Airborne DIAL/HSRL Characterization of Aerosol Profiles

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SEAC^{4}RS Science Team Meeting
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All data shown here are PRELIMINARY !

Ozone DIAL/HSRL System

Ozone Differential Absorption Lidar (DIAL)

and

Aerosol/Cloud High Spectral Resolution Lidar (HSRL)

NASA DC-8

SEAC^{4}RS Field Mission

<u>Instrument Summary</u>

Simultaneous Nadir & Zenith measurements

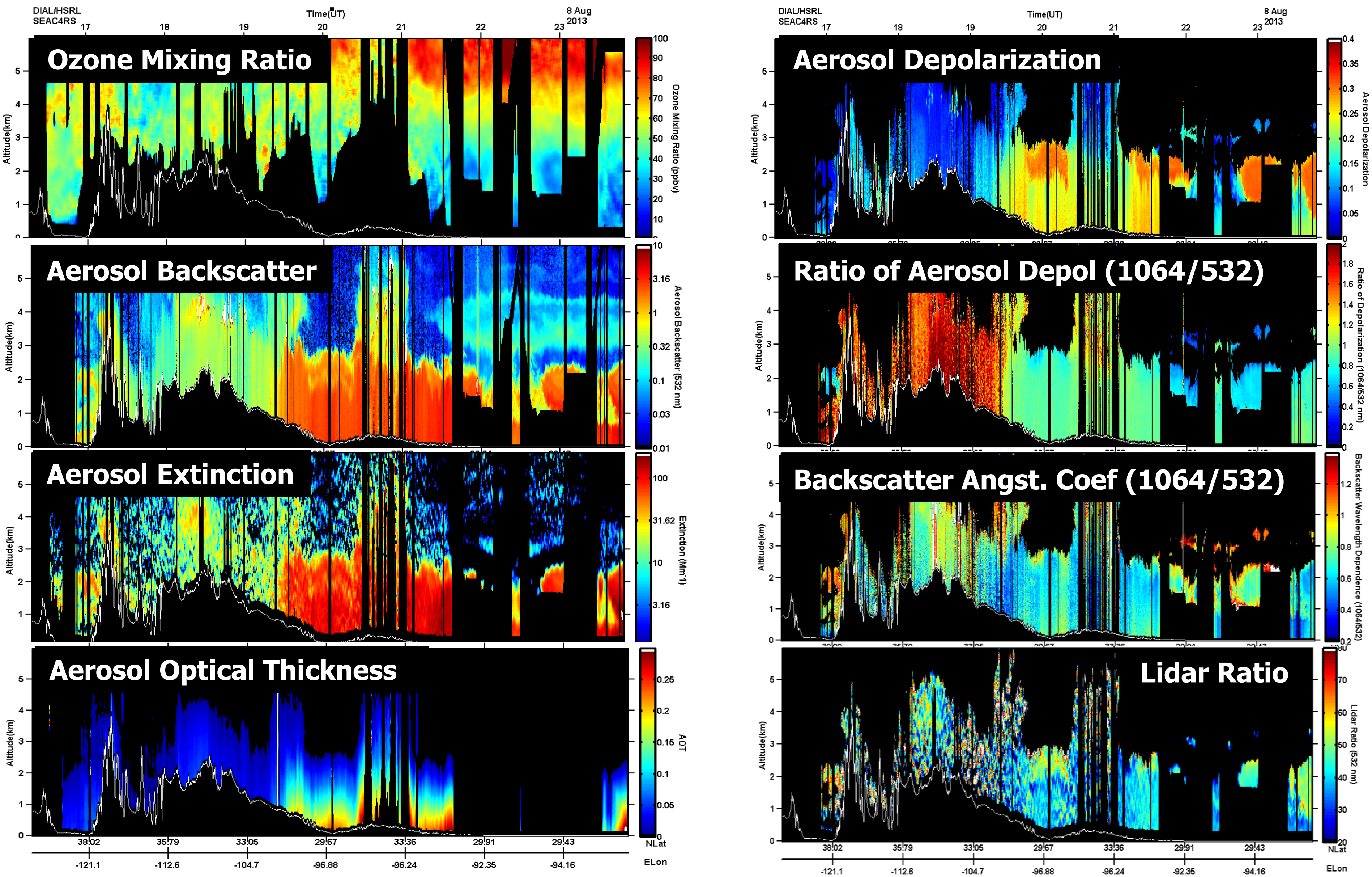
Ozone DIAL – 290 & 300nm
nominal resolutions: 3min, 270m

Aerosol/Cloud 355, 532 (HSRL), 1064 nm
Nominal resolutions:
Extinction: 1min (~12 km), 270m
Backscatter/Depol: 10sec (~2 km), 30m

<u>Profile Measurements in Archive:</u>

Ozone Concentrations (290/300nm)
Aerosol Extinction (532nm)
Layer AOT, AOT at 532nm (from aircraft altitude)
Aerosol/Cloud Backscatter (355*,532,1064nm)
Backscatter Color Ratio (1064/532nm)
Lidar Ratio (extinction/backscatter) (532nm)
Aerosol/Cloud Depolarization (355*,532,1064nm)
Spectral Depolarization Ratio (1064/532nm)
***not part of archive**

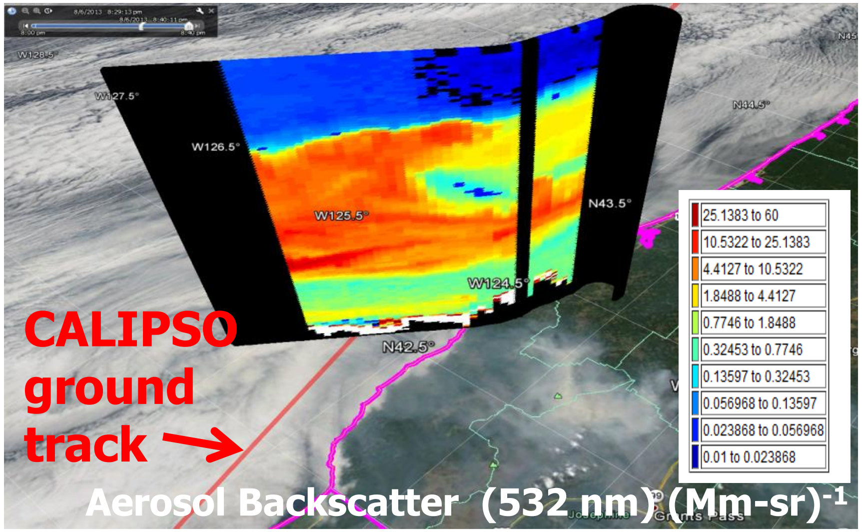
Suite of DIAL/HSRL Measurements (Aug. 8 transit flight)

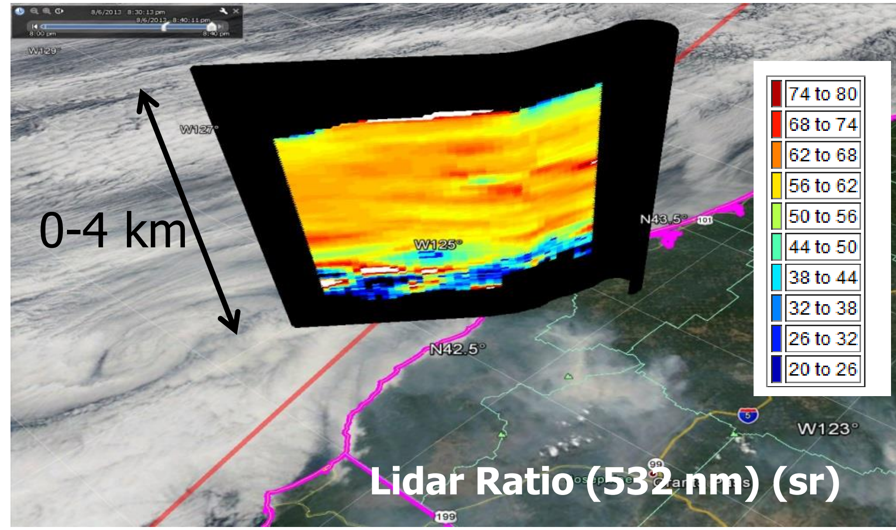


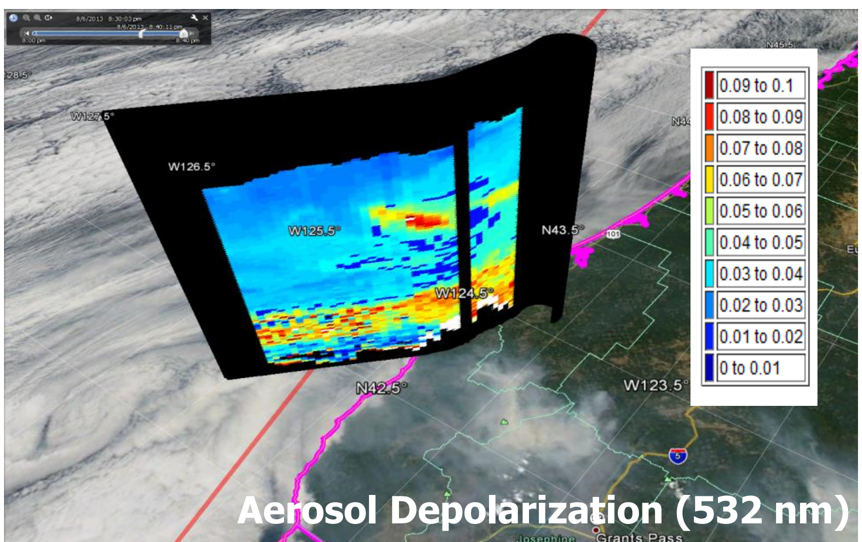
DIAL/HSRL Data used for Satellite Analyses

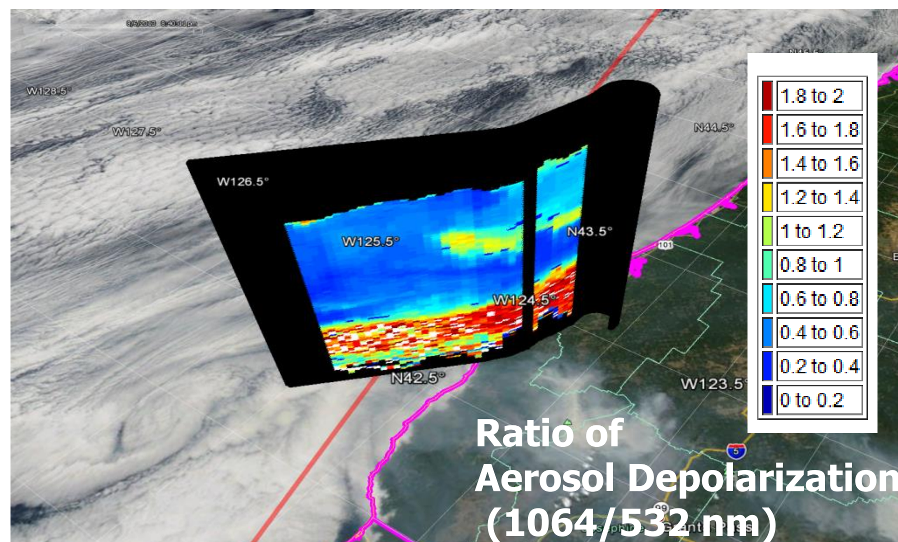
Aug. 6 - Smoke over Stratus

- Elevated smoke layers display variability in aerosol depolarization
- Smoke lidar ratio 55-65 sr



