained. Using culturing, qPCR, ELISA and also gene sequence method, we have analyzed biological contents from these auto filter samples. Our data showed that some filter dusts contained about 10^4 CFU/mg bacteria and 10^3 CFU/mg fungi with a total bacterial count of up to 10^6 cells/mg. The dust samples were also shown to contain various allergens up to 10 ng/mg. Gene sequence data revealed there were remarkable differences in bacterial structures from different countries. Preliminary data also showed that bioaerosol size distributions also varied greatly across locations. Using the developed protocol, we are able to easily profile global bioaerosol characteristics and thus accelerate the understanding of airborne micorbiota.

2BA.16

Use of Online Yeast Sensor (SLEPTor) for Analyzing PM2.5 Effects on Autophagy Gene Expression. TING ZHANG, Maosheng Yao, *Peking University*

Previously, in our lab we have developed a yeast based on PM2.5 toxicity sensor that is able to real-time analyze yeast responses to PM2.5 exposure. Here, we further applied the method to study the effects of PM2.5 exposure on the expressions of an autophagy gene of the yeast in real-time when exposed to the air samples. Our preliminary data suggest that the protocol is working and the system sensitivity need to be further improved to obtain a quicker response. In this presentation, a detailed protocol will be presented and relevant data will be also shown. Our work presents a very different solution for studying health effects of PM2.5 than currently available ones.

2BA.17

A Rotating Drum System with Environmental Conditioning for Research on Bioaerosols.

KELLY BRINKLEY, Benjamin Alvarez, Daniel Hahn, Elizabeth Corson, Michael Herman, Thomas Buckley, Michael House, Daniel Simon, *Johns Hopkins University Applied Physics Laboratory*

Environmental factors such as light, ozone, temperature and humidity potentially affect the physical or chemical attributes of a bioaerosol as well as its viability. Study of these interactions and assessment of their impact over time is important to areas of public health and biodefense. To address this research need, JHU/APL has designed, built and tested a Rotating Drum System (RDS), which is an aerosol testbed with temperature and humidity conditioning, simulated solar illumination, and controlled ozone injection, where each condition may be studied independently or coupled to simulate realistic environments.

JHU/APL conducted a series of tests to validate the RDS performance and capabilities for future research studies. Aerosolized polystyrene latex spheres (PSL) of 2 and 8µm were used to demonstrate the suspension capability of the 208L, 0.76m diameter drum. After 8hrs, 56% of 2µm PSLs remained and after 4hrs, 0.7% of 8µm PSLs remained, which was a measurable concentration of 86.2PPL. For 4 representative US weather setpoints of Hot/Humid (28°C/85%RH), Hot/Dry (40°C,20%RH), Cold/Humid(0°C/85%RH), Cold/Dry(5°C/35%RH), the RDS maintained the conditions within 0.2°C and 0.2%RH of the respective setpoints. Irradiance generated from the 6.5kW Xenon arc lamp matched the overall shape of the ASTM G177 spectrum for UV and Visible wavebands of interest (300-600nm). At these bands, the integrated irradiance was within 5% of the standard spectrum. The beam collimation was within 1^{o} and the uniformity varied less than 10% radially from center to edge at the entrance plane to the drum. Finally, the controlled ozone injection, which is designed to maintain ozone setpoints from 50 to 300ppb, maintained a mean concentration of 102ppb during a 6-hour test with a 100ppb setpoint.

2BA.18

Octanol-water Partition Coefficients of Airborne Fungi.

CHEOLWOON WOO, Naomichi Yamamoto, *Seoul National University*

Bioaerosol research has been largely focusing on identifying the diverse communities of bioaerosol in the atmosphere. However, the biophysical properties of bioaerosols have yet to be fully understood, especially for fungi. In this study, we utilized octanol-water partition coefficients to characterize the hydrophobicity and the hydrophilicity of airborne fungi sampled from the atmosphere of Seoul, South Korea. Airborne fungal particles were collected using the two-stage cyclone sampler. Collected airborne fungal particles were separated into octanol and water phases and the two immiscible phases were divided by the frozen-water phase method. Partition coefficients of each fungus at each taxonomic level were obtained based on the absolute concentrations derived from quantitative PCR and relative abundances produced by high-throughput sequencing. Result shows that fungal genera within the same family level tend to show similar partition coefficients. However, higher level similarities were not observed as the partition coefficients of fungal families of the same order level showed dissimilar partition coefficients. The genera *Biscogniauxia*, *Dicyma*, *Podosordaria* and *Subamaniomyces*, all members of the Xylariaceae family, showed hydrophobic properties. However, the genera *Eutypa* and *Eutypella*, members of the Diatrypaceae family, showed hydrophilic properties despite both the Xylariaceae and Diatrypaceae families being members of the Xylariales order. The results of this study indicate that the hydrophobic or hydrophilic properties of airborne fungal particles can be predicted by their family level classification, but not at the higher order level. The differences between fungal family and order level genetic similarities should be further studied to gain a deeper understanding of the underlying genetic traits responsible for hydrophobicity and hydrophilicity of airborne fungal particles.

Keywords: Octanol-water partition coefficient, Airborne fungi, Biophysical properties, Two-stage cyclone sampler, Frozen-water phase method, High-throughput sequencing.

2BA.19

Seasonal Changes of Bacteria Measured on a High Elevation Tower in Tokyo. JUN UETAKE, Yutaka Tobo, Ryohei Misumi, Paul DeMott, Thomas Hill, Sonia Kreidenweis, *Colorado State University*

Atmospheric bioaerosols can have far-reaching impacts on ecosystems, health and climate. Most previous outdoor bioaerosol studies in Japan have been limited to investigate the influence of transported microbes during Asian Dust events in spring. Long term sampling on even a semi-daily basis, which encompass both transitory weather events and seasonal variations, has not been conducted before. In order to understand seasonal airborne bacterial changes over Tokyo, 48-72h samples (from June 2016 to Feb 2017) were collected on filters using a low volume sampler (15-30L/min) housed in temporary science observatory at an elevation of 458 m a.g.l. in the "Tokyo Skytree" the highest tower (634m a.g.l.) in Japan, located in downtown Tokyo. Bacterial 16S rRNA genes (V3, V4) were amplified by PCR, and sequenced by MiSeq. All sequences were clustered into Exact Sequence Variants (ESVs) by the DADA2 program. Bacterial community structures were found to slightly shift month to month, but changed strongly in mid-October, when HYSPLIT trajectory modeling predicted a source region (3 days back trajectory) of particles coming consistently from the Eurasian mainland. Furthermore, lower alpha-diversity was observed during a typhoon occurrence and during the autumn rainy season in September indicating the influence of bacteria of local origin. These results indicate that air over Tokyo was affected by both local emissions and long range transport, and their respective contributions changed with weather and seasons.

2BA.20

Bacterial Diversity in the Indoor Environment: A Factorial Design Approach for Isolating the Impact of Environmental Conditions and Sampling Methods. DAHAE SEONG, Shamia Hoque, *USC*

Studies characterizing the indoor environment show that indoor air and its' microbiome is influenced by the various environmental factors, such as human activities, occupant number, ventilation, or/and interior design. Bacterial species detected was also dependent on the sampling approaches: active/passive sampling such as using an impinger or through gravitational settling and surface swabbing. However, information about how different indoor conditions as well as sampling methods impact on the species identified is still insufficient for a clear interpretation for source allocation. In this study we investigate the influence of presence and absence of occupants, gender and building type (residence or commercial), and sampling methods (ambient sampling and surface swabbing), on the type of bacterial species detected. Data was obtained from an extensive literature review. Factorial design approach isolated the impact of each variable or their interactions on the response (type of species present). The approach identified the dominant impact of male and female presence on *Micrococcus* sp. and *Staphylococcus* sp. which is expected as they are both skin related. *Staphylococcus* sp. did not show a specific gender signature. Sampling location and method also influenced the type of species detected.

2BA.21
Laser-Induced Fluorescence Measurements of CRISPR-Cas9 Bioaerosols. BRIAN DAMIT, Elizabeth Corson, Mellisa Theodore, Ellen Forsyth, Rebecca Lilly, Robert Player, Robert M. Miceli, *Johns Hopkins University Applied Physics Laboratory*

Advances in synthetic biology have the potential to transform the biodefense landscape. The advent of CRISPR-Cas genome editing tools can greatly enable development of designer biothreats by conferring more virulent properties, greater resistance to antibiotics, or enhanced transmission throughout a targeted population. Although studies have begun to explore the implications of CRISPR-Cas in the engineering of bioagents, negligible attention has been given to predicting the performance of fluorescent-based bioaerosol sensors against such emerging synthetic threats. The work here measured the laser-induced fluorescence (LIF) signatures of bacteria containing the CRISPR-Cas9 machinery in bioaerosols with time-of-flight LIF aerosol sensors, and compared the results to the signatures obtained from control microorganisms. CRISPR-Cas9-containing microbes were created by transformation of a GFP-expressing *E. coli* (ATCC 25922GFP) with plasmids containing genes for expression of 1) the Cas-9 enzyme (Addgene) and 2) sgRNA specific for the GFP target (Addgene). Test microbes were aerosolized with a Sono-Tek nozzle and sampled isokinetically by three LIF sensors: an Ultraviolet Aerodynamic Particle Sizer (UV-APS), a Wideband Integrated Bioaerosol Sensor (WIBS-4A), and a FLIR IBAC. Each sensor employed a different excitation wavelength and emission band thereby allowing comprehensive analysis of fluorescence discrepancies between test microbes. Microbes were aerosolized in both pure water and lysogeny broth. Generally, testing demonstrated that the addition of the plasmids negligibly altered fluorescence across all test sensors. For bioaerosol generation from lysogeny broth, fluorescence output was dominated by fluorescent materials contained in the broth rather than from microbes. Results from this study suggest that CRISPR/Cas9 plasmids and potentially CRISPR edits to the cell genome may not be discerned by LIF aerosol sensors.

2BA.22
Systematic Characterization and Fluorescence Threshold Strategies for the Wideband Integrated Bioaerosol Sensor (WIBS) Using Size-Resolved Biological and Interfering Particles. NICOLE SAVAGE, Christine Krentz, Tobias Könemann, Taewon Han, Gediminas Mainelis, Christopher Pöhlker, J. Alex Huffman, *University of Denver, CO*

Atmospheric particles of biological origin, also referred to as bioaerosols or primary biological aerosol particles (PBAP), are important to various human health and environmental systems. There has been a recent steep increase in the frequency of published studies utilizing commercial instrumentation based on ultraviolet laser/light-induced fluorescence (UV-LIF), such as the WIBS (wideband integrated bioaerosol sensor). Significant work over several decades supported the development of the general technologies, but efforts to systematically characterize the operation of new commercial sensors has remained lacking. Specifically, there have been gaps in the understanding of how different classes of biological and non-biological particles can influence the detection ability of LIF-instrumentation.

We present a systematic and comprehensive characterization of a commonly used commercial instrument (WIBS) for the real-time detection of fluorescent biological aerosols and suggest improved analysis and threshold strategies. Summaries of both biological and potential interfering, non-biological particles (69 aerosol types in total) are discussed in detail. We conclude that raising the fluorescence threshold from background + 3σ to background + 9σ causes minimal reduction in the ability to discriminate fluorescent particles considered biological in origin, but that it can significantly reduce the interference from non-biological particles. These recommendations can help users of similar instruments interpret ambient particle data more efficiently. The poster will be a summary of a manuscript currently in review: Savage et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2017-170, in review, 2017.

2BA.23

Raman Spectra of Individual Bioaerosol Particles in the Laboratory Using the Resource Effective Bio-Identification System (REBS). JACQUELINE MERLE, Nicole Savage, David Doughty, Steven Hill, J. Alex Huffman, *University of Denver, CO*

Airborne particles of biological origins can cause problems for respiratory health and are thought to impact a variety of environmental systems. Laser-induced fluorescence (LIF) measurements (e.g. WIBS or UV-APS) have been frequently deployed to investigate properties of bioaerosols on a single-particle basis, but provide relatively weak ability to differentiate between particle types. LIF instruments also face issues with certain kinds of weakly fluorescing materials that can add interference to investigations of biological aerosols. The Resource Effective Bio-Identification System (REBS) uses Raman micro-spectroscopy for the rapid chemical and size characterization of individual aerosol particles, providing detailed information about particle composition. The REBS can be operated to sample particles from the air and to automatically collect Raman spectra of impacted particles. The instrument offers the ability to differentiate particle types much more finely than LIF instruments and bioaerosol particles are reported by the manufacturer (Battelle) to be identifiable at the biological species level.

Several species of fungal spores were grown on agar plates and aerosolized. Raman spectra of these and several other aerosol materials were analyzed using the REBS. Initial results will be shown in comparison with complementary data outputs from the WIBS instrument as an example of a commercial LIF technique for bioaerosol detection.

2CA.1

Secondary Organic Aerosol Formation in Biomass-burning Plumes: Theoretical Analysis of Lab Studies and Ambient Plumes. QIJING BIAN, Shantanu Jathar, Jack Kodros, Kelley Barsanti, Lindsay Hatch, Andrew May, Sonia Kreidenweis, Jeffrey R. Pierce, *Colorado State University*

Secondary organic aerosol (SOA) has been shown to form in biomass-burning emissions in laboratory and field studies. However, there is significant variability among studies in mass enhancement, which could be due to differences in fuels, fire conditions, dilution, and/or limitations of laboratory experiments and observations. This study focuses on understanding processes affecting biomass-burning SOA formation in ambient plumes. The plume dilution rate impacts the organic partitioning between the gas and particle phases, which may impact the potential for SOA to form as well as the rate of SOA formation. We use an aerosol microphysics model that includes representations of volatility and oxidation chemistry to estimate SOA formation in the smoke emitted into the atmosphere. We add Gaussian dispersion to our aerosol microphysical model to estimate how SOA formation may vary under different ambient-plume conditions (e.g. fire size, emission mass flux, atmospheric stability). We find that smoke from small fires, such as typical prescribed burns, dilutes rapidly, which drives evaporation of organic vapor from the particle phase, leading to more effective SOA formation. Emissions from large fires, such as intense wildfires, dilute slowly, suppressing OA evaporation and subsequent SOA formation in the near field. We also demonstrate that different approaches to the calculation of OA enhancement in ambient plumes can lead to different conclusions regarding SOA formation. OA mass enhancement ratios of around 1 calculated using an inert tracer, such as black carbon or CO, have traditionally been interpreted as exhibiting little or no SOA formation; however, we show that SOA formation may have greatly contributed to the mass in these plumes.

2CA.2

Black Carbon Characterization in Aged Wildfire Plumes Observed at the Mt. Bachelor Observatory. JAMES LAING, Daniel Jaffe, Arthur J. Sedlacek, *University of Washington, Bothell, WA, USA*

Black carbon (BC) is the predominant light-absorbing aerosol constituent in the atmosphere and one of the largest sources in biomass burning. To better understand BC in biomass burning plumes a Single-Particle Soot Photometer (SP2) was deployed at the Mt. Bachelor Observatory (MBO, 2.7 km a.s.l.) in Central Oregon during the summer of 2016. The sampling site offers the observation of aged wildfire plumes transported in the free troposphere. The SP2 measures refractory black carbon (rBC) mass concentration and rBC number size distribution. Additional measurements at MBO included CO, CO_2, O_3, aerosol three wavelength scattering coefficients (σ_{scat}), PM1 mass, and total aerosol size distribution. Two instruments measuring aerosol absorption coefficients (σ_{abs}) were deployed; the 3-wavelength Tricolor Absorption Photometer (TAP) and 7-wavelength Aethalometer (AE-33).

Wildfire smoke from the Gap Fire in Northern California was observed at MBO over three days in late August. Thirteen individual plumes were identified. The plumes were transported 10 to 15 hours from emission to observation at MBO. All plumes had high single scattering albedos (0.96-0.97) and absorption Ångström Exponent (AAE) values (2.23-2.85). ΔrBC/ΔCO enhancement ratios for these plumes ranged from 2.57 to 5.31 ng m3 ppbv-1 and rBC fraction of PM1 (ΔrBC/ΔPM1) ranged from 0.76 to 1.37%. The geometric mean diameter (GMD) of the BB plumes size distributions ranged from 132 to 194 nm, and were proportional to plume concentration (i.e. σ_{scat}, PM1).

As the aerosol are highly scattering (SSA ~ 0.97), the absorption coefficients measured by the Aethalometer are significantly influenced by scattering corrections. Using scattering corrections Arnott et al. (2005) and Schmid et al (2006) in addition to the Aethalometers dual-spot filter-loading compensation parameter reduced σabs significantly across all wavelengths. Despite this, the σ_{abs} from the Aethalometer were 20 to 40% higher compared to the TAP. A detailed evaluation and comparison of aerosol absorption measurement correction schemes will be made as well as comparisons estimated BC (eBC) derived from the absorption measurements and rBC.

2CA.3

Characterization of Humic-like Substances in Particulate Matter in Malaysia Influenced by Indonesian Peatland Fires. FUJII YUSUKE, Ikeda Kazuhiro, Tohno Susumu, Mahmud Mastura, *Center for Environmental Science in Saitama*

Smoke emitted from Indonesian peatland fires has caused dense haze and serious air pollution in Southeast Asia such as visibility impairment and adverse health impacts (Fujii *et al.*, *Atmospheric Environment* **110**, 1–7, 2015). In this study, we characterized ambient total suspended particulates (TSP) with a focus on humic-like substances (HULIS) based on intensive ground-based field samplings in Malaysia during non-haze days and haze ones affected by peatland fires in Sumatra Island for the first time. The TSP samplings were performed at the roof of a building in Universiti Kabangsaan Malaysia in Bangi, Selangor, Malaysia from June 23 to July 8 in 2014. A high-volume air sampler was utilized to continuously collect TSP on a quartz fiber filter for 18 hours at a flow rate of 1.13 m^3/min. Detailed information has been provided in our former report (Fujii *et al.*, *Aerosol and Air Quality Research* **16**, 69–78, 2016). After sampling, we determined the water-soluble organic carbon (WSOC) and the carbon content of HULIS (HULIS-C) by a TOC analyzer. A Hydrophilic-Lipophilic Balanced solid phase extraction method was applied to isolate the HULIS from the water extracts (see Park and Son, *Environmental Science Processes & Impacts* **18**, 32–41, 2016). Furthermore, the fluorescence spectra of each HULIS sample was recorded by EEM (Excitation-Emission Matrix) fluorescence spectroscopy. During the sampling periods, the concentrations of WSOC and HULIS-C ranged from 4.1 to 24 and 1.3 to 18 $\mu g/m^3$, respectively. Significant difference in both concentrations between the haze (WSOC: 9.7–24 $\mu g/m^3$, HULIS-C: 7.2–18 $\mu g/m^3$) and non-haze (WSOC: 4.1–7.0 $\mu g/m^3$, HULIS-C: 1.3–4.4 $\mu g/m^3$) samples was found. Fulvic-like fluorophores were identified at highest intensity level in the EEM fluorescence spectra of the haze samples.

2CA.4

Optical Properties of Black Carbon Particles in Aircraft Engine Exhaust: Engine Type, Operating Conditions, and Fuel Effects. MIRIAM ELSER, Benjamin Brem, Lukas Durdina, David Schönenberger, Jing Wang, *Empa, Switzerland*

Black carbon (BC) from aircraft engine exhaust is a unique contributor to the particulate mass in the upper troposphere and has significant impacts on radiative forcing and climate. A detailed characterization of the optical properties of BC is essential to estimate its climate effects. Measurements were performed at the engine testing facility of SR Technics at Zurich Airport (Switzerland). Five widely used types of commercial turbofan engines were tested over a range of operating conditions from idle to take-off thrust using regular Jet A-1 fuel and various blends with HEFA (Hydro-processed Esters and Fatty Acids) fuel. The engine exhaust was sampled at the engine exit by a single-orifice probe. The non-volatile particulate matter (nvPM) mass and number concentrations as well as gaseous pollutants were measured according to the regulatory standards. To study the wavelength dependence of the optical properties of the BC emissions, we deployed a cavity Attenuated Phase Shift-based single scattering albedo monitor (CAPS PMssa, $\lambda = 532$ nm) and a Photoacoustic Extinctiometer (PAX, $\lambda = 870$ nm). Filter samples were taken during periods with stable operating conditions for the quantification of elemental and organic carbon (EC/OC) using thermal-optical analysis. For all engine types, the extinction, absorption, and scattering coefficients show similar increasing trends for increasing thrust level (and nvPM mass). The use of HEFA fuel blends reduced substantially the nvPM mass and optical coefficients, especially at low thrust levels. A detailed characterization of the major optical properties (including single scattering albedo, absorption and extinction Angstrom exponents, and mass absorption cross sections) of aircraft BC emissions and their dependence on engine type, operating conditions, and fuel type will be presented at the conference.

2CA.5

Light-absorbing Organic Carbon from Prescribed and Laboratory Biomass Burning and Gasoline Vehicle Emissions. MINGJIE XIE, Michael Hays, Amara Holder, *U.S. EPA*

Light-absorbing organic carbon (OC), i.e. brown carbon (BrC), from laboratory-based biomass burning (BB) has been studied intensively to understand the contribution of BB to radiative forcing. However, few measurements have been conducted on field burns and even fewer measurements have been done on BrC from other combustion sources like motor vehicle emissions. In this work, we examined the light absorption of methanol-extractable OC from prescribed and laboratory BB and gasoline vehicle emissions from spectrophotometric measurements. The light absorption by the methanol extracts had a strong wavelength dependence for both BB and gasoline vehicle emissions. The mass absorption coefficients at 365 nm (MAC_{365}, $m^2\ g^{-1}C$) – a measure of BrC – were significantly correlated ($p < 0.05$) with the ratios of elemental carbon (EC) to OC for BB from identical fuels, while no significant correlation could be observed across multiple fuels, indicating that both burn conditions and fuel types might impact BB BrC characteristics. The average MAC_{365} of all gasoline vehicle emission samples is $0.61 \pm 0.76\ m^2\ g^{-1}C$, the same magnitude as all BB samples ($1.27 \pm 0.76\ m^2\ g^{-1}C$). These results suggested that in addition to BB, gasoline vehicle emissions might also be an important BrC source in urban areas.

2CA.6

Characterization of Hydroxy/Carboxyl-Nitro Compounds in SOA from Aromatic Oxidation: Implication for PM2.5.

MOHAMMED JAOUI, John Offenberg, Michael Lewandowski, Amara Holder, Tad Kleindienst, *EPA/ORD/NERL*

SOA generated in our laboratory in the past fifteen years from the photooxidation of aromatics/NO_x systems were yellow to light brown in color as compared to those generated from biogenic precursors, indicative of light absorbing organic compounds also known as brown carbon. Literature review shows that compounds containing aromatic ring(s) and/or nitro group(s) formed through atmospheric oxidation may potentially be responsible, in part, for the optical properties associated with ambient particles, therefore influencing aerosol radiative forcing.

In this study, an analytical technique developed previously in our laboratory for the identification and quantification of multifunctional compounds was extended to compounds containing at least one nitro group(s). This technique is based on silylation using BSTFA as derivatizing agent, followed by GC-MS analysis in EI and methane-CI modes. This approach was tested on standards and on SOA from photooxidation experiments of toluene, benzene, ethylbenzene, o/m/p-xylenes, m-cresol, catechol, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, naphthalene, 1-methylnaphthalene and 2-methylnaphthalene in the presence of NO_X. This technique has the advantage for identifying unambiguously unknown organic compounds containing -OH/-COOH, and -NO_2 group(s). For example, CI spectra contain ions at m/z ($M^{\cdot+}$ + 1), ($M^{\cdot+}$ + 29), ($M^{\cdot+}$ + 41), ($M^{\cdot+}$ - 15), ($M^{\cdot+}$ - 89), and 73 for compounds bearing only hydroxy/carboxylic groups and ($M^{\cdot+}$ - 31) for those bearing also nitro group(s). To determine the presence of these compounds in the atmosphere, $PM_{2.5}$ filters collected in Research Triangle Park, NC, USA during 2003 were re-analyzed using the same analytical technique. GC-MS analysis showed the occurrence of some of these potential light absorbing compounds in chamber SOA and ambient $PM_{2.5}$, indicating the impact of aromatics on brown carbon. This work describes systematically a method for identifying multifunctional compounds containing one or more nitro/hydroxyl/carboxylic groups. This is a way of supplementing optical measurements with compound identification through established, tested, reliable GC-MS methods. This isn't a stand-alone tool, it is part of a broad suite of tools intended to address a larger problem than just aerosol composition and its relationship to optical properties.

2CA.7

Measured Absorption Spectra of Aerosolized Carbonaceous Species and Their Influence on Climate Forcing.

CHRISTOPHER ZANGMEISTER, James Radney, Rian You, Michael Zachariah, *National Institute of Standards and Technology*

Understanding the impact of aerosol climate forcing requires quantitative measured of aerosol optical properties across a broad wavelength range. We present measured mass specific aerosol absorption spectra from elemental carbon allotropes, carbon black, flame generated soots, and brown carbon (BrC) from smoldering biomass generated from six species of North American wood. Data were measured between 500 nm and 840 nm and reported as mass specific absorption cross section (MAC) for each sample. The wavelength dependencies were determined using the absorption Ångström exponent (AAE). AAE were independent of measured MAC. The data indicate that carbonaceous aerosol absorption are highly dependent on sp^2 bonding but independent of morphology. Particles generated from flames have morphology consistent with black carbon (BC) and the measured MAC was dependent on fuel and formation conditions. The MAC from flame generated particles varied between 3.8 $m^2 g^{-1}$ and 8.6 $m^2 g^{-1}$ at $\lambda = 550$ nm. Particles generated from smoldering biomass had AAEs between 3.5 and 6.2 with measured MAC from 0.014 $m^2 g^{-1}$ to 0.079 $m^2 g^{-1}$ at $\lambda = 550$ nm, nearly 2 orders of magnitude lower than flame generated soot. The results illustrate that to properly quantify carbonaceous aerosol absorption and to assess the impact of BC radiative forcing requires the measurement of aerosol with known mass across a broad spectral window.

2CA.8

Primary and Secondary Sources of PM2.5 in the Kathmandu Valley, Nepal. MD ROBIUL ISLAM, Thilina Jayarathne, Ashley Gilbert, Maheswar Rupakheti, Elizabeth Stone, *University of Iowa*

Kathmandu Valley, the capital region of Nepal, suffers from severe particulate matter (PM) pollution. In this study, we use molecular markers to identify and quantify sources of organic carbon (OC) in ambient $PM_{2.5}$. Recent efforts in the Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE) focused on characterizing emissions from different under sampled but locally important sources such as garbage burning, varieties of cooking stoves, agricultural pumps, brick kilns with traditional technologies, etc. To evaluate the contributions of these and other sources to $PM_{2.5}$, samples were collected at Bode site in the Kathmandu Valley during April 11-24, 2015. The daily average $PM_{2.5}$ concentrations varied between 30 $\mu g/m^3$ and 207 $\mu g/m^3$, which are 1.2 - 8.3 times the World Health Organization (WHO) 24 hour guideline of 25 $\mu g/m^3$. $PM_{2.5}$ was comprised in part by water-soluble ions, including sulfate (16%), ammonium (9%), nitrate (4%), indicating secondary inorganic aerosol contribution, as well as calcium (1.2%) and magnesium (0.1%), reflecting airborne soil dust. Major fractions of $PM_{2.5}$ were OC (27 ± 8%) and elemental carbon (13 ± 7%). To gain insight to sources of OC, gas chromatography coupled to mass spectrometry (GCMS) was used to quantify primary and secondary source molecular markers. Some well-established molecular markers identified and quantified in this study were levoglucosan (1230 ± 1153 ng/m^3), 1,3,5-triphynylbenzene (0.8 ± 0.5 ng/m^3), cholesterol (3.0 ± 6.7 ng/m^3), stigmastanol (1.4 ± 6.7 ng/m^3), and *cis*-pinonic acid (4.5 ± 0.6 ng/m^3) indicating contributions from biomass burning, garbage burning, food cooking, cow-dung burning, and monoterpene secondary organic aerosols, respectively. Chemical mass balance source apportionment modeling will be used to quantitatively estimate source contributions to OC. Incorporation of newly characterized source profiles will enable us to apportion a larger fraction of OC to a wider number of sources.

2CA.9

Chemical Characterization of Secondary Organic Aerosol under High NH3 in a Transitional Season of Biogenic VOC Emission using HR-ToF-AMS. YUNLE CHEN, Theodora Nah, David Tanner, Masayuki Takeuchi, Hongyu Guo, Amy P. Sullivan, Rodney J. Weber, Greg Huey, Lu Xu, Nga Lee Ng, *Georgia Institute of Technology*

The effects of human activities on secondary organic aerosol (SOA) have long been an intriguing topic. With high emissions from both anthropogenic and biogenic sources, the southeastern U.S. is an ideal area to study the interactions between the two. Here, the formation and evolution of SOA was investigated at Yorkville, a rural site 55km NW of Atlanta, in late summer (mid-August ~ mid-October, 2016), a period when the NH_3 concentration was high (average 8.1 ppb) and BVOC emissions were gradually decreasing. A High-Resolution Time-of-Flight Mass Spectrometer (HR-ToF-AMS) was deployed to characterize non-refractory submicron particles. Co-located instruments (CIMS, FIGAERO-CIMS, GC-MS, PILS-IC, etc.) were used to comprehensively characterize both gas- and particle-phase composition.

Positive Matrix Factorization (PMF) analysis of HR-ToF-AMS measurements resolved five factors, including isoprene-derived organic aerosol (Isop-OA), less-oxidized oxygenated OA (LO-OOA), two more-oxidized oxygenated OA (MO-OOA1, MO-OOA2), and an unknown OA (unknown-OA). The PMF results are different from previous measurements at the same site in early summer and in winter, implying different aerosol chemistry and composition during this specific transitional period. It is found that Isop-OA is decreasing throughout the campaign, as temperature and isoprene emission decrease. The LO-OOA factor and unknown-OA factor show correlation with particulate C_{10} and C_{15} organic nitrates, indicating possible aerosol sources from nitrate radical chemistry and/or photooxidation in the presence of NO_x. One of the MO-OOA factors correlates with organic acids in the particles, suggesting that it could be from aging of organic aerosols.

2CA.11

Climate Relevant Aerosol Properties from Biomass Burning. SAMANTHA BIXLER, Christian Carrico, Manvendra Dubey, Allison Aiken, Thom Rahn, *New Mexico Institute of Mining and Technology*

The atmospheric role of biomass burning emissions has substantially increased with continued warming and drying in the Southwestern United States. To better understand biomass burning aerosol properties, we conducted a laboratory study of smoke emissions focusing on invasive species and Southwestern US fuels. Aerosol physical and optical measurements included a custom controlled relative humidity (RH) nephelometry system to measure light scattering as a function of RH. To detect aerosol hygroscopic response controlled RH nephelometry relies upon the direct measurement of light scattering using two nephelometers—one at dry conditions and one at controlled high relative humidity conditions. Lab experiments with selected Southwestern US fuels examined the influence of fuel type and combustion conditions on emissions. Aerosol hygroscopicity was strongly linked to the fuel's chemical composition which in turn drives smoke composition. For example, invasive species with high inorganic salt contents had much stronger water uptake than native coniferous species. Fire phase, flaming or smoldering, also impacted the water uptake for a given fuel, with flaming conditions enhancing hygroscopicity and smoldering conditions diminishing water uptake. Several ambient events during summer in Los Alamos yielded interesting observations regarding local air quality impacts from biomass and other combustion sources. Episodes examined include smoke from the Dog Head Fire near Albuquerque, NM, and Independence Day fireworks near White Rock, NM. Results of this study enable the development of a framework for predicting water uptake and optical properties of emissions from biomass combustion. Through the further understanding of aerosol behaviors we can better understand and predict impacts from biomass burning on atmospheric aerosol properties.

2CA.12

Tar Ball Aggregates in the Plume of the Whitewater-Baldy Complex Wildfire, NM. Giulia Girotto, Swarup China, Janarjan Bhandari, CLAUDIO MAZZOLENI, Barbara Scarnato, Kyle Gorkowski, Allison Aiken, Manvendra Dubey, *Michigan Technological University*

Atmospheric tar balls (TBs) are carbonaceous particles abundant in slightly aged biomass burning smoke. TBs are currently defined based on their properties as measured under an electron microscope. These particles are almost perfectly spherical in shape and amorphous in structure, they are composed mostly of carbon and oxygen, they are resistant to the electron beam and they have typical sizes in the range of ~100 to 300 nm. Previous studies found that TBs absorb sunlight, although their optical properties are still debated, and published values especially for the imaginary part of the index of refraction are sparse and span three orders of magnitude. Because of their variable optical properties and concentrations, their radiative effects are highly uncertain.

In 2012, aerosol samples from the Whitewater-Baldy Complex (WB) fire plume were collected at the Los Alamos National Laboratory. The WB fire is to date, the largest wildfire in New Mexico's history. The plume traveled to the sampling site over a period of a few hours (~7-8). Using scanning electron microscopy we observed that TBs were the most abundant particles in the plume (~81%, by number). In previous studies on biomass burning smoke, TBs have been typically found to be externally mixed and separated from each other; however, in our samples, we observed a significant fraction of TBs aggregates (~27% by number). We analyzed the morphological characteristics of these TB aggregates and found that they follow a scale-invariant power law similar to that of soot particles with comparable fractal dimension, despite the considerably larger size and a smaller number of the monomers. We then used this morphological information to estimate the effect of aggregation on the optical properties of these particles using numerical simulations. We will discuss these findings and implications on the potential radiative effects of biomass burning.

2CA.13

Measured and Simulated Secondary Organic Aerosol Formation from Vehicle Exhaust in Light and Dark Conditions.

YING LI, Yu Morino, Yuji Fujitani, Kei Sato, Satoshi Inomata, Kiyoshi Tanabe, Yoshinori Kondo, Tomoki Nakayama, Akihiro Fushimi, Akinori Takami, Shinji Kobayashi, *National Institute for Environmental Studies*

Secondary organic aerosol (SOA) formed from vehicle exhausts contribute substantially to the atmospheric particulate matter levels in urban air, but are not well represented by current emission inventories or air quality models, due to the uncertainties in SOA formation varied by vehicle types, exhaust aftertreatment devices and oxidation conditions. In this work, smog chamber experiments were conducted to investigate the SOA formation from dilute emissions from two light-duty gasoline vehicles, one light-duty and one medium-duty diesel vehicles. Emissions were oxidatively aged in the smog chamber for a variety of dark (i.e., O3) and UV (i.e., OH) conditions. Substantial SOA formation was observed in all UV and dark aging experiments. The predictions of a volatility basis-set model were compared with the measurements from an aerosol mass spectrometer. The model predicted that the intermediate-volatility organic compounds (IVOC) played an important role in the diesel SOA formation, contributing more than 80% of the simulated concentrations. Inclusion of the unspeciated IVOC in the model improved the simulations but the model still underpredicted the observed diesel SOA concentrations in the dark experiments. The model could not reproduce the rapid burst of SOA production that occurred in the early phase of aging, especially for the dark ozonolysis experiments. OA formed from gasoline vehicles have higher O:C comparing to diesel vehicles. The ageing scheme applied in this study reproduced the measured O:C reasonably well for the light experiments. The model underestimated the O:C of gasoline OA and overestimated the O:C of diesel OA in the dark experiments. Future experiments characterizing the existence of organic nitrate (ON) and including explicit formation pathway of ON in models may improve the discrepancy between simulated and observed SOA concentration and oxidation state in dark conditions.

2CA.14

Preliminary Assessment of Aerosol Associated Organic Tracers in Rural and Urban Location of Western Himalayas.

SHWETA YADAV, Deepika Kaushal, Sarita Bamotra, Ankit Tandon, *Central University of Jammu, Samba, Jammu, India*

The Himalayan region with its unique location acts as a climate regulator in South-East Asia. Keeping in mind the limited knowledge about the sources and composition of organic aerosols in this region, aerosol associated organic tracers: n-alkanes, Polycyclic Aromatic Hydrocarbons (PAHs), Isoprenoid hydrocarbons, particulate bound nicotine, levoglucosan and isoquinoline have been investigated in PM_{10} samples collected in rural and urban locations of Western Himalayas. The aerosol sampling was conducted from January 2015 to December, 2015. The analysis of monthly representative aerosol samples was done using Thermal Desorption Gas Chromatography Mass Spectrometry (TD-GCMS). Established organic markers, associated diagnostic parameters, and molecular diagnostic ratios were used to assess and discern the contributing biogenic, petrogenic and pyrogenic sources in the region. The n-alkane based diagnostic parameters include—mass weighted Averaged Chain Length (ACL); Carbon number with maximum concentration (Cmax); Petroleum derived n-alkanes (PNA%), Carbon Preference Index (CPI) and the percentage contribution of Wax n-alkanes from plants (WNA%). The average value of ACL at rural and urban location is 29 ± 0.86 and 30 ± 1.15 respectively. A significant predominance of high molecular weight congeners C_{29}, C_{30} and C_{31} indicates contributions from leaf plant wax and other mixed sources like road dust, garden soil, cooking oil and cigarette smoke. Irrespective of the difference in altitude and land use pattern, CPI and WNA% clearly indicated the predominance of petrogenic sources in both the locations with an exception of biogenic spurts (CPI>1) at rural location in the harvesting season. Strong seasonal variations were noticed in determined n-alkanes, isoprenoid hydrocarbons, selected PAHs and markers like Levoglucosan. Particulate bound Tracers for Environment Tobacco Smoke (ETS) like nicotine were noticed in all the samples and the high values raise serious concerns.

2CA.16
Mass Absorption and Scattering Cross Sections of Brown Carbon Aerosol from Smoldering Biomass Combustion.

NISHIT SHETTY, Benjamin Sumlin, Yuli W. Heinson, Wei Min Hao, Jay Turner, Brent Williams, Rajan Chakrabarty, *Washington University in St. Louis*

Forest fires and biomass burning are significant contributors to atmospheric aerosol and trace gas emissions in many ecosystems, especially those in the boreal, arctic and tropical regions. A lot is known about the gaseous emissions from these fires, however, until recently, there has been little knowledge of the aerosol emission from fires in these regions. The amount and type of carbon released from these fires has a high dependence on combustion conditions and recent studies have shown that the smoldering (low temperature) phase of combustion release aerosols which are predominantly brown carbon (BrC) – a class of organic carbon absorbing light in the shorter visible wavelengths – along with a negligible amount of black carbon. In this study, we have simulated wildfires in our laboratory using different North American wildland fuels under varying smoldering combustion conditions, and measured the optical properties of the emitted BrC aerosols in-situ using multi-wavelength integrating photoacoustic nephelometers. The generated aerosols were also collected on filters to perform gravimetric studies for the quantification of mass. In this talk, I will discuss in detail our findings on the mass absorption and scattering cross-sections (MAC and MSC) of BrC aerosols as a function of fuel type, fuel-moisture-content, and combustion conditions. Initial findings show that the MAC of these aerosols have a strong dependence on wavelength ranging from 0.2 to 0.65 m^2/g for 375nm and drop sharply to around 0.05 to 0.1 m^2/g for 532nm. The mass scattering cross sections however, remained relatively constant in the given wavelength range and showed little to no dependence on wavelength from 375nm to 532nm.

2CA.17
Size and Volatility of Vehicle Emitted Primary Particles Measured in a Traffic Tunnel.

XIANG LI, Timothy Dallmann, Andrew May, Albert A. Presto, *Carnegie Mellon University*

On-road gasoline and diesel vehicles are a major source of several gaseous and particulate pollutants to the atmosphere, including CO, NOx, volatile organic compounds (VOCs), and particulate matter (PM). This poster presents multi-seasonal measurements of gas- and particle-phase pollutants from a traffic tunnel in Pittsburgh, PA. Using data from this field campaign, 1) we update the vehicle emissions factors of CO, NOx, particle phase Organic Carbon(OC) and Elemental Carbon(EC); 2) we provide size-distributions of vehicle emitted particles and their non-volatile components using a nano-SMPS and a long-SMPS together with a Thermodenuder(TD); and 3) we quantify the volatility of vehicle-emitted primary organic aerosol (POA) with a thermodenuder (TD) and an Aerodyne Aerosol Chemical Speciation Monitor (ACSM), as well as quartz filter samples analyzed by a thermal-desorption gas-chromatography mass-spectrometry (TD-GC-MS).

The measured emission factors are compared with emission factors measured in another tunnel study conducted in Pittsburgh 10 years ago, and the NOx, OC and EC emission factors of heavy duty diesel vehicles (HDDV) are ~30–50% lower. After evaporating under 250 °C inside TD, the nonvolatile PM appeared at two modes downstream of the TD – one consisting of EC with a peak at 80-100 nm, and another consisting of particles smaller than 10 nm. The chemical composition of the ~10 nm mode is uncertain. Our size-distribution measurements also suggest that smaller particles (less than 30 nm) emitted by vehicles are dominantly (over 90%) composed of volatile compounds.

2CA.18

Brown Carbon Chromophores from Biomass Burning and their Evolution during Oxidative Aging. BENJAMIN SUMLIN, Claire Fortenberry, Audrey Dang, Michael Walker, James Meyer, Brent Williams, Rajan Chakrabarty, *Washington University in St. Louis*

Brown carbon (BrC), a class of organic aerosols (OA) with wavelength-dependent absorption, has received increasing attention as a key driver of global radiative forcing and climate change. Long-lasting smoldering wildfires emit large quantities of BrC in biomass burning OA (BBOA), and these emissions are responsible for a significant fraction of the total radiative forcing attributed to carbonaceous aerosols. However, the mechanisms by which these aerosols absorb light are not fully understood. Models that successfully describe the absorption behavior of black carbon aerosols, such as the bandgap theory, break down when applied to amorphous, non-crystalline structures.

We present results from simultaneous optical, physical, and chemical measurements of BBOA experiments performed in a large-scale laboratory emissions and combustion chamber. Integrated photoacoustic-nephelometer-spectrometers at three discrete wavelengths (375, 405, and 532 nm) measured absorption and scattering, while a suite of on- and off-line chemical and physical analyses were performed, including thermal desorption aerosol gas chromatography, high performance liquid chromatography, UV-VIS-IR spectrometry, x-ray photoelectron spectrometry, and particle size distribution measurement. The elemental and chemical composition of BBOA from several relevant global wildfire fuels was compared to chemical components found in solvent extractions of the fresh, un-combusted fuel to evaluate the influence of the combustion process (e.g., fire phase, moisture content, combustion efficiency) on chromophore formation. Key chromophore compounds are identified and their contributions to light scattering and absorption are tracked as a function of atmospheric aging, simulated by accelerating oxidative photochemistry in a potential aerosol mass (PAM) reactor.

2CA.19

First Year of Black Carbon and Brown Carbon Measurements in a Mountain Top Station in Bogotá, Colombia. RICARDO MORALES BETANCOURT, Luis Carlos Belalcazar, Diego Miguel Quirama, Juan Manuel Rincón, Juan Felipe Mendez, *Universidad de los Andes*

Biomass burning aerosol emissions represent an important contribution to global atmospheric aerosol loadings. Emissions associated to wildfires and biomass burning can significantly degrade regional air quality. Furthermore, the light-absorbing nature of particles emitted during biomass burning have a substantial impact on the global and local radiation budget through direct and indirect effects. The seasonality of biomass burning emissions in Amazonia during the dry season have been extensively studied given its large contribution to the global inventory of carbonaceous aerosols. However, the seasonal cycle and regional impacts of biomass burning emissions in northern South America have received considerably less attention. In this study, we report the first year of continuous measurements of equivalent Black Carbon (eBC) in a mountain top site in the North Central Andes mountain range. Previous studies have shown a close relationship between the number of hot spots detected through remote sensing in the eastern plains of Colombia, and fine particulate matter concentration in several cities in the Andean region. In our study, eBC concentrations were monitored from April 2016 to present, with a 7-wavelength Aethalometer. The contribution of biomass burning to the light-absorbing aerosol particle concentration was performed through spectral analysis of the absorption coefficient. Two alternative for the spectral analysis were explored in this study: a two-wave-length model (Sandradewi et al 2004), and a multi-wavelength optical method (Massabo et al. 2015). A systematic back-trajectory analysis was performed for the full year of measurements, suggesting that several events occurred were long-range transport of biomass burning aerosol reached our station. A careful screening of the measurements is performed to minimize interference of emissions from the city of Bogota. A clear seasonal cycle is observed in the data, with episodes of several days in which the contribution of biomass burning can be up to 30% of the total light-absorbing aerosol concentration.

2CA.20

Choice of OC/EC Ratio in the EC Tracer Method to Estimate Secondary Organic Carbon over a National Park in Bhopal, India: A Sensitivity Analysis.

SHILPI SAMIKSHA, Ramya Sunder Raman, Samresh Kumar, *Indian Institute of Science Education and Research, Bhopal*

In this study, ambient PM2.5 samples were collected over Van Vihar National Park in Bhopal, central India over a period of two years (01 January, 2012 to 31 December, 2013). Samples were collected on to Teflon, Nylon, and Tissue quartz filter substrates. Punches of the quartz fibre filters were analyzed for organic and elemental carbon (OC/EC) using a thermal-optical-transmittance/reflectance (TOT-TOR) analyzer operating with a 632 nm laser diode. In this observation-based approach, EC is used as a tracer for primary OC (POC), which allows for the estimation of secondary OC (SOC).

The elemental carbon (EC) tracer method has been the most popular choice to estimate the primary and secondary organic carbon fractions using field measurements of organic carbon (OC) and EC. The estimation of primary OC/EC ratio is crucial in estimating the SOC. Typically periods of minimal or no SOC formation are used to estimate this ratio. In the mid-latitudes measurements made during cold winter months with few hours of sunlight have often been used to determine the primary OC/EC ratio. However, in a hot tropical country with abundant sunshine all-year round, the identification of periods when SOC formation is expected to minimum is rather tricky.

Thus, this study was conducted to explore and examine the various methods appropriate for estimation of primary OC/EC ratio at the study location. The influence of random measurement errors in both primary OC and EC measurements on the estimation of this ratio will also be examined. Finally, the sensitivity of SOC estimates to the choice of primary OC/EC ratio will be discussed and guidelines for choosing an appropriate ratio will be provided.

2CA.21

On the Density and Homogeneous Internal Composition of Brown Carbon Spheres from Biomass Burning.

Bongjin Seo, Christopher Oxford, BENJAMIN SUMLIN, Robert Pattison, Brent Williams, Rajan Chakrabarty, *Washington University in St. Louis*

Recent observations have provided strong evidence for brown carbon (BrC) to impact global climate change by radiative forcing. BrC aerosols produced from biomass burning strongly absorb light in the near-ultraviolet wavelengths. Not much is known about the densities of BrC aerosols that dictate their atmospheric movement, especially, when considering the influence of combustion temperature and fuel type. Here, we measured the effective density of nascent BrC spheres emitted from smoldering combustion of Alaskan peatlands using a differential mobility analyzer (DMA), a centrifugal particle mass analyzer (CPMA), and a condensation particle counter (CPC) system. The DMA selected monodisperse BrC particles based on their mobility diameters, and the particles were classified by the CPMA as a function of their individual masses. CPC determined the number concentrations of particles from the CPMA. The effective density and mass-mobility exponent were calculated with the mobility size selected by the DMA and the particle mass measured by the CPMA and CPC. The particle effective density of nascent particles ranged from 0.85 to 1.19 g $cm^{-3}$with increasing smoldering temperatures from 180 to 360 °C. We observed a critical combustion temperature of approximately 240 °C above which pyrolysis mechanisms begin to influence particle properties. The calculated mass–mobility exponent was a constant 3.0 confirming the spherical shape of these aerosols. Then, a volatility tandem differential mobility analyzer (V-TDMA), by replacing the DMA, was used to volatilize the organic matter constituting these particles. The effective density of particle phase mass remaining after thermal volatilization was confined to a narrow range between 0.9 and 1.1 g cm^{-3}. These findings show a homogeneous internal composition for these particles.

2CA.22

Development of a Unified Information System for Prescribed Fire and Air Quality in the Southeastern U.S.

SADIA AFRIN, Fernando Garcia-Menendez, *North Carolina State University*

Prescribed fire is one of the most important land management approaches used to reduce wildfire risk and restore ecosystems. However, smoke produced from prescribed burns can contribute to air quality concerns by increasing emissions of $PM_{2.5}$ (fine particulate matter) and precursors of ozone and secondary $PM_{2.5}$. Prescribed burning is commonly practiced in the Southeastern U.S., where it represents one of the most significant sources of carbonaceous aerosols. Fire and emissions data for prescribed burning in the region are available from different satellite-based products and burn records from government agencies. However, satellite-derived estimates may underestimate emissions and often not detect the low-intensity fires, making them an unreliable data source. In addition, there is no central bottom-up inventory of prescribed fire, as burn records vary widely across different states. There are major differences in data attributes and collection systems from state to state. For instance, burn permit records in Florida and Georgia are organized in structured databases, whereas digital burn records for North Carolina are incomplete. In contrast, North Carolina fire records contain defined spatial locations, while Georgia data does not include detailed geo-coordinates. In this study, we develop an integrated information system for prescribed fire data in the Southeast by unifying and systematizing available burn permit records. We further integrate relevant air quality and meteorological data with the burn records to develop a unified platform. Here we use the system to quantify statistical correlations between prescribed burning activity and observed high PM2.5 concentration at different monitoring stations of Florida. In addition, the effect of meteorology is incorporated into the analysis by considering it in moderator variables. Ultimately, the system will serve as a decision-making tool for fire, land, and air quality managers by providing a detailed overview of burning and smoke emissions patterns.

2CA.23

Controlled Combustion Experiments for Constraining the Light-absorption Properties of Brown Carbon.

ZEZHEN CHENG, Rawad Saleh, *University of Georgia*

The light-absorbing components of organic aerosol emitted by incomplete combustion, referred to as brown carbon (BrC), exhibit highly variable light-absorption properties usually quantified in terms of the mass-absorption cross-section (MAC) or imaginary part of the refractive index (k). MAC and k of combustion BrC reported in the literature vary over two orders of magnitudes. There are two major reasons for this variability: 1) BrC is a collection of poorly characterized organic compounds, thus the reported k (or MAC) values depend on which of these compounds are featured in a particular measurement, which in turn depends on the combustion conditions associated with the measurement; and 2) BrC is often co-emitted with black carbon (BC), complicating the retrieval of its k (or MAC) due to the overlap of light absorption by BrC and BC, thus leading to discrepancy between different approaches employed to perform the retrieval. To investigate the variability in BrC light-absorption properties, we designed experiments in which combustion can be controlled at different conditions (temperatures and air/fuel ratios) and carbonaceous aerosol products with a narrow distribution of optical properties can be achieved and characterized at each combustion condition. Here, we present results from model fuels (benzene and toluene). By varying the combustion conditions from relatively inefficient (low temperature and/or air/fuel ratio) to relatively efficient (high temperature and/or air/fuel ratio), we isolated BrC components with progressively increasing k (or MAC), spanning the wide range of values reported in the literature. This indicates that the discrepancy in reported BrC light-absorption properties stems largely from the discrepancy in combustion conditions between different measurements. Of particular interest is that bringing the combustion conditions close to the carbonization (BC-formation) regime produced highly absorptive BrC, the existence of which is hotly debated.

2CA.24

Refractive Index of Secondary Organic Aerosols Formed from Oxidation of Alpha-Pinene, Longifolene, Phenol and 1-Methylnaphthalene.

JUSTIN DINGLE, Stephen Zimmerman, Alexander Frie, Justin Min, Roya Bahreini, *University of California Riverside*

Secondary organic aerosols (SOA) formed in the atmosphere through oxidation processes play an important role in the perturbation of radiative forcing; however optical properties of SOA are still poorly characterized. In this study, we report on the complex refractive index (RI) of SOA formed from oxidation of α-pinene, longifolene, phenol and 1-methylnaphthalene. Experiments were conducted in a Teflon film chamber under varying NO_x conditions, with the utilization of hydroxyl radicals to initiate oxidation of the precursor compounds. Optical scattering and absorption coefficients (β_{scat} and β_{abs} respectively) at 375 nm were measured using a Photoacoustic Extinctiometer (PAX-375) and aerosol size distributions were measured with a Scanning Electron Mobility Sizer (SEMS). In order to determine SOAs' RI, scattering and absorption coefficients of aerosols corresponding to the average measured size distributions were calculated at 3 min intervals using Mie Theory and initial guesses for the real (*n*) and imaginary (*k*) components of RI. This calculation was repeated through an iterative process to minimize the least-squares deviation functions defined for the optical coefficients (Spinder and Riziq 2007). For the biogenic precursors, α-pinene and longifolene, *n* values for the SOA produced ranged from 1.39-1.68, with increasing values observed later in the experiment, but showed minimal *k* values indicating mostly scattering SOA. Exposure to NO decreased *n* values by ~2.7% for α-pinene and longifolene, with the *k* values remaining constant at 0.001-0.002 during NO exposure. In contrast, for the aromatic precursors, phenol and 1-methylnaphthalene, *n* values increased from 1.40 to 1.44 and 1.44 to 1.52, respectively. Additionally, brown carbon was formed with *k* values increasing with oxidation from 0.010 to 0.017 and 0.003 to 0.008, respectively.

2CA.25

Optical Properties of Secondary Organic Aerosol Generated via Photooxidation in Single and Multiple Precursor Systems.

ALEXANDER FRIE, Justin Dingle, Stephen Zimmerman, Justin Min, Roya Bahreini, *University of California, Riverside*

The optical properties of secondary organic aerosol from the photooxidation of a variety of precursors were investigated. Optical properties of organic aerosols are of interest as they control the aerosol direct effect, a highly uncertain component of future climate predictions. Compounds used as SOA precursors include longifolene, mixtures of longifolene+phenol, and 1-methylnaphthalene+phenol. All SOA was formed in an atmospheric chamber through photooxidation under low NOx conditions, using H2O2 as a hydroxyl radical source. During SOA formation, absorption and scattering coefficients at 375 nm and extinction coefficient at 632 nm were monitored. Additionally, particle chemistry was monitored via an aerosol mass spectrometer in order to investigate the chemical drivers of organic aerosol optical properties. Results will include single scattering albedo (SSA), mass normalized scattering and absorption coefficients (MSC and MAC), and chemical characteristics for each SOA type.

2CA.26

Aerosol Optical Properties of Biomass Smoke from Southwestern U.S. Fuels.

JARED LAM, Christian Carrico, Samantha Bixler, Dian Romonosky, Allison Aiken, Thom Rahn, Manvendra Dubey, *New Mexico Institute of Mining and Technology*

Biomass burning aerosol emissions are a critical driver of the climate system and have atmospheric effects on visibility and human health. Here we investigated physical and optical properties of smoke from flaming and smoldering combustion from both native and invasive plant species. A 3-wavelength total-backscatter nephelometer (TSI Model 3563) measured total and backscatter coefficients at wavelengths of 450nm, 550nm, and 750nm. Integrating parallel measurements from light absorption and extinction techniques, the extinction budget was dominated by light scattering by particles (smoldering cases) and had a larger light absorption by particles (flaming cases). Intensive aerosol optical properties measured here include the Ångström exponent (Å) and backscatter fraction (b) which parameterize aerosol effects on climate. Replicate experiments (n=10) showed considerable variation in the magnitudes of extensive optical properties such as light extinction coefficient, though nearly identical temporal profiles when normalized to the peak. In testing repeatability, intensive parameters including Å and b were much more tightly constrained with coefficient of variance values around 0.02. The wavelength dependence of optical properties was very steep due to the size distributions of emissions, with mean diameters from approximately 25 to 150nm and driven by combustion phase. Across all burns, flaming fuels typically generate Å ~ 2.4-2.5 while smoldering fuels generate Å greater than 3. Typical backscatter fractions were 0.16-0.19 and 0.20-0.24 respectively. Filter samples of sub-micrometer smoke composition and fuel species influence are under investigation. The measurements provide key aerosol parameters and enhance our understanding of biomass burning aerosols in our atmosphere and their climate significance.

2CA.27

Occurrence of Volatiles and Larger Molecular Weight Compounds in Organic Particulate Matter Using Thermal Desorption – Pyrolysis – Gas Chromatography/Mass Spectrometry.

BRETT NESPOR, Richard Cochran, Haewoo Jeong, David Delene, Alena Kubatova, Evguenii I. Kozliak, *University of North Dakota*

Atmospheric particulate matter (PM) consisting of both organic carbon (OC) and elemental carbon (EC) has been known to have an effect on the public's overall health as well as the radiation balance of Earth's atmosphere. To understand the impact of harvesting activity on the composition of PM in the atmosphere, chemical speciation and total carbon content of PM was analyzed during the Polarimetric Cloud Analysis and Seeding Test (POLCAST) in Grand Forks, ND. Concentrations of OC and EC were determined using thermal optical analysis. Speciation of the OC fraction of PM was assessed using thermal desorption and pyrolysis coupled with gas chromatography mass spectrometry (TD-pyr-GC/MS). Thermal desorption (300 °C) and pyrolytic (> 500 °C) temperature programs were used to profile alkanes, alkenes and a variety of other organic compounds to investigate their sources. While the TD revealed speciation of volatile organics, the pyrolytic temperatures were associated with specific higher molecular weight species. Harvesting activities appeared to be related to an increased concentration of alkanes with prevalence of longer chain n-alkanes (waxes) with an odd number of carbons, indicating biogenic origins. Alkenes were abundant in the pyrolytic fractions of the analysis, indicating breakdown of these high chain alkanes, and presumably other lipids. Furthermore, organic tracers from both anthropogenic and biogenic processes were detected, including the burning of biomass and plastics.

2CA.28

Climate Implications of Emissions from Traditional and Improved Cooking Stoves. GEORGES SALIBA, R. Subramanian, Kelsey Bilsback, Christian L'Orange, John Volckens, Michael Johnson, Allen Robinson, *Carnegie Mellon University*

The radiative effect associated with the use of cooking stove is largely uncertain due to: 1) large differences between field and lab measurements of primary pollutant emissions, such as particulate matter (PM) and black carbon (BC), coupled with the difficulty to extensively and accurately monitor real-time cooking activities, and 2) poorly constrained BC mixing state at the source. We measured real-time particle-phase emission factors and optical properties from thirty-two individual tests, using different combinations of stove types and fuels, to assess the climate impacts of these emissions. The stoves were tested on the firepower sweep protocol, which potentially better covers the wide range of actual cooking practices, and were selected to cover various geographical regions and a broad range of stove designs, from traditional stoves to gasifier stoves. Stoves were categorized into four distinct categories: rocket elbow stoves, improved charcoal stoves, gasifier stoves, and traditional stoves. Traditional stoves had the highest PM emission averaging: 6.6 ± 2.9 g/kg-fuel. The lowest measured emissions were from gasifier stoves, with an average PM of 0.8 ± 0.2 g/kg-fuel. We found no significant PM reductions from the “improved” design of the rocket elbow stove, which averaged 5.7 ± 1.0 g/kg-fuel. To assess the climate implications of our findings, we first characterized the BC mixing state using Mie theory and single-particle mixing state information from a single particle soot photometer. We found that Mie theory (assuming a complete internal mixture) could predict the measured forcing, implying that the size distribution of BC particles and the total PM-to-BC ratio (a measure of coating thickness) at the source, are the best predictors for accurately modeling forcing from cookstoves. Second, we performed a tradeoff analysis and found that the largest climate (and health) benefits were associated with replacing a traditional stove with a gasifier stove, due to their low PM and even lower BC emissions, resulting in predominantly scattering emissions.

2CA.29

Relating Chemical Evolution of Laboratory Generated SOA to Optical Properties. STEPHEN ZIMMERMAN, Justin Dingle, Alexander Frie, Justin Min, Roya Bahreini, *University of California, Riverside*

Atmospheric particles directly influence the global radiative budget by absorbing and scattering solar radiation. Particulate matter formed from oxidation of various gaseous precursors, otherwise known as secondary organic aerosol (SOA), influence the optical properties of bulk aerosol. In this study, laboratory generated SOA is formed via photooxidation of α-pinene (AP) and 1-methylnaphthalene (1-MNPH) with hydroxyl radical ($OH^{\cdot}$) in an atmospheric smog chamber, at high and low concentrations of hydrocarbons and nitrogen oxides (NO_x). An Aerodyne mini-aerosol mass spectrometer (mAMS) is used to obtain fast, size-resolved, non-refractory chemical composition and mass concentrations of organic and nitrate submicron particles while online optical properties are measured by a Cavity Attenuated Phase-Shift (CAPS) spectrometer and Photoacoustic Extinctiometer (PAX). High resolution analysis is performed to determine contributions of $C_xH_y^+$, $C_xH_yO^+$, and $C_xH_yO_{z>1}^+$ ion families. Fractional contribution of $C_xH_yO_{z>1}^+$ increases with photooxidation from both compounds and is greater for 1-MNPH, suggesting SOA becomes more highly oxygenated. Fractional contribution of $C_xH_yO^+$ decreases for AP and remains constant for 1-MNPH. Contribution of oxygenated vs. hydrocarbon-like ions at key fragments (e.g., m/z 43, 44, 55, 57) is also tracked to capture the effect of aging on the mass spectral characteristics of SOA. Distribution of *f*44 vs. *f*43 in triangle space indicates a larger contribution of semi-volatile oxygenated organic aerosol (SV-OOA) products from AP precursor, while SOA products of 1-MNPH oxidation over time move towards the low-volatility oxygenated organic aerosol (LV-OOA) region. Decreasing ratio of NO_2^+/NO^+ after addition of NO suggests growth of organo-nitrates. Changes in chemical signatures will be used to examine the observed variabilities in SOA mass absorption coefficient (MAC), single scattering albedo (SSA), and Ångström exponent of extinction.

2CC.1

Laboratory Measurements of the Removal of Interstitial Aerosol in a Cloudy Turbulent Environment. SARITA KARKI, Will Cantrell, Kamal Kant Chandrakar, David Ciochetto, Gregory Kinney, Raymond Shaw, *Michigan Technological University*

Aerosol properties such as number concentration, chemical composition and size influence many cloud properties including the probability for precipitation and hence the cloud's lifetime. Also, an increase in the number of aerosol particles can lead to an increase in cloud droplet number and decrease the effective droplet radius, which results in an increase in the cloud's albedo for a constant liquid water path. In response, clouds serve as a dominant removal mechanism for intermediate sized aerosol particles. This feedback between aerosol and cloud is the process of cloud cleansing through which, for example, cloudy, polluted air from a continent is slowly transformed into cloudy, clean air of a maritime environment.

We have simulated this process and measured aerosol-cloud feedbacks in Michigan Tech's cloud chamber, where we can create and sustain a mixing cloud for hours to days. In these experiments, once cloud properties reach steady state, the aerosol source is turned off to initiate the cloud cleansing process. The decay in cloud and aerosol properties are then recorded as a function of time.

Our data suggest that for aerosol particles with dry diameters between about 40 and 100 nm, the principal removal mechanism is activation which proceeds in a two-stage process; i.e. decay of interstitial aerosol concentration occurs slowly at first, then more rapidly as the cloud becomes cleaner. Smaller particles of diameters about 10 to 20 nm are not activated as readily, but removed through convective diffusion to cloud droplets. (Particles of this size are also lost by diffusion to chamber surfaces.) The cloud cleansing process thus demonstrates a simplified version of evolution of polluted clouds to a maritime state.

2CC.2

1-Octanol-water Partitioning as a Classifier of Water Soluble Organic Matters: Implication for Solubility Distribution. MIKINORI KUWATA, Wen-Chien Lee, *Nanyang Technological University*

Water-soluble organic matters (WSOMs) play an important role in determining magnitudes of climatic and environmental impacts of organic aerosol particles because of their contributions to hygroscopic growth and cloud formation. These processes are dependent on water solubility as well as distribution of this property in a particle, yet no method has been available to quantify such characteristics. In this study, we developed a theoretical framework to classify WSOM by 1-octanol-water partitioning that has a strong correlation with water solubility. 1-octanol-water partitioning coefficient also has a strong correlation with a traditional solid phase extraction method, facilitating interpretation of data from the technique. The theoretical analysis demonstrated that the distributions of WSOM classified by 1-octanol-water partitioning depend on (1) the volume ratio of 1-octanol and aqueous phases, and (2) extraction steps. The method was tested by using organic aerosol particles generated by smoldering of a mosquito coil, which serves as a surrogate for biomass burning particles. The WSOM extracted from the mosquito coil burning particles was classified by 1-octanol-water partitioning at different volume ratios. These solutions, including both the 1-octanol and aqueous phases, were nebulized to generate particles for measurements using an online aerosol mass spectrometer. The mass spectra indicated that highly oxygenated species tend to be highly soluble, while high molecular weight compounds are less soluble. Linear combinations of these mass spectra allowed the estimation of the mass fractions of WSOM partitioned to 1-octanol and aqueous phases, thereby facilitating the evaluation of the mass fractions of cloud condensation nuclei (CCN) active materials.

2CC.3

Decrease in Acid Rain over 26-year Study at Paradise, Mt. Rainier National Park. ASHLEEN REDDY, Juan Rodriguez, Rebecca Lofrgen, Barbara Samora, Anne Johansen, *Central Washington University*

Weekly wet precipitation samples from Paradise in Mt. Rainier National Park, WA, were analyzed for major anions and cations, conductivity and pH. Volume weighted 3-month averages were tested for significant trends throughout the 26-year monitoring period starting in 1989 and compared with analogous data collected at established National Atmospheric Deposition Program sites throughout the state. There is an increasing trend of sulfate, nitrate, and protons from 1989-2000. However, from 2001-2015 there is a decreasing trend of sulfate by 58%, nitrate by 38% and protons by 67%. The associated pH increased from 5.1 to 5.5. These results indicate that air pollution standards contribute significantly to the decrease in acid rain deposition to this pristine and vulnerable high elevation location, and that trans-Pacific transport of pollution is not detected in the form of acid rain and associated anions.

2CC.5

Biomass Burning as a Modulator of Droplet Number in the Southern Atlantic. MARY KACARAB, Steven Howell, Jennifer Griswold, Kenneth Thornhill, Rob Wood, Jens Redemann, Athanasios Nenes, *Georgia Institute of Technology*

Aerosols play a significant role in local and global air quality and climate. Their ability to scatter and absorb radiation and to act as cloud condensation nuclei (CCN) has a substantial impact on the earth's radiation balance and is a large source of uncertainty in global climate predictions. Biomass burning organic aerosol (BBOA) can drastically elevate CCN concentrations, but the response in cloud droplet number may be suppressed, or even reversed, due to low supersaturations that can develop from strong competition for water vapor (Bougiatioti et al. 2016). Understanding and constraining the magnitude of droplet response to biomass burning plumes is an important component of understanding aerosol-cloud interaction. The southeastern Atlantic (SEA) cloud deck provides a unique opportunity to study these cloud-BBOA interactions for marine stratocumulus, as it is overlain by a large, optically thick biomass burning aerosol plume from Southern Africa during the burning season. The interaction between these biomass burning aerosols and the SEA cloud deck is being investigated in the NASA ObseRvations of Aerosols above Clouds and their intEractionS (ORACLES) study. Measurements of CCN concentration, aerosol size distribution and composition, updraft velocities, and cloud droplet number in and around the SEA cloud deck and associated BBOA plume were taken aboard the NASA P-3 aircraft during the first and second years of the ORACLES study in September 2016 and August 2017. Here we evaluate the predicted and observed droplet number sensitivity to the aerosol fluctuations and quantify, using the data, the drivers of droplet number variability (vertical velocity or aerosol properties) as a function of biomass burning plume characteristics. This work seeks to contribute to an increased understanding of how CCN and aerosol properties affect the radiative and hydrological properties and impact of the cloud.

2CC.6

Gas-Phase Oxidation Impacts the CCN Activation of a 100nm Particle. Ashley Vizenor, AKUA ASA-AWUKU, *University of California, Riverside*

Our current knowledge of cloud condensation nuclei (CCN) activity and the hygroscopicity of secondary organic aerosol (SOA) depends on particle size and composition, explicitly, the thermodynamic properties of the aerosol solute and subsequent interactions with water. Here, we examine the CCN activation of 3 SOA systems (2 biogenic single precursor and 1 mixed precursor SOA system) in relation to gas-phase decay. Specifically, the relationship between time, gas phase precursor decay and CCN activity of 100 nm SOA are studied. The studied SOA systems exhibit a time-dependent growth of CCN activity at an instrument supersaturation ~0.2%. As such, we define a critical activation time, t50, above which a 100 nm SOA particle will activate. The critical activation time for isoprene, longifolene and a mixture of the two precursor SOA are 2.01 hours, 2.53 hours and 3.17 hours, respectively. The activation times are then predicted with gas-phase kinetic data inferred from measurements of precursor decay. The gas-phase prediction of t50 agrees well with CCN measured t50 (within 0.05 hours of the actual critical times) and suggests that the gas-to-particle phase partitioning may be more significant for SOA CCN prediction than previously thought. We also provide evidence that this is not attributed to doubly-charged aerosol effects.

2CC.7

Temperature- and Humidity-Dependent Phase States of Secondary Organic Aerosols. SARAH SUDA PETTERS, Sonia Kreidenweis, Andrew Grieshop, Megan Claflin, Paul Ziemann, Markus Petters, *Colorado State University*

Secondary organic aerosols (SOAs) can exist in amorphous semi-solid or glassy phase states whose viscosity varies with atmospheric temperature and relative humidity (RH). Here we report the viscosity and glass transition temperatures of 100 nm monodisperse SOA particles as a function of RH and temperature. SOAs were generated by dark ozonolysis of a series of monoterpenes in a laminar continuous-flow tube reactor. Monodisperse aerosol viscosity was measured online at different temperatures and RHs using the method of N.E. Rothfuss and M.D. Petters (doi:10.1080/02786826.2016.1221050). The method infers viscosity from the relaxation time scale of synthesized dimers. Glass transition temperatures were obtained by extrapolating the temperature-dependent viscosity in the range of measurement to 10^{12} Pa·s. The atomic oxygen-to-carbon (O:C) ratio was estimated using parametrizations of mass spectra from an Aerosol Chemical Speciation Monitor (ACSM). The SOA systems underwent an RH-controlled transition from glassy to semi-solid to liquid in a narrow temperature range, outside of which particles were either solid or liquid. Results suggest that pure SOA may be semi-solid or glassy even inside humid cool boundary layers. For each SOA system the weak dependence of viscosity on RH is likely due to the low hygroscopicity of the particles. Glass transition temperatures for five SOA systems varied by about 30°C. Based on prior work correlating functional group composition to viscosity, this is equivalent to the addition of one OH group. Glass transition temperatures decreased with increasing oxidation state, suggesting that molecules were either fragmented or oligomerized during oxidation. To our knowledge this work provides the first measurements of SOA glass transition temperatures using an online technique. SOA phase state diagrams presented in this work may help explain the evaporation and oxidative loss behavior of ambient and laboratory-generated aerosols.

2CC.8

A Multi-Instrument Cloud Condensation Nuclei Spectrum Product. EZRA LEVIN, Manasi Mahish, Peter Marinescu, Don Collins, Sonia Kreidenweis, *Colorado State University*

Multiple years of aerosol data have been collected from routine observations at the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site. These measurements include aerosol size distributions and hygroscopicity via a tandem differential mobility analyzer. We combine these measurements, along with other measurements of aerosol number and composition, to calculate best estimate concentrations of cloud condensation nuclei (CCN) at supersaturations from 0.1 to 10%. Direct measurements of CCN concentrations are also made at SGP via a CCN counter (Droplet Measurement Technologies). However, these measurements are limited to supersaturation values less than ~1% and could thus be missing large numbers of particles which could activate during strong updraft conditions. Our extended CCN spectra will therefore provide guidance for modeling efforts, especially those investigating convective systems which commonly occur in the Great Plains region. We also use the calculated CCN spectra and changes in CCN activated fraction as a function of supersaturation to investigate seasonal and interannual variations in aerosol types and sources impacting SGP.

2CC.9

Compaction of Soot Particles during Cloud Processing: Field and Laboratory Observations. JANARJAN BHANDARI, Gregory Kinney, Kamal Kant Chandrakar, Stefania Gilardoni, Stefano Decesari, M. Cristina Facchini, Nicola Zanca, Lynn Mazzoleni, Manvendra Dubey, Barbara Scarnato, Noopur Sharma, Paulo Fialho, Swarup China, Will Cantrell, Claudio Mazzoleni, *Michigan Technological University*

Soot particles freshly emitted during combustion processes, are aggregates of nanometer size carbonaceous spherical monomers. These monomers are typically arranged in a fractal-like structure. After emission, soot aggregates undergo various atmospheric processes and their structure can become compact. These structural changes in turn, can affect the scattering and absorption cross sections of soot particles, and therefore, their radiative effects. During their transport in the atmosphere, soot particles can also act as cloud condensation nuclei and form cloud droplets. The condensation and evaporation of water vapor and other dissolved matter can result in the compaction of the soot aggregates. We investigated this last process in both laboratory and ambient studies.

Ambient samples were collected during cloudy (foggy) and sunny periods in the rural site of San Pietro Capofiume, in the Po Valley, Italy, in fall 2015. We used scanning electron microscopy (SEM) and image processing to analyze more than 950 individual soot particles and to quantify their degree of compaction. We found higher soot compaction during the foggy events with respect to the sunny events. We hypothesize that the compaction is due to cloud processing, as we postulated also in previous studies.

To further investigate cloud processing in controlled laboratory conditions, we performed preliminary experiments in a turbulent cloud chamber at Michigan Technological University. We first injected kerosene flame soot particles and then produced a turbulent mixing cloud, and collected interstitial and residual soot particles using a pumped counterflow virtual impactor. We analyzed 361 individual soot particles from SEM images. The residual soot particles were found to be markedly more compact than the interstitial soot, supporting our hypothesis on cloud-induced compaction. We will present the results of these field and laboratory studies and discuss the implications on the optical properties of soot particles and the potential repercussions on their radiative effects.

2CC.10

Measurement of Atmospheric Organic Aerosol Hygroscopicity and Oxidation Level as a Function of Volatility. KERRIGAN CAIN, Spyros Pandis, *Carnegie Mellon University*

Hygroscopicity, oxidation level, and volatility of organic pollutants are three crucial properties that determine their fate in the atmosphere. This study assesses the feasibility of a novel measurement and analysis technique to determine these properties at the same time and to establish their relationship. The proposed experimental setup utilizes a cloud condensation nuclei counter to quantify hygroscopic activity, an aerosol mass spectrometer to measure the oxidation level, and a thermodenuder to evaluate the volatility. The setup was first tested with secondary organic aerosol (SOA) formed from the ozonolysis of α-pinene in a 10 m^3 smog chamber at Carnegie Mellon University. The results of the first experiments indicated that, for this system, the less volatile SOA contained components that had lower O:C ratios and hygroscopicity parameters, κ. The proposed analysis technique is used to express hygroscopicity and oxidation level as a function of volatility. The results from this analysis confirmed that the SOA had some low volatility material with a low O:C ratio and κ. These results also showed that both low and high volatility material can have a comparable oxidation level and hygroscopicity.

The technique was tested further with several other SOA systems generated from the oxidation of other monoterpenes and sesquiterpenes as well as ambient aerosol from Pittsburgh, PA. These results can provide valuable insights about the relationships among organic aerosol hygroscopicity, oxidation level, and volatility.

2CC.11

Using High-Spectral Resolution Lidar to Infer CCN Proxies: Results from NASA DISCOVER-AQ and NAAMES Field Campaigns. PATRICIA SAWAMURA, Richard Moore, Sharon P. Burton, Eduard Chemyakin, Detlef Müller, Alexei Kolgotin, Richard Ferrare, Chris Hostetler, Luke Ziemba, Andreas Beyersdorf, Ewan Crosbie, Edward Winstead, Yohei Shinozuka, Kenneth Thornhill, Bruce Anderson, *NASA Langley Research Center*

There has been intense interest in recent years in developing correlations between CCN number concentrations and satellite observables such as column-integrated aerosol optical depth (AOD) or ambient aerosol extinction in order to place constraints on the global CCN budget and geographical distribution. These parameters are chosen because of the existing NASA Earth Observing System Sensors, particularly MODIS, but also CALIPSO. Airborne and ground-based field campaigns provide the comprehensive observational datasets upon which to develop and test these correlations with a number of relationships being previously reported in the literature (e.g., Andreae, 2009; Liu et al., 2014; Shinozuka et al., 2015). Generally, these correlations are monotonic, but are ill-constrained (variability of 10-100-fold). Lessons from HSRL and CALIPSO lidar remote sensing aerosol classification efforts tell us that aerosol intensive optical parameters encode information about the aerosol size and composition regardless of number or mass concentration that can be used to differentiate aerosol types. Since aerosol size and composition are the primary drivers of CCN activity, this information holds promise for placing constraints on the shape of the CCN spectrum.

Here, we present comparisons of in situ aerosol and CCN properties with remotely-sensed aerosol microphysical and optical properties. Measurements were carried out during the NASA DISCOVER-AQ and NAAMES campaigns in urban and remote marine environments, respectively. Large differences in both aerosol loading and composition were observed during these campaigns, which makes them ideal for exploring much of the range in aerosol microphysical and optical properties.

2CC.12

Aerosol Optical Properties Derived from In Situ Measurements at the DOE ARM Site in Oklahoma.

MANASI MAHISH, Don Collins, *Texas A&M University*

Aerosol size and hygroscopic growth factor distributions measured at the rural ARM Southern Great Plains site in Oklahoma were used to estimate ground-level submicron aerosol extinction coefficient (b_{ext}), scattering coefficient (b_{scat}), hemispheric backscattering coefficient (b_{back}), and upscatter coefficient (b_{up}) at visible wavelengths. Those optical properties were subsequently used to calculate backscatter fraction (b_{back}/b_{scat}), upscatter fraction (b_{up}/b_{scat}) and f(RH) ($b_{scat\ @\ 90\%\ RH}/b_{scat\ @\ 24\%\ RH}$). The accuracy of the estimated b_{scat} and b_{back} was evaluated through comparison with direct nephelometer measurements. Upscatter fraction (β), a key parameter in assessment of radiative forcing, was determined for 30 selected days on which the boundary layer was deep and well mixed. The hygroscopicity of the aerosol measured at the surface was coupled with estimated height-dependent relative humidity to extend the calculation of β through the boundary layer. The estimated optical properties were also parameterized as functions of RH, scalar quantities derived from the particle size growth factor distributions, and, for β, solar elevation. The average normalized errors between estimated and measured b_{scat} and b_{back} were 16% and 20%, respectively. The calculated β approached a maximum of 0.5 at sunset and at other times was dependent on RH and, within the cases considered, varied seasonally. Parameterizations of the four optical properties, i.e., b_{ext}, b_{scat}, b_{back} and β, are promising, with comparison to the original resulting in an r^2 above 0.94.

2CC.13

Surface Tension in the Formation of Cloud Droplets.

JAMES F. DAVIES, Kevin Wilson, *Lawrence Berkeley National Laboratory*

Organic species in atmospheric aerosol show a propensity for partitioning to the surface of liquid droplets, lowering surface tension and impacting the ability of the aerosol to act as a source of cloud condensation nuclei (CCN). A constant reduction in the surface tension is associated with an increase in the CCN efficiency of an aerosol. However, surface tension must vary as a function of solute concentration and, as water condenses onto CCN and the system is diluted, changes in partitioning increase the surface tension. These effects have been directly observed using a thermal gradient chamber that measures the size of droplets as a function of water vapor saturation. However, typical CCN instrumentation are limited in their ability to resolve surface tension effects. Here, I will discuss measurements made using a commercial Cloud Condensation Nucleus Counter (Droplet Measurement Technologies) to identify signatures of surface tension effects in a series of mixed organic/inorganic aerosol. The effect of organic/inorganic ratio and the role of the inorganic salt will be explored, with initial measurements revealing that surface effects on CCN activity are highly system dependent and non-intuitive. A generalized description capable of capturing both size and composition effects will be explored and discussed.

2CC.14

Minimal Water Uptake by Fresh Indonesian Peat Burning Particles is Governed by Limited Availability of Water Soluble Organic Matter. JING CHEN, Sri Hapsari Budisulistiorini, Masayuki Itoh, Wen-Chien Lee, Takuma Miyakawa, Yuichi Komzaki, LiuDongQing Yang, Mikinori Kuwata, *Nanyang Technological University*

During last few decades, Indonesian peatland fires which include combustions of peat and vegetation (e.g., fern, acacia) have been recurrently happening. Particles emitted from peatland burning have significantly affected regional and global climate by complexly coupled aerosol-cloud-precipitation interactions. Accurate evaluations of these peat-burning-particle-driven effects require well characterized water uptake properties, yet they have been rarely explored. Here, we quantified water uptake by various types of fresh Indonesian peatland burning particles using the humidified tandem differential mobility analyzer (HTDMA). To link water uptake property with chemical composition, both the Aerodyne Time of Flight-Aerosol Chemical Speciation Monitor (ToF-ACSM) measurements and offline carbon analysis were conducted. The concurrent HTDMA and ToF-ACSM measurements were also performed for bulk water-soluble organic matter (WSOM) and its highly hydrophilic fraction classified with the 1-octanol-water partitioning method. We show that fresh peat burning particles are almost non-hygroscopic (mean hygroscopicity parameter, $\kappa < 0.06$) due to predominant contribution of water-insoluble organics. κ is greatly dependent on biomass types (e.g., mean $\kappa = 0.08$ (fern) and 0.04 (acacia)), likely determined by the variance in the water-soluble organic fraction. κ values for water extracts are high, especially for peat burning particles (bulk WSOM: $\kappa_{WSOM} = 0.18$, highly hydrophilic fraction: $\kappa_{H\text{-}HPHIL} = 0.30$). These results stress the importance of characterizing the bulk and highly hydrophilic water-soluble organic fractions in determining hygroscopicity of fresh peat burning particles. κ correlates positively ($R = 0.89$) with fraction of m/z 44 ion signal (f_{44}), demonstrating the importance of highly oxygenated organic species to water uptake by peatland burning particles. Further, our study provides an experimentally validated reference for organics-dominated particle hygroscopicity, thus contributing to more accurate estimation of climate impacts caused by Indonesian peatland burning particles.

2CC.15

The Role of Grid Resolution on the Overprediction of Aerosol Nitrate by Chemical Transport Models. MARIA ZAKOURA, Spyros Pandis, *University of Patras*

Results from recent studies have shown that particulate nitrate is often over-predicted in the Eastern US. NO_x from large coal burning power plants and traffic is the major precursor of the nitrate in this area. This study examines the role of horizontal grid resolution on the prediction of $PM_{2.5}$ nitrate by the three dimensional chemical transport model PMCAMx.

Four cases were investigated. First, the model was applied over the Eastern United States with a 36 km grid resolution during July 2001 (base case scenario). Then, two-way nested grids (36/12 km, 36/4 km and 36/12/4 km) were used over the same area during the same period. Due to lack of high resolution emissions, the emission inventory was interpolated for the higher resolution simulations. The model predictions were evaluated against daily average $PM_{2.5}$ measurements taken throughout the Eastern United States by the IMPROVE and STN monitoring networks. Hourly $PM_{2.5}$ measurements taken during the Pittsburgh Air Quality Study were also available.

The simulation with the telescoping nested grids reproduced better the nitrate measurements. The bias for $PM_{2.5}$ nitrate decreased by 69% for the STN and 65% for the IMPROVE network, when the resolution increased from 36 km to 4 km. Also, the bias decreased by 92% for Pittsburgh. Similar improvements were seen in other areas of the Eastern United States. These results suggest that at least part of the overprediction is caused by the artificial spreading of point-source emissions and the subsequent changes in the nighttime chemistry of both the power-plant plumes and the background atmosphere.

2CC.16

Development of a Method for the Measurement of the Water Solubility Distribution of Atmospheric Organic Aerosol. AIKATERINI LIANGOU, Kalliopi Florou, Magdalini Psichoudaki, Evangelia Kostenidou, Epameinondas Tsiligiannis, Spyros Pandis, *University of Patras, Patras, Greece*

The water solubility is one of the most important physical properties of atmospheric organic aerosol as it influences its ability to uptake water and also to act as cloud condensation nuclei (CCN). In this study, a method for the measurement of the water solubility distribution of atmospheric organic aerosol was developed. This method is based on the extraction of organic aerosol collected on filters, using different amounts of water and measurement of the corresponding water soluble organic carbon (WSOC) concentration. The solubility distribution is then estimated using the solubility basis set of Riipinen et al.(2015). The proposed approach can quantify the solubility distribution in the 10^{-3}-1 g L^{-1} range.

The method was applied on both ambient and source-specific aerosol. 58-63% of the atmospheric urban background organic aerosol analyzed had water solubility higher than 1 g L^{-1}. 11% of the fresh cooking organic aerosol (COA) had water solubility higher than 0.1 g L^{-1}, while 80% of the total COA had solubility lower than 10^{-3} g L^{-1}.

Reference:
Riipinen, I.; Rastak, N.; Pandis, S. N. Connecting the solubility and CCN activation of complex organic aerosols: a theoretical study using solubility distributions. Atmos. Chem. Phys. 2015, 15, 6305–6322.

2CC.17

Atomistic Study of Synergism Among Surfactants at the Air-Water Interface. Gözde Ergin, Mária Darvas, SATOSHI TAKAHAMA, *EPFL*

Recent work has shown that atmospheric aerosols can have significantly lower surface tensions laboratory aerosols (Baduel et al., 2012). Understanding the origins of this difference is essential for advancing our capability to model the effect of on cloud droplet formation. One hypothesis is that there are a class of understudied molecules in atmospheric particles that lower the surface tension significantly, such as biosurfactants (Eckström et al., 2010). A second hypothesis is that non-additive interactions among certain molecules lower surface tensions lower below that predicted from their individual contributions. For instance, such interactions can exist among ionic surfactants that have been found in atmospheric aerosols (Gérard et al., 2016).

In this work, we explore the atomistic interactions among surfactants and water which lead to synergistic behavior. We first present detailed analysis of pure and mixed systems containing sodium dodecyl sulfate (SDS) and lauryl betaine, which is a system known to exhibit strong synergism. For contrast, we present analysis for a non-synergistic system of SDS and cocoamidopropyl betaine, where the latter molecule varies from lauryl betaine by an amide group in the skeletal tail. We discuss possible implications of mixing surfactants on the surface tension in atmospheric aerosols.

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2CC.18

Measured In Situ Mineral Dust Absorption Spectra. Patricia Razafindrambinina, JAMES RADNEY, Christopher Zangmeister, *National Institute of Standards and Technology*

Depending upon the locality, mineral dust aerosols generated from wind-blown soils can represent a significant fraction of local aerosol mass loadings. Further, these aerosols are capable of significantly affecting local energy budgets and hence radiative forcings. However, little is known about the absorption spectra of these particles. Here, we will present laboratory-measured absorption spectra of aerosolized soil samples from locations across the United Sates (CA, IA, MD and MN) with land uses encompassing agriculture, forest and dirt road surfaces. Spectra were collected using a photoacoustic spectrometer with both a supercontinuum laser with a tunable wavelength and bandwidth filter and a diode laser allowing spectra to be measured from $\lambda = 405$ nm to 840 nm. We find that the measured spectra can be broadly grouped as either red clay-like or brown/gray dirt-like possessing Absorption Angstrom Exponents of > 4 or ≈ 3.5, respectively.

2IA.1

A Kitchen Degreaser Can Alter Aerosol Composition in a Room for Days. JAROSLAV SCHWARZ, Otakar Makeš, Jakub Ondrácek, Michael Cusack, Nicholas Talbot, Petr Vodicka, Lucie Kubelová, Vladimír Ždímal, *Institute of Chemical Process Fundamentals CAS*

Indoor aerosol is of great importance because people spend about 80% of their lives indoors. In this study the first indoor observation of an aerosol transformation is described being linked to a kitchen degreaser containing mono-ethanol amine. Mono-ethanol amine (MEA) used in the degreaser and being present in a room on cleaned surfaces and paper towel used for their cleaning transformed ammonium sulfate and ammonium nitrate into $(MEA)_2SO_4$ and $(MEA)NO_3$. This effect was visible for several days despite a high average ventilation rate. The influence was characterized using offline (filters, impactors, followed by ion chromatography analysis) and online (compact time-of-flight aerosol mass spectrometer, field OC/EC analyser) measurements.

Replacement of ammonia in ammonium salts was seen both in aerosol and in particles collected on a filter before the usage of MEA degreaser. A similar effect of other amines can be expected based on earlier laboratory data.

The described influence shows a new pathway for MEA exposure of people in an indoor environment that can be important especially for professionals working with similar degreasers. The stabilizing effect on indoor nitrate also causes higher indoor exposure to fine nitrates.

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2IA.3

Aerosol Constituents in Thirdhand Tobacco Smoke.

XIAOCHEN TANG, Noelia Ramirez Gonzalez, Marion Russell, Xavier Correig, Lara Gundel, Hugo Destaillats, *Lawrence Berkeley National Laboratory*

The term thirdhand smoke (THS) refers to tobacco constituents that remain, react, re-emit, and/or are resuspended (the four Rs) long after active smoking ends. Exposure to THS may elevate the harm caused by toxic tobacco-related pollutants due to its persistence, reactivity and harmful chemicals. This presentation focuses on the evolution of aerosols in secondhand smoke as it ages to thirdhand smoke. The objective of the study is to characterize the composition of semivolatile and particulate matter (PM) as the aerosol ages overnight, from secondhand smoke to THS. The approach prioritizes determination of concentrations of known tobacco-related toxicants, as well as harmful species in ambient PM. The long term goal is comparing the toxicity of THS aerosol to that of ambient PM for risk assessment.

Air monitoring began before smoking and restarted soon after generation of sidestream tobacco smoke in a large chamber at LBNL. An integrated gas and particle sampler collected sequential samples of semivolatile components on denuders and particulate matter on filters. Gas and particulate phase components of the smoke were extracted separately by pressurized liquid extraction with ethyl acetate and analyzed using several instruments: a gas chromatograph-ion trap mass spectrometer (GC-IT-MS), a two-dimensional gas chromatograph-time of flight mass spectrometer (GC×GC-TOF), and an ultra-high performance liquid chromatograph with triple quadrapole mass spectrometer (UHPLC/QQQ) and ifunnel technology. Total mass concentrations of PM and volatile organic compounds (VOCs) were calculated, and acetaldehyde, formaldehyde, acetone and acrolein, were identified as the most abundant aldehydes. Nicotine and a series of polycyclic aromatic hydrocarbons (PAHs) were detected in the THS particles, as well as tobacco-specific nitrosamines (TSNAs). Quantification and speciation of the PAHs and the TSNAs as well as profiling the GC×GC-TOF chromatograms enable a closer examination of differences in chemical properties (and possible health effects) between secondhand smoke and THS.

2IA.4

Modeling Exposure Close to Air Pollution Sources in Mechanically Ventilated Rooms: Association of Turbulent Diffusion Coefficient with Ventilation Power Input.

KAI-CHUNG CHENG, Yan Zheng, Lynn M. Hildemann, *Stanford University*

The turbulent diffusion coefficient has been used to model elevated exposures close to an indoor air pollution source. However, its highly variable magnitudes have been difficult to predict in the field, especially for indoor spaces with mechanical ventilation (i.e., HVAC systems or in-house fans). We conducted 11 experiments in 2 different-sized indoor spaces (a residential garage and an office), varying the operating speeds of two household fans to create a range of mechanical ventilation conditions. In each, we used SidePak monitors to sample $PM_{2.5}$ every 10 s at 15-16 points at different horizontal distances and angles from a controlled continuous particle emission source. An eddy diffusion model was used to deduce the turbulent diffusion coefficient from the measured spatial spreads of $PM_{2.5}$. Values ranged from 0.0008-0.0117 m^2/s for ventilation power inputs of 0-10.62 W, estimated by measuring air velocities at the fan registers. The model reasonably describes the observed $PM_{2.5}$ concentrations at different radial distances (0.25-4 m). By factoring in the room dimensions, we found a significant relationship between the turbulent diffusion coefficient and the ventilation power input, consistent with a derived theoretical expectation and generalizable across two different sized rooms. The ability to predict the turbulent diffusion coefficient using routinely measured indoor air quality (IAQ) parameters (i.e., ventilation power input and room dimensions) is useful for accurately modeling elevated exposures in close proximity to an indoor air pollution source.

2IA.5

Indoor/Outdoor Relationships and Anthropogenic Elemental Signatures in Airborne PM2.5 at a High School: Impacts of Petroleum Refining Emissions on Lanthanoid Enrichment. SHANKAR CHELLAM, Ayse Bozlaker, Jordan Peccia, *Texas A&M University*

Airborne fine particulate matter, particularly metal-enrichment, is an important concern in schools located in industrialized regions. In many such cases, anthropogenic metal emissions to the ambient outdoor atmosphere can transport indoors and negatively impact children's health. In this work, outdoor emissions of primary fine particles and their contributions to indoor air quality deterioration were examined by collecting PM2.5 paired indoor and outdoor PM2.5 from a mechanically ventilated high school in the ultra-industrialized ship channel region of Houston, TX over a two-month span. Samples were comprehensively analyzed for a total of 47 elements including lanthanoids (rare earth elements), transition metals and representative elements using inductively coupled plasma-mass spectrometry. To our knowledge, this is the first work to comprehensively measure the concentrations of all 14 lanthanoids in PM2.5 inside a United States school and relate it to outdoor anthropogenic contamination. This approach allowed us to capture indoor signatures of outdoor episodic emissions arising from non-routine operations of petroleum refinery fluidized-bed catalytic cracking units. Average indoor-to-outdoor (I/O) abundance ratios for the majority of elements were close to unity providing evidence that indoor metal-bearing PM2.5 had predominantly outdoor origins. Only Co had an I/O abundance ratio > 1 but its indoor sources could not be explicitly identified. La and 17 other elements (Na, K, V, Ni, Co, Cu, Zn, Ga, As, Se, Mo, Cd, Sn, Sb, Ba, W, and Pb), including air toxics were enriched relative to the local soil both in indoor and outdoor PM2.5 demonstrating their anthropogenic origins. Several lines of evidence including receptor modeling (chemical mass balancing), lanthanoid ratios, and La-Ce-Sm ternary diagrams pointed to petroleum refineries as being largely responsible for enhanced La and total lanthanoid concentrations in the majority of paired indoor and outdoor PM2.5.

2IA.6

Rapid Evaporation of Ultrafine and Fine Particulate Matters in Electronic Cigarette Emissions. Eon Lee, Charlene Nguyen, YIFANG ZHU, *University of California Los Angeles*

Previous studies had reported a rapid decrease of particle number and mass concentrations in electronic cigarette (e-cig) emissions, presumably due to high volatility of e-cig aerosols. There is, however, no direct experiment data about the evaporation of e-cig emitted aerosols. This study aimed to quantify the evaporation rates of e-cig emissions generated from a wide range of e-liquid mixtures in a temperature-controlled chamber. Mimicking the chemical compositions of commercially available e-liquids, ten e-liquid mixtures were prepared from individual chemical compounds of propylene glycol (PG, 99.5%), vegetable glycerin (VG, 99.5%), and nicotine (Nic, 99%). The e-liquid mixtures used in this study had PG/VG volume ratio of 0/100, 10/90, 30/70, 50/50, and 100/0 with and without 2.4 mg Nic/l. Saturation vapor pressures (P_{sat}) of e-liquid mixtures ranged from 10^{-2} to 20 Pa. In a temperature-controlled chamber, time-series measurements were conducted for the decay of number and mass concentrations for ultrafine particles (UFPs, diameter < 0.1 μm) and fine particulate matters ($PM_{2.5}$, diameter $\leq$ 2.5 μm). Finally, the decay rates of e-cig emitted aerosols were compared to the decay rates of DEHS (di-ethyl-hexyl sebacate) aerosols having extremely low volatility (i.e., $P_{sat} = \sim 10^{-6}$ Pa). Linear regressions analyses were performed to determine the evaporation rates of UFPs and $PM_{2.5}$ in e-cig emissions. This study found that the evaporation rate of $PM_{2.5}$ significantly increased at decreasing relative humidity. Although the evaporation of UFPs had insignificant impacts from the change of relative humidity, the evaporation of UFPs had significant dependence on the change of nicotine content and saturation vapor pressure of e-liquid mixture. The evaporation rate of UFPs was positively proportional to saturation vapor pressure without nicotine. However, with nicotine, the evaporation of UFPs was negatively proportional to saturation vapor pressure potentially because of the protonation of nicotine.

2IA.8

The Influence of Air Cleaners on Concentrations of Indoor Particulate Matter Components and Oxidative Potential in Beijing, China. Ying Zhan, CHRISTINA NORRIS, James Schauer, Martin Shafer, Michael Bergin, Karoline Johnson, Junfeng Zhang, Yinping Zhang, *University of Wisconsin-Madison*

In areas with poor air quality the number of indoor air filtration devices available has been growing steadily, with limited research undertaken to assess their effectiveness. We collected 48-hour filter-based $PM_{2.5}$ samples indoors and outdoors at six residences in Beijing, China in summer, 2016 to assess the effectiveness of Atmosphere® Air Purifiers to reduce air pollutants. We gathered samples twice per home – once during true filtration, with all filters installed in the purifier, and again during sham filtration, when we removed 2 of the 3 filters. We collected personal exposure samples for one resident of each home to assess the impact of air purification on personal exposure. We determined $PM_{2.5}$ mass concentrations and analyzed filters for components of $PM_{2.5}$ including organic carbon, elemental carbon, sulfate, nitrate, ammonium, dust and 21 metals. We conducted a toxicity assay to evaluate the effect of filtration on reactive oxygen species (ROS) as they may be implicated in $PM_{2.5}$-health relationships. The average indoor $PM_{2.5}$ concentration during true filtration was 8.47 $\mu g/m^3$, compared to 49.02 $\mu g/m^3$ during sham filtration. Purifiers significantly reduced the concentration of all components of $PM_{2.5}$ except for organic carbon. Air purification was not related to personal exposure to $PM_{2.5}$ or its components, likely because participants spent much of their time in unpurified microenvironments with high $PM_{2.5}$ concentrations or with other sources of $PM_{2.5}$ (e.g., traffic, cooking). Air cleaners reduced the ROS activity of $PM_{2.5}$, and most of the measured $PM_{2.5}$ components were found to be correlated with the ROS activity. In conclusion, the air purifier reduced the $PM_{2.5}$ total mass concentration as well as its components' concentration, and may also reduce the toxicity of the particles in the indoor environment. Additional research is needed to better understand the contribution of microenvironments to personal exposure to $PM_{2.5}$.

2IA.9

Method Development for Determining Particle/Air Partition Coefficient of SVOCs. YAOXING WU, Shengyang Chen, Clara Eichler, Eric Vejerano, Linsey Marr, John Little, *Virginia Tech*

Semivolatile organic compounds (SVOCs) are ubiquitous in the indoor environment, and exposure to them is linked to a variety of adverse health effects. Because SVOCs partition between the gaseous and particulate phase, total airborne SVOC concentrations and resulting human exposure can be higher than expected. When it comes to understanding interactions between airborne particles and SVOCs, there are numerous models based on different theories but few experimentally measuring SVOC partitioning between the gaseous phase and particulate phase. In this study, a specially-designed tube chamber operating in the laminar flow regime was developed to investigate the particle-mediated mass transfer of SVOCs; this approach is advantageous in terms of both predictability and simplicity. Di-2-ethylhexyl phthalate (DEHP) was selected as the target SVOC due to its widespread use in consumer products and building materials. The particle/air partition coefficient (Kp) of DEHP was determined to be 0.011 ± 0.004 m3/µg. Computational fluid dynamics modeling shows that the presence of particles increases the radial gas-phase concentration gradient, resulting in enhanced mass transfer from the source of emissions to the air. This novel experimental approach offers a rapid method for measuring Kp and a sound basis for characterizing gas-particle interactions of SVOCs.

2IA.10

Aerosol Sampling Experiment on the International Space Station Part II: Characterization Techniques and Results. GARY CASUCCIO, Kristin Bunker, Traci Lersch, Roger R. West, Marit Meyer, *RJ Lee Group, Inc.*

On October 17, 2016, active aerosol (AAS) and passive aerosol samplers (PAS) were launched to the International Space Station (ISS) as part of an experiment to investigate air quality in cabin areas on the ISS. The active aerosol sampler consisted of a thermophoretic sampler that was designed for low gravity operation. The passive aerosol sampler was designed with five compartments so that sampling could be performed for different time periods (e.g. 2, 4, 8, 16, and 32 days). Sampling on the ISS using the active and passive aerosol samplers was conducted from November 29, 2016 to January 18, 2017. The samples were returned to Earth on March 20, 2017 and are in the process of being examined using a variety of microscopic and spectroscopic techniques including light microscopy, manual scanning electron microscopy (MSEM) with energy dispersive X-ray spectroscopy (EDS); computer controlled scanning electron microscopy (CCSEM); electron backscatter diffraction (EBSD), scanning transmission electron microscopy (STEM) and Raman spectroscopy.

The PAS samples were initially evaluated by optical microscopy in order to document loading and general sample characteristics. This indicated that the seven passive samples were successful in the collection of airborne particulate matter. In the initial evaluation, a select set of samples were also analyzed in the SEM both manually and using CCSEM to determine, in general, what types of particles were collected. While particle characterization is ongoing, preliminary results obtained thus far show that the particulate matter consists primarily of fibrous material (white, red, blue, and yellow), metal particles as well as some biological material. Initial review of the active samples indicates that limited amounts of nanometer size particles were collected; however interesting structures have been observed.

The characterization methodology incorporating multiple analytical techniques along with the analytical results obtained using active and passive samplers will be discussed.

2IA.11

Lung Deposited Surface Area and Black Carbon in Urban High Rise Apartments. DONGHYUN RIM, Gwi Nam Bae, Jong Bum Kim, Chang Hyeok Kim, *Pennsylvania State University*

Human exposure to ultrafine particles (UFP) has been associated with adverse health effects such as pulmonary, cardiovascular, and premature illness. Lung-deposited particle surface area is closely linked to toxicity of particles. Few studies have characterized time-resolved lung-deposited surface area (LDSA) in urban residential environments. The objective of this study is to investigate LDSA and BC concentrations as well as residential exposure profiles in four high-rise apartments in a mega-city, Seoul, Korea.

Time-varying lung-deposited surface area (LDSA) and BC concentrations were continuously measured over a period of 60 hours in 4 high-rise apartments. UFP concentrations were measured using a NanoScan SMPS that monitored size-resolved concentrations in the size range of 10-420 nm. LDSA for the alveolar region was monitored by using Nanoparticle Aerosol Monitor (NAM) based on diffusion charging of sampled particles. Total suspended black carbon (BC) mass was monitored using an Aethalometer (Magee 133 Scientific, AE51) that measured absorbance from particles deposited on the filter and converted the absorbance to BC mass concentration. Indoor cooking stove types and cooking activities as well as window opening events were recorded during the measurements.

The results show that LDSA at eight apartments, averaged over 60-h monitoring at each site, ranged from 40 to 150 μm2/cm3, which are generally higher than urban background levels in other cities reported in the literature. Higher ranges of LDSA occurred mainly due to indoor cooking activities and penetration of outdoor particles via open windows. For the eight apartments, infiltration factor for UFP varied from 0.22 to 0.65 depending on the particle size and ventilation conditions, while it ranges from 0.55 to 0.84 for BC. The percentage of daily-integrated residential exposure to UFP attributable to particles of outdoor origin was 26-62% for the residents of the apartments.

2IA.12

A Controlled Study to Estimate PM Mass and Number Emission Rates during Grilling. MEHDI AMOUEI TORKMAHALLEH, Saltanat Ospanova, Nurbay Shynggys, Zhanakhmet Gulaina, *Chemical and Aerosol Research Team, Nazarbayev University*

Studies have shown that several factors such as type of stoves, the cooking additives, meat, oils and pans contribute to the production of PM and UFP. Reductions in the total number and PM2.5 emission from heated oils in the presence of table salt were reported which could be due to the saltation effects reducing the vapor pressure of the organic constitutes of the oil over its surface area. In addition to the cooking oils, it is also important to investigate the influence of the table salt on PM emissions from heated meat during grilling. However, the effect of the table salt on grilling emissions has not been yet investigated. Recent studies hypothesized that indoor SVOCs adsorbs on the surface of electric burners or pans, and are released to the air in the form of particulate matter during cooking. The current study investigates the PM and UFP emission rates from grilled beef meat excluding the particles from heated pan and burner. Additionally, the impact of table salt on grilling emission rate is investigated. An electric burner and a ceramic pan were heated constantly for several hours until PM emission reached the background level. Then, meat or salty meat was placed in the pan and grilled to estimate emission rates solely from the meat. UFPs were measured using a CPC 3007, TSI. PM1, PM2.5, PM4 and PM10 concentrations were simultaneously measured using a DustTrak DRX, TSI. A low cost monitor, Dylos, was also operated to compare its reliability against those reference instruments. While we are processing the results, so far, the average particle number emission rates for grilling pure meat (N=5) and Salty meat (N=4) were estimated to be 5.64e13 and 3.13e13 particle/h, respectively, suggesting a slight emission rate reduction due to the presence of salt.

2IA.13

Emission Factors of Fine Particulate Matter, Organic and Elemental Carbon, Carbon Monoxide, and Carbon Dioxide for Solid Fuels Commonly Used for Heating Navajo Homes. Wyatt Champion, Lea Connors, LUPITA MONTOYA, *University of Colorado Boulder*

Most homes in the Navajo Nation use wood as their primary heating fuel, often in combination with locally-mined coal. Previous studies observed health effects linked to this solid-fuel use in several Navajo communities. Emission factors (EF) for common fuels used by the Navajo have not been reported using a relevant stove type. In this study, two softwoods (Ponderosa Pine and Utah Juniper) and two high-volatile bituminous coals (Black Mesa and Fruitland) were tested with an in-use residential conventional wood stove (homestove) using a modified ASTM/EPA protocol. Filter sampling quantified PM2.5, and organic and elemental carbon in the emissions. Real-time monitoring quantified CO, CO2, and TSP. EF for these air pollutants were developed and normalized to both fuel mass and energy consumed. In general, coal had significantly higher mass emission factors than wood for all pollutants studied. In particular, coal emitted, on average, 10 times more PM2.5 than wood on a mass basis, and 2.4 times more on an energy basis. The EF developed here were based on fuel types, stove design, and operating protocols relevant to the Navajo Nation, but they could be useful to other Native Nations with similar practices, like the nearby Hopi Nation.

2IA.14

Personal Exposure to Airborne Particulate Matter due to Residential Dryer Lint Cleaning. KAI-CHUNG CHENG, Yan Zheng, Afua O. Tetteh, Hye-Kyung Park, Kari C. Nadeau, Lynn M. Hildemann, *Stanford University*

Exposure to airborne particles during and after cleaning dryer lint was examined via 30 experiments involving 4 dryers in a laundry room of a Northern California home. Gravimetric and real-time air samplers measured mass and size-resolved number concentrations in close proximity to the cleaning activity. The size distributions varied greatly between loads of clothing, with particle diameters > 10 µm contributing the bulk of the airborne lint dust volume. Average 5-min exposures to PM10 varied from <10 to >300µg/m^3. Cumulative frequency distributions of 1-min-averaged PM10 measurements were used to characterize the probabilities of different short-term exposure levels during and at different elapsed times after lint cleaning.

2IA.15

Characterization of a Flow Type Vacuum Ultraviolet Photocatalysis Reactor for Airborne Microorganisms and VOCs. JEONGHYUN KIM, Jaesung Jang, *Ulsan National Institute of Science and Technology, Korea*

Indoor air pollutants that can cause a risk for human health can be classified into biological, physical and gaseous pollutants. Biological pollutants include airborne viruses, bacteria and fungi. Volatile organic compounds (VOCs) are typical gaseous pollutants causing health problem such as sick building syndromes (SBS). Up to now, most of conventional air purification techniques have been focused on the degradation of single pollutant but not on multiple air pollutants. On the other hand, vacuum ultraviolet (VUV) photocatalysis has recently been considered as one of the promising techniques for the degradation of multiple air pollutants because of its high-energy photon, although residual ozone is generated by dissociation of oxygen. In this study, to characterize the performance of a flow type VUV photocatalysis reactor, where the residence time was less than 0.01 sec, for biological and gaseous pollutants, MS2 bacteriophage, Pseudomonas fluorescens (gram-negative), Bacillus subtilis spore (gram-positive) and toluene were used as the target pollutants. In addition, it is generally known that the influence factors of VUV photocatalysis involve the light wavelength (185 nm and 254 nm), ozone and reactive oxidant species. In order to clarify which component is more responsible for the degradation of the air pollutants, VUV photocatalysis was compared with five processes: VUV photolysis (without photocatalyst), UV photolysis, ozone dose combined with UV photolysis, ozone dose treatment alone and VUV combined with UV photocatalysis. We eventually developed the effective flow type VUV phtocatalysis reactor that not only can degrade both biological and gaseous air pollutants but also can reduce residual ozone generation (35 ppb), i.e., less than the Occupational Safety and Health Administration (OSHA) permissible level. Therefore, we think the VUV-based air purification technique has the potential for the simultaneous degradation of multiple air pollutants at large flow rates.

2IA.16

Using Aerosol Principles to Advance Exposure Science: Development of a Better Understanding of the Roles of Water and Water-Soluble Gases on Indoor Surface Chemistry and Indoor Air Composition. MARC WEBB, Sara Duncan, Liyong Cui, Joanna Atkin, Jason Surratt, Barbara Turpin, *University of North Carolina at Chapel Hill*

Surfaces play an important role in indoor chemistry, where surface area-to-volume ratios are greater than 3 m2/m3, orders of magnitude greater than typical of ambient aerosols. Even though "dampness" is a substantial issue in buildings, little is known about the hygroscopicity and water content of indoor surfaces, the concentrations and composition of water-soluble gases, the effects of liquid water on indoor surface chemistry, and the subsequent effects of that chemistry on exposure. However, even a 5 nm water film on indoor surfaces (assuming 20 m2/m3 of surface in a 300-m3 home) will provide more than 1000 times the volume of liquid water as is found in aerosols outdoors. Since the resulting aqueous solutions will be highly concentrated, aqueous surface chemistry on authentic indoor surfaces may mimic aqueous aerosol chemistry.

In this work, we provide results to date and outline future plans to study the effects of RH on indoor surface chemistry, including controlled experiments with authentic indoor surfaces. A custom parallel plate flow reactor designed to hold soiled/oxidized indoor surface materials and a high-resolution time-of-flight chemical ionization mass spectrometer (HR-ToF-CIMS) are used to measure reactive uptake of water-soluble organic compounds (e.g., hydroperoxides) and uptake of water at 5%, 50%, and 80% relative humidity (RH) on authentic surfaces. Changes in surface film functionality due to hydration, oxidation and reactive uptake are monitored in other experiments by Raman microscopy. Surface films will also be characterized by ultra-high resolution electrospray ionization QTOF-MS. This work is designed to provide quantitative constraints for indoor modeling that will ultimately improve our understanding of the impact of "dampness" on indoor exposures.

2IA.17

Aerosol Particle Emissions and Efficiency of Cookstove Prototypes for Use in Ethiopia. CLARISSA SMITH, Tsegaye Nega, Deborah Gross, *Carleton College*

Cooking using biomass fuels, such as wood, charcoal, or animal dung, is a source of indoor air pollution and causes negative climate impacts, health problems, and premature death in many areas of the developing world. Ethiopian families use charcoal stoves indoors in both rural and urban areas, causing detrimental health effects as well as deforestation. While more efficient cookstoves have been made, they are far too expensive to be practical for most people in Ethiopia. The Carleton College cookstove project seeks to create an affordable stove that will heat efficiently, have reduced emissions, and be viable for Ethiopians to use. We have evaluated seven different Top-Lit Updraft stoves in a controlled cooking test and water boiling test, investigating fuel use, PM 2.5 concentrations measured using TSI DustTrak DRX instruments and Aircasting AirBeam instrument inside and outside of an experimental test kitchen, and aerosol particle composition measured with a TSI Aerosol Time-of-Flight Mass Spectrometer. The various stoves' performance was compared to a well-characterized, commercially available stove, and performance and particle composition information will be presented.

2IA.18

Investigating Particle Emissions from a Consumer Fused Deposition Modeling 3D Printer with a Lognormal Moment Aerosol Dynamic Model. QIAN ZHANG, Girish Sharma, Jenny P.S. Wong, Aika Davis, Marilyn Black, Pratim Biswas, Rodney J. Weber, *Georgia Institute of Technolgy*

Consumer-level fused deposition modeling 3D printers are widely used in residential and public spaces due to their relative low cost, operational ease and the general public interest in 3D printing technology. This has led to concerns over potential exposures to unknown emissions related to the plastic extrusion process. A number of studies have measured particle emissions from 3D printers and all consistently reported significant levels of nanoparticle emissions during the printing period. However, the particle formation process and subsequent aerosol dynamics have not been investigated. We have measured concentrations and size distributions for 7 nm to 20 μm particles emitted from various 3D printers in an emission test chamber following a standard test method developed for laser printers. The experimental data is then coupled with a moment lognormal aerosol dynamic model to better understand particle formation and evolution mechanism. A sensitivity analysis is done to understand the effect of printer operating conditions and filament material on steady state particle concentration and size distribution. Model development, results and major parameters affecting observed particle concentrations in the chamber will be presented.

2IA.19

PM2.5, OC, EC, CO, and CO2 Emissions from Briquettes Made with Human Waste. WYATT CHAMPION, Lupita Montoya, *University of Colorado Boulder*

There is widespread scarcity of reliable energy sources as well as sustainable means of human solid waste disposal in the developing world. Solving these two significant challenges has been the object of many efforts. Among the proposed solutions, the waste-to-energy movement has emerged. Some research and on-the-field efforts have been focused on the production of briquettes made from char derived from human feces (*biochar*). Previous work in our lab (Ward et at., 2014) demonstrated that briquettes made from *biochar* and low-cost binding material can contain energy on par with charcoal commercially available in places like Africa.

The present study reports results from controlled combustion of briquettes made from human solid waste using a cookstove and following a Water Boiling Test protocol. For comparison, charcoal, wood, and coal types used by the Navajo Nation were also evaluated. Filter samples collected fine particulate matter ($PM_{2.5}$) for gravimetric and organic and elemental carbon (OC and EC) analyses. Gas monitoring was also conducted for carbon monoxide (CO) and carbon dioxide (CO_2).

Results showed that *biochar* briquettes emitted higher $PM_{2.5}$, OC, CO, and CO_2 per unit energy (g/MJ) delivered to the cooking pot, compared to the Navajo fuels tested. For example, the *biochar* briquettes emitted 19-fold higher $PM_{2.5}$ and 65-fold higher OC per energy delivered, compared to the wood tested. The *biochar* briquettes also had lower modified combustion efficiency, compared to the other fuels tested (87% vs. 95%, respectively). Therefore, the formulation of *biochar* briquettes tested here resulted in high emissions, in part due to observed low modified combustion efficiency. Continuing efforts to optimize this waste-to-energy alternative are presently being pursued in Ghana. Recent results from these efforts will be presented.

Reference:

Ward, B.J., Yacob T.W., Montoya L.D. (2014). “Evaluation of Solid Fuel Char Briquettes from Human Waste”, *Environmental Science and Technology*, 48 (16):9852–9858.

2IA.20

Analysis of Air Cleaner Test Results with Korea Air Cleaning Association Certificate from 2003 to 2015. Chang-gyu Woo, Bangwoo Han, Hak-Joon Kim, YONG-JIN KIM, *Korea Institute of Machinery and Materials*

Recently, high concentration of fine particulate matter in the Korean peninsula draws much attentions. People are staying more time in indoor and the threat of high concentration of particulate matter to human health has been identified. The market size of air cleaner of Korea is on the increase. Estimators are saying that the market size would be $1.3 billion by the end of 2017.

In Korea, the collective quality certification system for the indoor air cleaners was operated from 2003 according to SPS-KACA002-132. As fulfilling the standard, 'Clean Air' mark is given to the product by the Korea Air Cleaning Association. The standard is comprised of collection efficiency, clean air delivery rate, odor removal efficiency, ozone emission and noise level. Korea Institute of Machinery and Materials is performing the air cleaner tests as one of the association's standard performance test agencies from 2003. The test results over 354 Clean Air-certified air cleaners from 2003 to 2015 was analyzed for the development trend and product evaluation. The average air flowrate of most air cleaners was 5.6 m^3/min. The flowrate was on the increasing trend. The average Clean Air Delivery Rate was 4.5 m^3/min and it was proportional to flowrate with about 0.8 times. The operating type of air cleaner was all mechanical filter since 2012.

This work is supported by the Technology Innovation Program of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy (No. 20161110100210) as well as General Research Fund (SC1250) and Air Cleaning Equipment Test Fund (B16341) from the Korea Institute of Machinery and Materials.

2IA.21

Observation of Particles' Penetration and Deposition by the Difference of Particle Size and Charge in a Chamber. YOSHIRO SADATANI, Shigeru Kimoto, Yasuto Matsui, Chiaki Murai, Shota Shakagori, Minoru Yoneda, *Kyoto University*

Particulate radioactive substances were discharged from the reactor into the environment by the Fukushima nuclear power plant accident. It is therefore necessary to know the behavior of the particulate substances for more effective protective measures that would be applied in the future. Based on the results of post-accident monitoring on houses contaminated by the radioactive substances, it is found that the concentration of radioactive substances around a ventilation fan is higher than the other indoor locations. To explore the tendency of penetration and deposition by the difference of particle size and charge, we developed a chamber which simulates indoor and outdoor spaces by separating the chamber into two parts at the center. And a ventilation fan was installed in the center.

Particles with different level of electric charge were generated in the chamber simulating outdoor space. To analyze the difference of behaviors among the particles charged with the different levels, we observed particle size distributions, flow rates, and the charge density in the both chambers.

This research was supported by Nuclear Regulation Authority (NRA) and Japan Atomic Energy Agency (JAEA).

2IA.22

Ultrafine Particle Formation from Oxidation of Cigarette Smoke in the Indoor Environment. CHEN WANG, Douglas Collins, Rachel Hems, Nadine Borduas, Maria Antiñolo, Jonathan Abbatt, *University of Toronto, Canada*

Cigarette smoke is an important source of particles and gases in the indoor environment. Once emitted, the gas-phase organic compounds from cigarette smoke can be oxidized and form secondary products that contribute to secondary organic aerosol formation. In this study, aging of side-stream cigarette smoke exhaust, i.e. second-hand smoke, was studied in an environmental smog chamber under indoor relevant conditions with both ozone and hydroxyl radicals as oxidants. The influence of other parameters, including indoor lighting and relative humidity, on the oxidative aging of the cigarette smoke was also studied. Ultrafine particle formation was observed from ozonolysis of cigarette smoke exhaust with different concentrations of pre-existing primary cigarette smoke particles. Gas-phase compounds from primary (combustion) and secondary (aging) emissions of cigarette smoke were also monitored with chemical ionization mass spectrometry, specifically for nitrogen-containing compounds such as isocyanic acid (HNCO) and nitrous acid (HONO). The formation of ultrafine particles and of HNCO has potential adverse health effects for indoor occupants. The production of HONO in indoor environment is of significance as it is an important source of OH radicals, and may impact the oxidative capacity of the indoor atmosphere.

2IA.24

Comparison of Reactive Oxygen Species (ROS) Generation Ability of Size Segregated Aerosols of Ambient Origin in Indoor and Outdoor Environments. HAORAN YU, Haoran Zhao, Brent Stephens, Vishal Verma, *University of Illinois, Urbana, IL*

Exposure to ambient particulate matter (PM) is associated with increased risks of many adverse health effects including pulmonary disease, asthma, and heart attack. However, because people spend nearly 90% of their time indoors and ambient PM can infiltrate in and persist in buildings, much of human exposure to ambient PM occurs inside buildings. Although ambient PM mass concentrations have long been used in epidemiology studies, the oxidative potential (i.e., the ability of PM to generate reactive oxygen species, or ROS) of PM has been proposed as a more relevant health metric than PM mass. However, the oxidative potential of indoor PM has not been well characterized to date. In order to understand how the oxidative potential of PM of ambient origin changes as it infiltrates in persists indoors, we collected simultaneous size-segregated indoor and outdoor samples over the course of three weeks in an unoccupied student dormitory unit on the campus of Illinois Institute of Technology in Chicago, IL and measured the oxidative potential of both indoor and outdoor samples using a dithiothreitol (DTT) assay. An overall higher (2-5 times) intrinsic activity (i.e. DTT activity, the oxidation rate of DTT) was observed for the indoor PM than outdoor. The indoor PM mass was concentrated in the smaller size range (<0.5 μm), while outdoor PM was mostly concentrated in the larger sizes (1.5-7.0 μm). The intrinsic activity of the indoor PM was higher than the outdoor PM for all size ranges, but the indoor/outdoor (I/O) ratio peaked at around 1.0 μm. The results indicate that, consistent with penetration and deposition theory, the infiltration and persistence of outdoor PM concentrates mass in the ~0.1 to ~1 μm size range, which may contribute to changes in intrinsic oxidative potential of ambient PM. Moreover, aging of these particles in indoor environments may further increase the intrinsic oxidative potential. Given the higher concentrations of these toxic particles, exposure to the indoor PM could pose a more serious risk than previously considered.

2RA.1
Examine Spatial Gradients in Surface PM2.5 Fields by Integrating Low Cost Sensors with Satellite Data.

PRAKASH DORAISWAMY, Pawan Gupta, Olga Pikelnaya, Brandon Feenstra, Andrea Polidori, Robert Levy, *RTI International*

This paper will present initial findings from a study that uses low-cost sensors to examine the spatial gradients in surface fine particulate matter ($PM_{2.5}$) concentrations and compare it to satellite observations of aerosols. Using sensors evaluated at the Air Quality Sensor Performance Evaluation Center (AQ-SPEC) of the South Coast Air Quality Management District (SCAQMD), we will perform a prototype field deployment of about 20 sensors through citizen scientists. Sensors will be deployed in the South Coast air basin in the Los Angeles and in the inland Riverside/San Bernardino regions of Southern California. These regions were chosen to investigate spatial gradients of $PM_{2.5}$ as well as to cover regions with discrepancy between surface and satellite measurements. The spatial gradients from these sensors will be compared with that in satellite derived aerosol optical depth estimates. The prototype deployment will help us characterize column to surface relationships in the region and the role of low cost sensors in evaluating spatial distribution of pollution observed by satellites. The findings from this prototype study will help improve the sensor framework for a larger field deployment at three different regions proposed for Phase 2.

2RA.2
Data Processing, Fluorescence Removal, and Database Matching of Crustal Aerosols Using Raman Spectroscopy.

DAVID DOUGHTY, Steven Hill, *US Army Research Lab*

Raman spectroscopy can provide information about the physico-chemical composition of atmospheric aerosol particles. We use a semi-continuous aerosol Raman spectrometer (Battelle's REBS) to take Raman images of deposited aerosol particles. We discuss several methods for automatically removing fluorescence from Raman spectra. We look at the relationships between fluorescence of particles and Raman spectra of particles, and show that for some particles, there are strong relationships, whereas for other particle types, the relationships are weaker. The resultant Raman images are then clustered and analyzed for composition. Database matching tools are used for identification of aerosol composition and identification of crustal dust particles (using the RRUFF database and other data), from both laboratory and ambient examples, and analyze Arizona test dust, kaolin, and sand from White Sands, New Mexico.

2RA.3

The Project PerduS: Assessment of the Mineral Dust Related Reduction of Photovoltaic Power Generation in Central Europe with ICON-ART. JOCHEN FÖRSTNER, Andrea Steiner, Vanessa Bachmann, Daniel Rieger, Philipp Gasch, Bernhard Vogel, Heike Vogel, Bodo Ritter, *German Weather Service*

The importance of photovoltaic (PV-) power in Germany's energy mix is constantly increasing.
In 2015, approximately 7.5 % of Germany's net energy consumption was supplied by photovoltaic energy. Currently, about 1.5 Million PV-plants provide an installed capacity of 40 GW and, during sunny days, PV-power can supply up to 50 % of Germany's instantaneous energy consumption.

The research project PerduS is a collaboration of the German Weather Service (DWD), the Karlsruhe Institute of Technology (KIT) and meteocontrol GmbH with the aim to improve PV power forecasts during Saharan dust outbreaks.
Current operational numerical weather prediction (NWP) models rely on aerosol climatologies and do not consider the effects of the additional mineral dust in the atmosphere during such special weather situations. The core component of PerduS is the new online-coupled model system ICON-ART. It combines the global non-hydrostatic NWP model ICON and the ART modules for the treatment of Aerosols and Reactive Trace gases in the atmosphere in an integrated quasi-operational system.

Different case studies concerning Saharan dust outbreaks are considered in order to investigate, improve and validate against observations the dispersion forecast of mineral dust with ICON-ART. Clear sky cases are examined to study the dust emission and radiation interactions. During such weather conditions, the ICON-ART simulations can be compared e.g. to aerosol observations. Cloudy conditions instead complicate these measurements. Nevertheless, simulations including aerosol cloud interaction during cloudy conditions are conducted as well. The focus of these studies is on assessing the contribution of direct and indirect effects, i.e. the radiation and cloud feedback mechanisms to an improvement of PV-power forecasts.

Keywords: PV power, Saharan dust outbreaks, direct and indirect aerosol effects, numerical weather prediction, ICON-ART

2RA.4

Remote Sensing Sulfuric Acid Droplets in the Stratosphere. Wenbo Sun, GORDEN VIDEEN, Yongxiang Hu, Rosemary Baize, *Science Systems and Applications, Inc.*

Stratospheric aerosols are mostly sulfuric acid droplets with diameters smaller than one micron. They play important roles in the chemical balance of the stratosphere and can have a significant impact on Earth's radiation balance. Because of their high altitude, small size and low optical thickness, stratospheric droplets of sulfuric acid are difficult to detect with either in-situ or remote-sensing methods. Recently, Sun et al. (2014) reported a novel method for detecting cloud particles in the atmosphere. A distinct feature is the angle of linear polarization (AOLP) of backscattered solar radiation. The dominant backscattered electric field from the clear-sky Earth-atmosphere system is nearly parallel to the Earth surface. However, when clouds are present, this electric field can rotate significantly away from the parallel direction. Model results and satellite data both demonstrate that this polarization feature can be used to detect super-thin cirrus clouds having an optical depth of only ~0.06 and super-thin liquid water clouds having an optical depth of only ~0.01. We can use this method to probe the stratosphere through limb detection. We demonstrate this using the radiative-transfer model developed in Sun and Lukashin (2013), in which we simulated the backscattered solar light's AOLP from pure molecular atmosphere and the atmosphere including the stratospheric droplets of sulfuric acid.

