Synthesis of NASA King Air, MODIS, and CALIPSO aerosol observations during TexAQS II

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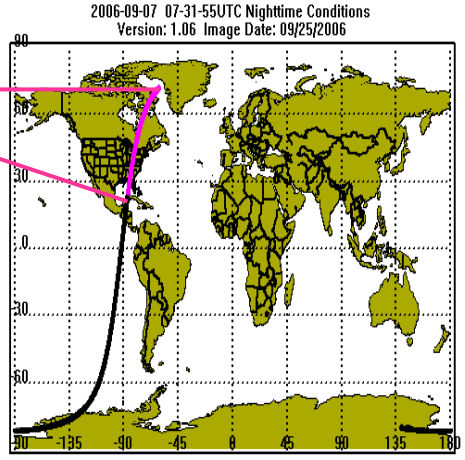
Presenter: R. Bradley Pierce

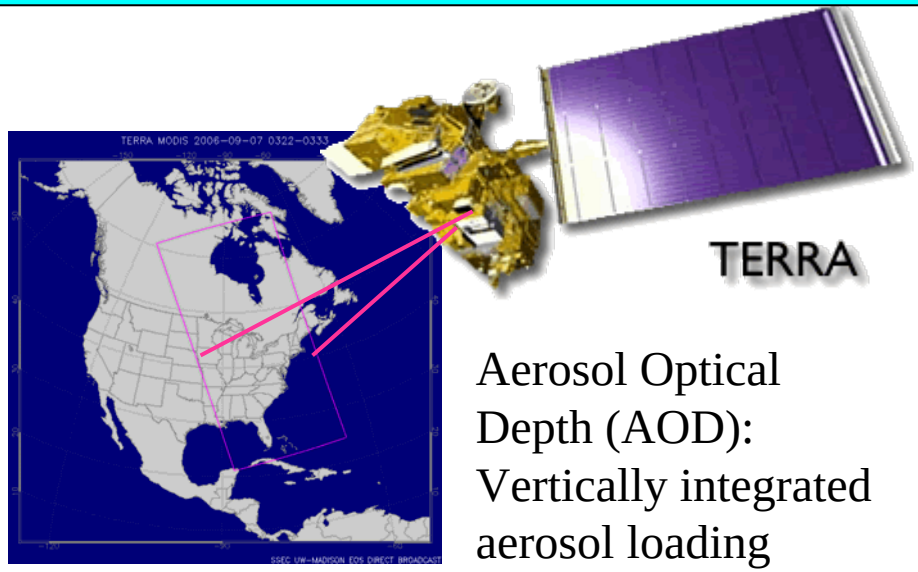
2006 The Texas Air Quality Study

Satellite data used in Analysis:

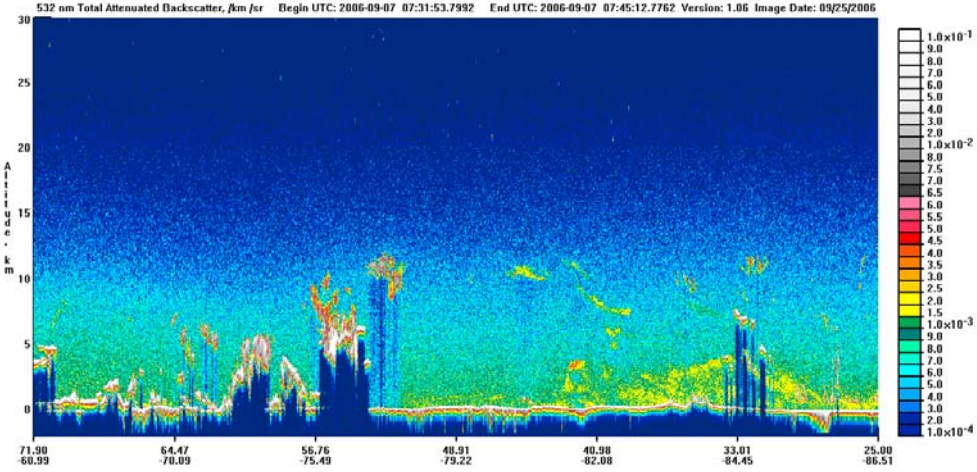
CALIPSO

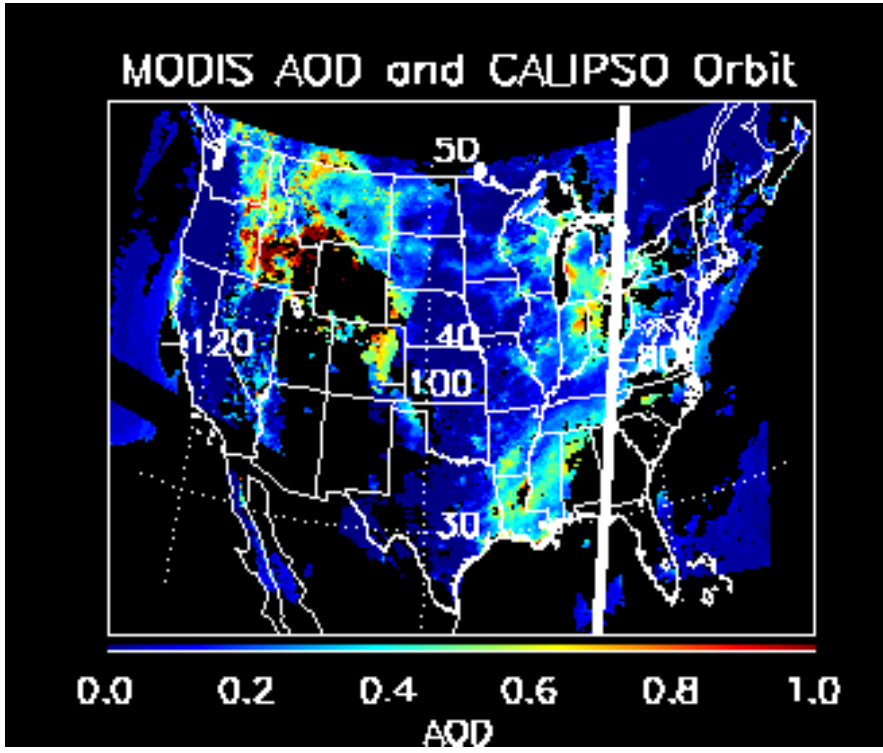
Integrated Attenuated Backscatter (IAB): Vertically resolved aerosol loading





Aerosol Optical Depth (AOD): Vertically integrated aerosol loading



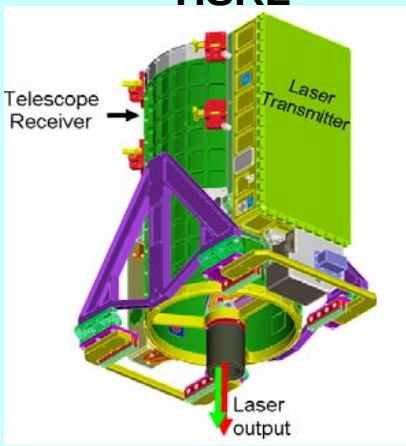


Combination of MODIS AOD and CALIPSO Backscatter provides a three-dimensional view of aerosol loading.

Aircraft data used in Analysis:

