Assessing Aerosol Mixed Layer Heights from the NASA LaRC airborne HSRL during the DISCOVER-AQ Field Campaigns

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DISCOVER-AQ

San Joaquin Valley, CA
January-February 2013
- HSRL-2 flew on 21 science flights (~84 hours)

Denver, CO
July-August 2014
- HSRL-2 flew on 25 science flights (~89 hours)

Washington, DC & Baltimore, MD
July 2011
- HSRL-1 was deployed July 1 – 29 for 25 science flights (~100 hrs)

Houston, TX
September 2013
- HSRL-2 flew on 26 science flights (~104 hours)

Airborne High Spectral Resolution Lidar

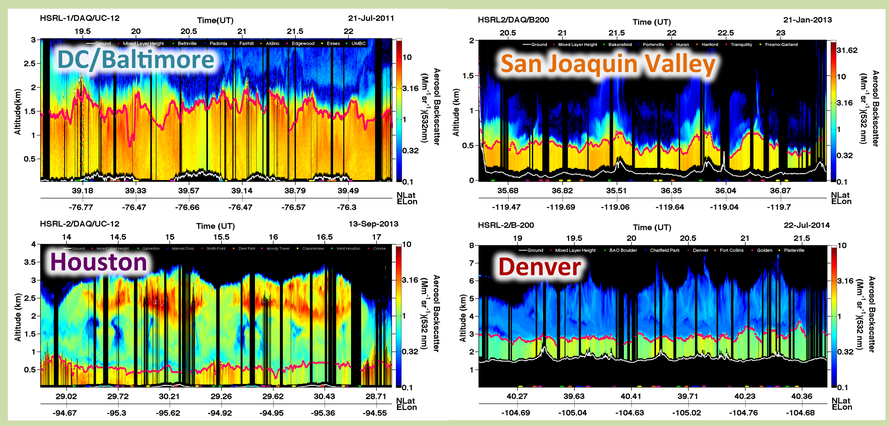
The first- and second-generation NASA airborne High Spectral Resolution Lidar (HSRL-1/HSRL-2) was deployed on board the NASA LaRC King Air aircraft during the Deriving Information on Surface Conditions from Column and VERtically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) field campaigns.

HSRL Technique:
Independently measures aerosol backscatter, extinction, and optical thickness

HSRL-1 and HSRL-2 Aerosol Data Products
- Backscatter coefficient (355, 532, 1064 nm)
- Depolarization (355, 532, 1064 nm)
- Extinction coefficient (355, 532 nm)
- Optical Thickness (AOT) (355, 532 nm)
- Mixed Layer (ML) Heights
- Aerosol type

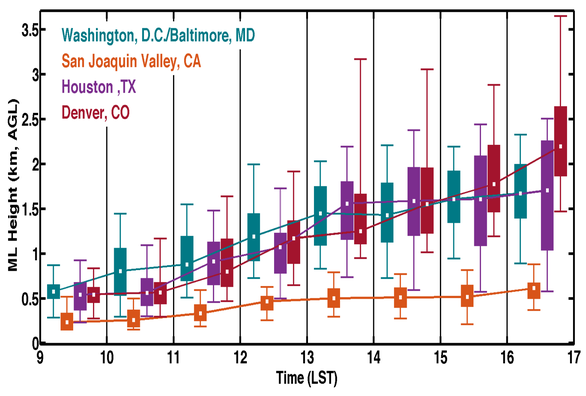
Mixed Layer Heights

Mixed Layer (ML) heights have been derived from the airborne HSRL-1/-2 data during the DISCOVER-AQ missions. These studies examine the temporal and horizontal variability of ML heights
- ML heights from airborne lidar are a good proxy for the daytime PBL heights and are useful for evaluating PBL heights from numerical weather and air quality models
- PBL height is key parameter for simulating climate processes and assessing model simulations of aerosol pollutant concentrations and transport
- ML heights were derived from daytime-only cloud-screened aerosol backscatter profiles measured by the airborne HSRL using a Haar wavelet covariance transform with multiple wavelet dilations to identify sharp gradients in the backscatter
- "Best-Estimate" ML heights combine results from automated algorithm, as well as results from manual inspection of HSRL backscatter profiles



- For more information on HSRL ML heights, see ***Scarino et al., ACP, 2014***
- ML heights and the height of the maximum aerosol gradients used to help relate column AOT measurements and extinction profiles to surface $PM_{2.5}$ concentrations ***[See Rich Ferrare's talk on Friday morning]***