References
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2RA.5

Laboratory and Field Based Evaluation of Chromatography Related Performance of the Monitor for AeRosols and Gases in ambient Air (MARGA).

XI CHEN, John Walker, *US Environmental Protection Agency*

The semi-continuous Monitor for AeRosols and Gases in Ambient air (MARGA) was evaluated using laboratory and field data with a focus on chromatography. The performance and accuracy assessment revealed various errors and uncertainties resulting from mis-identification and mis-integration of chromatogram peaks by MARGA automated software. To aid data reprocessing efficiency and flexibility, an alternative chromatography data processing software was adopted to further evaluate MARGA generated data for method detection limits as well as accuracy and precision. Such reprocessing and calibration significantly improved data quality by lowering method detection limits (by a factor of 1.5) and reducing variability between parallel sampler boxes. Further evaluation of instrument performance, including examination of diurnal patterns of observed gaseous and particulate water soluble species (NH_3, SO_2, HNO_3, NH_4^+, SO_4^{2-} and NO_3^-) as well fine particle neutralization state, was conducted during an intensive field campaign. The evaluation of MARGA chromatography software revealed various potential issues encountered during monitoring especially when ambient concentrations were low. Under such circumstances a bias as high as 30% could be associated with un-examined and un-screened MARGA datasets in addition to invalid data due to peak mis-identification and mis-integration. Furthermore, calibration and verification of accuracy by external standards is recommended for additional quality control given the current reliance on a single point internal standard. Analysis of field measurements across different synoptic meteorological patterns, including a NO_3^-rich arctic air mass, demonstrate that the MARGA is capable of resolving rapid changes in $PM_{2.5}$ composition.

2RA.6

Chemical Characteristics and Potential Sources of PM2.5 at a Regional Background Site in East China.

JUNJUN DENG, Yanru Zhang, Jinsheng Chen, Hongliang Zhang, Youwei Hong, Lingling Xu, *Institute of Urban Environment, Chinese Academy of Sciences*

$PM_{2.5}$ samples were collected daily at the Lin'an regional background station (LA) in Zhejiang, China during 2014-2015 and the chemical components including organic carbon (OC), elemental carbon (EC) and water-soluble inorganic ions (WSII) were determined. Backward trajectory clustering and potential source contribution function (PSCF) were adopted for identifying the transport pathways and potential source areas of $PM_{2.5}$ at LA. The annual mean concentration was 68.9±28.3 μg m^{-3}, indicating severe pollution in East China. Obvious seasonal variations were found, with highest level in winter and lowest in summer. Carbonaceous aerosols and WSII were the predominant compositions, accounting for 30.7% and 53.5% of $PM_{2.5}$, respectively. Secondary inorganic ions (SO_4^{2-}, NO_3^-, and NH_4^+) made a total contribution of 45.2% to $PM_{2.5}$. Heterogeneous formation played a dominant role in SO_4^{2-} formation and NH_4^+ formation promoted NO_3^- formation. Stationary sources played a more important role than mobile sources based on NO_3^-/SO_4^{2-} ratio of 0.53. Aerosol environment at LA was ammonium-poor and SO_4^{2-} was only neutralized sufficiently by NH_4^+ with the predominant production of $(NH_4)_2SO_4$ in winter. Four major transport pathways of air masses at LA were found based on trajectory clustering. Air masses from the northwest Gobi areas passing over the heavily polluted regions in North and Central China had the highest levels of $PM_{2.5}$, followed by the air masses from Central China. PSCF results suggested that surrounding areas in the Yangtze River Delta region were major regional sources of $PM_{2.5}$ and its major components. Northern region was an important source for carbonaceous components, and southwestern region was significant for secondary inorganic ions. This study helps understand $PM_{2.5}$ characteristics, identify potential regional sources and effectively control $PM_{2.5}$ in East China.

2RA.7

Partitioning of Particulate Matter and Elements of Suburban Continental Aerosols between Fine and Coarse Mode. Jelena Đuričić-Milanković, Ivan Anđelković, Ana Pantelić, Srđan Petrović, Andera Gambaro, DRAGANA ĐORđEVIć, *Centre of Environmental Chemistry and Engineering – ICTM*

The results presented in this work are from long-term measurements of masses of size-segregated aerosols and macro and micro elements in the range of PM$_{0.27\text{-}16}$. The following 25 elements: Al, Ag, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Ti, Tl, V and Zn were analysed; level of Be, Hg and Se were under the detection limits in all samples. The results showed the domination of particle content around the accumulation mode in the range of $0.53 < Dp < 1.06$ mm, but the fractional distribution of elements showed maximal average concentrations in different fractions depending on the origin of each element. Crustal elements (Al, Ca, Fe, Mg, Mn, Ti etc.) dominated in coarse mode while anthropogenic elements (As, Cd, Cu, Pb, Sb etc.) were mainly distributed in fine mode fractions. Some elements appeared in investigated aerosols only occasionally e.g. As and Ni, while others were constantly present e.g. Ca, Fe, Mg, Na etc. At the same time, contents of K in the fine fractions are higher, which is an indicator of wood mass and biomass burning. In fractions of fine mode, As, Cd, K, Pb, V, Sb dominate – elements of anthropogenic origin, emitted from traffic and high temperature processes in the closer and wider region: coal fired power plants, copper mining etc. The share of of Ca is constantly significantly high at all times in both fine and coarse mode, K dominates in fine mode, Al, Fe and Mg dominate in coarse mode, while other elements such as As and Ni appear sporadically. The results obtained in this study provide new insights into the characterization of the profile of suburban aerosols from the continental Balkans.

2RA.8

Ambient Aerosol Extinction in Great Smoky Mountains National Park. TIM GORDON, Gavin McMeeking, Jim Renfro, Ethan McClure, Anthony Prenni, Timothy Onasch, Andrew Freedman, Ping Chen, *Handix Scientific*

The IMPROVE (Interagency Monitoring of Protected Visual Environments) program, which is tasked with monitoring visibility in U.S. National Parks and Wilderness Areas, relies on aerosol-induced light extinction reconstructed from speciated filter measurements and humidification growth factors. Under many atmospheric conditions reconstructed extinctions compare favorably with measurements; however, there are several possible sources of discrepancy. First, the IMPROVE reconstructions are based on 24 h averaged filter measurements taken once every four days; thus, important transient events may not be well resolved. Second, at high relative humidities (RH) aerosol light extinction is very sensitive to RH perturbations; thus, under such conditions the humidification growth factors are highly uncertain.

The Open-Path Cavity Ringdown Spectrometer (OPCRDS) was designed to overcome the RH limitations of previous extinction instruments. The OPCRDS was recently deployed in the Great Smoky Mountains National Park (GSM), where the high RH and high photochemical activity typical in summer provided an opportunity to explore the upper limits of the aerosol hygroscopicity (f(RH)) curve and the accuracies of both the IMPROVE extinction reconstruction algorithm and the GSM nephelometer used to validate reconstructed extinction. True ambient extinction measured by the OPCRDS and dry extinction measured by a traditional closed-cell extinction monitor were used to investigate the hygroscopicity of aerosol at GSM and the importance of coarse-mode particles to light extinction.

During the majority of the campaign the OPCRDS data agree closely with the GSM nephelometer and the reconstructed extinction. However, we observed discrepancies between scattering and ambient extinction due to coarse-mode particles, and several high RH events were not resolved by the reconstructed extinction. Finally, we found that the extinction calculated with the revised reconstruction algorithm (IMPROVE-2) was about 12% lower than the values calculated from the original algorithm and provided a slightly better fit to the OPCRDS data.

2RA.9

Isotopic Source Apportionment of Carbonaceous Aerosols Observed in Noto Region, Japan: Impact of Biomass Burning on the East Asian Outflow. ATSUSHI MATSUKI, Reina Yamada, Fumikazu Ikemori, Kento Kinouchi, Yoko Iwamoto, Naoki Kaneyasu, Takayuki Kameda, Minami Masayo, Toshio Nakamura, *Kanazawa University*

One of the least understood characteristics of aerosols is the source and contribution of the organics. Our recent observation revealed that submicron aerosol particles in Northeast Asia have a variable but relatively high mass fraction (approximately 50%) of carbonaceous matter throughout the year. In order to investigate on their source and transport pathways, we analyzed the radio carbon isotope (14C) concentration within fine carbonaceous particles.

We collected weekly PM2.5 samples at NOTO Ground-based Research Observatory (NOTOGRO, 37.45ºN, 137.36ºE) from 26th Jun, 2014 to 17th June, 2015. The analysis of 14C was conducted using AMS 14C system (High Voltage Engineering Europe, Model 4130-AMS). In addition, the other parameters including concentrations of specific organic compounds, stable carbon isotope (δ13C), black carbon, PM2.5 and back trajectory analysis were combined to better constrain the carbon sources.

The results showed that contribution of carbonaceous matter originating from fossil fuel burning is generally small (30 pMC; percent modern carbon), whereas that from modern biological activity and/or biomass burning is large (70 pMC). Concentration of 14C in autumn samples were the highest in all seasons (90 pMC), and there were indications that large scale agricultural waste burning in Northeast China is the likely source. The lowest 14C concentrations in winter samples (55 pMC) can be linked to combustion of fossil fuel for domestic heating and little biological activity. In summer, active secondary organic aerosol formation was suggested, but a sporadic peak of modern carbon was observed which can be attributed to the plume from Siberian forest fire.

2RA.10

Unintentional Ozone Increase Due to Particulate Matter Controls in China. JIANLIN HU, Yanhong Zhu, Lin Huang, Hongliang Zhang, Qi Ying, *Nanjing University of Information Science & Technology*

China has been suffering severe particulate matter (PM) and ozone (O3) pollution due to large amount of fossil fuel consumption associated with rapid economic growth, industrialization, and urbanization during the past four decades. Air pollution control measures have recently been taken into action to reduce the levels of air pollutants, primarily focusing on PM2.5 by reducing SO2 and industrial smoke and dust emissions. Recent monitoring data shows that declining trends in PM2.5 in China, reflecting the effectiveness of PM2.5 control measures. However, ozone, the major pollutant of photo chemical smog which also causes serious damages to public health and agricultural products, is becoming more serious meanwhile. Although particles are not the precursors of O3, particles scatter and absorb the sunlight, reduce the UV radiation and consequently suppress O3 formation. We used Community Multi-scale Air Quality Model (CMAQv5.0.1) to simulated O3 concentrations under different PM and SO2 emission control scenarios. We simulated 2013 summer (June, July, and August) with a 36-km horizontal resolution East Asia region. We used the online photolysis rate module to calculate the effects of scattering and absorbing aerosols in modulating photolysis rates. The results show that seasonal average 8h peak O3 is predicted to increase with the reduction in the SO2 and PM emissions in the NCP area and its downwind ocean areas. The maximum 1h peak O3 concentrations in the three months are over 10 ppbv in the center and east China. The largest increase of 45 ppbv in 1h O3 concentration is over the east China sea, downwind of Shanghai and Jiangsu province. Moreover, the PM and SO2 controls also may greatly increase the 1h O3 concentrations (~15-25 ppbv) in Korea and Japan, even though the seasonal average increase of 8h maximum O3 is not significant (~0.5-1.5ppbv).

2RA.11

Summertime Maximum of Organic Functional Group Concentrations and High Organic Nitrogen from Ocean Biogenic Aerosols at Coastal West Antarctica during AWARE. JUN LIU, Jeramy Dedrick, Lynn Russell, Andy Vogelmann, Gunnar Senum, Stephen Springston, Chongai Kuang, Janek Uin, Dan Lubin, Anne Jefferson, *Scripps Institution of Oceanography*

Atmospheric aerosols can serve as Cloud Condensation Nuclei (CCN), affecting cloud properties and cloud albedo. Almost fifteen months of continuous observations of aerosol particle and CCN number and organic functional group mass concentrations, as well as selected periods of hygroscopicity measurements, were collected from November 2015 to January 2017 at McMurdo Station (77°51'S, 166°40'E) in West Antarctica. Submicron aerosol particle number and organic functional group mass concentrations both were high during the two summers (357 cm-1 and 0.16 g m-3, December 2015 to March 2016 and October 2016 to December 2017) and decreased to background levels in the winter (58 cm-1 and 0.04 g m-3, April to September 2016). The influence from the local transportation emissions on organic functional group mass concentrations analyzed by Fourier transform infrared spectroscopy (FTIR) was identified by K-means clustering and Positive Matrix Factorization (PMF) of the IR spectra. The seasonal variation after removing these emissions indicates that the background aerosol particles in this region are largely of marine origin and that phytoplankton activity could be affecting primary aerosol formation from sea spray. In addition to amine groups typical of marine conditions, spectra also included peak shifts indicative of carbonyl groups that are consistent with amide and amino acid groups. The hygroscopicity measured by both CCN counter and HTDMA (Humidified Tandem Differential Mobility Analyzer) was nearly constant during the year. The number of CCN was 3-10 times higher in summer than in winter, tracking the change in particle number concentration.

2SA.1

Spatiotemporal Trends of Fine and Ultrafine Particulate Matter in Cincinnati, OH. SIVARAMAN BALACHANDRAN, Jonathan Corey, Farzan Oroumiyeh, Harika Tadepally, *University of Cincinnati*

Several studies are currently being conducted to better understand spatial and temporal variation of PM2.5 in the Cincinnati metro area. First, a temporal interpolation model is applied to Cincinnati's central air quality monitoring data. Results will be utilized by Cincinnati Children's Health Medical Center in time-series epidemiologic studies. Second, several years (2008 – 2015) of hourly and daily PM2.5 data at seven continuous monitors over a four-county region have been analyzed to understand the importance of local-scale emissions and activity in impacting spatial differences in pollution concentrations. One particular focus is on transportation patterns, which can aid in better estimating exposure in activity-based models. Finally, we have been conducting several field campaigns at a near-roadway monitoring site operated by the local air quality agency. The goal of this research work is to characterize the concentrations of fine particulate matter air pollution (PM2.5), noise and PM2.5 metals content resulting from near-road transportation under varying traffic states at fine temporal scales. The results will provide insight into better understanding of near real-time composition of the metals composition of fine particulate matter.

2SA.2

Source Apportionment of High Temporal Resolution PM1 Data for Delhi, India. Sahil Bhandari, DONGYU S. WANG, Shahzad Gani, Sarah Seraj, Zainab Arub, Gazala Habib, Joshua Apte, Lea Hildebrandt Ruiz, *University of Texas at Austin*

Exposure to fine particulate matter (PM) poses significant health risks, especially to residents in heavily populated areas. The current understanding of the sources and dynamics of PM pollution in developing countries like India is limited. Delhi, India is the second most populated city in the world that has year-round high PM concentrations and frequent severe pollution episodes. This study reports on composition measurements of non-refractory submicron aerosol at 1-minute time resolution in the winter and spring of 2017, collected at the Indian Institute of Technology Delhi using an Aerodyne Aerosol Chemical Speciation Monitor (ACSM) and refractory submicron aerosol black carbon (BC) measurements using an Aethalometer. Source apportionment was conducted on organic and inorganic mass spectra measured by the ACSM using Positive Matrix Factorization (PMF).

High concentrations of particulate matter were observed with total PM_1 at times exceeding 200 $\mu g\ m^{-3}$ in winter. A significant drop in PM_1 concentrations was observed in the winter-spring transition. Along with diurnal variation in total PM_1 mass loadings, particulate chloride levels also exhibited a strong diurnal cycle with concentrations as high as 50 $\mu g\ m^{-3}$ observed in the early morning. As observed elsewhere, organic species dominated the submicron mass, contributing 60% of the total mass over the duration of the campaign. However, this fractional contribution varied substantially over the day: from 48% early in the morning to 73% late at night. PMF receptor modeling identified several factors with distinct diurnal patterns. Interestingly, hydrocarbon-like organic aerosol (HOA) factor has the largest mass fraction contribution in PMF results. These results point to substantial differences in aerosol composition in Indian cities in comparison to cities around the world, especially with regards to the abundance of particulate chloride, and provide insights into the sources of PM_1 measured in Delhi.

2SA.3

Air Quality Impact of a Power Plant in the Midwest: High Resolution CMAQ-ISAM Modeling and Policy Applications. CAN DONG, Scott N. Spak, Robert Bullard, Elizabeth Stone, Charles Stanier, *University of Iowa*

The air quality in Johnson County, IA is representative of other Midwest communities of commensurate size. The University of Iowa Power Plant is located in the downtown area of Iowa City, the county seat of Johnson County. It is a very publicly visible source of emissions, but the nature of the emissions has changed over the past decade due to fuel switching, combustion upgrades, and pollution control equipment. To evaluate the impact of the power plant to local air quality, annual simulations (between 08/15/2011 and 09/15/2012) are performed using the Integrated Source Apportionment Method within Community Multiscale Air Quality model (CMAQ-ISAM) at a high resolution (0.444 km). Meteorological fields from and WRF 3.4.1, chemical initial and boundary conditions from GEOS-Chem are used to drive the CMAQ-ISAM model. Novel features of this work include: (1) high spatial resolution, making it a potential replacement for AERMOD dispersion modeling assessments of the power plant impact, (2) comparison to receptor-based assessment of emission sector impacts, and (3) comparison to “fenceline” measurements of NOx, SO2 and filter based measurements of PM2.5. Results are compared with a previous study which uses chemical mass balance modeling for PM2.5 organic carbon (OC) source apportionment at an urban site and a peri-urban site located in the study domain. Though over 60% of OC was not assigned, that study reports relatively consistent (spatially and temporally) mobile sources and variable OC contributions from biomass burning and secondary OC. Modeling results from different emission scenarios are also analyzed to investigate the potential effects of different air quality policies.

2SA.4

A Comparison of the Source Apportionment of Fine Particles Measured over a National Park in Central India Using PMF2 and US EPA PMF5.

SAMRESH KUMAR, Ramya Sunder Raman, Jayant Nirmalkar, *Indian Institute of Science Education and Research, Bhopal*

Fine particulate matter ($PM_{2.5}$) samples were collected every other day between 01 January 2012 and 31 December 2013 over a National Park in Bhopal, central India. 12 hour integrated (alternating between day and night) samples were collected onto different filter substrates using co-located Mini-Vol® samplers to measure the concentrations of fine PM mass, trace elements, thermal/optical carbon fractions and water soluble inorganic ions. The objective of this study was to use these measurements in a receptor modeling framework to identify the sources of $PM_{2.5}$ mass measured over the study location and to quantify their mass contributions.

Receptor models identify and apportion ambient aerosol mass using mass balance analysis. Positive Matrix Factorization (PMF) is a popular factor analytic model for aerosol mass apportionment. Over the years, several algorithms have been developed to solve the PMF problem, each with their own advantages and limitations. PMF-2 and multilinear engine (ME-2) are two such algorithms. In this study, PMF-2 and ME-2 (US EPA PMF5) will be applied to a combination of fine PM mass and 35 chemical (329 samples in all) to apportion the fine particle mass measured over Bhopal, India. The model apportioned factors and factor contributions obtained using these two PMF implementations will be compared.

2SA.5

Positive Matrix Factorization of Microscopy Data to Apportion Emissions Generated from an Automotive Repair Shop to Ambient PM10 in Rome, Italy.

TRACI LERSCH, Gary Casuccio, Roger R. West, Adriana Pietrodangelo, Tommaso Rossi, *RJ Lee Group, Inc.*

The Consiglio Nazionale delle Ricerche (CNR), or National Research Council, is conducting a study to better understand the composition of ambient particulate matter with the goal of improving the current knowledge on the relationship between anthropogenic emission sources and ambient concentrations. Passive and active samples were collected from an automotive repair shop in Rome, Italy, along with airborne particle samples from the surrounding neighborhood, to assess the localized impact of PM10 from the facility. Automated scanning electron microscopy (SEM) techniques were employed to provide quantitative information on individual particle characteristics at the source and receptor locations. Individual particle data can be a powerful source apportionment tool providing resolution on particle characteristics related to size, morphology and composition. Results obtained from the automated SEM analysis of the automotive repair shop emissions were used to develop source profiles applying positive matrix factorization. Frequently observed source profiles included carbon-rich particles and carbon-rich particles containing sulfur, calcium, barium, iron and/or copper. Also detected were silica particles, silicates, aluminum-rich silicates, calcium and/or barium sulfates, and metal particles (aluminum-rich or iron-rich) where copper and zinc may also be observed. Mixed particles represented an important contribution, too. These particles were composed mainly of carbon-silicate, carbon-sulfate or carbon-iron, suggesting an external mixing structure. This investigation examines the source profiles established from the automotive repair shop emissions, and further evaluates the impact of these emissions on the local ambient environment.

2SA.6

Sensitivity of Geographically-Distributed Precursor Emissions Reductions for Mitigating PM2.5 in the Kaoping Air Basin in Taiwan. CIAO-KAI LIANG, Jason West, Joshua Fu, Hsin-Chih Lai, Der-Min Tsai, Li-Wei Lai, *University of North Carolina at Chapel Hill*

For the purpose of air pollution management, Taiwan is divided geographically into seven air basins. Based on Taiwan EPA observation data, the KaoPing air basin has been recognized as a $PM_{2.5}$ nonattainment area and has had higher $PM_{2.5}$concentrations than other air basins. In addition, its location downwind of other source regions with poor atmospheric mixing, particularly in fall and winter, contribute to poor $PM_{2.5}$ air quality in the KaoPing air basin. Previous studies have shown that secondary aerosol formation was responsible for high $PM_{2.5}$ concentrations over southern Taiwan when prevailing winds are northeasterly, indicating that to design effective $PM_{2.5}$ control management strategies in the KaoPing air basin, a comprehensive understanding is required for how $PM_{2.5}$ responds to changes in its precursors from the local and upwind sources. Here, we study the effect of emission controls on the formation of $PM_{2.5}$ in the KaoPing air basin under the typical winter stagnation conditions that existed on 21–24 December 2010. The community multiscale air quality (CMAQv5.0.2) coupled with decoupled direct method for particulate matter (DDM/PM) will be used to investigate the sensitivity of $PM_{2.5}$ concentrations to changes in precursor emissions (i.e. primary PM, SO_2, NOx, VOC, and NH_3), and the contributions of local and upwind emissions. CMAQ is driven by meteorological fields generated by the Weather Research and Forecasting (WRF) version 3.4.1 model. Initial and boundary conditions were derived from the global chemical transport model GEOS-Chem. Emissions from the Taiwan Emission Data System (TEDS 8.1) are processed by the Sparse Matrix Operator Kernel Emissions (SMOKE) version 3.7 for input to CMAQ. A backward trajectory analysis was employed to locate the source of the accumulated $PM_{2.5}$. The result is expected to determine quantitatively which emission sources regions are responsible for $PM_{2.5}$ formation in the KaoPing air basin, and to characterize $PM_{2.5}$ sensitivities, to support the development of emission reduction management strategies.

2SA.7

Regional Nucleation Events and Sources of Submicron Particles in Rochester (NY). MAURO MASIOL, Stefania Squizzato, David C. Chalupa, David Rich, Philip K. Hopke, *University of Rochester School of Medicine and Dentistry*

Extensive measurements of particle number concentration (PNC) and particle size distribution (PNSD) have been performed in Rochester (NY) since 2001. These long-term data allow assessment of past and current mitigation strategies for air pollution in the Northeastern US. This study investigates the three most recent years of data (2014/16).

Results show an average of $4.3 \cdot 10^3$ particles/cm^3, of which $1.4 \cdot 10^3$, $2.3 \cdot 10^3$, and $0.7 \cdot 10^3$ particles cm^3 were classified as nucleation (14-30 nm), Aitken nuclei (30-100 nm) and accumulation (100-470 nm) ranges, respectively. Annually, total PNC show two maxima, one on February and one during summer (May to September), while the daily pattern of PNC show two peaks related to the traffic rush hours (one in the early morning, one in the late afternoon-evening). Nucleation sized particles also show an evident increase during daytime, which is broadly comparable with the nucleation events driven by photochemical transformations.

Positive matrix factorization (PMF) was applied to identify and quantify the major airborne particle sources. Data were separately analyzed for summer, winter, and transition periods. For each period, 5 to 7 factors were apportioned and identified (nucleation, traffic, domestic and residential heating, secondary aerosol and ozone-rich aerosol). The application of PMF post-processing tools was useful to: (i) study the patterns of sources; (ii) depict the role of atmospheric photochemical processes; (iii) examine the locations of potential local sources by mean of conditional bivariate probability function analysis and (iv) investigate the role of regional transport of air masses to the concentrations of resolved sources. Finally, the contour plots of SMPS data were examined: an algorithm was applied to identify potential nucleation events and distinguish them between traffic nucleation events and regional photochemical nucleation events.

2SA.9

Modeling the Impact of Cookstove Emissions on Ambient Aerosol in Rural India. BRIGITTE ROONEY, Kirk Smith, John Seinfeld, Ajay Pillarisetti, Rufus Edwards, Lauren Fleming, Sergey Nizkorodov, Tami Bond, Nicholas Lam, Sumit Sharma, Seema Kundu, Shaocai Yu, Pengfei Li, Kelvin Bates, Ran Zhao, *California Institute of Technology*

In India, particulate matter (PM) pollution is a significant cause of health problems and increased mortality. However, specific source contributions to PM have remained largely understudied, as work that has been done has mostly focused on indoor air quality. Within the residential sector, a majority of Indian households still rely on solid biofuels, mainly wood and dung, for cooking. Combustion of solid fuels is known to produce more aerosol than liquid fuels, and thus cookstove use has been identified as a potential significant source of PM pollution.

To better understand the production of ambient aerosol by the residential sector in rural India, we have undertaken a series of modeling experiments using the Community Multiscale Air Quality (CMAQ) atmospheric chemistry transport model. This work incorporates updated emissions inventories and time varying boundary conditions, and represents some of the highest resolution (1km and 4km grid cells) modeling of its kind. By varying such parameters as fuel type and emission factors, we are able to determine the fraction of PM attributable to cookstove use. Our expectation is that the results will further incentivize the transition from household use of solid fuels to more modern liquid fuels in order to reduce the health risks associated with aerosol pollution.

2SA.10

Changes in PM2.5 Sources across New York State during 2005-2015. STEFANIA SQUIZZATO, Mauro Masiol, Philip K. Hopke, David Rich, *University of Rochester School of Medicine and Dentistry*

The highest mass concentrations of airborne fine particulate matter ($PM_{2.5}$) and PM-bound sulfate of North America are recorded over the Eastern US, which also exhibits high concentrations of ammonium and elemental carbon. However, the emission scenario has significantly changed during the last decades (e.g., US standards for vehicle emissions, the implementation of the highway diesel fuel sulfur program, use of heating oil containing less than 15 ppm sulfur).
This study aims to detect the trends of the most impacting $PM_{2.5}$ sources across the state of New York in the last decade (2005-2015). $PM_{2.5}$ chemical speciation data were retrieved from the US-EPA Chemical Speciation Network (CSN, https://aqs.epa.gov/api). $PM_{2.5}$ samples were collected in 8 sites scattered over the State and characterized by different emission scenarios: 6 urban (Albany, Buffalo, Rochester, New York - Bronx, New York-Division St, New York - Queens) and 2 rural (Pinnacle and Whiteface) background sites.
Samples were analyzed for $PM_{2.5}$ mass, water-soluble inorganic ions (NH_4^+, K^+, Na^+, NO_3^-, SO_4^{2-}), elemental (EC) and organic (OC) carbon and elements with atomic number ≥1. The final dataset was split in pre-IMPROVE and post-IMPROVE OC/EC analysis.
EPA PMF 5.0 was applied to identify and apportion the most impacting sources on $PM_{2.5}$ over the sites. Subsequently, the Theil-Sen method coupled with the non-parametric Mann-Kendall approach has been used to analyze the inter-annual trends of extracted PM sources.
For example, 9 $PM_{2.5}$ sources were extracted for Queens all over the period: ammonium sulfate (accounting for 34% of $PM_{2.5}$mass), ammonium nitrate (17%), gasoline (15%), diesel (10%), biomass burning (6%), aged sea salt (5%), road dust (4%), residual oil (3%) and fresh sea salt (2%). Among the main $PM_{2.5}$ contributors, a significant decrease was observed for ammonium sulfate (-7% y^{-1}) and ammonium nitrate (-6% y^{-1}) whereas the emissions associated with gasoline vehicles increased (+6% y^{-1}).

2SA.11

Source Apportionment of Carbonaceous Ultrafine Particulate Matter (PM0.1) in Four Polluted Cities in California.

JIAN XUE, Wei Xue, Michael Kleeman, *University of California, Davis*

Recent epidemiological studies suggest that Ultrafine particles ($PM_{0.1)}$ is associated with a range of public health impacts including premature mortality. The potential public health burden of $PM_{0.1}$ can only be understood by monitoring ambient concentrations. In this study, a sampling network was deployed across four polluted California cities for one year (2015/2016) to measure the concentration and composition of PM0.1 to support an exposure assessment and source apportionment study. Two measurement sites were located in the San Francisco Bay Area (East Oakland and San Pablo), one site was located in Fresno, and one site was located in Los Angeles. PM0.1 samples were analyzed for trace metals, EC/OC fractions, and molecular markers. A chemical mass balance (CMB) receptor model using molecular markers was then applied to quantify PM0.1 contributions in major California cities.

The $PM_{0.1}$ carbonaceous concentration were highest in the largest cities, in the order of LA>East Oakland>San Pablo>Fresno, reflecting the effects of regional anthropogenic emissions. Winter concentrations were higher than summer concentrations by a factor of approximately 1.5-2. The major primary sources that contribute $PM_{0.1}$ OC in California cities include meat cooking (22-38%), biomass burning (8-30%), diesel exhaust (14-20%) and gasoline exhaust (8-18%). Wood burning (30%) and mobile exhaust (diesel+gasoline) (36%) were identified as the most important sources for $PM_{0.1}$ OC at the Fresno and LA sites, respectively. These locations also had a much higher fraction of unidentified source contributions (22-25% vs. 2-5% at the SF Bay Area sites), suggesting more important contribution from the secondary organic aerosol (SOA). Distinct seasonal variation was observed with wood burning, accounting for 30-60% of $PM_{0.1}$ OC in winter (negligible contribution in summer) and SOA accounting for 20-70% of $PM_{0.1}$ OC in summer (negligible contribution in winter). Diesel exhaust accounted for 60-80% of PM0.1 EC, with the rest mainly contributed by gasoline exhaust. These results will support the evaluation of future model calculations for $PM_{0.1}$exposure conducted across California for 2015/16.

2SA.12

Source Apportionment of Carbonaceous Aerosol in the San Joaquin Valley, California – Sensitivity to Seasonal Variation.

MICHAEL OLSON, Alexandra Lai, Min-Suk Bae, Qingyang Liu, Matthew Skiles, Benjamin de Foy, James Schauer, *University of Wisconsin-Madison*

One-in-three day $PM_{2.5}$ samples were collected at Bakersfield and Fresno California over a fourteen month time period in 2015 and 2016. Samples were collected in parallel with the Environmental Protection Agency Chemicals Speciation Network (EPA CSN) samples and were analyzed for elemental and organic carbon (EC/OC), water soluble organic carbon (WSOC) and organic molecular marker compounds. The EPA chemical mass balance (CMB) and positive matrix factorization (PMF) models were applied to identify major source contribution to ambient OC. The primary sources identified by CMB were biomass burning, mobile source, meat cooking, vegetative detritus and “Other OC” sources. The PMF model, used as an independent validation of the CMB results, identified biomass burning, mobile sources, food cooking, two SOA sources, and forest fire emissions. The models showed good agreement, identifying a strong wintertime contribution of biomass burning and a steady annual mobile source contribution. CMB profiles were applied to segregate the gasoline, diesel, and smoking vehicle contribution, however the mobile source split could not be identified due to observed collinearity. As a result, the CMB mobile was identified as the sum of CMB gasoline, diesel, and smoking vehicle. These results showed similar trends with the identified PMF mobile source. However, PMF OC apportionment was consistently larger than the CMB mobile, likely due to fast forming SOA Compounds. This is highlighted by the inclusion of secondary acids, typical of atmospheric oxidation, in the resulting source profile. Trend analysis of the organic compounds and meteorological simulations, performed using the Weather Research and Forecast (WRF) model, further allowed verification of the source apportionment results. Unique seasonal trends were identified for meat/food cooking sources and source specific organic tracers, which indicated sensitivity to both atmospheric processing and meteorological mixing and dilution. Biomass burning, food cooking, and CMB “other” showed strong seasonal trends. However, detailed understanding of these contributors requires trend analysis of chemical species and detailed meteorological analysis to develop an accurate understanding of source contribution to ambient PM mass over the annual cycle.

2SA.13

Concentrations and Chemical Compositions of Size-resolved Particulate Matter in the Southwest of Pearl River Delta (PRD) Region. Yuanxun Zhang, DONGQING FANG, Yuqin Wang, Wei Huang, Reza Bashiri Khuzestani, Jing Shang, *University of Chinese of Academy of Sciences*

The PRD region, one of the most economically developed areas in China, has long been suffered with severe air pollution which was probably caused by rapid population expansion and intense industrialization. To characterize the mass size distributions of chemical compositions, size-segregated samples were collected by 10-stage Micro-Orifice Uniform Deposit Impactor (MOUDI) at an Atmospheric Environment Monitoring Super-Station in Jiangmen city, Guangdong province during November, 2010. The samples were analyzed for gravimetric mass, water-soluble organic carbon (WSOC), water-soluble ions and elements.

The average mass concentrations of coarse, fine and ultra-fine particles were 42.06±24.77 μg m^{-3}, 90.6±11.46μg m^{-3} and 5.78±2.16 μg m^{-3}, respectively. The dominant mass component in coarse particles was crustal materials, while the major component in fine and ultra-fine particles was organic matter, determined by chemical mass closure. Bimodal size distributions were found for particulate matter (PM), WSOC and NO_3^-, with their dominant mode at 0.32-0.56μm and plus a coarse mode at 1.8-3.2μm. While SO_4^{2-} and NH_4^+ showed a unimodal size distribution at 0.32-0.56μm. The droplet mode was most prominent for Cl^-, Na^+ and K^+. Mg^{2+} was more prominent in the coarse mode, whereas a single coarse mode was found for Ca^{2+}. Most of size-resolve particle in HeShan tend to be weakly alkaline due to re-suspend road or crustal dust and sea salt while some fine particles was weakly acidic. The crustal elements, such as Al and Ti, were mainly distributed in coarse particles. Heavy metals (Cr, As and V) were mainly distributed in the fine particle fraction. The results of crustal enrichment factor (CEF) revealed that Ca, Na, Sm, Tb and Gd were from crustal source, and Zn, Pb, Mo, Tl and Ni from anthropogenic sources. Co, Mn and Rb in particles might be contributed by multi-sources.

The results showed that the PM and relevant components mass concentrations had been reduced significantly compared with other studies conducted in PRD region. The emission control and prevention policies obtained a remarkable effect and significantly improved local air quality. In addition, more attention of local governments should be paid to the ship emissions which could increase PM concentration.

2SA.14

Source Attribution with PMF of Recent Speciated PM2.5 in Bakersfield, California. Yufei Dong, SHANNON CAPPS, *Drexel University*

Concentrations of particulate matter less than 2.5 μm in diameter ($PM_{2.5}$) in Bakersfield, California, have been higher than most U.S. cities in recent decades. Significant portions of these aerosol are ammonium nitrate. Emissions controls on oxides of nitrogen (NO_x) have changed the mix of aerosols observed from 2001-2013 (Pusede et al., 2016). We investigate the sources contributing to recently observed aerosol to support selection of the next targets for emissions control. Specifically, we apply the Environmental Protection Agency's Positive Matrix Factorization (PMF) software to a multi-year set of filter-based observations of speciated $PM_{2.5}$from the California Air Resources Board site at Bakersfield, California. Seasonal patterns and annual trends in the contributions of factors that represent unique source types provide insight into opportunities to further reduce concentrations of $PM_{2.5}$ in this part of the San Joaquin Valley.

3AC.1

Molecular Characterization of Individual Chromophores in Atmospheric Brown Carbon. PENG LIN, Lauren Fleming, Nir Bluvshtein, Yinon Rudich, Sergey Nizkorodov, Julia Laskin, Alexander Laskin, *Pacific Northwest National Laboratory*

The chemical composition and optical properties of brown carbon chromophores pertinent to different biomass burning emissions are investigated using high performance liquid chromatography coupled to a photo diode array and high resolution mass spectrometry detectors. Brown carbon chromophores identified using this approach are attributed several classes of chemical compounds, with nitroaromatic compounds being the most common and most strongly absorbing species. In combination, nitroaromatic compounds account for 50-80% of the total visible light absorption (> 400 nm) by brown carbon extractable with water and organic solvents. Our results indicate that nitroaromatic compounds, in particular nitrophenols, are important brown carbon chromophores in aged biomass burning organic aerosol, suggesting that night time chemistry of $\cdot NO_3$ and N_2O_5 with particles may play a significant role in atmospheric transformations of brown carbon. The absorption spectra of the brown carbon chromophores were found to depend on the extraction solvent and on solution pH, implying that aerosol acidity is an important factor controlling light absorption properties of brown carbon.

3AC.2

Evolution of Optical Properties of Biomass Burning-Derived Particles. CHRISTOPHER CAPPA, Christopher Lim, David Hagan, Jesse Kroll, Matthew Coggon, Abigail Koss, Timothy Onasch, *University of California, Davis*

Biomass burning constitutes a substantial source of particulate matter to the atmosphere. Black carbon is a strongly absorbing component of particulate matter and can be emitted in large quantities from biomass fires. Biomass fires also emit organic aerosol (OA) particles. The light absorption properties of emitted OA is dependent upon the conditions of the fire at the time of emission and the fuel type. These emitted particles undergo chemical transformations post-emission, which alter their chemical and optical properties. There are few studies that have addressed how photochemical processing impacts the optical properties of biomass burning-derived particles. Here, we report on measurements of the optical evolution of freshly emitted biomass-derived particles and gases from a variety of sources as they are subject to photochemical processing. The measurements were made as part of the Fire Influences on Regional and Global Environments Experiment (FIREX) campaign at the Missoula Fire Sciences Laboratory. Using a novel oxidation chamber, continuous photochemical ageing of particles and gases up to many days of equivalent aging is carried out. We examine the extent to which photochemical processing alters properties such as the wavelength-dependent single scattering albedo and mass absorption coefficient. We discern differences in how oxidation impacts black carbon absorption versus absorption by OA, and how this depends on particle mixing state. We consider how the optical evolution depends on the fire conditions (e.g. flaming vs. smoldering) and fuel type.

3AC.3

Climate-Relevant Compounds Produced from Burning Forest Fire Fuels in Conjunction with the FIREX Campaign. LAUREN FLEMING, Sergey Nizkorodov, Peng Lin, Alexander Laskin, Julia Laskin, *University of California, Irvine*

Forest fires are increasing in intensity and frequency in North America due to 20th century land practices and climate change. This increase in particulate emissions, in the form of black carbon and organic carbon, in turn affects climate. Biomass burning organic aerosol is unique in that it contains highly absorbing organic molecules in the smoke plume. Our aim was to identify the main visible-light-absorbing molecules produced from burning a variety of forest fire fuels. Fuels were burned at the Missoula Fire Lab in the first phase of the FIREX campaign. Filter samples were extracted in solvents spanning a wide range of polarities and analyzed using an HPLC-PDA-HRMS platform. We found that the types of chromophores in smoke depend strongly on the fuel. Additionally, some filter samples were photolyzed with 300 nm radiation. This analysis made it possible to determine whether the identified chromophores are photo stable or photo labile in the atmosphere. This work provides an improved understanding of the main brown carbon molecules in forest fire smoke from different parts of the United States and Canada, and of the way these molecules are transformed in the atmospheric environment.

3AC.4

Speciated Chemical Composition of Biomass Burning Aerosol from Various Fuels during FIREX. Coty Jen, Lindsay Hatch, Nathan Kreisberg, Vanessa Selimovic, Robert J. Yokelson, Kelley Barsanti, ALLEN H. GOLDSTEIN, *University of California, Berkeley*

Biomass burning is the largest global source of atmospheric primary carbonaceous aerosols and the second largest global source of non-methane organic compounds, including volatile and semi-volatile organic compounds that are now understood to be major contributors to secondary particle formation in the atmosphere. As wildfires in forested regions, such as the western United States, become larger and more frequent, understanding the chemical composition of biomass burning organic aerosol is needed to better predict their increasing impact on human health, air quality, and climate. This study presents emission profiles of chemically speciated intermediate and semi-volatile organic compounds present in biomass burning aerosol particles ≤1.0 µm. Biomass burning organic aerosol (BBOA) samples from a variety of fuel types and burning conditions were collected during the FIREX campaign at the USDA Fire Lab (Missoula, MT). Fuels were primarily selected from vegetation commonly found in the western United States, such as ponderosa pine, lodgepole pine, ceanothus, and chaparral. Collected BBOA was thermally desorbed from the filters and analyzed using online derivatization and 2-dimensional gas chromatography with an electron impact (70 eV) and vacuum ultra violet light (10.5 eV) high resolution time of flight mass spectrometer for compound identification. Emission profiles for specific compounds (e.g., levoglucosan) and families of compounds (e.g., sugars and methoxyphenols) show distinct variations between different fuel types, with major differences between fresh and partially decomposed fuels. Results also illustrate the variability in chemical species between burns conducted under similar conditions. Furthermore, chemical fingerprints, representing ratios of normalized emissions for key chemical compounds, were measured for specific fuels/conditions and could be used in future field studies to help identify contributions of various vegetation to total BBOA and in models to estimate the chemical composition of BBOA emissions.

3AC.5
OH-initiated Aging of Biomass Burning Aerosol during FIREX. CHRISTOPHER LIM, David Hagan, Christopher Cappa, Jesse Kroll, Matthew Coggon, Abigail Koss, Kanako Sekimoto, Carsten Warneke, *MIT*

Biomass burning emissions represent a major source of fine particulate matter to the atmosphere, and this source will likely become increasingly important due to changes in the Earth's climate. Understanding the effects that increased fire emissions have on both air quality and climate require understanding the composition of the the particles emitted, as chemical and physical composition directly impact important particle properties such as absorptivity, toxicity, and cloud condensation nuclei activity. However, the composition of biomass burning particles in the atmosphere is dynamic, as the particles are subject to the condensation of low-volatility vapors and reaction with oxidants such as the hydroxyl radical (OH) during transport. Here we present a series of laboratory chamber experiments on the OH-initiated aging of biomass burning aerosol performed at the Fire Sciences Laboratory in Missoula, MT as part of the Fire Influences on Regional and Global Environments Experiment (FIREX) campaign. We describe the evolution of biomass burning aerosol produced from a variety of fuels operating the chamber in both particle-only and gas + particle mode, focusing on the organic composition. In particle-only mode, gas-phase biomass burning emissions are removed before oxidation to focus on heterogeneous oxidation, while gas + particle mode includes both heterogeneous oxidation and condensation of oxidized volatile organic compounds onto the particles. Variability in fuels and burning conditions lead to differences in aerosol loading and secondary aerosol production. Despite this variability, aging of all burns showed significant increases in average carbon oxidation state with OH exposure.

3AC.6
Chemical Characterization of Brown Carbon from Primary and Aged Biomass Burning Emissions during 2016 FIREX Campaign. TIANQU CUI, Sophie Tomaz, Yuzhi Chen, Shiva Tarun, Shantanu Jathar, Barbara Turpin, Jason Surratt, *University of North Carolina at Chapel Hill*

An important portion of light-absorbing carbonaceous constituents of organic aerosol (OA), referred to as brown carbon (BrC), can efficiently absorb near-UV and visible radiation, potentially altering Earth's radiative forcing and cloud formation. In some instances, BrC can also contribute a considerable mass fraction of OA. Since BrC comprises a wide range of poorly characterized compounds and can be emitted primarily from biomass burning (BB), molecular-level characterization of OA derived from BB emissions becomes imperative to evaluate the impacts of BrC species on air quality and climate.

The study presented here involves the determination of the identities, quantities, and other key properties of BrC emitted directly by 107 "stack" or "room" combustion events of 39 fuel types (mostly biomass from western North America), systematically performed at the Fire Science Lab, Missoula, MT, during the 2016 Fire Influence on Regional and Global Environments Experiment (FIREX) campaign. In addition, select primary BB emissions of certain fuel types were aged in the Colorado State University (CSU) portable smog chamber to determine how photochemical reactions may alter primary BrC or produce new types of BrC not found in the original primary fraction. Teflon filter and particle-into-liquid sampler (PILS) samples of PM2.5 were collected from all the controlled combustion emissions and chemically characterized at the molecular level by (1) ultra performance liquid chromatography (UPLC) coupled to diode array detection (DAD), and to electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry (ESI-HR-QTOFMS) operated in both positive and negative ion modes; and (2) gas chromatography interfaced with electron ionization mass spectrometry (GC/MS) with prior trimethylsilylation. Preliminary findings show excellent identification of well-established BB-derived products and a number of known BrC species from primary emissions, enabling us to further investigate their quantities, composition, contribution and other properties associated with varying fuel types and burn conditions.

3AE.1

Workplace Ultrafine Particle Respiratory Deposition Measurement.

WEI-CHUNG SU, , *University of Texas Health Science Center at Houston*

Ultrafine particles (UFPs) in the workplace has been an important occupational health concern. Many workplace operational processes such as welding and high-speed grinding are known to generate UFPs in the workplace. The inhalation and the consequent deposition of UFPs in the worker's lower airways could lead to adverse health effects. Therefore, investigating the deposition of UFPs in the human respiratory tract is extremely vital from the viewpoint of occupational health. The experiment of UFP respiratory deposition can provide important information on the fate of inhaled UFPs in the lung airways and can be used to estimate the UFP inhalation dosimetry. However, due to the limitations of the current experimental method, it is extremely difficult to conduct UFP deposition experiments in human airway replicas. As a result, the nature of UFP deposition in the human airways remains not well understood. To fill this gap, a novel experimental method was developed in this study to measure the UFP respiratory deposition. A hollow human tracheobronchial airway replica down to the 10th lung generation was made by a 3D printer (with a total of 1,024 lung tube outlets). The tracheobronchial airway replica along with a human oral airway replica were used to construct a simplified human airway system. With the assistance of two GRIMM SMPS+C systems connected at the inlet and outlet of the simplified human airway system, the deposition of UFP in the airway replica could be correctly estimated according to the difference of the UFP concentrations measured. The performance evaluation and the deposition results acquired in this study showed that UFP respiratory deposition data could be directly and systematically measured for the 1st to 10th lung generations by the novel experimental method developed. The deposition data acquired can be used for developing worker UFP exposure index and also for validating relevant numerical simulation data.

3AE.2

Laboratory Evaluation of a Novel Real-time Respirator Seal Integrity Monitor.

BINGBING WU, Michael Yermakov, Yan Liu, Jonathan Corey, Sergey A. Grinshpun, *University of Cincinnati*

Firefighters are exposed to high concentrations of toxic particles, of which >99% are submicron (< 1 micro-meter) and >70% are ultrafine (< 0.1 micro-meter). Elastomeric respirators equipped with P-100 filters worn by firefighters during the fire overhaul stage provide extremely high protection against relatively large particles (~1 micro-meter). Therefore, significant increases in the concentration of these particles inside a well-fit, high-efficiency respirator can be considered as a fair indicator of its performance failure. This idea was utilized for the development of a novel Respirator Seal Integrity Monitor (ReSIM), which deploys a portable optical Particle Sensor Unit that detects particles size of ≳0.5 micro-meter and can identify respirator leakage in real time. In this study, the ReSIM was subjected to laboratory testing. First, the prototype was exposed to pre-determined concentrations of different aerosols, including monodisperse polystyrene latex (PSL) spheres and polydisperse NaCl particles in a controlled flow-through setting. The ReSIM responses in a concentration range of 0.5 to 300 cm^{-3} were calibrated against a reference optical size spectrometer (Grimm PAS 1.108: 0.3–20 micro-meter). Second, the effectiveness of the prototype was tested in an aerosol exposure chamber using a respirator-wearing manikin with controlled leaks. Results show that the ReSIM responded rapidly with sufficient sensitivity and accuracy. The aerosol number concentration measured with ReSIM strongly correlated with that measured with Grimm (R^2=0.936) in the chosen concentration range, which represents various levels of aerosol contamination. The ReSIM prototype revealed a leak detection accuracy of 92% over 1080 data processing intervals. This investigation demonstrates that ReSIM is capable of rapidly detecting a respirator performance failure and thus can be deployed to alert a respirator wearer of a sudden increase in their aerosol inhalation exposure during the work activity. This is a particularly important feature for firefighters, first responders and other groups.

3AE.3

Personal Exposure to Black Carbon and PM Oxidative Potential in Fresno, CA using an Automated Microenvironmental Aerosol Sampler (AMAS). CASEY QUINN, Dan Miller-Lionberg, Kevin Klunder, Jaymin Kwon, Betsey Noth, John Mehaffy, Laurelle Turner, Sheryl Magzamen, S. Katharine Hammond, Charles Henry, John Volckens, *Colorado State University*

Human exposure to particulate matter is a leading risk factor for disease and premature death. Current methods for assessing time-integrated personal exposure are cumbersome and relatively expensive, especially in the context of large-scale epidemiological studies. To address these limitations, we developed an automated microenvironmental aerosol sampler (AMAS). The AMAS is a low-cost, wearable device with a GPS-based algorithm that detects predetermined microenvironments (home, school, other) and collects PM2.5 particulate matter from each microenvironment on distinct 15mm filter channels. A pilot study in Fresno, CA enrolled 25 student participants to collect 42 microenvironment personal samples (139 filters) in November 2016. To measure reliability, 10 AMAS samples were paired with a reference instrument. Black carbon (BC) was quantified using optical transmissometry, and the oxidative potential (OP) on the AMAS filters was quantified with both the traditional dithiothreitol (DTT) assay and an electrochemical DTT assay. Participants spent an average of 31.5, 12.8, and 4.5 hours of the 48-hour sampling period in each microenvironment (home, school, other) based on the algorithm classification. The analytic techniques provided reliable, low-cost analyses, with method detection limits of: BC [0.485 μg LOD]; OP [0.252 $\mu M*min^{-1}$ LOD]. The BC sum on the AMAS filters had a mean error of 14% as compared to the reference filter. The BC and OP cumulative exposures were greatest at home(1.48μg, $0.290\mu M*min^{-1}$) compared to the school(0.391μg, $0.159\mu M*min^{-1}$) and other microenvironments(0.591μg, $0.192\mu M*min^{-1}$). While a strong correlation between BC and OP (R=0.66) was found, the number of filters exceeding the LOD for each analysis (76 BC, 42 DTT) was low. Future work will modify the AMAS to increase the volume of sample collected on each filter to improve the filter analyses. The results from this pilot study indicate that the AMAS is a feasible approach for low-cost, personal exposure assessment of BC and OP within microenvironments.

3AE.4

A Sensor Network for Multiple Hazards in Heavy-Vehicle Manufacturing. THOMAS PETERS, Sinan Sousan, Alyson Gray, Laura Hallett, Geb Thomas, Xiaoxing Liu, Christopher Zuidema, Kirsten Koehler, *University of Iowa*

Personal exposure sampling is the primary means to ensure that gaseous and aerosol hazards in the workplace are maintained below occupational exposure limits, although few exposures are measured to represent a large working population due to costs and time constraints. A novel sensor network for chemical hazards (aerosols, oxidative gas, and CO) and a physical hazard (noise) was developed and deployed in a heavy-vehicle manufacturing facility over a one-year period. Focusing on aerosol sensing, this presentation reviews development of a wireless monitor that served as individual nodes of the network, laboratory testing of 50 monitors, field validation of monitor performance over time, and spatial and temporal observations from network data. Laboratory tests revealed the need to select aerosol sensors 50 units from 100 based on preliminary data that best matched each other to minimize uncertainties in measurement. Field tests showed that active aerosol sensors (Sharp DN) rapidly became dirty (days to weeks), which caused substantial drift in zero values. Passive samplers (Sharp GP) provided similar information as the active sensors with substantially less zero drift. Comparison of monitor data compared to that from a reference photometer and gravimetric samplers demonstrated the value in performing periodic field verification of sensor performance. Temporal-spatial analysis of network data showed how aerosols move through the facility, enabling identification of key sources and targets for upgrades in controls. This type of network monitoring has potential for dramatically increasing the sample size, even if somewhat less accurate and precise than conventional sampling, upon which important decisions in industrial hygiene practice are made. Such a network may also facilitate medical surveillance and epidemiological study.

3AE.5

Facilitating Real-Time Exposure Studies on Traffic Related Air Pollution. Keith Bein, Christopher Wallis, Yongjing Zhao, ANTHONY WEXLER, *University of California Davis*

Toxicological studies continue to demonstrate causal relationship between exposures to traffic related air pollution (TRAP), including gases and particles, and various metrics of adverse pulmonary, cardiovascular and neurological health effects. The key challenge in these studies is replicating true human exposure in models that mimic human biology on accelerated time scales with sufficient resolution in physiological and/or behavioral response to demonstrate statistical significance. A core need is an exposure paradigm that addresses these issues in a robust and dependable manner. It is hypothesized that a roadway tunnel system provides a platform for acute and chronic exposure studies that maximizes toxicological response and minimizes bias by allowing for real-time exposure to concentrated ambient TRAP. The objective of this research is to design, construct and implement a core exposure and measurement facility above the eastbound bores of the Caldecott tunnel in California's Bay Area. First results from the operational characterization of this facility will be presented, including full physical and chemical characterization of the exposure environments.

3AE.6

Evaluation of the Transferability of Resolved Vs Unresolved Land Use Regression Models for Traffic-Related Air Pollutants. KEROLYN SHAIRSINGH, Cheol H. Jeong, Greg J. Evans, *SOCAAR, University of Toronto*

Land use regression (LUR) models are statistical models used to predict intra-urban variability of air pollution and are frequently employed in mapping human exposure to traffic-related air pollutants. While LUR models developed for a specific city should be able to predict concentrations in other cities with similar infrastructure, land use, topography and climate; this transferability of models generally has been poor.

In this study, we resolved mobile monitored high-resolution concentrations of black carbon (BC), ultrafine particles (UFP), nitric oxide (NO) and nitrogen dioxide (NO_2) into local and background signals, using time averaged minimum values, to investigate whether separation of the ambient measurements will improve LUR transferability. LUR models based on the unresolved (total) and resolved (local and background) input data were then developed for Toronto, Canada. These unresolved and resolved models were transferred to cities outside of the model domain, and their predictive performances were evaluated.

Our results showed that resolved models moderately improved the transferability of UFP and NO_2. The resolved and unresolved models displayed R^2 of 0.54 and 0.54 for UFP and 0.60 and 0.62 for NO_2, respectively. When transferred to cities outside of the model domain, the local models displayed the lowest reduction in R^2 for all pollutants, while background models transferred better than total models for UFP and NO_2. This resulted in better transferability of the resolved models for NO_2 (R^2=0.36) and UFP (R^2=0.3) when compared to their unresolved models (NO_2:R^2=0.26, UFP: R^2=0.22).

3AP.1

Kinetic Percolation. CHRIS SORENSEN, William Heinson, Amit Chakrabarti, *Kansas State University*

We demonstrate that kinetic aggregation forms superaggregates that have structures identical to static percolation aggregates, and these superaggregates appear as a separate phase in the size distribution. Diffusion limited cluster-cluster aggregation (DLCA) simulations were performed to yield fractal aggregates with a fractal dimension of 1.8 and superaggregates with a fractal dimension of $D = 2.5$ composed of these DLCA supermonomers. When properly normalized to account for the DLCA fractal nature of their supermonomers, these superaggregates have the exact same monomer packing fraction, scaling law prefactor, and scaling law exponent (the fractal dimension) as percolation aggregates; these are necessary and sufficient conditions for same structure. The size distribution remains mono-modal until these superaggregates form to alter the distribution. Thus the static percolation and the kinetic descriptions of gelation are now unified.

3AP.2

Mobility and Sedimentation of Agglomerates with Polydisperse Primary Particles. Anastasia Spyrogianni, Katerina S. Karadima, Eirini Goudeli, Vlassis G. Mavrantzas, SOTIRIS E. PRATSINIS, *ETH Zurich*

The precipitation of agglomerates is important in water cleaning, pharmaceutical processing, nanotoxicology and nanomedicine as well as for the stability of engineered nanofluids. Here, the mobility of nanosized fractal-like SiO_2 agglomerates in water is investigated and their settling rate in infinitely dilute suspensions is calculated by thoroughly validated Brownian dynamics tracking the agglomerate translational and rotational motion. Agglomerates are generated by an event-driven method (1) and have constant mass fractal dimension of 1.80 ± 0.01 but varying primary particle (PP) size distribution, mass and relative shape anisotropy. The calculated diffusion coefficient is used to obtain their mobility diameter d_m, which is in excellent agreement with that from scaling laws for fractal-like agglomerates (2). The agglomerate mobility to gyration diameter ratio, d_m/d_g, decreases with increasing relative shape anisotropy κ^2. For constant d_m, the agglomerate settling rate, u_s, increases with increasing PP diameter and geometric standard deviation $\sigma_{p,g}$ (polydispersity). A linear relationship between u_s and agglomerate mass to d_m ratio, m/d_m, is revealed leading to an analytical expression for calculation of u_s for agglomerates consisting of polydisperse PPs. This expression shows that the commonly-made assumption of monodisperse PPs underestimates u_s by a fraction depending on $\sigma_{p,g}$ and the agglomerate mass mobility exponent. For constant fractal dimension, increasing the PP polydispersity decreases the average agglomerate d_m but increases the average u_s. Simulations are in excellent agreement with precipitation rate measurements of steel (3) and SiO_2 (4) agglomerates in oil and water, respectively.

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3AP.3

Determination of the Binding Rate for Nanoclusters in the Gas Phase via Molecular Dynamics. EIRINI GOUDELI, Huan Yang, Christopher Hogan Jr., *University of Minnesota*

The earliest stages of nanoparticle formation and growth in the gas phase involve collisions and subsequent binding/reaction between molecular (or atomic) monomers and a growing nanocluster. In modelling nanocluster collisional growth rates, simplified approaches are often adopted, in which the binding rate (collision + sticking rate) is calculated assuming hard-sphere potential interactions between colliding entities and assuming a sticking efficiency of 100%. This approach neglects potential interactions between monomers and nanoclusters and does not accurately consider kinetic energy to internal energy exchange during collision (i.e. the assumption of perfect sticking is akin to assuming all monomer kinetic energy is lost during collision).

In this presentation, we show that it is possible to utilize Molecular Dynamics (MD) simulations to examine nanocluster-monomer collisions and sticking with accurate description of potential interactions (which increases the binding rate as compared to the hard-sphere approach) and kinetic-internal energy exchange during collision (which decreases the binding in comparison to conventional approaches). A framework is presented in which the binding probability is systematically determined as a function of monomer relative velocity, impact parameter, and nanocluster temperature. The binding rate can be determined directly once the binding probability function is obtained. Specific examples for Au nanoclusters and polyaromatic hydrocarbon clusters with short chain alkenes (precursors to soot) are provided.

3AP.4

Calculating the Translational Friction Coefficient of DLCA Aggregates in the Transition Regime using Extended Kirkwood-Riseman Theory. JAMES CORSON, George Mulholland, Michael Zachariah, *University of Maryland*

Knowledge of the friction coefficient is crucial to predicting particle diffusional, phoretic, and electrostatic behavior in real-world applications involving aggregate particles. Our study focuses on predicting the friction coefficient in the transition regime for clusters of spherical particles. We present results of our extended Kirkwood-Riseman method for the translational friction coefficient of DLCA aggregates in the transition flow regime. The EKR method is based on Kirkwood-Riseman theory for the continuum regime, which considers the effects of the individual spheres in an aggregate on the fluid flow pattern. These effects are quantified using a hydrodynamic interaction tensor evaluated for each pair of spheres in the aggregate. Our EKR method replaces the continuum hydrodynamic interaction tensor and monomer friction coefficient with appropriate Knudsen-number-dependent expressions obtained by solving the Boltzmann equation with the Bhatnagar-Gross-Krook model in place of the Boltzmann collision operator. EKR calculations are in good agreement with published experimental data, results of direct simulation Monte Carlo calculations, and values obtained using the adjusted sphere method of Dahneke (1973) and Zhang et al (2012). Our results show that aggregates exhibit more continuum-like behavior as both the primary sphere size and number of spheres increases. The shift to continuum behavior is evident for large aggregates even when the primary sphere size is smaller than the gas mean free path. We introduce an analytical expression for the translational friction coefficient of DLCA aggregates as a function of the primary sphere size and the number of primary spheres. This expression is in good agreement with our EKR method for Knudsen numbers between 0.01 and 100.

3AP.5

Investigating the Coagulation Coefficient and Sticking Probability of Nanoparticles at High Temperatures.

GIRISH SHARMA, Yang Wang, Rajan Chakrabarty, Pratim Biswas, *Washington University in St Louis*

Nanoparticles are widely synthesized using high temperature flame and furnace aerosol reactors (800-2000 K). At such high temperatures, the particles collide with each other and coagulate to form larger particles. The Fuchs-Sutugin interpolation expression is widely used to calculate the coagulation coefficient in the free molecular, continuum and transition regime. This theory is verified both experimentally and through modeling, but only at ambient temperatures. Ideally, a factor of sticking probability should be incorporated, especially at high temperatures while calculating the coagulation coefficient, which is usually assumed to be unity. A few previously reported modeling studies have shown that the sticking probability, even at ambient temperatures, is less than 1 for free molecular regime because of high thermal velocity of the nanoparticles. In fact, at high temperatures, this value should be much less than 1 because of even higher thermal velocity of these particles.

In this work, the aim is to investigate the coagulation coefficient and sticking probability of nanoparticles at high temperatures. To achieve this, particles with different initial lognormal size distributions are passed through furnace at different temperatures and final size distribution is measured using scanning mobility particle sizer (SMPS). The experimental measurement is then coupled with the theoretical aerosol dynamic equation to determine the exact coagulation coefficient as a function of different particle sizes and furnace temperatures. The coagulation coefficient, thus obtained is compared with the Fuchs-Sutugin expression to get the size and temperature dependent sticking probability.

3AP.6

The Collision Rates of Charged Aerosol Particles in Shear Fields.

HUAN YANG, Christopher Hogan Jr., *University of Minnesota*

Collisions between charged particles have a large influence on the behavior of many aerosol systems (e.g. in fluidized beds, electrostatic precipitators, volcanic plumes, and dust storms). Accurate collision rate calculations for charged species can therefore be of critical importance in predicting aerosol behavior. In determining particle-particle and particle-ion collision rates, the influence of thermal (Brownian) energy is often considered simultaneously with the influence of electrostatic energy, and a number of prior works have been devoted to collision rate calculation considering combined Brownian and electrostatically driven motion. However, for submicrometer and supermicrometer particles, Brownian motion is often negligible in comparison to the influence of differential motion brought about by laminar (linear) shear gradients present in flowing aerosols. Despite their potential significance for sub- and supermicrometer particles, it appears that the combined influences of shear and electrostatic potentials on particle-particle/particle-ion collisions in aerosols have not been investigated previously.

In this study, we have developed a trajectory calculation based approach to determine the collision rate coefficient between particles, accounting for the simultaneous effects of laminar shear gradients and electrostatic potentials (both attractive and repulsive). We additionally consider finite particle inertia (e.g. Stokes number effects). In this presentation, we outline the numerical approach developed, and present non-dimensionalized equations (dependent upon the Stokes number, electrostatic to kinetic energy ratio, and the particle size ratio) which enable simple calculation of collision rate coefficients in a wide range of circumstances.

3BA.1

Inactivation of Aerosolized Bacillus Anthracis Surrogates by Combustion Products of Energetic Powdered Materials: Effect of Exposure Time. WORRAWIT NAKPAN, Michael Yermakov, Reshmi Indugula, Tiina Reponen, Song Wang, Mirko Schoenitz, Edward Dreizin, Sergey A. Grinshpun, *University of Cincinnati*

The bio-weapon stockpiles and facilities can be targeted militarily in a terrorist attack. In case of an explosion or fire outbreak, highly pathogenic microorganisms may become airborne and subjected to atmospheric transport, which represents a high-level health risk for millions. There is evidence that some bio-threat agents such as *Bacillus anthracis* bacterial spores are extremely stress-resistant and may survive harsh conditions. As novel biocidal materials are being developed to neutralize the threat, it is important to better understand and quantify the response of viable airborne spores to environmental conditions, including thermal and chemical stresses. In this study, combustion products of different materials (Al, $Al•I_2$, $Al•B•I_2$, Mg, Mg•S, and $Mg•B•I_2$) were examined with respect to their ability to inactivate aerosolized spores of *Bacillus thuringiensis var kurstaki* (Btk), a well-recognized surrogate of *B. anthracis*. An inactivation factor (IF) was determined as a function of the spore exposure time, approximately from 0.1 to 2 seconds. The IF-value was quantified by comparing culture-based counts from the combustion-exposed and non-exposed samples. The tests were conducted at two air temperatures: weighted average ≈170°C (below the iodine boiling point) and ≈260°C (above it). The inactivation effect generally increased exponentially with exposure time. Under low temperature condition, the chemical effect of iodine was negligibly small while it became significant when the temperature was high enough for iodine to remain in the gaseous phase and continue inactivating the aerosolized spores over the entire exposure period. Combustion products of several new composite materials were found to effectively inactivate the aerosolized spores suggesting, in addition to the iodine effect, a significant chemical inactivation from boron and oxidation of magnesium. The results demonstrate a complex kinetics of the spore inactivation process. This investigation will contribute to major bio-agent defeat programs.

3BA.2

Airborne Inactivation of Bacteriophage MS2 by a Packed Bed Dielectric Barrier Discharge Non-thermal Plasma. TIAN XIA, Abby Kleinheksel, Eric Monsu Lee, Zhong Qiao, Krista Wigginton, Herek Clack, *University of Michigan*

Transmitted diseases are one of the greatest threats to modern agriculture and food security, reducing crop yields, diminishing animal productivity and increasing animal mortality. The building construction, air flows, and indoor volumes that typify existing animal confinement buildings present multiple challenges to the implementation of HEPA filtration or UV germicidal irradiation for preventing infectious disease transmission in ventilation air. A packed bed dielectric barrier discharge (DBD) non-thermal plasma reactor was designed and constructed for the purpose of developing a novel airstream disinfection technology. Bacteriophage MS2 was aerosolized by a nebulizer and suspended in an air flow that passed through the reactor. Two impingers sampled the virus-loaded air flow at both upstream and downstream positions in the reactor, and the samples were subjected to plaque assay and quantitative polymerase chain reaction (qPCR) analyses to determine the pre- and post-treatment abundance of infective MS2 (from plaque assay) as compared with the abundance of the viral genome (from qPCR), whether infective or rendered inactive. The results indicated that at a constant air flow rate of 171 liters per minute using a fixed 30 kV power supply, the reactor can achieve over 2.3 log reduction in infective MS2 by inactivation and ~0.35 log reduction in the abundance of the MS2 genome by physical filtration. With a variable 20 kV power supply, inactivation effectiveness varied proportionally with applied power, the highest inactivation efficiency reaching 90%. Ozone was generated by the reactor, but an ozone filter installed downstream of the reactor effectively counteracted the ozone increase and maintained ozone concentrations near the regulated levels applicable to indoor air cleaners. With further optimization, non-thermal plasma can be a viable technology for airstream disinfection and prevention of airborne disease transmission.

3BA.3

The Effect of Relative Humidity on the Viability of Airborne Bacteria and Viruses. KAISEN LIN, Aaron Prussin II, Eric Vejerano, Linsey Marr, *Virginia Tech*

Many pathogenic bacteria and viruses have been isolated from air samples in different environments. These bioaerosols can be emitted not only by infected humans and animals but also by wastewater treatment plants, animal feeding operations, land application of biosolids, toilets, showers, and ultrasonic humidifiers. While being transported in the atmosphere, microorganisms may be subject to loss of viability. For improved understanding of the microbial ecology of the atmosphere and the transmission and control of infectious disease, it is important to identify the factors that affect the viability of aerosolized bacteria and viruses. Previous studies have demonstrated that relative humidity (RH) may affect microorganisms' viability and infectivity. However, conflicting results have been reported. In this study, we investigated the influence of RH on the viability of gram-negative and gram-positive bacteria (E. coli and M. smegmatis) and unenveloped and enveloped viruses (MS2 and Phi-6) at RHs of 20%, 40%, 60%, 80%, and 100% in a custom rotating chamber. The microorganisms were aerosolized, kept suspended for an hour, and collected onto gelatin filters for determination of viability. Bacterial viability was higher under more humid conditions in general. Over 90% of E. coli survived after 1 hour of aging at 100% RH. The viability of E. coli decreased approximately monotonically with RH, while the viability of M. smegmatis was highest at 100% and 60% RH and was reduced at 80% RH. We expect to find different results with the viruses. Complementary studies of the physical and chemical composition of aerosols as a function of RH will help illuminate the mechanisms of inactivation.

3BA.4

Evaluation of Multiple-antibiotic Resistant Gram-negative Pathogenic Bacteria in the Bioaerosols of a Pharmaceutical Wastewater Treatment Plant in Northern China. ZHANG MENGYU, Zuo Jiane, *Tsinghua University*

An investigation on multiple antibiotic resistant level of the Gram-negative human opportunistic pathogenic bacteria in bioaerosols at a pharmaceutical WWTP (wastewater treatment plant, WWTP) mainly treating cephalosporin producing wastewater, a municipal WWTP and a residential community in northern China was performed in this study. Air samples in the around the pharmaceutical WWTP were collected over several months. At the same time, bioaerosol samples obtained from a municipal WWTP and a residential community were used as control. The species of isolated Gram-negative bacteria strains were identified, and if they were opportunistic pathogens, antibiotic susceptibility tests against 18 commonly used antibiotics including 11 βeta-lactam antibiotics and 7 other types of antibiotics were conducted. The results indicated the dominant genus of isolated opportunistic pathogenic bacteria from all bioaerosol samples were *Acinetobacter, Alcaligenes, Brevundimonas, Citrobacter, Enterobacter, Escherichia, Klebsiella, Pantoea, Pseudomonas* and *Sphingomonas*. The results of antibiotic susceptibility tests at sampled sites were serious. Over 50% of isolated strains were resistant to several antibiotics such as ampicillin, nitrofurantoin and so on. Moreover, the proportion of βeta-lactam antibiotics resistant strains in the bacteria isolated from the bioaerosols above or around the aeration tanks in the cephalosporin producing wastewater treatment plants were generally higher than those in the residential community and the municipal WWTP, which indicated aeration had significant impact on the frequency of antibiotic resistant bacteria in the air near WWTPs. Moreover, according to the multiple antibiotic resistance (MAR) index, air environment in and around the cephalosporin producing WWTP was to be a high-risk antibiotic-exposed site, which might cause potential hazard for the health of the staff and residents in neighborhood.

3BA.5

Spatial and Temporal Tracking of Pathogenic Bioaerosols in Beef Slaughter Facilities Using Airflow Model Based Dynamic Monitoring Techniques. Samuel Beck, Alejandro Castillo, Zahra Mohammad, Juan Pedro Maestre, Kerry Kinney, Yassin Hassan, MARIA D. KING, *Texas A&M University*

The air in beef harvesting establishments has been tested for the presence of aerosolized Shiga-Toxin Producing Escherichia coli (STEC) and Salmonella at small-sized facilities in Texas using the wetted wall cyclone (WWC) air sampling system units placed at various stages along the harvesting process. The air samples were tested by a quantitative, real time Polymerase Chain Reaction method (qPCR), with confirmation by selective microbial plating. In addition, DNA from the samples was extracted and sent for Illumina sequencing to delineate the aerosolized microbiome. This also permits confirmation of any STEC and Salmonella-positive samples. To this date, two abattoirs (Establishments A and B) with different ventilation methods have been sampled multiple times each. At this first stage, stationary WWCs were placed at the stunning, hide pulling area, carcass splitting and carcass washing stations for an entire day. In addition, portable (dynamic) WWCs were placed for 15 min at various stations of the process following the carcass flow. Furthermore, the air at the feedlot that supplied Establishment A was also sampled using a hexacopter aerial sampler and tested for STEC and Salmonella. Based on qPCR analysis both STEC and Salmonella were detected inside both establishments in increasing counts with each passing day.

When determining total bacterial counts, it was evident that the design of HVAC system is of great importance to prevent transporting aerosols from heavily contaminated areas to cleaner areas such as the carcass wash-station or chillers-fabrication. Using computational fluid dynamics airflow pattern models were created for each abattoir to enable the tracking of the sampled pathogens. Based on the modelling, new HVAC systems were designed to limit the spread of bioaerosols. For both abattoirs, displacement ventilation was found to be most effective at reducing particle spread and significantly increasing plant sanitation.

3BA.6

Transport and Characterization of Particulate Emissions from Three Wastewater Treatment Plants in Southern California. Pedro Piqueras, Md Robiul Islam, Fengying Li, Leigha Meredith, Mark Matsumoto, Elizabeth Stone, AKUA ASA-AWUKU, *University of California, Riverside*

Wastewater treatment plants (WWTP) are proliferating in urban environments and their aerosol emissions have been associated with local and regional health burden. Known toxic compounds and pathogens have been detected in neighborhoods surrounding the plants but their concentration and classification are still dubious. The airborne exposure route is also still poorly established due to the lack of information on aerosol characterization and transport.

This study presents a WWTP particulate dispersion analysis through the AMS/EPA Regulatory Model (AERMOD) and establishes a relationship between basin coverage, source emission flux and dispersion: Three coverage scenarios (fully covered basin, semi-covered and covered) were modeled with annual, monthly and daily meteorological data. In addition, filter samples were collected from three WWTP along the Santa Ana River Watershed in Southern California: Orange County Sanitation District (OCSD) in Fountain Valley, Western Municipal Wastewater Treatment Plant (WMWWTP) in Riverside, and the City of Redlands Wastewater Treatment Plant (RWWTP). These specimens were collected at the WWTP source, 100 m upwind and 50 m, 100 m and 200 m downwind for quantification and characterization of organic compounds, endotoxins, fungal glucans and proteins. Filter data was later compared with particulate concentrations obtained from a laboratory bioreactor.

Results suggest that biological materials that are being generated through bubble bursting in WWTP are transported away from the source. Fecal sterols and some PAH were found in the WWTP samples with concentrations as high as 200 ng/m3 (cholesterol). Endotoxins were also observed (maximum of 130 EU/m3 at WMWWTP, 20 EU/m3 at OCSD and 2.17 EU/m3 at RWWTP). Protein levels reached 1.10 µg/m3 and glucan concentrations ranged from 0.01 to 1.07 µg/m3. It was also determined that partial coverage of the basins does not efficiently reduce the particulate emissions as previously thought. This indicates that aerosols may cause disease in neighborhoods and public spaces as far as 200 meters away from the source. Therefore a full coverage of the basin is advised to mitigate WWTP aerosols.

3CC.1

Absorption Enhancement and Optical Properties of Black Carbon – Aging Diesel Emissions with Alpha-Pinene SOA Coatings. ALLISON AIKEN, Manvendra Dubey, Alla Zelenyuk, Rahul Zaveri, Claudio Mazzoleni, John Shilling, *Los Alamos National Lab*

Black carbon (BC) absorption enhancements (Eabs) assumed in climate models remain un-validated and depend strongly on BC morphology and composition. Core-shell Mie Theory predicts Eabs up to a factor of 2 for non-absorbing coatings. Ambient measurements indicate that BC Eabs may depend on different sources (Cappa et al., 2012, Liu et al., 2015). To further understand CARES 2010 results, the Soot Aerosol Aging Study (SAAS) at PNNL's Environmental Chamber investigates the relationship between internally-mixed BC with different morphologies and BC absorption enhancements. With the same BC core (120 nm mobility diameter) from a diesel engine and different coating thicknesses of α–pinene secondary organic aerosol (SOA) we isolate the effect of morphology on diesel BC Eabs.

Direct on-line measurements with the single particle soot photometer (SP2) of fresh and aged BC are coupled with photoactoustic spectroscopy to probe changes in BC light absorption when coated with different thicknesses of SOA. We focus on enhancements at 781nm for the SOA coating experiments that are tracked through SOA growth and quantified with SP2 coating thickness. Thermal denuder (TD) experiments determine Eabs, and are calculated using 2 different methods that agree well. TD loss rates are quantified at 14%-30% for 100-300 degC and Eabs are reported from 1.08–1.48 from 100-300 degC for coatings of 50+ nm. BC mass absorption coefficients (MAC's), single scatter albedo (SSA) and absorption enhancements (Eabs) are measured directly for SOA coating experiments and are compared with Mie theory. BC measurements from SPLAT-II confirm the presence of collapsed BC cores with SOA coatings. Our observations of Eabs, BC core size, coating thickness and morphology are used to perform closure studies by comparing measurements with calculated Mie Theory to evaluate Mie radiative modules that are currently used in climate models.

3CC.2

Hygroscopicity, CCN Activity and Droplet Kinetics of Aged Vehicle Emissions. Emmanuel Fofie, Patrick Roth, Georgios Karavalakis, AKUA ASA-AWUKU, *University of California, Riverside*

In this study, we evaluate the hygroscopicity and droplet kinetics of fresh and aged emissions from new generation gasoline direct injector engines retrofitted with a gasoline particulate filter (GPF). Furthermore, ageing and subsequent secondary aerosol formation is conducted in the presence of $(NH_4)_2SO_4$-seeded and non-seeded experiments. We explore the impacts on measured and predicted hygroscopicity, CCN-activity, and droplet kinetics of secondary aerosol mixed with initially insoluble carbonaceous materials versus very soluble $(NH_4)_2SO_4$ seed. The chemical composition and density of the secondary aerosol (SA) formed from aging is measured with an HR-TOF-AMS and a custom-built APM-SMPS system. The supersaturated and subsaturated hygroscopicity of the fresh and aged emission is measured with a DMT Streamwise Thermal Gradient CCN counter and a hygroscopicity tandem differential mobility analyzer (HTDMA), respectively. The measurements show that the fresh gasoline emissions is only slightly hygroscopic in both supersaturated and subsaturated environments, $\kappa_{CCN} = 0.0014$ and $\kappa_{HTDMA} = 0.006$, respectively. Photochemical aging and subsequent condensation of the secondary aerosol formed from the co-emitted gas phase precursors increases the hygroscopicity of gasoline emissions. Without the GPF, both subsaturated and supersaturated hygroscopicity increased from $\kappa_{CCN} = 0.0014$ to $\kappa_{CCN}= 0.0014$ and $\kappa_{HTDMA} = 0.006$ to $\kappa_{HTDMA} = 0.006$, respectively. When the engine was retrofitted with the GPF, the SA experiments were seeded with $(NH_4)_2SO_4$. In these experiments the presence of the condensing SA depresses the hygroscopicity of the salt-SA mixture ($\kappa_{CCN} = 0.50$ to $\kappa_{CCN} = 0.4$). The hygroscopicity was also depressed in the subsaturated regime ($\kappa_{HTDMA} = 0.18$ to $\kappa_{HTDMA} = 0.10$) with time. These changes in the hygroscopicity with aging were additionally sensitive to aerosol dry size distribution. We also used threshold droplet growth analysis (TDGA) to evaluate the effects of the condensing SA on droplet kinetics. These results have important implications for the assessment of cloud-aerosol indirect effects sulfate seeded of black carbonaceous aerosol cores.

3CC.3

Why Would Apparent CCN Activity Linearly Change with O/C? Assessing the Role of Volatility, Solubility, and Surface Activity of Organic Aerosols.

SHUNSUKE NAKAO, *Clarkson University*

Correlations between O/C and cloud condensation nucleus activity, represented by κ, are a computationally efficient approach to estimate the impact of aerosol aging on cloud formation and climate; however, previously reported correlations between these two variables are empirical and vary widely in their slopes and extrapolations to high O/C values. This study proposes a theoretical framework that bridges elemental ratios, volatility, solubility, and κ. The framework estimates intrinsic κ based on molecular formulas of organics composed of carbon, oxygen, and hydrogen that partition to condensed phase, and then it estimates apparent κ considering solubility distribution parameterized by O/C. This study applied the new framework to the two-dimensional volatility basis set (2D-VBS) and found that distribution of O/C and molecular size play key roles in determining apparent κ. For highly soluble organics, κ is dictated by gas-particle partitioning and it is unlikely for κ of organics to go beyond 0.3 in typical ambient organic material loadings. Sensitivity analysis showed that surface-active compounds are not likely to profoundly alter the overall trend within a reasonable range of surface activity. This framework provides a simple yet plausible explanation of why κ would and would not correlate with O/C; distributions of OA in the 2D-VBS as well as the presence of inorganic salts determine the trend. The framework opens up new opportunities to evaluate two-dimensional representations of organic aerosol aging using κ, a significant advancement from the current empirical linear fits to κ and O/C.

3CC.4

Determining Water Solubility Distribution of Organic Matters: Verification by the 1-Octanol-Water Partitioning Method and Application to Indonesian Biomass Burning Particles.

WEN-CHIEN LEE, Jing Chen, Masayuki Itoh, Mikinori Kuwata, *Nanyang Technological University*

Organic matters (OM) are often separated into water-soluble and water-insoluble species. Water-soluble organic matters (WSOM) have been considered to contribute to hygroscopic property and cloud condensation nuclei activity. However, this classification is inadequate since water solubility of WSOM varies in a wide range. Recently, water solubility distribution started to be regarded as one of the important properties of WSOM as it plays a crucial role in affecting water uptake properties of WSOM. In order to better investigate relationship between water solubility distribution and water uptake property, we developed the 1-octanol-water partitioning method. With 1-octnaol-water partitioning coefficient (K_{OW}), which is strongly correlated with water solubility, the method is able to categorize WSOM into different ranges of water solubility by changing volume ratio of 1-octanol and aqueous phases as well as extraction steps.

In this study, we verified the method by standard chemicals and applied the method to Indonesian biomass burning particles. Single and mixed atmospheric-relevant standard chemicals with a wide range of K_{OW} were selected to examine accuracy of the 1-octanol-water partitioning method by a Time-of-Flight Aerosol Chemical Speciation Monitor (ToF-ACSM). Afterwards, the method was applied to laboratory biomass burning particles. The sampled particles were dissolved in ultrapure water to extract WSOM. Subsequently, WSOM were classified into different ranges of water solubility using the 1-octanol-water partitioning method. After filtration, particles were regenerated by an atomizer then measured by ToF-ACSM. Water solubility distribution of the measured samples was estimated by the established data inversion algorithm. Derived mass spectra demonstrated that highly oxygenated species were highly water-soluble, while high molecular weight species tended to be less water-soluble.

3CC.5

Initiation of Secondary Ice Production in Clouds. Sylvia Sullivan, Corinna Hoose, Alexei Kiselev, Thomas Leisner, ATHANASIOS NENES, *Georgia Institute of Technology*

Disparities between the measured concentrations of ice-nucleating particles (INP) and in-cloud ice crystal number concentrations (ICNC) have led to the hypothesis that mechanisms other than primary nucleation form ice in the atmosphere. In this work, we model three such secondary production mechanisms -- rime splintering, frozen droplet shattering, and breakup upon collision -- with a six-hydrometeor-class parcel model. We quantify the ICNC enhancement magnitude and timing from all processes for a range of thermodynamic conditions and parameter values. We also calculate the number of primarily nucleated ice crystals that must exist before secondary ice production initiates, denoted $N_{INP}^{(lim)}$. This value is particularly relevant to bioaerosol: if biological INP are present at concentrations greater than $N_{INP}^{(lim)}$, they may be sufficient to generate large concentrations of cloud ice. Our simulations indicate that breakup upon collision is the only process for which a meaningful $N_{INP}^{(lim)}$ exists (0.002 L^{-1} up to 0.07 L^{-1}). For droplet shattering and rime splintering, a warm enough cloud base temperature and modest updraft are the more important criteria for initiation. Low, simulated values of $N_{INP}^{(lim)}$ suggest that, under appropriate thermodynamic conditions for secondary ice production, perturbations in CCN concentrations are more influential on cloud phase partitioning than those in INP concentrations.

3CC.6

Factors Controlling the Emissions and Activity of Ice Nucleating Particles Released in Sea Spray Aerosol. PAUL DEMOTT, Gregory Schill, Christina S. McCluskey, Gavin Cornwell, Grant Deane, Francesca Malfatti, Mitchell Santander, Hashim Al-Mashat, Thomas Hill, *Colorado State University*

Ice nucleating particles (INPs) from sea spray aerosol (SSA) are a distinct source to the atmosphere in comparison to land sources. The action of these INPs of biogenic origin, together with the action of the Wagener-Bergeron- Findeisen process, alter the optical properties, lifetime, and precipitation from mixed-phased clouds in similarly distinct ways in remote ocean regions. While progress has been made to indicate that marine INPs come both from seawater particulate organic carbon (POC) and dissolved organic carbon (DOC) pools (McCluskey et al., 2017, J. Atmos. Sci. 74, 151-166), less is known about the physical and chemical processes affecting their selective emissions.

In this work, we present results that examine the mechanisms controlling INP emissions in SSA. SSA was produced from a miniature Marine Aerosol Reference Tank (miniMART). Real and synthetic seawater were used, spiked with INPs of known activity, and real-time INP concentrations were monitored with a Continuous Flow Diffusion Chamber. Immersion freezing INP measurements of collected particles were also made. Pollen wash water (PWW) and Arizona Test Dust (ATD) were chosen to represent the two distinct size regimes of INP (POC larger, DOC smaller). Addition of isolated sea-surface microlayer to INP-spiked seawater affected INP emissions in both cases; PWW-INP emissions were enhanced and ATD-INP emissions decreased. Finally, the addition of the protein Bovine Serum Albunim (BSA) induced frothing at the air-seawater interface and selectively reduced the INP emissions of both PWW and ATD. BSA addition reduced the aerosol concentration by a factor of 2, but decreased INP emissions by over a factor of 100. Comprehensive data elucidating this selectivity mechanism, including jet versus film drop production, bubble-dynamics modeling, and aerosol chemical composition will be shown.

3IM.1

The Transfer Function of a Drift Tube Ion Mobility Spectrometer-CPC System. DAVID BUCKLEY, Christopher Hogan Jr., *University of Minnesota*

Drift tube – ion mobility spectrometers (DT-IMSs) are often used to rapidly characterize gas phase ions via high resolution mobility separation in time. Recent work in coupling an atmospheric pressure drift tube to a condensation particle counter (CPC) has enabled mobility separation and detection of singly charged nanoparticles up to 40 nm in mobility diameter. Beyond separation, important in nanoparticle analysis is determination of the true size or mobility distribution of the original aerosol, defined as the particle concentration per unit mobility/size. However, distribution function determination requires *a priori* knowledge of the DT-IMS-CPC transfer function. The transfer function wholly describes the mobility-dependent transmission of the measurement system. Motivated by the need for fast, high resolution size distribution characterization of nanoparticles in the 2 – 40 nm range, the transfer function of the DT-IMS-CPC was inferred via a unique application of the Twomey-Markowski algorithm to tandem mobility measurements. Specifically, the DT-IMS-CPC system was used to measure monodisperse particles exiting a well-characterized DMA set as a mobility filter. DT-IMS-CPC measurements were performed for a range of DMA-selected mobilities, and the Twomey-Markowski algorithm was employed to invert the transfer function at specific DT-IMS-CPC measurement times over this range of mobilities. Examination of the inverted transfer functions reveals DT-IMS-CPC system resolving power more than 10 and reaching 20 for nanoparticles in the studied size range. Previous model estimates agree well with these determined resolving powers.

3IM.2

Experimental Validation of the AAC Transfer Function and Data Inversion. TYLER J. JOHNSON, Martin Irwin, Jonathan Symonds, Jason S. Olfert, Adam M Boies, *University of Cambridge*

The Aerodynamic Aerosol Classifier (AAC) is a novel instrument that selects nanoparticles based on their aerodynamic diameter by generating known drag and centrifugal forces using a controlled sheath flow and rotational speed. Particles with aerodynamic diameters larger than the AAC setpoint impact the outer surface of the classifier, whilst particles of smaller aerodynamic diameter remain in the sheath flow. Particles of the setpoint aerodynamic diameter pass through the classifier, and thus the AAC generates a monodispersed aerosol (Tavakoli, Symonds, & Olfert, 2014) classifying particles independent of their charge state (i.e. no multiple-charge artefacts).

To quantify an aerosol's aerodynamic size distribution accurately, a tandem AAC (TAAC) setup was used to experimentally characterize the AAC transfer function. The upstream AAC (AAC1) was set at a constant setpoint and selected one aerodynamic diameter from a laboratory generated poly-dispersed aerosol, while the downstream AAC (AAC2) stepped through the aerodynamic domain of these classified particles. The final particle number concentration was recorded as a function of AAC2 setpoint. To capture particle behaviour not represented by the idealized AAC transfer function, such as particle diffusion and losses, a transmission efficiency factor and transfer function width factor were applied within the triangular transfer function. These factors were determined by minimizing the squared difference between the TAAC experimental data and theoretical transfer function convolution.

To determine the particle aerodynamic size distribution from the raw measurements collected by the AAC stepping through discrete setpoints, an inversion was developed (incorporating the previously determined transmission and width factors). This inversion was validated by measuring and comparing the same poly-dispersed aerosol with an AAC and Scanning Mobility Particle Sizer (SMPS) in parallel.

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3IM.3

A Performance Evaluation Method for Instruments for Aerosol Particle Size Distribution Measurement based on the Ttotal Number Concentration of Monodisperse Particles using Reference CPC.

YOSHIKO MURASHIMA, Hiromu Sakurai, *AIST*

Particle size distribution measurement instruments based on electrical mobility classification can accurately measure particle size and number concentration of fine particles and are used for various applications. Performance evaluation methods for them, however, have not been established. For the scanning mobility particle sizer (SMPS), the performance can be evaluated to some extent by individually inspecting and/or calibrating the components such as the charger, classifier, and detector. On the other hand, the fast-response instruments such as TSI's fast mobility particle sizer (FMPS) are packaged so that the integrated components are not separable for individual testing. The same can be said for recent battery-powered portable instruments. For those instruments, techniques to evaluate the overall performance of a complete system as a whole are needed by treating each instrument as a "black box". Such techniques would be also useful for testing the SMPS.

We propose a method that evaluates the overall performance of a size distribution measurement instrument based on checking the accuracy of the total number concentration using monodisperse particles. In this method, the total number concentration of monodisperse particles of the same aerosol is measured in parallel by a test instrument (e.g., SMPS) and a reference CPC. The total number concentration that is determined by integrating the size distribution density function measured by the test SMPS is compared with the number concentration measured by the reference CPC. Monodisperse particles are generated by passing particles from an electrospray aerosol generator through a neutralizer and subsequently classifying them with a differential mobility analyzer (DMA).Then, after mixed well with a dilution air, particles are delivered to the test SMPS and reference CPC simultaneously.

We will report the result of applying this method to commercial instruments such as TSI SMPS 3936L75.

3IM.4

Simulation and Experiments with a Modular Electrical Particle Detector.

MARIO ANTON SCHRIEFL, Alexander Bergmann, *Graz University of Technology*

With the latest updates of emission legislations for motor vehicles (e.g. Real Driving Emissions (RDE), exhaust examination Germany[1]), mobile determination of Particle Number (PN) has become mandatory. Established sensor technology for PN measurement – based on condensational particle counters – is hardly applicable for mobile PN measurements. A promising alternative to that technology is diffusion charging (DC), which consists of charging and subsequent current measurement of aerosol particles. DC enables to build compact, robust and lightweight PN sensors. However, its sensor response suffers from a strong dependency on the particle's size, which distorts the measurement.

In order to reduce the size dependency of the sensor signal, DC can be implemented in various configurations. The basic configuration consists of two stages, (i) modulated particle charging and (ii) current measurement using a Faraday cup electrometer (FCEM). This basic configuration can be extended by an electrostatic precipitation (ESP) stage (as suggested by Burtscher[2]) and another FCEM (Meier[3]). The mentioned sensor stages can be combined and operated in different ways, leading to different DC configurations and corresponding response characteristics. The aim of this study is to find the best configuration with respect to size dependency of the sensor response.

For that purpose, a 3D multiphysical finite element method model was developed. The model was applied to three different DC configurations. A modulated precipitation configuration showed the best results. Additionally, a modular electrical particle detector was designed, consisting of different charging stages, an ESP and two FCEMs. This device allows for the experimental investigation of the DC configurations used in the simulations. First experimental results nicely agree with the simulation results, however, further experimental work is ongoing to validate the findings.

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3IM.5

Rapid Measurements of Particle Hygroscopic Growth with a Humidity-Controlled Fast Integrated Mobility Spectrometer (HFIMS).

YANG WANG, Tamara Pinterich, Steven Spielman, Susanne Hering, Jian Wang, *Brookhaven National Laboratory*

Hygroscopicity is a key parameter in determining the impact of atmospheric aerosols on global radiation and climate change. Tandem differential mobility analyzer (TDMA) system is the most widely used instrument for determining the aerosol hygroscopicity. However, TDMA measurements are relatively slow because the time needed for a full scan of DMA voltage is typically in the range of minutes. The slow measurement speed becomes a significant issue when unsteady sources of aerosols are being studied, for example, direct measurement of combustion aerosols and measurement of aerosols onboard mobile platforms.

The recently developed water-based fast integrated mobility spectrometry (WFIMS) allows rapid mobility-based measurement of particle size distribution. It uses a parallel plate mobility system to separate charged particles with different mobilities. Upon exiting the mobility separator, the spatially separated particles are condensationally grown in a three-stage water-based growth channel and imaged onto a CCD array. The size distribution is obtained by counting particles located in each mobility bin shown on the image, providing a near instantaneous measurement (1 Hz) of mobility size distributions. The use of water vapor enables independent control of RH in the mobility separation region, which cannot be achieved with alcohol vapor due to their lower diffusivity. A humidity-controlled FIMS (HFIMS), consisting of a DMA, a relative humidity control unit, and a WFIMS coupled in series, was tested for measuring the hygroscopic growth of particles. In this study, a data inversion algorithm is developed to derive the growth factor distribution of the DMA-classified particles. The inversion algorithm uses the known transfer functions of the upstream DMA and the WFIMS, and calculates the growth factor distribution that reproduces the position distribution of particles measured by the WFIMS. The growth factor distributions of ambient particles at various RHs are analyzed with the inversion algorithm. Further optimization of the HFIMS system will be discussed.

3IM.6

The Caltech-ADI Portable Scanning Electrical Mobility Spectrometer.

STAVROS AMANATIDIS, Changhyuk Kim, Richard Flagan, Steven Spielman, Gregory Lewis, Susanne Hering, *California Institute of Technology*

The Differential Mobility Analyzer (DMA) is arguably one of the most popular instruments for sub-micron aerosol particle size characterization, serving both as a tool for calibration and size distribution measurement. While DMAs have been traditionally used in the laboratory, there is an increasingly higher interest for size distribution measurements in field applications, where portability and low power consumption are essential.

In this study, we present a highly portable Scanning Electrical Mobility Spectrometer that combines a newly-developed classifier with a self-sustaining water condensation particle counter. The classifier is a compact and lightweight radial-flow DMA developed at Caltech that is designed to operate at low flowrates (on the order of 0.3 L/min aerosol flow) to provide particle sizing in the 10-500 nm range. It operates at relatively low resolution in order to minimize both instrument volume and pumping/power requirements, while enabling size distribution measurement with the precision required for planned atmospheric studies. Particle counting is done with 0.3 L/min, self-sustaining water-based condensation particle counter developed at Aerosol Dynamics that tolerates jostling and tipping, and provides efficient particle counting above 7 nm.

The new DMA differs substantially from prior designs. Because of the low flow operation, aerosol entrance designs such as the tangential inlet previously employed in radial DMAs are no longer efficient for fast and uniform aerosol distribution over the classification region. To overcome this challenge, a novel geometry has been designed and optimized by 3D finite element modelling of flow, electric field and particle trajectories using COMSOL Multiphysics. This design not only allows for uniform aerosol inlet but also results in a narrow residence time distribution within the classification region, facilitating fast voltage scanning operation. This DMA consists of only a few parts, occupies a volume of ~100 cm^3 and weighs ~300 g. Higher resolution can be achieved by increasing the sheath flow, although this improved resolution leads to a reduction in the dynamic size range.

4AC.1

Laboratory Observations of Temperature- and Humidity-Dependencies of Nucleation and Growth Rates of Sub-3 nm Particles. Huan Yu, SHANHU LEE, *University of Alabama in Huntsville*

Temperature and relative humidity (RH) are the most important thermodynamic parameters in aerosol formation, yet laboratory studies of nucleation and growth dependencies on temperature and RH are lacking. Here we report the experimentally observed temperature and RH dependences of sulfuric acid aerosol nucleation and growth of sub-3 nm particles. Based on our laboratory observations, we provide empirical algorithms that show nucleation and growth rates as function of relative acidity (RA) of sulfuric acid, RH and temperature together. Experiments were performed in a flow tube in the temperature range from 248-313 K, RH from 1% - 80%, and RA of sulfuric acid from 6×10^{-5} - 0.38 (corresponding to 2×10^{7} - 10^{9} cm^{-3}). The impurity levels of base compounds were determined to be ammonia less than 23 pptv, methylamine less than 1.5 pptv and dimethylamine less than 0.52 pptv. Our results show that low temperatures favor nucleation at fixed sulfuric acid concentrations, but impede nucleation when RA is fixed. The nucleation mechanism based on collision-limited condensation of free sulfuric acid fails to predict the observed growth rates in the sub-3 nm size range, as well as its dependence on temperature and RH. This suggests that evaporation, sulfuric acid hydration and possible involvement of other ternary species should be considered for the sub-3 nm particle growth.

Yu, H., L. Dai, V. P. Kanawade, S. N. Tripathi, X. Ge, M. Chen, and S-H. Lee, Temperature and RH dependence of aerosol nucleation and growth rates of sub-3 nm particles, J. Geophys. Res., Doi:10.1029/2016JD025619 (2017).

4AC.2

Size-resolved Chemical Composition of Nanoparticles from Reactions of Sulfuric Acid with Ammonia and Dimethlylamine. HAIHAN CHEN, Michael Lawler, Sabrina Chee, James Smith, *University of California, Irvine*

Sulfuric acid (H_2SO_4) is widely accepted as the key species driving new particle formation in the atmosphere. Ammonia and amines contribute to nanoparticle growth by forming ammonium/aminium salts with sulfate and bisulfate ions. Measurements of molecular clusters up to ~2 nm in the sulfuric acid-base system at the CLOUD chamber show a nucleation process involving stepwise addition of H_2SO_4 and base in an acid-to-base ratio close to 1:1. But in another recent study at the CLOUD chamber, we observed highly acidic 10-30 nm nanoparticles from reactions of sulfuric acid with excess base. To better understand the growth mechanism of nanoparticles by acid-base chemistry, we measured the chemical composition of size-selected particles in the diameter range of 8-20 nm produced from reactions of H_2SO_4 with ammonia and dimethylamine in a borosilicate glass flow reactor. Those measurements were performed with Thermal Desorption Chemical Ionization Mass Spectrometry (TDCIMS). The concentration of base and relative humidity were varied to explore their effects on particle growth and chemical composition. The results suggest that particle growth by acid-base chemistry is very dynamic and complex. The acid-to-base ratio in nanoparticles shows a strong dependence on particle size and relative humidity. Smaller particles are more acidic, consistent with our previous observations from CLOUD, with higher bisulfate present, while larger particles are more neutralized and contain more sulfate. Possible explanations of this dynamic and complex growth mechanism are discussed.

4AC.3

Investigation of Nucleation Events in Wintertime Beijing, China. JUN ZHENG, Dongsen Yang, Yan Ma, *Nanjing University of Information Science & Technology*

Nucleation processes contribute substantial secondary aerosols in the atmosphere, which often lead to severe air pollution episodes in China, especially in heavily populated urban area. In this work, we conducted field observations of nucleation events in a rural site of Beijing, from January to March 2016. Nucleation events were frequently observed during the measurement period. The nucleation rates of 1.0 nm diameter aerosol (J_1) were determined from direct measurements of particle size distribution of 1.4 - 3.0 nm by a particle size magnifier (PSM) with a value up to a few hundreds particles cm^{-3} s^{-1}, significantly higher than what we observed during CAREBeijing 2008. Meanwhile, gaseous sulfuric acid (H_2SO_4) was measured with an atmospheric pressure ionization high-resolution time-of-flight chemical ionization mass spectrometer (API-HR-ToF-CIMS). H_2SO_4 dimers and sub-3 nm aerosols showed excellent correlations during the nucleation events. NH_3 was also observed by another chemical ionization mass spectrometer with a value ranging from a few ppbv up to ~20 ppbv. Cold ambient temperature (less than -10°C) and high NH_3concentration may explain the unusually high nucleation rates, which could contribute to the winter haze formation in the urban area of Beijing and should be investigated in more details.

4AC.4

Photochemical Synthesis of Oligomeric Surfactants at the Ocean-Atmosphere Interface. REBECCA RAPF, Veronica Vaida, *University of Colorado Boulder*

The synthesis and reactivity of lipid-like molecules, which selectively partition to air-water interfaces, are of interest because of their potential contributions to the formation of secondary organic aerosol (SOA). Sunlight can drive photo-initiated chemistry of organic species at air-water interfaces, such as the sea-surface microlayer (SML). The SML contains high concentrations of amphiphilic organic molecules and, as the boundary layer between the ocean and atmosphere, connects processes at the sea surface with the atmosphere, including the generation of sea spray aerosol. The surface-active molecules found in the SML are often biological in origin, but we show that abiotic photochemical sources may be additional, important contributors. Here, we report on the robust photochemical mechanism by which a class of molecules, α-keto acids, reacts in aqueous solution to form organic radicals, which can recombine to form larger, more complex molecules. The oligomers formed from this photochemistry are amphiphiles, many of which have two or three alkyl chains. The photoproducts generated from these alkyl α-keto acids are more surface-active, and spontaneously self-assemble into monodisperse, spherical aggregates over the course of photolysis. The aqueous photochemistry of α-keto acids also provides radical initiators for the polymerization of non-photoactive molecules. Additionally, the effect of environmental reaction conditions, including oxygen content and solution pH, on the branching ratio of photochemical pathways will be discussed.

4AC.5

Electrospray-Surface Enhanced Raman Spectroscopy (ES-SERS) for the Surface-Sensitive Characterization of Atmospherically Relevant Particles. Masao Gen, CHAK K. CHAN, *City University of Hong Kong*

We present an electrospray-surface enhanced Raman spectroscopy (ES-SERS) for measuring the surface chemical compositions of atmospherically relevant particles. The surface-sensitive SERS is realized by electrospraying Ag nanoparticle aerosols over particles analyzed. Raman peaks at $v(SO_4^{2-})$, v(C-H) and v(O-H) modes were observed from the normal Raman and SERS measurements of laboratory-generated supermicron particles of ammonium sulfate (AS), AS mixed with succinic acid (AS/SA) and AS mixed with sucrose (AS/sucrose) particles. SERS measurements showed strong interaction between Ag nanoparticles and surface aqueous sulfate. Furthermore, SERS spectra of the solid AS and AS/SA particles revealed the presence of surface-adsorbed water (SAW) on their surfaces at 60% relative humidity. These observations suggest a possible role of SAW in facilitating the dissolution of sulfate from the bulk phase into its water layers. Submicron ambient particles exhibited non-enhanced features of black carbon and enhanced features of sulfate and organic matter, indicating an enrichment of sulfate and organic matter on the particle surface.

4AC.6

Measurement of the pH of Individual Aerosol Droplets by Surface-Enhanced Raman Spectroscopy. HAORAN WEI, Linsey Marr, Peter Vikesland, *Virginia Tech*

Suspended aqueous aerosol droplets (<50 µm) are micro-reactors for many important atmospheric reactions. In droplets, and other aquatic environments, pH is arguably the key parameter dictating aqueous chemistry. The dynamic air/water interface of a droplet has the potential to significantly alter droplet pH from bulk water values. However, it is challenging to measure the pH inside single droplets due to their inaccessibility when using conventional pH meters. In this study, droplets containing ≈75 nm gold nanoparticle (AuNP) based pH nanoprobes were collected onto a superhydrophobic substrate and scanned by laser confocal Raman microscopy. The Raman signal of the pH reporter, 4-mercaptobenzoic acid (4-MBA), was enhanced substantially through surface-enhanced Raman scattering (SERS) enabled by the AuNP clusters. By using these nanometer-sized pH probes the pH inside individual aerosol droplets was for the first time acquired. We show that the pH in a droplet is higher than that of bulk water by ≈3.3 pH units, which we attribute to the accumulation of protons at the air/water interface. The existence of this unexpected pH shift was corroborated by the observation that two catalytic reactions that only occur under basic conditions (i.e., the decarboxylation of 4-MBA and dimercaptoazobenzene (DMAB) formation from 4-aminothiophenol (4-ATP)) occur within droplets, but not bulk solution.

4AC.7

Quantification of the Partitioning Behaviour of Surfactants in Picolitre Droplets. BRYAN R. BZDEK, Jonathan P. Reid, *University of Bristol*

The surface tension of atmospheric particles helps determine the critical supersaturation required for a particle to grow into a cloud droplet and, therefore, the cloud droplet number concentration. However, constraining the surface tension of ambient aerosol is challenging due to the very small mass and complex chemical composition of atmospheric particles. Recent studies demonstrate that surfactants are important components of ambient aerosol and alter the pathway by which particles grow into cloud droplets, but the relationship between surfactant concentration and particle surface tension is not straightforward. Due to the very high surface area and limited volume of a particle, partitioning of surfactant molecules to the particle surface reduces their “bulk” concentration. The result is a very different relationship between surface tension and concentration in particles compared to bulk measurements, where the number of molecules available for partitioning is effectively infinite. In this contribution, holographic optical tweezers is used to measure the surface tensions of picolitre droplets containing representative surfactants. This measurement is accomplished through sub-microsecond time resolved monitoring of the periodic shape oscillations resulting from controlled coalescence of two optically trapped micron-sized droplets. Surface tensions are resolved to <1 mN/m. Comparison of the droplet measurements with bulk tensiometry approaches demonstrates that surface-bulk partitioning can result in a difference of >10 mN/m between the droplet measurement and the bulk measurement at the same nominal concentration. Moreover, the apparent critical micelle concentration in picolitre droplets is approximately a factor of two larger than the comparable bulk measurement. The droplet measurements are mapped onto bulk measurements to develop a relationship that correlates a bulk surface tension with a corresponding droplet surface tension. This work quantifies the partitioning behaviour of surfactants in confined volumes and provides valuable information for models considering bulk-surface partitioning to predict cloud droplet number concentrations.

4AE.1

Commuter’s Air Pollution Exposure: Ventilation Rate and Urban Design Are Major Factors in Cyclist’s Elevated Intake. NICHOLAS GOOD, Jennifer Peel, John Volckens, *Colorado State University*

High air pollution exposures are often experienced when commuting. Cyclists may experience particularly high doses of air pollution as their ventilation rates are elevated. Few studies of commuter air pollution exposures have accounted for ventilation rate in a realistic setting. In this study, we quantify the differences in cyclist’s and driver’s air pollution exposure accounting for inhalation under realistic conditions and assess whether air pollution intake can be practically mitigated by choice of route.

Personal exposure to black carbon (BC), carbon monoxide (CO), $PM_{2.5}$ (the mass of particles < 2.5µm in diameter), and particle number (PN) were measured for 45 commuters over approximately 700 commutes. Each commuter drove and cycled to and from their workplace via direct and alternative routes designed to lower exposure levels. Commuter’s inhalation was modeled using their measured heart rate.
Trip duration and minute ventilation rate are major determinates of commuter’s exposure. On comparable direct routes cyclists inhaled: 460% [95% Confidence Interval (CI): 306%, 638%] more BC, 98% [95% CI: 38%, 173%] more CO, 727% [95% CI: 435%, 1073%] more $PM_{2.5}$, and 552% [95% CI: 263%, 1010%] more PN than when driving. By taking routes that avoid traffic cyclists saw relatively small reductions in the amount of pollution they inhaled: -36% [95% CI: -53%, -8%] less BC, -44% [95% CI: -63%, -15%] less CO, -26% [95% CI: -53%, 15%] less $PM_{2.5}$, and -9% [95% CI: -46%, 62%] less PN.
Relatively modest differences in commuter’s mean exposure levels are strongly modified by differences in their route and mode dependent minute ventilation rate and trip duration. The available alternative routes, designed to separate cyclists from their main source of exposure (motor vehicles), are of limited use.

4AE.2

Exposure to Ultrafine Particles and Black Carbon in Diesel-powered Commuter Trains. CHEOL H. JEONG, Alison Traub, Greg J. Evans, *SOCAAR, University of Toronto*

Concentrations of ultrafine particles (UFP), lung deposited surface area (LDSA), and black carbon (BC) were measured using portable monitors (i.e., DiscMini, Testo AG, MicroAeth, AethLabs) during 43 morning and evening trips inside commuter trains from July 6 to August 21, 2015. Walking measurements were taken on sidewalks of busy streets in downtown Toronto immediately before or after the in-train measurement.

Elevated concentrations of UFP, BC, and LDSA were observed on diesel-powered passenger trains under some conditions. When the passenger coaches were pulled by a locomotive (pull-train), UFP, LDSA, and BC were 18, 10, and 6 times higher than the exposure levels when the locomotive pushed the coaches (push-train), respectively. These concentrations in pull-trains were 5, 3, and 4 times the UFP, LDSA, and BC concentrations measured while walking on city sidewalks, respectively. Exposure to these pollutants was most elevated in the coach located closest to the locomotive: geometric means were 126,000 # cm^{-3} for UFP, 249 μm_2 cm^{-3} for LDSA, and 17,800 ng m^{-3} of BC. In addition, these UFP, LDSA, and BC exposure levels in pull-trains were substantially higher than those for other commuter options reported in the literature. Additional measurements of gaseous pollutants, particulate matter, and trace metals were also conducted in inter-city trains and during winter to better understand this exposure. Steps to reduce this exposure are already being evaluated and implemented. One follow-up study of the effectiveness of higher efficiency filters within the ventilation systems will be described.

4AE.3

Numerical Investigation of Occupational-related Metal Aerosol Transmission and Deposition Patterns in a Virtual Human Respiratory System. YU FENG, Jun Wang, Ahmadreza Haghnegahdar, Marcio Bezerra, *Oklahoma State University*

High-temperature metal fabrication activities such as welding and plasma cutting are commonly seen in workplaces. The pyroprocesses generate high concentrations of micro-/nano-sized particles loaded with toxic metals. Exposure to these metal aerosols poses serious adverse health effects such as respiratory diseases, neurological ailments and ultimately cancer to workers. Information on how the metal aerosol transmits and deposits in respiratory systems is critically needed to study these health effects and devise engineering controls. However, observations and measurements of respiratory deposition from human and animal studies are very restrictive regarding the limitations of flexibilities and resolutions. As an alternative, Computational Fluid-Particle Dynamics (CFPD) models are capable of providing high-resolution deposition data based on the natural laws of physics without invasive specimen collection. The objective of this study is to develop an experimentally validated CFPD model to predict the transport and deposition of the metal fume in a subject-specific human upper airway. Exposure conditions are determined by chemical and physical profiles of metal aerosols from the previous chamber and field studies on high-current stainless steel plasma arc cutting. Steady-state nasal inhalation conditions, i.e., 10 to 30 L/min are investigated in the parametric analyses. Results indicate that under the same inhalation flow rate, both the total and regional depositions in the nasal cavity increases when particle diameter decreases from 830 nm to 96 nm because of the enhanced Brownian motion effect. The particle deposition in the nasal cavity raised concern on anterograde movements of metals such as manganese to the brain through olfactory neurons. High inhalation flow rates lead to stronger inertial impaction and higher deposition. Moreover, the deposition mass of metal fume increases when the arc current increases from 20 to 50 A. Future work includes simulating transient breathing scenarios and intersubject variability studies.

4AE.4

Child Exposure by Aerosol Particles inside a Bicycle Trailer during the Usual City Ride. JAN BENDL, Jan Hovorka, *Charles University in Prague*

This innovative study shows how children in bicycle trailers are exposed by aerosol particles in comparison to cyclist during typical rides across the city of Prague, Czech Republic. We hypothesize, that resuspended coarse aerosol particles from dusty roads and submicron/nanoparticles from vehicle engines efficiently penetrate into a bicycle trailer due to low emission heights. The measurements were conducted by a laser nephelometer and twin condensation nuclei counters connected to omnidirectional inlets and sheltered in a box. Two boxes of identical instrumental were used. The first box is placed on handlebars holder at the cyclist breathing zone while the second box is placed inside the bicycle trailer. Temperature, wind speed/direction and GPS position were also concurrently measured. Overall data were recorded with integration time of 1 second. 19 km route including cycling paths, roads with low and high traffic and city park trails with different surfaces is being repeated twenty times at various time of day and weather conditions. Hot-spots of concentration ratios between cyclist and child breathing zone will be revealed, evaluated and displayed on the colored map. Aerosol concentrations during the ride will be also confronted with the city background and actual meteorological conditions and rider observations. Practical recommendations for elimination child exposition by aerosol particles during cycling will be one part of results.

This project is supported by the Charles University Grant Agency GA UK, no. 1474217 and the study is in progress.

4AE.5

High Spatial Resolution of Sources, Mixing State and Exposure of Particulate Matter Using Single Particle Mass Spectrometry. QING YE, Peishi Gu, Zhongju Li, Ellis Shipley Robinson, Joshua Apte, Ryan Sullivan, Allen Robinson, Albert A. Presto, Neil Donahue, *Carnegie Mellon University*

Large-scale epidemiological research is traditionally based on data from a limited number of monitoring sites that are usually in rural or urban background locations. Although studies of atmospheric pollutants in urban areas have been reported in the literature, intra-city levels of fine particulate matter with high spatial resolution are rare. We conducted extensive mobile measurements of atmospheric particulate matter with a state-of-the-art single particle mass spectrometer in Pittsburgh, PA. The sampling sites span various land use types including tunnels, highways, parks, suburban residential neighborhoods and commercial areas. We focus on emissions from traffic and restaurant cooking to investigate the relationship between emissions and exposure. We use the mass spectra of individual sampled particles to identify the sources and mixing state of the particles. We investigate the correlation of traffic/restaurant density and the abundance of their associated particles types using the mobile sampling data. We then extrapolate and apply the correlations to the entire city coupled with demographic data to understand contribution of various emission sources to people's exposure on the city-level. Our preliminary results shows that while background particles are relatively spatially homogeneous, there are large spatial gradients and hot spots associated with particles emitted from traffic and restaurant cookings. Some of these hot spots are also highly populous. Roughly a quarter to a third of the population in the city are exposed to high levels of fresh and externally mixed particles. This work provides us with unique opportunities to systematically understand how near-source emissions are driving neighborhood-level exposure.

4AE.6

Assessing Exposure Misclassification Error Using Cell Phone Location Data. Haofei Yu, ARMISTEAD G RUSSELL, James Mulholland, *Georgia Tech*

In air pollution epidemiologic studies, individual subject's exposure to particulate matter is usually modeled as that occurring at their corresponding home address. When spatiotemporal individual mobility is not accounted for, exposure misclassification errors are likely. In this study, we applied a detailed cell phone location dataset, the call detail record (CDR), to assess the potential exposure misclassification errors in the home-based approach, and to demonstrate its potential in improving exposure estimates of individuals to PM, PM species and other air pollutants. The CDR database was collected from Shenzhen, China on a mid-week day in October, 2013. It contains 9,886 unique simcard IDs and approximately 4.6 million location records. Air pollution exposures were calculated for each ID by matching their detailed location data with hourly ambient concentrations of six chosen pollutants, which were modeled by the Community Multi-scale Air Quality model (3 km resolution) and fused with observational data. The estimated exposures were compared with those obtained using the home-based approach. Our results show substantial differences between exposures estimated by the CDR-based and home address-based approaches, and indicate likely exposure misclassification errors when spatiotemporal subject mobility is not accounted for. The home address-based approach tends to over-estimate exposures for individuals with higher exposure levels, and under-estimate exposures for those with lower exposure levels. Our findings show potential of the cell phone location-based approach for improving exposure estimates in air pollution epidemiology and health impact studies.

4AE.7

Aerosol Deposition Efficiency Model for Exposure Systems with Diffusion-Sedimentation Driven Aerosol Transport. FRANCESCO LUCCI, Arkadiusz Kuczaj, *Philip Morris International R&D*

The modern multi-well aerosol exposure systems deliver sampled aerosol to a large number of biological samples (tissue cultures) at the air-liquid interface (e.g. Vitrocell, Cultex). Typical flow in an in-vitro exposure chamber geometry is laminar and at low-velocity at the aerosol exposure conditions. The aerosol mixture is brought to the tissue surface and turns along to leave the dilution/distribution system in the so-called trumpet-like shaped geometry. The operating sampling flowrate conditions to the exposure chamber dictate the aerosol dynamics in the system, its residence time and also deposition mechanisms. This flowrate is also constrained from the biological perspective in order to avoid large shear forces and evaporation acting in the system that could dry-out and potentially damage the tissue culture.

By applying our recently developed Eulerian modeling framework for simulations of the polydisperse multi-species aerosol transport and deposition, we have investigated aerosol deposition efficiency at varying geometry of exposure chambers, aerosol properties, and operating conditions. We have found that for the recommended operating conditions the aerosol deposition is mainly driven by the size-dependent sedimentation velocity and diffusion mechanisms. In the confirmed absence of inertial impaction, we have proposed a simple and very robust size-dependent model of aerosol deposition, which is generally applicable to different exposure systems and operative conditions by taking into account flow and geometry parameters. The proposed model was validated on the basis of experimental results finding good agreement with the available literature data.

4AQ.1

The Rise and Fall of Organic Matter in Clouds and Fogs: The Transition from Functionalization to Fragmentation. JEFFREY COLLETT, Misha Schurman, Alexandra Boris, Taehyoung Lee, Denise Napolitano, Pierre Herckes, *Colorado State University.* INVITED

Clouds and fogs play an important role as processors of many chemical species in the atmosphere. Particle scavenging followed by direct deposition or incorporation into precipitation represents an important atmospheric cleansing mechanism. Uptake of soluble gases followed by reaction in cloud/fog droplets can be an important source of secondary organic aerosol (SOA), while OA can also be “consumed” in clouds through chemical fragmentation to smaller, more volatile products that volatilize back to the gas phase. Here we provide an overview of research examining the processing of atmospheric organic matter by clouds and fogs in California, S. Korea, and China. Cloud and fog water were collected and analyzed for total organic carbon and a suite of organic acids that are often viewed as indicators of atmospheric aging of organics. Laboratory photooxidation studies were conducted on authentic cloud water samples using ultraviolet light and H_2O_2 to produce hydroxyl radical. Organic matter composition was followed during aging using on-line ESI-ToF-MS, offline IC, and direct atomization of aged cloud water followed by evaporation of resulting droplets and on-line drop residue measurements using an AMS. These experiments reveal functionalization and fragmentation regimes, where the organic aerosol from evaporated cloud drops respectively increases or decreases. Production of carbonyls and carboxylic acids is observed. The time to transition from overall organic matter functionalization to fragmentation appears to depend on the amount of organic matter available in the cloud/fog water, presumably reflecting altered competition for available oxidants. Overall, the rate of aqueous SOA production in studied cloud water decreases as oxygenation increases, with organic mass loss beginning at consistent values of $f44 > 0.23 \pm 0.05$ and $O:C > 0.61 \pm 0.05$. We hypothesize that there may be a parameterizable ‘peak oxidation level’ for cloud water above which functional group fragmentation is dominant.

4AQ.2

A Community Effort for Furthering Cloud Chemistry Studies. MARY BARTH, Annmarie Carlton, Sara Lance, Kerri Pratt, Jeffrey Collett, Delphine Farmer, James Schwab, Barbara Ervens, V. Faye McNeill, Hartmut Herrmann, Mauro Morichetti, *National Center for Atmospheric Research.* INVITED

Clouds cover 60% of the Earth’s surface at a given time and are the primary means by which constituents from the polluted boundary layer are lofted to the free troposphere. Clouds are also aqueous-phase chemical reactors, scavenging soluble gas-phase precursors and supporting oxidation reactions that contribute to increased aerosol mass when the cloud drops evaporate. However, atmospheric chemistry observations (field campaigns and satellite retrievals) typically avoid clouds resulting in a lack of knowledge of cloud chemistry impacts on tropospheric composition. To alleviate this lack of knowledge, we have begun an effort in connection with the Whiteface Mountain Observatory in New York to sample a suite of chemical compounds in cloud water and to evaluate and compare the state of knowledge of current gas-aqueous chemistry 0-dimensional models.

This talk will present outcomes from a workshop held at Whiteface Mountain. A cloud event occurred on the 17-18 September 2016, beginning just a few hours after the workshop completed. Cloud water was collected and frozen into 12-15 vials. These cloud water samples, along with blanks and rinse water samples, were distributed to several groups for chemical analysis of the cloud water. Preliminary results from this analysis will be presented. In concert with the observations, 0-d and 3-d regional scale cloud chemistry model intercomparisons are being pursued. The 3-d model simulations are focused on providing the meteorological and chemical composition context to the cloud water event, while the 0-d model intercomparison is evaluating the capabilities of these models to predict aqueous phase chemistry via comparisons with observations, where available.

4AQ.3

Recent Findings from Airborne Cloud Water Measurements off the Western United States Coast. ARMIN SOROOSHIAN, Zhen Wang, Hossein Dadashazar, Alex MacDonald, Ewan Crosbie, Haflidi Jonsson, Richard Flagan, John Seinfeld, *University of Arizona.* INVITED

Clouds play several critical roles in the atmosphere including being a key agent in radiative forcing, the hydrological cycle, transferring nutrients and contaminants from one area to another via in-cloud scavenging and eventual rainout, and chemical transformations of gases and particles. Quantifying the nature and magnitude of each of these cloud processes is challenging owing to the difficulty of obtaining measurements at sufficiently fine temporal and spatial scales. Application of chemical tracers presents a potentially effective means to identify emissions sources, dynamical processes, and chemical conversion processes impacting clouds. Of interest in this work are marine stratocumulus clouds, which are the dominant cloud type by global area, exerting a strong negative net radiative effect.

This presentation will report on findings based on cloud water measurements conducted over multiple field campaigns between 2011 and 2016 off the US western coast using the Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS) Twin Otter. Results to be discussed relate to the relative abundance of non-water dissolved species in cloud water as a function of factors such as altitude in cloud, the degree of coupling of clouds to the surface layer, and air mass source. In these campaigns a suite of carboxylic acids were speciated and quantified in both cloud water and droplet residual particles. Their characteristics, including relationships with metals, will be discussed.

4AQ.4

Effect of Aerosol Water on Chemical Composition and Aging of Organic Aerosols. SERGEY NIZKORODOV, Mallory Hinks, Julia Montoya, Lucas Ellison, Kurtis Malecha, Paige Aiona, Manabu Shiraiwa, Donald Dabdub, Peng Lin, Alexander Laskin, Julia Laskin, *University of California, Irvine.* INVITED

This presentation will discuss multiple effects water vapor and aerosol liquid water can have on chemical composition of organic particles: (a) gaseous water can directly participate in the VOC oxidation reactions, such as carbonyl oxides; (b) aerosol liquid water present in hygroscopic particles can lead to hydrolysis of organic compounds and other particle-phase reactions involving or catalyzed by water; (c) aerosol liquid water has a strong effect on acidity of particles and, therefore, affects acid-catalyzed processes occurring in particles; (d) water can act as a plasticizer for SOA particles making them less viscous, thus affecting the rate of their growth and chemical aging; (e) under supersaturated conditions, aqueous chemistry occurring in cloud and fog droplets promotes photolysis driven conversion of small water-soluble molecules into non-volatile products that would not form in the absence of liquid water, as well as photodegradation of dissolved SOA compounds. These effects will be exemplified with several recent studies, including the effect of relative humidity on the yield and chemical composition of SOA formed from toluene, hydrolysis of SOA compounds in aerosol water, and photochemistry of SOA at different levels of relative humidity.

4AQ.5

Influence of Aqueous-Phase Processing on the Chemical Composition of Fog Droplets and Interstitial Aerosols in California's San Joaquin Valley. QI ZHANG, Hwajin Kim, Sonya Collier, Jianzhong Xu, Xinlei Ge, Yele Sun, Pierre Herckes, Youliang Wang, *University of California, Davis.* INVITED

A fog chemistry study was conducted in Fresno, California's San Joaquin Valley (SJV), in January 2010. Fog droplets were collected while interstitial submicron aerosol was characterized in real time with an Aerodyne High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-AMS). The fog water samples were later analyzed by HR-AMS, ion chromatography (IC) and total organic carbon analyzer (TOC). Compared to interstitial aerosol, dissolved substances in fog droplets are composed of a higher mass fraction of ammonium, nitrate, sulfate, and oxygenated organic compounds, indicating aqueous-phase formation of secondary species as well as dissolution of water-soluble gases under humid conditions. Sulfate shows the highest relative enhancement in fog water although its contribution to total dissolved mass is relatively low. The HR-AMS mass spectra of organic matter in fog water (F-OA) are highly similar to the spectrum of oxygenated organic aerosol (OOA) derived from positive matrix factorization (PMF) of the HR-AMS spectra of interstitial aerosol (r2 = 0.95), but there are also significant chemical differences between F-OA and OOA. For example, F-OA appears to contain a larger fraction of nitrogen-containing organic compounds, with an average N/C ratio ~4 times that of OOA. Most strikingly is the enhancement of the CxHyN2+ ions in F-OA spectra, indicating the presence of imidazole compounds which commonly result from the aqueous reactions of aldehydes with amino compounds. The results of this study demonstrate that aqueous reactions in fogs and clouds are likely an important source of oxygenated and nitrogen-containing organic aerosol in the atmosphere.

4AQ.6

Studies of OH Oxidation of Cloudwater Organics. JONATHAN ABBATT, Rachel Hems, Alex Lee, Ran Zhao, *University of Toronto, Toronto, Canada.* INVITED

Although oxidative processes proceed readily in cloudwater, there remain significant uncertainties that preclude comprehensive modeling of this chemistry. This talk will present laboratory studies that address a number of these uncertainties. Particular attention will be given to the impacts of OH oxidation, wherein the properties of simulated and real cloudwater are observed. Most recent results are for the oxidation chemistry of dimeric substances that are common constituents of SOA. These molecules are easily oxidized in solution, forming monomers as products. Coloured compounds are also readily modified. For example, OH oxidation of the nitrophenols, a class of brown carbon constituent, leads initially to efficient formation of more colored compounds via functionalization of the aromatic ring, followed by loss of colour as ring-opening occurs under high oxidation conditions. The second portion of the talk addresses the sources of OH radicals in cloudwater. We demonstrate that dissolved SOA constituents can enhance the rates of OH generation, likely via direct photolysis of dissolved organic hydroperoxides. It is also observed that the rates of photoFenton chemistry involving light, dissolved iron, and hydrogen peroxide are suppressed in the presence of biogenic SOA compounds. We hypothesize that complex formation between iron and SOA molecules drives this behavior.