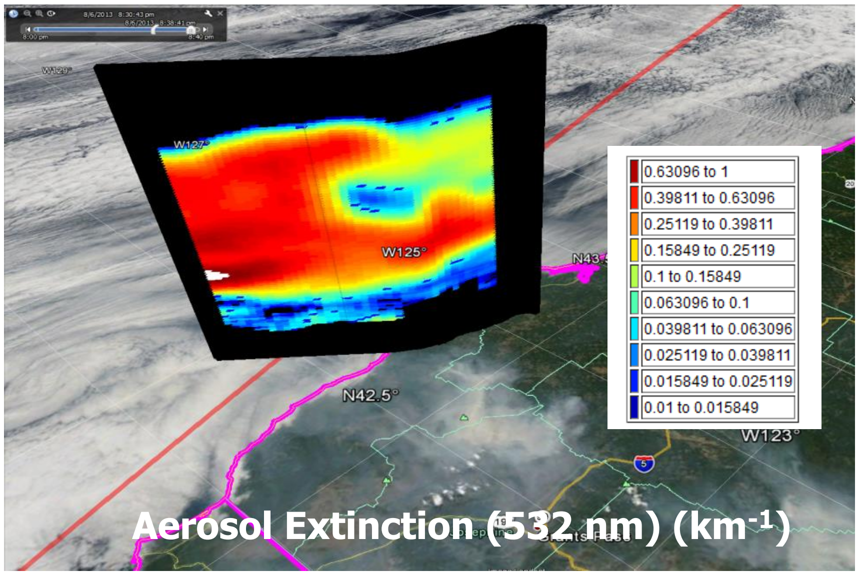


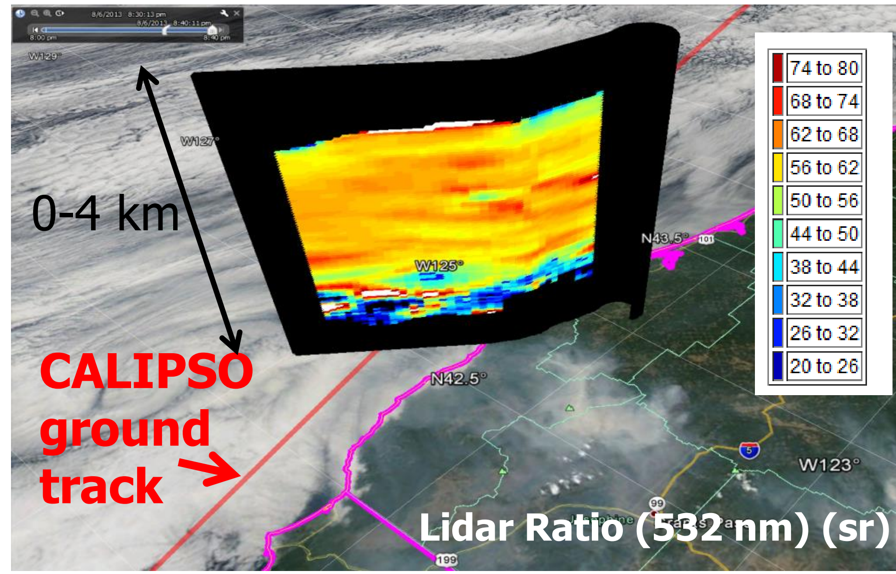


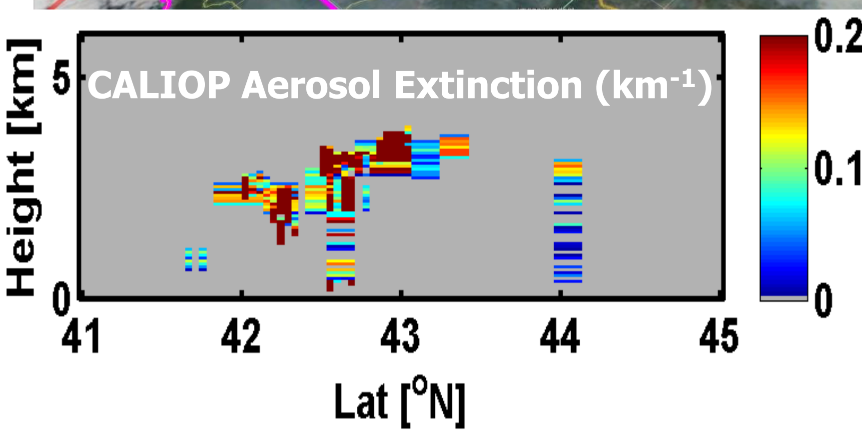


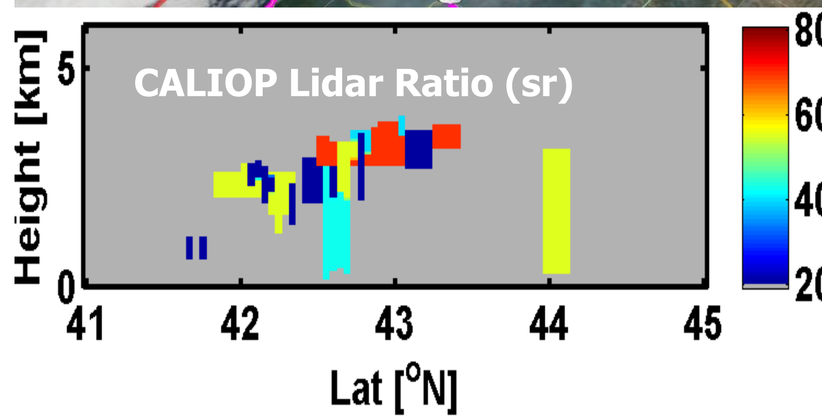
Aug. 6 – DIAL/HSRL And CALIOP Measurements of Smoke over Stratus

- CALIOP retrievals of aerosol extinction are highly variable…likely due to large variability in derived aerosol type and assigned lidar ratio
- DIAL/HSRL measurements of lidar ratio show less variability (55-65 sr)

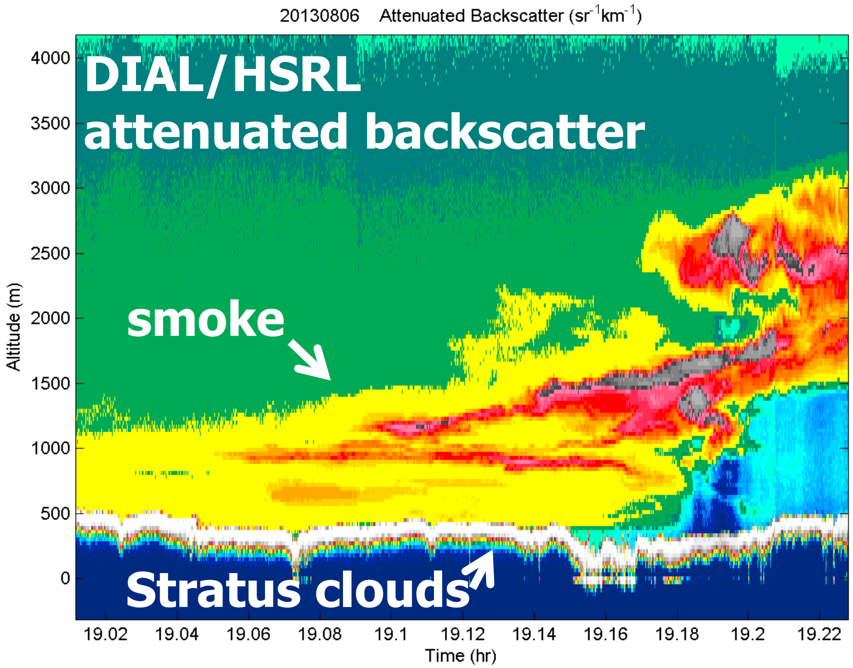


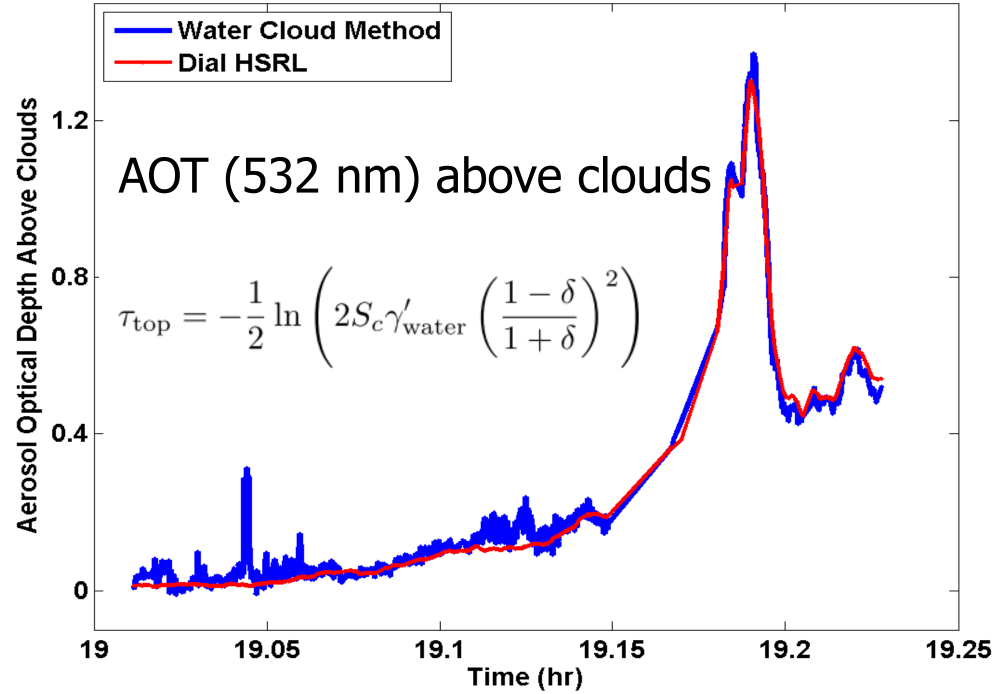






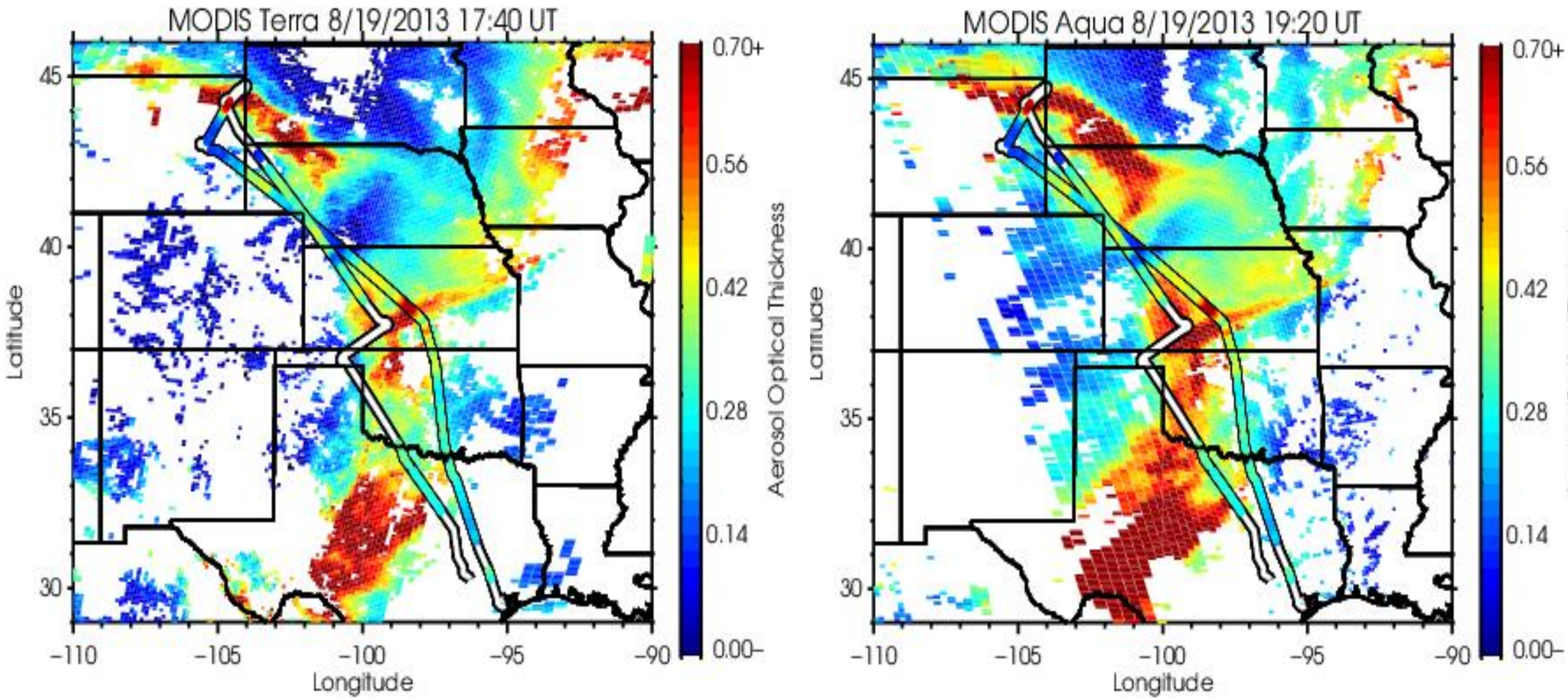
Evaluation of Alternative Method to Retrieve Above Cloud Aerosol Optical Thickness





