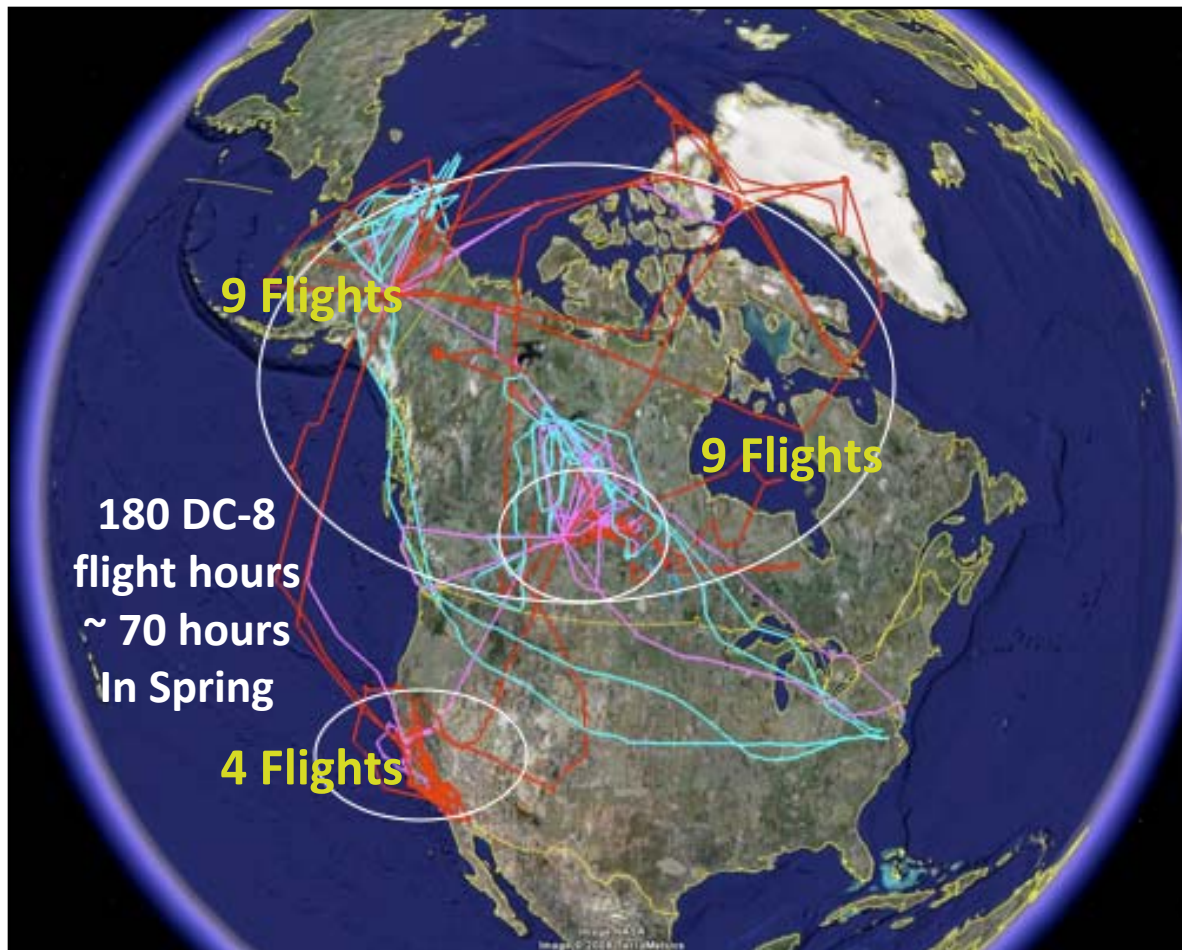# ARCTAS Data for Model Analysis and Assessment
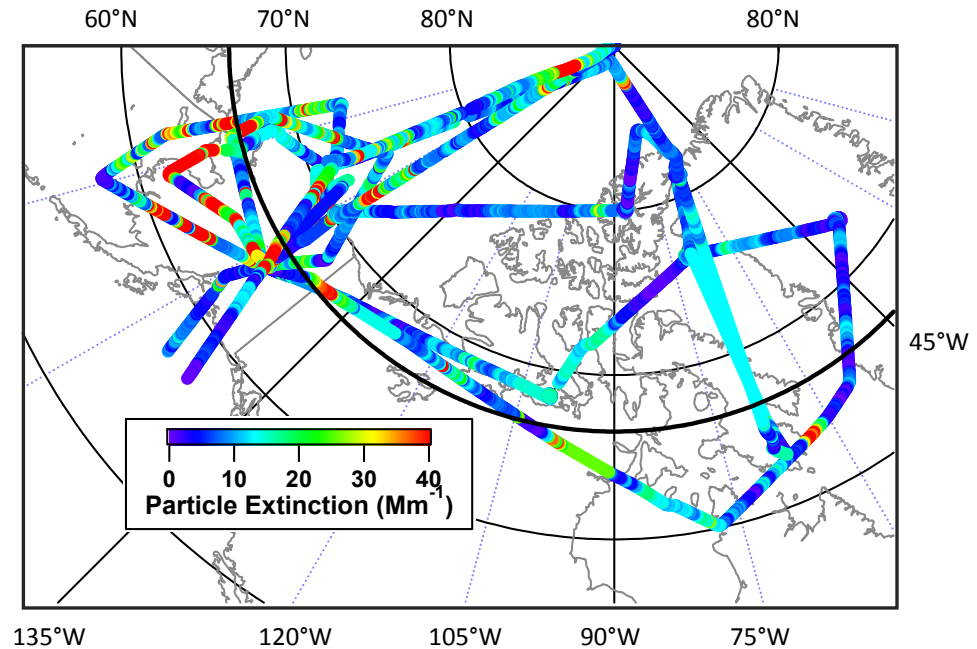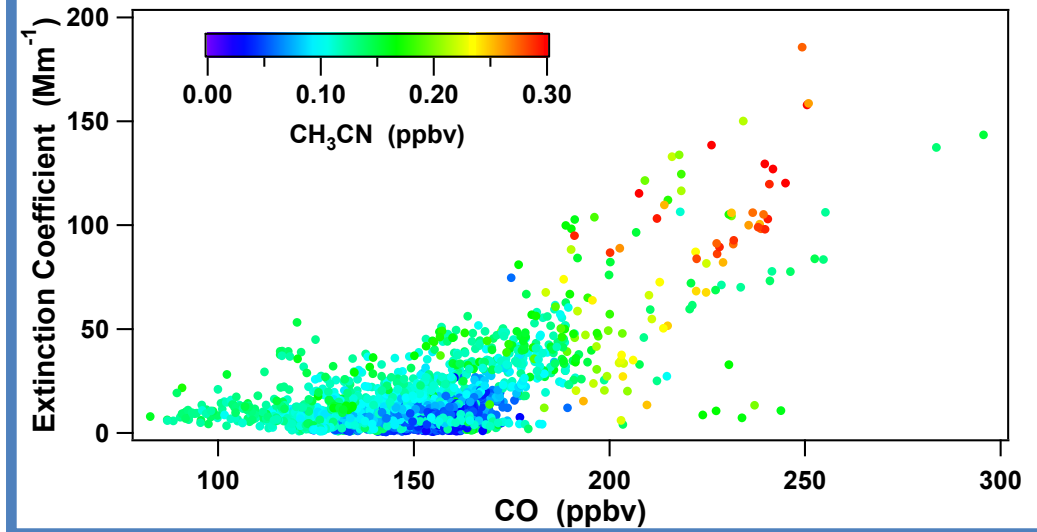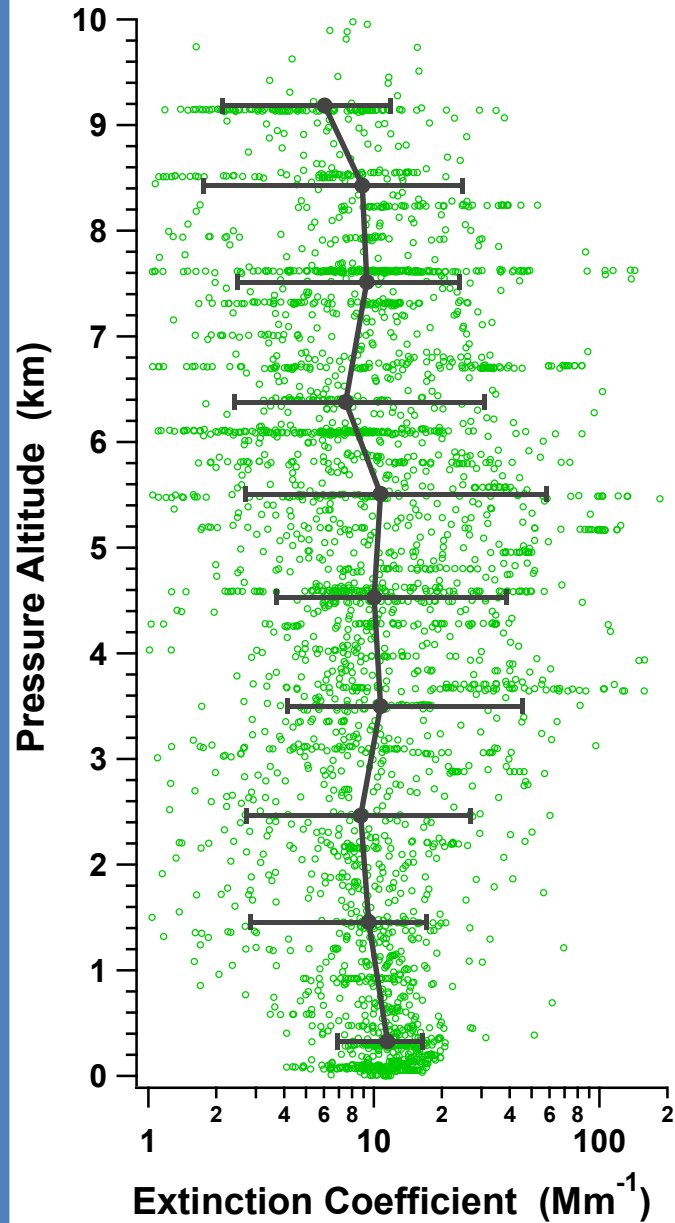
G Chen, MM Kleb, AJ Beyersdorf, BE Anderson, KL Thornhill, JH Crawford, and AM Wiley

