# PM$_{2.5}$ Source Changes for 2010-2019 in NY and NJ by Dispersion Normalized PMF


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## I. Background

Since Clean Air Act regulation in the 1970s, various efforts have been made in the United States to control ambient PM and improve air quality. In NY/NJ State, some major changes made to improve air quality in the past decade include but are not limited to the phasing out of all coal-fired power plants, a forced abandonment of No 6 oil for large building heating, a forced switch to ultra-low sulfur marine fuels, the introduction of Tier 3 light-duty vehicles, etc.

Receptor models like positive matric factorization (PMF) have been widely used in atmospheric studies for source identification and quantification. Recently, dispersion normalized PMF (DN-PMF) was developed to reduce the influence of meteorological dispersion on source resolution in PMF analysis.

**Objectives**: This presentation investigated the PM$_{2.5}$ source trends at 11 sites in NY and NJ states for the 2010-2019 period, corrected for meteorological dispersion through DN-PMF, and assessed the effectiveness of policy implementations.

## II. Methods

**Database**

2010-2019 speciated PM$_{2.5}$ from EPA's Chemical Speciation Network (CSN) for:

- 5 NYC metro area sites
- 3 Upstate urban sites
- 3 background sites

BLH at each site: retrieved from the ERA5 atmospheric reanalysis

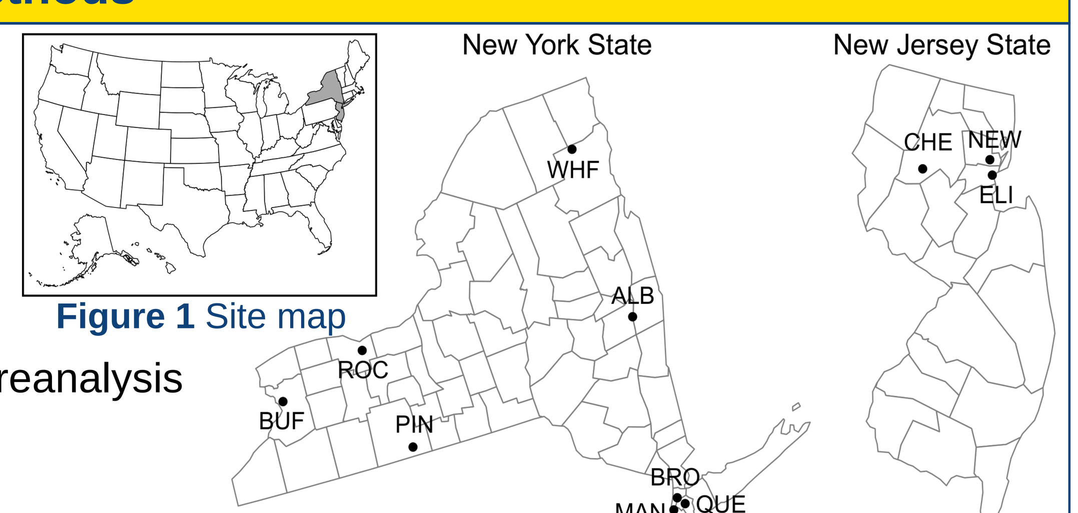



**Figure 1** Site map

**Source Apportionment: DN-PMF**

$$\mathrm{VC}_i = \mathrm{BLH}_i \times \bar{u}_i$$

$$\mathrm{C}_{\mathrm{VC},i,j} = \mathrm{C}_{i,j} \times \mathrm{VC}_i / \overline{\mathrm{VC}}$$

- $\mathrm{BLH}_i$: the boundary layer height for time period $i$
- $\bar{u}_i$: the mean wind speed for time period $i$
- $\mathrm{VC}_i$: the ventilation coefficient for time period $i$
- $\overline{\mathrm{VC}}$: the average VC over the entire sampling period

**Trend Analysis**

Seasonal Kalman filter: interpolate the missing values
STL decomposition: decompose time series into seasonal, trend, and residual components
Theil-Sen nonparametric estimator with Mann-Kendall tests: fit monotonic slopes
Piecewise linear regression: identify breakpoints and fit segmented slopes

**Source Analysis**

Conditional bivariate probability function (CBPF): identify directionality of local sources
Concentration weighted trajectory (CWT): locate the trajectories of regional sources

## III. Overview of Source Apportionment Results

Common anthropogenic sources resolved at all sites:

- Secondary sulfate (SS)
- Secondary nitrate (SN)
- Spark-ignition vehicle emission (GAS)
- Diesel vehicle emission (DIE)
- Road dust (RD)
- Biomass burning (BB)
- OP-rich aerosol (OP)

Only at NYC metro area sites:

- Fresh sea salt (FRS)
- Aged sea salt (AGS)
- Residual oil (RO)

Only at upstate NY sites:

- Road salt (RS)

Only at Buffalo site:

- Industrial source (IN)

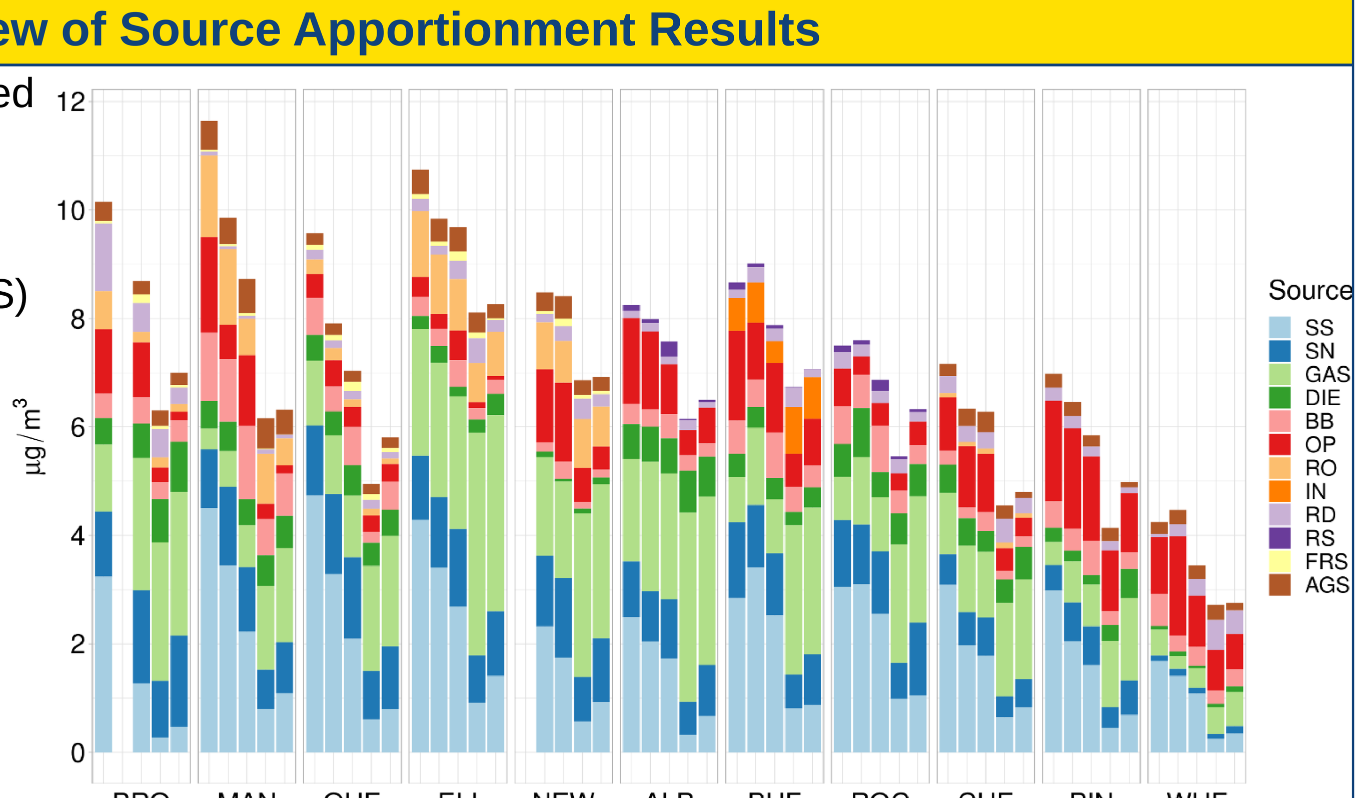



**Figure 3** Average biennial source contributions at each site. (2010-2011, 2012-2013, 2014-2015, 2016-2017, and 2018-2019 periods from left most to right most).