4AQ.7

What Aerosol Water do Organic Compounds See?

HAVALA PYE, Andreas Zuend, Jin Ma, Shannon Capps, Gabriel Isaacman-VanWertz, Juliane L. Fry, Lu Xu, Nga Lee Ng, Allen H. Goldstein, *Environmental Protection Agency.* INVITED

Large amounts of aerosol water are associated with inorganic salts such as ammonium sulfate with generally smaller but important contributions from hydrophilic organics. Ambient aerosols can be externally or internally mixed in addition to containing one or multiple phases. The degree to which organic compounds in a particle interact with water associated with inorganic salts will influence their partitioning between the gas and aerosol phase as well as opportunity to participate in aqueous chemistry. In this work, we examine the potential for liquid-liquid phase separation, or lack thereof, within PM2.5 particles to affect the partitioning of compounds between the gas and aerosol phases. We examine partitioning of ammonia and several isoprene- and monoterpene-derived organic compounds using common (absorptive partitioning, ISORROPIA) and advanced (AIOMFAC) approaches to describing gas-aerosol partitioning for conditions during the Southern Oxidant and Aerosol Study (SOAS). We aim to address the degree to which sophisticated techniques accounting for organic-inorganic interactions, deviations in ideality, and phase separation reproduce observations and the information gained or still needed to further their usefulness.

4CA.1

A New Instrument and Method for the Speciation of Carbonaceous Aerosols.

MARTIN RIGLER, Luka Drinovec, Athanasia Vlachou, Giulia Stefenelli, Jay G. Slowik, Andre S.H. Prévôt, Anthony D.A Hansen, Iasonas Stavroulas, Jean Sciare, Griša Močnik, *Aerosol d.o.o.*

Carbonaceous aerosols account for a large and often dominant fraction of fine particulate matter ($PM_{2.5}$) and are extremely diverse in composition. We present a new real-time method which combines an optical method for measuring black carbon (BC) by the Aethalometer (AE33 model), with a thermal method for total carbon (TC) determination, performed by the newly developed Total Carbon Analyzer (TCA). Organic carbon (OC) is calculated as $OC = TC - b \cdot BC$, where $b \cdot BC$ is equivalent to elemental carbon (EC) and the determined proportionality parameter b is region and/or site specific.

The TCA operates on the principle of rapid combustion of carbonaceous PM collected on a quartz fiber filter to create a pulse of combustion products which are converted to CO_2. This pulse is detected as a large transient increase above the CO_2 level in ambient air, which is used as the carrier gas. Unlike most OC/EC instruments that make use of thermal-optical methods for the analysis of carbonaceous PM, the TCA does not require special high purity gases or fragile quartz glass components for its operation.

The TC-BC method with the new TCA instrument was tested in field campaigns in Zurich (urban background) and Magadino (rural background), Switzerland; and in Ljubljana (urban background), Slovenia. The carbonaceous fractions in $PM_{2.5}$ were determined with the TCA with a time resolution of 1 hour, combined with AE33 Aethalometer data on a 1-minute time-base. In parallel, 24h filter samples were collected at both stations for OC/EC laboratory analysis. Additional measurements with AMS (at Swiss sites) and ACSM (in Ljubljana) provided OM concentration (converted to OC) data with high time resolution. The results show a good correlation between 24 h averages of BC and EC (EUSAAR2), and between TC obtained by TCA and TC = OC + EC determined from the 24h filters.

4CA.3

Measured Direct In-situ Mass Specific Absorption Spectra from Nine Forms of Carbonaceous Aerosol.

CHRISTOPHER ZANGMEISTER, Rian You, James Radney, Michael Zachariah, *National Institute of Standards and Technology*

This study will focus on quantitative measurements of black carbon (BC) across a wide spectral range to better understand the range of mass specific absorption cross sections (MAC) values of BC. In 2006 Bond and Bergstrom first assessed BC MAC as 7.5 m^2g^{-1} at a single wavelength (550 nm). This value is typically used in determination of the impact of BC climate forcing. Recent technical advances have allowed the MAC of BC to be re-assessed using new quantitative methods based on direct in-situ spectroscopic measurements across a broad wavelength range.

Mass specific absorption spectra were measured between λ = 500 nm and 840 nm for nine forms of carbonaceous aerosol, some of which meet the definition of BC: five samples generated from flames, fullerene soot, graphene, reduced graphene oxide (rGO), and C_{60}. Data were reported as mass specific absorption cross sections (MAC) for each sample. Particles generated from flames had morphologies consistent with black carbon (BC) and measured MAC between 3.8 m^2 g^{-1} and 8.6 m^2 g^{-1} at λ = 550 nm. MAC spectra were dependent on fuel type and formation conditions across the measured spectral window. Wavelength dependencies were determined using the absorption Angstrom exponent (AAE) and ranged between 0.5 and 1.3 for most samples; the AAE of $C_{60}$was 7.5 ± 0.9. The results illustrate that accurate quantification of carbonaceous aerosol absorption requires detailed measurements of aerosols with known mass across a broad spectral window.

4CA.4

Light Absorption Proprieties of Coated Soot Aggregates with Increasing Fractal Dimension and Comparisons to the Spherical Core-Shell Model.

WILLIAM HEINSON, Rajan Chakrabarty, *Washington University in St. Louis*

Soot Aggregates (SAs) in the atmosphere significantly influence the earth's radiation balance, visibility, and public health. They are formed from high-temperature, incomplete combustion of fossil and biomass fuels via diffusion-limited cluster aggregation (DLCA) of spherical monomers. SAs can contain significant amount of surface coatings of organic compounds which may alter their native fractal morphology through capillary and surface tension forces. Depending on the strength of these restructuring forces, the morphologies of SAs can be parameterized with increasing fractal dimension (Df) with values ranging from Df =1.8 to 3.0. We used three aggregation mechanisms–DLCA, Percolation, and Face-centered cubic stacking – to generate aggregates with Df = 1.8, 2.5, and 3, respectively. This range of Df closely mimics the different morphologies of real-world SAs: bare (Df = 1.8); partially collapsed (Df = 2.5); and fully collapsed (Df = 3). Next, we coated these numerical aggregates with non-refractory materials using a custom-made algorithm and calculated their numerically-exact optical properties using the discrete dipole approximation (DDA) algorithm. In many climate models, SAs are approximated by an equivalent-mass core-shell spherical model due to the ease of calculating optical properties using Lorentz-Mie theory. Keeping this in mind, we computed the optical properties of core-shell spheres equivalent in mass to our coated SAs. Comparisons of the core-shell spheres with the coated aggregates showed that the mass absorption cross-sections (MAC) were greatly underestimated in the core-shell approximation with increasing particle size. Due to their porous nature, the monomers of the aggregates are completely illuminated by the incident light while the optical skin depths of the equivalent core-shell spheres prevents the black carbon core from participating in light absorption.

4CA.5

An Investigation on Secondary Organic Aerosol Induced Restructuring in Soot Aggregates. Kaiser Leung, Elijah G. Schnitzler, Ramin Dastanpour, Steven Rogak, Wolfgang Jager, JASON S. OLFERT, *University of Alberta*

Two sets of photo-oxidation experiments were conducted to investigate the restructuring of soot aggregates induced by secondary organic aerosol (SOA) coating and its humidity dependence. The experiments involved soot aggregates generated from three sources, namely an ethylene premixed burner, an inverted diffusion burner, and a diesel generator. Soot aggregates were treated by denuding then size-selected by a differential mobility analyzer and injected into a smog chamber, and subsequently exposed to SOA using p-xylene as a precursor. The change in mobility of aggregates between the initial and final structures displayed a linear dependence on the number of primary particles in the aggregate. The linear relationship could allow modelers to predict the evolution of aggregate morphology induced by SOA coating. In the second set of experiment, the relative humidity (RH) dependence of the restructuring of aggregates induced by SOA coatings was investigated. Soot aggregates were generated using an ethylene premixed burner, classified by mobility diameter and injected into a smog chamber. The aggregates were then exposed to SOA coatings using p-xylene as a precursor and subsequently subjected to one of the RHs: < 12, 20, 40, 60, 85%. At RH < 12%, a uniform increase in mobility diameter with increasing coating mass was observed, indicating that the coating was too viscous to induce aggregate restructuring. At RH above 20%, restructuring of aggregates was observed in the form of a decrease in mobility diameter with increasing coating mass. Interestingly, the degree of restructuring increases with increasing RH, indicating that elevating humidity decreases coating viscosity and increases surface tension. Appreciable water uptake by the SOA coating was observed for RH above 60%, and the hygroscopicity parameter for SOA coating generated from p-xylene was determined. This result has significant implications on atmospheric restructuring of soot aggregates induced by SOA coatings.

4CA.6

Apportionment of Black Carbon to Fossil Fuel and Biomass Sources in Ontario. ROBERT HEALY, Uwayemi Sofowote, Yushan Su, Jerzy Debosz, Michael Noble, Cheol H. Jeong, Jon M. Wang, Nathan Hilker, Greg J. Evans, Geoff Doerksen, Keith Jones, Tony Munoz, *Ontario Ministry of the Environment and Climate Change*

Black carbon (BC) is of significant interest from an air quality perspective but also due to its impacts as a short-lived climate pollutant. In this study, sources of BC in Ontario, Canada were investigated using nine concurrent Aethalometer datasets collected between June 2015 and May 2016. The sampling sites represent a mix of background and near-road locations. An optical model, based on assumed absorption Ångström exponent values, was used to estimate the relative contributions of fossil fuel combustion and biomass burning to ambient concentrations of BC at every site. The highest annual mean BC concentration (1.7 $\mu g\ m^{-3}$) was observed at a Toronto highway site, where vehicular traffic was found to be the dominant source. Fossil fuel combustion was the dominant contributor to ambient BC at all sites in every season, while the highest seasonal biomass burning mass contribution (35%) was observed in the winter at a background site on the Toronto Islands, where traffic contributions are minimal. The mass absorption cross-section of BC was also investigated at two sites, where concurrent thermal/optical elemental carbon data were available, and was found to be similar at both locations. A strong seasonal dependence was observed for fossil fuel BC at every Ontario site, with mean summer mass concentrations higher than their respective mean winter mass concentrations by up to a factor of two. Using quantitative transport bias analysis (QTBA), this seasonal effect was investigated, and an increased influence from transboundary fossil fuel BC emissions originating in Michigan, Ohio, Pennsylvania and New York was identified for the summer months. The findings reported here indicate that transboundary sources of BC can impact ambient concentrations throughout southern Ontario, including the densely populated Greater Toronto Area, and that BC should not be considered as an exclusively local pollutant in future air quality policy decisions.

4CA.7

Characteristics and Processing of Black Carbon Particles in an Urban Environment: Insights from a Soot Particle – Aerosol Mass Spectrometer (SP-AMS). Sonya Collier, Leah Williams, Timothy Onasch, Christopher Cappa, Xiaolu Zhang, Lynn Russell, QI ZHANG, *University of California, Davis*

The coating of black carbon (BC) particles, i.e., inorganic and organic matter internally mixed with BC, can enhance light absorption and affect atmospheric lifetimes of BC particles thus having significant implications on regional and global climate. In order to study the physical and chemical characteristics of atmospheric BC and its associated coating, a soot-particle aerosol mass spectrometer (SP-AMS) was deployed during the winter of 2014-2015 for 4 weeks alongside a single particle soot photometer (SP2) in Fresno, a polluted city located in the San Joaquin Valley of California. The SP-AMS uses an infrared laser to volatilize absorbing particles and provides real-time size resolved chemical information on particles containing BC. During this campaign the SP-AMS was operated using only the laser without the thermal vaporizer in order to selectively analyze BC particles. We found that most BC-containing particles appeared to be associated with residential wood burning and vehicular traffic. However, a substantial fraction of the coating was found to be secondary in nature and this fraction was significantly enhanced via aqueous-phase processing during periods of persistent fog. Specifically, compared to periods with no visible fogs, the BC coating contained a higher concentration and larger fraction of secondary species including nitrate and oxidized organic matter and the size distribution of BC-containing particles displayed a prominent droplet accumulation mode during foggy periods.

4CM.1

Dieselgate - The Aerosol Analyst´s View. REINHARD NIESSNER, *Analytical Chemistry, Institute of Hydrochemistry, TU Munich*

Volkswagen dieselgate has created much public attendance. The reason for this is the possible violation of emission threshold limits for diesel exhaust, especially by particulate matter and nitrogen oxides.

From the viewpoint of an analyst there is a tremendous need for discussion, whether the determination techniques applied to determine particulate matter (PM), and NOx as well, are accurate. In Europe, the non-gravimetric monitoring of diesel exhaust (PMP particle counting) seems especially vulnerable.

This lecture likes to illuminate the possible artifacts of NO_2 determination with and without soot particle filters at the entrance of a NOx box. Interaction of nitrogen dioxide with soot creates heavy deviations. Secondly, the determination of PM is still unclear. Depending on chemistry of filter material (PTFE-coated glass fiber), total mass or soot determination result in non-comparable results among the various techniques. Any combination with a thermo-separation step opens the way to tremendous particle losses by early oxidation, or phoretic effects.

PMP - adequate particle counting exhibits strong dependencies on particle surface and its inner particle composition. The freely selectable pretreatment of the probed exhaust sample (catalytic stripping, volatilization and dilution) also creates ambiguities. New particle formation may happen. Calibration of these devices is still unsolved.

Currently, only on-line and in situ techniques (e.g. photoacoustics, incandescence) seem less affected by artifact formation. Filtration as sampling technique should be avoided. Thermophoretic particle sampling is proposed. Calibration remains discussable.

4CM.2

Sulfur Particulate Emissions from Ocean Going Vessels with Scrubber System.

JIACHENG YANG, David R. Cocker III, Kent C. Johnson, Wayne Miller, Thomas D. Durbin, Yu Jiang, Georgios Karavalakis, *University of California, Riverside*

Ship emissions generated by the merchant fleet are reported to represent a significant contribution to global anthropogenic emissions and lead to a change of the chemical composition of the atmosphere and of climate. Emissions from ocean going vessels (OGVs) not only effect the population living near the ports and coastlines, but also those living hundreds of miles inland. Sulfur emissions from OGVs are a particular concern in causing health and environmental effects worldwide. Since January 2012, the International Maritime Organization (IMO) has required all ships to operate with fuels less than 3.5% sulfur and the IMO will potentially set a future goal of using fuel with less than 0.5% sulfur depending on the midterm review in 2018. Additionally, the IMO has special fuel quality provisions for emission control areas (ECAs), where a rule has been in place since January 2015 requiring the use of less than 0.1% sulfur in the fuel. Currently, there are four existing ECAs around North America and Western Europe with the potential for further expansion into East Asia and Australia. Heavy Fuel Oil (HFO) is still allowed in ECAs if an equivalent method (i.e., exhaust gas cleaning system (EGCS) or scrubbers) is used to reduce sulfur emissions (gas and particulate) to levels equivalent to those provided by the fuel sulfur standard.

Utilizing a scrubber to reduce the sulfur emissions to an equivalent low sulfur fuel level is a strategy that has been generally accepted both by governmental agencies and ship owners due to its high sulfur emissions reduction and also the long term cost benefit of operation compared to the use low sulfur fuel. Few studies have been done to evaluate the performance of scrubber systems on OGVs and there is a need to understand how to accurately measure ship emissions during use. This study provides emission measurements of gaseous, particulate matter (PM), and elemental and organic carbon from three OGVs ranging from Tier 0 to Tier 2 with scrubber systems. The scrubber system show an over 95% reduction in SOx, but very limited reductions on sulfur from the particle phase. This is attributed to the natural formation of the nucleation mode sulfuric acid particles under conditions that they are not efficiently eliminated by the scrubber system. Considering sulfur emissions as a whole, both gaseous and particulates, the scrubber systems equivalent sulfur emissions were higher than those achieved by using low sulfur fuel alone.

4CM.3

Investigation of VOC Exposure from Nail Salon Products.

AARON LAMPLUGH, Feng Xiang, Janice Trinh, Elizabeth Ly, Lupita Montoya, *University of Colorado Boulder*

Nail salon workers are frequently exposed to compounds like xylene, toluene, and formaldehyde, which are known to cause skin and eye irritation, respiratory problems, allergies, and cancer. An estimated 76% of the “Miscellaneous Personal Appearance Workers” (e.g., manicurists, pedicurists, and skin care specialists) are minority and immigrant populations. Other sources indicate that nail technicians are 97% female, most of them of reproductive age. A 2013 survey found that 40% of nail salon workers had work-related health concerns and 23% did not have medical insurance. In Colorado, there are about 2,015 nail salons, which employ around 18,559 licensed nail technicians.

Exposure to hazardous indoor air pollutants is traditionally mitigated by increasing natural ventilation or through mechanical ventilation systems. VOC removal using sorption processes is being investigated in our laboratory as an alternative control strategy. Results from previous work in our group showed the removal of formaldehyde by porous media like expanded clay, Growstone and coco coir in a series of chamber and column studies. Previous research in our group also demonstrated that the use of localized ventilation can induce fluid vectoring and increase contaminant uptake by sorption materials.

This study utilizes chamber experiments to determine baseline emission profiles from products like nail polishes and hardeners and compares them to those in the presence of sorption materials (with and without local ventilation). A field study in the Denver area nail salons is also being conducted to determine typical exposure levels experienced by nail technicians. Promising sorption materials identified during the chamber studies will then be tested in Denver nail salons.

Preliminary data from our chamber experiments indicate that typical consumer nail polishes emit VOCs on the order of 65mg TVOCs per gram of nail polish, and that certain gel type nail polishes may emit substantially fewer VOCs by mass.

4CM.4

Performance of Respirator Filter Media under Breathing Flow Condition. PENG WANG, Da-Ren Chen, *Virginia Commonwealth University*

Respirator filter media in applications typically experience the flow in cyclic patterns due to the nature of human breathing, which is very different from the constant flow used in the NIOSH standard testing method. It is thus necessary to evaluate particulate respirator filter media under simulated human breathing conditions, i.e., at cyclic flow, in order to study the performance of media in practical applications. In this study, a new testing setup was proposed to investigate the performance of respirator filter media under breathing flow condition. In the setup, a special filter holder, integrating the mulit-point sampling probe and make-up air injection probe, was designed. A breathing flow simulator was connected to the filter holder to create the cyclic flow patterns. A condensation monodisperse aerosol generator was used to generate either liquid or solid sub-micro monodisperse particles in high concentration for testing. Two CPCs were used to measure the up- and down-stream number concentrations of test particles, from which the time-dependent particle penetration of filter media could be derived by taking the ratio of measured downstream to upstream concentrations. Because of the 0.1-second sampling time of CPCs, the new testing setup was able to measure close-to-instantaneous particle penetration through respirator filter media. This testing was performed under the inhalation and exhalation condition. Via the new testing method, individual effects of breathing frequency (BF) and peak inhalation flow rate (PIFR) on the collection efficiency of respirator filter media was studied. The performance of respirator filter media under equivalent constant flowrate (MIFR: Mean Inhalation Flow Rate) was also measured to compare with that under cyclic flow condition. The detail of data collected in this study will be presented in the conference.

4CM.5

Designing Composite Filters for High Efficiency, Low Pressure Drop, and High Loading Capacity. SHENG-CHIEH CHEN, Min Tang, Drew Thompson, Luying Liu, David Y. H. Pui, *University of Minnesota*

Pleated electret HVAC filters are often used in residences and commercial buildings to mitigate the particles that originate both indoors and outdoors. However, there are two concerns on the performance of electret media: 1. low efficiency for particles in diameter of 10-30 nm at initial filtration condition, which represent the MPPS (most penetrating particle size), and 2. significant efficiency reduction during the loading process due to the shielding of fiber charge. In this study, a composite filter media composed of a main layer of HVAC electret media on the top and a thin layer of nanofiber at the bottom was prepared and tested for its PM2.5 removal. In the initial efficiency tests, monodisperse nanoparticles ranging 8-500 nm were used to challenge the media. It was found that the nanofiber layer can enhance the efficiency for the MPPS (10-30 nm) of electret media significantly. In the loading performance, polydisperse NaCl particles which mimicked the size distribution of typical atmospheric PM2.5 were used to challenge the media. It was found the total efficiency reduction was less than 10% for particles with sizes 50-500 nm. This reduction due to the shielding of fiber charge was much less than the electret layer (>40%) without adding nanofibers. The observation of a decent performance over the loading process was expected since the composite media made full use of both the mechanical forces and electrostatic effects. Surprisingly, the overall loading FOM (figure of merit) of the composite media was close to that of electret media, indicating that there was only a minor tradeoff of pressure drop increase when adding the nanofiber layer. In conclusion, this type of combination provided a unique structure to take advantage of electret media and a nanofiber layer for PM2.5 removal in the application of pleated HVAC filters.

4CM.6

Air Intake Filter Media Loading by Solid and Oil Mixtures.

QISHENG OU, David Y. H. Pui, *University of Minnesota*

Current air filter test standards employ pure solid (ISO dust, carbon black, cotton linter, KCl, etc.) or pure oil (DEHS) as testing aerosols. Only pure solid particles are used to assess the filter holding capacity or to condition the filter in test standards. Filters used in field may face aerosols with different physical states, e.g. mixtures of solid and liquid (oil) particles for filters used for colloid/mist removal, including cooking or oil handling application, offshore oil drilling platform, and etc. Although the clean filter efficiency may not be affected much by aerosol physical state, the filter loading and clogging behaviors could be different.

In this study, particle loading and clogging behaviors on three types of air intake filter media (cellulose, cellulose with nanofiber coating on top, and ePTFE) were tested using solid and oil mixtures. Two types of solid particles were generated: sodium chloride and soot agglomerates. The solid fraction was mixed with oil particles generated from another Collison-type atomizer, in which DEHS or a series of high-viscosity PAO oil particles were generated. The solid and oil particle mixtures were loaded onto a 57-mm diameter flat filter media with controlled mixing ratio varying from pure solid to pure oil with 10% increment. The holding capacity of cellulose media is found to increase with increasing oil fraction in the mixture; while the clogging on nanofiber or ePTFE switches between two patterns. At high solid fractions, solid-oil mixtures deposit on the surface of media, forming cake, which leads to higher holding capacities than conventional cellulose media. At high oil fractions, solid-oil mixtures form a paste-like thin film, which spreads out and coats on top surface of fine fiber layer in nanofiber or PTFE media, resulting in faster clogging and reduced holding capacities than cellulose media.

4CM.7

Modeling and Simulation of Electrostatically Charged Particle Dynamics in the Inflow and Transition Area of Cabin Air Filter Media.

CAROLIN SCHOBER, David Keerl, Martin Lehmann, Miriam Mehl, *MANN+HUMMEL GmbH*

Cabin air filters are applied to prevent small particles such as pollen, fine dust and soot amongst others from being transferred into the interior (cabin) of a vehicle. The filter media often make use of the so called electret effect as means for achieving high filtration efficiency at low pressure drop. Thereby, electrostatic filtration effects are supplemented to the well-known mechanical collision mechanisms (such as inertia, diffusion, etc.). Besides the interference of several fiber-particle interactions (Coulombic attraction/repulsion, induced forces, etc.) particle-particle interactions potentially play an important role. However, this effect is completely neglected in previous research studies due to the high degree of complexity. The objective of this study is to determine the effect of particle-particle forces and whether a simplified approach is justifiable.

In this work, we present a detailed investigation of particle motion in the inflow and transition area of the filter media. For a precise description of the underlying physical procedures, the simulation is based on a fully coupled system. This approach takes into account the reciprocal influence between fluid flow and particle motion as well as the interactions between single electrostatically charged particles. The software package ESPResSo [1] provides a powerful tool for this four-way coupling. Based on a molecular dynamic approach the software offers the advantage of applying efficient algorithms for the modeling of long-ranged electrostatic interactions. In order to emulate the air flow, the molecular dynamic simulation is coupled with a Lattice-Boltzmann fluid.
For comparison with testing results a wired mesh is used instead of the filter media which allows for excluding the electrostatic charges by grounding and focusing on the particle-particle interactions. Despite the simplification the scenario includes all modeling requirements as necessary for the complex filter media structure. The simulation results show significant deviations of particle trajectories for charged and uncharged particles, respectively.

[1] Arnold A., Lenz O., Kesselheim S., Weeber R., Fahrenberger F., Roehm D., Košovan P., Holm C., “ESPResSo 3.1: Molecular Dynamics Software for Coarse-Grained Models”, Lecture Notes in Computational Science and Engineering (2013).

4IM.1

Detection and Characterization of Chemical Aerosol Using Laser Trapping Single-Particle Raman Spectroscopy. AIMABLE KALUME, Joshua Santarpia, Yong-Le Pan, *U.S. Army Research Laboratory, Adelphi, MD*

Studying physical and chemical properties of aerosol particles in the ambient medium presents a unique tool in order to understand their dynamics, evolution and effects on our environment. In this perspective, a rapid detection and characterization of the presence of chemical agent aerosols in various complex atmospheric environments is an essential defense mission. Despite considerable efforts vowed to prevent the development, production, stockpiling and the use of chemical weapons, the World faces a constant sense of threat and fear, resulting from the increasing criminal and terrorist activities. Our research focuses on characterizing chemical agents and simulants as airborne aerosol particles. Recently, we developed a laser-trapping single-particle Raman spectrometer system, we trapped and characterized microdroplets of the VX nerve agent chemical simulant, diethyl phthalate. In additional to the good agreement with previous works and theoretical prediction, the uniqueness of the chemical fingerprint is enhanced by appearance of additional spectral features, related to the spherical nature of the microdroplets, namely stimulated Raman scattering and morphology-dependent whispering gallery modes. The resonance spectrum, resulting from the variations in the elastic scattered light as function of time, was compared to the simulation, based on Lorenz-Mie theory, to determine the microdroplet size at any given time. Due to its high efficiency in trapping and its precision in spectroscopic characterization, this method could be particularly suitable for detecting and characterizing hazardous substances such as chemical agents in complex atmospheric environments.

4IM.2

Opto-Aerodynamic Manipulating and Focusing of Aerosol Particles. YONG-LE PAN, Aimable Kalume, Chuji Wang, Joshua Santarpia, *U.S. Army Research Laboratory, Adelphi, MD.*

We manipulate, focus, and concentrate micron-size aerosol particles using the combined drag force and optical force. The focusing, concentrating, and trapping process is carried out by using a counter-flow coaxial-dual-nozzle and a special optical configuration. Continuously sampled individual particles are concentrated, then slowed down, and eventually trapped. The special optically configured laser profile can, stably, trap both absorbing or transparent particles, make a particle rotate or vibrate along the trapping position. Working at certain conditions for such an opto-aerodynamic configuration, the micron-size airborne particles can be 6 times more concentrated/focused by using the combination of optical forces (radiative pressure force and photophoretic force) than using drag force alone. Subsequently, the aerosol stream can be focused from 250 micron diameter further down to less than 100 micron in diameter.

4IM.3

A New Single Particle Aerosol Mass Spectrometer: Multiple-Analyses of the Same Individual Airborne Aerosol Particle for Determination of Particle Size, Polycyclic Aromatic Hydrocarbon-Content as well as the Elemental Composition. Johannes Passig, Julian Schade, Matthias Fuchs, Markus Oster, Martin Sklorz, Sven Ehlert, RALF ZIMMERMANN, *Helmholtz Zentrum München and Rostock University, Germany*

Single-particle aerosol mass spectrometry (ATOFMS etc.) based on laser desorption ionization (LDI) is a versatile method for characterization of airborne particles. Currently available ATOFMS-technologies detect mainly inorganic species. Organics, such as polycyclic aromatic hydrocarbons (PAH), are important for aerosol-related health effects. Recently also field-applicable ATOFMS-approaches were developed, allowing on-line single particle PAH-detection (Bente et al., Anal.Chem. (2018) 8991-9004). For this in the ATOFMS-ion source particles are IR-laser pulse desorbed (LD). 1µs later, PAH are softly ionized by an UV-laser pulse (resonance-enhanced multiphoton ionization, REMPI) and ATOFMS-detected. A drawback is, however, that the LDI-information on the inorganic particle-composition is lost.

Here we present a new multi-step laser ionization ATOFMS-concept for detection of organic species (LD-REMPI) and element signatures (LDI) from individual aerosol particle. The approach is based on the sequential application of laser pulses to the very same particle and extraction field polarity-inversion of the dual-TOF mass analyzer between the REMPI- and LDI-laser ionization processes. The sized particle in the ion source it is IR-laser pulse desorbed and the PAH in the desorption plume subsequently are ionized by an UV-laser pulse (REMPI). After some 100 ns, when the PAH-ions have left the ion source, the field in the ion source is reversed and the same particle core, which is still on its fly-through path in the ion source, is hit by a third, intense laser pulse for LDI. Due to the inverted field the LDI-cations now are accelerated in the second TOF-Flight analyzer. By this procedure in addition to the particle size, the REMPI-spectrum of the absorbed PAH-molecules as well as the LDI-spectrum (showing e.g. Fe^+, C^+ or Al^+) from the same individual particles are detected. First measurements of redispersed wood-combustion and diesel-emission particles as well as ambient sampling results are shown. On-line multi-step ATOFMS represents a promising technology for source apportionment and internal and external mixing state-analysis of inorganics and organics.

4IM.4

The Sensitivity of a Q-ACSM in Measuring Chamber Generated SOA with Different Oxidation States. Yan Ma, XIAOXIAO LI, Hui Chen, Xin Ma, Youling Jiang, Rujin Yin, Jiming Hao, Jun Zheng, Jingkun Jiang, *Tsinghua University*

The accuracy in quantifying secondary organic aerosols (SOA) using an aerosol chemical speciation monitor with a quadrupole mass spectrometer (Q-ACSM) was studied. Pure SOA were generated under simulated photochemical oxidation conditions in a 4.5 m^3Teflon chamber from three different volatile organic compound (VOC) precursors at atmospheric relevant concentrations (dozens of ppbv): α-pinene, isoprene and toluene, representing both biogenic and anthropogenic VOCs. Different SOA oxidation states were achieved by changing the reaction ratio of the VOC precursor to the oxidants (O_3 or OH). SMPS and APM were used to measure the number-size distribution and the mass of the generated SOA, which were then used to deduce the SOA mass concentration. The sensitivity of the Q-ACSM to a specific SOA was found to be anti-correlated with the O/C ratio regardless of the VOC precursors. This may be due to the decreasing of relative ionization efficiency (RIE) or the decreased collection efficiency (CE) of the Q-ACSM for more oxidized SOA. To pinpoint the actual cause, $(NH_4)_2SO_4$ seed particles were injected into the chamber before SOAs were produced from VOC precursor. After coating with SOA, the sulfate signal increased significantly, indicating increased CE of coated $(NH_4)_2SO_4$ particles. However, it appears that CE of SOA coated $(NH_4)_2SO_4$ particles did not change substantially with changing O/C ratio, which then can be taken into account as a correction factor of the CE of the chamber generated SOAs for the Q-ACSM.

4IM.5

Coalescence Sampling of Ambient Aerosol Using Aerosol Optical Tweezers. JIM WALKER, Allen E. Haddrell, Lilly Manzoni, Jonathan P. Reid, Rebecca Hopkins, *University of Bristol*

We present the first exploratory study to assess the sensitivity and suitability of aerosol optical tweezers (AOT) as a technique for sampling and detecting free-flowing accumulation- and coarse-mode ambient aerosol. A subpicoliter aqueous droplet is captured in an optical trap and used as a sampling volume to accrete mass from free-flowing aerosol generated nearby using a medical nebulizer or atomizer.

Collection of the ambient aerosol by the sampling droplet is identified by real-time changes to the radius, refractive index and relative proportions of chemical species within the sampling droplet. These quantities are retrieved using Raman spectroscopy and are shown to be measured with high accuracy and low noise. Typical standard deviations in the initial (pre-sampling) size and refractive index of the sampling droplet over a period of 200 s are <±2 nm and <±0.0005, respectively, equivalent to <±0.04% in both measured quantities. A standard deviation of <±1% over a 200 s period is achieved in the measured intensity ratio between two spontaneous Raman bands, used to infer the OH:CH ratio of the sampling droplet.

When sampling coarse-mode aerosol, mass changes of <10 pg can be detected by the sampling droplet as individual coalescence events indicated by discrete step-changes to the measurement quantities. With accumulation-mode aerosol, we show that fluxes as low as 0.068 pg s–1 can be detected over a 50 s period, equivalent to ~3 pg of sampled material, identified by more gradual changes to the measured quantities.

We will present the sensitivity limits of this sampling approach and demonstrate the future potential of the technique for sampling and identifying secondary organic aerosol, among other ambient aerosols.

4IM.6

Determination of the Activity Coefficients of Water in Aqueous Solutions at Sub-zero Temperatures using a Novel Chilled optical Aerosol Tweezers. Hassan Beydoun, Kyle Gorkowski, Jim Walker, Jonathan P. Reid, RYAN SULLIVAN, *Carnegie Mellon University*

The activity coefficient of water in aqueous and organic solutions is a crucial property in the determination of an aerosol particle’s size and its ability to act as a cloud condensation nucleus. While many accurate techniques exist to measure water activity coefficients in aerosol particles, none have yet to do so below 0 °C. The inability to measure this key aerosol property in the temperature range most relevant to the tropospheric aerosol remains a significant deficiency in existing instrumental techniques.

We present a novel method for determining the activity coefficient of water in aqueous and organic solutions at sub-zero temperatures using a chilled optical aerosol tweezers (COAT). The new temperature controlled system retains the powerful capabilities of traditional aerosol optical tweezers: retrieval of a cavity enhanced Raman spectrum that can be used to accurately determine the size and refractive index of a trapped droplet. It has already been shown that for aqueous droplets these two properties can lead to an accurate determination of the activity coefficient of water if the relative humidity (RH) around the droplet is known. In the newly developed system, single aqueous KCl, NaCl, and NaCl-adipic acid droplets were cooled down from room temperature to -12 °C to investigate the temperature dependence of the activity coefficient of water in all three mixtures in the RH range of 70%-90%. The COAT technique is therefore the first to examine the temperature dependent aerosol aqueous thermodynamic properties on the same individual droplet in the “sub-zero” temperature range.

4IM.7

Mass Spectrometric Analysis of Aerosol Particles Levitated in an Electrodynamic Balance: a Platform for Atmospheric Chemistry Research.

ADAM BIRDSALL, Ulrich Krieger, Frank Keutsch, *Harvard University*

A droplet levitation device that suspends single aerosol droplets, such as an electrodynamic balance (EDB), provides an attractive system for atmospheric chemistry research. Laboratory control of aerosol composition allows isolation and careful study of particular physical or chemical processes of interest, on the timescale of an aerosol particle's multiday atmospheric lifetime. A suspended aerosol particle can depict more realistically the coupling of chemical and physical processes that can influence multiphase reactions, phase partitioning, or surface-mediated reactions, for instance, compared to bulk condensed-phase laboratory experiments. Considerable research with levitated droplets has been conducted using optical detection techniques; however, chemically complex systems can be better-suited to an analytical technique with more molecular specificity, such as mass spectrometry.

Here, an EDB has been coupled with a custom-built ionization source and commercial time-of-flight mass spectrometer as a platform for atmospheric chemistry research. A charged droplet (typical size 5-10 μm) is injected into the EDB and levitated for an arbitrarily long amount of time in an electric field within the trap, surrounded by a gas phase whose composition, including relative humidity, can be controlled. To analyze the droplet, the gas flow and electric field is manipulated to transfer the droplet to a vaporization–corona discharge ionization region before mass spectral analysis. The temporal evolution of an aerosol particle's composition is mapped out by analysing a series of identical particles that reside in the trap for increasing amounts of time. The apparatus is more than sufficiently sensitive for mass spectral analysis of a single particle in this size range. The utility of this system has been demonstrated with an experiment measuring differential gas-phase loss timescales for a family of model compounds mixed in a single droplet.

5AC.1

Controlled HOx and NOx Production via Alkyl Nitrite Photolysis for Use in Oxidation Flow Reactor Studies of Secondary Organic Aerosol Formation Pathways.

ANDREW LAMBE, Penglin Ye, William Brune, Anthony Carrasquillo, Jordan Krechmer, Paola Massoli, Roy Lee III Mauldin, Zhe Peng, Jonathan Raff, Jose-Luis Jimenez, Douglas Worsnop, *Aerodyne Research, Inc.*

Oxidation flow reactors (OFRs) that use low-pressure mercury lamps to produce hydroxyl (OH) radicals are an emerging technique for studying the formation and oxidative aging of organic aerosols. In these flow reactors, ozone is photolyzed at $\lambda = 254$ nm to produce $O(^1D)$ radicals, which react with H_2O and nitrous oxide (N_2O) to produce OH and NO, respectively. Here, we develop a complementary method adapted from previous environmental chamber and kinetics studies that uses photolysis of alkyl nitrites at $\lambda = 254$ or $\lambda > 350$ nm to produce hydroperoxyl (HO_2) radicals and nitric oxide (NO) followed by the reaction $NO + HO_2 \rightarrow NO_2 + OH$. We present experimental and model characterization of OH, HO_2, NO and nitrogen dioxide (NO_2) concentrations that are generated via photolysis of several $C_1 - C_4$ alkyl nitrites in the Potential Aerosol Mass OFR. We demonstrate proof of principle using chemical ionization mass spectrometer measurements of highly oxidized multifunctional compounds generated from the OH oxidation of biogenic volatile organic compounds.

5AC.2

Influence of Fuel to Primary Exhaust Emissions and Secondary Aerosol Formation Potential from a Ship Engine.

HILKKA TIMONEN, Niina Kuittinen, Päivi Aakko-Saksa, Minna Aurela, Pauli Simonen, Panu Karjalainen, Mia Isotalo, Matthew Bloss, Timo Murtonen, Hannu Vesala, Jukka-Pekka Jalkanen, Päivi Koponen, William Brune, Topi Rönkkö, Sanna Saarikoski, *Finnish Meteorological Institute*

Particulate emissions from international shipping aren't directly regulated, however the regulation for gaseous emissions (e.g. SOx, NOx) has been implemented in recent years. Also, limitations for shipping black carbon (BC) emissions are planned by IMO (International Maritime Organization). The aim of this study was to conduct a comprehensive characterization of gaseous and particulate emissions of a ship engine. Measurements were conducted at the VTT Technical Research Centre of Finland engine laboratory using a 1.6 MW Wärtsilä Vasa 4R32 LN medium-speed engine. Test fuels comprised fuels with 0.1%, 0.5% and 2.5% sulphur content and a biofuel blend. Two engine loads, 75% and 25% were used. Chemical composition of exhaust emissions was measured using a soot-particle aerosol mass spectrometer (SP-AMS). SP-AMS enables the real-time measurements of particulate matter (PM) mass and size-resolved chemical composition of submicron non-refractory particulate matter, refractory BC and some metals and elements. In addition, in-depth chemical composition was analysed from filters. The secondary aerosol formation potential from exhaust emissions was studied using a potential aerosol mass (PAM) chamber. In addition, gaseous emissions, black carbon concentrations, size distributions of PM as well as physical properties of PM (e.g. volatility, hygroscopicity) were analysed using several state-of-the art online instruments.

The main constituents of primary PM were BC, organic compounds and sulphates. Both fuel and engine load were observed to have a clear influence to both concentration and composition of the primary PM. Secondary aerosol was dominated by organic compounds and sulphur. The fuel was observed to have a large influence to secondary aerosol formation potential. Highest secondary aerosol formation potentials were observed for high sulphur (0.5-2.5% S) fuels.

5AC.3

Modeling of High-NO Chemistry in Oxidation Flow Reactors. ZHE PENG, Brett Palm, Ranajit Talukdar, Weiwei Hu, Andrew Lambe, William Brune, Jose-Luis Jimenez, *CIRES, University of Colorado*

Oxidation flow reactors (OFRs) using OH produced from low-pressure Hg lamps at 254 nm (OFR254) or both 185 and 254 nm (OFR185) are commonly used in atmospheric chemistry. We perform a comprehensive modeling study of OFR chemistry and find that high-NO (NO-dominated RO_2 radical fate) OFR experiments are very difficult to conduct by initial NO injection (OFR-iNO) due to its rapid oxidation to NO_2. Combustion sources used in OFR studies often contain very high VOC and NO, which should be diluted by >x100 to avoid non-tropospheric VOC photolysis at 185 and 254 nm. It needs to be realized, however, that strong dilution almost certainly results in low-NO conditions. We thus examine new experimentally-evaluated techniques maintaining high NO, i.e., injection of percent-level N_2O in both OFR185 (OFR185-iN_2O) and OFR254 (OFR254-iN_2O), and also a technique proposed based on model calculations: continuous NO injection along the flow in OFR185 (OFR185-cNO). OFR185-iN_2O represents the best compromise between performance and experimental complexity. Lowering O_2 or using lamps with higher 185-nm–to–254-nm emission ratio may improve the performance of OFR185-iN_2O experiments with certain precursors. In the case of precursors highly reactive toward NO_3 (e.g., dihydrofurans, α-terpinene, and terpinolene), OFR185-cNO may be needed to avoid significant NO_3addition pending experimental validation. To obtain high-NO chemistry and avoid various experimental artifacts (including non-tropospheric photolysis, RO_2 suppression by NO_2, and VOC oxidation by NO_3), high relative humidity, modest UV lamp setting, low VOC concentration, and substantial (but not too high) NO_x precursor injection are preferable.

5AC.4

Compounds Controlling SOA Formation from Stressed and Unstressed Scots Pine Emissions in an Oxidation Flow Reactor. CELIA FAIOLA, Angela Buchholz, Eetu Kari, Pasi Yli-Pirilä, Jarmo Holopainen, Minna Kivimaenpaa, Pasi Miettinen, Douglas Worsnop, Kari Lehtinen, Alex Guenther, Annele Virtanen, *University of Eastern Finland*

Most models describe secondary organic aerosol (SOA) formation based on parameters derived from laboratory experiments using single component standards. Few studies have looked at SOA formation from mixtures of volatile organic compound (VOC) precursors, which is more representative of SOA generation in the atmosphere. This laboratory study investigated SOA generation from a complex mixture of VOC emissions using real Scots pine (Pinus sylvestris) saplings as the VOC emission source. SOA generation was characterized for different plant volatile mixtures as the plant emissions evolved before, during, and after plant herbivore stress. The herbivore stress was an exposure to four pine weevils (Hylobius abietis) for two days. SOA generation was characterized using a custom-built oxidation flow reactor. Plant volatile emissions were measured continuously with a proton transfer reaction time-of-flight mass spectrometer (Ionicon, Inc) and supplemented with adsorbent cartridge samples (Tenax TA) analyzed offline with a thermodesorption gas chromatograph mass spectrometer (Agilent, Inc). Particle size distributions and composition were characterized with a scanning mobility particle sizer (TSI, Inc.) and high resolution aerosol mass spectrometer (Aerodyne, Inc), respectively. Prior to herbivore treatment, Scots pine emissions were dominated by monoterpene emissions with an average molar sesquiterpene-to-monoterpene emission ratio (SQT:MT) of 0.06. Even though emissions were primarily monoterpenes, the SOA mass yields from pre-treatment Scots pine emissions were higher than yields measured from a monoterpene standard, alpha-pinene, in the same oxidation flow reactor. During active herbivore feeding, monoterpene emissions increased by over 40-fold on average (with maximum observed increase over 100-fold) while sesquiterpene emissions increased by 1-fold. Consequently, after herbivore treatment the Scots pine emissions were even more dominated by monoterpenes with an average SQT:MT of 0.005. SOA yields during active feeding were similar to yields from the alpha-pinene standard. These results suggest that sesquiterpenes can play a significant role in SOA formation efficiency even when they comprise a small fraction of the precursor volatiles. SOA yields higher than alpha-pinene were observed when SQT:MT ratios entering the flow reactor were greater than 0.006. Current models could underestimate the role of sesquiterpenes in SOA production.

5AC.5

Secondary Organic Aerosol Formation from Ambient Air in an Oxidation Flow Reactor at GoAmazon2014/5. BRETT PALM, Suzane de Sá, Douglas Day, Pedro Campuzano-Jost, Weiwei Hu, Roger Seco, Steve Sjostedt, Alex Guenther, Saewung Kim, Joel Brito, Florian Wurm, Paulo Artaxo, Lindsay Yee, Rebecca Wernis, Gabriel Isaacman-VanWertz, Allen H. Goldstein, Ryan Thalman, Jian Wang, Yingjun Liu, Stephen Springston, Rodrigo A. F. Souza, Lizabeth Alexander, Scot Martin, Jose-Luis Jimenez, et al., *CIRES, University of Colorado*

Secondary organic aerosol (SOA) formation from the oxidation of ambient air was studied using an oxidation flow reactor (OFR) during both the wet and dry seasons at the GoAmazon2014/5 field campaign. Ambient air was oxidized using variable concentrations of either OH or O3, over ranges from hours to days (O3) or to weeks (OH) of equivalent atmospheric aging. The measured SOA formation from ambient air was compared to the amount predicted from the concentrations of measured ambient SOA precursors and their SOA yields. While measured precursor concentrations were generally sufficient to explain the amount of SOA formed from O3, they could only explain 10–50% of the SOA formed from OH. Previous OFR studies have shown that typically unmeasured semivolatile and intermediate volatility gases (S/IVOCs) are present in ambient air and can explain such additional SOA formation. To investigate the sources of SOA-forming gases (including unmeasured S/IVOCs) during this campaign, multilinear regression analysis was performed between measured SOA formation and gas-phase tracers representing different precursor sources. The observed potential for SOA formation was attributed roughly 50% (69%), 46% (13%), and 3% (18%) to biogenic, anthropogenic, and biomass burning emissions during the wet (dry) season. The comparisons and contrasts between the results in the wet and dry seasons will be discussed, and the strength of these conclusions will be evaluated in context of all available information. SOA yields of individual VOCs under OFR conditions were measured by standard addition into ambient air, and the yields were consistent with published environmental chamber-derived SOA yields. Also, the CCN activity of the OH-aged aerosol was measured while sampling under two types of conditions: where the measurements were dominated by new SOA formation in the OFR (~1–3 equivalent atmospheric days OH aging), or dominated by heterogeneous oxidation of pre-existing OA (~several equivalent weeks OH aging).

5AC.6

Highly Oxygenated Multifunctional Compounds in α-pinene Secondary Organic Aerosol. XUAN ZHANG, Andrew Lambe, Mary Alice Upshur, William Brooks, Ariana Gray Be, Regan Thomson, Franz Geiger, Jason Surratt, Zhenfa Zhang, Avram Gold, Stephan Graf, Michael Cubison, Michael Groessl, John Jayne, Douglas Worsnop, Manjula Canagaratna, *NCAR*

Highly oxygenated multifunctional organic compounds (HOMs) originating from biogenic emissions constitute a widespread source of organic aerosols in the pristine atmosphere. Yet, the molecular forms in which HOMs are present in the condensed phase upon gas-particle partitioning remain unclear. In this study, we show that highly oxygenated molecules that contain multiple peroxide functionalities are readily cationized by the attachment of Na^+ during electrospray ionization operated in the positive ion mode. With this method, we present the first identification of HOMs characterized as $C_{8-10}H_{12-18}O_{4-9}$ monomers and $C_{16-20}H_{24-36}O_{8-14}$dimers in α-pinene derived secondary organic aerosol (SOA). Simultaneous detection of these molecules in the gas phase provides direct evidence for their gas-to-particle conversion. Molecular properties of particulate HOMs generated from ozonolysis and OH-oxidation of unsubstituted ($C_{10}H_{16}$) and deuterated ($C_{10}H_{13}D_3$) α-pinene are investigated using coupled ion mobility spectrometry with mass spectrometry. The systematic shift in the mass of monomers in the deuterated system is consistent with decomposition of isomeric vinylhydroperoxides to release vinoxy radical isotopologues, the precursors to a sequence of autoxidation reactions that ultimately yield HOMs in the gas phase. The remarkable difference observed in the dimer abundance under O_3- versus OH-dominant environments underlines the competition between intramolecular hydrogen migration of peroxy radicals and their bimolecular termination reactions. Our results provide new and direct molecular-level information for a key component needed for achieving carbon mass closure of α-pinene SOA.

5AC.7

Impact of VOC Composition and Reactor Conditions on the Aging of Biomass Cookstove Emissions in an Oxidation Flow Reactor. ADITYA SINHA, Ingrid George, Andrew Grieshop, *North Carolina State University*

Oxidation flow reactor (OFR) experiments in our lab have explored secondary organic aerosol (SOA) production during photochemical aging of emissions from cookstoves used by billions in developing countries. Previous experiments, conducted with red oak fuel under conditions of high OH reactivity (OHR) and/or low humidity (RH), were non-ideal due to the possibly large contribution of pathways (e.g. UV photolysis) of lower atmospheric significance than OH oxidation. Also, the contribution of speciated volatile organic compounds (VOCs) cookstove emissions to SOA formation has not been investigated in detail. Here, we investigate the impact of non-ideal OFR operation and VOC speciation on properties and quantity of SOA formed during OFR aging of stove emissions. Emissions from ‘water boiling tests’ of 3 stone fire, natural draft and forced draft gasifier stoves (in order of increasing efficiency) are collected in a smog chamber, aged under varying conditions and measured with an Aerosol Chemical Speciation Monitor and other instrumentation. The relative contribution of UV photolysis to OFR reactions is reduced via additional dilution of emissions (dilution factor of 1.2-4) with humidified air (RH = 20-65%). VOC measurements are taken before and after aging using online and offline gas chromatography. Preliminary results indicate that lower OHR /higher RH operation results in lower organic aerosol (OA) enhancement than in previous tests at similar OH exposures. Peak OA enhancement occurs at approximately 3 equivalent days of aging, consistent with previous tests. The range of OH exposures experienced in these tests are higher, but evolution of key organic mass fragments, like f44 (oxidized species) and f60 (biomass burning aerosol) is similar and plateaus at higher exposures. Further tests will focus on the properties of SOA formed from a soft wood (pine) and exposing the same batch of emissions to different reactor conditions – OH exposure, RH and OHR levels.

5AC.8

Use of a Potential Aerosol Mass Flow Reactor for the Measurement of Secondary Organic Aerosol Production from Gasoline Vehicle Emissions. YUNLIANG ZHAO, Andrew Lambe, Rawad Saleh, Georges Saliba, Allen Robinson, *Carnegie Mellon University*

Secondary organic aerosol (SOA) formation from dilute gasoline vehicle exhaust was investigated using a Potential Aerosol Mass flow reactor during chassis dynamometer testing. The test fleet consisted of 16 vehicles, including 10 vehicles equipped with gasoline direct injection engines (GDI vehicles) and 6 vehicles equipped with port fuel injection engines (PFI vehicles). These vehicles spanned a wide range of emissions standards from Tier0 to Super Ultra-Low emission vehicles. We observed less SOA production from vehicles meeting more stringent emissions standards. GDI and PFI vehicles appear to have similar SOA production. We also measured lower effective SOA yields for vehicles meeting more stringent emissions standards, but this appears due to a combination of differences in experimental conditions and uncertainties in OH exposure. The effective SOA yields would be similar under the same experimental conditions. Therefore, the tightening of emissions standards effectively reduces SOA production from gasoline vehicle exhaust.

5AQ.1

Impact of Aerosol Acidity and Aerosol Liquid Water on Volatility and the Chemical Composition of SOA Formed from Alpha-Pinene Ozonolysis. MATTHIEU RIVA, Liine Heikkinen, Otso Peräkylä, Matti Rissanen, Mikael Ehn, *University of Helsinki*

The most abundant secondary organic aerosol (SOA) precursors are isoprene and monoterpenes, such as alpha-pinene. The formation of monoterpene-derived SOA has been qualitatively explained by gas-phase oxidation reactions of monoterpenes leading to condensable low-volatility products. Ozonolysis of alpha-pinene leads to the formation of multifunctional gas-phase products including alcohols, hydroperoxides, epoxides and carbonyls. Such compounds can then condense onto aerosol surfaces and contribute to SOA formation. Recent studies have highlighted the importance of multiphase chemistry, such as acid-catalyzed reactive uptake of epoxide products or decomposition of hydroperoxides, in SOA formation. Although many previous studies have characterized the oxidation of alpha-pinene and subsequent SOA formation, the coupled role of aerosol liquid water and acidity on the chemical composition and the physical-chemical properties of SOA remain uncertain.

In the present work, ozonolysis of alpha-pinene was systematically examined with varying composition and phase (i.e. effloresced/deliquesced) of seed particles. Size-selected ammonium sulfate aerosol particles (acidified and non-acidified) were injected into the chamber under dry or wet conditions to evaluate the importance of multiphase chemistry in the chemical composition of the monoterpene-derived SOA. Experiments were conducted at room temperature (27 ± 2°C) and atmospheric pressure in a 2-m3 Teflon chamber. Gaseous organic compounds were chemically characterized using two time-of-flight chemical ionization mass spectrometers (HR-ToF-CIMS) with iodide (I−) and nitrate (NO3−) ionization sources and a proton transfer reaction time-of-flight mass spectrometer (PTR-ToF-MS). In addition, the particle-phase was chemically characterized using a Filter Inlet for Gases and AEROsols (FIGAERO) coupled to an I−-HR-ToF-CIMS and a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). Hundreds of compounds, including highly oxidized products and oligomers, were observed in both gas- and particle phases. Thermograms of individual SOA constituents, reveal multiphase chemistry leading to an increase of the aerosol loadings and oligomers and impacting the aerosol volatility, especially in the presence of dry acidic particles.

5AQ.2

In-cloud AqSOA and Sulfate Formation: A New Microphysical Parameterization for Regional and Global Models. BARBARA ERVENS, Renee McVay, *NOAA/ESRL and CIRES/CU.* INVITED

It has been known for several decades that substantial amounts of atmospheric sulfate, and more recently secondary organic aerosol (SOA), are formed in the aqueous phase of clouds and fogs. While the former can be described by a few well-defined chemical reactions, aqSOA formation processes are much more complex, leading to a greater variety of products and aerosol properties.

The representation of these formation processes in models is challenging since both chemical and cloud microphysical parameters have to be taken into account. In this presentation, we will discuss the weaknesses of various parameterizations of sulfate and aqSOA formation that are currently implemented in regional and global models.

Based on process model studies, we will show the importance of surface-limited and drop-size dependent mass formation rates throughout cloud droplet size distributions. Usually neither observational data sets nor regional or higher-scale models can provide such detail of cloud droplet size distributions.

We present a microphysical parameterization of aqSOA and sulfate formation in clouds that reproduces the mass formation rates in polydisperse cloud droplet populations by using only one representative droplet size. The underlying reasoning of this simplification will be discussed together with its uncertainties and applicability. Finally an outlook will be given on how to implement this new parameterization into regional models.

5AQ.3

Particle-Phase Chemistry Leading to Sulfate Product.

RENYI ZHANG, *Texas A&M University.* INVITED

Sulfate (SO42-) is ubiquitous and is a key constituent of fine particulate matter (PM) in the atmosphere. Hygroscopic sulfate aerosols serve as efficient cloud condensation nuclei, affecting cloud formation, precipitation, and climate. A major fraction of regional acid deposition is attributed to the sulfate content that exerts debilitating effects on acid sensitive ecosystems. Furthermore, high levels of fine PM have been implicated in adverse human health issues, as exemplified by high fatality during the 1952 London Fog. Sulfur compounds are emitted globally from many natural and anthropogenic sources, and there have been high SO2 emissions from combustion of coal and petroleum products in developing countries (such as China) spurred on by fast economic development. Gaseous SO2 is converted to particulate sulfate through gas-phase oxidation or aqueous reactions, but the detailed chemical mechanisms remain controversial. The gas-phase oxidation of SO2 is dominated by its reaction with the OH radical, with a lifetime of about 1 week at the typical tropospheric level of OH radicals. The aqueous pathways of SO2 oxidation include the reactions with dissolved ozone, hydrogen peroxide, organic peroxides, OH, and NO2 via catalytic or non-catalytic pathways involving mineral oxides. Most recently, an interfacial SO2 oxidation mechanism involving O2 on acidic microdroplets has been suggested. Atmospheric measurements have revealed high sulfate production during severe haze events in China, which cannot be explained by current atmospheric models and suggests missing sulfur oxidation mechanisms. In this talk the sulfate formation is discussed, by combining field measurements of gaseous pollutants and aerosol particle properties in two Chinese Megacities and complementary laboratory experiments

5AQ.4

Formation of Hydrogen Peroxide and Hydroxyl Radicals by Ambient Particles in Simulated Cloud Water.

Xiaobi Kuang, John Scott, David Gonzalez, SUZANNE PAULSON, *University of California Los Angeles*

Aerosol aging plays an important role in modifying aerosol chemical composition, hygroscopicity, cloud condensation nuclei activity and optical properties. Aqueous phase aerosol aging is mediated by reactive oxygen species (ROS), which include hydroxyl radicals (OH), hydrogen peroxide (H_2O_2), superoxide anion ($O_2^{\cdot}$-) and organic peroxides. Similar oxidation processes in cloud water may provide a pathway for secondary organic aerosol (SOA) formation through cloud processing during nighttime. Two field campaigns were carried out in summer in Claremont, CA, a receptor site in the Los Angeles air basin, and in winter in Fresno, CA, a site with substantial influence from residential biomass burning aerosol. The resulting samples were extracted in an atmospherically relevant solution (water at pH3.5), and analyzed for particle mass, steady-state H_2O_2 concentration and OH generation, speciated soluble iron, and total soluble trace metals. Soluble iron was about 50% Fe(II) and 50% Fe(III) in the Claremont samples but was shifted slightly in favor of Fe(II) in the Fresno samples (66%). On a per-mass basis, the Fresno PM produced similar steady-state H_2O_2concentrations, and while morning and afternoon Fresno samples generated similar OH as the Claremont PM, overnight samples produced much more OH. H_2O_2 was poorly correlated with aerosol mass, but strongly correlated with soluble iron and manganese at both sites. OH formation was strongly correlated to Cu, Fe and aerosol mass for the Claremont samples. Further, samples that had experienced more aging (6-hour back trajectories were largely aloft) had higher H_2O_2, OH and soluble iron compared to those with less aging (6-hour back trajectories were predominantly along the surface). OH formation was most strongly related to biomass burning aerosols in the Fresno samples, and was otherwise low.

5AQ.5

The Sensitivity Of Particle pH To NH3: Can High NH3 Cause London Fog Conditions? Hongyu Guo, Rodney J. Weber, ATHANASIOS NENES, *Georgia Institute of Technology.* INVITED

High levels of ammonia (NH_3) have been suggested to elevate ambient particle pH levels to near neutral acidity (pH=7), a condition that promotes rapid SO_2 oxidation by NO_2 to form aerosol sulfate concentration consistent with "London fog" levels. This postulation is tested using aerosol data from representative sites around the world to conduct a thorough thermodynamic analysis of aerosol pH and its sensitivity to NH_3 levels. We find that particle pH, regardless of ammonia levels, is always acidic even for the unusually high NH3 levels found in Beijing and Xi'an (pH=4.5-5), locations where sulfate production from NO_x is proposed. Therefore, major sulfate oxidation through a NO_2-mediated pathway is not likely in China, or elsewhere (e.g., US, Mediterranean) where the aerosol is consistently more acidic. The limited alkalinity from the carbonate buffer in dust and seasalt can provide the only likely set of conditions where NO_2-mediated oxidation of SO_2 outcompetes with other well-established pathways. The mildly acidic levels associated with excessive amounts of ammonia can promote high rates of SO_2 oxidation through transition metal chemistry, this may be an alternative important aerosol chemical contributor to the extreme pollution events.

5AQ.6

How Important is Nitrogen Dioxide (NO2) to Sulfur (S(IV)) Oxidation at Air-Water Interface of Aquated Aerosol under Acidic Conditions? LIJIE LI, Agustin Colussi, Michael Hoffmann, *California Institute of Technology*

Water plays an essential role in aerosol formation. Understanding the chemical and physical processes at the air-water interface is critical for the development of more accurate heterogeneous reaction mechanisms that are included in aerosol modeling. Experimental field evidence indicates that heterogeneous reactions results in a dramatic enhancement in secondary aerosol formation as observed during mainland Chinese haze episodes. Inorganic sulfate is a major component of secondary aerosol that determines the hygroscopic state of the aerosol. Hence, the mechanisms of sulfate formation in the boundary layer not only affects aerosol nucleation but drives the ensuing chemistry within and on the surface of haze aerosol. Pathways for sulfur oxidation in the aqueous phase include reactions with ozone, hydrogen peroxide, organic peroxides, OH radical, oxides of nitrogen, and O_2. The mechanism of S(IV) oxidation during haze episodes is exceptional since thick haze aerosol layers limit the formation of photo-generated oxidants, such as ozone and OH radicals due to significant light attentuation. It has been proposed that $NO_2(g)$ is actually a major of S(IV) in haze aerosol. $NO_2(g)$ emitted from fossil fuel combustion sources has been identified a primary oxidant based on assumption that haze aerosol over China megacities is neutral or slightly basic. However, haze aerosols are more often acidic (pH= -0.5-6) worldwide. It essential to understand that the reaction rates, gas solubilities, and ionic equilibria involved in sulfur oxidation change as a function of pH. The importance of NO_2 as an oxidant of S(IV) oxidation with haze aerosol needs to be revisited. Further, the oxidation of sulfur at the air-water interface remains ambiguous. Our previous studies have shown orders of enhancement in $NO_2(g)$ uptake with millimolar concentrations of organic and inorganic anions and an increase in S(IV) oxidation rates under acidic conditions at air-water interface. In this presentation, we investigate the significance of NO_2 to S(IV) oxidation at air-water interface over a wide range of acidity, in the presence and absence of transition metal ions. The aqueous aerosol surface is generated by microjets containing S(IV) and is instantaneously exposed to $NO_2(g)$ in a reaction chamber. Products and intermediates formed on interfacial layers of the microjets are analyzed via in situ via online electrospray ionization mass spectrometry. The impact of NO_2 and its disproportionation products (e.g. HONO) on sulfur oxidation is studied over the pH range of 0-6. The interaction between iron (Fe(II)/Fe(III)) and NO_2 and its impact on the oxidation of S(IV) is explored. In addition, we evaluate the importance of direct and Fe(II)-catalyzed oxidation of S(IV) by $NO_2(g)$ vs $O_2(g)$ at air-aqueous interfaces at pH=5-6.

5AQ.7

Interactions of Glyoxal and SO2 in Clouds and Aqueous Aerosol: Production of SOA and Light-Absorbing Quinone Species. DAVID DE HAAN, Alyssa Andretta, Elyse Pennington, Hannah G. Welsh, Lelia Hawkins, Kevin Jansen, Margaret Tolbert, Mathieu Cazaunau, Edouard Pangui, Jean-François Doussin, *University of San Diego*

Field studies have shown that aerosol oxalate and sulfate are highly correlated. This correlation has been attributed to the fact that both ions are formed mainly via oxidation of precursor species glyoxal and SO_2 in cloudwater. Glyoxal and SO_2 react with each other in the aqueous phase, however, forming adduct species that can be oxidized and oligomerized into hydroxyquinone products. Hydroxyquinones are redox-active and strongly light absorbing, and thus their atmospheric formation could be relevant to both human health and climate change. Bulk aqueous studies of glyoxal + SO_2 chemistry have shown that hydroxyquinone products are rapidly formed at liquid surfaces at high pH, and these reaction mixtures turn brown at pH levels as low as 5. For these reasons, a series of SOA formation experiments were conducted with glyoxal and SO_2 in a cloud / smog chamber. Aerosol optical properties were monitored with cavity attenuated phase shift single-scattering albedo (CAPS-ssa) spectroscopy at 450 nm and PILS / waveguide UV-vis spectroscopy. Gas phase species were monitored by high-resolution PTR-MS and long-path FTIR, while aerosol-phase species were identified by high-resolution LCMS analysis of filter extracts. This dataset is utilized to describe the multi-phase reactivity of glyoxal – SO_2 reaction products.

5AQ.8

Aerosol Sulfate Production in Extreme Air Quality Episodes. V. FAYE MCNEILL, Kelsey Reed, Athanasios Nenes, *Columbia University*

Extreme air quality episodes are becoming increasingly frequent in megacities around the world. Accurate understanding and modeling of the atmospheric chemistry that leads to these episodes is necessary for the development of effective and economical policies for their prevention, and the protection of public health.

We discuss detailed modeling of sulfate production under the conditions representative of extreme pollution events in Beijing using both an equilibrium model and a kinetic approach using GAMMA 4.0, the McNeill Group model of multiphase atmospheric chemistry. We analyze the contribution of several sulfate formation pathways. In-particle sulfate formation chemistry is exquisitely sensitive to aerosol acidity, as determined by both thermodynamics and the kinetics of reactions which generate or consume H_3O^+. We find that detailed kinetic accounting of H_3O^+reveals possible limits on the SO_2+NO_2 pathway which has been proposed by other investigators.

5CA.1

A Systematic Inter-Comparison of Black Carbon Measurement Techniques using Biomass Burning Smoke.

HANYANG LI, Kara D. Lamb, Joshua P. Schwarz, Vanessa Selimovic, Robert J. Yokelson, Gavin McMeeking, Andrew May, *The Ohio State University*

Black carbon (BC) plays a major role in the climate system due to its ability to absorb solar radiation. One major source of BC is open biomass burning, which contributes roughly 40% of global BC emissions. These emissions are estimated from BC emission factors (EFBC; e.g., g-BC per kg-dry-fuel-burned). However, uncertainties in these EFBC is quite large and propagate through the total BC emissions estimates to atmospheric model predictions.

One challenge in reducing the uncertainty in EFBC is the many different techniques that are used for BC measurement. These techniques can be broadly categorized as light absorption, laser-induced incandescence, or thermal-optical analysis; the BC mass quantified by each type is inherently different. These differences must be reconciled in order to reduce uncertainties in reported EFBC values. Because emission inventories are typically based on real-world measurements, which are limited in number, the value of our dataset is heightened.

To address this issue, we conducted a systematic inter-comparison of eight different instruments at the Fire Sciences Laboratory in Missoula, MT during Autumn 2016 as part of the Fire Influence on Regional and Global Environments Experiment (FIREX) campaign. In this effort, we sampled fires from North American biomass burning fuels, in which aerosol emissions were stored in a 55-gallon drum to allow simultaneous sampling of identical aerosol via different instruments. In our presentation, we will focus only on our real-time measurements of BC concentrations from a Droplet Measurement Techniques (DMT) Photoacoustic Extinctiometer, a DMT Single Particle Soot Photometer, and several filter-based light-absorption instruments.

We have derived EFBC for each instrument and observed that the ratios between techniques are often different from one, yet the correlations are generally good, considering the number of covariates (e.g., modified combustion efficiency, single scattering albedo, angstrom absorption exponent). Nevertheless, we are continuing to explore the role of these covariates on differences between instruments in order to provide a robust set of recommendations that can be used to constrain uncertainties between different measurement techniques and improve emission inventory EFBC values.

5CA.2

Similarities and Differences in Aerosol Optical Properties between Smoke from Biomass Burning and Fireworks.

CHRISTIAN CARRICO, Samantha Bixler, Caroline Allen, Manvendra Dubey, Allison Aiken, Sanna Sevanto, Thom Rahn, *New Mexico Institute of Mining and Technology*

During the summer of 2017, we conducted a laboratory study of biomass burning emissions at Los Alamos National Laboratory, focusing upon Southwestern U.S. fuels and invasive species in particular. Parallel sampling of ambient air during interim periods showed a clear episode of smoke from fireworks displays associated with the Independence Day holiday. These measurements were focused upon aerosol optical properties and included measurements with a photoacoustic extinctiometer (PAX, DMT, Inc., Model 870nm) and a custom controlled relative humidity nephelometry system (Ecotech, Inc., 450nm Aurora) to measure aerosol hygroscopic response. Fresh biomass smoke emissions showed hygroscopicity ranging from shrinkage to light scattering growth factors exceeding two. The primary driver was the fuel species and its chemical composition, in particular its inorganic salt content, with a secondary effect of combustion efficiency. During the fireworks smoke-dominated period on Independence Day, ambient aerosol hygroscopic response declined to ~one at the peak of the event. Peak light scattering coefficient reached approximately 120 Mm^{-1}, the highest value during the summer and well above the typical background here of ~10 Mm^{-1}. The aerosol single scattering albedo was approximately 0.9, suggesting the aerosol was not dominated black carbon but more so brown carbon species with little water affinity. Lab testing with several sparkler types showed that pyrotechnics smoke can have a strong hygroscopic response, however; again, the fuel was key, as sparklers contain salt species such as potassium and lack the black powder explosives in aerial fireworks. The comparison here yields useful observations on the nature of combustion aerosol properties on atmospheric light extinction.

5CA.3

Linking Light Absorption Properties to Combustion Efficiency for Individual Residential Woodsmoke Sources.

K. Max Zhang, ALEXANDER LI, Wei Xu, Shaojun Zhang, Bo Yang, Khaled Hashad, Jeffrey Sward, George Allen, James Schwab, H. Dirk Felton, Oliver Rattigan, *Cornell University*

Woodsmoke resulting from residential wood combustion is a widespread air pollution problem in many parts of the world. We conducted field measurements of real-world residential woodsmoke plumes in Ithaca, NY during the winter 2016-2017 using a 7-wavelength Aethalometer (AE33) modified for high sensitivity for black carbon and brown carbon, multiple nephelometers (Thermo pDR-1500) for $PM_{2.5}$, and CO_2 sensors (Vaisala GMP343). The time resolution of each instrument was set to 1 second to capture the plume dynamics, and raw data were then processed for further analysis. We identified over 30 individual sources, characterized by concurrent, elevated $PM_{2.5}$ and Delta-C (BC(370nm)-BC(880 am)) values. For each source, we quantified the absorption Angstrom exponents, Delta-C/$PM_{2.5}$ ratios, black carbon (BC) mass and brown carbon (BrC) mass. In addition, the contributions of BC and BrC to woodsmoke PM were estimated for a woodsmoke source before and after significant improvement in burning practice. The rich dataset allowed us to test the hypothesis that cleaner burns produce more BC and less BrC, and low-oxygen smoldering burns more BrC and less BC.

5CA.4

A Comparative Study on Aerosol Emission Factors from Residential Biomass Cookstoves and Wildland Fires.

APOORVA PANDEY, Sameer Patel, Benjamin Sumlin, Shamsh Pervez, Suresh Tiwari, Gautam Yadama, Judith Chow, John Watson, Pratim Biswas, Rajan Chakrabarty, *Washington University in St Louis*

Biomass burning contributes nearly a third of the global carbonaceous aerosol emissions, and therefore impacts the earth's radiative budget and human health. The term 'biomass burning' encompasses combustion of biomass fuels for energy use (e.g. cooking, heating), agricultural open burning and wild and peatland fires; different types of biomass burning are significant at different regional scales. Estimates of radiative impact of biomass burning aerosol emissions are highly uncertain because of underlying uncertainties in aerosol mass concentration distributions and optical properties. Mass emission rates for biomass burning aerosols are necessary for better estimating their climate and health effects. We present here emission factors of particles with aerodynamic diameters less than 2.5 µm (PM2.5), elemental carbon (EC) and organic carbon (OC) from biomass cookstoves, ponderosa pine burning and Indonesian peat burning. Cookstove emissions were characterized in a field study in a rural household in central India. Emissions from common types of biomass fuels—fuel-wood, agricultural residue and cow dung — from different regions of India were sampled while typical meals were prepared in a household kitchen. Smoldering and flaming of Ponderosa pine and smoldering of Indonesian peat were simulated in a laboratory combustion chamber. In both field and lab studies, particles were collected on Teflon and quartz fiber filters for gravimetric and thermo-optical analyses, respectively. Emission factors per unit fuel mass were calculated using the carbon balance method. Thermal fractions of the total carbon content of cookstove, pine and peat burning emissions are compared. The links between carbonaceous aerosol profiles (OC- to-EC mass ratios and thermal carbon fractions) and aerosol optical properties are explored.

5CA.5

Comparison of Airborne-Based Measurements of Biomass Burning Markers Levoglucosan and Aerosol Mass Spectrometer m/z 60 and the Role of Residential Burning during the WINTER Campaign. AMY P. SULLIVAN, Hongyu Guo, Jason Schroder, Pedro Campuzano-Jost, Jose-Luis Jimenez, Teresa Campos, Joel A. Thornton, Steven S. Brown, Rodney J. Weber, *Colorado State University*

Biomass burning is one of the main sources of organic aerosols (OA). During winter, residential burning is likely to dominate over prescribed burning and wildfires. Therefore, in the winter, it is important to be able to determine the contribution of residential burning to the total OA concentration. One of the most common methods used to make this determination is through the use of smoke marker measurements. Therefore, as part of the WINTER (Wintertime Investigation of Transport, Emissions, and Reactivity) Campaign, a Particle-into-Liquid Sampler system with a fraction collector was flown aboard the C-130 aircraft during 13 research flights conducted along the East Coast of the United States. Two min integrated liquid samples were collected and analyzed off-line for the smoke marker levoglucosan using high-performance anion-exchange chromatography with pulsed amperometric detection. Levoglucosan correlated well with carbon monoxide (CO) ($R^2 = 0.51$) and OA ($R^2 = 0.47$) for all flights, suggesting the importance of biomass burning as a source during WINTER. Levoglucosan and the AMS (aerosol mass spectrometer) biomass burning marker *m/z* 60 were moderately correlated ($R^2 = 0.51$), but the behavior of the two species seemed to differ. Determination of the contribution of organic carbon (OC) due to residential burning suggested it ranged from ~25% to 90% of the OC and was a significant source across the entire sampling region.

5CA.6

Light Absorption Properties of Polar and Non-polar Aerosols in Fresh and Aged Biomass-Burning Emissions. DEEP SENGUPTA, Vera Samburova, Chiranjivi Bhattarai, Michealene Iaukea-Lum, Adam Watts, Hans Moosmuller, Andrey Khlystov, *Desert Research Institute*

Fresh and atmospherically aged biomass-burning (BB) aerosols are mostly comprised of Black Carbon(BC) and Brown Carbon (BrC), which significantly contribute to light absorption properties of combustion emissions. There is a lack of data on physical and chemical properties of atmospheric BB aerosols, leading to high uncertainties in estimates of BB impact on air quality and global climate, especially in the case of BrC. Polarity of chemical compounds determines their fate in the atmosphere. Most attention so far has been given to the water-soluble (polar) fraction of BrC, while non-polar fraction of BrC was largely ignored. In the present study, abundance and light absorption properties of polar and non-polar fractions of fresh and aged BB emissions were studied to estimate the contribution of different polarity organic compounds to the light absorption of BB BrC aerosols.

In our experiments, representative fuels were burned under open flame and smoldering conditions using the DRI's chamber facility. To mimic the atmospheric oxidation process (5-7 days), BB emissions were aged using an Oxidative Flow Reactor (OFR). Fresh and OFR-aged BB aerosols were collected on filters and extracted with water and hexane. The high molecular weight organic fraction was separated from inorganics and low molecular weight organics by the Solid-Phase Extraction (SPE) technique. All extracts were analyzed with UV-Vis spectrophotometer in the range of wavelengths between 190 and 900 nm. The measured spectra were used to calculate Mass Absorption Coefficients (MAC) and Absorption Ångström Exponents (AAE). The MAC and AAE values were compared among different fuel extracts and then plotted against OM/OC ratios to characterize the evolution of light absorption properties of BB emissions with OFR-aging. Comparison of light absorption properties of different polarity extracts (water, hexane, SPE) provides insights into the chemical nature of BB BrC and its transformation during atmospheric oxidation.

5CA.7

Refractive Index and Optical Properties of Brown Carbon Aerosols from Peat Fires. YULI W. HEINSON, Benjamin Sumlin, Nishit Shetty, Apoorva Pandey, Brent Williams, Rajan Chakrabarty, *Washington University in St. Louis*

Peatlands are extremely large sinks of carbon on the planet and face an increasing threat of wildfires due to human action. Thus, the impact of peat fires on health and climate has become a problem of great concern in recent years. Peat fires smolder at low temperatures and spread underground, which make them long lived and difficult to extinguish. Smoldering peat fires predominately produce a class of spherical organic aerosols – brown carbon (BrC) – which have a strong absorption in the short visible wavelengths (350 – 550 nm). It has been hypothesized that these aerosols, emitted in large quantities from these fires, could have a significant impact on radiative forcing. Therefore, accurately quantifying the optical properties and refractive indices of these aerosols are necessary for inclusion in climate models and satellite retrieval algorithms. We studied the optical properties of BrC aerosols emitted from laboratory combustion of Alaskan and Indonesian peatlands with varying fuel moisture content. Four integrated photoacoustic-nephelometers (IPN) operated at wavelengths 375 nm, 405 nm, 532 nm, and 1047 nm were used to measure the absorption and scattering coefficients, and the single scattering albedo in real time. Simultaneous measurements made using a scanning mobility particle sizer (SMPS) provided the size distribution of the emitted particles. Using a custom-made inversion algorithm based on the Lorentz-Mie theory, which took as input the aforementioned measurements, we were able to retrieve the complex refractive indices of the aerosols. In this talk, we will discuss in detail our results from the suite of experiments carried out over the last year.

5CA.8

Influence of Brown Carbon Aerosol Deposition on Snow Surface Reflection Spectra. NICHOLAS D BERES, Deep Sengupta, Vera Samburova, Andrey Khlystov, Hans Moosmuller, *Desert Research Institute*

Brown carbon (BrC) is form of light-absorbing organic carbon with a brownish or yellowish visual appearance caused by an imaginary part of the refractive index that increases strongly towards shorter visible and ultraviolet wavelengths, resulting in an absorption Ångström exponent much larger than one. Recently, optical properties of BrC aerosols have become the topic of intense research. However, very little is known about how BrC deposition onto snow surfaces affects the spectrum of their albedo and their radiative forcing.

We generated BrC aerosols through small-scale, smoldering biomass combustion and deposited them onto natural snow surfaces in the Carson Range of the Sierra Nevada, USA. After deposition, we monitored the spectral reflectivity of these disturbed snow surfaces and of adjacent undisturbed snow surfaces with a field spectroradiometer (ASD FieldSpec 3). We observed a strong reduction of snow surface reflectivity in the blue and ultraviolet spectral regions. We also will discuss (1) the temporal evolution of the snow surface reflectivity after BrC deposition, (2) modeling results for the influence of deposited BrC on snow surface albedo, and (3) BrC-on-snow radiative forcing.

5IA.1

Sub-10 nm Particle Emissions from Industrial 3D Printers. ANDREA TIWARI, Jeremy Kolb, Severine Dubroecq, Juergen Spielvogel, Robert Anderson, Brian Osmondson, *TSI Incorporated*

Desktop 3D printers have been previously shown to emit ultrafine particles. While these emissions may pose an inhalation health hazard to the many users of desktop 3D printers, the emissions of industrial printers may pose a workplace health hazard. The focus of this work was to characterize the emissions of a professional 3D printer, with sampling occurring both inside the device's internal print volume, and in the breathing space of a user standing near the device. One feature available in industrial printers (and more recently in less expensive models) is the use of a water-soluble support material, to permit the printing of more geometrically complex objects. Sampling was conducted during the extrusion of the acrylic copolymer water-soluble support material as well as the acrylonitrile-butadiene styrene (ABS) feedstock. Particle sizes and concentration were measured using an Engine Exhaust Particle Sizer (EEPS), an Optical Particle Sizer (OPS), and a 1 nm SMPS, all from TSI.

Measurements from the interior of the printer show particle concentrations exceeding 1 x 10^7 #/cm^3 during the printing of the acrylic copolymer. The onset of the acrylic copolymer printing was characterized by generation of particles ranging in size from 2.1 nm to over 1 μm. The size distribution at the onset of acrylic copolymer printing had a mode particle size above 60 nm, while the majority of this period was characterized by a particle size distribution peaking around 10-15 nm. To the authors' knowledge, this is the first study to measure particle production during the printing of a water-soluble support material. ABS printing, in contrast, showed very little particle production; particle counts declined steadily following acrylic copolymer printing until stabilizing at ambient room number concentrations during the ABS print.

Outside of the printer (which was operated with a closed and locked door), acrylic copolymer printing coincided with a sudden elevation of particle number concentration, exceeding 1 x 10^4 #/cm^3, and a mode particle size generally smaller than 40 nm. These results suggest that printing water-soluble support materials may produce measurable particle concentrations within a worker's breathing space, and may pose a worker health hazard.

5IA.2

Investigations into the Composition of Aerosols Emitted by 3D Printing Process. MARINA VANCE, Zachary Linden, David Pfotenhauer, Michael Hannigan, *University of Colorado Boulder*

3D printers are becoming increasingly popular in home and office applications, ranging from hobbyist projects to high-precision industrial manufacturing. Within 3D printing, the fuse-deposition modeling process (FDM) is most popular. It consists of extruding a polymeric filament through a heated nozzle while this nozzle moves over a platform to create a 3D object. This heating process has become known for emitting small aerosols and volatile organic compounds (VOCs). While aerosol emission rates and size distributions, as well as prevalent VOC species have been reported in the literature, little in-depth research has been conducted on the composition of aerosols and their potential emission mechanisms. The objective of this ongoing work is to further elucidate the heat-driven process that leads to the generation of ultrafine aerosols during 3d printing. Experiments are currently being conducted using a Lulzbot TAZ 6 desktop 3D printer, placed in a 500-l chamber, using different extrusion temperatures and a variety of polymeric filaments. Aerosol emissions are being characterized using a scanning mobility particle sizer (SMPS, TSI, Inc.). Aerosols are also collected on quartz-fiber filters and subsequently extracted and analyzed by gas chromatography-mass spectrometry (GC-MS). Filter samples are also analyzed for elemental carbon and organic carbon ratios (EC/OC, Sunset Laboratory Inc.). Volatile Organic Compounds (VOCs) are being sampled using sorbent cartridges and analyzed by Thermal Desorption Gas Chromatography that is equipped with both a Mass Spectrometer and Flame Ionization Detector (GC-MS/FID) that is run using EPA Method TO-17. Results will help elucidate the thermal degradation process that leads to VOC and ultrafine aerosol emissions in indoor environments. This understanding can lead to insights into the potential toxicity of emissions and may help guide the development of lower-emission feedstocks.

5IA.3

Chemical Composition of Particle Emissions from Clean Cookstoves. Clarissa Smith, Tsegaye Nega, DEBORAH GROSS, *Carleton College*

Clean cookstoves show tremendous promise for alleviating health and climate effects around the globe. In many areas in the developing world, people cook over open fires fueled by wood, charcoal, or animal waste. The emissions from these fires significantly impact the health of the cooks, leading to ~4 million deaths per year, globally, according to the World Health Organization. In addition, the demand for fuel is high and gathering fuel contributes to deforestation as well as having social costs, as it requires timely labor to gather the fuel. We have been developing a cookstove for use in Ethiopia, with the goal of developing a low-emission, high efficiency stove that meets the needs of Ethiopian cooks while being affordable. We have characterized the particulate emissions from a series of prototype Top-Lit Updraft (TLUD) stoves as well as one commercially available exemplar stove using single-particle mass spectrometry, and have found that the design has a significant impact on the PM2.5 emission rate as well as the EC/OC ratio and the specific composition of the emitted particles. We will present the impact of stove design on particle emissions and composition, based on adjustment of the distance between the secondary air intake and the pot on the best-performing stove. The cleanest prototype stove performed nearly as well as the commercially available stove and costs less to produce.

5IA.4

Multi-Year Characterization of Cookstove Activity and Emissions Measured in Two Rural Areas in India. MOHAMMAD MAKSIMUL ISLAM, Roshan Wathore, Grishma Jain, Karthik Sethuraman, Hisham Zerriffi, Julian Marshall, Andrew Grieshop, Rob Bailis, *North Carolina State University*

Biomass stoves, which are used by around 2.7 billion people globally, emit particulate and gaseous pollutants with adverse health and climatic impacts. Most households in rural India are dependent on wood for cooking. This study quantifies cookstove emissions measured in an ongoing field campaign in two rural areas (Kullu, in Himachal Pradesh and Koppal, in Karnataka) in India. We aim to test for a link between adoption of cleaner cooking options and reduced emissions, exposures, and other impacts. In the study, households choose from a range of stove models (e.g., advanced biomass, liquefied petroleum gas, induction). In-home measurements are carried out before and after introduction of new stove and include real-time concentrations of carbon dioxide, carbon monoxide (CO), particle light scattering and absorption, and gravimetric $PM_{2.5}$ and organic/elemental carbon analyses. Measurements are complete for baseline (BL) and a first follow-up (F1), totaling 162 tests (86 BL tests; 76 F1). A second follow-up season (F2) is ongoing. Most households chose to receive a modern-fuel stove (LPG, electric); few (12.5% in Koppal and 32% in Kullu) selected a biomass stove. Of 162 emission measurements, the number per stove-type are 85 traditional stoves, 37 ‘Tandoor’ chimney stoves of two types, 21 LPG, 7 Envirofit, and 12 others (e.g., Prakti and TERI biomass stoves). Preliminary data analysis shows that average $PM_{2.5}$ emission factors (EF; g/kg dry fuel) of Traditional Tandoor and Himanshu Tandoor are 27% and 24% lower, and CO EFs 32% and 44% higher, than traditional stoves, respectively. EFs from LPG stoves are dramatically lower than those from biomass stoves, but show substantial variability. We will discuss the seasonality as well as inter-site variability in integrated emissions and comparative analysis will explore the influence of real-time activity on emissions and particle optical properties.

5IA.5

Household and Ambient Contributions to Particulate Matter Exposures in Rural Households Using Traditional and Semi-Gasifier Stoves in the Tibetan Plateau.

ALEXANDRA LAI, Ellison Carter, Sierra Clark, Shan Ming, Kun Ni, Niu Hongjiang, Xudong Yang, Jill Baumgartner, James Schauer, *University of Wisconsin-Madison*

Household combustion of solid fuels (i.e. biomass and coal) creates high levels of air pollution including fine particulate matter ($PM_{2.5}$), which is linked to numerous adverse health outcomes. Globally, nearly three billion people still rely on solid fuels for cooking and heating. More efficient stoves and fuels have been widely promoted to reduce household air pollution, but with varying results and little data on the chemical composition of PM from traditional and improved stoves and/or fuels. Cellular bioassays and epidemiological studies provide evidence that PM composition may influence its biological effects, suggesting that changes in both PM mass and composition should be considered in evaluations of intervention studies. Chemical speciation data can illustrate changes in composition (as well as amount) of PM from improved cookstoves, as well as elucidate the relative contributions of indoor versus outdoor sources on personal exposures.

Here we quantify these chemical effects in $PM_{2.5}$ samples collected before and after the introduction of a semi-gasifier cookstove that burns pelletized biomass in the eastern Tibetan Plateau (Sichuan, China). Seasonal measurements of ambient (24-h), household (48-h), and cooks' personal exposure (48-h) $PM_{2.5}$ were conducted in 204 households, in both summer and winter. Mass and black carbon (BC) were measured for all samples, and water-soluble organic carbon (WSOC) and water-soluble ions for selected individual samples. Samples were composited seasonally for analysis of elemental composition and source-specific organic molecular markers. Laboratory emissions testing was also conducted for both traditional and semi-gasifier heating and cookstoves, and parallel chemical analyses conducted.

Comparing personal exposure sample composition with household and ambient samples collected concurrently, household air pollution appears to be the dominant contributor to baseline personal exposures in terms of both components and total mass. In laboratory emissions testing, traditional stoves emitted almost entirely organic matter and elemental carbon, while semi-gasifier stoves emitted almost no carbonaceous material, and more inorganic ions. Results will be presented that quantify changes in composition of personal particular matter exposures following the introduction of improved cookstoves.

5IA.6

Aerosol Mass Production via Oxidation and Non-Reactive Gas-Particle Partitioning of Semi-Volatile Organic Compounds from Cigarette Smoke.

DOUGLAS COLLINS, Chen Wang, Rachel Hems, Shouming Zhou, Jeffrey Siegel, Jonathan Abbatt, *University of Toronto*

Environmental tobacco smoke has been studied for decades, but sustained aerosol organic mass (OM) due to equilibrium with semi-volatile organic compounds (SVOC) adsorbed to indoor surfaces, termed 'third-hand smoke', has seen much less attention. This study was motivated by high-resolution aerosol mass spectrometer measurements of organic aerosol in a residence during controlled cigarette smoking experiments. After a cigarette was smoked in the residence, cigarette smoke tracers in the aerosol decreased more slowly than those in the gas phase (e.g., CO, HNCO) as concentrations gradually returned to 'background' levels. This observation suggests a sustained source of organics to the aerosol, such as equilibrium partitioning of SVOC from indoor surfaces to aerosol introduced to the residence from outdoors. Controlled studies of cigarette smoke SVOC partitioning were conducted using a Teflon chamber in order to carefully constrain ventilation rates, wall surface area, and the composition of particles introduced to simulate infiltration of outdoor aerosol. Sustained aerosol OM after removal of the airborne smoke particulate matter was investigated with and without oxidant present to probe the contribution of SVOC to aerosol OM in an environment influenced by third-hand smoke. Differences between SVOC partitioning to particles introduced to the chamber under various conditions will be discussed, including a comparison of oxidant-free conditions to those involving multiple oxidants known to exist in the indoor environment.

5IA.7

Assessing Exposures to PM2.5 and UFP from Secondhand Electronic Cigarette Emissions in Southern California Vape Shops.

Charlene Nguyen, Chanbopha (Amy) Sen, YIFANG ZHU, *University of California, Los Angeles*

Vape shops, stores that exclusively sell electronic cigarette (e-cig) products, have become more widespread with the increasing popularity of e-cigs. Recent regulatory actions have been taken to control e-cigs, including the local bans of e-cig use in public spaces and the FDA's regulation of e-cigs as tobacco products. However, there are currently no regulations addressing the indoor air quality of vape shops, where employees and customers vape at their leisure. This study aimed to assess exposures to particulate matter of aerodynamic diameter ≤ 2.5 µm ($PM_{2.5}$) and ultrafine particles (UFP, diameter 2.5 and UFP concentrations were conducted inside and outside the shops over multiple business days. Real-time CO_2, relative humidity, and temperature as well as room air exchange rate (AER) were also measured inside. Human activities including opening and closing doors/windows, ventilation types, and puffing frequency were recorded. This study found that secondhand e-cig emissions from vaping were the major source of particulate matter inside vape shops. During vaping activity, maximum indoor $PM_{2.5}$ and UFP concentrations ranged from $2.6\text{x}10^2$ to $3.2\text{x}10^4$ µg/m^3 and $2.5\text{x}10^5$ to $1.7\text{x}10^7$ #/cm^3 among the shops, respectively. The indoor-to-outdoor (I/O) ratio for particle concentrations reached as high as 1500 and 21 for $PM_{2.5}$ and UFP, respectively. Puffing frequency, or the number of e-cig puffs by all occupants of the shop per unit time, and room AER were significant predictors of elevated $PM_{2.5}$ and UFP concentrations inside the vape shops. This study demonstrates that exposures to fine and ultrafine particles emitted from e-cig use are high inside vape shops. Increasing AER and installing proper ventilation may help to reduce indoor exposures to secondhand e-cig aerosols.

5IA.8

The Impact of Cooking Pan Material on PM Emission.

MEHDI AMOUEI TORKMAHALLEH, Saltanat Ospanova, Soudabeh Gorjinezhad, *Chemical Engineering Department, Nazarbayev University*

Numerous previous studies demonstrated that cooking is one of the major sources of indoor PM. It is important to focus on different cooking components to identify the most influential source which controls the overall cooking PM. This identification may then create opportunities to reduce cooking PM emission. Oil, meat, stove and pan are among the key sources contributing to cooking PM. However, the relative importance of these sources has not been yet investigated under a controlled experimental protocol. It was found in the literature that desorption of semivolatile organic compounds (SVOCs) from the heated metal surfaces including pans and burners contributes to PM formation. Thus, the material coated on the surface of the pans may impact the amount of surface deposited SVOCs, and therefore the PM emission rate. Among different cooking components, the emission rate of PM generated from a heated cooking pan itself has not been yet investigated. The aim of this study is to examine the impact of type of cooking pans including Teflon, cast iron, ceramic and granitium pans on PM emission rates under controlled experimental conditions. Furthermore, this study investigates the relationship between the pan exposure time to indoor air prior to heating and the PM emission rates during the heating. PM1, PM2.5, PM4, PM10 and total particle number emission rates from heated pans are estimated using a DustTrak DRX, TSI and CPC 3007, respectively. A low-cost PM monitor, Dylos, is also implemented to investigate its performance compared to the well reference instruments. While the experiments are being conducted, the primary results showed that the granitium, ceramic, cast iron and Teflon pans produced 2.43×1012, 1.29×1012, 1.92×1013 and 2.42×1013 particles/h, respectively. The longer exposure time to indoor air, the longer required heating time to lower the PM emissions to the background level. More results will be presented during the AAAR 36th annual conference.

5IM.1

A Network of Low-Cost Sensors to Monitor Ambient PM2.5: A Case Study in Jining, China.

XIAOHUI QIAO, Qiang Zhang, Fenglin Liu, Jingkun Jiang, *Tsinghua University*

A distributed monitoring network consisting 176 particulate matter (PM) sensors was set up to measure spatial-temporal variations of ambient PM2.5 in Jining, China. Model A4 PM sensor from Oneair was selected among seven sensors from different manufacturers. Its performance was evaluated using laboratory generated NaCl and NH4NO3 aerosol. Test aerosol with stable size distributions was generated using an atomizer. A DustTrak (Model 8533, TSI Inc.) was used as the reference instrument. Relative humidity (RH) was varied from 15% to 95% during the experiments and its influence on sensor performance was elucidated. After calibrating the sensor performance, a monitoring network was set up in Jining, China. A total of 176 PM sensors were spatially distributed. The network includes 48 urban sites, 9 suburban sites, 53 sites near major pollution sources, 13 roadside sites, and 53 sites close to 8 national monitoring stations. The influence of local RH in Jining was corrected. A cosine similarity index (CSI) was used to test the reliability of the sensor during the campaign. This study illustrated that low-cost PM sensors can be used to complement existing national PM2.5 monitoring networks.

5IM.2

Performance Evaluation of "Low-Cost" Sensors for Measuring Gaseous and Particle Air Pollutants: Results from Three Years of Field and Laboratory Testing.

ANDREA POLIDORI, Brandon Feenstra, Vasileios Papapostolou, Hang Zhang, *South Coast Air Quality Management District*

In an effort to inform the general public about the actual performance of commercially available “low-cost” air quality sensors, in 2014 the South Coast Air Quality Management District (SCAQMD) has established the Air Quality Sensor Performance Evaluation Center (AQ-SPEC). This program aims at performing a thorough characterization of currently available “low-cost” sensors under ambient (field) and controlled (laboratory) conditions. In the field, air quality sensors are operated side-by-side with Federal Reference Methods and Federal Equivalent Methods (FRM and FEM, respectively), which are routinely used to measure the ambient concentration of gaseous or particle pollutants for regulatory purposes. Sensors that demonstrate an acceptable performance in the field are brought back to the lab where a “characterization chamber” is used to challenge these devices with known concentrations of different particle and gaseous pollutants under different temperature and relative humidity levels. Testing results for each sensor are then summarized in a technical report and, along with other relevant information, posted online on a dedicated website (www.aqmd.gov/aq-spec) to educate the public about the capabilities of commercially available sensors and their potential applications. During this presentation, the results from three years of field and laboratory testing will be discussed in detail, along with examples of how to use “low-cost” sensor technology to address specific air monitoring needs and develop sensor networks for measuring air quality in the South Coast Basin.

5IM.3

Development of an Environmental Chamber for the Laboratory Evaluation of "Low-Cost" Air Quality Sensors.

VASILEIOS PAPAPOSTOLOU, Hang Zhang, Brandon Feenstra, Andrea Polidori, *South Coast Air Quality Management District*

Recent technological advancement in air monitoring devices has promoted the use of low-cost air quality sensors in various ambient monitoring and measurement applications. The sensors have the potential of gapping the measurements between sparse government monitoring sites and the abundant need for personal exposure assessment. To provide guidance and clarity for the ever-evolving sensor technology, a state-of-the-art integrated chamber system has been developed to evaluate the performance of low-cost air quality sensors under controlled environmental conditions. The system consists of two professional grade chamber enclosures. A 1.3 m^3 stainless-steel outer chamber and a 0.11 m^3 Teflon-coated stainless-steel inner chamber are used to generate controlled aerosol and gaseous atmospheres, respectively. Both chambers are temperature and relative humidity controlled with capability to generate a wide range of environmental conditions. The system is fully equipped to generate stable and reproducible aerosol and gaseous pollutant concentrations at low, medium, and high concentrations. An array of Federal Reference Method (FRM), Federal Equivalent Method (FEM), and Best Available Technology (BAT) reference instruments are used to characterize sensor performance. This work discusses the development of the chamber system and the experimental methods to quantitatively evaluate sensor performance. Considering that a significant number of academic and research institutions, government agencies, public and private institutions, and individuals are becoming interested in developing and using low-cost air quality sensors, it is important to standardize the procedures used to evaluate their performance. The information discussed herein provides a roadmap for entities who are interested in characterizing air quality sensors in a rigorous, systematic and reproducible manner.

5IM.4

Assessing the Accuracy and Reliability of a Low-Cost Particle Counter for Determining PM1 Loadings Using a Fit-and-Integrate Approach.

DAVID HAGAN, Rebecca Sugrue, Jesse Kroll, *MIT*

The past several years have seen the emergence of a number of low-cost commercial devices for measuring particulate matter (PM) for the monitoring of both indoor and outdoor air quality. Although these devices are beginning to see widespread use, very little is known about the accuracy and reliability of their data. In particular, most such monitors measure particle number concentration only, and thus the extent to which they can be used to estimate particle mass concentration, the quantity on which most health-based assessments and PM regulations are based, is unclear. Low-cost PM counters are typically based on light scattering and cannot efficiently detect particles smaller than 500 nm, presenting challenges for estimating mass loadings of accumulation mode aerosol particles, especially in urban areas where a large fraction of the total mass is comprised of submicron aerosol particles. Here we explore the ability of a low-cost optical particle counter (Alphasense OPC-N2) to more accurately infer particle mass loadings through a process of fitting and integrating a volume-weighted histogram in real-time. Results will be presented comparing the ability of the OPC-N2 to accurately fit the particle size distribution as determined by an SMPS for a variety of laboratory-generated and ambient aerosol distributions. The integrate-and-fit approach will then be directly compared to existing approaches that either correlate the measured number concentration to a reference mass value or perform a step-wise volume integration across the histogram.

5IM.5

A Black Carbon Air Quality Network. JULIEN CAUBEL, Troy Cados, Chelsea V. Preble, Thomas W. Kirchstetter, *University of California, Berkeley*

We developed a portable, low-cost black carbon (BC) sensor for deployment in an air quality network in West Oakland, California. West Oakland is a San Francisco Bay Area residential/industrial community adjacent to regional port and rail yard facilities, and is surrounded by major freeways. As such, the community is affected by particulate matter emissions from heavy-duty diesel trucks, locomotives, and ships. In partnership with Environmental Defense Fund, the Bay Area Air Quality Management District, and the West Oakland Environmental Indicators Project, community members and local businesses throughout West Oakland were recruited to host 100 BC sensors. This distributed sensor network was operated over a period of several months to generate a map of BC concentrations that is highly resolved in both space and time.

The sensors employ the filter-based light transmission method to measure BC. Cost, power consumption, and performance are considered in choosing sensor components and operating conditions. Each sensor node in the network transmits data hourly via a cellular connection, and most are fitted with solar panels to extend battery life. Furthermore, a real-time measurement compensation algorithm was developed to reduce the sensor’s response to environmental temperature fluctuations. Dozens of sensors were collocated with commercial instruments at three monitoring locations in the field, and shown to provide BC measurements comparable to the commercial instruments over several weeks.

Following field validation, 150 sensor units were constructed, calibrated and validated in the field for one week to ensure that all units operate reliably and accurately. Completed sensors were deployed to 100 host sites throughout West Oakland and operated for several months. The highly resolved maps of BC concentrations generated by the network represent a marked expansion from traditional regulatory monitoring and will enable a better understanding of air quality in West Oakland and other cities.

5IM.6

A Low-cost Monitor for Simultaneous Measurement of PM2.5 and Aerosol Optical Depth. ERIC WENDT, Scott Kelleher, Lizette Van Zyl, Casey Quinn, Dan Miller-Lionberg, John Mehaffy, Jessica Tryner, Christian L'Orange, Bonne Ford, Azer Yalin, Marilee Long, Shantanu Jathar, Jeffrey R. Pierce, John Volckens, *Colorado State University*

This work developed and validated an outdoor monitor for simultaneous measurement of $PM_{2.5}$ and aerosol optical depth (AOD): the AOD-UPAS. This instrument consists of an active air sampler (utilizing continuous and time-integrated measures of $PM_{2.5}$) and four-channel sun photometer. Measurement of AOD is performed using low-cost, filtered photodiodes at four wavelengths (λ = 440, 520, 680, and 870 nm) that match those selected from the AErosol RObotic NETwork (AERONET). The AOD-UPAS is relatively low cost, solar powered, and operated using a mobile device (Bluetooth app for iOS and Android) for deployment in a citizen-science framework. The AOD-UPAS is compact, weighs approximately 500 g, and may operate autonomously for several days following setup and alignment.

Power management was optimized via Monte Carlo simulation of measured solar irradiance by season. Solar charging efficiency (6.7%) proved less than model assumptions (7.5%), however, the instrument is capable of near-continuous monitoring in Summer and 50% duty cycle in Winter. Instrument evaluation (and validation) was achieved through a series of laboratory and field deployments. The first deployment evaluated the $PM_{2.5}$ monitor downwind from a large prescribed fire (n=50 samples). Mass concentrations measured near the burn ranged from 8 to 800 $\mu g/m^3$ as 24-hr averages; co-located measurements with USFS reference monitors gave reasonable agreement (EBAM = -4.9 + 0.97[AOD-UPAS]; R^2=0.92). The second deployment along the Colorado Front Range demonstrated moderate agreement between the AOD-UPAS and federal reference method samplers for gravimetric analysis of $PM_{2.5}$ (48-hr averages). Bandpass of the photodiode array was approximately 15 nm at full-width half-maximum, which should be sufficient for valid AOD measurements under most conditions. Preliminary data suggest agreement within 10% when the AOD-UPAS was co-located with reference AERONOET instruments.

5IM.7

Ambient Observations from Low-cost Gas and Particle Sensor Packages Deployed in Malawi: Pre-validation and Initial Deployment.

ANDREW GRIESHOP, Eric Lipsky, Rebecca Tanzer, Eben Cross, R. Subramanian, *North Carolina State University*

The nearly complete lack of continuous surface observations in much of Africa limits understanding of air quality trends and climatology and evaluation of atmospheric models or remote sensing products. For example, Malawi, a poor (7% of population has grid access), rural country in Southern Africa, has no air monitoring and is subject to a seasonally varying mix of sources (e.g., diverse biofuel combustion, open burning, regional transport). In response, we are deploying a network of five low-cost/power sensor packages in rural and peri-urban Malawi to collect data on gases (CO_2, CO, NO/NO_2, O_3), particles (size/count) and meteorological parameters. Sensor packages include the Aerodyne Research 'ARISense' and the 'RAMP' developed at Carnegie Mellon University. Particles are measured via optical particle counters and gases via electrochemical and non-dispersive infrared sensors. Before deployment in Malawi in June, 2017, sensor packages are collocated with regulatory monitors in Pittsburgh, PA (RAMPs), Boston, MA (ARISense) and Durham, NC (both); algorithms and data products are evaluated against reference monitor data and each other. Pittsburgh RAMP collocations support their utility, even at low ambient concentrations (mean absolute errors for CO <40 ppb, <5 ppb for O_3 and NO_2). Initial pooled deployment in Malawi is at a peri-urban university campus, followed by at two rural sites for several months. 'Fenceline' subsampling downwind of biofuel combustion activities (e.g. brick kiln, tobacco barn) simultaneously measured with emission sampling equipment will enable evaluation of sensor packages under high-concentration conditions and yield valuable data on under-studied sources. This presentation will critically evaluate the measurement systems, provide a preliminary overview of air pollutant spatio-temporal variability and give insight into the utility of low-cost, low-power measurement systems in resource-poor environments, where they have great potential to fill large data gaps.

5IM.8

Towards an Improved Understanding of the Conditions that Undermine the Reliability of Low-cost AQ Sensor Systems.

EBEN CROSS, David K. Lewis, Leah Williams, David Hagan, Jesse Kroll, Ann Backus, Gary Adamkiewicz, Douglas Worsnop, John Jayne, *Aerodyne Research, Inc.*

Because of the large expense and expertise required to set up and maintain air quality monitoring stations, our understanding of communities' exposures to air pollutants is generally based upon an extremely limited number of measurements. Such measurements (no more than 1-4 monitoring stations per urban area, reporting concentrations on hourly or daily basis) do not capture the enormous temporal and spatial variability of air pollutants across densely populated urban areas. This greatly limits our ability to connect air quality to health outcomes and inform the public about local sources and levels of air pollution. In this presentation, we will describe results from the Dorchester Air Quality Sensor System (DAQSS) an initial 4-node network distributed in the Boston neighborhood of Dorchester. DAQSS provides an opportunity to assess the longer-term (~1-2 yr.) quantitative potential of electrochemical sensors (Alphasense model B4 series) for measurement of criteria gas pollutants (carbon monoxide, nitric oxide, nitrogen dioxide, and ozone), as well as a low-cost Optical Particle Counter (Alphasense OPC-N2) for measurement of particulate matter number concentration. Presented work will highlight the importance of calibrating/training/modeling sensor response against a comprehensive set of environmental conditions that mimic the magnitudes and rates-of-change of temperature, humidity (dew point), and pollutant gas concentrations encountered by the deployed sensor system out in the 'real-world'.

5SA.1

PM0.1 Trace Metal Concentrations and Source Apportionment at Four California Sites Using Positive Matrix Factorization (PMF).

WEI XUE, Jian Xue, Peter Green, Michael Kleeman, *University of California, Davis*

Airborne particulate matter (PM) has been linked to adverse health effects including cardiovascular diseases, respiratory diseases and premature death. Ultrafine particles (UFPs) are suspected to be especially toxic to human health due to their high number concentration, high surface area, and/or their ability to cross cell membranes where they can deliver a dose of potentially toxic material. Epidemiological studies have shown that UFP mass (PM0.1) is associated with premature death in California. Additional measurements of PM0.1 concentrations including the trace metals that could potentially induce oxidative stress would help to understand the mechanisms of injury associated with UFPs.

This study reports results of PM0.1 trace metal measurements at four California cities (East Oakland, San Pablo, Fresno, and Los Angeles) over 12 months of sampling in 2014/15. Two collocated Micro Orifice Uniform Deposit Impactors (MOUDIs) were operated at each site; one was loaded with Aluminum foil substrates for elemental carbon (EC) and organic carbon (OC) analysis, and the other one was loaded with Teflon substrates for trace metal analysis. The substrates for PM0.1 collection were changed on a 3-day basis. The PM0.1 on Teflon substrates were extracted with 25% 1N HNO3 and 75% Acetone, followed by sonication and N2 evaporation. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used to quantify 21 elements in collected samples, among which K and Rb could act as tracers for wood burning, and Fe, Zn and Pb could represent source of road dust and on-road break wear. Temporal trend of these elements will be shown and compared among the four representative California cities. This information, combined with EC/OC data, will be used for PMF analysis to identify sources of PM0.1. This PM0.1 concentration, composition, and source apportionment information will act as crucial reference for future epidemiology studies and possibly for future air quality regulation in California.

5SA.2

Long-Term Evaluation and Source Apportionment of Redox-Active Metals Using a Novel Metal Monitor and PMF.

AMIRHOSEIN MOUSAVI, Mohammad Sowlat, Constantinos Sioutas, *University of Southern California*

In this study, we measured the concentrations and diurnal variations of four important redox-active metals (i.e., Fe, Mn, Cr, and Cu) using a previously developed metal monitor with a time resolution of 2 hr in both warm and winter phases in central Los Angeles. Positive Matrix Factorization (PMF) model (ver. 5.0) was employed for source apportionment of the concentrations of metals and $PM_{2.5}$ mass following the approach by Masiol et al.(2017). We also used several auxiliary variables to help better identify the factors resolved by the model. The most plausible solution of the PMF model was the 4-factor solution for the metals data and the 5-factor solution for the particle size distribution data, with the factors being nucleation, traffic, urban background aerosol, secondary aerosol, and soil/road dust.

As results demonstrate, soil/road dust factor has the highest contribution (i.e., 34%) to the $PM_{2.5}$ mass, followed by traffic and secondary aerosol factors. The major contributor to the concentrations of Fe was traffic (54%), besides urban background with 22% contribution. Moreover, traffic factor was also the major source of Cu, making up to 56% of Cu concentrations. Furthermore, the diurnal variations of Fe and Cu concentrations, indicating peaks during morning and late afternoon/early evening traffic rush hours suggested the major influence of vehicular emissions for Cu and Fe. Urban background aerosol majorly contributed to Cr concentration (58%), which could be attributed to Cr plating facilities and other small local sources in the area. Mn, on the other hand, mostly comes from the urban background and soil/road dust factors, indicating the impact of wear debris tracers from vehicular traffic. Finally, average metal concentrations are higher in the cold phase than in the warm phase, which can be attributed to lower temperatures and depression in the mixing height.

5SA.3

Estimating Gasoline and Diesel Source Contributions to Organic Aerosol in Southern California using a Chemical Transport Model.

SHANTANU JATHAR, Matthew Woody, Havala Pye, Kirk Baker, Allen Robinson, *Colorado State University*

Gasoline- and diesel-fueled engines are ubiquitous sources of air pollution in urban environments. They emit both primary particulate matter and precursor gases that react to form secondary particulate matter in the atmosphere. In this work, we updated the organic aerosol module and organic emissions inventory of a three-dimensional chemical transport model, the Community Multiscale Air Quality Model (CMAQ), using recent, experimentally-derived inputs and parameterizations for mobile sources. The updated model included a revised volatile organic compound (VOC) speciation for mobile sources and secondary organic aerosol (SOA) formation from unspeciated intermediate volatility organic compounds (IVOC). The updated model was used to simulate air quality in southern California during May and June 2010 when the California Research at the Nexus of Air Quality and Climate Change (CalNex) study was conducted. Compared to the Traditional version of CMAQ, which is commonly used for regulatory applications, the updated model did not significantly alter the predicted organic aerosol (OA) mass concentrations but did substantially improve predictions of OA sources and composition (e.g., POA-SOA split), and ambient IVOC concentrations. The updated model, despite substantial differences in emissions and chemistry, performed similar to a recently released research version of CMAQ (Woody et al., 2016) that did not include the updated VOC and IVOC emissions and SOA data. Mobile sources were predicted to contribute 30-40% of the OA in southern California (half of which was SOA), making mobile sources the single largest source contributor to OA in southern California. The remainder of the OA was attributed to non-mobile anthropogenic sources (e.g., cooking, biomass burning) with biogenic sources contributing to less than 5% to the total OA. Gasoline sources were predicted to contribute about thirteen times more OA than diesel
sources; this difference was driven by differences in SOA production.

5SA.4

Investigating Chemical and Physical Atmospheric Properties of Wintertime Persistent Cold Air Pool Events in Salt Lake City for Air Quality Assessments.

CESUNICA IVEY, Xia Sun, Sivaraman Balachandran, Yongtao Hu, Armistead G. Russell, Heather Holmes, *University of Nevada Reno*

More than one million people live in Salt Lake Valley, Utah, where wintertime pollution reaches unhealthy levels due to the unique meteorology and orography of the region. Persistent cold air pool (PCAP) events occur when high pressure ridges create stagnant conditions over a valley, which hampers large-scale advection and reduces surface wind speeds. During PCAP periods the fraction of incoming solar radiation that reaches the valley floor is also reduced, leading to temperature inversions that allow pollution to build. Pollution levels continue to climb until a washout event removes the pollutants from the valley. Washout events include high winds or precipitation events with advection or wet deposition related removal processes, respectively. In this work, novel source apportionment techniques are applied for January 2007 to analyze source composition and source impacts for the Salt Lake Valley during PCAP events. First, a hybrid source-oriented apportionment model is applied over continental U.S. to determine observation and model-based impacts from 20 sources, including agricultural activities, fossil fuel combustion, dust, and metals processing. Then, a secondary bias correction method is applied to better quantify the source impacts on secondary $PM_{2.5}$, which constitutes the majority of the $PM_{2.5}$ mass. Further, $PM_{2.5}$ source profiles for the Salt Lake Valley were developed using a nonlinear optimization and data assimilation approach, which takes into account observed $PM_{2.5}$ data and model uncertainties. The optimized profiles are unique in that they are developed using both modeled and observed data, creating local profiles for the area of interest. The chemical mass balance model was applied for the years 2003-2015 using the optimized source profiles, highlighting the major sources of pollution during PCAP periods in the Salt Lake Valley.

5SA.5

Molecular Composition and Long-term Source Contributions to Organic Aerosol in Central Europe. KASPAR RUDOLF DAELLENBACH, Imad El Haddad, Ivan Kourtchev, Alexander Lucas Vogel, Gaëlle Uzu, Giulia Stefenelli, Carlo Bozzetti, Athanasia Vlachou, Paula Fermo, Andrea Piazzalunga, Jay G. Slowik, Samuel M. Luedin, Valentin Pflueger, Guido Vogel, Jean-Luc Jaffrezo, Markus Kalberer, Urs Baltensperger, Andre S.H. Prévôt, *Paul Scherrer Institute*

Field deployments of the aerosol mass spectrometer (AMS) combined with the application of positive matrix factorization have advanced the measurement of organic aerosol (OA) and the quantification of its most important sources. However, the investigation of regional and seasonal differences by long-term deployments of the AMS is impractical because of instrument cost and maintenance. To overcome these limitations and in order to assess the detailed chemical composition of OA, we have adapted the AMS for the measurement of offline filter samples (oAMS), in combination with a unique suite of analytical techniques, including laser-desorption/ionization-ToF MS (LDI), and ultrahigh-resolution mass spectrometer (Orbitrap).

We present oAMS source apportionment results of OA (smaller than 10 µm) at 9 stations in central Europe for the entire year of 2013 (819 samples). We demonstrate that the factors governing air quality are region-specific, e.g. biomass burning organic aerosol (BBOA) is strongly enhanced in alpine valleys relative to urban centers. LDI results suggest that the elevated BBOA concentrations in alpine valleys are mainly caused by less efficient burning conditions. In winter, a secondary organic aerosol (SOA) factor correlating with anthropogenic secondary inorganic species is dominant. While samples collected during winter in alpine valleys are similar to fresh wood burning emission from laboratory experiments, in Zurich the wood burning emissions are more aged and also other SOA precursors/formation pathways are important in winter (Orbitrap). We observe the production of SOA in summer, following the increase in biogenic emissions with temperature. The predominance of compounds with an H/C of 1.5 observed in summer is consistent with biogenic SOA (Orbitrap). Using LDI, the influence of aged/secondary traffic emissions with higher summer concentrations is separated from fresh emissions. This thorough assessment of local and regional sources affecting air quality will also be compared to health relevant compounds.

5SA.6

A Synergic Approach to Perform Source Apportionment of Organic Aerosol Using Offline and Online Measurements in Positive Matrix Factorization. DEEPCHANDRA SRIVASTAVA, Olivier Favez, Nicolas Bonnaire, Emilie Perraudin, Valérie Gros, Franco Lucarelli, Eric Villenave, Alexandre Albinet, *INERIS*

Understanding the sources and processes responsible for high-level atmospheric PM concentrations is required to implement effective PM control strategies. During the last decade, the use of AMS and ACSM instrumentations has successfully allowed real time measurements of particulate organic fraction. However, to profoundly understand the sources and formation processes of organic aerosol (OA), a comprehensive source apportionment analysis is still needed. The combination of different datasets from several measurements to refine the apportionment of OA sources, and notably secondary ones, is probably one of the best way to achieve this goal. In this study, we propose a novel approach combining online and offline measurements in Positive Matrix Factorization source-receptor model (PMF). An intensive campaign was performed at the SIRTA atmospheric research observatory, representing the suburban background air quality conditions of the Paris area (about 25 km SW from Paris). PM_{10} samples were collected every 4 hours over a period of intensive PM pollution events (PM > 50 $\mu g\ m^{-3}$ over several days) on March 6-24 2015, concomitantly with online measurements including ACSM, PTRMS, 7λ Aethalometer, TEOM-FDMS, NOx and O3 analyzers. Regular PMF was first performed on organic matrix obtained from offline measurements using specific primary (e.g. levoglucosan (biomass burning), methane sulphonic acid (MSA) (marine), 1-nitropyrene (traffic)) and secondary organic molecular markers (e.g. hydroxyglutaric acid (α-pinene), 3-methyl,5-nitrocatechol (biomass burning), α-methyl glyceric acid (isoprene)) and on ACSM OA matrix. Results show that PMF performed on individual dataset is not truly viable to procure complete information about the different atmospheric processes involved. Here, the synergic approach proposes to combine traditional off-line PMF factors, such as primary biomass burning, primary biogenics, secondary biogenics, traffic, with OA matrix from ACSM measurements. The unified matrix was again deconvolved with PMF in order to retrieve factors such as HOA, BBOA, OOA, and to explore additional information about OA sources.

5SA.7

Impact of Secondary Organic Aerosol Tracers on Tracer-based Source Apportionment of Organic Carbon and PM2.5: A Case Study in the Pearl River Delta, China.

Qiongqiong Wang, Xiao He, X.H. Hilda Huang, Stephen Griffith, Yongming Feng, Ting Zhang, Qingyan Zhang, Dui Wu, JIAN ZHEN YU, *Hong Kong University of Science & Technology*

Knowledge of the relative abundance of primary organic aerosol (POA) and secondary organic aerosol (SOA) forms an important scientific basis for formulating particulate matter (PM) control policies. Taking advantage of a comprehensive chemical composition data set of $PM_{2.5}$ including both POA and SOA tracers, we investigate the impact of inclusion of SOA tracers on the source apportionment of organic carbon (OC) and $PM_{2.5}$ in the Pearl River Delta (PRD) region of China using positive matrix factorization (PMF). In PMF runs incorporating SOA tracers (PMF_w), Ten PMF factors were resolved including four secondary factors: (1) SOA_I (α-pinene, β-caryophyllene and naphthalene derived SOA), (2) SOA_II (isoprene derived SOA), (3) a secondary sulfate factor, and (4) a secondary nitrate factor. In PMF tests without SOA tracers (PMF_{wo}), the SOA_I and SOA_II factors could not be extracted while the remaining eight source factors were resolved. Among the eight common source factors, the industrial emission factor, identified by high loadings of Zn and Pb, showed the largest variations between PMF_w and PMF_{wo} solutions. The source contributions of SOA_I and SOA_II resolved in PMF_w were largely shifted to the industry emission source in PMF_{wo}. Secondary organic carbon (SOC) summed from the four secondary factors in PMF_w contributed ~40% (4.47 $\mu gC/m^3$) while the SOC estimate by PMF_{wo} (3.51 $\mu gC/m^3$) was 21% lower due to the inability in extracting SOA_I and SOA_II. Secondary PM2.5 by PMF_{wo} was 6% lower than that by PMF_w (23.7 vs 25.2 $\mu g/m^3$). The PMF_w results indicated that SOC from specific precursors may have different formation pathways than secondary sulfate and nitrate formation processes and their source contributions could not be properly resolved without the indicative tracers included in PMF. This study highlights the importance of SOA tracers for estimating SOC contributions using PMF and suggests an urgency to find a more unique tracer for the industrial emission source in the region.

5SA.8

Classification, Variation and Spatial Patterns of Mass Spectra Extracted from Plume Events Observed from Mobile Measurement by Aerodyne Aerosol Mass Spectrometer and Comparison with PMF Results.

PEISHI GU, Zhongju Li, Qing Ye, Ellis Shipley Robinson, Allen Robinson, Albert A. Presto, *Carnegie Mellon University*

Highly time-resolved field measurement of organic aerosol (OA) can be strongly influenced by short-duration plume events. Such plume events may contribute significantly to OA exposure in particular places where abundant human activities of different kinds coexists. However the origin of such OA plume events is not always clear and improved source attribution of these plumes could be used to develop policies to reduce human exposures. Aerodyne Aerosol Mass Spectrometer (AMS) data coupled with Positive Matrix Factorization (PMF) has been widely used for source apportionment of field measurement data. Typically, primary emission factors like hydrocarbon-like OA (HOA), cooking OA (COA) and biomass burning OA (BBOA) have been identified. PMF results represent an average factor composition, but may be insensitive to plume-to-plume variation within each source category. Some minor sources might also get ignored by the mathematical model due to their limited appearance in the typically huge dataset. In this study we explore the contribution of plume events to mobile sampling data collected from Aug 2016 to June 2017 in Pittsburgh, PA. The plumes are identified as peaks in the time series of OA concentration, while the average mass spectrum of a plume is extracted by calculating the difference of the mass spectra of the peak period and that of the immediate background before and after the plume events. Hundreds of well-defined plume events were identified and extracted, and then clustered into interpretable categories. Similar to results from PMF, HOA and COA are two major factors, but variations within each plume cluster are clearly observable. Such variation may partly result from the oxidation of fresh OA, or simply the inherent variability of the emissions. There are also plumes that resemble a mixture of multiple factors. Geospatial analysis reveals the spatial pattern of different types of OA plumes (including the minor sources), and how their oxidation level varies across the sampling domain.

6AP.1

True vs. Average Electrical Mobility. Happel And Brenner's Settling Velocity vs. Mason and McDaniel's First Collision Integral. CARLOS LARRIBA-ANDALUZ, Tianyang Wu, *IUPUI*

Arguably, the most accepted simplifications when acquiring the average Collision Cross Section (CCS) for an ion are 1) the consideration that all directions are equally probable and 2) that non-inertial effects can be ignored. The first of such simplifications has had the most controversy in the last few years.

Two distinct approaches to calculating CCS are compared: A) the averaged first collision integral calculated by Mason and McDaniel (M&M) which assumes that all directions are equally probable, and B) the tensorial Drag Force calculation from Happel and Brenner which, for every orientation, provides a drift velocity that does not necessarily have to be in the direction of the field. The problem arises when comparing both approaches. The averaged CCS calculated from Happel and Brenner disagrees with that of the averaged first collision integral. The explanation of this difference was not well understood.

Preliminary Data shows that the CCS calculated using the Happel and Brenner (H&B) method is always equal or smaller than that calculated by the first collision integral. This is particularly obvious for planar and 1D structures (long cylindrical ions) where the difference can be more than triple. We show that this difference occurs due to a misinterpretation of the H&B method. Given an ion in an electric field, such as that in a drift tube, one is generally only interested in the time an ion takes to cover a desired length while assuming that the ion travels a straight path. This straight path consideration is however not true for all but spherical ions, i.e. the resultant velocity of drift is not in the direction of the field. In general, therefore, we have to talk about two displacements; the average displacement in the direction of the field and the true displacement of the ion which considers movements off axis. We show that the collision integral method(M&M) results in a CCS that provides an "average" Mobility for an average drift velocity assuming a straight path. It is the correct CCS to compare to experimental measurements. The H&B method on the contrary calculates the true displacement of the ion, including off axis, and therefore gives the true mobility of the ion. No instrument at the moment is capable of providing true mobility and therefore, its calculation should be used with care. However, this result is of extreme importance in developing new instruments. The mobility of ions with a preferential direction, such as those with a permanent dipole, can be easily calculated using the H&B method, whereas the first collision integral would lead to wrong conclusions. Moreover, this knowledge could lead to enhanced-separation instruments, due to the fact that the true displacement of each ion is unique.

6AP.2

Experimental Observation of Ballistic to Brownian Transition in an Aerosol System. PAI LIU, William Heinson, Rajan Chakrabarty, *Washington University in St. Louis*

We report an experimental observation of ballistic-to-Brownian transition in the chaotic advection of soot particles trapped in a laminar buoyancy-opposed flame. We found that the probability distribution of the particle step-wise turning angles follows the wrapped Cauchy distribution (WCD), commonly used in directional statistics. With an increase in timescale(τ) of observation, the WCD evolves from a delta function to a uniform distribution. This evolution qualitatively agrees with the ballistic-to-Brownian transition revealed from the scaling between particle mean-squared displacement (MSD) and τ. We next propose a theoretical model for the ballistic-to-Brownian transition kinetics. Three parameters of the motion, namely: the shape factor of WCD, the exponent of MSD-τ scaling power-law, and time are unified with simple mathematical expressions. We anticipate the applicability of our results to studying the motion of tracer objects among other systems across disciplines, as long as the turning angle distribution of the tracer can be described with WCD.

6AP.3

Resuspension Rates of Energetic Materials in an Aerodynamic Flow Cell. KALYAN KOTTAPALLI, Igor Novosselov, *University of Washington*

Most modern explosives have very low vapor pressures at room temperature. Because of that low volatility, small particles of explosive materials that are inadvertently deposited on surfaces remain accessible for long times, but, although high sensitivities have been achieved with many of these instruments, direct detection by gas sampling alone continues to be a challenging task. The effectiveness of trace explosives detection can be greatly enhanced by combining the analytical instrument with a sampling system that delivers the particles from the suspect surface directly to the analyzer. Aerodynamic non-contact sampling provides a fascinating, yet a challenging solution to this problem. Currently, comprehensive understanding of aerodynamic particle removal from surfaces has yet to be accomplished due to the difficulty in characterizing dependence on factors such as particle size, morphology, material, humidity, and turbulence. We studied the removal rates of two different types of trace explosives in an aerodynamic flow cell under various flow conditions. Samples of Trimethylenetrinitramine (RDX) and 2,4,6-Trinitrotoluene (TNT) were dry transferred to the glass surface and interrogated within an aerodynamic flow cell. The particles are examined optically and binned using an automated scanning software. The resuspension efficiency is calculated optically as a function of particle size and morphology. This model is applied to surrogates particles, and the particle size range is chosen based on the typical size distribution associated with trace explosives found in fingerprints. surface. We combine the use of particle removal data from a controlled flow cell experiment with Computational Fluid Dynamics (CFD) modelling to study the effect of wall shear stress on particle resuspension in the constant wall shear stress environment of the flow cell. Removal efficiency is proportional to the height (critical dimension) and inversely proportional to the dimension in the plane of the substrate. Wall shear stress shows a direct correlation with the aerodynamic particle removal rates.