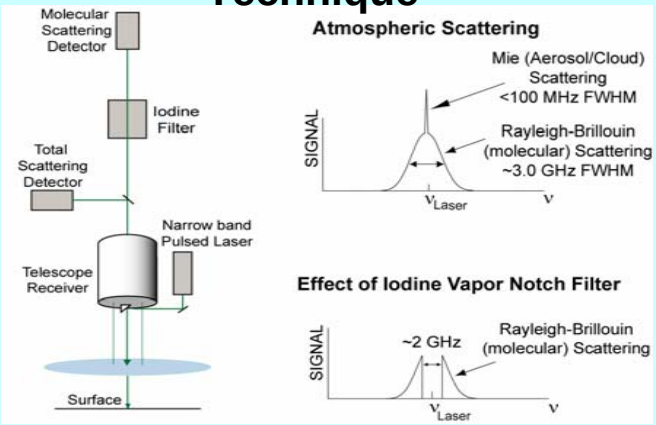
High Spectral Resolution Lidar

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

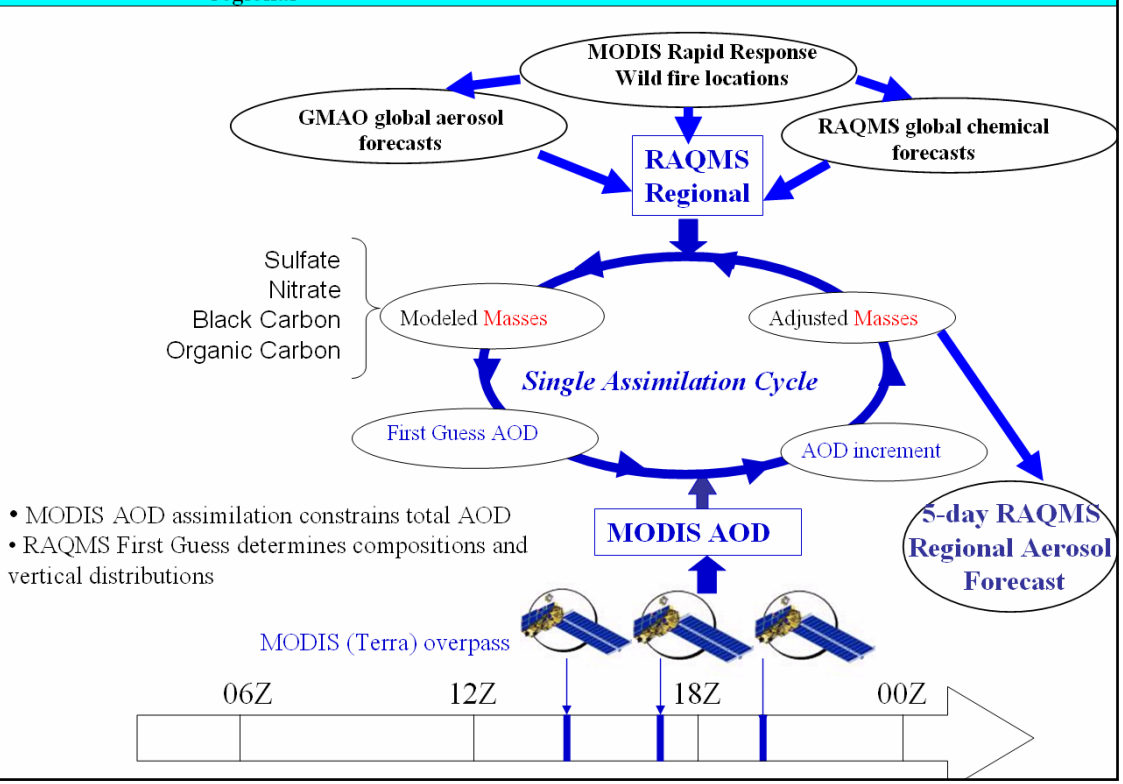
Intensive – depend on aerosol type

(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) HSRL data products with nominal horizontal and vertical resolutions. Resolutions can be varied depending on the application.

Modeling system used in Analysis (Chieko Kittaka, Lead)

Real-time Air Quality Modeling System (RAQMS)

$RAQMS_{regional}$ (80km) AOD Assimilation/Forecast Procedure



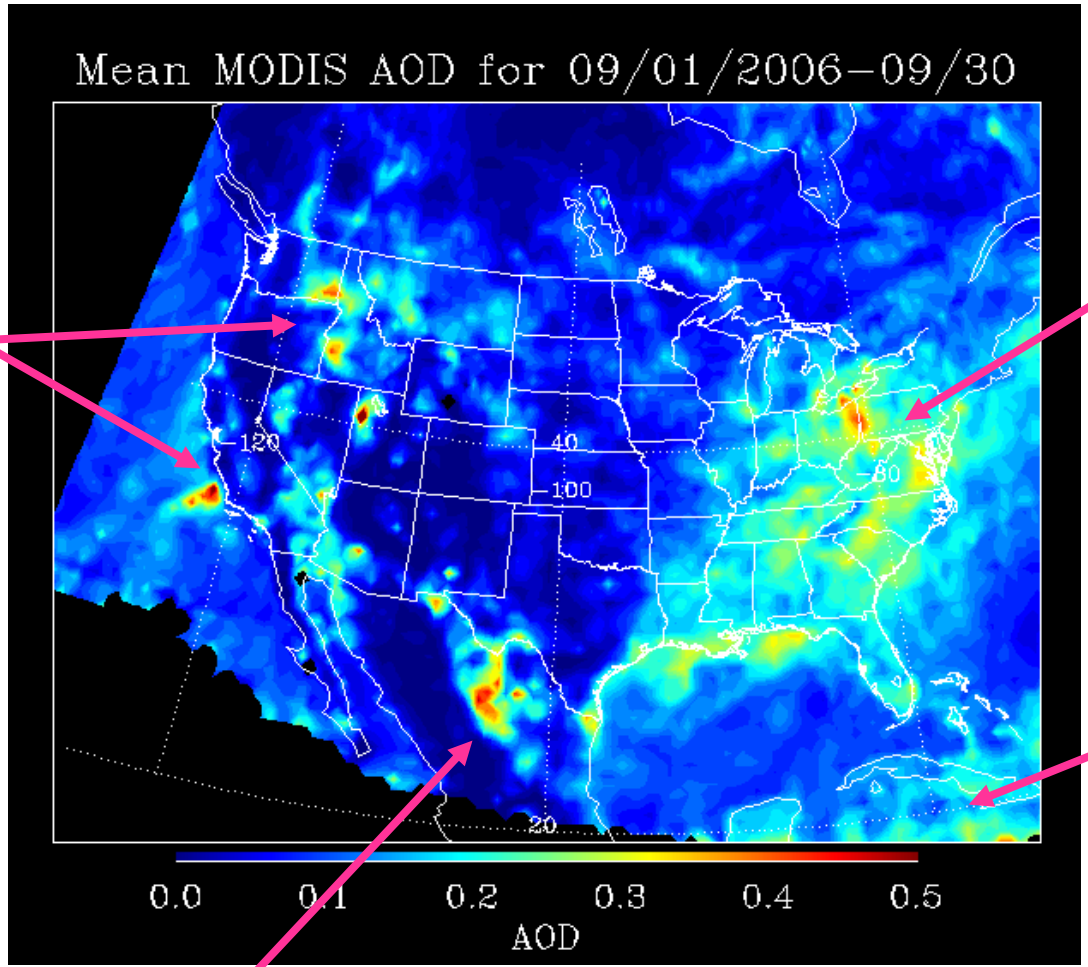
- **Assimilation of MODIS Direct Broadcast AOD**
- **CONUS domain (80km×80km×0.4km)**
- **RAQMS global analyses used for chemical constraints**
- **GMAO global aerosol analysis/forecast products used for lateral boundary conditions**
- **<u>Convective transport due to fires</u> is represented based on total carbon burned with the conversion factor of 8000 BTU/lb. The heat flux is partitioned into two components, sensible heat flux and radiative heat flux, and added to the soil layer of fire locations. Relative humidity is assumed to be 100 % where a fire location is.**

<u>RAQMS Aerosol Mechanism:</u>

- **Sulfate [Kittaka, 2004],**
- **Dust, Sea Salt, Carbonaceous Aerosol from GOCART [provided by Mian Chin, GSFC]**
- **Nitrate and Ammonium from GEOS-CHEM [provided by Rokjin Park, Harvard]**

