

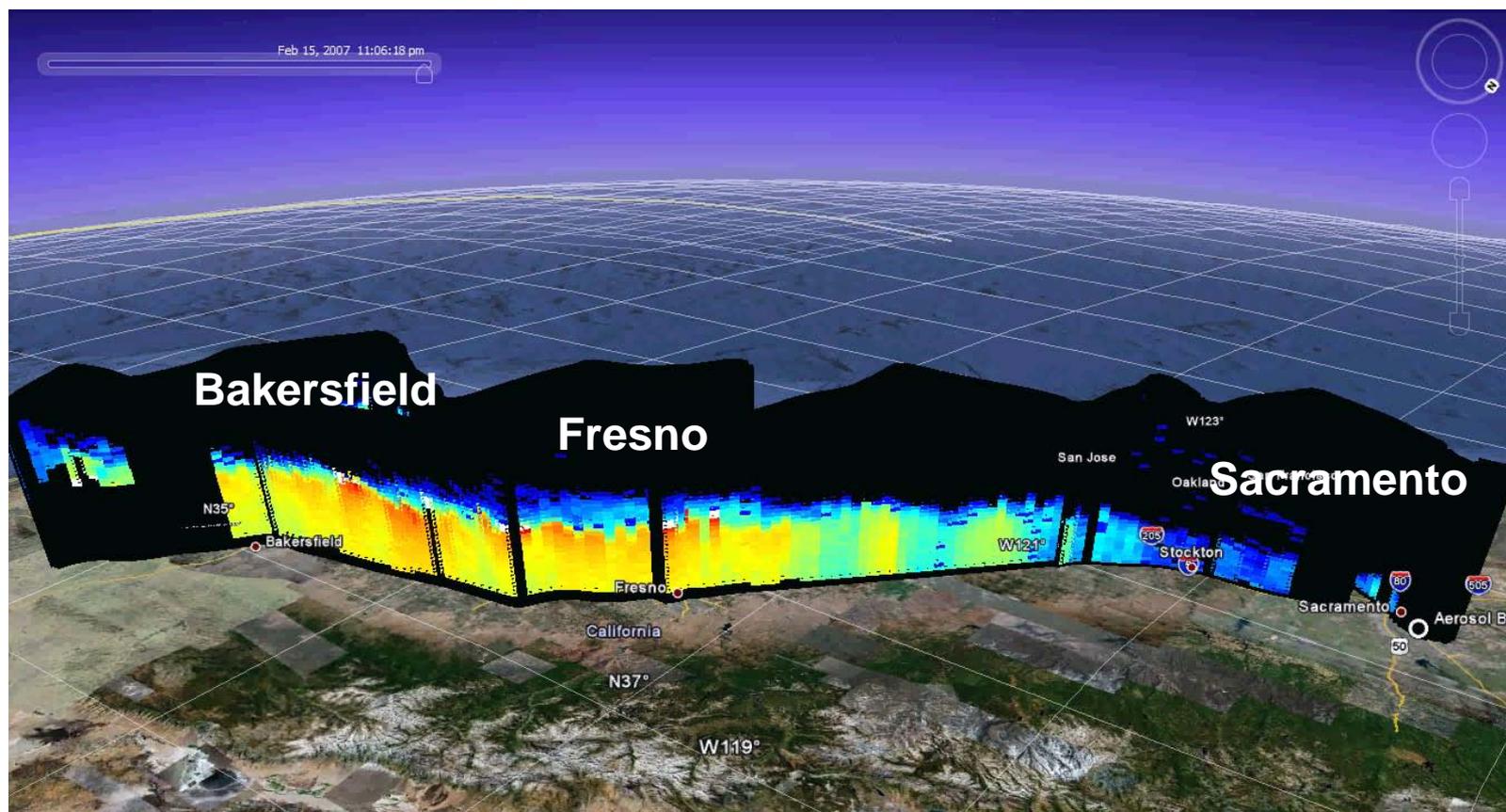


Past California ~~Air Quality~~ Observations **by HSRL**

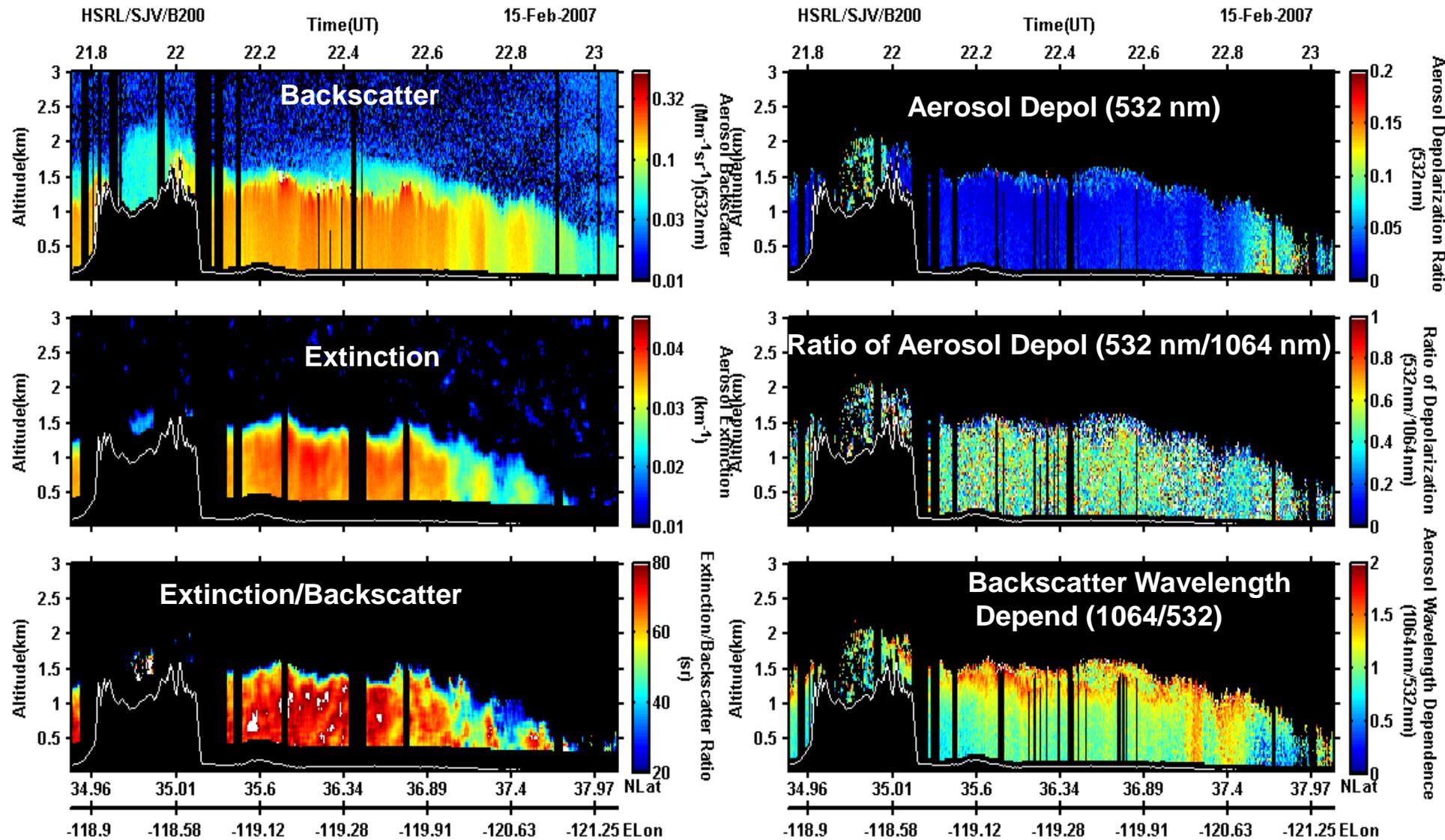
NASA Langley Airborne HSRL Aerosol Backscatter Profiles Acquired on February 15, 2007 During Flight over San Joaquin Valley (SJV)



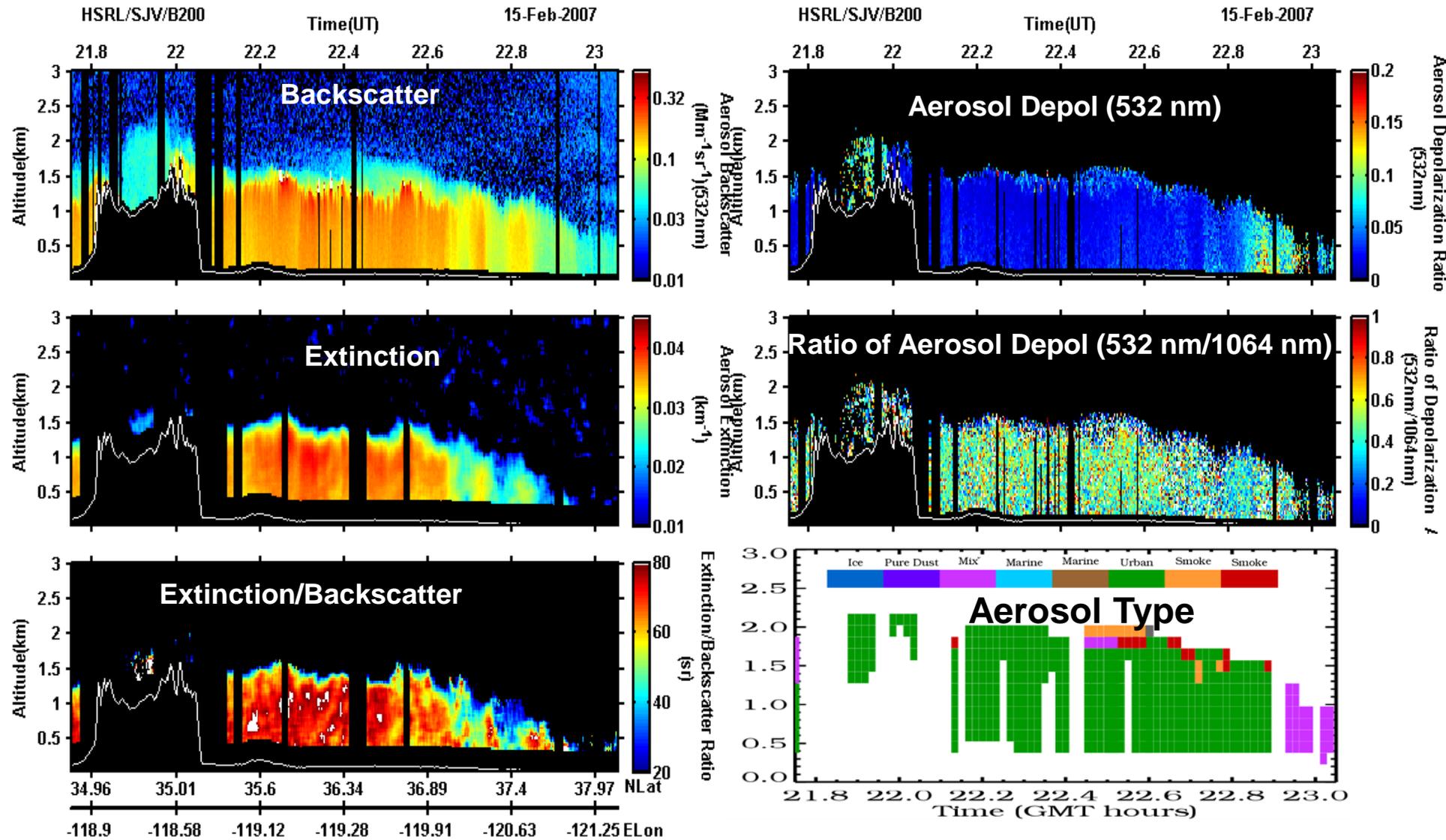
- Airborne HSRL aerosol backscatter measurements Feb. 15, 2007
- Highest AOT and PBL heights between Bakersfield and Fresno
- Low aerosol backscatter, extinction, AOT and PBL height in Sacramento region



NASA Langley Airborne HSRL Aerosol Backscatter Profiles Acquired on February 15, 2007 During Flight over San Joaquin Valley (SJV)



NASA Langley Airborne HSRL Aerosol Backscatter Profiles Acquired on February 15, 2007 During Flight over San Joaquin Valley (SJV)

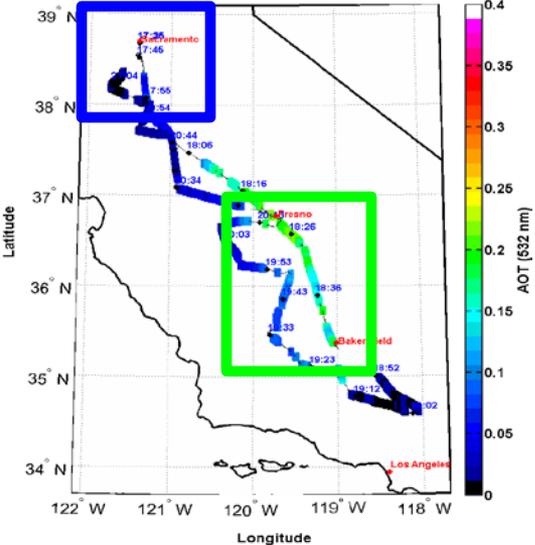


NASA Langley Airborne HSRL Aerosol Optical Thickness (AOT) Acquired on Several Flights During February 2007 over SJV

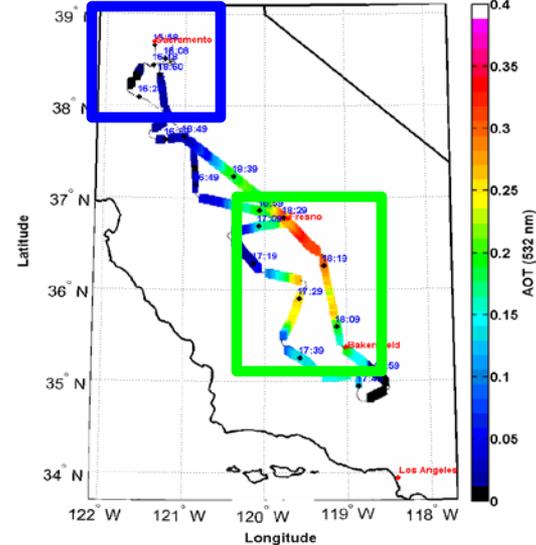


Highest AOT in SJV region; little AOT observed over or near Sacramento

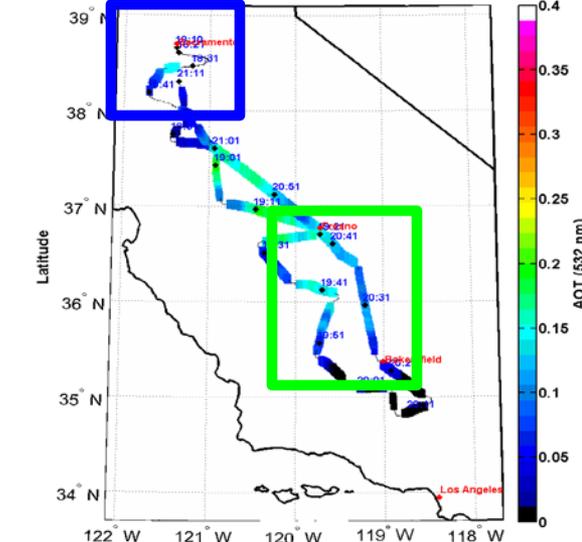
NASA Langley B200 HSRL SJV Feb. 14, 2007



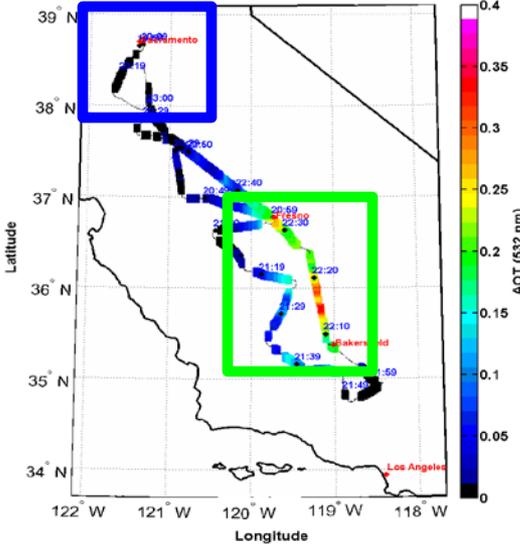
NASA Langley B200 HSRL SJV Feb. 16 L1, 2007



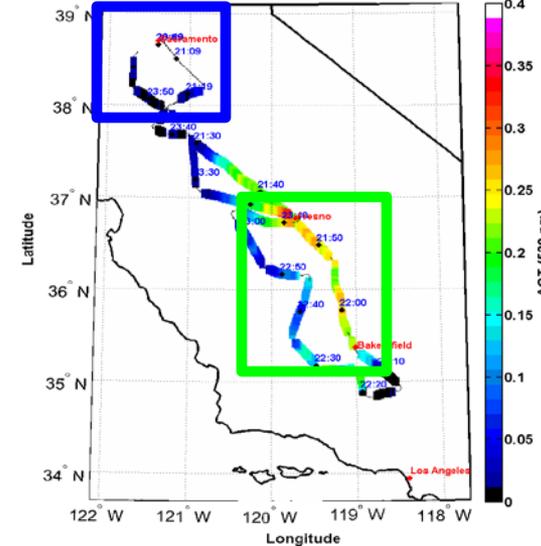
NASA Langley B200 HSRL SJV Feb. 17 L1, 2007



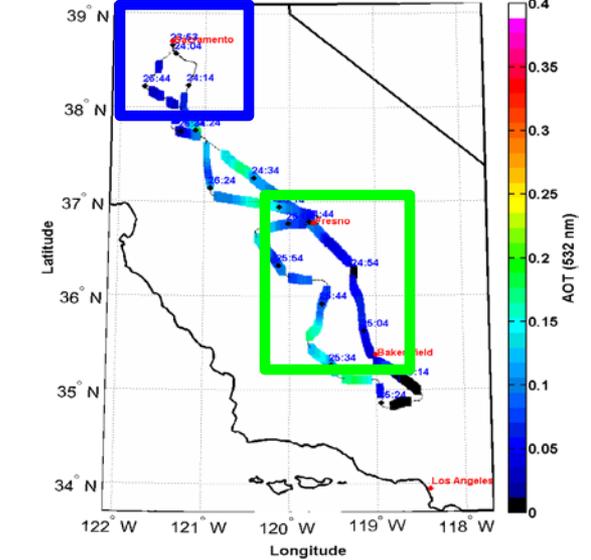
NASA Langley B200 HSRL SJV Feb. 15, 2007