6AP.4

Particle Removal from the Surfaces in Turbulent Flow: Effect of Large-Scale Surface Roughness. BABAK NASR, Jing Qian, Morgan Minyard, Andrea R. Ferro, Goodarz Ahmadi, Suresh Dhaniyala, *Clarkson University*

There are several factors that affect particle removal from surfaces by turbulent flow. Amongst these factors, surface roughness is the most dominant one. In most studies that have investigated the effect of surface roughness on particle removal, the length-scale of roughness was considered to be much smaller than the particles. For the case of small-scale roughness, particle removal rates were seen to be higher than that for the smooth surface condition. Often, however, real surfaces have roughness that may be comparable or much larger in size than particles. To understand the fate of particles on such surfaces, a new multi-scale surface roughness model is developed. In our new model, substrates with large-scale surface roughness are described as wavy surfaces. The relation between the important parameters of such a wavy surface, i.e. amplitude and wavelength and the critical velocity required to remove a particle from the surface was theoretically modeled. The analysis shows that the critical velocity of removal approaches that of smooth surfaces for large roughness scales, but at intermediate scales (comparably to particle sizes) the critical velocity increases significantly compared to smooth surface condition. In this presentation, the details of the theoretical model and main results from our study will be presented and implication for resuspension of micron-sized particles from real-substrates will be discussed.
Approved for public release, distribution is unlimited.

6AP.5

Optical Losses due to Aerosol Deposition on Solar Cells: Two-Stream Theory vs. Spectrophotometer Measurements.

PATRICIO PIEDRA, Laura Llanza, Hans Moosmuller, *Desert Research Institute*

The efficiency of solar cells is degraded by aerosols deposition, potentially resulting in significant efficiency losses (≳85%). However, very little is known about the role of electromagnetic scattering and absorption in reducing the total optical power received by the solar cell semiconductor. In this study, we have conducted suspension-deposition experiments with optically absorbing and non-absorbing mineral dust compounds. Suspended dust settled gravitationally onto glass slides acting as surrogate for solar cells. The optical transmission of dust-deposited slides was measured for forward scattering and direct beam with an integrating sphere spectrophotometer. Transmission into the forward direction was found to decline with increasing optical depth, with a slope depending on the absorptivity of the deposited dust. A multiple-scattering radiation transfer model (two-stream model) was found to yield good agreement (within 5%) with experimental results for both types of dust. The two-stream model yields a multiple-scattering transmission equation that depends on two single-scattering quantities, namely albedo and asymmetry parameter. This study has the potential to help predict energy output of solar cells subject to aerosol deposition.

6AP.6

Exploring the Phase Transitions of Highly Supersaturated Vapors and Supercooled Nanodroplets of Short-Chain (C5-C7) Alkanes in a Supersonic Laval Nozzle.

KEHINDE OGUNRONBI, Barbara Wyslouzil, *The Ohio State University*

The phase behavior of simple molecules in high speed flows has proven to be an interesting area of research both in basic science and applied science. Of particular importance is the phase behavior of chain molecules - normal alkanes – because condensation in high speed flows is one way to remove them from raw natural gas. In addition to the studies of vapor to liquid phase transitions of n-alkanes been done, a few researchers have also investigated the crystallization of supercooled n-alkane liquid droplets. Recently, it was shown that surface and bulk freezing could be observed in supercooled nanodroplets of n-octane and n-nonane in a supersonic flow (Modak et al., 2013). This contrasts with other reports in the literature (Wu et al., 1993) that concluded the surface freezing phenomenon was restricted to alkanes containing at least 14 carbon atoms. For these longer chained alkanes, surface-freezing at the vapor-liquid interface occurs at temperatures above the bulk melting temperature, Tm.

We have begun to study phase transitions of *n*-alkanes with $5<n<7$ using three experimental techniques: pressure trace measurements (PTMs), Fourier Transform Infrared (FTIR) spectroscopy, and Small Angle X-ray Scattering (SAXS). The PTMs characterize the expanding gas mixture flow, the SAXS experiments characterize the aerosols generated in the nozzle, and data from the FTIR experiments are used to determine the distribution of the condensible in the three phases. For these relatively short-chain alkanes, we observe evidence for freezing in heptane and hexane, but for n-pentane freezing is not observed in spite of sub-cooling the liquid by ~33 K.

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6BA.1
Evaluation of Two Concentrating Techniques for Bioaerosol Quantification. HYEON-JU OH, Taewon Han, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

Concentration process is a critical step when preparing liquid-based bioaerosol samples because that allows measuring lower bioaerosol concentrations. Here we investigated the performance of two concentrating techniques: BioChromato evaporator and Concentrating Pipette Tip (CPT). The tests were performed with polystyrene latex (PSL) particles of 1.0 and 2.9 µm in diameter, Bacillus subtilis and Pseudomonas stutzeri bacterial cells, and bioaerosols collected outdoors. For outdoor field test, bioaerosol samples were collected using BioSampler (SKC Inc.) with 20 mL of collection liquid for 120 min, and concentrated by using BioChromato evaporator and CPT had 20-40 mL of initial liquid volume. For the evaporator, it took 30-150 min to reduce sample volume to 10 mL; for CPT, 20-40 seconds were sufficient to reduce the sample volume to 0.3-0.8 mL. The losses, quantified by microscopy as particle numbers before and after the concentration, for the evaporator were 6.6-21.5 % for 1.0, 2.9 µm PSL and B. subtilis bacterial cells; the losses for the CPT were 13.3-70.8 % for 1.0, 2.9 µm PSL, B. subtilis and P. stutzeri bacterial cells. In the culture-based analysis, losses of bacteria by the CPT were 51.4-76.9 % for B. subtilis and P. stutzeri. When outdoor samples were concentrated using the CPT, the losses based on culture-based analysis were 57.8-79.4 % for bacterial cells and fungal spores. However, there was no loss of both bacterial cells and fungal spores when analyzed by microscopy, most likely due to deagglomeration of cells during the washing step involving a detergent. These results suggest that both concentration techniques were able to minimize the sample volume. However one has to keep in mind the loss of particles, especially the culturable fraction, during the process.

6BA.2
Long-Term Viable Bioaerosol Sampling Using a Temperature- and Humidity-Controlled Filtration Apparatus. HOWARD WALLS, Jean Kim, Lauren Harvey, Robert Yaga, Laura Haines, David S. Ensor, Susanne Hering, Steven Spielman, Nathan Kreisberg, *Research Triangle Institute*

Sampling for culturable (e.g. viable) aerosolized microbes (bioaerosols) is a useful means to provide information for public health monitoring and studies. However, it is challenging to maintain microbe culturability when sampling at high flow rates (>12 L/min) and extended periods of time (≥4 hours). We developed a first-generation, viable bioaerosol collection system (VBCS) utilizing temperature (T) and relative humidity (RH)–conditioned filtration at a flow rate of 25 L/min. A two-stage system of tube-in-shell Nafion™ exchange units provides cooling to ≤10°C and RH conditioning to 80–95%. Aerosol particles are collected on a polyurethane nanofiber filter providing a physical collection efficiency of >95% for sizes 0.06–10 µm. The T and RH conditions at the collection filter are maintained, despite changes to ambient conditions. The initial testing of the VBCS was done under indoor, laboratory conditions with aerosolized, vegetative E. coli. A scenario of a 30-minute challenge of bioaerosol followed by continued sampling of clean air for various times was used to judge culturability maintenance under extended-term sampling. An initial, loss of culturability upon collection onto the filter was observed; 23±13% relative to 4-mm all-glass impinger. However once collected, 98% of culturability was maintained for an additional 4.5 hours of sampling. An exponential decay in culturability was observed from 8 hours to 15 hours of sampling. Also, 24-hour cold storage of the filters collected was studied. The VBCS is based on the use of dry filter cassettes, needs minimal maintenance, and preserves culturability of vegetative bacteria for >4 hours.

6BA.3

Improved Collection of Airborne Bacteria and Yeast through Water-based Size Amplification. MAOHUA PAN, Leah Carol, John Lednicky, Arantzazu Eiguren Fernandez, Susanne Hering, Hugh Fan, Chang-Yu Wu, *University of Florida*

Inhalation of or exposure to airborne bacteria and fungi in the form of mycelium fragments, spores, or yeast, has been a great concern worldwide because of their association with numerous respiratory diseases and other health related impacts. One limitation for sampling these microorganisms is the deactivation of bacteria or yeast during the sampling process, due to the stresses from dehydration and/or impaction. In this study, lab generated bacteria (E. coli) and yeast (S. kudriavzevii) aerosol particles were collected by a laminar flow water-based condensational “growth tube collector (GTC)” and an industry-standard BioSampler. The GTC works by particle size-amplification through water vapor condensation and gentle deposition of the enlarged particles onto liquid collection media. In contrast, the BioSampler is an impinger that deposits collected particles into collection media in a more aggressive swirling motion. Comparison was made between the GTC and the BioSampler for the collection of vegetative bacteria and yeast using two collection media, PBS and nutrient media (NM). The GTC had equivalent performance to the BioSampler when PBS was used as the collection medium for E. coli, whereas 40% more bacteria were collected in the GTC than the BioSampler when NM was used. For S. kudriavzevii, the GTC had better performance for both PBS and the NM. The BioSampler rarely collected anything for air concentrations below 4´103 CFU/L, while the GTC collected yeast cells at a concentration as low as 4´102 CFU/L. These results indicate that the GTC is a promising device for sampling viable bacteria and fungus with a lower detection limit than the standard Biosampler.

6BA.4

Variability of Primary Biological Aerosol Particles at Different Growth Stages of a Model Grass. SWARUP CHINA, Daniel Veghte, Amir Ahkami, Johannes Weis, Libor Kovarik, Mary Gilles, Alexander Laskin, *Pacific Northwest National Laboratory*

Biogenic aerosols are an integral part of the atmosphere-biosphere interface and significantly impact the environment and Earth’s climate. Primary biological aerosol particles such as pollen, fungal spores, bacteria, and fragments of plant debris, are emitted directly from the biosphere into the atmosphere. Brachypodium (B.) distachyon is a C_3 (produce 3-carbon molecules as a first product of carbon fixation) grass, that is considered as a model both for bioenergy grasses and for important food crops such as wheat. B. distachyon serves as a tractable plant to study the effects of variable environmental conditions and global climate change on crop yields. In this study, B. distachyon accession of a particular genotype (Bd21) was grown in chambers under controlled conditions. Emissions of primary biological aerosol particles were monitored at seven principal growth stages starting from leaf development to senescence using an array of chemical imaging and micro-spectroscopic techniques. We observed that biological particles, including several species of bacteria and fungal spores, are most abundant during life stages of flowering and fruit development. We further investigated the chemistry of the biological particles emitted during different growth stages. Our findings indicate that depending upon the developmental stage of B. distachyon, the environmental impact of emitted biological particle is highly variable.

6BA.5

Probing the Fundamentals of Bioaerosol Longevity as a Function of Atmospheric and Particle Compositions through Using a Next Generation Electrodynamic Balance.

ALLEN E. HADDRELL, Mara Otero, Richard Thomas, Jonathan P. Reid, *University of Bristol*

The study of the fundamentals of bioaerosol is challenging. Firstly, there remain all the challenges associated with standard aerosol experiments (small sample size, broad concentration ranges), with the additional difficulty of studying the variability presented by micro-organisms residing in droplets (e.g. population variation, chemical composition). The methodologies currently employed in laboratory studies of bioaerosol are based on analytical approaches developed in the 1950s with minor adaptations (e.g. Goldberg drum). Numerous aspects of these technologies are problematic, from droplet generation (retaining viability, knowing chemical and biological composition (Zhen, 2014)), droplet suspension (avoiding wall loss, interaction with contaminants, etc.) and analysis (sampling inefficiency). Given these limitations, some basic questions about bioaerosol have yet to be fully answered (e.g. does the number of bacteria or chemical composition in a droplet influence the longevity and transmissibility of micro-organisms in the droplet?).

To be able to answer these fundamental questions, a novel technology has been developed and will be presented. This technology (utilizing electrodynamic levitation) produces and suspends a quantifiable number of near identical bioaerosol droplets within an atmosphere whose composition is controlled. Moreover, the complete chemical and biological composition of the droplets is tailorable. After a given period the droplets are extracted from the gas phase (at a 100% efficiency) onto a substrate wherein their viability is probed.

Of the many unique characteristics of this technology, the ability to produce droplets with identical chemical composition and size, with a similar absolute number of microorganism (±10%), is critical to being able to answer the most fundamental questions regarding bioaerosol. Some of the measurements to be presented include, the effect that the (a) absolute number of bacterium per droplet, (b) environmental parameters (e.g. relative humidity, temperature, solar irradiation), (c) biological species, and (d) chemical composition of the droplet itself, will have on longevity and infectivity.

Zhen, H. J.et al, G. J Aerosol Sci 2014, 70, 67.

6BA.6

Evaluation of a Self-Contained Personal Electrostatic Bioaerosol Sampler (PEBS) for Bioaerosol Collection.

TAEWON HAN, Nirmala Thomas, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

We recently developed a new personal electrostatic bioaerosol sampler (PEBS) for determining exposures to airborne microorganisms. The PEBS was shown to effectively collect airborne biological particles while producing very low ozone concentrations. Here we analyzed the performance of this sampler with two airborne microorganisms - Bacillus atrophaeus bacterial cells and Penicillium chrysogenum fungal spores - as a function of sampling flow rates (e.g., 10 and 20 L/min) and sampling time (e.g., 10, 60, and 240 min). The PEBS was also tested against the BioSampler and the Button Aerosol Sampler (both SKC Inc., Eighty Four, PA) when sampling bioaerosols outdoors for 240 min at a standard flow rate of each sampler (10, 12.5, and 4 L/min, respectively). The bioaerosols drawn into the PEBS were deposited on a collection metal plate coated with a superhydrophobic substance and were then removed by 5 mL of liquid medium (water or phosphate-buffered saline). The sampler's physical collection efficiency, viability and culturability of collected microorganisms were determined using microscopy, adenosine triphosphate (ATP), flow cytometry (Live/Dead test), and culture techniques.

The collection efficiency of PEBS was approximately 80% when sampling B. atrophaeus bacteria and P. chrysogenum fungal spores at 10 L/min for 10 min and at ~10^4/Liter airborne concentrations. The sampler also showed similar and steady collection efficiency (on average 83%) during 4-hour sampling period and produced low ozone concentration (< 10 ppb). Further, cell viability and culturability of the PEBS was expressed as Relative Luminescence Units (ATP method), a ratio of Live/Dead cells (flow cytometry), and Colony Forming Units, and compared against that of the two reference samplers when sampling for 10 and 240 min. The average ratios of Live/Dead cells of PEBS when collecting the microorganisms were similar or better compared to those of BioSampler and Button Aerosol Sampler.

6CA.1

Rapid Formation of Secondary Organic Aerosols from Alberta Oil Sands Emissions. Max Adam, ALEX LEE, Megan Willis, Jonathan Abbatt, Charles Odame-Ankrah, Jennifer Huo, Travis Tokarek, Hans Osthoff, Jeff Brook, Shao-Meng Li, *National University of Singapore*

Oil sands operations contribute significantly to organic aerosol (OA) formation, particularly secondary OA (SOA), which can have detrimental impacts on air quality. To better understand formation and characteristics of OA related to oil sands emissions, real-time measurements of refractory black carbon (rBC) and non-refractory particulate matter (NR-PM, including organic, sulfate, nitrate, ammonium and chloride) in PM1 were made in the Alberta oil sands region using an Aerodyne Soot-Particle Aerosol Mass Spectrometer (SP-AMS) from 11 August to 10 September 2013. Positive matrix factorization (PMF) of SP-AMS measurement was performed to identify sources of OA components. With supporting co-located gas-phase measurements (SO2, NOx and O3) and meteorological data, four types of OA were identified at the measurement site. Hydrocarbon-like OA (HOA) from combustion emissions showed significant correlations to rBC and NOx. Two oxygenated OA (OOA) factors with relatively low O/C ratios, referred to as sulfate-OOA and Oil Sands-OOA (OS-OOA), were secondary in nature. They were primarily transported from the southeast, indicating two strong anthropogenic emission sources in that direction. While sulfate-OOA was associated with acidic sulfate and SO2 plumes, OS-OOA strongly correlated to particle-phase nitrate. Lastly, an aged-OOA factor with relatively high O/C ratio was not wind direction dependent, suggesting that the aged-OOA was more evenly distributed in the oil sands region. Using -log(NOx/NOy) as a photochemical clock, we observed a higher overall Org-to-BC ratio with atmospheric aging and OS-OOA contributed up to ~45% of total OA mass in fresh air masses, indicating rapid formation of SOA from oil sands emissions. Results from single particle characterization of the particles from the SP-AMS validate the separation of sulfate-OOA and OS-OOA factors in PMF results.

6CA.2

Equilibration Timescales of Secondary Organic Aerosols under Dry and Humid Conditions. KHAIRALLAH ATWI, Mohamad Baassiri, Mariam Fawaz, Nareg Karaoghlanian, Alan Shihadeh, *American University of Beirut*

Semi-volatile secondary organic aerosols (SOA) comprise a major fraction of ambient particle pollutants. The partitioning of SOA in the atmosphere has commonly been assumed to be fast enough that it could be computed solely from thermodynamic equilibrium considerations e.g., using Raoult's Law. This simplifying assumption has been called into question by recent studies of single-particle SOA evaporation in a zero vapor concentration environment, which reported unexpectedly slow evaporation relative to atmospheric timescales. In this work we directly investigated the phase equilibration kinetics of systems of SOA particles under realistic atmospheric conditions. SOA was generated in an oxidation flow reactor (OFR) from engine exhaust or α-pinene and mixed with clean air in an atmospheric pressure smog chamber (32 °C) to induce evaporation. The evolution of the particle size distribution was monitored over time as the aerosol system returned to phase equilibrium under different of particle concentrations (2.5 and 5 μgm^{-3}) and humidity conditions (<10% and 60%). We found that under typical ambient conditions, and independent of relative humidity and precursor origin (engine vs. α-pinene), SOA reestablished equilibrium with the vapor phase within minutes, and that the evolution of particle size was well-fit by a computational model treating the particle phase as well-mixed. The effective thermodynamic saturation concentration of the SOA was found to be in the range 0.02-0.11 μgm^{-3} at 20 °C, assuming an enthalpy of vaporization of 150 $kJmol^{-1}$. The effective evaporation coefficient was found to be in the range 0.1-0.2 using a gas diffusion coefficient of 5×10^{-6} m^2s^{-1}. Unlike previous single-particle studies, this data suggests that under most conditions, anthropogenic and biogenic SOA rapidly attain phase equilibrium in the atmosphere and that their partitioning can be modeled assuming thermodynamic equilibrium.

6CA.3

Synthesis of Four Monoterpene-derived Organosulfates and their Quantification in Atmospheric Aerosol Samples.

YUCHEN WANG, Jingyun Ren, X.H. Hilda Huang, Rongbiao Tong, Jianzhen Yu, *Hong Kong University of Science and Technology*

Monoterpenes, a major class of biogenic volatile organic compounds (VOCs), are known to produce oxidation products that further react with sulfate to form organosulfates. Such a class of secondarily formed aerosol products involving anthropogenic sulfur precursor represent controllable secondary organic aerosol from biogenic VOCs. The accurate quantification of monoterpene-derived organosulfates (OSs) is necessary for quantifying this aerosol source; however, it has been hampered by a lack of authentic standards. In this work, we report a unified synthesis strategy of monoterpene-derived OSs from the respective monoterpene through Upjohn dihydroxylation and mono-sulfation with sulfur trioxide-pyridine complex. We demonstrate the successful synthesis of four monoterpene-derived OS compounds, including α-pinene OS, β-pinene OS, limonene OS and limonenaketone OS. Quantification of OSs is commonly achieved using liquid chromatography-mass spectrometry (LC-MS) by either monitoring the [M-H]- ion or through multiple reaction monitoring (MRM) of mass transitions between the [M-H]- and m/z 97 ions. Comparison between the synthesized standards and previously adopted quantification surrogates reveals that camphor-10-sulfonic acid is a better quantification surrogate using [M-H]- as the quantification ion while the highly compound-specific nature of MRM quantification makes it difficult to choose a suitable surrogate. Both could be rationalized in accordance to their respective MS quantification mechanisms. The in-house availability of the authentic standards enables us to discover that β-pinene OS, due to the sulfate group at the primary carbon, partially degrades to a dehydrogenated OS compound during LC/MS analysis and a hydroperoxy OS over a prolonged storage period (> 5 month). Limonene OS was positively identified for the first time in ambient samples and found to be more abundant than α-/β-pinene OS in the Pearl River Delta, China. This work highlights the critical importance of having authentic standards in advancing our understanding of the interactions between biogenic VOC emissions and anthropogenic sulfur pollution.

6CA.4

Significant Organic Aerosol Formation from Biogenic Volatile Organic Compounds in the Southeastern United States.

LU XU, Havala Pye, Jia He, Yunle Chen, Benjamin Murphy, Nga Lee Ng, *California Institute of Technology*

Organic aerosol (OA), which constitutes a substantial fraction of fine particulate matter (PM), has large impacts on air quality, climate change, and human health. However, due to complex sources and formation mechanisms of OA, the contributions from different sources to OA are highly uncertain. Positive matrix factorization (PMF) analysis on the organic mass spectra obtained by the high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) is a widely used method for OA source apportionment. However, it is largely unknown regarding what sources/processes contribute to OA factors, especially the more-oxidized oxygenated OA (MO-OOA) and less-oxidized oxygenated OA (LO-OOA). In this study, we apply novel experimental protocol and show that LO-OOA is related to fresh SOA from the oxidation of biogenic volatile organic compounds (VOCs) in the southeastern United States. To simulate the SOA formation in the southeastern U.S., we use Community Multiscale Air Quality model (CMAQ) with latest laboratory findings implemented. The model results agree well with measured SOA from biogenic VOCs at multiple sites in the southeastern U.S. Our novel experimental approach also provides substantial insights in understanding the sources of other OA factors.

6CA.5

Secondary Organic Aerosol Formation from OH-and Cl-Initiated Photo-oxidation of Non-combustion Intermediate Volatility Organic Compounds. SURYA VENKATESH DHULIPALA, Lea Hildebrandt Ruiz, *University of Texas at Austin*

Intermediate volatility organic compounds (IVOCs) are known to contribute significantly to secondary organic aerosol (SOA) in the atmosphere, but their emission, atmospheric concentrations and SOA formation potential remain poorly characterized. Most current air-quality models only account for SOA formation from IVOCs originating from mobile sources or biomass burning. In this work, we focus on Butyl CarbitolTM (Diethylene glycol monobutyl ether) and TexanolTM (ester alcohol), both oxygenated IVOCs which are important constituents in industrial solvents.

TexanolTM was not found to form a significant amount of SOA even after multiple injections of hydroxyl radical precursors as well as chlorine. Butyl CarbitolTM was found to form significant amounts of SOA under all experimental conditions: OH-initiated and Cl-initiated photo-oxidation as well as different levels of NOx. An aerosol chemical speciation monitor (ACSM) was used to quantify the amount of organic aerosol formed and to characterize its composition. A thermodenuder was used to partially evaporate the organic aerosol, and an evaporation model was used to estimate its volatility. A high resolution-time of flight -chemical ionization mass spectrometer (HR-Tof-CIMS) was used to track consumption of precursor IVOCs as well as identify gas-phase products. We found that the presence of NOx resulted in an increase in oxidation state of organic aerosol as compared to low NOx OH-initiated photo-oxidation systems. Overall, our results indicate that Butyl CarbitolTM has a high SOA formation potential and that this class of IVOCs can contribute significantly to SOA formation, which may need to be represented in chemical transport models.

6CA.6

Demonstrating That Speciation of Organic Fraction Does Matter for Source Apportionment: Use of Specific Primary and Secondary Organic Markers. DEEPCHANDRA SRIVASTAVA, Olivier Favez, Emilie Perraudin, Jean-Luc Besombes, Laurent Alleman, Grazia-Maria Lanzafame, Sophie Tomaz, Jean-Luc Jaffrezo, Clément Bret, Benjamin Golly, Eric Villenave, Alexandre Albinet, *INERIS*

Organic aerosol (OA) is a major part of atmospheric fine particulate matter (PM), accounting for approximately 20-60% w/w of PM in the continental mid-altitudes. However, ambient OA remains poorly understood due to mixed source origins and processes (anthropogenic and biogenic, primary and secondary). The objective of this study was to refine source apportionment of PM10 OA by Positive Matrix Factorization (PMF) using specific primary and secondary organic molecular markers. PM_{10} samples were collected over a one year period (2013) at an urban station in Grenoble (France) every third day (24 h-basis sampling) on quartz filters, and an extended chemical characterization was performed (~216 species quantified) including specific primary organic markers i.e. levoglucosan, polyols (arabitol, mannitol), 1-nitropyrene (diesel emission), PAHs, alkanes, hopanes, etc. and secondary markers i.e. nitro- and oxy-PAHs, hydroxyglutaric acid (α-pinene secondary organic aerosol SOA), α-methyl glyceric acid (isoprene SOA), DHOPA (toluene SOA), etc. together with other PM chemical species such as OC/EC, Humic Like Substances (HuLiS), ions/cations (Na^+, Mg_2^+, NH_4^+, Cl^-, SO_4^{2-}, NO_3^-), metals (Ba, Cu, Ti, Zn, Sb, …). Results showed that a better source apportionment of PM_{10} OA fraction was achieved using specific organic markers with additional sources resolved such as biogenic SOA, anthropogenic SOA, primary biogenic (fungi) and plant debris by comparison to more traditional PMF. More than 50% of OC seemed secondary in nature, and a high contribution of anthropogenic SOA was noticed in winter during a specific PM pollution event. Primary and secondary sources of HuLiS were also investigated in this study. Discussion will further underline the details of the chemical and temporal/seasonal profiles of each factor, and their relative contributions.

6CC.1

Sensitivity of Radiative Forcing to Uncertainties in Real and Imaginary Refractive Indices as Determined from Single Trapped Particle Measurements. ANTONIO VALENZUELA, Jonathan P. Reid, Rose Willoughby, Allen E. Haddrell, Bryan R. Bzdek, Andrew J. Orr-Ewing, *University of Bristol*

Radiative forcing (RF) caused by anthropogenic aerosols is thought to be the major contributor to the changing radiative balance of the Earth-atmosphere system. In clear-sky conditions scatter solar radiation back to space, reducing solar irradiance at the ground. This effect is usually known as ‘’the aerosol direct effect’’and is one of the largest uncertainties in quantifying the RF through the scattering and absorption of radiation. The parameter which governs how the light interacts with a particle is the extinction cross-section which depends on the complex refractive index, the radius of the particle and the wavelength of the radiation. The complex refractive index is defined as the sum of two terms, the real refractive index, which governs scattering, and the imaginary refractive index, which determines the extent of light absorption. However, determination of the complex refractive index is challenging because of the mixed composition of the aerosol in the atmosphere, the hygroscopic response of this parameter to ambient relative humidity, and the imprecision of current techniques. We will present a novel method for the accurate determination of the optical extinction cross-sections of individual particles and the dependence on environmental conditions, with continuous monitoring of the optical properties of the same particle over an indefinite timeframe. A combination of a quadrupole electrodynamic trap and cavity ring-down spectroscopy (CRDS) is used to trap a single particle and characterize the optical cross-section, leading to a determination of the complex refractive index. We will demonstrate that such a single particle technique leads to a significant reduction in the uncertainty in the complex refractive index reducing, for example, the uncertainty in the real part to ±0.3 %. We will report retrievals of optical properties of aerosol spanning from simple mixtures of organic components through to samples of laboratory surrogates of secondary organic aerosol. Finally, a sensitivity study of RF will be reported establishing the limits on the accuracy and precision of RF estimates from the refractive indices retrieved using our setup.

6CC.2

Top-down and Bottom-up Aerosol-Cloud-Closure: Towards Understanding Sources of Uncertainty in Deriving Cloud Radiative Flux. KEVIN SANCHEZ, Greg Roberts, Radiance Calmer, Keri Nicoll, Daniel Rosenfeld, Jurgita Ovadnevaite, Jana Preissler, Darius Ceburnis, Colin O’Dowd, Lynn Russell, *Scripps Institution of Oceanography*

Top-down and bottom-up aerosol-cloud-radiative flux closures were conducted at the Mace Head atmospheric research station in Galway, Ireland in August 2015. This study is part of the BACCHUS (Impact of Biogenic versus Anthropogenic emissions on Clouds and Climate: towards a Holistic Understanding) European collaborative project, with the goal of understanding key processes affecting aerosol-cloud-radiative flux closures to improve future climate predictions and develop sustainable policies for Europe. Instrument platforms include ground-based, unmanned aerial vehicles (UAV), and satellite measurements of aerosols, clouds and meteorological variables. The ground-based and airborne measurements of aerosol size distributions and cloud condensation nuclei (CCN) concentration were used to initiate a 1D microphysical aerosol-cloud parcel model (ACPM). UAVs were equipped for a specific science mission, with an optical particle counter for aerosol distribution profiles, a cloud sensor to measure cloud extinction, or a 5-hole probe for 3D wind vectors. UAV cloud measurements are rare and have only become possible in recent years through the miniaturization of instrumentation. These are the first UAV measurements at Mace Head. ACPM simulations are compared to in-situ cloud extinction measurements from UAVs to quantify closure in terms of cloud radiative flux. Two out of seven cases exhibit sub-adiabatic vertical temperature profiles within the cloud, which suggests that entrainment processes affect cloud microphysical properties and lead to an overestimate of simulated cloud radiative flux. Including an entrainment parameterization and explicitly calculating the entrainment fraction in the ACPM simulations both improved cloud-top radiative closure. Entrainment reduced the difference between simulated and observation-derived cloud-top radiative flux (dRF) by between 30 W m-2 and 40 W m-2. After accounting for entrainment, satellite-derived cloud droplet number concentrations (CDNC) were within 30% of simulated CDNC. In cases with a well-mixed boundary layer, dRF is less than 25 W m-2 after accounting for cloud-top entrainment, compared to less than 50 W m-2 when entrainment is not taken into account. In cases with a decoupled boundary layer, cloud microphysical properties are inconsistent with ground-based aerosol measurements, as expected, and dRF is as high as 88 W m-2, even after accounting for cloud-top entrainment. This work demonstrates the need to take in-situ measurements of aerosol properties for cases where the boundary layer is decoupled as well as consider cloud-top entrainment to accurately model stratocumulus cloud radiative flux.

6CC.3

Aerosol Size Distribution, Chemical Composition and CCN Activities in Eastern North Atlantic. GUANGJIE ZHENG, Tamara Pinterich, Janek Uin, Thomas Watson, Stephen Springston, Robert Bullard, Chongai Kuang, Allison Aiken, Rob Wood, Jian Wang, *Brookhaven National Laboratory*

The responses of marine low cloud systems to changes in aerosols are among major sources of uncertainty that limit our ability to predict future climate. Major contributions to the uncertainty derive from poor understanding of aerosol under natural conditions and the perturbation by anthropogenic emissions. The Eastern North Atlantic Ocean (ENA) is a region of persistent but diverse marine boundary layer (MBL) clouds, and whose albedo and precipitation are highly susceptible to perturbation in aerosol properties. In this study, we examine aerosol properties, trace gases, and meteorological parameters measured on Graciosa Island in the ENA since 2014. The concentrations of CO and O3 are well correlated, suggesting entrainment of free tropospheric air is a common source of both species in the boundary layer. Monthly averages of total aerosol number concentration (CN) in 2016 varied from 220 cm^{-3} in December to 620 cm^{-3} in April. The seasonal variation in CN is likely due to a combination of more efficient particle removal during the winter months and more frequent transport of continental pollution during the spring time. Observed particle volume size distribution in the accumulation size range typically consists of a condensation sub-mode (centered around 200 nm) and a droplet sub-mode (centered around 800 nm). This bimodal pattern could arise from cloud processing and/or production of sea spray aerosol. Non-refractory submicron aerosol composition measured by an Aerodyne Aerosol Chemical Speciation Monitor shows that sulfate and organics are the dominating species, while the contribution of nitrate is much lower. In addition, cloud condensation nuclei (CCN) concentrations are measured at five super-saturations (ss) of 0.1%, 0.2%, 0.5%, 0.8%, and 1%. The observed CCN spectra can be well fitted using a power-law function, i.e. CCN(ss)=C ssk. Monthly averages of the fitted C and k ranged from 222 to 440 cm-3 and from 0.4 to 0.7, respectively, in agreement with previous observations in this region. The hygroscopicity parameter, κ, is derived from the concurrent CCN spectrum and size distribution measurements, with the monthly averages ranging 0.3 to 0.6. The value of κ decreases with decreasing particle diameter, suggesting particles composition is increasingly dominated by organics at small particle sizes.

6CC.4

Sensitivity of Cloud Droplet Number to Environmental Changes in Aerosol and Cloud Condensation Nuclei (CCN) during the NASA North Atlantic Aerosols and Marine Ecosystems Study (NAAMES). RICHARD MOORE, Ewan Crosbie, Luke Ziemba, Mary Kacarab, Athanasios Nenes, Gao Chen, Michael Shook, Kenneth Thornhill, Edward Winstead, Bruce Anderson, *NASA Langley*

It has been hypothesized that increased ocean biological activity translates into increased concentrations of submicron aerosol that can be transported over large distances (e.g., O'Dowd et al., Nature, 2004); however, the impact of these aerosols on CCN and the sensitivity of clouds to these aerosols in the local remote marine atmosphere remain highly uncertain. Model simulations suggest that clouds in these remote oceanic regions are highly CCN-limited as compared to continental clouds that are close to aerosol emissions sources (Moore et al., Atmos. Chem. Phys., 2013). Thus, it might be expected that these clouds would be highly sensitive to presence of these biogenic aerosols.

We present airborne in situ measurements of aerosol and cloud microphysical properties and cloud condensation nuclei (CCN) spectra carried out during 2015-2017 as part of the North Atlantic Aerosols and Marine Ecosystems Study (NAAMES). These field campaigns target distinct cycles in the annually-occurring North Atlantic phytoplankton bloom, and provide excellent opportunities to examine the influence of biogenic aerosols on CCN and clouds against a backdrop of both the presence and absence of anthropogenic pollution. Aerosol concentrations and cloud droplet number concentrations observed during November were extremely low, and while the addition of aerosol (by ~10-fold) during the Springtime increases cloud droplet number concentrations, the shape of the CCN supersaturation spectrum remains similar between both campaigns. Our interpretation of these findings as well as the cloud droplet sensitivity to aerosols in this unique, pristine regions will be discussed within the context of past airborne campaign datasets.

6CC.5

Sensitivity of Estimated CCN Concentration at a Rural Site to Common Assumptions Regarding Aerosol Composition and Mixing State. MANASI MAHISH, Anne Jefferson, Don Collins, *Texas A&M University*

A 4-year record of aerosol size and hygroscopic growth factor distributions measured at the Department of Energy's SGP ARM site in Oklahoma, U.S. were used to estimate supersaturation (S)-dependent cloud condensation nuclei concentrations (N_{CCN}). Baseline N_{CCN}(S) spectra were first estimated by using the data to create matrices of size- and hygroscopicity-dependent number concentration (N) and critical supersaturation (S_c) and then integrating N over $S > S_c$. The accuracy of those estimates was assessed through comparison with the directly measured N_{CCN} at the same site. Subsequently, N_{CCN}(S) was calculated using the same dataset but with an array of simplified treatments in which the aerosol was assumed to be either an internal or an external mixture and the hygroscopicity either assumed or based on averages derived from the growth factor distributions. The CCN spectra calculated using the simplified treatments were compared with those from the baseline approach to evaluate the impact of commonly used approximations. N_{CCN} was calculated using κ-Köhler Theory for all mixing state and solution type assumptions. The average Normalized Root Mean Square Errors (NRMSE) between N_{CCN} derived from the baseline approach and those measured directly are 0.39, 0.25, 0.27 and 0.35 for data from 2009, 2010, 2011 and 2012, respectively. Among the simplified approaches, assuming the aerosol was an internal mixture with size-dependent hygroscopicity parameter (κ) resulted in estimates closest to those from the baseline approach, with a goodness of fit (r^2) of 0.86 and the smallest variation in best fit slope between 0.25% and 0.85% S (0.002).

6CC.6

Size-dependence of Aerosol Hygroscopicity Parameters at Sub- and Super-saturation. ANDREAS ZUEND, Natasha Hodas, John Seinfeld, *McGill University*

The equilibrium response in the size change of a hygroscopic aerosol particle to a change in ambient relative humidity is determined by the chemical composition of the particle and the thermodynamics of gas-particle partitioning and condensed phase mixing. At high relative humidity, the diameter growth factor is usually dominated by the uptake/loss of water, which is commonly represented in atmospheric models by a simplified hygroscopicity parameterization, such as the κ-Köhler model. The single-parameter κ-Köhler model is appropriate in many cases and experimental values for κ are frequently reported for single components as well as for the characterization of mixtures from laboratory and field studies. However, in the case of aerosol mixtures containing sparingly water-soluble organics, which only contribute to the water uptake at or near water-supersaturated conditions, κ values determined at lower relative humidities will be inappropriate for the description of particle size at supersaturation and the prediction of cloud condensation nuclei activity. This is a key contributor to an observed contrast in κparameters determined at sub-saturation vs. CCN activation conditions for certain aerosol systems.

In this presentation, we show how state-of-the-art thermodynamic equilibrium models provide insight into the behavior of diameter growth factors and related hygroscopicity parameters at sub- and supersaturated conditions. Furthermore, in applications of κ-Köhler theory for CCN activation, it is oftentimes overlooked that κ_{CCN} hygroscopicity parameters are size-dependent quantities, particularly so for ultrafine aerosol. We present a case study of this size dependence based on thermodynamic model predictions accounting for size and non-ideal mixing effects. In principle, such model predictions allow for an appropriate choice of κ_{CCN} values in applications of κ-Köhler theory.

6IM.1

Assessment of Measurement Methods using CAPS PMssa, PAX, Aethalometer, LII, and TOA for Measuring the Mass Concentration of Black Carbon Produced from a MiniCAST Soot Generator over a Wide Range of Setpoints. PREM LOBO, Fengshan Liu, Meghdad Saffaripour, Kevin Thomson, Gregory Smallwood, *National Research Council Canada*

Black carbon (BC) has been identified as a significant climate forcer just after CO2. Mitigation of BC emissions will provide benefits to the climate on a fairly short timescale due to the short lifetime of BC. To monitor BC mass concentrations, it is desirable to have real-time measurement capability, which is currently offered by a number of optically based measurement methods. Unfortunately, these methods are typically limited to providing optical properties and the conversion from them to aerosol mass concentration requires an empirical factor, which varies with the source of the aerosols but has been treated as a constant.

To understand how changes in black carbon particle properties affect the mass concentration measurements reported by different optically based instruments, extensive measurements of black carbon generated from a MiniCAST soot generator over a wide range of setpoints were conducted. The instruments were cavity attenuated phase shift with single scattering albedo (CAPS PMssa) particulate matter monitor (operated at 660 nm), photoacoustic extinctiometer (PAX) (operated at 870 nm), photoacoustic soot spectrometer, three wavelength (PASS-3) (operated at 405, 532, and 781 nm), laser-induced incandescence (LII 300), and a 7-wavelength aethalometer (between 370 and 950 nm). In addition, filter samples of black carbon particles were also collected for thermal optical analysis (TOA) to obtain the EC and OC contents and to provide benchmark mass concentrations for assessment of the optical methods, for Raman spectroscopy analysis of BC particle microstructure, and for transmission electron microscope (TEM) analysis for particle morphology.

The preliminary results indicate that there is reasonable agreement between the mass concentration measurements reported by LII, PAX, CAPS, and the aethalometer at most of the MiniCAST setpoints. However, PASS-3 measured lower aerosol absorption coefficients than CAPS and PAX (after conversion to the same wavelength for direct comparison). The filter samples are anticipated to provide further insight to the relationships between the optical properties measured by the different types of instruments. The results obtained in this study will help to improve our understanding of the relationship between the mass concentration measurement uncertainties of different optical instruments and the black carbon properties.

6IM.2

Limits to the Absolute Accuracy of the Optical Closure Technique. JAMES RADNEY, Christopher Zangmeister, *National Institute of Standards and Technology*

The optical closure technique represents a general methodology that has received wide usage in aerosol science. Historically, the optical closure technique was only used in the forward direction where integrated scattering coefficients were calculated from measured size distributions of a spherical non-absorbing aerosol population (i.e. ammonium sulfate or dioctyl sebacate) of well-known refractive index. This technique was most commonly used for nephelometer calibrations and typically resulted in scattering coefficient uncertainties on the order of 10 %.

In recent years, the optical closure technique has seen increasing use in the reverse direction to calculate a refractive index (using Mie theory) for an arbitrarily-shaped aerosol from parallel measurements of scattering coefficients, absorption coefficients and size distributions. Here, we compare the accuracy of refractive indices calculated using reverse optical closure to those calculated from size- and mass-selected particles; test cases consisted of pure ammonium sulfate, pure nigrosin, and 50:50 (m/m) and 75:25 (m/m) mixtures of ammonium sulfate and nigrosin. We find, in agreement with previous studies, that the optical closure method can suitably capture the refractive index of the pure, non-absorbing ammonium sulfate. For the absorbing particles, average absolute differences in refractive index are on the order of 3 % and 14 % in the real and imaginary components, respectively, without applying appropriate statistical methods for data analysis. Notably, these uncertainties were obtained for spherical, homogeneously mixed particles using a calibrated scanning mobility particle sizer with an accuracy better than a couple of percent (roughly half the width of a typical size bin at 64 bins/decade resolution). Lower resolution or accuracy significantly increases the magnitude of these errors. While these uncertainties in refractive index are modest for these idealized particles, propagating these values forward into calculated absorption and scattering coefficients for a theoretical distribution results in absolute errors of up to 50 % that are strongly size dependent. These sensitivities imply that, for absorbing particles, the reverse optical closure technique should only be used obtain relative, not absolute, refractive indices unless large errors in forward calculated absorption and scattering coefficients (and albedos) are acceptable.

6IM.3

Development of a Portable Aerosol Collector and Spectrometer (PACS). CAI CHANGJIE, Geb Thomas, Sivaram Gogineni, Tianbao Yang, Thomas Peters, *University of Iowa*

Objectives: Current portable instruments cannot continuously measure exposures to all particle size ranges and collect particles simultaneously. The aim of this study was to develop an instrument, the Portable Aerosol Collector and Spectrometer (PACS), to continuously measure particle size distributions by number, surface area and mass concentrations over a wide size range (from 10 nm to 10 µm), and to collect particles by size for post-processing chemical analyses.

Methods: We designed the PACS to direct aerosol from the breathing zone sequentially through a series of impactors and diffusion screens that separate particles into six bins by size. The number and mass concentration of the airborne particles exiting each bin are then measured with a water condensation particle counter and a photometer. The best-fit tri-modal, log-normal distribution is fit to this set of 12 measurements. In these experiments, we compared the number, surface area, and mass concentrations measured by the PACS for laboratory-generated fresh welding fume (nano-sized particles; ultrafine mode), aged welding fume (fine mode) and Arizona road dust (coarse mode) to that measured by a scanning mobility particle sizer (SMPS) and aerodynamic particle sizer (APS). The collected particles are then chemically analyzed to measure the particle size distributions of metal elements. In these experiments, we compared the mass concentrations of Fe and Cu collected by the PACS for laboratory-generated 3-mode aerosol to that collected by a reference cascade impactor (Nano-MOUDI). The percentage bias was calculated based on the measurements from the PACS compared to the measurements from the Nano-MOUDI. The correlation coefficient (r) was calculated based on fitting and reference particle size distributions for each metal element.

Results: In this study, by comparing to the SMPS/APS, for number concentration, the percentage bias was -3% coupled with an r of 0.98; for surface area, the percentage bias was 26% coupled with r of 0.67; for mass concentration, the percentage bias was -34% coupled with r of 0.9. By comparing to the Nano-MOUDI, for Fe element, the percentage bias was -20% coupled with an r of 0.93; for Cu element, the percentage bias was -1% coupled with R of 0.84. Moreover, we were able to use the elemental data to distinguish aerosols in different size modes. Therefore, the particle size distributions estimated with the PACS agreed reasonably well with those measured with the reference instrument.

Conclusions: Particle size distributions in various metrics (number, surface area and mass concentrations) measured by the PACS agreed reasonably well with those measured by reference instruments. This work also demonstrates that the PACS allows portable measurement of particle size distributions of the metals in ultrafine, fine, and coarse mode aerosols.

6IM.4

Development and Characterization of Thermal Dissociation Cavity Attenuated Phase Shift Spectroscopy (TD-CAPS). GAMZE ERIS, Masayuki Takeuchi, Ezra Wood, David Tanner, Greg Huey, Nga Lee Ng, *Georgia Institute of Technology*

Alkyl nitrates (AN) and peroxy nitrates (PN) are temporary NOx reservoirs in the troposphere. Formation of AN and PN terminates the chain reactions of ROx and NOx radicals; therefore the quantification of these nitrates is critical to understanding the global and regional distributions of NOx as well as it cycling and impact on ozone and SOA production. To measure these compounds, a thermal dissociation (TD) inlet can be coupled with various NOy detection techniques such as TD-CIMS, TD-LIF, TD-CRDS and TD-CAPS. Ambient measurements by TD-CAPS have been recently conducted in a remote region. However, there is no characterization study to quantify the limits and strengths of this technique. In this work, we developed a TD-CAPS instrument which consists of two quartz tube reactors at 563 K and 473 K (enabling decomposition of AN and PN, respectively, to NO2) and a reference channel that measures the ambient NO2. The NO2 concentration in each channel is measured by a CAPS monitor. Isopropyl nitrate (IPN) and peroxy acetyl nitrate (PAN) are used as AN and PN model compounds. NO2 biases from side reactions are determined by adding IPN and PAN to the reactors in the presence of atmospheric constituents such as O3, NO and NO2. In the presence of NO, the measured IPN and PAN concentrations are biased high. The presence of NO2 causes a slight overestimation of NO2 concentration for PAN. Correction factors are derived for binary reactions of model compounds with atmospheric constituents over a wide range of concentrations that is representative of both rural and urban areas. Ambient measurements from Atlanta to demonstrate the measurement capability of the instrument will be presented.

6IM.5

Experimental Evaluation of Components for a Super Compact In-Situ LII Probe Applicable on Automotive Exhaust Pipes.

MARTIN KUPPER, Pulko Jožef, Alexander Bergmann, Martin Kraft, *CTR Carinthian Tech Research, Villach, 9524, Austria*

Introduction Laser-Induced Incandescence (LII) is an established technology in science for studying soot in flames and aerosols. Its capability of measuring at high time resolution with accuracies meeting legally mandated limits renders it of high interest also for measuring soot concentrations in automotive exhausts. This work presents the first attempt to realise a highly compact in-situ LII system applicable directly at an automotive exhaust pipe.

Experimental Methods Key components for the proposed in-situ LII system are a super-compact high-power DPSS laser (CTR HiPoLas$^{®}$), fast KETEK silicon photomultipliers (SiPM) as detectors and a dedicated optical measurement setup. A measurement cell was specially designed for i) optimized collection of the incandescent radiation and ii) high flexibility, to allow verifying LII both with different aerosols from particle generators (e.g. Jing 5201 miniCAST – **C**ombustion **A**erosol **ST**andard) and automotive exhausts from an engine testbed.

Results Measurements using aerosol from the CAST proved the incandescence signals to be clearly distinguishable from scattered laser light and yielded corresponding LII signals, proving the fundamental feasibility of an in-situ LII probe. It thus appears very likely that previously used extractive cells and large-scale laser sources can be replaced by this approach, providing a true in-situ particle sensor. Further testing is ongoing, as are the tests with real automotive exhausts. Efforts now focus in particular on providing a calibration of the LII signals in dependence on the soot concentration using a CAST, and evaluate the applicability of this calibration for the use on exhaust gases.

6IM.6

Infrared Spectroscopy Analysis of Aerosols By Solvent Extraction.

Christophe Delval, Giulia Ruggeri, SATOSHI TAKAHAMA, *EPFL*

Transmission-mode analysis of Fourier Transform Infrared (FT-IR) spectroscopy of particulate matter (PM) collected on Teflon filters has provided chemically informative, quantitative analysis of PM in past studies. FT-IR analysis of solvent extracted fractions of PM has also provided qualitative information on organic PM composition separated by polarity (e.g., Polidori et al., doi:10.1080/02786820801958767, 2008; Chen et al., Environ. Sci. Tech., doi:10.1021/acs.est.5b05277, 2016), and also provides an alternative mode of analysis when direct transmission mode analysis is not possible on account of the optical characteristics of filter media. In this work, we evaluate methods for extraction and analysis of PM for organic matter to organic carbon (OM/OC) ratios by FT-IR in transmission and Attenuated Total Reflectance (ATR) modes. The extracted fraction is deposited onto a ZnSe support window (for transmission) or infrared element (for ATR). We compare three different methods for transfer of extracted solution: 1) deposition of a droplet onto the ZnSe crystal for analysis with FT-IR in transmission, 2) deposition of larger volumes (e.g., 500 microliters) onto a trough plate for analysis with ATR-FTIR and 3) electrospray deposition onto ZnSe crystal for FT-IR analysis. We report the development of an in-house electrospray device to improve uniformity of deposition, increase the rate of solvent evaporation, and advance our capability for extraction analysis. Evaluation of parameters for the electrospray deposition (e.g applied voltage, solvent choice, distance between needle and crystal, and solvent flowrate) are discussed in terms of reproducibility, rate of mass loading, and linearity of the resulting infrared spectra absorbance. Furthermore, we will present comparison of OM/OC ratios quantified from ambient aerosol collected onto quartz filters and parallel Teflon filters.

6OP.1

Particulate Oxidative Burden as a Predictor of Exhaled Nitric Oxide in Children with Asthma. Caitlin Maikawa, Scott Weichenthal, Amanda Wheeler, Nina Dobbin, Audrey Smargiassi, Greg J. Evans, Ling Liu, Mark Goldberg, KRYSTAL GODRI POLLITT, *University of Massachusetts Amherst.* INVITED

Background: Epidemiological studies have provided strong evidence that fine particulate matter ($PM_{2.5}$; aerodynamic diameter ≤ 2.5 μm) can exacerbate asthmatic symptoms in children. Pro-oxidant components of $PM_{2.5}$ are capable of directly generating reactive oxygen species. Oxidative burden is used to describe the capacity of $PM_{2.5}$ to generate reactive oxygen species in the lung.

Objective: In this study we investigated the association between airway inflammation in asthmatic children and oxidative burden of $PM_{2.5}$ personal exposure.

Methods: Daily $PM_{2.5}$ personal exposure samples (n = 249) of 62 asthmatic school-aged children in Montreal were collected over 10 consecutive days. The oxidative burden of $PM_{2.5}$ samples was determined in vitro as the depletion of low-molecular-weight antioxidants (ascorbate and glutathione) from a synthetic model of the fluid lining the respiratory tract. Airway inflammation was measured daily as fractional exhaled nitric oxide (FeNO).

Results: A positive association was identified between FeNO and glutathione-related oxidative burden exposure in the previous 24 hr (6.0% increase per interquartile range change in glutathione).

Glutathione-related oxidative burden was further found to be positively associated with FeNO over 1-day lag and 2-day lag periods. Results further demonstrate that corticosteroid use may reduce the FeNO response to elevated glutathione-related oxidative burden exposure (no use, 15.8%; irregular use, 3.8%), whereas mold (22.1%), dust (10.6%), or fur (13.1%) allergies may increase FeNO in children with versus children without these allergies (11.5%). No association was found between $PM_{2.5}$ mass or ascorbate-related oxidative burden and FeNO levels.

Conclusions: Exposure to $PM_{2.5}$ with elevated glutathione-related oxidative burden was associated with increased FeNO.

6OP.3

Ambient Size Distributions and Lung Deposition of Aerosol Dithiothreitol-Measured Oxidative Potential: A Contrast between Soluble and Insoluble Particles. TING FANG, Linghan Zeng, Dong Gao, Hongyu Guo, Vishal Verma, Aleksandr Stefaniak, Athanasios Nenes, Rodney J. Weber, *Georgia Institute of Technology*

The association of ambient particulate matter (PM) with adverse health may be through upsetting redox homeostasis by generating reactive oxygen species (ROS) in vivo and leading to oxidative stress. Oxidative potential (OP) measured by the dithiothreitol (DTT) assay has been widely used to represent the capability of aerosols to generate ROS and $PM_{2.5}$ OP^{DTT} levels have been linked to certain cardiorespiratory health outcomes in recent epidemiological studies. Although bulk measurements of $PM_{2.5}$ OP^{DTT} are common, size resolved measurements are rare but provide unique insights on the sources and atmospheric processes that contribute to observed OP^{DTT} levels. In this study, ambient size distributions of water-soluble and -insoluble fractions of OP^{DTT} (per air volume) are reported for samples collected at a road-side and urban site in Atlanta, GA. Water-soluble OP^{DTT} size distributions were unimodal with a peak at 1 to 2.5 μm due to contributions from fine-mode organic components plus coarse-mode transition metal ions. In contrast, water-insoluble OP^{DTT} was bimodal with a fine and coarse mode. The fine mode was mainly associated with DTT-active organic species absorbed on soot surfaces and the coarse mode with mainly transition metal ions associated with mineral-tire-brake dust surfaces. These size differences mean that the two main chemical components that drive OP (organic species, such as quinones, and transition metal ions) are largely externally mixed and deposit in different regions in the respiratory system; metals predominately in the upper regions, and quinones deeper in the lung. The data also show the importance of secondary processing for both forms of OP^{DTT}. This talk will present typical urban aerosol OP^{DTT} size distributions and discuss sources and processes that affect overall OP^{DTT} levels and report predicted lung deposition patterns.

6OP.4

Reduction in Dithiotreitol Oxidative Potential in Copper/Organic Aerosol Mixtures. SHUNYAO WANG, Jianhuai Ye, Rudraksha Dutta Majumdar, Andre Simpson, Arthur W. H. Chan, *University of Toronto*

The Dithiothreitol (DTT) assay has been widely applied to evaluate the oxidative potential (OP) of particulate matter and its components. However, the relative contribution of each component to overall OP remains unclear. Redox cycling of transition metals and quinone-like substances has been proposed to contribute to DTT consumption, and the OP of these components in a mixed PM are assumed to be additive. In this work, we examine the total OP of a PM mixture containing both quinones and copper, and compare to their individual OPs. Naphthalene secondary organic aerosol (NSOA), phenanthrene secondary organic aerosol (PSOA) and several quinone standards (1,4-naphthoquinone, 1,2-naphthoquinone, 9,10-phenanthrenequinone) were used to represent organic aerosol that is redox active. After mixing these organic compounds with copper (II) at 1:1 molar ratio, significant reduction in DTT activity (50±6%, 43±7%, respectively for NSOA and PSOA) was observed with SOA and copper mixture compared to the sum of the individual DTT activities of copper and SOA. While similar reductions were witnessed for both 1,2-naphthoquinone and 9,10-phenanthrenequinone (41±15%, 68±1%, respectively) no significant DTT activity reduction was detected in a copper / 1,4-naphthoquinone mixture, likely owing to the position of the carbonyl groups. We propose that the mixing between transition metals and organics reduces the OP through metal-organic chelation. The extents of chelation at various metal to organic ratios evaluated by 1H NMR will be discussed. The results of this study indicate OPs of individual components in a metal/organic mixture are not linearly additive, and more studies are needed to characterize metal-organic interactions in ambient particulate matter for a better prediction of adverse health outcomes based on the particle chemical composition.

6OP.5

Linking Chemical Composition and Volatility to the Oxidative Potential of Diesel Exhaust Aerosols. SHANTANU JATHAR, Cody Vanderheyden, Abril Galang, Liam Lewane, Kevin Klunder, Charles Henry, John Volckens, *Colorado State University*

The aerosol oxidative potential is emerging as an important aerosol property that could help identify the chemical mechanisms by which aerosols affect human health. While certain chemical constituents (e.g., semi-volatile organic compounds, transition metals, elemental carbon) have been shown to correlate strongly with the measured oxidative potential, it is unclear how each of these chemical compounds contribute individually to the total oxidative potential. Furthermore, the aerosol chemical composition varies significantly with atmospheric mixing as semi-volatile organic compounds evaporate with dilution, affecting the aerosol oxidative potential. To systematically probe chemical composition and volatility, we conducted experiments with a non-road diesel engine for two different fuels (conventional diesel and soy-based biodiesel) and two different engine loads (idle and 50% load) at 8 to 10 different dilution ratios on a combination of bare quartz, Teflon, and quartz behind Teflon filters. The aerosol was mostly composed of organic aerosol and elemental carbon (~95%) with trace amounts of inorganic ions and metals (<1%). The organic aerosol at all fuel-load combinations was found to be strongly semi-volatile where more than three-quarters of the particle mass in the tailpipe was found to evaporate when diluted to urban-like concentrations. The aerosol chemical composition and volatility was nearly identical for diesel and biodiesel exhaust implying that the aerosol properties were only loosely linked to the fuel type. The oxidative potential, expressed as the rate of DTT consumption per unit aerosol mass, was higher (factor of ~2) for diesel exhaust compared to biodiesel exhaust and higher (factor of ~3) at 50% engine load than at idle. The oxidative potential per unit aerosol mass was found to be significantly lower for the semi-volatile vapors in equilibrium with the organic aerosol suggesting that the oxidative potential was more closely associated with the non-volatile and possibly insoluble aerosol components. Ongoing work is focused on performing a multilinear regression to shed further light on the relationship between the measured aerosol properties (composition and volatility) and the oxidative potential.

6OP.6

Chemical Oxidant Production and Cellular Inflammatory Response from Secondary Organic Aerosols (SOA) Generated from the Photooxidation of Biogenic and Anthropogenic Precursors. WING-YIN TUET, Shierly Fok, Yunle Chen, Rodney J. Weber, Julie Champion, Nga Lee Ng, *Georgia Institute of Technology*

Exposure to particulate matter (PM) is a leading global health risk, with multiple epidemiological studies reporting associations between elevated PM concentrations and cardiopulmonary incidences. Prior health studies have focused on the health effects of primary aerosols even though field measurements have repeatedly shown that secondary organic aerosols (SOA) often dominate, even in urban centers. A proposed mechanism by which PM exposure results in detrimental health effects is PM-induced oxidant production, including reactive oxygen and nitrogen species (ROS/RNS). These species are known to induce inflammatory cascades, thus resulting in oxidative stress and cellular damage.

Here, we present chemical and cellular measurements from laboratory-generated chamber SOA formed from the photooxidation of six common precursors (isoprene, α-pinene, β-caryophyllene, pentadecane, m-xylene, and naphthalene) under different conditions (RO2 + HO2 vs. RO2 + NO dominant, dry vs. humid). Compounds were chosen to represent major classes of hydrocarbons found in biogenic and anthropogenic emissions. Murine alveolar macrophages were exposed to SOA samples for 24 hrs and the resulting ROS/RNS production and cytokine (TNF-α and IL-6) secretion was measured. Dithiothreitol (DTT) was also utilized to measure the concentration of redox-active species present in each SOA sample. The intrinsic DTT activity for all SOA systems investigated was found to be highly dependent on SOA precursor, with isoprene and naphthalene SOA generating the lowest and highest DTT activity, respectively. Furthermore, distinct cellular response patterns were observed for SOA systems whose photooxidation products shared similar chemical functionalities and structures. A positive nonlinear correlation was also observed between ROS/RNS levels and DTT activity. Finally, in the context of ambient samples collected during summer and winter in the greater Atlanta area, all laboratory-generated SOA produced similar or higher levels of ROS/RNS and DTT activities, suggesting that the health effects of SOA are important considerations for understanding the health implications of ambient aerosols.

7AC.1

Influence of Soluble Surfactants on Heterogeneous Photooxidation of Aqueous Aerosol. JENNIFER FAUST, Jonathan Abbatt, *University of Toronto, Canada*

Oxidative aging alters the composition of organic aerosol in the atmosphere over time. Here we explore the heterogeneous photooxidation of aqueous-phase glyoxal by gas-phase OH radicals. Glyoxal (CHOCHO) is an abundant molecule in the atmosphere that is highly water-soluble. Homogeneous reactions of glyoxal and OH radicals have been extensively characterized in bulk liquid and bulk gas, but we report for the first time the reaction of OH(g) with glyoxal(aq) at the surface of aerosol droplets in the presence of UV light. Using a flow reactor and aerosol mass spectrometer (AMS), we determine the reaction rate and uptake coefficient, as well as monitor products in the particle phase. We also quantify changes in reaction rate upon addition of succinic acid ($C_4H_6O_4$), a dicarboxylic acid that is known to exist in atmospheric aerosol. Succinic acid serves as a model soluble surfactant in our system; it should not directly interfere with glyoxal oxidation because OH reacts an order of magnitude more rapidly with glyoxal than with succinic acid in the aqueous phase. Finally, offline analysis, including electrospray ionization mass spectrometry (ESI-MS), is used for product identification.

7AC.2

Characterization of the Heterogeneous Reactivity of Alpha-Pinene Oxidation Products with Dimethylamine and Ammonia. MATTHIEU RIVA, Geoffroy Duporte, Jevgeni Parshintsev, Otso Peräkylä, Liine Heikkinen, Eva Canaval, Enna Heikkinen, Luis Barreira, Nana Myllys, Kari Hartonen, Markku Kulmala, Armin Hansel, Marja-Liisa Riekkola, Mikael Ehn, *University of Helsinki*

Amines are emitted to the atmosphere from industry, combustion, biomass burning, animal husbandry and oceans. These compounds are ubiquitous in the atmosphere and observed in several locations in the world. In addition, ammonium salts have been identified as a major component of atmospheric aerosol. Amines and ammonia are recognized to affect the chemistry and lifecycle of atmospheric aerosols, especially due to their unique acid-neutralizing capacity. Recently, a few studies have highlighted the role of amines in the formation and growth of secondary organic aerosol (SOA). It has also been demonstrated that carbonyl compounds, such as glyoxal, can react with amines and/or ammonia leading to the formation of N-containing species and oligomers, which could further impact SOA formation and the optical properties of the aerosols.

In the present work, the heterogeneous reactivity of dimethylamine and ammonia with the products generated from the ozonolysis of alpha-pinene was investigated. Experiments were performed using a flow tube reactor to chemically characterize the reactivity of dimethylamine (DMA) while the reactivity of ammonia with alpha-pinene oxidation products was carried out in a 2-m3 Teflon chamber. In the chamber experiments, size-selected ammonium sulfate particles were injected under dry and wet conditions. Gaseous organic compounds were chemically characterized using a time-of-flight chemical ionization mass spectrometer (HR-ToF-CIMS) with iodide (I−) ionization sources, and a proton transfer time-of-flight mass spectrometer (PTR3). In addition, particle-phase was chemically characterized using Filter Inlet for Gases and AEROsols (FIGAERO) coupled to an I−-HR-ToF-CIMS and using ultra-high-performance liquid chromatography coupled an Orbitrap mass spectrometer (UHPLC-HRMS) for the flow tube experiments only. Heterogeneous reactions between ozonolysis oxidation products of alpha-pinene, such as pinonaldehyde, and DMA or ammonia were observed. N-containing species as well as volatile unsaturated products were identified in both phases suggesting that such reactivity could further impact SOA composition and ozone concentration.

7AC.3

Effect of SO2 on the Yields and Optical Properties of Secondary Organic Aerosol from Limonene Ozonolysis.

JIANHUAI YE, Jonathan Abbatt, Arthur W. H. Chan,
University of Toronto, Toronto, Canada

Ozonolysis of monoterpenes is an important source of atmospheric biogenic secondary organic aerosol (BSOA). While enhanced BSOA formation has been repeatedly observed under sulfate-rich conditions, the underlying mechanisms, as well as the chemical and physical properties of BSOA formed remain poorly understood. In this study, the role of SO_2, an anthropogenic gaseous pollutant, on the yields and optical properties of BSOA was examined. BSOA was produced from limonene ozonolysis in a 1-m^3smog chamber or a 10-L quartz flow tube reactor in the presence of SO_2. Enhanced SOA formation was observed through interactions with SO_2. Over the course of experiments, SO_2 was consumed at time scales consistent with oxidation by Criegee intermediates, indicating that gaseous SO_2 interacts directly with reactive intermediates during ozonolysis. A considerable fraction of SO_2 (14-70%) was found to be oxidized by sCIs even under humid conditions. In addition to the reaction with Criegee, reactive uptake of SO_2 may also be significant. SO_2 depletion was observed when excess HCOOH was added as Criegee scavenger. This proposed SO_2 uptake increased significantly under more humid conditions. Light-absorbing components were also observed in the presence of SO_2. Preliminary results show that the averaged mass absorption coefficient of these components (~ 500 cm^3 g^{-1}) is comparable to those of 'brown carbon' in other studies with biogenic precursors. Our results demonstrate the synergistic effect between BSOA formation and SO_2 oxidation through Criegee/SO_2 chemistry and SO_2 uptake on organic aerosol. It is highlighted that not only does SO_2 increase the efficiency of SOA formation from limonene ozonolysis, SO_2 also enhances the potential formation of light-absorbing materials in BSOA and increases its ability to absorb radiation and affect global climate.

7AC.4

Aerosol Formation from Hydroxyl Radical Oxidation of Agricultural Amines and Reduced Sulfur Compounds.

PAUL VAN ROOY, Kathleen Purvis-Roberts, Philip Silva, David R. Cocker III, *University of California, Riverside*

Reduced sulfur compounds, from animal waste products, and amines, from cattle exhalation and rumination, are often co-emitted on agricultural land. Reduced sulfur compounds are thought to be important to new particle formation over the oceans. Amines are thought to play an important role in new particle formation around agricultural land. While both of these compound families have been recognized individually, there have been no studies focused on how these agricultural emissions interact to form particles. To begin filling this information gap, experiments were conducted using a 37.5 m^3 Teflon chamber housed within the Atmospheric Processes Laboratory at UC Riverside. 100 ppb of a reduced sulfur compound (dimethylsulfide, dimethyldisulfide, methanethiol, or hydrogen sulfide) was injected into the chamber, followed by 100 ppb of an amine (trimethylamine, diethylamine, butylamine, putrescine, ethylenediamine, cadaverine, or ammonia), and finally 1 ppm of hydroxyl radical to push photooxidation. A suite of real time gas-phase and particle-phase instruments measured chemical composition and physical properties of the aerosol. The aerosol yields were substantial and varied depending on the combination of precursors injected. For example, when trimethylamine was injected with dimethylsulfide over 250 $\mu g/m^3$ of aerosol formed, while trimethylamine with dimethyldisulfide formed around 150 $\mu g/m^3$. Over 900 $\mu g/m^3$ of aerosol formed when injecting putrescine with dimethyldisulfide. The presence of humidity had a profound impact on aerosol yield. In some experiments, (trimethylamine with dimethyldisulfide) humidity increased aerosol yield, while in others (ethylenediamine with dimethyldisulfide) aerosol formation was suppressed. Data acquired from the HR-TOF-AMS showed that the composition of the aerosol varied depending on the amine and reduced sulfur tested. Oxidation of dimethyldisulfide with an amine tended to form a larger fraction of sulfate aerosol (30-40%), while oxidation of other reduced sulfur compounds with an amine formed on average only 1-10% sulfate aerosol. Aerosol mass spectra of the individual precursor experiments were compared to that of the interaction experiments. There are several mass-to-charge peaks present in the interaction experiments that are not present in the individual precursor experiments. This novel investigation provides much needed insight into agricultural aerosol formation.

7AC.5

The Effects of Aerosol Phase State on Secondary Organic Aerosol Formation from the Acid-Catalyzed Reactive Uptake of Isoprene-Derived Epoxydiols. YUE ZHANG, Yuzhi Chen, Andrew Lambe, Amy Bondy, Nicole Olson, Rebecca Craig, Zhenfa Zhang, Avram Gold, Timothy Onasch, John Jayne, Douglas Worsnop, Charles Kolb, William Vizuete, Andrew Ault, Jason Surratt, *University of North Carolina at Chapel Hill*

Acid-catalyzed multiphase reactions between gas- and particle-phase constituents are an important formation mechanism for atmospheric secondary organic aerosol (SOA). Aerosol phase state is thought to influence the reactive uptake process of gas phase precursors, especially when the diffusion rate of gas species inside the particles is limited due to high particle viscosity. However, there is little experimental evidence to show the dependence of reactive uptake processes on particle phase state. This laboratory study systematically examines the reactive uptake probability of isoprene-derived epoxydiols (IEPOX) onto acidic sulfate particles with various types of pre-existing SOA coatings. The reactive uptake probability is obtained as a function of SOA composition, oxidation state, coating thickness, and relative humidity (RH). Results show that certain types of pre-existing SOA coatings may significantly reduce IEPOX reactive uptake probability, in some cases by nearly an order of magnitude, especially under low RH conditions. The diffusion coefficient of IEPOX in the particle phase is also derived by varying the coating thickness of SOA layers at different RHs, which could be expanded to similar gas-phase species that only form aerosol by reactive uptake processes. These results can be used in order to accurately characterize the formation and evolution of IEPOX-derived SOA. Moreover, the approach used in this study could be more widely applied to other multiphase chemical systems in regional and global scale models to better predict the impact of SOA on climate, human health, and visibility.

7AC.6

NOx-related Increases of Biogenic Secondary Aerosols (bSOA) in Summertime Southeastern U.S. JUN LIU, Lynn Russell, Megan Claflin, Paul Ziemann, Nga Lee Ng, Havala Pye, Benjamin Murphy, Karena McKinney, Jason Surratt, *Scripps Institution of Oceanography*

During the 2013 Southern Oxidant and Aerosol Study, Fourier Transform Infrared Spectroscopy (FTIR) and Aerosol Mass Spectrometer (AMS) measurements of submicron mass were collected at Look Rock (LRK), Tennessee, and Centreville (CTR), Alabama. CTR had higher concentrations of many aerosol and gas phase atmospheric components than LRK; for example, carbon monoxide, sulfate and organics concentrations were ~2 times higher at CTR. Despite these different concentration levels, the time series at LRK and CTR had moderate correlations of r= 0.51, 0.54 and 0.47 for carbon monoxide, submicron sulfate, and submicron non-refractory organic components (respectively). However, NO_x had a very low correlation (r=0.08) between the sites with nighttime-to-early-morning peaks 3~10 times higher at CTR than at LRK. Organic Mass (OM), extinction and absorption had a maximum in the afternoon at both sites but increased again during nighttime only at CTR. OM sources were apportioned using Positive Matrix Factorization (PMF) of both AMS and FTIR. Three very similar factors were identified on both sites from FTIR, identified as Fossil Fuel Combustion (FFC) related organic aerosols, Mixed Organic Aerosols (MOA) and Biogenic Organic Aerosols (BOA). FFC was related to anthropogenic combustion emissions and MOA is likely associated with sulfate-related selective uptake of isoprene-related secondary organic components. The BOA spectrum from FTIR is similar (cosine similarity > 0.6) to that of lab-generated OA at high NO_x conditions, The BOA fraction in the mornings was 51% higher at CTR than at LRK, and the FFC fraction was 18% higher at CTR than at LRK. These higher OM concentrations are consistent with higher atmospheric oxidation capacity associated with the higher NO_x levels at CTR. The bigger difference in BOA fractions shows a bigger NOx effect on BOA than on the MOA.

7AC.7

SOA Formation from Toluene Oxidation in the Presence of NOx: The Importance of Relative Humidity. DAO HUANG, Yunle Chen, Steve Kim, Nga Lee Ng, *Zhejiang University*

Toluene is one of the most important anthropogenic volatile organic compounds (VOCs). Many studies have shown that toluene is one of the most abundant aromatic VOCs in urban areas, and can contribute a large fraction of secondary organic aerosol (SOA) in urban areas and even some rural areas. However, in the past decade, knowledge about toluene SOA in the presence of NO_x is limited to SOA yield curve under dry conditions and only scattered yields are available under humid conditions. Little is known about toluene SOA composition and the effects of relative humidity (RH) on SOA yields and composition. In the present work, a series of experiments on photo-oxidation of toluene under dry (RH<3%) and humid (RH=~40% and ~70%) conditions were performed in the Georgia Tech Environmental Chamber facility (GTEC) to investigate toluene SOA composition and RH effects. In situ photolysis of HONO was used as OH radical and NO_x sources. Ammonium sulfate was used as seed aerosol. Particles were chemically characterized using a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) and a high-resolution chemical ionization time-of-flight mass spectrometer coupled with a filter inlet for gas and aerosol (FIGAERO-CIMS). Simultaneously, gas-phase compounds were determined by CIMS. Based on experimental results, we obtained different yield curves as a function of organic aerosol (ΔMo) at various RH and compared particle-phase composition under dry and humid conditions. RH affects SOA formation and composition under specific reaction conditions. This study provides new insights for understanding SOA and haze formation in the polluted atmosphere under different humidity conditions.

7CO.1

Coal Combustion as a Source to Levoglucosan in PM2.5 in China. CAIQING YAN, Amy P. Sullivan, Guofeng Shen, Yury Desyaterik, Xiaoying Li, Tian Zhou, Shuxiao Wang, Bin Zhao, Orjan Gustafsson, Jeffrey Collett, Mei Zheng, *Peking University*

Levoglucosan has been traditionally identified as a specific marker for biomass burning sources, and frequently used in estimating biomass burning contributions to atmospheric fine particles all over the world. In this study, residential biomass burning (such as crop straw and wood) and coal combustion have been simulated and tested in the lab, and characteristics of carbonaceous aerosols from these residential emissions were investigated. Saccharides, including anhydrosugars, monosaccharides, disaccharides, and alcohol-sugars, were examined in both source and ambient samples collected in Beijing, China. Interestingly our results show that levoglucosan can be found in the emissions from low temperature residential coal combustion, with emission factors ranging from 0.3 to 15.9 mg per kg of fuel. Ratios of levoglucosan to its isomers (i.e., mannosan and galactosan) differ between coal combustion and biomass burning emissions, and the wintertime ratios in Beijing ambient $PM_{2.5}$ suggest a significant contribution of levoglucosan from coal combustion. By combining source tests with ambient measurements, our research provides evidence to suggest that levoglucosan cannot be always taken as an unique tracer for biomass burning, at least in the Northern China during wintertime, where coal is still widely used in residential and industrial sectors. Furthermore, influences of burning state, coal quality and coal stoves on levoglucosan emissions are also investigated and discussed.

7CO.2

Gas and Particle Phase Emissions from Residential Wood Combustion. DEEPIKA BHATTU, Peter Zotter, Giulia Stefenelli, Jun Zhou, Thomas Nussbaumer, Amelie Bertrand, Nicolas Marchand, Brice Temime-Roussel, Urs Baltensperger, Jay G. Slowik, Andre S.H. Prévôt, Imad EI Haddad, Josef Dommen, *Paul Scherrer Institute*

Residential wood combustion is one of the largest sources of both, gaseous pollutants and primary particulate emission, contributes a large portion (~80%) of secondary organic aerosol (SOA) mass, and has adverse health and environmental effects. Large variability and uncertainty in the emissions poses a challenge to the policy makers and environmental regulating authorities to control the emissions. We have examined primary emissions and the SOA formation potential of non-methane volatile organic compounds (NMVOCs) using an oxidation flow tube as a function of combustion device type (namely pellet boiler and stoves, log wood boiler and stoves, and industrial moving grate boiler), fuel type and load, and operating conditions. Particulate emissions were measured using a high resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS), a scanning mobility particle sizer (SMPS), and an Aethalometer for black carbon , and non-methane gas-phase organic compounds with a proton transfer reaction mass spectrometer (PTR-MS) and a total hydrocarbons with a flame ionization detector (THC-FID), complemented by other conventional gas monitoring systems. The dependence of the intensity of gas-phase emissions on combustion conditions such as modified combustion efficiency, combustion temperature and excess air conditions was determined and linked to the observed chemical composition during combustion phases. NMVOCs were largely dominated by aldehydes, acids and alcohols with C< 6 for most of the combustion technologies. However, more poly-aromatic hydrocarbons (PAHs) and unsaturated hydrocarbons were observed during burn-out (char burning) phase compared to induction and flaming phase. An unsupervised clustering (bottom-up) approach along with the recursive partitioning (top-down) approach was used to deconvolute the effect of combustion devices, fuel type and their operating conditions on chemical composition. The aged OA: POA ratio in the log wood stoves was observed to be 6-27 times higher than in the pellet boiler depending on operating conditions. Further, we present the SOA formation potential of identified precursors during different combustion conditions to assess the overall contribution of residential wood burning to the total carbonaceous OA budget.

7CO.3

Physical and Chemical Characterization of Fresh and Aged Emissions from Open Combustion of Biomass Fuels. CHIRANJIVI BHATTARAI, Vera Samburova, Deep Sengupta, Michealene Iaukea-Lum, Adam Watts, Hans Moosmuller, Andrey Khlystov, *Desert Research Institute*

Biomass burning (BB) emissions and their atmospheric oxidation products can contribute significantly to radiative forcing (RF) of climate. This forcing could either be positive or negative, depending on whether light scattering or light absorption dominates the optical properties of the emitted particles. It has been long established that in addition to light scattering, BB organic aerosols (BBOA) contribute to direct absorption of solar radiation due to the presence of the so-called brown carbon (BrC). Very little is known about this fraction of BBOA, its abundance in BB emissions, its optical properties, and chemical evolution in the atmosphere. This lack of knowledge leads to large uncertainties in climate models. In this presentation we will describe a laboratory BB study aimed for comprehensive optical, physical, and chemical characterization of both fresh and aged BB emissions, as well as its main findings. In this study, Aerodyne Oxidative Flow Reactor (OFR) was used to mimic atmospheric oxidation processes. The OFR was characterized in terms of OH production rate, residence time distribution (RTD), and particle transmission efficiency. Emission factors of main air pollutants [particulate matter, organic carbon (OC) and elemental carbon (EC), nitric oxide (NO)] were determined for globally and regionally important biomass fuels: Siberian peat, Florida peat, FASMEE (fuels from high-elevation (2740 m) boreal forest) and Hawken fire (fuels from Reno, NV, USA, representing semi-arid dryland). Measured emission factors (EF) for OC ranged from 0.85 (± 0.24) mg/g to 6.56 (± 1.40) mg/g with the EFs for EC ranges 0.02 (± 0.01) mg/g to 0.16 (± 0.01) mg/g. The ratio of organic mass to total organic carbon mass for these fuel ranged from 1.04 (± 0.04) to 1.34 (± 0.24). The effect of oxidation processes on aerosol size distribution and optical properties will also be discussed.

7CO.4

Parametric Study of Secondary Air Injection to Reduce Particulate Emissions from Biomass Cookstoves. JULIEN CAUBEL, Vi Rapp, Sharon Chen, Ashok Gadgil, *Lawrence Berkeley National Laboratory*

Nearly half of the world relies on biomass stoves for their daily cooking needs. Exposure to indoor combustion pollution from these biomass fires is the world’s greatest environmental health risk, causing about 4 million premature deaths annually. Consequently, researchers have designed biomass cookstoves that aim to reduce harmful pollutant emissions, primarily focusing on particulate matter (PM). Previous research demonstrates that secondary air injection into the combustion zone increases turbulent mixing that can dramatically reduce PM emissions. However, the air injection design parameters driving emission reductions are not well characterized. Therefore, we designed and built a modular wood-fueled cookstove to parametrically investigate critical forced-air injection design parameters that reduce PM emissions. For our parametric study, the cookstove design was methodically adjusted and evaluated using repeated water-boiling experiments. During each experiment, total PM emissions were measured gravimetrically, while size resolved PM measurements from 5 nm to 2.5 µm were collected using a TSI Fast Mobility Particle Sizer and a TSI Aerodynamic Particle Sizer.

Our parametric testing results show that secondary air injection flow rate and velocity are the primary design parameters that impact PM emissions. By experimentally optimizing these two design parameters, we reduce the total mass of PM emitted during the water-boiling test by nearly 90% relative to a traditional biomass fire. However, results show that secondary air injection can increase the emission of ultrafine particles (<100 nm in diameter), which may have greater adverse health effects. Overall, this study demonstrates that secondary air injection can practically achieve significant PM mass emission reductions in biomass cookstoves that operate continuously with unprocessed wood fuels, but further work is needed to achieve emission reductions throughout the particle size range.

7CO.5

A Laboratory Assessment of PM2.5 and CO as Markers of Cookstove Air Pollution Composition. KELSEY BILSBACK, Nicholas Good, Kristen Fedak, Jordyn Dahlke, Ethan Walker, Lizette Van Zyl, Christian L'Orange, Jennifer Peel, John Volckens, *Colorado State University*

Exposure to air pollution from biomass cookstoves is estimated to lead to 3.5 million premature deaths annually. Cookstove emit a highly variable mixture of pollutants. Human exposure to some of these pollutants has been associated with health impacts; however, most epidemiological studies only measure particulate matter ($PM_{2.5}$) and carbon monoxide (CO) as markers of exposure. The aim of our study was to (1) develop a comprehensive inventory of air pollution emitted from cookstoves from traditional to cleanest-available stove technologies and (2) assess whether $PM_{2.5}$ and CO are markers of other health-relevant emissions. Over 100 gas- and particle-phase pollutants from thirty stove-fuel combinations were measured in the laboratory. Measurements included: $PM_{2.5}$, CO, elemental carbon (EC), organic carbon (OC), volatile organic compounds (VOCs) [including BTEX], carbonyls, ultrafine particles, ions, and polycyclic aromatic hydrocarbons (PAHs). Reductions in $PM_{2.5}$ were not always linked with reductions in carcinogenic compounds. The wick-kerosene stove reduced $PM_{2.5}$ emissions by 80% compared to a three-stone-fire, but had the highest average emissions of several carcinogenic pollutants (benzene: 107.5 mg/MJ, formaldehyde: 34.6 mg/MJ, acetaldehyde: 12.6 mg/MJ). Yet, the gasifier stove reduced $PM_{2.5}$ by 65% while reducing total BTEX emissions by >90%. Spearman’s correlation coefficients (ρ) were used to assess the relationship between $PM_{2.5}$ and CO and other pollutants. Generally, $PM_{2.5}$ had a weak association with carcinogenic compounds for liquid-fuel stoves; however, CO demonstrated a strong positive correlation between acetaldehyde ($\rho=0.95$), formaldehyde ($\rho=0.95$), and benzene ($\rho=0.9$). The correlation between CO and VOCs was weaker for wood stoves (acetaldehyde: $\rho=-0.03$, formaldehyde: $\rho=-0.11$, benzene: $\rho=0.37$). Many health-relevant compounds are poorly correlated $PM_{2.5}$ and CO, demonstrating that reducing $PM_{2.5}$ and CO emissions do not guarantee reductions in other harmful pollutants.

7CO.6

High-Resolution Mass Spectrometry of Soot Nuclei formed in a Laminar Premixed Flame Diffusionally Charged at Atmospheric Pressure. FRANCESCO CARBONE, Manjula Canagaratna, Andrew Lambe, Paola Massoli, John Jayne, Douglas Worsnop, Alessandro Gomez, *Yale University*

Flame-generated soot nuclei and precursors were analyzed in the mass to charge ratio range up to 3000 Th, to bridge the gap between the gas and the particle phase and take advantage of recent advances in both mass spectrometry and rapid dilution sampling and diffusional charging techniques. Elemental compositions of both negatively and positively charged flame products were obtained by coupling a highly sensitive Atmospheric Pressure Interface Time-of-Flight (APi-TOF, Tofwerk AG) Mass Spectrometer with mass resolving power in excess of 3000, to a horizontal tube dilution probe. The analyte was directly sampled from a moderately sooting premixed flame that had been the object of previous detailed studies. The flame was stabilized on a honeycomb burner fueled by an ethylene/air mixture with a C/O ratio of 0.69 and unburnt gas velocity of 58.7 mm/s. The sampled flame products were quickly diluted in nitrogen and transported to the APi-TOF inlet while diffusional charging was provided at atmospheric pressure by either the flame chemi-ions themselves or by collisions with bipolar ions purposely seeded in the dilution flow. Four dilution levels were used to investigate the low-temperature evolution of material in the path to the APi-TOF inlet following flame sampling. Samples were extracted at several heights above the burner (HAB) to track soot precursors and nuclei growth in the flame. The high resolution measured mass spectra revealed the chemical complexity of the flame pyrolysis and chemi-ionization products and the presence of hydrocarbon molecules that contain nitrogen and oxygen atoms. Patterns in the mass spectra measured under different conditions are investigated to discriminate between chemical reaction and physical condensation growth mechanisms. A comparison of these results with those obtained with Differential Mobility Analysis in recent studies is being evaluated to assess the self-consistency of disparate techniques.

7CO.7

The Catalytic Effect of Potassium Salts on Diesel Soot Oxidation. REINHARD NIESSNER, Alexander Rinkenburger, Kazuhiro Yasuda, *Technical University of Munich, Germany*

Health issues as well as global warming potential are the main reasons why diesel soot is removed by car exhaust after treatment. These filter systems minimize emissions, but require periodic regeneration by oxidation (combustion). Uncatalyzed oxidation needs temperatures >600°C in O_2 (5 vol% in N_2), which results in poor fuel efficiencies. These temperatures can be lowered down to exhaust gas temperatures i.e. by additives, which enhance soot reactivities during soot formation, leading to internally-mixed soot and possible oxidation temperatures <400°C. Besides oxidic additives, alkali metal salts are very effective. Unfortunately, combustion processes are still not fully understood and require further research.

In this work, different soot aerosols internally-mixed with salts were produced. Combustion in a Diesel Particulate Filter was simulated by applying Temperature-programmed oxidation (TPO). Soot samples were combusted under a defined atmosphere (5 vol% O_2 in N_2) and temperature range (100 - 700°C; 5°C/min), combustion products were detected in a FTIR spectrometer. All salts led to a pronounced decrease of the TPO temperatures of maximum CO + CO_2 emissions (T_{max}) with K_2CO_3 being one of the most effective salts leading to a decrease of up to T_{max} = 300°C compared to uncatalyzed soot. Structural parameters derived from Raman microspectroscopy, scanning electron microscopy, and scanning mobility particle sizing measurements did not vary significantly compared to undoped soot. BET surface area only showed slight trends to lower surface areas with higher salt content.

On the contrary, parameters derived from High-resolution Transmission electron microscopy (HRTEM) and electron paramagnetic resonance (EPR) measurements could be correlated to the oxidation reactivity. The salt doping is influencing the nanostructure of the graphene layers as well as the electronic structure, giving rise to a temperature-dependent chemical equilibrium depending on the K^+/anion binding strength.

7IM.1

Real-time Measurements of Gas Phase Organic Acids Using SF6- Chemical Ionization Mass Spectrometry. THEODORA NAH, David Tanner, Hongyu Guo, Yi Ji, Rodney J. Weber, Greg Huey, *Georgia Institute of Technology*

Organic acids play important roles in many atmospheric processes such as secondary organic aerosol formation, precipitation chemistry and acidity. The sources and atmospheric chemistry of gas-phase organic acids remain poorly understood due to the limited range of measurement techniques available. At present, research on gas-phase organic acids has focused primarily on formic and acetic acids. This is due to the analytical difficulties in measuring gas phase > C_2 organic acids in real time. In this work, we demonstrate the capabilities of SF_6^- chemical ionization mass spectrometry (CIMS) for the measurement of gas-phase inorganic and organic acids. Its in-field performance is illustrated using ambient measurements conducted in a mixed forest-agricultural area in Yorkville, Georgia from September to October 2016. Gas-phase organic acids as large as C_5 are detected at the site. Our measurements showed that ion-molecule reactions between SF_6^- and organic acids proceeded through charge transfer and fluorine abduct formation. Ambient concentrations of organic acids ranged from a few parts per trillion by volume (ppt) to several parts per billion by volume (ppb), with the largest concentrations observed for formic acid. All the organic acids displayed similar strong diurnal behaviors, reaching maximum concentrations between 5 and 7 pm local time. The organic acids generally showed strong correlations with temperature, but weak correlations with nitric acid and carbon monoxide. Our analysis suggested that biogenic emissions may be an important source of gas-phase organic acids in this rural environment. The combination of high sensitivities, low detection limits and fast response time of SF_6^- CIMS indicates that it is a promising technique for real-time measurements of atmospheric gas-phase organic acids.

7IM.2

Evaluation of the New Capture Vaporizer for Aerosol Mass Spectrometers (AMS): Fragmentation, Elemental Ratio and Source Apportionment, Quantification of Organic Aerosols (OA). WEIWEI HU, Douglas Day, Pedro Campuzano-Jost, Benjamin A. Nault, Taehyun Park, Taehyoung Lee, Philip Croteau, Manjula Canagaratna, John Jayne, Douglas Worsnop, Jose-Luis Jimenez, *CIRES, University of Colorado, Boulder*

The Aerosol Mass Spectrometer (AMS) and Aerosol Chemical Speciation Monitor (ACSM) are widely used for quantifying submicron aerosol mass concentration and composition. Using the standard vaporizer (SV) installed in almost all commercial instruments, a collection efficiency (CE) correction, varying with aerosol phase and chemical composition (Middlebrook et al., 2012) is needed to account for the particle bounce loss in the SV. Recently, a new “capture vaporizer” (CV) has been designed and successfully used to achieve CE~1 for ambient aerosols (Hu et al., 2017;Xu et al., 2017). Recent publications characterize the quantification of the inorganic species and total aerosol mass. This study reports on the performance of organic aerosol (OA) in CV-AMS regarding fragmentation, elemental ratios and source apportionment of OA for the first time. The quantification of OA in the CV including how oxidation and morphology affects CE and RIE of OA is also discussed. Compared with the spectra from the SV, the larger molecular-weight fragments of OA tend to shift toward smaller ions in the CV due to additional thermal decomposition arising from increased residence time and hot surface collisions. Unexpected CO^+ ions (and to a lesser extent, H2O+) when sampling long chain alkane/alkene-like OA (e.g. squalene) in the CV are probably caused by chemical interactions between sampled OA and residues on the vaporizer surfaces. No evidence for such CO^+ enhancement is found when studying the ambient OA. The elemental composition of pure OA standards and ambient OA can be accurately measured with the CV, with suitable modifications to the quantification procedure. Consistent variation of PMF factors and their fractions in total OA were found between the ambient CV and SV datasets no matter if biogenic- or anthropogenic- emissions dominate OA production, indicating no or limited loss of information despite the increased fragmentation.

7IM.3

Droplet Assisted Inlet Ionization (DAII) for Online Molecular Analysis of Nanoparticles. MICHAEL J. APSOKARDU, Devan E. Kerecman, Yao Zhang, Andrew J. Horan, Murray Johnston, *University of Delaware*

Molecular composition analysis is essential to our understanding of nanoparticle evolution and growth in the atmosphere, but typically can only be done offline, sacrificing time resolution. This creates a need for an analysis method capable of performing molecular analysis online. Droplet Assisted Inlet Ionization (DAII) has been developed for this purpose. In DAII, nanoparticles are first grown into aqueous microdroplets. The droplets subsequently pass through a heated capillary tube, where rapid vaporization results in the formation of molecular ions. Initial development of DAII has been done primarily with poly(propylene)-glycol (PPG) oligomers. DAII can detect PPG particles as small as 13nm in diameter, with sampled masses on the order of picograms. Additionally, particle and mass concentrations as low as 1000 particles/cm^3 and 100 ng/m^3 respectively can be measured, surpassing the necessary detection limits required to make ambient measurements. Further studies have been done with bovine serum albumin and angiotensin to demonstrate the capabilities of DAII to induce multiple charging on a single analyte, making DAII sensitive to both large and small molecules. Oligomers in secondary aerosol derived from cyclic siloxane oxidation have also been studied, with high resolution and good signal-to-noise in both positive and negative ion modes. These plus future studies of DAII will be presented.

7IM.4

Response of HR-ToF-AMS to Inorganic Sulfates and Organosulfur Compounds and Applications in Field Measurements. YUNLE CHEN, Lu Xu, Elizabeth Stone, Timothy Humphry, Jurgita Ovadnevaite, Colin O'Dowd, Shan Huang, Laurent Poulain, Hartmut Herrmann, Nga Lee Ng, *Georgia Institute of Technology*

Organosulfur compounds are ubiquitous components of secondary organic aerosols (SOA), and have been identified in both laboratory-generated and ambient aerosols. Organosulfur compounds can play an important role in altering aerosol physicochemical properties, and are also thought to be good tracers for aqueous aerosol-phase SOA formation. High-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) has been widely used in aerosol studies, but the response of HR-ToF-AMS to organosulfur compounds is not well-understood. In HR-ToF-AMS, organosulfur compounds can fragment into both organic and sulfate fragments. Typically, the sulfate fragments are only interpreted as inorganic sulfates in subsequent analysis, even though they can arise from organosulfur compounds. This leads to uncertainties in the quantifications of organosulfur species and inorganic sulfate species, and the contribution of organosulfur compounds to total organic mass is underestimated. Here, we developed a new method to differentiate and quantify the signals from organic vs. inorganic sulfates in AMS measurements. Specifically, we investigated the mass spectra of different sulfate containing species, including ammonium sulfate, sodium sulfate and 16 different types of organosulfur compound standards. It is found that the sulfate mass spectra of organosulfur compounds are distinctively different from that of inorganic sulfates, with HSO_3 (m/z 81) and H_2SO_4 (m/z 98) fragments showing the largest differences. While ammonium sulfate can produce both HSO_3 and H_2SO_4 fragments, most organosulfur compounds cannot produce either fragment, except for methanesulfonic acid, which has a distinctively high HSO_3 ion fraction. Making use of this difference, we can estimate organic sulfate concentration. This method is evaluated in the context of ambient measurements. For marine/coastal measurements, our method of sulfate apportionment provides a new perspective to estimate methanesulfonic acid concentration and evaluate the interactions between marine and anthropogenic aerosols. For inland measurements, it provides insights into sulfates originating from organic molecules.

7IM.5

An Electrospray Chemical Ionization Source for Real-time Measurement of Atmospheric Organic and Inorganic Compounds. YUE ZHAO, Jeremy Chan, Felipe Lopez-Hilfiker, Jeff Riffell, Joel A. Thornton, *University of Washington, Seattle, WA*

We present an electrospray ion source coupled to an orthogonal continuous-flow atmospheric pressure chemical ionization region. The source can generate intense and stable currents of several specific reagent ions using a range of salt solutions prepared in methanol, thereby providing both an alternative to more common radioactive ion sources and allowing for the generation of reagent ions that are not available in current chemical ionization mass spectrometry (CIMS) techniques, such as alkali metal cations. We couple the orthogonal electrospray chemical ionization (ESCI) source to a high resolution time-of-flight mass spectrometer (HRToF-MS), and assess instrument performance through calibrations using nitric acid (HNO3), formic acid (HCOOH), and isoprene epoxydiol (trans-β-IEPOX) gas standards, and through measurements of oxidized organic compounds formed from ozonolysis of α-pinene in a continuous-flow reaction chamber. When using iodide as the reagent ion, the HRToF-ESCIMS prototype has a sensitivity of 11, 2.4, and 10 cps pptv-1 per million cps of reagent ions and a detection limit (3σ, 5s averaging) of 4.9, 12.5, and 1.4 pptv to HNO3, HCOOH, and IEPOX, respectively. These values are comparable to those obtained using an Iodide-adduct HRToF-CIMS with a radioactive ion source and low pressure ion-molecule reaction region. Applications to the α-pinene ozonolysis system demonstrates that HRToF-ESCIMS can generate multiple reagent ions (e.g, I-, NO3-, acetate, Li+, Na+, K+, and NH4+) having different selectivity to provide a comprehensive molecular description of a complex organic system.

7IM.6

Towards Quantitative Organic Aerosol Sampling with an Extractive Electrospray Ionization Time-of-Flight Mass Spectrometer (EESI-TOF). JAY G. SLOWIK, Felipe Lopez-Hilfiker, Veronika Pospisilova, Lu Qi, Giulia Stefenelli, Yandong Tong, Alexander Lucas Vogel, Liwei Wang, Bin Yuan, Mao Xiao, Wei Huang, Claudia Mohr, Josef Dommen, Imad El Haddad, Urs Baltensperger, Andre S.H. Prévôt, *Paul Scherrer Institute*

Online aerosol mass spectrometry has significantly advanced our understanding of organic aerosol (OA) sources, composition, and aging processes. The new extractive electrospray ionization time-of-flight mass spectrometer (EESI-TOF) improves on previous measurement techniques by enabling rapid, online measurement of OA without thermal decomposition or ionization-induced fragmentation. The measured ion signals are proportional to mass concentration, although the relative response varies with molecular identity. Thus, while quantitative sampling by the EESI-TOF is attainable for analyte molecules for which calibration standards are measured, the large number and often unknown structure of OA components necessitates additional strategies for quantification.

Here we utilize inter-comparison studies between the EESI-TOF and other measurement techniques, including aerosol mass spectrometry (AMS) and chemical ionization mass spectrometry (CIMS), to constrain the EESI-TOF response to a range of ambient and environmentally-relevant systems. AMS measurements are used to constrain the EESI-TOF response in terms of total mass and bulk atomic ratios, while the response to individual ions is characterized in comparison to CIMS measurements. We investigate selected chemical standards, oxidation of model compounds (e.g. squalane, toluene, phenol, α-pinene) and real-world emissions (e.g. wood burning, coal, passenger vehicles), summer and winter ambient measurements from urban and rural field campaigns, and re-nebulized aerosol from a yearly cycle of collected filter samples from Zurich, Switzerland. The wide range of molecular weights, oxidation states, and functionalities measured provides a comprehensive assessment of the EESI-TOF response to environmentally-relevant OA and its potential for quantitative analysis.

7IM.7

Comprehensive Real-time Characterization of Particles Produced by Laser Ablation for Analysis by Inductively Coupled Plasma Mass Spectrometry. KAITLYN J. SUSKI, David Bell, Lizabeth Alexander, Matt Newburn, David Koppenaal, Dan Imre, Alla Zelenyuk, *Pacific Northwest National Laboratory*

Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is a powerful technique used for trace element analysis of solid samples. While quantitative analysis can be achieved for select masses with careful use of standards, the complex relationship between properties of LA-generated particles, their transport, and often incomplete evaporation and ionization in the ICP-MS prevents this technique from being fully quantitative over a wider range of masses and conditions. Previous studies have identified shorter laser wavelengths and pulse widths as being superior at producing particles that yield more quantitative results; however, a full understanding of how laser settings affect particle properties and how particle properties relate to ICP-MS signal is lacking.

We will present the results of a recent study that employed multidimensional particle characterization to investigate the effect of LA conditions (laser power, repetition rate, flow rate, scan rate, and spot size) on properties of particles generated by LA of a NIST standard reference material glass sample and their elemental composition as measured with the ICP-MS.

We characterize number concentrations, mobility and vacuum aerodynamic diameter distributions, mass, composition, and effective density of individual particles as a function of LA conditions. For the fractal particles generated by LA, these measurements yield fractal dimension, average diameter of primary spherules, number of spherules, void fraction, and dynamic shape factors as a function of particle mass or size.

Preliminary results indicate that an increase in laser power results in significantly higher particle number concentration. However, particle size distributions are highly variable, especially for high repetition rates, which effects ICP-MS results. All particles are fractal and comprised of agglomerated primary spherules with average diameters between 12 and 17 nm, depending on LA conditions. Particle effective density decreases with increasing mobility diameter/mass, but even for the smallest particles density is significantly lower than particle material density due to large particle void fractions. We find that particles with mobility diameters of 30 nm have ~25% voids, whereas 300 nm particles that are comprised of more than 1000 primary spherules have ~90% voids.

The ultimate goal of this work is to develop an understanding of the effects of particle mass, shape, and morphology on particle “critical” size and ICP-MS quantification.

7MO.1

Improving the Global Representation of Fine Particulate Matter (PM2.5) by Combining Satellites, Models and Monitors. AARON VAN DONKELAAR, Randall V. Martin, Michael Brauer, N. Christina Hsu, Ralph Kahn, Robyn Latimer, Robert Levy, Alexei Lyapustin, Andrew Sayer, Graydon Snider, Crystal Weagle, David Winker, *Dalhousie University.* INVITED

Fine particulate matter (PM2.5) is believed to be the leading environmentally-related risk factor for premature mortality worldwide. Aerosol optical depth (AOD) is available from multiple satellite remote sensing platforms (e.g. MODIS, MISR, SeaWiFS) and algorithms (e.g. Dark Target, Deep Blue, MAIAC). Chemical transport models allow these retrievals of aerosol total column to be related to near-surface PM2.5 concentrations. The global availability and quality of all these data sources vary with region. Brought together, and combined with ground-based measurements, these data sources provide an unparalleled view of the global distribution and magnitude of PM2.5. Additionally, a new ground-based aerosol network (SPARTAN) allows direct evaluation and improvement of satellite-based PM2.5 estimates by collocating PM2.5 and AOD measurements at urban regions around the world. This presentation will highlight recent advances in combining satellite remote sensing, global modeling, and ground-based measurements of atmospheric aerosols to improve understanding of global population exposure to PM2.5.

7MO.2

Regional Air Quality Modeling of Wildfires for Health Assessments over the Continental United States.

CESUNICA IVEY, Cong Liu, Ashley Pierce, Yang Liu, Howard Chang, Matthew Strickland, Heather Holmes, *University of Nevada Reno*

Human exposure to wildfire smoke is difficult to estimate both at the individual and regional levels due to uncertainties in wildfire smoke modeling and the spatial heterogeneity of fuel composition leading to uncertainties in fire emissions classification. Hence, in this work we incorporated wildfire emissions from the Fire Inventory of NCAR (FINN) into the CMAQ modeling framework, with the goal of improving modeled estimates of the chemical composition of the wildfire emissions and the transport of the related primary and secondary pollutants. FINN emissions have a higher spatial and temporal correlation with observed fire activity, due to the use of MODIS active fire products in the inventory development. We present a three-year evaluation of CMAQ simulations over the continental U.S., for which FINN emissions replace the wildfire emissions in the National Emissions Inventory. Simulated concentrations of bulk fine particulate matter ($PM_{2.5}$), $PM_{2.5}$ components (e.g., organic carbon, elemental carbon, and trace metals), and ozone are evaluated by comparing the estimates with observations from regulatory monitoring networks. Regional estimates of $PM_{2.5}$, $PM_{2.5}$ components, and ozone provide surrogate metrics for human exposure to wildfire smoke around and down-wind of active fires.

7MO.3

Role of Inter-regional Variability in Aerosol Size Distributions on Respiratory Deposition of PM2.5.

JACK KODROS, John Volckens, Shantanu Jathar, Jeffrey R. Pierce, *Colorado State University*

Many studies have quantified the increased risk of mortality from exposure to $PM_{2.5}$. The use of total $PM_{2.5}$ mass as the exposure metric is a noted limitation of this approach, as particle deposition in the respiratory tract is strongly size dependent. Additionally, particle size distributions vary substantially across regions, potentially limiting the ability to apply a single concentration-response function globally. To estimate the fraction of inhaled $PM_{2.5}$ mass that is deposited in the body, we apply the International Committee on Radiological Protection's size-resolved deposition model to characteristic ambient aerosol size distributions, measured aerosol size distributions, and simulated aerosol size distributions from a global chemical-transport model with size-resolved aerosol microphysics, GEOS-Chem-TOMAS. For typical size distributions in urban areas, we find that 28% of the inhaled $PM_{2.5}$ mass is deposited in the respiratory tract, compared to 40% in rural regions and 67% in desert regions. Though, we note that PM composition also has strong variations between these regions. Using simulated annual-average aerosol mass distributions, we perform linear regressions on regions defined in the Global Burden of Disease Study to estimate regional differences between $PM_{2.5}$exposure and deposited $PM_{2.5}$ mass. We find that 20% of mass deposits in Latin America (r^2 of 0.86), 65% of mass in Central Europe (r^2 of 0.91), and 40% of mass in high-income countries (r^2 of 0.61). These results suggest that regional variations in aerosol mass distributions may contribute to differences in the health effects following exposure to $PM_{2.5}$.

7MO.4

Significantly Reduced Health Burden from Ambient Air Pollution in the U.S. under Emission Reductions from 1990 to 2010. YUQIANG ZHANG, Jia Xing, Christian Hogrefe, Shawn Roselle, Jesse Bash, Jonathan Pleim, Chuen-Meei Gan, David Wong, Rohit Mathur, Jason West, *U.S. EPA*

The recent 2013 Global Burden of Disease Study has listed ambient $PM_{2.5}$ as the fifth-ranking mortality risk factor in 2015. While assessing the global or national burden of disease attributed to air pollution has become more common, fewer studies have tried to understand how these burdens change through time. Here, we aim to use long-term modelling of U.S. air quality to quantify how air pollution-related mortality has changed in the U.S. in each year from 1990 to 2010, and to quantify the importance of changes in contributing factors to the long-term trends. We use 21-year historical estimates of $PM_{2.5}$ and ozone concentrations from 1990 to 2010 simulated with the coupled WRF-CMAQ model with consistent U.S. emission inventories, and annual county-level baseline mortality rates and population archived by the U.S. Centers for Disease Control. We find that the $PM_{2.5}$-related health burden, including ischemic heart disease, chronic obstructive pulmonary disease, lung cancer, and stroke, has steadily decreased, with a reduction of 54% from 1990 to 2010. The $PM_{2.5}$ - related health burden would have decreased only by 26% if the $PM_{2.5}$concentrations had not decreased from 1990, due to decreases in baseline mortality rates for major diseases affected by $PM_{2.5}$. The health burden associated with O_3, including the chronic Respiratory diseases, has larger interannual variations compared with $PM_{2.5}$-related health burden, which is dominated by the interannual O_3 changes. The O_3-related health burdens have increased by 28% from 1990 to 2010, which is mainly caused by increases in the baseline mortality rates and population, despite ozone decreases. The O_3-related health burden would have increased by 59% if the O_3 concentration was kept constant at the 1990 level.

7MO.5

Quantifying PM2.5 Health Benefits of Coal Power Plant Phase-out in Ontario and Alberta: An Adjoint Sensitivity Analysis. Burak Y. Oztaner, Marjan Soltanzadeh, Shunliu Zhao, AMIR HAKAMI, Matt Turner, Daven Henze, Shannon Capps, Peter Percell, Jaroslav Resler, Jesse Bash, Sergey Napelenok, Kathleen Fahey, Rob Pinder, Armistead G. Russell, Athanasios Nenes, Jaemeen Baek, Gregory Carmichael, Charles Stanier, Adrian Sandu, Tianfeng Chai, Daewon Byun, *Carleton University*

Several studies have calculated the health impacts of Coal-Fired Power Plants (CFPP) in Canada and the US. In 2005 the Ontario government applied a policy to shut down CFPPs in the province by the end of 2013. Now the Alberta government, which has more CFPP emissions than other provinces in Canada, is planning to phase out coal plants in the province by 2030. We conduct a backward sensitivity analysis to re-evaluate Ontario's coal phase-out plan and to estimate the marginal health benefits from Alberta's proposed strategy for cancel out the CFPPs.

The CFPP phase-out was examined by scenario-based reduction of mortality rate analysis in previous studies. In this study, we conduct a backward/adjoint analysis to provide source-specific perspective into the effectiveness of CFPP shut downs, as well as the addition of natural gas power plants that replaced them. In our analysis, we determine the marginal health benefits of phasing out the CF power plants in Ontario and Alberta. Also, the study compares these impacts with contributions from other sources, as well as that of the cross border emissions from the US.

We apply U.S. EPA's (CMAQ) and its adjoint to quantify the health benefits of emission reduction of PM2.5. Meteorological inputs are from the (WRF) model, and emissions for Canada and the US are taken from National Pollutant Release Inventory (NPRI) and National Emission Inventory (NEI), respectively. Subsequently, these emissions are processed in (SMOKE) model to get hourly emissions. The simulations are done over a 36 km spatial resolution Canada-wide domain and 12 km spatial resolution Alberta and Ontario domains. Marginal benefits due to the reduced PM2.5 and the subsequent impact on long-term mortality are calculated and compared to those found previously in scenario-based studies. Our primarily results show that in 2011, marginal health benefits of PM2.5 reduction due to phasing out Nanticoke and Lambton power plants in Ontario were as high as 98k $/tone of PM2.5. The findings of marginal health benefit analysis and an evaluation matrix for control policy options for Alberta and Ontario will be discussed.

7MO.6

Estimation for Location-specific Marginal Benefits for Primary and Precursor PM2.5 Emissions using the Adjoint of CMAQ. Amanda Pappin, Shunliu Zhao, Marjan Soltanzadeh, Burak Y. Oztaner, AMIR HAKAMI, Masoud Naseri, Mieczyslaw Szyszkowicz, Rick Burnett, Matt Turner, Shannon Capps, Daven Henze, Peter B. Percell, Jaroslav Resler, Jesse Bash, Sergey Napelenok, David Fahey, Rob Pinder, Armistead G Russell, Athanasios Nenes, Jaemeen Baek, Gregory Carmichael, Charles Stanier, Adrian Sandu, Tianfeng Chai, Daewon Byun, *Carleton University*

Quantitative assessment of air pollution health impacts plays a key role in air quality regulation and decision-making. One metric with broad policy applications is marginal benefit or benefit-per-ton (BPT), which estimates the monetized public health benefit of reducing emissions by an additional ton of emissions at each location. Various models and methods have been used to quantify source-specific BPTs, but as a trade off to source-specificity, past estimates have been based on simplified models or simplifying assumptions. We use a backward sensitivity analysis approach, i.e. the adjoint method, to estimate BPTs on a source by source basis while accounting for all atmospheric processes as represented in a state-of-the-science air quality model.

Gridded emissions from SMOKE and meteorological fields from WRF are fed into the U.S. EPA's CMAQ model v5.0 and it's adjoint. Epidemiological concentration response functions (CRFs) considered for PM2.5 chronic exposure mortality include traditional effect estimates in Canada and the U.S., as well as the recently developed supra-linear CRFs from the Canadian Census Health and Environment Cohort (CanCHEC).

Our initial results for Canada estimate more than 9400 deaths annually to sources in Canada and the U.S., with a majority of impact coming from primary (organic and elemental) carbon emissions. For Toronto, we find BPTs of $820,000 and $650,000/ton for primary organic and elementary carbon emissions, respectively. Overall, emission-weighted averages of PM2.5 in Canada can be as high as $500,000/ton. We also combine our calculated BPTs with source-specific CO2 emission rates to estimate co-benefits of CO2 reduction from select sources. We find co-benefit estimates well above the social cost of carbon or its market price. For example, co-benefits from light-duty gasoline and heavy-duty diesel vehicles in large urban areas in Canada, are often in excess of $500 and $1000 per ton of CO2, respectively.

7OP.1

On the Health Effects of Urban Particulate Matter. Michal Pardo, YINON RUDICH, *Weizmann Institute of Science.* INVITED

People in cities are exposed to various types of particulate matter from numerous emission sources such as motor emissions, biomass burning aerosols and resuspended road dust. The biological effects of due to exposure to such particles may depend on chemical components in these particles and on the exposure extent. We will describe seasonal variations in the biological effects and oxidative potential of pollution particles from Beijing and of resuspended road dust from large cities in Europe. Specifically, we will describe in vivo and in vitro studies that highlight the interplay between oxidative stress, inflammation and activation of defense mechanisms in the overall biological effects of exposure to pollution

7OP.3

A Comparison of Oxidative Potential of POA and SOA Derived from α-Pinene and Gasoline Engine Exhaust Precursors. Khairallah Atwi, ALAN SHIHADEH, Constantinos Sioutas, Farimah Shirmohammadi, Vishal Verma, James Schauer, *American University of Beirut*

Organic aerosols in the atmosphere are thought to play an important part in the etiology of respiratory and cardiovascular diseases, largely through systemic inflammation and oxidative stress. Secondary organic aerosols represent a major fraction of ambient organic aerosols, however their relative contribution to the inhalation burden of inflammatory and oxidative agents is poorly characterized. In this study we compared the chemical composition (EC/OC, metals, water soluble OC, organics), particle size distributions, and oxidative stress potentials (using DTT and ROS macrophage assays) of raw and oxidized gasoline engine exhaust, and raw and oxidized α-pinene. The SOA was generated using a custom-built oxidation flow reactor, fed either by α-pinene vapors or by 500:1 diluted gasoline engine exhaust. The flow reactor was operated at 22C and 60% RH, and an equivalent atmospheric aging of several days to weeks, resulting in an engine exhaust SOA:POA mass ratio of approximately 100. Comparisons of oxidative stress potential between the various aerosol systems are made both per unit volume of aerosol sampled, and per unit particle mass, and contrasted to previously reported data for ambient air.

7OP.4

Synergistic and Antagonistic Interactions among the Particulate Matter (PM) Components in Generating the Reactive Oxygen Species (ROS). HAORAN YU, Jinlai Wei, Vishal Verma, *University of Illinois, Urbana, IL*

The capability of individual chemical components in ambient particulate matter (PM) to generate reactive oxygen species (ROS) has been investigated for more than a decade. However, a simple summation of the individual ROS activities of these components to obtain the total ROS activity of ambient PM is not sufficient, as there could be interactions among the PM components to enhance or suppress the ROS activity. Although, it is generally believed that PM components interact in complex ways, the exact nature of these interactions and its impact on the ROS activity of ambient PM is not known. We attempt to understand some of these interactions by investigating the mixtures of the individual ROS active compounds, i.e. four quinones [phenanthraquinone (PQN), 1,4-naphthoquinone (1,4-NQN), 1,2-naphthoquinone (1,2-NQN) and 5-hydroxy-1,4-naphthoquinone (5-H-1,4-NQN)] and three transition metals [Fe(II), Mn(II) and Cu(II)], for their capability in both DTT consumption and $OH^{\cdot}$ generation. Preliminary tests have shown that although the interactions within quinones and within metals were mostly additive in both DTT consumption and $OH^{\cdot}$ generation, there were strong interactions among quinones and metals for both endpoints (i.e. DTT consumption and $OH^{\cdot}$generation). For example, Cu showed antagonistic effect with most quinones in both DTT consumption and $OH^{\cdot}$ Generation. On the other hand, Mn enhanced the DTT consumption but suppressed $OH^{\cdot}$ generation when interacting with quinones. The nature of these interactions between organic compounds and metals were further confirmed by mixing the fulvic acid/ humic acid with metals mixture (Cu, Mn and Fe). Results showed that the interactions depend on the relative concentrations of Cu, Mn and Fe in the mixture. Higher concentrations of Fe caused a synergistic effect in $OH^{\cdot}$ generation, Cu and Mn lead to antagonistic and synergistic effect in DTT consumption, respectively. To confirm that these interactions as observed from the pure compounds exist in ambient PM as well, we extracted the ambient aerosol samples and separated the humic-like substances (HULIS) and metals by passing the aerosol extracts through a C18 column. The interactions among HULIS and metals mixture were more pronounced in the ROS generation than the DTT consumption. We are currently investigating if these interactions could be explained just by measuring the concentrations of three metals (i.e. Cu, Mn and Fe) in the ambient PM. This research would help in developing a model for predicting the ROS activity of ambient PM based on their measured chemical composition.

7OP.5

The Oxidative Potential of Gasoline-derived Organic Aerosols and Wood Smoke Particles. HUANHUAN JIANG, Myoseon Jang, *University of Florida*

Human exposure to fine particle matter ($PM_{2.5}$, aerodynamic diameter < 2.5 µm) has been linked to increased morbidity and mortality from respiratory and cardiovascular diseases. Organic aerosols (OA) formed from the photooxidation of gasoline vapor and wood smoke account for a large fraction of $PM_{2.5}$. However, the health effects of OA are still unclear due to the complex OA compositions. Among the diverse OA components, quinones, organic hydroperoxides, peroxyacyl nitrates and electron-deficient alkenes, which have been known to induce oxidative stress in biological systems, are valuable to be studied.

Given the dynamic evolution of OA during the photooxidation, it is necessary to investigate the change of compositions and oxidative potential of OA with the increase of aging time. Aged wood smoke particles and gasoline-derived OA were formed in a large outdoor photochemical smog chamber. OA was collected within a small amount of deionized water using a particle-into-liquid sampler. The aqueous OA samples were then applied to a series of chemical assays to quantify the oxidative potential (dithiolthreitol (DTT) assay), the concentrations of organic hydroperoxides (4-nitrophenylboronic acid assay), and peroxyacyl nitrates (Griess assay). A gas chromatograph-mass spectrometer was also applied to characterize the compositions of OA. The preliminary results show that the oxidative potential of both gasoline-derived OA and wood smoke particles decreased with aging, which was associated with the degradation of organic hydroperoxides and quinones.

7OP.6

Aerosol Oxidative Potential and Altered Oxidative Stress-Associated Gene Expression in BEAS-2B Cells Exposed to Major Isoprene Secondary Organic Aerosol Precursors and Constituents. YING-HSUAN LIN, Zhenfa Zhang, Avram Gold, Ilona Jaspers, Rebecca Fry, Jason Surratt, *University of North Carolina at Chapel Hill*

Isoprene (2-methyl-1,3-butadiene)-derived secondary organic aerosol (SOA) contributes a substantial mass fraction of ambient fine particulate matter (PM2.5) in many isoprene-rich regions. Recent studies have revealed that the OH-radical initiated oxidation of isoprene leads to the production of reactive gas-phase SOA precursors, such as epoxides (IEPOX and MAE) and hydroperoxides (ISOPOOH), and further promotes SOA formation through reactive uptake and multiphase chemistry. With synthesis of authentic standards, we have evaluated the oxidative potential (i.e., thiol reactivity) of major isoprene SOA precursors and the resultant SOA constituents with the acellular dithiothreitol (DTT) assay. We have also assessed the exposure-induced differential gene expression of heme oxygenase 1 (HMOX-1) using human airway epithelial cells (BEAS-2B) as an in vitro model. The dose-dependence of HMOX-1 gene expression was examined to evaluate the relative potency of the test compounds. Our findings suggest that ISOPOOH has remarkable DTT activity, but it induces a multiphasic non-monotonic response in HMOX-1 gene expression. Exposures to IEPOX, MAE and the 3-sulfate ester derivative of 2-methylglyceric acid result in significant cytotocxicity and upregulated HMOX-1 gene expression as concentrations increase, while the measured DTT activity of these compounds is insignificant. 2-Methylterols induce significant HMOX-1 gene expression at high dose levels, potentially through metabolic activation. The results indicate that both chemical characteristics and biotransformation (e.g., metabolic activation) of individual chemical components may be responsible for the observed cellular responses.

7OP.7

Impacts of Emission Sources on Spatiotemporal Variability in Aerosol Oxidative Potential. JOSEPHINE BATES, Rodney J. Weber, Joseph Abrams, Vishal Verma, Ting Fang, Cesunica Ivey, Mitchel Klein, Matthew Strickland, Stefanie Ebelt Sarnat, Howard Chang, James Mulholland, Paige Tolbert, Armistead G. Russell, *Georgia Institute of Technology*

Oxidative stress caused by the catalytic generation of reactive oxygen species induced by inhaled particulates is a suspected mechanism of aerosol toxicity. Oxidative potential, or ability to generation reactive oxygen species, of aerosols can vary spatially, temporally, and by composition. An acellular dithiothreitol (DTT) assay was used to measure the oxidative potential of ambient water-soluble PM2.5 at six sites (four urban and two rural) across the Southeastern United States from June 2012-July 2013. CMAQ-DDM was used to estimate 16 source impacts on ambient PM2.5 across the Eastern United States during the study time period. Ordinary least squares linear regression analyses with backward selection was used to relate particulate source impacts to water-soluble DTT activity, developing a model that estimates daily aerosol oxidative potential across the Eastern United States. This model was applied to daily estimates of CMAQ-DDM source impacts during the study time period to map spatial and seasonal patterns in oxidative potential of ambient aerosols. Spatial patterns show higher values in urban areas compared to rural areas, driven by the significant contribution of diesel vehicles to oxidative potential. Areas with fire activity also show aerosols with high oxidative potential, as supported by previous source apportionment work using the Chemical Mass Balance Method in Atlanta, GA. Overall, modelled oxidative potential is higher in the winter than the summer, which is supported by DTT assay measurements and the prevalence of prescribed burning in the winter in the Southeastern United States. Local source impacts affect the spatial and temporal distribution of aerosol oxidative potential, thus emphasizing the importance of understanding the association between source impacts and oxidative potential for both regulatory purposes and health studies.

7UA.1

Investigating Spatial Variation in Organic Aerosol Concentrations and Source Impact in a Metropolitan Area by Mobile Sampling with Aerodyne Aerosol Mass Spectrometer. PEISHI GU, Zhongju Li, Qing Ye, Ellis Shipley Robinson, Jiqiao Shi, Rishabh Shah, Naomi Zimmerman, Joshua Apte, Allen Robinson, Albert A. Presto, *Carnegie Mellon University*

Sharp spatial gradients of particulate matter (PM) and organic aerosol (OA) concentrations exist in intra-city scales (100 m) due to intense emission from sources like traffic and cooking activities. Typical stationary deployment of samplers is not capable of resolving these spatial gradients. By performing in motion sampling using Aerodyne Aerosol Mass Spectrometer (AMS) deployed on a mobile sampling platform, we are able to investigate the spatial variation of PM concentration and composition within a city. From August 2016 to June 2017, mobile measurement has been conducted with this platform in the Pittsburgh metro area. The sampling domain covers various types of land-use, including urban/suburban, high/low traffic area and high/low restaurant density area. Measurement took place during morning rush hour, daytime, afternoon rush hour and evening/dinner time. The data are corrected for day-by-day shift of regional background PM concentration, and an average concentration values were calculated on a 100 m x 100 m grid systems. Positive Matrix Factorization (PMF) results from our mobile data yield factors that are consistent with previous literature. Geospatial analysis shows that OA concentrations from traffic and cooking activities have very different spatial patterns over different communities in Pittsburgh, and in general, cooking creates higher localized OA concentrations than traffic. In some communities with high restaurant density, there is a factor of four difference on average in OA concentration over spatial scale of 200 meter. Cooking activities are often spatially correlated with population, and some restaurant-dense area are directly located inside populous residential area so nearby residents can be exposed to above average OA concentration. Thus findings from this study could lead to meaningful discussion in policy making and regulation for air quality related sectors.

7UA.2

Mobile Measurements of PM, NOx, and O3 Across California Using Google Street View Cars. ANDREW WHITEHILL, Surender Kaushik, Paul A. Solomon, Ashok K. Singh, Melissa M. Lunden, Okorie Puryear, Brian LaFranchi, Davida Herzl, *U.S. EPA, Office of Reserach and Development*

Understanding the spatial and temporal variability of particulate matter (and other air pollutants) in urban environments is important for improved understanding of human exposure and risk assessment. In collaboration with Google, Inc. and the United States Environmental Protection Agency, Aclima, Inc. performed a series of mobile air pollution monitoring campaigns across California over the past 12 months. Two Google Street View vehicles were equipped with the Aclima Environmental Intelligence ™ measurement and data acquisition platform. This platform provides data management, quality control, and visualization functions, facilitating extensive, routine measurements. We measured size-fractionated particulate matter (0.3 – 0.5 µm, 0.5 – 0.7 µm, 0.7 – 1.0 µm, 1.0 – 1.5 µm, 1.5 – 2.5 µm, and 2.5 µm and larger) and gas-phase pollutants (NO, NO_2, and O_3) using a suite of fast time-response reference-grade equipment. Measurements were conducted in a series of 2 – 4 month targeted measurement campaigns in San Francisco, Los Angeles, and the Central Valley.

We present preliminary results from the analysis of a large (over 10 million one-second observations), multidimensional, spatiotemporal air pollution dataset measured from 2 – 4 Google Street View cars over a period of 12+ months. We explore the variability of different parameters and their correlations to provide insights into (1) relationships between pollutants and (2) spatial and temporal patterns in the data.

7UA.3

Characterization of Winter Air Pollutant Gradients near a Major Highway. CHEOL H. JEONG, Nathan Hilker, Jon M. Wang, Jerzy Debosz, Robert Healy, Uwayemi Sofowote, Tony Munoz, Dennis Herod, Greg J. Evans, *SOCAAR, University of Toronto*

In Toronto, the largest city in Canada, approximately 13%, 24%, and 56% of the total population lives within 50 m, 100 m, and 250 m of major roadways, respectively. Living and spending significant time near major roadways has been identified as a risk factor for a number of adverse health outcomes. Previous studies have reported that elevated concentrations of traffic-related pollutants such as ultrafine particles (UFP), black carbon (BC), and nitrogen oxides (NO_x) generally occur within 50 m from roadways, while background levels are reached within 150-500 m. However, the spatial variability of air pollutants near roadways (< 250 m) can be affected both by distance to roadways and meteorological variables. Thus, influences of microscale meteorology, especially in winter, on the decay gradients of traffic-related and regional scale pollutants near major roadways should be characterized in order to estimate the extent to which populations are exposed to elevated pollution levels. Knowledge of decay gradients in winter is also required to better understand seasonal relationships between pollution exposure and health effects.

In this study, primary traffic-related pollutants (UFP, BC, NO_x) and $PM_{2.5}$ components (metals, organic aerosol, sulphate, nitrate, ammonium) were simultaneously and continuously measured at 10 m and 150 m distances from a major Canadian highway over 3 weeks, along with meteorological parameters and traffic counts. A wide range of ambient temperatures, -11°C to +18°C was observed during this winter intensive campaign. The spatial variabilities of traffic-related pollutants were characterized by wind profiles (downwind vs. upwind, stagnant air) and ambient temperature. In addition to the short intensive campaign, longer-term measurements of UFP, NO_x, and BC in winter months at the near-highway station will be discussed to elucidate the influence of ambient temperature on real-world emission factors.

7UA.4

A Study of the Impact of Diesel Buses on Downtown Boulder. Josue Hernandez Pedroza, SHELLY MILLER, *CU Boulder*

Many studies have reported the adverse health effects of diesel combustion engine emissions; diesel exhaust is considered carcinogenic to humans. This research examined the major pollutants produced by diesel-powered engines: particulate matter, black carbon, and nitrogen oxides. Ozone was also studied due to its secondary formation from nitrogen oxides. Summer and Winter measurements were taken next to the Boulder Downtown Station in Colorado, for one week in each season. It was not possible to estimate bus emissions due to variability in the number of vehicles and buses traveling in the study corridor. Results showed limited association between pollutant levels and traffic patterns, and followed regional pollution and seasonal trends. Only Winter particle number and nitrogen oxides followed traffic trends. NOx was elevated in winter, and Black carbon contributed 12-34% of the total fine particulate matter.

Bicycle rides were carried out to capture fresh emissions on-road. Black carbon concentration peaked when chasing certain buses, while emissions from other buses were low. Passenger vehicle emissions were not reflected in the black carbon levels. Bicycle ride pollutant averages were lower than averages from stationary measurements, while bicycle ride peak values were higher than peak values in stationary measurements for black carbon and particulate matter. Ozone was always higher on-road.