- Opaque water clouds are detected in about one-third of global CALIOP data
- Advanced technique (Hu et al., 2007; Chand et al., 2008, Jethva et al., 2014) to retrieve above cloud AOT from CALIOP data is evaluated using DIAL/HSRL data
  - Layer-integrated attenuated backscatter provides measure of transmittance
  - Depolarization measurements provide a measure of the cloud multiple scattering
- DIAL/HSRL data from SEAC4RS provides
  - Attenuated backscatter data similar to CALIOP
  - Evaluation of alternative retrieval method using HSRL extinction profile

DIAL/HSRL and MODIS Aerosol Optical Thickness: 19 August 2013

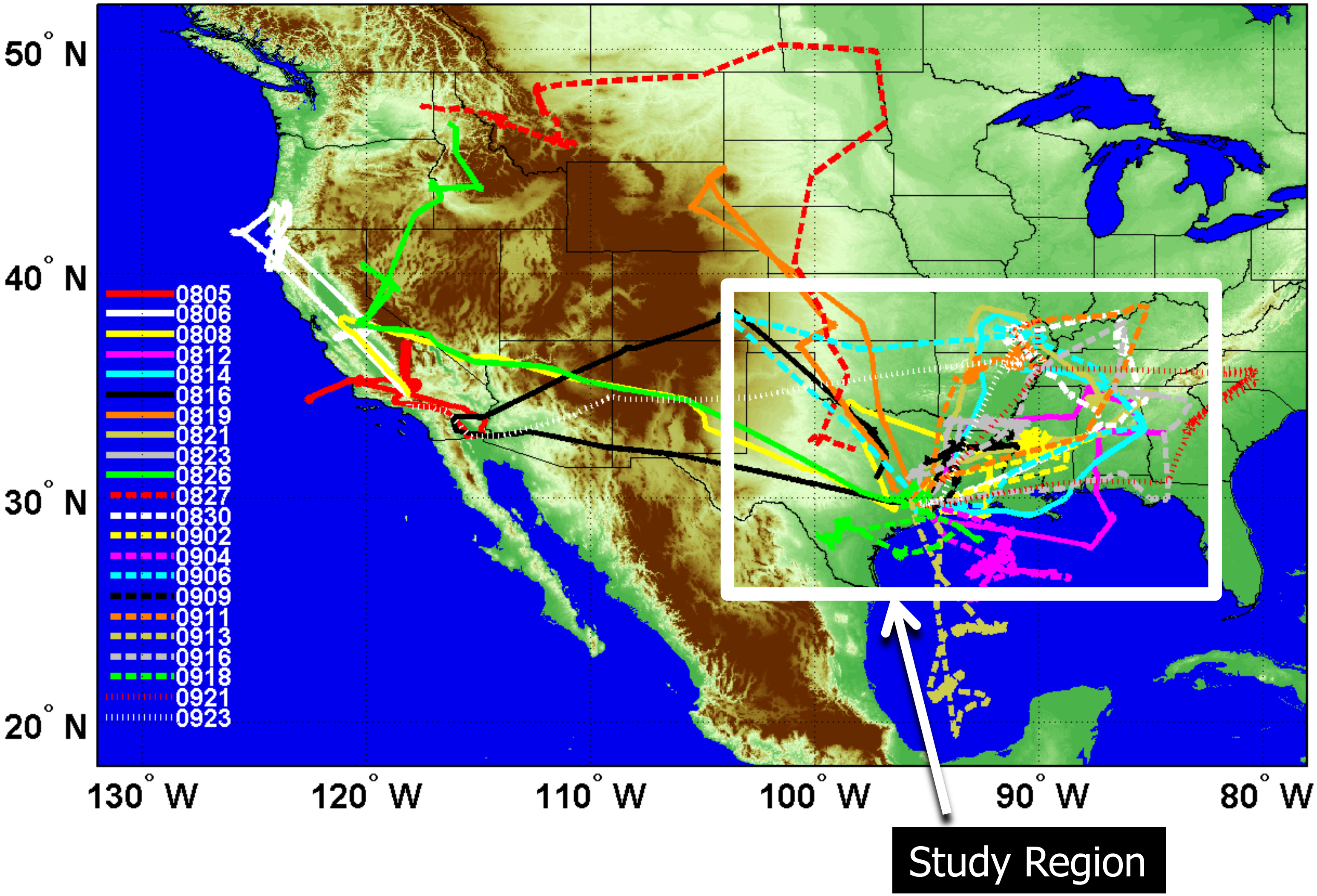


DIAL/HSRL Measurements between 15-23 UT

- DIAL/HSRL Measurements acquired when DC-8 flew at or above 5 km are used to derive AOT
- These AOT measurements can be used to evaluate satellite retrievals of AOT

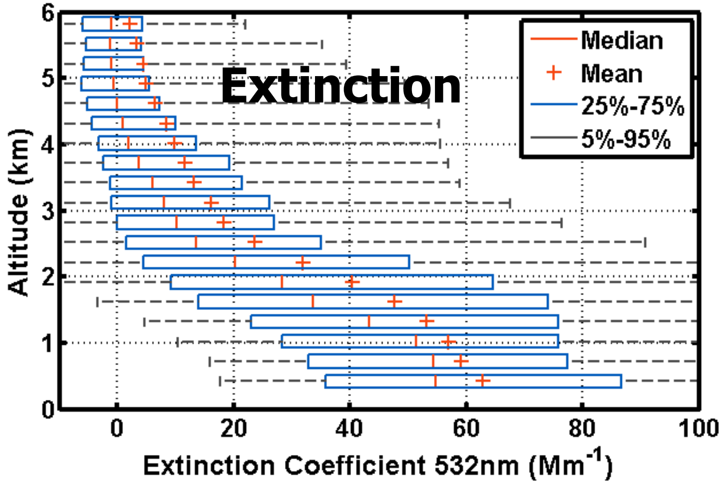
Aerosol Horizontal and Vertical Variability

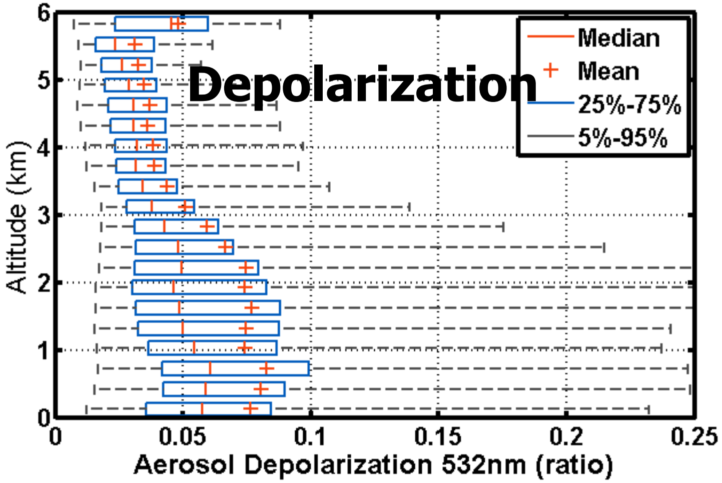
DC-8 Flight Track Map

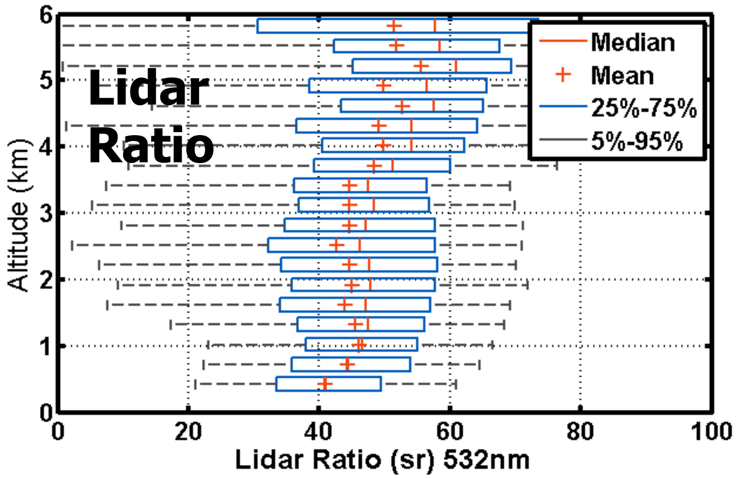


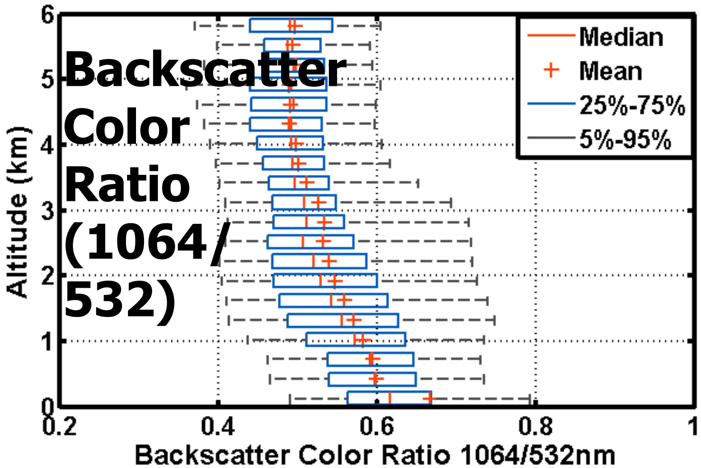
Mean and Median Aerosol Profiles

- Lidar intensive parameters suggest
  - Smaller, somewhat more spherical, particles aloft (e.g. smoke)
  - Larger, somewhat more nonspherical particles closer to surface (e.g. dust)