NASA Langley B200 HSRL SJV Feb. 16 L2, 2007



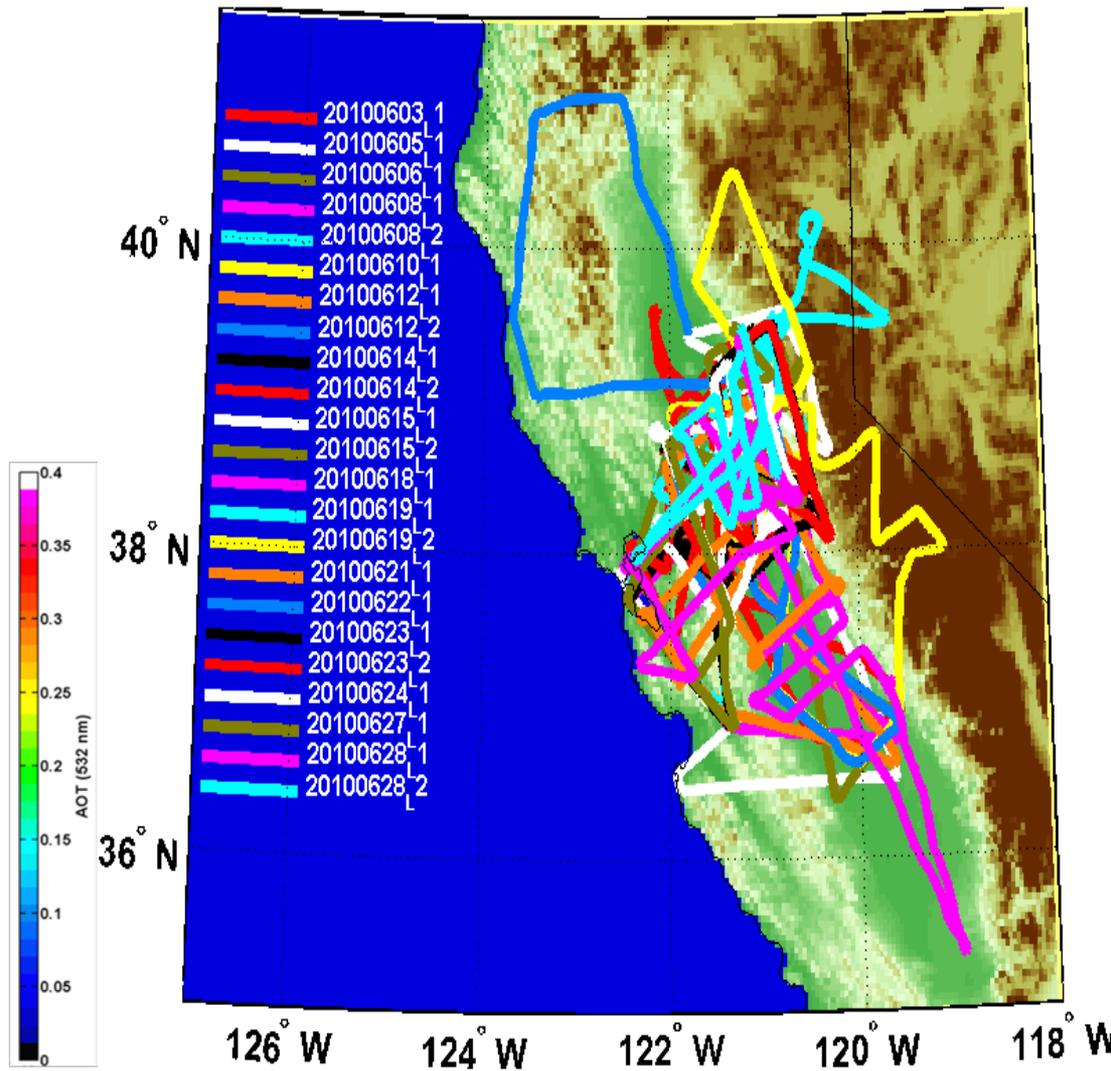
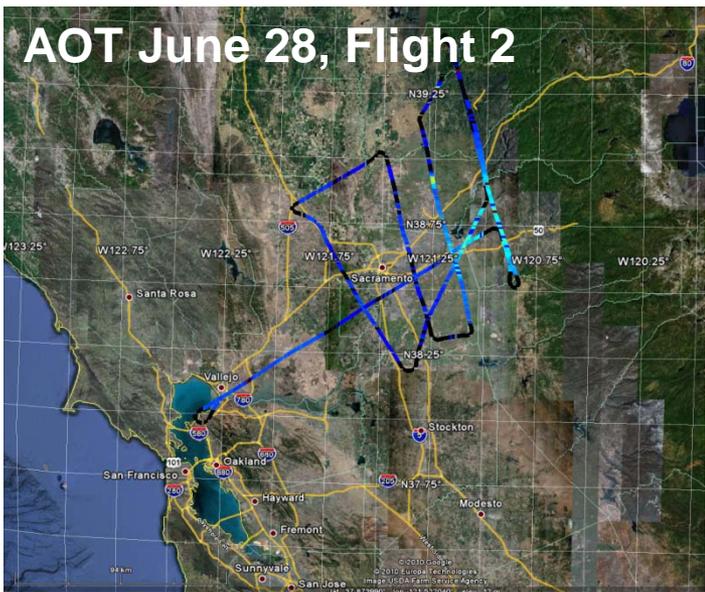
NASA Langley B200 HSRL SJV Feb. 17 L2, 2007





B200/HSRL Deployment during DOE CARES Mission June 2010

- Sacramento, California
- June 3 - 28
- 23 science flights (~68 hours)
 - 19 with DOE G1
 - 1 with NOAA R/V Atlantis
 - 2 with NOAA P3
 - 6 with NOAA Twin Otter
 - 11 with MODIS and/or MISR

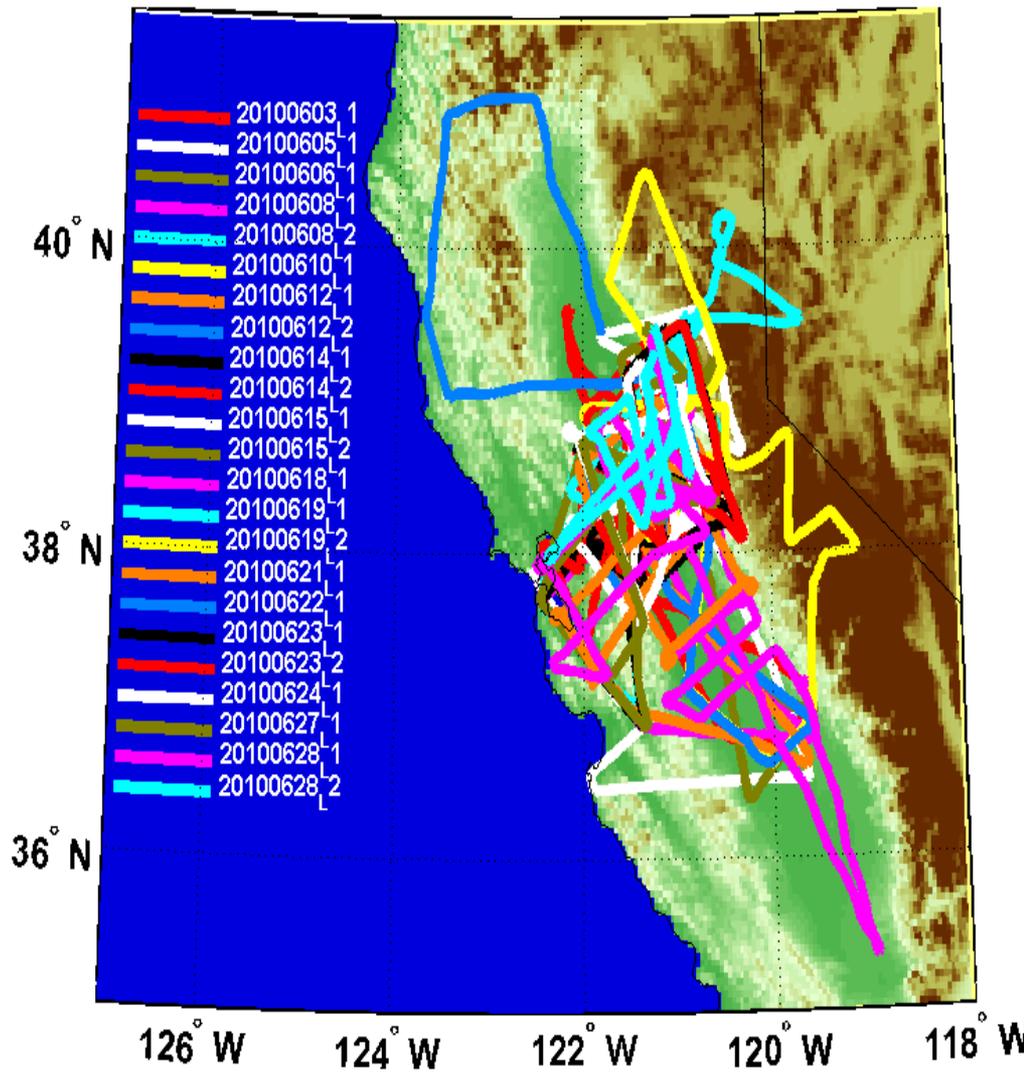
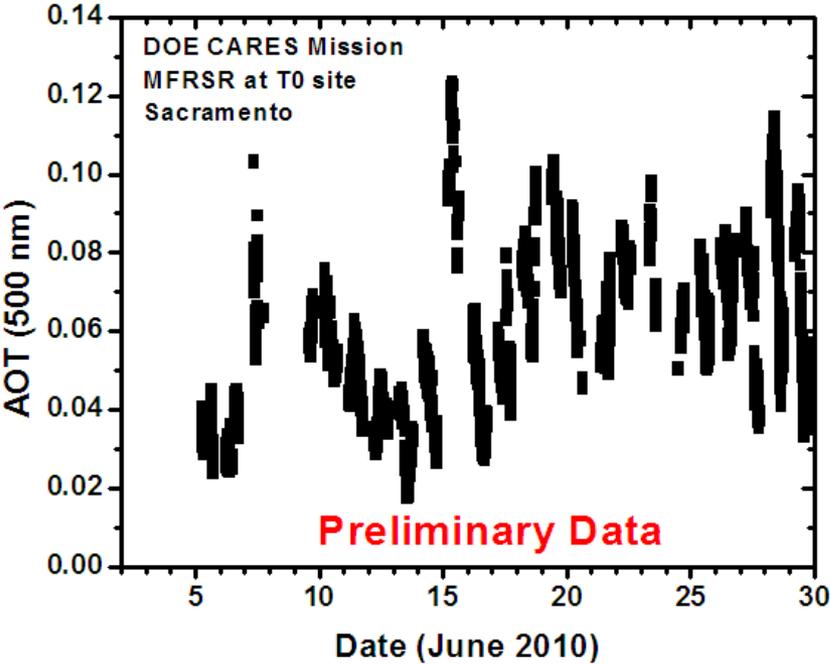




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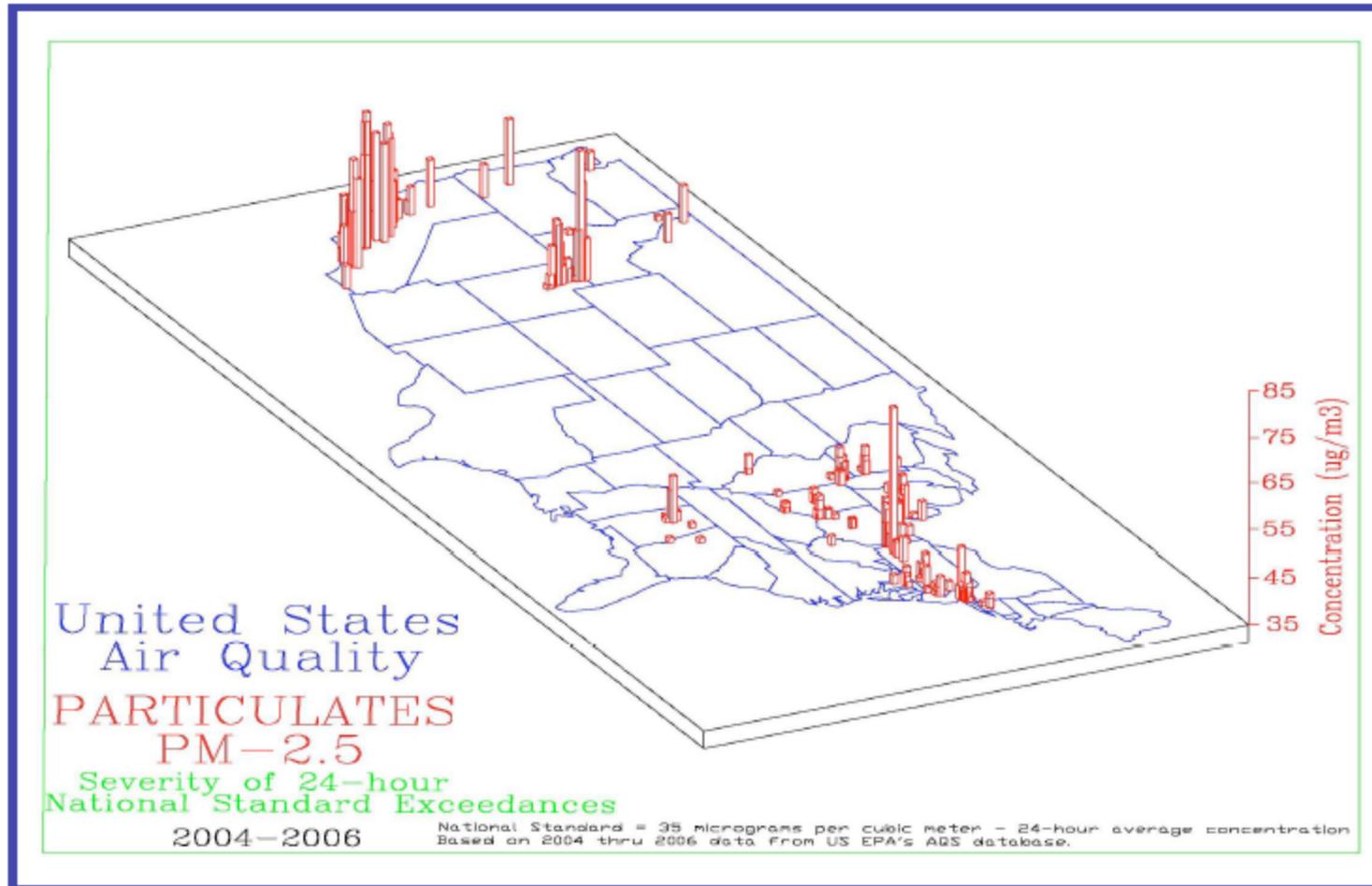
AOT was low!



High PM_{2.5} Concentrations



High PM_{2.5} Concentrations: 2004-2006 Exceedances

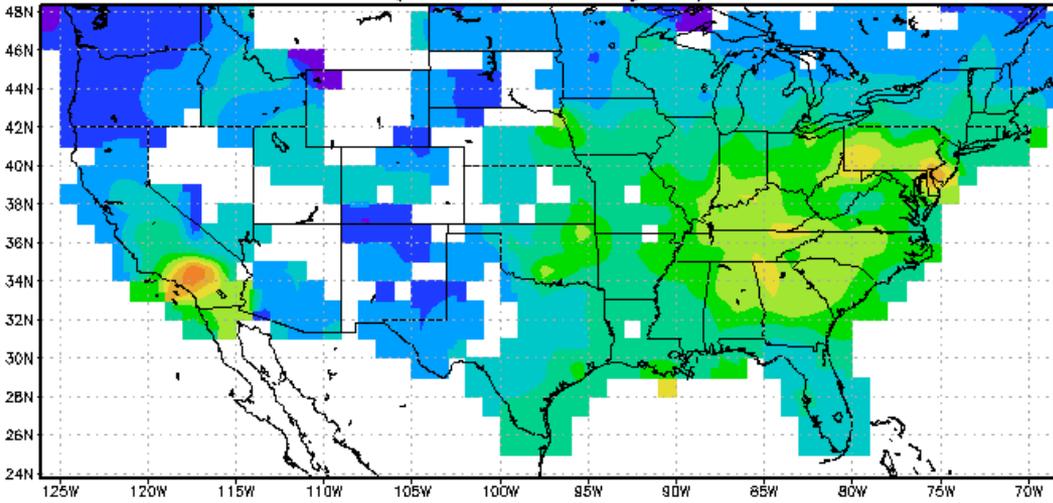
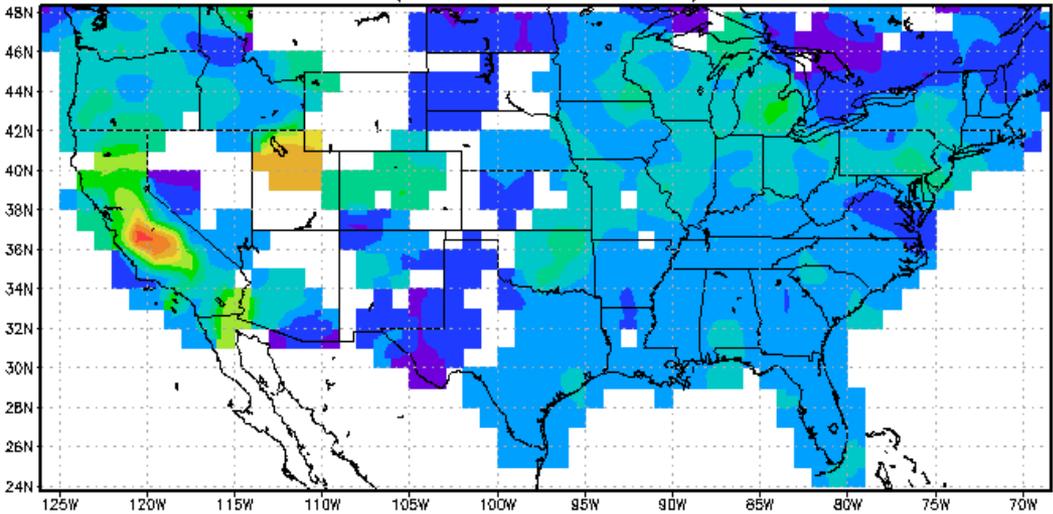


