Airborne High Spectral Resolution Lidar Measurements of Aerosols During MILAGRO

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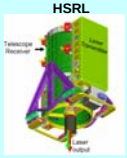
Introduction

NASA Langley Research Center (LaRC) recently developed an airborne High Spectral Resolution Lidar (HSRL) to measure aerosol distributions and optical properties. The HSRL measurements of aerosol extinction, backscattering, and depolarization profiles are being used to: 1) characterize the spatial and vertical distributions of aerosols, 2) quantify aerosol extinction and optical thickness contributed by various aerosol types, 3) investigate aerosol variability near clouds, 4) evaluate model simulations of aerosol transport, and 5) assess aerosol optical properties derived from a combination of surface, airborne, and satellite measurements.

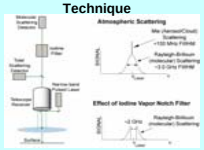
System and Data

HSRL



NASA Langley B200 King Air

Technique



Data Products

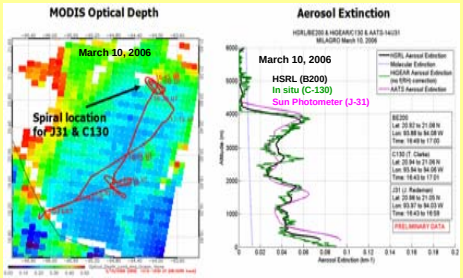
- Aerosol scattering ratio (aerosol/molecular backscatter) (532 nm) ($\Delta x \sim 1$ km, $\Delta z \sim 60$ m)
- Aerosol backscatter coefficient at 532 nm ($\Delta x \sim 1$ km, $\Delta z \sim 60$ m)
- Aerosol extinction coefficient at 532 nm ($\Delta x \sim 6$ km, $\Delta z \sim 300$ m)
- Aerosol wavelength dependence (532/1064) (i.e. Angstrom exponent for aerosol backscatter) (similar to backscatter color ratio)
- Aerosol extinction/backscatter ratio ("lidar ratio") (532 nm) ($\Delta x \sim 6$ km, $\Delta z \sim 300$ m)
- Aerosol depolarization (532 and 1064 nm) ($\Delta x \sim 1$ km, $\Delta z \sim 60$ m)

Extensive – depend on aerosol amount and type

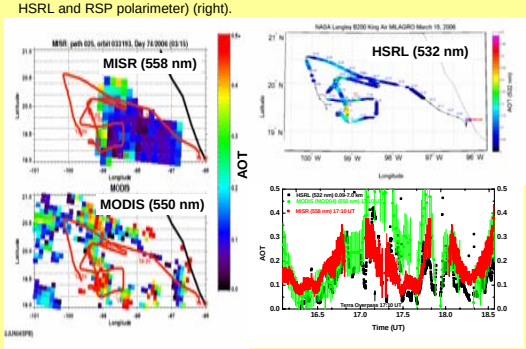
Intensive – depend on aerosol type

(Left) The HSRL technique takes advantage of the spectral distribution of the lidar return signal to discriminate aerosol and molecular signals and thereby measure aerosol extinction and backscatter independently. (Right) Preliminary data products were delivered to the INTEX-B archive on September 1, 2006. Final data products will be delivered by March 31, 2007.

Measurement Comparisons

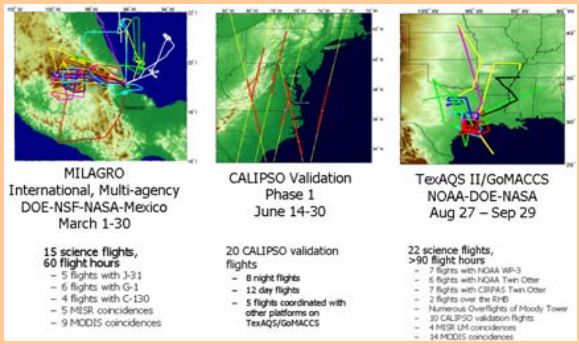


Several B200 King Air flights were coincident with MODIS (10 flights) and MISR (5 flights) (left) and were coordinated with J-31 and C-130 flights for comparison of data products (e.g. aerosol extinction) and retrieval studies (e.g., combined HSRL and RSP polarimeter) (right).



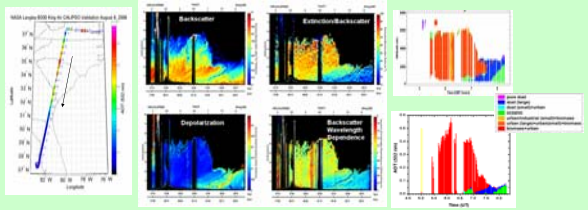
Aerosol optical thickness comparison on March 15, 2006