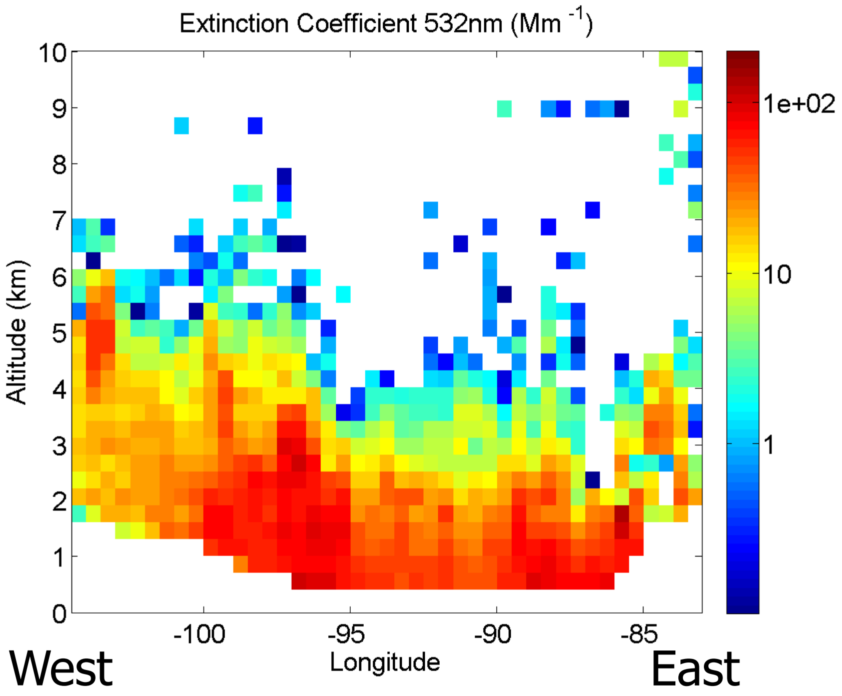








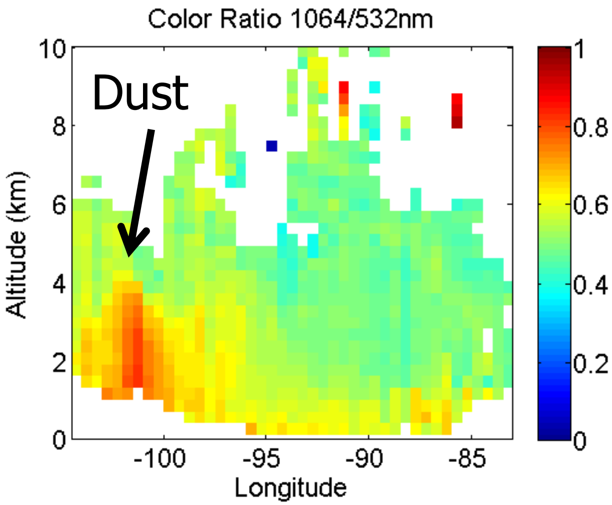
Longitude Distributions of Aerosol Optical Properties (Median)

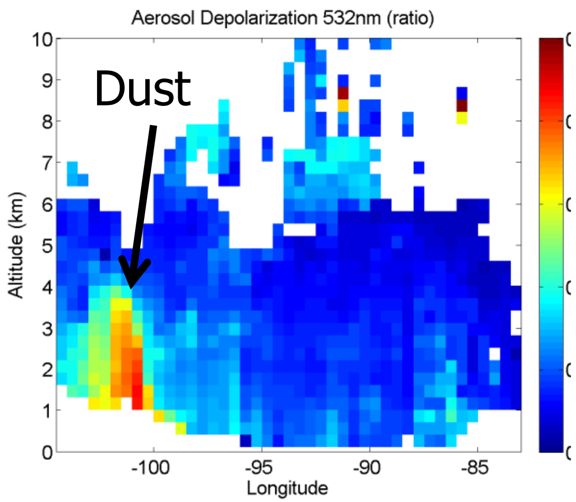


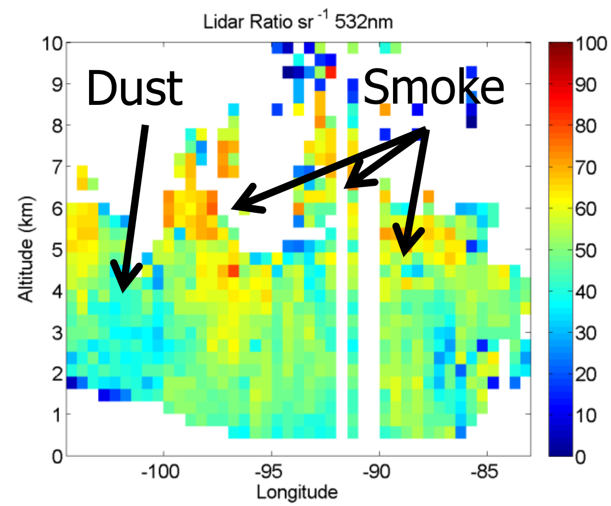
Lidar intensive products highlight various aerosol types in composited longitudinal profiles (e.g.)

- Dust observed at lower altitudes over western Texas
- Smoke observed in mid-troposphere

- For more details, see John Hair's poster

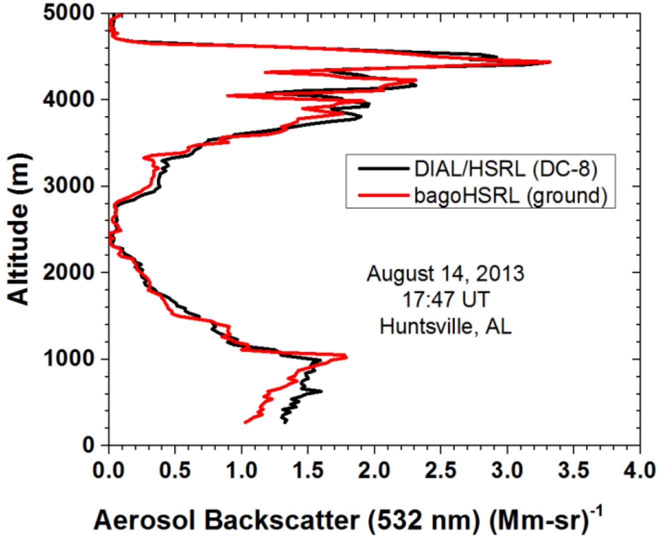


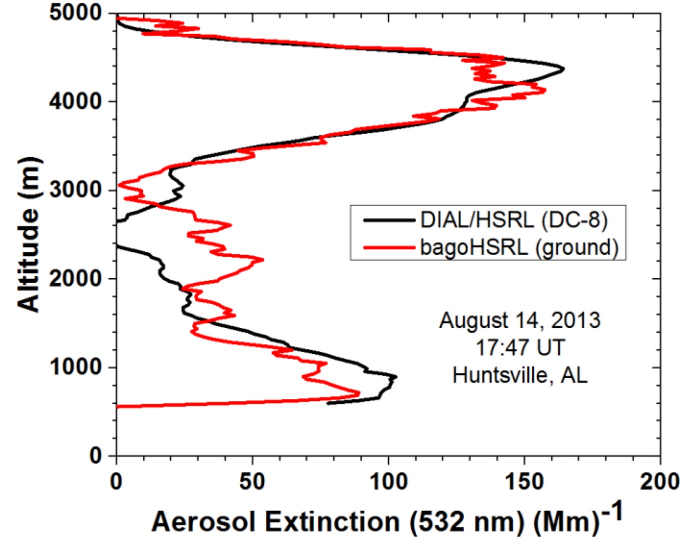


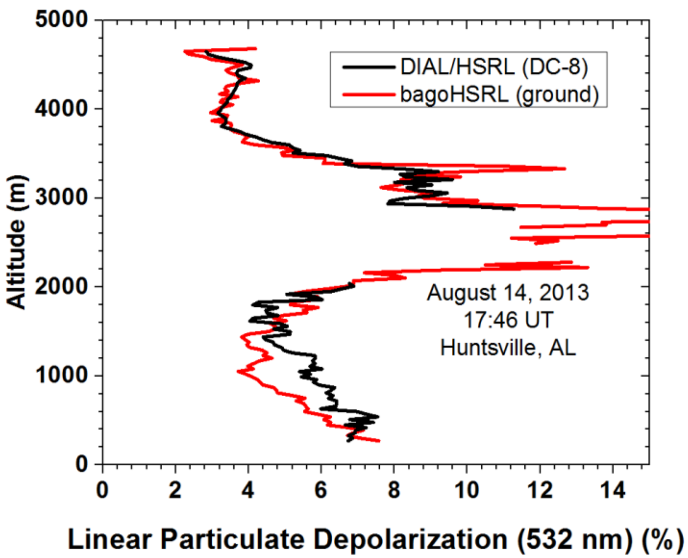


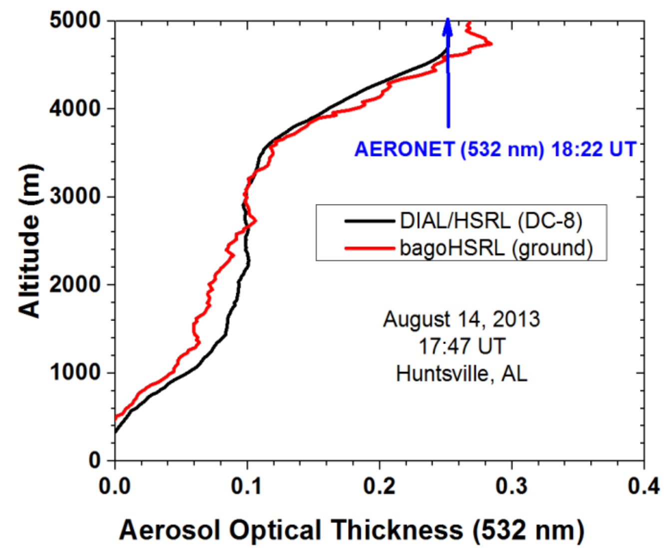
Aerosol Intercomparisons

DC-8 (DIAL/HSRL) and Ground (bagoHSRL) Comparisons over Huntsville (Aug. 14)