Average PM2.5 Concentrations During 2007



Jan-Feb 2007

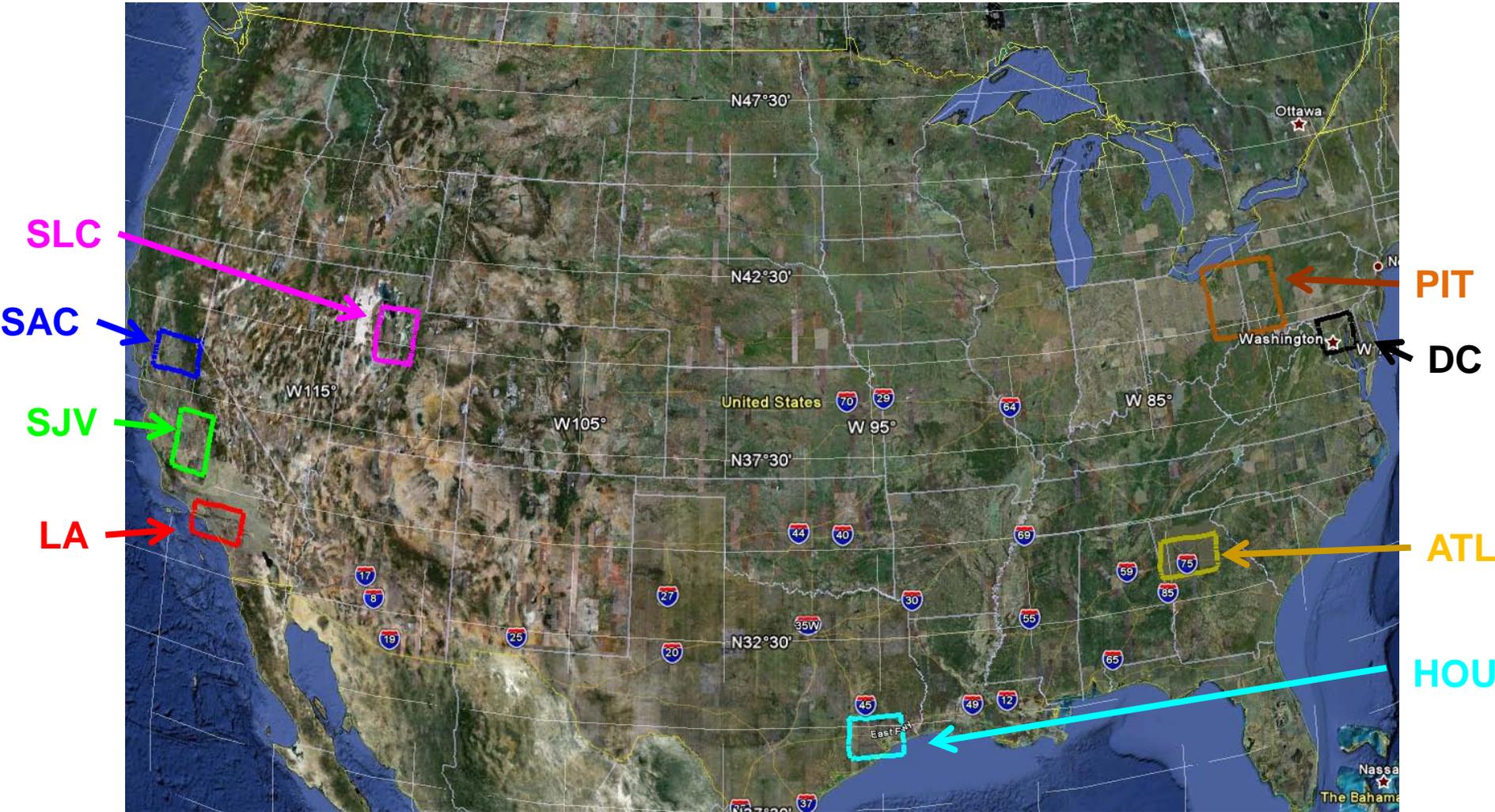
Jun-Aug 2007



Selected Regions of Interest

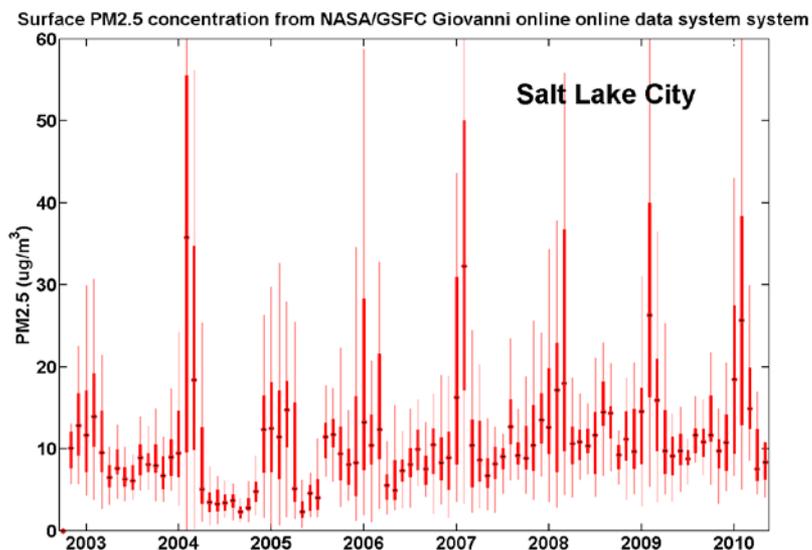
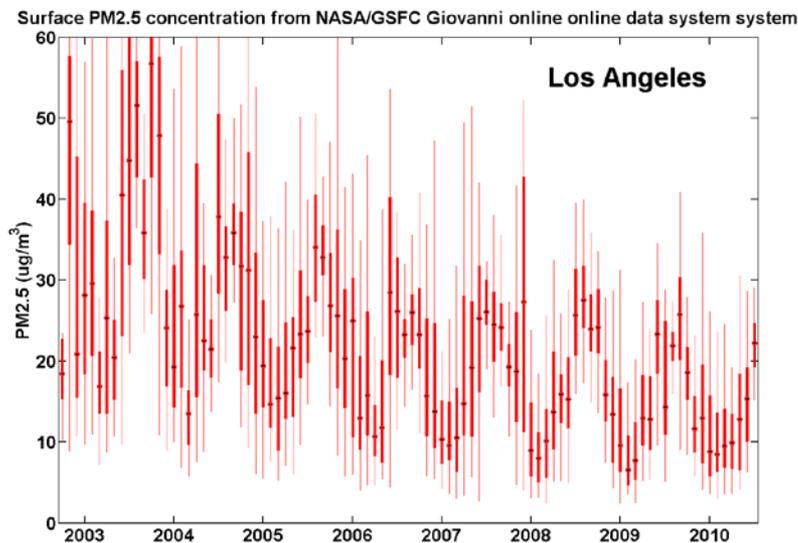
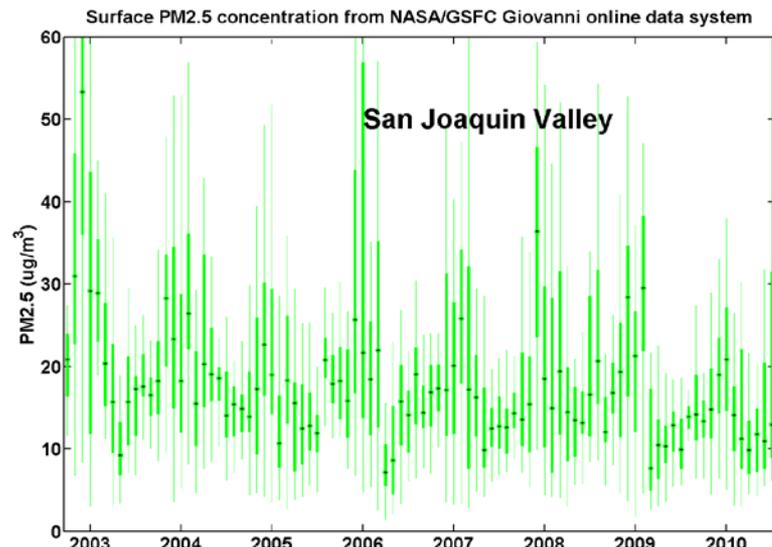
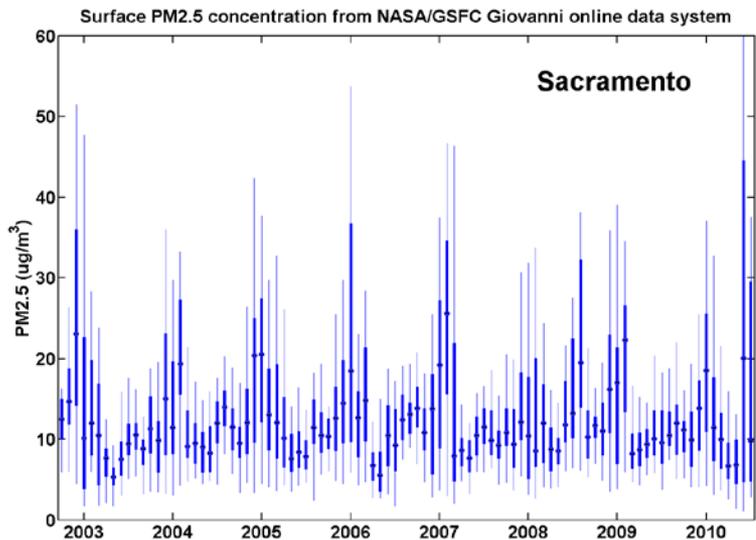


- Monthly median PM2.5 levels for locations of interest (7/2002-4/2010)



Data provided by NASA/GSFC Giovanni site

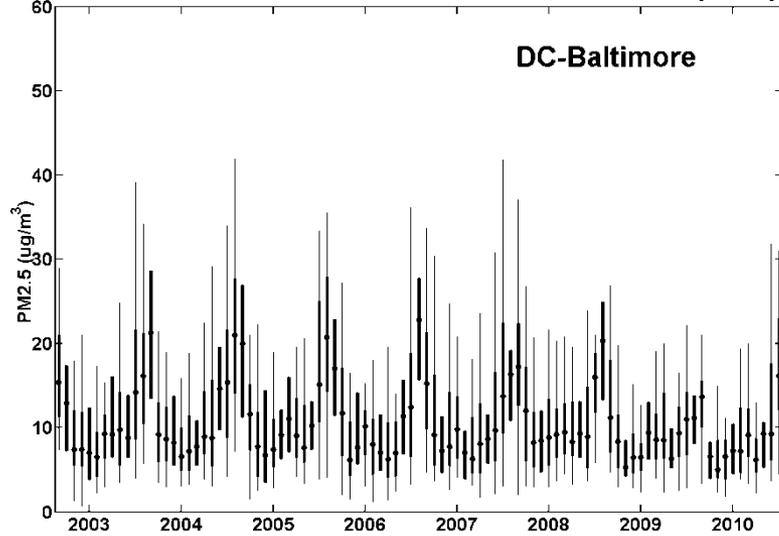
Box Plots Showing Monthly PM2.5 Concentrations for Selected Regions of Interest



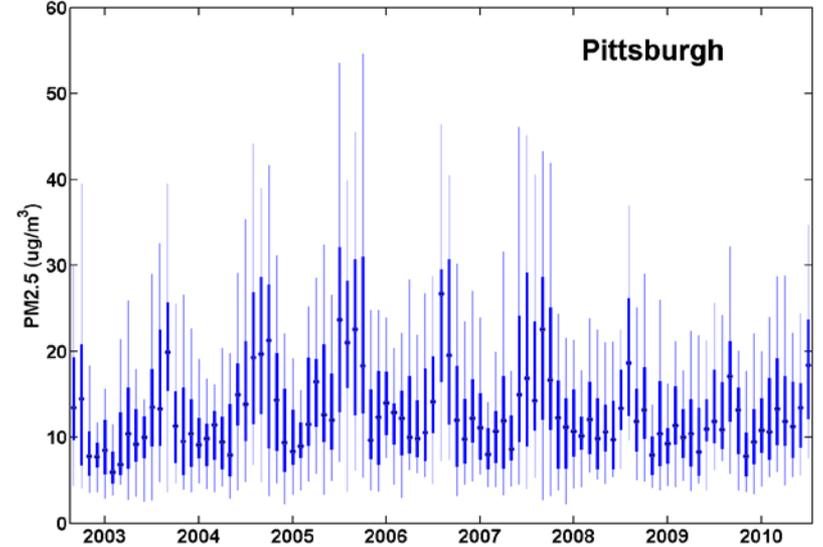
Box Plots Showing Monthly PM2.5 Concentrations for Selected Regions of Interest



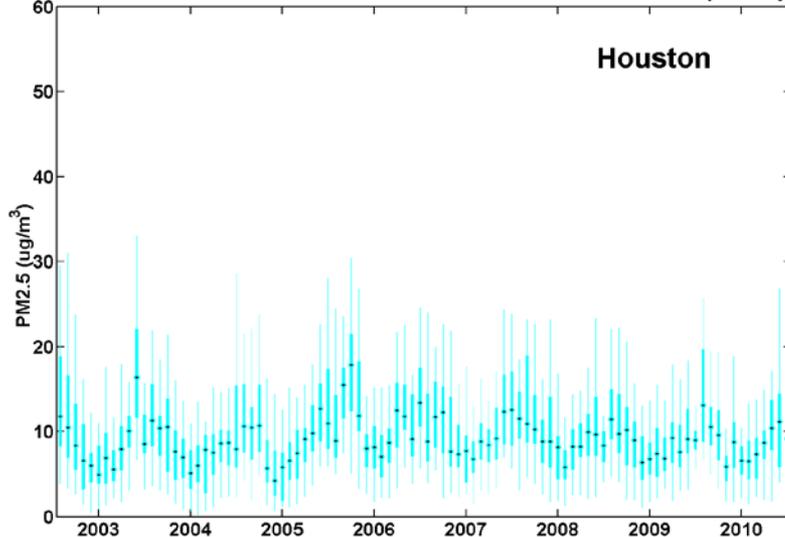
Surface PM2.5 concentration from NASA/GSFC Giovanni online data system



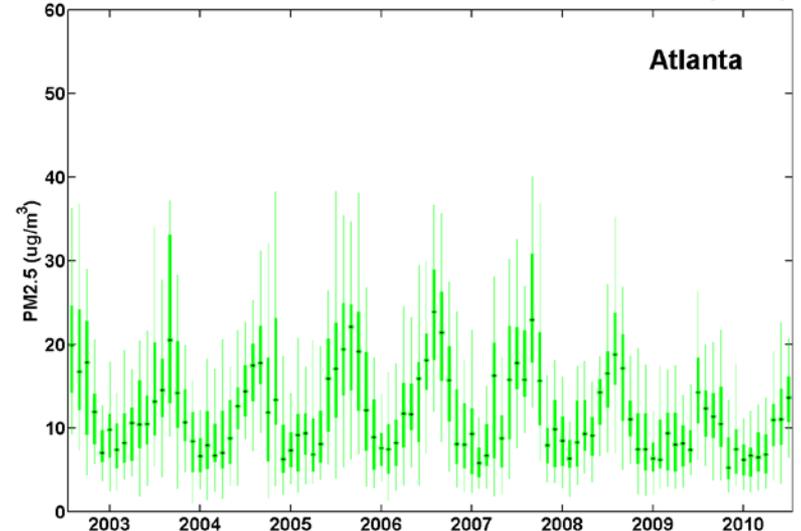
Surface PM2.5 concentration from NASA/GSFC Giovanni online data system



Surface PM2.5 concentration from NASA/GSFC Giovanni online data system



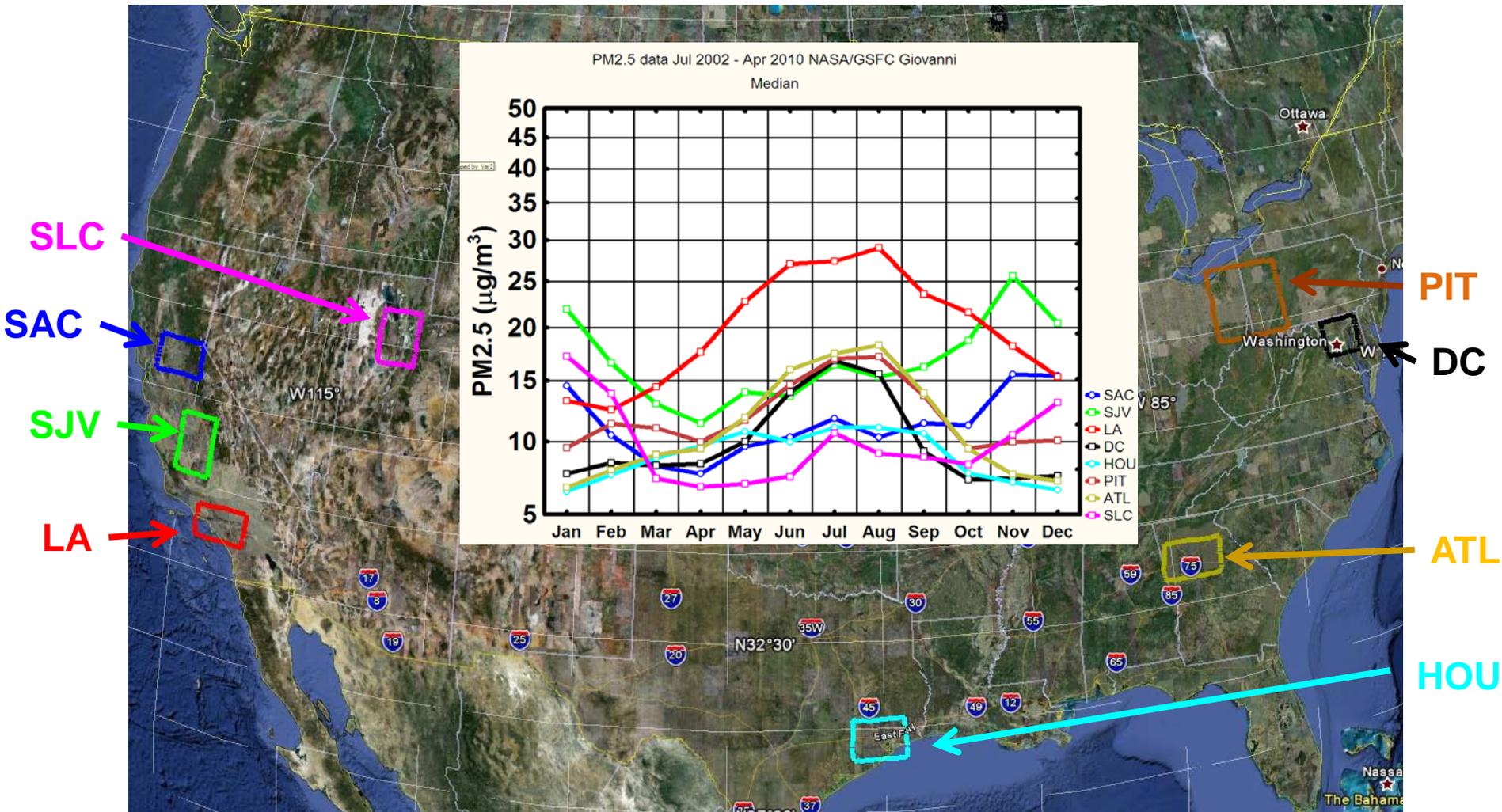
Surface PM2.5 concentration from NASA/GSFC Giovanni online data system





Monthly Median PM2.5 Concentrations for Selected Regions of Interest

- Monthly median PM2.5 levels for locations of interest (7/2002-4/2010)