Continental Aerosols observed from MODIS (Terra) during Sept. 2006

Biomass emission from wild fires



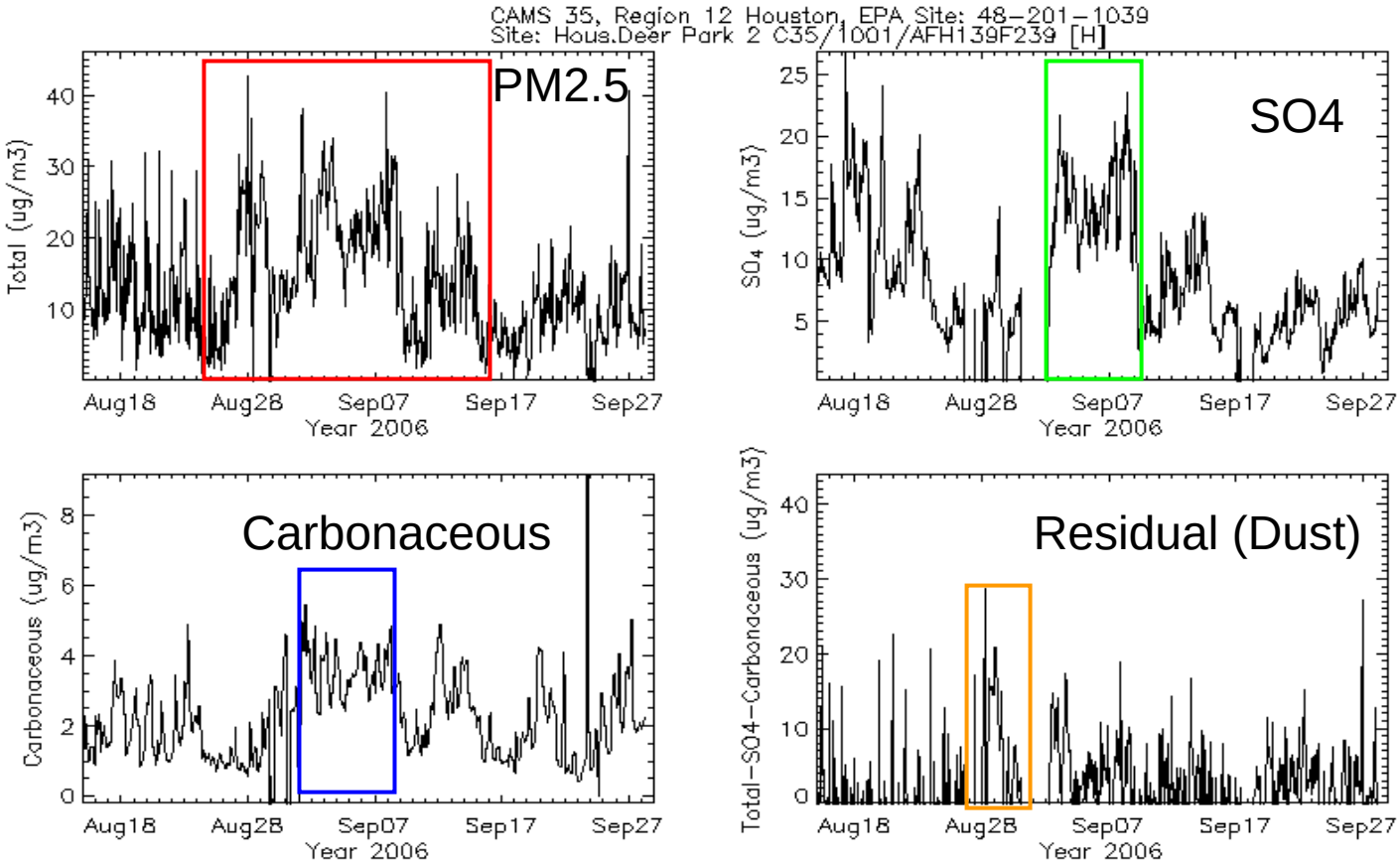
Persistent sulfate pollution

Dust from Sahara

Artifact due to high reflective surface

Deer Park surface data provided by TCEQ

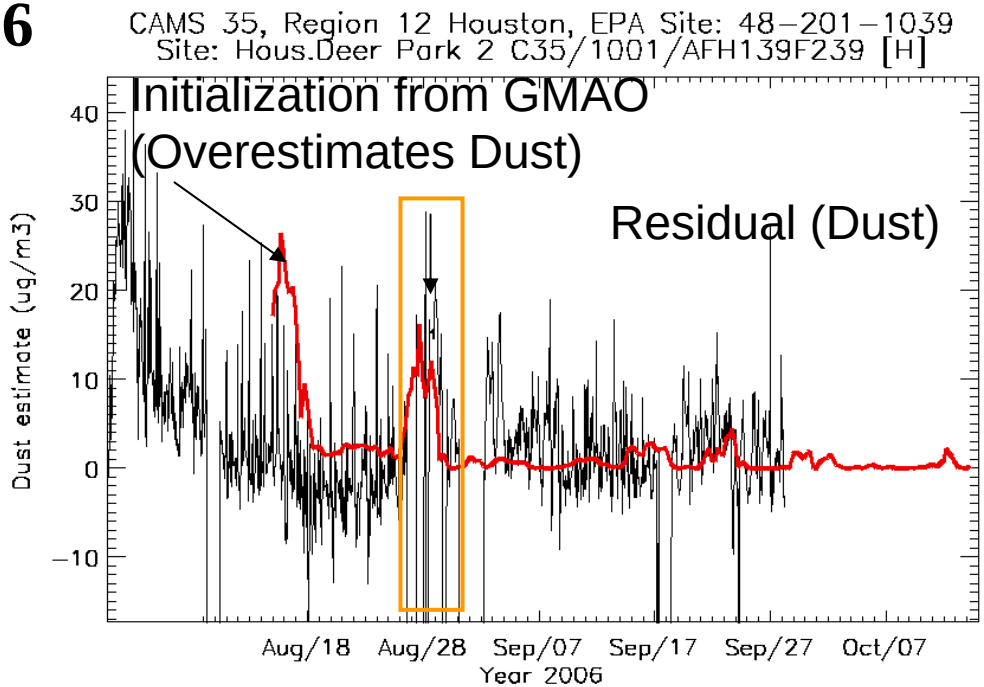
Analysis period: August 23-Sep 15th, 2006
August 28: Dust event
Sept 02-09: Sulfate/Carbonaceous event



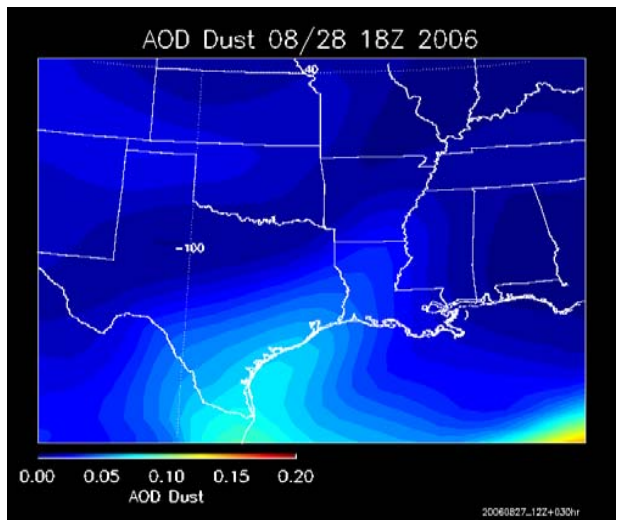
Dust Event: August 28th, 2006

RAQMS Dust analysis is in reasonable agreement with TCEQ residual dust estimates

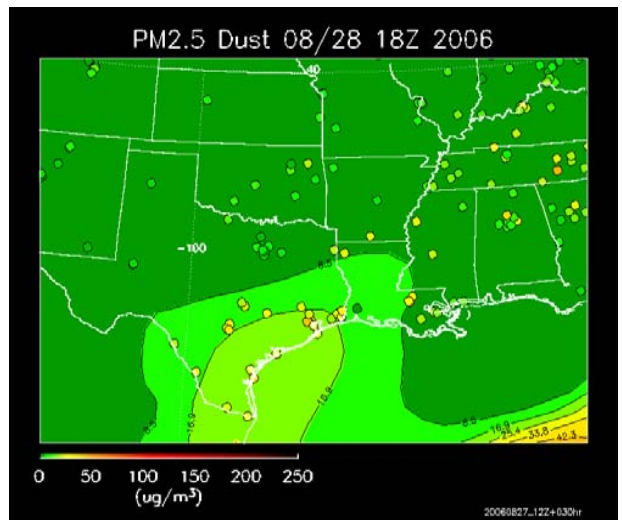
Shows onshore transport of dust from Gulf accounts for Significant fraction of AIRNow total PM2.5 observations in SE Texas on August 28th