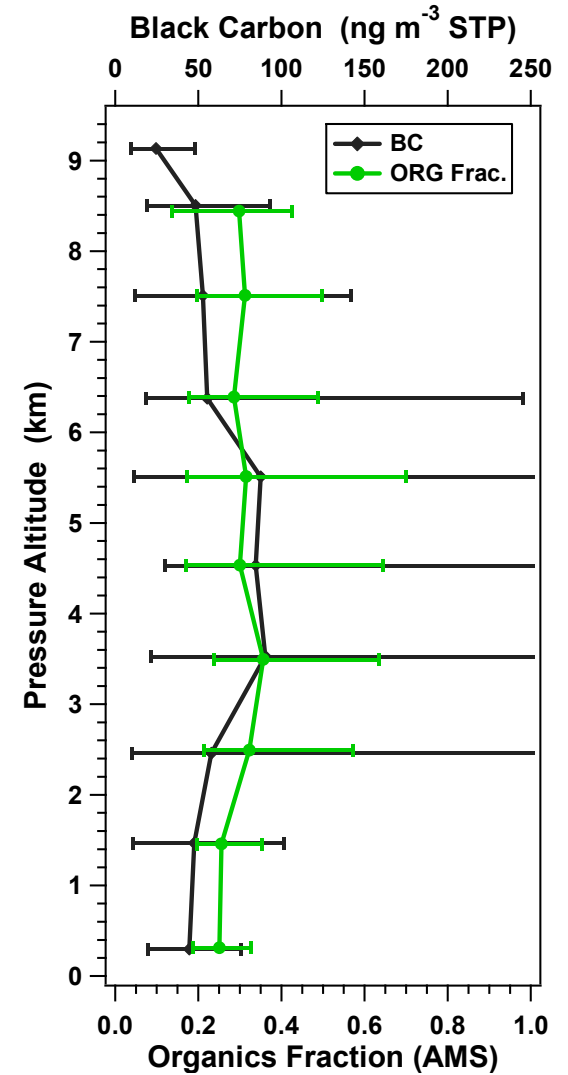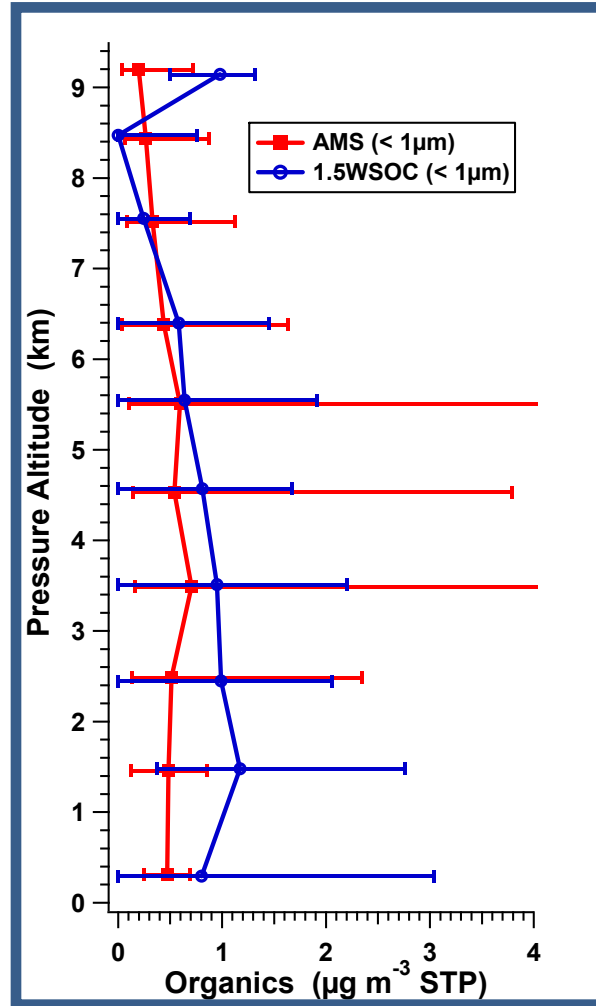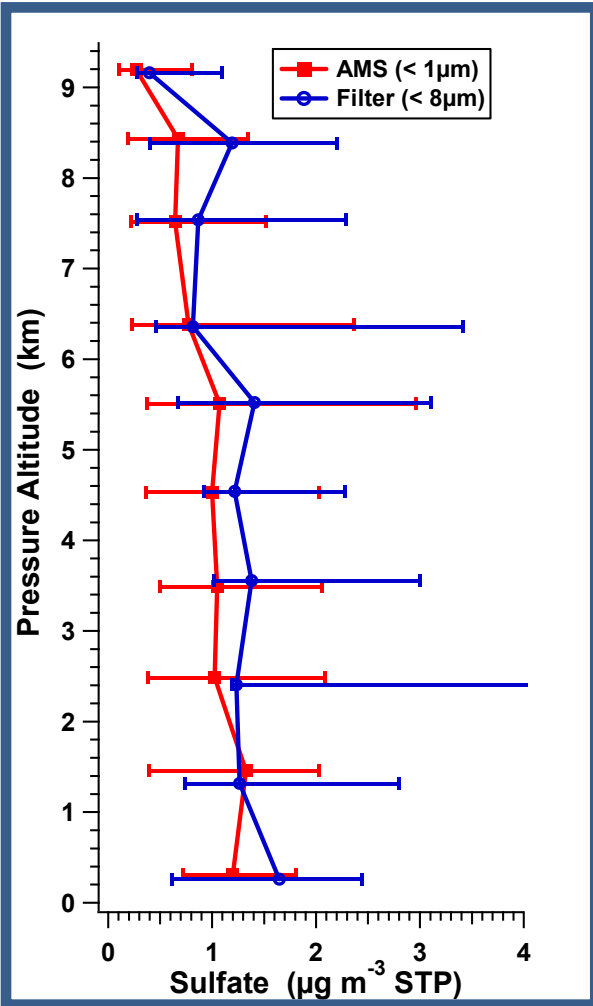## OBJECTIVES: Arctic Haze, Long-range Transport, and Bromine Chemistry
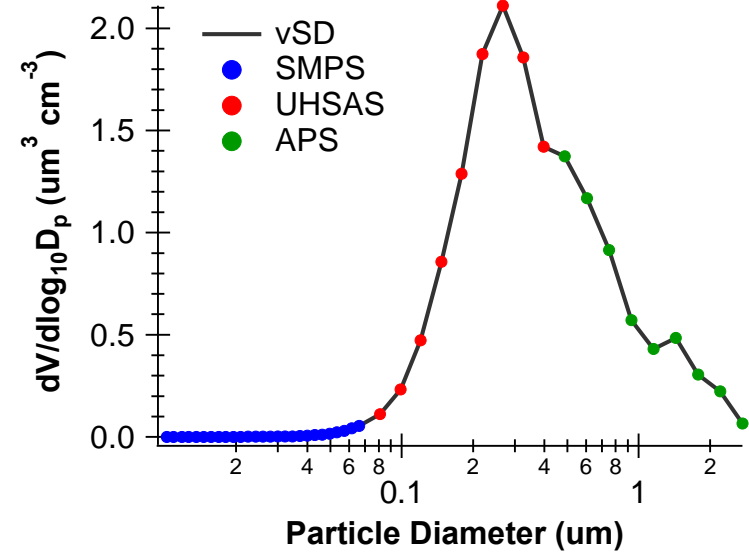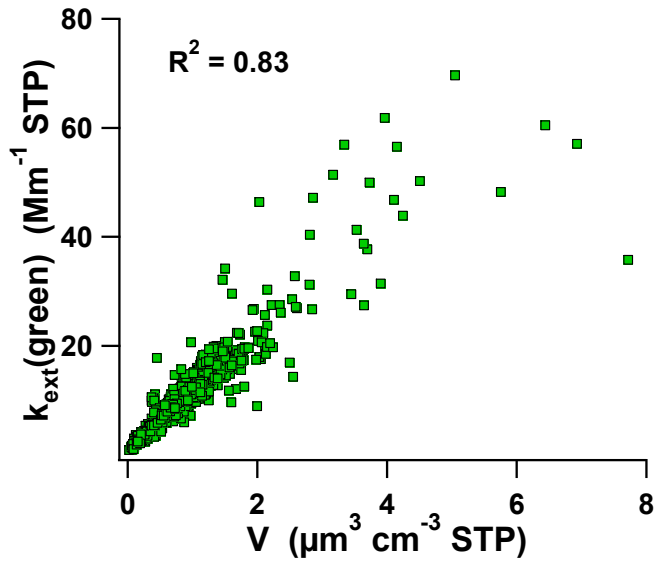### April 2008: Fairbanks, Alaska

