Aerosol Measurements for DISCOVER-AQ

Langley Aerosol Research GroupE (LARGE)

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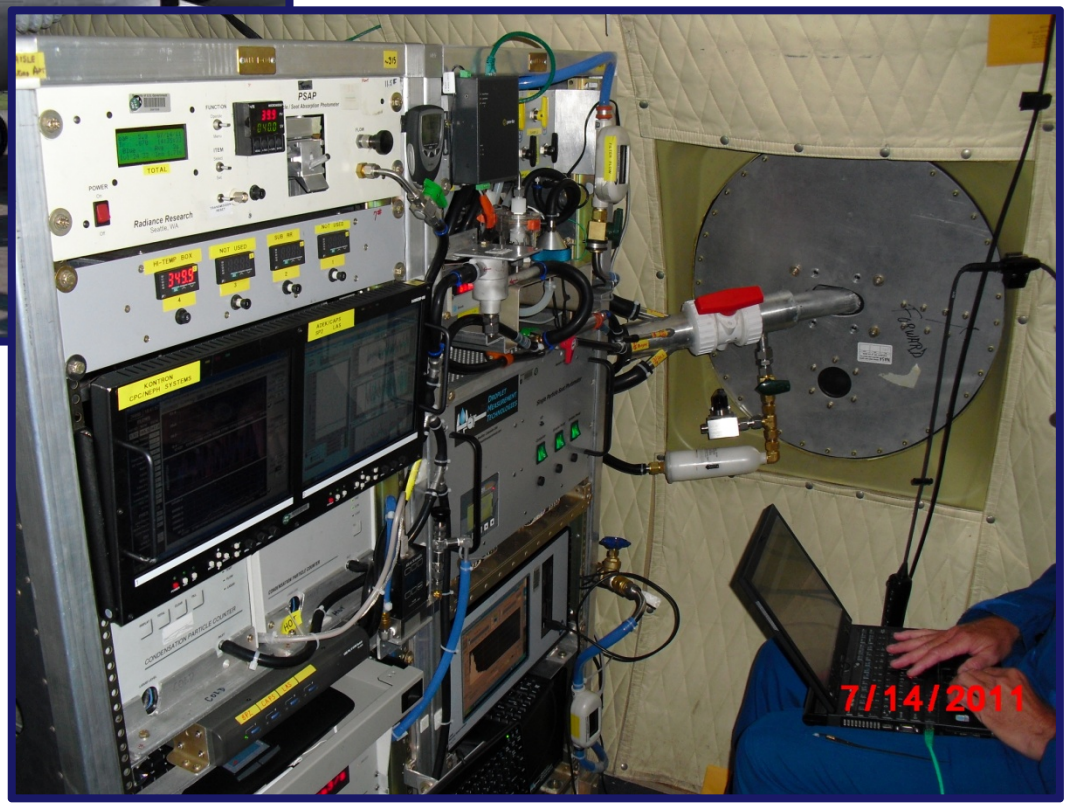
LARGE DISCOVER-AQ Objectives

- **Provide detailed measurements of aerosol optical and microphysical properties and chemical composition**
- **Archive additional aerosol parameters that can easily be compared to remote sensor data products (Fine mode fraction, AOTs, single scattering albedo, etc.)**
- Conduct collaborative studies to explore methods of improving remote-sensor-derived aerosol properties such as size distribution, water content, fine-mode fraction, aerosol type, etc.
- Examine aerosol spatial variability within satellite sensor footprint
- Examine how aerosol properties change with age and photochemical processing

This talk will describe measurements and archived data; Posters focus on analyses

Iso-kinetic Inlet/Cabin-Mounted Instruments

- “Hawaii” Shrouded Inlet
- Tested during DICE aboard DC-8
- Has ~4 μm cut size at 200 m/s
- Operated slight super-isokinetic
- No corrections—no coarse particles!



- Inlet flow split into multiple lines
- Used conductive tubing throughout
- Coarse-sizing instruments located near inlet
- Had Nafion drier in line to nephs
- Performed in-flight zero and calibration checks

In Situ Aerosol Measurements

Measured Parameter	Instrument	Size Range (µm)	Response time (sec)	Precision
Hot, Cold, Ultrafine CN	TSI 3025, (2) TSI 3010	>0.003	1	10%
Aerosol Particle Size	TSI SMPS	0.01 – 0.3	60	20%
	DMT UHSAS	0.06 – 1.0	10	20%
	TSI 3321	0.5 – 20	10	20%
	TSI LAS	0.1 – 7.5	10	20%
Cloud Condensation Nuclei Spectra	Scanning Flow CCN	INSTRUMENT MALFUNCTIONED		
Wet and Dry Scattering at 450, 550, and 700 nm	(2) TSI 3563	<10	1	5e-7 m^{-1}
Total and Submicron Absorption at 467, 530, and 660 nm	(2) RR PSAP	<10	1	5e-7 m^{-1}
Submicron Scattering at 535 nm	Radiance Research Neph	<10	20	-
Black Carbon Mass/Size	DMT SP2	0.1-0.5	1	20%
Water Soluble Organic Carbon	PILS/TOC	>0.01	10	-
Soluble Ion Composition	PILS/IC	>0.01	300	Varies by ion