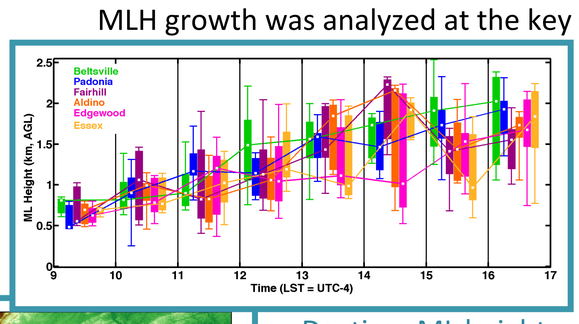
Mission MLH Variability

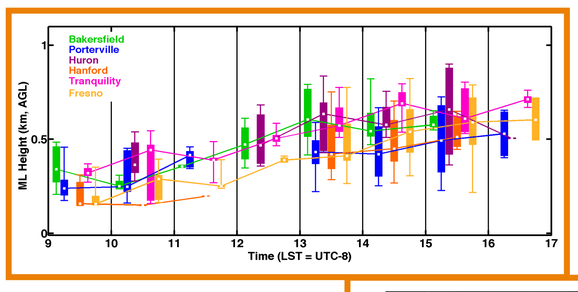


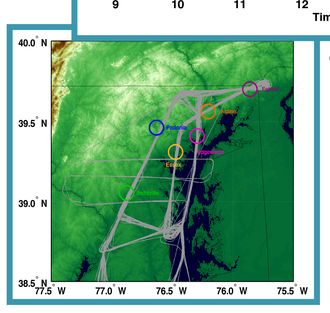
Across all four locations:
- Daytime ML height growth is visible at all locations
- ML heights in in the San Joaquin Valley were the lowest of the locations
- ML heights in DC/Baltimore, Houston, and Denver all had about the same median ML height, except for some outlying ML heights in the foothills of the Rockies

Horizontal Variability

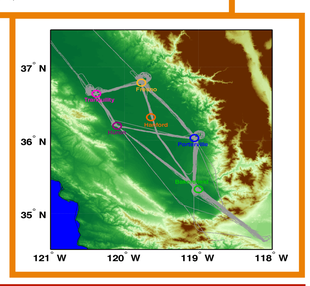
MLH growth was analyzed at the key site locations at all four mission locations



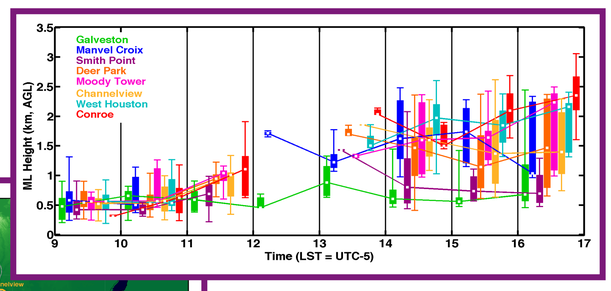


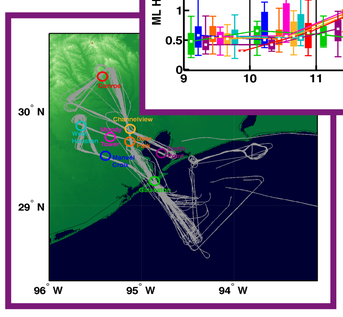


- Daytime ML height growth is similar at all sites; in afternoon, noticeable differences at sites near the Chesapeake Bay (Essex/Edgewood)

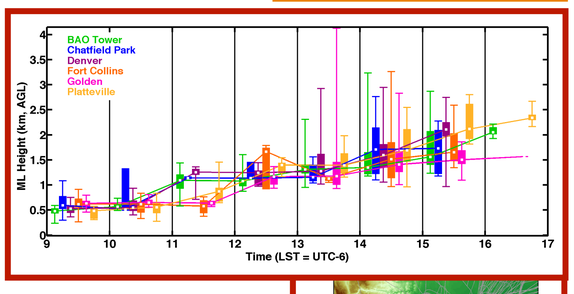


- Variations in daytime ML height growth varied in the West (Huron/Tranquility) to East (Porterville/Fresno) directions