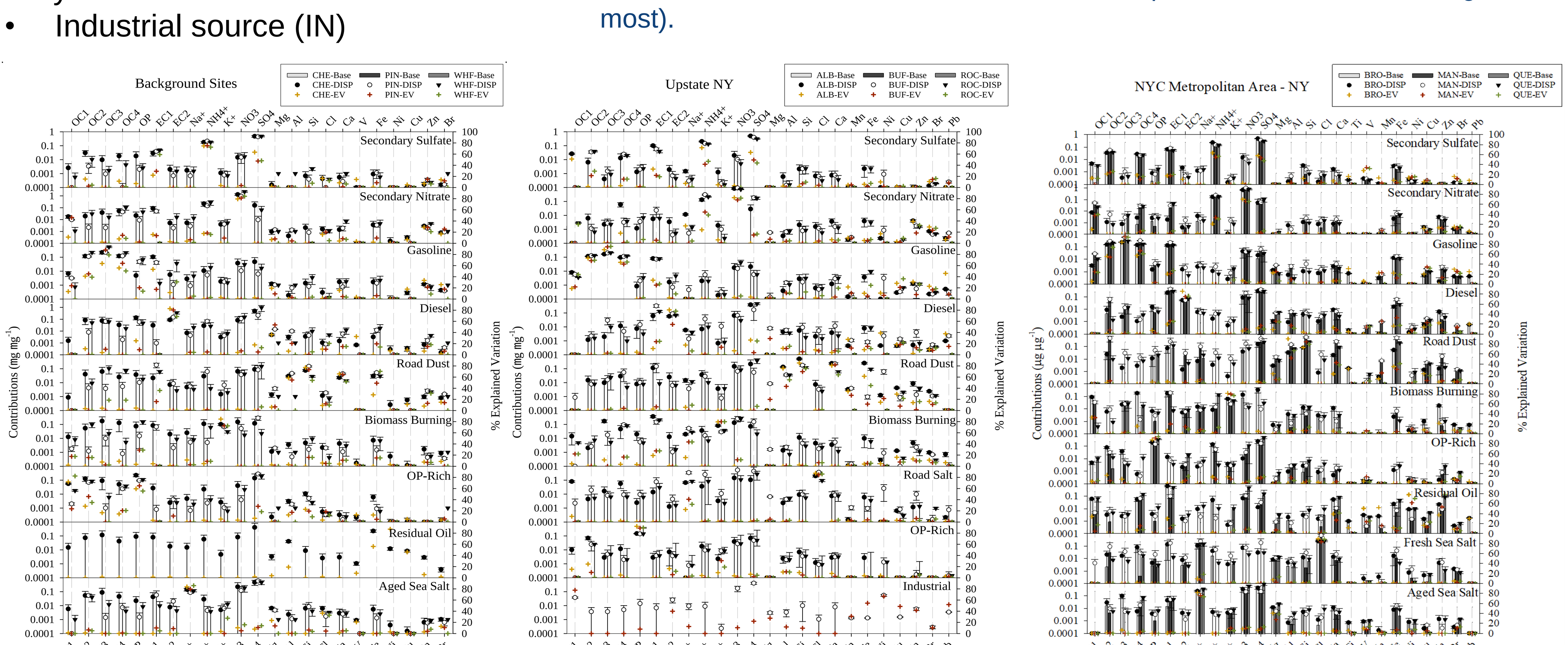



**Figure 4** Profiles of background sites (left), Upstate NY sites (middle), and NYC metro sites (right)

**Table 1** Summary of average source contributions (μg/m$^3$)

| Site | Period | SS | SN | GAS | DIE | RD | BB | OP | RO | IN | RS | FRS | AGS | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRO | 01/2010-06/2010 02/2014-12/2019 | 2.85 | 1.55 | 1.85 | 0.82 | 0.61 | 0.36 | 0.91 | 0.49 | 0 | 0 | 0.08 | 0.27 | 10.34 |
| MAN | 01/2010-12/2019 | 2.09 | 1.02 | 1.12 | 0.54 | 0.07 | 1.00 | 0.77 | 0.92 | 0 | 0 | 0.03 | 0.54 | 8.99 |
