

Can We Characterize Aerosol Type Using Aerosol Optical Properties?

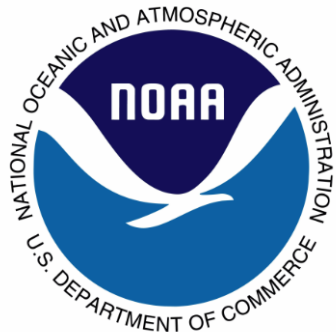


Lauren Schmeisser^{1,2}, Betsy Andrews^{2,3},
John Ogren², Patrick Sheridan²

¹Universiteit van Amsterdam, Amsterdam, the Netherlands

²NOAA, Earth Systems Research Laboratory, Boulder, CO

³CIRES, University of Colorado at Boulder, Boulder, CO



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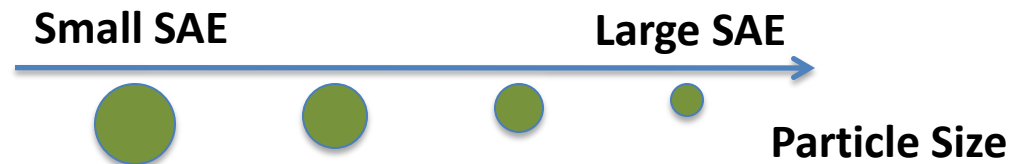
Background



- Why do we care about aerosols?
 - Major source of uncertainty in assessing climate change
- Why do we care about aerosol type?
 - Different aerosol types contribute differently to climate forcing
 - High variability in aerosol type
- In what ways can aerosol type be determined?
 - Directly: In-situ chemical composition measurements
 - Indirectly: Inference from aerosol optical properties

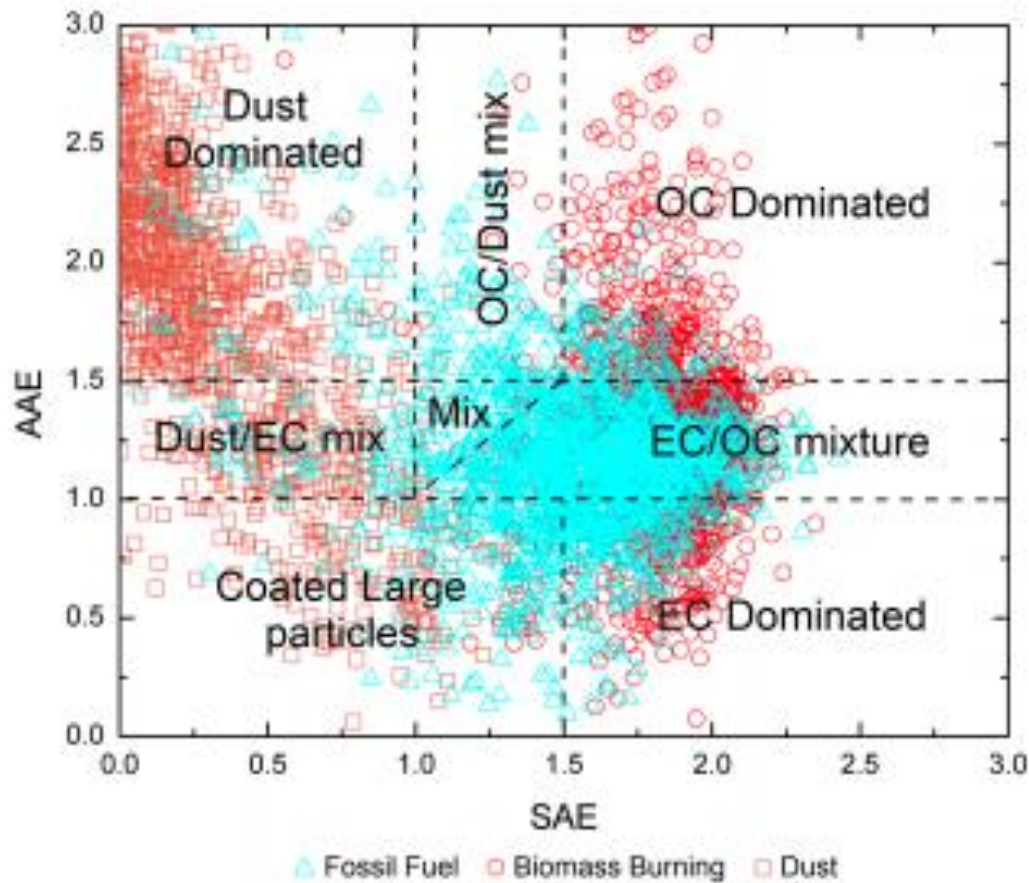
Aerosol Optical Properties

- Scattering Ångström Exponent (SAE)
 - Wavelength dependence of aerosol light scattering
 - SAE and particle size negatively correlated



- Absorption Ångström Exponent (AAE)
 - Wavelength dependence of aerosol light absorption
 - AAE correlated with aerosol type
 - E.g.: Black carbon has theoretical value of 1