17 instruments in 2 racks + floor mounted pump plate; 16 different Archive Files

Data Products—Aerosol Number and Size

DISCOVERAQ-LARGE-CNC

- Data from Condensation Particle Counters
- 1-sec resolution
- Data filtered to remove cloud encounters, smoothing applied to ultrafine
- Total >3 nm, Total >10 nm, Nonvolatile (350C)>10 nm
- Nonvolatile composed of soot, dust, sea salt, metals, etc.
- Ultrafine – Fine yields # of nucleation mode particles

Instruments Cover Most of Observed Particle Size Range

DISCOVERAQ-LARGE-SMPS

- Data from Scanning Mobility Particle Sizer
- ~60-sec resolution; Dry Sample
- Data flagged above 2 km on several flights due to leaky air pump
- Total number, surface area, and volume density over 10 to 300 nm size range
- 48 size bins over 10 to 300 nm diameter range

DISCOVERAQ-LARGE-UHSASsd (plus -UHSASstats)

- Data from DMT Ultra-high Sensitivity Aerosol Spectrometer
- 10-sec resolution; Dry Sample; Data very good quality
- Total number, surface area, and volume density over 60 to 1000 nm size range
- 98 size bins over 60 to 1000 nm diameter range

Measurements reported at ambient temperature and pressure; convert to STP for comparison to gas phase chemical species mixing ratios

Data Products—Aerosol Number and Size

DISCOVERAQ-LARGE-OPCsd (plus -OPCstats)

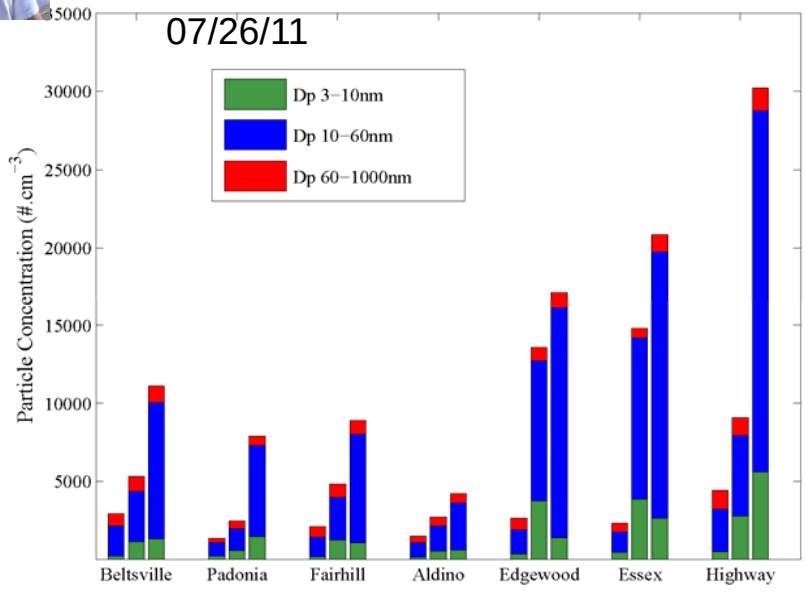
- Data from TSI Laser Aerosol Spectrometer
- 10-sec resolution; Dry Sample
- Total number, surface area, and volume density over 0.1 to 7.5 mm size range
- 98 size bins over 0.1 to 7.5 mm diameter range

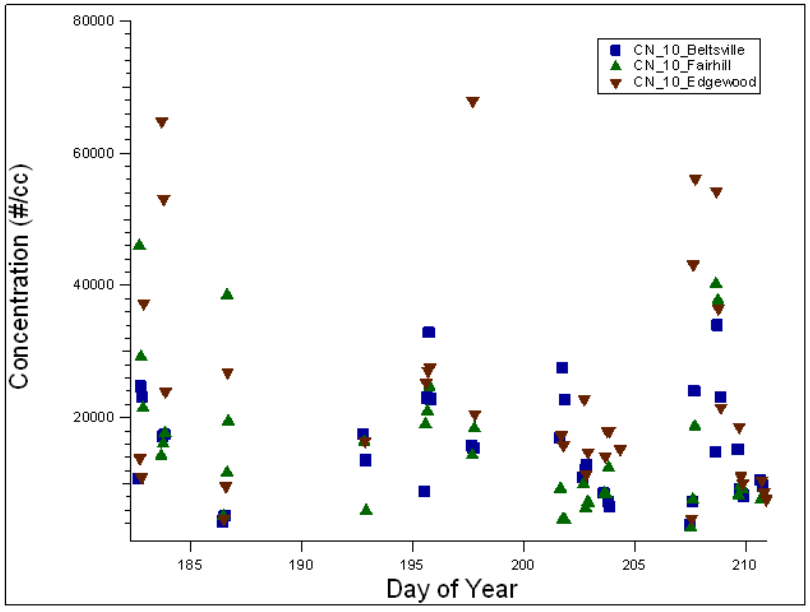
DISCOVERAQ-LARGE-APSsd (plus –APSstats)