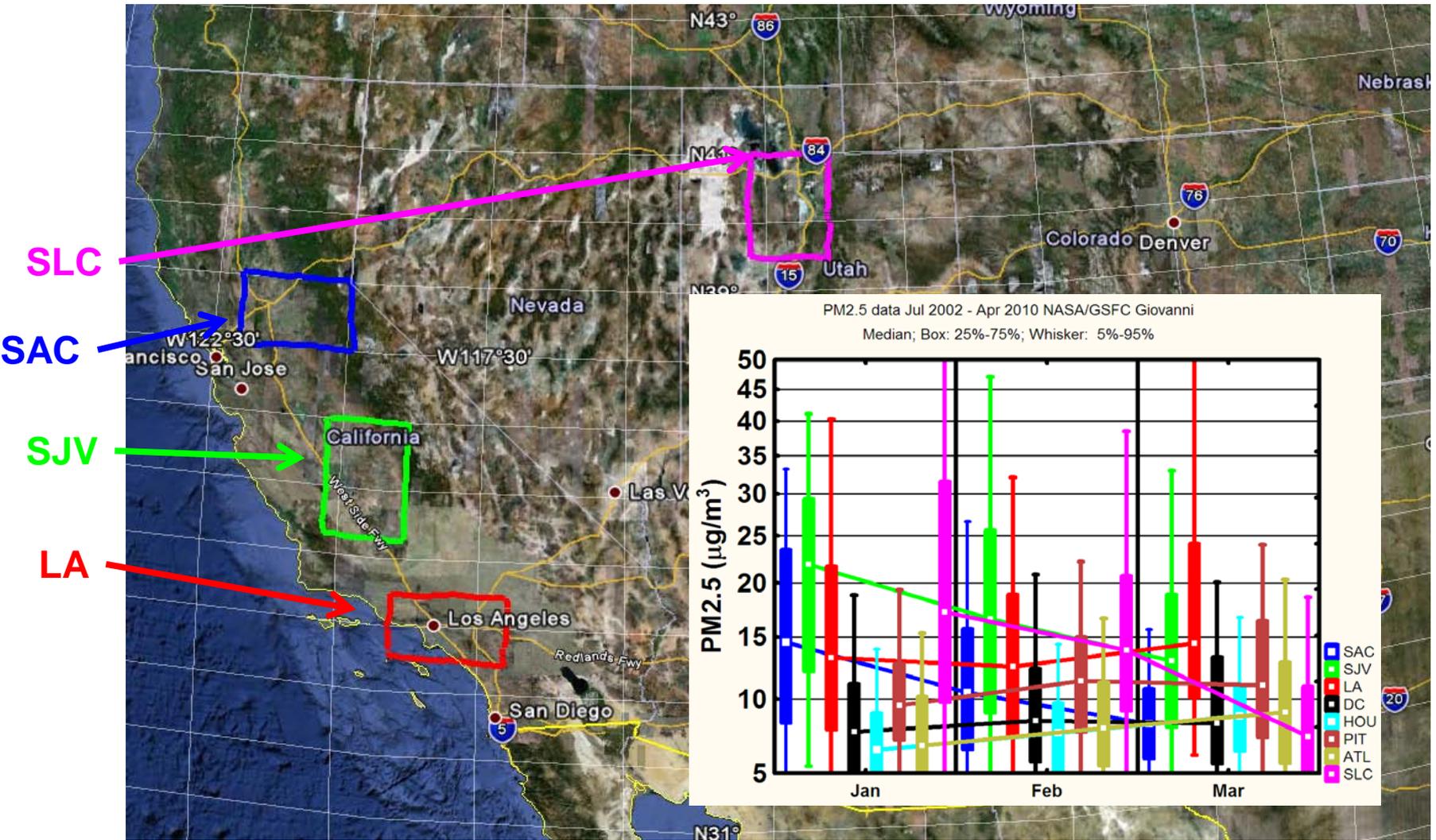


Data provided by NASA/GSFC Giovanni site



Box Plots Showing Monthly PM2.5 Concentrations During January-March for Selected Regions of Interest

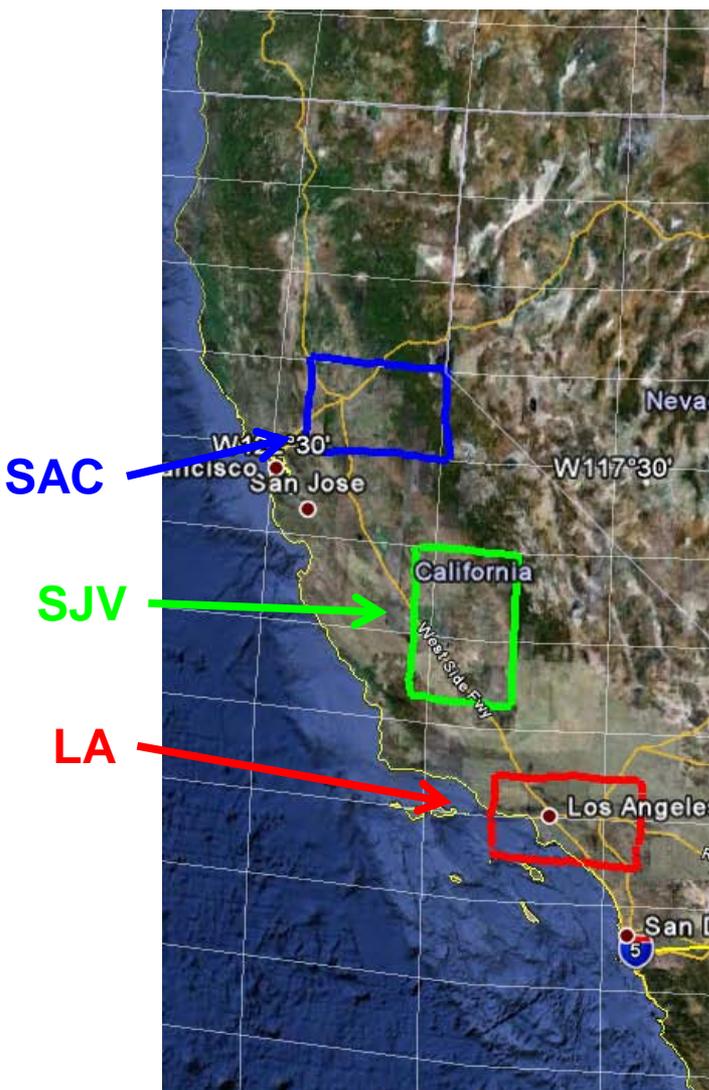
- January-March PM2.5 levels for locations of interest (7/2002-4/2010)
- SJV has highest median values, followed by SLC



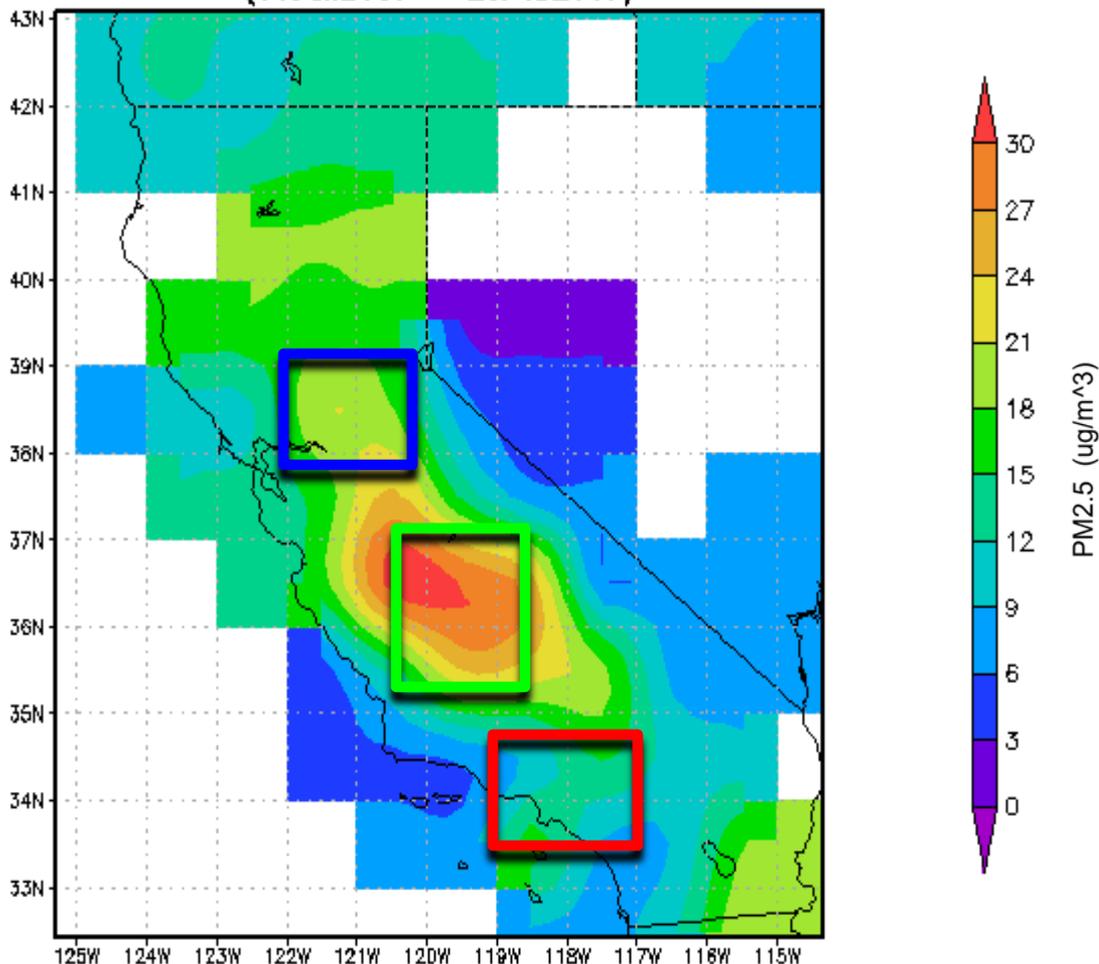
PM2.5 Concentrations Over California During January-February 2007 March for Selected Regions of Interest



- SJV region has highest values



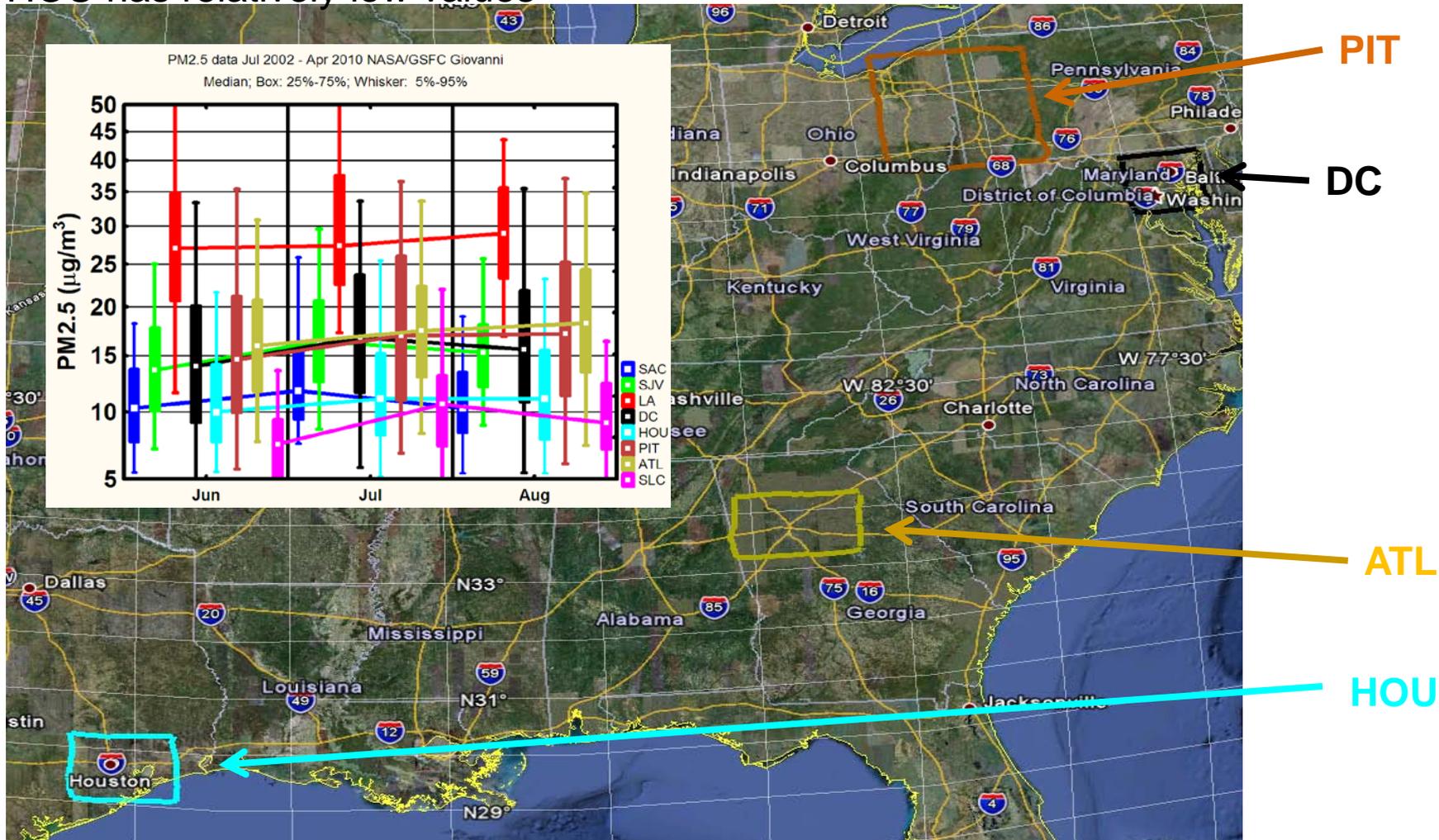
AIRNOW_PM.001 Fine Particulate Matter - PM2.5 [$\mu\text{g}/\text{m}^3$]
(01Jan2007 - 28Feb2007)



Box Plots Showing Monthly PM2.5 Concentrations During June-August for Selected Regions of Interest



- June- August PM2.5 levels for locations of interest (7/2002-4/2010)
- LA has highest median values, followed by DC, PIT, ATL
- HOU has relatively low values

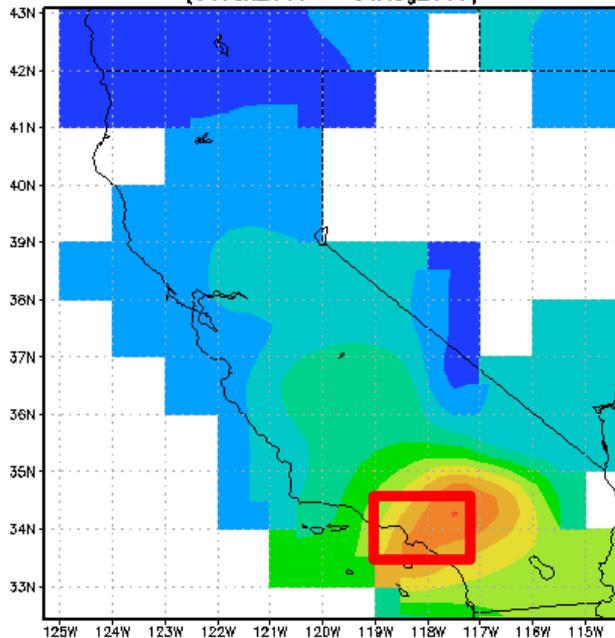


PM2.5 Concentrations Over California and Eastern U.S. During June-August 2007 for Selected Regions of Interest

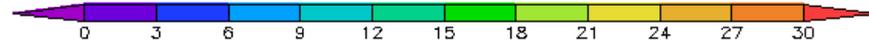
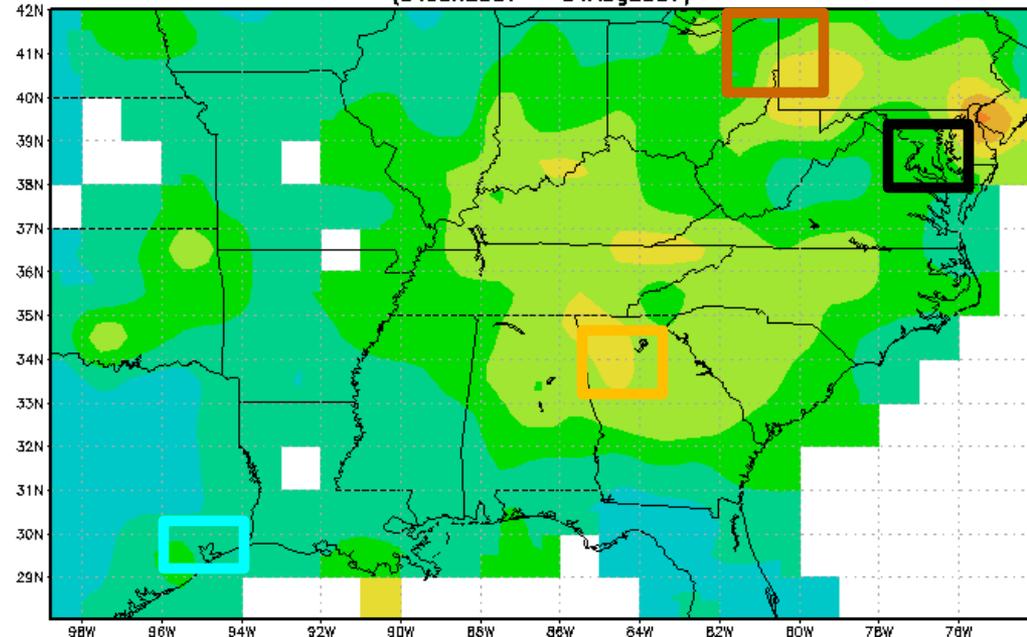


- June- August PM2.5 levels for locations of interest (7/2002-4/2010)
- LA has highest median values, followed by DC, PIT, ATL
- HOU has relatively low values

AIRNOW_PM.001 Fine Particulate Matter - PM2.5 [$\mu\text{g}/\text{m}^3$]
(01Jun2007 - 31Aug2007)



AIRNOW_PM.001 Fine Particulate Matter - PM2.5 [$\mu\text{g}/\text{m}^3$]
(01Jun2007 - 31Aug2007)





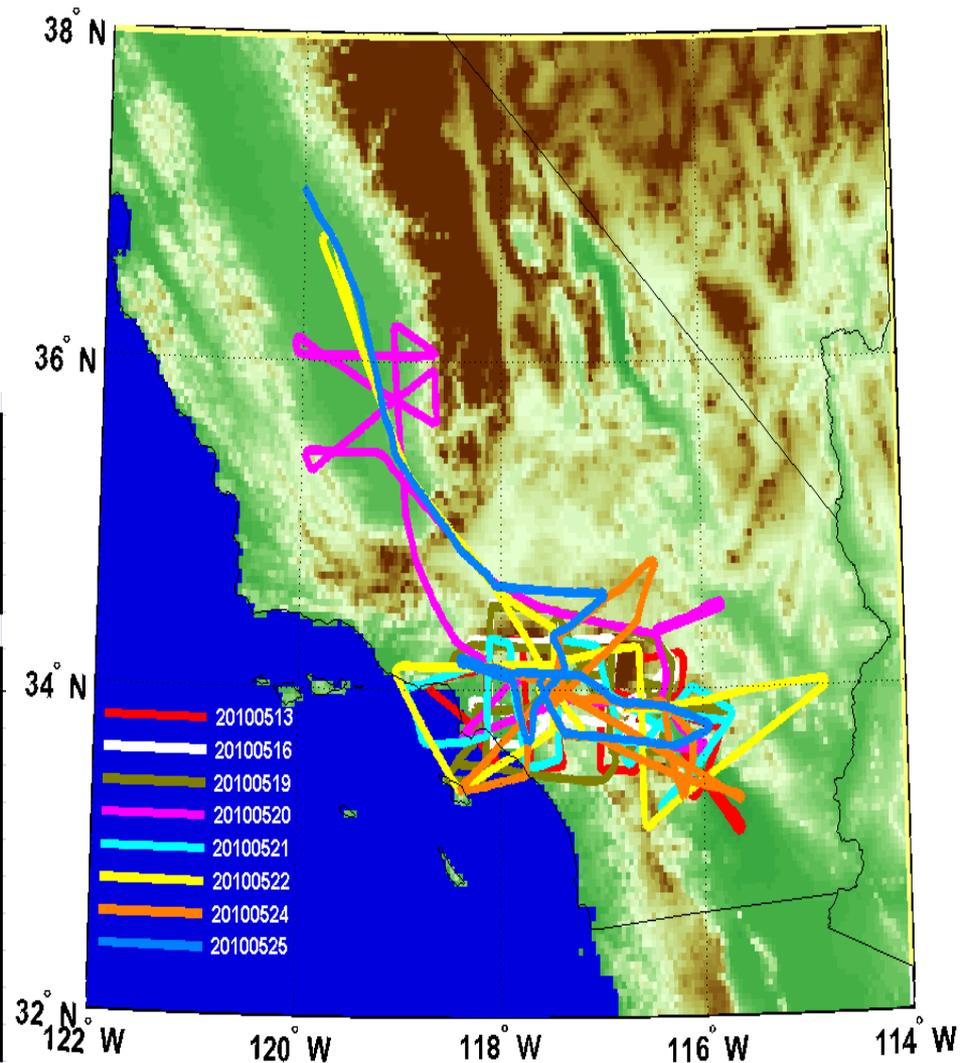
B200/HSRL Deployment over Los Angeles during NOAA CALNEX Mission May 2010