| QUE | 01/2010-12/2019 | 2.20 | 1.25 | 1.51 | 0.48 | 0.15 | 0.51 | 0.38 | 0.17 | 0 | 0 | 0.11 | 0.20 | 7.68 |
| ELI | 01/2010-12/2019 | 2.46 | 1.19 | 3.04 | 0.28 | 0.28 | 0.32 | 0.26 | 0.95 | 0 | 0 | 0.09 | 0.38 | 9.97 |
| NEW | 01/2012-12/2019 | 1.36 | 1.19 | 2.39 | 0.10 | 0.26 | 0.19 | 0.93 | 0.82 | 0 | 0 | 0.08 | 0.32 | 8.34 |
| ALB | 01/2010-12/2019 | 1.56 | 0.94 | 2.55 | 0.68 | 0.14 | 0.34 | 1.06 | 0 | 0 | 0.11 | 0 | 0 | 7.81 |
| BUF | 01/2010-12/2019 | 1.98 | 1.03 | 1.84 | 0.36 | 0.23 | 0.55 | 1.07 | 0 | 0.69 | 0.05 | 0 | 0 | 8.25 |
| ROC | 01/2010-12/2019 | 1.99 | 1.09 | 1.61 | 0.62 | 0.23 | 0.56 | 0.43 | 0 | 0 | 0.10 | 0 | 0 | 7.25 |
