

Airborne High Spectral Resolution Lidar Aerosol Measurements During the First DISCOVER-AQ Field Mission

Richard Ferrare¹, Chris Hostetler¹, John Hair¹, Mike Omland¹, Ray Rogers¹,
Anthony Cook¹, David Harper¹, Richard Hare¹, Sharon Burton¹,
Bruce Anderson¹, James Crawford¹, Amy Jo Swanson², Marian Clayton²,
Lee Thornhill², Brent Holben³, Ken Pickering³, Ralph Kahn³,
Arlindo DaSilva³, Allen Chu^{3,4}, Ray Hoff⁴, Ruben Delgado⁴,
Jaime Compton⁴, Tim Berkoff^{3,4}, Pius Lee⁵

¹NASA Langley Research Center, Hampton, VA, USA

²Science Systems and Applications, Inc., Hampton, VA USA

³NASA Goddard Space Flight Center, Greenbelt, MD USA

⁴University of Maryland Baltimore County, Baltimore, MD USA

⁵NOAA/Air Resources Laboratory, Silver Spring, MD USA

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DISCOVER-AQ (July 2011)

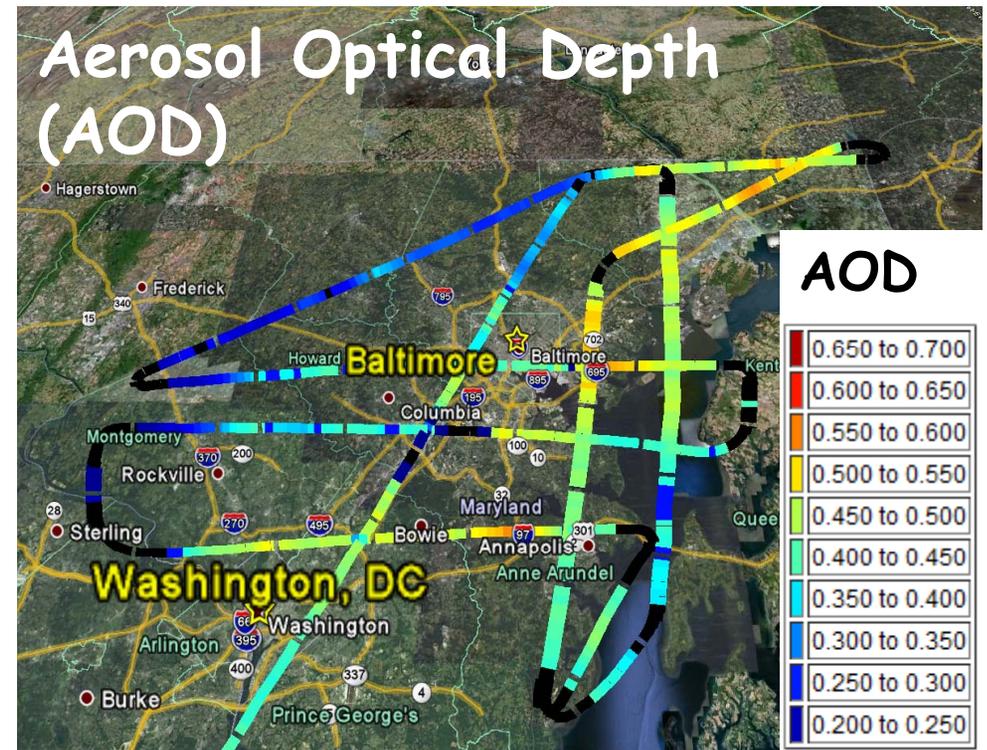
- NASA/LaRC King Air
- Flight altitude ~ 9 km
- Nadir pointing lidar

HSRL Technique:

- Independently measures aerosol backscatter, extinction, and optical thickness

HSRL Aerosol Data Products:

- Backscatter coefficient (532, 1064 nm)
- Depolarization (532, 1064 nm)
- Extinction Coefficient (532 nm)
- Optical Depth (AOD) (=Optical Thickness (AOT)) (532 nm)
- Planetary Boundary Layer (PBL) Height





DISCOVER-AQ (July 2011)

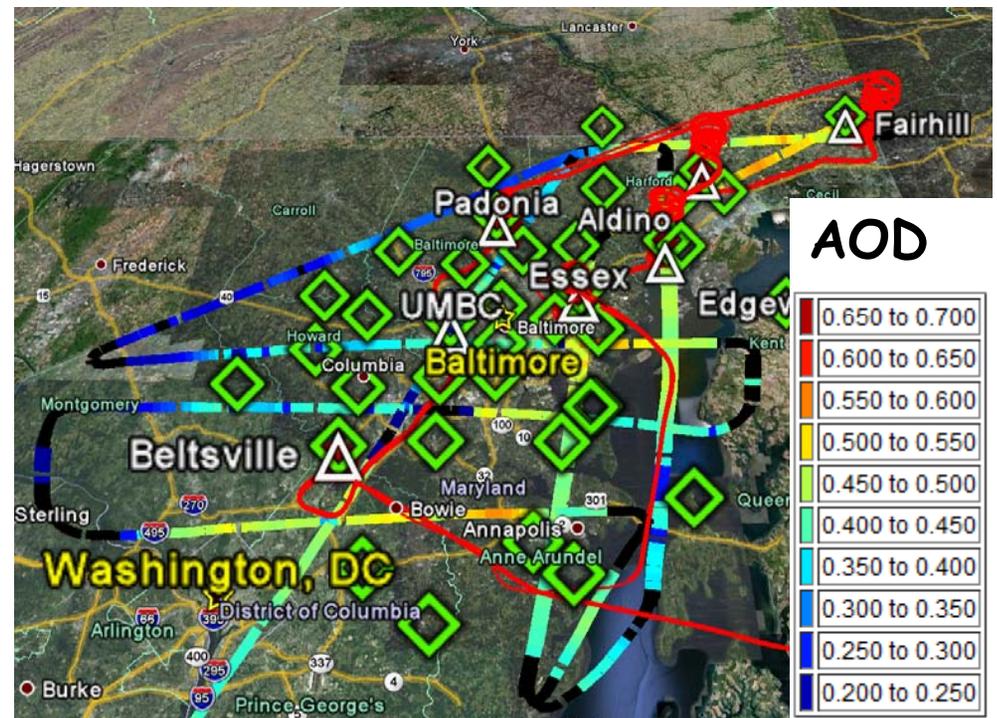
- 25 science flights
- ~100 science hours
- Overflights of:
 - DISCOVER-AQ ground stations
 - Dense AERONET "DRAGON" area
 - Coincident NASA P-3 flights

