SAIL-Net: Aerosol and Cloud Nuclei in Mountainous Terrain

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Handix SCIENTIFIC

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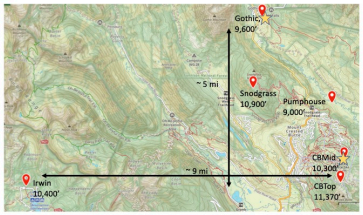
What is SAIL-Net?

- SAIL-Net supported the Surface Atmosphere Integrated Field Laboratory (SAIL) campaign in the East River Watershed (ERW) which advanced mountainous watershed science.
- Earth System Models need more data to improve predictions of mountain water availability.
- SAIL had 2 sites with more than 4 dozen atmosphere and surface measurements.

SAIL-Net: A Novel network of six aerosol microphysics sites in the ERW to study aerosol variability and aerosol-cloud interactions in mountainous terrain.



Science Goals:

(1) Assess spatial & temporal variability of aerosol.

(2) Investigate the usefulness and optimal placement of aerosol measurement networks in complex terrain.

SAIL-Net Instrumentation

Aerosol size distributions: POPS

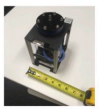
- **P**ortable **O**ptical **P**article **S**pectrometer (Gao, at al.)
- A light-weight, high-sensitivity particle spectrometer for PM2.5 measurements.
- ~140 nm – 2.5 µm; 1 s resolution

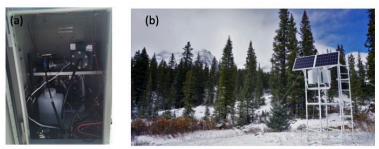
Cloud Condensation Nuclei: CloudPuck

- Static diffusion chamber design; ~5 min resolution
- Collab w/ DU Huffman group
- First ambient deployment of a low-cost CCN counter

Ice Nucleating Particles: TRAPS

- Sequential filter sampler based on Creamean et al., 2018
- 24 - 48hr time resolution; 8 filter spots

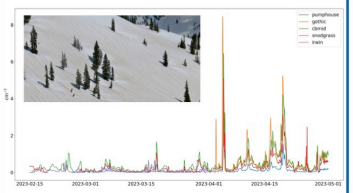




(a) POPS, CloudPuck, and TRAPS (formerly IcePuck) mounted in the Handix enclosure. (b) Site setup: instruments mounted on scaffolding to stay above the snow.

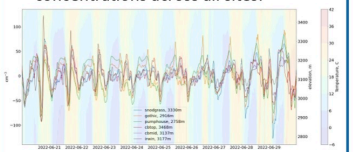
Highlights from the POPS

- Captured many dust on snow events.



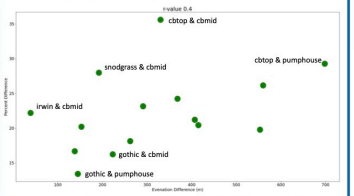
Timeseries of supermicron concentrations from the POPS during Winter 2022 – Spring 2023. The largest signal over the two winters measured occurred April 4, 2023 (pictured).

- Recorded diurnal cycles in aerosol concentrations across all sites.



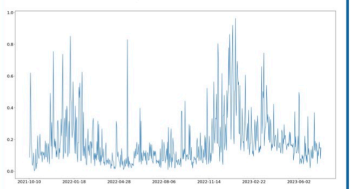
Seasonal decomposition reveals diurnal patterns in total aerosol concentration, as seen from POPS data.

- Aerosol concentration are more similar across similar elevations than at geographically proximal sites.



The average pairwise percent difference in 170 nm – 3.4 um aerosol concentrations between sites plotted as a function of the elevation difference. The Pearson r-value of 0.4 shows there is some positive linear correlation. Site proximity does not imply measurement similarity. The most geographically close sites (cbmid & cbtop) are the most different on average.

