Can We Characterize Aerosol Type Using Aerosol Optical Properties?

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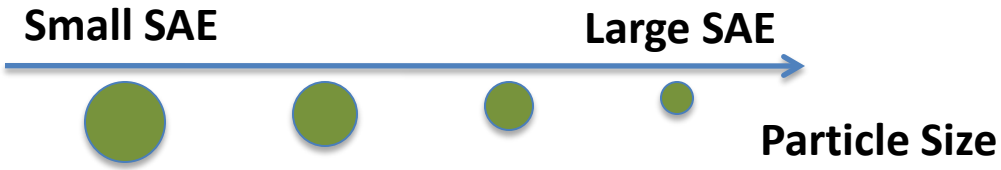
Background

- 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

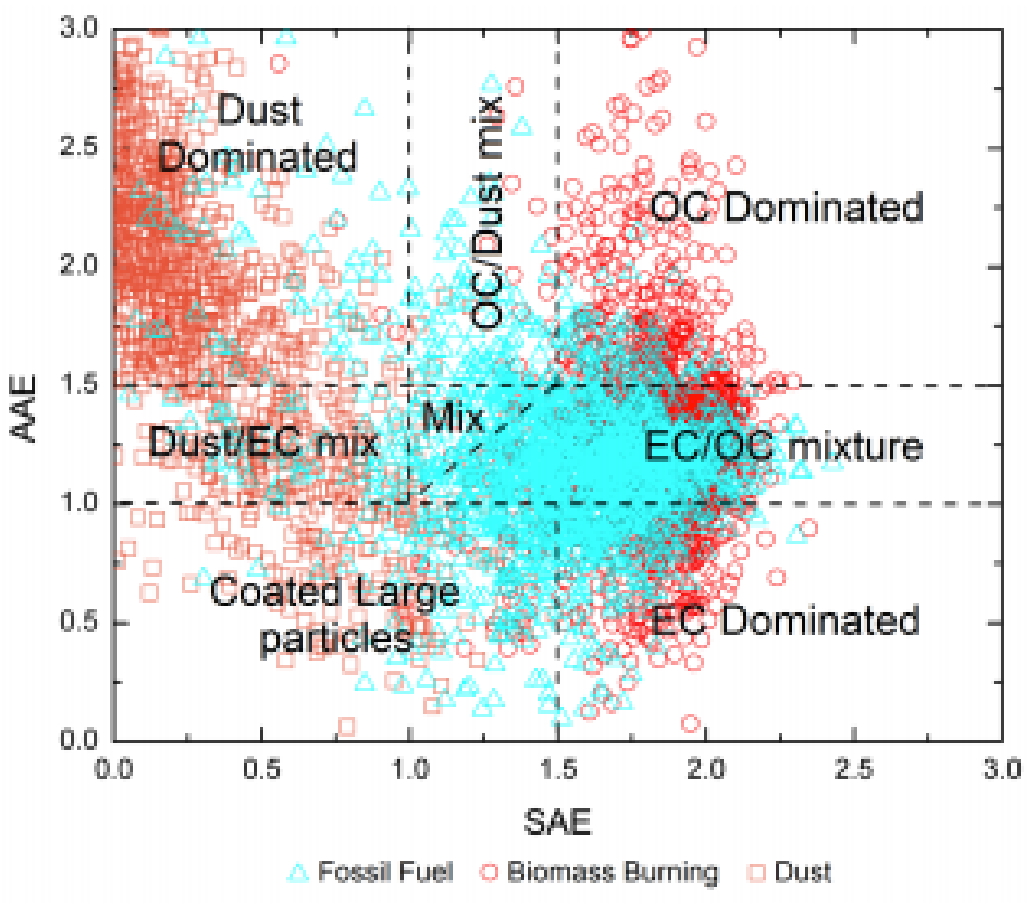
Aerosol Optical Properties

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



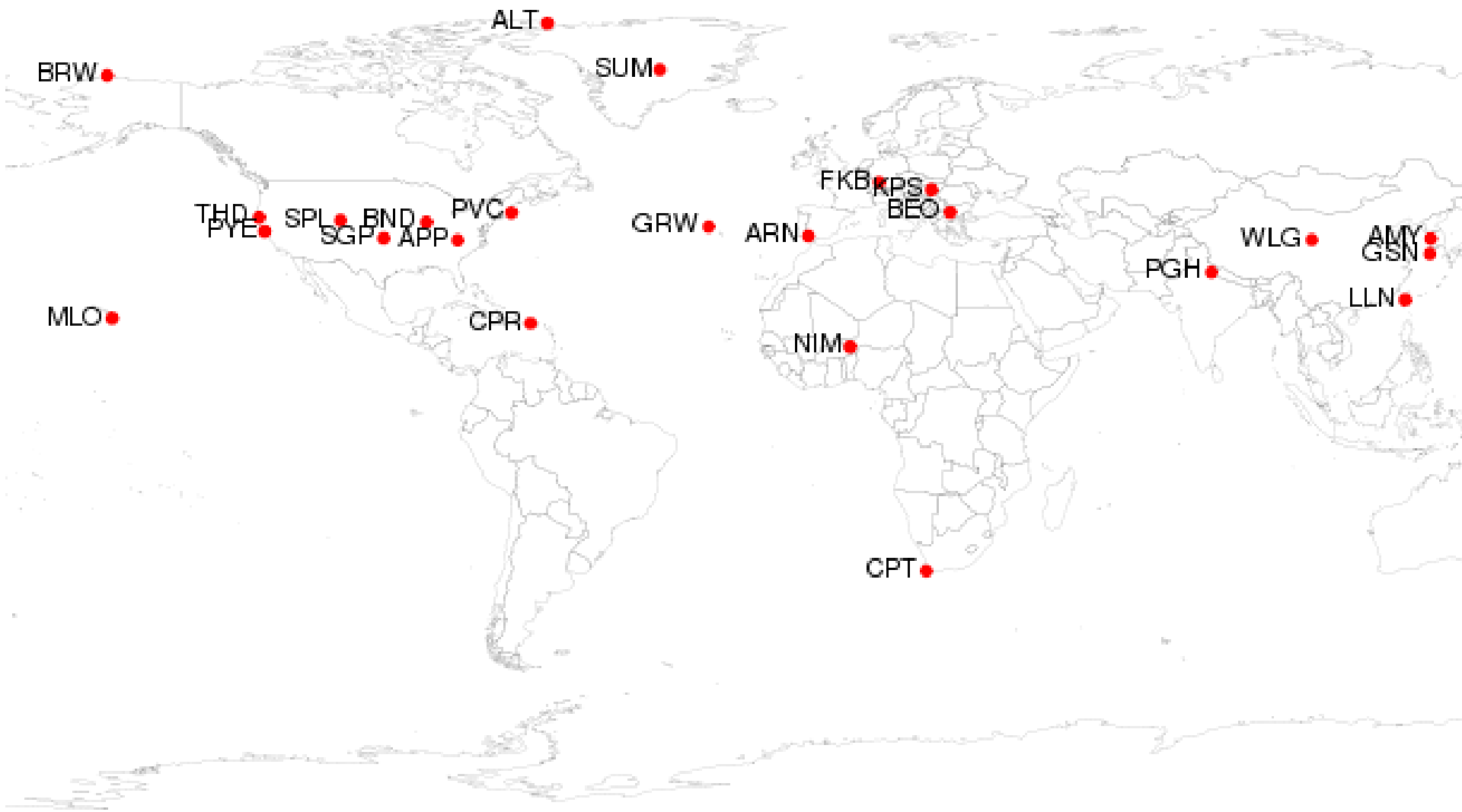
- Absorption Ångström Exponent (AAE)
  - Wavelength dependence of aerosol light absorption
  - AAE correlated with aerosol type
    - E.g.: Black carbon has theoretical value of 1