| CHE | 01/2010-12/2019 | 1.83 | 0.57 | 1.37 | 0.49 | 0.32 | 0.24 | 0.09 | 0.85 | 0 | 0 | 0 | 0.27 | 6.85 |
| PIN | 01/2010-12/2019 | 1.37 | 0.57 | 1.02 | 0.32 | 0.17 | 0.40 | 1.41 | 0 | 0 | 0 | 0 | 0.20 | 6.00 |
| WHF | 01/2011-12/2019 | 0.75 | 0.11 | 0.47 | 0.08 | 0.38 | 0.33 | 0.95 | 0 | 0 | 0 | 0 | 0.22 | 3.90 |

## IV. Changing Trends over the Decade

### Spark-ignition vehicle emission (GAS)

- Traffic-related
- A breakpoint occurring in mid-2017 was resolved for the NYC area and Upstate urban sites after which GAS started to decrease

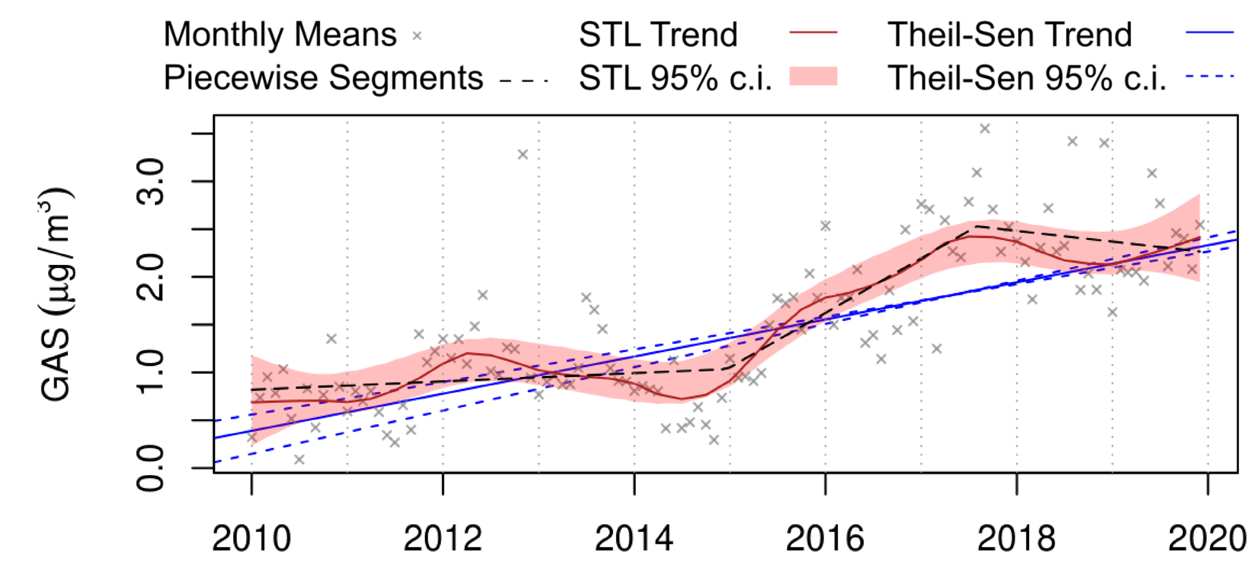
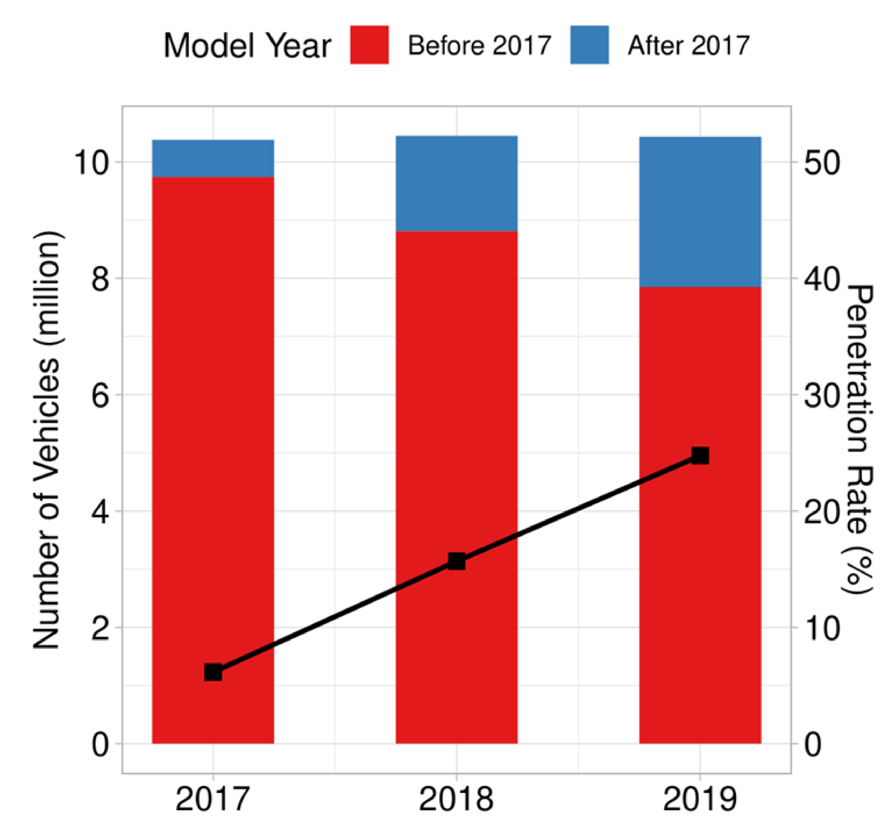