Arctic Haze Observation I – Optical Properties

Arctic Haze Observation II
Chemical Composition

Arctic Haze Observation III
Microphysical Properties
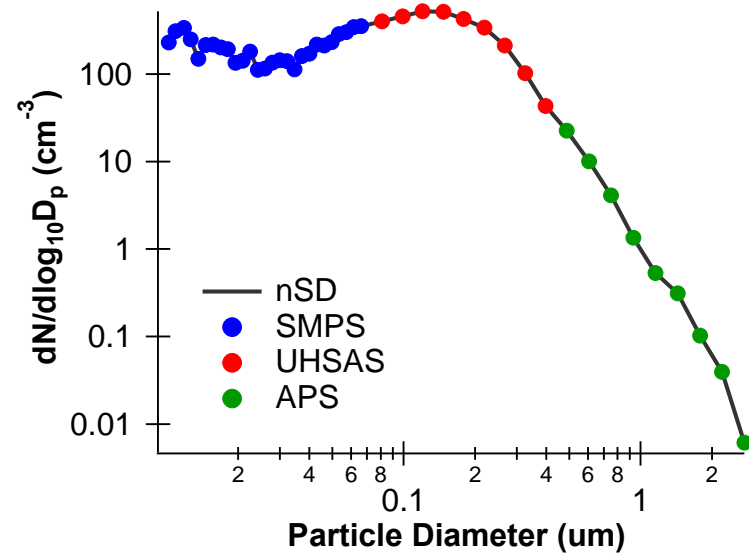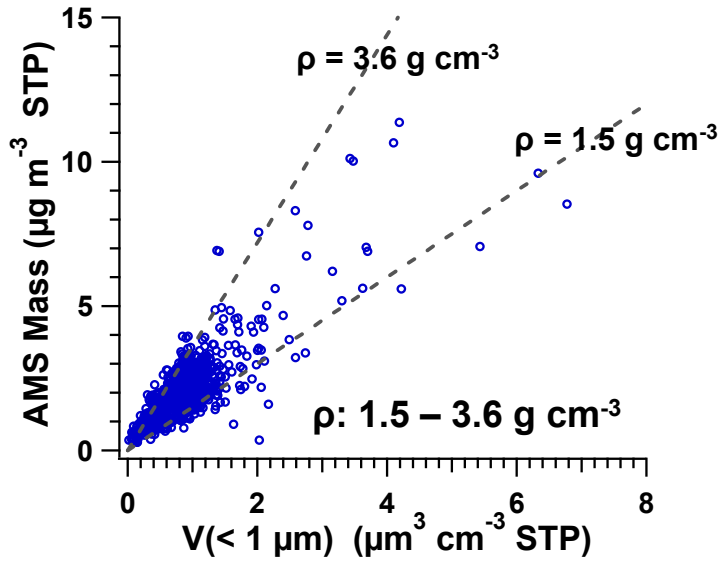
Full size distribution data available for alt < 3 km

Arctic Haze Observation IV
Intensive Properties

Single Scattering Albedo
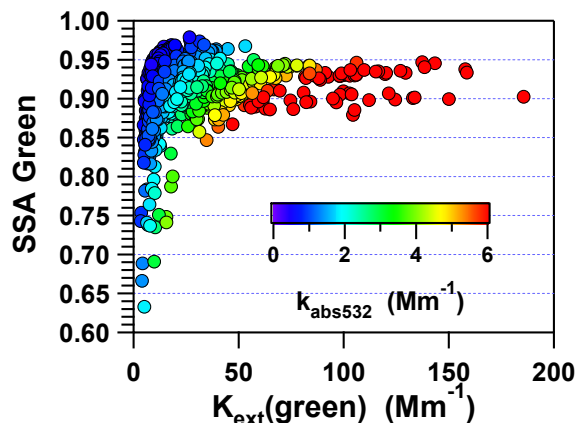
- SSA dependence on sources.
- Very Low SSA value due to measurement uncertainties or just clean atmosphere?
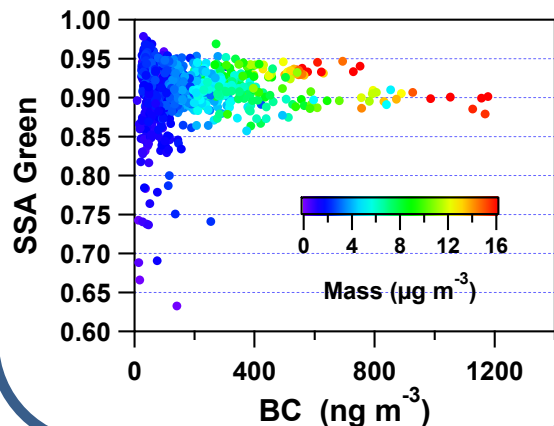
Angstrom Exponents
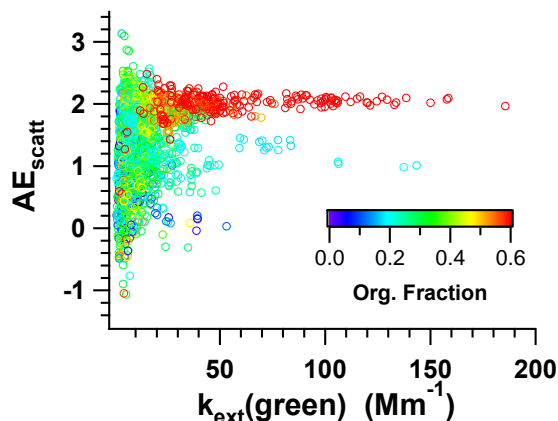
- AE$_{scatt}$ suggests sampling of various sizes.
- AE$_{abs}$ dependent on org. fraction and particle size.
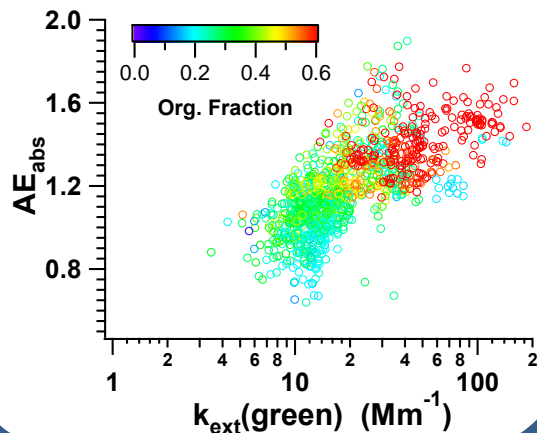
Mass Extinction Coef.
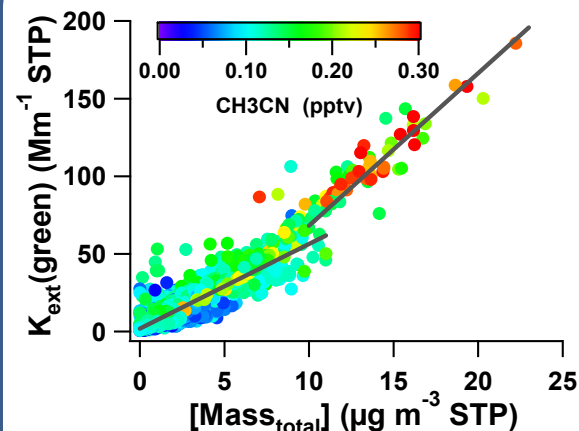
- μ_{mass} = 5.5 m^2 g^{-1} for haze.
- μ_{mass} = 9.8 m^2 g^{-1} for haze.
- Org. important component.
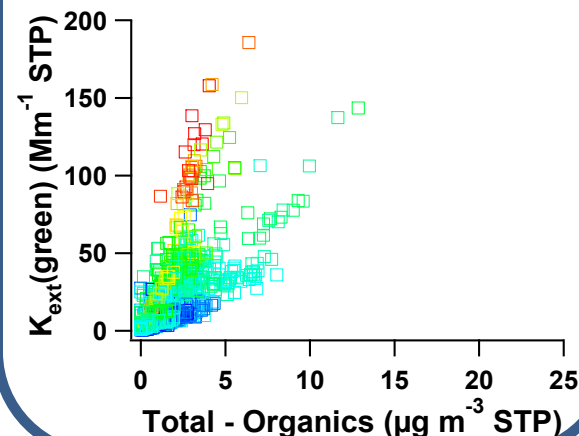
Measurement Uncertainty Assessment
Tropospheric Airborne Measurement Evaluation Panel

