Aerosol Measurements for DISCOVER-AQ

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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

- 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

- “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!
## In Situ Aerosol Measurements

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

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 (350°C)>10 nm
• Nonvolatile composed of soot, dust, sea salt, metals, etc.
• Ultrafine – Fine yields # of nucleation mode particles

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
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
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
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 $f(RH) = 1.6 \pm 0.2$
- Hygroscopicity 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 (µg/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

\[
\text{Correction Factor} = \frac{\text{Fit}}{\text{Measured}}
\]

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?