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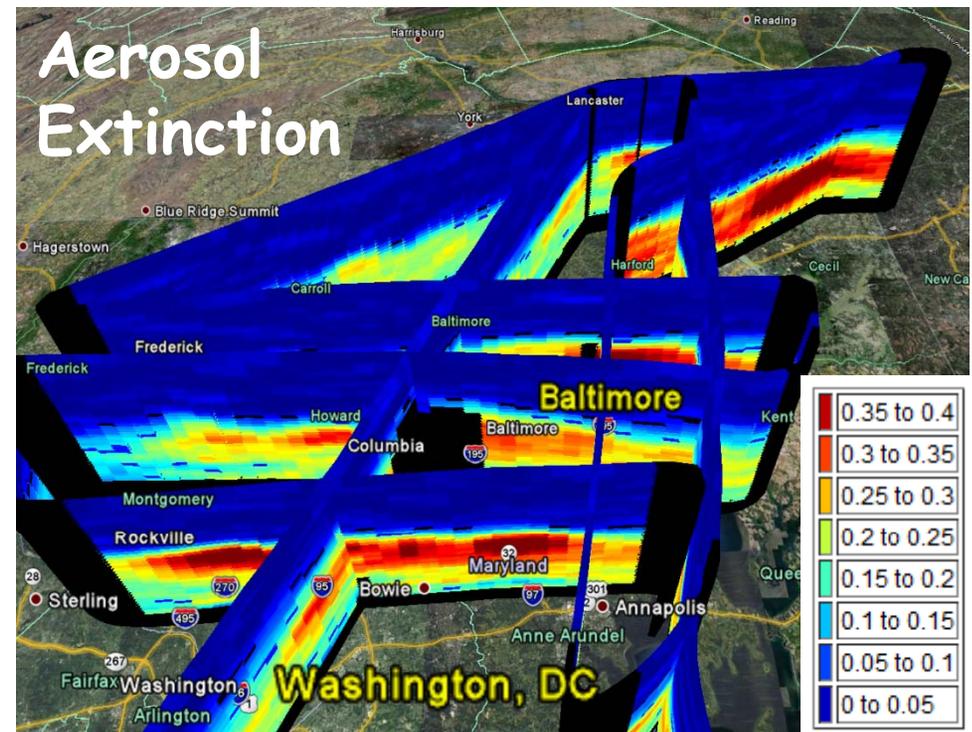
- 25 science flights
- ~100 science hours
- HSRL “curtains” provide:
 - measurement of horizontal and vertical variability over domain
 - vertical context for surface and satellite column measurements

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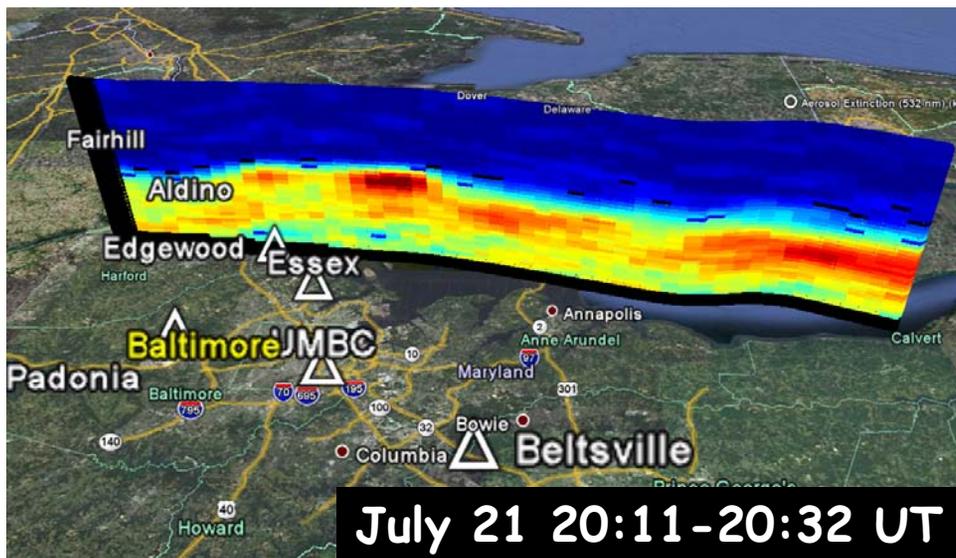
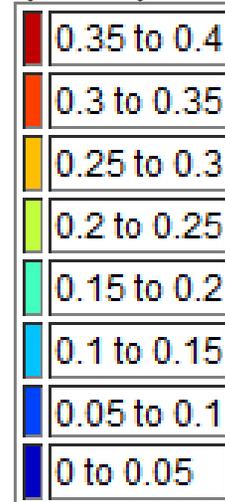


Aerosol Spatial and Vertical Variability

Considerable day-to-day variability in aerosol vertical and horizontal distributions ...

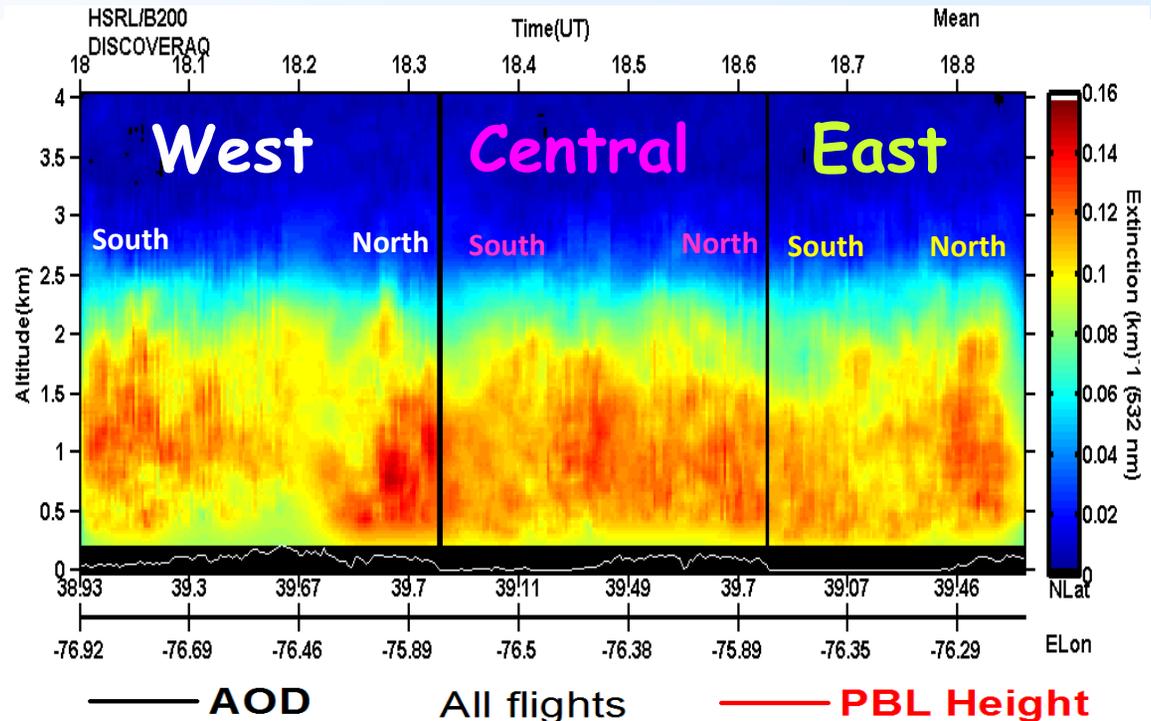


Aerosol Extinction (km^{-1})