RAQMS Dust AOD

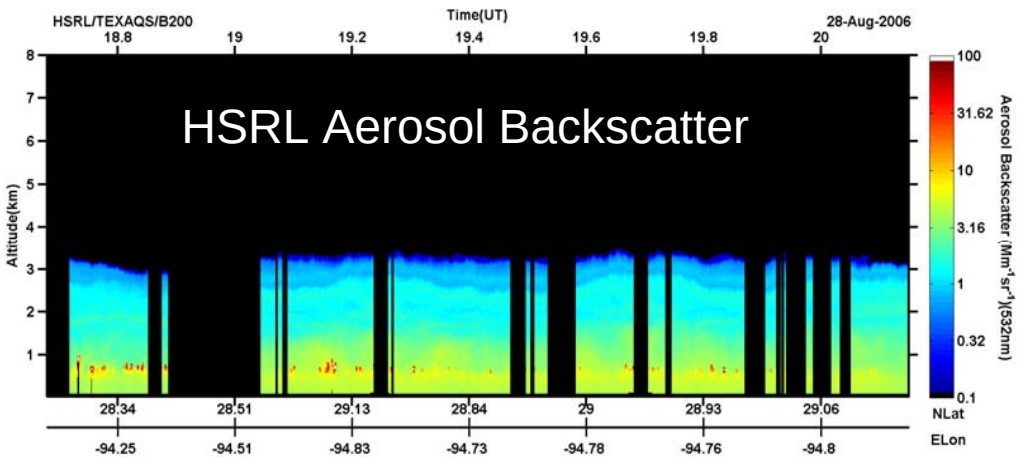


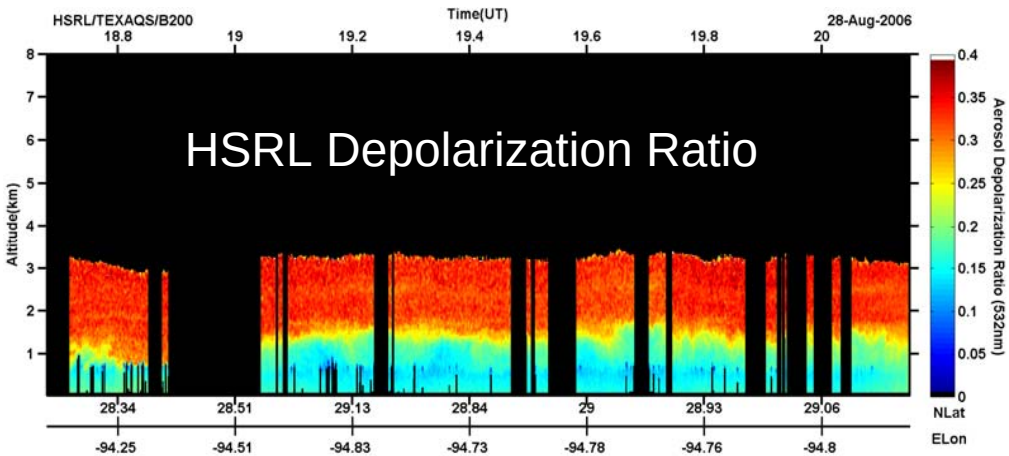
RAQMS vs AIRNow PM2.5

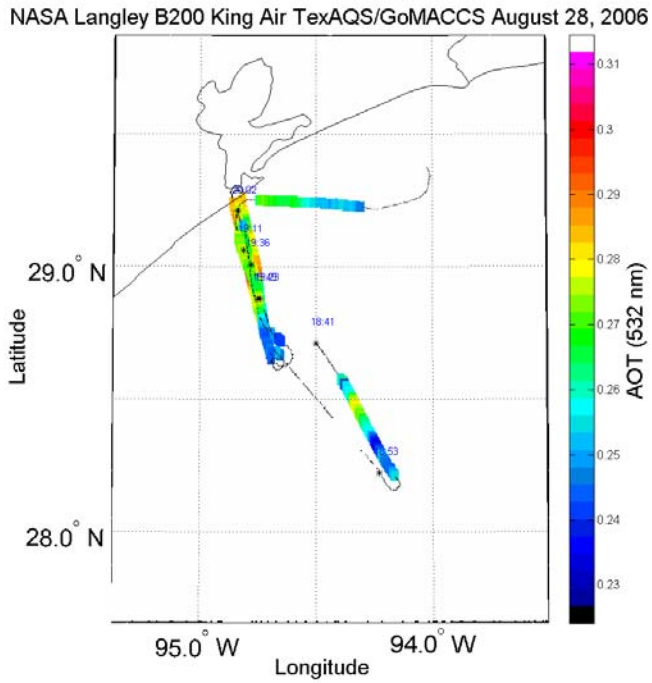


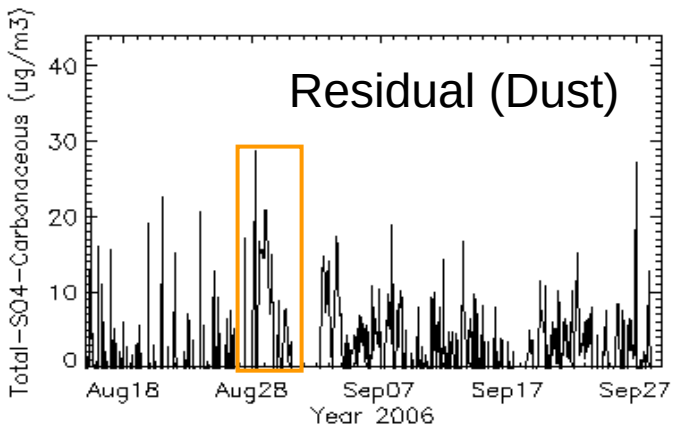
Dust Event: August 28th, 2006

Very High (>0.3) to High (>.15) depolarization Ratios below 3km indicate Dust