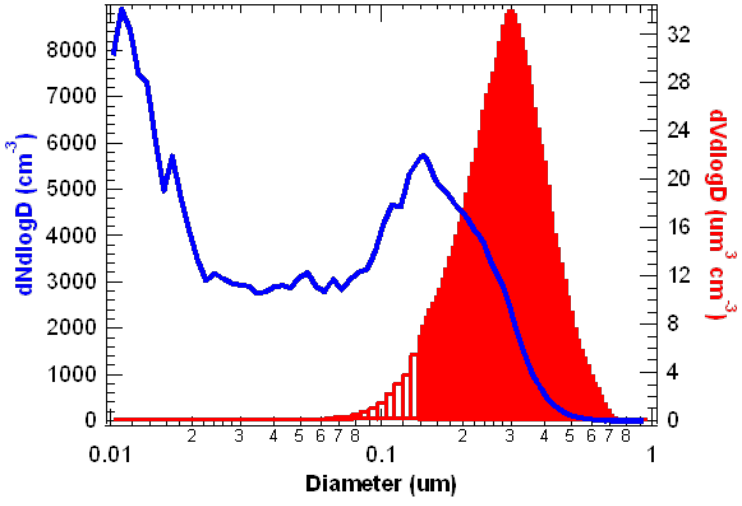
- Data from TSI Aerodynamic Particle Sizer
- 10-sec resolution; Dry Sample
- Total number, surface area, and volume density over 0.52 to 20 mm size range
- 51 size bins over 0.52 to 20 mm diameter range

APS more reliable than LAS, but gives Aerodynamic Diameter
Saw very few particles > 1 μm, UHSAS tell most of story

Variations in Aerosol Number and Size







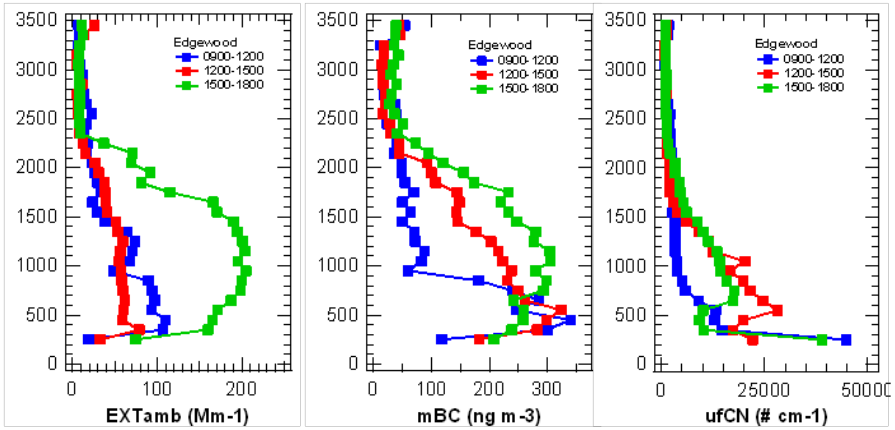
- CN varied from 700 to 130,000 cm^{-3}
- Majority of aerosols < 60 nm in diameter
- Number densities highly variable due to transportation source
- Aerosol nucleation was evident on a number of flights
- Number-based size distributions peaked in 100 to 200 nm range; Volume peaks in 300 to 400 nm range
- Very few particles > 1 μm in diameter observed

