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

NASA B200 King Air

ASR Atmospheric System Research

NASA

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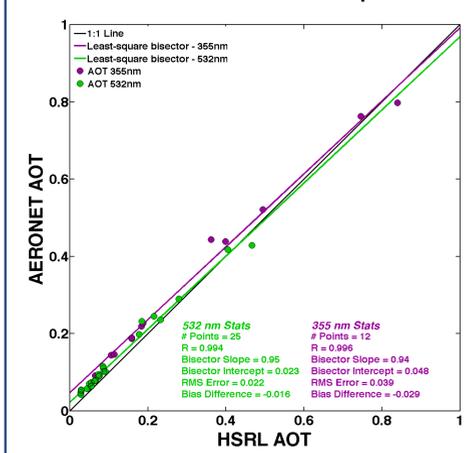
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Introduction

- NASA Langley has developed the first airborne multi-wavelength high spectral resolution lidar (HSRL) instrument, "*HSRL-2*"
  - Follow-on to HSRL-1 flown on past ASR missions
  - Prototype lidar for the NASA Aerosols-Clouds-Ecosystems (ACE) satellite mission
  - The Two-Column Aerosol Project (TCAP) was the first deployment of HSRL-2
- Data from TCAP are being used to retrieve vertically resolved aerosol microphysical parameters using the "$3\beta + 2\alpha$" technique
  - The $3\beta + 2\alpha$ retrieval provides separate <u>vertically-resolved</u> profiles of scattering and absorption that are required for estimates of direct and semi-direct aerosol forcing and radiative heating
  - Better quantification of aerosol type (via refractive index) and loading (via concentration) enables assessments of aerosol transport models
  - <u>Vertically-resolved</u> retrievals of aerosol concentration and particle size enhance studies of aerosol-cloud interactions
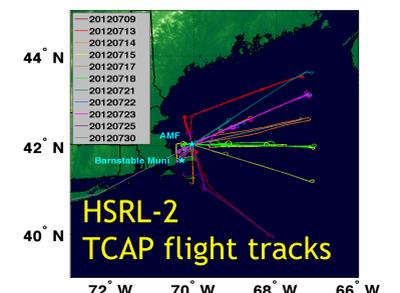
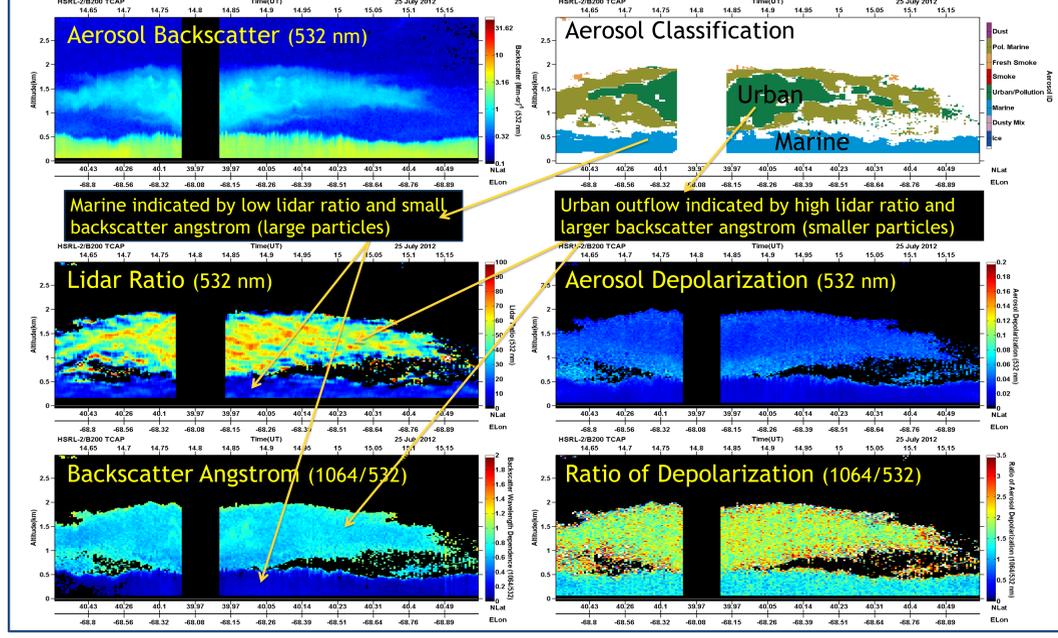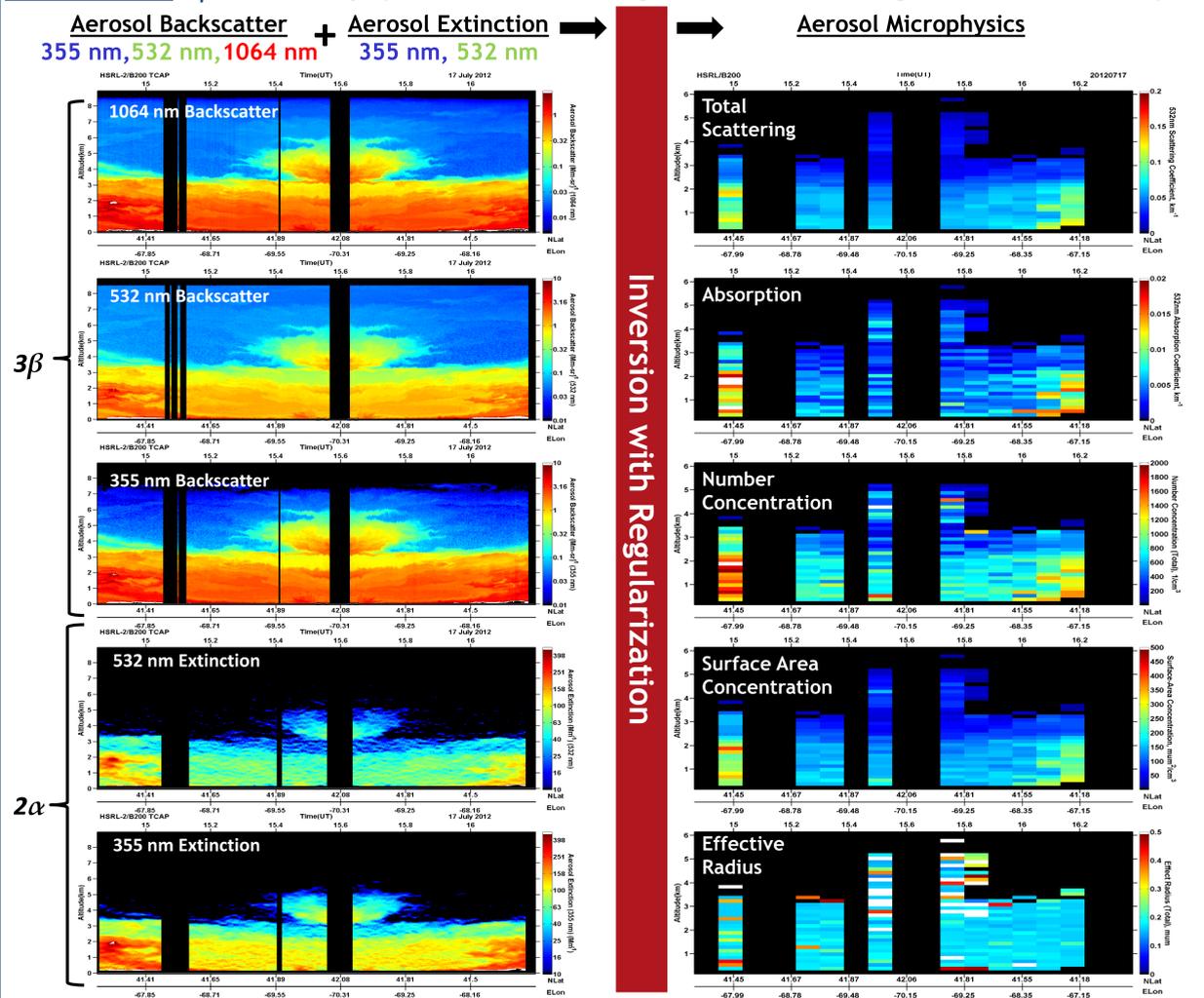| Extensive Aerosol Data Products (used in $3\beta+2\alpha$ retrievals)	
Extinction	355, 532 nm
Backscatter	355, 532, 1064 nm
Intensive Aerosol Data Products (used for Aerosol Classification)	
Depolarization	355, 532, 1064 nm
Depolarization spectral dependence	1064/532, 532/355
Backscatter spectral dependence	1064/532, 532/355
Extinction spectral dependence	532/355
Lidar Ratio	355, 532 nm