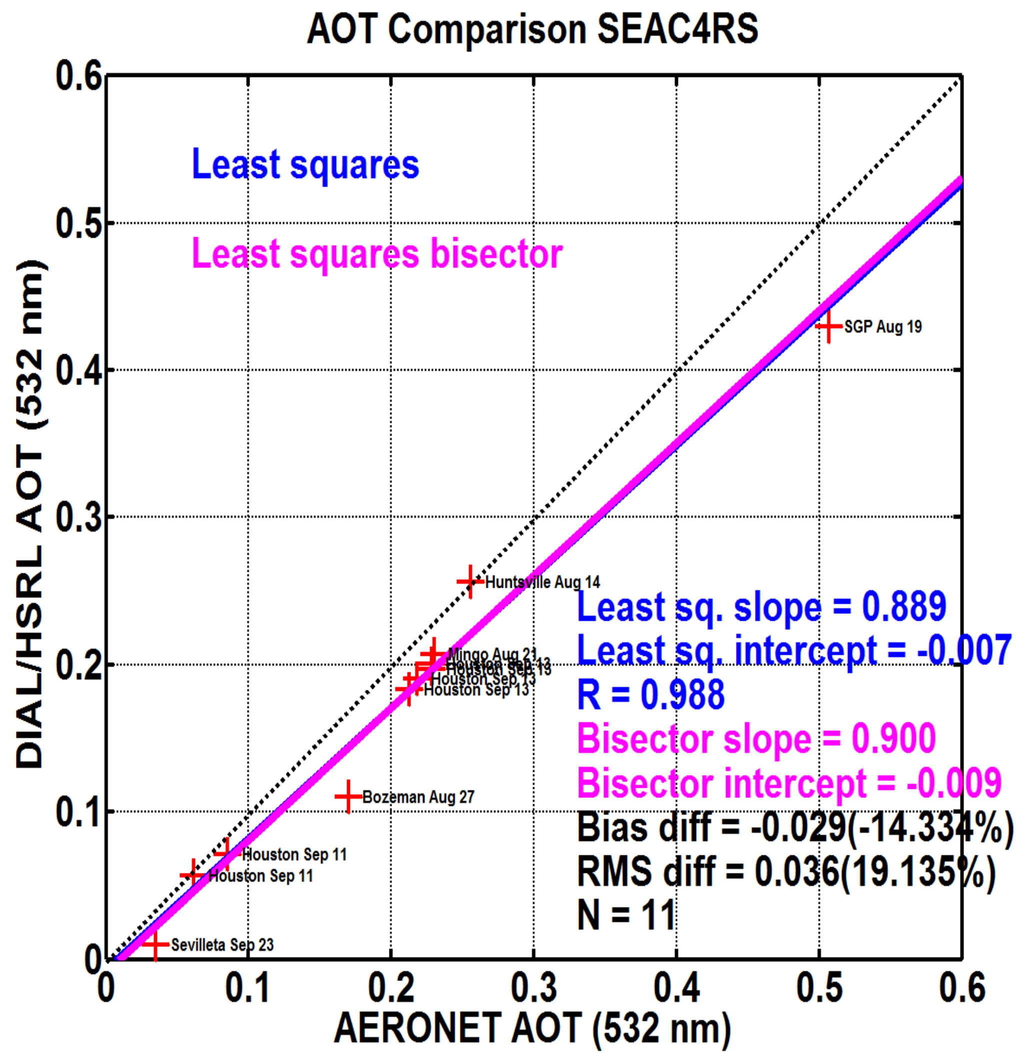




bagoHSRL data – thanks to Ed Eloranta

DIAL/HSRL AOT comparison with AERONET

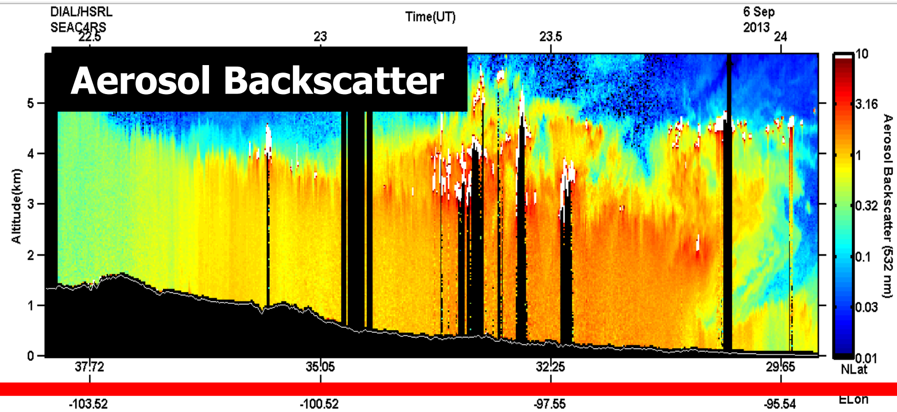
- AOT derived from DIAL/HSRL nadir data when DC-8 flew at or above 5 km
- AOT compared with AERONET level 1.5 AOT
- DIAL/HSRL AOT slightly lower than AERONET, possibly due to AOT not included above (> 5 km) or below (<150 m) profile



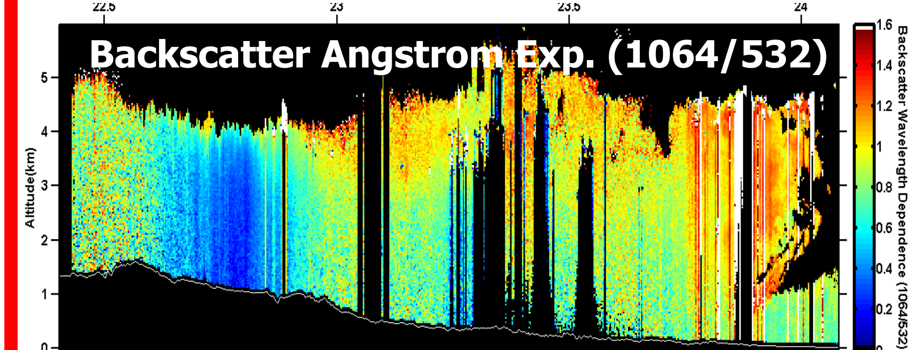
AERONET data – thanks to Brent Holben, Rick Wagener, Joe Shaw, Kevin Repasky, Kevin Knupp, Doug Moore

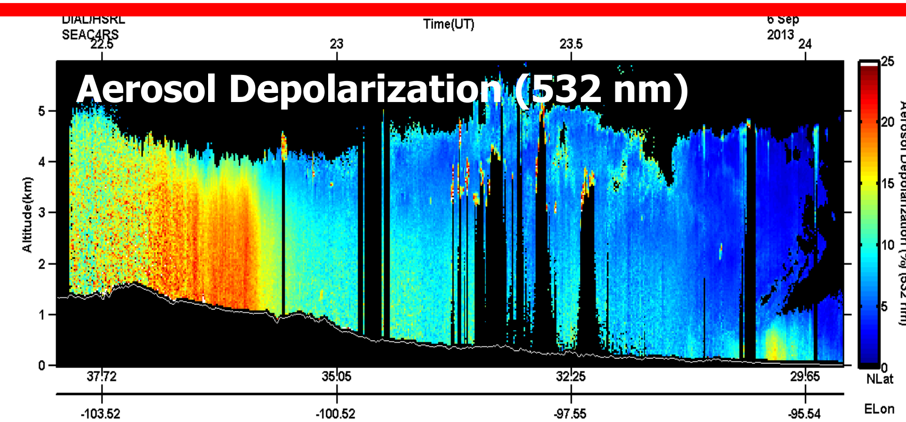
Aerosol Classification

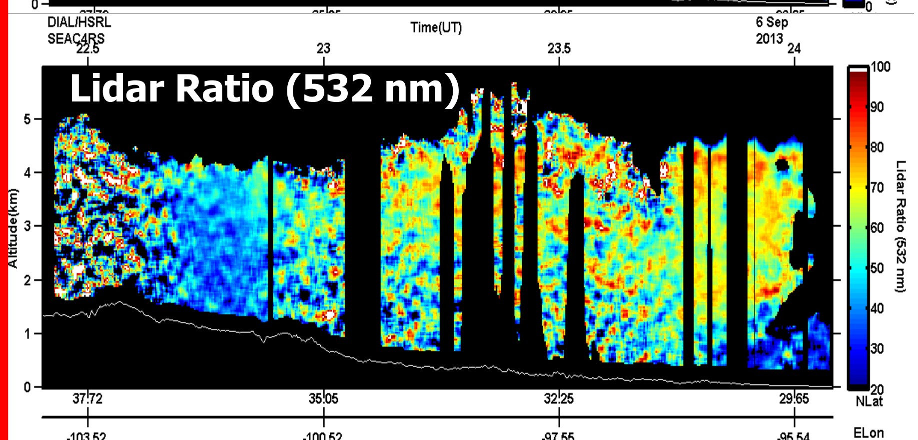
Variation in Aerosol Optical Properties (Sep. 6) Colorado to Houston

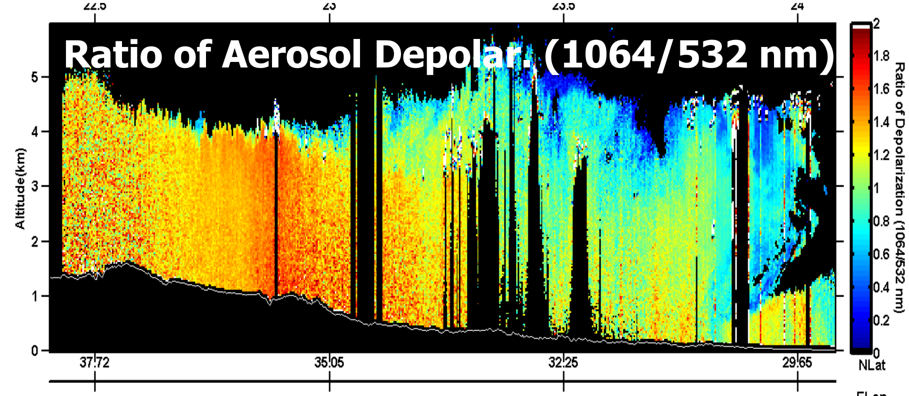


- Final Portion of flight from SE Colorado to Houston
- Aerosol intensive parameters are used to classify aerosol type as described by Burton et al. (2012, 2013)



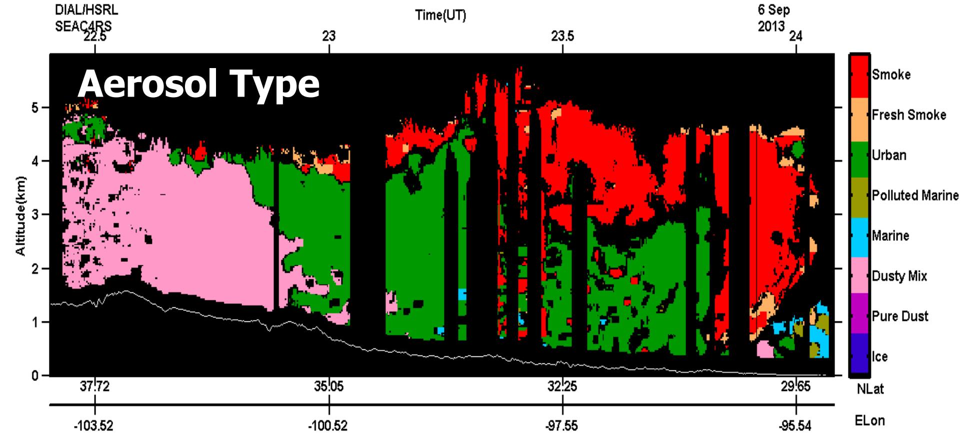


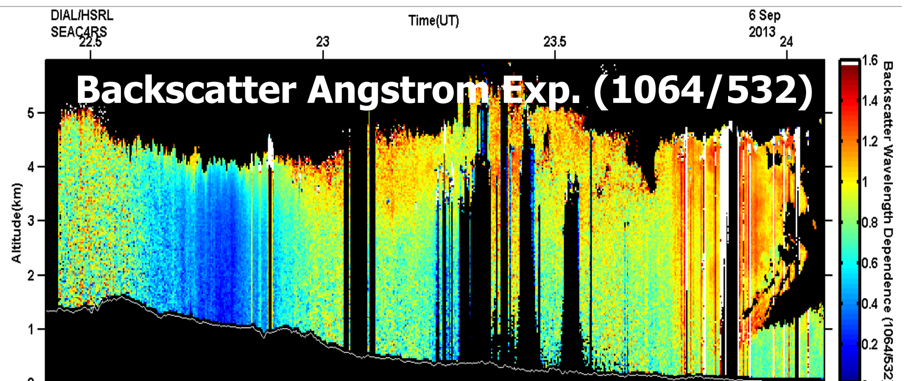


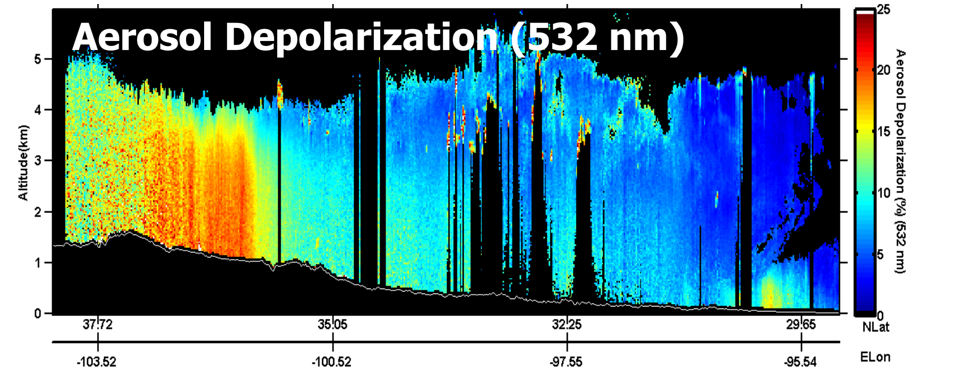


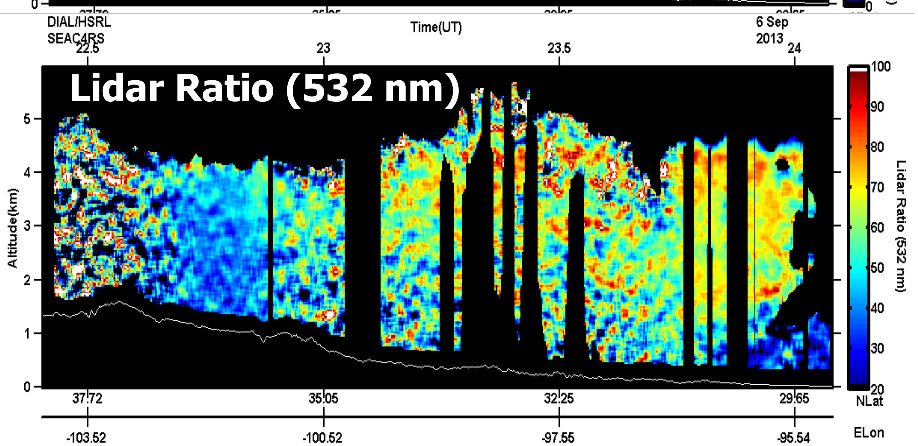
Aerosol Classification (Sep. 6) Colorado to Houston