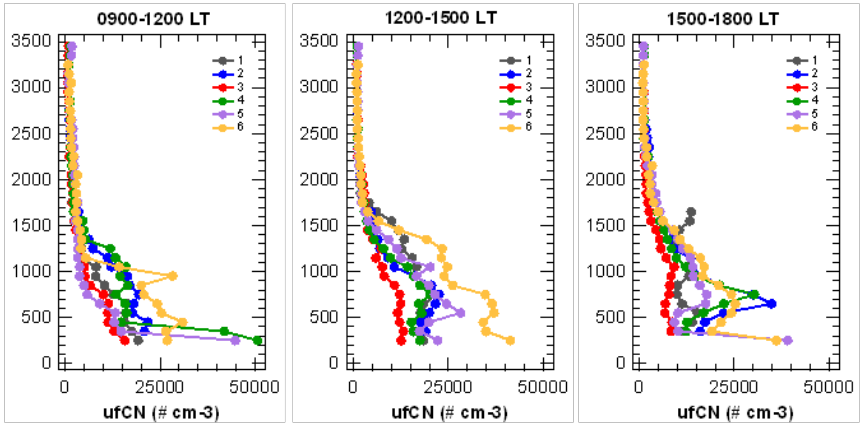
See Winstead et al., Poster for More on Aerosol Number and Size

Aerosol Spatial Variability

1. Summary of the DISCOVER-AQ profiles

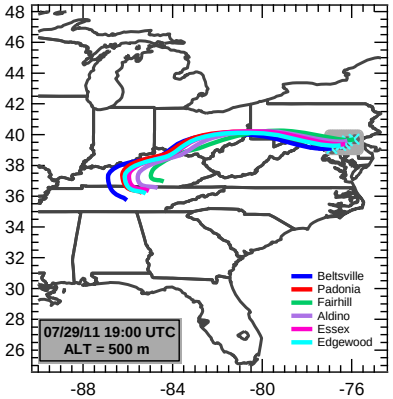
- Look at the evolution in the vertical profiles as a function of the time of day
- Look for the importance of local sources versus long range transport

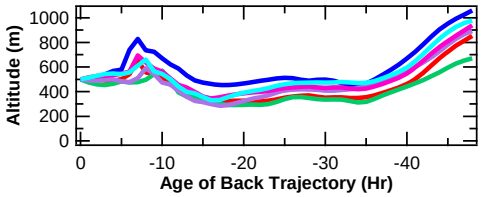


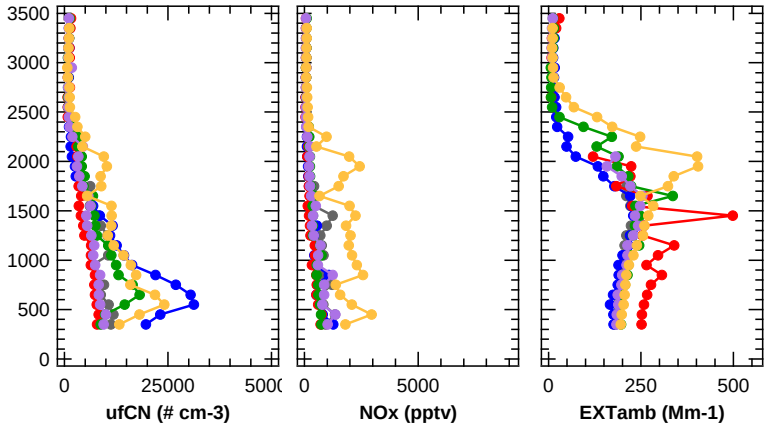


2. Airmass Origins From Trajectory Analysis

- Use HYSPLIT4 to look at 48hr back trajectories using the 40km EDAS meteorology data archive
- Look for a statistical link between regional transport patterns and the observed aerosol loadings and trace gas concentrations seen in the vertical profiles







Thornhill et al.,Trajectory Analysis and Summary of the P-3B Vertical Profiles

Data Products—Aerosol Optical Parameters

DISCOVERAQ-LARGE-ABS

- Aerosol Absorption Coefficients at 470, 532, and 660 nm
- 1-sec resolution with smoothing and correction for humidity
- Corrected for a variety of errors using Virkkula, AS&T, 44:706-712, 2010

DISCOVERAQ-LARGE-SCAT

- Total and Submicron Aerosol Scattering Coefficients at 450, 550, and 700 nm
- 1-sec resolution
- Corrected for truncation errors using technique developed by Tad Anderson

DISCOVERAQ-LARGE-OPT

- Calculated optical parameters
- 1-sec resolution
- Anstrom Exponents for Scattering, 450/700, 450/550
- Anstrom Exponents for Absorption, 460/660, 460/535
- Single Scattering Albedoes at 450, 550, and 700 nm

Measurements reported at ambient temperature and pressure; convert to STP for comparison to gas phase chemical species mixing ratios

Data Products—Aerosol Optical Parameters

DISCOVERAQ-LARGE-fRH

- f(RH) parameters for 550 nm scattering
- 1-sec resolution
- %RH values for wet and dry nephelometers
- Wet and dry scattering coefficients at 550 nm
- Gamma value calculated from scattering coefficients and RH
- f(80/20), Ratio of scattering at 80 and 20% RH (calculated)
- Ambient scattering at measured RH (calculated from dry scattering and gamma