Previous Work



- 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

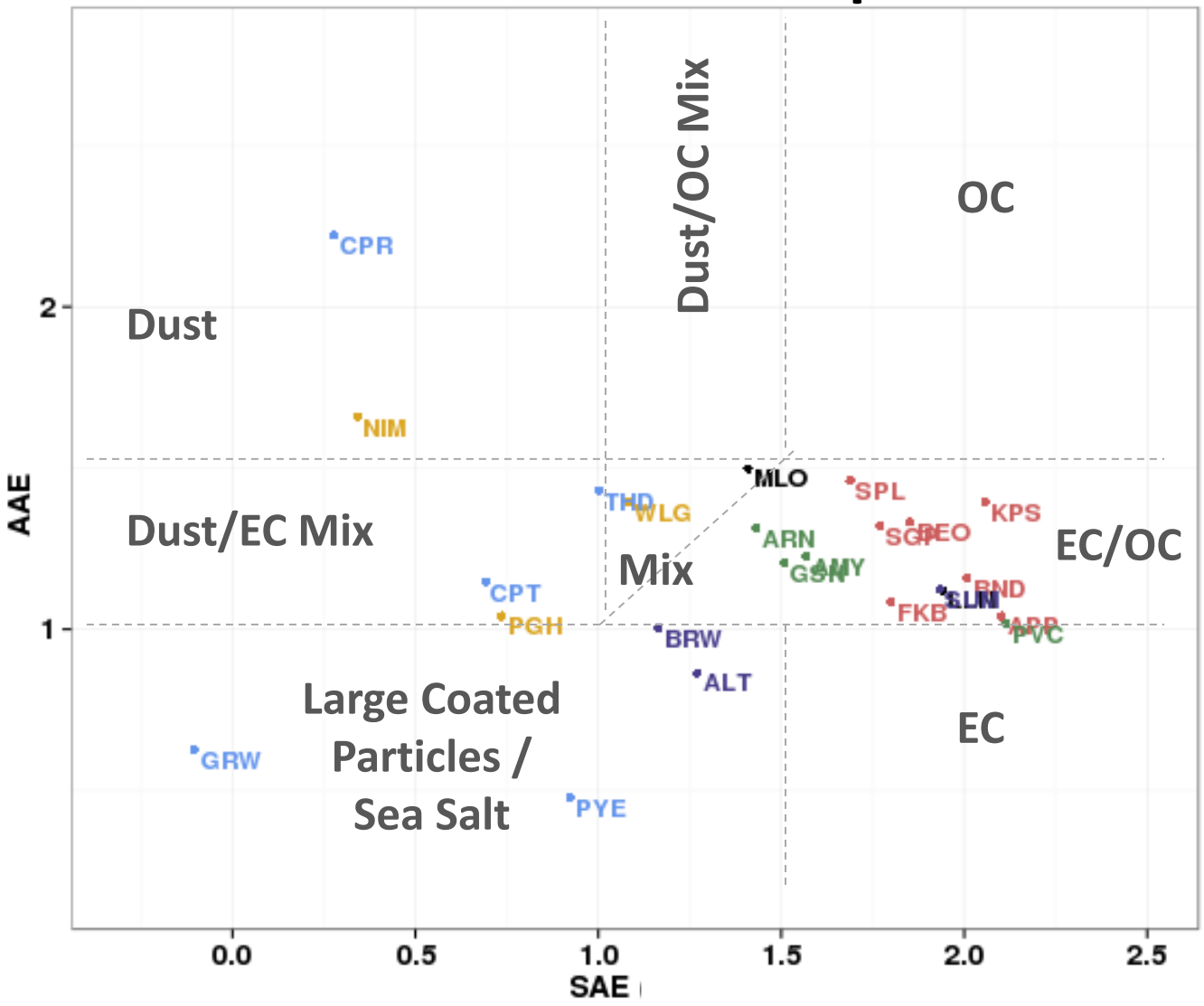
Global Monitoring Stations



Methods

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

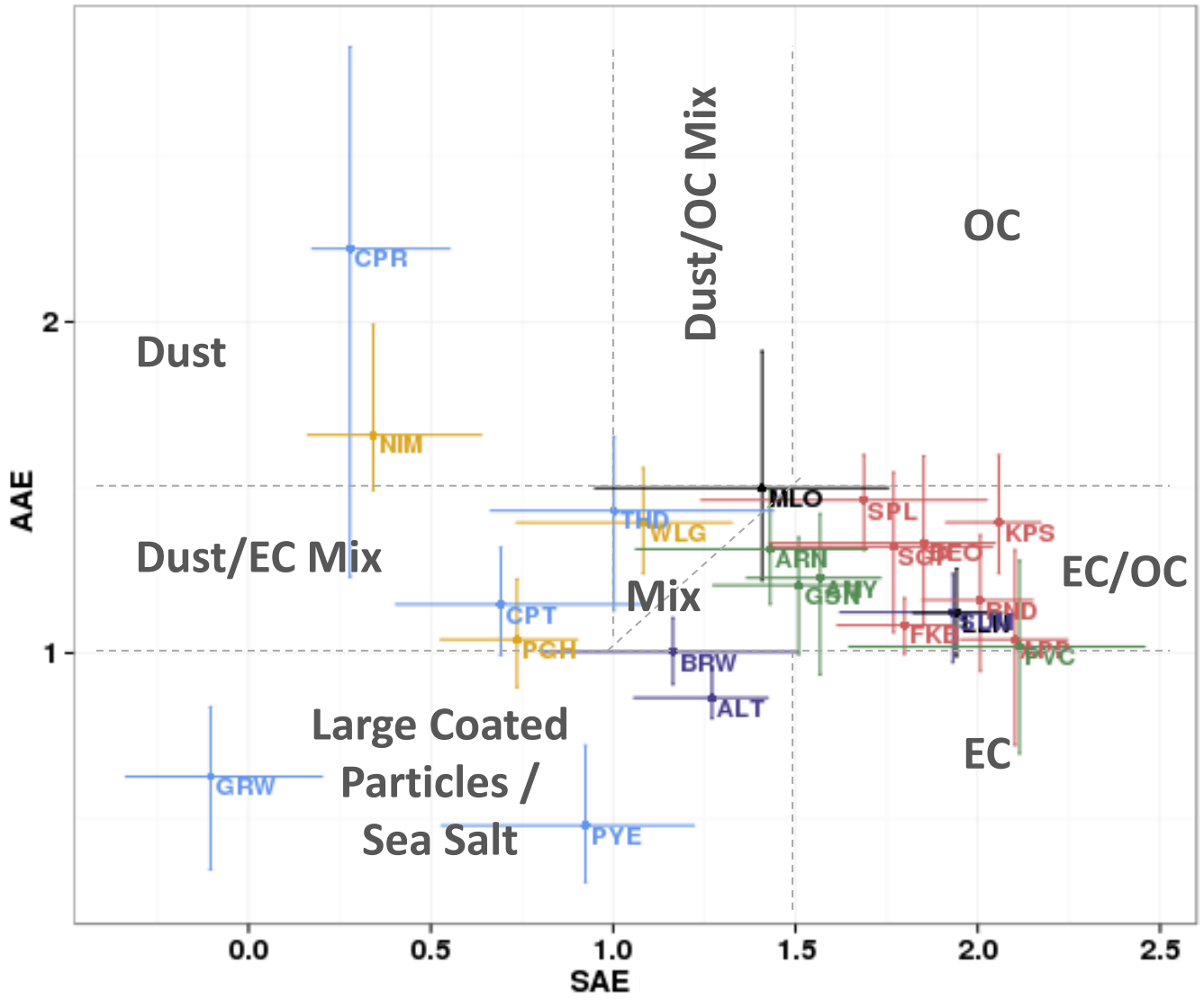
AAE-SAE Plot Space



Station Location Type

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