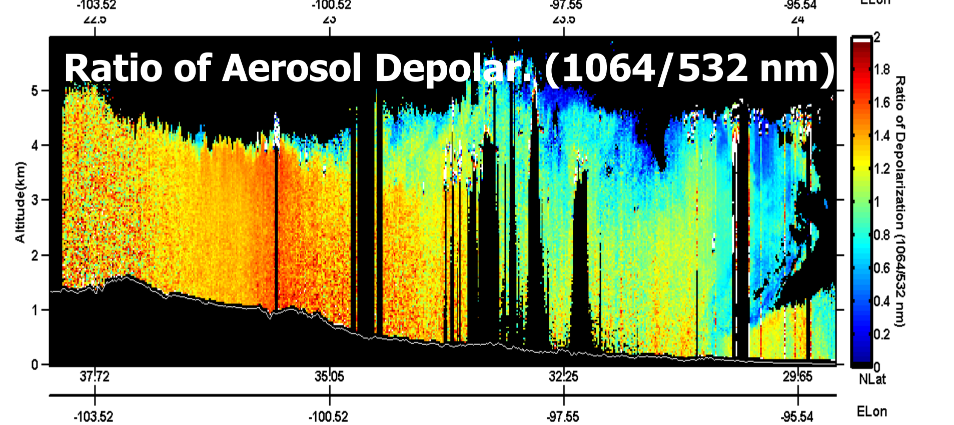
Transition from dusty mix to mixture of urban and smoke near Houston





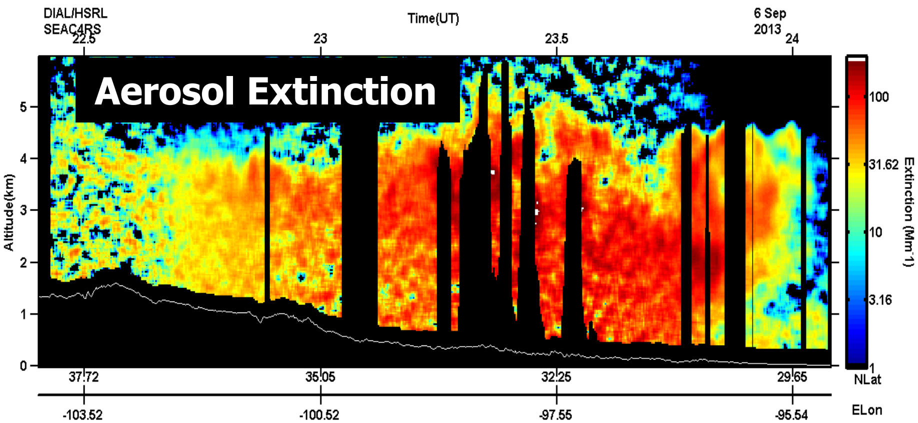


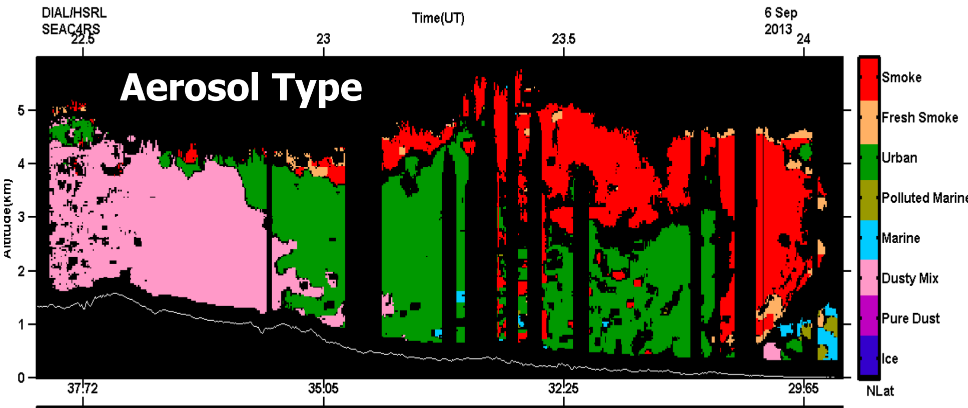


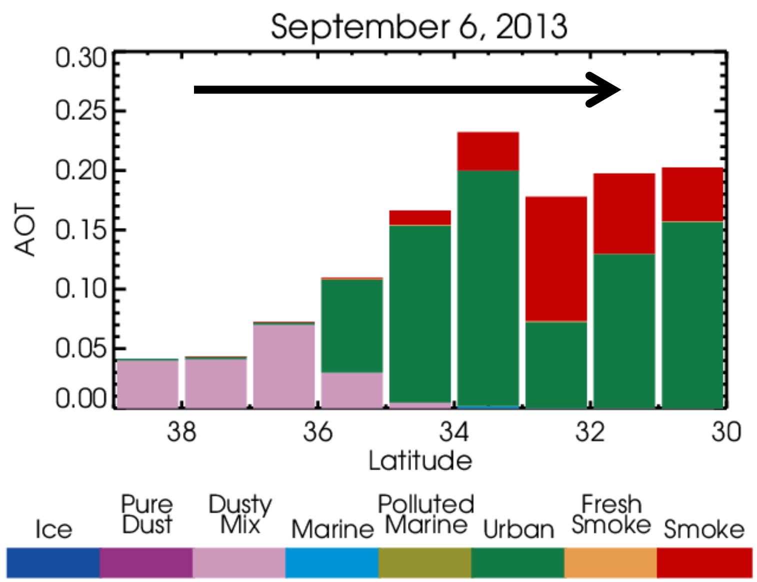


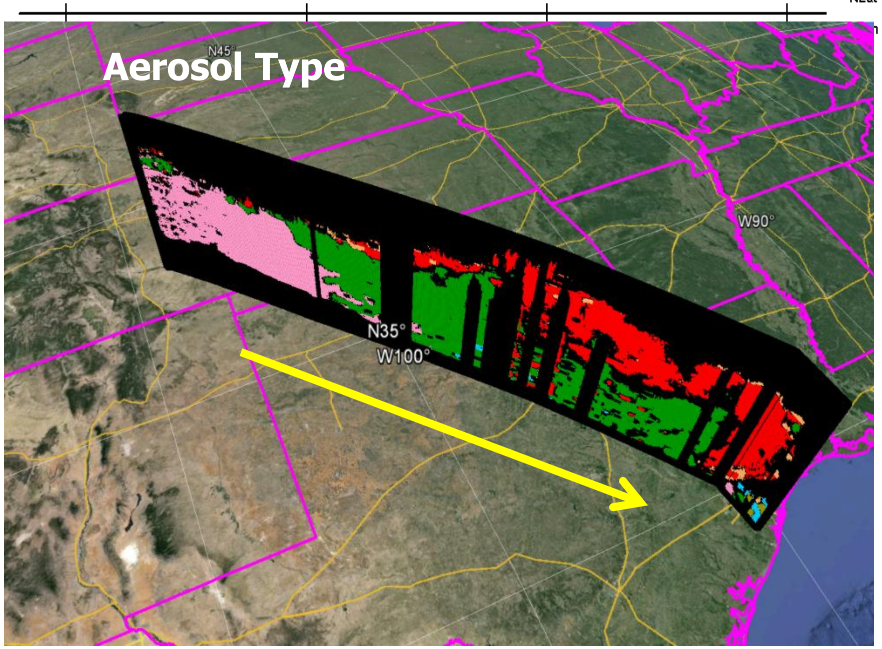
AOT Apportionment to Aerosol Type (Sep. 6) Colorado to Houston

- DIAL/HSRL were used to apportion AOT to aerosol type
- Low AOT over SE Colorado comprised entirely of dusty mix
- Higher AOT over SE Texas comprised of combination of urban and smoke