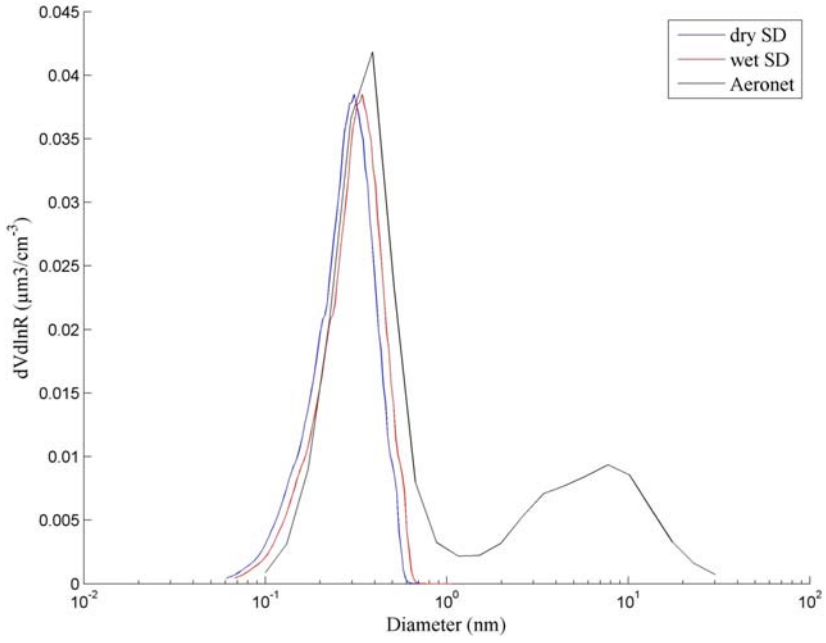
DISCOVERAQ-LARGE-EXT

- Calculated optical parameters for 532 nm (doubled Nd:YAG wavelength)
- 1-sec resolution
- Dry Absorption, Scattering and Extinction Coefficients
- Ambient Scattering at Extinction Coefficients

Measurements reported at ambient temperature and pressure; convert to STP for comparison to gas phase chemical species mixing ratios

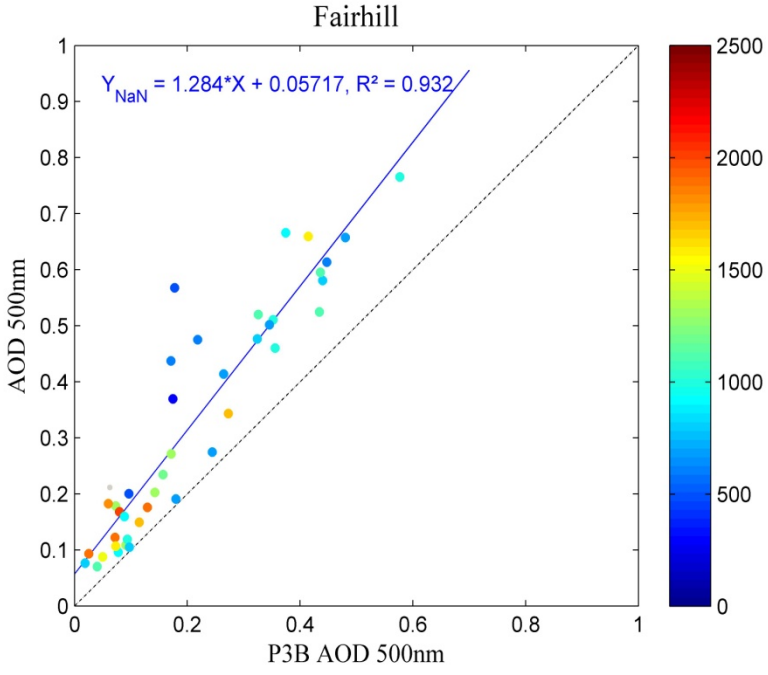
Methodology to correct Aerosol Size to Ambient RH

1. Interpolate the P-3B data with the ground based measurements
2. Determine the refractive index of sampled aerosol particles
3. Estimated the growth factor