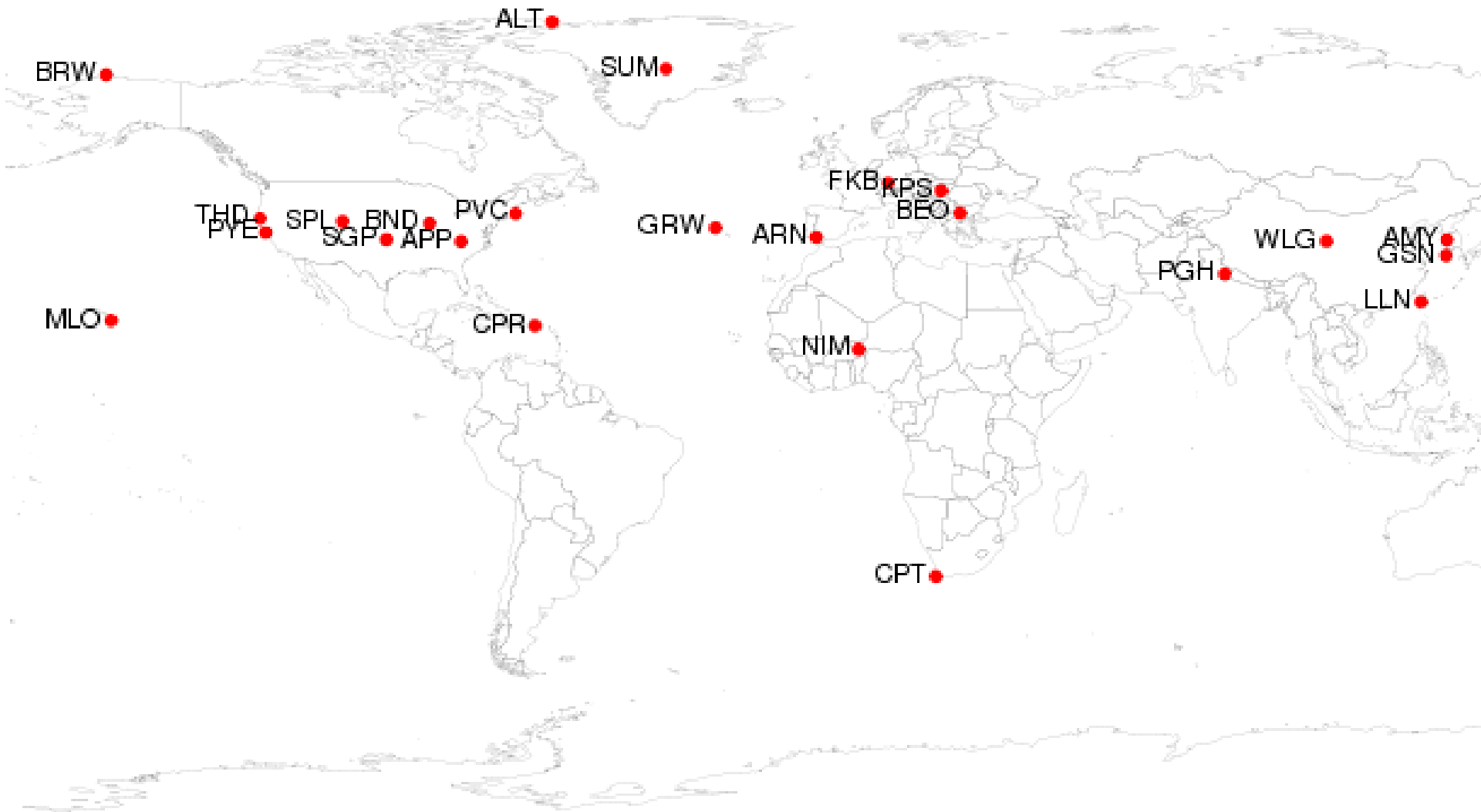
Previous Work



← Larger aerosol particles Smaller aerosol particles →

- Cazorla et al., 2013
- SAE and AAE values from AERONET sites
 - Used to deduce aerosol composition
- Chemical composition measurements from aircraft campaigns in California used to validate results

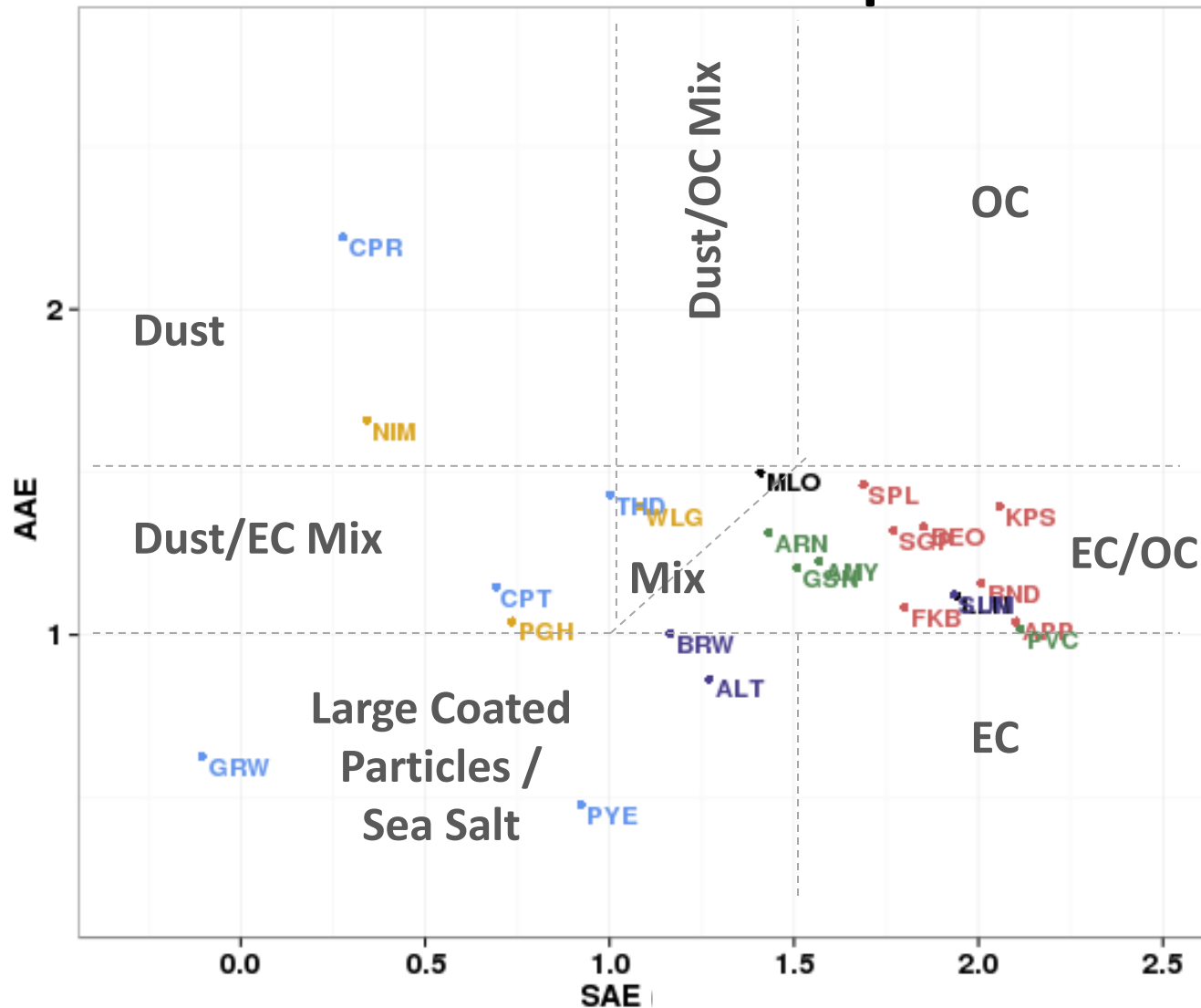
Global Monitoring Stations



Methods

- Monitoring stations must have optical property records ≥ 6 months
- Plot station property medians in SAE-AAE space
- Constraints:
 - $\sigma_{\text{absorption}} > 0.5 \text{ Mm}^{-1}$
 - $\sigma_{\text{scattering}} > 1.0 \text{ Mm}^{-1}$
- All values SAE and AAE at 450/700nm wavelength pair
- Measurements at PM_{10} (except SUM, $\text{PM}_{2.5}$)