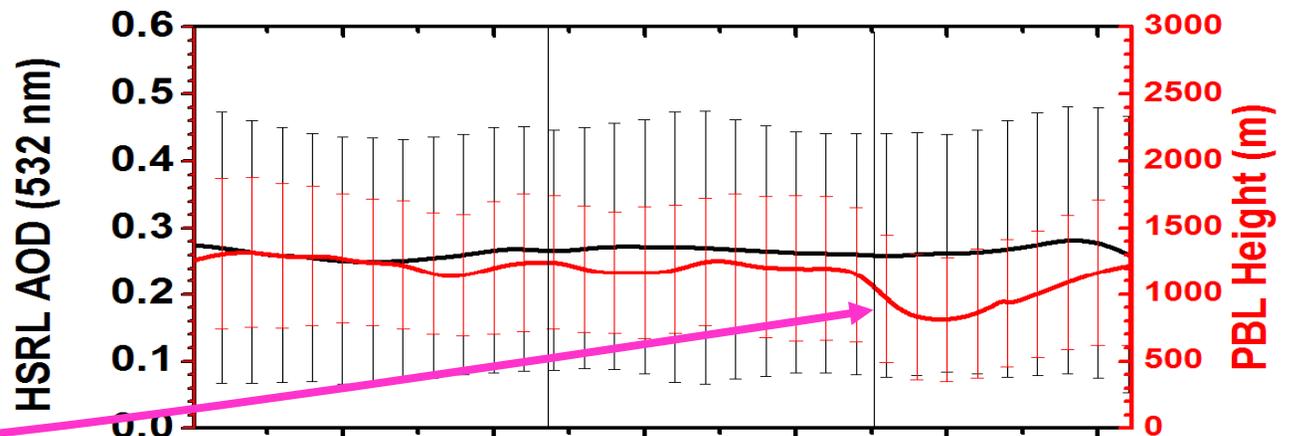


- HSRL “curtains” of aerosol extinction from 0-3 km show considerable day-to-day vertical and horizontal variability
- July 20
 - Low extinction, AOD, PBL over Chesapeake Bay
 - Highest extinction near the surface
- July 21
 - High extinction, AOD, and PBL over Chesapeake Bay
 - Highest extinction aloft associated with high RH

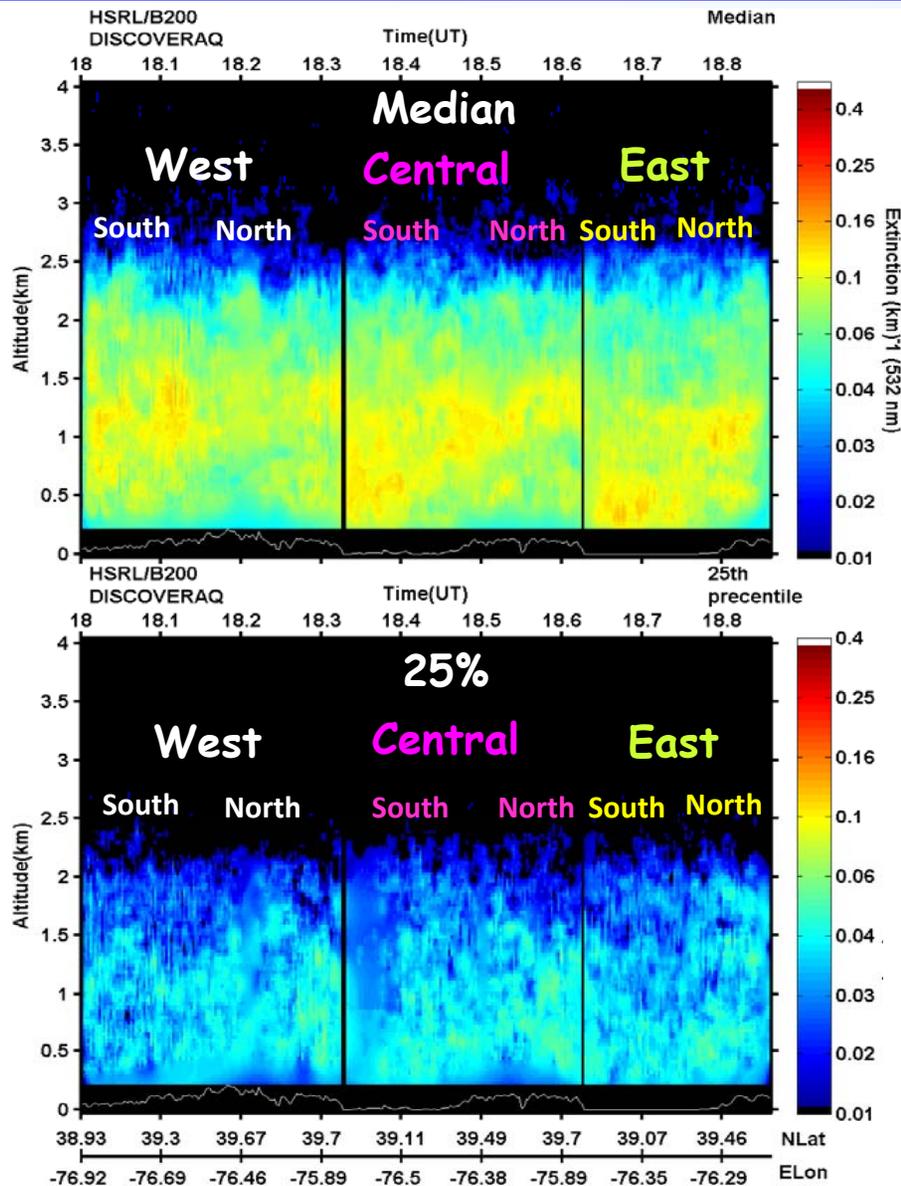
...but not much spatial and vertical variability in average distributions