Before correction :
Aeronet AOD = **1.65***P-3B AOD

After correction :
Aeronet AOD = **1.26***P-3B AOD



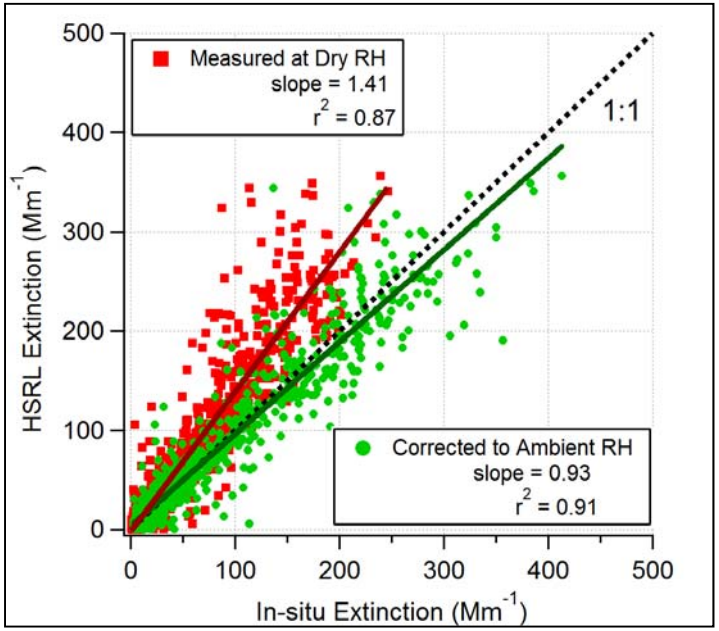
Diameter increase is about 10%

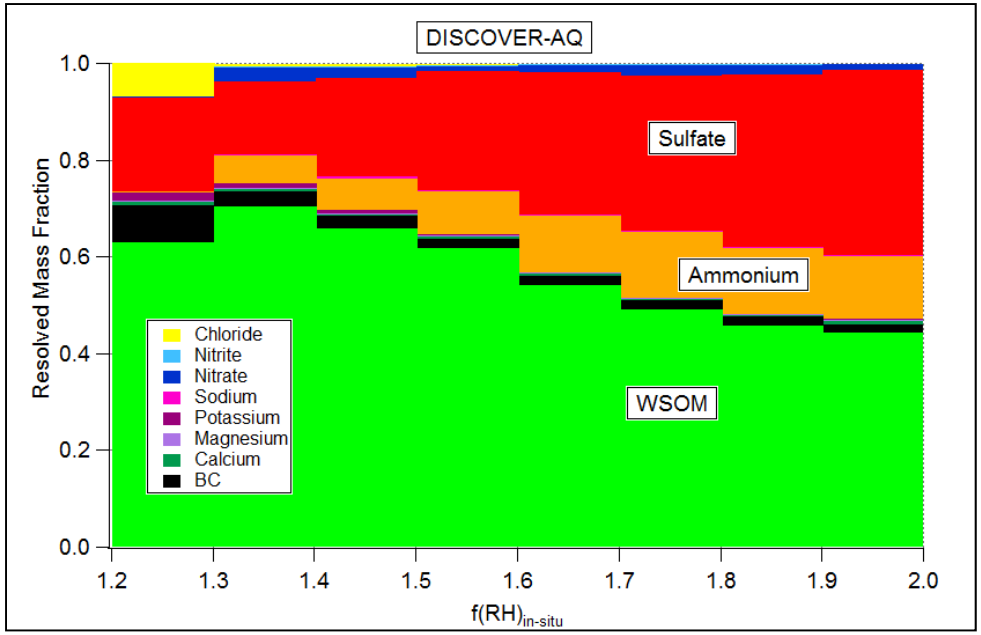
Discrepancy of mean geometrical diameters between Aeronet and P-3B is decreasing from 21% and 12%

See Crumeyrolle et al., Poster for Comparison of P-3B with AERONET AOD

Hygroscopicity of Urban Aerosols during DISCOVER-AQ

- Average f(RH) = 1.6 ± 0.2
- Hygrocopicity of aerosols is dependent on chemical composition





- Independent verification by HSRL yields excellent comparison
- Aerosol loading is the biggest driver of ambient variability

See Ziemba et al., Poster for More on f(RH) and its dependence on composition

Data Products—Aerosol Composition

DISCOVERAQ-LARGE-SP2

- Data from DMT Single Particle Soot Photometer
- 10-sec resolution
- Black carbon mass (ng/m3) derived from measurements over 145 to 475 nm size range
- In process of deriving coating thickness data
- Size distributions available as research product