- Ontario, California
- May 13-25
- 8 science flights (~29.5 hours)
 - 6 with CIRPAS Twin Otter
 - 2 with NOAA P3
 - 6 with MODIS and/or MISR

| | |
|--|--|
| | Aircraft and HSRL spatially and temporally coordinated flights |
| | Aircraft and HSRL flew partially coordinated flights |
| | Aircraft and HSRL flew UNCOORDINATED flights |
| | B200 Transit flight |
| | Aircraft operations unknown |
| | Aircraft did not fly CalNex science flight |

| Date | HSRL Flight Number | HSRL Data Filename | CIRPAS Twin Otter ² | NOAA P-3 ² | Satellite underflight? |
|----------|--------------------|--------------------|--------------------------------|-----------------------|-------------------------|
| 05/12/10 | R-220b | 20100512_L2 | | | |
| 05/13/10 | R-221 | 20100513_L1 | Morning Flight | | |
| 05/14/10 | | | | | |
| 05/16/10 | R-223 | 20100516_L1 | | | Aqua MODIS |
| 05/19/10 | R-224 | 20100519_L1 | | | Aqua MODIS |
| 05/20/10 | R-225 | 20100520_L1 | | | Aqua MODIS |
| 05/21/10 | R-226 | 20100521_L1 | | | |
| 05/22/10 | R-227 | 20100522_L1 | | | Aqua MODIS |
| 05/24/10 | R-228 | 20100524_L1 | | | Terra, Aqua MODIS; MISR |
| 05/25/10 | R-229 | 20100525_L1 | | | Aqua MODIS |

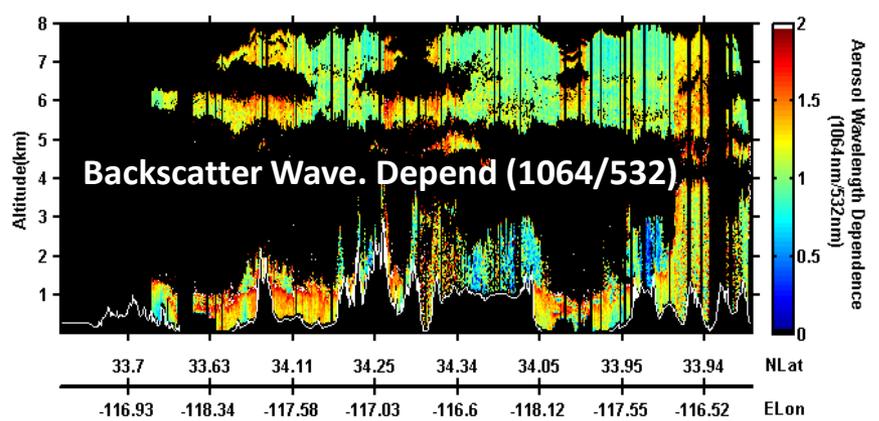
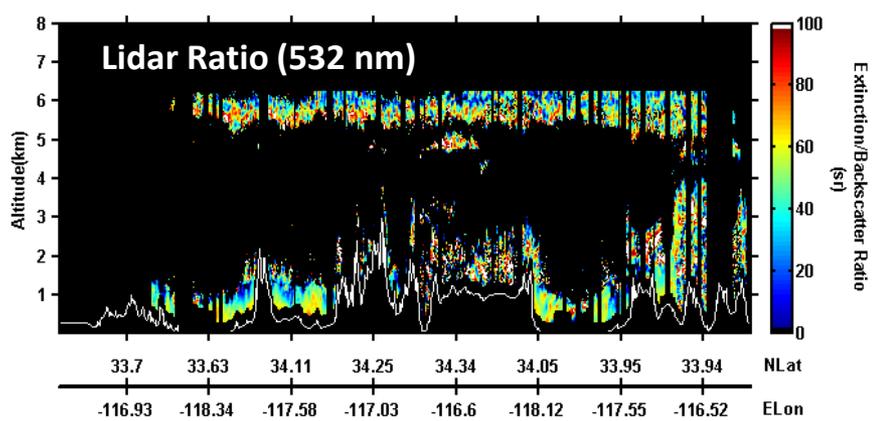
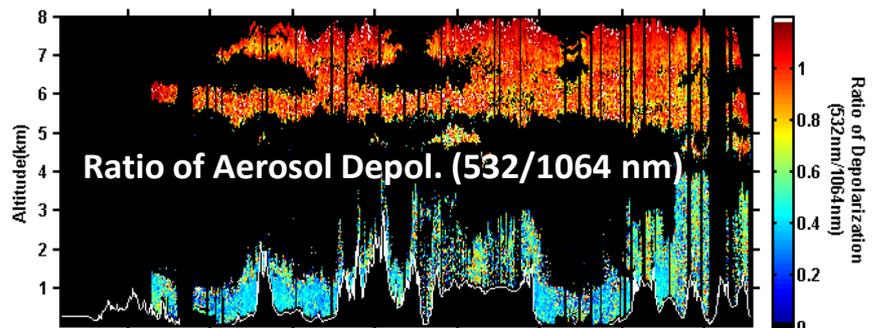
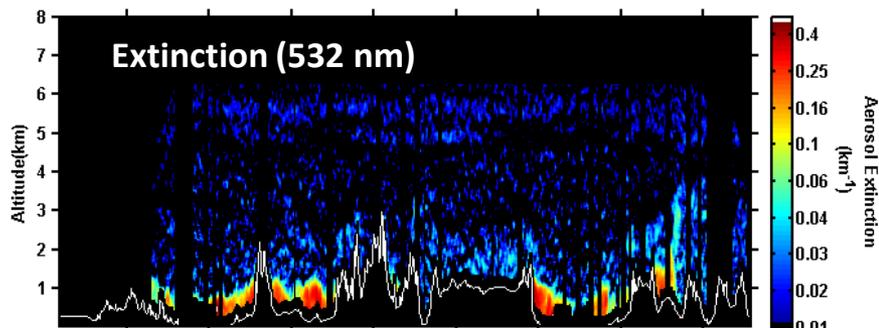
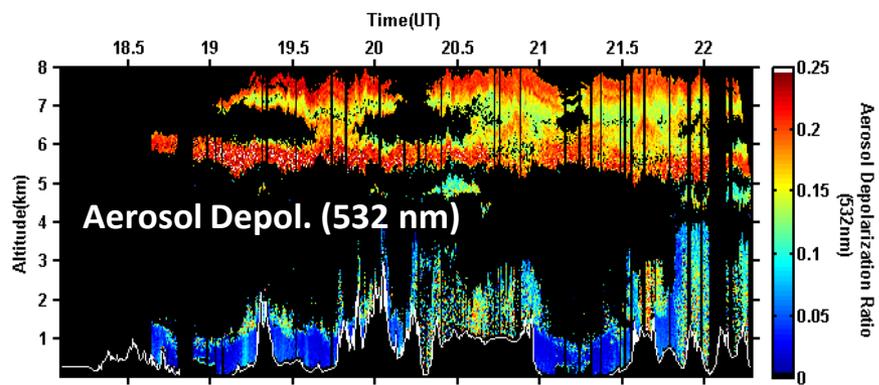
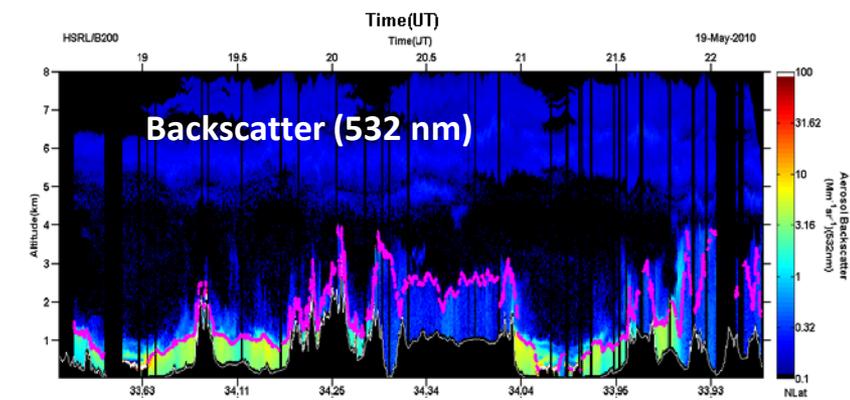
| | | | |
|---|---|---|---|
| Total Number of Coordinated Flights with NASA HSRL: | 6 | 2 | 6 |
|---|---|---|---|



HSRL data over Los Angeles during May 19, 2010

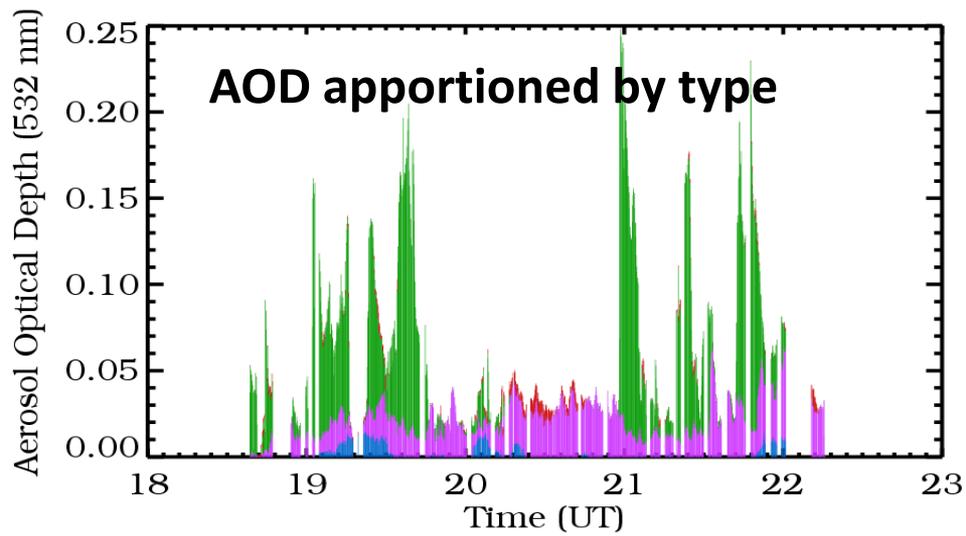
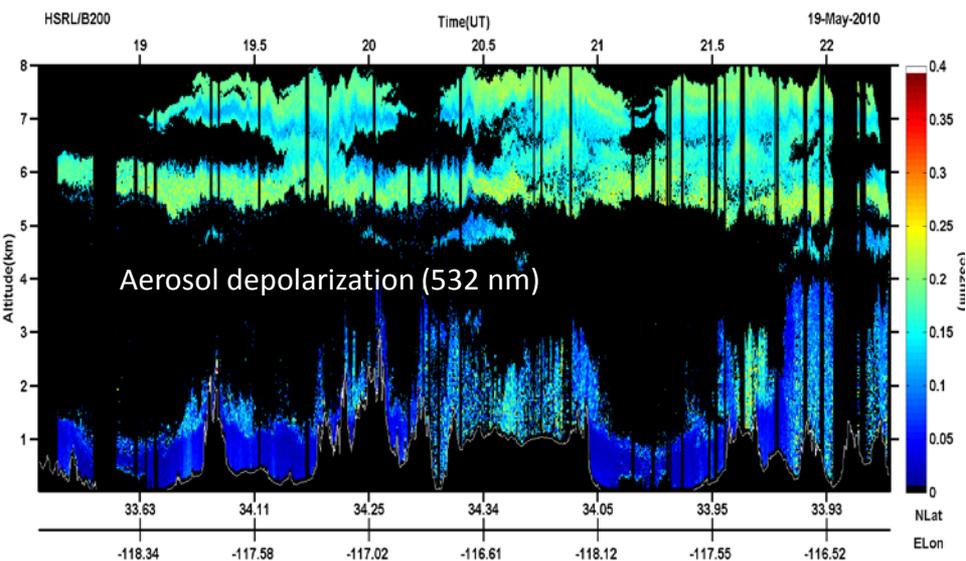
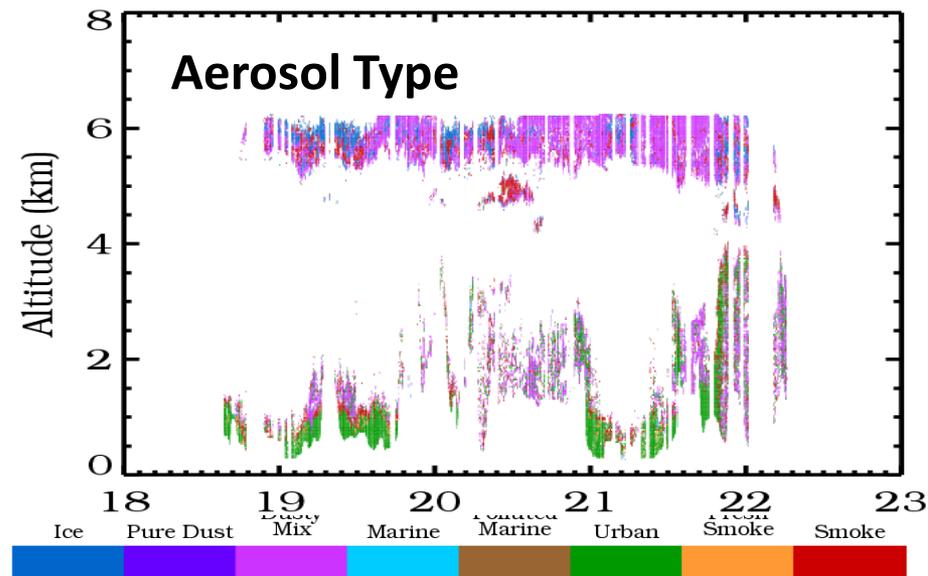
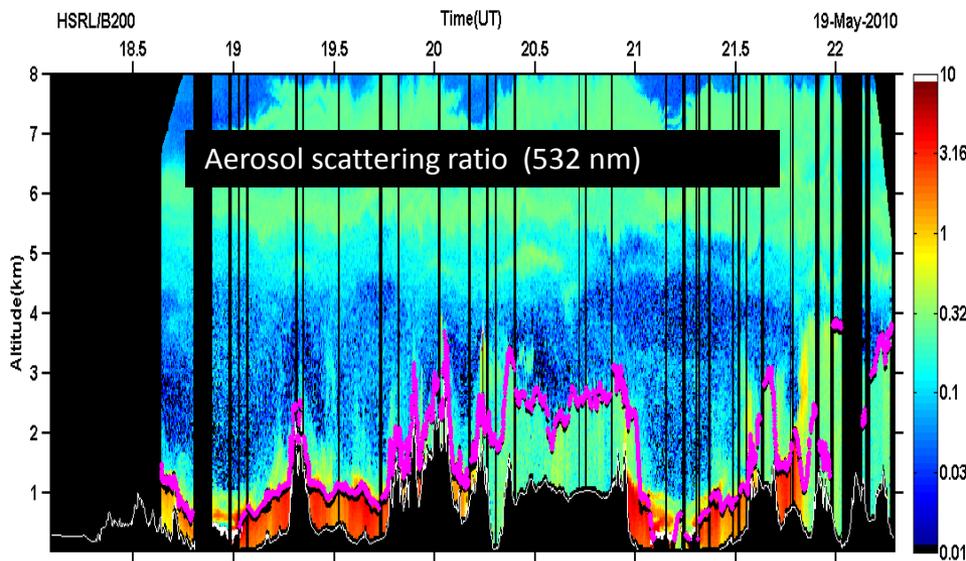