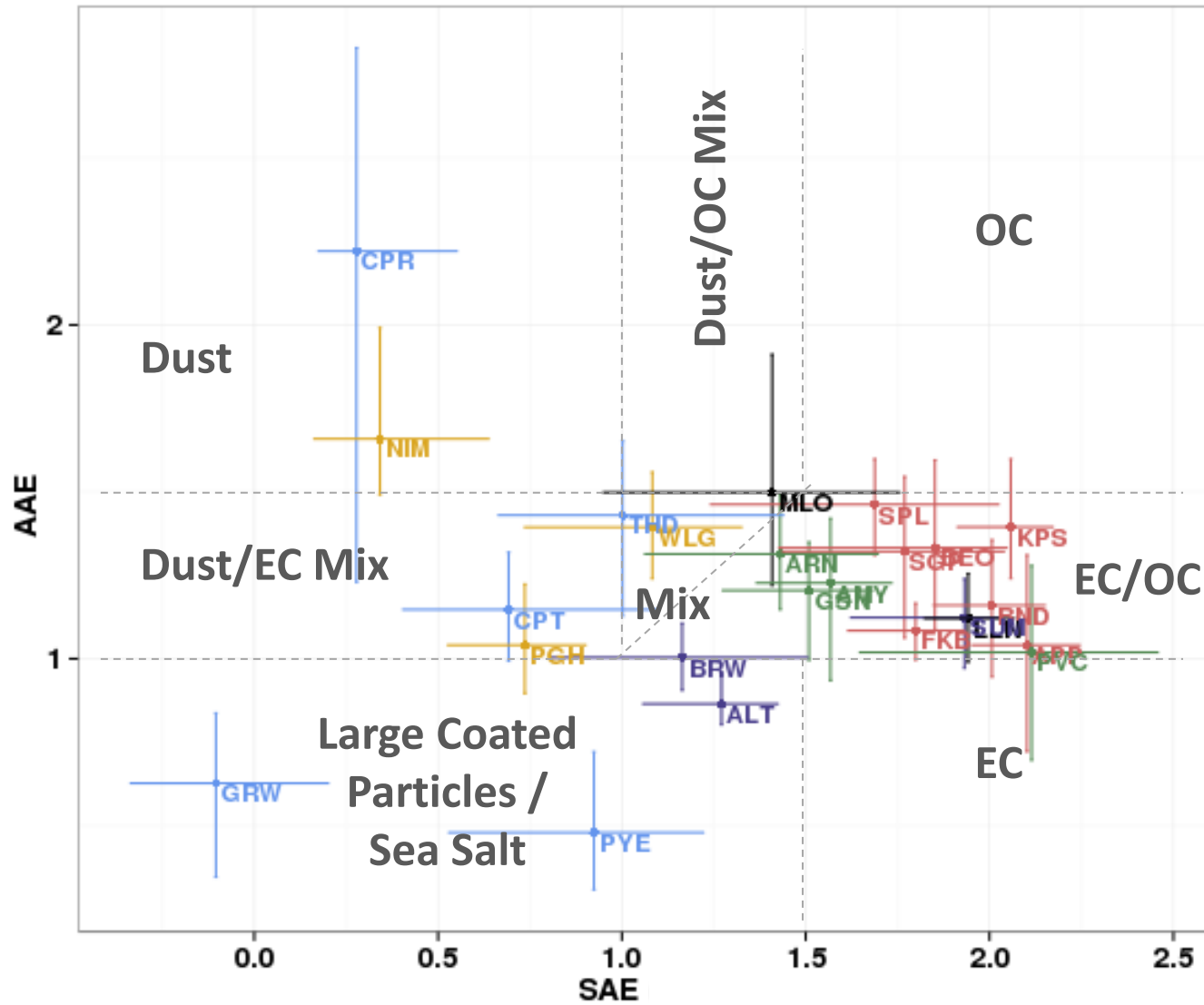
AAE-SAE Plot Space



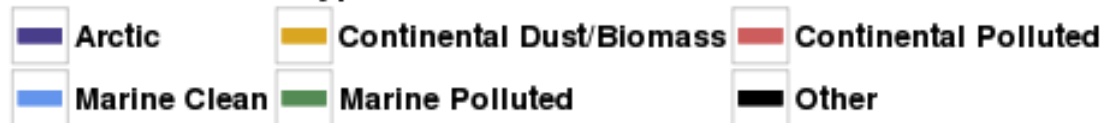
Station Location Type



AAE-SAE Variability



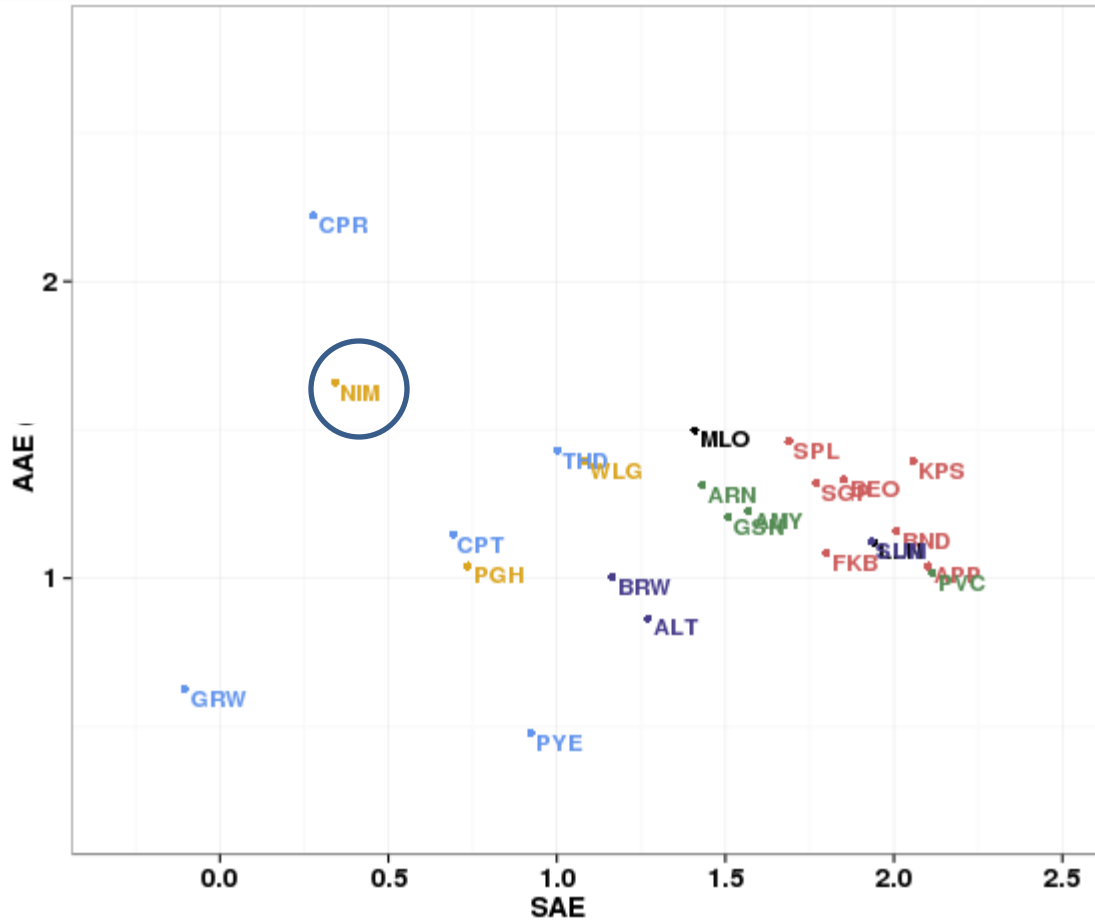
Station Location Type



Back Trajectory Analysis

- Reduce ambiguity in likely aerosol type using back trajectories and clustering
- Methods
 - 3-day back trajectories generated using HYSPLIT
 - Trajectory cluster data paired with aerosol optical properties for plots