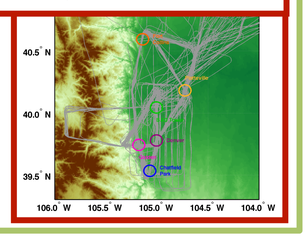




- Daytime ML height growth was more pronounced further inland

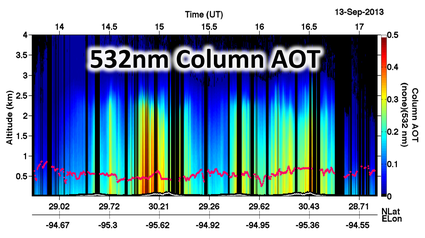


- Daytime ML height growth is noted in two groups of sites: (1) BAO Tower/Denver/Chatfield Park and (2) Golden/Platteville/Fort Collins

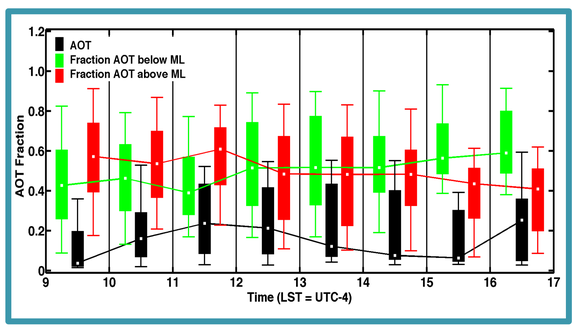


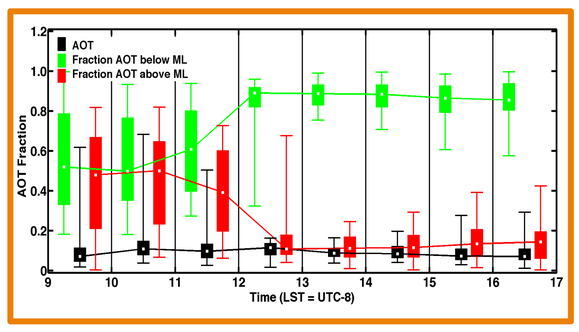
Fraction of AOT

HSRL measurements are used to determine the fraction of AOT in 0-7 km layer that is below and above the ML height

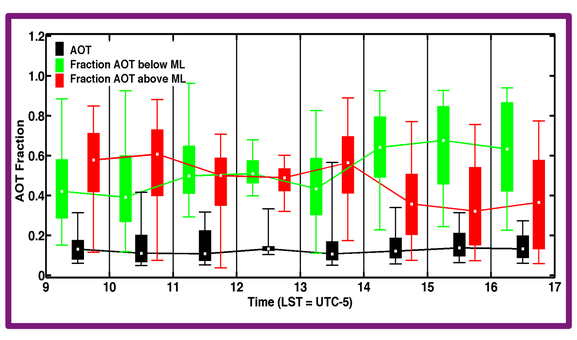


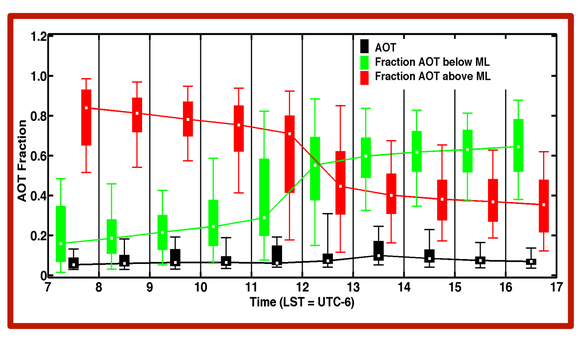
Overall, across all four locations there similar patterns on the fraction of AOT within and above the ML





- Fraction of AOT within ML in DC/Baltimore varies from 40-60% depending on time, same is true for AOT above the ML
- Fraction of AOT within ML in San Joaquin Valley varies from 50% in the morning and increases to ~90% after local noon





- Fraction of AOT within ML in Houston metro region varies from 40% in the morning and increases to 60 % in the afternoon
- Fraction of AOT within ML in Denver area varies from 20-40% in the morning and increases to 60 % in the afternoon