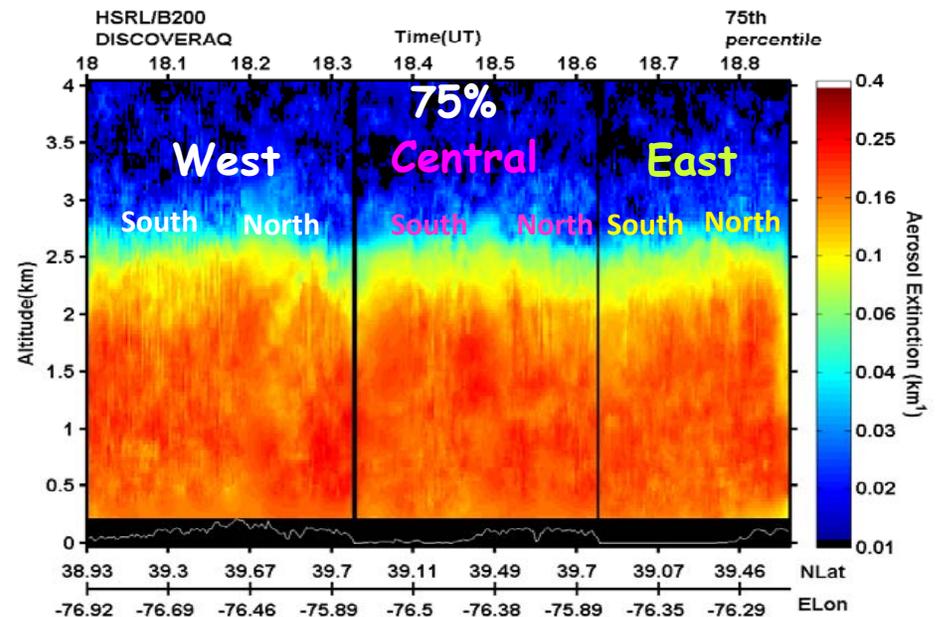
- HSRL data from all flights averaged over 3 legs
- No large systematic changes in extinction profiles or AOD with location
- Lower PBL heights on eastern leg over water



Spatial and Temporal Variability of Aerosol Extinction



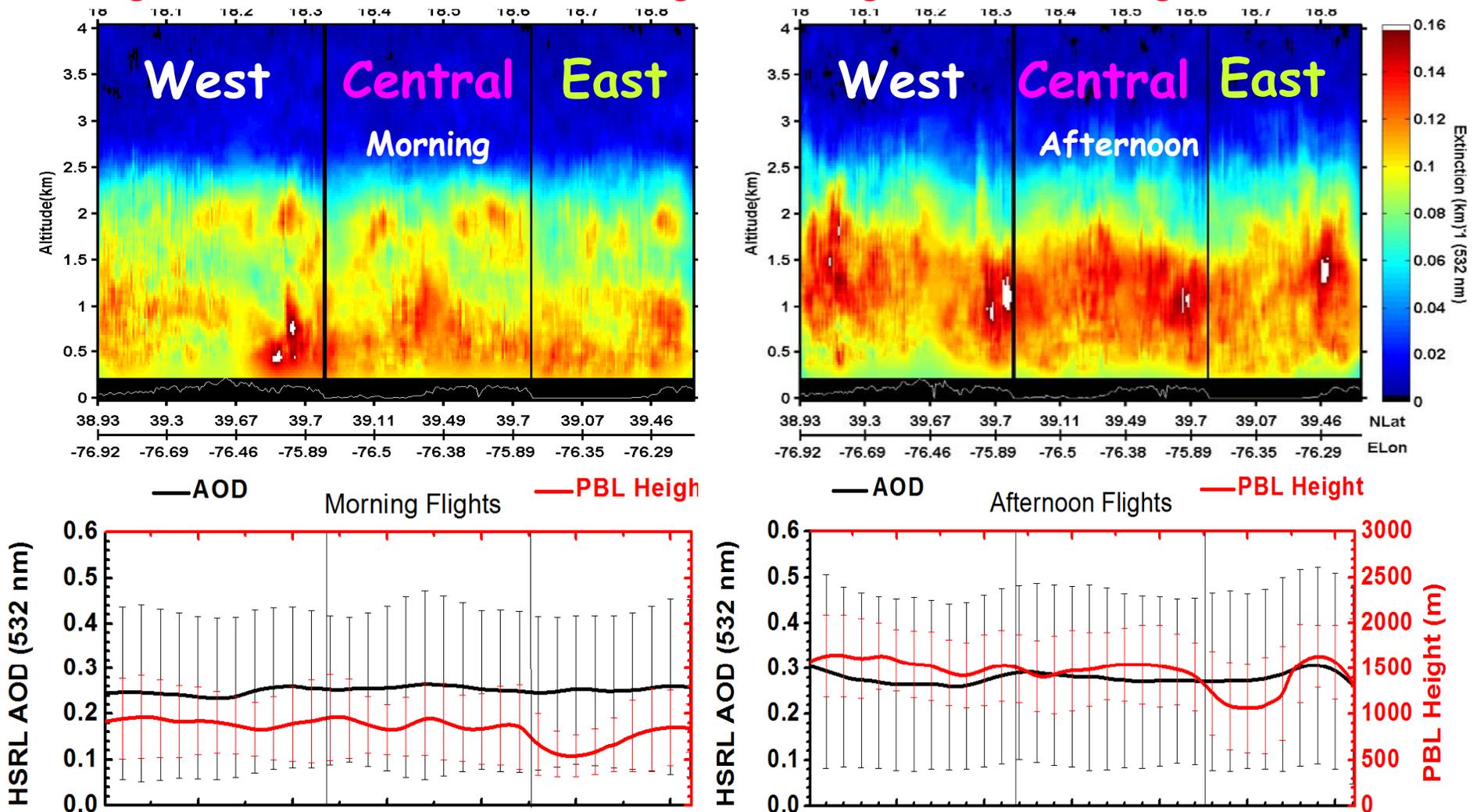
- Median, 25-75% distributions show large day-to-day variability in extinction
- One average, not much variability among legs
- Day-to-Day variability dominates over spatial variability



Average spatial and vertical variability (morning and afternoon)