CALNEX flight



HSRL data over Los Angeles during May 19, 2010

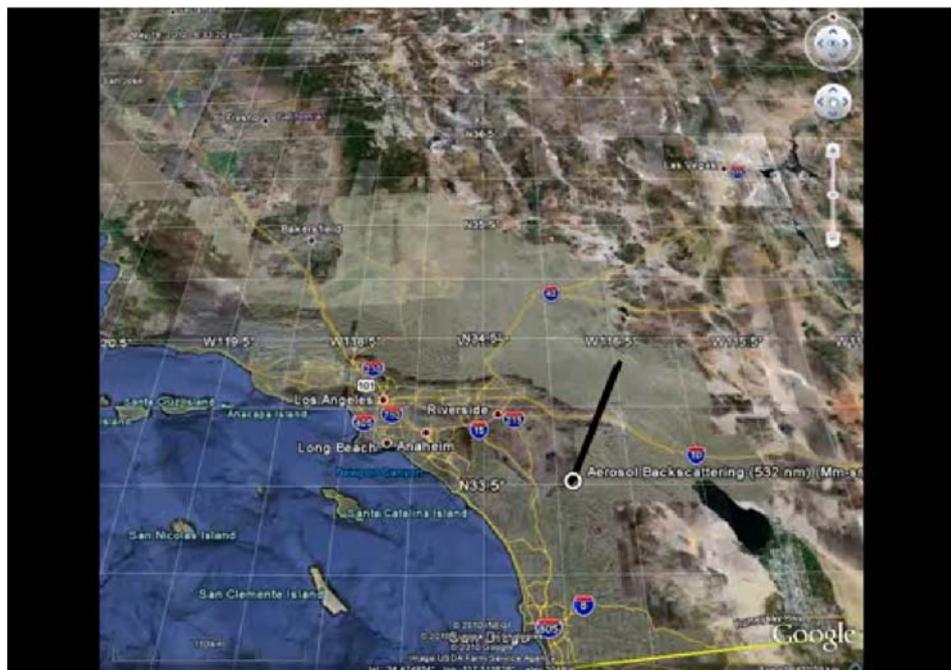
CALNEX flight



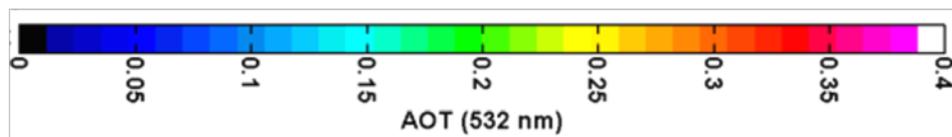
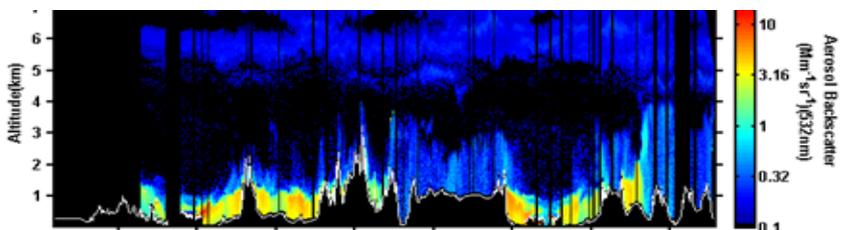
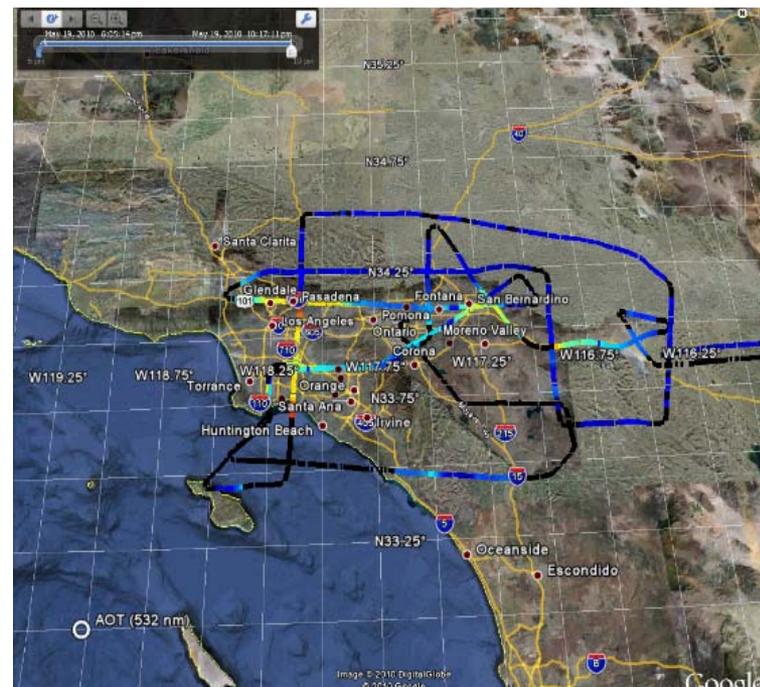
HSRL Measurements over Los Angeles - May 19, 2010



Aerosol Backscatter (532 nm)



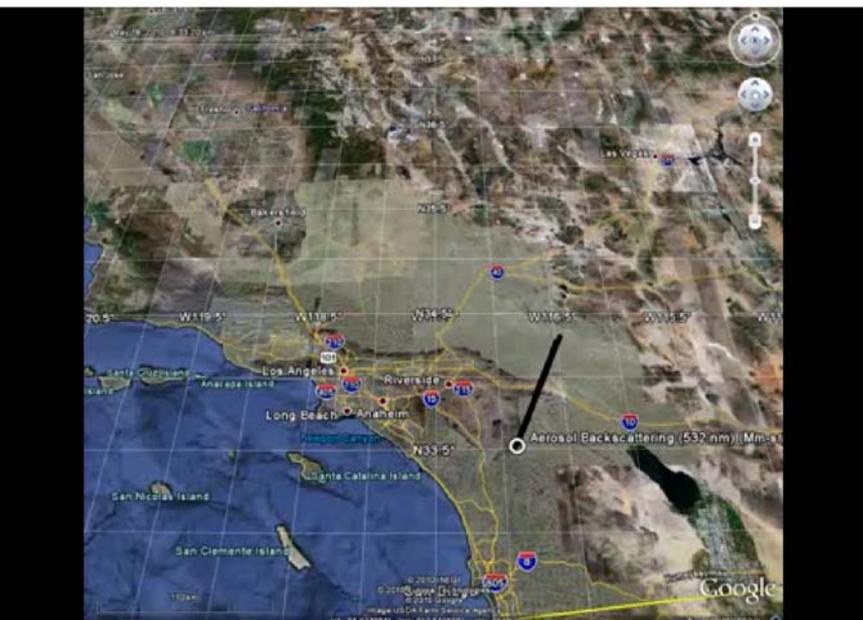
Aerosol Optical Thickness



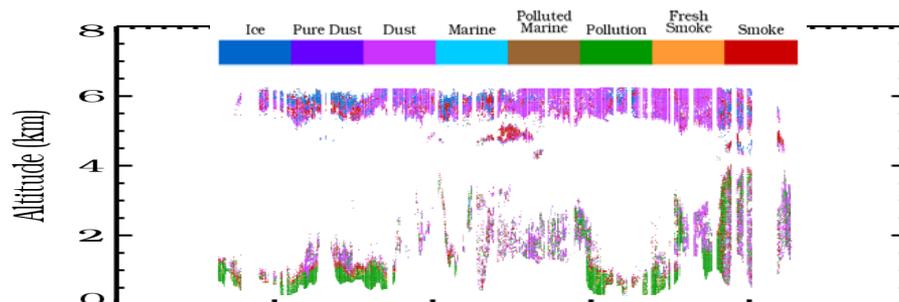
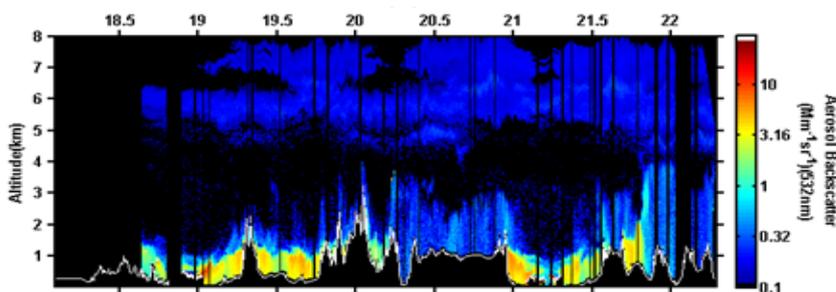
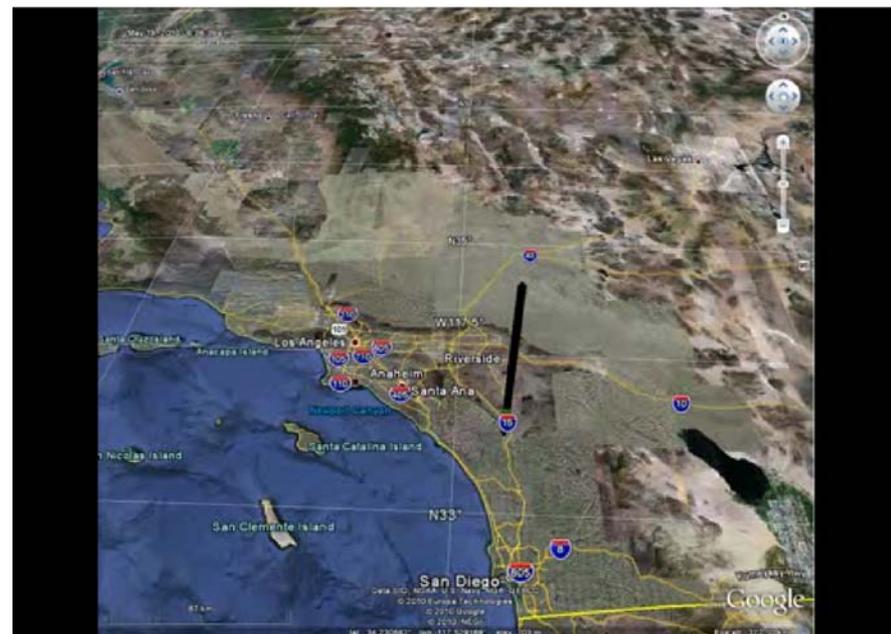
HSRL Measurements over Los Angeles - May 19, 2010



Aerosol Backscatter (532 nm)

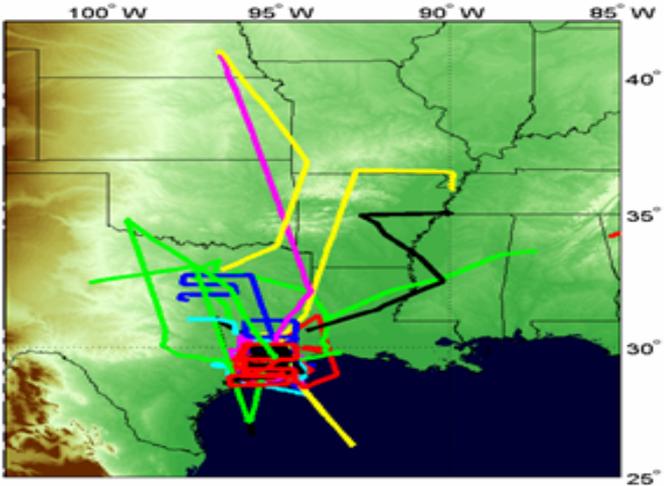


Aerosol Type



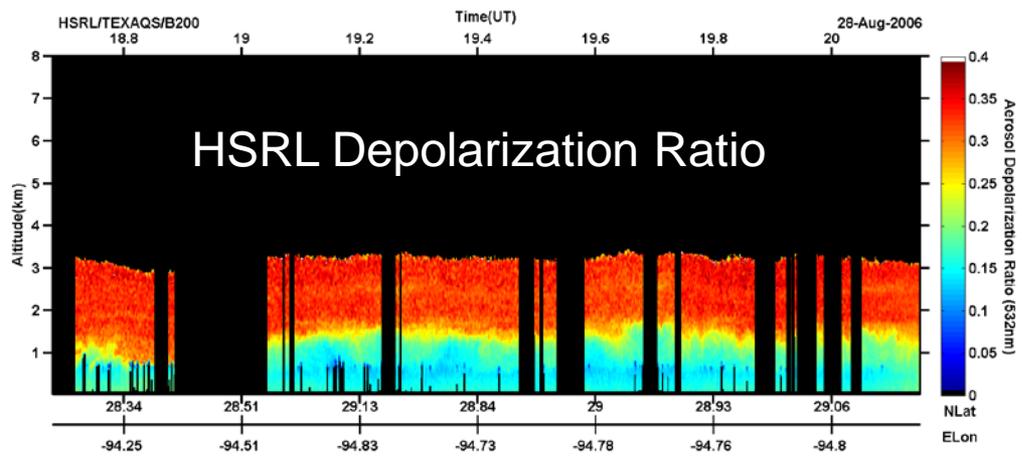
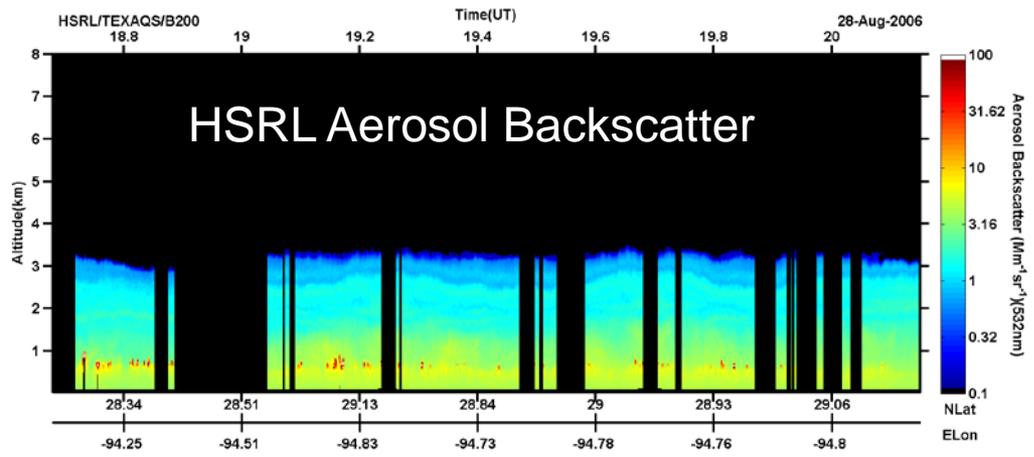


B200/HSRL Deployment over Houston during NOAA CALNEX Mission May 2010



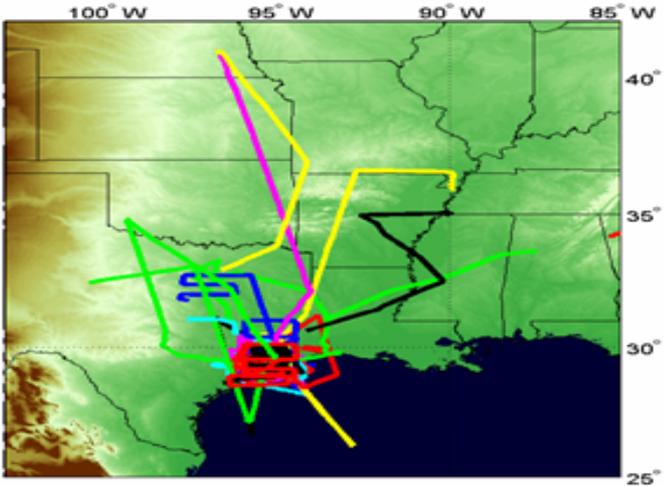
TexAQS II/GoMACCS
NOAA-DOE-NASA
Aug 27 – Sep 29

- 22 science flights,
>90 flight hours
- 7 flights with NOAA WP-3
 - 6 flights with NOAA Twin Otter
 - 7 flights with CIRPAS Twin Otter
 - 2 flights over the RHB
 - Numerous Overflights of Moody Tower
 - 10 CALIPSO validation flights
 - 4 MISR LM coincidences
 - 14 MODIS coincidences



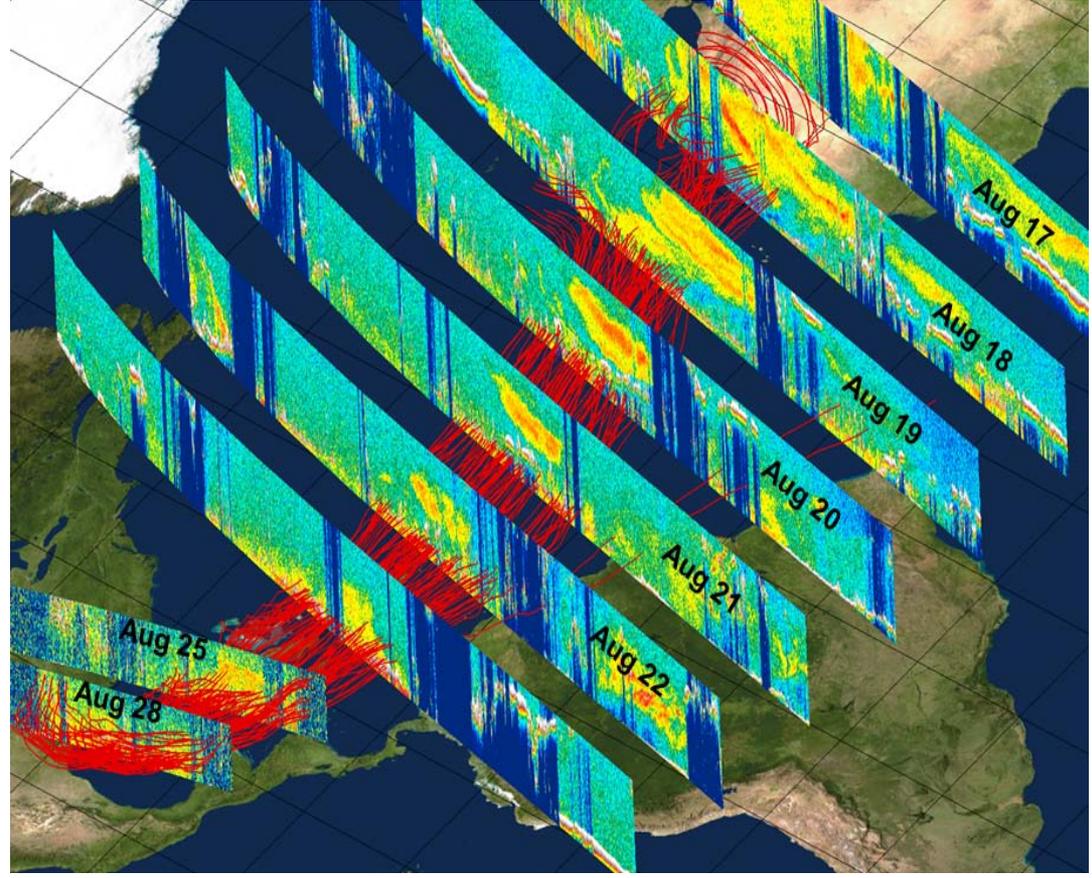


B200/HSRL Deployment over Houston during NOAA CALNEX Mission May 2010



TexAQS II/GoMACCS
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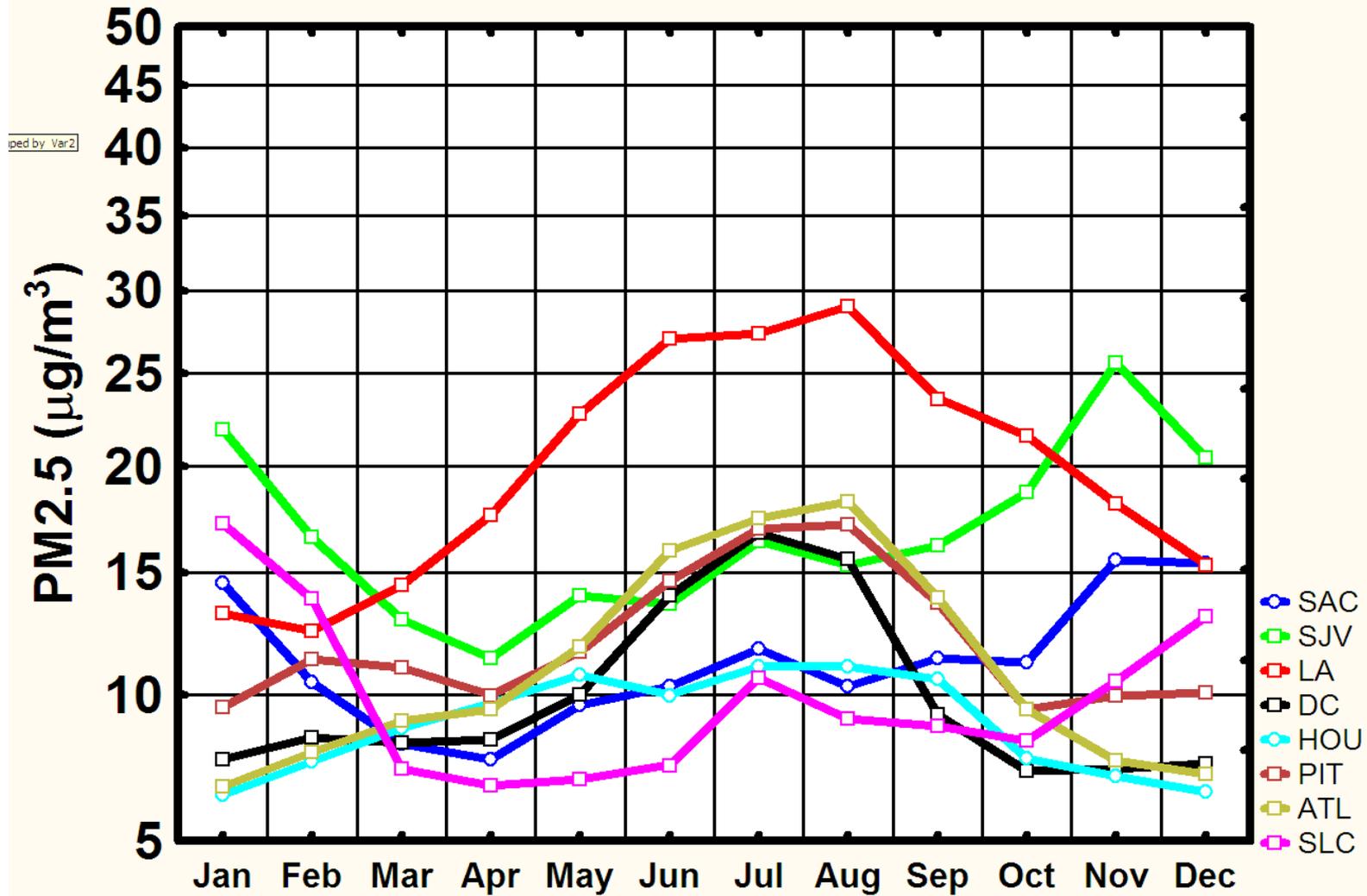