With the use of MOVES and R-Line, the impact of buses on the concentration of pollutants was analyzed. Emission rates were estimated with MOVES in Summer and Winter by running simulations with and without buses. The R-Line dispersion model was used to estimate the concentration of pollutants at the Boulder Downtown Station and the street right in front of the station. Results showed a concentration ratio without and with buses ranging between 0.55-0.84 without buses and with buses. These values would have been higher if traffic-related emissions from additional surrounding streets would have been included. Bus emissions due to the idling period represented a significant part of pollutants emitted. Therefore, the bus station contributed significantly to the total traffic emissions of Boulder Downtown.

7UA.5

Characterization of On-road Vehicle Emissions in a Roadway Tunnel in Hong Kong. XIAOLIANG WANG, Judith Chow, John Watson, L.W. Antony Chen, Kin-Fai Ho, Shun-Cheng Lee, *Desert Research Institute*

Traffic emissions were measured in the Shing Mun tunnel (SMT) in Hong Kong during winter 2015. Fleet-average emission factors (EFs) were calculated and compared to the 2003–2004 measurements in SMT to assess emission changes over time. The EF differences between the 2003–2004 and 2015 measurements were not statistically significant for carbon monoxide (CO), ammonia (NH_3), and nitrogen dioxide (NO_2). Sulfur dioxide (SO_2) and $PM_{2.5}$ measured in 2015 were only ~20% of those in 2003–2004. In contrast, nitrogen oxide (NO) and nitrogen oxides (NO_x) measured in 2015 increased by ~20%. While the total measured volatile organic compounds (VOCs) were ~50% lower, the marker species for liquefied petroleum gas (LPG; e.g., n-butane and isobutene) increased in 2015, likely due to the increased LPG fleet. The EMFAC-HK mobile source emission model estimates and SMT measurements differed <40% for the 2015 data with EMFAC-HK being lower, while EMFAC-HK estimates were ~2 and ~5 times higher for CO and NO, respectively, in 2003. Polycyclic aromatic hydrocarbons (PAHs) were predominantly in gas phase, with gaseous PAH concentrations being ~15 time higher than those of particulate PAHs. Over 85% of the two- and three-ring PAHs were in the gaseous phase, while over 75% of the four- to six-ring PAHs were in particulate phase. Elemental and organic carbon were the major constituents of $PM_{2.5}$ collected in the tunnels. Source apportionment of the tunnel $PM_{2.5}$ using Positive Matrix Factorization (PMF) suggests the dominance of diesel engine exhausts, accounting for 48±16% $PM_{2.5}$ mass concentration on average, followed by secondary sulfate and nitrate (27±9%), gasoline engine exhausts (20±6%), and road dust (5±4%).

7UA.6

High Temporal and Spatial Variability in Ambient Black Carbon in an Urban Area from Fixed-Site and Mobile Monitoring. AJA ELLIS, Naomi Zimmerman, Hugh Li, Peishi Gu, Ellis Shipley Robinson, Allen Robinson, Joshua Apte, Albert A. Presto, R. Subramanian, *Carnegie Mellon University*

Black carbon (BC) is used as an air quality indicator for exposure to combustion-related primary particles, especially diesel exhaust particulate matter (DEPM), a known carcinogen. Fixed-site BC observations are often limited by low spatial and/or temporal resolution, and may not adequately represent population exposure by highly localized combustion sources. To better characterize spatial and temporal gradients in the urban environment, concurrent BC measurements were made across a rural-urban transect and a downtown area over a year-long period in Pittsburgh, PA. Mobile BC measurements were also made to increase the spatial resolution. Sites included a range of traffic, tall building, and restaurant densities, along with upwind and downwind urban background sites. Ambient BC was monitored using an array of instruments including a Magee Scientific Aethalometer, MetOne BC-1050, and multi-angle absorption photometers (MAAP), along with collocated measurements of ultrafine particle number, PM2.5, carbon dioxide (CO2), carbon monoxide (CO), nitrogen dioxide (NO2), and ozone (O3). The high spatial and temporal resolution measurements will be jointly analyzed with the collocated gaseous and aerosol measurements as well as mobile laboratory BC measurements to investigate the sources of and population exposure to BC across Pittsburgh. There are consistent diurnal trends with daytime peaks in BC across the city and substantial decreases in BC over weekends, particularly in downtown sites. Urban background BC increases across all monitors during atmospheric stagnation events. Two sites in downtown Pittsburgh revealed steep gradients in BC concentrations over short distances (~0.3 km) due to the urban street canyon effect. One downtown green space measured daily weekday concentrations over 2 µg m-3 and short duration (~30-min) events often topping 20 µg m-3, likely driven by nearby diesel bus traffic.

7UA.7

Effects of After-Treatment Emission Control Technologies on In-Use Heavy-Duty Diesel Trucks under Two Different Driving Modes. CHELSEA V. PREBLE, Troy Cados, Robert Harley, Thomas W. Kirchstetter, *University of California, Berkeley*

Heavy-duty diesel trucks (HDDT) are a major source of nitrogen oxides (NO_x) and black carbon (BC) in urban environments, contributing to persistent ozone and particulate matter air quality problems. Recently, diesel particle filter (DPF) and selective catalytic reduction (SCR) emission control systems have become standard equipment on new HDDT. DPFs can also be installed as a retrofit. Prior work has shown that in-use DPF and SCR systems effectively reduce BC and NO_x emission rates by up to 90% and 80%, respectively (Preble et al., ES&T 2015). There is concern that DPFs may promote the formation of ultrafine particles (UFP) and can increase tailpipe nitrogen dioxide (NO_2) emissions. SCR systems may form nitrous oxide (N_2O), a potent greenhouse gas.

To evaluate the in-use performance of DPF and SCR systems, pollutant emissions from thousands of HDDT were measured over several years at the Port of Oakland and the Caldecott Tunnel in the San Francisco Bay Area. Gas- and particle-phase pollutants in the exhaust plumes of individual HDDT were measured at high time resolution (≥1 Hz) as trucks passed under an emissions lab stationed on an overpass. Fuel-based emission factors ($g\ kg^{-1}$) were calculated on a truck-by-truck basis and linked via recorded license plates to vehicle attributes, including engine model year and installed after-treatment controls.

DPFs reduced the BC emission rate by up to 95% at both locations. SCR systems were more effective at reducing NO_x emissions under the uphill, highway driving conditions at the Tunnel compared to the flat, arterial roadway near the Port. The impact on co-emitted species NO_2, UFP, and N_2O showed driving mode dependence. Some aging DPF systems showed evidence of deterioration (i.e., failure), leading to BC emission rates greater than the average for trucks without filters.

8AQ.1

Ambient Biomass Burning Influenced Fog and Aerosol Samples: Molecular Insights on Aging. MATTHEW BREGE, Marco Paglione, Stefania Gilardoni, Stefano Decesari, M. Cristina Facchini, Lynn Mazzoleni, *Michigan Technological University*

Ambient samples of fog and aerosol influenced by regional biomass burning emissions and secondary processes were collected in the Italian Po Valley during the 2013 Supersito field campaign. Two samples of fog water and two samples of PM1 aerosol were selected for ultrahigh resolution Fourier transform ion cyclotron resonance mass spectrometric analysis after the extent of “fresh” vs “aged” biomass burning influence was determined from factor analysis of ^{1}H-NMR results and analysis of AMS mass spectra. Over 4300 distinct molecular formulas were assigned and sorted into 4 elemental groups (CHO, CHNO, CHOS and CHNOS) and 64 subclasses. These samples had an atypically large frequency of molecular formulas containing nitrogen and sulfur, attributed to nucleophilic substitution reactions with nitrate and sulfate ions in the aqueous phase of fog and aerosol water. Samples with significant influence of “aged” biomass burning emissions contained highly oxygenated ($O/C > 0.6$) and more saturated ($H/C > 1.2$) molecular formulas compared to those with primarily “fresh” emissions. Averages of the molecular formula double bond equivalents and carbon numbers were higher in the “fresh” biomass burning influenced samples, whereas the average O/C and H/C values were higher in samples influenced by “aged” biomass burning. Several molecular formulas detected in the Po Valley samples were identical to those from ambient biomass burning emission samples previously studied, however a large fraction were not previously observed, highlighting the importance of additional studies with respect to biomass burning aging in atmospheric aerosol.

8AQ.2

Vertically Resolved Concentration and Liquid Water Content of Atmospheric Nanoparticles at the US DOE Southern Great Plains Site. HAIHAN CHEN, Anna Hodshire, John Ortega, James Greenberg, Peter H. McMurry, Annmarie Carlton, Jeffrey R. Pierce, David Hanson, James Smith, *University of California, Irvine*

Most previous field studies of new particle formation (NPF) have been performed at or near ground level, but some measurements suggest that nucleation can be altitude dependent. Lower temperature and high relative humidity (RH) at higher altitudes can favor nucleation and growth pathways that are not important at ground level. Vertically resolved studies of NPF are thereby needed to better understand the chemical species and mechanisms driving NPF, as well as adequately assess the impacts of NPF on cloud formation and climate. We report measurements of 10-20 nm diameter particle number concentrations from ground level to 1000 m above ground during the 2013 New Particle Formation Study at the Atmospheric Radiation Measurements Southern Great Plains site in Lamont, Oklahoma. The measurements were performed using a tethered balloon carrying two condensation particle counters that were configured for two different particle cut-off diameters. Those observations are compared to data from three scanning mobility particle sizers at the ground level to examine the spatial and temporal profiles of NPF. We observed that 10-20 nm diameter particles were generated at the top region of the boundary layer, and were then rapidly mixed throughout the boundary layer. We estimate liquid water content (LWC) of newly formed particles using ground-based measurements of particle hygroscopicity obtained with a Humidified Tandem Differential Mobility Analyzer and vertically-resolved relative humidity and temperature measured with a Raman Lidar. Our estimates of liquid water content suggest that nanoparticles typically contain up to 50% water by volume in ambient air. The effect of LWC of newly formed particles on particle growth is examined by the MABNAG nanoparticle growth model. The modelling results indicate that the increased liquid water content of nanoparticles at high RH greatly enhances the partitioning of water soluble species like organic acids into ambient nanoparticles.

8AQ.3

Chemical and Biological Analysis of Cloud-Water in Marine Boundary Layer Clouds. EWAN CROSBIE, Luke Ziemba, Richard Moore, Taylor Shingler, Michael Shook, Kenneth Thornhill, Edward Winstead, Hossein Dadashazar, Alex MacDonald, Armin Sorooshian, Bruce Anderson, *NASA*

Direct measurements of cloud water from airborne platforms provide a means to help understand aqueous chemistry and biological activity within clouds. However, collection of cloud water on an airplane presents a number of sampling challenges associated with the removal of the cloud water from the air with high efficiency will avoiding contamination from interstitial aerosols and gases.

A new axial cyclone cloud-water collector (AC3) has been developed and tested during airborne field deployments on the NASA C-130 and the Center for Interdisciplinary Remote Piloted Aircraft Studies (CIRPAS) Twin Otter. On the Twin-Otter, the AC3 was integrated alongside a slotted-rod cloud-water collector, which has been used for several decades for cloud-water collection but is unsuitable for pressurized (or high speed) aircraft. We present results comparing AC3 and the slotted-rod from cloud-water samples collected during the Fog and Stratocumulus Evolution (FASE) campaign, which comprised flights in marine boundary layer clouds near California.

We also present results of multiple collaborative chemical and biological analysis of clouds measured during the North Atlantic Aerosols and Marine Ecosystems Study (NAAMES), which was focused on the sub-polar North Atlantic (45-55N, 35-50W) in May and September.

8AQ.4

Characterizing the Behavior of Ambient Organic Aerosols Under Conditions of Aerosol Liquid Water Evaporation. MARWA EL-SAYED, Dziedzorm Amenumey, Christopher Hennigan, *University of Maryland, Baltimore County*

Aerosol liquid water (ALW) can affect the quantity and chemical composition of organic aerosols; however, the interaction between ALW and ambient organic aerosol compounds is highly uncertain at present. To characterize the behavior of organic aerosols under conditions of drying, water-soluble organic matter (WSOM) in $PM_{2.5}$ was measured during two consecutive summers in Baltimore, MD. The WSOM measurements were alternated through an unperturbed ambient channel and through a 'dried' channel maintained at ~35% relative humidity (RH). Sample drying induced systematic evaporation of the WSOM during both summers. The quantity of evaporated WSOM was strongly related to RH, WSOM concentrations, and isoprene emissions. Significant differences in meteorological conditions (including RH), isoprene emissions, and overall WSOM concentrations were observed between the two summers. This led to major differences in the amount of evaporated WSOM during summer 2016 in comparison to summer 2015. We used the sensitivity of evaporated mass to each of the aforementioned parameters to build a statistical model describing the effect of liquid water evaporation on ambient organic matter in the eastern United States. These results have implications for secondary organic aerosols formed through aqueous pathways (aqSOA), and for a measurement approach that is widely applied in aerosol science.

8AQ.5

Bimodal Aerosol Caused by Cloud Processing. JAMES HUDSON, Stephen Noble, *Desert Research Institute*

Higher cloud droplet concentrations and less drizzle were found in stratus clouds formed on bimodal CCN spectra than clouds formed on unimodal CCN. Cumulus clouds formed on bimodal CCN had lower droplet concentrations and more drizzle than clouds formed on unimodal CCN. These opposite effects are due to chemical cloud processing dominance making bimodal aerosol in stratus clouds, which are thinner with smaller droplets, compared to thicker cumuli with larger droplets where coalescence is the main cause of aerosol bimodality. Since maritime stratus cause most of the indirect aerosol effects (IAE), cloud processing enhances first IAE (greater cloud albedo due to more droplets) and second IAE (greater cloudiness due to drizzle suppression; greater cloud lifetimes).

Surface aerosol and CCN bimodality measurements that were correlated with greater cloud fractions and lower cloud base altitudes substantiated that cloud processing causes aerosol bimodality, i.e., the accumulation or cloud-processed mode. DMA (SMPS) dry size spectra transposed to critical supersaturation (S_c) spectra compared well with simultaneous CCN spectra in both aircraft and surface measurements. This transposition of size to S_c was done by applying various hygroscopicities, kappa. The kappa that tuned the best fit of these simultaneous spectra was ambient kappa. For the vast majority of cases agreement was good over most of the S_c range, except sometimes at high S_c where some small particles are marginally hygroscopic; i.e., not CCN but detected by the DMA. Kappa differences for the two modes indicate chemical cloud processing whereas the same kappa fitting both modes indicates coalescence cloud processing. Kappa differed between the two modes more often in stratus clouds whereas cumulus clouds had greater incidence of kappa similarity between modes. Thus, kappa differences between cloud type are consistent with cloud microphysics and drizzle responses to CCN modality; chemical dominance in stratus, coalescence dominance in cumuli.

8AQ.6

Photosensitized SOA Production by Humic Acid in Aqueous Aerosols. WILLIAM TSUI, V. Faye McNeill, *Columbia University*

Photosensitized reactions involving humic acid, a proxy for water-soluble humic-like organic compounds (HULIS), have been experimentally observed to contribute to secondary organic aerosol (SOA) growth (Monge et al., 2012). However, the extent of photosensitized reactions in ambient aerosols remains poorly understood and unaccounted for in atmospheric models. Here we use GAMMA 4.0, a photochemical box model that couples gas-phase and aqueous-phase aerosol chemistry, to analyze photosensitized SOA formation by humic acid in laboratory and ambient settings. We find that this pathway may be a significant contributor to aqueous aerosol SOA (aaSOA) formation, particularly under less acidic conditions where other aaSOA formation mechanisms are less efficient.

Reactive uptake coefficients were determined for reactions of gas-phase limonene and isoprene with photoactivated humic acid-containing particles based on the experimental data of Monge et al. (2012) using GAMMA. Reactions of these VOCs with photoactivated humic acid are efficient. This plus the fact that HULIS is relatively abundant in ambient aerosols results in a reactive uptake coefficient nearly 500 times greater than that for limonene with photoactivated imidazole carboxaldehyde (IC)-containing particles. For simulations using GAMMA under ambient conditions, we find that the contribution of SOA formation from this pathway is much greater than for the IC pathway, contributing up to 58% by mass of aaSOA growth. The contribution of this pathway to overall SOA production will be explored using a regional model.

8AQ.7

In-Particle Chemistry and Gas-Particle Partitioning of Isoprene SOA Tracers. ALISON FANKHAUSER, ManishKumar Shrivastava, Gabriel Isaacman-VanWertz, V. Faye McNeill, *Columbia University*

Understanding the formation and properties of secondary organic aerosol (SOA) formed from the oxidation of isoprene is critically important for air quality and climate. Recent laboratory and field data suggest significant revolatilization of IEPOX SOA tracers with atmospheric aging, while other data indicate lower than expected volatility of isoprene SOA. We use GAMMA 4.0, a recently updated version of the McNeill group model for multiphase SOA formation, to systematically test a series of changes in the chemical mechanism of isoprene SOA formation which impact volatility, including the formation and subsequent decomposition of oligomers and organic-inorganic adducts, and the incorporation of recent laboratory results for the gas-particle partitioning and oxidative revolatilization of 2-methyltetrols. Simulation results are compared to field data from GoAmazon2014/5.

8AQ.8

Aerosol Interactions with Fog in Urban and Suburban Sites in Northeastern France: Applications of Carbon Isotopic Analysis. DENISE NAPOLITANO, Olivier Delhomme, Maurice Millet, Pierre Herckes, *Arizona State University*

The Grand Est region of France experiences autumnal radiation fog that plays an important role in local atmospheric chemistry and the formation of secondary organic aerosol material. Fog and particulate matter studies have been conducted in this region, but the study of the effect of fog on the concentration and composition of particulate matter through tandem sampling of these phases has yet to be deeply explored. Moreover, the analysis of temporal changes in the stable carbon isotopic composition ($\delta^{13}C$) of these phases could provide information on the sources, droplet activation, and reactivity of carbonaceous particulate matter. Samples of fog and particulate matter were collected in the city of Strasbourg and the nearby suburb of Geispolsheim in the fall of 2016 and were characterized for their stable carbon isotopic compositions. In the presence of fog, the stable carbon isotopic composition of aerosols was depleted by up to 0.7‰ in $PM_{2.5}$ in Strasbourg and up to 1.1‰ in PM_{10} collected in Geispolsheim. This type of isotopic depletion may be due to source-specific particle activation in which larger particles originating primarily from biogenic sources are preferentially scavenged as condensation nuclei relative to smaller, anthropogenically-derived particles. Additionally, the carbon isotopic composition of fog samples collected in Geispolsheim were enriched relative to interstitial particles by up to 1.7‰. This enrichment may also be attributed to the preferential activation of larger biogenic particles during fog formation, leaving smaller anthropogenic particles in the solid phase. Fog samples were also collected during this season in the neighboring suburb of Erstein. In both Geispolsheim and Erstein, fog samples were enriched in $\delta^{13}C$ compared to fog collected in Strasbourg by up to 1.2‰, which may be due to the presence of a higher fraction of biogenic emissions relative to anthropogenic emissions in these areas. Similarly, in 2015, the stable carbon isotopic composition of fog samples collected in Geispolsheim was enriched by an average of 0.6‰ relative to those collected in the city of Metz. This study highlights the potential application of stable carbon isotopic analysis in studying dynamic multi-phase aerosol production processes.

8AQ.9

Hydrolysis of Daytime and Nighttime Organic Nitrates from α-Pinene and β-Pinene. MASAYUKI TAKEUCHI, Gamze Eris, Nga Lee Ng, *Georgia Institute of Technology*

Particulate organic nitrates (ONs) have been observed ubiquitously across different continents and their contributions to the mass fraction of organic aerosols are found to be substantial in various field studies. Since ONs serve as a NO_x reservoir and/or sink, the fate of ONs could affect the NO_x cycle and O_3 production. One known loss process of particulate ONs is hydrolysis in the presence of aerosol water. Results from recent field studies suggested that BVOC-derived particulate ONs in the Southeast U.S. have a short lifetime of a few hours. Although several laboratory studies have investigated the hydrolysis of speciated ONs in bulk solutions, hydrolysis of particulate ONs in aerosol water is largely unexplored. In this study, we conducted a series of chamber experiments to investigate the hydrolysis of ONs from α-pinene and β-pinene under two oxidation conditions: photooxidation in the presence of NO_x (i.e. daytime) and NO_3 oxidation (i.e. nighttime). The HR-ToF-AMS is used to monitor changes in the mass fraction of ONs in total organic aerosols and the HR-ToF-FIGAERO-CIMS provides speciated molecular information of ONs. Our results suggest that nighttime ONs undergo negligible hydrolysis whereas some fractions of daytime ONs appear to hydrolyze, suggesting that the type of oxidants may play a more important role than the identity of the precursor hydrocarbon in determining the hydrolysis of particulate ONs. Oxidation conditions (OH vs. NO_3) could be responsible for the differences in chemical structures of ONs; nighttime chemistry favorably generates primary and/or secondary ONs that undergo slow hydrolysis while daytime chemistry forms tertiary ONs that undergo more rapid hydrolysis. Our work provides the fundamental data to understand and evaluate the fates of ONs formed under different oxidations in ambient environments.

8AQ.10

Characterizing Oxidized North American Fire Emissions and Their Aqueous/Multiphase Atmospheric Transformations through the FIREX Campaign. SOPHIE TOMAZ, Tianqu Cui, Yuzhi Chen, Kenneth Sexton, Jason Surratt, Barbara Turpin, *University of North Carolina at Chapel Hill*

Aqueous multiphase chemistry of water-soluble organic gases (WSOGs) is now recognized to be a potential and significant source of atmospheric secondary organic aerosol (SOA). However, SOA formation through aqueous-phase chemistry of wildfire emissions is not well understood. Furthermore, most oxidized organic constituents of biomass burning (BB) emissions remain unidentified and may represent a major missing source of atmospheric aqueous SOA (aqSOA).

In the present work, we investigated the chemical composition of gas-phase emissions from the combustion of several western U.S. fuels, at the Fire Science Laboratory as part of FIREX (Fire Influence on Regional and Global Environments Experiment), using a high-resolution time-of-flight chemical ionization mass spectrometer (HR-ToF-CIMS) equipped with iodide reagent ion chemistry. By using the HR-ToF-CIMS, more than 50 oxygen (O)-containing and 15 nitrogen (N)-containing organic compounds were characterized in the gas-phase emissions from BB of the western U.S. fuel types. From among these compounds, we selected potential precursors of aqSOA based on their atomic O/C ratio, water solubility, abundance and potential reactivity toward hydroxyl (OH) radical using literature data. The selected compounds such as oxo-butanoic and hydroxypropanoic acids, were oxidized in the aqueous phase in the presence of OH radical (H_2O_2/UV). We evaluated the formation of low-volatility organics using both ion chromatography (IC) and high-resolution electrospray ionization mass spectrometry (ESI-HR-MS). We compared these results with water samples collected during the FIREX experiments, by scrubbing gaseous emissions into water using mist chamber samplers. We investigated the composition of these samples and their reactivity toward OH. Reactive compounds were identified and were compared with those tested based on the HR-ToF-CIMS measurements of primary BB emissions.

8AQ.12

Photosensitized Processes as an Alternative Photochemical Pathways in the Atmospheric Bulk Aqueous Phase. MAJDA MEKIC, Wei Deng, Wei Song, Xinming Wang, Xiang Ding, Sasho Gligorovski, *Guangzhou Institute of Geochemistry, CAS*

Dicarboxylic acids are ubiquitous water-soluble organic compounds that have been detected in atmospheric aerosols, cloud water and rainwaters. Photolysis and oxidation by atmospheric oxidants such as hydroxyl radical (OH) play an important role in controlling the concentrations of dicarboxylic acids in the atmospheric aqueous phase.

In addition to direct photolysis and oxidation processes, degradation of dicarboxylic acids can also occur by indirect photolysis or photosensitized process. In this study, the importance of atmospheric photosensitization is evaluated in bulk aqueous solution. Irradiation experiments in aqueous solution indicate that excited triplet state of pyruvic acid is able to photosensitize the degradation of other dicarboxylic acids. The effect of ionic strength on the photosensitization was evaluated.

Moreover, laboratory batch experiments suggest that the photosensitized process toward dicarboxylic acids could be a relevant source of oligomers (e.g. HULIS (HUmic Like Substances)). In this study oligomers were analyzed using high-resolution linear ion trap Orbitrap mass spectrometer which can deliver high resolving power and mass accuracy. This analytical technique allowed to suggest the unambiguous composition of formed molecules during the photosensitized process as data were gathered in the range between m/z 50 and m/z 2000 amu. Typical regular patterns of oligomer formation were observed, and extended up to 1200 amu.

The present findings strongly suggest that photosensitized degradation of dicarboxylic acids in atmospheric aqueous phase may be an effective degradation pathway in comparison to their removal induced by OH radical and direct photolysis processes.

8AQ.13

Characterizing Brown Carbon Formation and Persistence in Various Conditions: Cloudwater pH, Evaporation, and Photodegradation. LELIA HAWKINS, Hannah G. Welsh, Matthew V. Alexander, *Harvey Mudd College*

Secondary organic aerosol (SOA) composes a non-negligible fraction of brown carbon (BrC), and typically appears as small, nitrated aromatics or larger, highly functionalized humic-like substances (HULIS). Both nitrated aromatics and HULIS contain nitrogen, indicating the importance of nitrogen to light-absorbing aerosol. It is therefore unsurprising that BrC, when generated in aqueous phase reactions (aqBrC) between amines and small aldehydes, often resembles atmospheric HULIS. The effects of atmospheric aging on absorptivity and composition were simulated using bulk (microliter) samples under a variety of experimental conditions, including evaporation, pH control, and hydroxyl radical degradation. The system of amines and small aldehydes included methylamine, ammonium sulfate, glyoxal, and methylglyoxal. Chemical composition of these products was characterized using an Aerosol Chemical Speciation Monitor (ACSM). The results of this study indicate that methylamine and methylglyoxal form the most absorptive BrC, cloud processing serves to increase BrC absorptivity, and the generated BrC is highly persistent to oxidative and photodegradation. Results of this research also show that evaporation increased formation of large molecular fragments ($m/z > 100$). Furthermore, the mass spectra showed significant formation of these larger fragments in methylamine systems with little evidence for similar compounds in ammonium sulfate systems. Systems with methylglyoxal had higher absorptivity than all other systems, although in both methylamine and ammonium sulfate systems, glyoxal appeared to result in a higher percentage of large fragments than methylglyoxal. Lastly, hydroxyl radical degradation seemed to have a minimal effect on absorptivity and composition, although longer reaction time may produce a larger effect on both properties. These results may simplify some aspects of atmospheric models (like negligible degradation) but may complicate others (highly variable absorptivity between glyoxal and methylglyoxal).

8AQ.14

Recommended Reactive Uptake Coefficients for Uptake of Glyoxal and Methylglyoxal by Several Aerosol Types and Cloud Droplets in Atmospheric Chemistry Models. Leah Curry, V. FAYE MCNEILL, *Columbia University*

Reactive uptake of glyoxal and methylglyoxal to aerosol particles and cloud droplets has been a source of secondary organic aerosol material in some chemical transport models for the past decade. We have calculated updated values of the reactive uptake coefficient, γ, for the uptake of glyoxal and methylglyoxal to several aerosol types and cloud droplets, starting from fundamental aqueous chemical kinetics and mass transfer considerations. We considered the nitrate/sulfate/ammonium system and sea salt particles, over a range of relative humidities and for several particle sizes. ISORROPIA was used to determine the equilibrium aerosol composition, and Henry's Law constants for the multi-component mixtures were calculated, taking into account salting effects. γ values were calculated based on GAMMA, the McNeill group model of multiphase atmospheric chemistry, following Hanson, Solomon, and Ravishankara (1994).

Recommended values range over several orders of magnitude and in many cases are significantly lower than the values currently used in atmospheric chemical transport models.

8AQ.15

Following Carboxylic Acid and Peroxyacid Chemistry in the Formation of Aqueous Secondary Organic Aerosol Produced from Oxidation of Monoterpenes. MICHAEL LINK, Delphine Farmer, *Colorado State University*

Anthropogenic emissions facilitate the formation of aerosol liquid water which perturbs the oxidation chemistry of the atmosphere including the oxidation of biogenic volatile organic compounds. Monoterpenes undergo oxidation in the atmosphere to form small oxygenated water-soluble organic compounds that can further undergo oxidation in the aqueous phase and serve as precursors for secondary organic aerosol (aqSOA). This oxidation pathway produces compounds that can help to explain the high oxygen to carbon ratios commonly observed in ambient aerosol. While the mechanisms of oxidation and subsequent aqSOA formation are well understood for a few compounds (i.e. methylglyoxyl, isoprene epoxydiol) the role of organic peroxides in aqueous reactivity and radical recycling are not as well constrained. We have oxidized two model monoterpenes, limonene and terpinolene, in an oxidation flow reactor under variable relative humidity conditions and hydroxyl radical exposures (OHexp) to study how these variables influence the production of water-soluble organic species in the gas-phase and how that affects aqSOA production. Under constant OHexp conditions increasing humidity in the chamber was observed to generally increase SOA mass production from monoterpene oxidation by an order of magnitude or more. Under constant relative humidity conditions, different gas-phase species were generally observed either to be produced or removed in response to changes in OHexp. Formic and performic acid were chosen as surrogate acid/peroxyacid species to follow mechanistically through the cycle of aqueous oxidation to understand how the evolution of organic acid and peroxyacid species contribute to the magnitude of SOA formation under conditions of high relative humidity.

8CM.1

A Study on the Filtration Characteristics of Charged Porous Fiber Filters. CHIH-TE WANG, Tsung-Ming Tu, Shao-Tai Lee, Yu-Hao Tseng, Bi-Ling Huang, Jia-Xi Shi, Wen-Yinn Lin, *Institute of Environmental Engineering and Management, NTUT*

This study evaluated the charging characteristics of Electrospinning fibers. Nanofibers are used suitable in filtration because of high filtration efficiency and low pressure drop. In addition, nanofibers are also provided with exceptional properties which included highly specific area, high aspect ratio, and pore diameter. They are broadly used in a variety of applications, such as filtration for air or water, tissue engineering scaffolds, protective clothing and biomedical application, etc. Electrospinning fibers are nanofibers with electrostatic attraction on their surface. The surface of electret filters has electrostatic attraction, as increasing the electricity, particle penetration will gradually decrease. Besides, some researches indicated porous fiber having higher surface area. However, no research on the filtration characteristics of charged porous fiber has been found. Therefore, this study discusses the filtration characteristics of charged porous fiber.

An electrospinning system was set up in this study and nanofibers can be produced by electrospinning technology. The material of filters was PMMA. In addition, the surface voltage and penetration efficiency were investigated in this research.

The results of this study showed that the porous fiber had better efficiency improvement. The surface voltage of the porous fiber filter with a diameter of about 500nm was more than that of the smooth fiber surface voltage -0.088kV. Moreover, the average penetration efficiency is 12.42% lower than that of smooth fiber. The experimental results indicated that the surface voltage, penetration and filter quality of porous fiber were more prominent than smooth fiber after charging.

8CM.2

Charge Decay of Electret Filters with Various Surface Charge Densities by Liquid Isopropyl Alcohol Exposure. EUN-SEON PARK, Myong-Hwa Lee, *KITECH*

Electret filters have high collection efficiency due to the electrostatic attraction between charged fibers and particles even at the low pressure drop. However, the electret filters exposed to organic solvents led to drastic decrease in their collection efficiencies. Therefore, it is important to understand the charge decay mechanisms in the electret filter in order to extend the filter lifetime. Various electret filters were exposed to liquid isopropyl alcohol and their collection efficiency changes were investigated as functions of surface charge densities and physical structures of the filters in this study. The surface charge densities of the test electret filters were determined theoretically from the single fiber collection efficiencies by induced force and mechanical forces. In addition, the challenged amounts of isopropyl alcohol required to neutralize the test electret filters with various surface charge densities were compared.

8CM.3

An Optimization and Sensitivity Study on SALSCS Design by Using Numerical Method. QINGFENG CAO, Lian Shen, Sheng-Chieh Chen, David Y. H. Pui, *University of Minnesota*

A Solar-Assisted Large-Scale Cleaning System (SALSCS) has been proposed for the remediation of air pollution in urban areas around the world. The system is mainly composed of a solar collector, a tower, filtration elements and fans for generating more flow rate if necessary. Previous study shows that a full-scale system with a solar collector of 2.5 km in radius and a tower of 500 m in height can generated a system flow rate of 2.64×10^5 m^3/s. Many factors can affect the flow rate and system performance on removing urban $PM_{2.5}$ pollution. This includes the geometry and dimensions of SALSCS, pressure drop of the filtration elements, fans inside the system, ambient temperature, wind speed and solar radiation intensity. For the current study, numerical models within the ANSYS Fluent fluid solver are developed for both the SALSCS itself and an atmospheric domain encompassing the system. For each scale of system flow rate, an optimum design of the system geometry and dimensions has been proposed based on our numerical results. Extra flow rate generated by fans and the corresponding power supply is considered in this study. By utilizing the numerical model, a sensitivity study on the impact of ambient temperature and solar radiation intensity on the system air flow is conducted. At last, a numerical model simulating the atmospheric domain of SALSCS surrounding areas is applied to study the effect of ambient wind velocity on the system flow rate, and the impact of a medium-size SALSCS on its local surrounding $PM_{2.5}$ concentration field. The final goal of this study is to provide a guide for the SALSCS design and development for air pollution removal in the future.

8CM.4

Effect of Relative Humidity Hysteresis on Loading Characteristics of Air Intake Filter Media by Hygroscopic Salt Particles. Chenxing Pei, QISHENG OU, David Y. H. Pui, *University of Minnesota*

Air intake filters are widely used to remove particles in the ambient air to protect automobile engines and gas turbines. The mass of the particles that an air intake filter can hold before reaching the designated pressure drop reflects the life of the air intake filter. The higher the mass loading a filter can hold, the longer the replacement period. However, the current lab loading test conditions do not reflect the actual working environment. For example, NaCl and KCl are commonly used in the lab as the test particles because they are cheap, non-toxic, and insensitive to changes in relative humidity. Thus, the filter test standards do not strictly regulate relative humidity during testing. In ambient air, NaCl and KCl are found in lower concentrations than $(NH_4)_2SO_4$ and NH_4NO_3, and their hygroscopicities are extremely different. Therefore, it is worthwhile to use $(NH_4)_2SO_4$ and NH_4NO_3 to mimic the ambient particles for filter loading tests, and considering their hygroscopicities, to control the relative humidity and the state of the particles during these tests.

For a hygroscopic salt particle, when the relative humidity in the environment is above its efflorescence relative humidity and below its deliquescence relative humidity, the particle can be in either a dry state or a wet state. In this study, synthetic Nano-fiber coated cellulose filter media were loaded with sub-micron particles of KCl, $(NH_4)_2SO_4$, or NH_4NO_3 respectively until a specific pressure drop was reached. This process was repeated at different relative humidities and different particle states. To compare the volume loadings between different salts, the particle distributions were generated to be alike and the volume loading was calculated from the mass loading and the salt density. The results show that the volume loadings of all particles are dependent on relative humidity, the higher the relative humidity, the higher the volume loading. The $(NH_4)_2SO_4$ and KCl volume loadings were similar, but $(NH_4)_2SO_4$ was a little greater than KCl when particles were dry. The NH_4NO_3 particles could only be generated in the wet state and the volume loadings were greater than other wet particle loadings but less than other dry particle loadings. By comparing current results with the volume loading of conventional cellulose filter media at the same pressure drop, we conclude that dry particles can load more on Nano-fiber coated cellulose filter media, while wet particles can load more on conventional cellulose filter media.

8CM.5

Comparison of Different Neutralizing Methods by IPA on Electret Filter Media. MIN TANG, Sheng-Chieh Chen, Luying Liu, David Y. H. Pui, *University of Minnesota*

The mitigation of nanoparticles is becoming an important topic as nanoparticles are produced in large numbers from manufacturing and combustion emission. Nanoparticles may affect human health because they can easily enter into the human body through respiratory system and their toxicity is very high due to large specific surface area. Air filtration is an effective way to mitigate nanoparticles and protect human health. It's believed that nanoparticles were captured on the filter surface due to the Brownian diffusion mechanism. Many studies have shown that those small nanoparticles striking a filter surface could rebound if the initial kinetic energy is higher than the adhesion energy between the particle and the surface. Consequently, filtration efficiency against nanoparticles is thought to decrease due to the thermal rebound. In this study, sub-3 nm salt nanoparticles were generated by evaporation and rapid condensation method using a high temperature furnace. The filtration efficiency for sub-3 nm nanoparticles through metal mesh filter was measured using 1 nm nano-enhancer and condensation particle counter system. In addition, the effects of face velocity and high temperature were investigated for various nanoparticle diameters. Measurable thermal rebound was detected for sub-3 nm nanoparticles. Various theoretical models of thermal rebound from different researchers were compared and evaluated.

8CM.6

Electrodynamic Dust Shield for Dust Removal. BING GUO, Wasim Javed, Benjamin Figgis, *Texas A&M University at Qatar*

There are major plans to build solar photovoltaic power plants in regions with abundant solar irradiation, where there are also high airborned dust concentrations. In these places, dust accumulation on solar panels could reduce the electricity output by 15-20% every month. Research is under way in search for solutions to mitigate dust accumulation on the solar panels. Electrodynamic dust shield (EDS) is one of the potential "anti-dust" solutions. In this presentation, we will report our research work on the development of an electrodynamic dust shield technology in the Middle Eastern country Qatar. This includes characterization of dust accumulation in the field, laboratory characterization of EDS dust removal efficiency, and preliminary field test results.

8CM.7

Use of Nanofibrous Membranes for Effective Filtration of Fine Particles. Jun Xi Lee, Sundarrajan Subramanian, RAJASEKHAR BALASUBRAMANIAN, *National University of Singapore*

Air filters are widely used to protect indoor building occupants from being adversely affected by toxic components in airborne particulate matter (PM). Conventional air filters based on nonwoven fibers are not capable of capturing fine particles (PM2.5) efficiently due to the micro-sized fiber diameter. To enhance the filtration efficiency of the filter media, it is necessary to make much thicker media for smaller pore sizes. However, thicker filter media can be difficult to use due to increased pressure drop, and thus higher energy cost. In recent years, nanofiber-based filters have received considerable attention for air filtration because of large surface-area-to volume ratio and low basis weight, nanoporous structures, as well as the uniform size electrospun nanofiber materials, contributing to their enhanced filtration performance. A major drawback of nano-sized filters is that they cannot be used alone due to their low mechanical strength. To overcome this problem, we combined the advantages of electrospun nanofibers with those of conventional filter media to yield hybrid functional membranes. Nanofiber coated filters showed much higher filtration efficiency without any increase in the pressure drop than the conventional filter media. In addition, the filters can be reused. Consequently, the operating life of the filter media is eventually expected to be longer.

8CM.8

Electrodynamic Mitigation of Dust for Solar Panels via Computational Simulation. Chesnutt Jennifer, Husain Ashkanani, Chia-Yang Chen, Hiroyuki Kan, Rowan Malvezin, Satoru Watano, Hideya Nakamura, Bing Guo, CHIH-HSIANG CHIEN, Chang-Yu Wu, *University of Florida*

A largely neglected aspect necessary to prevent energy losses of solar panels is efficient and cost-effective mitigation of dust soiling. A potential solution is an electrodynamic dust shield (EDS) to transport dust off panels via electrodynamic waves generated by electrodes on panel surfaces. Accordingly, the objectives of this research were to determine the effects of EDS design and operating parameters, as well as dust particle size, on cleaning efficiency, and to establish EDS optimization. With a standing square wave, inclined EDS, and 20-micron diameter particles, simulation results showed the optimal distance between electrodes was 14 mm, which resulted from a balance between increasing pitch that aided dust transport off the panel and concomitant decreasing electric field strength that hindered transport. Optimal voltage was 2.8 kVp-p, while particles remained adhered to the surface at low voltages but at high voltages were often repelled and attracted by the same electrode because they remained airborne during the next phase change. To optimize waveform with 20-micron diameter particles and with conditions closely matching an inclined experimental EDS with 7-mm pitch, 6-kVp-p voltage, similar results were obtained with square, sine, and triangular waveforms. Most particles adhered to the surface with ~10% cleaned for all waveforms; only a few particles had large enough charge and were close enough to electrodes to experience a Coulomb force large enough to lift particles against adhesion and gravity. Hence, with respect to implementation, the square waveform was deemed optimal. Overall, under various conditions, such as horizontal or inclined EDS, traveling or standing wave, low or high particle adhesion, and presence of single or multiple sizes of particles (10 to 200 micron diameter), 10-micron diameter particles were the most difficult to clean, often traveling slightly in the direction opposite to larger particles.

8CO.1

Effect of Residence Time on Chemical Composition of Soot in Inverted Gravity Diffusion Flames. KARTIK TIWARI, Justin Davis, Igor Novosselov, *University of Washington*

The effect of residence time and fuel flow rates on the chemical composition of soot are studied in an Inverted Gravity Flame Reactor (IGFR) for methane- air diffusion flame. Although the mechanism for soot surface reactions, dimerization and coalescence are studied by several research groups; the transition of gas-phase species to liquid or solid particles is still not well-understood. Due to buoyancy force acting opposite to the inertial force, IGFR leads to longer residence times including recirculation of flow near the flame front. This provides a conducive environment for carbon soot growth producing large primary particle sizes (≈ 60 nm). The mass flow rates of methane and air are varied to achieve the desired residence time and flame structures. Soot formed in IGRF and upright flame under these conditions is analyzed using an electron microscope. The characterization of soot chemical composition is performed using gas chromatography/mass spectroscopy (GC/MS). Raman spectroscopy is used to characterize the structural order and determine sp2/sp3 carbon ratio of the soot formed in the two reactors. Numerical simulations based on detailed methane chemistry and moment closure for soot particle population balance equation also confirmed higher primary particle size for IGFR. Chemical Reaction Network modeling using detailed mechanisms for reactions of Polyaromatic Hydrocarbons (PAH) showed larger concentrations of higher PAHs with recirculation of flow. The comparison of in primary particle size distribution and their chemical composition for IGFR and upright flame provides a better understanding of soot growth mechanism.

8CO.2

Chemical Composition of Emissions Originating from Biomass and Municipal Solid Waste Burning in a Masonry Heater. MATTHEW BLOSS, Fanni Mylläri, Minna Aurela, Marek Maasikmets, Hanna Lii Kupri, Keio Vainumäe, Pauli Simonen, Laura Salo, Ville Niemelä, Topi Rönkkö, Hilkka Timonen, *Finnish Meteorological Institute*

In this study, wood logs or a combination of wood logs and normal household plastic waste called as municipal solid waste (MSW) were burnt in a masonry heater. The fire was lit by the top down method, which provides a higher heat from the start reducing the amount of unburnt emissions. After the fire had begun to die down, additional logs were added. The flue gases were diluted using a double ejector diluter. The emissions of three burning phases, ignition, flaming and smouldering were measured. The emissions of submicron particles were analysed using a Soot Particle - Aerosol Mass Spectrometer (SP-AMS), to gain information on the real time mass concentration, chemical composition and size distribution of submicron particles as well as concentrations of refractory black carbon (rBC) and some metals. Physical properties (e.g. number size distribution, number concentration) of submicron particles and concentrations of trace gases were also measured with an ELPI, CPC, FTIR and SMPS. The secondary aerosol formation potential was also studied by using a PAM (Potential Aerosol Mass) chamber which allowed simulation of the atmospheric aging of the emissions.

The aim was to compare primary and secondary emissions originating from biomass burning and from the inclusion of MSW to biomass burning. During ignition, primary particulate matter (PM) mostly consisted of BC and organics, very little inorganics were present. During the burning phases inorganics especially nitrate concentration in the particles increased with a decrease in organics. rBC concentrations remained the same for both primary and secondary, as expected. It was found that the PM mass and the amount of oxidised organic compounds were increased after the PAM chamber.

8CO.3

Morphology and Internal Structure of Soot Carbon Characterized by Transmission Electron Microscopy and Raman Spectroscopy. RAMIN DASTANPOUR, Alberto Baldelli, Steven Rogak, *University of British Columbia*

Accurate measurement of the properties, emission rates, and environmental impacts (i.e. climate forcing) of black carbon particles depend on precise measurements of their composition, morphology, and internal structure.

This study investigates the morphology, internal structure, and graphitisation level of soot particles produced at different conditions with a combination of Transmission Electron Microscopy (TEM), High Resolution TEM (HRTEM), Raman Spectroscopy, and Surface Enhancement Raman Spectroscopy (SERS). Particles were collected at different operating conditions from an inverted diffusion burner and a lab-scale flare of up to 80 mm in diameter with turbulent flames up to 3 meter tall.

Size distributions of the soot particles and their constituting primary particles were measured by TEM. This method provides visual observation on the structure of individual soot particles and quantitative measurements are performed on the images produced. The internal structure of the particles was measured by HRTEM. An image processing program was developed to characterize the length, tortuosity, and spacing of the graphite layers (fringes). This method provides both qualitative and quantitative information on how graphitic or amorphous soot particles are.

Raman spectroscopy is a method commonly used for the analysis of various forms of carbons. This method was used in parallel to the HRTEM method to distinguish different types of soot by their degree of graphitization and to estimate the crystal sizes in disordered carbon. Due to a low collection rate, SERS was used to increase the Raman signal. This technique is used for the first time with flame-made carbon soot. Substrates of silver nanofibers are placed on the collection system generating an enhancement of the scattering signal in the order of 10^4.

8CO.4

Predicting Fouling and Slagging Tendencies during Ash Deposition in Non-isothermal, Turbulent Parallel Flows: Applications to Utility Boilers. AKSHAY GOPAN, Zhiwei Yang, Richard Axelbaum, *Washington University in St. Louis*

Staged, pressurized oxy-combustion (SPOC) is a unique process that burns coal under pressure with low flue gas recycle, and is a promising technology for CO_2 mitigation in coal-based power plants. One of the challenges of this technology is to minimize ash deposition and slagging in the boiler. The SPOC boiler features a co-axial, turbulent parallel flow, which is completely different from the swirl- or recirculation-based flows in conventional coal-fired boilers. The difference in flow leads to different ash deposition behaviors. To better understand ash deposition under these conditions, the particle transport and heat transfer processes are modeled in a non-isothermal, turbulent parallel flow. The particle impact rates and particle deposition temperatures (i.e., the temperature of a particle when it hits the wall) for different sized particles are predicted. These two parameters are critical in determining the ash slagging tendency in a pressurized boiler. Simulation results show that, with the boundary layer being accurately resolved and an appropriate turbulence model being carefully chosen, the predicted particle impact rate agrees well with experimental data from the literature. For particle cooling, we defined a non-dimensional particle deposition temperature, T_d^+, and a non-dimensional characteristic time for particle cooling, τ_T^+. Simulation results showed T_d^+ is a function of only τ_T^+ and the non-dimensional particle relaxation time, τ^+. When τ^+ is less than 5, the deposition temperature is always close to the wall temperature. When τ^+ is larger than 5, T_d^+ increases with τ_T^+/τ^+. Since for most practical boiler models the near-wall mesh can't be refined enough to finely resolve the viscous boundary layer, an empirical relation to extend the results to practical boilers with coarse near-wall mesh will also be presented.

8CO.5

Evaluation of Semi-Empirical Soot Formation Models in Strained, Oxygen-Enriched Flames. PHILLIP R. JOHNSON, Benjamin M. Kumfer, *Washington University in St. Louis*

Soot is carbonaceous particulate formed during hydrocarbon combustion. Its presence in industrial boilers and furnaces plays an important role for radiation heat transfer and its emission to the atmosphere affects both the environment and human health. For these reasons, soot volume fraction is often included in CFD combustion models of industrial systems. The complexity of modeling in such applications has led to the widespread use of semi-empirical models rather than computationally-expensive detailed models. Many of these models were developed for a particular application and validated under fuel-air combustion conditions with a specific characteristic mixing time; their use in a different contexts, such as oxy-combustion, can lead to inaccurate predictions. In this study, commonly used semi-empirical soot models and their ability to respond to oxygen enrichment and variable-strain conditions are evaluated. As reported in the literature, a soot-producing flame can become non-sooting (blue) with the combination of oxygen enrichment and fuel dilution, even while maintaining constant flame temperature. In addition, soot-producing flames may become blue with increasing strain rate. In this work, a series of counter-flow flames are modeled which span the sooting-to-non-sooting transition. Flames are modeled using the OPPDIF code and results are post-processed to include soot formation rates and particle transport . Results indicate that these models do not adequately capture the sooting-to-non-sooting transition and thus will be inaccurate under conditions of oxy-combustion or variable strain.

8CO.6

Three-Wavelength Optical Characterization of Fresh and Photochemically-Aged Aerosols from Siberian Peat Burning. MICHEALENE IAUKEA-LUM, Chiranjivi Bhattarai, Deep Sengupta, Patricio Piedra, Jessica Connolly, Vera Samburova, Andrey Khlystov, Adam Watts, Hans Moosmuller, *Desert Research Institute*

Carbonaceous aerosols emitted by biomass burning greatly influence radiative forcing and climate on regional and global scales. In this study, we characterized the optical properties of emissions from the laboratory combustion of Siberian peat. This fuel frequently burns in large and long-lasting wildland fires affecting boreal and arctic ecosystems. Peat burns mostly in smoldering combustion, emitting large amounts of organic and brown carbon. Here, we characterized the optical properties of both fresh and photochemically-aged emissions. Atmospheric aging was simulated using a Potential Aerosol Mass (PAM) flow reactor, which was operated with different ultraviolet actinic fluxes to simulate atmospheric aging on timescales ranging from days to months. Aerosol characterization utilized real time instruments including a photoacoustic three-wavelength soot spectrometer (PASS) and a scanning mobility particle sizer (SMPS) with additional analysis of aerosols collected on quartz and Teflon filters. Three-wavelength optical properties of fresh and aged aerosols including single scattering albedo and absorption and scattering Ångström exponents will be presented. In addition, retrieval of complex refractive indices will be discussed.

8CO.8

Chemical Characterization of Submicron Aerosol Particles and Light Extinction Apportionment before and during Heating Season in Beijing, China. QINGQING WANG, Yele Sun, Qi Jiang, Wei Du, Chengzhu Sun, Pingqing Fu, Zifa Wang, *Institute of Atmospheric Physics, CAS*

Despite extensive efforts into characterization of the sources and formation mechanisms of severe haze pollution in the megacity of Beijing, the response of aerosol composition and optical properties to coal combustion emissions in the heating season remain poorly understood. Here, we conducted a 3-month real-time measurement of submicron aerosol (PM1) composition by an Aerosol Chemical Speciation Monitor and particle light extinction by a Cavity Attenuated Phase Shift extinction monitor in Beijing, China from 1 October to 31 December 2012. The average (±σ) PM1 concentration was 82.4 (±73.1) µg/m3 during heating period (HP, 15 November – 31 December), which was nearly 50% higher than that before HP (1 October – 14 November). While nitrate and secondary organic aerosol (SOA) showed relatively small changes, organics, sulfate and chloride were observed to have significant increases during HP, indicating the dominant impacts of coal combustion sources on these three species. The relative humidity - dependent composition further illustrated an important role of aqueous-phase processing for the sulfate enhancement during HP. We also observed great increases of hydrocarbon-like OA (HOA) and coal combustion OA (CCOA) during HP, which was attributed to higher emissions at lower temperatures and coal combustion emissions, respectively. The relationship between light extinction and chemical composition was investigated using a multiple linear regression model. Our results showed that the largest contributor to particle extinction was ammonium nitrate (32%) and ammonium sulfate (28%) before and during HP, respectively. In addition, the contributions of SOA and primary OA to particle light extinction were quantified. The results showed that the OA extinction was mainly caused by SOA before HP, and by SOA and CCOA during HP, yet with small contributions from HOA and cooking aerosol for the entire study period. Our results elucidate substantial changes of aerosol composition, formation mechanisms, and optical properties due to coal combustion emissions and meteorological changes in the heating season.

8CO.9

Air Quality Implications of Replacing Natural Gas with Biomethane in Vehicles and Home Appliances. YIN LI, Jian Xue, Chris Alaimo, Joshua Peppers, Peter Green, Norman Kado, Minji Kim, Christoph Vogel, Ruihong Zhang, Thomas Young, Michael Kleeman, *University of California, Davis*

Biomethane is a renewable fuel produced from bacterial degradation of biomass under anaerobic condition that has great potential to be widely used in California. Compared to traditional fossil fuels, the use of biomethane helps reduce GHG emission and contributes to the overall carbon balance. Biomethane and traditional natural gas have comparable energy values, but biomethane contains trace compounds that are not present in natural gas. The health effects of the residual trace compounds must be fully analyzed before biomethane can be widely adopted as a fuel for use in industry, transportation, and residential applications.

In this study, the chemical composition and potential health impacts of biomethane and its combustion products were compared with those of natural gas. Three different biomethane sources and two different natural gas sources were collected and analyzed to characterize potential air pollution resulting from fugitive emission. Biomethane and natural gas were then used as fuel for a cargo van. Tailpipe emission was injected into a 5.5 m3 photochemical chamber to study the final products after atmospheric aging under both dark and light conditions. Finally, biomethane and natural gas were used in a residential water heater and a cooking range to study their exhaust either after atmospheric aging (water heater) or after releasing into indoor environment (cooking range). Gas and particle samples were collected on a wide variety of sampling media to support comprehensive analysis for each of the scenario described above. Results from chemical, biological and toxicological analysis will be presented, and the air quality and human health implications of widely adopting biomethane as a substitute for natural gas will be discussed.

8CO.10

Emission Factors of Carbonaceous Aerosol and Brown Carbon Constituents for Biomass Fuel Combustion in Rural Cookstoves: A Field Study. ANNADA PADHI, Gazala Habib, Ramya Sunder Raman, *IIT Delhi*

Carbonaceous aerosol emissions from biomass fuel combustion in cooking stove is an important and less understood contributor to climate forcing over South Asian region. Also the contribution of brown carbon (BrC) from this source is unresolved and need utmost importance to understand climate change. The global simulations suggest that the strongly absorbing BrC contributes up to +0.25 W m^{-2} or 19% of the absorption by anthropogenic aerosols. Emissions from biomass burning are a significant source of brown carbon (BrC) in the atmosphere. On field studies on emission of OC, EC and BrC from biomass fuel combustion in cookstoves are particularly limited in key regions like India, where over 80% of residential energy requirement meet through these fuels. In this study, we present the mass emission factor of OC, EC, and BrC from on-field measurement of fine aerosol during meal preparation in villages of North India. The emission measurement was conducted during regular cooking of the household using biomass fuel as a source of cooking energy. Fine aerosol samples were collected on quartz filters with the help of a multistream sampler equipped with cyclone saperator designed for cutoff diameter 2.5 µm at 10 lpm flow rate. The filters were subjected for OC, EC and Brc analysis using standard protocols. This study, will present the emission factor of carbonaceous aerosol and brown carbon and will discuss its climate implications.

8CO.11

Black Carbon and Nox Measurement from Three Ocean Going Vessels. JIACHENG YANG, David R. Cocker III, Kent C. Johnson, Wayne Miller, Thomas D. Durbin, Yu Jiang, Georgios Karavalakis, *University of California, Riverside*

Ship transportation plays a major role in the global economy and international trade by contributing to 80% of global trade by volume and over 70% of global trade by value. Black carbon (BC) emissions from ocean going vessels (OGVs) are a concern in terms of global warming and human health, especially in the Arctic regions where BC is associated with accelerated ice melting due to light absorption by BC deposited on the ice. Currently, ship-related BC emission factors range from 0.1 to 1 g/kg fuel. Uncertainty in BC emission factors is magnified by the use of a multitude of analytical instruments measurement technologies based on a variety of scientific principles. Therefore, it is necessary to quantify and standardize measurements of BC emissions from OGVs.

This study utilizes three different BC measurement methods conducted on each of three OGVs operating with heavy fuel oil (HFO) or marine gasoline oil (MGO). The ship fleet include two Tier 2 vessels and one Tier 0 vessel. The instruments utilized were an AVL microsoot sensor (MSS), which represents a light absorption photoacoustic method, an AVL smoke meter, which represents a paper-based light absorption method, and a thermal optical method, which characterizes elemental carbon (EC) emissions from a Quartz filter using the NIOSH protocol. The light absorption photoacoustic method correlates well with the paper-based light absorption method for all three vessels. However, the Quartz filter method differentiate while the ship was operating with HFO fuel. Sulfur PM dominated the PM mass when the engine burned HFO, which made the relative BC loading on the Quartz filters small. When running the heating procedure for the NIOSH ECOC Quartz filter, unexpected pyrolysis of organic carbon to BC occurred at the early heating stage, which led to a high BC result by impacting the ECOC split point. Since the NIOSH ECOC method was initially created for health study purposes, it may be worth revisiting that method to take into consideration the sulfur or heavy metal effect on EC measurements.

8CO.12

Sampling Temprature Effects on the Size Distribution of Paricles Emitted by a Two-Stroke Engine.

Ricardo Morales Betancourt, YADERT CONTRERAS BARBOSA, Ana Paola Corredor, Joseph Herrera, Juan Camilo Vigoya, *Universidad de los Andes*

In this work we estimate the particle number and mass emissions produced by a 50 c.c two-stroke engine working with an oil-gasoline mixture as fuel. Exhaust gases were sampled and analyzed with an Electrical Low Pressure Impactor Dekati Mass Monitor (DMM-230) after dilution of the sample with a two stage ejection diluter. Two operating conditions were explored: Full Throttle engine load and at Idle. A new data inversion method was developed for the analysis of the raw data of the DMM-230. This new inversion method allows to calculate the number size distribution without the need of assuming a log-normal shape. The data inversion method is a modification of previous inversion algorithms (Mamakos et al., 2007). To interpret the effect of temperature on the size distribution of particles a sectional aerosol model was employed to simulate the transformations undergone by the aerosol size distribution in the sampling line. The TwO-Moment Aerosol Sectional (TOMAS) was used. Aerosol particles are assumed to be formed of five components, elemental carbon, water, sulfate, and two components of semi-volatile organic carbon. The two-component organic carbon model used here was used successfully to predict partitioning in other studies (Shrivasrava et al., 2006). To ensure reproducibility of the measurements, a total of 40 samples were carried out. In some of these samples heated diluted air was used to explore the effect of temperature on the size distribution. Results indicate that at higher sampling temperatures the characteristic fine mode of the 2-stroke engine exhaust emissions decreases in size, suggesting it is mainly composed of semi-volatile organics. At lower sampling temperatures, semi-volatile organics condense on the particles increasing the particle size. The measurements are consistent with the results obtained with the sectional aerosol model. Large values for the emission factors were observed, ranging from 120 to 250 grams per kilogram of fuel. Similar values were obtained with a carbon balance method.

8CO.13

Size, Mass-Mobility, Effective Density, and Volatility of Soot Particles Generated from Large-Scale Turbulent Diffusion Flames.

MOHSEN KAZEMIMANESH, Melina Jefferson, Alireza Moallemi, Kevin Thomson, Matthew Johnson, Jason S. Olfert, *University of Alberta*

Size distribution, mass-mobility, effective density, and volatility of soot particles generated from a large-scale turbulent diffusion flame was characterized under various fuel composition and exit velocity conditions. The turbulent diffusion flame was set up at Carleton University Lab-scale Flare (CULF) facility which allowed controlled experiments on turbulent flames up to approximately three meters tall at fuel gas flow rates up to ~250 SLPM (standard litres per minute at 0°C and 101.325 kPa). Three different burner sizes with a diameter of 38.1, 50.8, and 76.2 mm were used in this study. The fuel exit velocities at the burner tip were 0.5, 0.9, and 1.5 m/s and the fuel flow rates were adjusted accordingly for each burner size, which resulted in a range of flow rates from 60.5 to 246.2 SLPM. Three different fuel mixture compositions (light, medium, heavy) were tested which resembled Alberta flare gas composition. The fuel gas mixture had 6 components (i.e., C1 to C4 alkanes, carbon dioxide, and nitrogen) and the mole fraction of methane in the light, medium, and heavy composition was 0.925, 0.866, and 0.769, respectively.

Combustion products were diluted by the ambient air on the order of ~20:1 to ~120:1 as they were drawn in the collecting fume hood and insulated duct using a variable speed fan. Size distribution of soot particles was measured using a scanning mobility particle sizer (SMPS), sampling from the downstream of the duct and after the sample was further diluted by a factor of ~8:1 using an ejector diluter. Mass-mobility relation of soot particles were studied by a tandem arrangement of a differential mobility analyzer (DMA), a centrifugal particle mass analyzer (CPMA), and a condensation particle counter (CPC). Such arrangement was also used to determine the effective density of soot particles. The volatility of particles was studied by adding a catalytic stripper denuder between the DMA and the CPMA. Results showed that the total particle concentration ranged from 9.13×10^{6} cm^{-3} to 4.85×10^{7} cm^{-3}corresponding to light fuel mixture burned in the 76.2 mm burner at 232.5 SLPM and heavy fuel mixture burned in the 50.8 mm burner at 60.7 SLPM, respectively. The particle median diameter did not change significantly for medium and heavy fuel mixtures with various burner sizes and fuel flow rates and was approximately 100 nm; however, it was consistently smaller at ~55 nm for light fuel mixture and different burner sizes and fuel flow rates. Mass-mobility and effective density results showed that the average mass-mobility exponent, D_m, was approximately 2.55 for all combustion conditions, which is in good agreement with the reported values for the mass-mobility exponent of particles from different combustion sources in the literature (i.e., 2.49). Finally, the results showed that the mass fraction of volatile coating on the soot particles was negligible for all studied combustion conditions.

8CO.14

Effects of Fuel Moisture Content on Pollutant Emissions from a Rocket-Elbow Cookstove. LIZETTE VAN ZYL, Nicholas Good, Kelsey Bilsback, Kristen Fedak, John Volckens, *Colorado State University*

Rudimentary cookstoves are a major but poorly quantified source of air pollution. Fuel moisture content is expected to be an important determinant of cookstove emissions, however it has been investigated in few studies and for a limited number of climate- and health-relevant pollutants.

We measured emissions from fuels with 5%, 15%, and 25% fuel moisture contents. The tests were conducted in a controlled laboratory environment on a rocket-elbow cookstove with chopped and milled Douglas fir wood from the same tree. Gas-phase emissions measurements included carbon dioxide, carbon monoxide, and volatile organic compounds. Particle-phase emissions included $PM_{2.5}$, elemental carbon, organic carbon, and ultrafine particles.

At 5% fuel moisture content, $PM_{2.5}$ emissions (grams per kilogram of fuel burned) were reduced by 63% ($p<0.001$) compared to 25% fuel moisture content. The $PM_{2.5}$ composition changed significantly between 5% and 25% fuel moisture content, with the elemental carbon to organic carbon ratio decreasing from 1.2 at 5% to 0.1 at 25% ($p<0.001$). Carbon monoxide emissions (grams per kilogram of fuel burned) were reduced by 49% ($p=0.001$) at 5% compared to 25% fuel moisture content. Carbon dioxide emissions did not change significantly ($p=0.6$) between fuel with 5% and 25% fuel moisture content. The hand cut and milled fuels showed no significant differences ($p>0.05$) in pollutant specific emissions on a dry fuel-mass basis, suggesting no comparative benefit of either preparation method.

These results suggest that using fuel with 5% moisture content instead of 25% substantially reduces emissions of some health-relevant pollutants. Our results indicate that drying fuel below the EPA recommended 20% moisture content could be of further benefit. Analysis of emission factors for volatile organic compounds, carbonyls, and ultrafine particles is currently underway.

8CO.15

Black Carbon Measurement Intercomparison during the 2017 Black Carbon Shootout. TAYLOR SHINGLER, Richard Moore, Claire Robinson, Edward Winstead, Ewan Crosbie, Luke Ziemba, Kenneth Thornhill, Michael Shook, Bruce Anderson, *NASA*

The NASA Langley Aerosol Research Group (LARGE) provides multiple black carbon (BC) based aerosol particle measurements and engine emission factors for airborne and ground-based field campaigns and laboratory studies. These datasets are made available to the general public where accuracy is key to enable further use in environmental assessments, models, and validation studies. Studies are needed to establish the accuracy and precision of BC measurements of particles with varying physical properties using variety of detection techniques. Work is also needed to develop calibration and correction schemes for new sensors and to link these measurements to heritage instruments on which our understanding of BC emissions and characteristics has been established. Black carbon particles were produced from a mini-CAST (Jing) diffusion flame soot generator and passed to instruments measuring optical absorption, extinction, scattering, and black carbon mass. Generated particles were analyzed with and without treatment from a 350 C thermal denuder. Filter based measurements of optical absorption were performed using a PSAP (Radiance Research) and a TAP (BMI). Absorption was also measured using two photoacoustic based instruments: the MSS-plus (AVL) and PASS-3 (DMT). Measurements of aerosol extinction and scattering were performed using three CAPS PM-ex (Aerodyne Research) instruments at multiple wavelengths and an integrating nephelometer (Air Photon). Black carbon mass was also measured using laser incandescence from two separate LII-300 (Artium Technologies) instruments (standard and high-sensitivity). Mass measurements were inferred using filters collected concurrently during sampling and analyzed by an OC/EC (Sunset Labs). Black carbon quantification measurements are analyzed between instruments to assess agreement between platforms using manufacturer's calibration settings as well as after calibrations performed to a single standard soot source (mini-CAST).

8ET.1

Single Particle Studies of Atmospheric Meteor Ablation.

DANIEL CZICZO, Daniel Murphy, *MIT*

Single-particle analyses of stratospheric aerosol show that about half of the particles contain meteoritic components. Although predominantly sulfuric acid and water by mass, a few weight percent, including 0.5 to 1.0 iron by mass, can be attributed to an extraterrestrial flux to the atmosphere. This material likely ablated at ~100 km altitude, condensed and coagulated to form meteoritic 'smoke' particles, and then acted as condensation centers for sulfuric acid and water as they gravitationally settled through the stratosphere. The overall mass of material can be used to infer an extraterrestrial flux of 8 to 28 gigagrams per year. Component ratios, such as sodium/iron, magnesium/iron and calcium/iron can be compared to common meteorites and imply that the fraction of material that is ablated must lie at the low end of previous estimates. This result suggests the extraterrestrial component that resides in the mesosphere and stratosphere is not of chondritic composition but is instead enriched in volatiles and correspondingly depleted in more refractory components.

8HA.1

Comparison of Aircraft Emissions near Los Angeles International Airport (LAX) to Urban Vehicle Traffic Emissions and Its Impact on Air Quality in Los Angeles.

FARIMAH SHIRMOHAMMADI, Christopher Lovett, Mohammad Sowlat, Sina Hasheminassab, Arian Saffari, George Ban-Weiss, Vishal Verma, Martin Shafer, James Schauer, Constantinos Sioutas, *University of Southern California*

Among various combustion sources of particulate matter (PM) in urban areas, accurate assessment of airport-related emissions and how they compare to other predominant PM sources such as traffic emissions is essential in understanding the impact of airports on air quality and human health. Air monitoring measurements of particle number (PN), black carbon and PM2.5 mass concentrations were performed in the vicinity of the LAX (roughly 150m downwind of the LAX's south runways) as well as on-road measurements of the aforementioned pollutants using a mobile platform on three major freeways near the airport (i.e., I-110, I-105, and I-405). PN concentration was, on average, 4.1±1.2 times greater at the LAX site than on the studied freeways. Particles measured at LAX had an average diameter of about 20nm, while on-road freeway measurements on I-110, I-105, and I-405 indicated an average particle diameter of >40nm, a particle size range that is more typical of vehicle traffic and not aircraft emissions in urban areas. Particle number emission factors for takeoffs and landings were comparable, with average values of 8.69×10^{15} particles/kg fuel and 8.16×10^{15} particles/kg fuel, respectively, and indicated a nearly 4-fold statistically significant reduction in PN emission factors for takeoffs during the past decade. Moreover, quasi-ultrafine particles ($PM_{0.25}$) were collected near the LAX airport as well as an urban traffic site close to the I-110 freeway. Samples were chemically analyzed for carbonaceous species (elemental and organic carbons) and individual organic compounds, metals and elements. Redox activity of the PM samples was measured by means of an in vitro alveolar macrophage assay that quantifies the formation of reactive oxygen species (ROS) in cells. ROS activity levels showed little spatial variability, with no statistically significant difference between the averages observed at LAX and the urban traffic site, suggesting similar levels of inhalation exposure to redox active species of $PM_{0.25}$.

8HA.2

Effect of Combustion Particle Size on Pathologically Important Responses in Lung Cells. KAMALJEET KAUR, Raziye Mohammadpour, Isabel C. Jaramillo, Robert Paine, Chris Reilly, Hamid Ghandehari, Kerry Kelly, *University of Utah*

Although combustion-derived particulate matter(cdPM) is a significant contributor to fine and ultrafine PM levels, our understanding of its health effects is complicated by cdPM's complex nature: a dynamic mixture of particles and condensed material with different sizes, shapes, and chemical compositions that is generated from a range of sources. Furthermore, several confounding factors make comparing results from various studies of PM's adverse effects difficult including, for cdPM, fuel composition, the age of the combustion device, combustion conditions, lubricants, and sampling methods. For example, experimental and epidemiological studies about the effect of various PM size fractions (PM_{10}, $PM_{2.5}$, and PM_1) provide somewhat conflicting results. As particle size diameter decreases, its relative surface area increases, which in turn increases the bioavailability of atoms or molecules and may lead to increased pro-inflammatory effects. This study focuses on directly testing the effect of cdPM size on biological responses in lung cells.

cdPM with consistent properties is generated from a premixed flat-flame burner combusting a jet-fuel surrogate at an equivalence ratio of 2.1. A nitrogen shroud and a glass housing minimize atmospheric effects. cdPM onsistency is verified by examining the particle size distribution and cdPM composition. The sample is then diluted, thermally denuded, and size separated using a differential mobility analyzer. Three different cdPM size fractions are examined (with particle diameters of 25, 45, and 65 nm) for their effect on oxidative potential, cell viability, cellular uptake, inflammatory response, cytochrome P450 (CYP) 1 A1 and 1 B1 mRNA induction, and the activation of transient receptor potential Ankyrin-1 (TRPA1). The biological outcomes are evaluated in A 549 human alveolar basal epithelial cells, with the exception of the TRPA1, which is evaluated in TRP over-expressing HEK293 cells. These results are a step towards understanding some of the interactions between the links between combustion particle physicochemical properties and health effects.

8HA.3

Nasal Deposition of Aerosols and Sprays in Adults: A Wide Ranging Computational Study. Milad Darunkola, Herbert Wachtel, Michelle L. Noga, Andrew R. Martin, WARREN H. FINLAY, *University of Alberta*

High resolution Computed Tomography (CT) images of the nasal airways of seven adult subjects were obtained, segmented and meshed. Computational Fluid Dynamics (CFD) simulations of the flow and particle motion in these subjects' airways were then performed using OpenFOAM (version 3.0.1) for particle diameters of 5-40 micrometers, spray cone angle of 17.5 and 30 degrees, for two spray release directions (either upward or directed toward the nasal valve), particle injection speeds of 0-20 m/s, flow rates of 0 and 15 L/min, with 200 randomly chosen particle injection locations within each nostril of each subject. This resulted in 224,000 simulations performed over this parameter space. Total deposition in the nose was found to agree with previous in vivo studies. Regional deposition in six regions (vestibule, valve, anterior turbinate, posterior turbinate, olfactory, nasopharynx) was determined for each parameter value. While the data supported expected trends in regional deposition (e.g. deposition in the nasal valve and vestibule increases with particle size and speed), surprisingly high olfactory deposition was found for certain parameter values in some subjects. In particular, injection of particles near the upper wall of the vestibule gave high olfactory deposition (well above 20%), despite an average value of 1.6% olfactory deposition over all parameter values.

8HA.4

Accuracy of the Temperature Control Feature in Advanced Electronic Cigarettes. SEYED AHMAD REZA DIBAJI, Suvajyoti Guha, Bruce Murray, Matthew R. Myers, Aarthi Arab, Jenna F. Dumond, *U.S. Food and Drug Administration, CDRH*

Electronic cigarettes, or electronic nicotine delivery systems (ENDS), are rapidly gaining popularity among tobacco products. ENDS electrically heat a wire coil, made of kanthal, stainless steel, nickel and other materials, and vaporize an e-liquid solution, containing propylene glycerol, vegetable glycerin, and nicotine, to produce an inhalable nicotine-containing aerosol. Compared to earlier devices, many products among the latest generation of ENDS are capable of delivering much higher power (up to 300 Watts) and have a temperature control feature enabling the user to pre-set the temperature of the coil to as high as 300 ˚C. At high temperatures (~ 250 ˚C), e-liquid components have been shown to decompose, resulting in the generation of toxins and carcinogens such as acrolein and formaldehyde. Substantial knowledge gaps exist regarding temperature distribution within the heating coil, as well as the generated aerosol by the latest generation of ENDS. This knowledge is critical for managing the risk associated with ENDS use.

To the best of our knowledge, this is the first study to test the accuracy of the temperature control feature and investigate the temperature of the heating coils. Thermocouples were attached to the heating coil using thermally conductive cement, and temperature measurements were performed for three different brands of e-cigarettes. The measurements were made at different power levels and puffing flow rates. The heating coil temperatures were found to exceed the temperature set point, by up to 117 ˚C, in 4 out of the 12 devices tested. The recorded temperatures also revealed a substantial variation along the coil length, with the mid-coil temperature significantly exceeding the temperature at the endpoints (sometimes by 100 ˚C). The results provide insight into functionality of the temperature control feature provided in ENDS and, when correlated with known toxin production at different temperatures, will be useful in assessing the risk associated with ENDS.

8HA.5

Comparison of Airway Responses Induced in a Mouse Model by the Gas and Particulate Fractions of Gasoline Direct Injection Engine Exhaust. CAITLIN MAIKAWA, Naomi Zimmerman, Manuel Ramos, Mittal Shah, James S. Wallace, Krystal Godri Pollitt, *University of Massachusetts Amherst*

Exposure to environmental pollutants can exacerbate asthmatic symptoms as well as induce airway inflammation and mucus production. Whilst exposure to diesel exhaust has been associated with asthma exacerbations, the response to other engine type emissions is not clear. The increasing prevalence of vehicles with gasoline direct injection (GDI) engines motivated this study. The objective of this study was to evaluate the pulmonary responses induced by acute exposure to gasoline direct injection engine exhaust in an allergic asthma murine model. Balb/c mice were sensitised with an allergen (Dermatophagoides pteronyssinus) to induce airway hyperresponsiveness or treated with saline as the control group. Saline- and allergen-sensitised mice were challenged for two hours to engine-out exhaust from a laboratory GDI engine operated at conditions equivalent to vehicle highway cruise conditions. Exhaust was filtered to assess particulate and gas fractions. Lung mechanics and mRNA production were evaluated post-exposure as well as the inflammatory airway response through histology examination. Particulate matter released from GDI engine exhaust induced upregulation of a genes related to polycyclic aromatic hydrocarbon (PAH) metabolism (Cyp1b1), inflammation (Tnfα, Cxcl1) and remodelling (Vegf) in the lungs of naïve mice. High molecular weight PAHs dominated the particulate fraction of the exhaust and were likely attributable to this response. Mice with airway hyperresponsiveness exhibited elevated basal levels of airway inflammation, compared to naïve animals, such that no differences were found between GDI engine exhaust and HEPA filtered air exposure scenarios as noted by mRNA production and histology examination. Exposure to particle fraction of GDI engine exhaust by allergen-sensitised mice was further found to enhance resistance in the central airway and dampening in the peripheral tissues in response to methacholine. As GDI engines become more predominant in the global vehicle fleet, understanding the impacts of their tailpipe emissions on respiratory health becomes increasingly important. Short-term exposure to particulate PAHs released from GDI engine exhaust exacerbates airway inflammation and remodelling in naïve mice. The particle fraction of GDI engine exhaust further contributed to enhanced methacholine responsiveness in the central and peripheral tissues in animals with airway hyperresponsiveness.

8HA.6

Sampling Efficiencies of two Modified Cascade Impactors.

JANA KESAVAN, Pamela Humphreys, Daniel Mcgrady, Garrett Nelson, Meera Kesavan, Ana Rule, *US Army Edgewood Chemical Biological Center*

Prevention of airborne contagious diseases depends on successful characterization of aerosols in the environment. Andersen viable cascade impactors have been extensively used to characterize the size and concentration of culturable biological aerosols. Recently, several studies have modified the Andersen cascade impactors to acquire more information than what is provided by traditional use of agar-based impactors. In this study, we evaluated a method recently published that used liquid instead of agar in the Petri dishes (CI-L) and compared it to a method that uses wet membrane filters on top of wax-filled Petri dishes (CI-WWMF) as collection surfaces. Sampling efficiencies of the cascade impactors were evaluated using 0.5, 1, 3, and 5 µm polystyrene latex (PSL) microspheres and single spore Bacillus atrophaeus var. globigii (BG). The sampling efficiency of the CI-L was 5%, 11%, 17%, 21% and 58% for 0.5, 1, 3, 5 µm PSL and BG. Higher overall sampling efficiencies of 76%, 91%, 60%, 64% and 73% were observed for the same size and type of particles for the CI-WWMF. This study indicates that using wet filters on top of wax-filled Petri dishes (CI-WWMF) in a viable cascade impactor is a more efficient method for size-selectively collecting biological aerosols into liquid from the environment and can be used in health care settings to determine the size distribution of bioaerosols.

8HA.7

Simulation of Particle Deposition in Laryngotracheal Stenosis Using Computational Fluid Dynamics.

TRACY CHENG, David Carpenter, David Witsell, Seth Cohen, Dennis Frank-Ito, *Duke University School of Medicine*

Laryngotracheal stenosis (LTS) is a compression or narrowing of the endolaryngeal/endotracheal airway often caused by intubation during surgery. LTS patients experience significant respiratory morbidity which may progress to acute airway compromise if not properly managed. One common medical therapy for LTS is inhaled corticosteroids to prevent granulation tissue formation after surgery. However, these corticosteroids inhalers were designed to target lower airway deposition in asthma treatment rather than the endolaryngeal/endotracheal airway. In this study, computational fluid dynamics modeling was used to investigate drug particle transport in endolaryngeal/endotracheal airway three-dimensional models of 10 LTS subjects with glottic stenosis (3 subjects), subglottic stenosis (3 subjects), and tracheal stenosis (4 subjects). Airflow and particle transport were simulated through these LTS models with particles sizes ranging from 1-50µm at a velocity of 1m/s. Airflow simulations were conducted with an inspiratory pressure of 25Pascals through both nostrils and mouth for all subjects. Glottic stenosis subjects had the highest total particle deposition fraction across all particle sizes in the stenotic region (6.6-34.8%) compared to subglottic (0.5-3.4%) and tracheal (0.1-1.1%) stenosis subjects. In addition, particle sizes with the most deposition fraction (DF) in the stenotic region for glottic stenosis subjects were 8µm (DF=84.9%), 17µm (DF=28.2%), and 19µm (DF=82.7%); for subglottic stenosis subjects, 1µm (DF=6.8%), 10µm (DF=15.6%), and 11µm (DF=3.3%); and for tracheal stenosis subjects, 4µm & 5µm (DF=2.8%), 7µm (DF=0.6% & 7.7%), and 10µm (DF=4.3%). Furthermore, the number of different particle sizes (and largest particle size; LPS) depositing into the stenotic region for glottic stenosis subjects was between 46 and 50 different particle sizes (LPS=50µm); between 8 and 29 different particle sizes (LPS=33µm) for subglottic stenosis subjects, and between 14 and 30 different sizes (LPS=37µm) for tracheal stenosis subjects. These results suggest that particle deposition may differ in LTS depending on the anatomic location of stenosis.

8HA.8

Scaling the Idealized Infant Nasal Airway to Mimic Average Deposition in Neonates. Scott Tavernini, Tanya Church, David Lewis, Michelle L. Noga, Andrew R. Martin, WARREN H. FINLAY, *University of Alberta*

While we have recently quantified the nasal filtration properties of realistic neonatal (newborn) infant nasal airways, it is unknown if the Alberta Idealized Infant Nose (AIIN), designed to mimic average deposition in 3-18 month old infants, can be scaled to mimic average deposition in neonates. Due to the rapid changes and rate of growth occurring in infants after birth it is expected that the AIIN model developed for older (3-18 month old) infants will under predict nasal filtration in the younger population simply due to its size. Idealized airway geometries are useful for the design of aerosol delivery devices for pharmaceutical applications as well as atmospheric aerosol studies where lung dose is of interest. This study sought to identify a scaling factor to be applied to the AIIN to produce a model with the appropriate characteristic diameter, and evaluate the ability of this scaled model to successfully mimic average deposition in the 0-3 month old population. Deposition characteristics of the idealized model was measured by passing a representative aerosol (jojoba oil) through two paths, one including an airway model and the other a blank sampling line, under varying flow conditions. The aerosol distribution was measured by an electrical low pressure impactor (ELPI) downstream of each path. Comparing the distributions gave the deposited fraction of aerosol particles classified by aerodynamic diameter. Non-dimensional analysis of the deposition data to yield empirical correlations that predict deposition was also examined.

8HA.9

Assessing the Biological Effects of Various Components of Isoprene-Derived Secondary Organic Aerosol. MAIKO ARASHIRO, Ying-Hsuan Lin, Kenneth Sexton, Avram Gold, Ilona Jaspers, Rebecca Fry, Jason Surratt, *University of North Carolina at Chapel Hill*

Isoprene (2-methyl-1,3-butadiene), a volatile organic compound released primarily by terrestrial vegetation, is an important precursor to the formation of secondary organic aerosol (SOA). Isoprene-derived SOA, which comprises a large mass fraction of global fine particulate matter ($PM_{2.5}$), results from the atmospheric chemical transformations of isoprene with controllable anthropogenic emissions such as oxides of nitrogen (NO_x) and sulfur dioxide. Through a series of *in vitro* exposure studies, we explored the effects of isoprene-derived SOA on oxidative stress-related gene expression levels in human bronchial epithelial cells (BEAS-2B). We generated atmospherically-relevant compositions of isoprene-derived SOA under light conditions in an outdoor smog chamber to expose BEAS-2B cells to the total isoprene SOA mixture. We then systematically explored the effects of three known composition types of isoprene-derived SOA by generating SOA through dark reactive uptake experiments by starting with key gaseous intermediates, including *trans*-β-isoprene epoxydiol (*trans*-β-IEPOX), methacrylic acid epoxide (MAE), or isoprene hydroxyhydroperoxides (ISOPOOH).

Chemical characterization coupled with biological analyses showed that atmospherically-relevant compositions of isoprene-derived SOA altered the levels of 41 oxidative stress-related genes. Of the different composition types of isoprene-derived SOA, MAE-derived SOA altered the greatest number of genes on the same mass basis. Together, the different composition types accounted for 34 of the genes altered by the total isoprene SOA mixture while 7 remained unique to the mixture indicating that there is either a synergistic effect between the different isoprene-derived SOA components or an unknown active component in the total mixture. Finally, this work reveals an enrichment for altered expression of genes associated with Nuclear factor (erythroid-derived 2)-like 2 (Nrf2), a key transcription factor protecting against oxidative stress, in cells exposed to all types of isoprene-derived SOA.

8HA.10

Toxicological and Chemical Properties of Fine Particles Produced from Various Sources. MINHAN PARK, HungSoo Joo, Kwangyul Lee, Tsatsral Batmunkh, Lucille Joanna Borlaza, Heung-Bin Lim, Han-Jae Shin, Myoseon Jang, Ji Yi Lee, Min-Suk Bae, Kyu-Hyuck Chung, Daeun Kim, Kihong Park, *Gwangju Institute of Science and Technology*

Fine particles in the ambient atmosphere are a complex mixture of various chemical components. Determination of source-specific toxicity can be an useful way to disentangle effects of PM on human health. The goal of this study is to assess variability in toxicity of particles produced from various sources, diesel and gasoline engine, biomass burning, coal burning, and dust, including secondary organic aerosols. Physical and chemical characterization of aerosols was conducted to relate source-specific toxicity of aerosols to their chemical components. In addition, ambient PM samples collected from urban, rural, roadside, and industrial areas were analyzed for determination of their chemical composition and toxicity. Chemical characteristics such as ion, metal, organic carbon (OC)/elemental carbon (EC) was determined by ion chromatography (IC), inductively coupled plasma mass spectrometry (ICP-MS), and thermal-optical transmittance (TOT) method, respectively. OC speciation was conducted by gas chromatography-mass spectrometry (GC-MS). Toxicity test was conducted using chemical and biological assays. For chemical assay, oxidative potential (OP) was measured by OPDTT and OPESR. For biological assay, various end points, cytotoxicity, mutagenicity, oxidative stress, and inflammation, were determined by neutral red uptake (NRU) assay and water soluble tetrazolium salt (WST-1), Ames test and comet assay, DCF-DA (2’,7’-dichlorofluorescein diacetate) assay, IL-6 and IL-8, respectively. A statistical analysis was applied to relate chemical and toxicity of various aerosols. Preliminary results show the rankings of source-specific risks based on the results obtained up to the present can be suggested; 1) Primary aerosols from various sources: DEP > biomass burning particles > coal burning particles (550°C) > Tunnel dust, 2) Secondary organic aerosols: Toluene SOA > Isoprene SOA > TMB SOA > α-pinene SOA, and 3) Ambient aerosols (PM2.5): Roadside > Industrial > Urban > Rural site.

8HA.11

Study on a Commercial Nasal Filter Against Environmental Tobacco Smoke Particulates. JINTUO ZHU, Xinjian He, Steve Guffey, *West Virginia University, Morgantown, WV*

Introduction: Environmental Tobacco Smoke (ETS) is associated with various respiratory diseases. People who live with smokers or work in restaurants, bars, casinos are long-term exposed to ETS. Wearing filtering facepiece respirators (FFRs) may be not feasible for cosmetic and comfortable reasons. Commercially available nasal filters may be a practical alternative for daily use as people breath 90% of air through the nose. However, there is limited research available on the filtration efficiency of nasal filters against ETS smoke particulates.

Methods: A nasal filter testing system was designed. Mainstream smoke (smoke filtered by the cigarette filter) and sidestream smoke (spontaneous combustion smoke) were generated and measured by a TSI NanoScan SMPS (10-420nm, 13 channels) and a CPC (10-1000nm), respectively. Three constant flows (15, 30, and 50 L/min) and three cyclic breathing flows (mean inspiratory flow, MIF = 15, 30, and 50 L/min) were tested. The concentrations of downstream (C_{down}) and upstream of the tested nasal filter (C_{up}) were measured; particle penetration (P) was determined as Cdown/Cup. The total number of runs is 96 (2 smoke aerosols×2 measurement devices×2 flow types×3 flow rates×4 replicates).

Results: The results reported by SMPS and CPC agreed with each other. It was found that the tested nasal filter had limited effectiveness against ETS with almost all penetration values > 50%. The SMPS results showed that as the particle size increased, the penetration decreased. Duncan’s grouping showed that the penetration of sidestream smoke was significantly higher than mainstream smoke, while the penetration under cyclic flow was significantly higher than constant flow. Surprisingly, regardless of the smoke pattern and flow type, as the flow rate increased, the penetration value decreased.

8HA.12

Evaluation of Glass Fiber Lengths Collected on a Screen Using a Periodic Purging Flow System. BON KI KU, G.J. Deye, Leonid Turkevich, *Centers for Disease Control and Prevention, NIOSH*

Classification of airborne fibers by length is important to understand the effect of fiber length on toxicity because fiber length is believed to be an important variable in determining various toxicological responses to asbestos and other elongate mineral particles. Recent studies have shown that nylon mesh screens can be effective in classifying fibers by length and that a purging flow system for harvesting of long fibers collected on a screen may be useful in their recovery. In this study, we have further investigated the evaluation of glass fiber lengths collected on a screen, using the periodic purging flow system. Re-aerosolization of fibers collected on a screen would refine length classification for the fibers with that size range. Fibers aerosolized by vortex shaking were provided to different nylon mesh screens (10, 20, 30, and 41 µm mesh sizes) and the fibers collected on each screen were purged periodically using a computer-controlled purging flow system. The purged fibers were collected on a filter and their lengths were measured using a phase contrast microscope. These fiber length distributions were compared to those determined by washing the screen. It was found that the lengths of the fibers purged by this technique are smaller than those of the fibers from the washed screen. The mean fiber length from the screen are larger than the parent aerosol fibers and the fiber length was in the range of 35-54 µm. The results indicate that the screens have the effect of preferentially capturing the longer fibers, although our measurements have not determined any systematic variation with screen mesh size.

8HA.13

The Impact of Head Composition and Design on the Physical Properties of Waterpipe Tobacco Smoke. CINDY DEFOREST HAUSER, Sarah Coats, David DeGrood, Ronnae Mailig, *Davidson College*

Hookah use is increasingly prevalent among college age students. The health impacts of hookah or waterpipe tobacco smoke (WTS), however, are only poorly understood and potentially hampered by the limitations of approaches comparing WTS to secondhand smoke from cigarettes. The combination of shisha as a very different matrix from cigarette tobacco and indirect heating versus combustion, however, may present unknown health hazards. In particular, we are focused on the potential physical toxicity associated with the inherent physical properties of particles in WTS. In previous studies, we have found that the height of the waterpipe or hookah impacts the distribution and concentration of the particulate component of waterpipe tobacco smoke (WTS). Here, we present the results of systematic investigations into the contribution of different components within shisha as well as the use of charcoal or an electronic heating source to the distribution and concentration of the particulate component of WTS under different smoking regimes. Additionally, the results from preliminary investigations of different hose lengths will be presented.

8HA.14

Bioaccessibility and Health Risk of Trace Elements in Fine Particulate Matter Using Different Simulated Body Fluids.

DONGYANG NIE, Mindong Chen, Xinlei Ge, Yun Wu, *Nanjing University of Information Science & Technology*

Long-term exposure PM2.5-bound metal have been proved to cause hazardous effects to human health. In this study, the bioaccessibility and health risk of trace elements in fine particulate matter were investigated. Four kinds of simulated body fluids were employed to extract the PM2.5 for simulating different exposure routes (inhalation, ingestion and dermal contact). Phosphate buffered saline(PBS) and the artificial lysosomal fluid (ALF) were used as surrogate human lung fluids, artificial sweat(AS) was used for simulating dermal contract, artificial gastric juice was employed to mimic human digestion. It showed that many trace elements were less soluble in PBS than other body fluid, especially for Pb Al. Cu, Mn, V, As were observed to be the most soluble trace elements in all simulated body fluids. The United States Environmental Protection Agency (USEPA) human health risk assessment model was used to assess the carcinogenic and non-carcinogenic effects. The results showed the carcinogenic risks from As, Cr, and Pb were higher than 10-6(an acceptable level for human health) especially for children, indicating that there were potential carcinogenic risks posed by these toxic elements. The high hazard quotient value for As, Cr, and Pb were also observed to children. It suggested that the sampling site was experiencing trace elements pollution, especially for As, Cr, and Pb.

8HA.15

Oxidative Potential of Various Laboratory-generated PM from Biomass Burning, Coal Burning, Fuel Combustion, and Road Dust.

LUCILLE JOANNA BORLAZA, Seojong Kim, Minhan Park, Kwangyul Lee, HungSoo Joo, Kihong Park, *Gwangju Institute of Science and Technology*

Numerous studies have assessed the potential of ambient particulate matter (PM) to generate reactive oxygen species (ROS) via oxidative potential (OP) analysis. But, very limited studies have quantified specific sources of PM and its ROS-generating capability. To address this issue, this study aimed to quantify OP of source-specific PM that are common in ambient particulate matter including biomass burning, coal burning, fuel combustion, and road dust in order to identify PM sources that have higher health impact than the others. Controlled volume chambers and aerosol generating systems were developed for this purpose. Laboratory-generated PM from various sources were collected using URG cyclones at different sampling parameters that closely simulate real-world conditions. Particle size distribution and mass concentration were monitored by coupling an optical particle counter and a scanning mobility particle sizer. Chemical characterization was done by analyzing ions, metals, organic carbon (OC), and elemental carbon (EC) concentrations. Two a-cellular chemical assays were used to characterize OP of water-soluble PM2.5: Dithiothreitol (DTT) and Electron Spin Resonance (ESR) assay. OP-DTT was carried out through assessment of the capability of redox active compounds in PM2.5 to transfer electrons from DTT to oxygen thereby generating superoxides. The consumption of DTT over specific time intervals (5, 15, 25, 35 and 45 mins) was interpreted as a measure of the capability of ambient PM2.5 to produce ROS. On the other hand, OP-ESR was performed using ESR with a spin trap (5,5 – dimethylpyrroline – N – oxide or DMPO) which measures the capability of PM2.5 to generate hydroxyl radicals (•OH) though Fenton type reactions with the presence of hydrogen peroxide. Varying OP, physical, and chemical properties of different PM sizes and sampling conditions will be presented in this study.

8HA.16

Differential Lung Toxicity of Biomass Smoke from Smoldering and Flaming Phases Following Acute Inhalation Exposure. YONG HO KIM, Charly King, Todd Krantz, Ingrid George, Marie McGee, Lisa Copeland, Michael Hays, Matthew Landis, Mark Higuchi, Stephen Gavett, Ian Gilmour, *U.S. EPA*

We previously demonstrated that, on a mass basis, lung toxicity associated with particulate matter (PM) from flaming smoke aspirated into mouse lungs is greater than smoldering PM. This finding however has to be validated in inhalation studies to better predict real-world exposures. Thus, we modified an existing combustion system to precisely control and maintain smoke concentrations during the combustion process. We generated biomass smoke from peat and eucalyptus fuels under smoldering and flaming phases for up to 1 hour, and measured PM and volatile organic compounds (VOCs) levels. Smoldering PM levels were ~10 times higher than flaming PM with carbon monoxide (CO) held at similar levels to equalize potentially interfering CO health effects. Mice were exposed by inhalation for 1 hour/day for 2 days and then assessed for lung toxicity at 4 and 24 h after the second exposure. PM levels were ~40 and ~4 mg/m^3 under smoldering and flaming phases, respectively, while CO levels ranged from ~80 to 110 ppm for all exposures. Notably, VOCs/PM ratios were higher (up to 7 times) in flaming than smoldering smoke. Smoldering peat and eucalyptus smoke elicited significant inflammation (neutrophils) in mouse lungs at 4 h post-exposure while flaming smoke from either fuel caused even greater lung inflammation at 24 h post-exposure. Similarly, a significant increase in an index of airflow obstruction was observed in mice exposed to flaming peat and eucalyptus, and smoldering eucalyptus smoke immediately after each day of exposure. These results suggest that although flaming smoke contains much less PM mass than smoldering smoke, the health risk of this exposure is, on a mass basis, greater than that from smoldering emissions. These observations support the concept that health risks of smoke exposure vary depending on the type of fuel and combustion conditions. [This abstract does not represent EPA policy]

8HA.17

Exposure to Respirable Crystalline Silica during Stone Countertop Grinding/Polishing using Handheld Tools. CHAOLONG QI, Alan Echt, *NIOSH*

Stone countertops became increasingly popular among consumers in recent years. Unfortunately, a large amount of dust that contains crystalline silica can be produced during stone countertop fabrication and installation. Inhalation of respirable crystalline silica (RCS) is one of the best-documented workplace hazards, with a large body of research strongly demonstrating that chronic overexposures cause silicosis and increase the risk of lung cancer. Grinding and polishing stone countertop using handheld tools were found to be tasks with the highest exposure to RCS in a Health Hazard Evaluation conducted by NIOSH, and the exposure levels exceeded the NIOSH Recommended Exposure Limit (REL) even under wet operations. In this study, we conducted a series of field surveys and characterized workers' exposure to RCS during stone countertop grinding and polishing with different wetting method (water-spray-wetting and center-feed-wetting) and local exhaust ventilation. The field survey results will be used to set up a target for additional engineering control requirements for reducing the exposure levels below the NIOSH REL.

8HA.18

The Dissemination and Fate of Inert Aerosolized Particles in a Clinical Biocontainment Unit (BCU). David Drewry, Thomas Pilholski, Jennifer Therkorn, FELIX SAGE, Kaitlin Rainwater-Lovett, Kathryn Shaw-Saliba, Lauren Sauer, Gregory Bova, Brian Garibaldi, *Johns Hopkins University Applied Physics Laboratory*

Johns Hopkins Hospital created a Biocontainment Unit (BCU) to care for patients with highly infectious diseases (HIDs), such as influenza A (H7N9), while assuring healthcare worker (HCWs) safety. Research to date for BCU protocols and practices are based off of case reports and lessons learned from patient care and exercises. This study seeks to be the first to systematically study the influences of HCW movement and personal protective equipment (PPE) doffing, and the HVAC controls for containment. First, 1 µm fluorescent polystyrene beads (PSLs) were released by a biomimetic coughing device in the patient room. Then, the transport of the PSLs was examined under three BCU scenarios: 1) patient-only, no HCW; 2) HCW walk-through of the patient room; 3) 5-min HCW patient care activity. Airborne PSL concentrations were quantified every 1-second for 30 min throughout these scenarios by seven optical sensors (IBACs, FLIR Systems) located throughout the different areas within the BCU. Each BCU scenario was repeated at least 3 times. PSLs were undetected in the donning room area. In the patient room, the addition of a HCW walkthrough of the space and contamination of this HCW with PSLs prior to exiting increased the presence of PSLs near the exit door by a factor of 2.5 and 4.7, respectively. HCW removal of PPE and HCW movement throughout the space was found to re-aerosolize PSLs from their PPE and the floor, respectively. Next, we sought to test multiple HVAC failure conditions to understand the transport of PSLs within the BCU under abnormal operating conditions. Under failure conditions, we identified transport of PSLs from the patient room to the doffing room. This study provides a systematic method for evaluating airborne infection mitigation protocols in the BCU and suggests further steps to avoid HCW exposure to high risk pathogens in the BCU.

8HA.19

Deposition of Ultrafine Particles in Human Airway. WEI-CHUNG SU, Yi Chen, *University of Texas Health Science Center at Houston*

To date, occupational health-related ultrafine particle (UFP) lung deposition studies have been all carried out in laboratory settings using a human airway replica containing merely a few sections of the upper lung airways. The applications of these laboratory-based lung deposition studies are restricted because it is known that very few UFPs deposit in the upper airways. Moreover, the generated UFPs are not representative of the UFPs that are generated due to processes and activities in actual workplaces. As a result, the relevance of the data acquired from the present UFP lung deposition studies is very limited. To improve the representativeness of lung deposition data as well as to overall advance the experimental approach of UFP lung deposition studies, this study used an improved approach to carry out UFP lung deposition experiments for the purpose to enable on-site workplace UFP lung deposition measurement. The experiment was designed by using a human airway replica and its modifications, and two SMPS units to directly estimate the UFP airway deposition fractions for each lung generation in the tracheobronchial airways. The initial deposition results obtained from using UFP surrogates showed that UFP lung deposition data can be efficiently and systematically acquired, which demonstrated the feasibility and the suitability of the experimental approach developed. The success of this study also ensures that UFP lung deposition data can be collected on-site in workplaces in the near future. The long-term goal of this research is to apply this experimental approach in various workplaces and ambient (non-work) environments having serious UFP exposure concerns to enhance the assessment of the UFP inhalation dosimetry.

8IM.1

The Pollution Particulate Concentrator (PoPCon), an Ambient Pollution Concentrator for the Study of Pathogen-Particulate Interactions. NICOLAS GROULX, Bruce Urch, Caroline Duchaine, Samira Mubareka, James Scott, *University of Toronto*

Severe smog events are associated with the exacerbation of respiratory disease. Despite the significant health burden associated with such events, little is known about how the particulate matter (PM) in air pollution interacts with viruses in the air. In order to improve our understanding of this complex interaction and its implications on human health, new research methods need to be developed. We developed a novel system to characterize aerosol interactions between PM and viruses using a particle concentrator capable of concentrating ambient outside PM in an urban setting.

Phi6 (Φ6) bacteriophage is an enveloped RNA virus used to model influenza virus in biosafety level 1 settings. PhiX174 (ΦX174) bacteriophage is a non-enveloped ssDNA virus used to model poliovirus in the same conditions. Viruses were aerosolized into a 0.43 m^3 chamber containing HEPA (High Efficiency Particulate Air) filtered air (control) or unfiltered concentrated ambient fine particles (PM2.5). Virus infectivity was determined by plaque assay against their bacterial host. Relative humidity (RH), temperature and ozone were recorded. PM2.5 mass concentration, as well as particle counts and size distribution were also recorded inside the chamber. Concentrated ambient PM2.5 mass concentration ranged from 100 - 1300 $\mu m/m^3$ and were mixed with an artificial aerosol of Φ6 bacteriophage (n = 5) or Φ6/ΦX174 bacteriophages (n = 3). Preliminary data reveal that the presence of PM2.5 decreases Φ6 infectivity by 28.8% after aerosolization (t = 0min) compared to HEPA-filtered air. ΦX174 co-aerosolized with Φ6 displayed increased viability (+ 35.8%, at t = 0 min) compared to Φ6 (-26.7%, at t = 0 min) while interacting with PM2.5.

This novel system allows the study of the interactions between aerosolized viruses and high levels of PM2.5 as can occur during smog events. More work is required to understand the precise mechanisms and to assess the potential modifying effects of temperature, relative humidity and ozone. This work has implications for the aerosol infectivity and potential transmissibility of human respiratory viruses during air pollution events.

8IM.2

Calibration of the Laser Induced Incandescence-Mass Spectrometric Analyzer (LII-MS) Using Polydisperse Aerosol Particles. CUIZHI SUN, Nobuyuki Takegawa, *Tokyo Metropolitan University*

Online measurements of chemical composition provide useful insights into the sources and formation processes of ambient aerosols. Routine calibrations of online aerosol instruments are important for assessing the performance of the instruments during field measurements. The choice of materials and optimal size distributions for calibration particles can vary depending on the detection methods and size-dependent collection efficiency of the instruments. The combination of a differential mobility analyzer (DMA) and a condensation particle counter (CPC) is a reliable, conventional method for calibrations. However, the use of a radioactive source as a neutralizer sometimes requires special cares when deploying a DMA for filed measurements because of regulation for using radioactive materials, especially in Japan. The purpose of this study is to propose a simple calibration method without using a DMA and CPC for the recently developed laser induced incandescence-mass spectrometric analyzer (LII-MS; Miyakawa et al., AST, 2014). Polydisperse aerosol particles of some selected chemical compounds are generated by atomizers (Model 226, TOPAS). The size distribution of polydisperse aerosols can be optimized by adjusting the solution concentration, atomizer flow rate, and dilution air. The LII section is used as an optical particle counter for estimating the mass concentration of polydisperse aerosol particles. The accuracy of the LII sizing and counting efficiency is critical for this method and regularly checked by measuring pulse height distributions for polystyrene latex (PSL) particles. Here we present the results for ammonium sulfate (AS), ammonium nitrate (AN), and potassium nitrate (PN). A comparison of this method with the conventional DMA-CPC method in laboratory and its potential uncertainties are presented and discussed.

8IM.4

Improvement of Quantitative Fit Testing Methods Using Ambient Aerosols. SHYANG-HAW YANG, Kai–Jie Yang, Chih-Wei Lin, Sheng-Hsiu Huang, Yu-Mei Kuo, Chih-Chieh Chen, *National Taiwan University*

Fit testing should be performed before the use of tight-fitting respirators. However, it may not always be conducted for various reasons, including time and cost. This study aimed to evaluate the feasibility to shorten the fit testing time by improving the instrumental settings, sampling system design, and data analysis procedure.

Experiments of fit factor measurements were divided into two mode: constant flow and cyclic flow. To simulate leakage, capillaries (10 mm in length, diameter 1.0-1.5 mm) were used to insert on N95 or N100. The ratio of total to leak flow was considered the “true fit factor, FFt”. Flow rates ranging from 5-50 L/min were adopted to study the flow dependency of fit factor. The measured fit factors were determined by concurrent particle concentration measured by a Portacount and a OPS 3330. A 1.7-m sampling tube was used to connect filtering facepiece and the aerosol instruments. In addition, the effects of breathing pattern (tidal volume: 0.5-1 L, frequency: 5-20 times/min) and lung deposition (with/without HEPA filter behind the respirator) on in-mask particle concentration during fit testing were analyzed, to explore the minimal sampling time that approximated the FFt.

Results showed that the particle measurement response time for Portacount and OPS were approximately 5 and 2 seconds, respectively. For P100 respirators, most measured fit factors were similar to the FFt, whereas there was an underestimation while using N95 respirator due to filter penetration. Therefore, N95-companion was necessary while testing N95 respirator. For the cyclic flow tests, the fit factor was overestimated because the sampling tube was connected onto the facepiece where filtered air was partly sampled. The higher the breathing flow rate, the more the fit factor was overestimated. On the other hand, the measured fit factor would be close to the FFt when using the highest concentration during a breath cycle (FFmin), and it could be decided in only one breath. Consequently, with improved design, a fit test would take approximately only 12 seconds, while the whole fit testing process could be shortened from 7.5 to about 3 minutes.

8IM.6

Application of "Low-Cost" Particulate Matter Sensors to Measure Fugitive Dust at the Fenceline of a Waste Processing Facility. BRANDON FEENSTRA, Vasileios Papapostolou, Hang Zhang, Andrea Polidori, *South Coast Air Quality Management District*

With the emergence of low-cost air sensing technology, novel applications and case studies are being developed that increase the spatial and temporal resolution of current air monitoring networks. While air quality is typically measured at a regional level (25 by 25 km), stationary sources of air pollution can significantly contribute to the overall air pollution impacts at a local level. An air quality sampling campaign was designed to monitor fugitive dust emissions from a waste processing facility in southern California. A network of nine solar-powered sensor nodes equipped with an Optical Particulate Counter (Model OPC-N2, Alphasense, UK) and a 900 MHz mesh network gateway were deployed at the fence-line of the facility. The OPC-N2 reported PM mass concentrations for three PM size fractions (i.e., PM_{10}, $PM_{2.5}$, and $PM_{1.0}$), while the gateway allowed the nodes to transmit data to a central cellular communication gateway. The waste transfer facility is located in close proximity to and upwind of an elementary school and residential housing. Results of the air monitoring campaign will show how fugitive dust emissions from the facility relate to meteorological data, facility activities, and exceptional events. The results of the sensor network provide valuable real-time PM measurements pre, post, and during the renovation process with the opportunity of quantifying the costs and benefits of specific emissions control strategies. Real-time monitoring data can provide both the facility and the community stakeholders with valuable information to better understand local air quality conditions.

8IM.7

Spatial and Temporal Variability of Particulate Matter Using a Network of Air Quality Sensors in a Southern California Community. BRANDON FEENSTRA, Vasileios Papapostolou, Olga Pikelnaya, Hang Zhang, Andrea Polidori, *South Coast Air Quality Management District*

Air quality is typically measured by regulatory agencies by mean of highly accurate but very expensive EPA approved monitors. With the emergence of low-cost air quality sensors and the development of sensor networks, community groups and citizen scientists can now measure air pollution at the neighborhood, local, and even regional level. This study employs a network of 23 Purple Air PA-II sensors deployed at community members' homes in southern California primarily in the cities of Redlands and Yucaipa located in San Bernardino County. The PA-II sensor measures particulate matter (PM) mass concentrations in three size ranges (i.e., $PM_{1.0}$, $PM_{2.5}$, and PM_{10}), temperature, and relative humidity. Prior to deployment, the performance of the sensors was evaluated at the South Coast Air Quality Management District Air Quality Sensor Performance Evaluation Center (SCAQMD AQ-SPEC) program and was found to correlate well with Federal Equivalent Method (FEM) instruments with an R^2 value of 0.96, 0.93, and 0.66 for $PM_{1.0}$, $PM_{2.5}$, and PM_{10}, respectively. In this study, we discuss the spatial and temporal variability of PM in with respect to topography, large roadways, local area PM sources, meteorology, and weather conditions. The information gathered from the sensor network developed for this work will also allow SCAQMD to better understand how sensor data can be used to complement PM data from existing network stations and to better characterize air quality conditions in the region. Additionally, surface level $PM_{2.5}$ gradients can be used to validate satellite-derived aerosol optical depth (AOD) $PM_{2.5}$ gradients, therefore allowing to fine-tune region-specific interpretation of satellite AOD measurements.

8IM.8

A Novel Inversion Method to Calculate the Mass Fraction of Coated Refractory Black Carbon Using a Centrifugal Particle Mass Analyzer and Single Particle Soot Photometer. Kurtis Broda, JASON S. OLFERT, Martin Irwin, Gregory Schill, Gavin McMeeking, Elijah G. Schnitzler, Wolfgang Jager, *University of Alberta*

Refractory black carbon (rBC) has important atmospheric impacts due to its ability to absorb light, and its interactions with light are partly governed by acquisition of coatings or other mixing processes. Here, a novel inversion method is presented that derives the mass fraction of coated rBC using a coupled centrifugal particle mass analyzer (CPMA) and single particle soot photometer (SP2). The CPMA classifies all particles by their mass-to-charge ratio, and the SP2 detects the mass of rBC in each individual particle. The inversion outputs the simultaneous number distribution of both rBC mass and total particle mass. The distribution can be integrated to find properties of the total aerosol population including the mass fraction of coating and the mass of coating on a particle of known total mass. These capabilities were demonstrated via smog chamber experiments, initially, particles in the chamber were pure rBC. An organic (non-rBC) coating was grown onto the aerosol over several hours via photooxidation of p-xylene. As the coating grew, the CPMA-SP2 system sampled the aerosol. The CPMA was sequentially stepped over a mass range from 0.3 to 28 fg and the SP2 measured the mass of rBC in each individual CPMA-classified particle. Number and mass distributions were constructed using the inversion. As expected, the mass and number distributions of rBC and total mass were equivalent for uncoated particles. As the non-rBC coating thickness increased over time, the number distribution shifted towards a higher total mass. After several hours of sampling, fresh uncoated rBC particles were injected into the chamber creating an external mixture of coated and uncoated particles. This external mixture was clearly resolved in the number distribution of rBC and total particle mass. The CPMA-SP2 method offers several advantages over SP2 only methods namely, i) coating mass information can be obtained over a much wider range of particle mass (restricted in the SP2 by sensitivity to light scattered by rBC), ii) coating mass is measured directly (i.e., no assumptions for coating density or refractive index), and iii) does not make morphology assumptions (e.g. core-shell).

8IM.9

Numerical Study of Miniature Plate Differential Mobility Analyzers (Mini-plate DMAs). THAMIR ALSHARIFI, Da-Ren Chen, *Virginia Commonwealth University*

The geometrical effects on the transfer function of miniature plate DMAs (mini-plate DMAs) were systematically studied in this work for non-diffusive particles. COMSOL was utilized to set up the numerical model. Prior to the parametric study, the model was validated by the comparison with the experimental data obtained in the work of Liu and Chen (2016). The studied parameters include the aspect ratio and the cross-sectional area of particle sizing cross section (i.e., the width to height), aerosols entrance/exit slit ratio, and the ratio of aerosol to sheath flow rates (β).

Our study shows that, because of the presence of side walls, the DMA transfer function was deteriorated as the aspect ratio was decreased to less than 8%. The opening of aerosols entrance/exit slits (relative to the width of DMA sizing zone) is also of importance on the performance of mini-plate DMAs. The aerosol entrance angle becomes important in the cases with less aerosol entrance slit opening. The effect of other geometrical parameters, such as, the cross-sectional area of DMA sizing zone, on the DMA performance was not observed. The detail of this study will be present in this talk.

8IM.10

Performance Testing of Two Virtual Impactors. Maria D. King, John Haglund, Ahmad Kalbasi, Samuel Beck, Alexander Zuniga, PAUL A. SOLOMON, *Texas A&M University*

Virtual Impactors (VI) are used to separate particles in air into two size ranges based on the inertia achieved by the particles as they are accelerated through the inlet or acceleration nozzle. The air stream is typically split 90% / 10% to the major (fine particle)/minor (coarse particle) flow channels often with subsequent collection on filters. Nozzle design and particle deposition (wall losses) within the virtual impactor may affect the cutpoint (50% collection efficiency), slope of the collection efficiency curve, and wall losses within the VI leading to undesirable performance of the sampler.

This study focuses on the performance of two different virtual impactors using fluorescently labelled monodisperse particles in the size range of 0.5 to 10 micrometers to determine their collection efficiency. Regional wall losses were evaluated by wiping different areas of the VI to remove the deposited particles after each cycle. Two sampler designs with two different nozzle geometries are evaluated using fluorescent particles. A commercially available VI with a conical nozzle (Tisch Environmental) operating at 1000 L/min is evaluated for its collection efficiency and used as a basis for comparison. The second VI operates at 1000 L/min and is a redesign of the 1000 LPM sampler replacing the conical nozzle with a newly designed nozzle to achieve improved performance of the VI. The ratio of the collection and acceleration jet diameters and spacing between the two jets were maintained at classical values (in the range between 1.25 and 1.4). The different nozzle profiles play an important role in performance, with the newly designed nozzle expected to result in a steeper slope of the efficiency curve and reduced wall losses.

8IM.11

Laboratory and Field Calibration of a Low-Cost Particulate Matter Sensor. TOFIGH SAYAHI, Kerry Kelly, *University of Utah*

The availability of low-cost light-scattering particulate matter (PM) sensors offers the possibility of improved spatiotemporal PM information. However, this type of sensor needs to be characterized for the conditions of use. This work focuses on field and laboratory calibration of the Plantower PMS PM sensor. The field evaluation took place over two years through multiple seasons and a variety of elevated PM events, including wintertime inversions, fireworks, and wildfires. It compared the Plantower PMS $PM_{2.5}$ and PM_{10} concentration with co-located federal equivalence and federal reference methods. The laboratory evaluation included the development of a cylindrical calibration chamber that addresses the issue of uneven particle distribution found in conventional cubic chambers. This test chamber is designed for monodisperse polystyrene sphere particles, ammonium nitrate, dust, or sodium chloride particles. The PM sensors, along with a reference sensor, track the particle concentration and changes within laboratory chamber. Both the laboratory and field evaluations allow for the determination of sensor precision, accuracy, limit of detection, drift and linearity of the response.

8IM.12

Effects of Detection Wavelengths on Black Carbon Measurements Using the Auto-Compensating Laser-Induce Incandescence Technique. FENGSHAN LIU, David Snelling, Kevin Thomson, Gregory Smallwood, *National Research Council Canada*

Autocompensating laser-induced incandescence (AC-LII) has been utilized to measure black carbon (BC) concentrations in many applications. In LII, a pulsed laser of nanoseconds duration is used to rapidly heat the BC particles to temperatures much higher than the ambient temperature, typically to 3000 to 4000 K. Detection and analysis of the incandescence signals reveal the BC concentration. It is preferred to use a uniform laser fluence in LII measurements; however, there is always certain laser fluence non-uniformity in practice. The detected LII signals are biased towards the highest particle temperatures associated with the hot spots in the laser beam. It has been demonstrated that the laser fluence non-uniformity is partially responsible for the so-called soot volume fraction anomaly – the measured soot volume fraction increases with increasing the mean laser fluence in the low-fluence regime.

In AC-LII, soot volume fraction is inferred from the absolute LII signal intensity, the equivalent laser beam width, and the effective soot temperature based on the ratio of LII signals detected at two wavelength bands in the visible spectrum, i.e., the two-color pyrometry principle. When soot particles are non-uniform in temperature due to the laser fluence non-uniformity, the derived effective soot temperature is not unique but dependent on the detection wavelengths. Consequently, the AC-LII inferred soot volume fraction is likely influenced by the pair of detection wavelengths. It is noticed that the effect of detection wavelengths on AC-LII inferred soot volume fraction or the magnitude of soot volume fraction anomaly has not been investigated thus far.

The effect of detection wavelength on soot volume fraction measurement using AC-LII was experimentally and numerically investigated. Soot was produced from a MiniCAST. AC-LII measurements were conducted using a pulsed Nd:YAG laser at 1064 nm and the resultant LII signals were detected at 445, 692, and 797 nm. It was found that the detection wavelength pair affects the effective soot temperature and consequently the inferred soot volume fraction. Strategy to alleviate the detection wavelength effect and soot volume fraction anomaly in AC-LII is also provided.

8IM.13

Application of Novel Sensors for Assessing Indoor Air Pollution. JENNIE COX, Tiina Reponen, Sergey A. Grinshpun, Seung-Hyun Cho, *University of Cincinnati*

This study employs two novel sensors: RTI's Micro Personal Exposure Monitor (MicroPEM) and a real-time black carbon sensor (MicroAeth). The MicroPEM provides PM2.5 data representing both the integrated exposure (from filter samples) and the patterns of exposure (real-time measured). To obtain accurate real-time data, the data obtained by sensors should be corrected utilizing the filter sampling results. The objective of this study was to determine the correction factors for the MicroPEM and MicroAeth to be used for analysis of indoor aerosols in the Cincinnati metropolitan area.

In conjunction with an ongoing study funded by the U.S. Department of Housing and Urban Development (HUD), the devices were collocated in 45 indoor sampling events for 2 days in an asthmatic child's bedroom. Preliminary PM2.5 results obtained with 15 samples ranged from 2.4 to 43.5 $\mu g/m^3$ with an average of 16.5 $\mu g/m^3$ as determined by real-time measurements and from 1.4 to 46.8 $\mu g/m^3$ with an average of 17.4 $\mu g/m^3$ as determined by the filter-based measurements. The black carbon values from the optical filter analysis ranged from 0.0 to 4.4 $\mu g/m^3$ with an average of 0.9 $\mu g/m^3$. The 48-hour average values from the MicroAeth black carbon sensor ranged from 0.1 to 1.3 $\mu g/m^3$ with an average of 0.5 $\mu g/m^3$. The average correction factors were found to be 1.5 for the MicroPEM and 2.1 for the MicroAeth. Following analysis of the additional 30 samples, we will assess the effect of home characteristics on the correction factors. This study is expected to ensure to field researchers and industrial hygienists that these real-time exposure monitors are capable of accurately detecting PM2.5 and black carbon, which creates the foundation for the further development of user-friendly, field-compatible aerosol instruments to be deployed in indoor air quality monitoring.

8IM.14

Assessing Occupational Exposure to Silica and Soot in Diamond Mines using Wearable Sensors and Samplers. ALBERTO BALDELLI, Steven Rogak, Winnie Chu, *University of British Columbia*

Mining dusts can be a health hazard. Mining industries are interested in recording the silica presence. Diesel soot is found in mining environments and should be measured as a health hazard in its own right and as a potentially interfering constituent of samples collected for silica analysis. Realtime measurement of personal silica exposures is not currently possible; we aim to develop a method combining real-time and offline sample analysis, providing better estimates of exposure for miners than previously possible.

Nanozen Industries have developed a portable air pollution sensor, consisting of a microchannel system with an integrated particle detector. This sensor has been calibrated for PM4 Arizona road dust. The measurable particulate size has been selected due to limits imposed by the regulations, which concern the range of 0.3 to 10 μm. Samples from a diamond mine have been collected for 8-10 hours sampling time, at different times in a working day, according to miner activities, such as transporting the mine dust and drilling, and related to environmental conditions, such as wind speed or low humidity. The influence of several factors to the amount of silica and soot in mining dust is investigated; the realtime data provides information that could be used to minimize exposure.

Measurements of mass and chemical composition of mining dusts collected with a real-time optical sensor have been correlated with off-line techniques, like gravimetric analysis, Raman Spectroscopy, Fourier Transformation Infrared Spectroscopy (FTIR), and X-ray diffraction (XRD). Experimental steps consist of estimation of the quantity of soot relative to silica, development of a calibration curve for the detection of the silica amount, and analysis and comparison of the data obtained with the mentioned techniques.

8IM.15

A General Uncertainty Analysis for Measurements of Black Carbon Emissions from Gas Flaring Using Sky-LOSA.

BRADLEY CONRAD, Matthew Johnson, *Carleton University*

Gas flaring is a ubiquitous practice in the oil and gas industry where unwanted gases are destroyed in an open flame, frequently from a vertically-raised stack. With estimates of global flaring on the order of 5 trillion cubic feet per year, anthropogenic emissions of climate-relevant species during flaring activities are of notable concern. Flare emissions include black carbon (BC), a $PM_{2.5}$-species that has been recognized as an important short-lived climate forcer. Despite the climatic importance of BC and the scale of gas flaring, only recently have direct measurements of in-field BC emission factors for gas flaring been obtained. These data were acquired using sky-LOSA, an imaging technique enabling the quantification of BC emission rates from flares, made possible through the consideration of visible light attenuation through the BC-laden atmospheric plume.

To extend the knowledge-base of flare-generated BC emissions, dissemination of a general sky-LOSA procedure to make the implementation of measurements available to third parties is necessary; to this end, a general uncertainty analysis (GUA) under a Monte Carlo framework is vital. The primary goal of the GUA is to quantify the effect of various input variables on the uncertainty of computed BC emission rates. Relevant input variables include flame-generated BC aggregate properties, ground-level irradiance by the sun and sky, and camera position with respect to the sun and horizon. Through the latter, a sky-LOSA user has indirect control over measurement uncertainty. Consequently, the GUA can be used to define a generalized procedure for sky-LOSA data acquisition enabling a user to meet desired uncertainty thresholds as a function of ambient conditions. Key results and implications from the GUA will be presented, including practical limitations, achievable uncertainties, and proposed future work to reduce measurement uncertainty.

8IM.16

Limits to the Precision of the Optical Closure Technique When Quantifying Measurement Uncertainties.

JAMES RADNEY, Christopher Zangmeister, *National Institute of Standards and Technology*

The reverse optical closure technique has seen increasing use in recent years as a method to determine a refractive index for an arbitrary aerosol with biomass burning aerosols receiving the most attention. The reverse optical closure method determines a refractive index from measured absorption coefficients, scattering coefficients and size distributions assuming spherical particles (electrical mobility sizing accuracy and Mie theory). Here, we calculate refractive indices using the reverse optical closure method from measured the absorption coefficients, extinction coefficients and size distributions for pure ammonium sulfate, pure nigrosin and 50:50 (m/m) and 75:25 (m/m) mixtures of ammonium sulfate and nigrosin. We treat measured particle number densities as Poisson distributions and use quantifiable uncertainties (i.e. 0, 1, or 2 σ) to assess significance. We find that calculated refractive indices depend strongly upon the chosen confidence intervals; pure nigrosin refractive indices vary between $1.66 + 0.19i$ (0σ) and $1.71 + 0.21i$ (2σ) for $D_g = 116$ nm to 1.76 + 0.23i (0σ) to 1.81 + 0.25i (2σ) for $D_g = 131$ nm. The primary difference between the 0 and 2 σ values is the number statistically significant particles counted at large mobility diameters; notably, these particles account for less than 0.25 % of the total concentration. The best agreement with refractive indices determined from mass- and mobility- selected particles is somewhere between 1 and 2 σ depending upon the type of particles measured and the underlying size distribution of the particles under investigation. These results highlight that optical closure method is not a robust way to determine refractive index and should only be used for obtaining relative values of the refractive index.

8IM.17

A 2-D Numerical Study of Virtual Impactor with Ultra-low Air Flow-rates. WONYOUNG JEON, Hyunwoo Lee, Youngjin Seo, *Kumoh National Institute of Technology*

Nowadays, the threat of terrorism using biological weapons is increased and real-time detection of biological weapons became important. A virtual impactor is currently being utilized as a part of real-time detection system. This study presents preliminary 2-D numerical results of virtual impactor with ultra-low flow-rates. A commercial CFD tool is employed to optimize several important dimensions in the impactor. As the device is real-time detection system, it has to be operated 24 hrs and 365 days. Therefore, the power consumption is going to be an important design factor. The objective of this study is to design the optimized 2-D virtual impactor which will be eventually expanded into 3-D for the purpose of fabrication and also for experiments. The proposed air flow-rates is lower than 200 Liter per min (LPM) and the target cut-point is approximately 1 μm.

8IM.18

On the Use of the Field Sunset Semi-continuous Analyzer to Measure Equivalent Black Carbon Concentrations. Nadežda Zíková, Petr Vodicka, Wolfgang Ludwig, Regina Hitzenberger, JAROSLAV SCHWARZ, *Institute of Chemical Process Fundamentals CAS*

This study describes a method how to calculate EBC concentrations obtained from raw laser intensity data measured by a semi-continuous thermo-optical EC/OC analyzer (Sunset Laboratory Inc., USA), compares the calculated EBC concentrations to several EBC-dedicated instruments, and introduce a new correction method for EBC determination.

During two intensive campaigns in Prague, Czech Republic during summer and winter campaign in 2012 and 2013, the derived EBC data were compared to EBC-dedicated filter-based instrumentation: MAAP (5012, Thermo Scientific), aethalometer (AE31, Magee Scientific), and microaethalometer (AE51, AethLab AE51). The EBC concentrations from all instruments were compared to the MAAP EBC concentrations with a good agreement in both the summer and winter campaigns. Several corrections were applied on EBC data as well to show the applicability, advantages, and also disadvantages of deriving EBC concentrations from the EC/OC analyzer, originally not intended to EBC measurements. The derived EBC data were corrected for simple loading, multiple scattering, and wall reflection correction for a quartz tube in the semi-continuous analyzer.

Based on the analyses, we conclude it is necessary to correct the laser signals given by the Sunset semi-continuous analyzer for light reflection on the quartz tube, with new correction introduced. With the new correction, it is possible to use the semi-continuous Sunset analyzer to derive EBC concentrations with a reasonable agreement to aethalometer data with no additional costs or alterations of the instrument, and same possibilities of additional corrections. In the absence of a dedicated instrument, EBC from the semi-continuous Sunset analyzer can be used to get a reasonable indication of EBC concentrations.

This work was performed in the framework of a project by the ÖAD, WTZ CZ 03/12, MEYS MOBILITY grant No. 7AMB12AT021, and the infrastructure project of the MEYS of the Czech Republic ACTRIS-CZ - LM2015037.

8IM.19

Experimental Investigation of a Multi-notched Electrospray. YANG ZHANG, Da-Ren Chen, *Virginia Commonwealth University*

Electrohydrodynamic spraying or electrospray (ES) has been widely proposed for various applications. It is because of its capability of generating highly charged, monodisperse particles in the diameters ranging from nanometers to micrometers. However, the industrial application via electrospray remains challenging because of low mass throughput of single-capillary ES systems. A multi-notched nozzle had been proposed to increase the mass throughput of ES. Difference from multiple-capillary ES reported in the literature, a multi-notched ES nozzle has multiple tips machined along the outer edge of nozzle exit. The electric field is intensified in the area around individual tips when the nozzle is exposed to an external electrical field. Multiple jets are emitted from the tips once the nozzle is fed in a spray liquid. In this work, the performance of multi-notched ES nozzle was evaluated with respect to its mass throughout and size distribution of particles. The I-V relationship was characterized. Particle size distributions were measured either by Scanning Mobility Particle Sizer (SMPS) or aerodynamic particle sizer (APS). The factors affecting the droplet size and spray current were investigated. The detail result of this work will be given in this presentation.