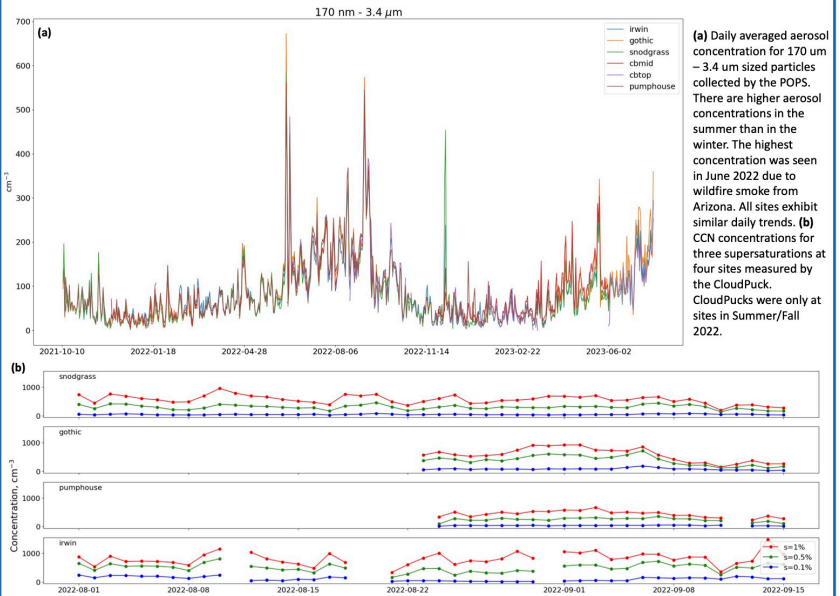
- Aerosol concentrations vary spatially and seasonally.



The variability within the sites is displayed over time using the coefficient of variation, which allows the comparison of variance across datasets with different means. We observe a seasonal trend in variability, with more variability in the winter.

Maintaining off-the-grid, year-round measurements was challenging, especially in winter 2022. Our instruments proved to be incredibly resilient and continued to work even when buried in snow.

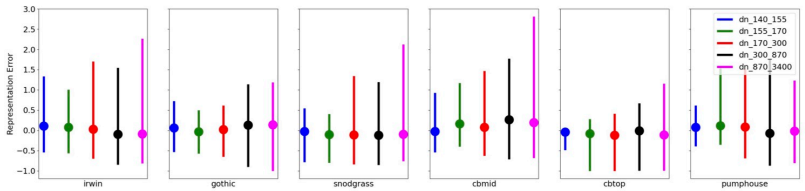
1.5 Years of Data



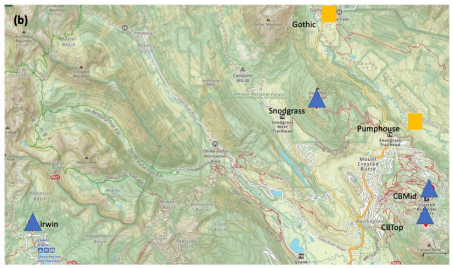
(a) Daily averaged aerosol concentration for 170 um – 3.4 um sized particles collected by the POPS. There are higher aerosol concentrations in the summer than in the winter. The highest concentration was seen in June 2022 due to wildfire smoke from Arizona. All sites exhibit similar daily trends. **(b)** CCN concentrations for three supersaturations at four sites measured by the CloudPuck. CloudPucks were only at sites in Summer/Fall 2022.

Representativeness of the Data & Network Groupings

Poor representation of a region occurs when a point observation inside an area does not agree with the value assigned by a model. We used the representation error to determine which site(s) in SAIL-Net better represent the ERW. Using the network mean (N) as a proxy for the true regional value, the representation error at site s (e_s) is the normalized difference between a station observation (O_s) and the network mean. The plot below shows the average and range of the representation error from daily averaged observations over the entire measurement period.



The average and range of the representation error from daily averages of 170 nm – 3.4 um aerosol concentrations from the POPS. Representation is likely worse for the largest size bin because there are typically so few particles of this size.



Site groupings using 2-means clustering. This grouping occurred 30% of the days and has a silhouette score of 0.67. The next most common group occurred on 11% of days but had a higher silhouette score of 0.7.

The large range of representation errors indicates that there may be enough variability in this region that assigning a single value to represent the region is not accurate enough. Using k-means clustering, we determined the optimal site groupings for representing distinct subregions. This information yields two valuable conclusions:

i. 2-3 clusters best represent this region, but there is little consistency in the ideal groupings, especially when using 3 clusters.

ii. Groupings are independent of spatial proximity.

Data availability: All processed data will be posted to the ARM Data Discovery. For data during the campaign, contact Leah at lgibson@handixscientific.com.