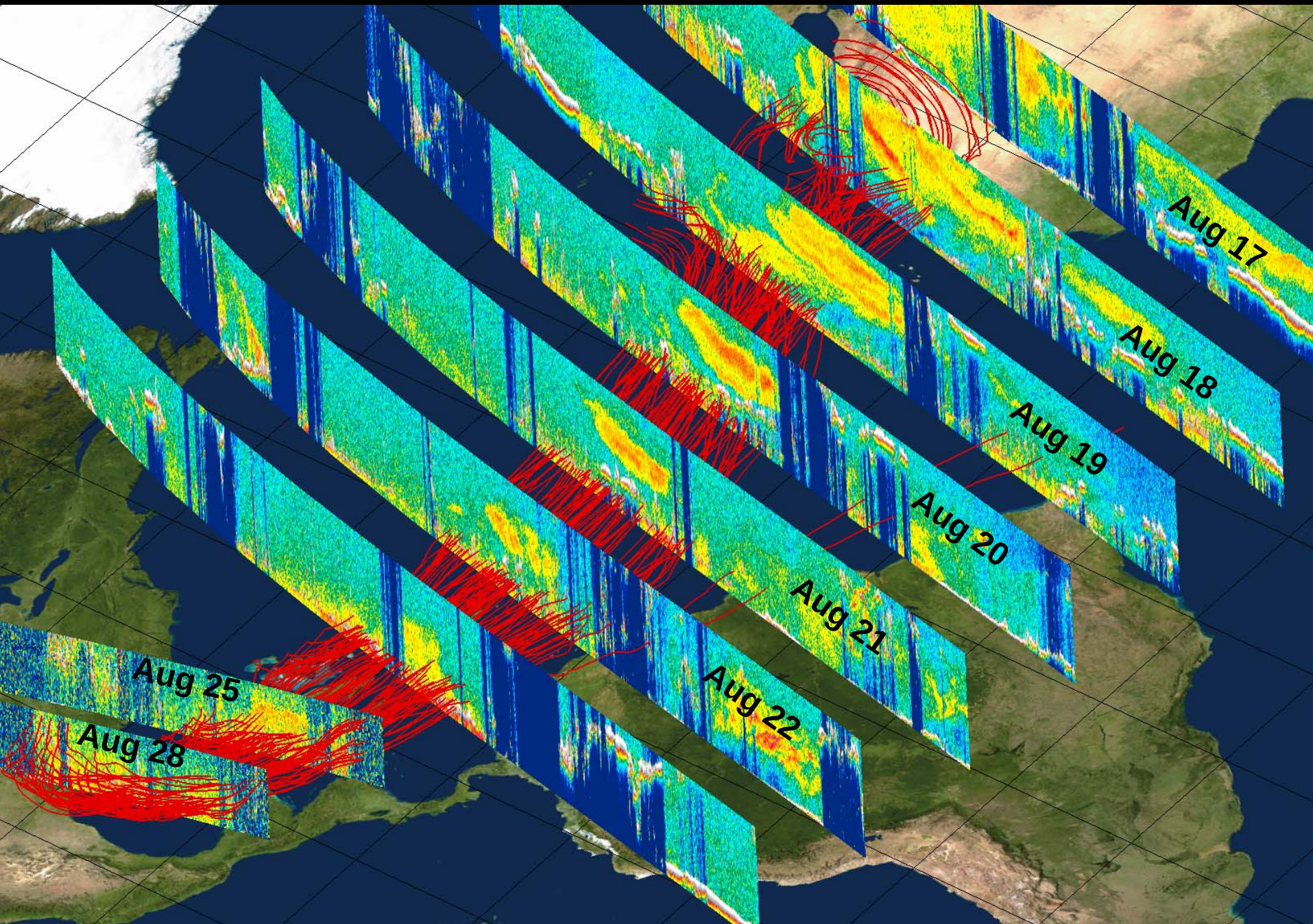




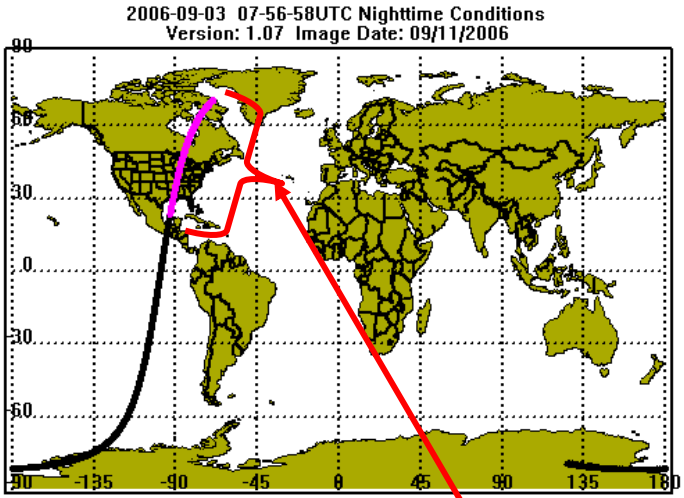


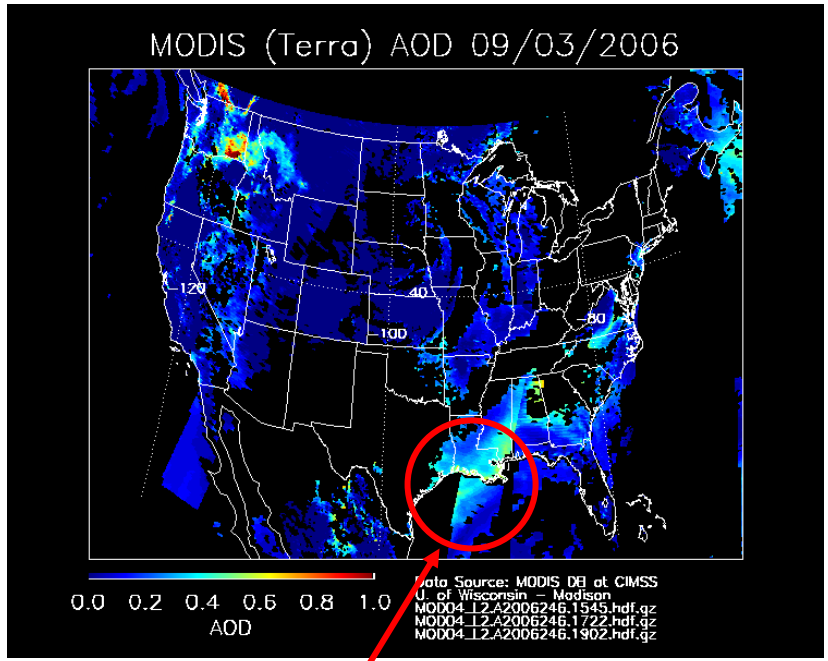


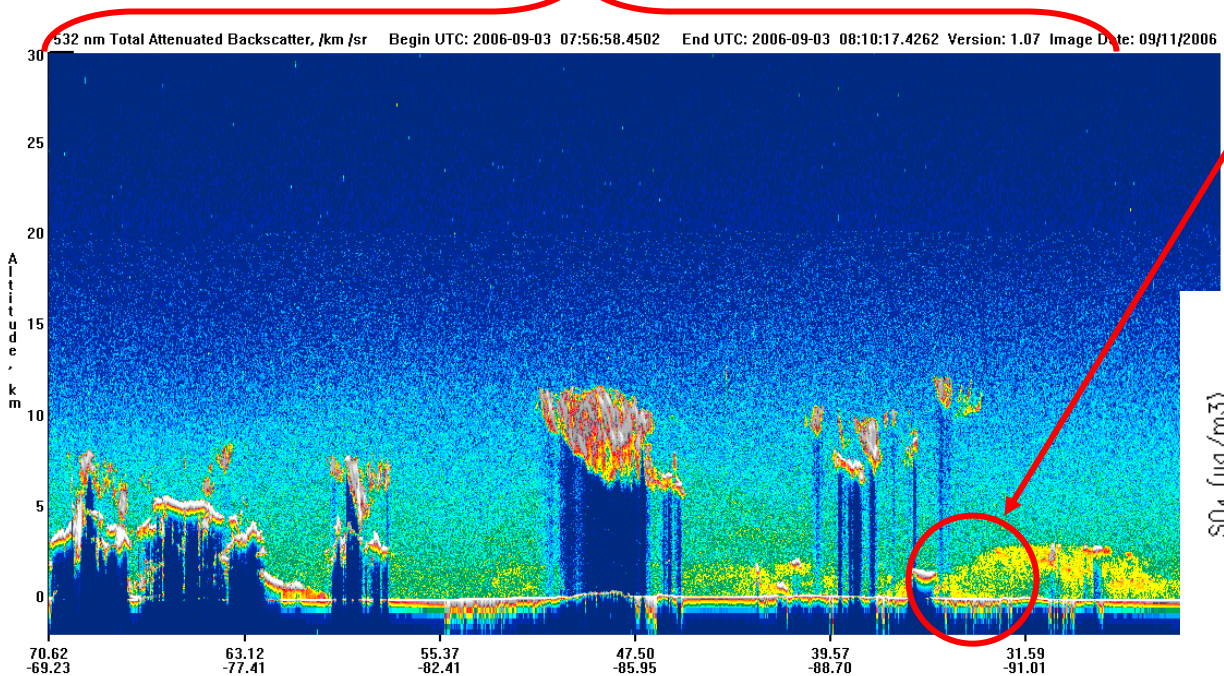
CALISPO Backscatter profiles for August 17-28, 2006
Boundary Layer back trajectories from August 28 CALIPSO track shown in red