8IM.20

Response of a Filter-based Instrument with a BC Surrogate. COURTNEY GRIMES, Russell Dickerson, James Radney, Joseph Conny, Christopher Zangmeister, *University of Maryland*

Black carbon (BC) is formed during the incomplete combustion of biomass and fossil fuels, impacting the Earth's energy balance and adversely affects human health. The most commonly used BC concentration measurement methods rely on the attenuation of light from the material loaded onto a filter. However, a reliable and reproducible material to calibrate and validate instrument performance does not currently exist. Here, we present data on using a water soluble, commercially available carbon black as a potential material to mimic BC for use in filter attenuation measurements. A commercially available filter-based instrument was used as a test case for instrument assessment. Monodisperse carbon black aerosol was generated through size- and mass-selection by a differential mobility analyzer (DMA) and an aerosol particle mass analyzer (APM), respectively. We used this material to compare the measured mass concentrations reported by the filter-based instrument to those measured by a condensation particle counter (CPC) operated in parallel. We find that for 300 nm mobility selected particles the filter-based instrument and CPC are within measurement uncertainty for concentrations up to 2 $\mu g/m^3$. This indicates that the material has the potential to serve as a BC mimic to assess the performance of filter-based attenuation instruments. We also investigated the impact of mass concentration up to 18 $\mu g/m^3$ on filter attenuation response. Finally, to mimic ambient measurements, we compared the mass concentration of internally mixed carbon black and ammonium sulfate between a filter-based attenuation instrument and a CPC. We observed the filter-based attenuation instrument reported BC mass concentrations that were up to 1.6 times higher than reported by the CPC.

8IM.21

Indicating Particulate Matter (PM) Exposure with a Smartphone App. GANG CHEN, Bruce Urch, Frances Silverman, Arthur W. H. Chan, *University of Toronto*

Exposure to particulate matter (PM) emitted from solid fuel cook stoves is a significant health risk in developing countries, leading to an estimated 2 million premature deaths every year. One of the main obstacles to adopting clean cook stoves is the poor understanding of the health impacts of PM in these areas. Current commercial PM sensors remain too costly to deploy widely and indicate PM exposure. The objective of this project is therefore to develop an affordable and relatively accurate PM-indicating smartphone app by image analysis. Here we use image analysis to determine the amount of PM collected on a filter substrate, e.g. face masks. An image of the filter substrate is first obtained using a smartphone, and the smartphone app we develop will determine the darkness of the filter substrate using standardized gray ramp scales. To obtain the relationship between the filter darkness and PM mass, we have analyzed over 700 filter samples collected in urban Toronto by the Synchronized Hybrid Ambient Real-time Particulate (SHARP) monitor. Preliminary results show a good correlation ($R^2>0.70$) between PM concentration and the darkness on the filter substrate, demonstrating the feasibility of our method. The algorithms will be further improved using machine learning techniques to obtain better predictabilities. Further tests using a breathing machine and commonly used face masks are under way, and their results will be discussed. This project will potentially lead to a relatively accurate method to measure PM exposure at significantly lower costs compared to commercially available PM sensors, and can be used to inform the general public in developing countries about PM exposures.

8IM.22

Comparison of Four Consumer-Grade Air Quality Monitors. RUIKANG HE, Sanjeevi Thirumurugesan, Daniel Bachman, Dominick J. Carluccio, Rudolph Jaeger, Clinton J. Andrews, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

Consumer-grade air quality monitors have been on the US market since 2012 and can report a variety of metrics including humidity, temperature, atmospheric pressure, VOCs, carbon dioxide, and particulate matter levels. Many of them stream the data in real-time to smartphone apps or provide data to be downloaded via web. 3 Foobot, 3 AirVisual Node, 1 Particle Matter-Dust Sensor (Libelium Tec.) and 1 Fidas® Frog were involved in this study. The reference instruments were DustTrak DRX for particulate matter and IAQ Monitor (both TSI Inc.) for CO_2, humidity, and temperature. Three measurements were done in different environments and with different particles: Polystyrene latex (PSL) beads with diameter of 0.72um and 2.00um; Arizona road dust; Nano silver particles; and dust from cooking event. Temperature, humidity and CO_2 were not controlled. All devices were run side-by-side in each environment. The results have shown that for particulate matter measurements, the Pearson correlation coefficients between Libelium, Airvisual, Fidas and DRX were always higher than 0.85, while this value for Foobot dropped to 0.72. Since most correlations were statistically significant (P-value<0.01), it is reasonable to say that Foobot, AirVisual, Fidas and Libelium are linearly correlated with DRX. For temperature and humidity measurements, the Pearson correlation coefficients between Foobot, Airvisual and IAQ monitor were higher than 0.92 (P-value<0.01), and the R-squares were higher than 0.84 when doing linear regressions with IAQ monitor. For CO_2 measurements, the Pearson correlation coefficient between Airvisual and IAQ monitor were higher than 0.99 (P-value<0.01), while Foobot had correlation coefficients lower than 0.56 or even not correlated with IAQ monitor. The data show that consumer-grade devices are reliable in some cases; however, testing in different conditions is needed before using them in field studies.

8IM.23

Innovative Analytical Solution for Inverted Drift Tube Characterization and Validation by Experimental Methods.

MD MINAL NAHIN, Carlos Larriba-Andaluz, *IUPUI*

A new mobility particle analyzer, which has been termed Inverted Drift Tube(IDT), has been modeled analytically as well as numerically and proven to be a very capable instrument. The basis for the new design have been the shortcomings of the previous ion mobility spectrometers: a) diffusional broadening for high mobilities and b) inadequate low and fixed resolution (not mobility dependent). To overcome the diffusional broadening and have a mobility based resolution, the IDT uses two varying controllable opposite forces, a gas flow with velocity v_{gas}, and a linearly increasing electric field that opposes movement. The separation ratio $\Lambda=v_{drift}/v_{gas}$, is employed to determine the best possible separation for a given set of nanoparticles. Due to the system's need to operate at room pressure, two methods of capturing the ions have been developed; Intermittent Push Flow for a large range of mobilities, and Nearly-Stopping Potential Separation, with very high separation but limited only to a very narrow mobility range. The following conclusions have been obtained:

1) Analytical description of the 1D IDT problem for an initial distribution of nanoparticles has been shown to yield very high resolutions without any optimization. Resolution is close to being proportional to the square root of the length, but has a dampening effect on the standard deviation that increases the resolution several folds when compared to a drift tube. It is shown that the resolution is an ill-conditioned parameter to express whether or not separation occurs inside the drift cell. The IDT has autocorrecting capabilities and fixes the diffusional broadening existing in other commercial instruments.

2) 3D numerical simulations for single particle trajectories using stochastic diffusion in SIMION for the IDT are used to obtain separation ratios. Instrument is shown to be able to separate particles of 55.89 and 55.93nm with ease. This would require effective resolutions of several thousands.

3) A chromatography existing concept of resolving power is used to differentiate between peak resolution in the IDT and acceptable separation between similar mobility sizes (resolving power).

4) A prototype of the instrument has been built and experimental results are shown in comparison to those achieved theoretically.

8IM.24

Design Criteria and Development of the Next Generation of Butanol CPC's.

AXEL ZERRATH, Andrea Tiwari, Jacob Scheckman, Brian Osmondson, *TSI Incorporated*

For over four decades Butanol-based Condensation Particle Counters (CPCs) have contributed significantly to the understanding of nanometer-sized particles and their physical properties. As times and research requirements changed, the instrumentation has evolved as well. Again the needs of CPC users and their research activities are leading to new design criteria and the development of 4th generation Butanol-CPCs.

Specialized Butanol-CPCs serve specific research needs such as detecting low concentrations with high sensitivity; measuring high concentrations with accuracy; detecting the smallest, freshly formed particles at the 1 nm threshold; and performing in conjunction with a particle sizer to produce a size spectrum based on number concentration. Further specialization is needed for applications that involve regulations, e.g. the CEN/TS 16976 guideline that harmonizes the measurement of ultrafine particles in the atmosphere for regulatory purposes. This range of requirements resulted in a group of four new Butanol-CPCs being developed at TSI with a couple of focus points in mind:

1. Consistency of results over years of research is very important to get the most out of the data and to make sustainable conclusions. This requirement needs to be balanced with the need for improvements.

2. Various types of research need to cover different ranges of particle sizes. For example, lower (50%) counting efficiency for engine exhaust measurements (23 nm), regulated environmental monitoring (7 nm), particle nucleation process measurements (1 nm), or size distribution measurements using electrical mobility classification (typically between 5 and 10 nm) are all common uses of CPCs, but yet require different CPC models.

3. Field campaigns link laboratory results to applied research. Once the instrumentation is set up in the field, remote control frees up time for the researcher to focus on results instead of maintaining the deployed instruments via time-consuming visits.

4. Quality control also becomes increasingly important in the quantitative measurement of nanometer-sized particles. New enhancements, such as continuous monitoring of the particle-to-droplet growth process using pulse height will support users to ensure data quality.

The results of the characterization of the new set of instruments will be detailed.

8IM.25

Measurement Uncertainties of Black Carbon Concentration Using Photoacoustic Method. MAJI NAJI, Kevin Thomson, *National Research Council Canada*

Photoacoustic spectroscopy (PAS) has been successfully developed as a commercially available method for the measurement of atmospheric black carbon concentration. With any aerosol measurement instrument, it is desirable to have a method of calibration that can be deployed by the user rather than requiring return to the instrument manufacture.

The Droplet Measurement Technology offers a field-calibration option with their PAX and PASS-3 instruments; however, the accuracy of the PAS measurement is dependent on accurate PAS signal calibration so the robustness and uncertainty of the field calibration method should be considered prior to report BC concentrations.

As an example, the PAX instrument, calibrates the scattering and absorption coefficients reported by the instrument using highly scattering and high absorbing aerosols respectively. In the first step, the PAX scattering measurement is calibrated using highly scattering materials, with a particle size around 200-260 nm. The uncalibrated scattering signal is compared to extinction measurement made through the measurement cell. For performing absorption measurement PAX uses PAS resonance method to measure laser light absorption of a highly absorbing aerosol. The absorption coefficient is determined through the difference of the extinction and calibrated scattering measurement.

There are several possible uncertainties introduced through the calibration process. For example truncation error in the scattering measurements which may vary with particle size and type. The calibration is performed at very high concentration levels relative to those that would likely be measured during operation and so putting high demands on the linearity of the instrument. In the interest of understanding the robustness of the instrument’s calibration, we investigate the calibration method.

By measuring the scattering calibration, using Ammonium sulfate aerosol particles at different concentration and particle sizes, using a TSI 3936 Scanning mobility particle sizer (SMPS) spectrometer along with PAX, the uncertainty of PAX scattering calibration to the truncation effect and particle size is determined.

A mini-CAST (RSG mini-CAST Model 5201) soot generator is used to generate highly absorptive black carbon (BC) particles. By selecting different BC particle size using SMPS the effect of the BC particles size and concentration on the absorption calibration variation of the PAX is studied.

8IM.26

Design and Evaluation of a Low Flow Personal Cascade Impactor. MODI CHEN, Francisco Romay, Virgil Marple, *MSP Corporation*

A very compact cascade impactor with a low sampling flow rate has been developed. Its dimensions are 8.5 cm L x 5.0 cm W x 11.4 cm H, and weighs 0.27 kg. It has ten impaction stages that cover the size range of 60 nm to 9.6 µm at a 2 L/min inlet sampling flow rate. The top eight stages, measuring particle aerodynamic diameter down to 170 nm, can be used as a stand-alone impactor with a portable, battery-powered pump, while the ten stage impactor requires a larger vacuum pump to operate. Particle collection efficiencies for each stage were obtained experimentally with two types of commonly used substrates, aluminum foil and glass fiber filters. Impactor cutpoints for aluminum foil substrates agree well with conventional impactor theory. The efficiency curves are sharp with minimum overlap between them. Thus, the compact design does not compromise its performance when compared with the larger cascade impactors such as the MOUDI, making it suitable for general purpose applications where a lower sampling flow rate provides adequate mass collection. With glass fiber filter substrates, impactor cutpoints are smaller and the efficiency curves are less steep, especially for the last stages. Also, the collection efficiency curves do not drop to near zero at small Stokes numbers. Instead, excess particle collection efficiency of around 10% is observed for the top six stages, and becomes even higher for the last four stages. This is due to the collection of particles by filtration as the impinging jets penetrate the filter substrate. Thus, when using glass fiber filter substrates, only the upper 8 stages of the impactor should be used.

8IM.27

Measuring Sub-10 nm Particles from DPF Diesel and Gasoline DI Cars using PMP Methodology. HIROYUKI YAMADA, *Tokyo Denki University*

Sub-10 nm particles from DPF diesel and gasoline DI cars were observed using PMP methodology with condensation particle counters (CPC) which lower 50 % detection limits are 2.5, 10 and 23 nm. We observed sub-10 nm particles emissions specific to diesel and gasoline DI cars. These particles are not only affected by engine type, but also the setting of PMP system. We also conducted real time particle size distribution measurement to discuss the nature of observed sub-10 nm particles.

8IM.28

Aerosol Detection using Unmanned Aerial Vehicles. ANDREW DART, Jonathan Thornburg, *RTI International*

The goal of this research is to develop an aerosol detection capability that will enable real time analysis of telemetry data from a mobile aerial sensor platform. This effort strives to achieve a level of accuracy and repeatability in aerosol measurement that is comparable to stationary ground-based platforms, but with the freedom to collect continuous measurements in flight. This will provide access to measure aerosol concentrations in a dynamically changing plume of aerosol, in motion. The association between adverse health outcomes and poor air quality has been clearly demonstrated and the Global Burden of Disease Study ranks air pollution as the fourth greatest cause of death worldwide behind high blood pressure, dietary risks, and smoking. Ambient samples of particulate matter are routinely collected for purposes of conducting special research studies and for assessing compliance with ambient health regulations. EPAs Air Quality System contains data from approximately 4,000 monitoring stations around the country. Data from the AQS is considered the “gold standard” for determining outdoor air pollution, but this comes at a cost. Fixed stations are primarily located in urban areas and resolution of measurement data is poor. Detailed information on air pollution concentrations is needed when quantifying their effects on human health and the environment. However, spatial and temporal resolution of data from these fixed locations is relatively low and often inadequate for local and regional applications.

8IM.29

Aerosol Loading Effects on Particle Size-Selective Samplers. SHENG-HSIU HUANG, Chih-Wei Lin, Ting-Ju Chen, Yu-Mei Kuo, Chih-Chieh Chen, *National Taiwan University*

The main objective of this work was to characterize the particle loading effects on size-selective samplers as a function of particle size. Five $PM_{2.5}$ cyclones of different body diameters similar to VSCC were fabricated to investigate the effects of particle loading. An ultrasonic atomizing nozzle was used to generate micrometer-sized potassium sodium tartrate (PST) particles (CMD=3 µm, GSD=1.42, conc.=4.3 mg/m^3) and Sodium chloride (NaCl) particles (CMD=3 µm, GSD=1.3, conc.=3.5 mg/m^3) as solid and di-ethyl-hexyl-sebacate (DEHS) particles (CMD=3 µm, GSD=1.37, conc.=5.5 mg/m^3) as liquid challenge particles. Aerosol number size distributions and concentrations, both upstream and downstream of the cyclones, were measured using an aerodynamic particle sizer. Each cyclone was tested for loading effects in the same chamber for an hour. We also evaluated the effects of other operating parameters, including challenge aerosol size distribution, chamber humidity, and the material of the cyclone.

During loading test with PST particles, aerosol penetration of particles of 2.5-µm in diameter decreased drastically at the first 20 minutes of the test, then became stabilized at the same penetration level, with an average decrease of 20%. In addition, the time for the curve to reach equilibrium differed by particle size, but not affected by the cyclone body diameter. Liquid aerosols did not cause loading effect, apparently due to the deposited liquid draining down to the grit pot. This aerosol loading effects were found to be influenced not only by the size distribution of the challenge aerosols, but also the environmental condition of the test chamber, the test agent, the cyclone material, and even the surface roughness of the cyclone and the challenge aerosol particles.

8IM.30

Development of Single Particle Mass Spectrometer Coupled with Light Scattering Module to Increase the Detection Efficiency. HEE-JOO CHO, Taewan Son, Donggeun Lee, Kihong Park, *Gwangju Institute of Science and Technology*

In this research, we developed a new single particle mass spectrometer (SPMS) coupled with light scattering module to determine size resolved chemical composition of individual particles as well as chemical mixing state. The SPMS consist of four major parts: aerodynamic lens inlet, light scattering module, single step laser desorption/ionization system, and positive mode of linear time-of-flight mass spectrometer. The new aerodynamic lens system was used to focus 30 nm-10 µm sized particles, based on theoretical calculation. The light scattering module was used to measure optical particle diameter and to trigger ionization laser. We used a Nd:YAG laser with a 266 nm wavelength and the maximum frequency of 20 Hz for particle ionization to achieve high hitting efficiency. The laser power was ~1 – 10 mJ/pulse, and its power density is ~10^6 W/cm2 at laser focal point. The light scattering module in the SPMS was calibrated and evaluated by using various sized PSL particles. Finally, the SPMS was applied to determine chemical constituents and mixing state of individual particles generated from various combustion process such as cooking, biomass burning, coal combustion, and diesel exhaust in laboratory. The mass spectrum achieved from the SPMS will be sub-classified by C-means-OPTICS and K-means algorithm for the further analysis.

8IM.31

Accurate Signal Prediction of SEMS under Fast-Scan Operation. MARK KANAPARTHI, Suresh Dhaniyala, *Clarkson University*

The Scanning Electrical Mobility Spectrometer (SEMS) has been traditionally used to make Aerosol size distribution measurements. The SEMS is generally operated by stepping up the voltage exponentially (up-scan) followed by an exponential step down (down-scan). The classification characteristics are dictated by the instrument transfer function. Dubey and Dhaniyala (2008) proposed a semi-theoretical approach to calculate the SEMS transfer function under an up-scan operation. In this study, the approach of Dubey and Dhaniyala has been extended to calculate the transfer function for a down-scan operation. Also, the calculation approach has been extended to consider the effect of concentration smearing on both and up-scan and down-scan transfer functions. The calculated transfer functions are validated experimentally for a range of scan times and DMA operating conditions. The effects of signal smearing and plumbing delays are considered in the validation. Our study determined that a scan-time-dependent offset time is required to match theoretical predictions with experimental data. Using computational fluid dynamics (CFD) simulations, the possible influence of geometry non-idealities on the observed scan-time-dependent offset time was examined. We will present the details of the theoretical calculation, experimental validation and the implication of the results for accurate inversion of fast-scan data.

8IM.32

Performance of a New Tandem Differential Mobility Analyzer Inversion Routine to Interpret Non-Ideal Responses. CHRISTOPHER OXFORD, Brent Williams, *Washington University in St. Louis*

Non-ideal (multi-modal and asymmetric) response curves from a Tandem Differential Mobility Analyzer (TDMA) can occur while evaporating aerosols during volatility experiments or while condensing water on aerosols in an unstable relative humidity environment. TDMA inversion routines either assume linear mobility relationships between Differential Mobility Analyzers (DMAs) or assume experimental distribution shapes (i.e. Gaussian) in order to simplify the inversion process. For some volatility and hygroscopicity experiments, either assumption can be incorrect since TDMA inversions neglect the experimental models during the inversion process. The models are added post inversion which can complicate the interpretation of non-ideal responses.

We present a TDMA forward inversion routine that models the experimental phenomena during the inversion process. These physical models determine the shape of the experimental response, and, ultimately, the shape of the raw output distribution. The new inversion process can create non-ideal responses. Comparing the inversion response to the measured response provides the value of the desired experimental variable (e.g. vapor pressure, hygroscopicity).

8IM.33

Using a Low-Cost Electrochemical Wireless Sensor Network to Provide Spatiotemporal Measurements of Hazardous Gases in a Manufacturing Setting.

CHRISTOPHER ZUIDEMA, Nima Afshar-Mohajer, Sinan Sousan, Geb Thomas, Thomas Peters, Kirsten Koehler, *Johns Hopkins School of Public Health*

Heavy industrial manufacturing facilities have complex profiles of hazardous air contaminants resulting from work processes, particularly welding and other metal work, which vary over space and time. Contaminants of specific interest in this setting include: particulate matter, carbon monoxide (CO) and oxidizing gases such as nitrogen dioxide (NO_2) and ozone (O_3); here, we focus on gases. We have designed, validated and deployed a wireless sensor network (WSN) constructed with Alphasense (Essex, UK) electrochemical sensors for CO (CO-B4) and oxidizing gases (OX-B421) in a manufacturing facility. These electrochemical sensors have a linear response, fast response time, and sensitivity in the ppm range. The sensors are small, relatively inexpensive ($100-$200), have low power requirements and are modular, permitting dense spatial deployment in our WSN and facilitating high-resolution temporospatial measurements. Each sensor node connects wirelessly with a central, online database in the facility. The sensor nodes integrate the manufacturer's signal processing circuit with an open-source microprocessor. The nodes of the WSN were calibrated for a range of concentrations of occupational interest for application in the manufacturing facility. The CO sensors in our WSN demonstrate good linear response in the range of 1-12ppm (R^2=0.998). The oxidizing gas sensor detects both NO_2 and O_3 but is incapable of discriminating between the two gases. The oxidizing gas sensors in our WSN were tested over the range of 0.2–2.0ppm NO_2 and 25–100ppb O_3 separately and also demonstrated highly linear responses (NO_2: R^2=0.996; O_3: R^2=0.978). In a preliminary deployment, the WSN measured CO in the range of 0–12ppm and oxidizing gases in the range of 0–100ppb with clear diurnal and weekly patterns and spatial heterogeneity. Four pairs of co-located sensors also showed high measurement agreement ($0.8996<R^2<0.9976$).

8IM.34

Towards a Calibration Procedure for Thermal Optical Analysis. COURTNEY GRIMES, Russell Dickerson, Christopher Zangmeister, Joseph Conny, *University of Maryland*

Elemental carbon (EC) is a product of incomplete combustion, and EC prevalent in the atmosphere is known to have adverse effects on human health and Earth's radiation budget. Due to the complex nature of ambient air particles, there is no standard technique for EC measurement. Thermal Optical Analysis (TOA) has been widely used for ambient EC analysis where carbonaceous material is thermally desorbed at different temperature steps. Unlike with other optical methods, TOA does not require an absorption coefficient for mass determination. TOA determines the mass of organic carbon and elemental carbon, but this separation is difficult to define due to charring effects. Currently, the only calibration procedure to determine the instrument's response involves a known amount of OC (such as sucrose) deposited on a filter. However, there is no calibration procedure for determining the EC quantity. Here, we present data on using a water soluble, commercially available carbon black as a potential material to mimic EC for use in TOA. Different ratios of this surrogate with sucrose were created and analyzed with different temperature protocols to mimic ambient sampling. By introducing known amounts of EC with OC, the EC/TC ratio could be calculated and compared to values determined experimentally.

8IM.35

UV-Visible Photoacoustic Spectroscopy for Aerosol Absorption. AL FISCHER, Geoffrey Smith, *University of Georgia*

Atmospheric aerosols directly affect climate by absorbing and scattering sunlight, leading to warming and cooling effects, respectively. After CO_2, absorbing carbonaceous aerosols are thought to be one of the largest contributors to warming of Earth. However, the exact magnitude of this effect remains one of the largest uncertainties in climate predictions. Although many methods exist for measuring aerosol absorption, they often suffer from artifacts and drawbacks. For example, many rely on impinging aerosols on a filter prior to measurement, which may inherently alter the aerosols and change their optical properties or lead to a need for filter-based correction factors that must be measured empirically; alternatively, techniques not relying on filter collection, such as photoacoustic spectroscopy, are often limited in their wavelength coverage. Direct, in-situ, wavelength-resolved measurements of aerosol absorption have been difficult to achieve. We have constructed two photoacoustic instruments designed to be used in tandem. Together, they cover 7 wavelengths from the UV (320 nm) to the near-IR (785 nm) to provide wavelength coverage similar to many filter-based techniques (e.g. aethalometry). Each instrument consists of either 3 or 4 diode lasers coupled into a single multipass photoacoustic cell. Extra care has been taken to keep the instruments compact and robust while maintaining exceptional detection limits (<1 Mm^{-1}). This has created a portable photoacoustic system capable of measuring absorption by ambient aerosols in even the cleanest of environments. The construction, calibration, and early applications to ambient aerosols will be presented.

8IM.36

UAIR – Building a Distributed AQ Sensor Network for the Union College Community. ANDREW HUISMAN, Sarah Connolly, Alexandra Novak, Paige Kotowitz, Eben Cross, *Union College*

We describe the Union College Air Quality Network (UAIR), a distributed network of five low-cost, integrated air quality measurement systems each comprised of electrochemical sensors for trace gas measurements of CO, NO, NO2, and O3 along with light-scattering-based quantification of PM. The sensors, developed by Aerodyne Research, Inc. (i.e. ARISense), were placed at indoor and outdoor locations at Union College, a small (2100 students; ~0.25 km2 campus) undergraduate residential college in Schenectady, NY. The UAIR network was used to observe trends in air quality on campus at three outdoor locations across campus as well as inside the campus copy center and the atrium of the student center / cafeteria. The network ran continuously in this configuration from November 2016 to May 2017. Observations over this time include characterizing the impact of local biomass burning activities (prescribed burn at a nearby forest reserve; wood combustion for home heating), understanding how student activities can influence indoor air quality, and capturing seasonal variability in pollutant concentration trends. In addition to the deployed network results, data from a series of sensor co-location tests will be presented, underscoring the importance of assessing node-to-node variability when interpreting low-cost sensor data.

8IM.37

Design and Performance Characterization of a Dilution Sampling System for the Measurement of Biomass Combustion Aerosols. JAKE LINDBERG, Dave Guerrieri, Gerald Willson, *NYS DEC*

NYS DEC Emissions Measurement and Research Group has previously developed small scale dilution systems to sample exhaust gases from mobile sources directly at the vehicle tailpipe in efforts to evaluate primary ultrafine particulate matter. The success of these dilution sampling systems in measuring ultrafine particulate matter warrants the adaptation of this technique to stationary sources: specifically, biomass-fueled combustion appliances.

In this work we present a two-stage dilution system for direct stack sampling of biomass combustion aerosols at high concentration (10^3-10^8 particles per cubic centimeter) over a large size range (0.01 – 10 microns). The primary dilution stage features an adjustable inlet flowrate (0.4 – 30 liters per minute) which can be used to achieve isokinetic sampling conditions given exhaust velocity is between 1.4 and 110 centimeters per second. Further, the primary stage is designed to minimize diffusion losses and to mitigate agglomeration and condensation effects. In the secondary stage the sample can be further diluted to achieve ultimate dilution ratios in the continuous range between 20:1 and 180:1. In the future we intend to use the system to measure ultrafine particulate mass and number concentration, size distribution, PAH content, and EC/OC ratio on a selection of biomass-fueled combustion appliances in collaboration with NYS DOH and Brookhaven National Laboratory.

8IM.38

Experimental Evaluation of Opto-Dielectrometric Sensors for Monitoring of Total Incombustible Content (TIC) in Underground Coal Mines. OMID MAHDAVIPOUR, John Sabino, Michael R. Shahan, Clara E. Seaman, Larry D. Patts, Paul Wright, Igor Paprotny, *University of Illinois at Chicago*

Finely divided coal dust produced during underground coal-mining, i.e. float dust, which deposits throughout the coal mine can be feedstock for coal dust explosions. To prevent such explosions, inert rock dust (limestone dust) is applied in underground areas of a coal mine. The ratio of total incombustible mass (rock dust + incombustible content of coal dust) divided by total mass of the deposited dust is called the Total Incombustible Content (TIC) of dust deposited within the mine. Regulations require that TIC ratios be maintained above 80% to promote safe working conditions within the mine.

This paper presents the results from the evaluation of the distributed wireless sensing module called Sensor for Automated Control of Coal Dust (SACCD), developed by the University of Illinois at Chicago and the University of California, Berkeley. This sensing module uses optical reflectance (through the application of a modified Bouguer-Beer-Lambert Law) and dielectrometric spectrometry to probe the total incombustible content (TIC) of the deposited float dust/rock dust stack. The SACCD sensors were extensively evaluated in the laboratory, using both a float dust deposition setup at UIC, as well as in the float dust deposition gallery at the National Institute for Occupational Safe and Health (NIOSH) laboratory facilities in Pittsburgh, PA. Both sets of experiments confirmed the ability of our sensor to discern the TIC content to within 20%. Improvements to the opto-dielectrometric sensing setup, based on the obtained experimental results, are discussed, which will further lower the detection limit. Inverse solution to a computational fluid dynamic model (CFD) of the airflow through the mine is discussed, which will potentially allow the SACCD sensors to be used for predicting TIC content throughout the entire mine using a relatively sparse sensor data.

8IM.39

The Development of a Unique Multi-Wavelength Polar Nephelometer for the Retrieval of Ambient Aerosol Refractive Indices via Reverse Mie Theory. AUSTEN SCRUGGS, Geoffrey Smith, *University of Georgia*

Ambient aerosols are known to perturb the Earth's radiative balance via scattering and absorption processes. These perturbations lead to global warming and cooling events that have been shown to significantly contribute to climate change. Irradiance equilibrium perturbations due to direct aerosol-radiation interplay are often quantified via radiative transfer models which employ Mie theory; and thus, rely upon effective refractive indices for aerosol particles which are estimated from particle compositions and their respective abundances, densities, and quintessential refractive indices. However, the refractive indices for some aerosol particles, such as organic carbon particles, are not well understood. Measurements utilizing unique instrumentation focused upon the accurate determination of climate-relevant wavelength dependent aerosol scattering parameters such as the aerosol phase function and scattering asymmetry, are necessary in order to provide accurate refractive indices with minimal uncertainty through reverse Mie theory. Thus, we are developing a unique Multi-Wavelength Polar Nephelometer spanning an angular scattering range of 3° to 177° with high angular resolution. The instrument will be used in conjunction with multi-wavelength photoacoustic and broad band cavity enhanced spectrometers for refractive index retrievals. The instrument development and preliminary retrievals from span gases, 903 nm polystyrene latex particles, and local ambient aerosol are the subject of the current work.

8IM.40

A Broadband Cavity-Enhanced Spectrometer for UV-Vis Extinction. MICHAEL POGASH, Al Fischer, Geoffrey Smith, *The University of Georgia*

Aerosols predominately scatter light, offsetting the warming effects caused by greenhouse gases. They have a direct radiative forcing that may be second to only CO2, but the magnitude is not well known. Uncertainties in aerosol radiative forcing propagate into climate models and prevent precise predictions. Broadband cavity-enhanced spectroscopy (BBCES) is a technique that can provide extinction measurements with high sensitivity and large wavelength coverage. With mirrors near 99.99 % reflective, cavity-enhancement allows path lengths on the order of kilometers to be achieved in a portable instrument. There have been a few, recent measurements of aerosols using BBCES, but they only cover discrete regions of the solar spectrum. We have constructed a three-channel broadband cavity-enhanced spectrometer that measures from 385 - 435, 512 - 552, and 640 - 680 nm. With a limit of detection near 1 Mm-1, extinction by ambient aerosols can be measured in their natural, suspended state and with great temporal resolution. The instrument design and recent measurements will be presented.

8IM.41

Surface Enhanced Raman Spectroscopy of Aerosol Particles. Vasanthi Sivaprakasam, Matthew B. Hart, Paul Lane, Gary Kushto, JAY D. EVERSOLE, *Naval Research Laboratory*

Raman spectroscopy is a widely used technique to measure vibrational and rotational molecular modes which can provide very specific spectral signatures for chemical identification. However, typically low Raman scattering cross-sections have been a barrier to using this technique for in-situ characterization of environmental aerosols or monitoring hazardous materials present in the air. By combining metallic nano-particles (MNPs) with aerosol particles, we have been able to observe Surface Enhanced Raman Spectra from single suspended aerosol particles. We have explored the comparison measurements of spontaneous Raman spectra with MNP-enhanced Raman spectra using identical materials under controlled conditions both as aerosols and as bulk liquid samples. The experimental repeatability of this approach has enabled investigation of spectral responses and enhancement factors, and their dependence on factors such as, MNP composition, MNP concentration and material composition.

This presentation describes the design and construction of a Raman spectroscopy test-bed capable of interrogating single aerosol particles or bulk samples in a cuvette for comparison/validation studies. Aerosol particles are suspended in a linear Electrodynamic quadrupole (LEQ) trap, that provides ample time to study the weak spontaneous Raman. Aerosol particles are generated and charged using a customized nozzle-reservoir droplet generator, and particles ranging from 1 micron to 60 microns in diameter have been successfully generated and maintained. Droplets of materials such as glycerol, dibutly sebacate and ethyl cinnamate have been used for validation and calibration. SERS data has been obtained for Rhodamine 6G dye as bulk sample and aerosols, comparison of these measurements and enhancement factors will be discussed. Plans to extend the study to other chemicals are under way. The latest spectral signatures and enhancement factors resulting from the addition of the MNP's to these materials will be presented.

8IM.42

A Compact, Battery-Operable, Dual-Channel, Water-Based Condensation Particle Counter. GREGORY LEWIS, Steven Spielman, Arantzazu Eiguren Fernandez, Susanne Hering, Melissa Grose, *Aerosol Dynamics Inc.*

A compact, dual-channel, water based condensation particle counter is being developed to provide simultaneous measurements of ultrafine particle concentrations in two separate flow streams. Envisioned applications encompass those requiring simultaneous measurements in multiple size fractions, or in two distinct physical spaces. The long term goal is a battery powered instrument that is wearable.

The approach is the "MAGIC" (moderated aerosol growth with internal water cycling) technology which uses growth tubes to capture water vapor internally, allowing sustained operation without rewetting the wick. The MAGIC uses a continuous wick that spans three temperature regions, the middle one of which is warmer than the other two. Water evaporation from the warmed, middle section provides the water vapor that creates the supersaturation for particle activation and growth, while the cooler, downstream section captures the water vapor. Capillary action transports the water back to the warmed mid-section, providing sustained operation. MAGIC has no reservoirs, and tolerates jostling and tipping. This dual channel MAGIC system employs a newly developed, miniaturized optical droplet detector based on an existing system. The dual-channel growth tube and optics, excluding electronics and supporting components, measures approximately 6x10x10cm. The lower limit for particle detection is below 10nm. The response is linear to the highest concentrations tested of 8x104/cm3. Standard deviation between the two channels while sampling ambient air was 2%.

8IM.43

Size-Resolved Acid:Base Ratio of Atomized Nanoparticles from Salt Solutions. SABRINA CHEE, Haihan Chen, Michael J. Lawler, James Smith, *University of California, Irvine*

Bulk solutions comprised of sulfuric acid and ammonia or amines are commonly aerosolized at varying pH as a source of seed particles in studies of secondary organic aerosol formation and cloud droplet activation. However, during atomization, relatively volatile ammonia and amines may evaporate from the droplets before the formation of low-volatility acid-base pairs. This may result in particles that are more acidic than the bulk solution. This phenomenon may happen to differing degrees depending on particle size as well as the concentration and ratio of acid and base in solution. To test this, we atomized aqueous solutions containing sulfuric acid and ammonia or amine, size selected nanoparticles with a nano differential mobility analyser (nanoDMA), and collected particles for analysis on aluminium and quartz filter substrates with a sequential spot sampler (Aerosol Devices, Inc.). We quantified the acid:base ratio of size-resolved nanoparticles by extracting the sample into solvent and analysing the solution with Ion Chromatography (IC) coupled with a conductivity detector. Results of this study are discussed, as well as its implications for the use of atomizers for generating nanoparticles consisting of these compounds

8IM.44

Design and Evaluation of a NOx Denuder with Cobalt Oxide Adsorbent. Blake Actkinson, Stone Yan, BENJAMIN SUMLIN, Christopher Oxford, Brent Williams, Rajan Chakrabarty, *Washington University in St. Louis*

Nitrogen monoxide and nitrogen dioxide, collectively known as NO_x, play an important role in atmospheric chemistry. NO_x is an atmospheric pollutant that has detrimental effects on human health, air quality, and visibility. When present in high levels, NO_xinhibits the formation of OH radicals and ozone, key components of many atmospheric chemical cycles. Additionally, NO_x emissions from combustion sources can interfere with aerosol absorption measurements at certain wavelengths. A denuder was designed and developed to remove NO_x from aerosol flow streams with the objective of reducing gaseous interference during optical measurements. With dimensions of 2 ft. in length and total volume of 2.2 L, the denuder’s small size makes it ideal for conducting field and laboratory measurements. A mixture of fine firesand and chamotte particles known as GroG were coated with cobalt nitrate hexahydrate and oxidized to cobalt oxide at 300 ºC. Early experiments suggest successful removal of NO from sample streams; the denuder shows promise for enabling more accurate aerosol measurement.

8IM.45

Modeling and Optimization of Wearable Personal Dust Exposure Monitor (WPDEM) for Underground Mines.

MANDANA HAJIZADEHMOTLAGH, Omid Mahdavipour, Igor Paprotny, *University of Illinois at Chicago*

Lung disease in underground mining has been a long-standing health problem due to excessive exposure to respirable coal mine or silica dust. Consequently, underground mining operations must be controlled so that levels of respirable particles remain below regulatory standards set by Mine Safety and Health Administration (MSHA). Federal law stated that coal mine respirable particle dust concentrations in the work environment could not exceed 1 mg/m^3 for 10 hour work shift. Current exposure limits to silica dust are set at 100 µg/m^3. Lung damage due to chronic silicosis is irreversible, thus it is important to determine the miners exposure to silica dust, in addition to coal mass fraction.

In this work, we present a comprehensive numerical, analytical, and computational fluid dynamic modeling for a novel miniaturized wearable personal dust monitor, which can be used for continuous monitoring of respirable (ISO respirable convention) dust concentrations. Highly variable ambient operating conditions, including high dust concentration (up to 10 mg/m^3), and high humidity are some of the challenges facing dust monitors being used in underground mining environment. To overcome those issues, we developed comprehensive design of a miniaturized direct read respirable PM mass sensing system consisting of a pre-dryer (elutriator), dryer, respirable fractionator and direct read Particulate Matter (PM) mass sensing element. This design allows for significant removal of the moisture water content of particles before they reach the fractionator and the mass-sensing resonator. Trade-off between flow rate, power consumption and design of the system were evaluated, and the design trade-offs are analyzed. The presented comprehensive numerical model can further be used to evaluate design trade-offs for other types of direct-read PM mass sensors.

8IM.46

Field Deployment of a Nanometer-Capable, Water-Based Condensation Particle Counter.

SUSANNE HERING, Gregory Lewis, Chongai Kuang, *Aerosol Dynamics Inc*

A newly-developed, versatile water condensation particle counter (vWCPC) capable of near 1nm particle detection was deployed at the Southern Great Planes Atmospheric Radiation Measurement Site during August and September, 2016. Measurements were made as part of the Hi-SCALE program, with a focus on the formation of new particle formation. The vWCPC (Hering et al, Aerosol Science and Technology, 2017) provides particle detection near 1nm at an aerosol flow of 0.3L/min, without use of a sheath. It employs a three-stage, laminar-flow growth tube. The temperature difference between the first two stages is user-selectable, and determines the peak supersaturation, and hence the lower particle activation size. The cooled third stage maintains supersaturated conditions that permit continued droplet growth while reducing the temperature and water content of the flow prior to particle counting. This approach makes feasible operation at the large temperature differences necessary for high supersaturations and small particle detection. This new growth tube was mounted in the box from a TSI Model 3787 WCPC, and operated with the TSI optics and mother board. Operating temperatures are flexible, and can be chosen either to maximize particle detection near 1 nm, or to eliminate sensitivity to charger ions. For the HiSCALE field study the latter mode of operation was used, which provides 50% detection at 1.8nm. Data are compared to parallel measurements with a TSI Model 3776.

8IM.47

Dual Differential MEMS PM2.5 Mass Sensor: Mitigating Temperature and Humidity Effects through Dual Alternating Thermophoretic Precipitation.

DORSA FAHIMI, Shravan Nagarjun Rangaraj, Omid Mahdavipour, Igor Paprotny, *University of Illinois at Chicago*

Airborne fine particulate matter (PM2.5) has been linked to reduced lung functionality, bronchitis, and heart attacks. The negative health impacts resulting from PM2.5 exposure are significant. Consequently, it is important to develop portable inexpensive PM sensors that can allow the general public to mitigate PM exposure. In this work, we present the evaluation of a new dual differential direct-read MEMS PM2.5 mass sensor. The sensor extends our previous work on the direct-read MEMS PM2.5 mass sensor. The new device is designed such that an air-microfluidics circuit separates fine particulate matter from the airstream by means of a microfabricated particle fractionator, and the mass concentration is measured directly using a film bulk acoustic resonator (FBAR) by particle deposition on its surface using thermophoretic precipitation. The improved design presented in this work greatly increases the utility of the MEMS PM sensor by mitigating its temperature and humidity dependence. In our new design, we introduce a dual differential FBAR configuration, where PM is deposited on one FBAR, while a nearby reference FBAR is kept clean. By switching the deposition between the two FBARs, the drift in the resonant frequency of these resonators due to temperature and humidity variations can be mitigated.

We present new designs for the dual differential PM2.5 mass sensor, and show the results of how the differential reading can be obtained, despite local variations in the ambient temperature due to alternative localized heating created by alternating thermophoretic precipitation. The sensor is evaluated and calibrated at variable temperature and humidity levels using test aerosol in our laboratory setup at UIC. The results show that the new dual differential FBAR design can be used to reduce the dependence of the sensor's response to temperature and humidity changes, and increase the utility of the MEMS PM2.5 mass sensor. A demo of the improved sensor will be presented.

8IM.48

Application of Laser Induced Breakdown Spectroscopy for Real Time Detection of Contamination Particles in Industrial Fabrication Process at Various Pressure and Temperature Conditions.

KYOUNGTAE KIM, Haebum Lee, Hyunok Maeng, Giback Kim, Jinsung Kim, Kihong Park, *Gwangju Institute of Science and Technololgy*

Industrial fabrication processes are typically done under extreme conditions (e.g., high temperature and low pressure). Such processes generate particles that could lead to contamination in the fabrication process causing manufacturing defects. Rapid detection of these particles is necessary in order to solve contamination problem. To identify elemental composition of contamination particles in real time, the laser-induced breakdown spectroscopy (LIBS) technique was used for multi-element detection of particles. In this study, a modular type of aerosol-LIBS was developed to be easily adapted into pre-existing tubes and chambers used in on-site fabrication systems. This modular chamber can be easily connected to exhaust lines. In brief, the modular aerosol-LIBS is composed of a pulse laser (1064 nm, 650 mJ/pulse, Surelite II-10, Continuum Inc., USA), an aerosol chamber, and a spectrometer (Aurora, Applied Spectra Inc., USA) with a charge-coupled device (CCD) detector. A window is installed as a view port to allow evaluation of laser beam and light emissions from the micro-plasma inside the modular aerosol-LIBS. Lastly, heating tape and oil vacuum pump were used to control temperature and pressure inside the aerosol chamber. Laboratory-generated calcium chloride (CaCl2) aerosols were used to evaluate the analytical performance of the modular LIBS developed. Results show that Ca peaks in LIBS spectra were not conspicuous dependent on the surrounding temperature (25-200ºC). At low pressure conditions, Ca peaks spectra show mildly affected trends in terms of detection intensity and efficiency. Not only Ca aerosols, but also another laboratory-generated aerosols could be detected.

The research was supported by the Samsung Electronics, Co., Ltd.

8IM.49

Evaluation of a Miniature, Low-Cost Black Carbon Sensor for Unmanned Platforms. GAVIN MCMEEKING, Julien Caubel, Troy Cados, Nicholas Good, Thomas W. Kirchstetter, *Handix Scientific*

Black carbon (BC) is an important light-absorbing aerosol component that affects radiative forcing, visibility and human health. Its spatial distribution in the atmosphere, particularly in the vertical, must be known in order to accurately represent its impacts on climate and health. To date most BC observations have been fixed to single points on the ground, such as monitoring stations, or performed for limited time periods during intensive field campaigns over a broader spatial extent. The increasing adoption of unmanned aerial platforms, including tethered and free balloons, allows for the bridging of these to measurement strategies, providing platforms for routine atmospheric soundings for various species of interest. Here we evaluate a low-cost, filter-based absorption sensor for measuring atmospheric BC developed by Lawrence Berkeley National Laboratory and UC Berkeley. We compare the BC sensor response with that of a photoacoustic-based absorption measurement for several mixtures of absorbing and non-absorbing aerosol produced in the laboratory, smoke from controlled biomass burning experiments, and ambient air. We controlled and varied relative humidity during a subset of experiments to examine the sensor response to conditions that would likely be encountered during vertical profiling in the atmosphere, and introduced a modified, heated cell to reduce the impact of varying RH. We also examined the response of the sensor for several different filter media. We find that the sensor response was consistent with measurement artifacts previously reported for other filter-based absorption measurement techniques. Sampling hygroscopic aerosol onto the measurement filter, coupled with variations in sample RH, lead to changes in apparent light absorption not captured by the clean reference filter. Consequently, the sharp RH changes that can be expected during vertical profiling may introduce apparent BC signals large in magnitude compared to the low BC concentrations aloft. Sample cell heating was shown to mitigate such artifacts that would affect its suitability for atmospheric vertical sampling.

8IM.50

Continuous Flow Hygroscopicity-Resolved Relaxed Eddy Accumulation (Hy-Res REA) Method of Measuring Size-Resolved Sea-Salt Particle Fluxes. NICHOLAS MESKHIDZE, Taylor Royalty, Brittany Phillips, Kyle Dawson, Markus Petters, Robert Reed, Jason Weinstein, Adam Hook, Russell Wiener, *NC State*

The accurate representation of aerosols in climate models requires direct ambient measurement of the size- and composition-dependent particle production fluxes. Here we present the design, testing, and analysis of data collected through the first instrument capable of measuring hygroscopicity-based, size-resolved particle fluxes using a continuous-flow Hygroscopicity-Resolved Relaxed Eddy Accumulation (Hy-Res REA) technique. The different components of the instrument were extensively tested inside the US Environmental Protection Agency's Aerosol Test Facility for sea-salt and ammoniums sulfate particle fluxes. The new REA system design does not require particle accumulation, therefore avoids the diffusional wall losses associated with long residence times of particles inside the air collectors of the traditional REA devices. The Hy-Res REA system used in this study includes a 3-D sonic anemometer, two fast-response solenoid valves, two Condensation Particle Counters (CPCs), a Scanning Mobility Particle Sizer (SMPS), and a Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA). A linear relationship was found between the sea-salt particle fluxes measured by eddy covariance and REA techniques, with comparable theoretical (0.34) and measured (0.39) proportionality constants. The sea-salt particle detection limit of the Hy-Res REA flux system is estimated to be ~ $6x10^5$ $m^{-2}s^{-1}$. For the conditions of ammonium sulfate and sea-salt particles of comparable source strength and location, the continuous-flow Hy-Res REA instrument was able to achieve better than 90% accuracy of measuring the sea-salt particle fluxes. In principle, the instrument can be applied to measure fluxes of particles of variable size and distinct hygroscopic properties (i.e., mineral dust, black carbon, etc.).

8IM.51

Comparison of Aerosol Chemical Characterization Techniques Utilizing a PTR-ToF-MS: A Study on Biogenic SOA Formation and Gas-To-Particle Partitioning.

GEORGIOS GKATZELIS, Philipp Eichler, Iulia Gensch, Thorsten Hohaus, Markus Mueller, Patrick Schlag, Sebastian Schmitt, Ralf Tillmann, Kang-Ming Xu, Zhujun Yu, Rupert Holzinger, Armin Wisthaler, Astrid Kiendler-Scharr, *Forschungszentrum Jülich*

Atmospheric organic aerosol (OA) play a key role in climate change and air quality. OA are either directly emitted through e.g. combustion processes or formed as secondary OA (SOA) through the oxidation of volatile organic compounds. SOA constitute a major fraction of OA with biogenic VOC oxidation products strongly affecting their global contribution. A detailed understanding of biogenic SOA (BSOA) formation and aging still remains a challenge. In order to better quantify and chemically characterize BSOA, new online and semi online measurement techniques have been developed.

In this framework, a comparison of three different aerosol chemical characterization techniques has been performed. The aerosol collection module (ACM, Hohaus et al. 2010), the chemical analysis of aerosol online (CHARON, Eichler et al. 2015) and the collection thermal desorption unit (TD, Holzinger et al. 2010) are different inlets utilizing a PTR-ToF-MS. These techniques were deployed in a set of chamber experiments at the atmosphere simulation chamber SAPHIR to investigate the composition of fresh and aged BSOA from the ozonolysis and photooxidation of β-pinene, limonene and real plant emissions.

Comparison of the measured mass concentration of the individual instruments to an SMPS showed recovery rates between 20 and 80 %, independent of the identity of the monoterpene oxidized. Further classification of the SOA composition showed that the conditions in the reaction ionization chambers of the PTR-ToF-MS (E/N) played a key role in the fragmentation patterns. Increasing recovery rates of organic mass were observed for reduced E/N conditions thus reduced fragmentation. A detailed analysis of the gas-to-particle partitioning of major BVOC oxidation products was performed. The observed saturation concentrations were compared with values predicted from the molecular structure of the individual compounds. Good agreement within the range of uncertainty was found for most of the compounds studied.

8IM.52

Accuracy and Reproducibility of DMS500 Fast Mobility Size Spectrometers Over 10 Years.

Jonathan Symonds, CHRIS NICKOLAUS, *Cambustion*

Fast response particle mobility sizers, such as the Cambustion DMS500 and the TSI EEPS / FMPS have been commercially available for around 15 years. Compared with a Scanning Mobility Particle Sizer (SMPS), these instruments trade spectral resolution and absolute accuracy for a fast time response (up to 200 ms $T_{10-90\%}$). Some initial studies showed that early examples of these instruments were not as accurate as established methods of sizing, and instrument consistency was rather variable.

In response to these studies, a traceable calibration using aerosol sizing and number standards was developed for the DMS500. Recognising that soot agglomerates gain more charge in a corona charger compared with “compact” (near spherical) particles, separate calibrations were produced for soot and compact particles, via different data inversion matrices (Symonds and Reavell, 2006).

As it is a decade since traceable calibrations for compact and soot aerosols were pioneered for the DMS500, we here present a statistical analysis of the full corpus of instrument calibrations undertaken over that time.

The results show that in the last decade all DMS500s when challenged with 100 nm DMA selected aerosol exhibited a sizing error of less than 5% for NaCl aerosols, less than 10% for CAST soot aerosols and a number concentration error of less than 10% compared with a standard electrometer for both types of aerosol. Gradual improvement is observed over the decade. Over the last 3 years, the median deviation from the size and number standards at 100 nm is less than 1% for both types of aerosol, with upper and lower quartiles each within 2% of the median. Similar data across the full size range is presented.

Symonds, J.P.R. and Reavell, K.St.J. (2006). *Calibration Of A Differential Mobility Spectrometer*. European Aerosol Conference, Salzburg T02A034.

8IM.54

A Novel Miniature Inverted Burner for the Steady Generation of Soot Particles.

MOHSEN KAZEMIMANESH, Kerry Chen, Jordan Titosky, Jason S. Olfert, *University of Alberta*

A miniature inverted burner was designed and its emitted soot nanoparticles were studied. The burner consisted of two co-annular tubes for fuel and co-flow air with internal diameters of 5.54 and 30 mm, respectively. The fuel of choice was ethylene due to its high sooting tendency. The generated flame was an inverted diffusion flame, enclosed in a quartz tube. Part of the co-flow air near the flame was used for the combustion of the fuel while the rest of the co-flow air in the vicinity of the quartz tube diluted the combustion products downstream of the flame, without the need for a secondary dilution. Three different sizes for the fuel tube (1.75, 3.35, and 5.54 mm in diameter) and the co-flow air tube (16, 24, and 30 mm in diameter) were tested to investigate the effect of geometry on flame stability and emission of soot particles. Different fuel and air flow rates were also tested to study the characteristics of the soot emissions from the burner. A scanning mobility particle sizer (SMPS) was used to determine the soot particle size distribution in each case. The effect of adding nitrogen to the fuel flow on the particle emissions was also studied for various fuel to nitrogen ratios. Moreover, the morphology of the emitted soot particles was studied using a transmission electron microscopy (TEM).

Results showed that only the large co-flow air tube could generate a flame with a dynamic range of soot particle concentration. The flame had a closed tip with low particle concentration for lower fuel flow rates, while it was open tip with high particle concentration beyond a certain threshold for the fuel flow rate. Small and medium sized co-flow tubes resulted in a closed tip flame due to overventilation. Moreover, the results showed that for the large co-flow geometry, the size distribution of soot particles did not change much with variation in co-flow air flow rate and, therefore, the co-flow air flow rate was held constant at 10 SLPM (standard litres per minute at 25°C and 101.325 kPa); however, the particle size distributions were strongly dependent on the fuel flow rate. Concentration and count median mobility diameter of soot particles changed significantly with slight changes in fuel flow rate until it reached a saturation state and the size of particles did not change noticeably. For fuel flow rates of 0.087, 0.096, 0.113, and 0.130 SLPM, the total concentration of soot particles was 2.35×10^5, 1.37×10^6, 1.91×10^7, and 3.66×10^7 cm^{-3}, respectively. For the same fuel flow conditions, the count median diameter of soot particles was 85, 140, 166, and 168 nm, respectively. The addition of nitrogen to the fuel flow caused a gradual decrease in both particle mobility diameter as well as particle concentration as the nitrogen to fuel ratio increased up to 50%. Repeatability tests suggested that the miniature inverted burner could be used in applications such as a portable source of soot nanoparticles with great reproducibility of particle size and concentration.

8IM.55

Development of a Methodology for Generation of the Iodine Mixture Particles, and its Chemical Composition Analysis.

SHIGERU KIMOTO, Kenji Shiota, Yuki Yasumoto, Yasuto Matsui, Minoru Yoneda, *Kyoto University*

It is very interested to know the deposition process in the indoor. To keep our good health, an indoor protection method in case of plant accident/disaster, is one of important topics for urgent protective actions. That is because residents, who live around accident site, need to prevent an exposure from toxic gas and aerosols as soon as possible. We developed an evaluation system for sheltering. To evaluate the aerosol behavior using our chamber system, the test of a particle generation is necessary. The iodine mixture particles were evaluated in this study, because the iodine is an important material to evaluate the radiological effects on inhabitants due to a nuclear power plant accident. The iodine mixture particles were generated using the electrospray. Potassium iodide and sodium chloride dissolved in solution for the electrospray. To analyze its chemical compositions as aerosols in the gas phase, the online-measurement technique is required. Therefore, we developed a tandem system that consists of a differential mobility analyzer (DMA), the gas exchange device (GED) and the ICP-MS (DMA – GED – ICP-MS). We will report our method and its results.

This research was supported by the Nuclear Regulation Authority (NRA) and the Japan Atomic Energy Agency (JAEA).

8IM.56

Counting Efficiency Evaluation of Optical Particle Counters in Micrometer Range by Using Inkjet Aerosol Generator as a Monodisperse Particle Number Standard.

KENJIRO IIDA, Kensei Ehara, Hiromu Sakurai, Naoyuki Taketoshi, Fuminari Ito, *AIST*

This poster presentation introduces a SI-traceable method to evaluate the counting efficiencies of optical particle counters. The method uses inkjet aerosol generator (IAG) as monodisperse particle number standard, and the particle diameter range of SI-traceable calibration is from 0.5 µm to 10 µm. IAG delivers monodisperse particles at precisely controlled rate into an OPC inlet. The method using the IAG defines the size of test particles as volume equivalent diameters because test particles are evaporation residue of an inkjet solution. PSL equivalent optical diameter of the test particles is evaluated by analyzing the pulse height of light scattering signals, and aerodynamic diameter is also measured by using an aerodynamic particle sizer. In order to simulate the sampling of uniformly mixed aerosol the IAG introduces particles at various points across the cone shaped inlet of an OPC. These points are chosen to simulate the spatial distribution of particle flux across the inlet assuming that the velocity distribution of gaseous component is either parabolic or plug. The circular area of the inlet is divided into four segments with equal flow rate under an assumed flow profile; the innermost segment is a circle and the other three are rings. The outlet tube of the IAG travels horizontally through a set of injection points across the inlet to make the number of particles injected to each equal-flow segment is nearly equal. Counting efficiency under an assumed velocity distribution is reproducible, and the reported uncertainty includes the error caused by that the true velocity distribution is somewhere between parabolic or plug. This presentation shares our recent calibration results obtained at 5 µm and 10 µm. The chemical composition of the test particles are lactose monohydrate and sodium chloride. The sampling flowrate and inlet diameter of the tested OPC are 6 L/min and 50 mm, respectively.

8IM.57

Determining the Validity of Storing Biomass Burning Aerosol in Water Using an Impinger for Laboratory Studies on Physicochemical and Optical Properties.

MARC FIDDLER, Damon Smith, Samin Poudel, Marquin Spann, Solomon Bililign, *North Carolina A&T State University*

Since it is not always practical to carry laboratory equipment into the field, it is useful to collect samples and store them for future analysis. The goal of this study is to determine if there is a significant difference in the properties of fresh biomass burning aerosol compared to samples stored in distilled water using an impinger. A previous field study has determined that the size distribution of BB aerosol samples stored in water remains unchanged for at least two weeks after storage, but it is currently unknown if this is representative of the original field sample and if the aerosols have undergone significant chemical changes that affect their optical properties. The primary factors being considered are size distribution, composition, and single scattering albedo. A tube furnace and smog chamber were used to generate BB aerosol in a laboratory setting. These results were also compared with T-Matrix calculations using electron microscopy images of filter samples.

8IM.58

Characterization of a Smog Chamber for Analysis of the Formation, Physicochemical, and Optical Properties of Aging Biomass Burning Aerosol. DAMON SMITH, Marquin Spann, Marc Fiddler, Solomon Bililign, *North Carolina A&T State University*

Biomass burning (BB) is recognized as one of the largest sources of absorbing aerosols in the atmosphere and significantly influences the radiative properties of the atmosphere. The chemical composition and physical properties of particles evolve during their atmospheric lifetime due to condensation, oxidation reactions, etc. Changes in chemical composition due to aging is likely to change the optical properties of these particles as well. To this end, an indoor smog chamber, having a volume of ~9 m^3, was constructed to study aging BB aerosol in a laboratory setting. Injections to the chamber, such as NOx, O3, and various biogenic and anthropogenic VOCs, can simulate a variety of atmospheric conditions. These components and some of their oxidation products can be monitored and characterized during the aging process. A tube furnace is used for combustion of biomass to be introduced into the chamber, while size distributions are taken as the aerosol ages. Optical properties are measured from samples taken directly from the chamber and analyzed using a Cavity Ring-down Spectrometry and Integrating Nephelometry system.

8IM.59

Measurement of Crystalline Silica Aerosol Using Quantum Cascade Laser-based Infrared Spectroscopy. SHIJUN WEI, Pramod Kulkarni, Kevin Ashley, Lina Zheng, *Centers for Disease Control and Prevention, NIOSH*

An approach using quantum cascade laser (QCL)-based infrared (IR) spectroscopy to quantify airborne concentrations of crystalline silica aerosol has been developed. Three aerosol collection methods were investigated for effective coupling with QCL: i) conventional total aerosol filter collection; ii) focused spot sample collection directly from the aerosol phase; and iii) dried spot RCS analysis after deposition using liquid sample slurries. Spectral analysis methods were developed to obtain IR spectra from the collected particulate samples in the range 750-1030 cm^{-1}. The system was calibrated and the QCL results compared with standardized methods using Fourier transform infrared (FTIR) spectrometry. Results show that significantly lower detection limits for crystalline silica (~330 ng) could be achieved with effective microconcentration and careful coupling of the particulate sample with the QCL beam. These results offer promise for further development of sensitive filter-based laboratory methods and direct-reading portable monitors for near real-time measurement of crystalline silica aerosol.

8IM.60

In-situ Comparison of SFCA to Constant Flow Operation of Two CCNcs during KORUS-AQ. JAMES HITE, Andreas Beyersdorf, Chelsea Corr, Edward Winstead, Kenneth Thornhill, Bruce Anderson, Athanasios Nenes, *Georgia Institute of Technology*

Scanning flow CCN analysis (SFCA) is a mode of operation for the Droplet Measurement Technologies (DMT) Continuous-Flow Streamwise Thermal-Gradient Cloud Condensation Nuclei Counter (CCNc). This method has been utilized on airborne platforms many times providing high temporal resolution CCN concentrations at a range of supersaturations. The supersaturation is controlled by the flowrate through the column rather than the temperature gradient, as with standard (i.e. constant flow) operation. During the summer 2016 KORUS-AQ field deployment, two CCNcs were in the payload of the DC-8. One was operated in an SFCA mode and the other was operated at constant flow for a single supersaturation (nominally 0.6%). This work presents the results of a first ever direct comparison of SFCA to constant flow operation with ambient flight data and demonstrates the successful agreement between the two measurements. Recommendations for the supersaturation calibration and other limitations are also discussed.

8IM.61

Using Low-cost PM2.5 Sensors for Air Quality Education Outreach. CHARLES STANIER, Can Dong, Nathan Janechek, Nathan Bryngelson, Joseph A'Hearn, Megan Christiansen, *University of Iowa*

As part of the CLE4R air quality education project, the University of Iowa has been working with AirBeam low-cost consumer-grade PM2.5 sensors in educational and outreach settings, both in K-12 environments and in informal settings such as science days and technology fairs. For use in K-12 classrooms, requirements for robust startup, operation, and ease-of-use are high. Mapping of concentrations is a desirable attribute but adds additional sources of failure to the hardware-software system used for education/outreach. The AirBeam sensor is a portable, low-cost sensor based on the Shinyei PPD60PV-T2 sensor which measures light scattering due to aerosols as a single bin, converting the detected signal to a particle count and uses a calibration fit to estimate particle mass. The AirBeam is able to detect particle sizes of 0.5 – 2.5 µm, concentrations up to 400 µg m^{-3}, and with a time resolution of 1 s. A corresponding Android device is used to visualize, record, and upload measured data to a community website that maps the spatial and temporal resolved data. As of April 1st, 2017, through the CLE4R project, 109 people had used the AirBeam sensors for educational purposes, for a total of 271 person hours. In the poster, we will explain the outreach that was done, and share best practices for education and outreach using consumer-grade PM sensors. Strengths and needed improvements to the technology for these outreach, education, and classroom uses will also be detailed. Sources of particles that can be artificially generated for educational use, including authentic smoke, spray smoke, and various dust sources will be enumerated.

8IM.62

Probing Structure and Chemical Properties of Free-standing Clusters with Synchrotron Radiation. NONNE PRISLE, J. Malila, K. Jänkälä, M. Patanen, M. Huttula, *University of Oulu, Oulu, Finland*

Despite intensive laboratory and field measurements, dating back over a century ago, molecular details of formation and growth of new atmospheric particles remain elusive. Changes in new particle formation and growth rates can affect global concentrations of cloud condensation nuclei, thus contributing to anthropogenic radiative forcing (Merikanto et al., *Atmos. Chem. Phys.*, 8601, 2009). A mechanistic understanding of these processes, including phase and surface properties of newly formed particles, is therefore vital for reducing uncertainties in climate forecasts. Deductions based on indirect measurements have proven inconclusive (Kupiainen-Määttä et al., *J. Aerosol Sci.*, 127, 2014), and recently there has been a surge towards measurements setups yielding molecular-level resolution of cluster properties.

Surfaces are moving into the spotlight of the atmospheric aerosol community. A suite of novel instrumentation developments now allow for highly surface sensitive chemical characterization of systems with increasing resemblance to atmospheric aerosols. The Multiuse Setup for Clusters Emission (MUSCLE) is custom-built for producing freestanding multicomponent nanoparticles with well-defined composition, and directly characterizing their chemical, structural, and phase-state properties using synchrotron radiation based spectroscopy at the FinEstBeAMS beamline, MAX IV Laboratory. The brightness of the new MAX IV synchrotron light source enables the use of powerful surface sensitive photoelectron spectroscopy for low density samples, in particular freestanding cluster beams of atmospherically relevant trace components.

MUSCLE is our next generation cluster source based on the proven basic design of the Exchange Metal Cluster (EXMEC) source (Huttula et al., *J. Electron Spectroscopy and Related Phenomena*, 145, 2010). Using this setup, we have generated clusters of e.g. aqueous alkali halides with controlled composition (Hautala et al., *Phys. Rev. B*, 45402, 2016) and semi-volatile atmospheric organics, including stearic acid (unpublished data). With synchrotron based photoelectron spectroscopy we have e.g. observed size-dependent structural phase transitions for CsBr clusters (Hautala et al., 2016).

8IM.63

A Real-time Impactor for Ambient and Vehicle Exhaust Particle Mass Distribution Measurement. Yue Lin, Liem Pham, Heejung Jung, MODI CHEN, Francisco Romay, *University of California, Riverside*

A real-time cascade impactor based on quartz crystal microbalance (QCM) was developed for measuring aerosol mass distribution. This instrument contains two key components: an RH conditioner that conditions particles in the 45% to 65% relative humidity range to ensure reliable mass sensing, and a cascade impactor with QCM sensors to measure the mass of particles between 45 nm and 2.5 μm aerodynamic diameter.

In this study, the real-time impactor was compared with the Fast Mobility Particle Sizer Spectrometer (FMPS) and the Scanning Mobility Particle Sizer Spectrometer (SMPS) during simultaneous measurements of ambient particles at the South Coast Air Basin. These instruments were tested with aerosols from urban background, on-road and roadside environments. The urban background aerosol measurement was conducted at the UC Riverside campus. The ambient particles without thermal conditioning were sampled for 12 hours. In another 17-hour experiment particles were thermally treated with a Catalytic Stripper working at 300°C to remove the semi-volatile particle fraction upstream of the sampling instruments. An aerosol chamber was installed at the inlet of the instruments to smooth particle size and mass variation. The SMPS data was collected simultaneously with the real-time impactor and the FMPS data. The roadside measurement with the real-time impactor and the FMPS was conducted for 2 hours at the downwind side of Freeway I-215 during afternoon traffic hours. On-road measurements with the impactor and the FMPS were conducted on a round-trip from UC Riverside to Yorba Linda taking State Freeway 91. Preliminary analysis indicates that the real-time impactor could track ambient aerosol mass evolution closely when compared with the FMPS. The mass distribution of real-time impactor also agrees well with that calculated from FMPS for the various size distributions when using a proper particle density for the FMPS mas distribution calculation. The real-time impactor is stable and reacts sensitively to relatively fast-changing roadside aerosol concentrations. In addition time resolved mass distribution was compared between QCM and AVL MSS (Micro Soot Sensor). QCM showed mass distribution as well as desorption of semivolatile PM during the transient test cycle.

8IM.64

Influence of Shape Factor and Effective Density on Aerodynamic Sizing of Particles Generated by the TSI/MSP 1520 Flow-Focusing Monodisperse Aerosol Generator (FMAG). Andrea Tiwari, LIN LI, Francisco Romay, *TSI Incorporated*

The Flow-focusing Monodisperse Aerosol Generator (FMAG, Model 1520) from TSI (MSP) generates highly monodisperse particles out of both solid and liquid solutions. While liquid particles may safely be assumed to be spherical and have the same density as the bulk substance, those assumptions are not always applicable for solid particles. Both shape factor and effective density can influence the measured aerodynamic size of solid particles; this has implications for the user both in preparing solutions for aerosol generation, and from a data interpretation perspective.

This work explores the influence of shape factor and effective density on the agreement between experimental and theoretical aerodynamic particle sizes. Monodisperse supermicron particles of different compositions, including ammonium sulfate, sodium chloride, oleic acid, glycerol, etc., were generated by FMAG using the same volume fraction solution. Their aerodynamic sizes were measured by an Aerodynamic Particle Sizer (APS, Model 3321). Published literature values for shape factor and effective density are applied to calculate the theoretical aerodynamic size. The detailed comparison between the experimental and theoretical aerodynamic sizes will be presented in the poster.

8IM.65

Development and Evaluation of Cost-Efficient Multipollutant Monitors and High Spatiotemporal Resolution Measurement Networks. DREW GENTNER, Fulizi Xiong, Kate Skog, Misti Zamora, Joseph Kohrman-Glaser, Kevin Ryan, Branko Kerkez, Kirsten Koehler, *Yale University*

We present custom multipollutant monitors designed and deployed as part of the EPA-funded SEARCH center at Yale-Johns Hopkins. Our monitors actively measure PM_1, $PM_{2.5}$, PM_{10}, CO, CO_2, CH_4, NO_2, NO, O_3, and SO_2 via a mix of spectroscopic and electrochemical techniques, all within in a small monitor housing. Data resolution ranges from 1 second to 1 minute with detection limits that match or exceed current sensor industry performance. The device uses custom ultra-low noise electronics to interface with all sensors and collect/transmit data from a local microprocessor via cellular communications to real-time cyber infrastructure for data assimilation across the network. We present lab and field data demonstrating monitor performance across the suite of pollutants measured, and results from our initial deployment.

8IM.66

Limitations and Modifications of Impregnated Filter Method for Sampling Sulfur Dioxide Gas. Chufan Zhou, CHIH-HSIANG CHIEN, Alexandros Theodore, Chang-Yu Wu, Yu-Mei Hsu, Brian Birky, *University of Florida*

Collection of sulfur dioxide gas (SO_2) using a filter impregnated with a solution containing Na_2CO_3 and glycerol is a NIOSH method to assess SO_2 concentration in the occupational setting. However, this method is subject to relative humidity (RH), and the breakthrough kinetics is unknown. To investigate the issue, a family of filters treated by solutions with an increasing amount of glycerol (0 – 20% v/v) and a constant amount of sodium carbonate (2.5% w/v) were tested under medium (45%) RH condition. The results showed these treated filters did not have enough capacity for sampling 10 ppm of SO_2 under both 200-minute sampling and 8-hour occupational exposure conditions. The breakthrough curve illustrated that filters coated with less glycerol had earlier 50% breakthrough, indicating the role of the coated glycerol amount on the filter in building up the water content. Sufficient water content, important to the dissolution and dissociation of Na_2CO_3, enhances ion transport in the mixture that helps increasing the utilization of the coated Na_2CO_3. Secondly, experiments were conducted to evaluate the performance with more Na_2CO_3 coated on the filter (10% and 20%). The results demonstrated that the new protocols successfully increased the breakthrough time under 45% RH for 8-hr. However, early breakthrough still occurred in dry (25%) RH condition due to low utilization of Na_2CO_3 resulting from the insufficient water absorbed. The results suggest that incorporating more Na_2CO_3 and glycerol in the coating protocol can further improve performance. Finally, a kinetic model was proposed to describe SO_2 sorption behavior on the impregnated filter. This model predicted well when the impregnated filter works under medium RH range or holding sufficient glycerol amount, i.e., when the ion diffusion rate in the liquid phase was high and the coated Na_2CO_3 could be utilized fully.

8IM.67

Evaluation of a Low-Cost Monitor for PM2.5 in Two Chinese Cities. QI YING, Jianlin Hu, Qiao Xue, Hongliang Zhang, *Texas A&M University*

A low-cost PM monitor based on the popular PPD42 sensor was developed was developed and deployed in two Chinese cities, Nanjing in the Yangtze River Delta and Chengdu in the Sichuan Basin, from December 2015 to August 2017, side by side with BAM-1020 PM2.5 monitors to determine their capability in measuring PM2.5 concentrations under concentrations relevant to pollution levels in China. A novel algorithm based on artificial neural network (ANN) was developed to better account for the influence of relative humidity and temperature to improve the correlation between low-cost monitor raw readings with the reported PM2.5 concentrations by the BAM-1020. At the Nanjing site (on campus of Nanjing University of Information Science and Technology, or NUIST), multiple instruments were developed to test the reproducibility of the sensor readings. The low-cost monitors were shown to be able to reproduce the observed PM2.5 concentrations within ±20%, with better performance at higher concentrations. Reproducibility of the sensors were shown to be acceptable when the sensors were of the same age. However, the response of the sensors appears to change slowly, due to either decay of the sensor or accumulation of dust within the sensor so that sensors of different ages lead to different raw readings.

8IM.68

Black Carbon Estimates from Optical Carbon Analysis of Federal Reference Method Teflon Filters. Paige Presler-Jur, PRAKASH DORAISWAMY, Oliver Rattigan, H. Dirk Felton, *RTI International*

Black carbon (BC), a by-product of incomplete fuel combustion, contributes adversely to human health, visibility, and climate impacts. In this study, we present estimates of black carbon from optical carbon analysis of federal reference method (FRM) Teflon filters. We build upon our earlier work that used a Magee OT21 transmissometer to evaluate mass absorption efficiency of samples previously collected as part of the Chemical Speciation Network (CSN). As part of this work, we present results from ongoing optical carbon analysis of FRM filters for samples collected in New York State as part of the routine FRM network. We evaluate the added benefit of doing a filter-specific initial transmittance analysis in BC estimates. We then compare BC estimates from these measurements against elemental carbon (EC) measurements from the CSN samples as well as against BC data from absorption measurements made by the aethalometer at selected sites. The sites include both urban and rural sites, including a remote background site with typically very low BC concentrations. The analysis examines the utility of the optical analysis, its relationship to commonly used thermal optical EC analysis, and the applicability for clean environments.

8IM.69

Light Absorption and Chemical Speciation of Organic Carbon in Wood Smoke, Diesel Exhaust and Urban Particulate Matter. Alena Kubatova, Klara Kukowski, JAMES DIEKMAN, *University of North Dakota*

Current climate models either disregard or underestimate the contribution of light absorption by organic carbon (OC) within particulate matter (PM) to radiative forcing. While light absorption by black carbon is recognized, OC was long viewed only as light-scattering. By contrast, recent studies have demonstrated the light absorption potential of OC mainly in the low-visible and ultraviolet wavelengths. To assist developing the climate models, the absorptivities of wood smoke, diesel exhaust and urban PM were measured in the visible and ultraviolet spectrum range using a newly developed instrumentation, vacuum ultraviolet detector coupled to a gas chromatograph (GC-VUV). With GC-VUV, organic compounds were chromatographically separated and their individual absorptions were measured in the gas phase. This setup eliminated the interference of solvent absorption, which is observed in traditional UV-Vis spectrophotometry.

Furthermore, GC-VUV together with GC-MS were used for chemical speciation allowing for a comparison of the OC chemical composition to absorption. To isolate OC from PM, exhaustive Soxhlet extractions were performed using both methanol and dichloromethane. For all three PM samples, OC extraction recoveries were the highest in methanol amounting to 40–60%. However, for wood smoke PM, dichloromethane extracted higher-absorbing compounds compared to methanol. The OC absorptivity was wavelength dependent and decreased towards the visible light region with the highest absorption observed for wood smoke PM. The OC absorptivity at visible light wavelengths correlated with the occurrence of polycyclic aromatic hydrocarbons.

8MO.1

Implications of Emission Inventory Choice for Modeling Fire-Related Pollution in the U.S. SHANNON KOPLITZ, Christopher Nolte, *U.S. EPA*

Fires are a major source of particulate matter (PM), one of the most harmful ambient pollutants for human health globally. Within the U.S., fire emissions can account for more than 30% of total PM emissions annually. In order to represent the influence of fire emissions on atmospheric composition, regional and global chemical transport models (CTMs) rely on fire emission inventories developed from estimates of burned area (i.e. fire size and location). Burned area can be estimated using a range of top-down and bottom-up approaches, including satellite-derived remote sensing and on-the-ground incident reports. While burned area estimates agree with each other reasonably well in the western U.S. (within 20-30% for most years during 2002-2014), estimates for the southern U.S. vary by more than a factor of 3. Differences in burned area estimation methods lead to significant variability in the spatial and temporal allocation of emissions across fire emission inventory platforms. In this work, we implement fire emission estimates for 2011 from three different fire emission products (NEI, FINN, and GFED4s) into the Community Multi-scale Air Quality (CMAQ) model to quantify and characterize differences in simulated fire-related PM and ozone concentrations across the contiguous U.S. due solely to the emission inventory used. Understanding the sensitivity of modeling fire-related PM and ozone in the U.S. to fire emission inventory choice will inform future efforts to assess the implications of present and future fire activity for air quality and human health at national and global scales.

8MO.2

The Influence Pre-existing Organics on Secondary Organic Aerosol Formation from Reactive Uptake of Isoprene Epoxydiols in a Regional Scale Model. MUTIAN MA, Havala Pye, Yue Zhang, Yuzhi Chen, Chitsan Wang, Jason Surratt, William Vizuete, *University of North Carolina at Chapel Hill*

Isoprene oxidation products formed under low-nitric oxide (NO) conditions are important precursors for the formation of particulate matter (PM). Specifically, isoprene epoxydiols (IEPOX), an abundant isoprene-derived oxidation product, forms secondary organic aerosol (SOA) via acid-catalyzed multiphase (heterogeneous) reactions. Recent experimental studies at UNC-Chapel Hill, using synthetically-derived IEPOX, have quantified the reactive uptake of IEPOX to determine how much gas-phase IEPOX could form SOA. An accurate description of this process is critical in regulatory modeling to predict the formation of SOA. These experiments, however, consisted only of pure sulfate aerosol of varying acidity without a pre-existing organic coating. Under some atmospheric conditions, organic layers can exist on pre-existing aerosols potentially changing both the physical and chemical properties of IEPOX-derived SOA. Prior experiments, using α-pinene as a surrogate for an organic coating on an ammonium bisulfate seed, have found that IEPOX uptake ceased when the mass of alpha-pinene derived coating exceeds 85% of the total aerosol mass. Ongoing experiments at UNC are quantifying how the thickness and type of organic coating at varying levels of relative humidity will influence IEPOX diffusivity within the aerosol phase. Leveraging this new data, we will estimate the impact of organic coating on regional model predictions of IEPOX-derived SOA using the Community Multiscale Air Quality (CMAQ) v5.2 system. This version of CMAQ was developed by Environmental Protection Agency (EPA) and includes IEPOX and aqueous-phase chemical reaction pathways leading to IEPOX-derived SOA formation. These modeling algorithms, however, have yet to include the influence of pre-existing organic coatings. Using the new UNC experimental data as a guide, we will provide sensitivity runs changing the reactive uptake parameter and predicting the change in IEPOX-derived SOA. This modeling episode also coincided with the Southern Oxidant and Aerosol Study (SOAS), allowing for comparisons with measured IEPOX-derived SOA.

8MO.4

Assessment of Important SPECIATE Profiles in EPA's Emissions Modeling Platform and Current Data Gaps. CASEY BRAY, Madeleine Strum, Heather Simon, Lee Riddick, Mike Kosusko, Venkatesh Rao, *US EPA*

The US Environmental Protection Agency (EPA)'s SPECIATE database contains speciation profiles for both particulate matter (PM) and volatile organic compounds (VOCs) that are key inputs for creating speciated emission inventories for air quality modeling. The objective of this work is to identify the most influential profiles based on mass and reactivity for various regions of the US. These profiles will be further investigated to characterize the profile quality and determine whether current matching between profiles and source types appropriately captures source type and regional variability in speciation. In cases where this analysis identified either low quality or poorly matched profiles, an in-depth review of the SPECIATE database and the literature will be conducted to identify currently available suitable replacements. In cases where no suitable replacement profiles are found, this analysis will identify important gaps in the current literature which may be used to prioritize future speciation source testing. Through this process we aim to identify critical research needs, improve the SPECEATE database and improve a critical input for photochemical modeling efforts.

8MO.5

Evaluating Regional Air Quality Model Impacts during the 2013 Rim Fire. MATTHEW WOODY, Kirk Baker, Benjamin Murphy, Jose-Luis Jimenez, Pedro Campuzano-Jost, *United States Environmental Protection Agency*

Wildland fires are one of the largest sources of $PM_{2.5}$ emissions in the U.S. and adversely impact air quality, human health, and visibility. Anthropogenic emissions have trended down in recent years and as that trend continues, the relative importance of wildland fires on air quality will continue to rise. However, the skill in photochemical models (e.g. the Community Multiscale Air Quality (CMAQ) model) to predict air quality impacts from wildland fires remains somewhat uncertain. In this work, we characterize CMAQ wildland fire performance by evaluating predictions for the 2013 Rim Fire, the third largest wildfire in California history, against gas and particle-phase measurements collected onboard NASA's DC-8 aircraft during the SEAC4RS field campaign.

Results suggest that CMAQ captures the fire's plume location and CO concentrations well. However, CMAQ significantly under-predicts the $PM_{2.5}$ concentrations, the majority of which is comprised of organic aerosols (OA), in the vicinity of the fire by up to a factor of 8, likely a result of underrepresented emissions. While the traditional non-volatile primary organic aerosol treatment in CMAQ limits the underestimate of OA emissions and PM concentrations, the recently implemented semivolatile primary organic aerosol treatment more accurately captures the organic aerosol evolution of PM in the plume as it moves downwind of the fire. Finally, results suggest the need for biomass burning-specific model OA species and treatment, including aging, to better represent biomass burning PM in regional air quality models.

8MO.6

Size-resolved Mixing State of Black Carbon in the Arctic and Implications for Simulated Direct Radiative Forcing.

JACK KODROS, Sarah Hanna, Allan Bertram, W. Richard Leaitch, Hannes Schulz, Andreas Herber, Marco Zanatta, Julia Burkart, Megan Willis, Jonathan Abbatt, Jeffrey R. Pierce, *Colorado State University, Fort Collins, USA*

Transport of anthropogenic aerosol emissions into the Arctic in the spring months has the potential to affect regional climate; however, modeling estimates of the aerosol direct radiative effect (DRE) are strongly sensitive to uncertainties in the mixing state of black carbon (BC). A common approach in previous modeling studies is to assume an entirely internal mixture (all primarily scattering species are mixed in the same particles as BC) or external mixture (all primarily scattering species are in separate particles from BC). In order to provide constraints on the size-resolved mixing state of BC, we use airborne Ultra-High Sensitivity Aerosol Spectrometer (UHSAS) and Single Particle Soot Photometer (SP2) measurements from the POLAR6 flights from the NETCARE/PAMARCMIP2015 campaign to estimate coating thickness as a function of BC core diameter as well as the fraction of particles containing BC in the springtime Canadian high Arctic. For BC core diameters in the range of 200 to 500 nm, we find average coating thicknesses of approximately 30 to 50 nm and BC-containing particle number fractions ranging from 3 to 20%. We combine the observed mixing-state constraints with simulated size-resolved aerosol mass and number distributions from GEOS-Chem-TOMAS to estimate the DRE with observed bounds on mixing state as opposed to assuming an entirely external or internal mixture. We find that the pan-arctic average springtime DRE is 0.12 W m^{-2} less negative when constraining the coating thickness of the mixed particles compared to an entirely external mixture but only 0.04 W m^{-2} less negative when constraining the BC-containing particle fraction compared to an entirely external mixture. The difference between these methods is due to an underestimation of BC mass fraction in the springtime arctic by a factor of 3 in GEOS-Chem-TOMAS compared to POLAR6 observations.

8MO.7

Contributions of Semi-Volatile Compounds from Combustion Sources in Japan.

YU MORINO, Satoru Chatani, Kiyoshi Tanabe, Yuji Fujitani, Tazuko Morikawa, Kei Sato, *National Institute for Environmental Studies*

In Japan, emission factors of particulate matters (PM) from stationary combustion sources have been measured without dilution or cooling, thus semi-volatile compounds were not included in the PM emission inventory. Recently, contributions of semi-volatile compounds were analyzed by comparing measured PM concentrations from stationary combustion sources (e.g., heavy oil or gas combustion) before and after dilution. From these data, we modified emission inventory to include semi-volatile compounds from stationary combustion sources. Total emission rates of organic aerosol (OA), dominant contributor to semi-volatile compounds from large combustion sources, increased by a factor of five. Emissions of OA of this estimate became even higher than the total PM2.5 emissions of the previous estimate. In addition, road transport and biomass burning were the dominant OA sources in the previous estimate, while large combustion sources in industrial or power generation sector became the largest contributors to OA emissions over Japan. These results indicate that semi-volatile compounds from combustion sources had critical contributions to total PM2.5 emissions.

Contributions of semi-volatile compounds from combustion sources were also evaluated from simulations of a chemical transport model with a volatility basis set (VBS) module. Simulated OA concentrations drastically increased around urban and industrial areas, including Tokyo Metropolitan Area, both in winter and summer. On average, OA concentrations increased by a factor of 1.9-2.2 and 2.1-3.0 over Tokyo Metropolitan Area in winter and summer, respectively. By considering semi-volatile compounds from combustion sources, model performance of OA was improved in winter. However, in summer, OA concentrations were largely overestimated by the model which considers both semi-volatile compounds from combustion sources and chemical aging. Contributions of primary and secondary OA should be further evaluated from comparison with measurement data of organic compounds.

8MO.8

Insights into a Haze Episode over a Coastal City Based on Multiple Measurements and Modeling Study. XIN WU, Junjun Deng, Youwei Hong, Lingling Xu, Lisi Zhao, Jinsheng Chen, *Institute of Urban Environment, Chinese Academy of Sciences*

To further investigate the aerosol characteristics and probable causes of atmospheric pollution, a severe accumulated regional haze episode over a coastal city Xiamen, China, was diagnosed. Daily samples were collected to analyze the chemical components of fine particulate matters ($PM_{2.5}$). Aerosol optical properties were acquired through a sun-photometer. The results show that stagnant meteorological conditions played a key role in the accumulation of aerosol particles during this episode. The height of the planetary boundary layer (PBL) was considered as one of the key factors together with other factors in the haze formation. Aerosol optical depth (AOD), light extinction coefficient and depolarization ratio in surface layer indicate that $PM_{2.5}$ dominated this haze event. A negative correlation was found between the concentrations of $PM_{2.5}$ and visibility. The distributions of gas pollutants (SO_2, NO_x and CO) were similar to that of fine particulate matters. Rising temperature, high relative humidity and low wind speed were the inducements of this episode. Water-soluble inorganic ions (WSIIs), organic carbon (OC) and elemental carbon (EC) were detected to elaborate the probable sources. Secondary inorganic ions and secondary organic carbon significantly influenced this haze episode. Backward trajectories results indicate that local circulation and slow air-mass prevented the diffusion of atmospheric pollutants. Simulated results of concentration of $PM_{2.5}$ and surface wind field by WRF-CMAQ demonstrate the evolution of this haze episode, indicating that this episode was mainly caused by local emission, barely by long-ranged transportation from north. Pollution accumulated by local emission, secondary aerosol formation and the stagnant meteorological conditions dominated the formation of this haze episode.

8MO.9

Reductions in Airborne PAHs with a Zero Emissions Vehicle Fleet. CYNTHIA WHALEY, Elisabeth Galarneau, Paul Makar, Wanmin Gong, Michael Moran, Craig A. Stroud, Junhua Zhang, Qiong Zheng, *Environment and Climate Change Canada*

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous toxic compounds released by biomass burning, industrial activities, and fossil fuel combustion, and they have been identified as pollutants of concern under the U.S. National Scale Air Toxics Assessment program and the Air Toxics in Canada project. Environment and Climate Change Canada's operational air quality forecasting model, GEM-MACH, was modified to simulate atmospheric concentrations of benzene and seven PAHs: phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, and benzo(a)pyrene. In the model, PAHs are emitted from major point, area, and on- and off-road mobile sources and undergo gas-particle partitioning, atmospheric transport, cloud processing, oxidation, and dry and wet deposition.

The GEM-MACH-PAH high-resolution, limited-area model was run for three summer months, and three winter months in 2009 using two emissions scenarios. The first included all emissions in the two national inventories, and the second omitted on-road mobile emissions of all pollutants, thereby simulating a zero emissions on-road fleet. Hourly output on a 2.5-km grid covering southern Ontario and much of the north-eastern United States was produced. Model predictions of atmospheric concentrations, wet deposition, and gas-particle partitioning were evaluated against measurements from a high spatial resolution field campaign in Hamilton, Ontario, as well as network observations from Canada's National Air Pollution Surveillance network, the U.S. National Air Toxics Trends Stations network, and the binational Integrated Atmospheric Deposition Network/Great Lakes Basin program.

The model experiment showed that on-road vehicles contribute a substantial fraction of benzene and PAHs at ground level where human exposure occurs. The model domain is home to more than 35 million people, and our results indicate that reductions in mobile emissions could reduce inhalation exposure to these pollutants significantly.

8MO.10

Overview of Lake Michigan Ozone Study (LMOS 2017). MEGAN CHRISTIANSEN, Nader Abuhassan, Jassim Al-Saadi, Timothy Bertram, Gregory Carmichael, Charles Stanier, Stephen Conley, Alan Czarnetzki, Angela F. Dickens, Marta Fuoco, Scott Janz, Laura Judd, Rob Kaleel, Donna Kenski, Matt Kowalewski, Russell Long, Dylan Millet, Brad Pierce, Stephanie L. Shaw, Elizabeth Stone, Jim Szykman, *University of Iowa*

Spring and summertime ozone pollution remains a challenging air quality problem along the coast of Lake Michigan. Production of ozone over Lake Michigan combined with onshore daytime “lake breeze” airflow is thought to increase ozone concentrations preferentially at locations within a few kilometers of the shore. A collaborative field campaign (Lake Michigan Ozone Study 2017, LMOS 2017) took place during May and June 2017 to gather high spatio-temporal resolution data to address this issue. The campaign provided extensive observational datasets regarding ozone, its precursors, particulate matter, and meteorology associated with ozone events through a combination of airborne, ship, mobile lab, and ground-based sites. In addition, chemical transport model (CTM) and meteorological forecast tools were employed. The ultimate goal of the campaign is to allow evaluation and improvement of CTMs used for regulatory and research purposes.

An overview of the campaign and its experience sampling atmospheric features relevant to scientific and air quality management goals will be discussed. Main observing systems during the campaign included GeoTASO (the airborne version of the future geostationary TEMPO instrument for remote sensing of column O3, NO2 and formaldehyde), aircraft in situ ozone and NO2 (Scientific Aviation), mobile lab trace gases (EPA region 5 GMAP), AirHarp (the airborne version of the Cubesat Hyper-Angular Rainbow Polarimeter HARP), boundary layer profiling and column O3, NO2 and formaldehyde using a network of Pandora spectrometers and ceilometers, and on-lake sampling from the NOAA research vessel R5503. Two ground stations (Sheboygan WI and Zion IL) included meteorological vertical profiling, and in situ gas and aerosol sampling of a wide variety of aerosol, VOC, NOy, and oVOC compounds. LMOS 2017 partners include LADCO and its member states, NASA, NOAA, EPA, EPRI, Scientific Aviation, University of Iowa, University of Minnesota, University of Wisconsin, and the University of Northern Iowa.

8MO.11

Nitrogen Oxide Emissions Perturbation and its Effects on the WRF-Chem Forecast. MEGAN CHRISTIANSEN, Maryam Abdioskouei, Negin Sobhani, Charles Stanier, Gregory Carmichael, Can Dong, *University of Iowa*

A collaborative field campaign (Lake Michigan Ozone Study 2017, LMOS 2017) occurred during May and June 2017 to address the high ozone episodes in coastal communities surrounding Lake Michigan. Episodic ozone concentrations exceed EPA/Clean Air Act National Ambient Air Quality Standards. Sampling of numerous chemical and meteorological parameters during LMOS 2017 permits in depth testing of chemical transport model (CTM) skill for meteorology, ozone, ozone precursors, speciated PM2.5, and ozone sensitivity indicator species and ratios such as HNO3 and H2O2. Sampling platforms included one research vessel on Lake Michigan, two aircraft, two major ground sites, one mobile van, and supplemental ground sites. A daily forecast of meteorology and air quality was used to direct mobile platforms. The computer transport model, WRF-Chem, was used as a forecast tool to evaluate the gas phase and aerosol mechanisms and spatial resolution of chemically reactive area of interest during flight planning meetings. The key challenge of the forecast was to simulate the lake breeze effect. Two separate full chemistry 48-hour forecasts were initialized every evening of the campaign. The first was a base simulation with NEI-2011(v2) emissions. The second was a NOx sensitivity simulation to test the model response to NOx emissions. Model performance evaluation of the two WRF-Chem configurations will be presented together with modeled sensitivity of O3 to NOx. Plans for post-campaign model-based analysis and CTM optimization will be presented. The perturbation of a 50% reduction in the NOx emissions allows for the evaluation of NOx and its contribution to the ozone concentration. Through extensive testing of the model’s configuration WRF-Chem was optimized to provide insight to ozone, NOx, VOC, formaldehyde, nitric acid, and other various air pollutants during the campaign.

8MO.12

Comprehensive Atmospheric Modeling of Gas-phase Cyclic Volatile Methyl Siloxanes and Their Oxidation Products.

NATHAN JANECHEK, Kaj Hansen, Charles Stanier, *University of Iowa*

Cyclic volatile methyl siloxanes are common chemicals in personal care products, especially antiperspirants and lotions. In the atmosphere, cyclic siloxanes are oxidized by hydroxyl radicals (OH) forming oxidation products that likely contribute to secondary aerosol loadings. In this work, we use the Community Multiscale Air Quality (CMAQ) atmospheric chemistry transport model to simulate gas phase cyclic siloxane behavior over North America, including first-ever comprehensive predictions of the potential for secondary aerosol from this source. This may be of interest to aerosol measurement groups, as modeled silicon SOA concentrations may guide measurement efforts in the absence of measurements. The model has been modified to include the most common cyclic siloxanes (D4, D5, and D6) and their OH oxidation products, emissions and seasonally varying boundary conditions calculated using measurement ratios accounting for differential oxidative aging, and wet and dry deposition for the cyclic siloxane species. This work represents the highest resolution modeling to date, and for the first time expected concentrations and the spatial distribution of the oxidation products, which some fraction likely exists in the particle phase, are reported. Using the model, four 1-month periods are modeled to quantify seasonal variability, expected concentrations, spatial patterns, and vertical profiles. Modeling results show urban parent cyclic siloxane seasonal concentrations are insensitive to regional OH but are rather controlled by the degree of localized vertical and horizontal dispersion. Monthly averaged peak concentrations for D5 were up to 432 ng m^{-3} occurring in major urban areas while the oxidized D5 product was much lower, up to 9 ng m^{-3} and occurred downwind of cities. Model results were evaluated against available measurement and modeling studies. Error metrics remain high but are improved compared to previous modeling attempts, especially for urban locations.

8MO.13

Expanding the Modeling of Semivolatile Aerosols within the CMAQ Framework: Development and Application to Oxidized Cyclic Siloxanes and Polychlorinated Biphenyl Compounds.

NATHAN JANECHEK, Scott N. Spak, Keri Hornbuckle, Charles Stanier, *University of Iowa*

Cyclic volatile methyl siloxanes (cVMS) and polychlorinated biphenyl (PCB) are well-studied anthropogenic chemical classes with some important similarities in atmospheric behavior. PCB and cVMS oxidation products can exist as semivolatile compounds that partition to the aerosol phase. For example, the saturation (c*) concentrations of PCB congeners range from 0.1 to 10^5 µg m^{-3}, while the oxidized cVMS compounds have been estimated at 0.01 to 100 µg m^{-3}. PCBs were important industrial chemicals used in electrical capacitors and transformers, fire retardants, and plasticizers. Banned in the 1970s, they are still present in the environment and pose health concerns. Cyclic siloxanes on the other hand are also important industrial chemicals common in personal care products, especially antiperspirants and lotions. In the atmosphere, parent cVMS are primarily degraded by reaction with hydroxyl radicals (OH) to form semivolatile oxidation products which contribute to atmospheric secondary organic aerosol and may be an important source of ambient nanoparticles. In this work, semivolatile aerosol species for cVMS and PCBs are added to the Community Multiscale Air Quality (CMAQ) model using an equilibrium-partitioning model (subroutine orgaer). The secondary aerosol species for the oxidation products of the most common cVMS (D4, D5, and D6) are added using experimentally derived yield and volatility data. Mass stoichiometric yield, effective saturation concentration, enthalpy of vaporization, and molar mass were used in the model parameterization. Using the model, aerosol phase partitioning of the cVMS oxidation products are quantified, as well as the first reported ambient concentrations and the spatial distribution, which can be used to guide future measurements to confirm secondary aerosols. Similarly, semivolatile PCB and PCB oxidation species are added using new urban emission estimates to the CMAQ model to simulate gas and aerosol species. PCB concentrations and deposition are quantified to determine air exposure, an important tool in determining cost-effective cleanup strategies.

8MO.14

Development of a CMAQ Adjoint Model with Aerosol Capabilities. SHUNLIU ZHAO, Amir Hakami, Matt Turner, Daven Henze, Shannon Capps, Peter Percell, Jaroslav Resler, Jesse Bash, Sergey Napelenok, Kathleen Fahey, Rob Pinder, Armistead G. Russell, Athanasios Nenes, Jaemeen Baek, Gregory Carmichael, Charles Stanier, Adrian Sandu, Tianfeng Chai, Daewon Byun, *Carleton University*

An adjoint air quality model provides location- and time-specific gradients of an air quality metric to model inputs and lends itself to backward sensitivity analysis, source apportionment, optimal pollution control, data assimilation and inverse modeling for scientific and policy applications. A gas-phase adjoint model for CMAQ was previously developed (Hakami et. al, 2007) and has been used in various applications related to ozone. However, the lack of aerosol and cloud processes in the adjoint model has so far prevented applications related to aerosols, which in turn has imposed significant limitation on multi-pollutant applications on topics such as human health and climate. A collaborative effort has been underway for the past few years to develop a full adjoint version for CMAQ. In this work, we will present the development work and provide example applications.

The adjoint model development has been assisted with different Automatic Differentiation (AD) tools for different processes. Code pre-processing is required for AD and one example is to address the problem associated with the bisection procedure in the aerosol thermodynamics module, ISORROPIA, and the secondary organic aerosol module. The adjoint code generated by AD was originally evaluated on a process-by-process basis against the Finite Difference Method (FDM). The FDM, which has long been used for verification of forward (DDM) or backward sensitivity modules, repeatedly failed to produce reliable sensitivity estimations. We have instead moved to using the Complex Variable Method (CVM) for evaluation of the adjoint code where the FDM proves problematic. A continuous adjoint of advection was developed manually which is superior in certain applications. Finally, we will discuss various applications that the CMAQ-adjoint model can be used for, provide examples in using the adjoint model to address policy and health questions, and discuss the specific pre-processing modules that have been developed for such applications.

8MO.15

Viewing Satellite-Based PM2.5 Data through an Urban Lens. SARAH SERAJ, Sarah Chambliss, Joshua Apte, *University of Texas at Austin*

Fine particulate matter ($PM_{2.5}$) is associated with a range of adverse health effects and is a growing concern in cities worldwide. The scarcity of in situ monitors historically limited the tracking of global air quality trends, particularly in developing countries. Recently, high-resolution global maps of $PM_{2.5}$ (0.01° × 0.01° grid) have been developed that combine satellite retrievals, geophysical models, and ground measurements from 1998-2015. Linking these remotely-sensed data with a map of urban areas to produce time-resolved $PM_{2.5}$ concentration estimates for 4,231 major cities reveals that the global population-weighted average urban $PM_{2.5}$ concentration has increased from 25 $\mu g/m^3$ to 33 $\mu g/m^3$ from 2000-2015. Of the 2.5 billion urban residents considered, 75% live in cities where $PM_{2.5}$ concentrations have risen. While 1072 cities (25%) showed improvement in $PM_{2.5}$, the majority of them are in high-income countries. Moreover, 3,665 of the 4,231 cities (87%) have average concentrations above the WHO guideline of 10 $\mu g/m^3$, corresponding to 89% of the population in those cities. Trends in both absolute urban concentrations and intra-urban variability are most strongly influenced by the region of the world in which a city is located, and show a secondary association with economic variables. Cities in predominantly high-income regions show lower mean concentrations and lower intraurban variability, while GDP provides little predictive power for concentration in cities in middle- and low-income countries. Cities in Asia, with the exception of those in Southeast Asia and Japan, tend to have the highest concentrations regardless of income level. Remotely-sensed urban $PM_{2.5}$ levels tend to agree more closely with ground-based monitors in high-income regions than low-income regions, which may be indicative of sub-1km scale heterogeneity in pollution from local sources in developing world cities.

8MO.16

Evaluation of pH Biases in Chemical Transport Models and Their Role on Nitrate Substitution.

PETROS VASILAKOS, Armistead G. Russell, Athanasios Nenes, *Georgia Institute of Technology*

Throughout the decade of 2001 to 2011 strict regulations on SO2, coupled with increasing ammonia concentrations, have been hypothesized to lead to increasingly alkaline aerosol, and the subsequent replacement of sulfate with nitrate. Increased alkalinity also has important implications for the formation of Secondary Organic Aerosol (SOA), since many production pathways are contingent on low pH conditions. Long-term observations from the SEARCH network however do not validate this hypothesis (Blanchard et al. 2012). On the contrary, aerosol has been found to remain strongly acidic, while nitrate is remaining relatively constant with a modest decrease in concentration over the SE US. Chemical transport models (CTMs) used for future policy-making are seldom evaluated on their ability to predict pH, and given the important role that aerosol acidity plays on nitrate partitioning and SOA formation, predictive biases can lead to incorrect estimations of aerosol composition.

In order to investigate existing biases of CTMs and the “nitrate substitution paradox”, we hypothesize that models overpredict aerosol pH, with an increasing positive bias as SO2 emissions are decreased in the simulations. We test this hypothesis with the Community Multiscale Air Quality (CMAQ) model, by evaluating the model pH trends over the US between 2001 and 2011, as well as the sources of potential biases, such as the relative humidity (RH), temperature (T) and the concentration of crustal elements, and comparing them to the thermodynamic analysis of ambient data from the SEARCH network throughout all season and sites, with the ISOROPIA II model. While CMAQ predictions of RH, T and PM2.5 pH during 2001 and 2011 compare favorably with observations from SEARCH sites, there is a clear decadal positive trend, with pH over the Eastern US increasing by 1 unit within the decade, something that is not observed in the data. In addition, non-volatile cations are identified as the reason for this inconsistent trend, since they are internally mixed in modelled PM2.5 at concentrations that increasingly influence aerosol pH as sulfate levels decrease. This resulting bias tends to be higher during the late afternoon through early morning for all the sites, and coincides with the times where the maximum of cation concentrations and RH are simulated.

We estimate that a predictive positive pH bias of 1 unit can result in a positive aerosol nitrate bias of 1-2 µg m-3. Possible pH biases, especially in future prognostic studies, can reaffirm the otherwise incorrect expectation of “nitrate substitution”. Therefore, evaluation of simulated aerosol pH against observations is a vital, but neglected, aspect of model evaluation for robust emissions policy.

8MO.17

Simulation of an Actual Emissions Scenario with the Gaussian Plume Model.

XIANGWEI LIU, *HongX Enterprises Inc.*

The dispersion model of Gaussian plume approximations to the advection-diffusion equation with a continuous point source is a standard approach for studying the transport of airborne pollutants. In this paper, the Gaussian plume model is applied to an actual emissions scenario with real data.

8MO.18

The Impact of the New York Clean Energy Standard on Urban and Regional Air Quality. JEFFREY SWARD, Danyang Guo, Kaleb Roush, Mackenzie Kinard, K. Max Zhang, *Cornell University*

New York State recently announced a Clean Energy Standard (CES) which mandates that 50% of all electricity be generated using renewable resources by 2030. This CES is referred to as the 50 by '30 goal. Possible scenarios for New York's 2030 electricity mix should be evaluated not only in terms of supplying the necessary capacity and reliability to the grid, but also in terms of urban and regional air quality. No studies up to this point have considered the air quality impacts in New York State, focused on New York City (NYC), associated with proposed electricity mix scenarios meeting the Clean Energy Standard. To assess the impacts of pursuing these different electricity mix scenarios, we developed an integrated modeling framework consisting of renewable resource assessment, economic dispatch modeling, emissions inventory changes, meteorological and air quality modeling, and health impact analysis. We simulated air quality using the Community Multiscale Air Quality (CMAQ) model with nested model grids. The spatial resolutions of each grid were 15, 5, and 1 kilometer, respectively. The highest spatial resolution grid was centered over NYC. Future emissions inventories were developed under the constraint that 50% of total electricity generated must come from renewable resources. We reported the changes in ozone (O_3) and fine particulate matter ($PM_{2.5}$) concentrations over NYC and the entire state. This will allow decision makers to better direct investment to develop energy projects that will have the greatest benefit to air quality and therefore public health.

8MO.19

Impacts of Future Climate, Emission, and Land Use Changes on Aerosols and Air Quality over the Continental U.S. PATRICK CAMPBELL, Jesse Bash, Christopher Nolte, Tanya Spero, Ellen Cooter, Havala Pye, *U.S. EPA*

Changes in climate, emission, and land use in the U.S. over the next century are imminent. The response of geologic, biogenic, and anthropogenic aerosol to interactions between these changes, however, are more uncertain and difficult to quantify. To explore these interactions, a "one atmosphere" modeling system consisting of the WRF (Weather Research and Forecast) model used with the CMAQ (Community Multiscale Air Quality) model, and linked to agricultural cropping management and soil biogeochemical processes in the EPIC (Environmental Policy Integrated Climate) model, is used to simulate emissions, dynamic air-surface exchange of trace gases and aerosols, gas-phase chemistry, secondary aerosol formation, transport, and deposition. Significant advancements have been incorporated into the latest aerosol module in CMAQ that include updates to organic and inorganic aerosol formation and properties, as well as an improved physics-based windblown dust parameterization. To consistently represent climate, land use, and air quality changes in this work, we modify WRF version 3.8.1 to improve its linkage to CMAQ version 5.2, and apply the advanced and modified WRF/Noah-CMAQ-EPIC system to dynamically downscaled Community Earth System Model (CESM) climate simulations, regional emission projections, and regional land use changes to study the impacts on aerosol formation and concentration, and ultimately the potential future of U.S. air quality by 2045 - 2055 under the RCP4.5 scenario. Specifically, we explore the changes in (1) inorganic aerosol formation regimes (e.g., in response to ammonia- vs. nitrate-limited regime changes), (2) organic aerosol formation and concentration changes (e.g., in response to biogenic volatile organic compound emission changes), and (3) windblown dust concentrations (e.g., in response to soil moisture and land use changes). We aim to relate the sensitivity of changes in (1) – (3) to their dominant climate, emission, and land use impacts to help provide insight into beneficial air quality management and mitigation strategies in the future.

8MO.20

Organic Emission Profiles for Gasoline, Gas-turbine and Diesel Engines Using the Volatility Basis Set. QUANYANG LU, Yunliang Zhao, Albert Presto, Tim Gordon, Andrew May, Allen Robinson, *Carnegie Mellon University*

Organic emissions from motor sector are important contributors of both primary organic aerosol (POA) and secondary organic aerosol (SOA) precursors in urban environment. Recently, extensive researches have been conducted on intermediate volatile organic compound (IVOC) and semi-volatile organic compounds (SVOC) emissions, and measurements have been performed on different engines using gasoline, jet and diesel fuel. Based on the results of recent studies, complete emission profiles for on- and off-road gasoline, gas-turbine and diesel engines were integrated and evaluated across the entire volatility range. Sources using same type of fuel shares similar ranges of IVOC content, 3-10% of IVOC is identified for on- and off-road gasoline engines while 20-40% of IVOC is observed for jet engine, and more than half of IVOC fraction in total emission for on- and off-road diesel vehicles. Comparison between EPA profiles, fuel composition and exhaust measurements indicated close relationship between unburnt fuel and exhaust, while EPA profiles fall short in IVOC and SVOC collection and speciation. SOA potential based on measurements showed consistency with EPA profiles for VOC forming SOA, but gain 0.5, 13 and 24 times increase on total SOA yield due to updated IVOC and SVOC contents in terms of gasoline, jet and diesel engine exhaust. Combing EPA profiles with IVOC composition in liquid fuel using SOA-weighted enrichment factors provide us with close approximation of SOA forming potential from IVOCs. Box model calculation of total OA production based 2014 National Emission Inventory using new profiles indicate 40% increase by off-road gasoline engines, 1.2 times for on- and off-road diesel engines and 3 times for aircrafts. Model-ready profiles based on exhaust measurements are also proposed.

8MO.21

Physical and Model-based Characterization of Ultrafine Particle Size Distributions, Nucleation, and Particle Growth in the Central US. CAN DONG, Robert Bullard, Ashish Singh, Yuyan Cui, Alma Hodzic, Charles Stanier, *University of Iowa*

New particle formation (NPF) is a frequently observed phenomenon worldwide. Ten months (July 2013 to June 2014) of continuous measurements of particle number size distribution were performed at a rural Midwestern location of Bondville, IL. A twenty-year record of particle number observations is also available at the site. The site is characterized by a large decrease in regional sulfur dioxide (SO2) emissions over the twenty-year period. Observation data show that NPF occurred during each month of the field campaign, with different frequency and intensities. NPF events were more frequently observed in spring (65.3% of classifiable days) and summer (58.8% of classifiable days). Observed growth rates were highest in summer with a median value of 3.49 nm/h. The minimum growth rate occurred in winter. These measurements are combined with the NPF-explicit WRF-Chem model to investigate the model’s skill at reproducing the influence of SO2 on NPF, as well as diel patterns, nucleation intensity, growth rates, and seasonal patterns in these features. Results from sensitivity model simulations on the growth rates of newly formed particles from condensable oxidation products of biogenic gases are discussed.

8MO.22

Effects of Near-Source Coagulation of Biomass Burning Aerosols on the Global Aerosol Size Distribution. EMILY RAMNARINE, Jeffrey R. Pierce, *Colorado State University*

Biomass burning is a significant global source of aerosol number and mass. These aerosols can act as cloud condensation nuclei, affecting the cloud albedo and lifetime, causing an indirect forcing, and they directly scatter and absorb solar radiation. The size distribution of these particles greatly determines their direct and indirect climatic effects. Coagulation of particles is an important process in determining size distribution. As coagulation occurs, the number of particles is diminished and the distribution is shifted larger. Sakamoto et al. (2016) found that the rate of growth by coagulation can be approximated by fire area, mass flux of fire emissions, initial size distribution, plume mixing depth, and surrounding wind speed. In this work we explore the effects that coagulation has on the global aerosol size distribution, and therefore the aerosol radiative effects, in the global aerosol model, GEOS-Chem-TOMAS. In the default configuration of GEOS-Chem-TOMAS, the fire emissions are given a fixed size distribution, regardless of fire characteristics and meteorology. When adding the Sakamoto et al. (2016) parameterization for near-source coagulation, the peak in the number distribution of the particles moves to a higher mean diameter with a smaller number concentration for larger, boreal fires relative to smaller, tropical fires. Overall, the number of CCN-sized particles decreased globally relative to the previous fixed-size assumption in GEOS-Chem-TOMAS. The results are sensitive to the assumption of overlap of plumes of nearby fires. To constrain this and determine the effectiveness of the parameterization, we will be comparing our model results to observations.

Sakamoto, K. M. et al., Atmos. Chem. Phys., 16, 7709-7724, doi:10.5194/acp-16-7709-2016, 2016.

8MO.23

Single Particle Morphology and Phase State Analysis of Secondary Organic Aerosol Particles. NICOLE OLSON, Rebecca Craig, Ziying Lei, Yue Zhang, Yuzhi Chen, Amy Bondy, Jason Surratt, Andrew Ault, *University of Michigan*

A large fraction of submicron organic particulate matter (PM) is formed by the condensation of volatile organic compound (VOC) oxidation products onto pre-existing aerosol particles, thus leading to the formation of secondary organic aerosol (SOA). Isoprene epoxydiol (IEPOX) isomers have been identified as key products of isoprene photo-oxidation under low nitric oxide conditions, which partition to the aerosol phase and undergo further reaction to form isoprene-derived SOA. Traditionally, the aerosol particles where these organic species condense are considered to be homogenous mixtures at thermodynamic equilibrium. However, chamber and field studies have observed more complex physicochemical properties, including organic coatings onto inorganic particles, liquid-liquid phase separations, and viscous or glassy organic phases. To determine the impact of these complex morphologies on the formation of IEPOX-derived SOA, laboratory experiments were conducted by exposing gaseous IEPOX to acidic inorganic sulfate particles mixed with varying amounts and types of SOA precursors (e.g. alpha-pinene or toluene) at a range of relative humidities (15, 30, and 50%).To determine individual particle morphology and internal structure, single particle microscopic and spectroscopic techniques including scanning electron microscopy coupled with energy dispersive x-ray spectroscopy (SEM-EDX), Raman microspectroscopy, and atomic force microscopy with infrared spectroscopy (AFM-IR) were used. A range of morphologies were observed, which may have impacted IEPOX uptake and subsequent particle growth. Understanding the individual particle properties that have the greatest impact on SOA formation is crucial to eventually predicting the formation, evolution, and fate of SOA under a range of atmospheric conditions.

8MO.24

Development and Assessment of an NEI-based U.S. Emissions Inventory for 1980-2015. MARGUERITE COLASURDO MARKS, Peter Adams, Allen Robinson, *Carnegie Mellon University*

Two large sets of U.S. health data exist covering the time period from the early 1980s to near the present day, but the lack of corresponding air quality measurements has thus far limited their use in research into the health effects of PM. As part of the Center for Air, Climate, and Energy Solutions, chemical transport modeling will be used to simulate measurements to be used in epidemiological analyses of this data.

In order to produce the necessary gridded estimates of health-relevant air pollutants over the time period 1980-2015, the model requires an inventory of pollutant emissions over the relevant time period. An emissions dataset exists that is based on EPA's National Emissions Inventory (NEI) and covers part (1990 to 2010) of the desired time period. A procedure for scaling this inventory forward and backward in time has been developed. Because this procedure relies on changes in activity levels and emission factors, those parameters have been identified with as much spatial resolution as possible. Records from 1980 to present of dozens of indicators (e.g., vehicle-miles traveled, acres of agricultural tillage, BTUs of power plant output) have been compiled. Published and measured emission factors have been gathered and compared, and previous EPA modeling work from the 1980s has been used to constrain estimates. The emissions are spatially and temporally allocated using the Sparse Matrix Operational Kernel Emissions (SMOKE) model.

A large dataset of air quality measurements ($PM_{2.5}$, PM_{10}, NO_2, NO_x, SO_2, O_3, EC/OC, SO_4^-, NO_3^-) has been used to investigate regional trends in pollutant levels and to constrain emissions trends. The few measurements of $PM_{2.5}$ that were performed prior to 1992 are used for process evaluation, which will be discussed. Trends in emissions are consistent with national-level EPA estimates and generally show slight-to-moderate declines throughout the 1980s.

8NM.1

Efficient Uptake of Aerosolized Nano-fertilizers by Plants as a Smart Agriculture Application. RAMESH RALIYA, Pratim Biswas, *Washington University in St. Louis*

We developed a process to make nanocomposite of Nitrogen (N), Phosphorous (P) and Potassium (K) and their aerosolized delivery to plants. NPK are the essential and major nutrient required by the plants. Globally, natural resources for these elements, in particular, P are being consumed at an alarming rate. The trends of fertilizer mining and consumption show that demand and application of fertilizer are being increased to enhance crop production. Currently, P is applied to soil as mono- or di-ammonium phosphate, and N as urea and K as an additive as potassium hydrogen phosphate and other similar compounds. In particular, P nutrient source is mined as rock phosphate. When the nutrient is applied in bulk form to the soil, due to low solubility and larger particle size (micrometer scale), a major fraction of the nutrient either run-off or produces complexes in the soil so the plant nutrient uptake rate is limited. The available P for plants by the conventional fertilizer is limited to less than about 20%. To enhance the NPK nutrient content and make them readily available for plants to uptake, we developed a process to make nanoscale (~100 nm) NPK composite using synthesis routes in a furnace aerosol reactor (FuAR). The composite has 53% available phosphorus which is more than double of that present in conventional fertilizers. Furthermore, we developed innovative foliar delivery methods for the nanoscale nutrients using conventional aerosol generation methods. This allowed efficient targeting of the fertilizer to the plant, thus minimizing the amount of material needed. The results of both the synthesis and delivery methodologies will be discussed.

8NM.2

Sub-2 nm Particle Measurement in High-temperature Aerosol Reactor. YANG WANG, Michel Attoui, Pratim Biswas, *Washington University in St Louis*

Aerosol science and technology enable continual advances in material synthesis and atmospheric pollutant control. Among these advances, one important frontier is characterizing the initial stages of particle formation by real-time measurement of particles below 2 nm in size. Sub-2 nm particles play important roles by acting as seeds for particle growth, ultimately determining the final properties of the generated particles. Tailoring nanoparticle properties requires a thorough understanding and precise control of the particle formation processes, which in turn requires characterizing nanoparticle formation from the initial stages. High-resolution differential mobility analyzers, diethylene glycol-based condensation particle counters, and atmospheric pressure interface time-of-flight mass spectrometers are recently developed advanced instruments probing sub 2 nm particle formation pathways. These instruments show promise for studying incipient particles generated in high-temperature aerosol reactors.

This presentation intends to provide a state-of-the-art overview of these advanced instruments and related studies in high-temperature aerosol reactors, including flame aerosol reactors (FLARs), furnace aerosol reactors (FUARs), glowing wire generators (GWGs), and spark discharge generators (SDGs). The influence of reaction-generated ions on incipient particle growth is discussed in details. Numerical modeling shows that the influence of charging on particle growth dynamics was more prominent when the ion concentration was comparable to or higher than the particle concentrations, a condition which may be encountered in flame synthesis and solid fuel-burning. Some possible improvements to existing measurements of incipient particles at high temperatures are also discussed.

8NM.3

On-demand Gas-to-liquid Process to Fabricate Thermoresponsive Antimicrobial Nanocomposites and Coatings. Bijay Kumar Poudel, Jae Hong Park, JEONG HOON BYEON, *Yeungnam University*

Antimicrobial material is emerging as a major component of the mitigation strategy against microbial growth on abiotic surfaces. In this work, a newly designed process is proposed to fabricate thermoresponsive antimicrobial nanocomposites (TANs) and coatings (TACs) as an on-demand system. Thermoresponsive polymer (TRP)-incorporated silver (Ag) nanocomposites with silica nanoparticles (SNPs) or carbon nanotubes (CNTs; Ag-SNP@TRP or Ag-CNT@TRP) were produced by a single-pass gas-to-liquid process. The SNPs or CNTs were first produced by spark ablation and successively injected for dispersal in a liquid cell containing polydimethylsiloxane, poly(N-isopropylacrylamide), and silver nitrate under ultrasound irradiation. Suspensions of Ag-SNP@TRP or Ag-CNT@TRP nanocomposites were then deposited on a touch screen panel (TSP) protection film via electrohydrodynamic spray to form transparent antibacterial coatings. Fundamental antibacterial activities of TANs were evaluated against Escherichia coli and Staphylococcus epidermidis. The TANs showed stronger antibacterial activities at the higher temperature for all testing conditions. Lower minimum inhibitory concentrations of Ag-SNP@TRP and Ag-CNT@TRP nanocomposites were required against the two bacteria at 37°C compared to those at 27°C. The TACs on display showed elevated antimicrobial activity when the panel was turned on (38.1°C) compared with when the panel was turned off (23.8°C). This work provides a utilizable concept to continuously fabricate TANs and TACs, and it specifically offers stimuli-sensitive control of antimicrobial activity on TSPs, including other frequently touched surfaces.

8NM.4

Low Pressure Differential Mobility Analysis for Online Characterization of Silicon Nanocrystals Synthesized in a Nonthermal Plasma. XIAOSHUANG CHEN, Jasmine Johnson, Takafumi Seto, Uwe R. Kortshagen, Christopher Hogan Jr., *University of Minnesota*

Low pressure nonthermal plasmas are used extensively in the synthesis of semiconductor nanocrystals. However, online characterization of reactor output has previously been challenging, as such plasmas are typically operated below 20 Torr, and because the nanocrystals are produced at higher number concentrations than are encountered in atmospheric pressure, non-plasma synthesis systems. We have developed a system for online size distribution measurement of nonthermal plasma synthesized nanoparticles using a low pressure differential mobility analyzer (LPDMA) and faraday cage electrometer (FCE). LPDMA calibration is carried out with a tandem DMA technique with a conventional nanoDMA upstream of the LPDMA. A calibration coefficient is introduced, which is dependent upon the LPDMA dimensions, molecular mass of the sheath gas, and LPDMA temperature; this coefficient enables direct inference of the mobility selected by the LPDMA at any operating pressure. The minimum pressure in the LPDMA is bounded by the sheath and aerosol flow rate and at any pressure the accessible size/mobility range of the LPDMA is governed by the Paschen's law.

Following calibration the LPDMA-FCE system has been used to examine the size distribution function of Silicon nanocrystals produced in an Ar-silane non-thermal plasma at operating pressures below 20 Torr. The number concentration of particles existing the plasma was modulated (reduced) using a metal mesh screen at the plasma outlet; concentration reduction mitigated the influences of post-plasma coagulation on the size distribution. With coagulation minimized, it was confirmed that the reactor produces low polydispersity, sub 10 nm diameter nanocrystals, with the nanocrystal size influenced by plasma reactor residence time.

8NM.5

Modeling Simultaneous Coagulation and Charging of Nanoparticles at High Temperatures Using Moment Lognormal Size Distribution. GIRISH SHARMA, Yang Wang, Rajan Chakrabarty, Pratim Biswas, *Washington University in St Louis*

A large amount of chemically and thermally ionized species is produced in the flames. During flame synthesis of nanoparticles, these ions collide with particles while particles coagulate among themselves. Both the phenomenon of charging and coagulation decide the particle size distribution but the existing models do not consider the coupling of these two effects. In the past, detailed two-dimensional discrete-sectional population balance modeling has been conducted but it is computationally expensive. In this work, a moment model simulating simultaneous charging and coagulation is developed with the help of asymptotics and perturbation theory. This model takes care of the different charged states as well as particle size distribution in each charged state and their interactions. This model is then compared with a monodisperse model incorporated with coagulation and charging mechanisms. Following this, the effects of particle and ion concentrations on particle growth in bipolar/unipolar environment are studied.

To achieve this, a simplified polynomial expression for charging coefficient is derived from Fuchs expression. This expression is found to be in good agreement with the complete Fuchs theory expression at high temperatures in the free molecular regime. This expression is then used in the general dynamic equation for simultaneous charging and coagulation to derive moment balance equations. Both the models, monodisperse and moment show very good agreement for different simulated cases. They show that influence of charging is more prominent when the particle concentration was comparable to or lesser than the ion concentration. This also confirms that monodisperse model is able to capture the phenomenon in most of the cases.

8NM.6

Aerosol Routes to Fabricate Stable Perovskite Solar Cells under Ambient Conditions. SHALINEE KAVADIYA, Pratim Biswas, *Washington University in St. Louis*

Perovskite ($CH_3NH_3PbI_3$) solar cells have huge potential to be the future photovoltaic technology in the market, due to the rapid rise in their efficiency and low processing costs. Despite their high efficiency, the instability of perovskite material is a hindrance in their commercialization. Perovskites readily degrades in the presence of moisture. Thus, most of the studies are performed in a controlled humidity environment. In this work, we use a simple and scalable aerosol-based technique, electrohydrodynamic atomization (Electrospray in short) to make stable perovskite solar cells under ambient condition[1]. A two-step deposition method is used to form the perovskite layer, where PbI_2 is spin coated and CH_3NH_3I (MAI) is electrosprayed on the PbI_2 layer at room temperature. Both the precursors react on the surface and form perovskite ($CH_3NH_3PbI_3$). We then optimize the process parameters, namely, electrospray deposition time, MAI concentration, substrate-to-nozzle distance, and flow rate (droplet size) to make efficient solar cells.

Furthermore, the stability of the devices under ambient condition is tested for 5.5 months. The cells fabricated using the electrospray retain 75% of the initial efficiency on average. The key feature of the electrospray is controlling the reaction between the two precursors precisely, by gradually supplying MAI nanoparticles onto the PbI_2 layer. The controlled reactivity leads to the formation of ultra-smooth and moisture-resistant perovskite film. After fabricating highly stable cell, we now aim to understand the effect of other parameters, namely, post-annealing of the electrosprayed perovskite film, deposition temperature, and electrospray polarity. An interesting phenomenon of intermediate perovskite phase formation occurs during the electrospray-assisted fabrication, which then vanishes after annealing at high temperature. Another important point to note here is that the type of ions generated from electrospray changes with the changes in electrospray polarity and affect the perovskite formation reaction. We performed in-situ Grazing Incidence Wide Angle X-ray Scattering (GIWAXS) at Synchrotron Facility, Advanced Photon Source at Argonne National Laboratory to understand the phase transition and perovskite formation reaction in electrospray. We will present the aerosol-assisted fabrication of stable perovskite solar cells and some interesting fundamental results from in-situ electrospray-GIWAXS measurement.

1. Kavadiya et al., Electrospray-assisted fabrication of efficient and highly stable perovskite solar cells at ambient conditions, Advanced Energy Materials, doi: 10.1002/aenm.201700210, 2017.

8OP.1

Chemical Exposure-Response Relationship Between Air Pollutants and Reactive Oxygen Species in the Human Respiratory Tract. PASCALE LAKEY, Thomas Berkemeier, Haijie Tong, Andrea Arangio, Kurt Lucas, Ulrich Pöschl, Manabu Shiraiwa, *University of California, Irvine*

The inhalation of air pollutants such as O3 and particulate matter can lead to the formation of reactive oxygen species (ROS) which can cause damage to biosurfaces such as the lung epithelium unless they are effectively scavenged. Although the chemical processes that lead to ROS formation within the ELF upon inhalation of pollutants are well understood qualitatively, ROS concentrations within the ELF have hardly been quantified so far. The kinetic multi-layer model of surface and bulk chemistry in the epithelial lining fluid (KM-SUB-ELF) has been developed to describe chemical reactions and mass transport and to quantify ROS production rates and concentrations within the epithelial lining fluid.