DISCOVERAQ-LARGE-pilsIC

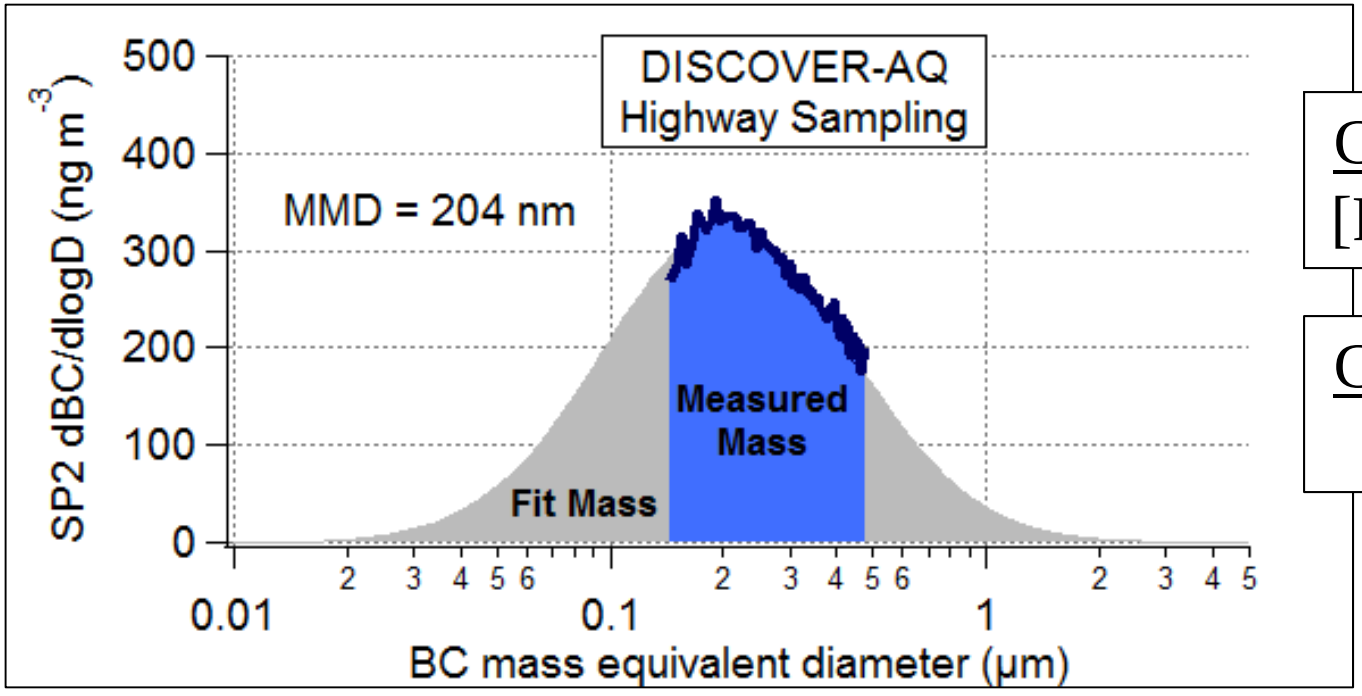
- Data from Particle-Into-Liquid-Sampler + offline Ion Chromatography
- ~5-minute resolution
- Anions: Chloride, Nitrite, Nitrate, Sulfate (ug/m3)
- Cations: Sodium, Ammonium, Potassium, Magnesium, Calcium (μg/m3)

DISCOVERAQ-LARGE-pilsTOC

- Data from Particle –Into-Liquid-Sampler + Total Organic Carbon Analyzer
- 10-sec resolution
- Total Water Soluble Organic Aerosol (μg/m3)

No PILS IC Data on Flights 1 & 2; No PILS WSOC on Flight 3
Ammonia too high in some Cases—10% of data will be corrected/rearchived

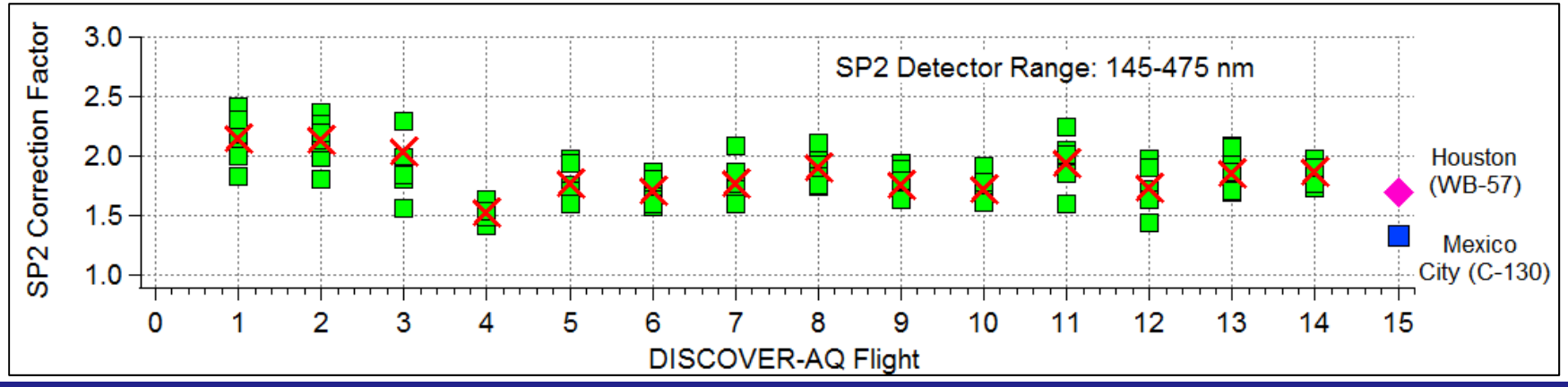
BC Size Distribution and Correction Factor