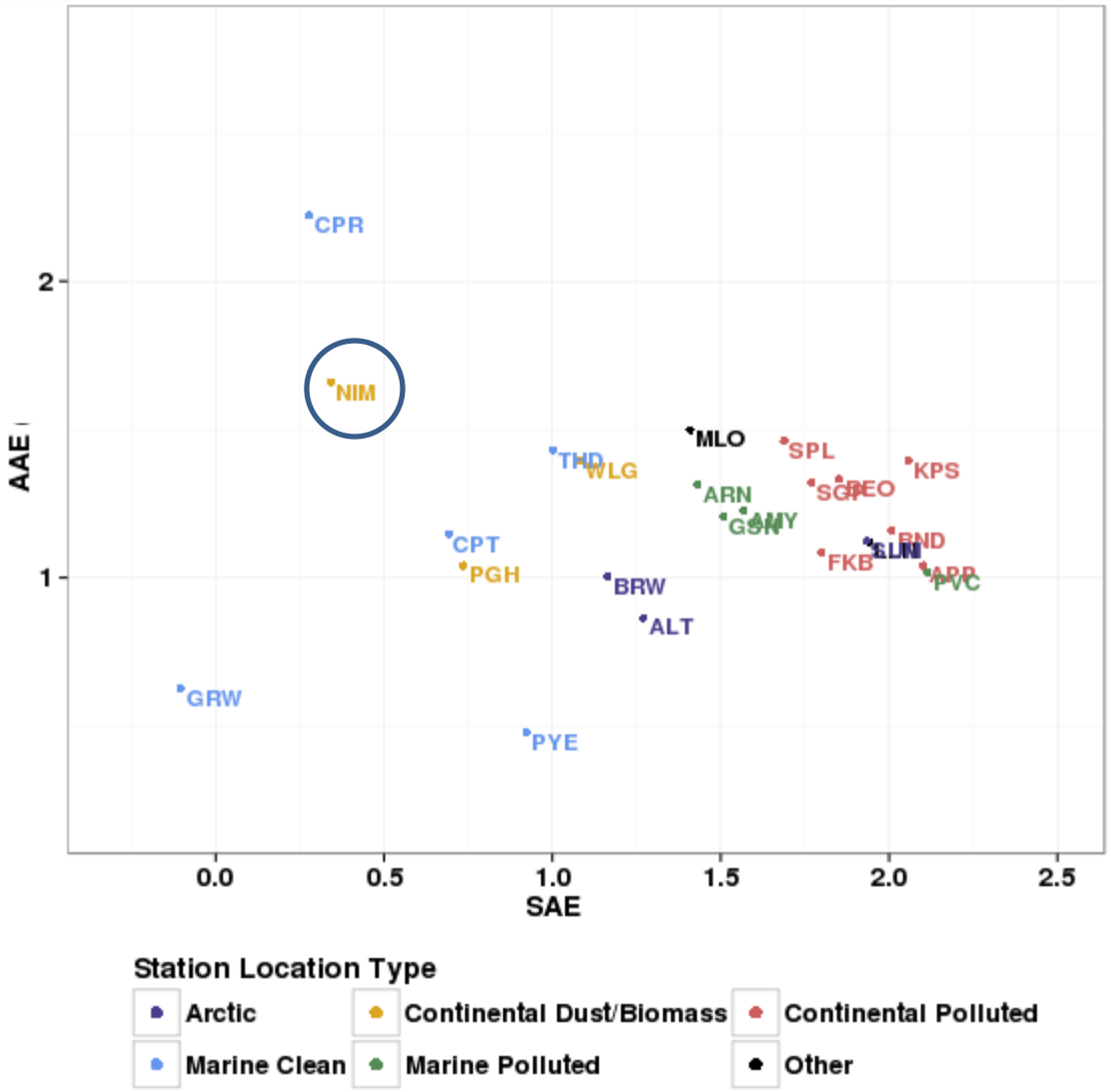
AAE-SAE Variability



Back Trajectory Analysis

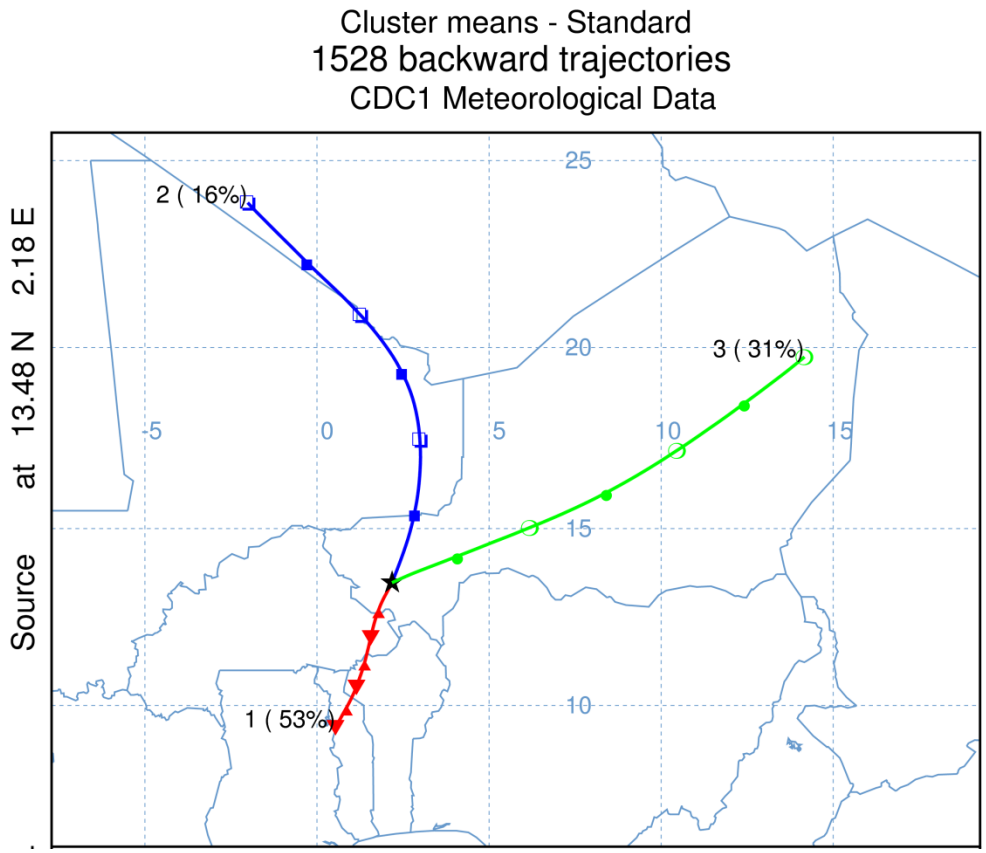
- Reduce ambiguity in likely aerosol type using back trajectories and clustering
- Methods
  - 3-day back trajectories generated using HYSPLIT
  - Trajectory cluster data paired with aerosol optical properties for plots