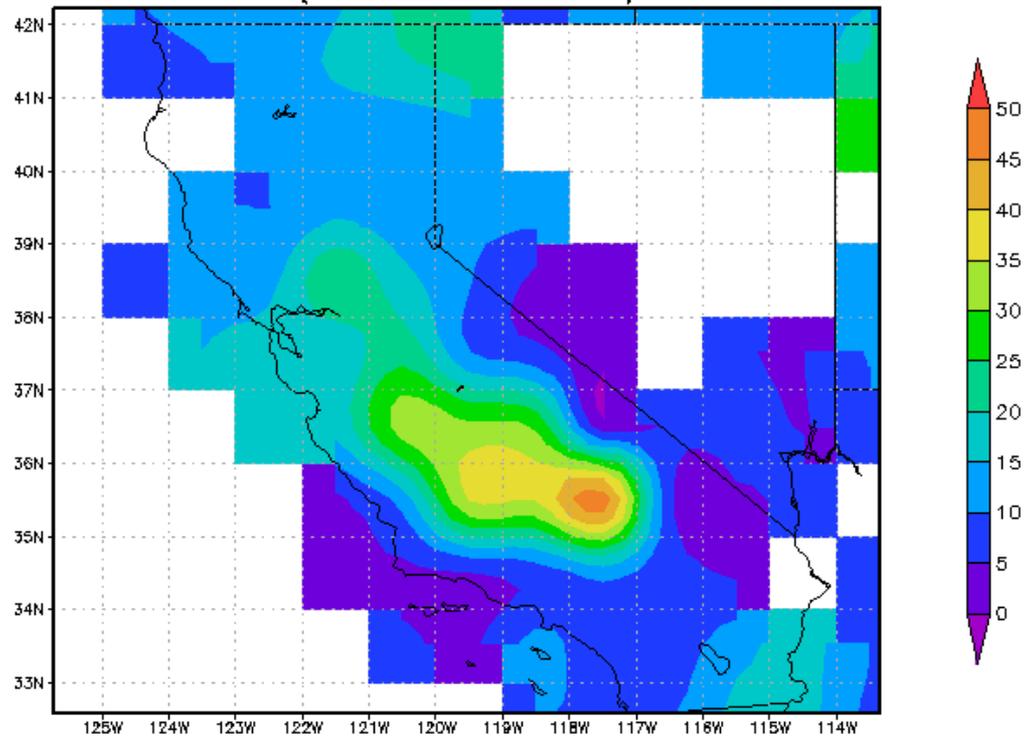


PM2.5 data Jul 2002 - Apr 2010 NASA/GSFC Giovanni

Median



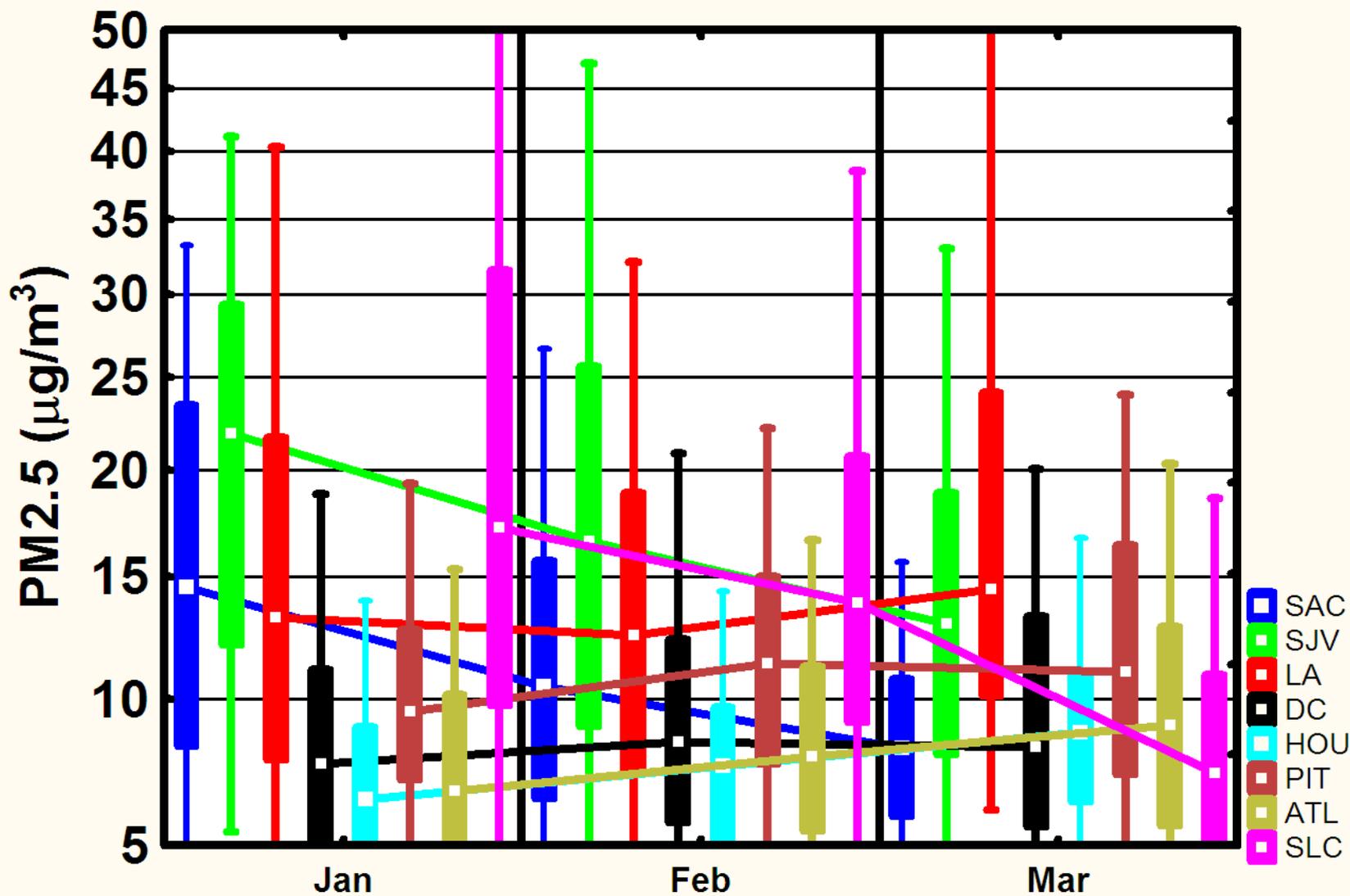
AIRNOW_PM.001_Fine Particulate Matter - PM2.5 [$\mu\text{g}/\text{m}^3$]
(01Jan2009 - 31Jan2009)





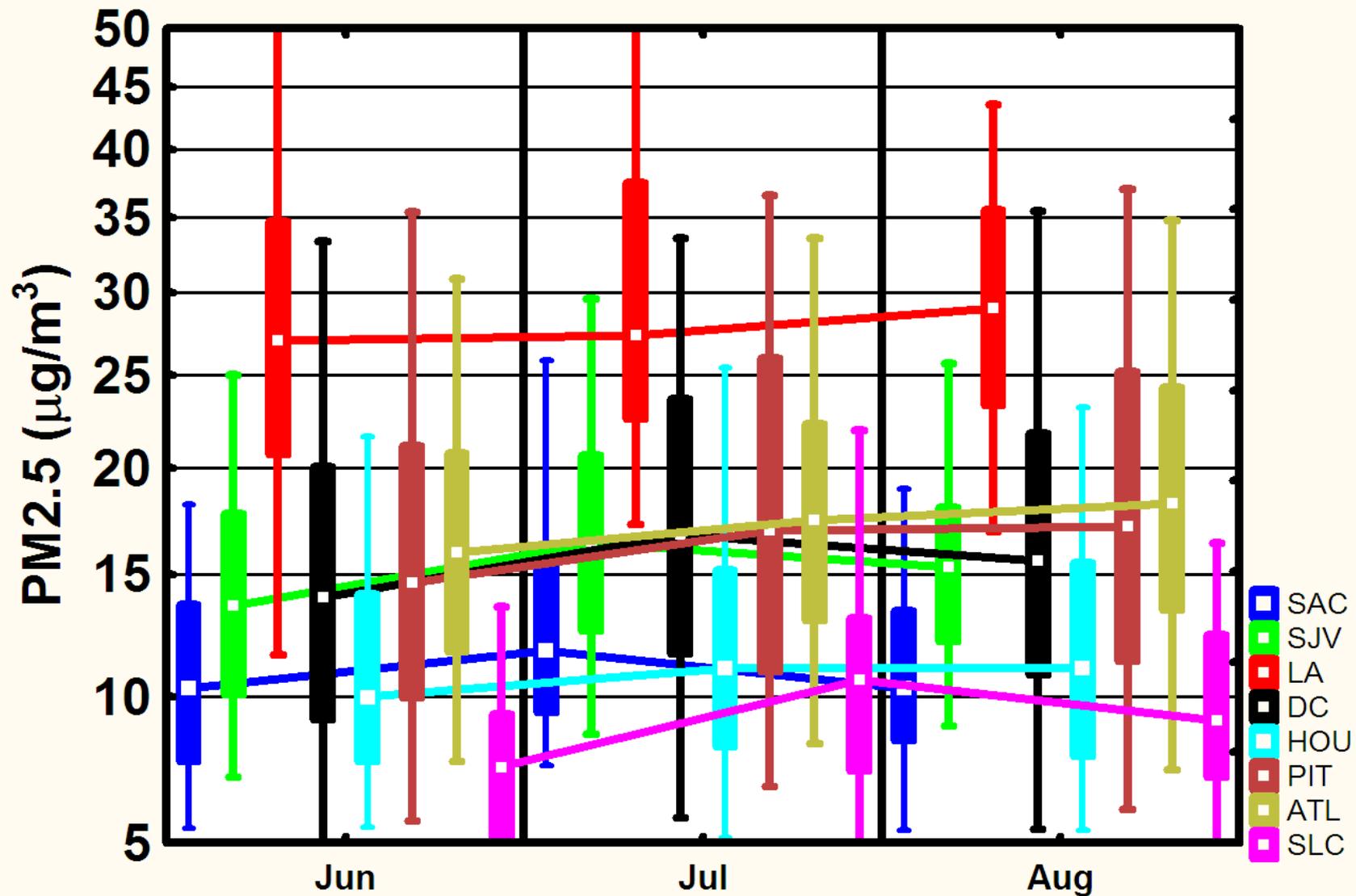
PM2.5 data Jul 2002 - Apr 2010 NASA/GSFC Giovanni

Median; Box: 25%-75%; Whisker: 5%-95%



PM2.5 data Jul 2002 - Apr 2010 NASA/GSFC Giovanni

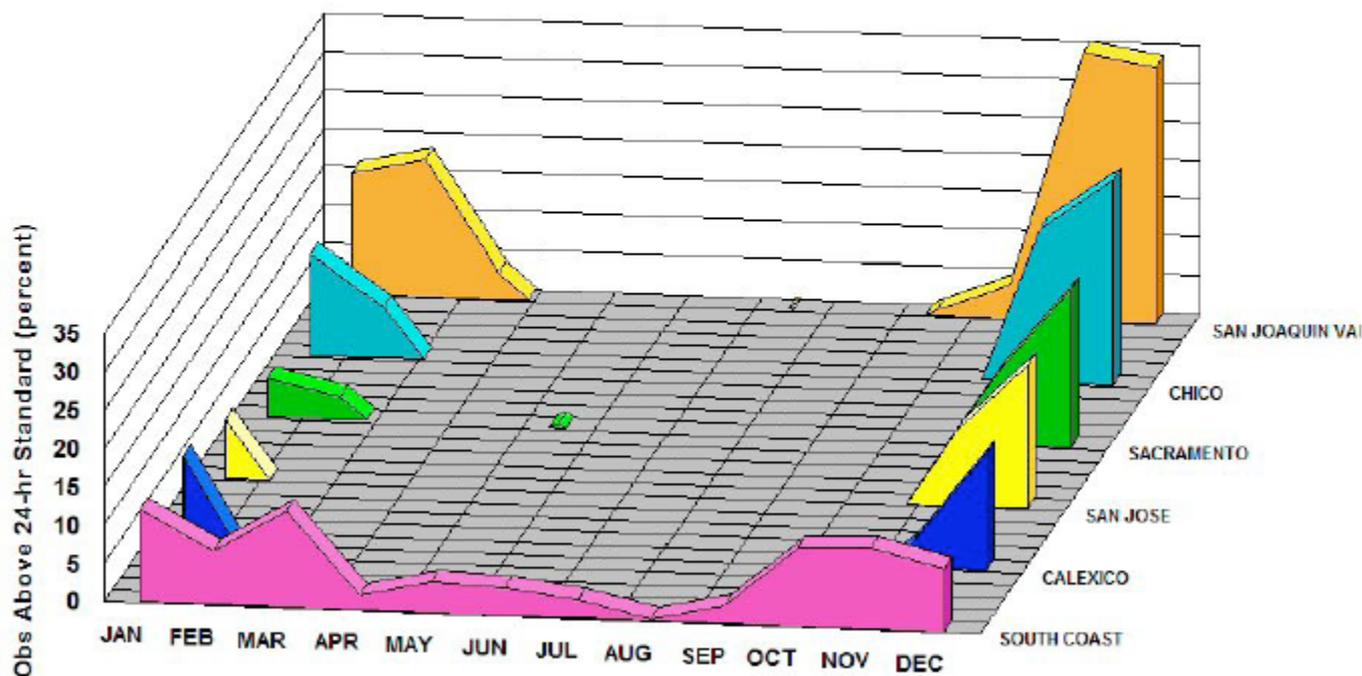
Median; Box: 25%-75%; Whisker: 5%-95%





SJV high PM_{2.5} concentrations and seasonal variation

U.S. EPA Region 9 Air Quality PARTICULATE MATTER - PM-2.5 Monthly Variation of 24-hour Exceedances 2004-2006



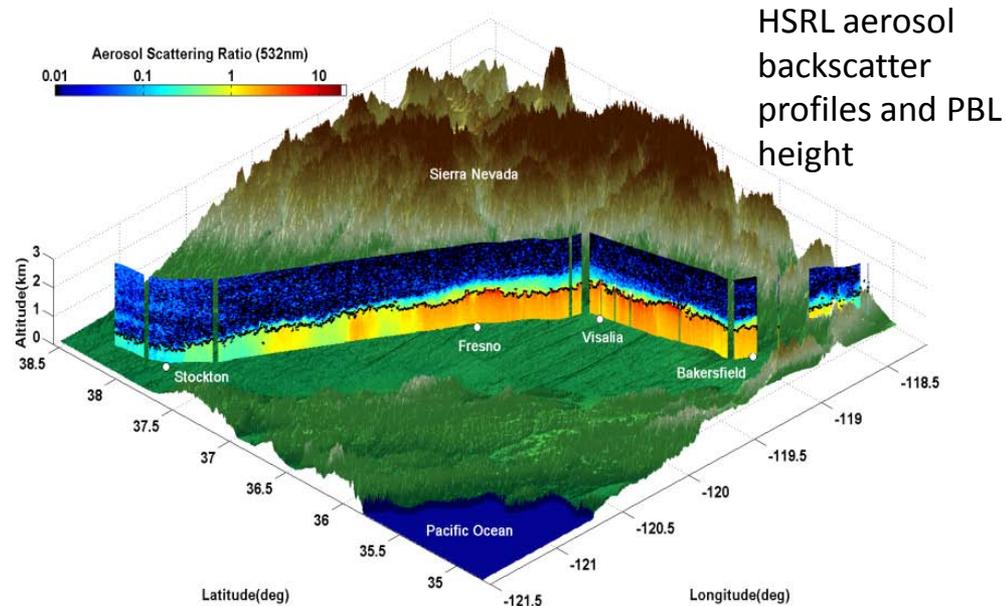
National PM-2.5 24-hour standard is 35 micrograms per cubic meter.
Based on data in AQS as of 3/5/07.



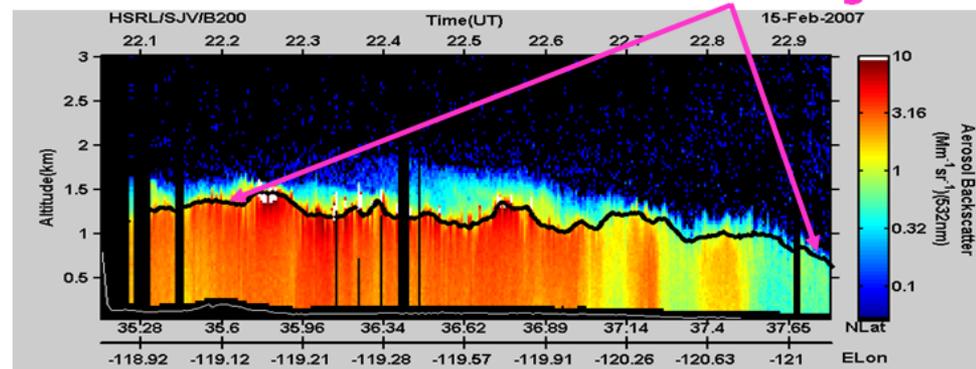
Science Questions:

- What is the relationship between satellite AOT and measured surface $PM_{2.5}$?
- Can satellite measurements be used to adequately characterize $PM_{2.5}$ spatial gradients/distributions in SJV?
- What are the effects of PBL height and vertical aerosol distributions on the relationship between column AOD and surface $PM_{2.5}$?