KM-SUB-ELF simulations suggest that O3 will rapidly saturate the ELF whereas antioxidants and surfactant species are effective scavengers of OH. High ambient concentrations of O3 can lead to the depletion of surfactants and antioxidants within the ELF, potentially leading to oxidative stress. KM-SUB-ELF reproduced measurements for the formation of H2O2 and OH due to the presence of iron, copper and quinones in surrogate lung lining fluid. This enabled ROS production rates and concentrations in the ELF to be quantified. We found that in polluted megacities the ROS concentration in the ELF due to inhalation of pollutants was at least as high as the concentrations in the ELF of patients suffering from respiratory diseases. Cu and Fe are found to be the most important redox-active aerosol components for ROS production upon inhalation of PM2.5 in polluted regions. Therefore, a reduction in the emission of Cu and Fe should be major targets of air pollution control. Chemical exposure-response relations provide a quantitative basis for assessing the relative importance of specific air pollutants in different regions of the world, showing that aerosol-induced epithelial ROS levels in polluted megacity air can be several orders of magnitude higher than in pristine rainforest air.

8OP.2

Cellular Neuroinflammatory Responses to Traffic Generated vs. Photochemically Aged Particulate Matter (PM2.5).

CHRISTOPHER LOVETT, Mafalda Cacciottolo, Farimah Shirmohammadi, Constantinos Sioutas, Caleb E. Finch, Todd E. Morgan, *University of Southern California*

Primary (traffic derived) and secondary (photochemically aged) PM2.5 samples were obtained using a direct aerosol-into-liquid collection system located adjacent to a major freeway (I-110) near downtown Los Angeles, CA. The aqueous slurry samples were characterized by chemical analyses, and their effects on living neuronal cell cultures, including BV-2 (microglia) and N2a-APPswe (neuroblastoma) cell lines, were examined by performing in vitro neurobiological assays to quantify known biological endpoints associated with neuroinflammation and Alzheimer's Disease, including Tumor Necrosis Factor α (TNF-α), Interleukins 6 and 1β (IL-6 & IL-1β), Interferon γ (IFN-γ), and the cellular signaling molecule nitric oxide (NO). A precise characterization of these two types of ambient PM2.5, using both chemical and neurobiological techniques of analysis, allows for increasingly finer distinctions to be made regarding individual particulate species and the associated neurobiological consequences of exposure.

Prior studies of primary vs. secondary particulates (e.g. Verma, et al., 2009) have found that products of photochemical oxidation (secondary PM) contain higher concentrations of oxygenated organic acids and water-soluble organic carbon (WSOC) species, and exhibit a greater intrinsic oxidative potential, as quantified by the dithiothreitol (DTT) assay. Other studies (e.g. Saffari, et al., 2015), have found a larger inflammatory response, as indexed by the macrophage ROS (reactive oxygen species) assay, to primary PM samples collected during morning hours as compared to secondary (afternoon) PM samples.

In the current study, neural cell lines were exposed to primary PM2.5, emitted by vehicles during morning rush hour (6-9am), and secondary PM2.5, dominated by photochemically oxidized products formed during afternoon hours (12-4pm). In vitro assays revealed a greater neuroinflammatory dose-dependent response, as indicated by the previously mentioned biological endpoints of interest, in response to primary, as compared to secondary, PM exposures. Additionally, ROS activity was found to be greater in response to the morning (primary) PM samples, and DTT activity was found to be greater in response to afternoon (secondary) PM exposure, duplicating the results of both previously mentioned studies.

This research will ultimately allow us to gain a more complete understanding of the complex, multi-component nature of particulate matter, as well as its health effects and possible role in the etiology, onset and development of Alzheimer's Disease.

8OP.3

Oxidative Potential of Ambient Aerosol in Athens, Greece and its Dependence on Chemical Composition.

DESPINA PARASKEVOPOULOU, Aikaterini Bougiatioti, Ting Fang, Eleni Liakakou, Rodney J. Weber, Athanasios Nenes, Nikolaos Mihalopoulos, *National Observatory of Athens*

Airborne particulate matter (PM) has been identified as a major cause of adverse health effects. The ability of PM to catalyze reactive oxygen species generation in vivo and lead to oxidative stress is thought to be correlated with aerosol chemical characteristics. This mechanism of aerosol species to catalytically deplete the antioxidant buffering capacity of cells and/or result in ROS production is called oxidative potential (OP). The variability of OP is studied for the first time in the area of Eastern Mediterranean in conjunction with site, local and regional sources and the age of aerosol. For this purpose, we have used a semi-automated system developed at the Georgia Institute of Technology, which is based on dithiotreitol (DTT) assay. DTT simulates the in vivo transfer of electrons during reduction of O_2 to superoxide anion (O_2^-), caused by the presence of redox-active species in PM. Aerosol toxicity is measured through DTT consumption rate per unit volume of air, called water-soluble "DTT activity".
The present study is conducted from July 2016 to April 2017, at a downtown site of Athens. The daily DTT activity is in the range of 0.02-0.81 (nmol/min)/m^3 while, biomass burning organic aerosol (BBOA) presents intrinsic water-soluble DDT activity of 63±6 pmol/min/μg, indicating that water soluble aerosol components possess significant oxidative properties in the studied area. The seasonal variability demonstrates a higher fine aerosol DTT activity during the coldest period of the year, presenting very good correlations with BBOA (r^2=0.83) and biomass burning oxidized organic aerosol (OOA-BB) (r^2=0.83) during wintertime. The ameliorated winter correlations emphasize on the important association of redox activity with biomass burning activities, since wood burning is widely used for domestic heating during wintertime in Greece, due to the economic recession.

8OP.4

Chemical Characterization and Dithiothreitol Reactivity of Fine Particulate Matter Derived from Fourth Generation E-Cigarette Usage. RACHEL LONG, Ilona Jaspers, Phillip Clapp, Barbara Turpin, Jason Surratt, *University of North Carolina at Chapel Hill*

Advanced electronic cigarettes (e-cigarettes), or advanced personal vaporizers (APVs), have larger battery capacities than older e-cigarette models, and allow for greater user control of output wattage. It remains unclear how particle-phase composition and toxicity of APV emissions change as a function of wattage. This study physically and chemically characterized particle-phase constituents in APV emissions derived from typical e-liquid vehicles propylene glycol (PG) and glycerol (VG) at settings between 40 and 100 watts. APV emissions were injected into a 1-m^3 Teflon chamber to measure real-time particle size distributions and to collect fine particles for offline chemical analyses and determination of their oxidative potential using the acellular dithiothreitol assay. Higher particle numbers were present at higher wattages, with the majority being < 100 nm. Particle-phase composition was dominated by VG at all wattages, with many low-abundance polyols also present, suggesting gas-phase radical chemistry. APV-derived particles have lower oxidative potentials compared to other particle types such as diesel exhaust and secondary organic aerosol.

8OP.5

Developing an Online System for Measuring the Oxidative Potential of Ambient Particles Based on Dithiothreitol (DTT) Assay. JOSEPH PUTHUSSERY, Vishal Verma, *University of Illinois Urbana-Champaign*

Exposure to ambient particulate matter (PM) is known to have an adverse effect on human health. One hypothesized mechanism by which PM affects human health is by inducing the oxidative stress, which can lead to cell damage. Measuring this oxidative stress induced by ambient PM would help in further improving the associations between PM and health impacts, compared to the commonly used PM mass concentrations.

In this study, an online system for measuring the oxidative potential of ambient PM was developed using a mist chamber coupled to an automated analytical system. The system collects ambient particles mainly by two mechanisms: a) continuous washing of the particles attached on to the filter by the mist spray, b) scrubbing of the soluble gases and particulate matter from the sampled air by the mist formed inside the chamber. The extraction solvent, after a specific sampling duration, is removed from the chamber and analyzed using an automated instrument, based on the dithiothreitol (DTT) assay to quantify the oxidative potential of the sampled PM.

Unlike conventional filter based air sampling, the online system has shorter sampling duration and lesser sampling artifacts, especially when measuring the reactive components in the ambient air. The results from the online system correlated well with conventional filter extraction method using both deionized water and methanol. The diurnal trend in the oxidative potential of ambient PM was also determined on an hourly resolution. Overall, mist chamber sampling method appears to be a better alternative to the conventional filter based sampling for measuring the oxidative potential of ambient PM.

8OP.6

Chemical and Cellular Oxidant Production Induced by Naphthalene Secondary Organic Aerosol (SOA) Formed in the Presence of Iron Sulfate.

WING-YIN TUET, Yunle Chen, Shierly Fok, Rodney J. Weber, Julie Champion, Nga Lee Ng, *Georgia Institute of Technology*

Results from toxicology studies suggest that PM-induced oxidant production, including reactive oxygen and nitrogen species (ROS/RNS) may be a possible mechanism by which PM exposure results in detrimental health effects. Secondary organic aerosols (SOA) constitute a significant portion of PM, and recent health studies have shown that SOA exposure induces inflammatory responses. The effect of redox-active metals on SOA health effects, however, have not been considered.

Here, we present oxidative potential and ROS/RNS measurements from laboratory-generated naphthalene SOA formed in the presence of inorganic (ammonium sulfate, AS) and metal-containing inorganic (iron sulfate, FS) seed. Naphthalene was chosen as it has previously been shown to have the highest oxidative potential and induce high levels of ROS/RNS among different types of SOA. All chamber experiments were conducted under humid conditions in the presence of NO using H2O2 as the hydroxyl radical precursor. Alveolar macrophages were exposed to SOA samples and ROS/RNS production was measured post-exposure. Similarly, dithiothreitol (DTT) was used to assess the oxidative potential of SOA. Experiments were conducted with different initial naphthalene concentrations to evaluate whether the degree of oxidation affected health effects. In general, exposure to FS seeded SOA resulted in higher ROS/RNS levels compared to AS seeded SOA, although this is likely due to differences in oxidation state as a positive exponential correlation was observed between ROS/RNS levels and average carbon oxidation state (OS) for both AS and FS seeded SOA. No trends were observed for DTT activity, consistent with previous studies. Finally, multiple filters were collected from a single experiment to investigate the effect of aging. The results also followed the ROS/RNS vs. OS trend observed in this study. Together these results have significant implications for future health studies as atmospheric aging leads to increases in oxidation, which may affect cellular responses.

8OP.7

Relationship between Reactive Oxygen Species (ROS) Activity and Cytotoxicity of Ambient Particles.

YIXIANG WANG, Michael Plewa, Vishal Verma, *University of Illinois at Urbana-Champaign*

Associations of particulate matter (PM) concentration with cardiopulmonary disease and mortality have been reported in several studies. Threat of PM to public health is likely due to reactive oxygen species (ROS) generation by PM. However, only a handful of studies could demonstrate a consistent correlation between biological toxicity endpoints and ROS formation measured in acellular assays. In this study, we targeted to investigate these associations by measuring the acellular ROS generation and cytotoxicity of ambient particulate matter (PM) samples collected from an urban site. The cytotoxicity of water-soluble PM is assessed by exposing aerosol extracts to Chinese hamster ovary (CHO) cells. Two methods were used to assess the ROS generation ability – 1. dithiothreitol (DTT) loss (conventional DTT assay); and 2. hydroxyl radical generation through redox cycling in the DTT system. Inhibition of CHO cells by soluble PM was observed, and half maximal inhibitory concentrations (IC_{50}) were calculated for the PM samples, which range from 43.6% to 74.0% (percentage of soluble PM extract). Interestingly, we found strong and significant correlation between ROS generation in the DTT system and IC_{50} ($R^2 = 0.60$, $p<0.05$). To further understand the chemical components, which might drive the response of both DTT and cytotoxicity assays, we measured the concentrations of metals and water-soluble organic carbon (WSOC) in PM extracts. Fe, Cu, Zn and WSOC were significantly correlated with both IC_{50} and ROS generation in DTT assay. Further chemical analysis of the collected samples in underway and would be presented in this talk. However, Our preliminary results indicate that measuring the ROS generation from PM could be used as a biologically relevant metric to assess the toxicity and health impacts from ambient aerosol pollution.

8OP.8

Effect of Sources and Chemical Aging on the Oxidative Potential of Organic Aerosol and Cellular Oxidative Stress.

SHUNYAO WANG, Jianhuai Ye, Xiaomin Wang, Chow Chung-Wai, Arthur W. H. Chan, *University of Toronto*

Organic aerosol (OA) accounts for a large fraction of particulate matter (PM) mass, which could induce oxidative stress once inhaled, leading to both acute and chronic cardiopulmonary outcomes. While recent epidemiological studies suggest that the chemical composition of ambient PM plays an essential role in its oxidative potential (OP), the relationship between OP and cellular generation of oxidative stress remains poorly understood. Here, we use the dithiothreitol (DTT) assay to study the OP of a wide variety of OA from field and laboratory studies, including naphthalene SOA (NSOA), phenanthrene SOA (PSOA), diesel exhaust particles, ash from the 2016 Fort McMurray wildfires, urban PM2.5 samples from India and downtown Toronto. We measured OP using the dithiothreitol (DTT) assay, and measurement of intracellular ROS production in BEAS-2B cells, a normal human airway epithelial cells. OPs and expression of inflammatory biomarkers were found to vary significantly between ambient PM from different urban areas, and between the sources. Atmospheric photochemical aging processes, including oligomerization and oxygenation, were observed to increase OP in both NSOA and PSOA systems. OP measurements were performed on chromatographically separated fractions of SOA, and SOA dimers were found to contribute significantly to DTT activity (16±3%, 40±8% for monomers, 52±10%, 56±5% for dimers, respectively for NSOA and PSOA). Further oxidation of SOA was also found to enhance the OP of NSOA. Our study provides important insights into how the chemical composition and atmospheric formation process of PM are related with its ability to cause adverse health impacts.

8OP.9

Complexation State of Metals in Ambient Particulate Matter (PM) and Its Effect on the Oxidative Potential.

JINLAI WEI, Vishal Verma, *University of Illinois Urbana-Champaign, Urbana IL*

Transition metals have long been recognized as an important component contributing to the toxicological property of ambient particulate matter (PM). One method of assessing this toxicity is to measure the capability of PM components to generate reactive oxygen species (ROS). However, whether transition metals are complexed with organic compounds or free in ambient PM, which could be an important factor determining their capability to generate ROS, is not well understood. We target to investigate the complexation states of important atmospheric metals in this study. A novel fractionation scheme is developed to separate metals from ambient PM into hydrophilic, hydrophobic and free fractions. The scheme has been validated by applying it on a mixture of Suwannee River fulvic acid (SRFA) and Fe. SRFA is selected as a model compound as it represents the humic-like substances present in ambient PM, which are believed to be complexed with Fe. The preliminary results show that a significant amount of iron pre-mixed with SRFA is detected in both hydrophobic and hydrophilic fractions, indicating potential complexation with both types of organic substances. Similar tests conducted with the ambient PM show up to 60%-80% of iron complexed with organic compounds. The experiments to assess the impact of complexation on the ROS generation capability of metals are underway and would be discussed in this talk.

8OP.10

Understanding the Relationship between Aerosol Oxidative Potential, Electrophilicity, and Chemical Composition: Role of Particle-Phase Carbonyl Compounds. JIN CHEN, Cody Cullen, Justin Dingle, Alexander Frie, Stephen Zimmerman, Justin Min, Roya Bahreini, Ying-Hsuan Lin, *University of California, Riverside*

Recent toxicological and epidemiological studies have shown strong evidence for adverse effects of ambient particulate matter (PM) on human health such as respiratory and cardiovascular diseases. PM represents a complex mixture consisting of numerous individual chemicals. Carbonyl compounds, which play an important role in atmospheric oxidation processes, are ubiquitous in the environment in both gas and particle phases. Carbonyls, such as aldehydes, are electrophiles that can react with biological nucleophiles (e.g., cysteine and histidine residues), and result in cellular oxidative stress and cell death. Studies have shown that structurally different aldehyde derivatives vary in electrophilic activities which can lead to different levels of cytotoxicity. The connections between their oxidative potential (thiol reactivity) and chemical characteristics have not been fully understood. In this study, we will measure the oxidative potential of representative particle-phase carbonyl compounds with authentic standards using dithiothreitol (DTT) assay, and compare the consumption of DTT with their electrophilicity index. Further, we will test the oxidative potential of selected model systems from mixtures generated in controlled chamber experiments. Gas chromatography-mass spectrometry (GC-MS) with O-(2,3,4,5,6-pentafluorobenzyl)-hydroxylamine (PFBHA) derivatization will be used to identify and quantify the carbonyl compounds from chamber samples. The relationship between aerosol oxidative potential, electrophilicity, and chemical composition will be discussed.

8OP.11

Black Carbon Reactivity toward Antioxidant Glutathione. KAYLEE TROTH, Juan Rodriguez, Anne Johansen, *Central Washington University*

Black carbon (BC), a component of atmospheric particulate matter emitted during the combustion of fossil and biomass fuels, is known to adversely affect human health. The mechanism through which BC is thought to cause damage to cells is through the generation of reactive oxygen species (ROS), yet particle characteristics responsible for this detrimental effect are not well understood. In this research project, BC particles are investigated in a biologically relevant medium to shed light on detailed chemical mechanisms that lead to ROS production. This will be accomplished by using fluorescent spectroscopy to study the oxidative capacity of commercially available BC particles in reaction with the natural and biologically relevant antioxidant within cells, glutathione (GSH). Physicochemical properties of these BC particles will be studied on various instruments including the scanning electron microscope (SEM), laser particle analyzer (Malvern Mastersizer 3000), and the inductively coupled plasma mass spectrometer (ICP-MS) to determine particle surface area, particle diameter, particle morphology, and trace metal concentration. These physical and chemical properties will be correlated with the oxidative capacity of BC particles in reaction with GSH and in comparison to the frequently used dithiothreitol (DTT) assay. This research will contribute to the analytical determination of particle toxicity and will help increase our understanding of the mechanisms that control their adverse effects.

8OP.12

Contribution of Open Burning of Agricultural Residues to PM2.5 in Suburban Tokyo: PM Mass and Oxidative Potential.

AKIHIRO FUSHIMI, Ana Villalobos, Akinori Takami, Kiyoshi Tanabe, James Schauer, *National Institute for Environmental Studies*

Oxidative potential of freshly emitted open burning aerosol is in the lower range of vehicle exhaust and atmosphere[1]. Therefore, the contribution of open burning may be relatively small to the oxidative potential of atmospheric particles. In this study, fine atmospheric particles ($PM_{2.5}$) in suburban Tokyo (Tsukuba), Japan were collected for 24 h every week over the course of a full year (2012–2013) to estimate the source contributions with a focus on open burning of agricultural residues. Elemental carbon, organic carbon, water-soluble organic carbon, inorganic ionic species, and organic markers were measured. Particulate mass, elements, and oxidative potential using an in-vitro rat alveolar macrophage reactive oxygen species (ROS) assay were also measured. Chemical mass balance analysis using the organic marker data suggested that vehicles, open burning, and cooking were the most important primary sources and secondary organic carbon also had large contribution to organic aerosols. The measured oxidative potential was higher in spring and summer, and was higher than the reported values in Los Angeles but lower than Milan. Secondary aerosol and emissions from residual oil burning (including ship) were most strongly associated with $PM_{2.5}$ oxidative potential as compared to source contributions from open burning.

1. Fushimi A., Saitoh K., Hayashi K., Ono K., Fujitani Y., Villalobos A.M., Shelton B.R., Takami A., Tanabe K., Schauer J.J. (2017) Chemical characterization and oxidative potential of particles emitted from open burning of cereal straws and rice husk under flaming and smoldering conditions, Atmospheric Environment, 163, 118–127.

8OP.13

Pro-inflammatory Effects of PM2.5 from Beijing Winter Haze: Revealing the Role of Individual External and Internal Microbiome.

SHEN FANGXIA, Liu Fobang, Zhang Xiangyu, Li Jing, Ziegler Kira, Ting Zhang, Zhu Tianle, Manabu Shiraiwa, Maosheng Yao, Haijie Tong, Kurt Lucas, Ulrich Pöschl, *Beihang University*

China has experienced frequent serious haze episodes in recent years, which accordingly has led to increasing number of studies regarding its formation mechanisms. On the other hand, the public is becoming more concerned about the health impact of the haze problems. Oxidative stress and inflammation is generally accepted mechanism by which air pollutants cause adverse health effects. However, the molecular level mechanism is far away from clear. Human microbiome, which composes 10 times more microorganisms than our own cells, has gained increasing attention in its roles in people's health. In particular, components from our resident microbiome, i.e., lipopolysaccharide (LPS), play an important role in regulating immune homeostasis. This study aims to investigate the potential synergistic role of air pollutants and microbial components, and relevant results could further shed new light on the understanding of the mechanism.

Particulate matters smaller than 2.5 µm (PM2.5) collected in Beijing during 2016 winter haze period were used to stimulate THP-1-derived macrophages. The cellular immune response was evaluated by measuring the cytokine production, including IL-1b, IL-8, TNF and IL-6. To simulate the internal body microenvironment exposure, elevated LPS of different concentrations together with PM2.5 water extractions was applied to study the cellular response. No toxicity was detected when 10 µg/ml PM2.5 water extractions were given to the macrophages. The pro-inflammatory immune effect of PM2.5 collected on days of different pollution levels varies, however, it was not induced by the cytotoxicity. Characterization results of PM2.5 indicated that this discrepancy in cellular inflammatory response was attributed to particle-borne LPS and metal levels (Fe and Ni). Furthermore, the pro-inflammatory cytokine secretion was augmented when macrophages were stimulated with PM2.5 in the presence of elevated lipopolysaccharide (LPS). Samples collected from heavily polluted episodes show stronger enhancing pro-inflammatory effects when 100 pg/ml LPS was applied. Whereas, the enhancing effect was weak in the presence of either 1 or 10 pg/ml LPS. PCR array assay results suggest that oxidative stress plays vital role in the magnifying effects of PM2.5. Knowing the body internal microenvironment can be of great importance to evaluating the PM2.5 health effects. The results obtained here provide an evidence about the synergistic effects of PM2.5 and microbial LPS. Overall, this study highlights the importance of studying roles of human microbial structures, especially respiratory microbiome, when unraveling the underlying mechanism at cellular and molecular level.

8OP.14

High Oxidative Potential of Metal Oxides in Welding and Plasma Cutting Fume Aerosols. JUN WANG, Jacob Bartels, *University of Oklahoma*

Aerosols generated from metal fabrication processes (welding, plasma cutting) contain a large proportion of metal oxides that exert high oxidative potential, such as hexavalent chromium. The formation of reactive oxygen species (ROS) is a cell metabolism process in the human body, as a manifestation of reaction to these metal oxides after inhalation. In this study, aerosols were collected onto filters using a high-volume sampler in a welding fume chamber. They were then ultrasonically extracted through solvents (water and methanol). The extracted aerosols were transferred to vials and dried overnight at 37 ºC with a constant flow of pure nitrogen. Before the toxicity experiment, all extracts were resuspended with deionized water to a fixed concentration. We started with in-vitro acellular protocols developed for testing ambient particulate matter, namely the dithiothreitol (DTT) assay and ascorbic acid (AA) assay. The level of DTT and AA concentration in the protocols were modified to better suit the levels of metal fume in the occupational environment. The rate of DTT consumption was calculated using linear regression of the data from a plot of absorbance (412 nm) against concentration gradient/time. The maximum depletion rate of AA was determined similarly with absorbance at 265 nm. The results indicated AA is more suitable for metal aerosols. The reaction rates of highly oxidized metal are much rapid than the ambient particles which are relatively low in oxidative potential. Welding fume showed averaging 0.0611 nmol of AA/µg of aerosol, while plasma cutting fume had an average 0.1035 nmol of AA/µg of aerosol. The presence of shielding gas in welding operation appears to help mitigate the oxidation of metals, therefore resulted in less oxidative potential than plasma cutting which has no shielding gas. The results need to be verified with in-vitro cellular ROS assays in the future study.

8PM.1

Comparing Different VIT Formulations on Near-Road Dispersion of Particulate and Gaseous Pollutants. KHALED HASHAD, Bo Yang, Vlad Isakov, K. Max Zhang, *Cornell University*

Traffic-related air pollution is associated with a range of health issues including respiratory and cardiovascular problems, birth defects, and cancer. Recent studies suggest that the presence of roadside barriers can potentially mitigate exposure to air pollution for those living and working close to major roads. As vehicle-induced turbulence (VIT) has a strong effect on the initial dispersion of pollutants, it would be challenging to explore the impact of roadside barriers without a proper understanding of VIT. Our study compares three different techniques to model VIT. The first method models VIT as a fixed volume source where turbulence is uniformly produced in the highway computational domain. The second method treats each highway lane as a forcing zone where an estimate for the drag force produced by vehicles in that lane would be imposed into the domain. The third method distributes the drag force of each vehicle into the domain using a Gaussian function such that computational grid points close to vehicles would experience a strong forcing as opposed to grid point further away. To evaluate the accuracy of each method, the simulation results are compared to experimental data obtained in an USEPA field study on a major highway in Las Vegas. The experimental data include extensive, collocated measurements of traffic, turbulence and air pollutant concentrations. The turbulent kinetic energy and pollutant concentration obtained from the simulations are compared with those of the field study. The impact of VIT on pollutant dispersion will also be explored for the different techniques.

8PM.2

Size-dependent Particle Filtration Efficiency of Stand-Alone HEPA Filters: Results From In-Home Experiments and Modeling. CAZ NICHOLS, Aidan McLaughlin, Jennifer Vaccaro, Scott Hersey, *Franklin W. Olin College of Engineering*

HEPA filtration is a nearly $3 billion per year industry, with rapid growth in areas impacted by high concentrations of ambient pollutants. Emerging research from environmental epidemiology suggests that the particles most detrimental to human health are the smallest in diameter, with increasing evidence that ultrafine particles (UFP; diameter < 100 nm), are most strongly associated with systemic inflammation, asthma and cardiovascular disease. Regulations dictate that HEPA filters remove 99.97% of particles *larger than* 300 nm in diameter, meaning that the smallest particles – those most damaging to human health – are not captured in this standard. Further, the *rate* at which a HEPA filter removes particles is not characterized in standard testing and validation, but is a crucial factor in determining the steady-state indoor concentration of UFPs and total particles. This represents an important gap in knowledge for researchers in the field of environmental health, who regularly employ the devices in studies and interventions on the physiological response to reductions in exposure to ultrafine particles.

This work presents results from a battery of tests performed by undergraduate students from the Affordable Design and Entrepreneurship capstone program at Olin College of Engineering, with commercially available and do-it-yourself HEPA filters. Initial particle concentrations on the order of 200-300,000 cm^{-3} were generated before turning on HEPA filters and continuously measuring aerosol size distributions and total particle number concentrations (PNC) with a nano-SMPS and water-based CPC, respectively. Results suggest that all HEPA filters are capable of reducing PNC and UFP concentrations to well below 1000 cm^{-3} in a sealed room with no source, but that the exponential decay constants associated with different filters vary widely. Further, all filters performed well at removing UFP, though removal rates were slower than observed for larger particles.

8UA.1

High Resolution Air Quality Modeling in an Urban Area. PABLO GARCIA, Peter Adams, Spyros Pandis, *Carnegie Mellon University*

Human activity in urban areas produces significant emissions of atmospheric pollutants that have adverse health effects on those exposes. Multiple emission sources have significant spatial variations on the urban scale such as restaurant and traffic emissions. Determining the spatial resolution of pollutants associated to these sources requires high resolution emissions inventories, simulations and measurements to accurately determine their health impacts. A high resolution emission inventory was developed for the city of Pittsburgh and surrounding counties based on the EPA's National Emission Inventory (NEI) with novel spatial surrogates to geographically distribute emissions in a grid of 1x1 km cells. This inventory was used to predict gaseous pollutants and speciated particle matter (PM) concentrations with the PMCAMx chemical transport model for the period of the Center for Air, Climate and Energy Solutions (CACES) campaign in Pittsburgh. Model predictions were compared with measurements taken with a mobile laboratory at high spatiotemporal resolution in urban and suburban areas in Pittsburgh. The predictions were also compared with measurements from the CACES supersite. These comparisons were repeated with a baseline simulation using the standard NEI approach. PMCAMx predicts concentrations reasonably well, showing improvement when compared to the standard NEI approach.

8UA.2

Modeling Urban Intake Fraction Gradients Using the InMAP Model. SARAH CHAMBLISS, Christopher Tessum, Julian Marshall, Joshua Apte, *University of Texas at Austin*

A major challenge in alleviating the health burden of urban air pollution is identifying which emission sources cause the most exposure. The exposure to fine particulate matter ($PM_{2.5}$) resulting from an emissions source depends not only on the total mass of primary $PM_{2.5}$ and aerosol precursor gases emitted, but also on the source's location relative to city residents and regional atmospheric conditions that affect secondary $PM_{2.5}$ formation. These additional factors are reflected in a source's intake fraction, or the ratio of mass inhaled (as $PM_{2.5}$) to mass emitted. Mechanistic models have been used to predict and compare intake fractions of various emissions sources, but these models are often run at a resolution too coarse to identify urban-scale variation or are only run for a single urban area. We use a source-receptor matrix created using the Intervention Model for Air Pollution (InMAP) with variable grid size, allowing up to 1-km resolution modeling of primary and secondary $PM_{2.5}$ intake fractions for all urban areas within the continental United States. This model shows that the locality of emissions within a city greatly affects the resulting exposure. Centrally-located emissions of primary $PM_{2.5}$ result in up to 25 times more exposure than emissions at the urban periphery. For emissions of nitrogen oxides (NO_X) and secondary organic aerosol (SOA), location causes up to a tenfold variation in secondary $PM_{2.5}$ exposure. Intake fractions are highest in the largest cities. Comparing mean intake fractions, a ton of primary $PM_{2.5}$ emitted in a city with a population >3 million (n=14) would result in ten times the exposure as the same emissions in a city with a population <100,000. For secondary $PM_{2.5}$ from NO_X and SOA, mean intake fractions are higher in large cities by a factor of 2 and 4, respectively.

8UA.4

Investigating the Source Dependence of Aethalometer Correction Factors Using an In-House Developed Multi-Wavelength PhotoAcoustic Spectrometer. MÁTÉ PINTÉR, Gergely Kiss-Albert, Noémi Utry, Tibor Ajtai, Gábor Szabó, Zoltán Bozóki, *University of Szeged, Hungary*

Atmospheric carbonaceous particulate matter (CPM) is in the spotlight of scientific interest as an air pollutant regarding its impact on climate and human health as well. Due to this, there is an intensive public debate conserving its legal regulation too. As the characteristics of CPM have large spatial and temporal variation, numerous measurement campaigns have been organized for a more thorough understanding of the large scale of parameters describing the properties of ambient aerosol. In climatic models, mayor uncertainty is attributed to light absorption by ambient CPM nowadays. This is partly due to issues of instrumentation. The commercially available and most popular instruments for the measurement of optical absorption are based on the filter method that require posterior site and aerosol composition specific calibration factors for proper data interpretation. PhotoAcoustic Spectroscopy (PA) is a generally accepted reference method for determining calibration factors.

In this study, the results of a field measurement campaign carried out during the late winter and the early spring of 2015 in Budapest, the capital of Hungary are presented. We in-situ measured size distribution (SD), total scattering coefficient (TSC), optical absorption coefficient (OAC), absorption angstrom exponent (AAE) and the thermo/optical organic, elemental and total carbon (OC, EC, TC) concentration of ambient aerosol. We also collected filter samples with 6-hour time resolution that were analyzed for levoglucosan (LG) and total carbon (TC) concentrations. Based on the diurnal variation of the measured parameters, traffic and household heating were identified as the most dominant sources of CPM. Moreover, on five measurement days, new particle formation events were observed. As OAC was parallel measured by a 7-wavelength Aethalometer and our in-house developed 4-wavelength PA Spectrometer (PAS), calibration factors (C and f) were determined for all Aethalometer wavelengths based on reference measurements. Our findings indicate that the Aethalometer C factors have both wavelength dependence and diurnal variation. Based on the latter, this study proposes that the relative strength of the emitting sources should be considered during Aethalometer data correction. Interestingly, we also observed that nucleation events require the use of individual C factors.

8UA.5

Restaurant Impacts on Outdoor Air Quality: Elevated Organic Aerosol Mass from Restaurant Cooking with Neighborhood-scale Plume Extents. ELLIS SHIPLEY ROBINSON, Peishi Gu, Rishabh Shah, Zhongju Li, Qing Ye, Naomi Zimmerman, Joshua Apte, Allen Robinson, Albert Presto, *Carnegie Mellon University*

Organic aerosol (OA) is the principal component of sub-micron particulate matter (PM) in urban locations, which is a regulated air pollutant in the United States due to its harmful effects on human health. We performed ambient sampling from a mobile platform with an aerosol mass spectrometer (AMS) to better understand the spatial variability and sources of OA in the setting of Pittsburgh, Pennsylvania. Previous studies have shown that OA from cooking activities contribute equally, if not more, to sub-micron PM in urban background locations compared to OA from vehicle exhaust. We sampled in some of the most populated areas in and around Pittsburgh, which included substantial sampling around major roads, areas with high restaurant density, and urban background locations. We found instances of greatly elevated concentrations (greater than 5 $\mu g/m^3$ above the background concentration and up to ≈200 μg/m3) of OA around numerous restaurants and commercial areas containing multiple restaurants. The spatial extent of these elevated OA concentrations could be seen in some instances up to 200 m downwind of the restaurant(s), indicating that these sources can influence air quality on neighborhood scales. The spatial scale of elevated concentrations observed here is on the same order of the extent of pollutants downwind of highways that others have observed. We classified OA plumes using mass spectral similarity and the presence of mass spectral tracers into categories of cooking plumes, vehicle exhaust plumes, or plumes from some undetermined source. The majority of observed plumes were from cooking sources. Approximately 20 percent of the population of Allegheny County, where Pittsburgh is located, lives within 200 m of a restaurant. Allegheny County does not have regulations of cooking emissions from restaurants, which is typical of most urban areas in the United States, with some notable exceptions.

8UA.6

Particle Size Distribution in New Delhi: Role of Coagulation and Nucleation. SHAHZAD GANI, Sahil Bhandari, Sarah Seraj, Zainab Arub, Gazala Habib, Lea Hildebrandt Ruiz, Joshua Apte, *University of Texas at Austin*

As part of the 2017 Delhi Aerosol Supersite campaign, we explore the sources and dynamic mechanisms that influence the size distributions of urban background aerosols in a polluted megacity. This investigation is motivated by the observation that fine particulate matter ($PM_{2.5}$) mass concentration in Delhi, India are ten times or more higher than in many western cities, but the particle number (PN) concentrations are not similarly elevated.

We deployed a scanning mobility particle sizer in a high-income area of Delhi to collect continuous long-term measurements of particle size distributions (PSDs). In this study, we investigate diurnal and seasonal variation of PSDs. For the observed size range of 12 to 560 nm, estimated mass concentrations dropped from 120 $\mu g\ m^{-3}$ during winter months to 55 $\mu g\ m^{-3}$ in spring (-55%). The corresponding drop for PN concentrations was from 37,000 to 29,000 cm^{-3} (-20%) and for ultrafine particles (UFP, d_p < 100 nm) from 21,000 to 19,000 cm^{-3} (-10%).

Calculations based on measured PSDs and coagulation theory suggest wintertime UFP concentrations suppression by a rapid coagulation sink. Our modeling suggests coagulation timescales of ~1 minute for 30 nm particles in winter and ~2 minutes in spring. High wintertime particle surface area, mostly from particles in the accumulation mode, provides a plausible sink for UFP. A smaller accumulation mode for warmer months result in increased UFP proportion, likely owing to a comparatively smaller coagulation sink. We also see evidence suggestive of nucleation which may also contribute to the increased UFP proportion in spring. The 24h average median-diameter of the PSD drops from ~90 to ~60 nm from winter to spring, while the daytime PSD shifts from being unimodal (peaks at ~100 nm) to bimodal (peaks at ~30, ~100 nm).

8UA.7

Source Apportionment of Fine Particulate (PM2.5) Air Pollution in Jeddah, Saudi Arabia. HAIDER KHWAJA, Omar Aburizaiza, Azhar Siddique, Shedrack Nayebare, Jahanzeb Qurashi, *King Abdulaziz University*

Ambient air pollution in major cities of Saudi Arabia is a substantial environmental and health concern. A study was undertaken to assess the air quality of Jeddah, Saudi Arabia by the analysis of respirable particulate matter ($PM_{2.5)}$, black carbon (BC), trace metals (Na, Mg, Al, Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, Sr, Cd, Sb, and Pb), and water-soluble ions (F^-, Cl^-, NO_3^-, SO_4^{2-}, $C_2O_4^{2-}$, and NH_4^{2+}). Sulfur and BC mass concentration ranged 0.99 - 7.39 µg/m^3 and 0.70 - 3.09 µg/m^3, respectively, while the $PM_{2.5}$ mass concentration ranged 23 - 186 µg/m^3. Maximum BC contribution to $PM_{2.5}$ was 5.6%. Atmospheric $PM_{2.5}$concentrations were well above the 24 h WHO guideline of 25 µg/m^3. Air Quality Index (AQI) indicates that there were 8% days of moderate air quality, 28% days of unhealthy air quality for sensitive groups, 55% days of unhealthy air quality, and 9% days of very unhealthy air quality during the study period. Sulfate SO_4^{2-} dominated the identifiable components. The major contributors to $PM_{2.5}$ were fossil-fuels combustion (36.0%); soil and crustal material (34.1%); sea-spray (15.4%); and vehicular emissions (14.5), according to the Positive Matrix Factorization (PMF). This study highlights the importance of focusing control strategies not only on reducing PM concentration, but also on the reduction of toxic components of the PM, to most effectively protect human health and the environment.

8UA.8

Adsorption of Trace Atmospheric Gases by Carbon-based Aerosol Particles Dispersed from Industrial Sources. BORIS KRASOVITOV, Tov Elperin, Andrew Fominykh, Itzhak Katra, *Ben-Gurion University of the Negev, Israel*

Adsorption of trace atmospheric gases by aerosol particles contributes to the evolution of concentration distribution of the trace constituents and can affect subsequent chemical reactions in the atmosphere. We suggest a two dimensional model of adsorption of trace atmospheric constituents by carbon-based particulate matter in air pollution plume dispersed from industrial source. The model is based on the application of theory of turbulent diffusion in the atmospheric boundary layer (ABL) in conjunction with plume dispersion model and model of gas adsorption by porous solid particles. The wind velocity profiles used in the simulations were determined by field measurements conducted in the Northern Negev (Israel) using the experimental wind mast. The adsorbate concentration distributions are calculated for the carbon-based $PM_{2.5-10}$, which is typical for industrial emissions. The analyses of the obtained results are performed for different meteorological conditions and atmospheric stability classes. We found that spatial evolution of active gas concentration in the gaseous phase strongly depends on the stability of the atmosphere and efficiency of adsorption of various gases by a particulate matter. In the case of the unstable atmosphere, we calculated the ground level concentration distribution of active gases as a function of the distance from the point of release. The obtained results are compared with the available experimental data. The calculated concentration distribution can be used for the assessments of human exposure to hazardous gaseous contaminants in the atmosphere and in various air quality models.

8UA.9

Diurnal and Day-to-Day Characteristics of Ambient Particle Mass Size Distributions from HR-ToF-AMS Measurements in Hong Kong. BERTO PAUL YOK LONG LEE, Hao Wang, Chak K. Chan, *City University of Hong Kong*

Mass concentration based particle size distributions measured by a high-resolution aerosol mass spectrometer were systematically analyzed to assess long and short-term temporal characteristics of ambient particle size distributions sampled at a typical urban environment close to emission sources and a suburban coastal site representing a regional and local pollution receptor location in Hong Kong. Measured distributions were bimodal and deconvoluted into submodes which were analyzed for day-to-day variations and diurnal variations. Traffic and cooking emissions at the urban site contributed substantially to particle mass in both modes, while notable decreases in mass median diameters were limited to the morning rush hour. Inorganic particle components displayed varying diurnal behavior, including nocturnal nitrate formation and daytime photochemical formation evident in both modes. Suburban particle size distributions exhibited notable seasonal disparities with differing influence of local formation, particularly in spring and summer, and transport which dominated in the fall season leading to notably higher sulfate and organic accumulation mode particle concentrations. Variations in particle mixing state were evaluated by comparison of inter-species mass median diameter trends at both measurement sites. Internal mixing was prevalent in the accumulation mode in spring at the urban site, while greater frequency of time periods with external mixing of particle populations comprising different fractions of organic constituents was observed in summer. At the suburban site, sulfate and nitrate in the accumulation mode more frequently exhibited differing particle size distributions in all seasons signifying a greater extent of external mixing. At the urban site, periods of greater submicron inorganic mass concentrations were more likely to be caused by increases in both Aitken and accumulation mode particle mass in summer, while at the suburban receptor location organic and nitrate Aitken mode particle mass contributed more regularly to higher total submicron species mass concentrations in most seasons (spring, summer and winter).

8UA.10

A Distributed Network of Low-Cost Black Carbon Sensors to Evaluate Community Exposure to Diesel Exhaust. CHELSEA V. PREBLE, Julien Caubel, Troy Cados, Thomas W. Kirchstetter, *University of California, Berkeley*

West Oakland is a mixed residential/industrial community in the San Francisco Bay Area that is adjacent to the Port of Oakland and the Union Pacific/BNSF rail yards and is bounded by three major freeways. As such, the community is disproportionately burdened by diesel particulate matter (PM) emissions associated with freight movement. Black carbon (BC) comprises the majority of diesel PM mass emissions and is currently monitored at a single, centrally located site in West Oakland. This study seeks to better understand the community's outdoor exposure to diesel exhaust by employing a network of 100 custom, low-cost BC sensors to make spatially resolved ambient BC measurements over 100 days.

In partnership with the Environmental Defense Fund and West Oakland Environmental Indicators Project, we collaborated with community members and local businesses to place BC sensors throughout West Oakland. Locations were chosen to create a well distributed network that included sites along commercial corridors, near port/rail operations, and within both residential neighborhoods and industrial areas. The spatial and temporal variability in outdoor BC concentrations across West Oakland will be evaluated with this network. We will identify local hotspots where BC concentration is elevated relative to the community-average exposure and the centrally located concentration. For instance, there are likely to be higher outdoor concentrations near major roadways where heavy-duty diesel trucks operate, including the mandated drayage truck corridors through the community and those areas downwind of the major freeways. Identified hotspots will be categorized according to observed local combustion activity, such as trucks, ship/rail, and industrial operations. We will compare the relative impact of these local sources to the community-average exposure concentration to examine how the single regulatory air monitor represents community exposure to diesel exhaust compared to the high-resolution network of sensors.

8UA.11

Spatial and Temporal Variation of PM2.5 and Gaseous Pollutants in Environmental Justice Communities.

REBECCA TANZER, Sriniwasa Kumar, Naomi Zimmerman, Albert A. Presto, R. Subramanian, *Carnegie Mellon University*

The state-of-the-art in air quality monitoring consists of precise, but expensive and poorly dispersed monitors. Air quality measurements are extrapolated over large domains and therefore may not paint an accurate picture of the spatial and temporal variation of pollutants. There exists a need for reliable low-cost air quality monitors to more accurately assess individuals' exposure to air pollution. We have developed a low-cost air quality monitor called the Real-time Affordable Multi-Pollutant (RAMP) sensor package. The RAMPs were coupled with off-the-shelf PM2.5 sensors from Met One. The RAMP measures PM2.5 and various gaseous pollutants including SO2, CO, CO2, NO2, and O3. A network of five RAMPs has been deployed within the Monongahela Valley, an environmental justice region, with plans to deploy fifteen more. A coke plant in Clairton and a steel mill in Braddock both contribute to the historic noncompliance of the Monongahela Valley to National Ambient Air Quality Standards. Initial analysis of variations of SO2 and PM2.5 at different RAMP locations indicate that the region is spatially heterogeneous with respect to pollutant dispersion. Preliminary data show a peak exceeding 80 μg/m3 of PM2.5 for over an hour at a RAMP three miles east of the Clairton coke plant. A sensor four miles west of the first RAMP however, did not detect the same PM2.5 spike. The data indicates that pollutant concentrations are highly variable. Further analysis will be conducted on the RAMPs within the Monongahela Valley and the low-cost sensor network will be compared to two state-of-the-art air quality monitors that are situated within the domain. The reliability of the low-cost sensors will be quantified and a high resolution spatial and temporal understanding of the dispersion of air pollutants within the region will be obtained.

8UA.12

Vertical Characteristics of Particle Number Size Distributions in the Megacity of Beijing, China.

WEI DU, Yele Sun, Jian Zhao, Yuying Wang, Yingjie Zhang, Conghui Xie, Qingqing Wang, Weiqi Xu, Wei Zhou, Tingting Han, *Inst. of Atmospheric Physics, Chinese Academy of Sciences*

Understanding the particle number size distributions in atmospheric environments is important to investigate the mechanism of haze formation, while our knowledge of the vertical characteristics of particle number size distributions remains poor. The simultaneous measurements of size-resolved particle number concentrations were performed at ground level in the size range from 10 to 550 nm and at 260 m in the size range from 14 to 736 nm in urban Beijing from 21 November to 13 December, 2016 using two Scanning Mobility Particle Sizers (SMPS). Our results showed significant differences between the particle number size distribution at ground level and that at 260 m. The average number concentration in the size range between 20 nm and 550 nm at 260 m was 10312 cm^{-3}, which was 39% lower than the ground level value of 16889 cm^{-3}. The evolution of size-resolved ratio between 260 m and ground level changed dramatically throughout the observation. For example, the ratios in the whole size range were smaller than 0.6 during the scavenging of haze. The diurnal evolution of ratios showed higher values during daytime, and reached high peaks in the afternoon. Detailed analysis suggests that meteorological conditions (e.g. wind, relative humidity), pollution intensity, and sources had great impact on the vertical distribution of particle number concentrations. For example, relative humidity had a stronger impact on large Aitken mode particles at ground level while it had much smaller influence at 260 m. The ratios between 260 m and ground level were increased with the rise of total number concentrations. In addition, new particle growth events (NPE) were occasionally observed throughout the study, and the different mechanism between different heights were also compared and discussed.

8UA.13

The Effect of NO gas on the Solubility of Dust-Borne Iron. MUNKHZAYA BOLDBAATAR, Brian Majestic, *University of Denver*

Despite being the most abundant element on the Earth's crust and atmosphere, iron is the limiting micronutrient for phytoplankton due to its highly water-insoluble nature. The most significant source of iron in the oceans is via atmospheric deposition of Aeolian dust, where the iron is < 1% soluble. In contrast, particles collected in urban settings contains 20-70% soluble iron and is estimated that, globally, 20-50% of atmospheric soluble iron is contributed from anthropogenic sources. The increase in solubility is thought to be attributed to particle size, acidification during transport, and mineralogy of the dust source. Particularly of interest is how anthropogenic gases affect the acidification of iron. Therefore, the focus here is to study the effect of a largely anthropogenic gas on the solubility of iron and to understand its paths of solubilization.

With more than half of emissions stemming from vehicles, NO is a common anthropogenic air pollutant. While previous studies on Asian dust have found nitric acid vapors to solubilize trace elements, the effects of NO have not been studied. To better understand iron solubilization and acidification during transport, we exposed dust to a constant concentration of NO in both a dry and humid environment. The PM2.5 fraction of the dust was resuspended onto Teflon filters and exposed in polypropylene vacuum desiccators for 27 hours. Post-exposure, the samples were cut in half. One half was rocked for 2-hrs in a simulated cloudwater buffer and the soluble Fe was analyzed via quadrupole ICP-MS. The other half underwent a total acid digestion and was measured for total iron. The pre- and post-exposure soluble Fe is compared to the total Fe on the filter.

Thus, in this presentation, we will present how NO affect the acidification and/or subsequent solubilization of dust-borne iron.

8UA.14

Evolving Urban Emissions: Increasing Impact of Non-Combustion Secondary Organic Aerosol Precursor Sources on Urban Air Quality. PEEYUSH KHARE, Drew Gentner, *Yale University*

Particulate matter less than 2.5 µm in size ($PM_{2.5}$) is directly emitted but is also formed as secondary organic aerosol (SOA) via the atmospheric oxidation of key, reactive gas-phase precursors (e.g., volatile organic compounds). Decades of successful policy on combustion-related emissions in the developed regions has elevated the relative impact of SOA precursor emissions from other anthropogenic sources. In our case study megacity Los Angeles, we find that emissions from consumer products and commercial/industrial processes now contribute a similar fraction of SOA precursor gases as on-road vehicles. Through chemical analyses and surveys of highly used consumer/industrial products, we demonstrate that these product/process-related sources have chemically diverse emission profiles with a wide range of SOA and ozone formation potentials that rival automobile sources. Key SOA precursors observed include intermediate- to semi-volatile organic compounds (I/SVOCs) and single-ring aromatics with weight fractions reaching up to 95% and 93% of product composition respectively, and emission timescales ranging from minutes to years. I/SVOCs are excluded or underrepresented in current inventories, and are largely exempt from emission targets. As major contributors to outdoor SOA, product/process-related sources warrant inclusion or updating in emission inventories taking into account their regional variability. Moreover, existing bottom-up estimates and top-down assessments of the SOA produced from gasoline and diesel vehicles (on- and off-road) cannot explain all of the observed fossil SOA in Los Angeles in 2010, which indicates the potential for other major sources of fossil-derived SOA precursors. We show that products/process related emissions in Los Angeles could be misattributed to fossil fuel combustion emissions due to the isotopic signature of their petroleum feedstocks. Our study highlights new avenues of research in the characterization of urban sources of VOCs, IVOCs, and SVOCs that will improve emissions inventories and urban air quality management plans.

8UA.15

Air Quality, Infrastructure, and Well-Being: Are They Linked? RAJ LAL, Armistead G. Russell, Anu Ramaswami, Kirti Das, Yingling Fan, *Georgia Institute of Technology*

Air Quality, infrastructure and emotional well-being are aspects of day to day life that we likely think about, but probably don't assess. Further, it's unlikely that we consider the extent to which they are related, if at all. Given the association between each of the three to human health and livability within cities, the association between the three could be a critical, but currently missing component, of developing healthy, livable, sustainable and environmentally friendly cities.

Field sampling methods and results exploring the relationship between air quality, infrastructure and well-being are presented from a case study in Minneapolis, MN. during Fall 2016. Air pollution (PM2.5, NOx, O3, T, RH) was assessed using low-cost air pollution monitors that were deployed in six neighborhoods of varying SES and accessibility to the light rail transit system. Concurrently, well-being and infrastructure assessment surveys through a smart phone application were conducted by n~250 survey respondents within each of the six neighborhoods. In addition, dispersion modeling is used to provide spatiotemporal exposure fields to extend the observations across the study area. With the pollution modeling and monitoring results, which are being calibrated every two weeks with MPCA research-grade instruments, and findings from the well-being and infrastructure surveys, we will be able to characterize the association between air quality, infrastructure, and emotional well-being.

This work can provide an in-depth analysis of air quality, infrastructure and well-being that city planners may consider for future, sustainable development. Further, these methods are planned to be applied with similar setups in Atlanta, GA. and Rajkot, India in the coming years, which can give insight on the intra-city and intra-country relationship between air quality, infrastructure, and emotional well-being.

8UA.18

Characteristics and Formation Mechanism of Severe Winter Hazes in Beijing. TAO MA, Fengkui Duan, Kebin He, *Tsinghua University*

We observed four severe haze episodes in Beijing from December 16, 2015 to January 9, 2016 with hourly-based continuous gas and particulate measurements. These episodes were frequent (intervals between episodes were usually less than 1 day) and durations were from 2 to 7 days. Overall, the PM2.5 concentration varied from 2.7 µg m-3 to 506.3 µg m-3, with an average of 125.0 (±106.5) µg m-3. During clean periods, organic compounds were dominant. With the deterioration of pollution, SNA increased quickly to be major components while the ratio of organic compounds decreased slowly. High concentration of SO2 and NO2 promoted the formation of sulfate and nitrate, and high concentration of CO reflected primary emission and boundary layer height. Low concentration of O3 during episode indicated weak photochemical reaction. Meteorological conditions have a strong impact on pollution level. High PM2.5 concentrations usually appeared under the condition of low wind speed and high humidity, which were in favor of the accumulation of pollutants and secondary transformation. PM1/PM2.5 increased with RH when RH was below 50%, and kept stable when RH was between 50% and 80%, and decreased when RH was larger than 80%, indicating PM1-2.5 was dominant during severe hazes. PM2.5/PM10 was discrete when RH was below 50%, and kept stable around 0.9 when RH was larger than 50%. The oxidation ratio of sulfur and nitrogen increased with RH, indicating the importance of aqueous reaction on secondary inorganics formation during severe hazes. These results suggested that stable synoptic conditions, formation of secondary species and hygroscopic growth contributed to the formation of the severe winter hazes.

8UA.19

Predicting the Spatial Variability of PM in Urban Areas with Low-Cost Monitors and Land Use Regression Modelling. MAURO MASIOL, Nadezda Zikova, Gursumeeran Satsangi, Philip K Hopke, David C. Chalupa, David Rich, Andrea R. Ferro, *Clarkson University*

Urban air monitoring stations are used to measure city-wide pollution levels (i) for regulatory purposes and (ii) to estimate the average exposure for the population. However, the spatial coverage from one or at most a few regulatory monitoring stations is insufficient to capture the spatial variability in PM concentrations across urban areas. This lack of spatial data represents a serious knowledge gap when performing human inhalation exposure studies. Inadequate spatial resolution may mask the exposure variability in the study population and may lead to potential exposure misclassifications.

The intra-urban variation of air quality can be resolved by using land-use regression (LUR) models, which require sampling measurement campaigns at multiple locations along with a set of predictor variables derived from geographic information systems (e.g., various traffic representations, population density, land use, physical geography and climate). However, such sampling campaigns are usually short in time or use mobile monitoring networks due to the high cost for deployment and maintenance of scientific-grade instruments. The recent development of low-cost PM monitors is potentially a viable solution to increase the spatial resolution of air quality monitoring and to perform long-term sampling campaigns at multiple sites.

This study aims to produce an hourly-resolved LUR model to predict hourly PM concentrations at individual locations across Monroe County, NY. The study uses spatially-resolved PM data measured with low-cost monitors for the development of the LUR model. Low cost PM monitors (Speck, Airviz Inc. PA, USA) were placed at 23 sites across Monroe County, NY during the 2015/16 heating season (November to March). Data were handled according to the results of previous intercomparison studies with reference instruments to assure a robust and reliable dataset. Coefficients of determination for ***hourly*** PM predictions were between 0.6 and 0.65 for the various sites, which is comparable with previous LUR studies for ***daily*** PM predictions.

8UA.20

Trace Metals in Aging Urban Particulate Matter. JOSEPH SALAZAR, David Pfotenhauer, Frank Leresche, Fernando Rosario-Ortiz, Michael Hannigan, Brian Majestic, *University of Denver*

Here, we introduce the Platte River Photochemical Experiment, a sampling campaign aimed at understanding organic carbon and trace element photochemical interactions. We present the sample design, total metals, and soluble metals acquired from the winter campaign. In this study, Fe is of particular importance because, annually, 56.6 Tg of Fe enter the atmosphere, more than any other transition metal. Atmospheric particles also contain red-ox and photo-active organic species which may contribute to the solubilization of Fe. Fe collected in urban regions ranges from 22-50% soluble, compared to 0.2-1% the wind-blown desert dust. The origin of the elevated soluble Fe in urban areas is currently unclear. Two hypotheses are 1) soluble Fe is formed directly from urban sources or 2) chemical reactions during dust transport increases iron solubility. As Fe-containing dust travels through urban airsheds, it mixes with organic carbon and also has the potential for photochemistry. It has been demonstrated from lab procedures that, when exposed to sunlight and organic substances (e.g., PAH), Fe solubility can increase up to 10 fold. The likely mechanism for this process is via photo-Fenton chemistry. In photo-Fenton reactions, Fe(III), water and UV light react to produce the more soluble Fe(II) and hydroxyl radicals. In this study, PM2.5 was collected at three sites along the Platte River in the high plains in Colorado to understand if Fe solubility is affected by different types of organic sources (crustal, urban, and a mixture). The water soluble extracts are irradiated under simulated sunlight and the changes in soluble Fe measured and compared to the changes and quantity of organic carbon. This study is one of the first in attempting to understand how water soluble organic carbon affects the water solubility of trace elements.

8UA.21

Effects of Meteorology Changes on Reduction of Air Pollutants Concentrations. Pengfei Wang, Sri Kota, Jianlin Hu, Qi Ying, HONGLIANG ZHANG, *Louisiana State University*

Tremendous efforts have been made to improve the severe air pollution in China in recent years. However, no significant improvement was observed according to annual fine particulate matter (PM2.5) concentrations and the concentrations in severe air pollution events in winter. This is partially due to the role of meteorology, which affects the emission, transport, transformation, and deposition of air pollutants. In this study, simulation of air pollutants over China was conducted for six years from 2010 to 2015 with constant anthropogenic emissions to verify the changes of air pollutants due to meteorology changes only. Model performance will be validated by comparing with meteorological observations and air pollutants measures from various sources. Different regions/cities will be selected to understand the changes in wind, mixing layer height, temperature, and relative humanity at different seasons. The changes in concentrations of pollutants including PM2.5 and its chemical components and ozone will be analyzed and associated with meteorological changes. This study would provide information for designing effective control strategies in different areas with the consideration of meteorological and climate changes.

8UA.22

Identification of the Main Contributors Producing Nitrosamines in the Atmosphere at Seoul, Republic of Korea. NARAE CHOI, Yun Gyong Ahn, Hyung Bae Lim, Ji Yi Lee, Yong Pyo Kim, *Ewha Womans University*

Nitrosamines are a class of chemical compounds with the general structure containing N-NO functional group attached to the amine nitrogen and they have been suspected as prime urban carcinogens during the last decades. Nitrosamines in the atmosphere can be emitted from primary emission sources including industrial use, vehicular exhaust, tobacco smoke and cooking. In addition, nitrosamines are produced from the atmospheric reactions such as dark reactions indicating nitrosation under the humid condition and photochemical reactions initiated with OH radical. The ambient levels of nitrosamines have been rarely reported in spite of their detrimental health effects, since the ambient concentrations of nitrosamines have been assumed to be low due to the rapid removal process. Thus, the ambient levels and main contributors producing nitrosamines in the atmosphere over Seoul should be investigated.

Five nitrosamines (nitroso-methyl-ethylamine (NMEA), nitrosodi-ethylamine (NDEA), nitroso-pyrrolidine (NPYR), nitroso-piperidine (NPIP), and nitrosodi-butylamine (NDBA)) in the atmospheric particulate matter with an aerodynamic diameter of less than or equal to a nominal 10 μm (PM_{10}) at Seoul were identified and quantified by using a gas chromatography (GC) coupled with single quadrupole mass spectrometry (MS) in chemical ionization (CI) mode. The ambient concentrations of nitrosamines show distinctive seasonal and diurnal patterns; higher in winter (2.79±3.04 ng/m^3) than in summer (1.13±2.63 ng/m^3) and slightly higher in night time (1.89±3.81 ng/m^3) than day time (1.57±3.81 ng/m^3). In this study, the main contributors producing nitrosamines in the ambient atmosphere will be identified using statistical tools such as correlation and PCF (principal component factor) analysis based on the seasonal and diurnal concentrations trends of nitrosamines.

8UA.23

Using Low-Cost Sensors to Probe Changes in Urban Aerosol on a Neighborhood Scale. KAITLYN LIESCHKE, Alexis Shusterman, Catherine Newman, Jinsol Kim, Ronald Cohen, *UC Berkeley*

Human aerosol exposure and related risk are typically monitored using spatially-sparse measurements by expensive, robust instruments. However, as aerosol concentrations can change dynamically within a neighborhood these measurements lack the spatial resolution to adequately address the question of changing individual exposures within a region. The BErkeley Atmospheric CO2 Observation Network (BEACO2N) employs a range of low-cost air quality sensors to monitor aerosols, CO2 and other air quality gases in the San Francisco Bay Area. By reducing the cost of each node, a greater number can be deployed, resulting in a network that currently contains over 50 nodes distributed on a grid of approximately 2km x 2km. The network, which was established in 2012 and is continuing to expand, can be used to supplement to the typical one or two monitoring sites within a city. Using this unique platform, we are able to observe aerosol gradients across a community as well as localized events that result in high aerosol loadings at a given site. In addition, by combining the changes in aerosol concentrations with measurements of other gases and meteorological conditions, it is possible to identify the sources of local air pollution events.

8UA.24

Characterizing Aerosols Near Major Highways Using the US EPA's National Near-road Monitoring Network. BRETT GANTT, *U.S. EPA*

As part of the United States Environmental Protection Agency's 2010 NO_2 National Ambient Air Quality Standards (NAAQS) revision, a national network of monitors was established to determine compliance, better understand human exposure on and near roads, and improve the characterization of pollutant behavior, interaction, and dispersion in the near-road environment. Sites for these monitors were required to be placed "as near as practicable" to major highways within CBSAs having a population greater than 1 million people. In addition to monitoring NO_2, both CO and $PM_{2.5}$ were required to be monitored by January 1, 2015 and January 1, 2017 for CBSAs greater than 2.5 million and 1 million people, respectively. Optional measurements at these sites include black carbon, ultrafine PM, air toxics, ozone, meteorology, and traffic counts.

Although most of the near-road sites do not yet have the 3 years of data required for determining regulatory compliance for $PM_{2.5}$, many have a sufficient data record to characterize aerosols in the near-road environment. Analyses that have been performed include quantifying the seasonal and diurnal cycles of $PM_{2.5}$ mass concentration, chemical composition of $PM_{2.5}$, and increment of $PM_{2.5}$ mass concentration relative to other sites within the CBSA. Data from this network are compared to that of existing sites close to major highways to estimate the long-term trends in $PM_{2.5}$ mass and chemical composition relative to non-near-road sites. Finally, the annual average and 98th percentile $PM_{2.5}$ mass concentrations at near-road sites across the US for 2016 are summarized to determine their potential regulatory impact in the future.

8UA.25

Reduced New Particle Formation in Urban Air due to Anthropogenic Emissions Reductions. PROVAT SAHA, Ellis Shipley Robinson, Rishabh Shah, Naomi Zimmerman, Joshua Apte, Albert Presto, Allen Robinson, *Carnegie Mellon University*

The formation of new particles by homogeneous nucleation is an important source of ultrafine particles in many urban areas. Sulfur dioxide (SO2) and ammonia (NH3) emissions have been indicated as major precursors for nucleation-sourced ultrafine particles in the northeastern United States. Over the past few decades, emissions of SO2 and other air pollutant emissions from anthropogenic sources have been substantially reduced in the United States. However, the extent to which reduction in anthropogenic emissions alters the new particle formation events is largely undetermined. Here, we present observational evidence on how the reduction in anthropogenic emissions influence the frequency and intensity of nucleation events based on long-term comprehensive ambient measurements in the northeastern United States. We analyzed year-long particle size distributions measurements collected at an urban background site in Pittsburgh, Pennsylvania during 2001-02 (Pittsburgh Air Quality Study) and 2016-17 to explore any changes in trends in nucleation events in last 15 years. Our preliminary analysis results show that frequency of regional and local nucleation events and contribution of nucleation-sourced ultrafine particles are lower, and particle growth rates slower than those observed in 15 years ago. The changes are more pronounced during winter than warm seasons. Overall, our results indicate that with a substantial reduction in SO2 and NH3 emissions, the frequency and intensity of nucleation events are reduced in Pittsburgh, consistent with prior modeling study. The results from this study highlight that future reduction in SO2, NH3, and other anthropogenic emissions may considerably reduce the nucleation-sourced ultrafine particles burden in many polluted urban environments.

8UA.26

Using High Complexity Analysis to Probe the Evolution of Organic Aerosol during Pollution Events in Beijing. JACQUELINE F. HAMILTON, William Dixon, Rachel E. Dunmore, Freya Squires, Stefan Swift, James D. Lee, Andrew R. Rickard, Yele Sun, Weiqi Xu, *University of York*

There is increasing evidence that exposure to air pollution results in significant impacts on human health. In Beijing, home to over 20 million inhabitants, particulate matter levels are very high by international standards. Changes in particle composition during pollution events will provide key information on sources and can be used to inform strategies for pollution mitigation and health benefits.

The organic fraction of PM is an extremely complex mixture reflecting the diversity of sources to the atmosphere. In this study we attempt to harness the chemical complexity of OA by developing an extensive database of over 700 mass spectra, built using literature data and sources specific tracers. Using a high throughput analysis method, involving UHPLC coupled to Orbitrap mass spectrometry, chromatograms are integrated, compared to the library and a list of identified compounds produced. Purpose built software based on R is used to automatically produce time series, alongside common aerosol metrics and data visualisation techniques, dramatically reducing analysis times.

Offline measurements of organic aerosol composition were made as part of the Sources and Emissions of Air Pollutants in Beijing project, a collaborative program between leading UK and Chinese research groups. Rather than studying only a small number samples, we collected ~250 filters at a range of time resolutions, from 30 minutes to 12 hours, depending on the time of day and PM loadings. In total 643 species were identified based on their elemental formula and retention time, with species ranging from C2-C22 and between 1-13 oxygen atoms. Here we will present preliminary results on the factors that impact the evolution of organic aerosol in Beijing, highlighting the role of biomass burning in winter and photochemistry in summer. Modern data mining and statistical analysis methods will be used to identify patterns in the OA composition.

9AC.1

Properties of Secondary Organic Aerosols Formed in the Oxidation of Alfa-pinene at Different Temperatures. Kasper Kristensene, Louise Normann Jensen, Marianne Glasius, MERETE BILDE, *Aarhus University*

Secondary organic aerosol (SOA) derived from biogenic volatile organic compounds contribute significantly to the aerosol mass burden of the atmosphere. The chemical composition of SOA is important for the SOA climate impact, and may be highly influenced by temperature. Few studies have however addressed this, and in particular the chemical composition of SOA at temperatures below ambient represents an understudied area. In this work, the formation and properties of secondary organic aerosol formed in the dark ozonolysis or OH initiated oxidation of alfa-pinene was studied in a new chamber facility at Aarhus University. For the dark ozonolysis experiments temperature was varied over the range 258-293 K. The particle elemental composition was probed using an aerosol mass spectrometer (HR-ToF-AMS) and molecular speciation was obtained from off-line (UHPLC/ESI-qTOF-MS) analysis of filter samples. Particle size distributions were measured using a scanning mobility particle sizer (SMPS) system and SOA yields as derived from the integrated size distributions compared with literature studies. In the chemical analysis 16 organic acids and 30 dimer esters were identified. The concentration of the identified organic acids formed in the dark ozonolysis of alfa-pinene was higher (~30% of total SOA mass) at the coldest temperature (258 K) compared to the warmest temperature of 293 K (~20% of total SOA mass) whereas dimer esters were found to be suppressed at low temperatures. Vapour pressures of the identified carboxylic acids and dimer esters have been estimated and the gas/particle distribution of these compounds will be discussed in relation the temperature dependence of their vapour pressures.

9AC.2

Quantifying Oligomerization in Organic Aerosol through Desorption Thermogram Modeling. SIEGFRIED SCHOBESBERGER, Felipe Lopez-Hilfiker, Emma L. D'Ambro, Olli-Pekka Tikkanen, Joel A. Thornton, *University of Eastern Finland*

Recent studies have indicated a major role of oligomer formation and decomposition in controlling the volatility of secondary organic aerosol (SOA). State-of-the-art mass spectrometric techniques now allow us to measure aerosol molecular composition at a sufficiently high time resolution to access such molecular-scale mechanisms. Using the Filter Inlet for Gas and AEROsols (FIGAERO), coupled to a time-of-flight chemical ionization mass spectrometer, composition-resolved thermograms can be measured for a major fraction of an SOA sample through temperature-controlled evaporation.

In our study, we developed a model to simulate these thermograms and applied it to chamber experiments of SOA formation from monoterpenes. The model describes desorption of aerosol constituents using a modified Hertz-Knudsen equation. Additional terms, with rates modeled after Arrhenius' equation, describe the formation and dissociation of oligomers. Interactions of desorbed molecules with inner instrument surfaces are accounted for as well, and a series of special experiments provided additional constraints.

Our model produces thermogram peaks similar to those observed in FIGAERO experiments. Disregarding oligomerization at first, peak position is sensitive to particle-phase diffusivity and the compound's vapor pressure, whereas the enthalpy of vaporization also affects peak width. When sampling SOA however, a substantial fraction of the signal for most compounds desorbed at higher temperatures than their elemental composition suggests, supporting the hypothesis of the pivotal role of oligomer formation and decomposition in determining SOA properties. The corresponding thermograms usually exhibited an initial peak, followed by a plateau or second peak towards higher temperatures. We are able to simulate these peak shapes, when we include the oligomer formation and dissociation terms, and use the controlling rate constants and activation energies as free parameters. By using a state-of-the-art optimization algorithm, we fit all free parameters to the observed thermograms, thus gaining quantitative insights into the dynamics of the reversible oligomerization reactions occurring in SOA.

9AC.3

High Molecular Weight Dimeric Products from α-pinene Oxidation: Molecular Composition, Formation Mechanisms, and Implications for Particle Formation and Growth.

YUE ZHAO, Emma L. D'Ambro, Megan McKeown, Jiumeng Liu, John Shilling, Joel A. Thornton, *University of Washington, Seattle, WA*

Recent studies have shown that high molecular weight dimeric compounds formed from atmospheric oxidation of biogenic emissions constitute a significant source of low-volatility organic compounds in secondary organic aerosol (SOA) and play an important role in particle formation and growth as well as in controlling the volatility of the particles. However, the underlying mechanisms forming these dimeric compounds remain largely unclear. Although plausible mechanisms involving reactions of stabilized Criegee intermediates (SCI), organic peroxy radicals, and monomeric end products either in the gas or particle phase have been proposed, unambiguous elucidation of these formation pathways and their relative importance is still rather limited. Here we present a detailed experimental investigation of ozonolysis of α-pinene both in a flow reactor and in a continuous-flow environmental simulation chamber, with a focus on the formation mechanisms of dimers and their role in the initial stage of SOA formation. A high resolution time-of-flight chemical ionization mass spectrometer (HRToF-CIMS) utilizing iodide-adduct ionization coupled to the Filter Inlet for Gases and Aerosols (FIGAERO) was used for simultaneous measurement of the gas and particle composition. Another iodide-adduct HRToF-CIMS coupled to an orthogonal atmospheric pressure ion-molecule reaction (IMR) chamber was also deployed to measure the molecular composition of dimers in the gas phase with minimum wall losses of these extremely low-volatility species in the sampling inlet and IMR. The effects of water vapor, SCI and OH scavengers, nitric oxide, and ammonium sulfate seed particles on the formation and gas vs. particle phase distribution of dimers are examined. Implications for particle formation and growth are discussed.

9AC.4

Synergistic O_3 + OH Oxidation Pathway to High Molecular Weight, Extremely Low-Volatility Organic Compounds Revealed in Beta-Pinene Secondary Organic Aerosol.

CHRISTOPHER KENSETH, Yuanlong Huang, Ran Zhao, Nathan Dalleska, Caleb Hethcox, Brian Stoltz, John Seinfeld, *California Institute of Technology*

High molecular weight, extremely low-volatility dimeric compounds have been identified as significant components of both ambient and laboratory-derived monoterpene secondary organic aerosol (SOA), and have been implicated as key players in new particle formation and growth. Recent studies have shown that these compounds are formed only through O_3- and not OH-initiated oxidation, despite the apparent monomeric building blocks being present in the OH system. This result, together with prompt formation of the dimers observed at the onset of O_3 oxidation experiments, strongly suggests that traditionally cited particle-phase formation pathways are not significant in dimer production, pointing instead toward formation through gas-phase reactions involving early-stage oxidation products and/or reactive intermediates, e.g., stabilized Criegee intermediates (SCI) or organic peroxy radicals (RO_2). However, unambiguous elucidation of the mechanisms underlying dimer formation and their relative importance remains sparse. In this study, we present a comprehensive dataset on the identity, abundance, and kinetics of molecular products in SOA formed from the O_3- and OH-initiated oxidation of beta-pinene, the second most abundant monoterpene in the atmosphere (global emissions estimated at 19 Tg yr^{-1}). Through a combination of ultra performance liquid chromatography/electrospray ionization mass spectrometry (UPLC/ESI-MS), hydrogen/deuterium exchange (HDX) UPLC/ESI-MS, ^{13}C isotopic labeling, and OH/SCI scavenging, we identify a new reactive pathway to extremely low-volatility dimeric compounds in SOA formed from O_3 oxidation involving gas- and particle-phase reaction of O_3-derived products/intermediates with those generated from oxidation by OH produced *in situ* via vinyl hydroperoxide (VHP) decomposition. This novel feature of monoterpene SOA formation represents a potentially significant source of high molecular weight, extremely low-volatility organic compounds to the atmosphere, and also highlights the importance of understanding and accounting for the likely role of oxidative synergism in ambient aerosol formation, where SOA precursors are susceptible to concurrent oxidation by O_3 and OH.

9AC.5

Reduced Nitrogen Organic Species Partitioning to Aerosol in the Indoor Environment. PETER DECARLO, Anita Avery, Michael Waring, *Drexel University*

Submicron aerosol in the indoor environment is often directly related to the penetration of outdoor aerosols in to the indoor space. New particle and SVOC sources in the indoor environment can modify the overall chemical composition of the outdoor aerosol. A series of studies using a High-Resolution Aerosol Mass Spectrometer examined the differences in the indoor and outdoor aerosol composition and identified a reduced nitrogen component unique to the indoor aerosol. Positive Matrix Factorization was used to characterize the mass spectral signature and mass loading of the reduced nitrogen component. This component had significant (~20-30%) mass contribution to the total indoor submicron aerosol loading, and was the largest single component in the indoor aerosol. Partitioning of this species is to the aqueous phase of the aerosol through an acid base reaction mechanism with reactive uptake. Uptake to the organic phase is not supported by the measurement data. Subsequent tests in the laboratory indicate that the likely source of the reduced nitrogen species is likely aged residual cigarette smoke.

9AC.6

Characterization of Primary and Secondary Organic Aerosol using a Novel Extractive Electrospray Ionization Time-of-Flight Mass Spectrometer (EESI-TOF) from Chamber Studies. Bin Yuan, Giulia Stefenelli, Imad El Haddad, Veronika Pospisilova, Felipe Lopez-Hilfiker, Liwei Wang, Mao Xiao, Yandong Tong, Lu Qi, Sepideh Esmaeilirad, Simone Pieber, Josef Dommen, Urs Baltensperger, Andre S.H. Prévôt, JAY G. SLOWIK, *Paul Scherrer Institute*

Organic aerosol (OA) is a large component in atmospheric particulate material, affecting urban visibility, human health, and global climate. Secondary organic aerosol (SOA) formation and aging in the atmosphere are still not fully understood. Current online OA measurement techniques are subject to ionization-induced fragmentation and/or thermal decomposition, decreasing the molecular information obtained and thereby compromising source identification and mechanistic studies. A novel extractive electrospray ionization time-of-flight mass spectrometer (EESI-TOF) was recently developed at PSI. The fast-response EESI-TOF was shown to measure organic aerosol without fragmentation or thermal decomposition, including oligomeric and thermally unstable species.

In this study, we deploy the EESI-TOF along with other state-of-the-art gas-phase and aerosol measurement techniques (AMS, PTR-TOF, and TOF-CIMS) in a smog chamber to study primary emissions and secondary formation from several important emission sources (e.g wood combustion, coal burning, vehicular emissions, and etc) and representative SOA precursors (e.g. aromatics) in the atmosphere. Emissions (or SOA precursors) are aged using OH or NO3 radicals to simulate daytime and nighttime oxidation processes. These chamber studies provide valuable reference mass spectra for source apportionment of ambient EESI-TOF spectra. Further, the chemical information provided by the EESI-TOF enables investigation of important organic aerosol transformations, including oligomerization, gas-particle partitioning and aging.

9AC.7

Particle-phase Organic Peroxides; Where Are You? RAN ZHAO, Christopher Kenseth, Yuanlong Huang, John Seinfeld, *California Institute of Technology*

Organic peroxides comprise a significant fraction of extremely low-volatility, highly oxygenated organic compounds in secondary organic aerosol (SOA). Analyses of particle-bound organic peroxides at the molecular level present a significant analytical challenge, due to their chemical instability and complexity. Recent applications of liquid chromatography-electrospray ionization-mass spectrometry (LC-ESI-MS) techniques facilitated the detection of a large variety of particle-phase oxidation products, among which many were proposed to be organic peroxides. However, unambiguous assignment of functional groups using mass spectrometry is challenging, and unique analytical techniques must be employed to distinguish organic peroxides in complex chemical matrices. In this study, we have developed a novel LC-ESI-MS technique assisted by iodometry. Iodide ion (I^-), in an acidic solution, selectively reduces organic peroxides (ROOR) to the corresponding alcohols (ROH). The application of iodometry so far has been limited to the determination of the total peroxide content which can be tracked with the UV absorption of I_3^- forming in the solution. In this study, iodometry is employed for the first time in molecular-level analyses of organic peroxides by coupling to an LC-ESI-MS technique, where mass spectrometric peaks that are converted by the iodometry treatment can be identified as organic peroxides. The characterization of this technique and its application to the water-soluble fraction of α-pinene SOA are presented. Our preliminary results imply that none of the major dimers detected by our LC-ESI-MS can be concluded as organic peroxides.

9AC.8

Direct Measurement of Size Resolved Aerosol Acidity. REBECCA CRAIG, Peter Peterson, Ryan Dodson, Andrew Ault, *University of Michigan*

Aerosol acidity is an important parameter for assessing the impact of aerosol particles on climate, as many particle phase chemical processes are highly dependent on acidity, such as secondary organic aerosol formation and gas-particle phase partitioning. Particle acidity also affects aerosol chemical composition and hygroscopicity, which can influence cloud droplet nucleation and, ultimately, climate forcing. Disagreement between traditional methods for estimating aerosol pH and thermodynamic models used to predict aerosol pH calls for more refined techniques for direct measurement of aerosol acidity. Herein, we present a novel method for direct measurement of aerosol acidity using pH indicator. Aerosol particles are impacted onto pH indicator paper and the resulting color change of the paper is analyzed to determine pH. pH measurements of laboratory-generated standard aerosol particles shows a size dependent acidity trend, with aerosol acidity increasing with decreasing particle size. This result of non-uniform acidity within the atmospheric aerosol population could have implications for acidity-dependent particle phase processes.

9CS.1

Take-Off Engine Particle Emission Indices for In-Service Aircraft at Los Angeles International Airport. RICHARD MOORE, Michael Shook, Luke Ziemba, Josh DiGangi, Edward Winstead, Bastian Rauch, Jurkat Tina, Kenneth Thornhill, Ewan Crosbie, Claire Robinson, Taylor Shingler, Bruce Anderson, *NASA Langley*

Aircraft engine particle emissions are important contributors to local air quality near airports. These emissions occur during multiple stages of aircraft movement including idling at terminal gates, taxiing, runway take-offs, and runway landings, which are collectively referred to as the landing-takeoff (LTO) cycle. Engine LTO emissions are quantified by their manufacturers prior to certification and operation in terms of a smoke number; although, current and future efforts are underway to measure engine LTO emissions in a more rigorous fashion by measuring particle number and/or mass emissions indices. While these data will inform transportation modeling of the next generation of aircraft engines, there are currently no plans to recertify older engines that are currently in service. In addition, the LTO certification process is idealized as engine conditions are measured under discrete, steady thrust settings that may differ from thrusts actually applied by pilots. Consequently, there is a need to understand the emissions from these currently in-service engines under real-world conditions. Here, we investigate particle emissions emitted by aircraft during takeoff operations at Los Angeles International Airport (LAX).

We present engine emissions indices from 275 distinct aircraft takeoff plumes for a range of engine types and aircraft configurations. The most prevalent single aircraft type sampled were 737 class -700, -800, and -900 series with CFM56-7B engines. Other engine types included contrasting Engine Alliance and Rolls-Royce Trent 970 engines on the Airbus A380-800 aircraft and GE Genx engines on Boeing 747-800s. Particle number EIs are in the range of 10^{16}-10^{17} kg-fuel^{-1} on a number basis and 100-1000 mg kg-fuel^{-1} on a mass basis, which are consistent with previous advected plume measurements (e.g., Lobo et al., 2012). This work substantially expands the database of takeoff emissions indices both in terms of plumes sampled and diversity of engine types. Comparison of measured number and mass EIs and estimates based on the First Approximation Method (FOA3) will be discussed.

9CS.2

Secondary Aerosol Forming Potential of Gasoline Direct Injection Vehicles with Varying After-Treatment Technologies. PATRICK ROTH, Jiacheng Yang, Diep Vu, Thomas D. Durbin, Georgios Karavalakis, Akua Asa-Awuku, *University of California, Riverside*

Gasoline Direct Injection (GDI) technology has become the preferred standard to Port Fuel Injection (PFI) engines in the US and European markets due to its improved fuel economy. However, GDI vehicles may have difficulty meeting the new two phase LEV III PM Standard set at 3 mg/mile by 2017, and 1 mg/mile by 2025. The use of gasoline particulate filters (GPF), as seen in Europe, can help GDI vehicles meet future PM emissions standards.

In addition to PM, vehicle emissions are an important source of VOCs, NO_x, NH_3 and CO which through a variety of complex oxidation reactions, can contribute to secondary aerosol and ozone formation in the atmosphere. The focus of this work was to evaluate how the addition of PM emission control systems affects the secondary aerosol formation potential of new technology GDI vehicles over realistic driving cycles.

For this study, the SOA and ozone forming potential from two GDI vehicles (with and without a GPF filter, both in triplicate) were generated over a cold start, LA-92 driving cycle. The exhaust was measured to certification standards, and subsequently collected in CE-CERT's 30m^3 Mobile Atmospheric Chamber (MACh). The emissions were then photochemically aged for 8-10 hours, and real-time particle and gaseous phase measurements were analyzed.

As expected, the GPF equipped vehicles displayed a considerable decrease in primary PM (~95%) compared to the stock configurations. The composition of the primary aerosol varied with only ~25% of PM mass attributable to BC in the GPF configurations compared to 85% BC in stock configurations. As the gaseous emissions aged and condensed, primary fractal particles (ρ=0.6 g/cm^3) quickly transitioned to more dense (ρ=1.4-1.7 g/cm^3), spherical particles, composed of ammonium nitrate and organic species. The change in composition and morphology impacted both volatility and hygroscopicity measurements. Aged emission masses were found to exceed the primary masses with varying ratios of inorganic ammonium nitrate and secondary organic material (HR-TOF AMS). The data generated from this work will aid manufacturers and regulatory agencies understand the atmospheric impacts of the increasing market share of GDI equipped vehicles with varying after-treatment technologies.

9CS.3

Impact of Exhaust Aftertreatment on Primary and Secondary Particulate Emissions of a Non-Road Diesel Engine. PANU KARJALAINEN, Leonidas Ntziachristos, Pauli Simonen, Kimmo Teinilä, Hilkka Timonen, Henna Saveljeff, Mika Lauren, Matti Happonen, Pekka Matilainen, Teuvo Maunula, Jukka Nuottimäki, Topi Rönkkö, Jorma Keskinen, *Tampere University of Technology*

The new Stage V for non-road mobile machinery (NRMM) calls for the introduction of diesel particle filters (DPFs) as a result of the decision to regulate particle number on top of particle mass. Stage V goes several steps beyond Stage IV, for which only deNOx aftertreatment was enough to reach required emission levels. With Stage V, understanding the potential of different aftertreatment technologies to bring real world reductions in NOx and PM emissions is required.

Recent research suggests that vehicles contribute to atmospheric PM concentrations not just through their direct (primary) PM emissions measured at the tailpipe but also through photo-oxidation and gas-to-particle processes of initially gaseous exhaust components (secondary PM). To understand the health and environmental effects of exhaust emissions, both primary particulate emission and secondary formation need to be characterized. In this study we used a comprehensive set of measurements to characterize both particulate types produced by a modern nonroad engine equipped with the most relevant exhaust aftertreatment systems.

Two fuel grades, one typical diesel fuel oil (DFO) and one so-called renewable diesel – hydro-treated vegetable oil (HVO) were used in the testing. Primary emissions were measured following raw exhaust sampling with a porous tube dilutor. Secondary particle formation was initiated using a Potential Aerosol Mass (PAM) chamber to simulate secondary aerosol formation in the atmosphere.

Our results suggest that advanced aftertreatment seems to satisfactorily decrease both primary and secondary PM emissions. In particular DPF efficiency is above 90% for both particle types. A well operating selective catalytic reduction (SCR), combined with a diesel oxidation catalyst, also leads to significant PM and NOx reductions. Excess ammonia events (NH3 slip) may lead to disproportional increase of secondary PM and have to be carefully controlled and avoided.

9CS.4

The Effects of Aggressive Drive Cycles on the Characteristics and Measurement of GDI Vehicle PM Emissions. MATTI MARICQ, Joseph Szente, Amy Harwell, Michael Loos, *Ford Motor Company*

Changing emissions regulations are broadening the range of driving conditions subject to motor vehicle PM emissions standards. In the US, the EPA and CARB have introduced a 6 mg/mi PM standard for the US06 drive cycle. Europe and the remainder of the world are moving to the World Harmonized Light Vehicle Test Procedure, which includes an extra high speed portion. And solid particle number standards will apply to Real World Driving Emissions regulations.

This paper describes recent work which shows that PM emissions from GDI vehicles can change dramatically between moderate driving, such as on the Federal Test Procedure (FTP), and aggressive driving, such as the US06 cycle. These include changes to the size distribution as well as composition. Whereas PM emissions largely exhibit a lognormal accumulation mode of soot over the moderate FTP cycle, the distribution often becomes bimodal during the US06 cycle. The accumulation mode can also shift to a mean size of order 30 nm. This shift is accompanied by a decrease in the black carbon / elemental carbon ratio to 50% or less. These changes suggest that soot in aggressive driving is younger and less carbonized.

These changes also impact the ability of various aerosol instruments, such as the Engine Exhaust Particle Sizer, Dekati Mass Monitor, and AVL Micro Soot Sensor to accurately measure PM levels. The changes in size distribution alter the assumptions built in to PM mass determination from size distribution measurements, and the change in soot particles affect the ability to determine soot mass by light absorption.

Finally, the high exhaust temperatures encountered during aggressive driving lead to storage / release effects that interfere with PM emissions measurements. These can come from the vehicles exhaust system or the exhaust sampling system. Their impact on repeatable PM measurement is examined.

9CS.5

Passive Control Systems for Improving Air Quality in Urban Street Canyons: The Origins, Current State of Art and Next Steps. JOHN GALLAGHER, Brian Broderick, Prashant Kumar, Aonghus McNabola, Francesco Pilla, *Trinity College Dublin.* INVITED

Strategies to improve urban air quality have primarily focused on reducing emissions through campaigning for green alternative modes of transport and improving the efficiency. Despite their associated improvements for air quality, our cities continue to represent some of the most polluted zones on the planet. In the last decade, solid and porous barriers have received growing attention from the research community as the presented solutions can potentially mitigate this air pollution. This passive solution considered methods of improving air quality by influencing air flow patterns and enhancing the dispersion and deposition of gaseous and particulate pollutants.

Previous research has demonstrated how street canyon geometry and local meteorological conditions are the dominant characteristics that affect air quality in the urban environment. Through measurement, modelling and wind-tunnel experimentation, a deeper understanding of how passive control systems in urban street canyons can work in harmony with local conditions to maximise pollutant dispersion and deposition. Solid barriers, including low boundary walls and parked cars, have been shown to improve air quality on the windward footpath and trap pollutants on the leeward footpath depending on the size, orientation and spacing of these control measures. Alternatively, green infrastructure, such as trees, hedges, green roofs or green walls, delivers improved air quality under the same varying conditions, but has the benefit of achieving both dispersion and deposition of pollutants.

The next steps in this field suggests more detailed analysis of real-world condition, as understanding the performance of passive control systems in different climatic conditions is required. In addition, improving the ability of numerical modelling and scaled wind-tunnel experiments to account for vehicular turbulence effects, fluctuating wind conditions and ensure that passive barriers abate as opposed to trap pollutants. Therefore, more real-word measurement studies are necessary to enhance current findings and to allow for the accurate extrapolation of findings.

9CS6

Effectiveness of Road-side Vegetation and Noise Barriers on Reducing Ultrafine and Fine Particulate Matters under Variable Wind Speeds. Eon Lee, Dilhara Ranasinghe, Faraz Enayati Ahangar, Seyedmorteza Amini, Steve Mara, Wonsik Choi, Suzanne Paulson, YIFANG ZHU, *University of California Los Angeles*

Recent studies have focused on the effectiveness of road-side barriers, such as soundwall and vegetation barrier as a potential mitigation strategy to reduce near-road air pollution. However, our understanding is limited because of insufficient scientific evidence in this area of study and there are variable findings reported in the literature. This study executed a series of field sampling campaigns at three near-freeway (10-15 m away) sites in California. At each study site, two to three weeks of real-time measurements of ultrafine particles (UFPs, diameter ≤ 100 nm) and $PM_{2.5}$ (diameter ≤ 2.5 µm) were conducted concurrently at four fixed locations that have different configurations of soundwall and/or vegetation barriers upwind and downwind of the freeways. This study specifically aimed to determine to what extend the soundwall and/or vegetation barrier reduce the near-freeway air pollution under variable wind conditions. Overall finding of this study is that a combination barrier of soundwall and vegetation can be more effective on reducing both UFP and $PM_{2.5}$ concentrations than either soundwall or vegetation alone. While this is consistent with majority of previous findings, this study also found the effectiveness of road-side barriers could be different for $PM_{2.5}$ and UFP and specific to wind speeds. The soundwall barrier was more effective for reducing $PM_{2.5}$ than UFP, and it was most effective when the wind speed ranged between 1 and 2 m/s. In contrast, the vegetation barrier had little effect on reducing $PM_{2.5}$ but exhibited more effective reduction for UFP than the soundwall barrier. For both types of roadside barrier, decreasing wind speed resulted in greater reduction of UFP concentrations (i.e., inversely proportional). However, this trend was observed only within specific particle size ranges (i.e., diameter < 20 nm for the soundwall barrier and 12-60 nm for the vegetation barrier). Out of these size ranges, additional reduction of UFP concentration was proportionally more effective at increasing wind speed.

9CS.7

Effectiveness of Sound Wall-Vegetation Combination Barriers as Near-Roadway Pollutant Mitigation Strategies. DILHARA RANASINGHE, Isis Frausto-Vicencio, Wonsik Choi, Eon Lee, Yifang Zhu, Faraz Enayati Ahangar, Akula Venkatram, Seyedmorteza Amini, Steve Mara, Suzanne Paulson, *University of California Los Angeles.* INVITED

Evidence of the dangers of roadway pollutant exposure is growing, elevating the need to protect populations from roadway pollution. Many pollutants are elevated around roadways, including black carbon, carbon monoxide, ultrafine particles, NO_x, and gasses such as benzene. Vegetation planted in combination with solid barriers along the sides of major roadways can potentially reduce downwind pollutant concentrations. However, to date, studies of the effect of sound/vegetation walls have not yet produced definitive results. Here, we report results from field studies characterizing the effectiveness of sound and vegetative barriers in dispersing and removing pollutants at four sites in California. The sites had a variety of different barrier configurations, including no barrier, a solid soundwall, a soundwall combined with vegetation, and vegetation only. Several traffic-related pollutants including fine particulate matter (PM2.5), ultrafine particles, and oxides of nitrogen, as well as micrometeorology were measured during both nighttime and daytime hours and in different seasons. Stationary monitoring, mobile monitoring, vegetation characterization and detailed data analysis and analytical models are combined analyze pollutant concentrations in the barriers. Traffic volumes, speeds and fleet mix on the roadway, were also considered. The measurement data and model indicate that barriers reduce pollution levels downwind of roadways by a maximum of about 50% compared to no-barrier, although more generally reductions are more modest. Both solid barriers and vegetation barriers were observed to be effective at reducing pollutant levels. As vegetation used in combination with a solid barrier can extend the height of the effective height of a solid barrier, the addition of vegetation to a solid barrier can enhance its effectiveness. However, in the configurations studied here, this enhancement was modest, no more than 25%, and likely closer to 10%. Under conditions with light winds, tall vegetation alone was more effective at reducing pollutant concentrations than a shorter combination of vegetation and solid barrier. In summary, trees planted along roadways confer modest benefits in their ability to reduce pollutant levels downwind.

9CS.8

Optimizing Urban Green Designs to Mitigate Traffic-Related Air Pollution. KHALED HASHAD, Bo Yang, K. Max Zhang, *Cornell University*

Near-road vegetation could mitigate the impact of traffic-related air pollutants on human exposure to the community. The way vegetation is structured influences plume transport and if strategically designed, the vegetation layout would aid in reducing downwind pollutant concentrations. To explore different urban green designs, a computational fluid dynamics (CFD)-based model was employed to model the vegetation as a sink for both fluid momentum and pollutants. We performed a case study for an urban park located between a busy expressway and a residential community in Louisville, Kentucky. We studied three different design scenarios: the current conditions with sparse vegetation, a case with no vegetation, and a structured design with dense vegetation. The impact of the different designs was studied by comparing the downwind pollutant concentration for each case. The case with structured vegetation had the lowest particle number concentrations while the case with sparse vegetation had the highest concentrations. This demonstrates that vegetation could also have adverse effects if not implemented properly, which creates a need to examine and determine the different vegetation designs and study their impact. Vegetation designs should be done in a scientifically driven manner to obtain optimal results and reduce the amount of pollutants reaching the community.

9HA.1

Particle Size Characterization of a 4th Generation Electronic Cigarette Under Physiological Conditions. LANDON HOLBROOK, Elizabeth Monaghan, Chris Jadelis, Kirby Zeman, Robert Tarran, Ilona Jaspers, William Bennett, *University of North Carolina at Chapel Hill*

In order to model the respiratory deposition of inhaled electronic cigarette (ECIG) aerosols, the mass median aerodynamic diameter (MMAD) should be determined by cascade impaction. Analytical models of respiratory deposition are a function of initial aerosol size and potential hygroscopic growth in the respiratory tract. To achieve physiologically realistic conditions in a 4th generation ECIG, a streamlined connector was designed and 3D printed to enable control of the relative humidity (RH) and temperature at the ECIG air inlet port. Methods: MMAD of the aerosol was measured within a Sierra Cascade Impactor at flows of 3, 14, and 21 liters per minute (LPM). The ECIG power was 100 Watts using a 0.25-ohm coil and the aerosolized liquid was either a commercial flavor containing 55% Propylene Glycol (PG) or 100% PG. Results: Decreasing the impactor flow rate affected the aerosol measurement of 55% PG; MMAD = 0.71, 0.85, and 1.55 µm at 21, 14, and 3 LPM respectively. The MMAD of 55% PG at 14 LPM was unchanged for ambient and 95% RH conditions. At ambient conditions, the MMAD of 100% PG was 1.05, 1.30, and 1.81 µm at 21, 14, and 3 LPM respectively. Conclusions: Particle sizing of ECIG aerosols by cascade impaction show fine particles of 0.7 – 1.4 µm MMAD are generated at realistic flows of 14 and 21 LPM. For a commercial ECIG with 55% PG the MMAD was unaffected by RH. The MMAD of the aerosolized 100% PG increased by 50% for realistic flows. Our data suggest that lung deposition of an aerosol generated by an ECIG is likely low (< 20% by deposition models) and occurs primarily in the alveolar region of the lung. The increased aerosol size associated with PG content may further enhance deposition throughout the respiratory tract. Supported by NIH/FDA 5P50HL120100.

9HA.2

Aerosol Emission during Human Speech. SIMA ASADI, Anthony Wexler, Christopher Cappa, Nicole M. Bouvier, Santiago Barreda-Castanon, William D. Ristenpart, *University of California Davis*

The physical pathways governing airborne disease transmission between humans remain poorly understood. The traditional emphasis has been on coughing and sneezing, which are dramatic expiratory events that yield easily visible droplets. Nonetheless, it has long been known that normal speech also yields expiratory aerosol particles, and indeed recent research indicates that, compared to coughing, speech can actually release even larger quantities of such particles that are too small to see with the naked eye, but are large enough to carry a variety of respiratory pathogens (e.g., influenza). This observation raises an important question: What types of speech emit the most aerosol particles? Here we show that the rate of aerosol particle emission during healthy human speech is correlated with the loudness (amplitude) of vocalization, and that it varies significantly with different articulations. Experimental measurements indicate that speaking in a loud voice (just short of yelling) yields on average a factor of 10 more particles than speaking in a quiet voice (just above a whisper). Furthermore, certain ‘phones’ (the basic units of speech) associated with voiced plosives (e.g., [d]) yield more particles than unvoiced fricatives (e.g., [f]) or nasal obstruents (e.g., [m]). We interpret these results in terms of the egressive airflow rate associated with the vocalization, which is known to vary significantly with both overall loudness and consonant type. The results suggest that individual speech patterns, including language spoken, could affect the probability of airborne disease transmission.

9HA.3

A Novel Nanofiber Nasal Filter for Improved Respiratory Health. TAEWON HAN, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

The goal of this research was to develop and test novel nasal filter capable of reducing personal exposures not only to large allergenic particles, such as molds and pollen, but also to ultrafine particles, thus reducing respiratory health risks. Several nasal filters are commercially available, and in the first step of this project we investigated performance of seven such filters when collecting 1 and 3 µm monodisperse PSL particles at 10 L/min sampling rates. The aerosol concentration upstream and downstream of each filter was determined by an optical particle counter. All but one tested nasal filter were not efficient at collecting 1-3 µm PSL particles: less than 31% collection efficiency for 1 µm PSL. Thus, it was concluded that they were not well-suited for effective protection against airborne contaminants, especially those of smaller size (fine or ultrafine particles). We, therefore, designed and developed a novel nasal filter by using an electrospun nanofiber filtration approach: a thin coat of electrospun nanofibers was laid over a conventional non-woven microfibrous substrate (e.g., low efficiency Minimum Efficiency Reporting Value (MERV) series of filters). A MERV 5 carbon filter was coated with Nylon-6 polymer nanofibers (~100 nm in diameter) at mass concentration of 2.97 g/m^2 at the applied voltage of +25 kV for electrospinning. The resulting and newly developed nanofiber nasal filter (NNF) showed about 3-5× higher removal efficiency of 25 nm particles compared to commercially available nasal filters. The NNF also showed a much better overall performance when capturing larger particles (1 to 3 µm, which represents bacteria and molds) without introducing any substantial resistance to breathing. Thus, the NNF could be used as a new personal protection device designed to help protect individuals from exposures to airborne particles, ranging in size from pollen to ultrafine to nano-sized particles.

9HA.4

Particulate Exposures in Asthmatic Kids (PEAK): Differences between Ultrafine and Fine Particle Exposures in Baltimore, USA. KIRSTEN KOEHLER, Ehsan Majd, McCormack Meredith, Hansel Nadia, *Johns Hopkins School of Public Health*

Particulate matter (PM) air pollution is known to exacerbate asthma symptoms in children; however, it is still unclear which metric (particle size, morphology or chemical composition) of PM is most relevant to respiratory health. Most studies have focused on the health impacts of fine PM ($PM_{2.5}$; particles with diameter less than 2.5 µm), yet recent toxicological evidence suggests that health effects may be more strongly related to the ultrafine portion of PM exposure. Due to complexities of exposure assessment and the lack of a regulatory monitoring network for ultrafine particles (UFP), few epidemiologic studies have evaluated the relationship between UFP and respiratory health. The aim of this work is to determine which potentially modifiable factors of fine PM, including UFP, microenvironment, and peak exposure, are associated with respiratory effects among inner-city children with asthma. We have conducted personal exposure assessment to ultrafine and fine PM exposures in a panel of 15 children (to date; study target of 50 children) with asthma, each with 4 days of continuous monitoring of $PM_{2.5}$ and UFP (10-s resolution), geographic location, biomarkers (urinary LTE_4), and asthma symptoms. UFP was measured using a Partector (expressed as lung deposited surface area; CH Technologies) and fine PM mass was measured with a MicroPEM (expressed as mass concentration; RTI International). Inner-city children were exposed to levels of PM mass often exceeding WHO recommendations for $PM_{2.5}$ in indoor air (24-hr mean: 7.2 $\mu g/m^3$; range of 1-hr averages: 1-377 $\mu g/m^3$). UFP exposures (24-hr mean: 39 $\mu g^2/cm^3$; range of 1-hr averages: 1-1413 $\mu g^2/cm^3$) typically varied over 2 orders of magnitude within 24-hours. $PM_{2.5}$ and UFP were highly variable within-day, between-day and between-participant. Furthermore, $PM_{2.5}$ and UFP were only weakly correlated ($R^2<0.3$).

9HA.5

Estimating Personal Exposure to Particulate Matter Using a Low-Cost Wireless Sensor Network and Indoor Positioning System. CHRISTOPHER ZUIDEMA, Thomas Peters, Geb Thomas, Kirsten Koehler, *Johns Hopkins School of Public Health*

Personal sampling is the gold standard for occupational exposure assessment. However, personal sampling is expensive, burdensome to employees, and typically suffers from a low number of samples. In most cases, one to six samples are used to judge if employees are overexposed or if facilities are in compliance with occupational exposure limits. To overcome these shortfalls of personal sampling, we have devised a technique to estimate personal exposure by combining two sources of data: geospatial hazard data from a wireless sensor network (WSN) and employee location information from an indoor positioning system (IPS). To evaluate our approach, we have deployed a 50-node WSN covering 806,400 ft^2 of a +2million ft^2 manufacturing facility. The WSN nodes are distributed in in a spatially-optimized pattern designed to capture hazard variability. In this heavy industrial manufacturing facility workers cut, grind, machine, blast with abrasives and weld. Consequently, each WSN node is constructed with low-cost sensors for carbon monoxide, ozone, noise and particulate matter (PM), to measure hazards inherent in these processes. This presentation is focused on PM, which is measured by the WSN with inexpensive ($10-$15) SHARP dust sensor (GP2Y1010AU0F). The WSN records measurements from each node to an online database every five minutes. Hazard maps can then be generated for time periods of interest. The facility is equipped with a commercially-available IPS originally developed to manage the location and movement of raw materials and equipment. Experiments indicate that the location of a mobile phone connected to the facility’s wireless internet can be tracked with a precision of approximately 30 ft, suitable resolution to position workers and estimate personal exposure with our technique. Estimating personal exposure is less expensive and can provide more exposure data on more employees with higher temporal resolution compared to traditional personal sampling.

9HA.6

Estimates of the Annual U.S. Mortality Burden Attributable to Fine Particulate Matter Exposure in Indoor and Outdoor Microenvironments. PARHAM AZIMI, Brent Stephens, *Illinois Institute of Technology*

Elevated ambient concentrations of fine particulate matter (i.e., the mass concentration of particles ≤ 2.5 µm in aerodynamic diameter; PM2.5) have been consistently associated with increased mortality in epidemiology studies. Although epidemiology studies typically use ambient PM2.5 concentrations as surrogates for human exposures, the majority of exposure to PM2.5 in the U.S. and other industrialized nations typically occurs in various other microenvironments, including inside residences, offices, schools, and vehicles. The objective of this work is to estimate the U.S. mortality burden attributable to PM2.5 exposure in various microenvironments in which people spend most of their time. We first modify outdoor air epidemiology concentration-response (C-R) functions and mortality effect estimates from the existing literature to account for estimates of the underlying exposures to ambient PM2.5 in the various microenvironments in which people spend the majority of their time that are likely to have occurred in the original study populations. We then apply these modified ambient-origin C-R function effect estimates to estimates of long-term average PM2.5 concentrations of both indoor and outdoor origin found in various non-smoking microenvironments, including inside residences, indoor environments other than residences (e.g., offices, schools, etc.), vehicles, and outdoors. We use Monte Carlo simulations with 10,000 iterations to sample from distributions of each input parameter to estimate the likely bounds of the mortality burden attributable to exposure to PM2.5 of both indoor and outdoor origin in various microenvironments. Our best estimate of the annual U.S. mortality burden associated with indoor and outdoor PM2.5 exposures across all microenvironments was ~287,000 deaths annually, with an interquartile range (IQR: 25th to 75th percentile) of ~150,000 to ~322,000 deaths annually. Ambient PM2.5 exposures across all microenvironments contributed ~139,000 deaths (IQR: ~90,000 to ~177,000) and indoor PM2.5 exposures contributed ~148,000 deaths (IQR: ~26,000 to ~154,000). The contribution of exposures to PM2.5 of ambient origin in outdoor microenvironments accounted for only ~5% of the total mortality associated with PM2.5, while indoor exposures to PM2.5 of ambient and indoor origin accounted for ~42% and ~52% of the total mortality burden of PM2.5 exposures, respectively.

9HA.7

Source Contributions to Premature Mortality Attributable to Particulate Matter in India. HAO GUO, Sri Kota, Shovan Sahu, Jianlin Hu, Qi Ying, Hongliang Zhang, *Louisiana State University*

Exposure to high fine particulate matter (PM2.5) concentrations significantly increases the mortality of cardiovascular and pulmonary diseases. Limited studies have been done to quantify excess mortality (ΔMort) in India due to PM2.5 exposure and the sources contributing to it. In this study, the ΔMort of adult (> 30 years old) ischemic heart dis-ease (IHD), cerebrovascular disease (CEV), chronic obstructive pulmonary disease (COPD) and lung cancer (LC) in 2015 in India were determined using source-oriented version of the Community Multiscale Air Quality (CMAQ) model. Meteorological inputs were generated using the Weather Research and Forecasting (WRF) model version 3.6.1. Anthropogenic emission was from Emissions Database for Global Atmospheric Research (EDGAR), and the biogenic emission was from the Model for Emissions of Gases and Aerosols from Nature (MEGAN) version 2.1. The open burring emissions is from National Center for Atmospheric Research (NCAR) while dust and sea salt emissions were generated in line CMAQ. The eight tracked source types are energy, industry, residential, on-road, off-road, agriculture, open burning and dust. This reveals the health effects of air pollution and the important sources which should be targeted to reduce pollution.

9HA.8

The Oxidative Potential of Particulate Matter from Residential Coal Combustion in China. XIAOYING LI, Jianzhong Sun, Caiqing Yan, Guorui Zhi, Yingjun Chen, Shexia Ma, Mei Zheng, *Peking University*

Adverse health effects by ambient fine particulate matter (PM) have been suggested to be associated with production of reactive oxygen species (ROS), such as hydroxyl radical (·OH), superoxide (·O2-), and hydrogen peroxide (HOOH). Transition metals and quinones could contribute to ROS formation, and coal combustion is one of their most important sources in China. Recent studies show that residential coal combustion has a significant contribution to ambient PM in winter in the Northern China due to low temperature and incomplete combustion conditions. To investigate their oxidative potential, chemical species in PM emissions from residential coal combustion were tested in the laboratory, including organic carbon (OC), elemental carbon (EC), soluble ions and multiple trace metals. The amount of ·OH generated by these PM was also measured in an aqueous buffered extract solution as a surrogate lung fluid (SLF). Our preliminary analyses show that the geological maturity of coal plays an important role in the oxidative potential of PM from residential coal combustion. The amount of ·OH generated per unit of particle mass from honeycomb coal was lower than chunk coal. However, due to higher emission factor of PM from honeycomb coal, the total amount of ·OH generated from honeycomb coal was much higher than chunk coal. The influence of coal types, coal stoves, and chemical compositions on ·OH production of PM will be also discussed.

9IM.1

Direct Measurements of Gas/Particle Partitioning and Mass Accommodation Coefficients in Environmental Chambers.

JORDAN KRECHMER, Xiaoxi Liu, Douglas Day, Paul Ziemann, Jose-Luis Jimenez, *University of Colorado, Boulder*

Secondary organic aerosols (SOA) are a major contributor to fine particulate mass and wield substantial influences on the Earth's climate and human health. Despite extensive research in recent years, many of the fundamental processes of SOA formation and evolution remain poorly understood. Most atmospheric aerosol models use gas/particle equilibrium partitioning theory as a default treatment of gas-aerosol transfer, despite questions about potentially large kinetic effects. We have conducted fundamental SOA formation experiments in a Teflon environmental chamber using a novel method. A simple chemical system produces a very fast burst of low-volatility gas-phase products, which are competitively taken up by liquid organic seed particles and Teflon chamber walls. Clear changes in the species time evolution with differing amounts of seed allow us to quantify the particle uptake processes. We reproduce gas- and aerosol-phase observations using a kinetic box model, from which we quantify the aerosol mass accommodation coefficient (α) as 0.7 on average, with values near unity especially for low volatility species. a appears to decrease as volatility increases. α has historically been a very difficult parameter to measure with reported values varying over three orders of magnitude. We use the experimentally-constrained model to evaluate the correction factor (Φ) needed for chamber SOA mass yields due to losses of vapors to walls as a function of species volatility and particle condensational sink. Φ ranges 1 – 4.

9IM.2

In-situ Nanoparticle Characterization at Ambient Pressure by Small Angle X-Ray Scattering (SAXS).

PAULUS S. BAUER, Heinz Amenitsch, Paul M. Winkler, *Universitaet Wien, Vienna, Austria*

Direct characterization of aerosol nanoparticles is a challenging task in aerosol science. Common aerosol analyzers usually extract the particles from their original environment for analysis. Thereby, nanoparticles can be modified or get lost e.g. by wall collisions inside the instrument, which can affect the measured size distribution and concentration. Thus, there is an essential demand for an in-situ measurement technique. Small-angle X-ray scattering (SAXS), commonly used in material science or in biochemical process analysis, can fill this gap. It is capable of measuring in-situ particle size distribution in the nanometer range if the scattering contrast between nanoparticles and gas molecules is sufficiently large. SAXS has already been applied in nucleation studies with extremely high nanoparticle concentrations of ~10^{12}/cc and carrier gas pressures ~2kPa. (Laksmono (2011), Phys.Chem.Chem.Phys.,13,5855) However, in order to compare the in-situ SAXS results to the DMPS and CPC measurements it is important to choose system settings as close to ambient conditions as possible.

Here we report experiments on nanoparticle characterization in helium by SAXS at concentrations of about 10^6/cc. The experiments were conducted at the Elettra synchrotron near Trieste, Italy, due to the available high beam intensity and the experience on aerosol studies in flow tubes (Jungnikl (2011), Aerosol.Sci.Technol.,45,805). To provide a representative environment for aerosols a flow tube was operated at ambient pressure. A critical issue for SAXS experiments with aerosols is the background scattering signal originating from the carrier gas. The air background usually is of the same order of magnitude as the signal from the tungsten nanoparticles. This issue was lately resolved by replacing air with helium as carrier gas. The usage of helium provides the opportunity of operating the flow tube under ambient conditions (temperature, pressure), and allows the parallel sampling by modified state-of-the-art aerosol instruments like CPC and DMPS system.

Due to the low background of helium and the high electron density of tungsten particles, we obtained defined signals from aerosol SAXS measurements. Thereby a comparison between in-situ results from SAXS and conventional measurement techniques can be achieved.

9IM.3

Freezing of Aerosol Liquid Mimics in a Microfluidic Device.

ANDREW METCALF, Christopher Hogan Jr., Cari Dutcher,
University of Minnesota, Twin Cities

In situ observations of atmospheric aerosol particle morphology are difficult; thus, controlled laboratory studies to understand the underlying physics that determine particle morphology are necessary. Recently, microfluidic experiments have been used to assess the surface activity of aerosol chemical mimics and secondary organic aerosol collected on filters to measure interfacial tension and predict the presence of liquid-liquid phase separation at thermodynamic equilibrium. These measurements provide important constraints for thermodynamic models and yet more variety of measurements are necessary to translate laboratory studies to atmospheric conditions.

In this talk, a new microfluidic experiment platform capable of temperature control to at least -40 degrees C will be introduced. The microfluidic device includes an embedded platinum resistance temperature detector array which precisely measures temperature at 19 points along the fluid flow channel. The microfluidic device sits on a temperature control block which has 7 discrete temperature zones capable of causing a temperature gradient along the fluid flow. Initial experiments with this new platform include high-speed observations of water droplet freezing and liquid-liquid phase separations driven by temperature changes. Multiple temperature zones also allow hot-cold-hot hysteresis cycles to be observed in single droplets.

9IM.4

Exploring Interfacial Reactions on Ammonium Sulfate Particles Using a Novel Atmospheric Cloud Simulation Chamber.

CECILIA SMITH, Angela Ziegler, Matthew Brown, Erin M. Durke, Suresh Dhaniyala, John Morris,
Virginia Tech

A novel rotating aerosol suspension chamber with cavity ring down spectroscopy (CRDS) has been developed for the investigation of specific molecule-aerosol and aerosol-aerosol interactions under atmospheric conditions. The Atmospheric Cloud Simulation Chamber (ACSC) design allows for the creation of a well-defined and controllable atmosphere of suspended particles, analyte gases, and background gas molecules, which remains stable up to several days. Concentrations of key gas phase components and aerosol suspension characteristics in the main chamber can be ascertained in real time in response to a perturbation to the model atmosphere, such as the introduction of a gas-phase reactant. Cavity ring down spectroscopy, performed *in situ* along the center rotational axis, records mid-infrared spectra (1010 cm^{-1} to 860 cm^{-1}) to determine concentrations and identifications of new gas species evolved from gas-particle chemistry. Aerosols are characterized *ex situ* with particle-sizing instrumentation, filter collection, or cascade impactor. Preliminary studies have shown that polystyrene latex (D_p = 0.994 µm) and ammonium sulfate (D_p = ~100 nm) particles remain suspended for at least 22 hours while the drum rotates at 2 RPM. Initial investigation into the atmospheric life cycle of ammonia involved studying the efficiency of the monomethylamine–ammonia exchange reaction on ammonium sulfate particles. In accord with previous studies, our results show that this reaction occurs readily on suspended ammonium sulfate particles under atmospheric conditions. CRDS spectra recorded after introducing monomethylamine shows a quantifiable amount of ammonia released from the salt particles. Future studies involve correlating ammonium sulfate acidity to reactive uptake of carbonyl-containing organic molecules, which lead to particle growth and particle composition changes. Overall, the new ACSC approach to atmospheric science provides the opportunity to study the influence of interfacial chemistry on particle growth, aging, and re-admission of gas-phase compounds.

9IM.5

Laboratory Measurements of Total Suspended Organic Carbon: Technique Development and Application to Chamber SOA Photo-Oxidation Experiments. JOSHUA MOSS, Jesse Kroll, Stephen Duncan, *MIT*

Secondary organic aerosol (SOA) comprises a major fraction of particulate matter in the atmosphere and is principally formed via the oxidation of volatile organic compounds (VOCs). Laboratory chamber studies aimed at elucidating the underlying chemical mechanisms pertaining to SOA formation and evolution have been unable to enumerate all organic species produced in SOA-forming reactions, largely due to the extreme chemical complexity of the system and poorly constrained depositional losses to chamber walls and instrument inlets. While particle wall losses are relatively easily accounted for, vapor depositional losses remain poorly constrained and difficult to predict, varying from species to species and even from chamber to chamber. Additionally, these vapor losses may also decrease SOA yields in chamber studies and could lead to profound differences in the chemistry observed in chambers from that observed in the atmosphere. Here we describe the development and deployment of an apparatus to measure Total Suspended Carbon (TSC) for use in laboratory studies of SOA formation and aging to both directly quantify vapor wall losses and provide a new constraint on the extent of “carbon balance” measured in atmospheric oxidation studies. This work builds on an established technique for TSC measurement, involving the use of a platinum catalyst to fully oxidize VOCs to carbon dioxide which is directly quantifiable. Coupling this new apparatus to a suite of analytical instruments to measure gas- and particle-phase organic species will yield novel insight into chamber wall losses. Numerous characterization studies, centered around chamber SOA photo-oxidation experiments, will comprise the bulk of the work presented and will draw novel connections between the “bottom-up” measurements obtained from the suite of instruments and the “top-down” constraint imposed by our TSC apparatus. These comparisons will allow us to assess the extent of carbon balance obtained from and the speciation capabilities of our suite of instruments.

9IM.6

Experimental Evaluation of a Wearable, Bluetooth Enabled, Direct- Reading MEMS PM2.5 Mass Sensor. DORSA FAHIMI, Omid Mahdavipour, John Sabino, Lisa Soderlind, Nobuhiko Fukushima, Hide Nagai, Richard White, Igor Paprotny, *University of Illinois at Chicago*

This work describes the development and experimental evaluation of a Bluetooth-enabled wearable direct reading MEMS PM2.5 sensor called PM badge. In this sensor, an air-microfluidics circuit separates fine particulate matter from the airstream by means of a microfabricated particle fractionator, and a film bulk acoustic resonator (FBAR) directly measures the mass of the particles deposited on its surface by thermophoresis. PM badge is designed to have a small footprint, reduced power usage, down conversion electronics, and a wireless link to an off-board cellular platform. All the components of the system including resonator electronics, thermophoretic heaters, and fan are run by a single Li-ion battery and all the components are implemented in a small footprint wearable package. A new vertical impactor is developed. The vertical virtual impactor (VVI) is fabricated using a silicon on insulator (SOI) microfabrication process, allowing for its economic integration with the rest of the air-microfluidic circuit. In contrast to the in-plane PM fractionator used in earlier PM sensor prototypes, this fractionator is fabricated such that it can be placed in close proximity to the thermophoretic precipitator/mass sensing element of the sensor. PM badge sensor has been experimentally evaluated in presence of test aerosols and has exhibited the highest sensitivity of 7.56 Hz × m^3 / µg × min ever achieved with a direct-read MEMS PM mass sensor. A demo of the new wearable units will be presented at the meeting.

9IM.7

Oxidation Flow Reactors: Best Practices for Operation and Analysis, and Overview of Results from Ambient Studies. JOSE-LUIS JIMENEZ, Zhe Peng, Brett Palm, Weiwei Hu, Amber Ortega, Douglas Day, *University of Colorado-Boulder*

Oxidation Flow Reactors (OFRs) including the PAM reactor are being rapidly adopted as atmospheric chemistry research tools, given their limited cost, flexibility, fast response time, and portability. Typically OH oxidation is pursued using low-pressure Hg lamps as UV light sources. Careful attention to the input conditions is needed to avoid chemical regimes that are not relevant to the atmosphere. Quantification of reactor output requires several calibrations and corrections. In this presentation we will discuss the different problems that can affect OFR chemistry, including OH suppression, hard UV photolysis, impact of undesired oxidants and chemical pathways etc. Strategies for avoiding these problems will be highlighted. Best practices for calibration and estimation of OH exposure and for quantification of secondary aerosol formation in the reactor will be discussed. Finally, the results from all published ambient OFR field studies to date for the quantification of Secondary Organic Aerosol (SOA) potential will be compared and summarized.

9IM.8

Optical Characterization of the Low-Cost Sensor and Its Application with Robots. JIAYU LI, Pratim Biswas, *Washington University in St Louis*

Compact low-cost sensors for measuring particulate matter (PM) concentrations are receiving significant attention as they can be used in larger numbers and in a distributed manner. To ensure accurate and reliable determination of PM mass concentrations, a relationship of the scattering signal to mass concentration should be established. The scattering signal depends on the aerosol size distributions and particle refractive index. A systematic calibration of a low-cost particle sensor (Sharp GP2Y1010AU0F) was carried out by both experimental and computational studies. Sodium chloride, silica, and sucrose aerosols were used as test cases with size distributions measured using a scanning mobility particle sizer (SMPS). Calculations of the scattered light intensity were done using these measured size distributions and known refractive index of the particles. The calculated scattered light intensity showed better linearity with the sensor signal compared to the mass concentration. To obtain a more accurate mass concentration estimation, a model was developed to determine a calibration factor (K). K is not universal for all aerosols but depends on the size distribution and refractive index. To improve accuracy in estimation of mass concentration, an expression for K as a function of geometric mean diameter, geometric standard deviation, and refractive is proposed. This approach not only provides a more accurate estimation of PM concentration but also provides an estimate of the aerosol number concentration.

The calibrated sensor was applied to several scenarios for air quality measurement. One application was in a wood-working shop wherein a set of distributed sensors was used to map the plume. Another application involved mounting the wireless sensors on a robot to automatically determine the highest concentration in a region. This application will be very helpful on wildfire rescue and industrial leakage detection.

Wang, Yang et al. Aerosol Sci. Technol. 49.11 (2015): 1063-1077.
Jiayu Li et al. Aerosol Air Qual. Res. (to appear in 2017).

9MO.1

Advancing Understanding of Aerosols: The Intersection of Models and Observations. COLETTE HEALD, *MIT*. INVITED

Only models can be used to assess the global climate and air quality impacts of aerosols. However, the fidelity of these models must be thoroughly assessed and continually improved based on observations. Field campaigns, satellite observations, and network measurements all provide opportunities to explore the representation of processes and model parameters. In this presentation I will discuss some recent examples from my group of using measurements and models to provide fundamental insight into the processes controlling tropospheric aerosols, including dust, black carbon, and organic aerosol.

9MO.2

Modelling of SOA Markers: Simulation Through Detailed Mechanisms and Validation by Comparison with Measurements. A New Approach to Understand SOA Formation. GRAZIA-MARIA LANZAFAME, Deepchandra Srivastava, Nicolas Bonnaire, Florian Couvidat, Olivier Favez, Bertrand Bessagnet, Alexandre Albinet, *INERIS*

Secondary organic aerosol (SOA) is formed via the oxidation of both anthropogenic and biogenic gas-phase organic compounds and is a large and often dominant fraction of total organic aerosol (OA). SOA markers from specific precursors have been identified and are currently used to assess Secondary Organic Carbon (SOC) sources. As a matter of fact, air quality models have still difficulties to reproduce observed particulate matter (PM) concentration levels due notably to a poor simulation of the SOA fraction. It is then necessary to develop atmospheric chemistry models that properly describe the formation of the SOA markers in the atmosphere to improve the understanding of SOA formation to improve air quality simulations (forecast, scenario analysis). In this context, the modelling approach developed must be compared with data obtained through field measurements.
The aim of this work is to implement SOA marker mechanisms into the air quality model CHIMERE and to compare model results with field measurements data. This comparison gives an insight on the ability of the model to form SOA from specific precursors and on several processes (e.g. emissions, gas/particle partitioning).

Measurements of SOA markers were performed at SIRTA station, representing the suburban background air quality conditions nearby Paris (25 km SW from city center). PM10 samples were collected every third day all over the year 2015. SOA markers have been quantified using native standard compounds by LC/MS-MS and/or GC/MS. The mechanisms of SOA markers formation implemented in CHIMERE were taken from the Master Chemical Mechanism (NCAS, Universities of Leeds and York) otherwise, data were issued from the scientific literature. The gas phase mechanism simulation was performed using MELCHIOR2, the gas-particulate partitioning was calculated using the thermodynamic model SOAP. Biogenic emissions were computed with the MEGAN 2.1 algorithm. Simulated markers included both biogenic, (e.g; pinonic acid, pinic acid and MBTCA:α-pinene oxidation), and anthropogenic (e.g. DHOPA and nitrophenols: toluene oxidation) precursors.

9MO.3

Evaluating Models of Secondary Organic Aerosols Produced from the Athabasca Oil Sands. JACOB SOMMERS, Craig A. Stroud, John Liggio, Junhua Zhang, Ayodeji Akingunola, Katherine Hayden, Shao-Meng Li, Peter Liu, Jason O'Brien, Richard Mittermeier, Daniel Wang, Mengistu Wolde, Patrick Hayes, *Université de Montréal*

Organic aerosols (OA) are a major component of atmospheric particulate matter (PM), which has a complex effect on climate, both globally and regionally. PM is also detrimental to human health in both urban and rural regions. Some OA mass is emitted directly from industrial, vehicular and cooking sources, which are relatively well characterized. However, secondary organic aerosols (SOA) formed from gaseous precursors are relatively poorly understood, which makes it difficult to assess their impact on health and climate. A customized box model was developed to evaluate several chemical parameterizations for their ability to simulate SOA formation rates and oxygen-to-carbon ratios resulting from the oxidation of volatile organic compounds (VOCs), semivolatile organic compounds (SVOC), and intermediate volatility organic compounds (IVOCs) emitted from the Athabasca oil sands. The model results are compared to measurements taken from an aircraft during the summer of 2013. Several SOA parameterizations are implemented in the box model and evaluated against observations of the formation and evolution of SOA in a plume of emissions up to 120 km downwind of the oil sands operations. SVOC and IVOC emission factors from the oil sands are isolated as a function of black carbon emissions. By constraining emissions using the aircraft measurements and modeling their oxidation using published parameterizations with no additional tuning, we found good agreement between measured and modeled OA concentrations along two Lagrangian flights. The results of this study are currently being incorporated into a version of the 3-D Global Environmental Multi-scale – Modeling Air Quality and Chemistry (GEM-MACH) model that simulates the evolution of primary OA and SOA formed from VOCs and IVOCs emitted by the continued extraction of bitumen in Northern Alberta.

9MO.4

Sources of Ambient Ammonia in the Athabasca Oil Sands and North-Western Canada. CYNTHIA WHALEY, Paul Makar, Mark Shephard, Leiming Zhang, Michael Moran, Junhua Zhang, Qiong Zheng, Ayodeji Akingunola, Greg Wentworth, Jennifer Murphy, *Environment and Climate Change Canada*

Atmospheric ammonia (NH3) is a short-lived pollutant that plays an important role in aerosol chemistry, nitrogen deposition, and soil acidification. Dominant sources of ammonia emissions are agriculture and forest fires, both of which have been increasing globally. In the absence of forest fires, the Athabasca oil sands region has relatively low background ammonia concentrations due to its remote location in northern Canada; however, a previous attempt to model NH3 in the region showed a low bias compared to satellite NH3 column observations and aircraft in situ measurements. Known missing sources in the model were the re-emission of NH3 from plants and soils (bidirectional flux) and forest fire emissions. However, the relative impact of these missing emissions sources on ammonia and particle ammonium concentrations was unknown. Here, we have used a high-resolution research version of the air quality forecasting model, GEM-MACH, to quantify the relative impacts of emissions of ammonia from natural (bidirectional fluxes and forest fires) and anthropogenic (agriculture and fossil fuel combustion) sources, on ammonia concentrations. We evaluate our model results using surface, aircraft, and satellite observations of ammonia and particle ammonium for an August to September 2013 time period corresponding to a monitoring-intensive campaign. Three GEM-MACH simulations were considered: a base case; a case with bidirectional fluxes added; and a case with both bidirectional fluxes and forest fire emissions added. Comparison of the model predictions from these scenarios showed that bidirectional fluxes had the greatest impact on NH3 concentrations over the northern Alberta/Saskatchewan region. Direct anthropogenic sources were second in magnitude (except very close to the facilities, where they were dominant), and forest fires were third. While the changes in predicted ammonia gas concentrations between the scenarios were large, the impact of these changes on modelled particle ammonium was relatively small – the likely reasons for this finding will be discussed.