- **TAbMEP consists of both measurement and modeling experts from NASA, NOAA, DOE, and universities.**

- **TAbMEP goal:**
  - Establish objective, data driven, and systematic approaches to assess measurement uncertainties (Both random and systematic uncertainties)
 - Review wingtip-to-wingtip intercomparison results.
  - Provide unbiased and clear measurement uncertainty reports for user community.

- **ARCTAS/ARCPAC data review meeting held in July 2009, in NCAR, Boulder CO.**

Measurement Uncertainty I
Scattering and Absorption

- **Nephelometer scattering measurement represents one of the best particle measurements in terms of consistency and reliability.**

- **Absorption Measurement:**
  - Effect of different data processing procedures.
  - Effect of organic coating on accuracy. Both lab and field experiment showed significant impact, e.g., up to 100%, (Lack et al., 2008). This may have at least some impact on ARCTAS data.
  - Typical uncertainty: 20 – 30%, < 10 Mm^{-1} data may be subject to larger uncertainties.

- **Scattering Measurement:**
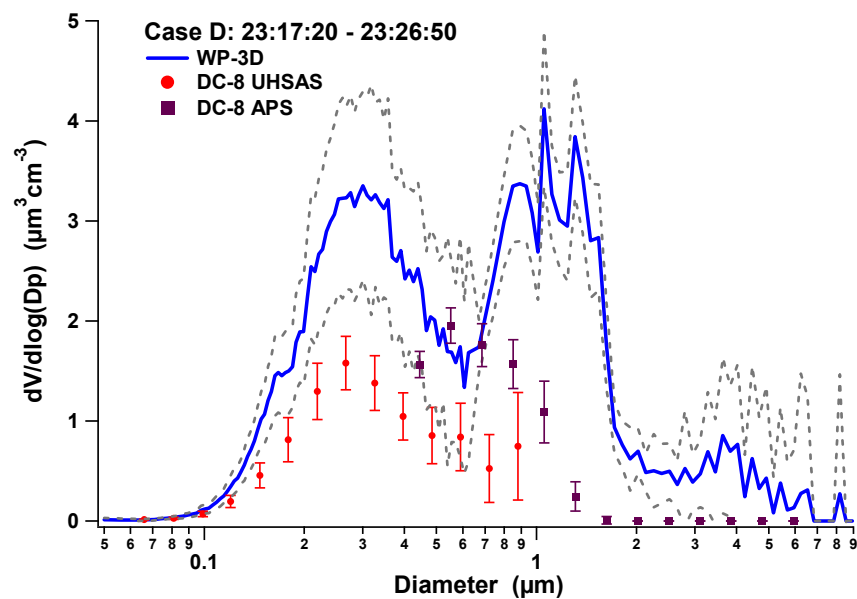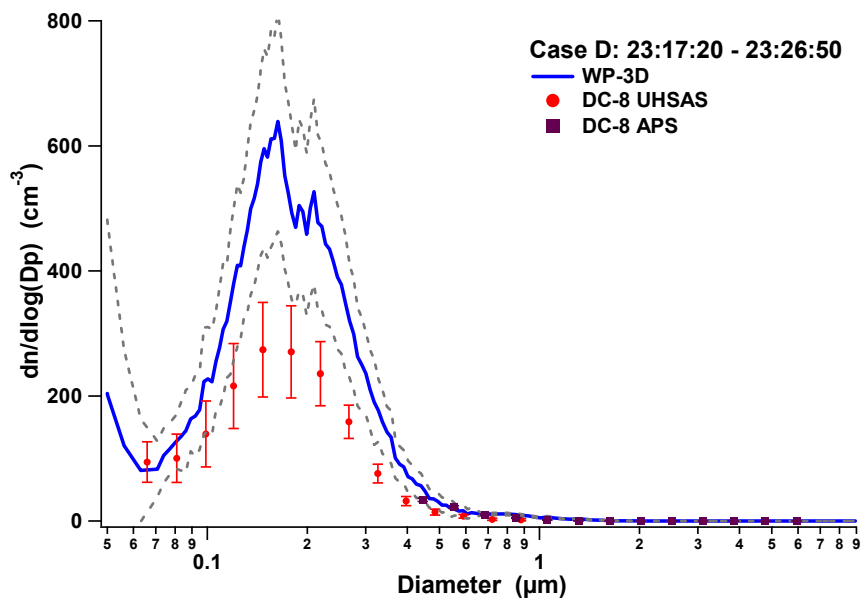 - Controlled comparison showed precision better than 20%.
  - Having difficulty in closure test for supermicron particles.

Combined P-3B vs DC-8 Green Abs
ODR Fit y = a + bx
a = 0.03 ± 0.02
b = 0.51 ± 0.00
R^2 = 0.99

Difference partially due to processing schemes

- 04/08/2008
- 04/19/2008
- 07/10/2008

P-3B 530 nm Absorption (Mm^{-1})
DC-8 532 nm Absorption (Mm^{-1})