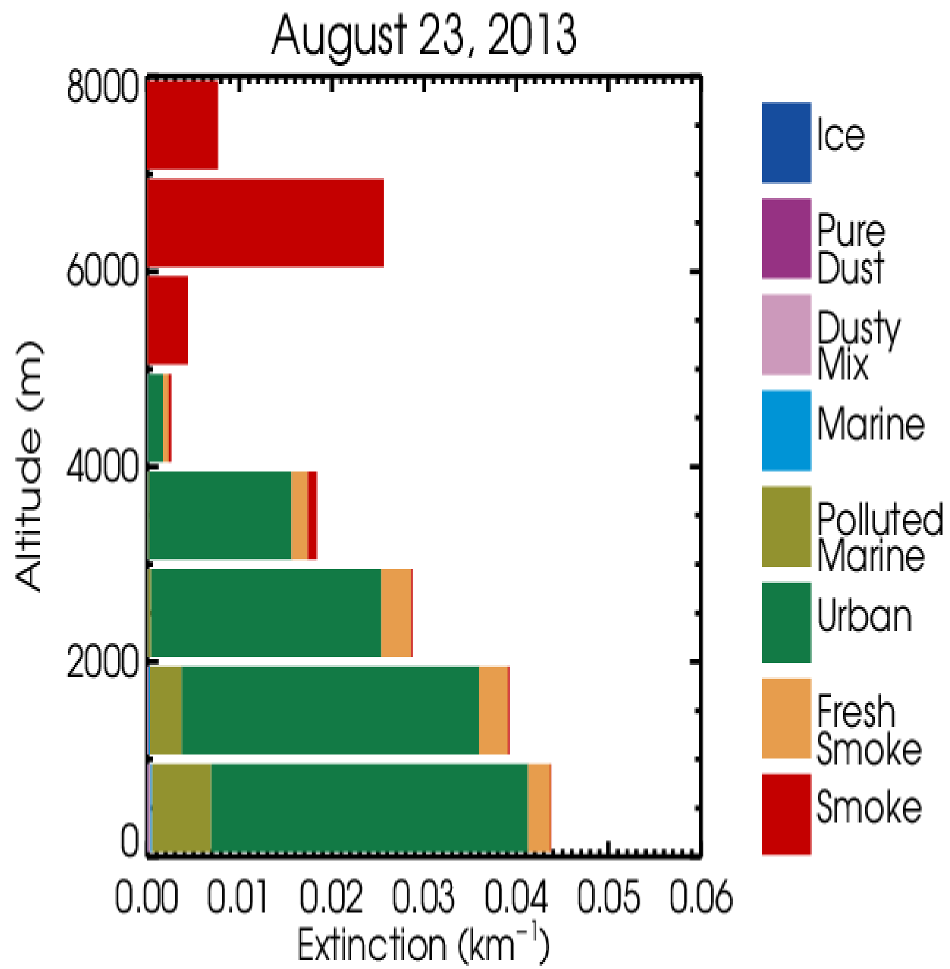






Vertical Profile of Extinction Apportionment to Aerosol Type

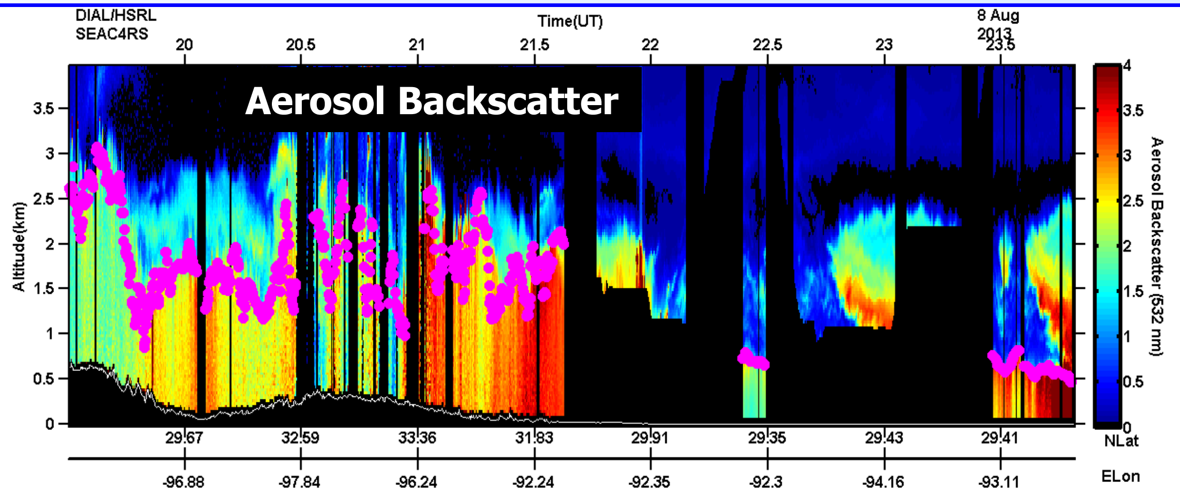
- DIAL/HSRL measurements can be used to apportion profiles of aerosol extinction to aerosol type
- LaRC airborne HSRL measurements have shown that it is not uncommon to see multiple aerosol types accounting for significant fractions of aerosol extinction and AOT in a vertical profile
- Such variability complicates interpretation of column average aerosol retrievals obtained by surface and satellite passive remote sensors

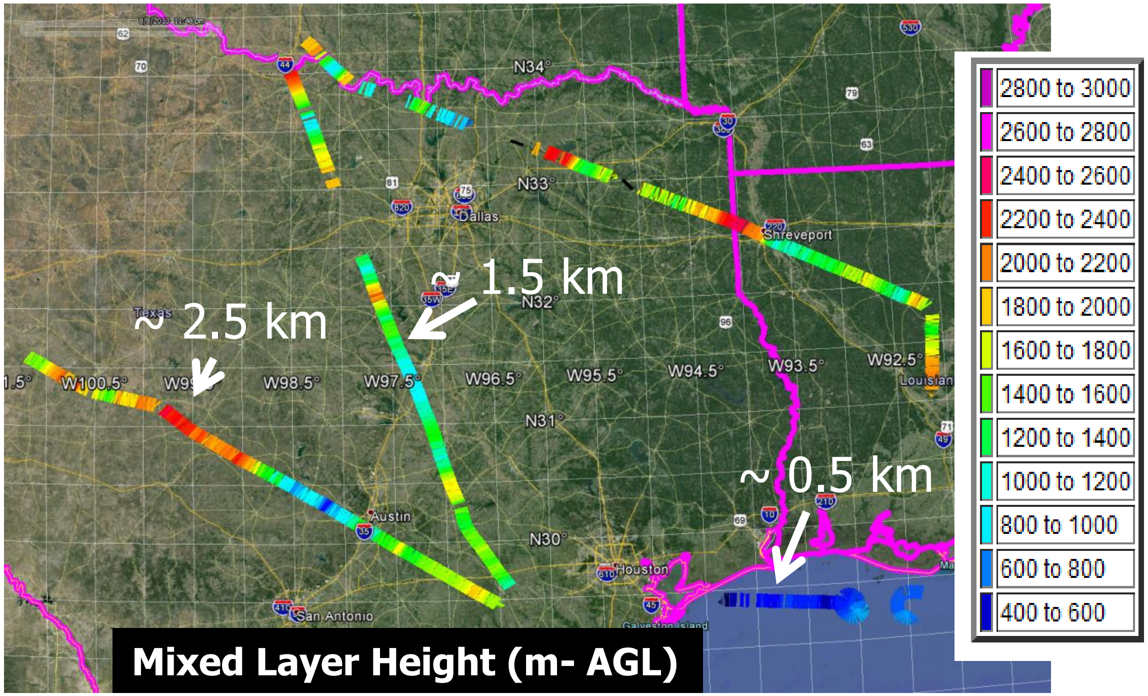


Mixed Layer Heights

Mixed Layer Height Retrieval (Aug. 8 transit)

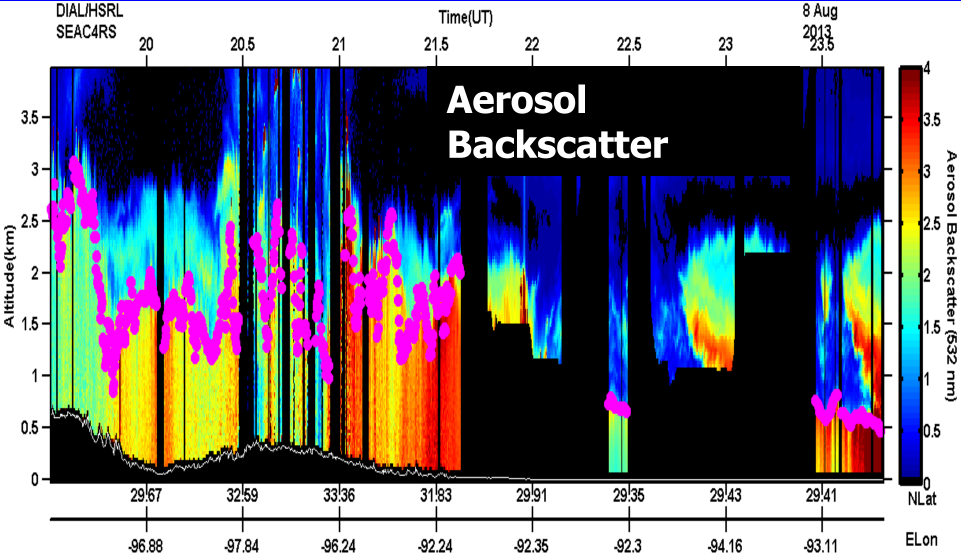
- Mixed Layer heights computed from aerosol backscatter profiles show variability in ML height
- In this example from Aug. 8 transit flight, ML heights range from 1-2.5 km over land, decrease to 500-800 m over Gulf

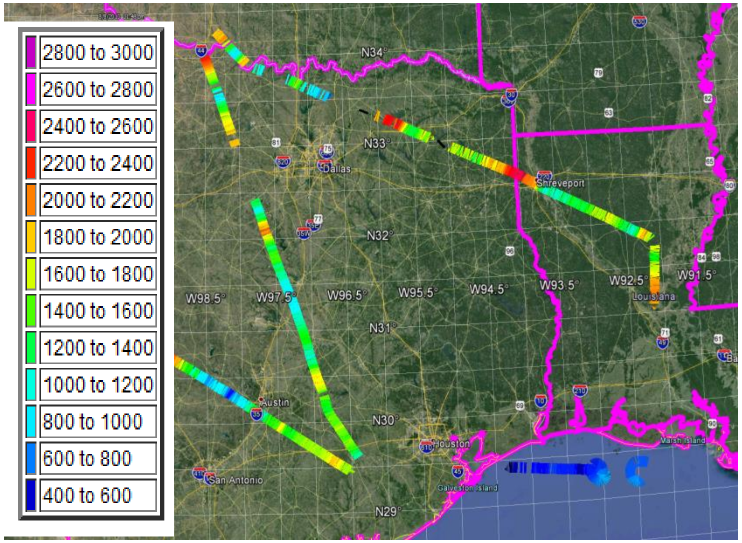


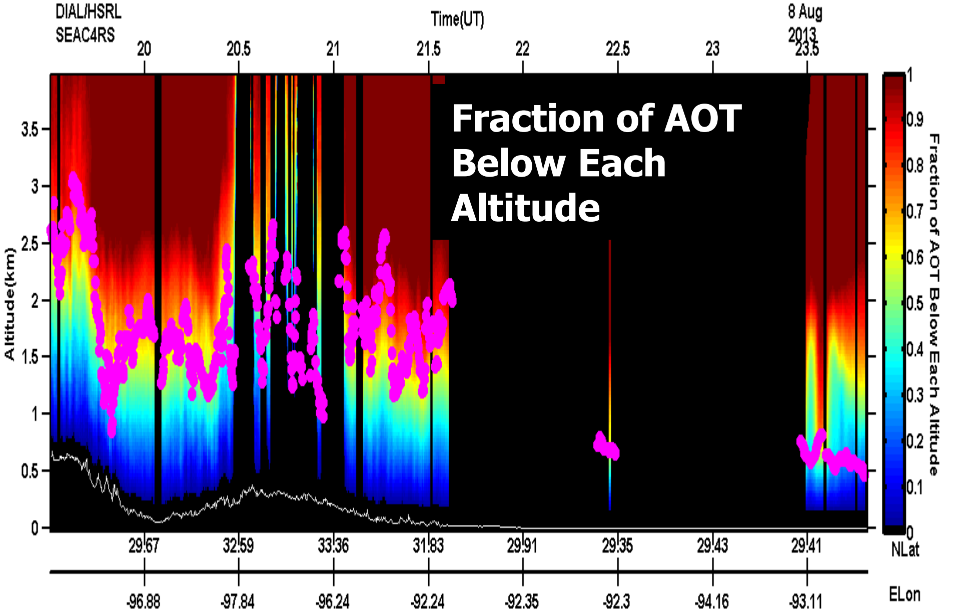


Aerosol Optical Thickness within Mixed Layer (Aug. 8 Transit)

- DIAL/HSRL measurements of column AOT are used to determine the fraction of AOT above Mixed Layer
- In this example from the Aug. 8 transit flight, about 60-70% of AOT is within the ML over land, but only 20-30% of AOT is within boundary layer over water



