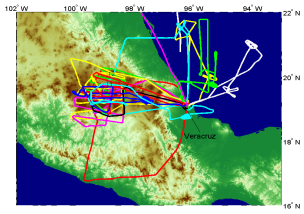
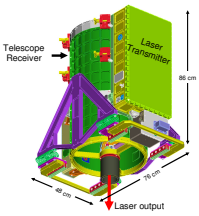
Airborne High Spectral Resolution Lidar Observations of Aerosol Spatial Distribution and Optical Properties from MILAGRO/MAX-MEX/INTEX B

Johnathan W. Hair, Richard A. Ferrare, Chris A. Hostetler, Anthony L. Cook, David B. Harper, NASA Langley Research Center, MS 401A Hampton, Virginia, 23681-2199, USA. Email Johnathan.W.Hair@nasa.gov
Larry Kleinman, Brookhaven National Laboratory;
Philip Russell, NASA Ames; Jens Redemann, BAERI/NASA Ames; John Livingston, SRI/NASA Ames;
Antony Clarke, University of Hawaii

INTRODUCTION

NASA Langley Research Center (LaRC) deployed the LaRC Airborne High Spectral Resolution Lidar (HSRL) on the MILAGRO/MAX-MEX/INTEX-B field mission to provide quantitative, vertically and horizontally resolved measurements of aerosol optical properties. The HSRL was deployed on the LaRC King Air B-200 aircraft along with three other instruments, the Langley Airborne Oxygen A-band Spectrometer (LAABS), the HyperSpectral Polarimeter for Aerosol Retrievals (HySPAR), and a digital camera. All instruments were nadir-viewing. This poster focuses on preliminary HSRL measurements of aerosol distributions and optical properties.





Science Objectives

- Characterize the vertical and horizontal distribution of aerosol optical properties and type using profiles of extinction, backscatter, and depolarization
- Evaluate/validate the retrieved profiles of aerosol extinction and optical depth
- Evaluate predictions from aerosol transport models
- Provide vertical context for in situ measurements from the G-1 and C-130
- Investigate combined use of lidar and MODIS, PARASOL to determine vertical distribution of aerosol effective radius, fine mode fraction – prelude to combined CALIPSO/A-train retrievals

Mission Summary

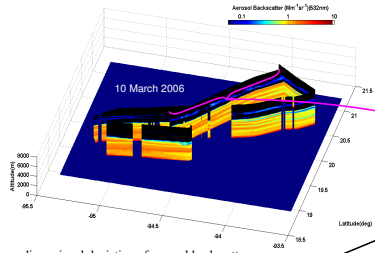
- March 2-29
- 15 science flights, ~60 flight hours
  - 5 flights with NASA Ames/Sky Research J-31
  - 6 flights with DOE G-1
  - 4 flights with NCAR C-130
- Satellite validation/retrieval studies
  - 5 MISR coincidences (4 Local Mode)
  - 8 Terra MODIS coincidences
  - 1 Aqua MODIS coincidence

HSRL Data Products

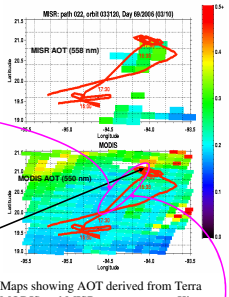
Extensive Products (vertical, horizontal resolutions)
- Aerosol Backscatter 532 nm (60m, 1km)
- Aerosol Extinction and AOT 532 nm (300m, 6km)
- Aerosol Backscatter 1064nm - standard retrieval (60m, 1km)

Intensive Products (vertical, horizontal resolutions)
- Extinction/Backscatter (Sa) 532 nm (300m, 6km)
- Aerosol Depolarization - 532 & 1064 nm (60m, 1km)
- Ratio of Aerosol Depolarization Ratios ($\delta_{a,1064}/\delta_{a,532}$) (60m, 1km)
- Aerosol Backscatter Wavelength Dependence - (1064/532) (60m, 1km)

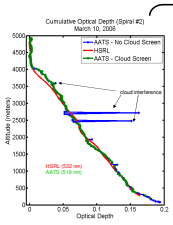
EXTINCTION AND AEROSOL OPTICAL DEPTH INTERCOMPARISONS

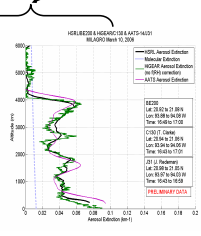


Three-dimensional depiction of aerosol backscatter profiles measured by HSRL on March 10, 2006.

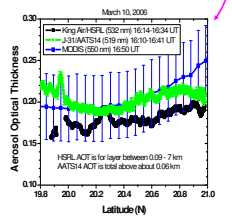


Maps showing AOT derived from Terra MODIS and MISR measurements. King Air flight track is also shown.



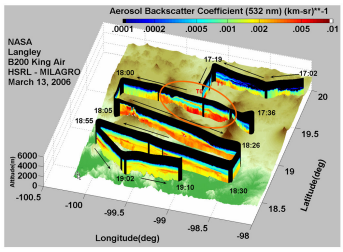


Comparison of aerosol optical thickness (left) and extinction (profiles) derived from HSRL (King Air), NASA Ames AATS14 airborne Sun photometer (J-31), and HiGear (C-130) in situ aerosol measurements.