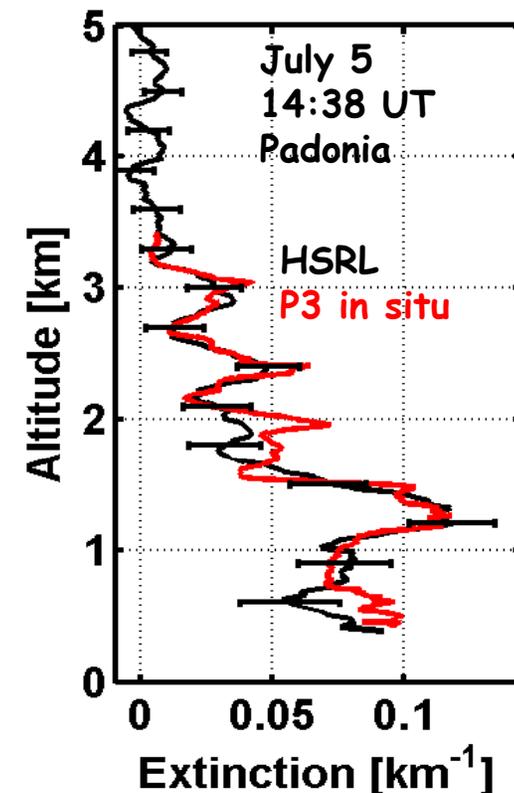
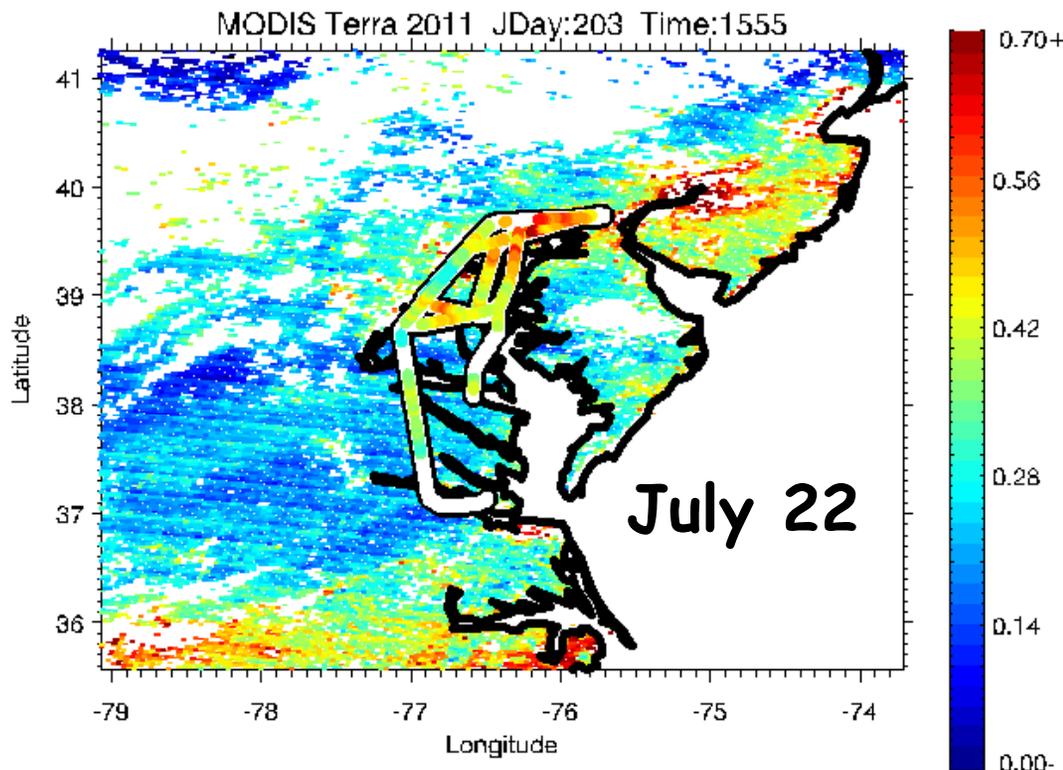


- Max extinction values increase in altitude from morning to afternoon
- Small (<0.05) increase in average AOD from morning to afternoon
- Large (~ 500 m) increase in average PBL height from morning to afternoon



AOD and Aerosol Extinction Comparisons

- HSRL data have been/can be compared with other surface (AERONET, UMBC lidar), airborne (P3 in situ), satellite (MODIS, MISR) sensors
- Comparisons show good agreement with P3 and AERONET measurements
- Details to be presented during Wednesday AM aerosol breakout

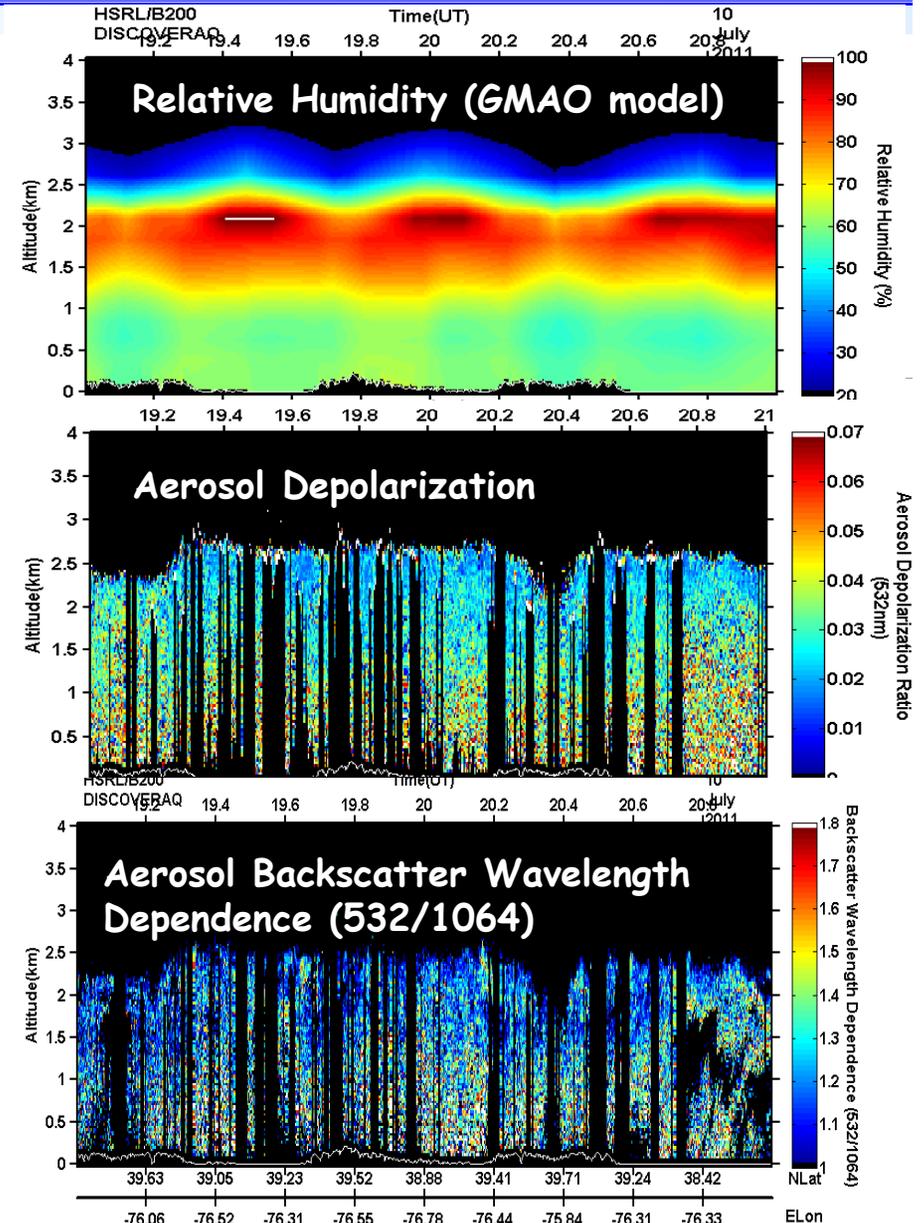
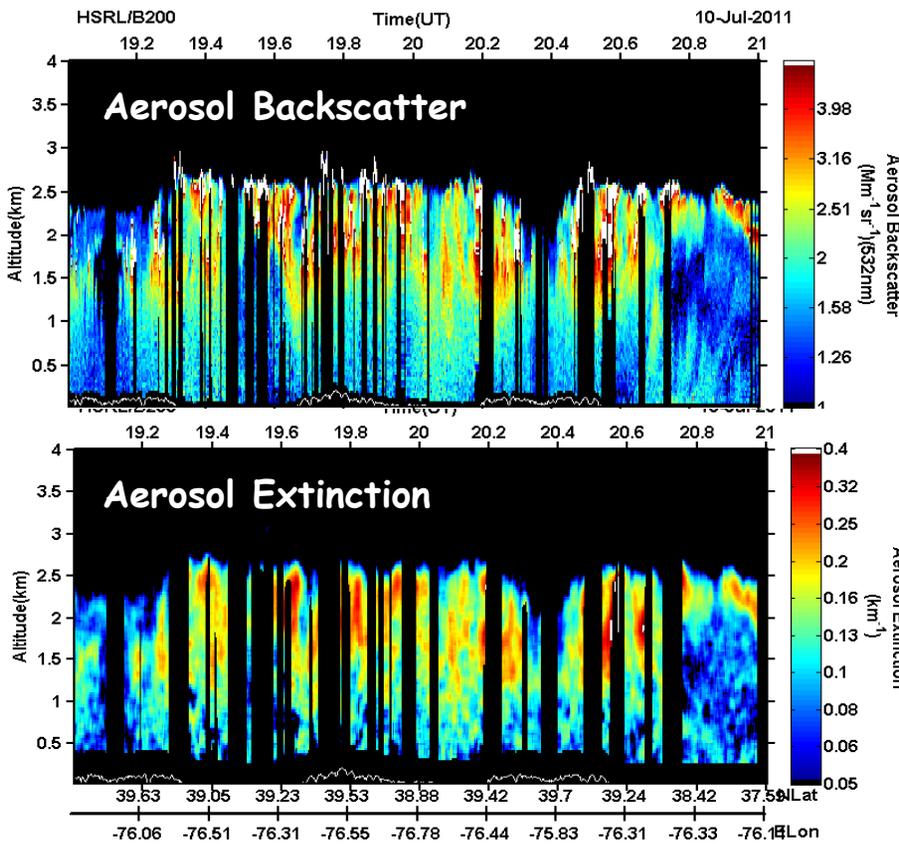