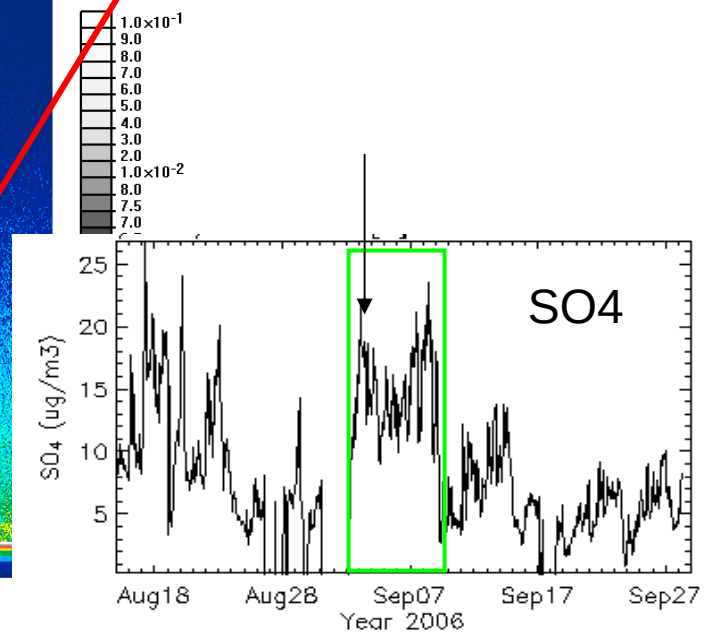


Sulfate Event: Sept. 03, 2006

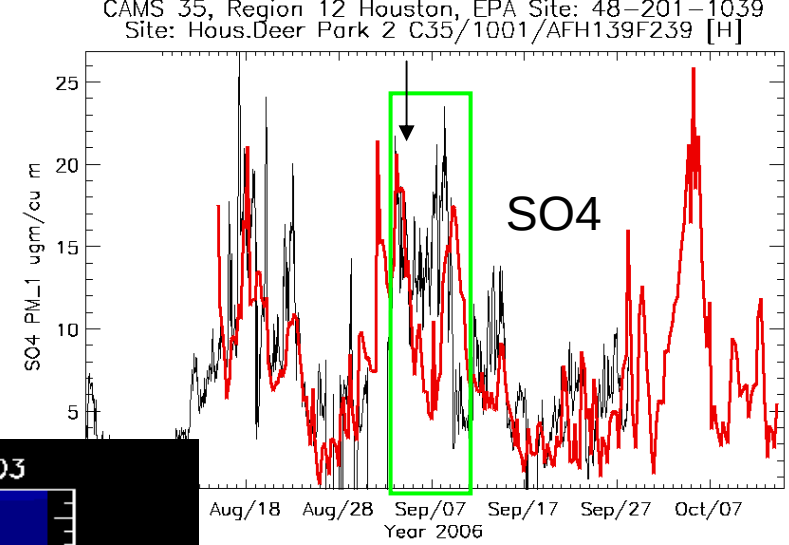


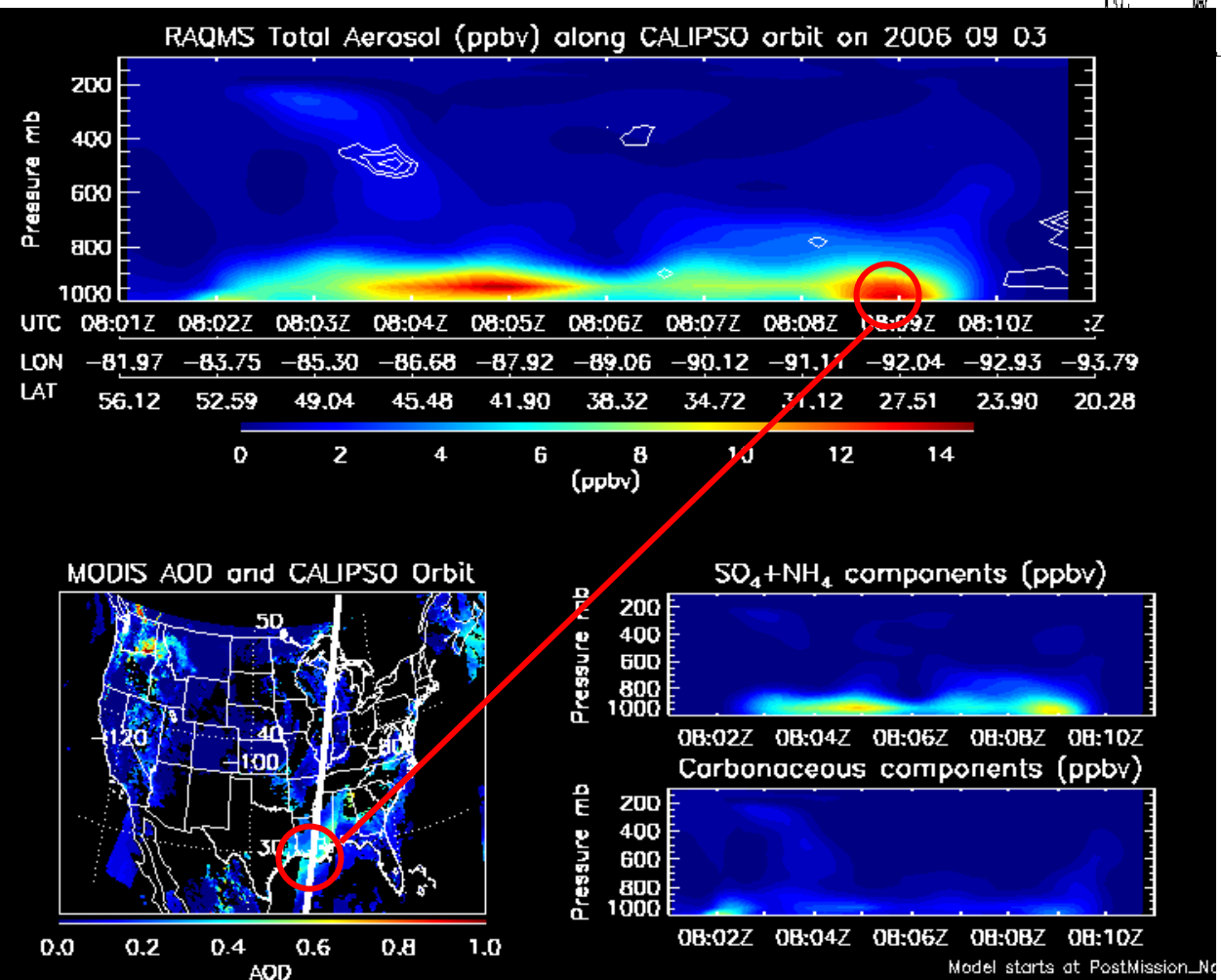






Sulfate Event: Sept. 03, 2006



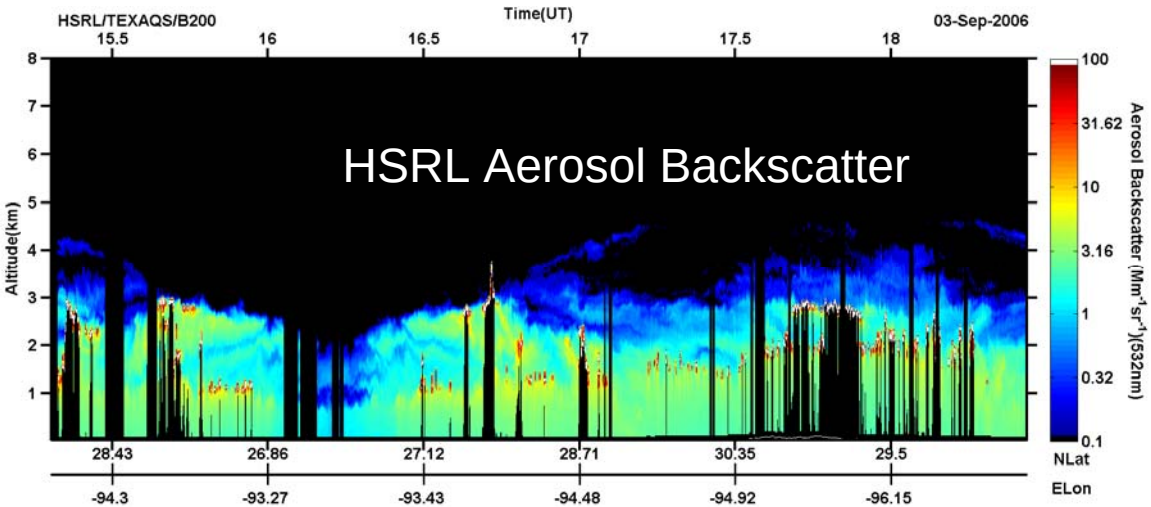


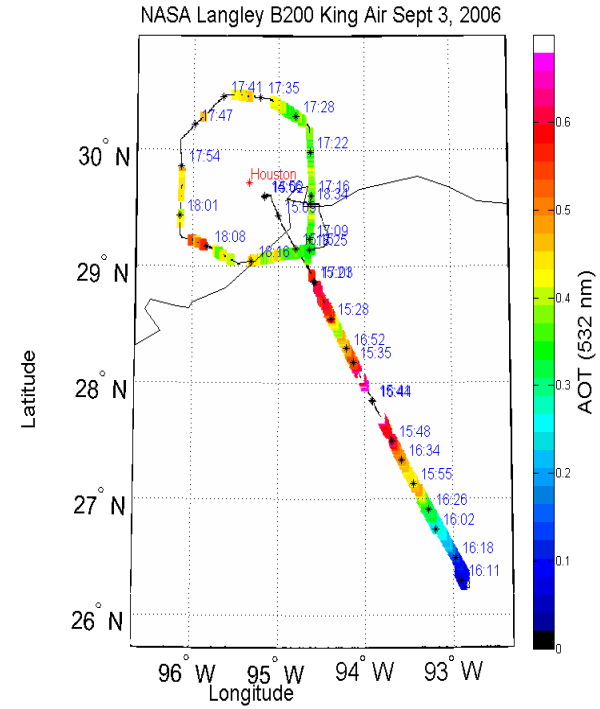
RAQMS aerosol analysis is in good agreement with TCEQ SO4 measurements on Sept 03.

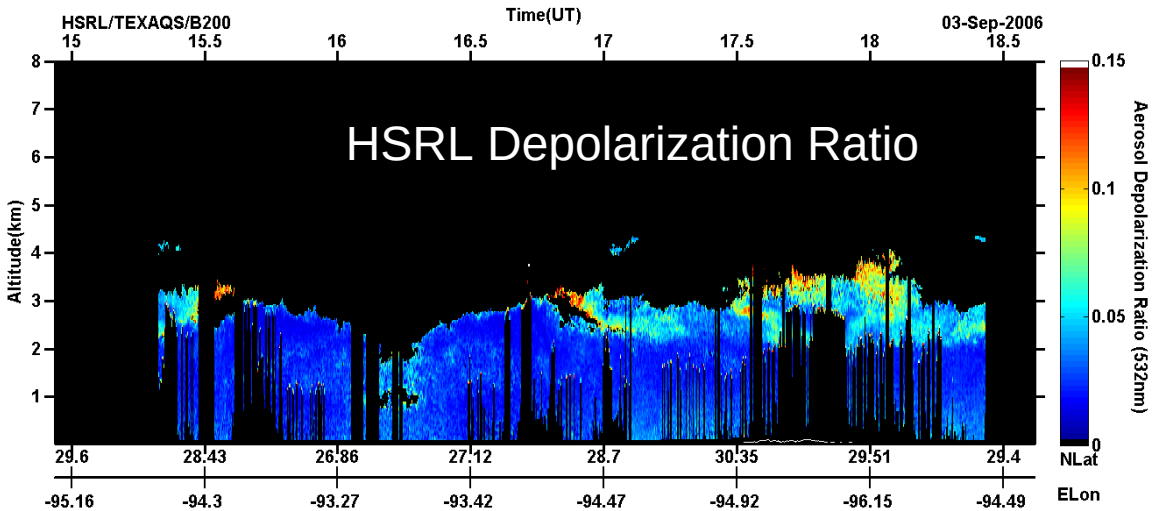
Shows sulfate dominated aerosols along CALIPSO track east of Houston

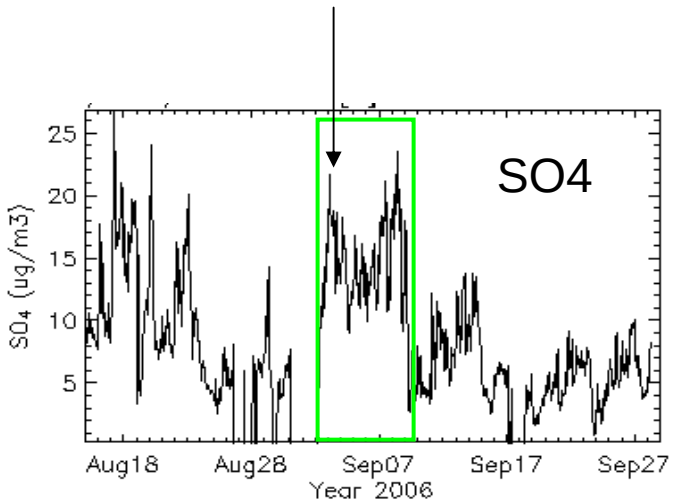
Sulfate Event: Sept. 03, 2006

HSRL Observations show significant >0.5 AOD
With low Depolarization Ratios, consistent with sulfate aerosols