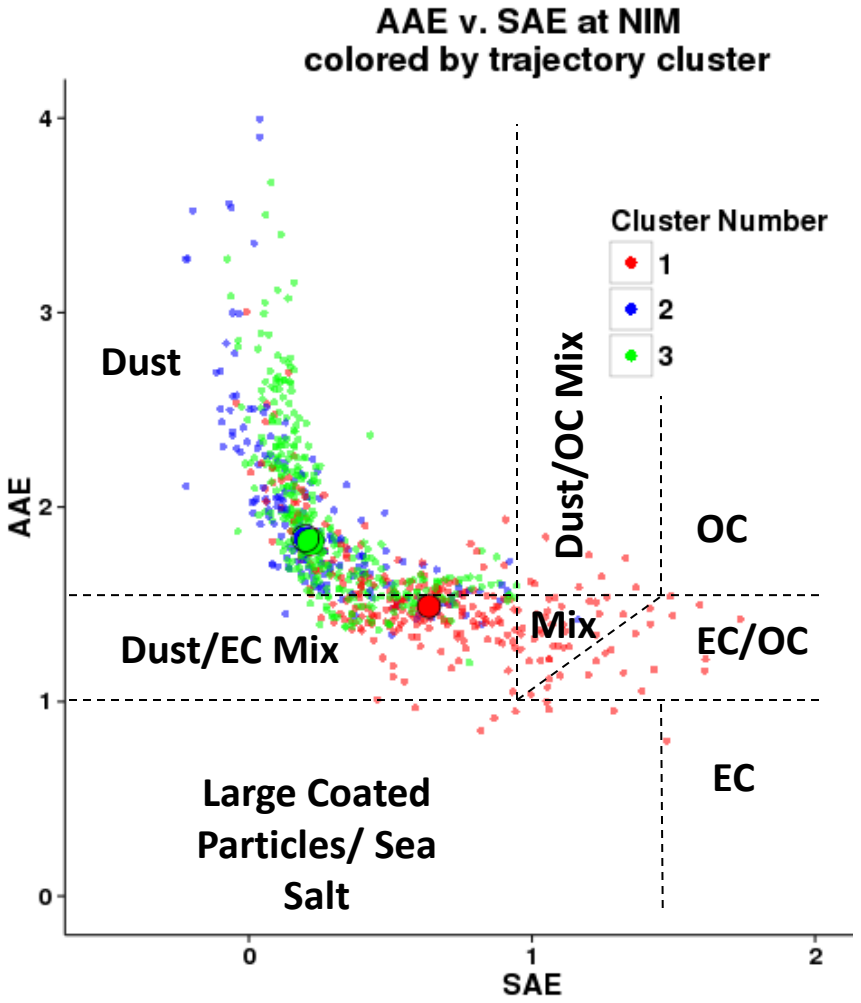
Niamey, Niger



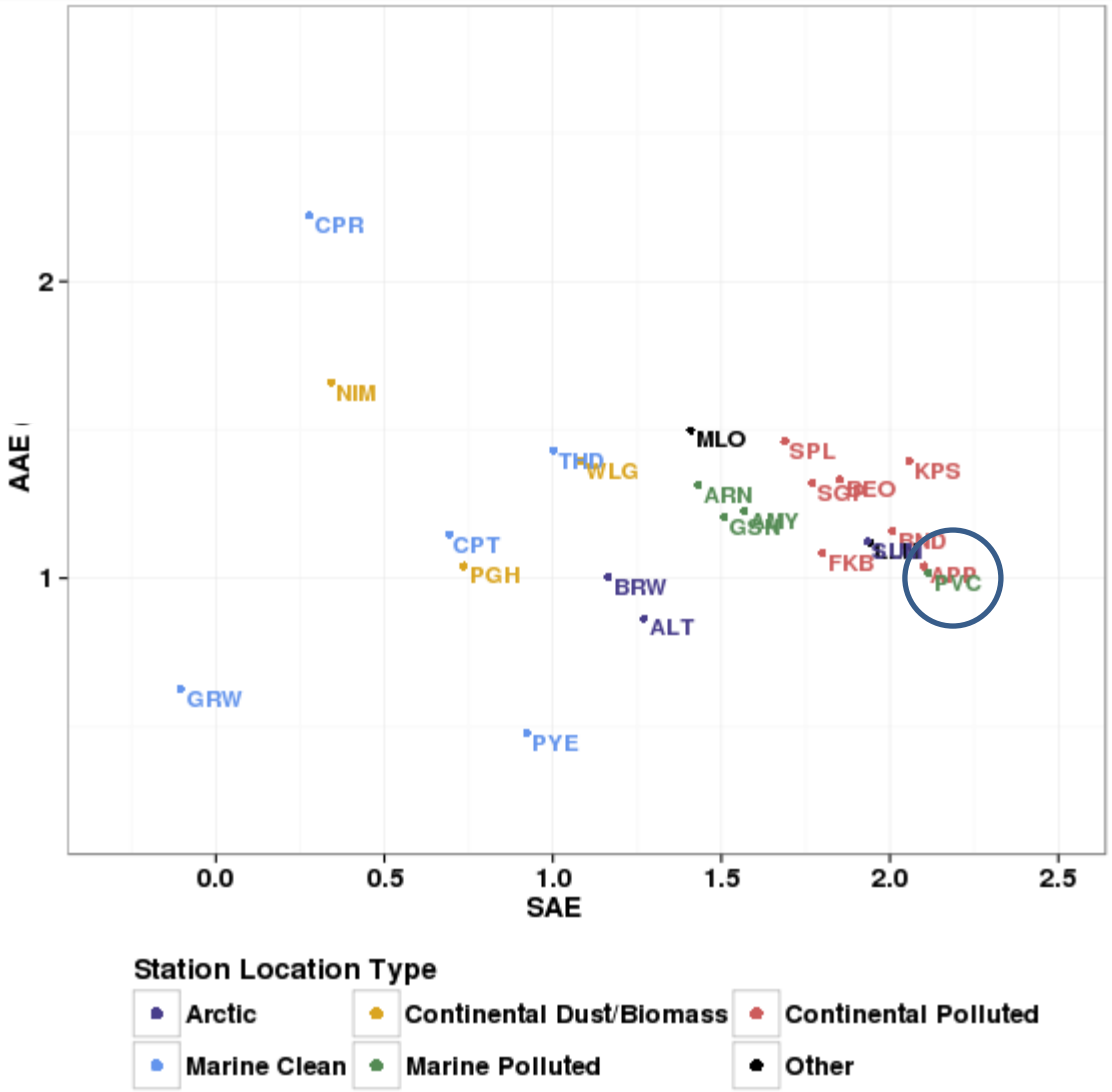
Back Trajectory Analysis

NIAMEY, NIGER



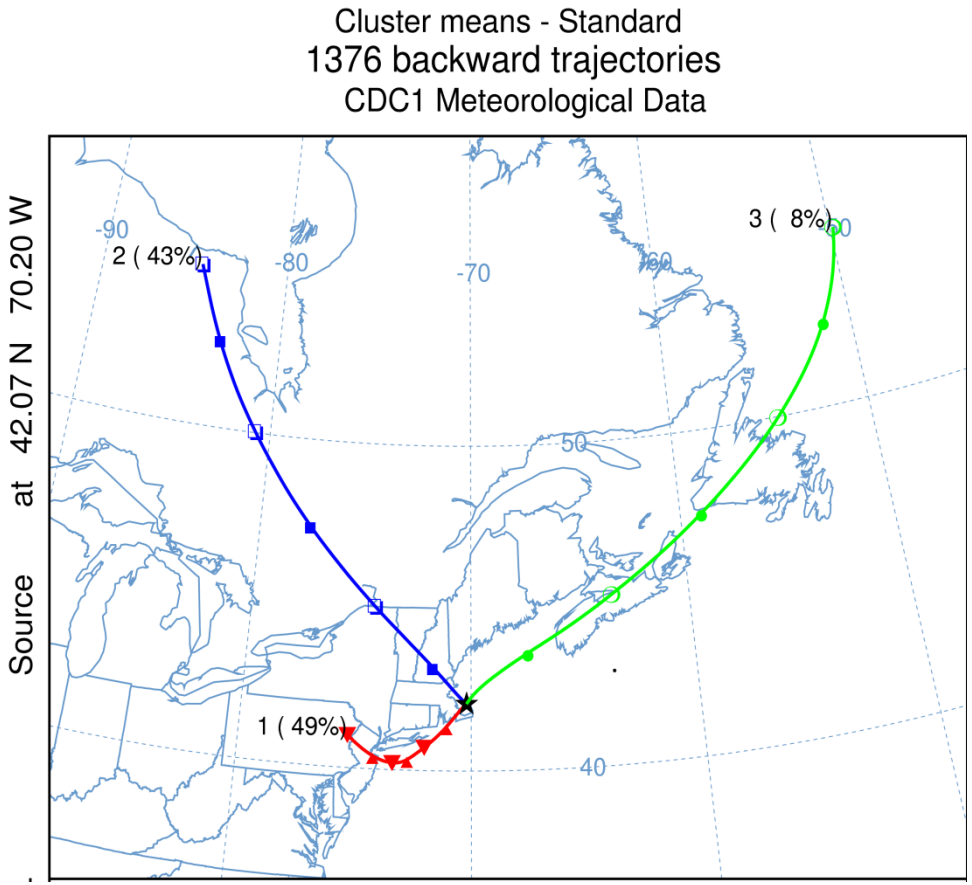


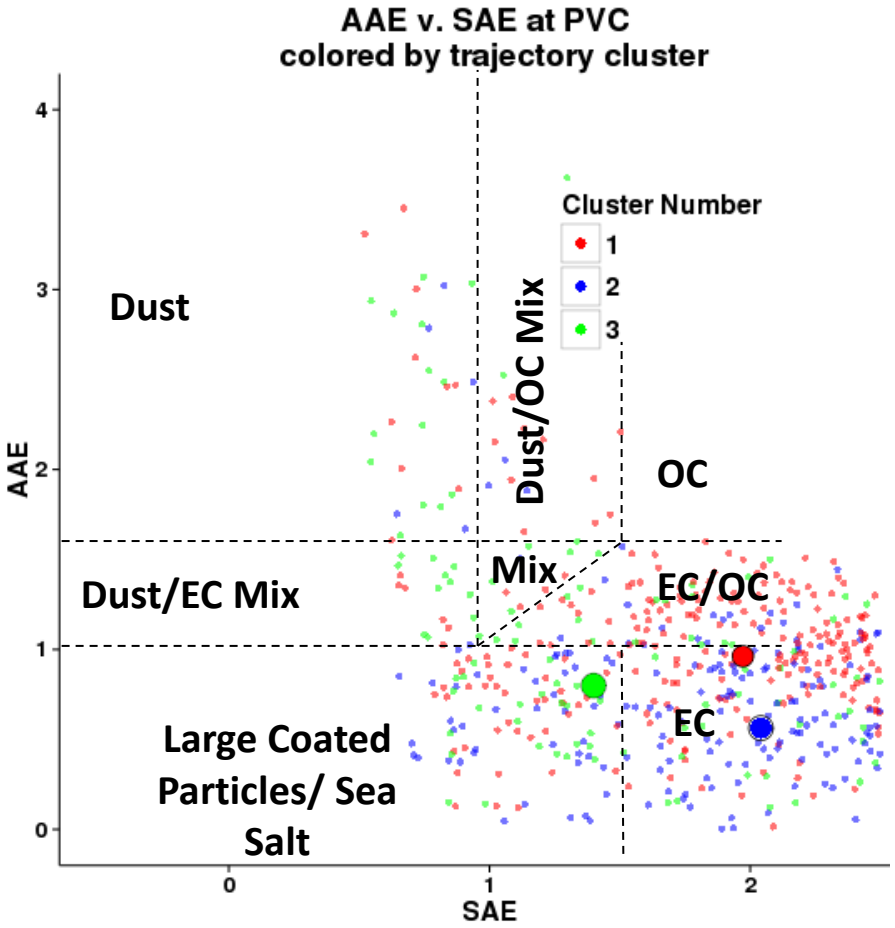
Cape Code, Massachusetts



Back Trajectory Analysis

Cape Cod, Massachusetts