Correction Factor
[Fit] / [Measured]

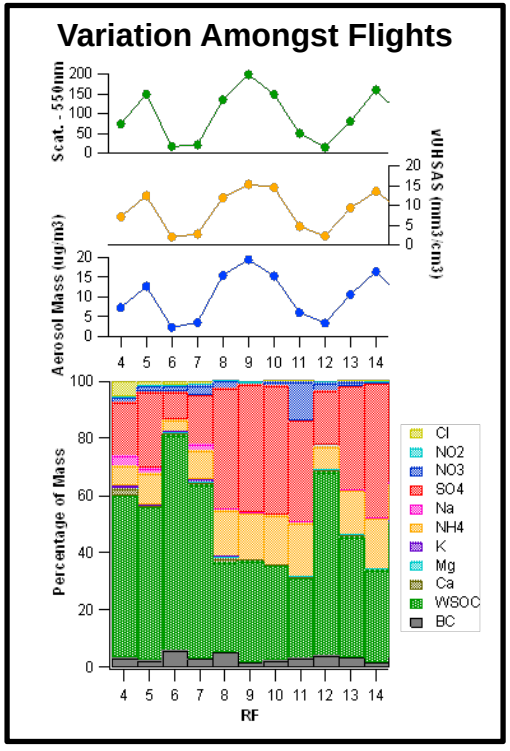
Correction Factor
1.85 ± 0.25

- correction factors applied for all archived data



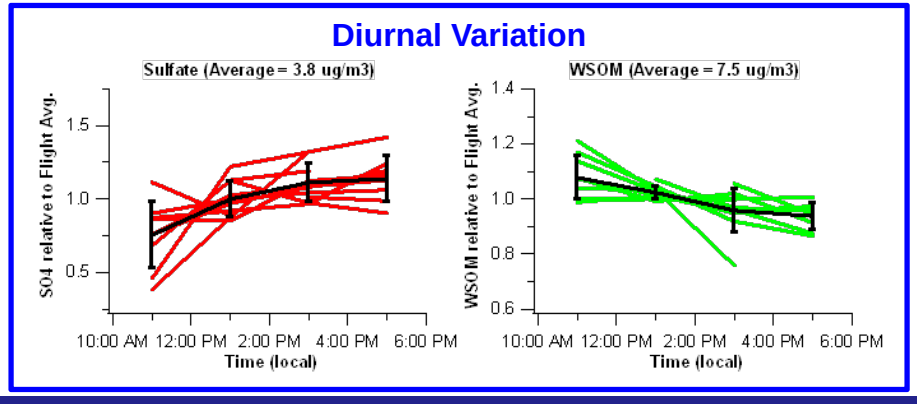
Size statistics and coating thickness data still being processed—available ?

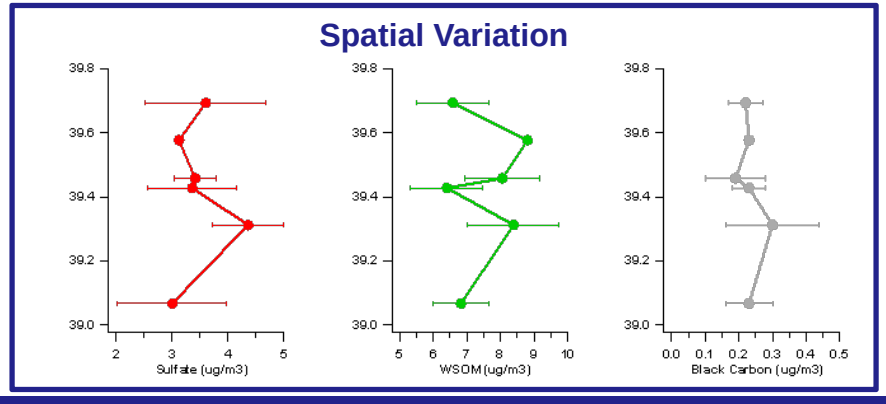
P-3B Aerosol Composition



Aerosol composition measured with a PILS and SP2

- In general, 60% organics and 40% ammonium sulfate.
- **Variation Amongst Flights:** Composition varied with aerosol loading with ammonium sulfate dominating on highly polluted days.
- **Diurnal Variation:** Sulfate increased during the day while organics decreased.
- **Spatial Variation:** Edgewood had the highest loadings for most compounds.





See Beyersdorf et al., Poster for More on Composition and Variability

Questions?