Niamey, Niger



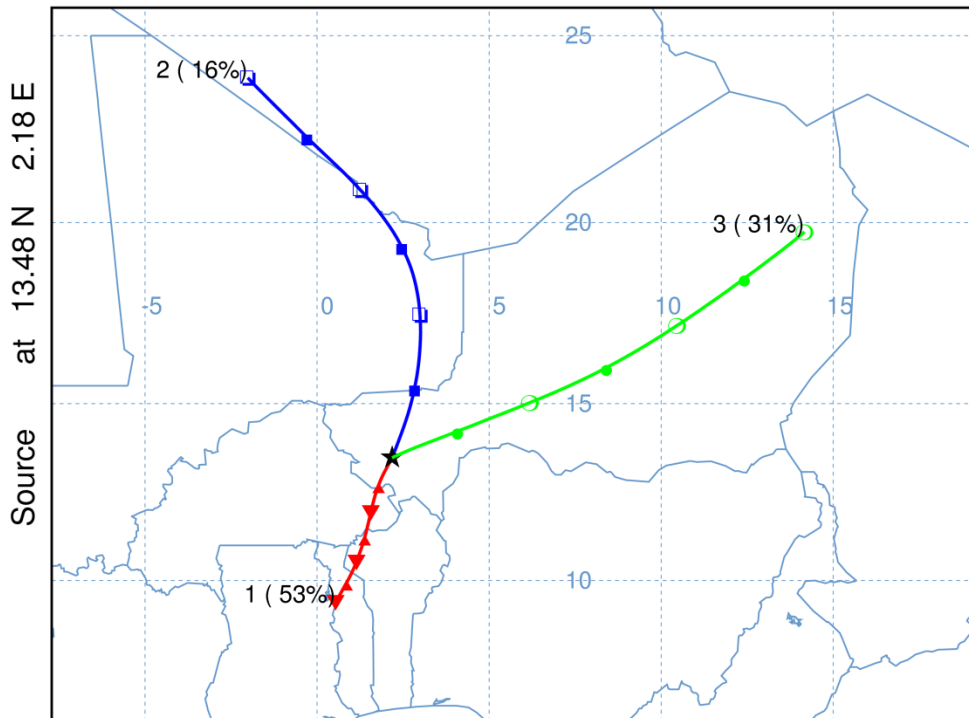
Station Location Type

- | | | |
|--------------|--------------------------|----------------------|
| Arctic | Continental Dust/Biomass | Continental Polluted |
| Marine Clean | Marine Polluted | Other |

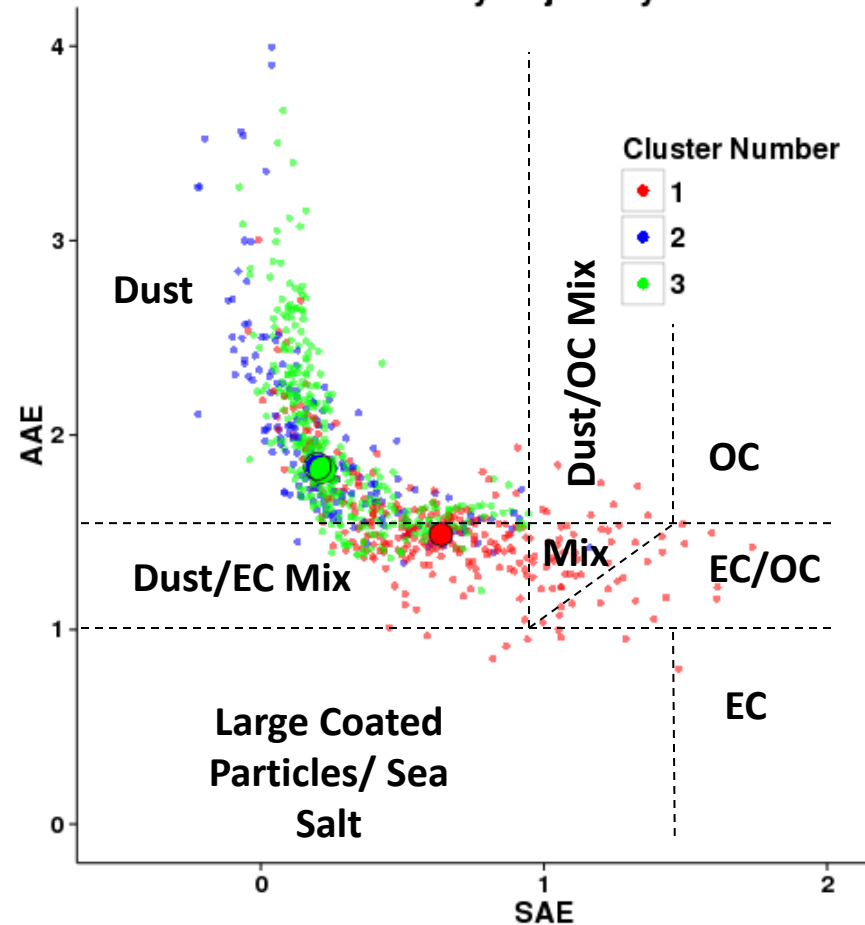
Back Trajectory Analysis

NIAMEY, NIGER

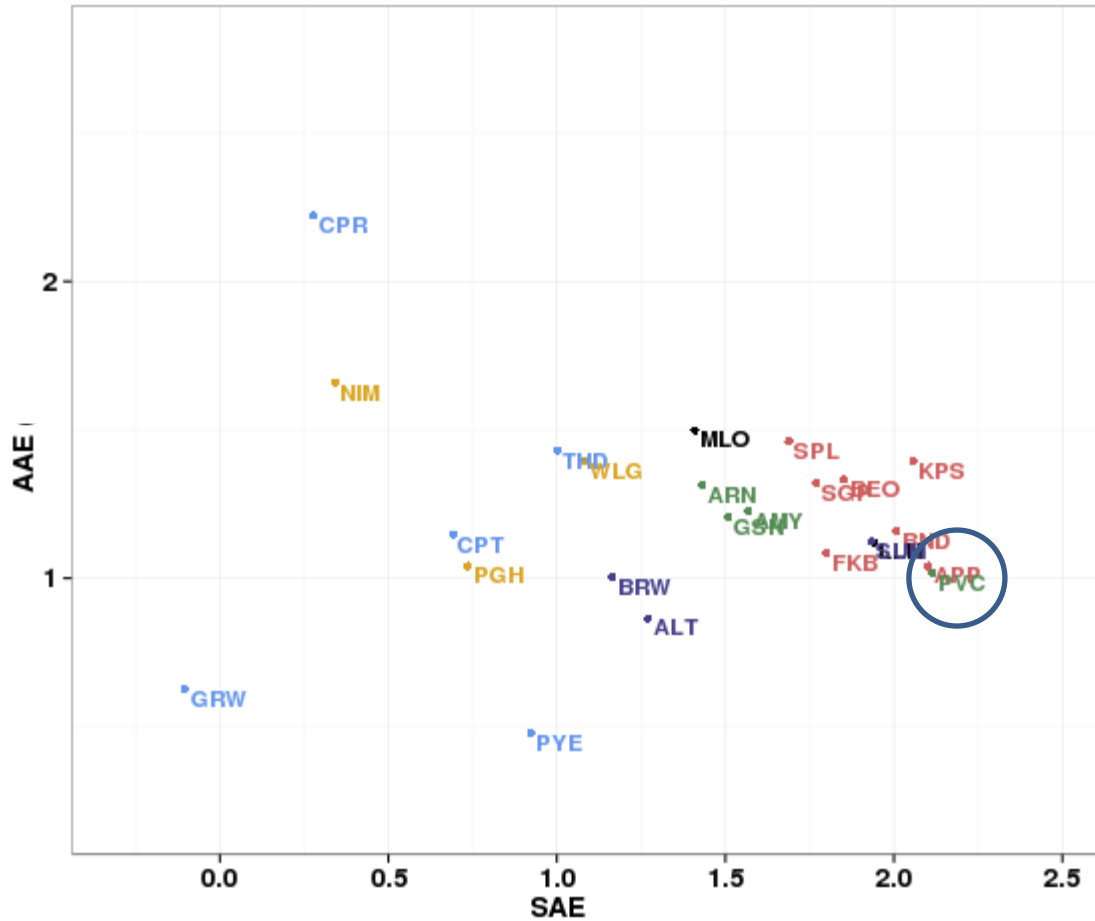
Cluster means - Standard
1528 backward trajectories
CDC1 Meteorological Data