Land and Water Interactions

Assess variability between land and water (Chesapeake Bay & Galveston Bay)
- ML heights tend to be higher over land than water
- Over the land, ML grows during the day, but remains nearly constant over water
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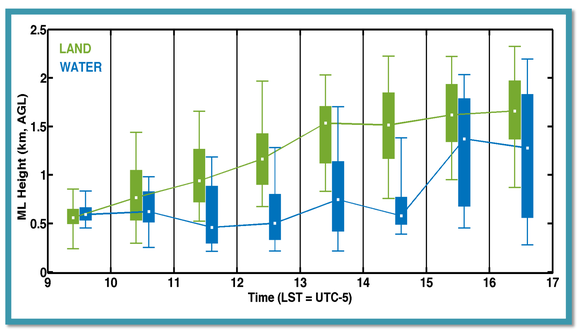
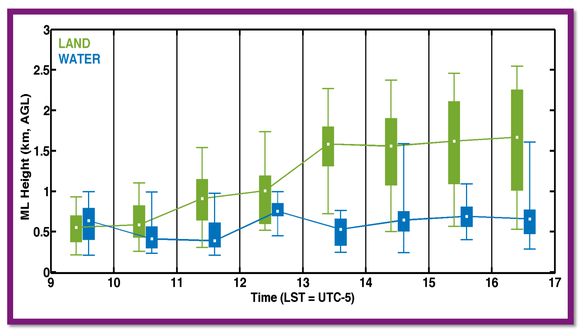
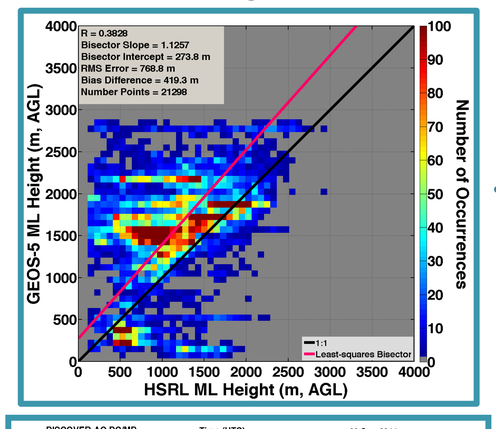
- Over the land, ML grows during the day, but remains nearly constant over water



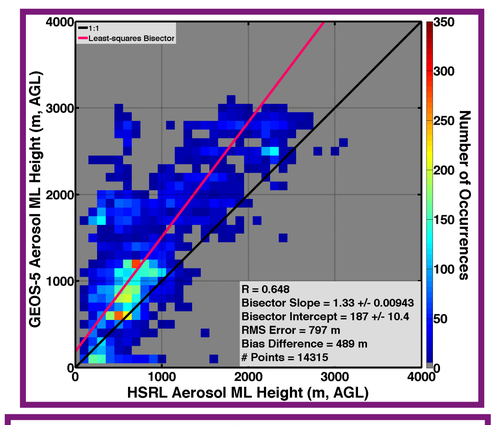


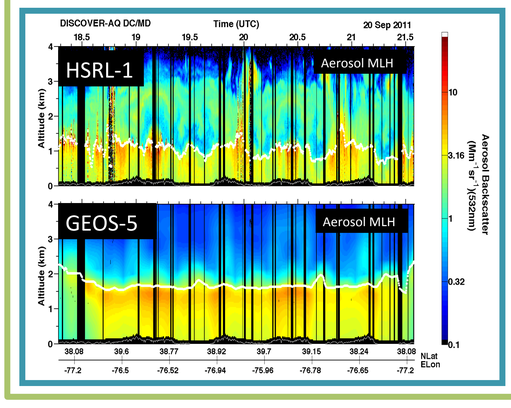
Evaluation of Global Forecast Models

- The HSRL ML heights are used to evaluate the performance in simulating the temporal and spatial variability of ML heights from the GEOS-5 model
- GEOS-5 modeled backscatter profiles were processed the same way as HSRL backscatter to obtain GEOS-5 ML heights

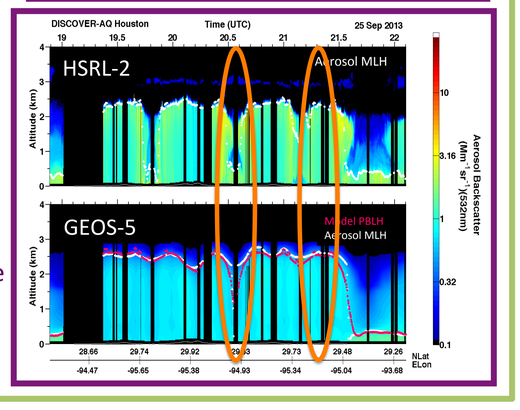


GEOS-5 ML heights are higher than the HSRL ML heights by ~400 m
- GEOS-5 backscatter captures the amount of backscatter, but located higher in atmosphere, therefore, placing the ML heights higher





GEOS-5 ML heights are higher than the HSRL ML heights by ~500 m
- GEOS-5 backscatter captures what is observed by HSRL, all heights compare well, including the transition areas between land and water



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