550 nm Scattering
ODR fit: y = a + bx
b = 0.96 ± 0.00
a = 1.13 ± 0.14
R^2 =0.99

- 04/08/2008
- 04/19/2008
- 07/10/2008

NASA P-3B (Mm^{-1})
NASA DC-8 (Mm^{-1})
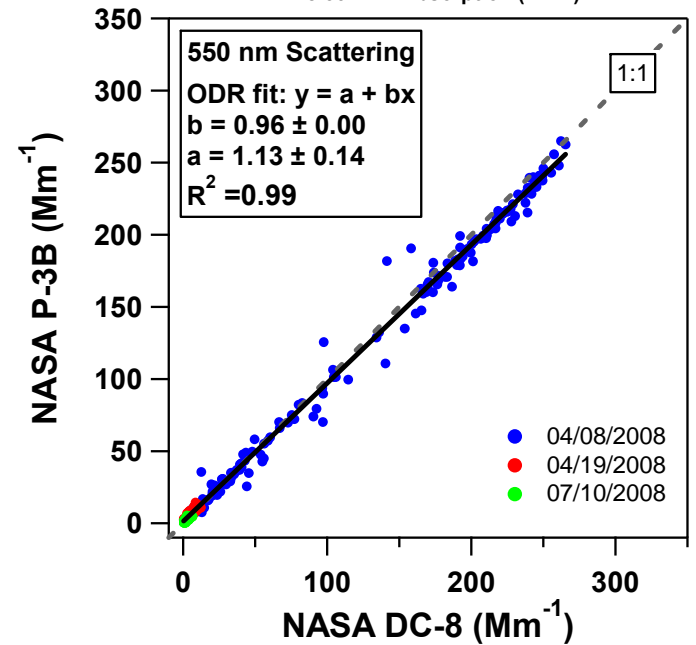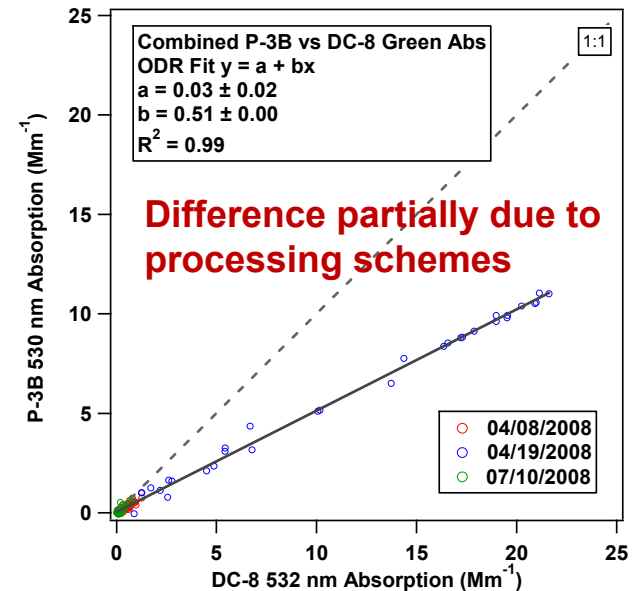
Measurement Uncertainty IIa
Particle Size Distribution
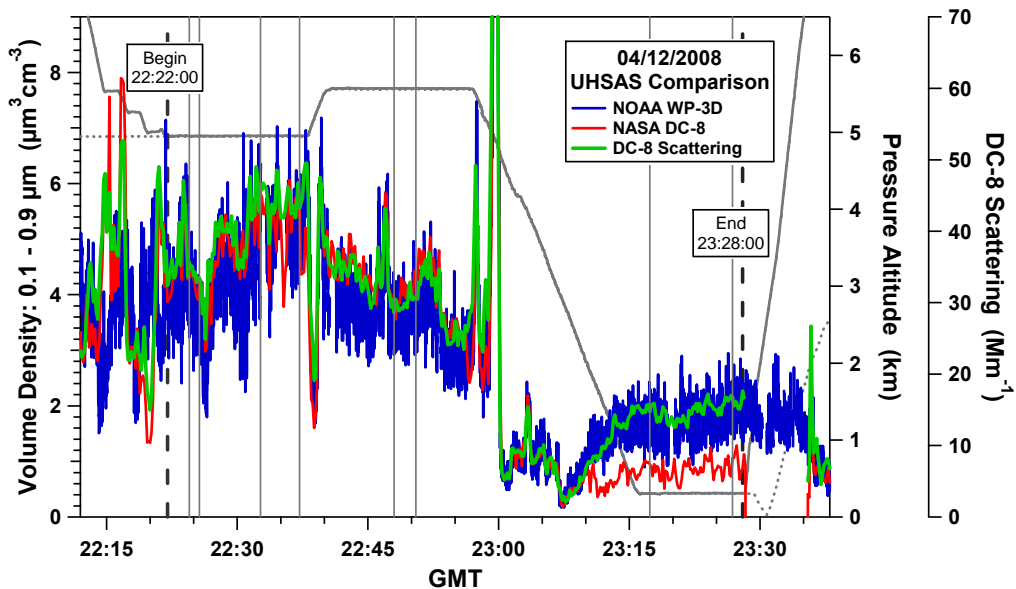
Measurement Uncertainty IIb
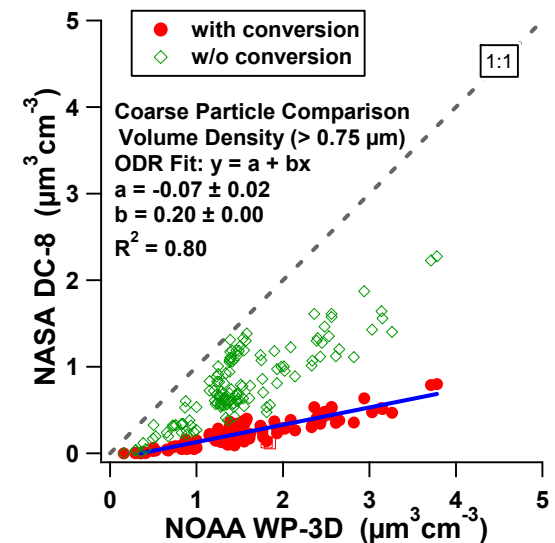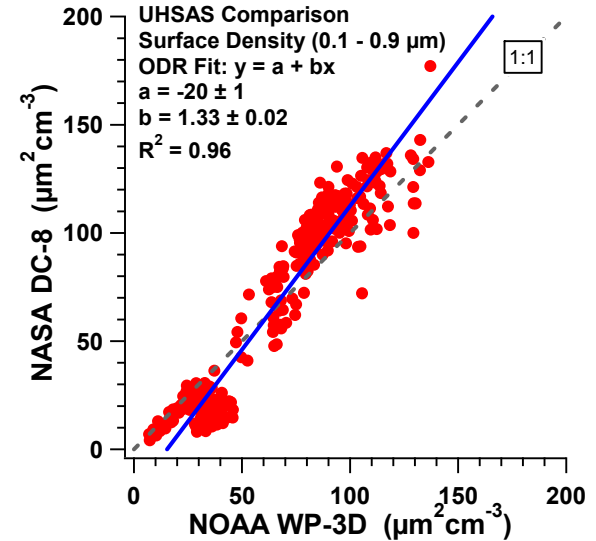## Particle Size Distribution

ARCTAS DC-8 Size Distribution Measurements

- **Instruments:**
  - SMPS: 10 – 200 nm (aerodynamic size).
  - UHSAS: 50 – 1000 nm (optical size).
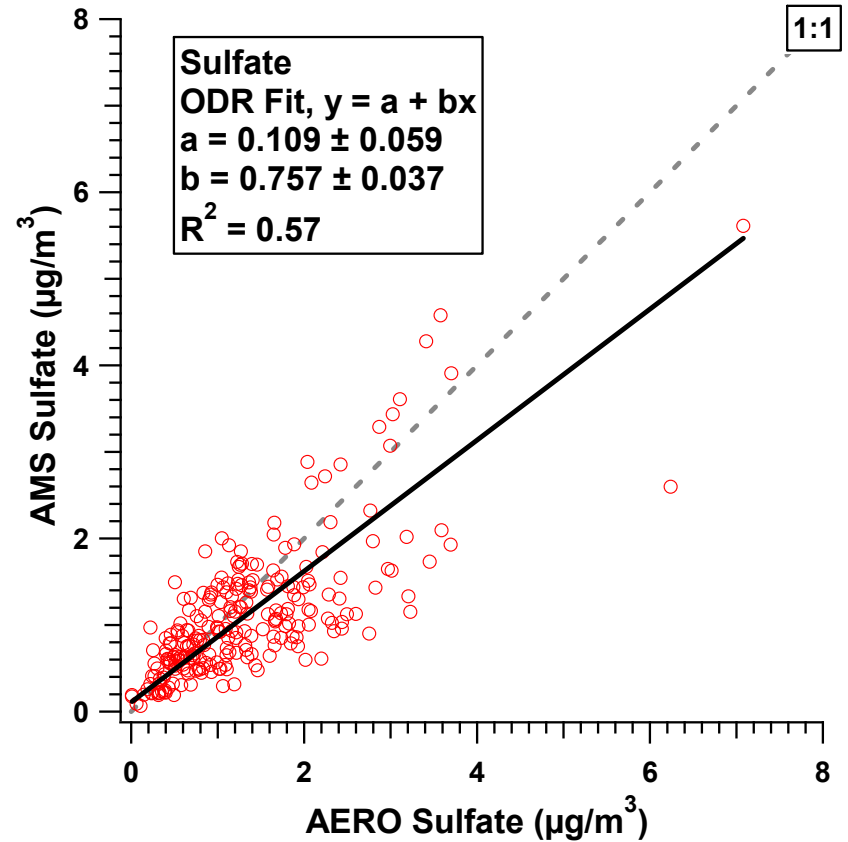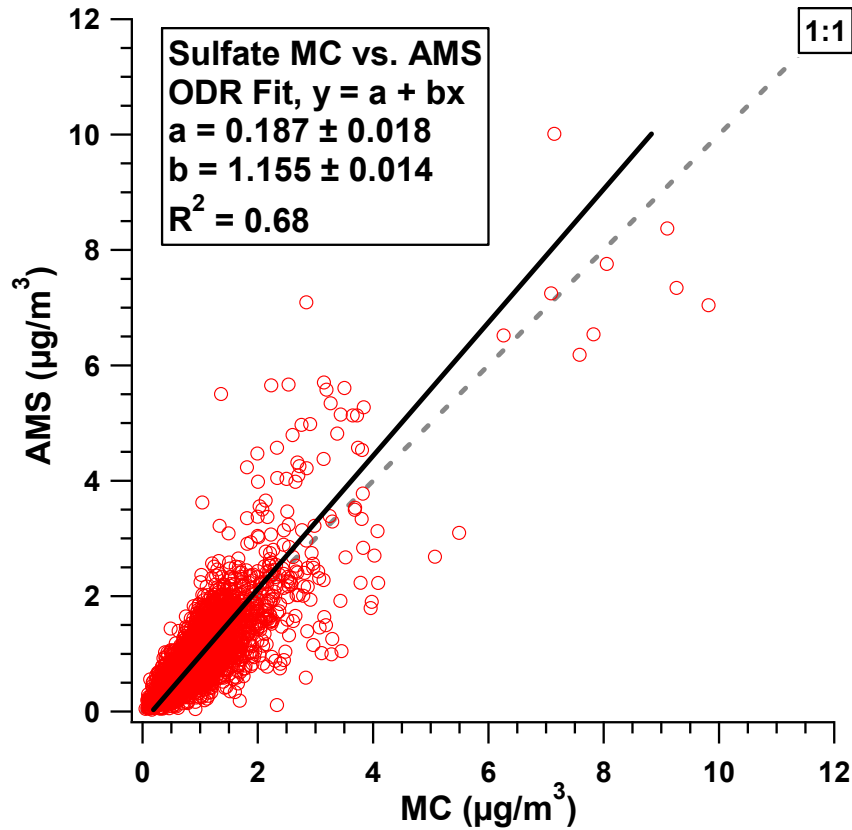 - APS: 0.5 – 20 µm (aerodynamic size).