9MO.5

Modeling NH4NO3 in the San Joaquin Valley during the 2013 DISCOVER-AQ Field Campaign. JAMES KELLY, John Nowak, David Miller, Kang Sun, Mark Zondlo, Caroline Parworth, Qi Zhang, Andrew Weinheimer, Sally Pusede, Ronald Cohen, Gail Tonnesen, Luke Valin, Jesse Bash, Kirk Baker, James Crawford, *US EPA*

The San Joaquin Valley (SJV) of California is in non-attainment of the 24-hr and annual $PM_{2.5}$ U.S. National Ambient Air Quality Standards due in part to prolonged periods of elevated NH_4NO_3 concentrations in winter months. Simulating the processes that lead to elevated NH_4NO_3 in SJV is challenging due to the complex terrain, diverse emission sources, and stagnant meteorological conditions during the wintertime episodes of high $PM_{2.5}$ concentrations. A rich dataset of observations related to NH_4NO_3 formation was acquired during multiple periods of elevated $PM_{2.5}$ during the DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) field campaign in SJV in January and February 2013. The DISCOVER-AQ dataset is used here to evaluate predictions of NH_4NO_3 and its precursors from the Community Multiscale Air Quality (CMAQ) model version 5.1 with 4-km horizontal resolution. NOy predictions are in reasonable agreement with measurements from the P3 aircraft, and spatial patterns of NH_3 predictions are consistent with measurements from a mobile ground laboratory. However, NH_3 mixing ratios are underestimated in source regions. Predictions of the gas-particle partitioning of total nitrate (NO_3^-+ HNO_3) are in reasonable agreement with measurements in Fresno, as are predictions of elevated $PM_{2.5}$ NO_3^- during a period in January. However, NO_3^- concentrations are underpredicted in Fresno during a high $PM_{2.5}$ episode in February, possibly due to issues with modeled meteorology. Modeled chemical production of HNO_3 is relatively important from the reaction of OH with NO_2 during daytime in the surface layer over major urban centers and from N_2O_5 hydrolysis during nighttime in the residual layer over relatively rural areas. Model predictions suggest that NO_3^- formed in the relatively rural areas can sometimes be transported to the urban centers and influence urban $PM_{2.5}$ concentrations.

9MO.6

On the Sensitivity of Fine Particle Nitrate to Ambient Ammonia Concentrations Assessed through a Detailed pH Analyses. HONGYU GUO, Athanasios Nenes, Rodney J. Weber, *Georgia Institute of Technology*

Ammonium nitrate is a large fraction of ambient fine mode inorganic particles in some regions of US, Europe, and China. Ammonia (NH_3) in the gas phase, mostly produced from agricultural activities and predicted to increase steadily in the future, is recognized as a key factor to control fine particle ammonium nitrate concentrations. NOx emissions also play an important role. Since fine particle mass is linked to public health, the argument is that agricultural emissions, and hence food productivity, may be relevant to improve air quality in many regions. In this research, we present a sensitivity study of ammonium nitrate levels to gas phase NH_3concentrations using a thermodynamic model, ISORROPIA-II. This model can accurately predict the effect of pH, particle water, and ambient temperature on gas-particle partitioning of semivolatile species, such as NH_3-NH_4^+ and HNO_3-NO_3^-. A consistent particle pH response to NH_3 was found regardless of aerosol composition and meteorological conditions in which an order of magnitude increase in gas phase NH_3 produces an increase in pH by about one unit. Combining with the “S curve” relationship between pH and the particle nitrate fraction of total nitrate (nitric acid plus nitrate), $\varepsilon(NO_3^-)$, shows that reducing NH_3 leads to a non-linear response in NO_3^- reduction, with the greatest efficiency when $\varepsilon(NO_3^-)$ is approximate 50%. This condition depends on location. Besides NH_3, we also show the thermodynamic response of particle mass and composition to NOx and SO_2, which are important secondary aerosol precursors, based on observational data from the US, Europe, and China. The effectiveness of reducing these gas phase precursors on ammonium nitrate are compared for these various contrasting regions.

9MO.7

Comparison of Model Simulated Ammonia with Observations: A Case for Implementation of Improved Gas/Aerosol Partitioning Schemes.

ARSHAD NAIR, Gan Luo, Fangqun Yu, *University at Albany*

Ammonia plays a key role in our atmosphere by virtue of its alkaline nature. It comes mainly from agriculture, and has sources in industrial and vehicular emissions. In the recent years, there has been increase in the concentration of gaseous ammonia. This has generated worry about negative impacts on the climate and human health. Especially so in the formation of smog due to its reaction with acidic species in the atmosphere. Additionally, ammonia receives increasing attention because of its potential to enhance new particle formation in the atmosphere. In this regard, it is pertinent to evaluate if models are sufficiently capturing the change in ammonia. We examine GEOS-Chem simulated ammonia concentrations with ground-based and remote sensing measurements. Our preliminary results over the continental United States, using the Ammonia Monitoring Network for ground based observations and Atmospheric Infrared Sounder (AIRS) aboard NASA's Aqua satellite, indicate that simulated ammonia concentrations are generally lower when compared to observed values. This underestimation is also pronounced in the warmer months. We present this analysis, also extended over other regions by incorporating data from other sources including the UK National Ammonia Monitoring Network, and remote sensing by instruments such as the Infrared Atmospheric Sounding Interferometer (IASI) aboard ESA's MetOp satellite and Tropospheric Emission Spectrometer (TES) aboard NASA's Aura satellite. By evaluating the model estimated ammonia over the global, regional, and local scales, we hope to uncover factors that may improve such simulated concentrations of ammonia. This may indicate scope for further improvement of gas-particle partitioning schemes, even at a higher cost of computation, towards more reliable performance of global 3D tropospheric chemistry models.

9MO.8

Investigating the Role of Aromatic Compounds on Anthropogenic Secondary Organic Aerosol in Urban Environments.

ALI AKHERATI, Christopher Cappa, Michael Kleeman, Shantanu Jathar, *Colorado State University*

Aromatic compounds, found in emissions of combustion sources ranging from motor vehicles to biomass burning, photochemically react in the atmosphere to efficiently form secondary organic aerosol (SOA). While a lot is understood about the chemistry of aromatic compounds leading to SOA formation, there are large uncertainties surrounding their relative importance in controlling the atmospheric aerosol burden and air quality in urban environments where numerous sources and processes compete with each other. To study this issue, we performed simulations with a chemical transport model (CTM) to examine the summertime contribution of aromatic compounds to anthropogenic SOA in the South Coast Air Basin (SoCAB). The CTM had a state-of-the-science model (statistical oxidation model) to simulate the chemistry and thermodynamics of SOA and included (i) a semi-volatile and reactive treatment of primary organic aerosol emissions, (ii) emissions of and SOA formation from intermediate-volatility organic compounds, (iii) NOx-dependent, multi-generational aging, and (iv) SOA parameterizations that accounted for artifacts from vapor wall losses in chamber experiments. Most of the aromatic emissions in the SoCAB were from mobile sources with gasoline- and diesel-powered sources accounting for more than 95% of those emissions. Baseline predictions for 2005 of gas-phase aromatic mixing ratios compared exceptionally well with routine measurements made at three SoCAB sites. The same simulations showed that benzene, low-yield, and high-yield aromatics accounted for ~3, 13, and 40% of the anthropogenic SOA formed in the SoCAB; considered together aromatics accounted for ~25% of the total SOA. Of all the processes modeled, the inclusion of the vapor wall loss artifact had the largest influence of doubling the anthropogenic SOA contribution from aromatics. Ongoing work is focused on examining the sensitivity of the aromatic SOA contribution to decadal (2000 to 2010) changes in the emissions and speciation of volatile organic compounds (VOC) from mobile sources and increase in the potential for aromatics to form SOA under lowered NOx concentrations.

9UA.1

Reactive Uptake of Ammonia by Secondary Organic Aerosols: Implications for Air Quality. JEREMY HORNE, Shupeng Zhu, Julia Montoya, Mallory Hinks, Sergey Nizkorodov, Donald Dabdub, *University of California, Irvine*

In the South Coast Air Basin of California (SoCAB), a large fraction of total $PM_{2.5}$ mass is comprised of aerosol nitrates, such as ammonium nitrate (NH_4NO_3). Ammonium nitrate aerosol is formed from the reaction of ammonia (NH_3) and nitric acid (HNO_3) and can cause adverse health effects and reduce visibility. In the SoCAB, the largest ammonia emissions sources are agricultural activities and automobiles. Although the total automobile and agricultural NH_3 emissions are estimated as similar in magnitude, the spatial concentration and high emissions rates of dairy facilities cause downwind NH_3 mixing ratios to be a factor of 10 higher than those from automobile emissions sources. The high concentration of ammonia in these plumes drives most of the HNO_3 into the particle phase, resulting in high $PM_{2.5}$ concentrations in the northeast portion of the SoCAB.

While the conversion of inorganic gases into particulate phase sulfate, nitrate, and ammonium is now fairly well understood, there is considerable uncertainty over interactions between gas phase ammonia and secondary organic aerosols (SOA). In this study, the University of California, Irvine - California Institute of Technology (UCI-CIT) regional airshed model is used to investigate the potential air quality impacts of the chemical uptake of ammonia by SOA. A first order loss rate for ammonia onto SOA is implemented into the model based on the NH_3 uptake coefficients onto SOA reported in the literature to determine the impact of this process on ammonia and $PM_{2.5}$ concentrations in southern California. Air quality simulations are performed with a range of uptake coefficients to determine the sensitivity of NH_3 removal to the magnitude of the uptake coefficient. The model predicts that the chemical uptake of ammonia by SOA can significantly reduce the concentration of gas-phase ammonia, thereby indirectly affecting the amount of ammonium sulfate and ammonium nitrate in particulate matter.

9UA.2

Development of Novel Model Fusion Method for Simulating Spatially Resolved (250-m) Air Pollutant Concentration Estimates. JOSEPHINE BATES, Audrey Pennington, Xinxin Zhai, Mariel Friberg, Francesc Metcalf, Matthew Strickland, Lyndsey Darrow, James Mulholland, Armistead G. Russell, *Georgia Institute of Technology*

Air pollutant concentrations can vary greatly in time and space, especially near strong emission sources like roadways. Modelling spatially resolved air pollutant concentrations is critical for accurately capturing urban air quality influenced by numerous local emission sources. Two novel model fusion methods were developed to estimate gaseous and particulate matter air pollutant concentrations at a fine spatial resolution without losing chemistry or emission source information. Methods were applied to the Atlanta, GA region to obtain daily estimates of 24-hr averaged PM2.5 and 1-hour maximum CO and NOx from 2002-2011 at a 250m grid resolution. The methods combine 12km CMAQ estimates, which are temporally resolved and contain comprehensive chemistry and source information but are spatially coarse, and 250m annual average RLINE estimates, which are spatially resolved but temporally coarse and only account for primary, inert emissions from vehicles, in a computationally efficient manner using linear combinations and a mass conservative bilinear interpolation algorithm. The model fusion methods can be applied to different grid resolutions, inputs from different model types, and different pollutants, providing flexibility. Results for Atlanta, GA show steep spatial gradients in pollutant concentrations near roadways, accurately capturing intraurban variability due to vehicle use. Model fusion estimates were evaluated against data from available monitoring sites with withholding and results show an improvement in both spatial R and temporal R2 compared to CMAQ and RLINE, emphasizing the ability of the model fusion results to capture not only fine-scale spatial variation but also comprehensive chemistry leading to significant secondary formation and other local and regional emission sources. Simulating gradients near roadways while also capturing effects of regional sources that can influence daily variation in concentration can potentially reduce exposure errors in health studies.

9UA.3

An Improved Hybrid Modeling Framework for Estimation of Human Exposure to Near Roadway Air Pollution.

Fatema Parvez, KRISTINA WAGSTROM, *University of Connecticut*

The rapid growth of the world's motor-vehicle fleet due to population growth and economic improvement causes a significant negative impact on public health. The currently available air quality modeling approaches can compute the source specific pollutant fate on either a regional or a local scale but still lack effective ways to estimate the combined regional and local source contributions to exposure. Temporal variabilities in human activities and differences in pollutant dispersion pattern in stable and unstable atmospheric conditions greatly influence the exposure. Estimating air pollution exposure from local sources such as motor vehicles while considering all the variables impacting the dispersion make the process computationally intensive.

In this study, we employ a hybrid modeling framework combining a 3-D Eulerian chemical transport model and a pseudo steady state dispersion model to provide improved estimation of near road pollutant concentrations. We use the Comprehensive Air Quality Model with Extensions (CAMx), one of the two major air quality models used by Environment Protection Agency (EPA). For local dispersion modeling, we use R-LINE, a line source dispersion model for near surface releases. We employ this modeling framework and estimate human exposure for a wide variety of primary and secondary pollutants. Exposure to roadway emissions mostly depends on population density and temporal activities. In our study, we quantify exposure considering census tract population density and temporal and spatial variability in concentrations. Our approach using a dispersion model is unique as it uses the mass fraction of the total dispersed pollutant at different receptor points and hence is not dependent on either roadway emissions data or extensive model runs. This approach helps overcome the limitation associated with computational burden of regional models.

9UA.4

Investigating the Influence of Photocatalytic Cool Wall Adoption on Meteorology and Air Quality in the Los Angeles Basin.

Jiachen Zhang, Xiaochen Tang, Ronnen Levinson, Hugo Destaillats, GEORGE BAN-WEISS, *University of Southern California*

Solar reflective "cool materials" can be used to lower urban temperatures, useful for mitigating the urban heat island effect and adapting to the local impacts of climate change. While numerous past studies have investigated the climate impacts of cool surfaces, few studies have investigated their effects on air pollution. Meteorological changes from increases in surface albedo can lead to temperature and transport induced modifications in air pollutant concentrations. In an effort to maintain high albedos in polluted environments, cool surfaces can also be made using photocatalytic "self-cleaning" materials. These photocatalytic materials can also remove NOx from ambient air, with possible consequences on ambient gas and particle phase pollutant concentrations. In this research, we investigate the impact of widespread deployment of cool walls on urban meteorology and air pollutant concentrations in the Los Angeles basin. Both photocatalytic and standard (not photocatalytic) high albedo wall materials are investigated. Simulations using a coupled meteorology-chemistry model (WRF-Chem) show that cool walls could effectively decrease urban temperatures in the Los Angeles basin. Preliminary results indicate that meteorology-induced changes from adopting standard cool walls could lead to ozone concentration reductions of up to 0.5 ppb. NOx removal induced by photocatalytic materials was modeled by modifying the WRF-Chem dry deposition scheme, with deposition rates informed by laboratory measurements of various commercially available materials. Simulation results indicate that increased deposition of NOx by photocatalytic materials could increase ozone concentrations, analogous to the ozone "weekend effect" in which reduced weekend NOx emissions can lead to increases in ozone. The impacts of cool walls on particulate matter concentrations are also discussed. Changes in particulate matter concentrations are driven by albedo-induced changes in air pollutant transport in the basin, temperature induced changes in photochemistry and aerosol phase partitioning, and changes to secondary organic aerosol.

9UA.5

Washoff of Dry Deposited Atmospheric Aerosol from a Traditional Roof and a Green Roof. ALEXANDER JOHNSON, Cliff Davidson, *Syracuse University*

Dry deposited aerosols accumulate onto urban surfaces such as building roofs. In a rainstorm, some of these aerosols are washed off by stormwater runoff, thereby contaminating the runoff. Wet deposition may also contribute additional contaminants to the runoff. Not much is known on the relative contributions of wet and dry deposition to stormwater runoff contamination. There is also essentially no information on the extent to which an observable "first flush effect" exists, where most of the dry deposited contaminants on building roofs are removed during the early part of a rainstorm.

Besides traditional building roofs, green roofs are also dry deposition sites for atmospheric aerosols. Falling rain can wash deposited aerosol off of the vegetation and growth medium surfaces of a green roof. Some chemicals within the growth medium may contribute additional contamination to the runoff, while other contaminants in the runoff may be filtered out by the growth medium. The complex processes influencing the chemical content of stormwater runoff on a green roof have not been well-studied.

To better understand these processes, experiments were conducted on two adjacent roofs in downtown Syracuse, New York: a 1.3 acre traditional roof on the War Memorial Sports Arena and a 1.5 acre green roof on the Onondaga County Convention Center. Runoff was collected from both roofs during several rainstorms and analyzed for sulfate and nitrate. In separate experiments, dry deposition fluxes of these two chemical species were measured using large flat disks on the Syracuse University campus approximately 1.6 km away. Airborne concentrations were simultaneously measured to obtain dry deposition velocities. These data are being used to construct mass balances to better understand the processes occurring on both roofs.

9UA.6

Sources and Dynamics of the Submicron Aerosol in Delhi, India: Overview of the 2017 Delhi Aerosol Supersite Campaign. Joshua Apte, Shahzad Gani, Sahil Bhandari, Sarah Seraj, Dongyu S. Wang, Zainab Arub, Gazala Habib, LEA HILDEBRANDT RUIZ, *University of Texas at Austin*

Delhi consistently ranks as one of the most polluted megacities in the world, where annual average $PM_{2.5}$ levels exceed 130 µg m^{-3}, and wintertime episodes commonly reach 500 µg m^{-3} or higher. While Delhi's pollution has attracted international attention, understanding of the sources and atmospheric dynamics of high aerosol concentrations is still incomplete. To address these data gaps, we established a supersite to characterize the chemical composition of the ambient submicron aerosol at the Indian Institute of Technology, Delhi. Continuous online measurements of aerosol composition have been collected since January 2017, including nonrefractory PM_1 (NR-PM_1, via an Aerodyne aerosol chemical speciation monitor), black carbon (BC, via aethalometer) and particle size distributions (scanning mobility particle sizer).

This overview presentation summarizes the key scientific findings of the Delhi Aerosol Supersite campaign to date. We observe marked seasonal and diurnal variability in the concentration and composition of PM_1 owing to the interactions of sources and atmospheric mixing. Nocturnal concentrations of some primary species routinely exceeded daytime levels by factors of 3-5. Winter nights had unusually large particles (count median diameter ~ 100-120 nm) and high PM_1 mass loadings (150-200 µg m^{-3}), with concentrations dropping and particles shrinking in warmer months. Biomass burning and traffic are likely major sources for BC, for which concentrations exhibit twin evening and morning peaks exceeding 30 µg m^{-3} in winter months. A pronounced and recurring early morning peak of PM_1 chloride (~20-30 µg m^{-3}) may reveal a previously unappreciated emissions source in Delhi. Diurnal variation was less pronounced for sulfate, nitrate, and ammonium species (mass loadings ~10-20 µg m^{-3}), implying that these species may also have strong regional sources surrounding Delhi. As observed elsewhere, organic species dominated NR-PM_1 and exhibited sharp diurnal variability.

9UA.7

Dynamics of Nanoparticle Size Distribution in a Boundary Layer by an Airborne and Ground Measurements. JAN HOVORKA, Nikola Kuzelova, Cecilia Leoni, Jan Bendl, Oliver F. Bischof, *Charles University in Prague*

Diurnal variations of vertical profiles for number-size distributions and concentrations of aerosol nanoparticles in planetary boundary layer were measured and evaluated from ground and airborne measurement. One minute integrates of the aerosol distributions by nanoscan spectrometer positioned in an unmanned airship were compared with five minute distributions recorded on the ground. Airborne measurements were conducted at heights 20-500m (1000m) of winter planetary boundary layer of urban atmosphere aloft residential district of Kladno city, Czech Republic. Vertical size distribution profiles recorded above sports field in the residential district exhibited strong diurnal variation. While early morning profile recorded during strong temperature inversion indicated nanoparticle sources on the ground, increasing intensity of the Sun radiation during time of the day causes temperature inversion disappearance, decrease of PM1 mass and relative humidity, steep increase of ozone concentration. This conditions favor new particle formation at heights about 250-350m. Newly formed particles are then being transported downward by strongly evolved turbulence in planetary boundary layer and detected on the ground. This finding supports the hypothesis that new particle formation, frequently observed on the ground may, in fact, originate at elevated altitudes.

The study is supported by the Czech Grant Agency (P503/12/G147).

9UA.8

Active Remote Sensing of Air Quality: Comparison of In Situ Measurements and Lidar-Based Retrievals of Aerosol Volume Concentration During DISCOVER-AQ. PATRICIA SAWAMURA, Richard Moore, Sharon P. Burton, Eduard Chemyakin, Detlef Müller, Alexei Kolgotin, Richard Ferrare, Chris Hostetler, Luke Ziemba, Andreas Beyersdorf, Bruce Anderson, *NASA Langley Research Center*

Ground- and space-based measurement platforms are essential tools for continuous monitoring and evaluation of global, regional, and local air quality. Ground-based measurement networks are relatively inexpensive to deploy, are capable of comprehensive measurements of aerosol and trace gas chemistry and physical properties, and possess excellent temporal resolution. However, these networks are sparsely distributed and often lack broad spatial coverage. Current satellite-based remote sensors offer excellent horizontal spatial coverage with more limited temporal resolution and specificity with regard to aerosol vertical extent and composition. While the temporal resolution of the space-based sensors is expected to improve dramatically with the anticipated launch of the TEMPO, GEMS, and Sentinel geostationary satellites over the next decade, the passive-based sensors on these platforms continue to lack the vertically-resolved aerosol compositional information needed to constrain air quality and climate models. High-Spectral Resolution Lidar (HSRL) may be an attractive solution to this problem.

We present a detailed evaluation of remotely-sensed aerosol microphysical properties obtained from an advanced, multi-wavelength High Spectral Resolution Lidar (HSRL-2) during the 2013 NASA DISCOVER-AQ field campaign. Vertically-resolved retrievals of fine mode aerosol number, surface area, and volume concentration as well as aerosol effective radius are compared to 108 co-located, airborne in situ measurement profiles in the wintertime San Joaquin Valley, California, and in summertime Houston, Texas. We show that the HSRL-2 retrievals of ambient fine mode aerosol surface area and volume concentrations agree with the in situ measurements to within 25% and 10%, respectively, once hygroscopic growth adjustments have been applied to the dry in situ data. Since the retrieval of aerosol volume is most relevant to current regulatory efforts targeting fine particle mass ($PM_{2.5}$), these findings highlight the advantages of an advanced $3\beta + 2\alpha$ HSRL for constraining the vertical distribution of the aerosol volume or mass loading relevant for air quality.

10AC.1

Monoterpene Oxidation Products Dominate Organic Aerosol Mass in Centreville, Alabama during the SOAS Field Campaign. HAOFEI ZHANG, Lindsay Yee, Ben Lee, Michael Curtis, Dave Worton, Gabriel Isaacman-VanWertz, Claudia Mohr, Felipe Lopez-Hilfiker, John Offenberg, Michael Lewandowski, Tad Kleindienst, Melinda Beaver, Amara Holder, William Lonneman, Kenneth Docherty, Mohammed Jaoui, Havala Pye, Weiwei Hu, Douglas Day, Pedro Campuzano-Jost, Jose-Luis Jimenez, Joel A. Thornton, Allen H. Goldstein, *University of California, Berkeley*

Comprehensively characterizing atmospheric organic aerosol (OA) composition is crucial to understanding its origins and environmental impacts. The extreme chemical complexity of OA has been a barrier to progress in this field. Here, we provide new constraints on OA origins through molecular-level speciation coupled to bulk measurements of fossil vs. modern carbon and oxygenated OA at Centreville, Alabama, during summer 2013, as part of the Southern Oxidant and Aerosol Study (SOAS) field campaign. 254 ambient aerosol samples were collected at 4-hour time resolution and analyzed using a Thermal Desorption Two-Dimensional Gas Chromatography High-resolution Time-Of-Flight Mass Spectrometer (TD-GC×GC/HTOF-MS) with on-line trimethylsilylation derivatization to obtain clear chemical separation with extensive ranges of volatility and polarity. This off-line measurement was complemented by on-line analysis of OA chemical composition using a high-resolution time-of-flight chemical ionization mass spectrometer with a filter inlet for gases and aerosols (FIGAERO-HRToF-CIMS) using iodide-adduct (I^-) ionization.

By comprehensively analyzing OA chemical composition combining the two molecular-level approaches, we determined that monoterpene secondary OA (MTSOA) contributes more than half of total fine OA (PM_1) mass, significantly higher than current regional model predictions. The time series of the measured MTSOA correlate strongly with the total of oxygenated OA (OOA) factors resolved by AMS-PMF analysis, suggesting that the majority of oxidized OA during SOAS are MTSOA. Moreover, characterized anthropogenic OA (POA + anthropogenic SOA) which have < 10% of total OA mass account for almost all the fossil carbon mass measured by radiocarbon (^{14}C) analysis, confirming that most OA at SOAS are modern carbon.

10AC.2

Reaction of Criegee Intermediates with Organic Acids in the Condensed Phase. SHOUMING ZHOU, Shira Joudan, Matthew Forbes, Jonathan Abbatt, *University of Toronto, Toronto, Canada*

It is believed that gas-phase Criegee intermediates (CIs) play a role in the degradation of unsaturated species in the atmosphere, and in the formation of free radicals, oxygenated organics and secondary organic aerosol (SOA). Gas-phase CIs can also efficiently oxidize SO2, leading to the production of H2SO4. Following direct observations of the smallest CIs (e.g. CH2OO) in the gas-phase, studies on the chemistry of CIs have gained increased attention. Due to their biradical nature, the CIs could also be important oxidants in the condensed phase. However, studies on the multiphase reactions of CIs are very limited.

In this presentation, we will present our recent work on the oxidation of a highly unsaturated model organic - squalene (C30H50, with 6 C=C double bonds in the molecule) with ambient levels of ozone. Using direct analysis in real time-mass spectrometry (DART-MS), high molecular weight products from the heterogeneous reaction with ozone were observed, which are attributed to the CI reaction with acids. To confirm this reaction in the condensed phase, squalene was mixed with a saturated fatty acid (i.e. palmitic acid) or a perfluorinated acid (i.e. perfluorotetradecanoic acid) prior to oxidation. The degradation of the organic acids under ozonolysis conditions was confirmed by HPLC-MS/MS analysis. The effect of relative humidity on this heterogeneous reaction was investigated. The reaction products and mechanism will be discussed.

10AC.3

Secondary Organic Aerosol and Ozone Formation from Photo-Oxidation of Unburned Whole Gasoline and Diesel in a Surrogate Atmospheric Environment. WEIHUA LI, Chia-Li Chen, Lijie Li, Mary Kacarab, David R. Cocker III, *University of California, Riverside*

Direct evaporation from unburned gasoline and diesel is an established source of ozone and secondary organic aerosol (SOA) forming precursors. A recent report from California Air Resource Board (CARB) presents that exhaust from tailpipe and evaporative loss contribute to total organic emissions equivalently. As new vehicle control technologies continue to decrease primary organic aerosol and gas-phase emissions, whole fuel evaporation becomes a more significant source of ambient organic aerosol. Therefore, determining the SOA forming potential of whole gasoline and diesel vapor is of significant interest. While SOA formation from some gasoline and diesel components such as aromatics and alkanes have been individually studied under controlled conditions, there are only a few studies on how these complex mixtures behave in the atmosphere.

Given changes in fuel formulations over time, it is important to revisit whole gasoline and diesel as important SOA precursors, especially in light of increased knowledge on the impact of reactivity on aerosol formation and improved atmospheric chambers and instrumentation. Multiple photo-oxidation experiments with the presence of NOx were conducted in the University of California College of Engineering-Center for Environmental Research and Technology dual 90m3 smog chambers to investigate SOA and ozone formation from the select commercial gasoline, #2 diesel and reference diesel samples. Additionally, the fuel samples were also added to a surrogate reactive organic gas (ROG) mixture to best mimic the reactivity of an urban atmosphere. SOA formation from photo-oxidation of gasoline samples was consistent regardless of fuel manufacturer or octane rating and was driven by aromatics content in the gasoline. The greater the estimated hydroxyl radical concentrations, the more SOA formed. Photochemical aging of diesel samples rapidly produce significant SOA in the presence of the surrogate ROG mixture. SOA mass cannot be solely explained by aromatics content.

10AC.4

Investigation of Biogenic Influences and Day/Night Chemistry on Secondary Organic Aerosol by Extractive Electrospray Ionization Time-Of-Flight Mass Spectrometry (EESI-TOF). GIULIA STEFENELLI, Felipe Lopez-Hilfiker, Veronika Pospisilova, Alexander Lucas Vogel, Christoph Hueglin, Martin Rigler, Urs Baltensperger, Andre S.H. Prévôt, Jay G. Slowik, *Paul Scherrer Institute*

Anthropogenic and biogenic emissions contain large amounts of volatile organic compounds (VOCs) which may undergo photochemical aging to yield secondary organic aerosol (SOA). The magnitude of SOA production from different sources remains highly uncertain, hindering the estimation of the contribution of these sources to the total ambient organic aerosol. Measurement techniques with high time resolution and chemical specificity are thus urgently needed. PSI has recently developed a novel extractive electrospray ionization time-of-flight mass spectrometer (EESI-TOF), which enables real-time chemical analysis of atmospheric particles without thermal decomposition or ionization-induced fragmentation (Lopez-Hilfiker et al., 2017).

We present results from the first field deployment of the EESI-TOF. Measurements were performed during summer 2016 at a well-characterized urban site in Zurich. Positive matrix factorization (PMF) analysis of EESI-TOF data yielded several organic aerosol factors related to primary and secondary emissions. Factors were separated according to different mass spectral fingerprints and aging processes. Some of the retrieved factors correlated strongly with reasonable counterparts from AMS PMF analysis while others provided previously inaccessible insight into sources and ambient processing. Primary factors related to cooking processes, traffic and cigarette smoke emissions were obtained. The retrieved secondary factors were strongly influenced by biogenic emissions, and exhibited significant day/night differences. Factors dominating during daytime showed predominantly ions characteristic of monoterpene and sesquiterpene oxidation while the night-time factor included less oxygenated and more volatile terpene oxidation products, as well as organonitrates which were likely derived from NO3 radical oxidation of monoterpenes. These results contrast with measurements in a Swiss alpine valley during winter 2017, where wood burning emissions were dominant.

10AC.5

Measurements of Particulate Chloride Using the FIGAERO-CIMS and ACSM. DONGYU S. WANG, Lea Hildebrandt Ruiz, *University of Texas at Austin*

Chlorine radicals can readily oxidize a wide range of atmospheric organic compounds. Studies have reported significant reactive chloride concentrations both inland and near coastal regions, where chlorine chemistry can dominate the initial oxidation of alkanes and other volatile organic compounds (VOCs) under certain conditions. Furthermore, there is an increasing number of reports of high particulate chloride concentrations in polluted environments; for example, as suggested by ambient measurements in megacities in China, India, and Mexico. Because of measurement challenges, the quantity and origin of particulate chloride remain highly uncertain.

We performed environmental chamber experiments, forming aerosol from a wide range of VOCs using chlorine as the primary oxidant. Aerosol particles were collected and analyzed using a Filter Inlet for Gases and AEROsols (FIGAERO) coupled to a High-Resolution Chemical Ionization Mass Spectrometer (CIMS) using water-hydronium and water-iodide clusters as ionization reagents. Aerosol composition was also measured using an Aerosol Chemical Speciation Monitor (ACSM). Challenges associated with ACSM chloride measurements were investigated using laboratory generated inorganic and organic aerosol, as well as recently collected ambient data from New Delhi, India.

Particulate chloride formation was observed with the FIGAERO-CIMS in select systems, including isoprene and alpha-pinene. In New Delhi, India, high concentrations of chloride were detected in the ACSM. Overall, our results suggest that chloride can constitute a significant fraction of the fine aerosol mass, and, despite some analytical challenges, existing instrumentation may be able to quantify this important component.

10ET.1

Stable Isotope Fractionation in Titan Aerosol Formation. MELISSA TRAINER, Jennifer Stern, Melissa Ugelow, Thomas Gautier, Joshua Sebree, *NASA Goddard Space Flight Center*

Stable isotope ratios of major elements can be used to infer much about local- and global-scale processes on a planet. On Titan, aerosol production is a significant sink of carbon, nitrogen, and hydrogen in the atmosphere, and isotopic fractionation of these elements may be introduced during the advanced organic chemistry that leads to the condensed phase products. Several stable isotope pairs, including $^{12}C/^{13}C$ and $^{14}N/^{15}N$, have been measured in situ or probed spectroscopically by Cassini-borne instruments, space telescopes, or through ground-based observations. However, the effect of a potentially critical pathway for isotopic fractionation – organic aerosol formation and subsequent deposition onto the surface of Titan – has not been considered due to insufficient data regarding fractionation during aerosol formation. To better understand the nature of this process, we are conducting experimental studies of the isotopic fractionation associated with the formation of Titan aerosol analogs via far-UV irradiation of methane (CH_4) and nitrogen (N_2) mixtures, with and without trace species such as benzene (C_6H_6). We will report on the effect of temperature and pressure on the direction and magnitude of isotope fractionation for C, N, and H. In addition, a new recirculating experiment allows the gas phase products to be monitored over time as the CH_4 reservoir is depleted, providing a comprehensive picture of the gas-phase sinks for carbon and its isotopes. We will present results alongside interpretation of the driving processes for fractionation and implications for photochemical aerosol formation in the atmosphere of Titan, as well as other solar system atmospheres.

10ET.2

Chemical Characteristics of Haze Particles Generated from the VUV Photolysis of C2 Hydrocarbons Under Oxygen-Free Conditions. JONATHAN FRANKLIN, Jesse Kroll, *MIT*

The atmospheres of some planetary bodies (such as Saturn's moon Titan) are characterized by the presence of organic haze particles, formed by irradiation of simple organic species in the absence of oxygen. In this study, simple organic haze particles were generated in the laboratory from the photolysis of a series of C2 hydrocarbons and chemically characterized using an Aerodyne High-Resolution Time-of-Flight Soot-Particle Aerosol Mass Spectrometer (SP-AMS). Particles were formed via photolysis of ethane (C2H6), ethylene (C2H4), or acetylene (C2H2) with vacuum ultraviolet (VUV) light. The particles formed from ethane and ethane have similar mass spectra with aliphatic characteristics and an H:C ratio of ~1.9. Particles formed from the photolysis of acetylene produce mass spectra characteristic of more aromatic compounds. Consequently, the H:C ratio of these particles was much lower, ~1.3. Previous studies of laboratory analogs of haze particles produced via UV photolysis of methane show an N:C of 0.18, while particles formed in these experiments show no N incorporation. The particles from this study lack strong IR absorption, suggesting that soot or graphene-like structures are not formed. The chemistry of particles formed from photolysis of these species provides insight into the mechanisms by which small organic radicals undergo "molecular weight growth" under oxygen-free conditions, ultimately leading to the formation of high-MW, low-volatility haze particle components.

10ET.3

Generation of Abiotic Molecular Complexity at Aerosol Air-Water Interfaces. VERONICA VAIDA, Rebecca Rapf, *University of Colorado Boulder*

In the search for other habitable worlds, it is important to understand the key characteristics of habitable environments and the chemical mechanisms involved in the generation of biomolecules that are signatures of life. Sunlight-driven reactions of organic molecules contribute to the atmospheric processing of organic compounds, including the generation of molecular complexity via aqueous chemistry. In addition to bulk processes, the interfacial and heterogeneous chemistry that occurs at environmental water surfaces is a key source of atmospherically-relevant processing. Such favorable interfaces would be widely available on any cosmic body with liquid water, because aqueous atmospheric aerosols are formed by wind action on a liquid ocean. Any planet with a tilted axis of rotation, an atmosphere, and a liquid ocean will generate atmospheric aerosols. The interfaces provided by such aerosols are auspicious reaction environments, including for both photochemical and condensation reactions, leading to the synthesis of more complex molecules. This presentation discusses results of our laboratory experiments modeling the use of sunlight to generate abiotically the chemical complexity needed for the synthesis of biopolymers necessary for life. Specifically, the reactivity of high-energy molecules that are precursors to metabolism as it has evolved in life on Earth will be discussed. The photochemical synthesis and reactivity of complex organic systems under conditions representative of early Earth will be presented and connections will be made to the possibility of such reactions occurring on Earth-analogue exoplanets.

10ET.4

Chemical Composition of Ions During Laboratory Simulations of Titan's Haze Formation. JENNIFER BERRY, Melissa Ugelow, Margaret Tolbert, Eleanor Browne, *University of Colorado, Boulder*

Understanding the chemistry of organic haze formation in the N_2/CH_4 atmosphere of Saturn's largest moon, Titan, has been an active area of research due to the fundamental role of the haze on Titan's climate and the possible connection to the chemistry of early Earth. Haze formation on Titan is initiated by UV photons and energetic electrons and results in a complex series of ion-neutral and radical reactions leading to higher molecular weight hydrocarbons and nitrogen containing species. Measurements of both neutral and ionic species in Titan's atmosphere have been made by the Ion Neutral Mass Spectrometer (INMS) and the Cassini Plasma Spectrometer (CAPS). A long history exists of laboratory studies focusing on both fundamental ion-neutral reactions and on the composition of haze particles produced from the complex chemistry that occurs upon the irradiation of N_2/CH_4 mixtures. However, there has been little experimental work on the role of ion chemistry in haze production. Here, we present results using an Aerodyne/Tofwerk Atmospheric Pressure interface Time-of-Flight Mass Spectrometer (APi-ToF-MS) to study ion chemical composition and relative abundance during the formation of aerosols. This high-resolution instrument (R ~9000) allows for *in-situ*identification of the exact mass of positive ions from 1 to >1700 m/z during the irradiation of different concentrations of CH_4 in N_2. We observe the growth of ions that vary in saturation and carbon number during aerosol formation. Families of $C_xH_v^+$, $C_xH_vN_w^+$, $C_xN_w^+$, and $H_vN_w^+$ are detected with increasing saturation at higher masses during the irradiation of CH_4/N_2 mixtures. No ions containing nitrogen are observed during the irradiation of CH_4/Ar mixtures. We compare the APi-ToF-MS measurements to Aerosol Mass Spectrometer (AMS) data in order to explore connections between ion chemistry and haze formation.

10ET.5

A Study of Exoplanet Aerosols by Earth Means. ALEXANDRIA JOHNSON, Tajana Safran, Amy Bauer, Daniel Cziczo, *MIT*

Some exoplanet atmospheres lack strong spectral features, which may suggest the presence of a high, optically thick cloud layer and poses great challenges for atmospheric characterization. There is hope however – the study of extraterrestrial atmospheres with terrestrial based techniques has proven useful for understanding the cloud-laden atmospheres of our solar system. Here we build on this by leveraging lab-based, terrestrial cloud particle instrumentation to better understand the microphysical and radiative properties of exoplanet clouds.

The work to be presented focuses on the scattering properties of single particles, believed representative of those suspended in exoplanet atmospheres, levitated in an Electrodynamic Balance. I will discuss how we leverage terrestrial based cloud microphysics for exoplanet applications, the instruments used in this work, our investigation of ammonium nitrate (NH4NO3) scattering across temperature dependent crystalline phase changes, and the steps we are taking toward the collection of scattering phase functions and polarization of scattered light for exoplanet cloud analogs.

Through this and future studies we hope to better understand how particles representative of those in exoplanet atmospheres interact with incoming radiation from their host stars and what information may still obtainable via remote observations when no spectral features are observed.

10HA.1

Acellular Sources of Reactive Oxygen Species (ROS): Links between In Situ Ambient and Laboratory Quantifications of Different Emission Sources. JUN ZHOU, Miriam Elser, Manuel Krapf, Roman Fröhlich, Deepika Bhattu, Giulia Stefenelli, Peter Zotter, Emily Bruns, Simone Pieber, Haiyan Ni, Qiyuan Wang, Yichen Wang, Jay G. Slowik, Thomas Nussbaumer, Marianne Geiser, Andre S.H. Prévôt, Urs Baltensperger, Imad EI Haddad, Rujin Huang, Josef Dommen, *Paul Scherrer Institute*

Aerosols affect human health through their oxidative potential (OP), which causes oxidative stress and consequently variable diseases when intracellular reactive oxygen species (ROS) overwhelm antioxidants in the body. However, the OP of different types of particulate matter (PM) to induce oxidative stress when inhaled is largely unknown. In this study, a high resolution aerosol mass spectrometer and an online ROS analyzer based on the 2',7'-dichlorofluorescin (DCFH) assay were employed to study the variable chemical nature and the OP of PM generated from different sources. These sources included primary and secondary organic aerosols from biogenic as well as anthropogenic emissions, which were generated under different conditions and aged in atmospheric photochemical reaction simulators. Additionally, ambient PM in two contrasting locations, Beijing (China) and Bern (Switzerland), was investigated. A novel positive matrix factorization procedure was used to apportion the sources of organic aerosols (OA). A model was then established to attribute the observed ROS to different sources. The main parameters affecting ROS formation were determined and the particles' OP of different emission sources obtained was reconfirmed based on laboratory-characterized sources of OA. This study provides reliable evidence to infer the OP of aerosols at different ambient locations.

10HA.2

Analysis of Oxidative Potential and Chemical Composition of Fine Particulate Matter in Bucaramanga, Colombia. KENTO MAGARA-GOMEZ, Victor Herrera-Galindo, Laura Rodriguez-Villamizar, Yurley Diaz-Ferreira, Maria Rondon-Villabona, *Universidad Pontificia Bolivariana-Bucaramanga*

This study correlates the results of a sensitive macrophage-based in vitro reactive oxygen species (ROS) assay with chemical characterization and a 1-year sampling program to further understanding of the role of water-soluble trace elements, ionic species, water-soluble organic carbon (WSOC), and black carbon (BC) in aerosol toxicity. The location is the city of Bucaramanga, Colombia, a city with a population of about 520.000, where PM2.5 samples were collected every sixth day from September 2014 to February 2016 in two sites: one with history of high PM10 concentrations and another with mid to low concentrations. Through multivariate statistical analysis it was found that chemical species cadmium, chromium, lanthanum, titanium and sulfur showed the best correlation with ROS activity, and thus a strong association with PM2.5 toxicity. Intrinsic toxicity (ROS activity per PM mass) of the Bucaramanga aerosol is comparable with that of highly polluted cities in developing countries such as Lahore (Pakistan), and 4 and almost 10 times higher than Denver and Los Angeles respectively. At the same time, ROS activity values per sampling volume were considerably lower than those of Lahore (about 6 times), but almost 10 and 5 times higher than Denver and Los Angeles respectively, according to results published by Saffari et al in 2014. Application of the source apportionment model "Chemical Mass Balance" (CMB), to chemical composition of aerosol samples collected in Bucaramanga during this study, resulted in the identification of spark-ignition and compression-ignition engines as the main sources of PM2.5 in Bucaramanga in that order, which indicates that aerosol toxicity in this city could be potentially associated with fuel quality, vehicle type, maintenance, and age. In Bucaramanga, more than 35.000 motorcycles transit daily, from which there are still some operating on 2-stroke engines despite Colombian policy prohibiting their use.

10HA.3

Ambient PM2.5 in South Korea and Philippines: Oxidative Potential, Chemical Characteristics, and Source Apportionment. LUCILLE JOANNA BORLAZA, Enrique Cosep, Seojong Kim, Kwangyul Lee, HungSoo Joo, Daphne Bate, Jinsang Jung, Mylene Cayetano, Kihong Park, *Gwangju Institute of Science and Technology*

There has been growing literature supporting the hypothesis that one of the most important pathways underlying the adverse health effects of exposure to fine particulate matter (PM2.5) is through oxidative stress derived from the interaction of PM2.5 with cells. This has been quantified by substantial research via determination of oxidative potential (or OP) of PM2.5. The OP analysis can assess the capability of PM2.5 to produce reactive oxygen species (ROS) which is suggested that at exceeding normal range have considerable health implications. This study looked into OP and its association with chemical composition of source apportioned ambient PM2.5 collected from different site types in South Korea and an urban site in the Philippines. Ambient PM2.5 was collected on zeflour and quartz filters using URG cyclones and Airmetrics Minivol samplers during country-specific seasons. Chemical characterization was done by analyzing ions, metals, organic carbon (OC), and elemental carbon (EC) concentrations. Two a-cellular chemical assays were used to quantify OP of water-soluble PM2.5: Dithiothreitol (DTT) and Electron Spin Resonance (ESR) assay. The correlations between the measured OP from both assays and the concentrations of PM2.5 chemical components were investigated. Positive Matrix Factorization (PMF) and Principal Component Analysis with Multiple Linear Regression (PCA-MLR) were performed in order to apportion the relative contributions of various sources to OP of water-soluble PM2.5. Results of OP, chemical analysis, and source apportionment will be presented in this study.

10HA.4

Murine Precision-cut Lung Slices Exhibit Acute Responses Following Exposure to Gasoline Direct Injection Engine Emissions. CAITLIN MAIKAWA, Naomi Zimmerman, Khaled Rais, Mittal Shah, Brie Hawley, Pallavi Pant, Cheol H. Jeong, Juana Delgado-Saborit, John Volckens, Greg J. Evans, James S. Wallace, Krystal Godri Pollitt, *University of Massachusetts Amherst*

Gasoline direct injection (GDI) engines are increasingly prevalent in the global vehicle fleet. Particulate matter emissions from GDI engines are elevated compared to conventional gasoline engines. The pulmonary effects of these higher particulate emissions are unclear. This study investigated the pulmonary responses induced by GDI engine exhaust using an ex vivo model. The physiochemical properties of GDI engine exhaust were assessed. Precision cut lung slices were prepared using Balb/c mice to evaluate the pulmonary response induced by one-hour exposure to engine-out exhaust from a laboratory GDI engine operated at conditions equivalent to vehicle and highway cruise conditions. Lung slices were exposed at an air-liquid interface using an electrostatic aerosol in vitro exposure system. Particulate and gaseous exhaust was fractionated to contrast mRNA production related to polycyclic aromatic hydrocarbon (PAH) metabolism and oxidative stress. Exposure to GDI engine exhaust upregulated genes involved in PAH metabolism, including Cyp1a1 (2.71, SE=0.22), and Cyp1b1 (3.24, SE=0.12) compared to HEPA filtered air ($p < 0.05$). GDI engine exhaust further increased Cyp1b1 expression compared to filtered GDI engine exhaust (i.e., gas fraction only), suggesting this response was associated with the particulate fraction. Exhaust particulate was dominated by high molecular weight PAHs. Hmox1, an oxidative stress marker, exhibited increased expression after exposure to GDI (1.63, SE=0.03) and filtered GDI (1.55, SE=0.04) engine exhaust compared to HEPA filtered air ($p < 0.05$), likely attributable to a combination of the gas and particulate fractions. Exposure to GDI engine exhaust contributes to upregulation of genes related to the metabolism of PAHs and oxidative stress.

10HA.5

Investigation of Combustion Aerosol Toxicity within the HICE-Project: Chemical Composition of Different Combustion-Emissions and Their Molecular Biological Effects on Air/Liquid-Interface Exposed Lung Cells (In-Vitro) as Well as on Exposed Mice (In-Vivo). RALF ZIMMERMANN, Gunnar Dittmar, Tamara Kanashova, Jeroen Buters, Sebastian Öder, Hanns Paur, Marco Dilger, Carsten Weiss, Bert Buchholz, Benjamin Stengel, Karsten Hiller, Sean Sapcariu, Kelly BeruBe, Tobias Krebs, Thorsten Streibel, Jürgen Schnelle-Kreis, Martin Sklorz, Johannes Passig, Jürgen Orasche, Pasi Jalava, Mikko Happo, Maija-Riitta Hirvonen, Olli Sipppula, Jorma Jokiniemi, and further HICE co-workers (et al.), *Helmholtz Zentrum München and Rostock University*

Combustion aerosol emissions are important for health effects. The acute response of lung cells onto combustion aerosols include e.g. oxidative stress, inflammation or apoptosis. Only few links between aerosol chemical composition and biological effects have been established yet. In the framework of the Virtual Helmholtz Institute-HICE (www.hice-vi.eu), physical and chemical properties of combustion emissions as well as their biological effects on lung cells (human epithelial cells, A549, BEAS2B, primary cells and murine macrophages, RAW) are jointly analysed. Partly animals were exposed (BL6 mice) for validation purposes. Chemical composition and physical parameters of the emissions were thoroughly characterized. For addressing the biological activity/toxicity of the aerosols, the lung cell-cultures were realistically exposed by novel air-liquid interface (ALI) exposure-systems. After 4h exposure biological effects were analysed by multi-omics characterisation (transcriptomic, proteomic and metabolomics level). Emissions of wood-pellet- and log wood-stoves, ship engines, car diesel- and gasoline-engines were investigated by this approach using two field-deployable ALI-exposure-station systems and a mobile S2-bio safety laboratory. After exposure biological effects were comprehensively characterized (viability, cytotoxicology, multi-omics) and are put in context with the chemical and physical aerosol data [Oeder etal., PLoSone2015, DOI:10.1371/journal.pone.0126536]. Interestingly, the observed biological response-strength differs considerably for different aerosol sources and is not correlated to the deposited PM2.5-mass. This points towards large differences in the relative toxicity of the aerosol emissions from different combustion sources and fuel types. Furthermore adverse and protective effects are observed for different compounds. For example, well burnt-out, low-PM2.5 pellet-burner emission cause higher adverse biological effects than organic-rich, high-PM2.5 logwood stove-emissions. The high abundance of antioxidant compounds such polyphenols in the logwood stove-emissions likely explains this counter-intuitive observation. The latter findings are supported by detailed analyses of activated cellular response pathways (GO-term analysis), depicting regulation of pathways such as pro-inflammatory signalling, xenobiotic metabolism, phagocytosis or oxidative stress and findings from the animal exposure experiments. Further experiments included e.g. exposures with simulated atmospherically-aged emissions (UV-aging in flow tube).

10IM.1

Characterization of Miniaturized Aerosol Spectrometer for Unmanned Aerial System Application. FAN MEI, Hagen Telg, Gavin McMeeking, Tim Gordon, Joree Sandin, Mikhail Pekour, *Pacific Northwest National Laboratory*

Unmanned aerial systems (UAS) are significantly expanding observational perspectives in atmospheric science. With rapid growth in the variety of both platform and UAS applications, the opportunity for these platforms to provide high-quality atmospheric measurements continues to expand. The measurements provided by various platforms are essential for contributing scientifically significant datasets. However, limited aerosol UAS instruments are available, due to the weight, size and power constrains in UAS. The information about miniaturized instrument performance, characterization, and especially the compatibility with their sibling version used in aircraft are very rare.

This work focuses on characterization of miniaturized aerosol spectrometer-printed optical particle spectrometer (POPS, Handix Inc.) in Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Aerial Facility (AAF). The operation of POPS compared with aircraft version – Passive Cavity Aerosol Spectrometer Probe (PCASP, DMT) were performed. In addition, two POPS are deployed to the Inaugural Campaigns for ARM Research using Unmanned Systems (ICARUS) field campaign, and the aerosol number concentration and size distribution from Oliktok Point, Alaska will be discussed.

10IM.2

Autonomous, UAV-based Sampling of NOx, O3, CO, and PM: Collaborative Innovation Between Olin College Undergraduates and Aerodyne Research Inc. ROCCO DIVERDI, Taylor Sheneman, Kyle Flores, Riley Chapman, Pratool Gadtaula, Cynthia Chen, Maximillian Schommer, John Jayne, Eben Cross, Scott Hersey, *Franklin W. Olin College of Engineering*

Throughout the 2016-2017 academic year, a new partnership between Olin College of Engineering and Aerodyne Research, Inc. developed an affordable, self-contained air quality monitoring instrument, called Modulair, subsequently integrating the instrument into mobile-ready sampling platforms (bicycle and UAV). The Modulair instrument is based on the same operating principles as Aerodyne's newly-developed ARISense integrated sensor system, employing electrochemical sensors for gas-phase measurements of CO, NO, NO_2, and O_3 and an off-the-shelf optical particle counter for particle concentration, number, and size distribution information ($0.4 < d_p < 17$ μm). Modulair was designed from the ground-up, with custom electronics - including a more powerful microcontroller, a fully re-designed housing and a device-specific backend with a mobile, cloud-based data management system for real-time data posting and analysis. Open source tools and software were utilized in the development of the instrument. All work was completed by a team of undergraduate students as part of the Senior Capstone Program in Engineering (SCOPE) at Olin College.

Further development of Modulair by two undergraduate research students resulted in Modulair integration into a custom-built drone sampling platform. Initial tests were run to better understand potential sampling bias due to rotors and drone communication. Design goals for the drone integration include maximizing airborne sampling time, and laying the foundation for software integration with the drone's autopilot system to allow for autonomous plume sampling across concentration gradients.

We will present an overview of the Modulair instrument, results from benchtop and field validation, including mobile sampling in the Boston area.

10IM.3

Chemical Speciation of Biomass Burning Aerosol Collected above and below the Forest Canopy with an Unmanned Aerial Vehicle during Prescribed Fires. AUDREY DANG, Michael Walker, Claire Fortenberry, Christopher Oxford, Benjamin Sumlin, Jiayu Li, Jonathan Myers, Brent Williams, *Washington University in St. Louis*

Biomass burning organic aerosol (BBOA) contributes a significant fraction of global organic aerosol, which can impact health, visibility, and radiative forcing. While previous field and laboratory studies have advanced understanding of BBOA chemical composition, the analysis of molecular tracers is complicated by photochemical aging and dilution, which drive chemical transformation and phase partitioning.

We present results from experiments aimed at characterizing BBOA chemical composition at the ground and forest canopy levels during an active forest fire. In these experiments, BBOA was collected on quartz filters above the canopy with an unmanned aerial vehicle (UAV) as well as at ground level during prescribed burns of six 2.5-hectare deciduous forest plots at Tyson Research Center in Missouri.

The samples collected on quartz filters were thermally desorbed with helium at 300°C and analyzed with gas chromatography mass spectroscopy using a recently developed Filter Thermal Desorption Aerosol Gas Chromatograph (Filter TAG). Ground and canopy measurements are compared to examine changes in speciation with plume aging and dilution. Resolved compounds are compared with BBOA tracer molecules identified in previous chamber studies.

10IM.4
Development and Evaluation of MEMS Air-Microfluidic Particle Focusing Systems.

OMID MAHDAVIPOUR, Dorsa Fahimi, Apoorva Jain, Igor Paprotny, *University of Illinois at Chicago*

All of the current aerosol detection, sorting and counting methods will be greatly improved if the particles suspended in the airstream can be focused into a narrow stream. Focusing particles can improve the functionality (e.g. sensitivity) of established detection methods. Also many undesirable effects due to contact between particles and outer walls of a channel (e.g. wall losses) can be avoided by confining the aerosol stream in the center of a channel.

Air-microfluidics is the field of developing microfluidic devices that use air, as oppose to liquid, as the working fluid. In this work, we present a microfabricated three dimensional (3D) air-microfluidic particle focusing systems. In the hydrodynamic version of this system, horizontal focusing is achieve by squeezing the main flow using clean sheath flow from the sides of the microchannels. To extend the focusing to the vertical direction, grooved structures on top and bottom of microchannels are utilized. A novel fabrication technique has been used which is compatible with fabrication process of MEMS PM mass sensors, making it easier to integrate these two components into a small air-microfluidic footprint. Several different designs are investigated and discussed. The performance of this system is evaluated using a unique opto-gravimetric system developed at UIC. Polystyrene latex spheres (PSLs) of different sizes are collected on membrane filters attached to the outlet of the system. Epi-fluorescent microscopy techniques are then used to image and investigate the distribution of the particles on the filter. Experimental results confirm the efficacy of this method for focusing particles in microchannels.

10IM.5
Development and Field Test of a Compact Diluter and Optical Particle Counter for Emissions Measurements.

AMARA HOLDER, Brannon Seay, William Mitchell, Johanna Aurell, Brian Gullett, *U.S. EPA*

EPA has developed a lightweight, portable emissions measurement platform that can be lofted into plumes to sample for an array of pollutants from open area sources such as prescribed forest burns. However, the measurement of particle size distribution, a key characteristic of particle emissions that determine their lifetime in the atmosphere and potential for impacts on human health, has been unavailable until recently due to the large size, weight, and limited dynamic range of available particle sizing instruments. With the advent of lightweight, low-profile optical particle counters, a portable size distribution measurement is now possible at low particle concentrations. However, these devices quickly become saturated in typical smoke plumes.

We have developed a compact aerosol diluter to work in conjunction with an optical particle counter (OPC-N2, αlphasense) to measure aerosol size distribution in the concentrated plumes often observed from open burning. The diluter uses a bifurcated flow design with a capillary tube and miniature particle filter to achieve dilution ratios in the range of 1:10 to 1:80. The dilution ratio is continuously monitored with a pressure sensor to account for the impact of filter loading. The diluter and optical particle counter were deployed on an instrumented, helium-filled aerostat to sample emissions from grassland burns in the Konza prairie. PM1 concentrations from the particle counter were highly correlated (r2 = 0.80) with PM1 measured by a DustTrak (DRX, TSI), demonstrating the potential of the diluter and particle counter for in-plume size distribution measurements

10MO.1

Processes Controlling Aerosol Size Distributions and Climate Effects in the Arctic. JEFFREY R. PIERCE, Betty Croft, Jonathan Abbatt, Allan Bertram, Julia Burkart, Sarah Hanna, Anna Hodshire, John Kodros, W. Richard Leaitch, Randall V. Martin, Emma Mungall, Benjamin Murphy, Jennifer Murphy, Greg Wentworth, *Colorado State University.* INVITED

In remote atmospheric locations, such as in the Arctic, the size distribution and climate impacts of particles is sensitive to the balance of long-range transport, local primary aerosol sources, local aerosol precursor-vapor emissions, the availability of gaseous bases, and wet scavenging/chemistry. Due to the distance from major mid-latitude sources, the size distributions and aerosol-climate impacts are quite sensitive to relatively small uncertainties in many of these processes. In this talk, I will highlight recent measurements and modelling work describing seasonal and day-to-day variability in the Arctic, and show how this work has provided insight into several the processes described above.

10MO.2

Nucleation and Growth Under High Oh Conditions: Using an Oxidation Flow Reactor and the Tomas Box Model to Learn About Chemistry, Nucleation, and Growth Potential of Ambient Pine-Forest Air. ANNA HODSHIRE, Brett Palm, Jose-Luis Jimenez, Qijing Bian, Jeffrey R. Pierce, Pedro Campuzano-Jost, Douglas Day, Zhe Peng, Amber Ortega, James Hunter, Eben Cross, Jesse Kroll, Lisa Kaser, Werner Jud, Thomas Karl, Armin Hansel, *Colorado State University*

Volatile organic compounds (VOCs) and semivolatile and intermediate-volatility organic compounds (S/IVOCs) can undergo oxidative aging to form lower-volatility compounds that can then participate in secondary organic aerosol (SOA) formation. Recent studies have shown that a portion of SOA species are major contributors to nucleation and growth in many regions of the atmosphere. The majority of studies on SOA formation have focused on determining the SOA potential of single SOA-precursor VOC (e.g. α-pinene) rather than ambient mixtures of VOCs and S/IVOCs; furthermore, many of these studies have used “smog” chambers, which are highly susceptible to losses of both particles and vapors to the walls. The oxidation flow reactor (OFR) was developed in order to both study the SOA potential of ambient air and minimize wall losses by using a short residence time. OFRs can simulate high and variable oxidant concentrations, with the aim of simulating days to weeks of atmospheric aging in ~2-4 minutes. OFR studies to date have focused on aerosol mass and aging. In this presentation, we discuss the nucleation, growth, and size-distribution dynamics from an OFR deployed at the 2011 BEACHON-RoMBAS campaign in a ponderosa pine forest of Colorado, USA. This is, to our knowledge, the first time particle size distributions have been examined from an OFR study. We show that in order to model the evolving distributions, gas-phase fragmentation of the lowest-volatility species, heterogeneous chemistry, and diffusion limitations at larger particle sizes must be considered along with nucleation, condensation, and coagulation. We explore the parameter spaces of the rate constants of nucleation, OH oxidation, gas-phase fragmentation, heterogeneous chemistry, and diffusion limitations in order to determine what set(s) of parameters are best able to simulate the OFR size distributions.

10MO.3

Enhanced Characterization of Particle Size Distribution in the Community Multiscale Air Quality Model (CMAQ): A Case Study of Commercial Aircraft Emissions.

HUANG JIAOYAN, Lakshmi Pradeepa Vennam, Benjamin Murphy, Francis Binkowski, Saravanan Arunachalam, *University of North Carolina, Chapel Hill*

Currently, the Community Multiscale Air Quality Model (CMAQ) treats particles size distribution without considering variations in particle size distribution (PSD) from individual emission sectors. Individual source sectors have varying PSD, and having a constant PSD for all source sectors might lead to uncertainties in predicted aerosol characteristics – number and mass concentrations. Prior work has shown that ultrafine particles (UFP) mass concentrations are underestimated from emissions in current CMAQ configuration. In this study, a new CMAQ module was developed to read particle emissions from a specific sector, and treat its PSD separately. Impacts on ambient particulate matter due to commercial aircraft emissions in North America were investigated using this new module, and based upon information on aircraft emissions characteristics from engine measurement campaigns. Three scenarios were simulated: nonaircraft (all anthropogenic and biogenic emissions except aircraft emissions), base (nonaircraft and aircraft emissions with uniform particle size distribution called the default configuration), and sensitivity (nonaircarft and aircraft emissions with two different PSDs) scenarios. Total and aircraft attributed number concentrations of UFP are improved using this new CMAQ module. Number concentrations of UFP dramatically increase in the immediate vicinity of the airport locations due to changes in aircraft emitted PSD. Number concentrations of UFP in LAX from sensitivity scenario are 5.2 times higher than from nonaircraft scenarios. This finding matches the observation in recent field measurements of UFP due to aircraft emissions. Although mass concentrations in accumulation modes in airports were marginally lower, values in UFP were higher in sensitivity than in base scenarios. This study is the first CMAQ-based study to look into ambient particle matter impacted by PSD changes in emissions from an individual source sector. Shifting particles to small size increases available surface areas which can impact deposition, aerosol chemistry and gas-particle partitioning processes. We will present results from this study focusing on UFP impacts both from US-wide aircraft activity as well as at individual large airports.

10MO.4

A Stability-based Inverse Model Applied to the General Dynamic Equation.

DANA MCGUFFIN, Peter Adams, Erik B. Ydstie, *Carnegie Mellon University*

The goal of this work is to use measured aerosol size distributions to constrain atmospheric box model simulations of aerosol microphysics based on the general dynamic equation. We use a zero-dimensional version of the TOMAS microphysical code to model size-resolved aerosols as they undergo emission, nucleation, condensation, coagulation, and deposition to the surface. Such measurements of aerosol mass and number distributions are available at several ground sites. Measured size distributions implicitly contain a great deal of information about microphysical processes such as nucleation, primary emissions, and condensational growth rates and are generally used to validate models. This is usually done through sensitivity analyses in forward models in which tuning factors or model parameters are systematically adjusted until the model reproduces a measured distribution of aerosols. However, a more robust way to do this is to generate and run an inverse model.

In general, inverse models are used to constrain uncertain processes based on a set of measurements. Inverse models usually minimize a cost function related to the least-squares error by linearizing the forward model. However, inverse modeling of aerosol microphysics is challenging since it involves nonlinearities that span large spatial and temporal scales. This work develops a new, stability-based inverse modeling technique that is not computationally intensive and rigorously accounts for nonlinear dynamics.

Here, we present the development of the inverse modeling technique and preliminary applications to representative aerosol size distributions. Parameters tuned by the inverse model include those that are highly uncertain in atmospheric applications: nucleation rates, growth rates due to organic condensation, and primary emissions. The methodology developed here will facilitate future work that estimates uncertain parameters in a global model based on a measurement network.

10MO.5

Quantifying the Contribution of Primary and Secondary Emissions to Ultrafine Particle Contributions in the United States with the Regional Chemical Transport Model.

BENJAMIN MURPHY, Francis Binkowski, Ekbordin Winijkul, Tinja Olenius, Ilona Riipinen, Matthew Alvarado, Matthew Woody, Havala Pye, *United States Environmental Protection Agency*

Both direct particle emissions and secondary formation and growth from vapor precursors are responsible for increasing ultrafine particle (UFP) concentrations and have impacts on aerosol properties (e.g. bulk surface area). We have updated the Community Multiscale Air Quality (CMAQ) model with new algorithms and data to investigate the contributions of gaseous and particulate sources to UFP concentrations throughout the US.

In a traditional model, new particle formation (NPF) events rely principally on sulfuric acid, charged ions and, more recently, a stabilizing molecule (e.g. NH3, amine, etc) to begin. However, evidence shows that organic compounds are capable of participating with sulfuric acid or, when sulfuric acid concentrations are low, forming particles on their own. Moreover, organic vapors drive the growth of particles to larger sizes in many environments. The new aerosol processing module in CMAQ is designed for robust prediction of particle number sources, sinks, and concentrations, while leveraging the speed and flexibility of modal aerosol techniques, and including state-of-the-art schemes for treating new particle formation (e.g. Atmospheric Cluster Dynamics Code). We have also updated the parameterization of aerosol emissions from a single-distribution approach to a rich dataset of multiple distributions with dependencies on emission source, technology, and fuel.

We apply the new model to observations made throughout the US including California, the mountain west, the southeast US and the northeast US. This combination of sites allows us to characterize the model in urban, suburban, and rural locations, among which the drivers of UFP concentrations are expected to change dramatically. We then quantify the spatio-temporal variation in the contribution of primary/secondary sources to particle number and surface area, two metrics thought to be important for connecting particulate pollution to human health impacts. This exercise improves our understanding of the most effective ways to mitigate the highest UFP concentrations in the US.

10UA.1

Understanding of the Chemical Processes Involving Nitro- and Oxy-PAHs in Ambient Air and Evaluation of SOA PAH Contribution on PM via Annual and Intensive Field Campaigns.

ALEXANDRE ALBINET, Sophie Tomaz, Deepchandra Srivastava, Grazia-Maria Lanzafame, Olivier Favez, Clément Bret, Jean-Luc Jaffrezo, Jean-Luc Besombes, Nicolas Bonnaire, Valérie Gros, Laurent Alleman, Franco Lucarelli, Emilie Perraudin, Eric Villenave, *INERIS*

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous compounds emitted by all combustion sources. They are of major health concern because of their toxic properties and are therefore, regulated pollutants in ambient air. In the atmosphere, PAH oxidation through homogeneous and heterogeneous reactions may lead to the formation of oxy- and nitro-PAHs. These latter species are also emitted concomitantly with PAHs during incomplete combustion processes. Oxy- and nitro-PAHs are potentially more toxic than their parent PAHs. The identification of the origins of oxy- and nitro-PAHs is challenging, due to the coexistence of their primary and/or secondary sources. These species are also of prime interest because they are, typically part of the secondary organic aerosol (SOA) generated from gaseous PAH oxidation, which is significant in urban environments.
Based on ambient air field observations, the objective of this work is to better understand the chemical processes involved in the formation of nitro- and oxy-PAHs, their sources and to identify specific molecules that could further be used as molecular markers of PAH oxidation and SOA formation.

Field measurements were performed at both locations in France (Grenoble, 2013 and at the SIRTA station, 2015 (25 km SW from Paris)) over 1 year with samplings, every third day, of the gaseous and particulate (PM_{10}) phases. Intensive observations at SIRTA have been also performed with PM_{10} samples collected every 4-hour during a period of severe PM pollution event (PM>50 $\mu g\ m^{-3}$for several days) in March 2015, concomitantly with online measurements (e.g. ACSM, 7λ-Aethalometer).

The study of the occurrence of nitro-, -oxy and parent PAHs in the atmosphere, the seasonal and diurnal variations of their concentrations and substance patterns and the assessment of the cancer risk induced by these compounds have been performed. Based on these observations combined with literature knowledge and an extended aerosol chemical characterization, specific molecules of PAH oxidation have been identified. These substances were then used in source-receptor models such as positive matrix factorization (PMF) to apportion the SOA contribution from PAH oxidation on PM_{10} mass.

10UA.2

Size-Resolved Ultrafine Particle Concentrations near Busy Roadways: A Decade of Diameter Data. NATHAN HILKER, Cheol H. Jeong, Jon M. Wang, Kelly Sabaliauskas, Greg J. Evans, *SOCAAR, University of Toronto*

In large metropolitan areas such as Toronto, Canada, sizable portions of residents live within close proximities to major roadways. Exposure to high levels of traffic-related air pollution is a risk factor for a wide array of adverse health outcomes. One subset of these air contaminants, ultrafine particles (UFPs; particles with diameters less than 100nm), has garnered significant attention in recent years. While UFP concentrations in cities are often strongly related to traffic, the association is complex. Total UFP concentrations near roadways varies diurnally due to differences in traffic and meteorological conditions, as well as by season as temperature plays a critical role in nucleation and gas-to-particle partitioning dynamics. Separation of these shorter-term sources of variability allows resolution of long-term patterns reflective of the slowly evolving vehicle fleet in Toronto, as well as more stringent emission standards for the release of sulphur dioxide (SO2) from major industrial facilities.

In this study, UFP measurements were taken using two collocated instruments: a Scanning Mobility Particle Sizer (SMPS; TSI 3080), and a Fast Mobility Particle Sizer (FMPS; TSI 3091), at the Southern Ontario Centre for Atmospheric Aerosol Research (SOCAAR) in Toronto, Canada between 2006 and 2016. The objectives of this study were to 1) examine the long-term trends in UFP concentrations over the last decade, 2) infer the underlying causes of these changes in UFP concentrations, and 3) examine seasonal and diurnal variability. Using time series analysis and signal processing, the relationship between UFP, traffic volume, and meteorological parameters were examined. These long-term trends were compared with other commonly measured air pollutants (nitrogen oxides, NOx; carbon monoxide, CO; black carbon, BC; SO2; and particulate matter less than 2.5 microns in diameter, PM2.5), thereby showing the co-benefits of improved traffic emissions and control technologies over time.

10UA.3

Seasonal Variations and Possible Sources of Atmospheric HULIS in Urban Beijing, China. Xinghua Li, Junzan Han, Qing Chang, PHILIP K HOPKE, *Beihang University, Beijing China*

Beijing experiences some of the worst particulate air pollution in the world. Thus, understanding the nature of the particulate matter (PM) and its origins is important in the development of effective control strategies. In this study, samples of PM2.5 (particles with aerodynamic diameter less than 2.5 μm) that had been previously analyzed for routine compositional variables (elements, ions, organic and elemental carbon) were further analyzed to measure water-soluble organic compounds (WSOC) and humic-like substance carbon (HULISC). The seasonal variations of the WSOC and HULISC show strong peaks in the winter with lowest concentrations during the summer. There are strong correlations with primary pollutants such as elemental carbon, carbon monoxide, and sulfur dioxide and a weak correlation with ozone. Measurements were made of the emissions of WSOC and HULISC from typical emission sources including a heating stove fueled with wood, corn stover, and coal, as well as light- and heavy-duty vehicles. The relationships among the measured pollutants strongly suggest that there are substantial primary emissions of WSOC and HULISC. Coal combustion in residential stoves is widespread in the region with an estimate of 36 Tg of coal burned per year. The annual emission of HULIS from residential coal burning is estimated to be about 10 Gg with approximately two thirds of this primary HULIS being emitted during the heating season. This study suggests that much of the wintertime OC and sulfate are primary emissions with coal combustion being a major source.

10UA.4

Optical Properties of Aerosol at Different Altitude in Beijing: Based on Measurements at Ground Level and 260 m during 2016 Winter. CONGHUI XIE, Wei Du, Wei Zhou, Jian Zhao, Yingjie Zhang, Weiqi Xu, Qingqing Wang, Tingting Han, Junwang Wang, Yele Sun, *IAP*

Abstract. Despite extensive studies into optical properties of fine particle at ground level, comprehensive measurements above the urban canopy has never done before. Simultaneous measurements of physicochemical properties at ground level and 260 m and vertical optical properties in low boundary layer were conducted in urban Beijing during 2016 winter by a series of advanced optical instruments combined with two AMS (a High-Resolution Aerosol Mass Spectrometer and an Aerodyne soot particle-aerosol mass spectrometer) and an Aerosol Chemical Speciation Monitor. Our results showed that the average PM2.5 extinction coefficients are 471.5 Mm^{-1} and 383.8 Mm^{-1} at ground level and 260 m, respectively. Compared to the SSA at ground, the SSA at 260 m was slightly higher at night and comparable at day time. Higher values (~1.6) of absorption angstrom exponent were found in this campaign compared to the previously studies, which can be explained as the increase mass fraction of BBOA in PM1. The absorption coefficients at 630 nm of brown carbon were also investigated, which was found to be correlated very well with the mass concentration of BBOA, CCOA and MO-OOA. Similar temporal variations was found between PM1 and PM2.5 scattering coefficients at ground level, the average contribution of PM1 scattering coefficient to PM2.5 scattering coefficient was 62.5% and the average SSA of PM2.5 and PM1 were 0.81 and 0.86, respectively. The OA mass fraction of BC related PM1 was much higher than that of total PM1 (70% vs. 44%), but lensing effect of coating materials on BC was found to be more obvious as the mass fraction of SIA increase, indicating that in addition to the coating thick, the components of coating materials and aged degree may also have impact on the lensing effect. Further studies are needed to investigate the lensing effect and vertical optical properties.

Keyword: Optical properties; Black carbon; Brown carbon; Lensing effect

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10UA.5

Size-resolved Measurements of Water and Methanol-extracted Brown Carbon in Beijing. ZHENYU DU, Yuan Cheng, Jiumeng Liu, Shuping Dong, Ting Zhang, Yuwu Li, *CNEAC, China*

Contribution of light-absorbing organics, namely brown carbon, to total light absorption budget of atmospheric particles was of crucial importance for estimating the climatic effect of atmospheric particles. However, direct measurement of light absorption of brown carbon was still elusive. In this case size-resolved atmospheric particulate matter was collected in Beijing during April of 2016 using a cascade impactor. Solution light absorption spectra of both water and methanol-extracted brown carbon were measured with a UV-Vis spectrophotometer equipped with Liquid Waveguide Capillary Cell, and water-soluble organic carbon (WSOC), organic and elemental carbon (OC and EC) were analyzed. Meanwhile, light absorption of atmospheric fine particle was observed with a multi-angle absorption photometer (MAAP). Size distribution of absorption of water and methanol extracts both exhibited significant temporal variations. In days with severe air pollution, the absorption of water and methanol extracts mostly peaked between 0.18-0.56 μm (aerodynamic mean diameter), while in days with fine air quality the light absorption also peaked around an aerodynamic mean diameter of 1.8 or 2.5 μm. However, the mass absorption efficiency of water and methanol extracts were highest with aerodynamic mean diameter between 0.18-0.56 μm. Absorption refractive indices were calculated for water and methanol extracts of particles with aerodynamic mean diameter below 2.5 μm based on their solution light-absorption properties, and Mie theory was applied to estimate the light absorption of atmospheric particles comprised of water and methanol-extracted brown carbon, assuming brown carbon and other components of particles were externally mixed. It was found that the contribution of brown carbon absorption predicted by Mie theory to total fine particle light absorption slightly dropped when the absolute absorption of brown carbon increased during April of 2016 in Beijing. Generally, the absorption of brown carbon contributed about 30% to total fine particle absorption at the wavelength of 365 nm, similar with the result of another research in Atlanta and Yorkville, indicating an important role of brown carbon played on radiative forcing.

11AC.1

The Importance of Particle History When Exploring Particle Phase, Viscosity, and Structure within Individual Organic-Inorganic Mixed Particles Using Microscopy and Spectroscopy.

ANDREW AULT, Amy Bondy, Rebecca Craig, Sydney Niles, Nicole Olson, *University of Michigan*

Recent work has shown that atmospheric aerosols with secondary components, such as secondary organic aerosol (SOA) and ammonium sulfate, are frequently not in a well-mixed aqueous state at thermodynamic equilibrium. The presence of viscous or glassy aerosol, efflorescence/deliquescence behavior, and liquid-liquid phase separations have been shown experimentally in the atmosphere and through laboratory studies, along with global model simulations. These non-equilibrium states can challenge many assumptions about aerosol behavior, such as limited diffusion impacts on heterogeneous and multiphase reactions. Herein, we focus on the behavior of organic-inorganic mixtures, such as SOA and ammonium sulfate as a function of relative humidity (RH) using both ambient samples and model systems to probe changes to structure and viscosity. This is probed using established methods, such as scanning electron microscopy with energy dispersive X-ray spectroscopy (EDX), and novel methods for studying atmospheric aerosols including atomic force microscopy with infrared spectroscopy (AFM-IR) and Raman microspectroscopy. By varying how aerosols are generated, studying particles formed during different atmospheric conditions, and cycling RH, insights into how particles change in the atmosphere have been obtained. Specifically, these measurements and experiments show that particle history plays an important role in determining phase and structure, and that it is not safe to assume that particle behavior is reversible after changes in RH. This has important implications for processes such as SOA formation, heterogeneous reactions, cloud droplet and ice crystal nucleation. Further measurements are needed to create a framework that can account for these non-equilibrium and non-reversible processes.

11AC.2

Global Distribution of Particle Phase State in Atmospheric Secondary Organic Aerosols.

MANABU SHIRAIWA, Ying Li, Alexandra Tsimpidi, Vlassis Karydis, Thomas Berkemeier, Spyros Pandis, Jos Lelieveld, Thomas Koop, Ulrich Pöschl, *University of Calfornia, Irvine*

Secondary organic aerosols (SOA) are ubiquitous in the atmosphere. The phase state of SOA is important for their effects on climate and air quality, but its global distribution is poorly characterized. Our analysis of SOA phase state builds on the molecular corridor approach, which is a two-dimensional framework of volatility and molar mass of SOA components constrained by boundary lines of low and high molecular O:C ratio. We developed a method to estimate glass transition temperatures based on the molar mass and molecular O:C ratio of SOA components, and we used the global chemistry climate model EMAC with the organic aerosol module ORACLE to predict the phase state of atmospheric SOA. For the planetary boundary layer, global simulations indicate that SOA are mostly liquid in tropical and polar air with high relative humidity, semi-solid in the mid-latitudes, and solid over dry lands. We find that in the middle and upper troposphere SOA should be mostly in a glassy solid phase state. Thus, slow diffusion of water, oxidants, and organic molecules could kinetically limit gas-particle interactions of SOA in the free and upper troposphere, promote ice nucleation and facilitate long-range transport of reactive and toxic organic pollutants embedded in SOA.

11AC.3

Formation and Properties of Secondary Organic Aerosol Particles Generated by Ozonolysis of β-Caryophyllene with and without the Presence of Gas-phase Pyrene. David Bell, Kaitlyn J. Suski, Dan Imre, ALLA ZELENYUK, *Pacific Northwest National Laboratory*

Sesquiterpenes are an important class of biogenic volatile organic compounds (BVOCs) with a high potential to form secondary organic aerosol (SOA). However, the formation and properties of SOA particles formed from the oxidation of sesquiterpene has received significantly less attention compared to other BVOCs, such as monoterpenes. Studies by our group, and others, have shown that at low relative humidity (RH) α-pinene SOA particles are highly viscous semi-solids with viscosity of ~10^8 Pa·s, characteristic of tars, and their evaporation rates are orders of magnitude slower than previously assumed. We have also shown that when hydrophobic organic vapors, like polyaromatic hydrocarbons (PAHs) are present during SOA formation and growth their presence significantly affects particle number concentrations, mass loadings, composition (i.e. fraction of non-volatile components, like oligomers), evaporation kinetics, and viscosity. We will present the results of a recent study focused on the formation and properties of SOA particles formed by ozonolysis of β-caryophyllene with and without the presence of gas-phase pyrene. We find that β-caryophyllene SOA particles formed with or without pyrene are composed of 80% of non-volatile products and are initially spherical. However, with time these particles coagulate to form aspherical particles, which in the case of "pure" β-caryophyllene SOA coalesce within 20 min, yielding viscosity of ~2 x 10^8 Pa·s. In contrast, coagulated β-caryophyllene SOA particles formed in the presence of pyrene do not coalesce, even after more than a day, yielding estimate of a viscosity greater than 3 x 10^{10} Pa·s. Preliminary data indicate that at ~60% RH, 30% of the particle volume evaporates in 24 hours and coalescence rates become faster, such that particles formed in the presence of pyrene become spherical after 360 min, yielding a viscosity of 7 x 10^9 Pa·s. Moreover, we find that the presence of pyrene during β-caryophyllene SOA formation results in three-fold higher number concentrations and mass loadings, compared with "pure" β-caryophyllene SOA.

11AC.4

Diel Variations in the Phase State of Atmospheric Aerosol in a Mixed Forest: The Role of Molecular Composition and Liquid Water. JONATHAN SLADE, Alexander Bui, Ryan Cook, Amy Bondy, Sarah Desrochers, Rebecca Harvey, Jenna Ditto, Drew Gentner, Kerri Pratt, Andrew Ault, Robert Griffin, Brandon E. Boor, Giuseppe Petrucci, Paul Shepson, *Purdue University*

Phase state is a fundamental but poorly quantified physical property of atmospheric aerosol particles that influences reactive uptake and partitioning of trace reactive gases and semi-volatile compounds, ultimately affecting the lifetime, optical, and cloud condensation/ice nuclei activation properties of aerosol. Secondary organic aerosol (SOA) represents a significant fraction of the total global aerosol budget and exhibits different amorphous phase states that range from solid to semisolid and liquid particles, which change in response to the ambient relative humidity and temperature. While recent studies have shown that the phase state of SOA can vary regionally and as a function of altitude, whether particle phase state varies on a diurnal basis is currently unknown. Here we present an analysis of the nighttime and daytime particle phase state of aerosol particles sampled in a mixed deciduous/coniferous forest. To elucidate particle phase state, continuous one hertz measurements of particle bounce factors were made below the forest canopy during the summer of 2016 as part of the Atmospheric Measurements of Oxidants Study at the PROPHET research site in northern Michigan. A maximum in particle bounce was generally observed overnight and a minimum in the early afternoon and appears to be a strong function of both molecular composition and ISORROPIA-estimated aerosol liquid water (ALW). The morphology and phase state of individually impacted particles, determined by atomic force microscopy, show reasonable agreement with the measured bounce factors. During periods of significant biogenic influence, the mostly organic particles, determined by aerosol mass spectrometry (AMS), exhibited the largest bounce factors. In contrast, particles sampled from anthropogenically-impacted air masses generally contained more ALW and exhibited less bounce. No significant dependence on AMS-derived O:C was observed. In general, more ALW content corresponded to an overall decrease in particle bounce. However, while calculated ALW concentrations were generally greatest overnight, the overnight maximum and daytime minimum in particle bounce suggests a potentially significant dependence on particle molecular properties other than ALW. We will discuss the potential influence of variations in the average particle molar mass, based on a more detailed analysis of particle molecular composition using a suite of high-resolution mass spectrometric techniques, with preliminary results suggesting influence of predominantly larger molecular weight monoterpene-derived SOA products overnight and smaller isoprene-derived SOA products during the day.

11AC.5

Probing the Microphysical Properties of Single Secondary Organic Aerosol Particles. GRAZIA ROVELLI, Young-Chul Song, Kelly Pereira, Jacqueline F. Hamilton, David Topping, Jonathan P. Reid, *University of Bristol*

Secondary Organic Aerosols (SOA) can reach highly viscous and glassy states at certain RH and T conditions. This phase state can produce possible kinetic limitations to the gas-particle partitioning of semi-volatile organic compounds (SVOCs), which can affect the chemical composition and the size of SOA in the atmosphere, their CCN and ICN activity, their hygroscopic and optical properties and eventually their effects on climate.

The representation of SOA in atmospheric models needs to be improved and could greatly benefit by a systematic investigation of microphysical properties and the dynamic response of SOA to external changes in T and RH, including their dependency on temperature. Here we present a comprehensive experimental approach that will provide further insight on the volatility, on the formation of liquid-liquid phase separation and inhomogeneity in chemical composition, the hygroscopic and optical properties of single SOA particles deriving from various volatile precursors, together with correlations between the formation conditions of SOA (VOC precursor, NOx and VOC concentration, RH), the resulting chemical composition and microphysical properties.

In this work, SOA is formed in a flow reactor (300 L polyvinyl fluoride bag, controlled VOC and oxidant concentrations, controlled RH, University of York) from different precursors (e.g. α-pinene, limonene, β-caryophyllene, toluene). SOA particles are then sampled with an electrical low pressure impactor and fully extracted for offline analysis with a 1:1 mixture of ethanol and water. An extensive characterisation of the chemical composition of the collected samples can be performed (UPLC-UV/Vis-UHRMS, NMR, elemental analysis, ATR-FTIR) and the microphysical properties of individual charged SOA aqueous droplets can be investigated using an electrodynamic balance (EDB, University of Bristol), at variable RH and T conditions (0 to >90% RH, -25 to 50°C).

11HA.1

Critical Evaluation of Air-Liquid Interface Cell Exposure Systems for in Vitro Assessment of Atmospheric Pollutants. JOSE ZAVALA, Mark Higuchi, *EPHD, NHEERL, U.S. EPA*

Conventional *in vitro* exposure studies of airborne pollutants involve, for example, the addition of particulate matter (PM) or PM extracts to the cell culture medium, or the bubbling of gases into the culture medium; these methods alter the pollutant's physical and chemical characteristics. Exposing cells at the air-liquid interface (ALI) mimics a more realistic cell exposure due to the direct pollutant-to-cell interaction. We compared various ALI *in vitro* exposure systems under identical conditions for their ability to expose cells to particles and gases. The systems tested used different mechanisms to deliver aerosols, vapors, and gases to the cells: diffusion, sedimentation, thermophoresis (THP), and electrostatic precipitation (ESP). We used fluorescent polystyrene spheres (50-1000 nm) as a surrogate for particulate matter to assess particle deposition. Deposition was determined by dissolving the spheres in ethyl acetate and measuring the fluorescence. Applying external forces, such as THP or ESP, enhanced deposition for all particle sizes. For example, deposition was 3-fold higher with THP compared to diffusion. Similarly, deposition was 3- to 6.5-fold higher with ESP compared to diffusion, depending on particle size and *in vitro* system. We also assessed the ability of the systems to deliver gases to cells by using ozone (O_3) as a test gas. The reaction of O_3 with an indigo dye at the ALI surface showed that diffusion allowed gas-cell interaction. Increasing the flow rate in diffusion systems where air flow was perpendicular to the cells increased gas delivery. Our study showed that *in vitro* systems with THP or ESP were the most effective at delivering aerosols to the cells, whereas flow rate was a critical parameter for the delivery of vapors and gases. [Abstract does not necessarily reflect the views or policies of the U.S. EPA.]

11HA.2

Recommendations for Reducing CFD Model Variability and Matching Experimental Data When Simulating Microparticle Deposition with Two-Equation Turbulence Models.

KARL BASS, Worth Longest, *Virginia Commonwealth University*

When modeling flow through the respiratory tract, two-equation turbulence models provide several advantages over more complex models, which include computational efficiency, mature model development, and successful in vitro and in vivo validations in previous studies. However, CFD models often require several iterations of parameter selection before capturing experimental aerosol deposition data. This study aims to determine both mesh and CFD solution parameters that enable the accurate simulation of microparticle deposition under flow conditions consistent with the upper respiratory airways, including turbulent flow, evaluated in a model 90-degree bend system. First, parameters that control the near-wall cell layers are manipulated to produce four distinctly different meshes, which vary from settings that are ideal for the nasal cavity to the recommended industry standard. A range of CFD models and their parameters are then applied to these meshes, including spatial discretization schemes, wall roughness, and anisotropic turbulence correction. Both hexa- and tetrahedral meshes are evaluated, with tetrahedral meshes being more suitable for intricate and detailed airway geometries. The results are compared to evaluate which CFD model parameters produce the least amount variability between the meshes, with the intention of reducing the variability in the meshes of complex geometries. Focus is applied to analyzing the near-wall turbulence kinetic energy, as this drives deposition by turbulent dispersion. Finally, numerical results are compared with experimental data available from the literature for a range of microparticle sizes from 1 to 7µm. The recommendations provide a good match between numerical and experimental microparticle deposition results for Stokes and Reynolds numbers that are similar to the transport of pharmaceutical aerosols through the upper airways. Applying these recommendations to future CFD models of the respiratory tract will reduce the effort that is required to capture respiratory aerosol deposition.

11HA.3

Quantifying Inter-individual Variability in Nasal Filtration of Nebulized Micron-sized Particles as a Function of Nasal Anatomy using Computational Fluid Dynamics.

Azadeh Borojeni, John Rhee, GUILHERME GARCIA, *Medical College of Wisconsin*

Background: Pharmaceutical aerosols are often used to treat nasal diseases, such as nasal airway obstruction (NAO) and chronic rhinosinusitis (CRS). Inter-individual differences in nasal anatomy are expected to have a significant impact on the dose of nebulized medication that reaches each region of the nasal cavity. However, the relationship between inter-subject variability in nasal anatomy and intranasal doses of inhaled medications remains poorly understood.

Objectives: The goal of this study is to develop a quantitative understanding of how inter-individual variations in nasal anatomy lead to inter-individual differences in nasal deposition of nebulized micron-sized particles.

Materials and Methods: Three-dimensional models of the human nasal cavity were created from cone beam computed tomography (CBCT) and medical CT scans representing 27 healthy subjects and 15 patients with NAO. The paranasal sinuses were excluded under the assumption that they have a minimal impact on airflow in the main nasal cavity. Tetrahedral meshes with 4 prism layers were created with ~4 million cells. Nasal airflow was modeled as laminar. The deposition of spherical particles with aerodynamic diameters d_a = 1-30 µm was studied for a steady-state inhalation rate of Q = 15 L/min.

Results: Our numerical results confirmed that particle deposition in the human nasal cavity is dominated by inertia with 1µm particles having <10% deposition, while 30µm particles have nearly 100% deposition in all individuals. Substantial inter-individual variability was observed for particle sizes 5µm to 20µm. For example, the deposition efficiency of 10µm particles varied from 10% to 100% among individuals. NAO patients had higher intranasal doses than healthy subjects. Unilateral nasal deposition efficiency (DF) nearly collapsed onto a single curve when the data for all subjects was plotted as function of the modified impaction parameter IP = $d_a^2\Delta p$, where Δp is the transnasal pressure drop.

Conclusions: Inter-individual variations in nasal filtration of micron-sized particles can be mostly attributed to inter-individual variations in transnasal pressure drop (i.e., nasal resistance to airflow).

11HA.4

Progress in the Development of a Complete-Airway Computational Fluid Dynamics (CFD) Model for Pharmaceutical Aerosols. WORTH LONGEST, *Virginia Commonwealth University*

Computational fluid dynamics (CFD) provides a powerful technique to capture the complex physics of pharmaceutical aerosol delivery. Complete-airway CFD simulations can provide highly detailed results of regional and local aerosol dosimetry, leading to new insights in the performance of current inhalers and the development of new respiratory drug delivery strategies. However, both complete-airway CFD simulations and comparisons of CFD simulations with in vivo data are rare. At Virginia Commonwealth University, we have been developing a complete-airway CFD model of pharmaceutical aerosol delivery for over a decade. Simulations begin at the site of aerosol formation in the inhaler and include all lung regions from the nasal or oral cavity through the alveoli. Use of CFD enables direct incorporation of factors that are important for the deposition of pharmaceutical aerosols including inhaler jet or spray momentum, interaction between the inhaler and mouth-throat geometry, inhalation waveform, airway wall motion, turbulence, heat and mass transfer, charge effects, and droplet size change due to condensation or evaporation including hygroscopicity. Model results in the upper airways have been extensively validated with concurrent in vitro experiments for multiple inhaler types. Recently, complete-airway model results for multiple inhalers across a range of inhalation waveforms were compared with in vivo gamma scintigraphy data in humans. Regional comparisons with 2D gamma scintigraphy included the inhaler, mouth-throat, upper conducting airways (bifurcations B1-B7) and peripheral airways (bifurcations B8 through alveoli). For both a dry powder inhaler (DPI) considered at multiple flow rates (which influence the polydisperse aerosol size distribution) and a soft mist inhaler (SMI), complete-airway predictions across all regions of interest were within approximately 10% of the in vivo data. Based on these findings, complete-airway CFD simulations of pharmaceutical aerosol delivery are possible, compare well with in vivo data, and provide a valuable tool for drug development and toxicological applications.

11HA.5

Multi-component Droplet-Vapor Interaction in a Realistic Human Whole-Lung Airway Model. ARUN V KOLANJIYIL, Clement Kleinstreuer, *North Carolina State University*

Respiratory drug delivery is becoming an increasingly popular way of administering medicine. In many cases validated computer simulations can be useful for establishing guidelines for effective treatment of both adverse pulmonary and systemic conditions. However, the sheer complexity of the human lung, featuring a total of 16 million tubular airways, prohibits detailed computer simulations of the fluid-particle dynamics for the entire respiratory system. Thus, in order to obtain realistic and accurate particle deposition results, a new modeling approach is necessary where the whole-lung geometry is approximated with physiological boundary conditions which simulate actual breathing. So, a whole-lung-airway model (WLAM), covering the entire human lung was developed by using any subject-specific human upper airway followed by triple bifurcation units both in series and parallel. Physiologically breathing modes were implemented via realistic expanding and contracting motion of the alveoli. The airflow and particle transport through the lung airways were successfully validated with in vivo and in vitro data sets. As a practical application, the fate of inhaled multi-component droplets and associated vapors emanating from an inhaler (e.g., a pMDI or nebulizer) was simulated and analyzed. Specifically, in the upper airways the transport of these droplets was modeled with hygroscopic growth during droplet–vapor interaction. In the lower airways, where the droplets are in equilibrium with the vapor, transport and deposition of these droplets were simulated, neglecting droplet–vapor interactions. The computer simulation results provide critical insight to and quantitative information of drug-aerosol deposition in the human whole-lung airway model. In summary, WLAM can predict inhaled therapeutic (or toxic) multi-component aerosol deposition. It is also useful for establishing inhaler-design guidelines to improve drug-aerosol delivery.

11IM.1

A New Electrical Particulate Matter Sensor (eM Sensor). DI LIU, Da-Ren Chen, *Virginia Commonwealth University*

Miniature optical sensors are widely used to measure the mass concentration of particulate matter (PM) because of their simple configuration and low cost. The readout of optical PM sensors are, however, highly depended on the physical and chemical property of sampled PM. PM monitors based on the electrical principle are also available. The readouts of these electrical PM monitors are either based on an empirical signal-to-PM-mass-concentration correlation or algorithms with the assumed lognormal particle size distribution.

In this work, a new electrical PM sensor had been designed and its performance has been evaluated. The prototype in general consists of a corona-based aerosol charger and a precipitator. Different from existing electrical PM sensors, the signal of prototype eM sensor is directly proportional to the volumetric concentration of spherical particles. In addition to the overall performance evaluation, the performance of the charger and precipitator are individually studied. The detail of our experimental data collected will be presented in the conference.

11IM.2

Implications for the Sampling System in Extending Automotive Particle Regulations Below 23 nm. First Results of the DownToTen Project. PANU KARJALAINEN, Jorma Keskinen, Markus Bainschab, Alexander Bergmann, Athanasios Mamakos, Jonathan Andersson, Barouch Giechaskiel, Leonidas Ntziachristos, Zissis Samaras, *Tampere University of Technology*

We present the objectives, the impacts and first experimental results of the Horizon 2020 Green Vehicle project “DownToTen”. This project is developing a robust methodology that will enhance the regulatory approach towards particle number emissions in the sub-23 nm region. The focus is on the newest generations of direct injection gasoline and diesel engines under real world conditions. Based on detailed investigations of the nature and characteristics of these particles, DownToTen is evaluating a variety of sub-23 nm PN measurement instruments and sampling approaches, using rigorous criteria under conditions of challenging aerosol from a variety of sources. The objective is a PN-Portable Emission Measurement System (PEMS) demonstrator with high efficiency in determining PN emissions of current and future engine technologies in the real world, including the sub-23 size fraction.

The first direction of research is to design a sampling system with minimized losses for nanometre-sized particles and the potential to be used for on-board measurements. Important factors like robustness against artefacts (re-nucleation, growth of subcut particles), losses of (solid) particles, storage/release effects of gas phase compounds are assessed in detail by multiphysical simulations and laboratory-scale experiments. Special attention is drawn to losses of secondary aerosol precursors within the primary dilution stage.

This paper presents the selection of the setup’s components (primary and secondary dilution stage, conditioning system, mixing elements, measurement devices) in order to meet the aforementioned criteria are based on experimental and theoretical data. The success in meeting these criteria is evaluated by comparing the sampling setup to commercial PMP reference system. Critical components are discussed in detail. CFD simulations and particle penetration optimizations based on the simulation results are also presented.

11IM.3

Efficient and Improved Processing of Chromatographic Data Using Peak Fitting and Deconvolution. GABRIEL ISAACMAN-VANWERTZ, Donna Sueper, Brian Lerner, Kenneth Aikin, Jessica Gilman, Joost de Gouw, Douglas Worsnop, Allen H. Goldstein, *Virginia Tech*

Decades of data on the composition of organic aerosol have been collected by using chromatography to measure the concentrations of individual components with molecular- and isomer-level specificity. However, the complexity of the ambient atmospheric organic mixture, and its tendency to contain many structurally and chemically similar compounds, challenges the separation and resolution of individual compounds. Consequently, processing chromatographic data from raw signal to integrated peak areas representing ambient concentrations requires substantial operator effort and is a “bottleneck” in analysis that decreases data quality, reduces instrument “uptime”, and increases costs. As advances in field-based instrumentation multiply the quantity and informational density of data generated, data processing will become a major limitation to collecting, analyzing, and interpreting chromatography data. We present here a new approach to processing chromatographic data that efficiently integrates chromatographic peaks by fitting idealized mathematical functions to both well-resolved and co-eluting peaks; this approach reduces analysis time by an order of magnitude. Peak fitting is shown to yield results comparable to traditional integration for 70,000 peaks representing a wide range of compounds measured by two different on-line instruments at four different locations. The quantitative parameters describing the fit (e.g. coefficients, residuals, etc.) are exploited to increase the efficiency of quality control, constrain integration of poor chromatographic peaks, and yield higher accuracy in the deconvolution co-eluting peaks than is possible by traditional methods. We will also explore additional opportunities to use these parameters to improve data analysis and use peak fitting to measure and analyze compounds that are otherwise un-resolvable or inaccessible. Current and planned implementation of the described approach for use by the broader community of atmospheric and environmental scientists will be discussed.

11IM.4

Evaluation of Sampling Artifacts in Phase Partitioning Measurements of Semi-Volatile Organic Compounds in Denuders. SUKRANT DHAWAN, Pratim Biswas, *Washington University in St Louis*

The partitioning of semi-volatile organic compounds (SVOCs) between gas and particle phase plays an important role in the formation of secondary organic aerosols (SOAs) in the atmosphere. However, it is not well understood due to the uncertainties and problems associated with the simultaneous sampling of both gas and particle phases. In the recent studies, semi-volatile thermal desorption aerosol gas chromatograph (SV-TAG) has been used for in situ measurements of organic compounds in both gas and particle phases. In SV-TAG, ambient air is sampled with and without the denuder installed at the sample inlet. The denuder removes gas phase from the sample stream and provides organic species in the particle phase. Whereas, the sample without denuder provides the total amounts of organic species present in inlet sample. However, there are potential artifacts associated with this sampling method. The removal of the gaseous species in the denuder distorts the gas-particle equilibrium and leads to dissociation of the particulate phase. This phenomenon is particularly true for volatile organic species and lead to significant error in determining gas-to-particle phase partitioning of organic aerosols due to underestimation of the particle phase.

In this study, a theoretical model for simultaneous gas diffusion and aerosol decomposition/evaporation in the parallel plate denuder[1] is developed to investigate the effects of denuder sampling artifacts on gas–particle partitioning measurements of semi-volatile organic compounds. We further studied the effect of the denuder design parameters and organic species properties, which may influence the evaporation of the particulate phase. It is observed that the decomposition of pyrene’s (SVOC) particulate phase in the denuder results in the substantial reduction in size of the particles smaller than 0.2 µm and results in the significant error in the phase partitioning measurements of SVOCs.

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11IM.5

A Miniature Ionic Wind Electrostatic Collector for Ultrafine Particles. RAVI SANKAR VADDI, Yifei Guan, Igor Novosselov, *University of Washington*

Exposure to fine and ultrafine particulate matter can cause significant health issues. Conventional particle monitors and collectors require an external pump for the air flow and are usually heavy, power consuming and difficult to use. We demonstrate a high-efficiency electrostatic collector that uses a needle and tube ionizer to charge the particles and at the same time provides electro-hydrodynamic (EHD) flow for sample aspiration. The charged particles are directed towards the inner surface of the collecting electrode (tube collector) by the electric field between the grounded collecting electrode and the high voltage corona needle. Additionally, a central repelling electrode is used to increase the particle collection. The corona voltage and repelling voltage are varied from 3kV-5kV and 0kV-1kV respectively to determine the optimized parameters for the device. For the optimal operating conditions, the collection efficiency of the device is greater than 90% for the range of 10-2000 nm corona voltage >3kV and repelling voltage - 1kV. In the absence of the repelling voltage, the collection efficiency of the PM2.5 is about 50%, while for the particles in 50-200 nm range is near 70%. The computational fluid dynamics (CFD) model for EHD flow is used to gain insight into flow patterns, particle trajectories. The CFD model couples the interactions between fluid mechanics, electrostatics, particle charging and particle transport mechanisms. The model shows excellent agreement with flow sampling rate and flow profiles at the exit of the electrostatic collector. The collection substrate and well-defined collection region allow for analysis of the collected particulate matter using multiple analytical methods.

11MO.1

Towards a Fuller Understanding of the Benefits of Aerosol Reductions. DREW SHINDELL, *Duke University.* INVITED

Emission reduction policies typically affect our environment in multiple ways, such as via altering climate change, air quality, water quality, and agricultural productivity, yet policies are often targeted at and evaluated for a single end point. I will discuss efforts to take an expanded view and consider multiple end points in formulation of emissions reduction policies, focusing in particular on climate change and air quality. Results relevant to both near- and long-term strategies will be presented, covering both US and international policy scenarios. I will emphasize human health and temperature responses to aerosol and aerosol precursor emissions, impacts that can be relatively well constrained. I will also report on ongoing research that endeavors to quantify the effects of aerosols on the hydrologic cycle, an effort that remains extremely challenging.

11MO.2

Effects of Aerosol Direct Feedback Effects on Surface Ozone and PM2.5 in Continental USA in 2005 by a Two-Way Coupled WRF-CMAQ Model. CHOWDHURY MONIRUZZAMAN, Jared Bowden, Saravanan Arunachalam, *University of North Carolina, Chapel Hill*

Aerosol or particulate matter (PM) in air scatters and absorbs radiation from sun which blocks incoming short-wave radiation reaching earth surface, known as aerosol direct effects (ADEs), thus affecting ozone (O3) photolysis reaction and surface temperature which in turn affects PM concentration. The changed PM concentration further affects chemistry and meteorology by ADEs through a feedback cycle. The aerosol direct feedback effects (ADFEs) are neglected in traditional air quality models (where meteorology is used as input and not affected by chemistry). In this study, a coupled Weather Research and Forecasting - Community Multiscale Air Quality (WRF-CMAQ) modeling system was used to determine the ADFEs on surface O3 and PM2.5 change as well as change of meteorological variables such as short-wave radiation (SWR) at surface, temperature at 2 m (T2) and planetary boundary layer (PBL) height in continental USA in a 36-km grid domain for the year 2005. The novelty of this new application is that the WRF fields were driven using the global-scale NASA's Modern Era Reanalysis for Research and Applications (MERRA) meteorological data. We found that ADFEs cause annual perturbation of domain average of O3 and PM2.5 by -0.4 ppb (daily range -23 to +22) and +0.28 micro-g/m3 (daily range -32 to +25) respectively in 2005 in continental USA. ADFEs perturb the meteorological variables: SWR, T2, and PBL (domain-wide annual average) by -7.37 W/m2, -0.47 K and -21 m respectively. We also found that as high as 60% of PM2.5 increases by the ADFEs during summer were caused by secondary organic aerosol increase. We extended this application to assess the incremental air quality impacts due to a single source sector – aircraft emissions during landing and takeoff (LTO) cycles – and found that ADFEs in this coupled WRF-CMAQ application decrease aircraft-attributable surface O3 and PM2.5 change by 21% and 23% respectively.

11MO.3

Large Reductions in Solar Energy Production Due to Dust and Air Pollution. MICHAEL BERGIN, Chinmay Ghoroi, Deepa Dixit, James Schauer, Drew Shindell, *Duke University*

Atmospheric Particulate matter (PM) diminishes solar energy production via several pathways: directly scattering and absorbing solar energy (direct effect), modifying cloud albedo and lifetime (indirect effect), and depositing to solar panel surfaces, thereby reducing solar energy transmittance to photovoltaics (PVs). This is particularly important in regions that experience high levels of wind-blown and/or fugitive dust emissions, as well as areas with poor air quality characterized by high PM levels. Worldwide solar energy production is expected to rapidly increase at a rate higher than any other renewable energy into the middle of this century, particularly in regions that experience high levels of dust and/or PM pollution including large areas of India, China, and the Arabian Peninsula. Here we combine field measurements and global modeling to estimate the influence of both ambient dust and PM related to anthropogenic sources (e.g. fossil and biomass fuel combustion) on the reduction of solar energy generation. We present measurements of the influence of deposited PM on solar panel transmittance in northwest India, and characterize the chemical components of the deposited particles including dust, as well as species linked with anthropogenic combustion sources including elemental carbon (EC), organic carbon (OC), and ionic species. Results indicate that in several key regions solar energy production is being reduced by ~ 17-25%, with roughly equal contributions from ambient PM and PM deposited to PV surfaces. Solar power reductions of ~21% are predominantly attributable to dust in the Arabian Peninsula, whereas N. India experiences comparable contributions from dust (9%) and anthropogenic PM (7%). In contrast, 15% of the 17% reduction in eastern China is due to ambient and deposited PM from anthropogenic sources. Based on current solar energy capacity PM is responsible for ~823 MW and ~7400 MW of solar power reduction in India and China, respectively, underscoring the role that PM plays in reducing solar power generation.

11MO.4

Impacts of New Particle Formation on Short-term Midwestern Meteorology and Air Quality as Determined by the NPF-explicit WRF-Chem. CAN DONG, Hitoshi Matsui, Scott N. Spak, Charles Stanier, *University of Iowa*

Nucleation is a frequently observed gas to particle conversion process. Results from the new particle formation (NPF) explicit WRF-Chem model show that PBL nucleation can induce the changes of both meteorology and air pollutants in the Midwestern US. Simulations are conducted for the period during a field campaign in Iowa in June-July 2008. The model has a horizontal resolution of 36 km and uses CBMZ and MOSAIC for gas-phase chemistry and aerosol modules, respectively. In general, simulations with NPF have more shortwave radiation, higher surface temperatures and a deeper boundary layer. NPF changes the timing and location of precipitation. Nucleation enhances the concentration of condensation nuclei. Meanwhile, cloud condensation nuclei (CCN) concentrations are enhanced and suppressed at high and low supersaturations, respectively. For air pollutants, the most pronounced influence of PBL nucleation is PM2.5 reduction, which is mainly caused by SO4 decrease. Sensitivity tests demonstrate that reductions in secondary sulfate (SO42-) via cloud processing of sulfur dioxide (SO2) are primarily responsible for SO4 reduction with the PBL nucleation parameterization. The interactions among nucleation, CCN, cloud droplets, aqueous chemistry and OH radicals are investigated. The missing features of NPF and NPF-cloud feedback present in all models that do not treat NPF, and in models with limitations in feedbacks of meteorology and nuclei particles, may have implications beyond CN and cloud brightness such as PM mass and composition.

11MO.5

Simulating the Evolution and Sources of Organic Aerosols Observed during the 2016 Holistic Interactions of Shallow Clouds, Aerosols, and Land-Ecosystems (HI-SCALE) Field Campaign. JEROME FAST, Larry Berg, Lizabeth Alexander, David Bell, Jiumeng Liu, Fan Mei, Siegfried Schobesberger, John Shilling, Stephen Springston, ManishKumar Shrivastava, James Smith, Joel A. Thornton, Jian Wang, Alla Zelenyuk, *Pacific Northwest National Laboratory*

We use the chemistry version of the Weather Research and Forecasting model (WRF-Chem) to simulate the regional-scale evolution of organic aerosols and their precursors observed during the Holistic Interactions of Shallow Clouds, Aerosols, and Land-Ecosystems (HI-SCALE) campaign. This campaign was conducted in north-central Oklahoma near the Department of Energy's Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site. The model predictions are compared with aerosol and aerosol precursor measurements from a research aircraft and a ground site, including those from High Resolution Time-of-Flight Aerosol Mass Spectrometers (HR-ToF-AMS), single particle mass spectrometers, chemical ionization mass spectrometers (CIMS), a proton transfer reaction mass spectrometer (PTR-MS), the Fast Integrated Mobility Spectrometer (FIMS), and Scanning Mobility Particle Sizer Spectrometers (SMPS). Other instrumentation characterized nanoparticle concentration, composition, and growth. Sampling was done during two month-long periods, one in the spring and the other in the late summer of 2016 to investigate how differences in biogenic emissions and meteorology affect new particle formation, anthropogenic enhancement of biogenic secondary organic aerosol, cloud condensation nuclei, and other aerosol properties in the region. The extensive field campaign measurements are used to evaluate aspects of the volatility basis set approach in representing SOA. The model is also used to identify anthropogenic, biogenic, and biomass burning sources of organic aerosols. In addition, we use the Large-Eddy-Simulation (LES) version of WRF-Chem to investigate how explicit and parameterized boundary layer mixing affects the vertical distribution of biogenic aerosol precursors and consequently SOA evolution.

11NM.1

Size Focusing of Metal Nanoparticles in Low-Temperature Plasma. NECIP BERKER UNER, Elijah Thimsen, *Washington University in St. Louis*

Gas phase synthesis methods constitute a major route to production of nanomaterials with high throughput. These methods usually employ a thermal environment, like a flame, a furnace or an arc to convert vapor or liquid precursors into nuclei. The consequent growth of nanoparticles is well understood by the aerosol community, where nucleation is followed by condensation, surface growth and coagulation. Although the thermal environment is flexible in terms of producing particles of various sizes and compositions, high temperatures favor coagulation and in most cases the broad self-preserving size distributions are obtained, leading to polydisperse particles and/or aggregates. Such products are valuable when high surface area is the desired parameter, as in the case of SiO_2 and TiO_2. However, for applications that require monodispersity, gas-phase methods fall behind when compared to colloidal methods.

In this work, we show that aerosols undergo unique transformations within a low temperature plasma. Upon sending a pre-generated polydisperse aerosol of metal nanoparticles into a low temperature plasma, we observed that the size distribution of the plasma-treated aerosol becomes significantly narrower, with a geometric standard deviation of less than 1.1. The mass yield was found to be as high as 65%. Although measured gas temperatures were below 120°C, particles were shown to vaporize at relatively low power inputs, due to bombardment by ions and electrons. We hypothesize that a mechanism, in which the resultant supersaturated vapor produces new particles by nucleation and re-condenses on the remaining fragments, is responsible for uniform growth. The uniformity of particle growth is assisted by the absence of coagulation due to unipolar charging in the plasma. This mechanism, which is unique since a polydisperse to monodisperse transformation is involved, is supported with a quantitative model of aerosol dynamics that involves nucleation, condensation, charging, sputtering and thermal evaporation. We will present the effects of particle material and inlet mass concentration. Ways of tuning the final size and increasing productivity will be discussed.

11NM.2

Surface-Enriched Zinc on Copper Particles Generated via Spray Pyrolysis. Ryan Felix, Joseph Repac, Afshan Urooj, Howard Glicksman, SHERYL EHRMAN, *University of Maryland College Park*

Copper has been considered as an inexpensive replacement for silver in electronic applications such as solar cell metallization, electromagnetic interference packaging, and printable electronics. However, copper oxidizes much easier than silver and copper oxidation is continuous rather than self-limiting. Recently our group has explored addition of a second metal to copper to promote formation of a sacrificial oxide barrier layer that would prevent continuous oxidation of copper. Here, we describe a single step spray pyrolysis process for formation of zinc-copper particles at compositions ranging from pure copper to 45 at% zinc. The resulting particles were enriched in zinc at the surface, determined with X-ray photoelectron spectroscopy combined with ion beam sputtering, even though the precursor consisted of a uniformly mixed aqueous phase mixture of zinc chloride and copper nitrate salts. No oxide phases were detected using X-ray diffraction. Also with X-ray diffraction, we observed the formation of an unexpected metal ammine chloride complex under certain reaction conditions. High reaction temperatures (1000 C) promoted formation of the target morphology, smooth dense particles formed by droplet to particle reaction.

11NM.3

Determination of Mass Mobility Exponent and Fractal Dimension of Crumpled Graphene Oxide Synthesized in a Furnace Aerosol Reactor (FuAR). SHALINEE KAVADIYA, Yao Nie, Pratim Biswas, *Washington University in St. Louis*

Crumpled graphene oxide (CGO) was synthesized to overcome the restacking issue of two-dimensional (2D) graphene oxide (GO) sheets. CGO has gained immense attention because of their dispersion as a single crumpled ball, their ability to encapsulate metal/metal oxide nanoparticles and make composite nanomaterials for various applications. CGO particles are mainly synthesized by aerosol-based processes, in which 2D GO sheets are aerosolized into droplets and dried either at room temperature[1] (in the case of small droplets generated by electrospray) or inside a furnace reactor at high temperature[2] (in the case of big droplets generated by nebulizer). Evaporation of the solvent imparts a capillary force on the GO sheet and induces crumpling. Until now, the mechanism of crumpling and the estimation of force required for GO crumpling has been explained based on the macroscale system such as paper and foils. However, the nanoscale system of GO sheets is significantly different from the macroscale system.

In this study, we synthesize the CGO particles using a furnace aerosol reactor and correlate the mass mobility of the CGO particles to their mobility size, physical size and the morphology (extent of crumpling). Mobility size of the particles is measured online using scanning mobility particle sizer (SMPS), then particles of a particular size are classified using differential mobility analyzer and passed through a centrifugal particle mass analyzer (CPMA) to measure the mobility mass. Finally, a size (and crumpling) - dependent mass mobility exponent is calculated. Crumpling of GO sheets depends on the various parameters such as, furnace temperature and GO concentration. We study the effect of these parameters on the mass mobility exponent. Since the expression of force required for crumpling also depends on the fractal dimension of crumpled particle, fractal dimension of CGO is measured using Small Angle X-ray Scattering (SAXS) technique. Finally, a relationship between the fractal dimension and the mass mobility exponent for CGO particles is derived.

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11NM.4

Coagulation of Agglomerates with Polydisperse Primary Particles from Free Molecular to Transition Regime. EIRINI GOUDELI, Georgios Kelesidis, Maximilian L. Eggersdorfer, Sotiris E. Pratsinis, *ETH Zurich*

Agglomeration of nanoparticles is encountered in both atmospheric and industrial processes as in volcanic plumes and aerosol manufacture of carbon black or fumed silica. Even though the dynamics of coagulating spherical particles, such as self-preserving size distribution (SPSD) and coagulation rate are reasonably well-understood, there is significant uncertainty for fractal-like agglomerates. For the latter, coagulation rates have been proposed, their mobility and SPSDs have been determined. All these have been confined to agglomerates with monodisperse primary particles (PPs). Realistic agglomerates, however, consist of polydisperse PPs.

Here coagulation of nanoparticles of varying PP polydispersity ($\sigma_{g,PP} = 1 – 3$) in the absence of coalescence, sintering or surface growth is investigated by a discrete element method (DEM) (Goudeli et al., 2015) from the free molecular (Goudeli et al., 2016) to transition regime. The effect of PP polydispersity on agglomerate size (radius of gyration, mobility radius and volume-equivalent radius), morphology (fractal dimension, D_f, mass mobility exponent, D_{fm}, and their prefactors) as well as on the attainment of the well-known asymptotic fractal-like structure ($D_f = 1.91$ and $D_{fm} = 2.15$) and SPSD is investigated. Increasing the polydispersity of the constituent PPs from $\sigma_{g,PP} = 1$ to 3 does not affect but only delays the attainment of the asymptotic D_f, D_{fm} and SPSD of the resulting agglomerates. Furthermore, the effect of PP polydispersity on agglomerate dynamics (coagulation rate and polydispersity) is elucidated quantitatively.

Such characteristics affect the environmental impact of agglomerates (climate forcing or visibility impairment by soot) or performance of gas sensors and catalysts.

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11NM.5

Controlling the Microphysical Processes Occurring During Droplet Drying. JONATHAN P. REID, Florence Gregson, Jim Walker, Rachael E.H. Miles, *University of Bristol*

Droplet routes to fabricate structured nano- and micro-structured particles are routinely used in processes such as spray drying. Starting from simple solute-solvent droplets or from more complex colloidal dispersions, the evaporative drying can lead to the formation of monodisperse crystalline, amorphous or porous particles of simple or complex morphology. The final structure and morphology are dependent on the microphysical processes occurring on millisecond to second timescales. Evaporation rates are dependent on factors such as the gas phase temperature and composition, the surface and bulk composition of the droplet, the dependence of diffusion constants in the particle bulk on composition, and the nucleation and growth rates of crystal structures. Measurements of single droplet evaporation can provide important insights into the detailed microphysical processes at work. We will report on the use of single particle instruments to study the evolving composition, size and morphology of micron-sized droplets during the evaporative drying process. Using an electrodynamic balance to investigate evaporation processes occurring in <1 s, we will begin by exploring the success with which the evolving composition and size of evaporating droplets can be predicted from continuum models that incorporate the interplay of heat and mass transfer. Studies will focus on solution droplets of increasing complexity, increasing the number of solvents of varying volatility. The influence of droplet composition (e.g. the presence of a surface film), drying rate and temperature on the formation of crystalline or amorphous particles will be reported, comparing involatile inorganic or organic solute containing aqueous droplets, before progressing to the drying kinetics of droplets containing silica nanospheres. Finally, we will introduce a new technique for studying drying kinetics on millisecond timescales, reporting measurements of time-dependent size and composition.

11UA.1

Mapping Fine Particulate Matter and Ozone in Southern California Using Low-Cost Sensor Technologies.
RACHELLE DUVALL, Ron Williams, Dena Vallano, Andrea Polidori, Brandon Feenstra, Vasileios Papapostolou, Sam Garvey, *US EPA*

The emergence of small, portable, low-cost air sensors has encouraged a shift from traditional monitoring approaches for air quality. Over the past years, EPA has been actively involved in the development and testing of these emerging sensor technologies as well as promoting informed use, deployment, and interpretation of data. EPA, in an effort involving the South Coast Air Quality Management District (SCAQMD) Air Quality Sensor Performance Evaluation Center (AQ-SPEC), deployed custom-built sensor pods measuring fine particulate matter ($PM_{2.5}$), ozone (O_3), relative humidity and temperature at nine locations throughout Southern California from January to April 2017. Southern California is an ideal testing location as it often experiences elevated air pollutant levels resulting from gasoline and diesel engines, ports, and industries. Meteorology (frequent sunny days and little precipitation) and geography also contribute to elevated pollution levels in the area. The goal of this project was to better understand performance and potential applications of low-cost sensors especially in the area of community monitoring. This presentation will highlight AQ-SPEC laboratory and field performance evaluations of the Citizen Science Air Monitor (CSAM) sensor pods designed and developed at EPA. In addition, this presentation will summarize the spatial and temporal variability of $PM_{2.5}$ and O_3measurements collected at the monitoring locations which covered approximately a 200 km area in Southern California. This project will generate data that can be used to better understand air quality throughout the study area and provide the community with low-cost tools to measure air quality.

Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

11UA.2

Characterizing Intra-Urban Air Pollution Gradients with a Spatially-Distributed Network of Lower Cost Sensors.

NAOMI ZIMMERMAN, Zhongju Li, Ellis Shipley Robinson, Aja Ellis, R. Subramanian, Allen Robinson, Joshua Apte, Albert A. Presto, *Carnegie Mellon University*

Urban air pollution measurements have typically relied on a small number of widely separated regulatory monitoring sites to assess population-scale exposure. However, air pollutant concentrations may exhibit significant spatial variability depending on local sources and features of the built environment, which may not be well captured by the existing monitoring regime. To better understand urban spatial and temporal pollution gradients on the <1 km scale, a network of 12 air quality monitoring stations was deployed for one year of monitoring beginning July 2016 in Pittsburgh, PA. The stations were deployed both at sites along the urban-rural transect and in downtown urban locations with a range of traffic, restaurant and tall building densities. The stationary monitoring measurements comprise ultrafine particle number (UFP, Aerosol Dynamics “MAGIC” CPC), $PM_{2.5}$ (Met One Neighborhood PM Monitor), black carbon (Met One BC 1050), and a low-cost air quality monitor, the Real-time Affordable Multi-Pollutant (RAMP) sensor package for measuring CO, NO_2, O_3, and CO_2. Measurements from the monitoring stations were reported at high time resolution (2 min or faster), enabling insight into dynamic pollutant behaviour. RAMP data was calibrated using machine learning-based models to convert sensor response into pollutant concentrations at sensitivities comparable to reference instrumentation. Intra-urban pollutant differences were largely associated with traffic and restaurant density. For example, a site within 30 m of a restaurant plume had on average 3x higher UFP concentrations compared to an urban background site, and 50% higher UFP compared to a high traffic site less than 250 m away. Three sites each within 15 m of a busy roadway also showed elevated $NO_2$and suppressed O_3 concentrations compared to the urban background. Findings from this study combined with land use and population metrics will enable better air pollutant exposure estimates and aid in environmental policy priorities towards improved air quality.

11UA.3

Variations in Wintertime PM among Communities in Sacramento Measured with a Combination of Traditional and Low-Cost Sensor Methods.

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Residential wood smoke is one of the largest contributors to wintertime particulate matter (PM) in Sacramento, CA. To understand how wood smoke and PM varied across Sacramento and between environmental justice (EJ) and non-EJ communities, we conducted measurements during December 2016 and January 2017 of black carbon (BC) with Aethalometers (AE33) at six locations, of PM with low-cost AirBeam sensors at 15 locations, of hourly PM with beta attenuation monitors (BAMs) and 24-hour PM via filter measurements at two locations, and of levoglucosan via filter measurements at three locations. Before and after the main study period, 20 AirBeam sensors were collocated with a BAM and a filter PM instrument to determine calibration factors for the sensors. In addition, the AirBeam sensors were collocated with a BAM and a filter PM instrument at two locations throughout the study to assess whether there was drift in the sensor measurements and to determine the comparability of PM measurements among the sensors, BAM, and filter instrument.

The 20 AirBeam sensors had extremely high precision during the pre- and post-study collocations, with AirBeam-to-AirBeam correlation coefficients (r^2) greater than 0.95. AirBeams also had very high precision with very little drift at the two locations with collocated AirBeams throughout the study. Since each AirBeam had a consistent PM concentration response relative to the other collocated AirBeams, we developed an AirBeam-specific calibration based on the collocated data, and used the calibrated AirBeam data to assess with high confidence how PM varied across communities. We also determined the extent to which AirBeam data can be corrected to BAM or 24-hr filter measurements using meteorological data.

11UA.4

Air Quality in East Africa: Measurements with Portable and Low-cost Sensors. R. SUBRAMANIAN, Nestor Gomez, Rebecca Tanzer, Naomi Zimmerman, Nathan Williams, Paulina Jaramillo, *Carnegie Mellon University*

Seven million people prematurely die every year due to air pollution worldwide (WHO, 2014), including an estimated 400,000 in Rwanda and Tanzania. However, only limited air quality data is available for these countries, partly due to the high cost of traditional reference monitors. We have developed a new low-cost air quality monitor, the Real-time Affordable Multi-Pollutant (RAMP) sensor package, which measures carbon monoxide (CO), nitrogen dioxide, nitric oxide, ozone, and carbon dioxide, with performance comparable to reference monitors. Two RAMP sensors coupled with Met-One Neighborhood PM (NPM, to measure fine particulate mass, $PM_{2.5}$) monitors were recently deployed in Kigali, Rwanda. Over a three-week period in April, $PM_{2.5}$ was similar (within instrumental uncertainty) at the side of a major road and at a residential location 3 km away, averaging around 27 $\mu g/m^3$. However, CO was higher at the roadside location (583±22 ppb) than at the residential location (492±14 ppb.) Preliminary analysis indicates $PM_{2.5}$ was reasonably correlated with CO at both sites (r^2 ~0.5), indicating the influence of primary combustion emissions. We plan to expand the Kigali network to five RAMPs this summer to provide more information on the spatial and temporal variability. We also conducted exploratory measurements with a RAMP and a Met-One Aerocet-831 PM monitor in two villages in rural Tanzania, where the Aerocet reported ambient $PM_{2.5}$ mass ranging from 10-70 $\mu g/m^3$ and PM10 from 20-360 $\mu g/m^3$. The Aerocet size-resolved data and onsite observations suggest dust and cooking emissions contribute to elevated PM levels even in this remote, unelectrified region. These results indicate air pollution patterns that are different than in developed countries and highlight the need for more robust air quality monitoring in East African countries.

11UA.5

CitySpace Air Sensor Network: Evaluating Spatial Gradients of Urban Air Pollution with Low-Cost Air Sensor Technology. STEPHEN FEINBERG, Ron Williams, Gayle Hagler, Judy Low, Larry Smith, Ryan Brown, Daniel Garver, Michael Davis, Michael Miller, Joe Schaefer, John Campbell, Tim McArthur, *ORD-US EPA, RTP, NC*

Traditional air monitoring approaches, using regulatory monitors, have historically been used to establish regional-scale trends in air pollutants across large geographical areas. Recent advances in air pollution sensor technologies could provide additional information about nearby sources, support the siting of regulatory monitoring stations, and improve our knowledge of finer-scale spatiotemporal variation of ambient air pollutants and their associated health effects. Sensors are now being developed that are much smaller and lower-cost than traditional ambient air monitoring systems and are capable of being deployed in a nodal pattern to provide greater coverage of a given area. A recent significant sensor network implementation, the CitySpace project, was conducted by the US EPA and the Shelby County Health Department. A total of 16 solar and/or land powered sensor pods that collected one-minute time resolution data of particulate matter, wind direction and speed, temperature and humidity, were deployed across Memphis, TN for six months. The study began in October 2016 and involved local community review and support. The sensor pods were first deployed at the Shelby Farms NCore site to compare their measurements with a regulatory Tapered Element Oscillating Microbalance (TEOM) particulate monitor and establish sensor pod precision. The pods were then deployed at 16 locations throughout the city and surrounding area to develop a wireless sensor network with real-time data streaming capabilities (EPA's VIPER network). The six-month deployment yielded a substantial data set, with on the order of 200,000 observations per parameter, per pod. After the monitoring period (March 2017), a selection of sensor pods was returned to the Shelby Farms site to evaluate potential changes in sensor performance. Sensor pod pollutant data was normalized to regulatory TEOM data, based on the colocation periods, and used to develop comparisons between locations and explore the spatiotemporal variability of particulate pollution in the Memphis area.