DOE-G1 Light Scattering and Absorption Measurements

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G1 Optical Instrumentation Description

• 3-λ Nephelometer (TSI)
  - 700, 550 & 450 nm
  - heated Inlet
  - Anderson-Ogren correction

• 3-λ PSAP (Radiance)
  - 648.1, 522.7 & 448.1 nm
  - heated inlet
  - spot size, flow, Bond corrections

• 1-λ Photothermal Interferometer (BNL)
  - 532 nm
  - maiden deployment
Example of flight patterns discussed today

**Outbound**: characterized by below, in cloud and above cloud measurements

**Inbound**: characterized by level flight below cloud (today’s focus)
Outbound: Flight 081028a

- $B_{\text{scat}}^{\text{ac}}$ decreases from $\sim 6$ Mm$^{-1}$ (-72°) to $\sim 1$ Mm$^{-1}$ (-77.7°)
- $B_{\text{scat}}^{\text{bc}}$ $\sim 3$ Mm$^{-1}$ (-71°); $\sim 2.3$ Mm$^{-1}$ (-73°); $\sim 1.4$ Mm$^{-1}$ (-74°); $\sim 1.1$ Mm$^{-1}$ (-75.5°); $\sim 0.5$ Mm$^{-1}$ (-76.5°)
- $B_{\text{scat}}^{\text{ic}}$ $\sim 12$ Mm$^{-1}$ (-71.7°); $\sim 9$ Mm$^{-1}$ (-73.3°); $\sim 8.7$ Mm$^{-1}$ (-74.5°); $\sim 6$ Mm$^{-1}$ (-77°)

ac: above cloud; bc: below cloud; ic: in cloud
Flight 081028a: Inbound

- Level flight: 125 m
- -77° (-18.5°) to -71° (-18.35°)
- B\text{scat}: near shore influence
- B\text{abs}: essentially no abs except near shore
- SSA: 0.96±0.026 (-77° to -73°)
- Near shore SSA(λ) suggests presence of urban pollution (Bergstrom et al. 2002; Collaud Coen, et al. 2004 & Meloni et al. 2006)
Flight 081028a: Inbound

- **SAE (-77° to -74°):** 1.0±0.25
- **SAE ~1** suggests presence of large particles...sea salt (?)
- **SAE increase** near coast: presence of smaller particles

- **Weak B_abs signal (< 1 Mm⁻¹)**
- **AAE (-77° to -74°):** 0.011±0.048
Outbound: Flight 081101a

- $B_{\text{scat}}^{ac}$ decreases from $\sim 20 \text{ Mm}^{-1}$ $(-72.5^\circ)$ to $\sim 1 \text{ Mm}^{-1}$ $(-74.6^\circ)$
- $B_{\text{scat}}^{ic}$ $\sim 1.5 \text{ Mm}^{-1}$ $(-71.1^\circ)$; $\sim 0.2 \text{ Mm}^{-1}$ $(-73^\circ)$; $\sim 1 \text{ Mm}^{-1}$ $(-75^\circ)$; $\sim 0.6 \text{ Mm}^{-1}$ $(-77^\circ)$
- $B_{\text{scat}}^{bc}$ $\sim 15 \text{ Mm}^{-1}$ $(-71.7^\circ)$; $\sim 9 \text{ Mm}^{-1}$ $(-74^\circ)$; $\sim 7 \text{ Mm}^{-1}$ $(-75.5^\circ)$; $\sim 8 \text{ Mm}^{-1}$ $(-76.4^\circ)$

ac: above cloud; bc: below cloud; ic: in cloud
Flight 081101a: Inbound

- Level flight: 120 m
- -77° (-18.5°) to -71° (-18.35°)
- $B_{\text{scat}}$: near shore influence
- $B_{\text{abs}}$: essentially no abs except near shore
- SSA: 0.98±0.031 (-77° to -72°)
- Near shore SSA($\lambda$) suggests urban pollution (Bergstrom et al. 2002; Collaud Coen, et al. 2004 & Meloni et al. 2006)
Flight 081101a: Inbound

- SAE (-76.5° to -73°): 0.57±0.23
- SAE ≤ 1 suggests presence of large particles...sea salt
- Coastal influence last 110 kms

- Weak B_{abs} signal (<1 Mm^{-1})
- AAE (-76.5° to -73°): 0.039±0.56
- Last ~110 kms, AAE incr. from ~0 to 1.7: suggests presence of OC aerosols; (e.g., Barnard et al., 2008; Kirchstetter, et al, 2004)
Near Shore SSA

Longitude range: -71.5° to -70.3°
Nominal Alt: 120 m
SSA Angstrom Exp:
  - flight 081028a: 0.037 ± 0.027
  - flight 081101a: 0.098 ± 0.043
  - flight 08113a: 0.011 ± 0.025

SSA(λ) suggests presence of urban pollution

Bergstrom et al. 2007 & 2002; Collaud Coen, et al. 2004; Meloni et al. 2006; Sololik & Toon, 1996
Photothermal Interferometry (PTI)

It is highly desirable to directly measure aerosol absorption & without interference from aerosol scattering.

Photothermal Spectroscopy

- Optical interaction
- Energy Transfer
- Radiative Relaxation
- Thermal Relaxation
- Metastable state
- Chemical Rxn
- Sample Heating
- Δ Temperature
- Δ Density Change
- Δ Pressure
- Chemical change

PTS relies on the thermal dissipation of spectrally absorbed energy for its signal.
Maiden Deployment

Flight 081028a inbound leg

Sedlacek and Lee, 2007
Sedlacek, 2006

UTC

3:45 PM 4:00 PM 4:15 PM 4:30 PM 4:45 PM 5:00 PM 5:15 PM

B_{abs} (Mm^{-1})

Neph (550 nm)  PSAP (550 nm)  PTI (532 nm)

B_{scat} (Mm^{-1})

3:45 PM 4:00 PM 4:15 PM 4:30 PM 4:45 PM 5:00 PM 5:15 PM

0 10 20 30 40 50 60

0 8 16 24 32 40

0 2 4 6 8

0 2 4 6 8

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Summary of Observations.....so far

- $B_{\text{scat}}$ in cloud observed to be very low ($\leq 2 \text{ Mm}^{-1}$)
- Coastal influence obs. within 100 km of shore.
- Scattering Angstrom Exponents (SAE) $\sim 1$ (and lower) observed. Indicative of large particles

- Exceptionally weak absorption has, so far, prevented meaningful extraction of AAE trends for cloud penetration.
- $B_{\text{abs}}$ very small ($\leq 1 \text{ Mm}^{-1}$)
- Absorption Angstrom Exponents (AAE) $< 1$ over ocean: $B_{\text{abs}}$ uncertainty or increasing imaginary part of the RI with wavelength.

- SSA wavelength dependence suggests presence of pollution near coast & no evidence of coastal dust (below cloud)

- Maiden deployment of PTI.