AAE v. SAE at NIM
colored by trajectory cluster



Cape Code, Massachusetts



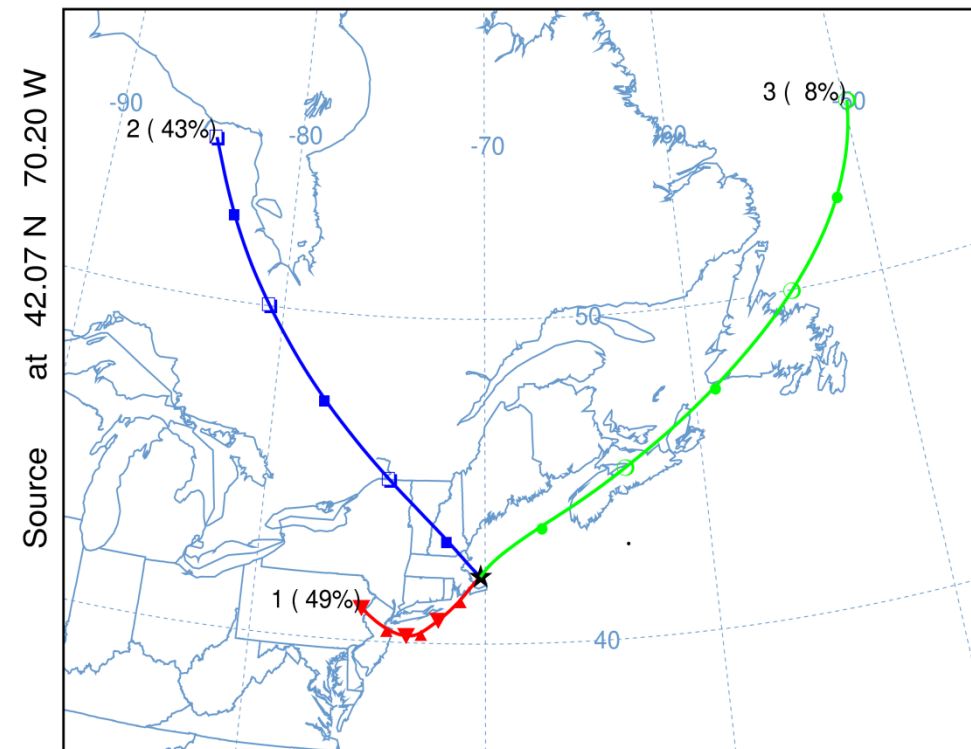
Station Location Type

- | | | |
|--------------|--------------------------|----------------------|
| Arctic | Continental Dust/Biomass | Continental Polluted |
| Marine Clean | Marine Polluted | Other |

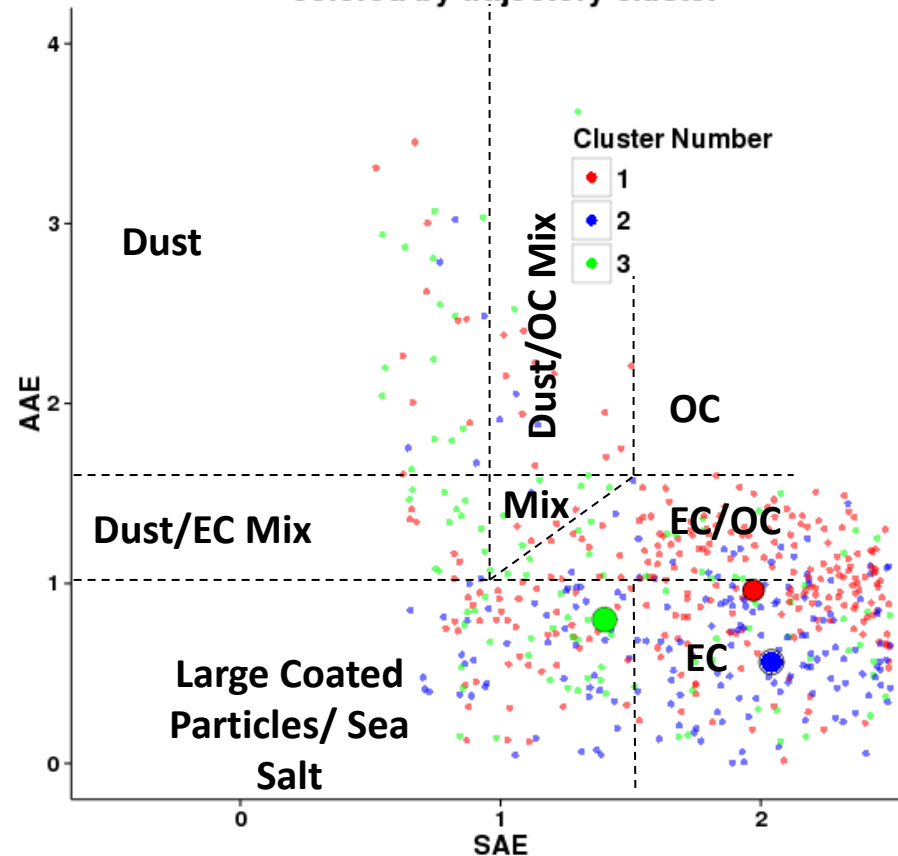
Back Trajectory Analysis

CAPE COD, MASSACHUSETTS

Cluster means - Standard
1376 backward trajectories
CDC1 Meteorological Data



AAE v. SAE at PVC
colored by trajectory cluster



Conclusions



- Aerosol optical properties can be used to infer likely dominant aerosol type
 - single medians of optical properties can mask variation in aerosol type at monitoring sites
- Trajectory analyses can reduce ambiguity in classification of aerosol type at some stations
- Cluster analyses (not presented here) can help further aerosol type classification
- ... more to come!

Questions? Comments?



Thank you to collaborating monitoring stations for use of
your data!