Conclusions

- Aerosol optical properties can be used to infer likely dominant aerosol type
  - sing 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!

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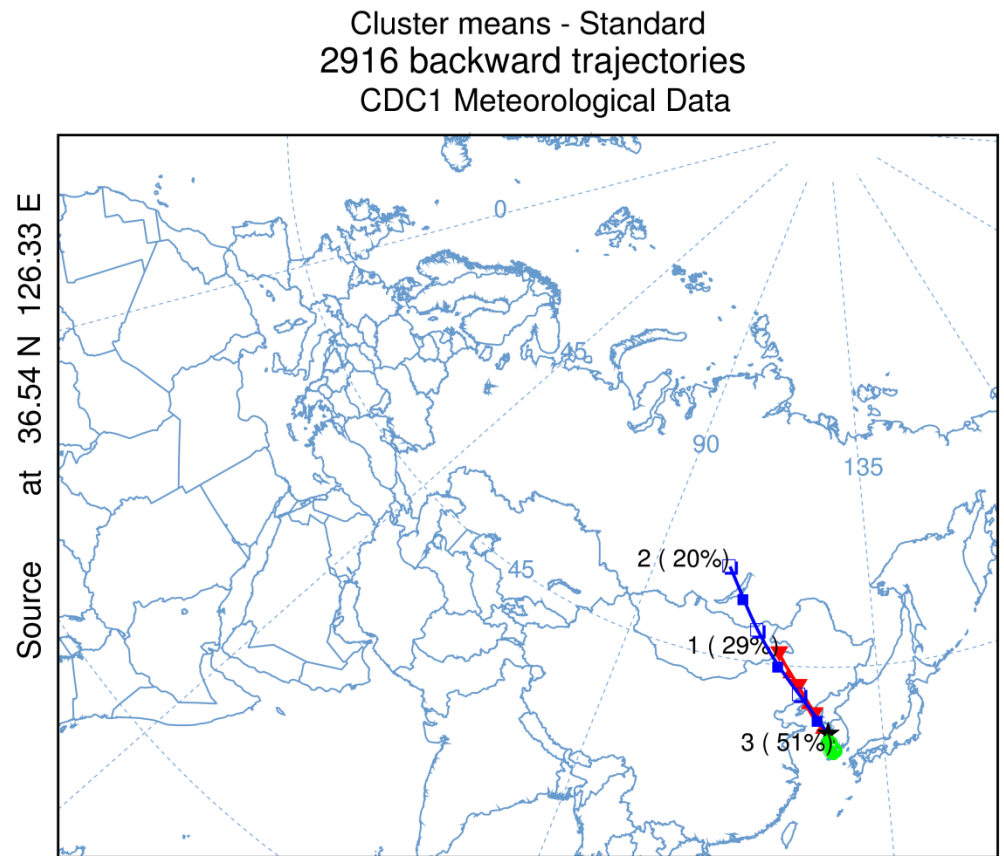
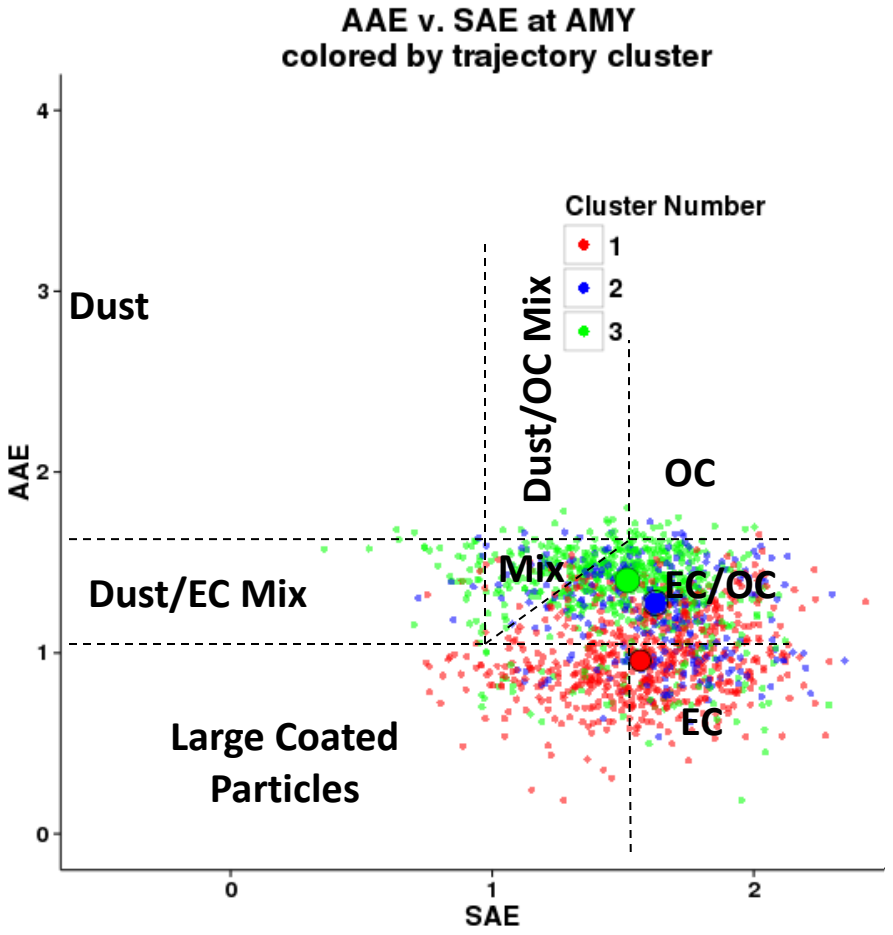
Back Trajectory Analysis