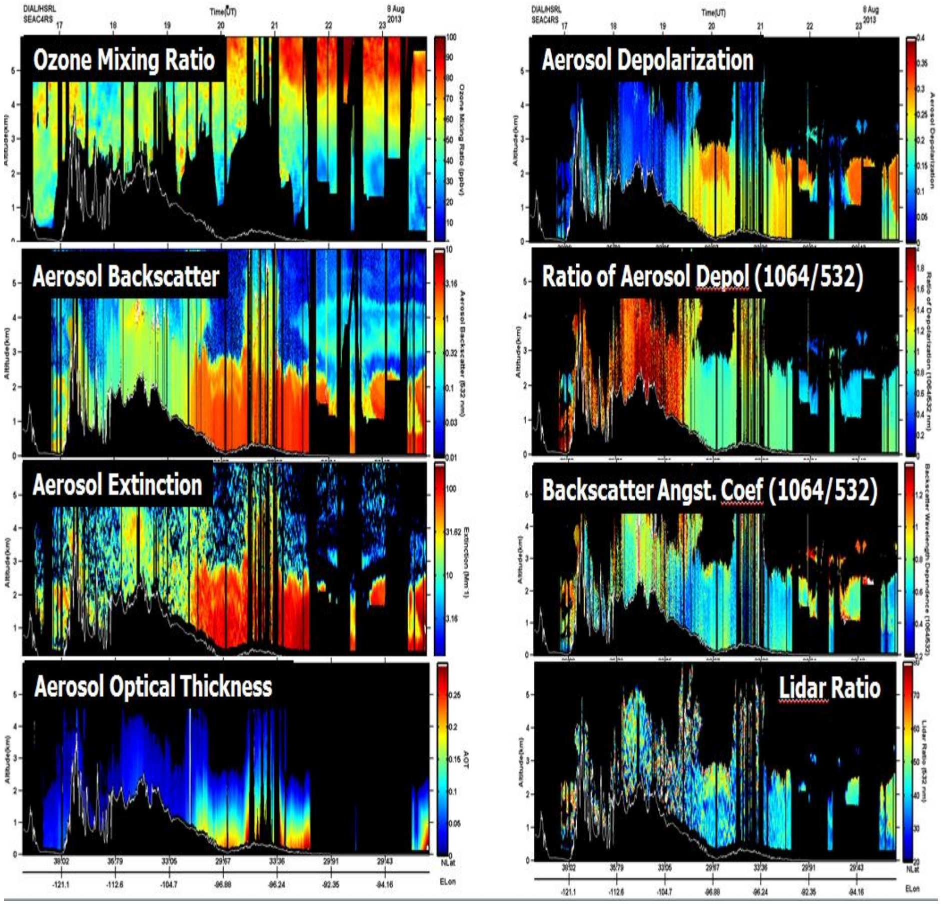




Summary

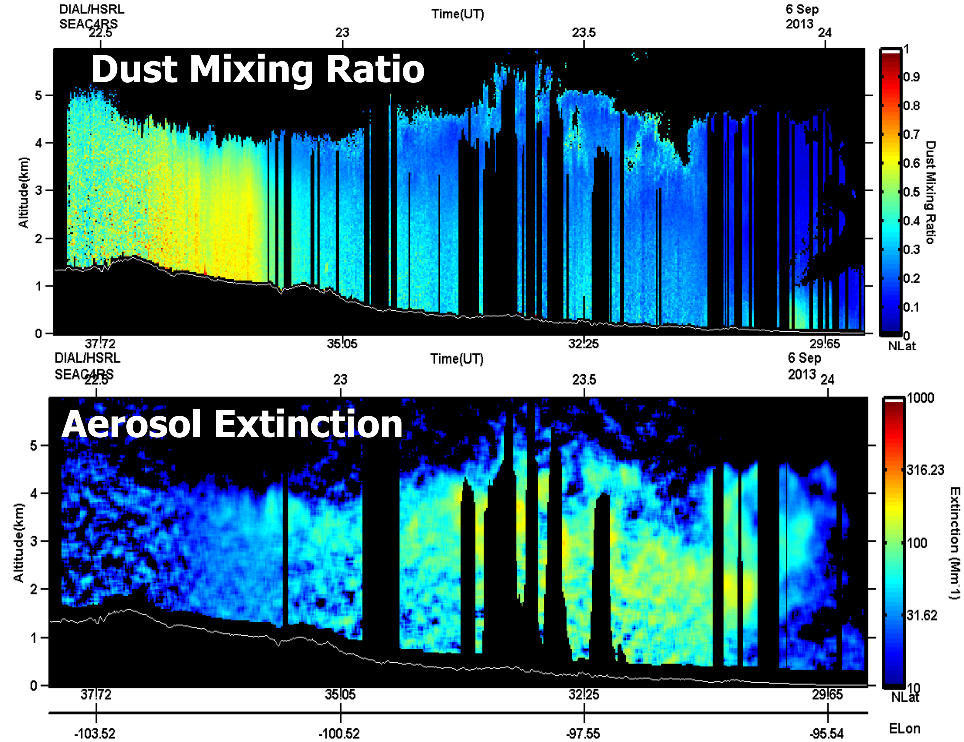
- DIAL/HSRL measurements provide suite of aerosol products as well as ozone
  - Aerosol extinction, backscattering, depolarization, optical thickness
  - Aerosol profiles are optimal when aircraft flies at or above 5 km

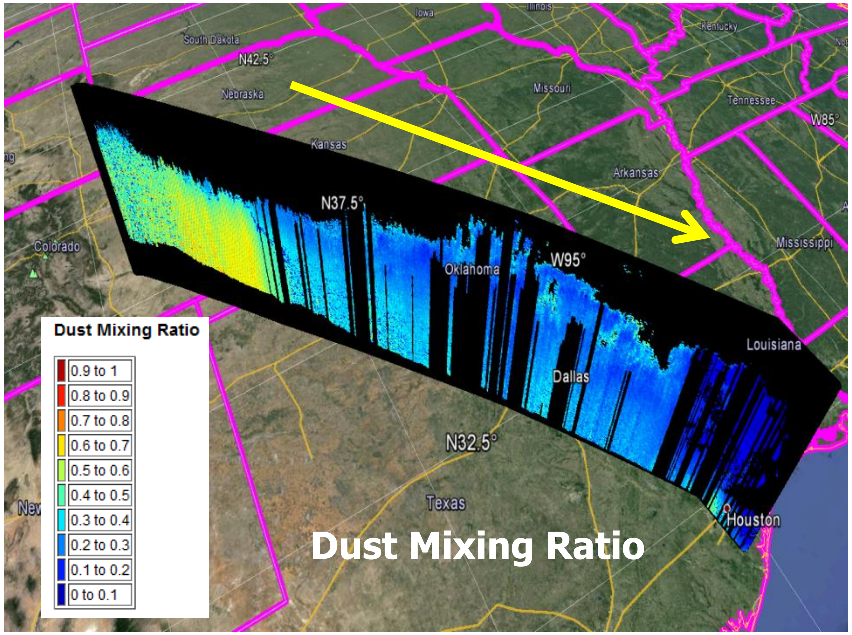
- Aerosol products are used for:
  - Mapping horizontal and vertical aerosol distributions
  - Qualitative aerosol classification
  - Apportionment of AOT to aerosol type
  - Determination of daytime Mixed Layer (ML) height
  - Apportionment of AOT within and above ML
  - Determination of Nonspherical Fraction
- Relevant Studies
  - Radiation
  - Smoke
  - Aerosol/cloud interactions
  - UT/LS
  - Cirrus
  - Chemistry (ozone)

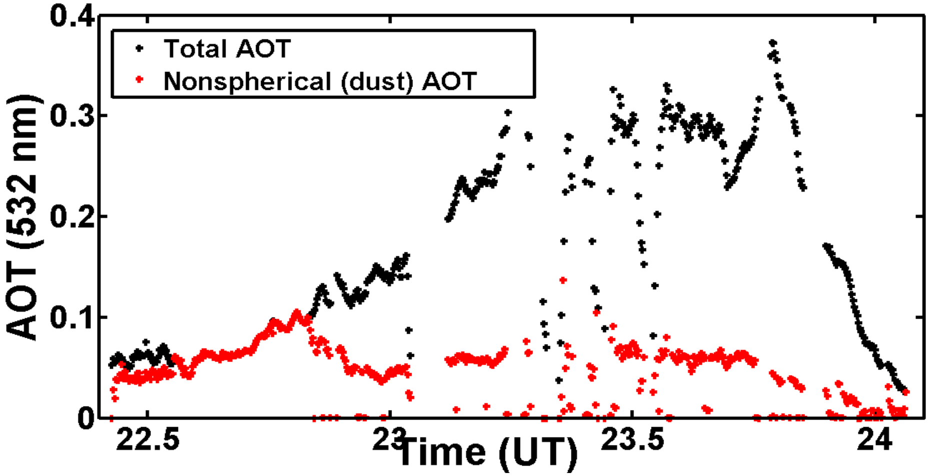


Nonspherical (i.e. dust) fraction (Sep. 6)

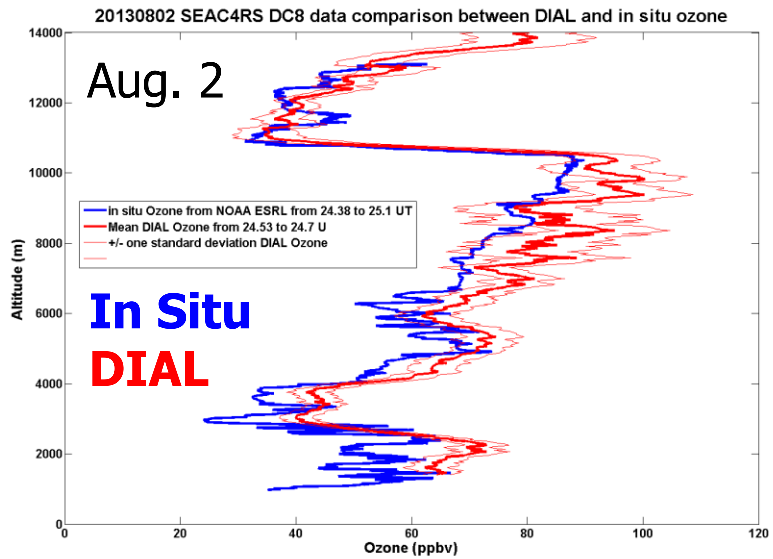
DIAL/HSRL measurements of aerosol depolarization were used to derive fraction of extinction and AOT due to nonspherical aerosols (i.e. dust) following Sugimoto and Lee (2006) and Tesche et al., (2009)

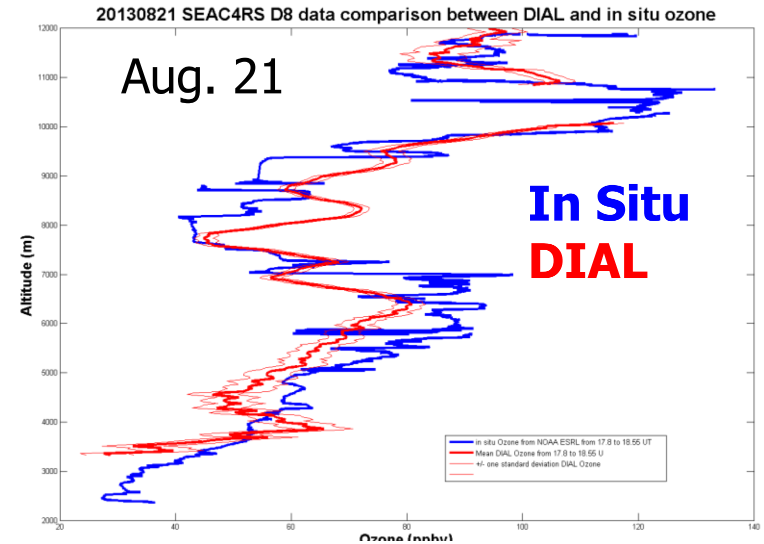


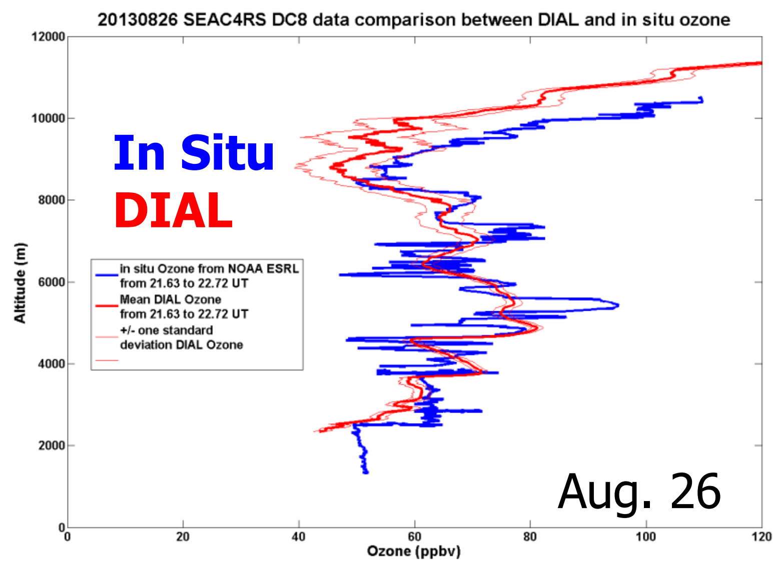




Ozone Comparisons







- DIAL ozone comparisons with NOAA ESRL Ozone measurements on DC-8 in ramps along more homogeneous scenes show in general good agreement
- Comparisons during ramps often encounter high variability in vertical and horizontal structure which complicates comparison
- Comparisons with sondes are currently being assessed
- Comparisons with ground lidars possible (however very limited cases)

In situ ozone data – thanks to Tom Ryerson