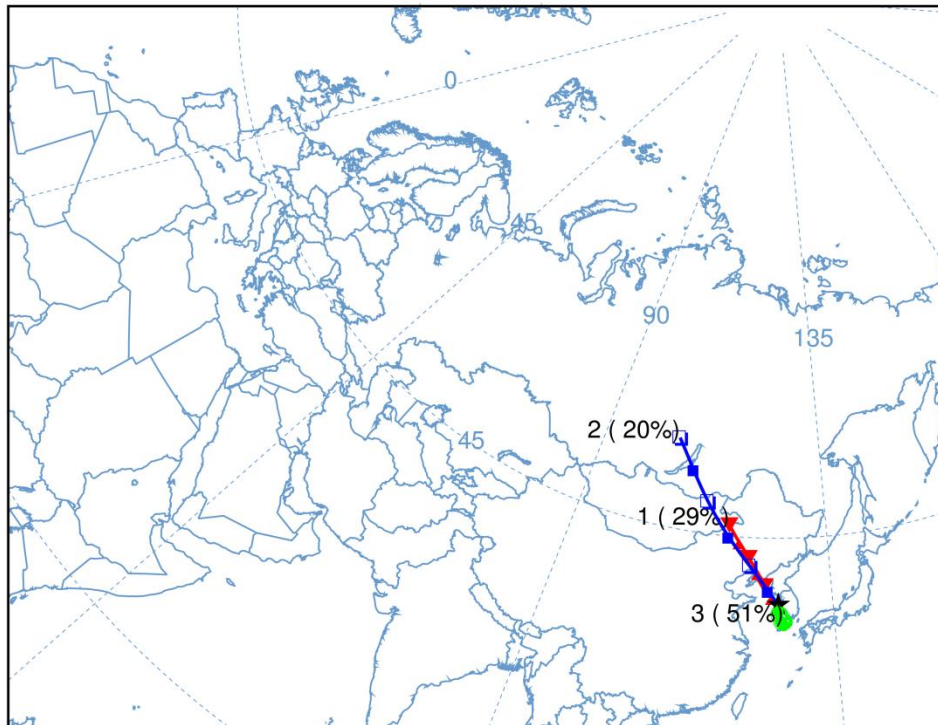
References

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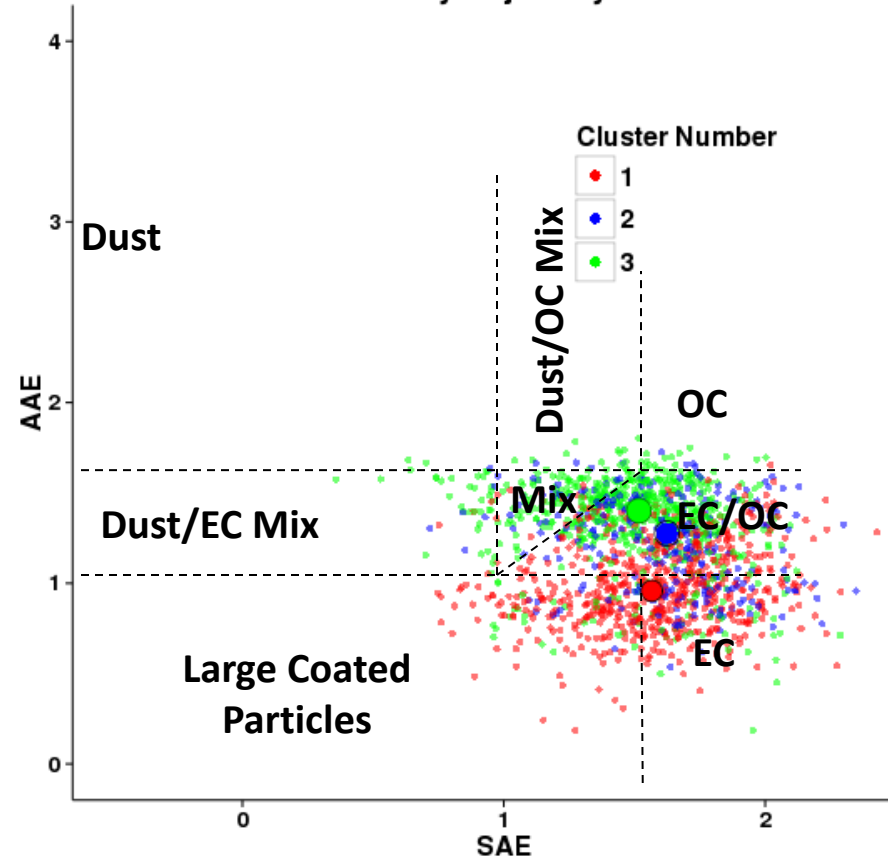
Back Trajectory Analysis

ANMYEON-DO, KOREA

Cluster means - Standard
2916 backward trajectories
CDC1 Meteorological Data



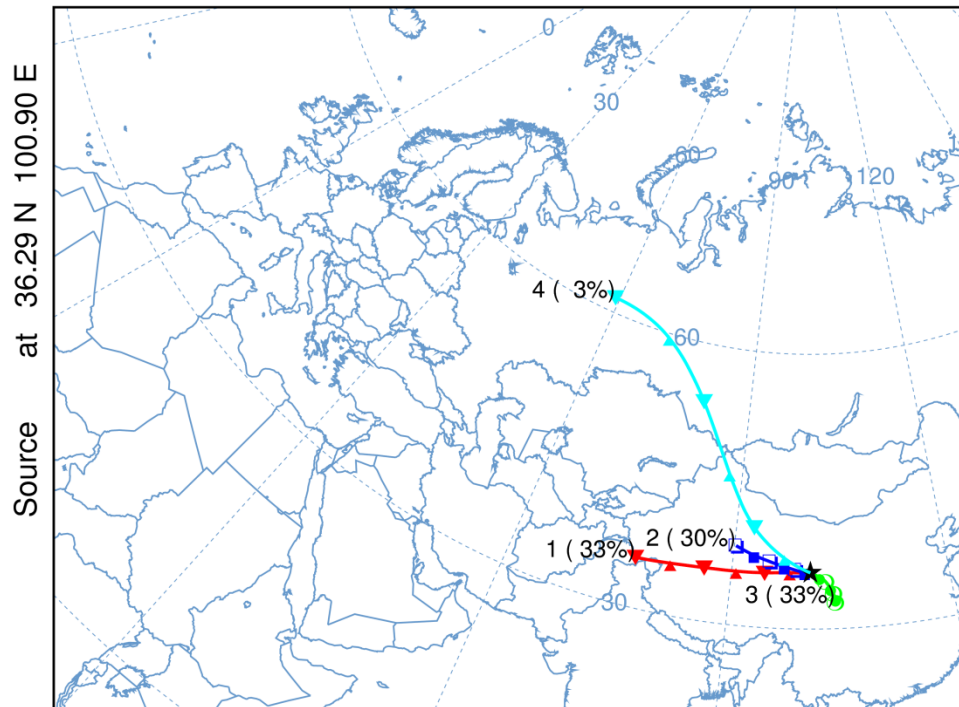
AAE v. SAE at AMY
colored by trajectory cluster