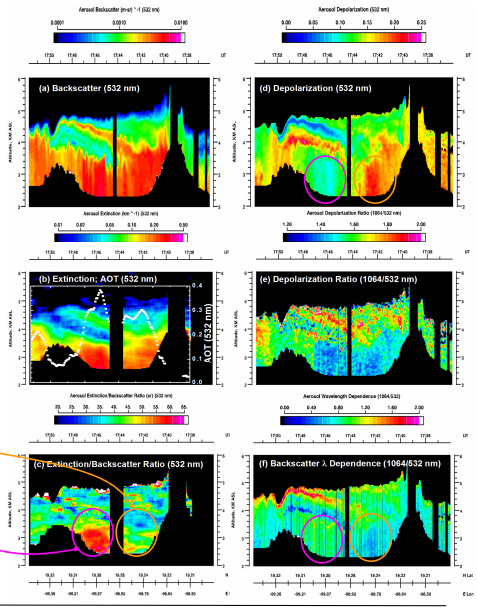


Comparison of AOT derived from HSRL (King Air), NASA Ames airborne Sun photometer (J-31), and Terra MODIS along flight track segment shown above.

MAPPING THE DISTRIBUTION OF AEROSOL OPTICAL PROPERTIES AND TYPE

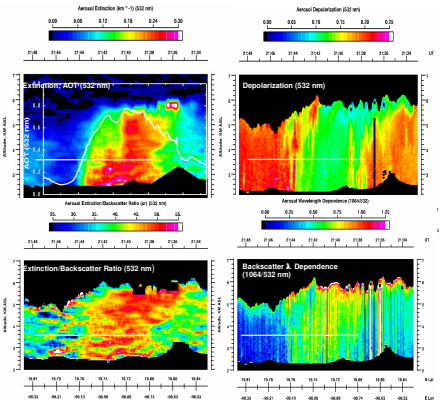


Full Suite of HSRL measurements (right) for circled segment (above) of King Air flight leg over Mexico City basin between 17:37 and 17:48 UT on March 13, 2006, covering a horizontal distance of about 115 km. Observations indicate urban pollution on west side of MC basin and dust dominated aerosol on east side.

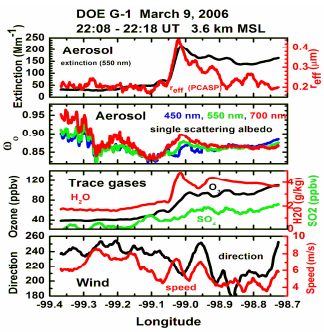


Eastern part of city - dust
- lower Sa, low WVD
- higher depolarization

Western part of city- urban aerosols
- higher Sa, high WVD
- lower depolarization



NASA King Air & DOE G-1 coordinated fight March 9, 2006

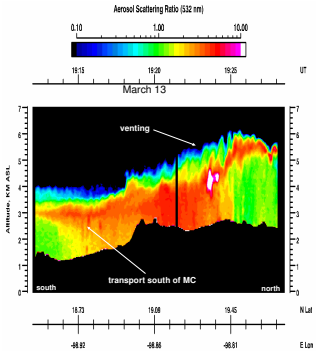


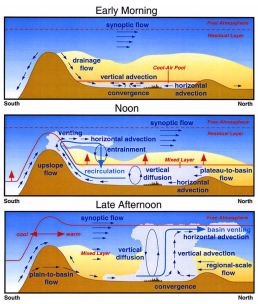
PRELIMINARY DATA

The panels on the left show portions of the NASA Langley HSRL measurements on March 9, 2006 when the NASA Langley B200 King Air flew from east to west over Mexico City. These images show about 15 minutes of HSRL data and cover a horizontal distance of about 90 km. Note the abrupt increase in aerosol extinction and AOT over the eastern (right) portion of MC. AOT increased by nearly an order of magnitude over the eastern part of the city. This change in AOT was also accompanied by a change in aerosol type as shown by the HSRL measurements. High values of aerosol depolarization and low values of aerosol extinction/backscatter ratio and backscatter wavelength dependence on the western portion of this flight segment indicate the presence of larger, nonspherical dust particles. Low values of aerosol depolarization and high values of aerosol extinction/backscatter ratio and wavelength dependence on the eastern portion indicate the presence of smaller, more spherical particles associated with urban air pollution. The plots on the right show in situ measurements of aerosol extinction and effective radius, single scattering albedo, trace gases, and winds measured by instruments on the DOE G-1 aircraft as it flew under the King Air; the location of the G-1 track is shown by the horizontal white line in the lidar images. The in situ measurements also show the increase in aerosol extinction over the eastern part of the city as well as the increase in trace gases associated with air pollution.

COMPARISONS WITH MODELS

Aerosol Venting in the Free Troposphere





The figure on the left shows HSRL data from one leg of the flight on March 13, 2006, when the NASA Langley B200 King Air flew from southwest to northeast over the Mexico City basin. The figure shows profiles of the aerosol scattering ratio (532 nm), which is the ratio of aerosol scattering to molecular scattering. This portion of the flight segment covers about 120 km. The lidar data show the transport of aerosols south of MC through the gap in the mountains southeast of MC, the region of high aerosol scattering over MC, and the lofting of aerosols over MC on the right portion of the figure. Compare the lidar image with the image on the center right, which show model representation of the flow over Mexico City at noon for a typical day.

Acknowledgments

We gratefully acknowledge the support of NASA HQ Science Mission Directorate Radiation Science Program and the Department of Energy Atmospheric Science Program for their support of the deployment of the B-200 on the MILAGRO field mission.
We also wish to acknowledge the excellent flight operations and logistics support from the NASA Langley Flight Research Support Directorate.