Impacts of High RH on Aerosol Optical Properties

Humidification Effects on Aerosol Properties



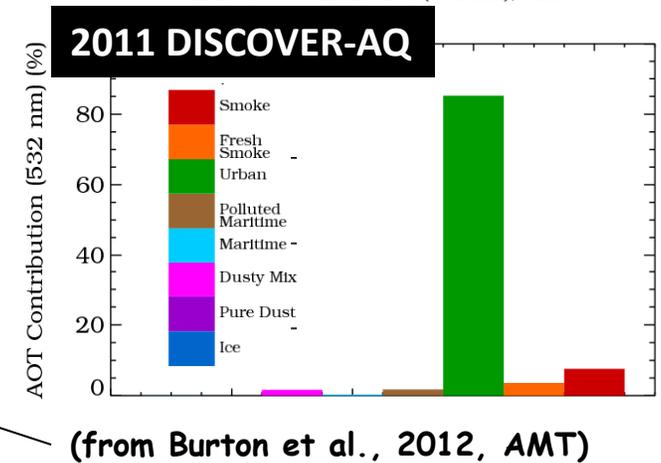
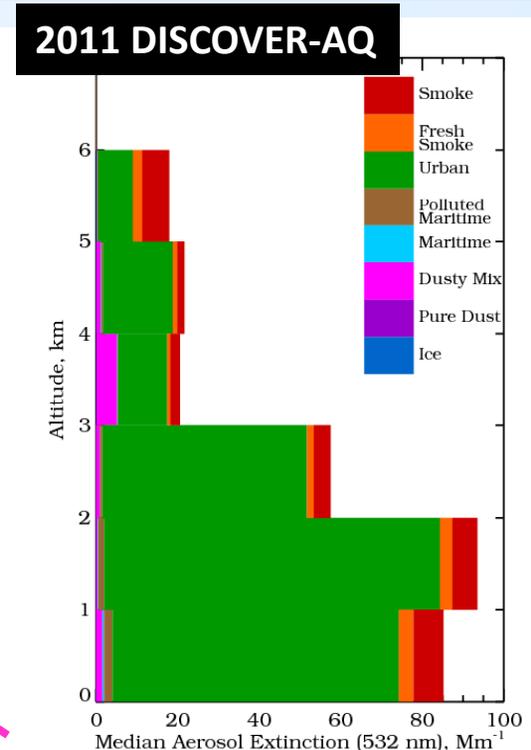
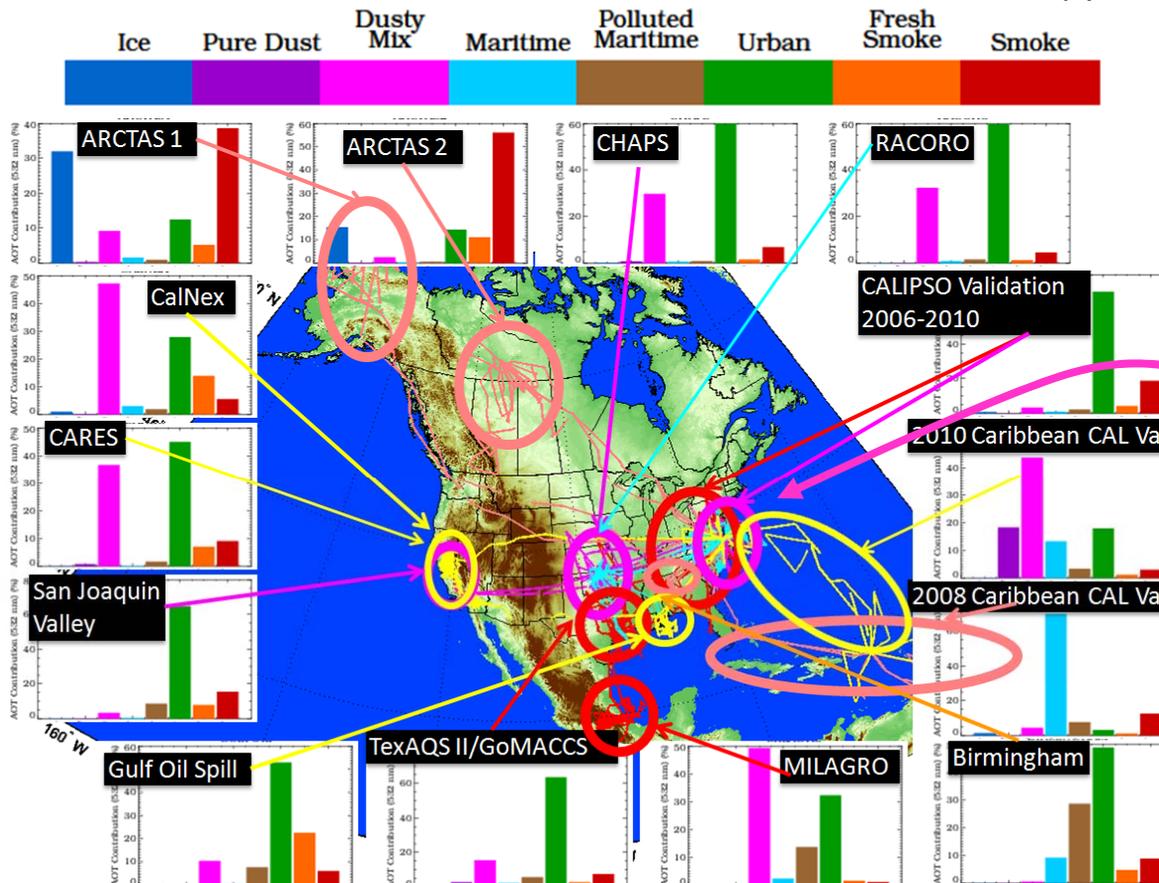
- Change in aerosol extensive (backscatter, extinction) and intensive (depolarization, lidar ratio, wavelength dependence) properties often associated with changes in relative humidity
- A closer look in Wednesday AM session