HSRL-2 TCAP flight tracks

HSRL/AERONET AOT Comparison

Preliminary $3\beta+2\alpha$ Microphysics retrieval using Inversion with Regularization: 17 July

Aerosol Backscatter 355 nm, 532 nm, 1064 nm + **Aerosol Extinction** 355 nm, 532 nm → **Aerosol Microphysics**

Inversion with Regularization

Aerosol classification: two layers on 25 July 2012

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)

Summary and Conclusions

Basic Level-2 Products
- Much higher laser energy and hence much higher Signal-to-Noise Ratio than HSRL-1
- 355 and 532 nm aerosol extinction validated via comparison to AERONET AOT

Aerosol Classification
- Aerosol type full-curtain product provides context for composition measured in situ at G1 altitudes.

Preliminary $3\beta + 2\alpha$ retrieval of aerosol microphysics and optical properties
- Aerosol effective radius typically in good agreement with in situ measurements, but outliers exist
- Aerosol concentrations typically in good agreement with in situ
  - Surface area concentration shows excellent agreement
  - Number and volume concentrations have outliers
- Separation of total extinction into scattering and absorption
  - Aerosol total scattering and extinction in good agreement with in situ measurements
  - Absorption biased high relative to in situ measurements in some cases
- Overall: $3\beta + 2\alpha$ aerosol microphysics products are *preliminary*. Work is underway to assess the products against in situ observations and improve the algorithms/software.

Outlook: Advanced microphysical products (e.g., effective radius, concentration, scattering vs. absorption) and aerosol type from HSRL-2 provide full horizontally and vertically resolved curtains for extrapolating detailed information gathered in situ on G-1 aircraft for estimating aerosol microphysical evolution by type.

Comparison of *Preliminary* $3\beta+2\alpha$ microphysics with in situ measurements from PSAP/Nephelometer and PCASP

17 July 2012 • B200:16.0 UT • G1:15.7-16.0 UT

22 July 2012 • B200:16.8 UT • G1:16.8-17.0 UT

25 July 2012 • B200:14.7 UT • G1:14.9-15.1 UT