- **Insights and Issues:**
  - Airborne size distribution remains to be a research product, not routinely available.
  - Integrated quantities have been shown to have significantly better consistencies.
  - UHSAS performance inconsistent during airborne experiments.
  - APS aerodynamic size conversion dependent on particle density and particle shape factor, the latter is not a well defined quantity.

UHSAS Comparison
Surface Density (0.1 - 0.9 µm)
ODR Fit: y = a + bx
a = -20 ± 1
b = 1.33 ± 0.02
R^2 = 0.96

NASA DC-8 ($\mu m^2 cm^{-3}$) vs NOAA WP-3D ($\mu m^2 cm^{-3}$)

Coarse Particle Comparison
Volume Density (> 0.75 µm)
ODR Fit: y = a + bx
a = -0.07 ± 0.02
b = 0.20 ± 0.00
R^2 = 0.80

with conversion
w/o conversion

NASA DC-8 ($\mu m^3 cm^{-3}$) vs NOAA WP-3D ($\mu m^3 cm^{-3}$)
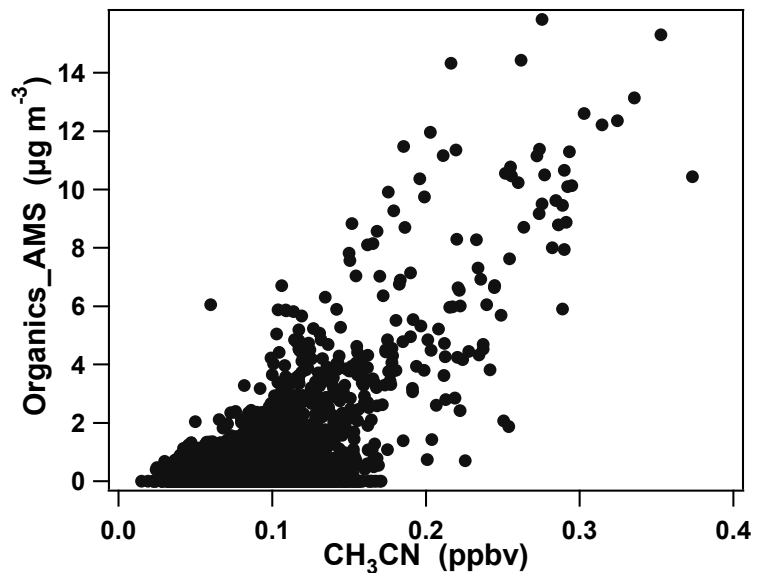
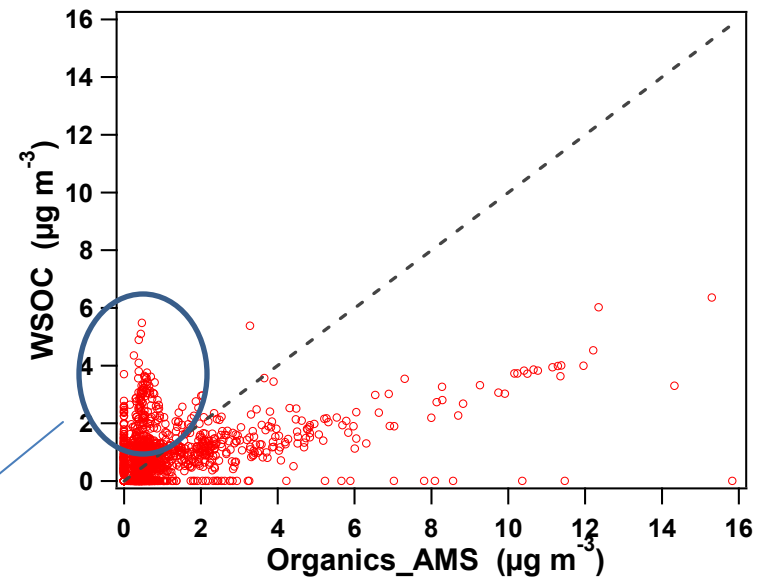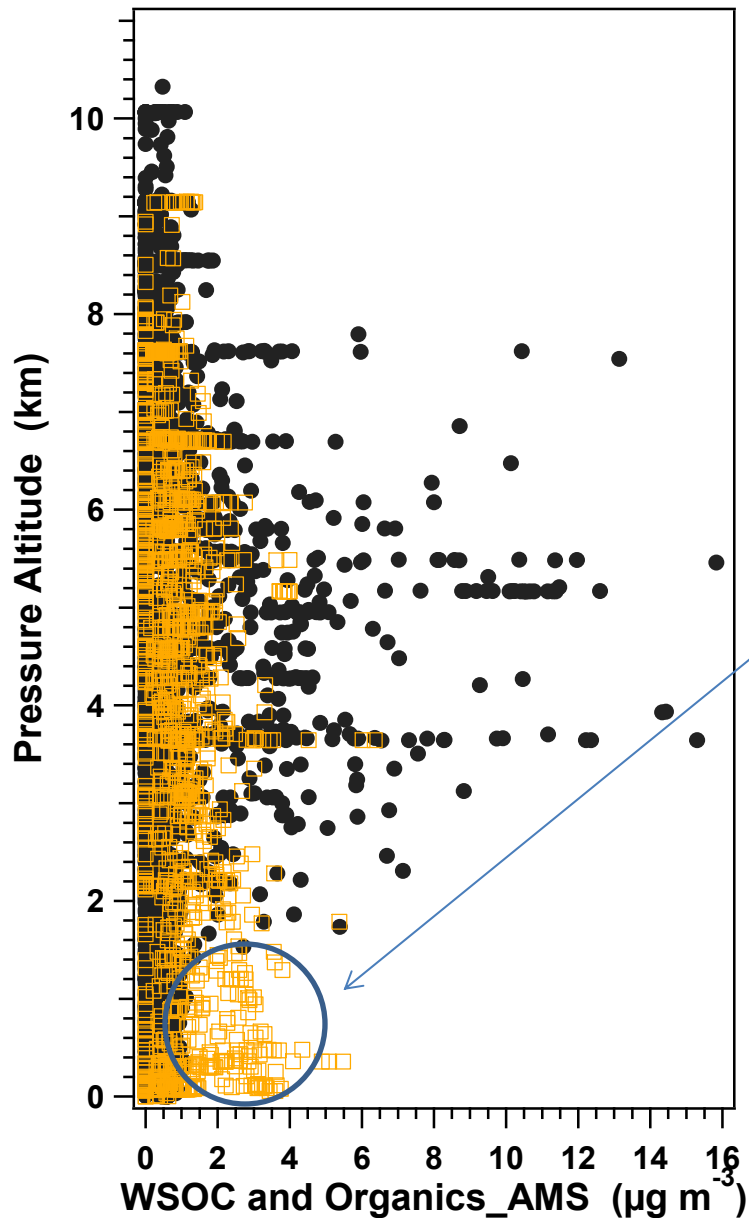# Measurement Uncertainty IIIa
Particle Composition: Sulfate

Sulfate measurements typically agree with reported uncertainties.
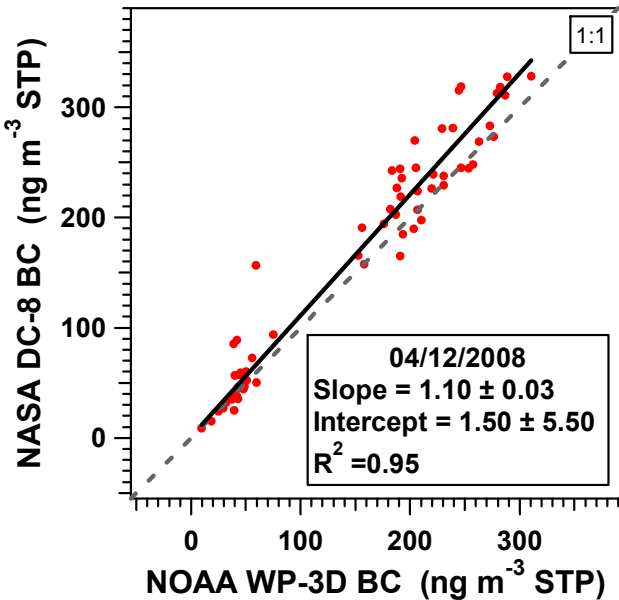
Measurement Uncertainty IIIb
Particle Composition: Organics
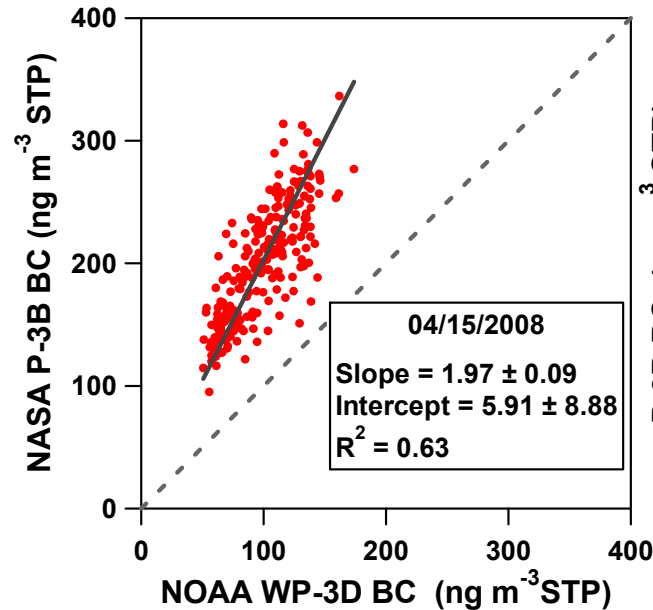
Measurement Uncertainty IIIc
Particle Composition: Black Carbon