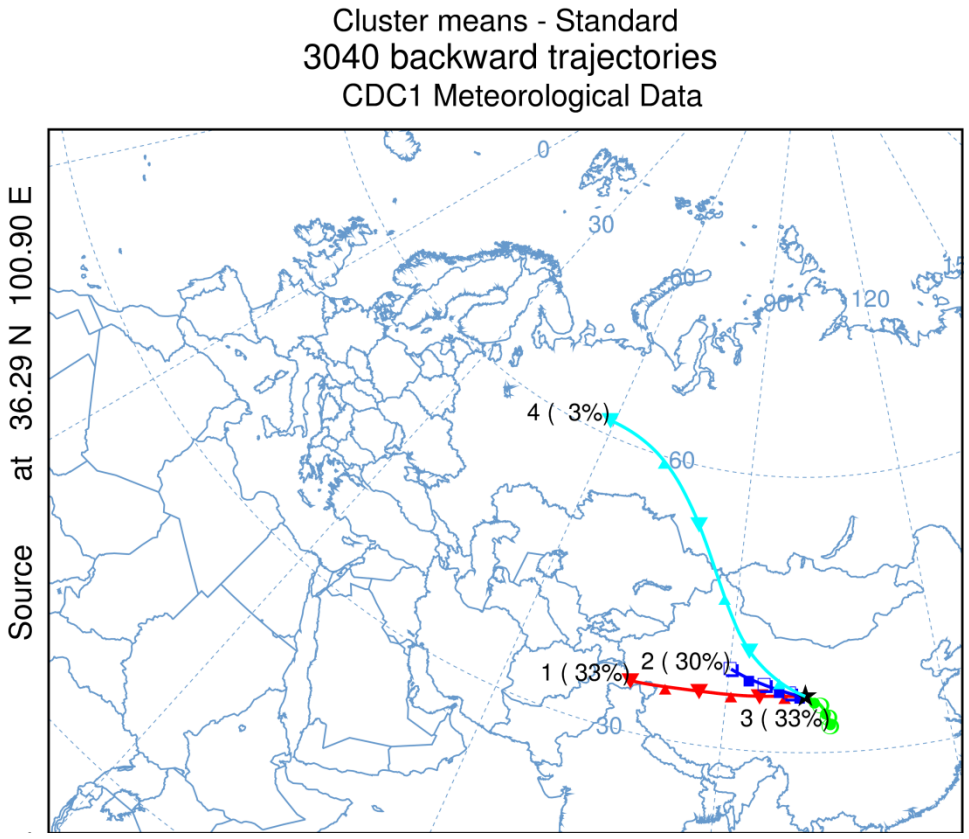
ANMYEON-DO, KOREA

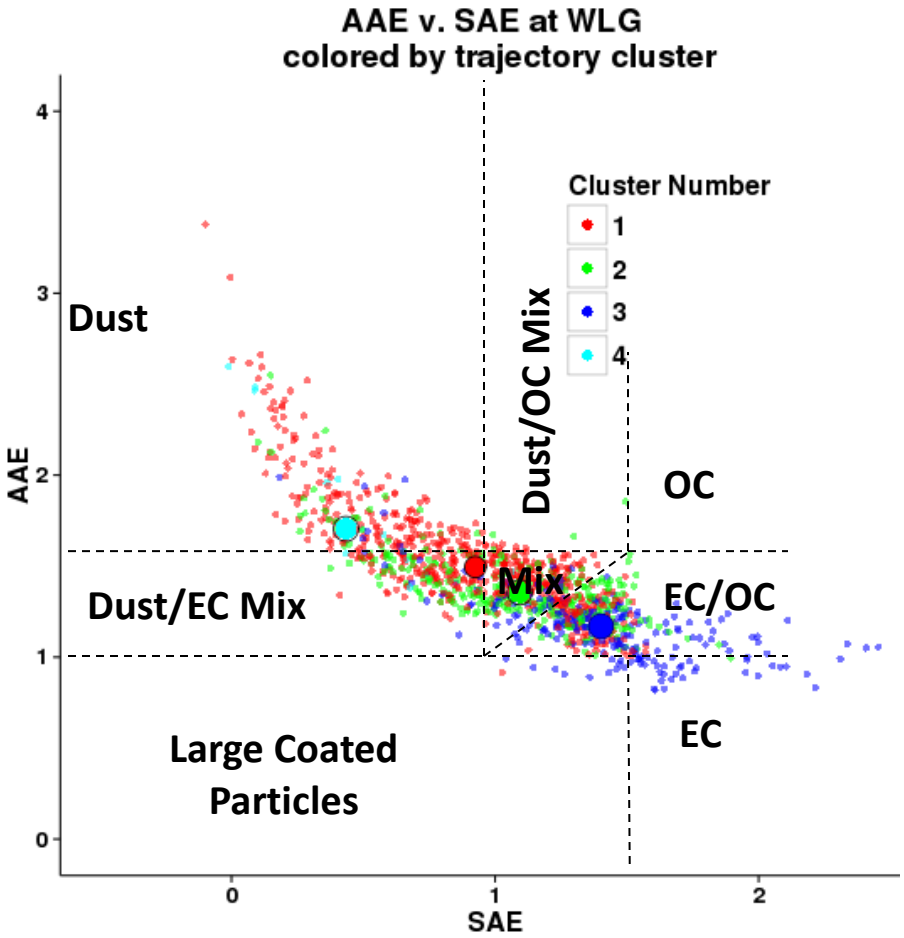




Back Trajectory Analysis

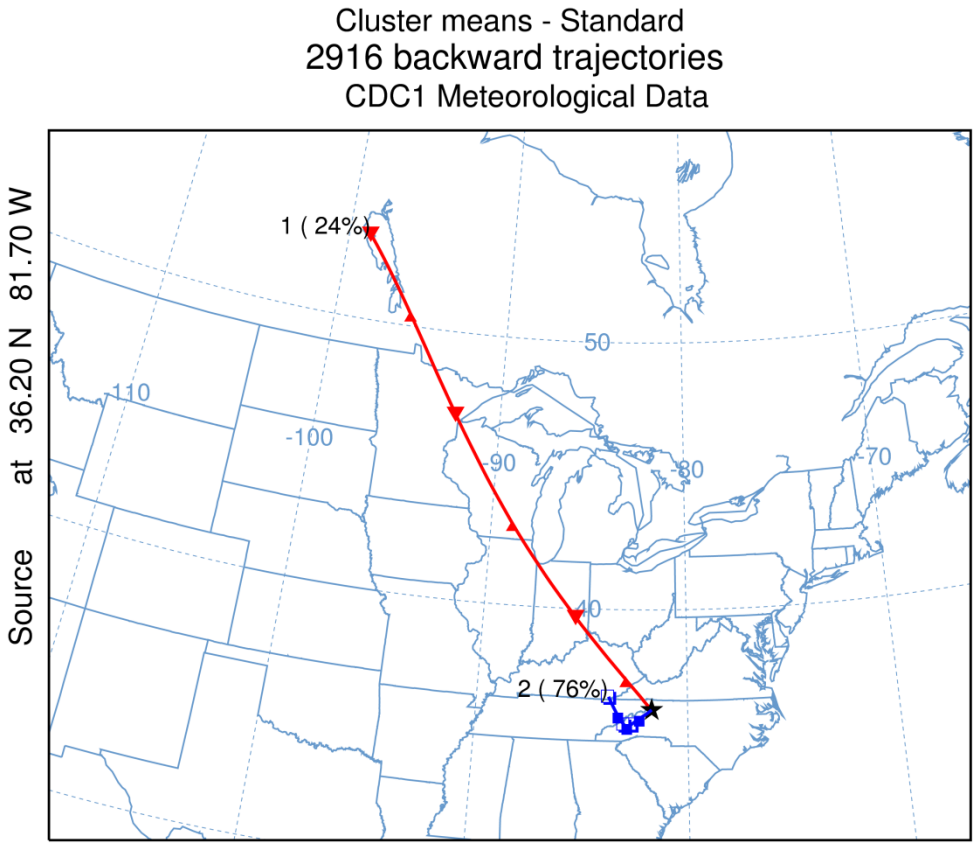
Mt. Waliguan, China

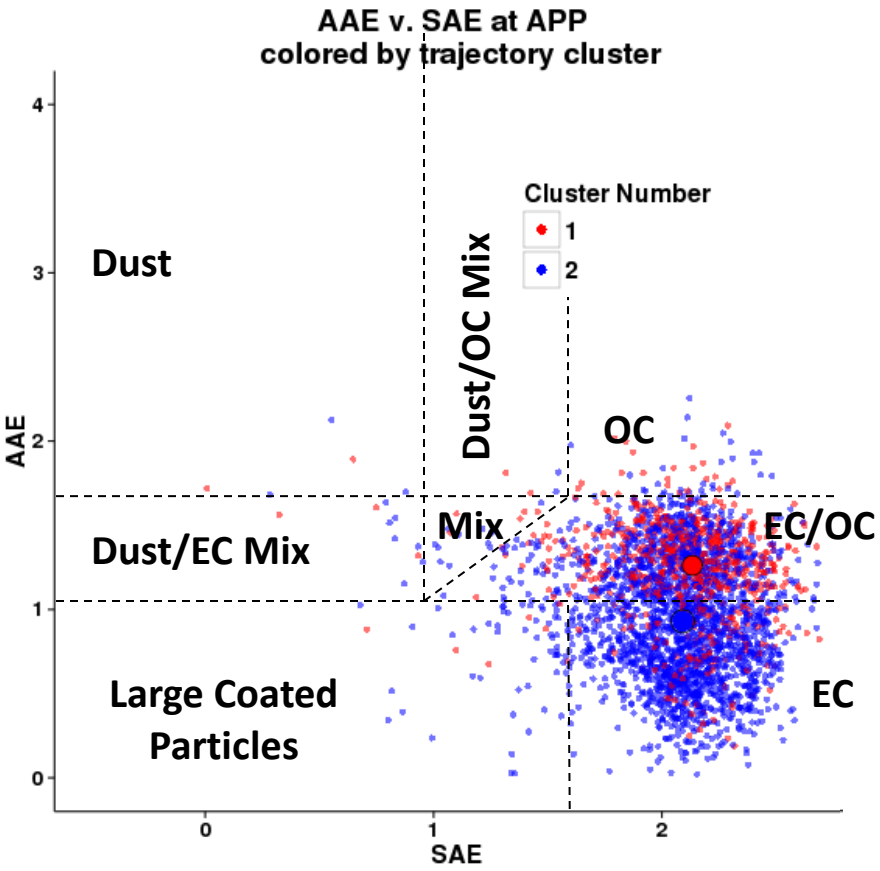




Back Trajectory Analysis

Boone, North Carolina





Aerosol Optical Properties

- Scattering Ångström Exponent (SAE)
  - $-\log(\frac{\sigma_{s1}}{\sigma_{s2}})/\log(\frac{\lambda_1}{\lambda_2})$
  - Wavelength dependence of aerosol light scattering
  - SAE and particle size negatively correlated (Bergstrom et al., 2007)
- Absorption Ångström Exponent (AAE)
  - $-\log(\frac{\sigma_{a1}}{\sigma_{a2}})/\log(\frac{\lambda_1}{\lambda_2})$
  - 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)