Aerosol Classification

AOD and aerosol extinction apportioned to aerosol type

- Most (>80%) of AOD during DISCOVER-AQ apportioned to “urban” aerosols similar to other HSRL campaigns that occurred over eastern USA
- Future DAQ campaigns will provide opportunities to evaluate inferences of other aerosol types



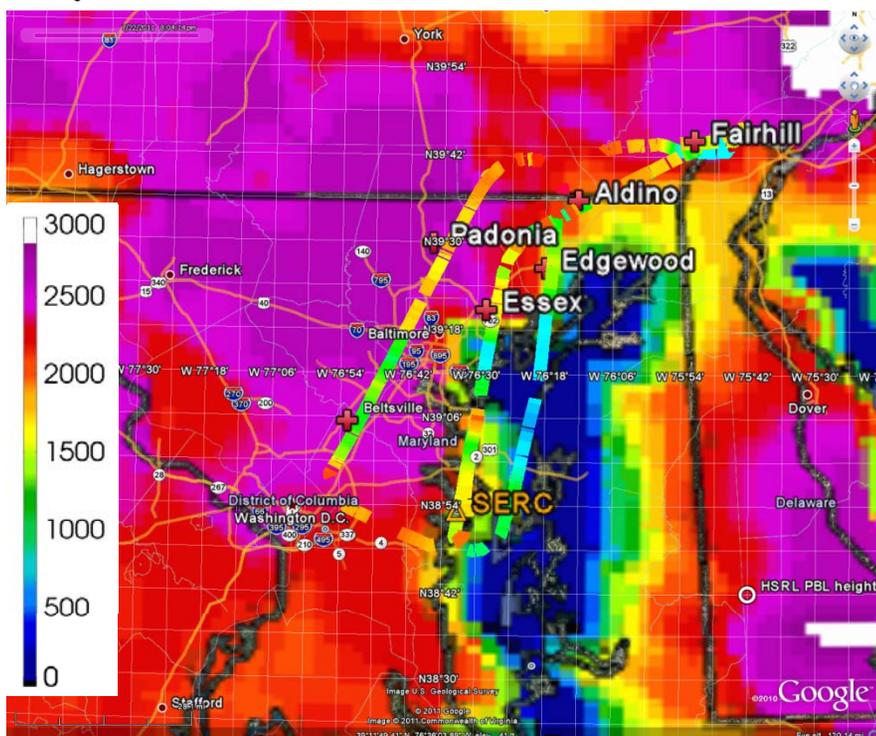
Comparisons of HSRL Measurements and NOAA CMAQ Forecasts

HSRL data used to evaluate NOAA experimental CMAQ simulations

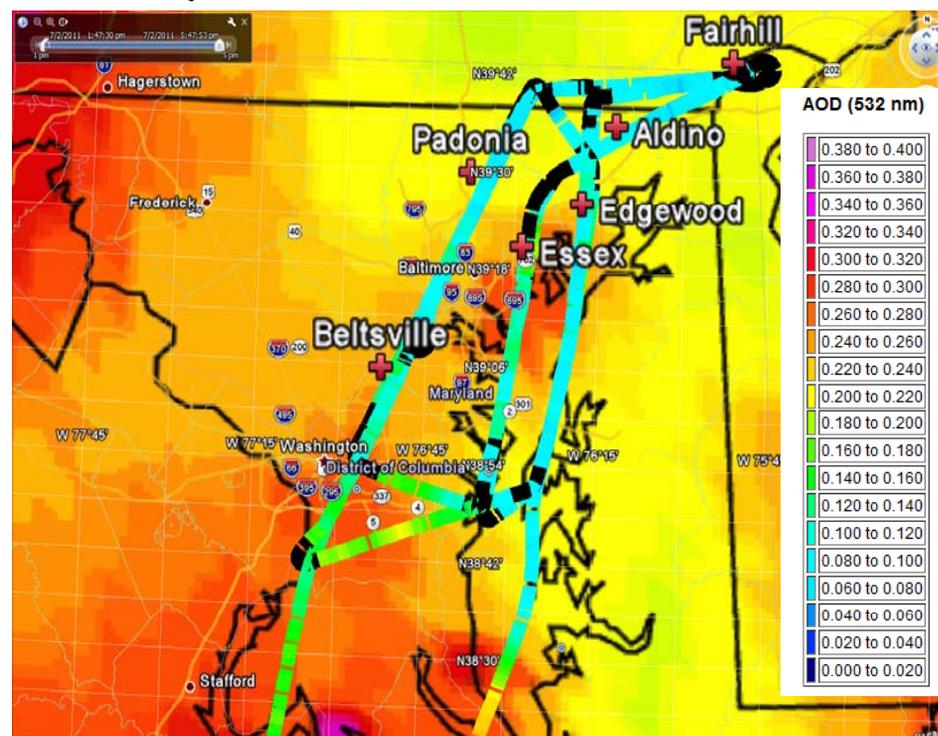


- HSRL data used to evaluate NOAA CMAQ simulations of PBL heights, AOD, and aerosol extinction profiles
- Comparisons reveal some systematic differences in these parameters
- Details of these comparisons presented during Wednesday morning session
- **We are prepared to help evaluate CMAQ and other model simulations**

PBL height (m)
July 22 19 UT (7 hour forecast)



AOD
July 2 16 UT (4 hour forecast)



CMAQ results provided by Pius Lee (NOAA/ARL)