DC-8 vs. WP-3D

04/12/2008
Slope = 1.10 ± 0.03
Intercept = 1.50 ± 5.50
R^2 = 0.95

Final data

P-3B vs. WP-3D

04/15/2008
Slope = 1.97 ± 0.09
Intercept = 5.91 ± 8.88
R^2 = 0.63

Preliminary P-3B data

P-3B vs. DC-8

04/19/2008
Slope = 1.00 ± 0.02
Intercept = 22.7 ± 13.3
R^2 = 0.99
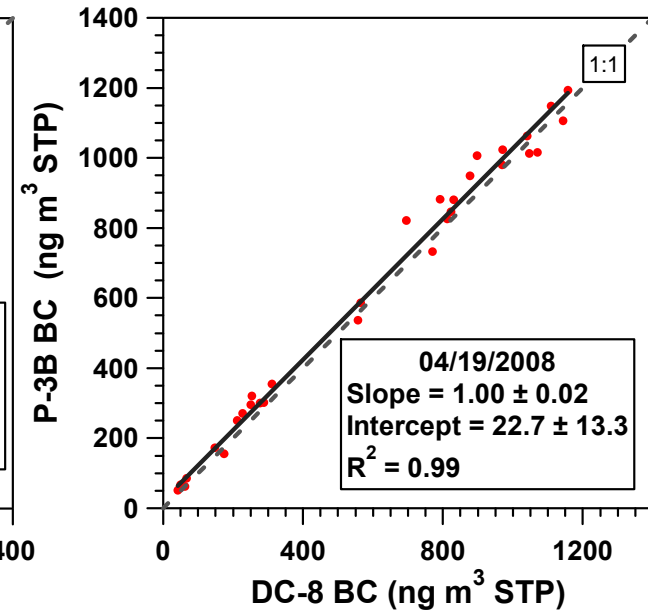
ARCTAS DC-8 Data Product I
## Merge file along flight track
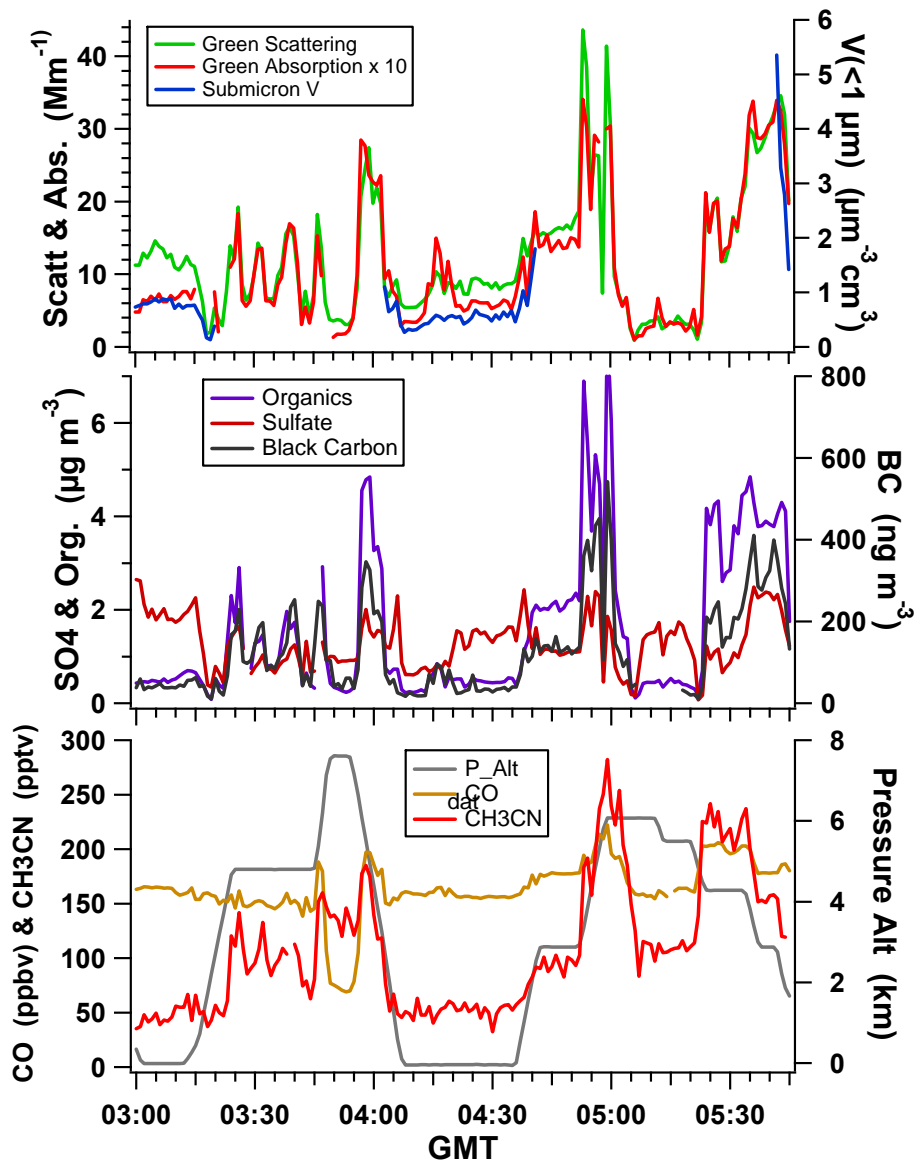
Data Status:

- Individual PI data available.
- Common time base merge files available for 1, 10, and 60 sec.
- Several special PI merge files available.
- Special requests can be accommodated.
- To become available: TAbMEP assessed uncertainties
- Web tools are under development to automate the data extraction/distribution processes.
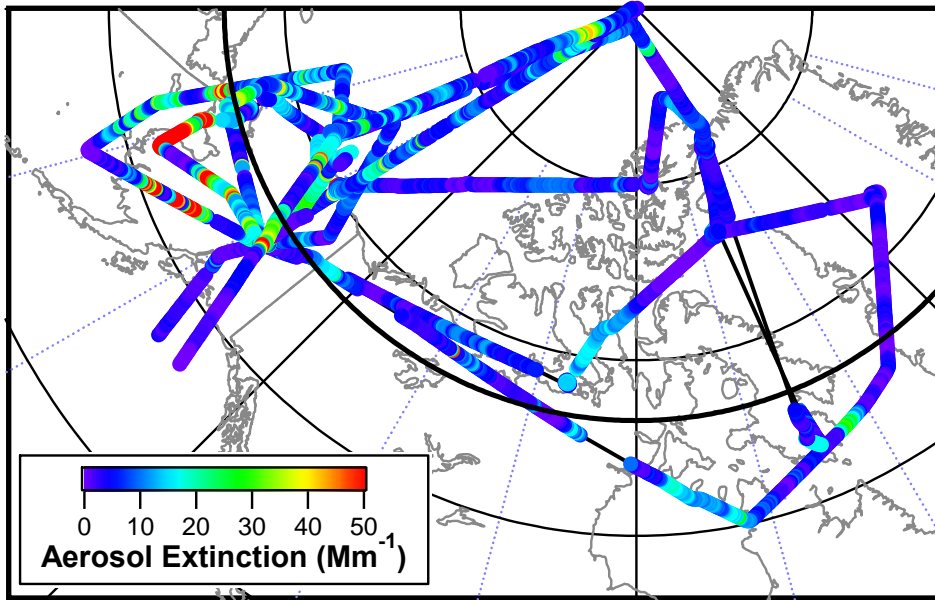
ARCTAS DC-8 Data Product II
Vertical Profile Example
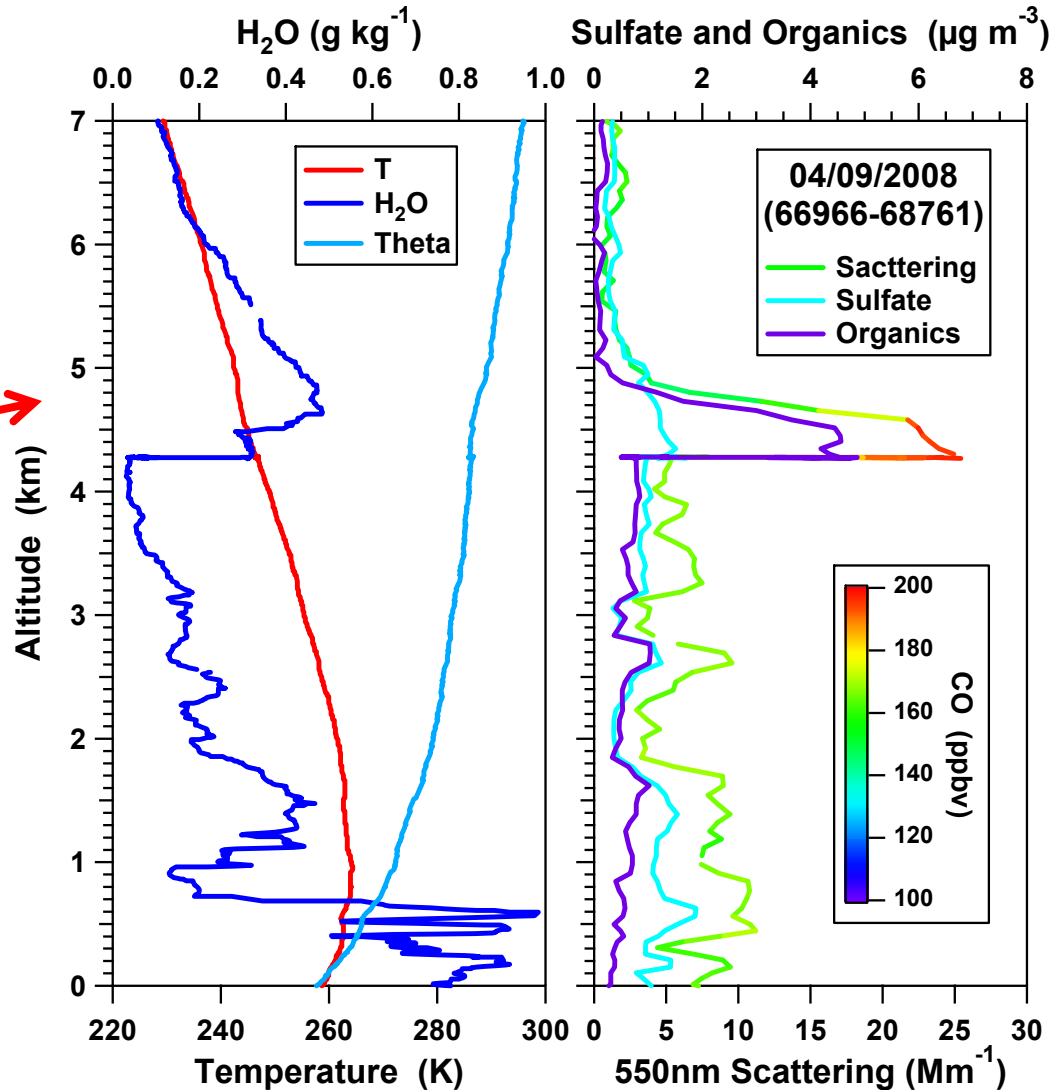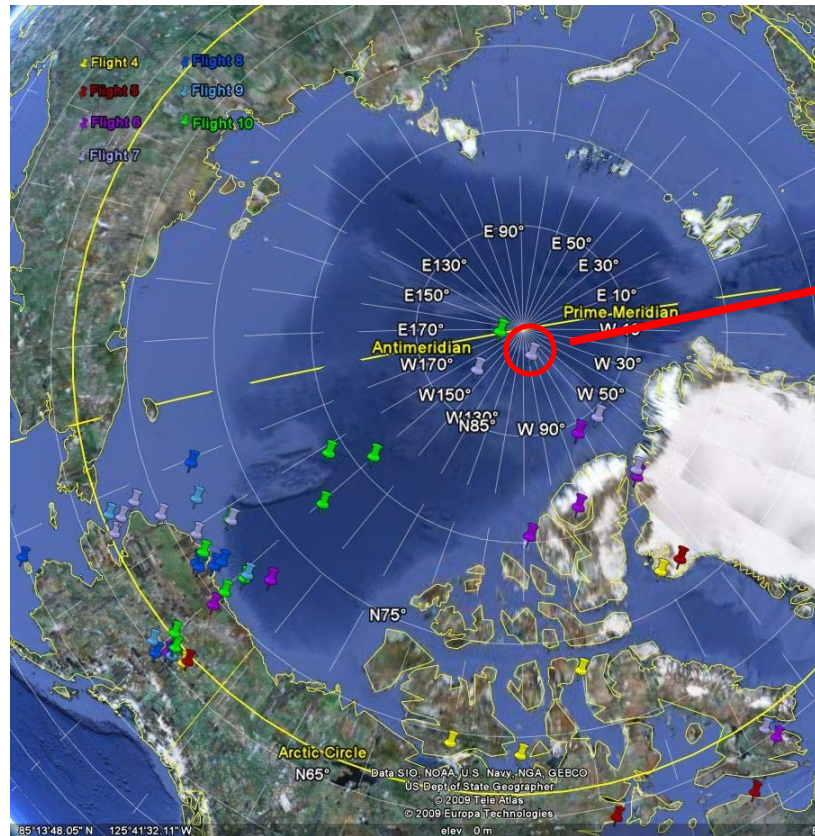
ARCTAS DC-8 Data Product III
Grid Average Example

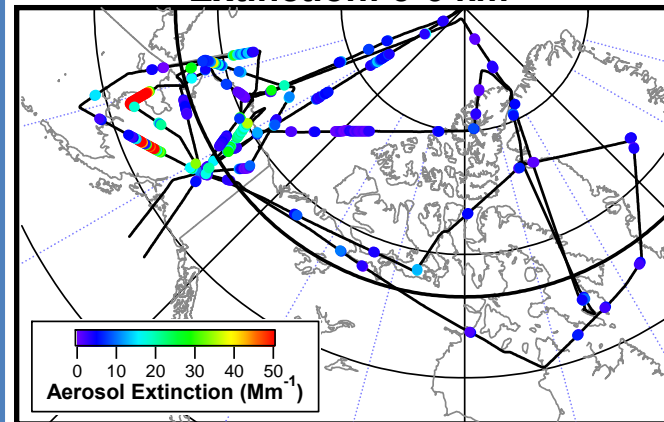Extinction: All Altitudes

Aerosol Extinction (Mm⁻¹)

- Grid averages and other statistics will be calculated for altitude layers.
- Spatial distribution plots will be provided to indicate the data coverage.
- Measurement uncertainty will be propagated when applicable.

Extinction: 0-1 km

Aerosol Extinction (Mm⁻¹)

Extinction: 5-6 km

Aerosol Extinction (Mm⁻¹)
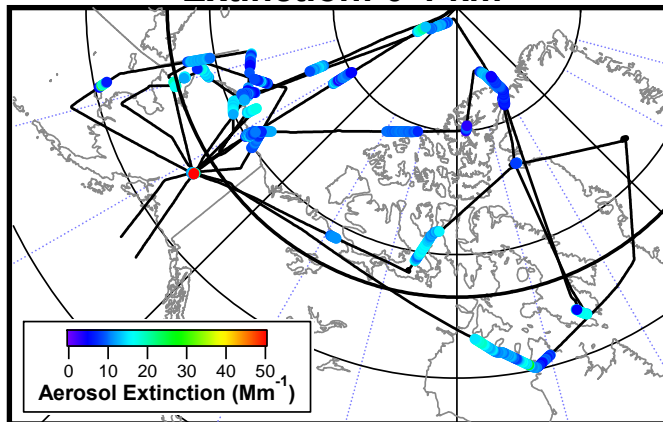
Developing an Airborne Data Archive

- Data collection nearly completed for airborne field campaigns over the past 10 years.

- Assessed measurement uncertainty: ICARTT (2004) and POLARCAT (2008), more to come.

- All NASA campaign data (both PI and merge files) available online: **www-air.larc.nasa.gov**

- Measurement comparison results available for ICARTT, INTEX-B, and POLARCAT.

- Web software tools under development to extract data according to given ranges of time or locations, to display vertical profiles, and create merges for special needs.