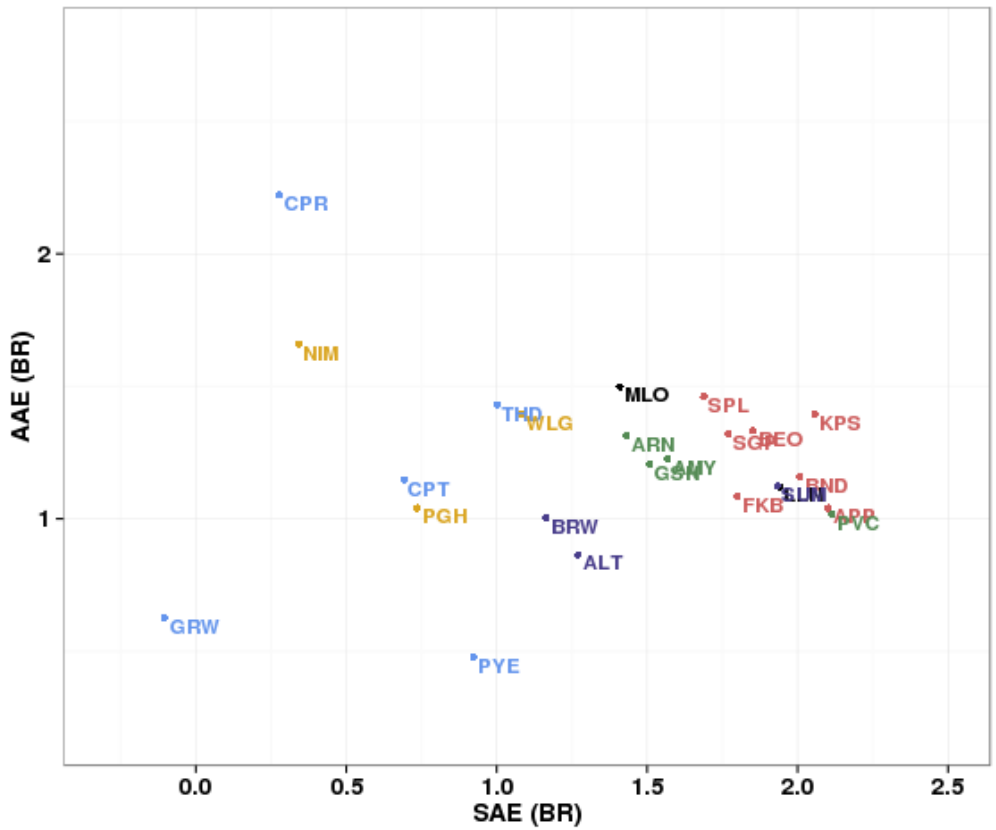
Parameter Cluster Analysis

- 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

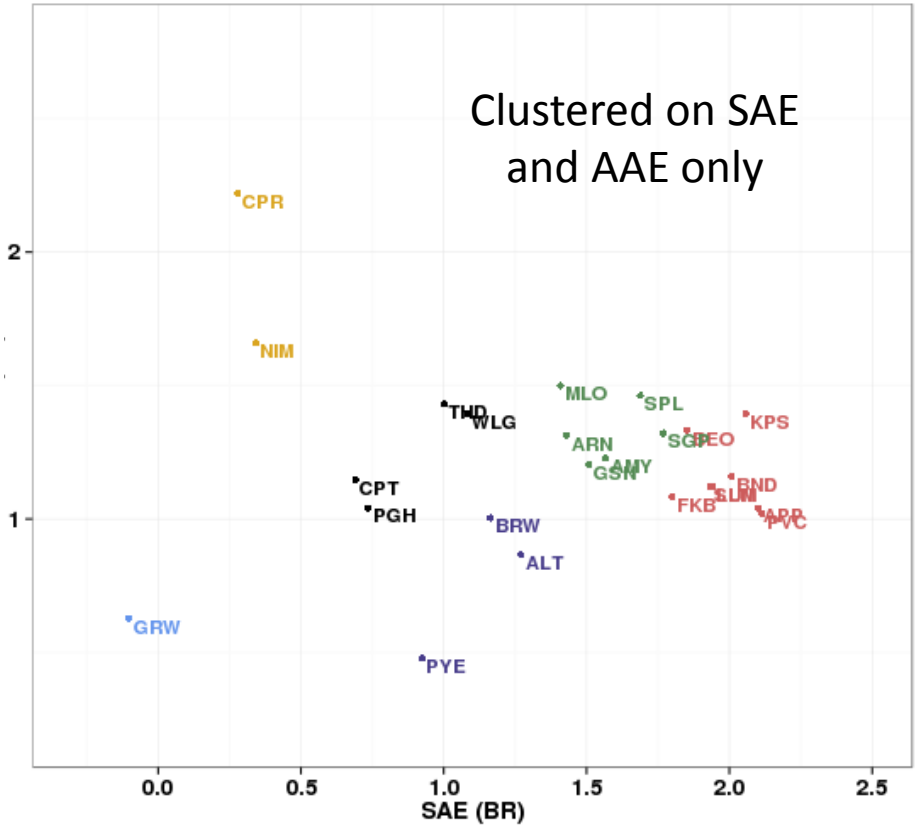
Colored by station location type



Station Location Type

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

Colored by cluster number



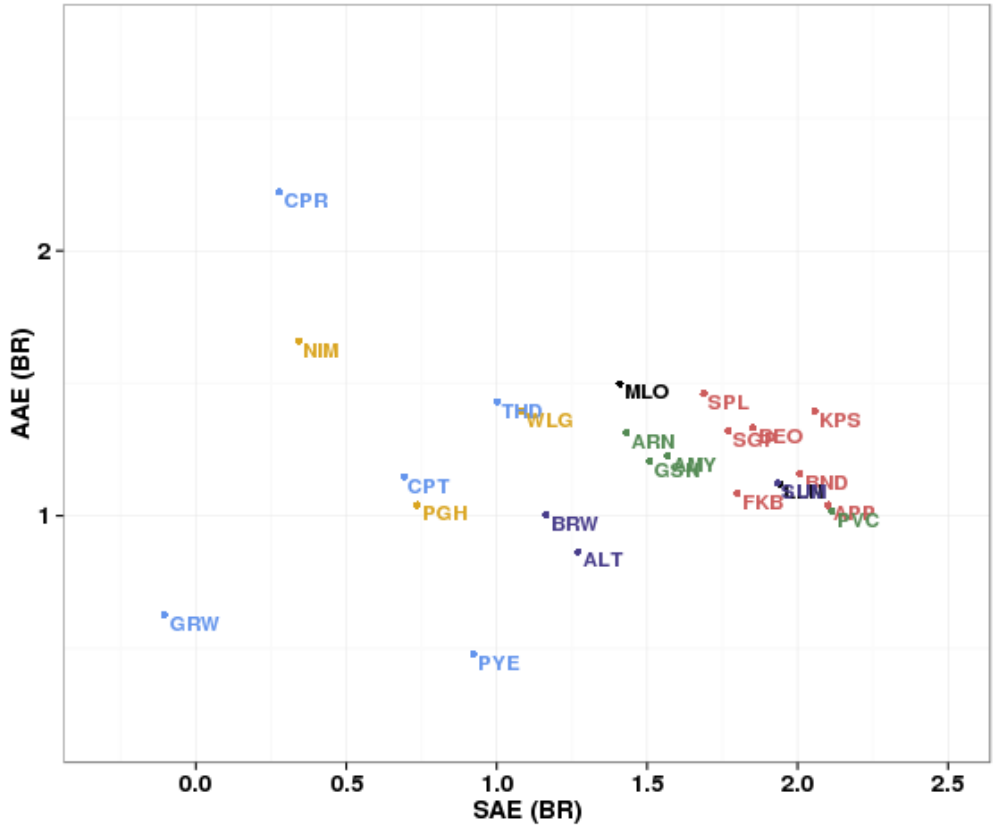
Station Location Type

1 | 2 | 3 | 4 | 5 | 6

Parameter Cluster Analysis

SAE-AAE Plot Spaces

Colored by station location type



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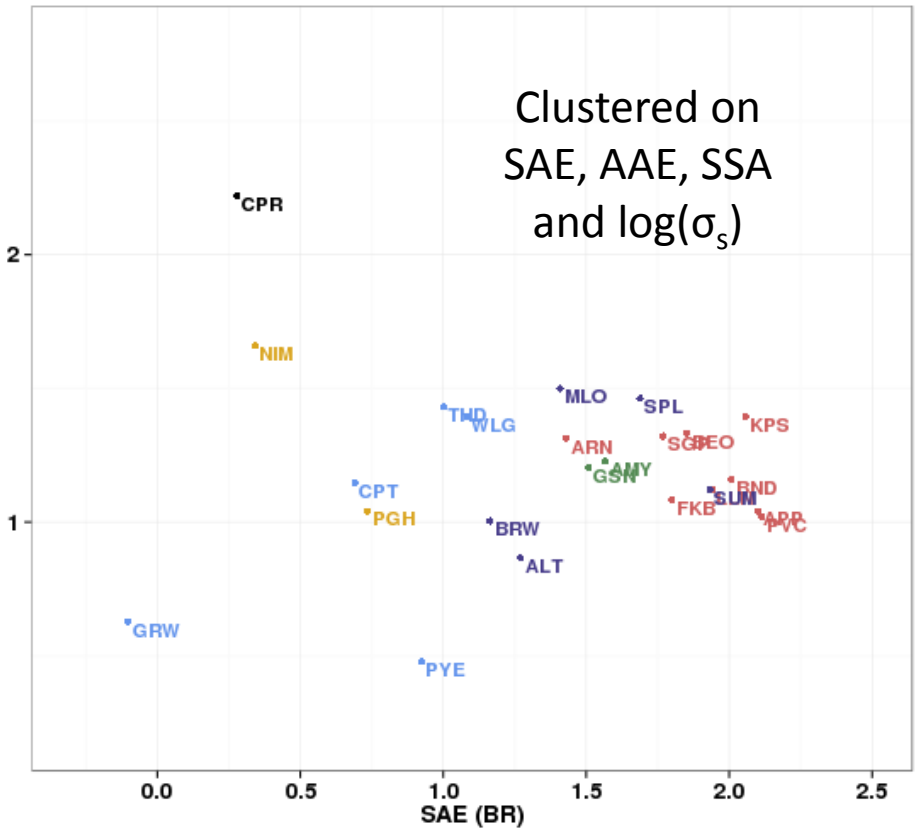

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Station Location Type

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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