Airborne HSRL Deployments During 2006

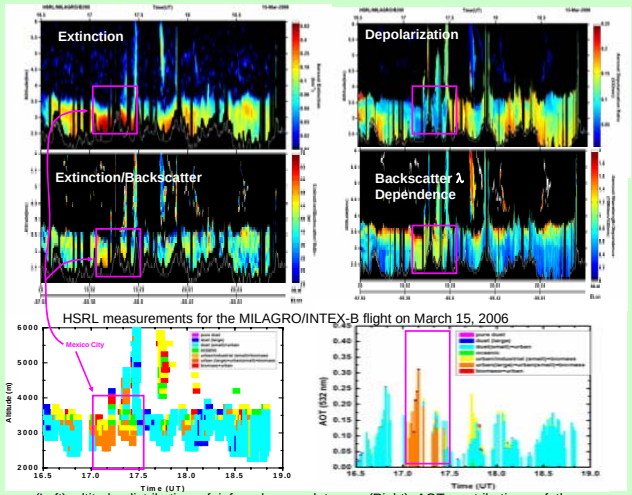


During 2006, the airborne HSRL acquired over 215 flight hours of data deployed on the NASA King Air B200 aircraft during several field experiments. These experiments were MILAGRO/INTEX-B, validation of Cloud-Aerosol LIdar with Orthogonal Polarization (CALIOP) lidar on board the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite (CALIPSO) satellite, and the Texas Air Quality Study (TEXAQS)/Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS) that was conducted during August and September 2006 to investigate climate and air quality in the Houston/Gulf of Mexico region.

Classification of Aerosol Types



Cattrall et al. (2005) used global ground-based Aerosol Robotic Network (AERONET) measurements to derive representative values of lidar intensive parameters corresponding to various aerosol types. The HSRL measurements of aerosol intensive parameters were used with these results to infer aerosol types. The images above show an example for a flight on August 8, 2006. The altitude distribution of these aerosol types and the contributions of these aerosol types to the aerosol optical thickness (AOT) are shown in the graphs on the right.



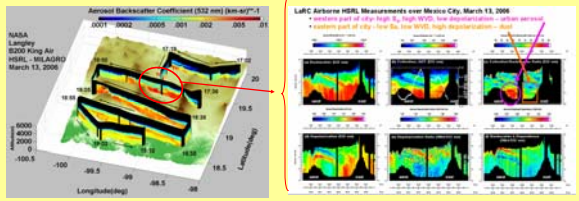
HSRL measurements for the MILAGRO/INTEX-B flight on March 15, 2006

(Left) altitude distribution of inferred aerosol types; (Right) AOT contributions of these aerosol types. Note the change in aerosol type over Mexico City.

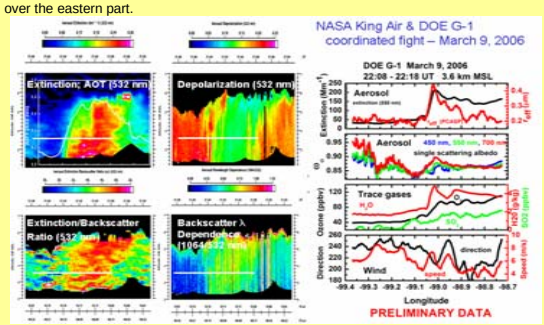
Summary and Key Findings

- HSRL mapped vertical and horizontal distributions of aerosols in and around Mexico City region
- Preliminary comparisons show excellent agreement among HSRL, in situ, and airborne Sun photometer aerosol extinction profiles
- HSRL measurements are being used to assess MODIS and MISR measurements and evaluate active-passive aerosol retrieval techniques
- HSRL measurements used to classify aerosol types & apportion aerosol optical thickness by type
  - Aerosols were dominated by nonspherical (dust) during MILAGRO
  - Small, spherical, urban pollution aerosols observed directly over Mexico City
  - During MILAGRO – aerosol optical thickness dominated by dust+urban mix
  - Over eastern U.S. and Houston – aerosol optical thickness dominated by urban/biomass mix

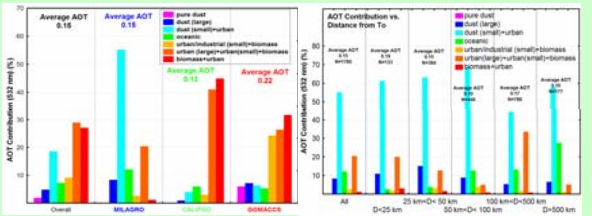
HSRL Measurements over Mexico CIty



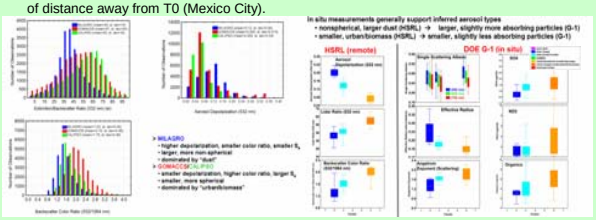
(Left) Aerosol backscatter "curtain" showing distribution of aerosols in and around Mexico City area on March 13, 2006. (Right) Expanded view of HSRL measurements acquired directly over Mexico City showing urban aerosols over the western part of the city and dust over the eastern part.



(Left) HSRL measurements over Mexico City on March 9, 2006. White line indicates location of coincident G-1 in situ measurements (Right).



(Left) Fraction of AOT contributed by various aerosol types during MILAGRO and other field missions. (Right) Fraction of AOT contributed by various aerosol types as a function of distance away from T0 (Mexico City).



(Left) Variability of aerosol parameters during MILAGRO and other field missions. (Right) Aerosol optical and microphysical parameters as a function of aerosol type derived from HSRL and G-1 in situ measurements during MILAGRO.

Acknowledgements

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