**Figure 5** Monthly averaged GAS concentrations and the corresponding trend results for ROC site




Tier 3 LDVs were phased in beginning in 2017, which alone still cannot explain the immediate GAS decrease happening in mid-2017

**Figure 6** NYS LDV registered in 2017-2019 with model year before 2017 (red bar), after 2017 (blue bar), and Tier 3 vehicle estimated penetration rate (black line and marker).

### Secondary Sulfate (SS) and Secondary Nitrate (SN)

- Secondary in nature
- Overall decreasing, but both increased in the 2018-2019 biennial compared to the prior one

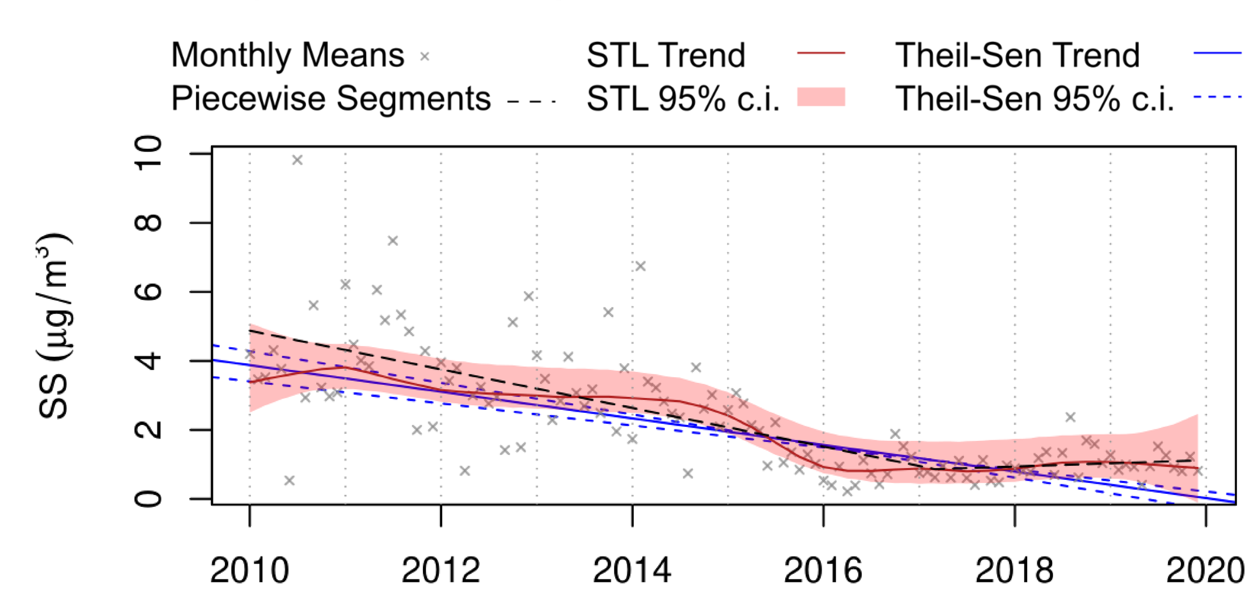



**Figure 7** Monthly averaged SS concentrations and the corresponding trend results for MAN site

### Biomass Burning (BB) and OP-Rich (OP)

- Both can be traced back to Southeastern U.S.
- BB showed the highest concentrations in winter for urban sites, attributed to local domestic heating

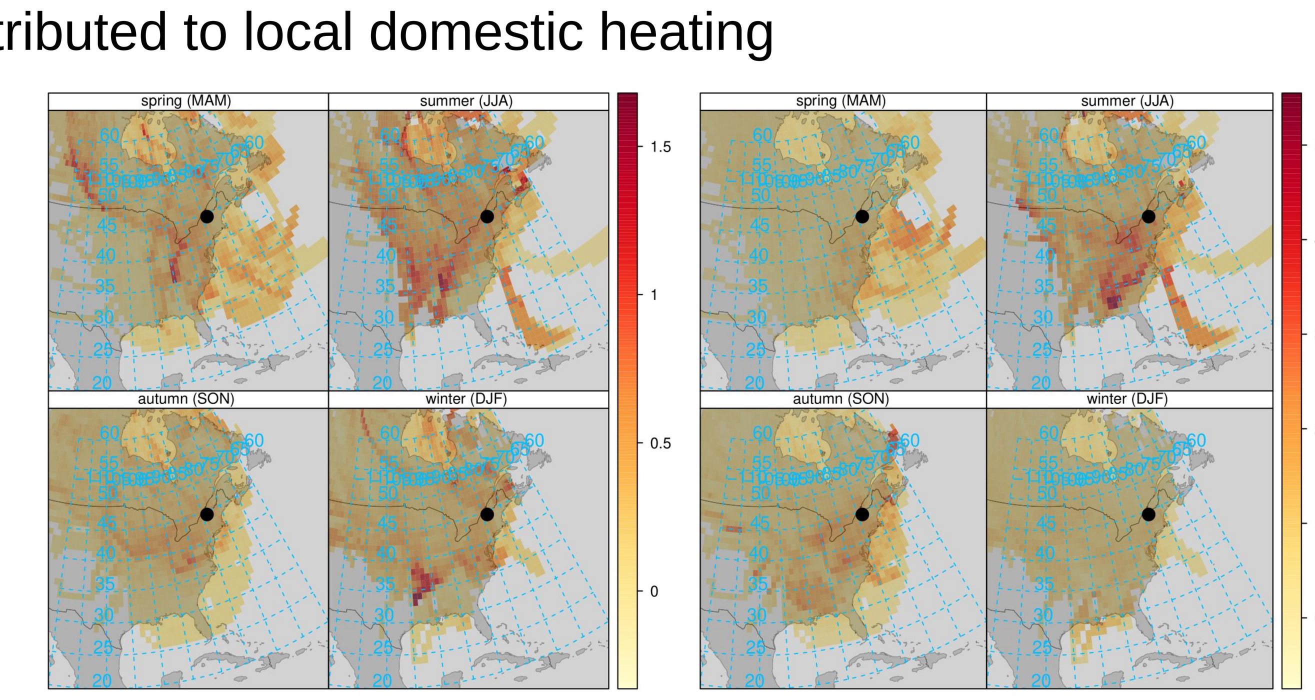



**Figure 8** Seasonal CWT trajectory for BB (left) and OP (right) at WHF site

## Acknowledgement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