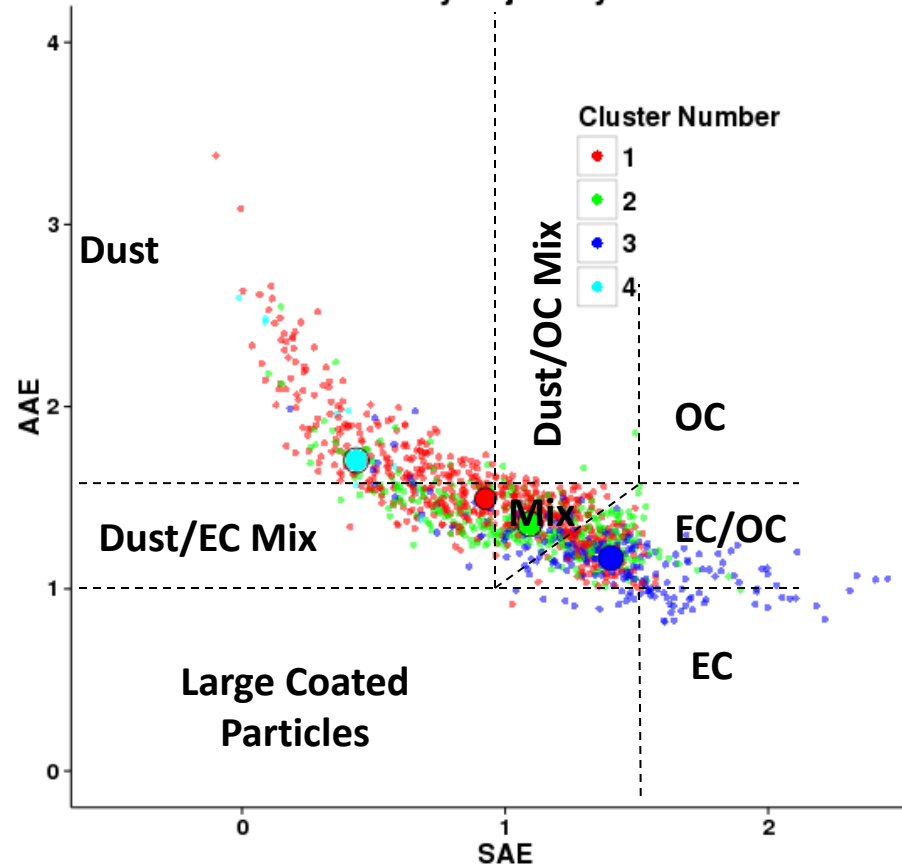
Back Trajectory Analysis

MT. WALIGUAN, CHINA

Cluster means - Standard
3040 backward trajectories
CDC1 Meteorological Data



AAE v. SAE at WLG
colored by trajectory cluster



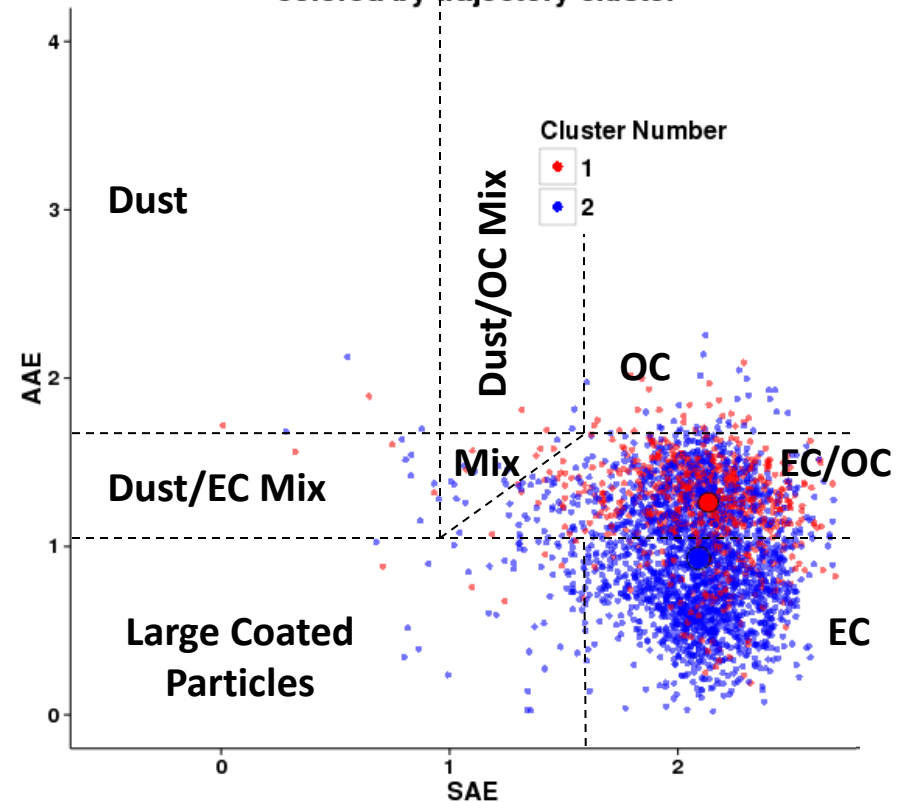
Back Trajectory Analysis

BOONE, NORTH CAROLINA

Cluster means - Standard
2916 backward trajectories
CDC1 Meteorological Data



AAE v. SAE at APP
colored by trajectory cluster



Aerosol Optical Properties

- Scattering Ångström Exponent (SAE)
 - $-\log\left(\frac{\sigma_{s1}}{\sigma_{s2}}\right)/\log\left(\frac{\lambda_1}{\lambda_2}\right)$
 - Wavelength dependence of aerosol light scattering
 - SAE and particle size negatively correlated (Bergstrom et al., 2007)
- Absorption Ångström Exponent (AAE)
 - $-\log\left(\frac{\sigma_{a1}}{\sigma_{a2}}\right)/\log\left(\frac{\lambda_1}{\lambda_2}\right)$
 - Wavelength dependence of aerosol light absorption
 - AAE correlated with aerosol type (Russell et al., 2010)
- Single Scattering Albedo (SSA)
 - $\frac{\sigma_s}{\sigma_s + \sigma_a}$
 - Fraction of extinction due to scattering
 - SSA indicates amount of scattering, 'whiter' vs. 'darker' aerosol (Yang et al., 2009)

Parameter Cluster Analysis

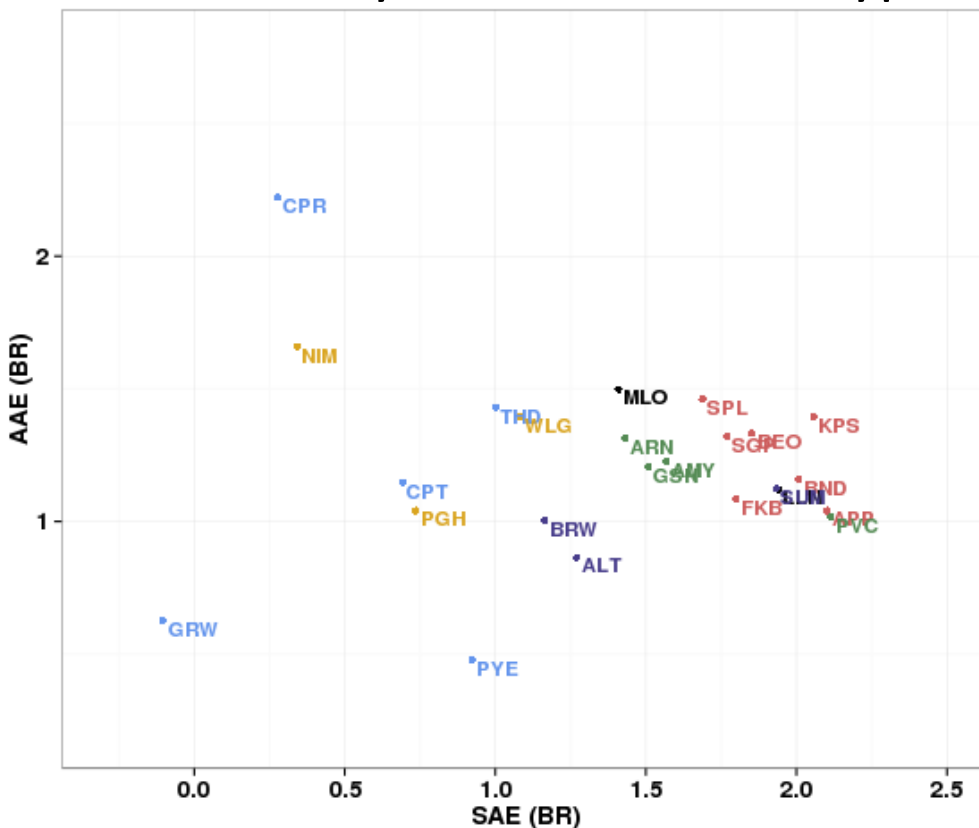


- Cluster analysis is used to determine groups of stations with similar dominant aerosol type, based on aerosol properties
- Cluster using: SAE, AAE, SSA, $\log(\sigma_s)$