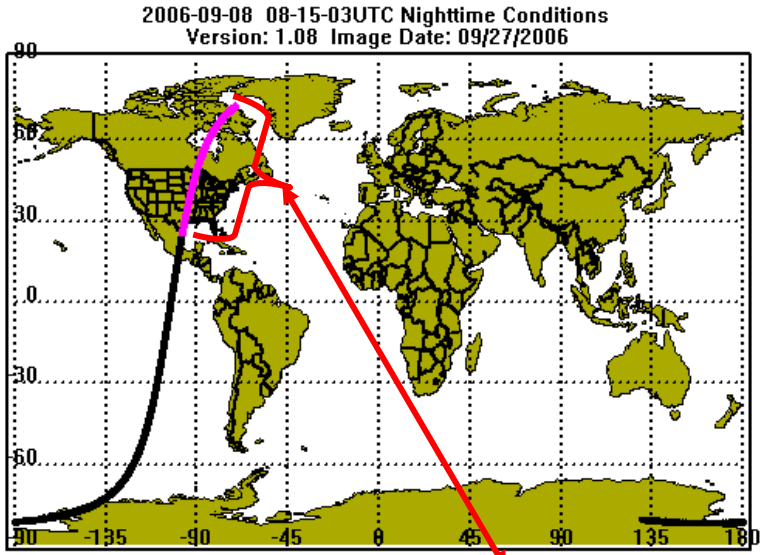


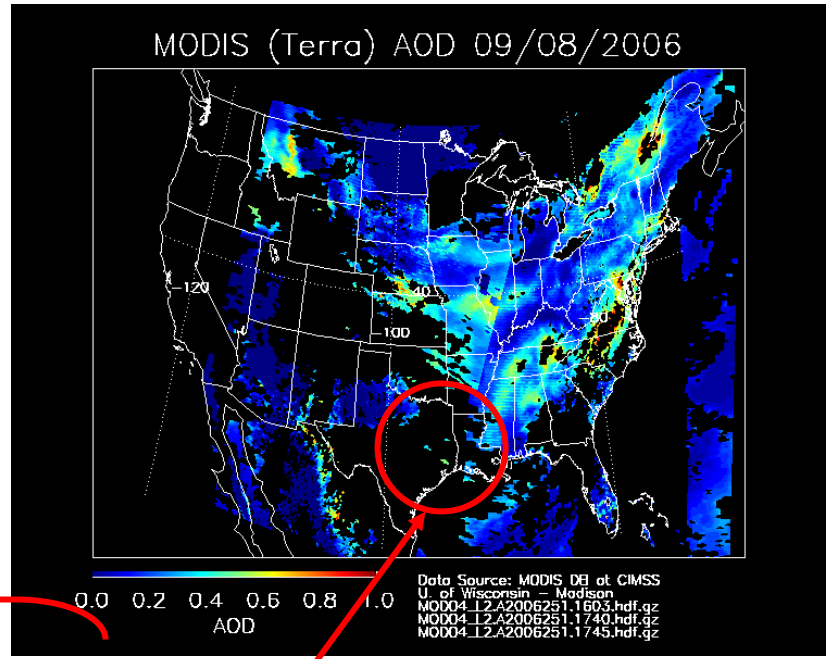


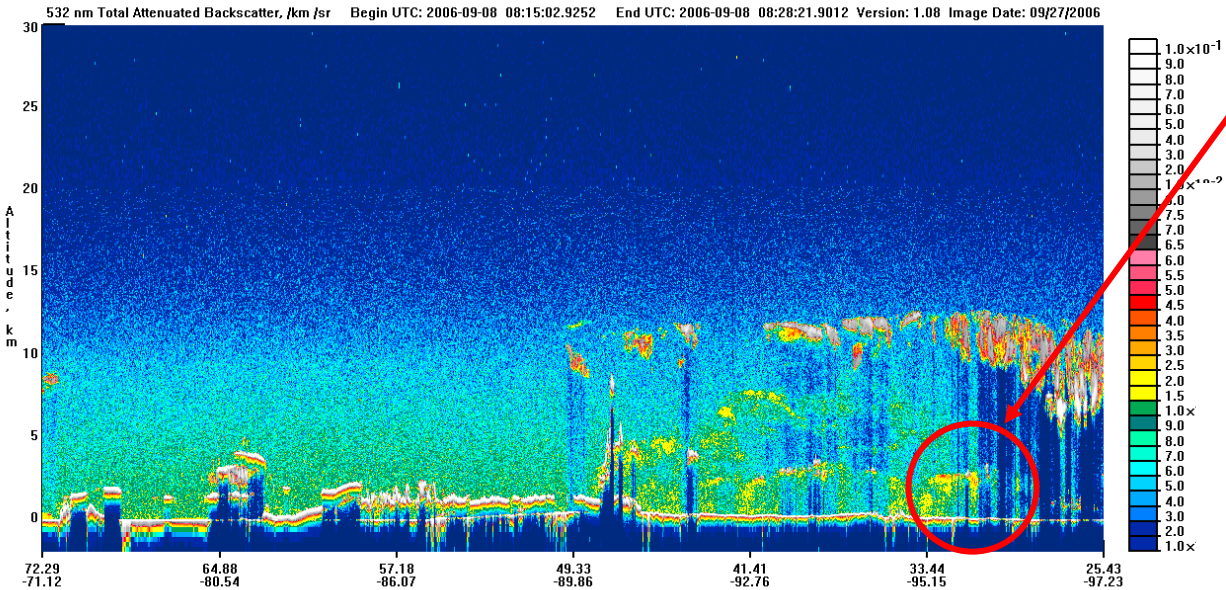


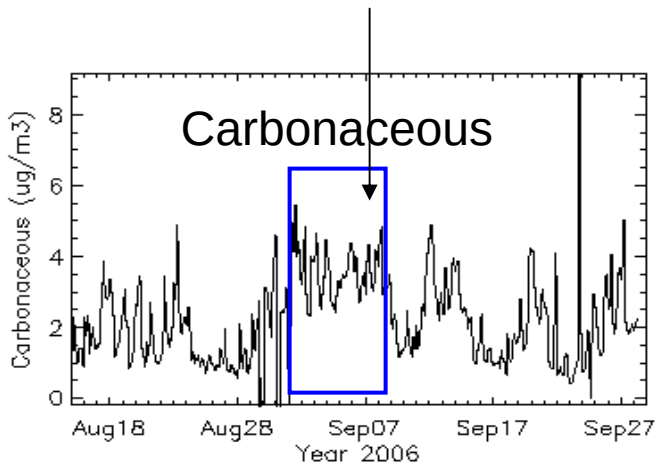


Sulfate/Carbonaceous Event: Sept. 09, 2006

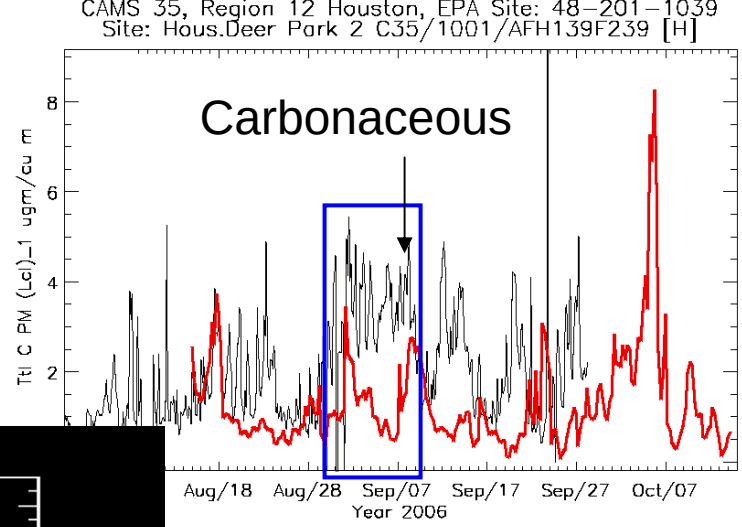


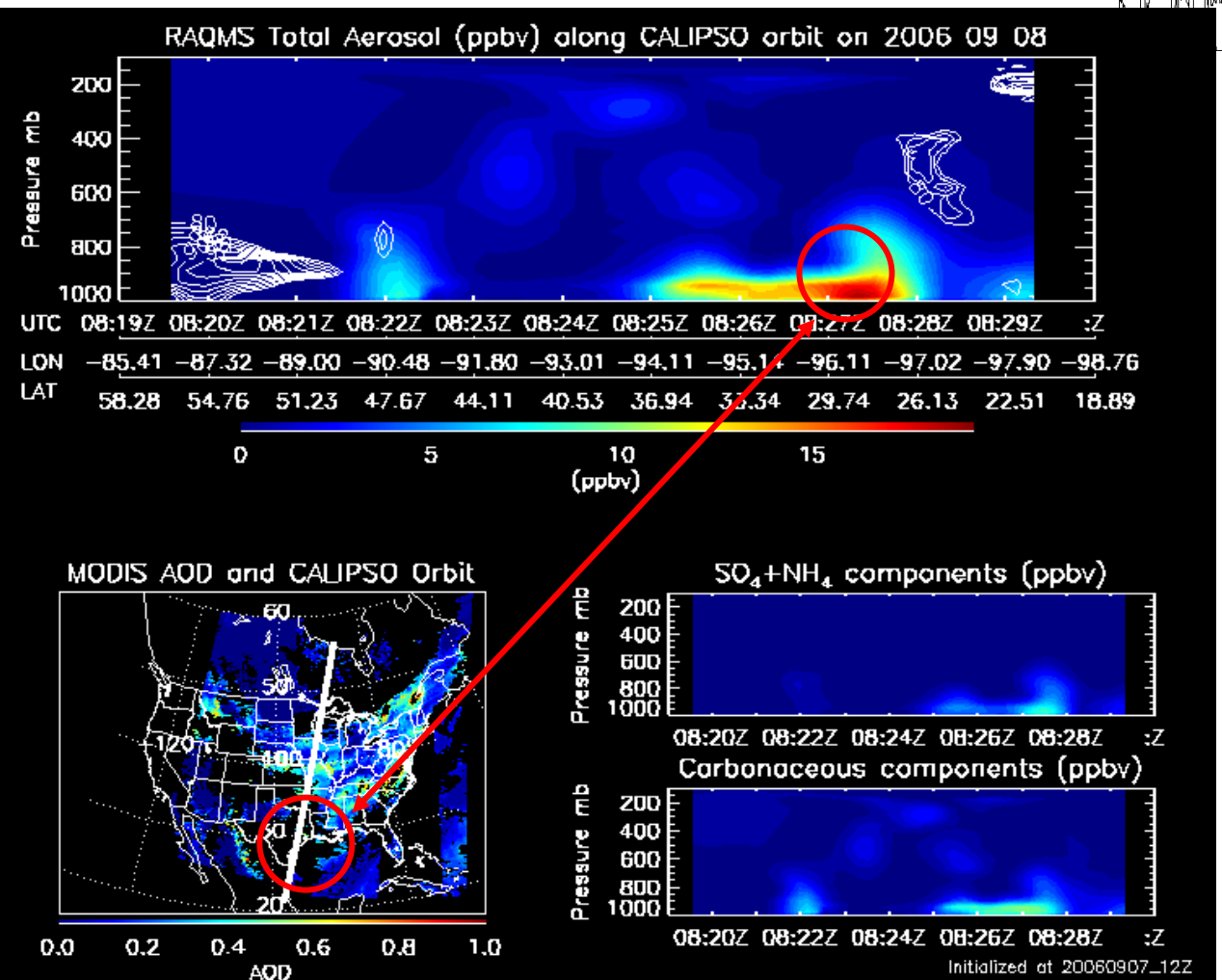






Sulfate/Carbonaceous Event: Sept. 09, 2006



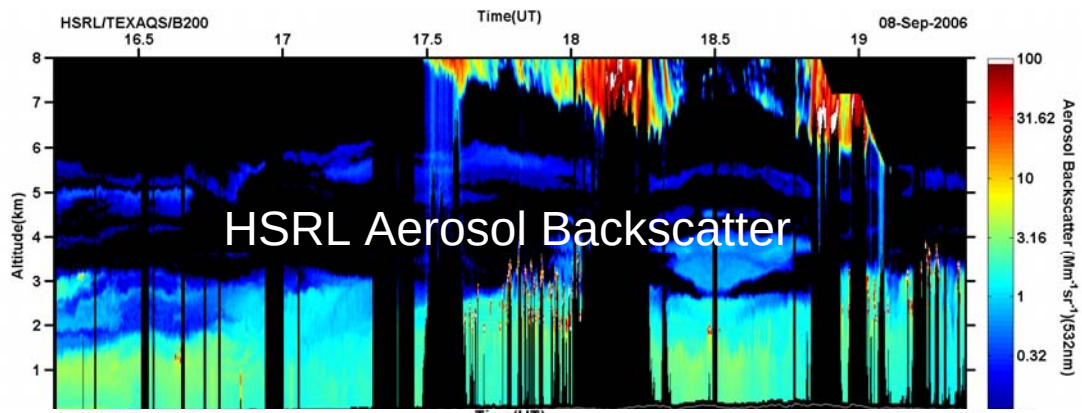


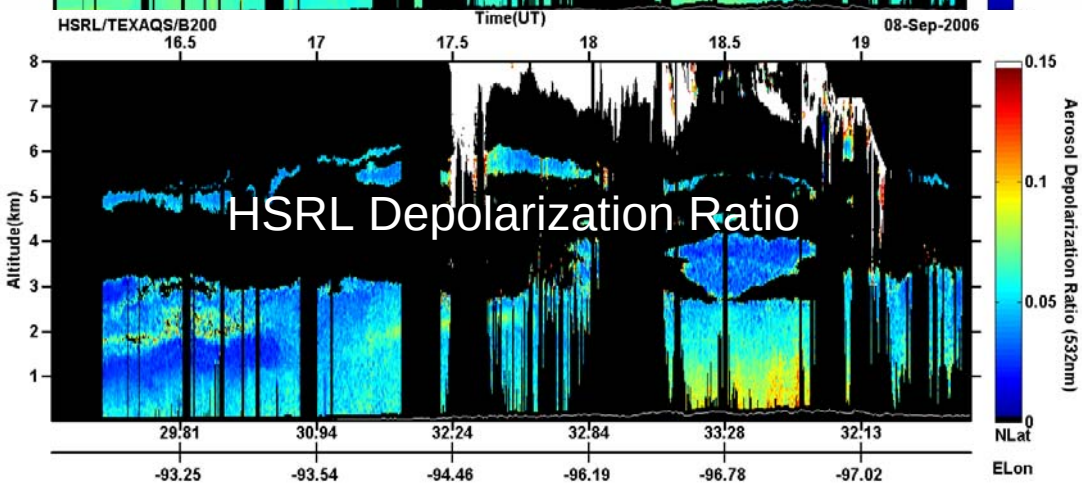
RAQMS underestimates carbonaceous aerosol mass relative to TCEQ measurements.

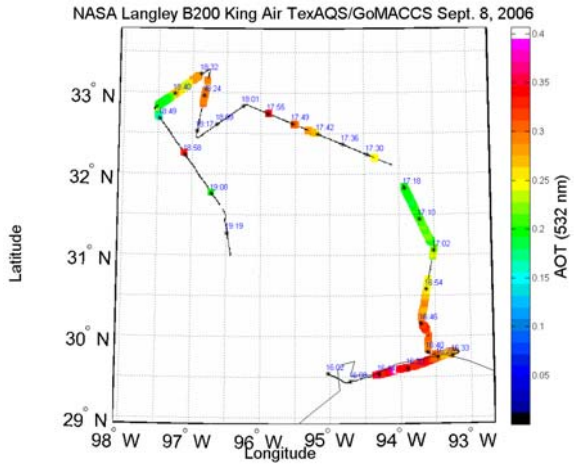
RAQMS aerosol analysis shows carbonaceous dominated aerosols along CALIPSO track near Houston

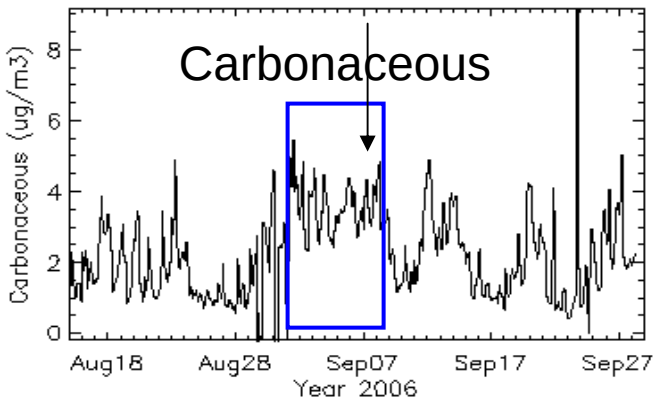
HSRL Aerosol Classification Sept 08, 2006

- pure dust
- dust (large)
- dust(small)+urban
- oceanic
- urban/industrial (small)+biomass
- urban(large)+urban(small)+biomass
- biomass+urban









Summary

MODIS AOD, combined with CALIPSO attenuated backscatter measurements, provides a 3-dimensional view of continental scale aerosol transport.

RAQMS aerosol analyses provide insight into continental aerosol composition and provide link between continental scale satellite, local airborne and surface measurements.

HSRL aerosol optical measurements provide insight into 3-dimensional SE Texas aerosol composition, validation of CALIPSO attenuated backscatter, and verification of RAQMS analyses.

Synthesis of these observations and model analyses show the influences of synoptic and hemispheric scale transport processes on speciated aerosol measurements from the TCEQ Deer Park during TEXAQS II.