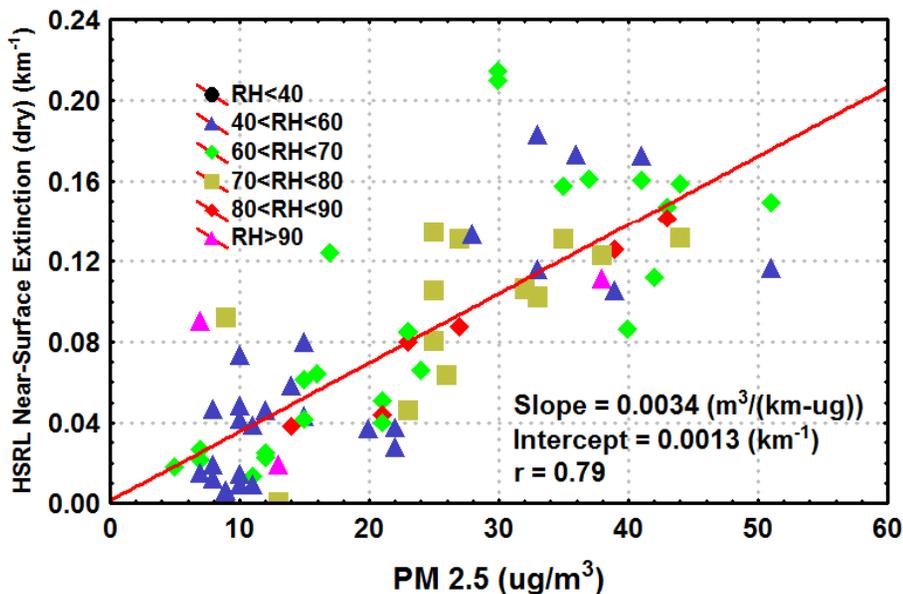
HSRL Measurements and Surface $PM_{2.5}$

HSRL data used to examine relationship between AOT and surface $PM_{2.5}$

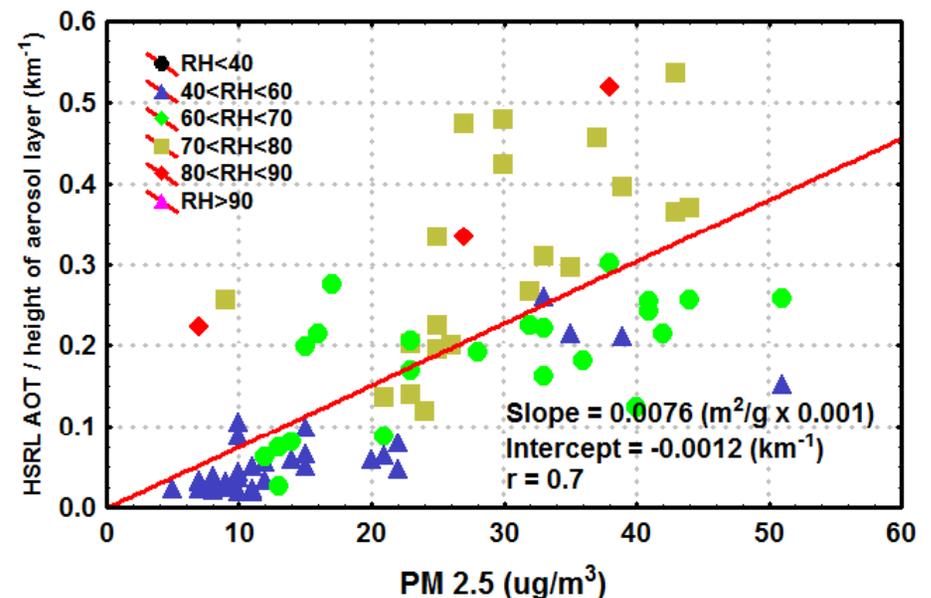


- HSRL measurements of extinction, AOD, and aerosol layer height, and $f(RH)$ derived from airborne P3 in situ measurements were used to examine the ability to estimate surface $PM_{2.5}$
- Examined correlations between the HSRL measurements and hourly surface $PM_{2.5}$ data from four stations (Beltsville, Fairhill, Edgewood, UMBC)
- Details presented in Wednesday AM session

HSRL near-surface extinction (dry) vs. $PM_{2.5}$

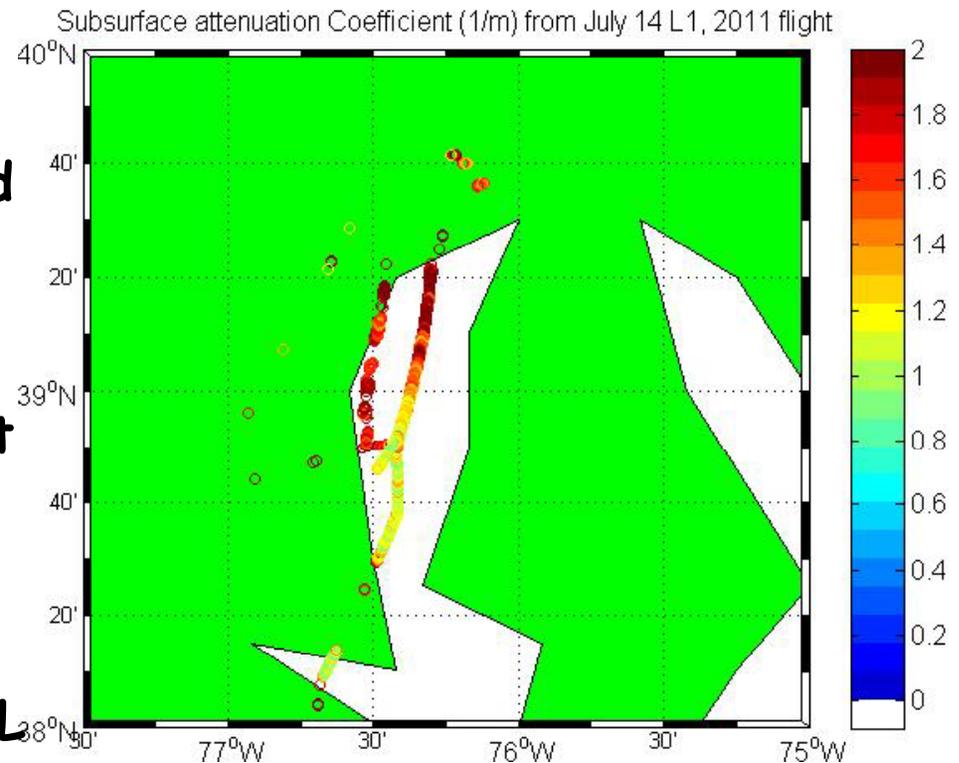


HSRL AOD/Layer height vs. $PM_{2.5}$



Water Attenuation Coefficient Derived from HSRL

- Led by Yong Hu (LaRC)
- Water attenuation coefficient derived from 532 nm Brillouin scattering measurements
- Equivalent to diffuse attenuation at 532 nm; needs to be validated
- Potential use of attenuation coefficient
 - Turbidity estimates
 - Estimate profiles of inherent optical properties (such as particulate backscatter profile)
- **Seek collaborations on validation**
- Yong will provide support on HSRL data analysis
 - Experimental product retrieval from HSRL
 - Theoretical modeling analysis



- HSRL measurements provide vertical context for surface and satellite column aerosol measurements
- HSRL data used to derive PBL height and aerosol layer heights
- Although there were large day-to-day variability in aerosol spatial and vertical distributions, average distributions do not show much spatial variability
- Aerosol hygroscopic growth had significant impacts on aerosol extensive (e.g. backscatter and extinction) and intensive (e.g. lidar ratio, depolarization, color ratio) parameters
- HSRL data used to evaluate model simulations and ability to infer surface $PM_{2.5}$ from column AOD
- More information regarding these and other studies to be presented during Wednesday morning aerosol session