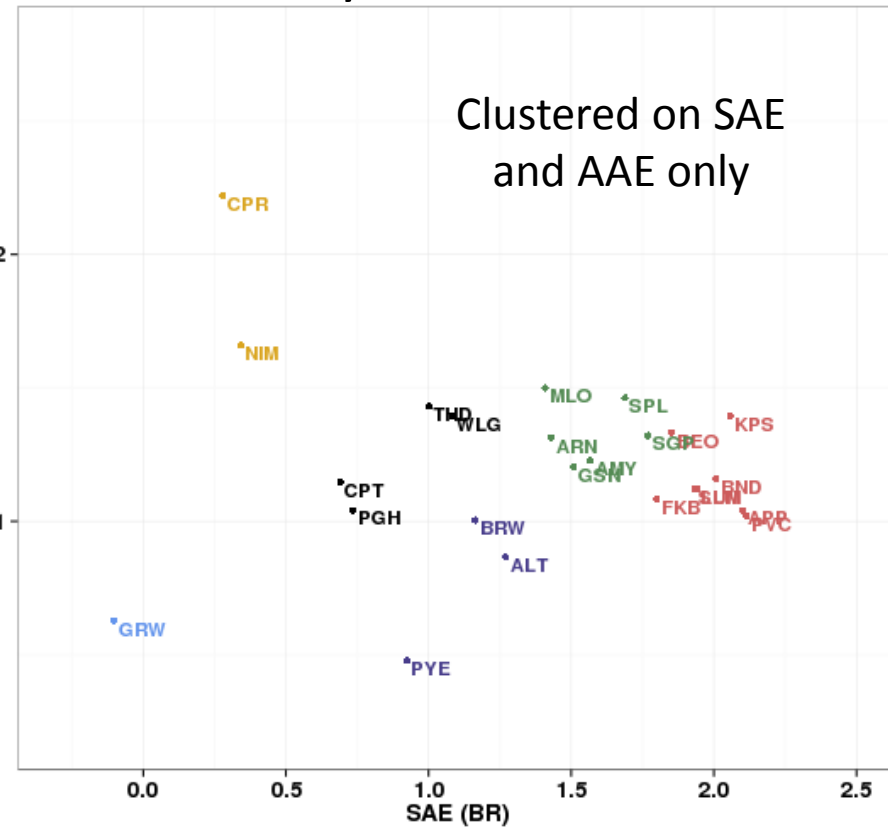
Parameter Cluster Analysis

SAE-AAE Plot Spaces

Colored by station location type



Colored by cluster number



Station Location Type



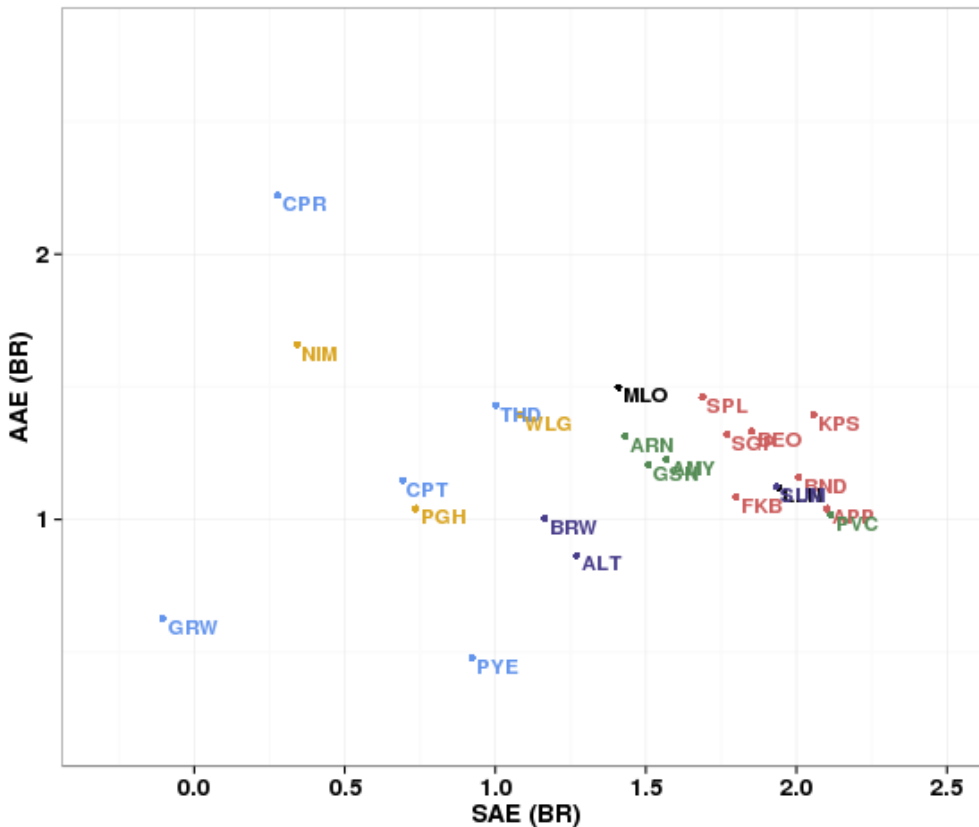
Station Location Type



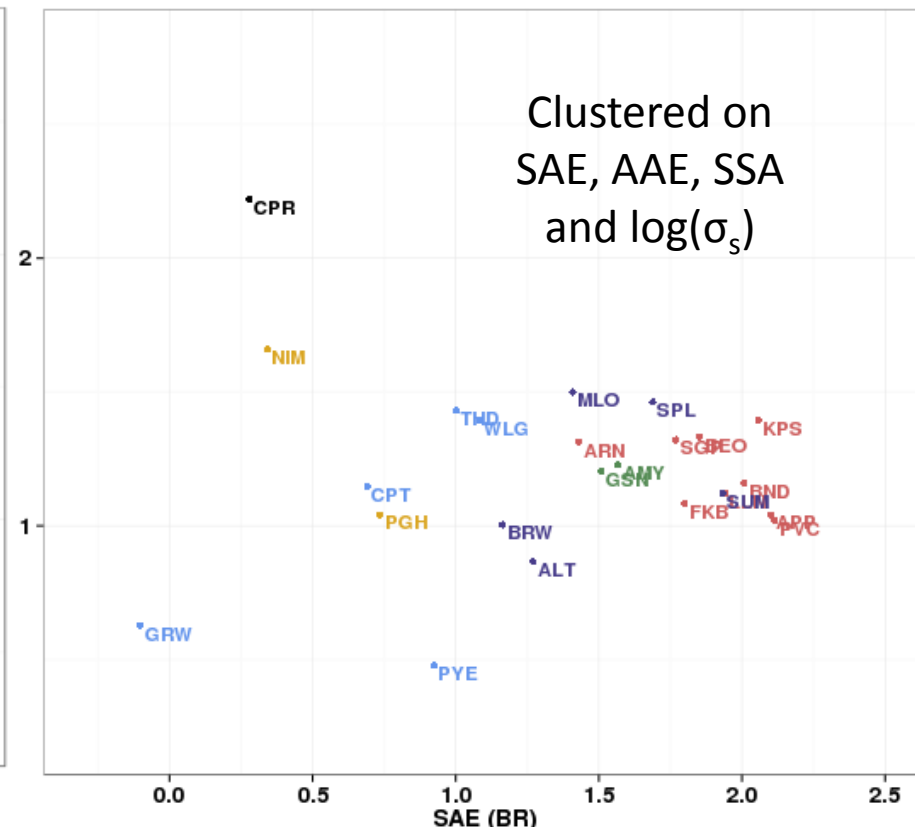
Parameter Cluster Analysis

SAE-AAE Plot Spaces

Colored by station location type



Colored by cluster number



Station Location Type



Station Location Type



Future Work



- Seasonality
- Daily cycles
- Incorporating information on aerosol shape
- Determining aerosol mixtures

Innovative Aspects of this Research



- Wide geographical range of monitoring stations (24 stations including urban, remote, mountaintop, desert and marine sites)
- Long-term records used
- Trajectory analyses for all stations