Airborne Multi-wavelength High Spectral Resolution Lidar Observations and Applications from TCAP

Chris Hostetler¹, Richard Ferrare¹, John Hair¹, Anthony Cook¹, David Harper¹, Terry Mack², Rich Hare¹, Craig Cleckner¹, Ray Rogers¹, Detlef Müller³, Eduard Chemyakin⁴, Sharon Burton¹, Amy Jo Scarino³, Michael D. Obland¹, Duli Chand⁵, Jason Tomlinson⁵, Brian Cairns⁶, Phil Russell⁷, Jens Redemann⁷, Yohei Shinozuka⁸, Beat Schmid⁵, Jerome Fast⁵, Larry Berg⁵, Connor Flynn⁵

Summary

- HSRL-2 products are available from the TCAP ftp archive site
- These products include:
  - Quick look images of many parameters and flight track
  - Google Earth (kmz) files showing aerosol backscatter ratio and flight path color-coded by AOT
  - Data files in hdf5 format
- Data files include:
  - Aerosol backscatter, extinction, depolarization, AOD (532 nm)
  - Aerosol backscatter, depolarization (1064 nm)
  - Flight parameters (lat, lon, time, etc.)
- Have produced preliminary retrievals of aerosol optical and microphysical characteristics
  - Not archived but available from LaRC upon request
  - Currently working with G-1 data to assess retrievals
  - Seek additional results for further assessments
- Currently working on producing ML heights
Airborne multi-wavelength “3β+2α” HSRL measurements from the TCAP field campaign

07/17/2012 TCAP flight on B200 aircraft

- High Spectral Resolution Lidar (HSRL) provides independent retrievals of aerosol extinction and backscatter
- HSRL-2 Capabilities
  - Backscatter at 355, 532, and 1064 nm
  - Extinction at 355 and 532 nm (HSRL)
  - Depolarization at 355, 532, 1064 nm
HSRL-2 “3β+2α” Microphysical Retrieval

07/17/2012 TCAP flight on B200 aircraft

- Inversion with Regularization (Muller et al. 1999, Veselovskii et al. 2002)
- Produces horizontally and vertically resolved curtains of microphysics including:
  - Effective radius
  - Complex index of refraction
  - Scattering coefficient
  - Absorption coefficient
  - Single scatter albedo
  - Number, Surface and Volume Concentration

Preliminary
HSRL-2 Microphysics
Comparison with G1 In Situ

Preliminary

20120717

Altitude (km)

Absorption (Mm$^{-1}$)

Total Scattering (Mm$^{-1}$)
(amb PT & RH)

Extinction (Mm$^{-1}$)

Relative Humidity

Altitude (km)

Effective Radius (µm)

Number Concentration (cm$^{-3}$)

Surface Area Concentration

Volume Concentration (µm/cm$^3$)

(µm$^2$/cm$^3$)

B200:16.0 UT • G1:15.7-16.0 UT

17 July
HSRL-2 Microphysics
Comparison with G1 In Situ

20120722

Absorption (Mm⁻¹)
Total Scattering (Mm⁻¹)
Extinction (Mm⁻¹)
Relative Humidity

Altitude (km)
Altitude (km)
Altitude (km)
Altitude (km)

0 5 10 15 20
0 30 60 90 120 150
0 30 60 90 120 150
0 20 40 60 80 100

0 1 2 3 4
0 1 2 3 4
0 1 2 3 4
0 1 2 3 4

Effective Radius (µm)
Number Concentration (cm⁻³)
Surface Area Concentration (µm²/cm³)
Volume Concentration (µm/cm³)

B200:16.8 UT • G1:16.8-17.0 UT

Preliminary
Aerosol Backscatter

Lidar Ratio (532 nm)

Backscatter Angstrom (1064/532)

Aerosol Classification

Marine indicated by low lidar ratio and small backscatter angstrom (large particles)

Urban outflow indicated by high lidar ratio and larger backscatter angstrom (smaller particles)

Marine indicated by low lidar ratio and large backscatter angstrom (smaller particles)

Urban indicated by high lidar ratio and small backscatter angstrom (large particles)
HSRL and AERONET AOD Comparison

- Data points from when HSRL was within 15 km/30 min of the AERONET sites
- AERONET is Level 1.5 Data
- Bias Diff is HSRL-AERONET

<table>
<thead>
<tr>
<th>Distance</th>
<th>15km / 30min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>355</td>
</tr>
<tr>
<td># Points</td>
<td>12</td>
</tr>
<tr>
<td>R</td>
<td>0.996</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.048</td>
</tr>
<tr>
<td>Slope</td>
<td>0.94</td>
</tr>
<tr>
<td>RMS Error</td>
<td>0.039</td>
</tr>
<tr>
<td>Bias Diff</td>
<td>-0.029</td>
</tr>
</tbody>
</table>
HSRL-2 Microphysics
Comparison with G1 In Situ

17 July

Preliminary

20120717

Altitude (km)

Absorption (Mm$^{-1}$)

Total Scattering (Mm$^{-1}$) (amb PT & RH)

Extinction (Mm$^{-1}$)

Single Scattering Albedo

Altitude (km)

Effective Radius (μm)

Number Concentration (cm$^{-3}$)

Surface Area Concentration Volume Concentration (μm/μm$^3$)

B200:16.0 UT • G1:15.7-16.0 UT
HSRL-2 Microphysics Comparison with G1 In Situ

25 July

Preliminary

B200: 14.7 UT • G1: 14.9-15.1 UT
TCAP 4STAR Vertical Profiles

The 4STAR Team and Collaborators
Figures generated by Yohei Shinozuka
20km, +-30min

- 0.355 μm
- 0.532 μm
- 1.064 μm
HSRL-2 Microphysics
Comparison with G1 In Situ

Preliminary

22 July

B200:16.8 UT • G1:16.8-17.0 UT