San Joaquin Valley, California



HSRL Aerosol Backscatter and PBL heights



HSRL data used to:

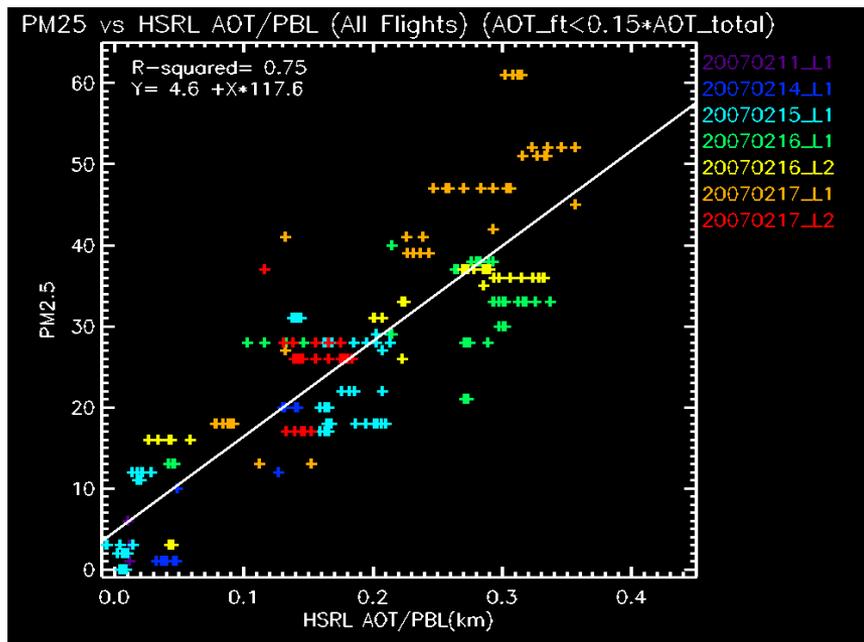
- define PBL height
- evaluate MODIS research AOT retrievals
- determine AOT above/below PBL



- Normalizing AOT with PBL height (z_i) significantly improves correlation with surface $PM_{2.5}$ (r^2 increases from 0.36 to 0.75)

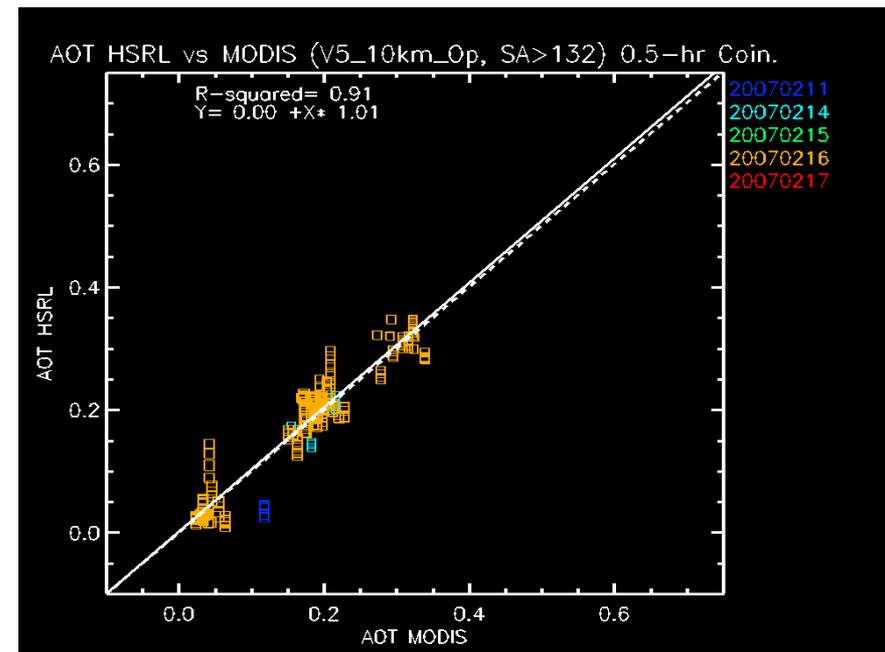
- Very good correlation between MODIS and HSRL AOT when MODIS retrievals restricted to large (>132 deg) scattering angles – reduces dependence of MODIS AOT on surface reflectance

Surface $PM_{2.5}$



AOT/PBL Height (HSRL)

AOT (HSRL)

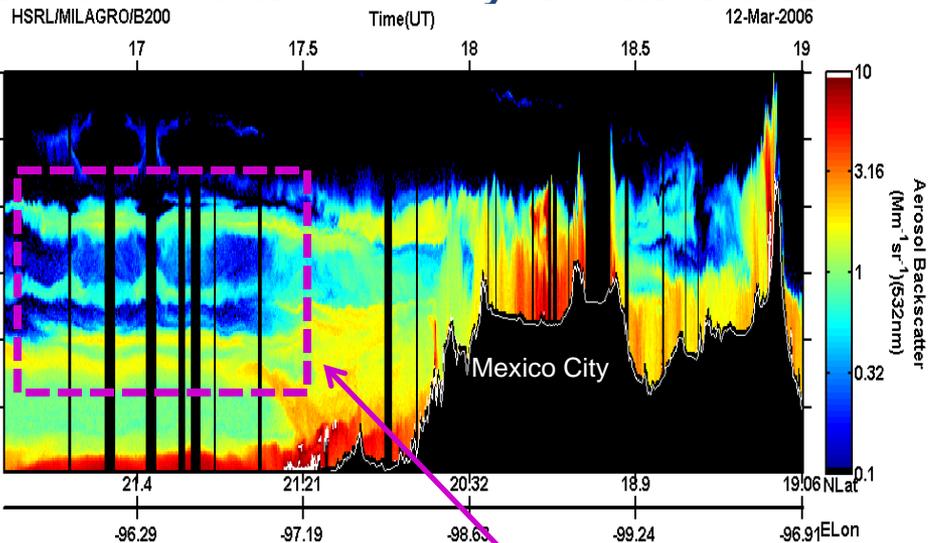


AOT (MODIS)

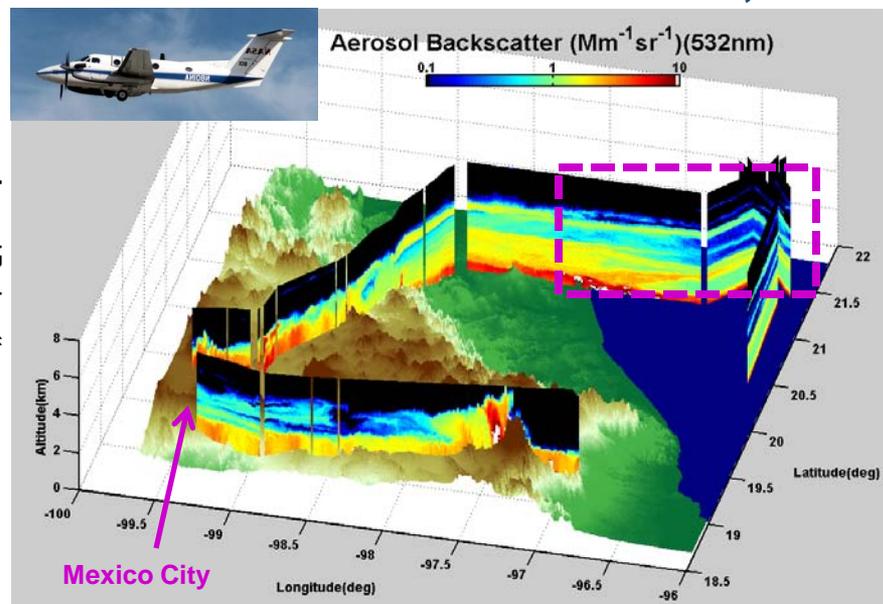


**Assessment of Model Aerosol Simulations and
Using Aerosol Model Simulations to Interpret HSRL
Measurements**

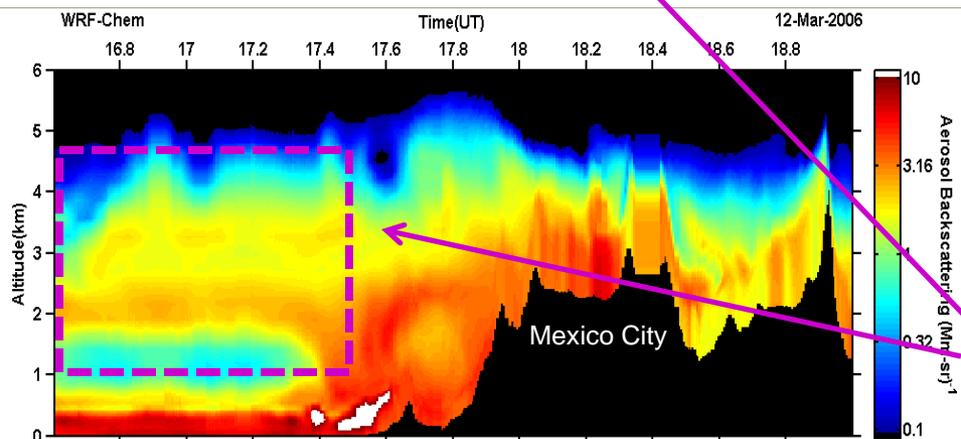
Backscatter measured by airborne HSRL



NASA/LaRC B200/HSRL March 12, 2006



Backscatter predicted by WRF-Chem model



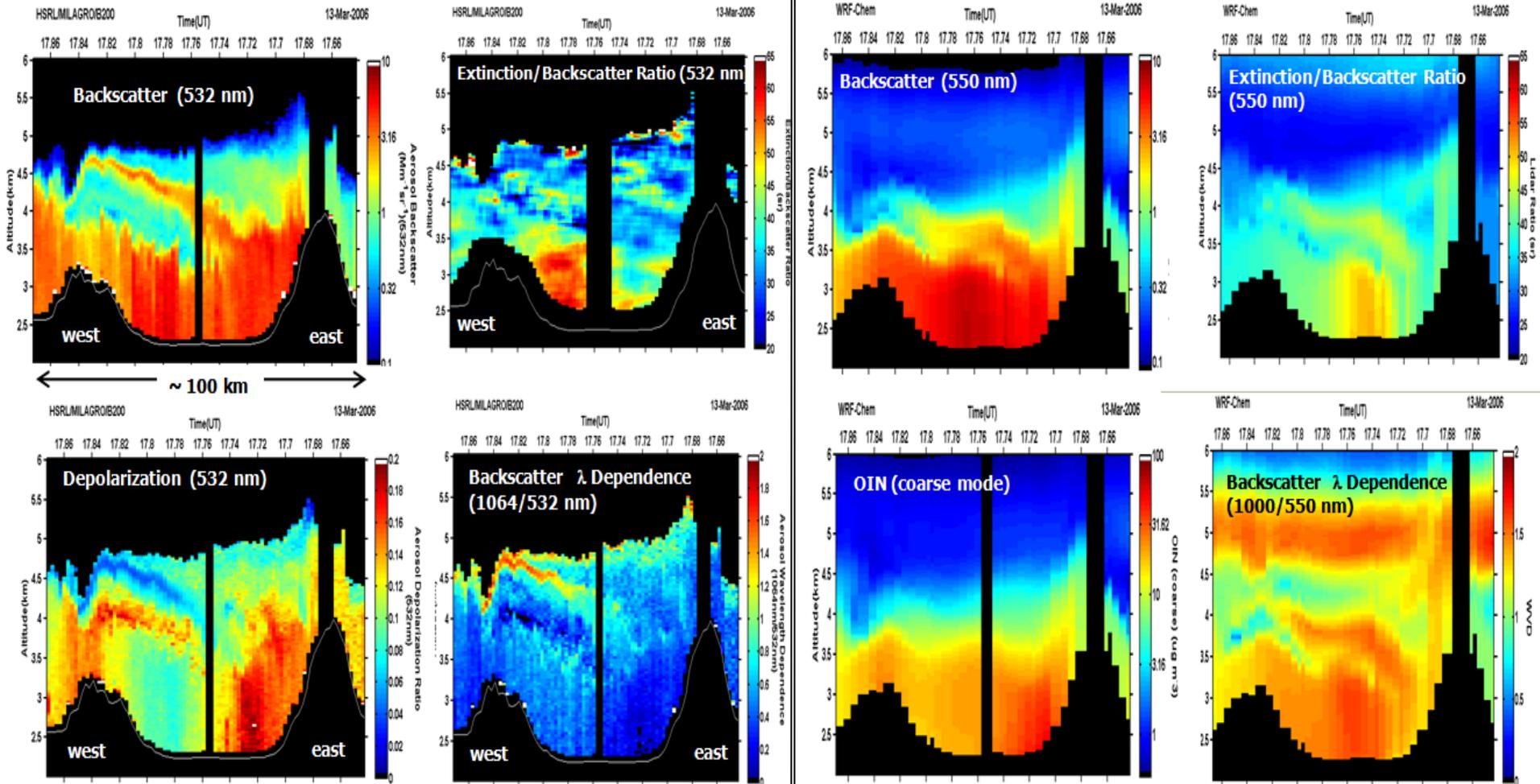
WRF-Chem (Jerome Fast – PNNL)

- Airborne HSRL data:
 - reveal complexity of mixing and transport of particulates
 - used to indirectly evaluate meteorological predictions
- Model can reproduce most aspects of PBL in vicinity of Mexico City
- Model requires smaller vertical grid spacing to resolve shallow layering observed by lidar

➤ High resolution WRF-Chem shows much of the small scale structure shown in HSRL data

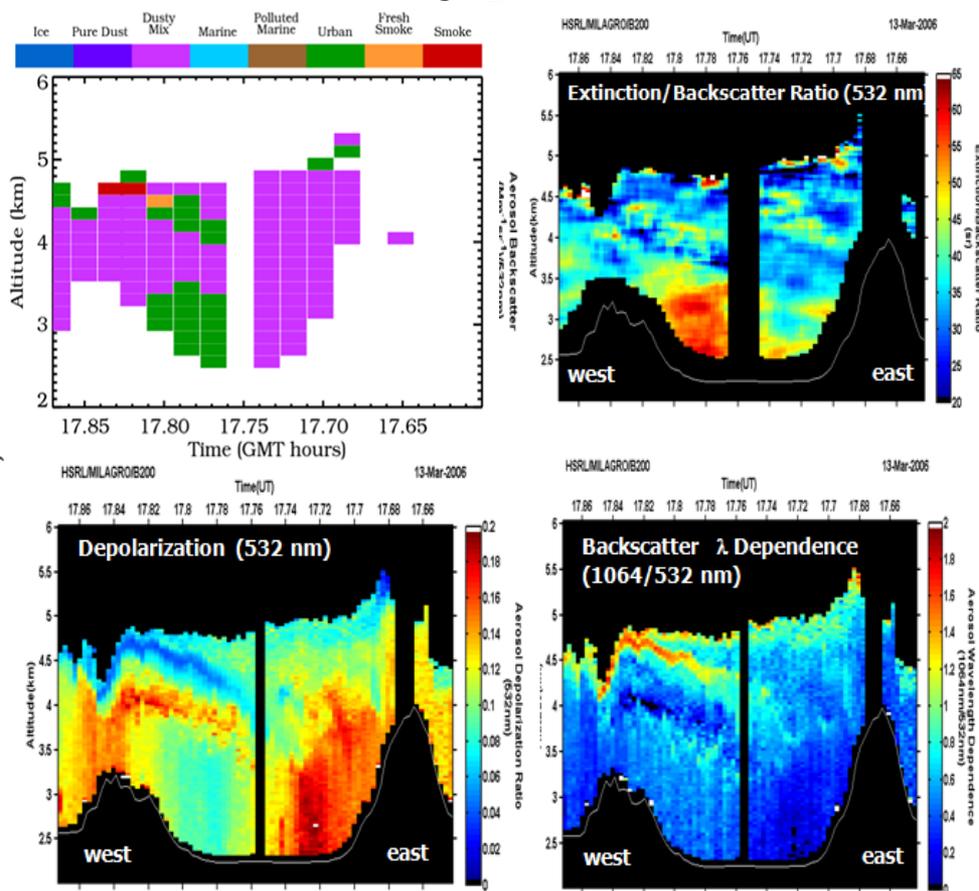
HSRL

WRF-Chem

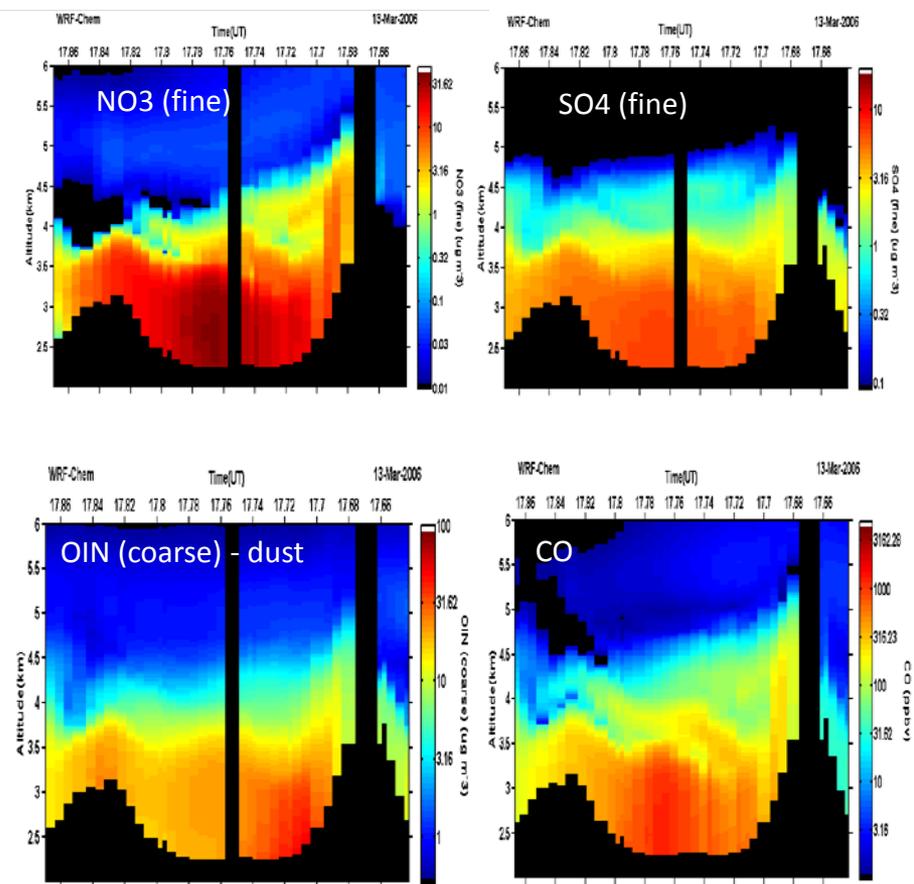


- In the vicinity of Mexico City, WRF-CHEM compositions qualitatively agree with aerosol types inferred from HSRL measurements
 - High concentrations of NO_3 , SO_4 , EC -> urban
 - High concentrations of dust (other inorganics, OIN, in the model) -> mix of dust and urban
- Outside of Mexico City, dust and urban pollutants mix together

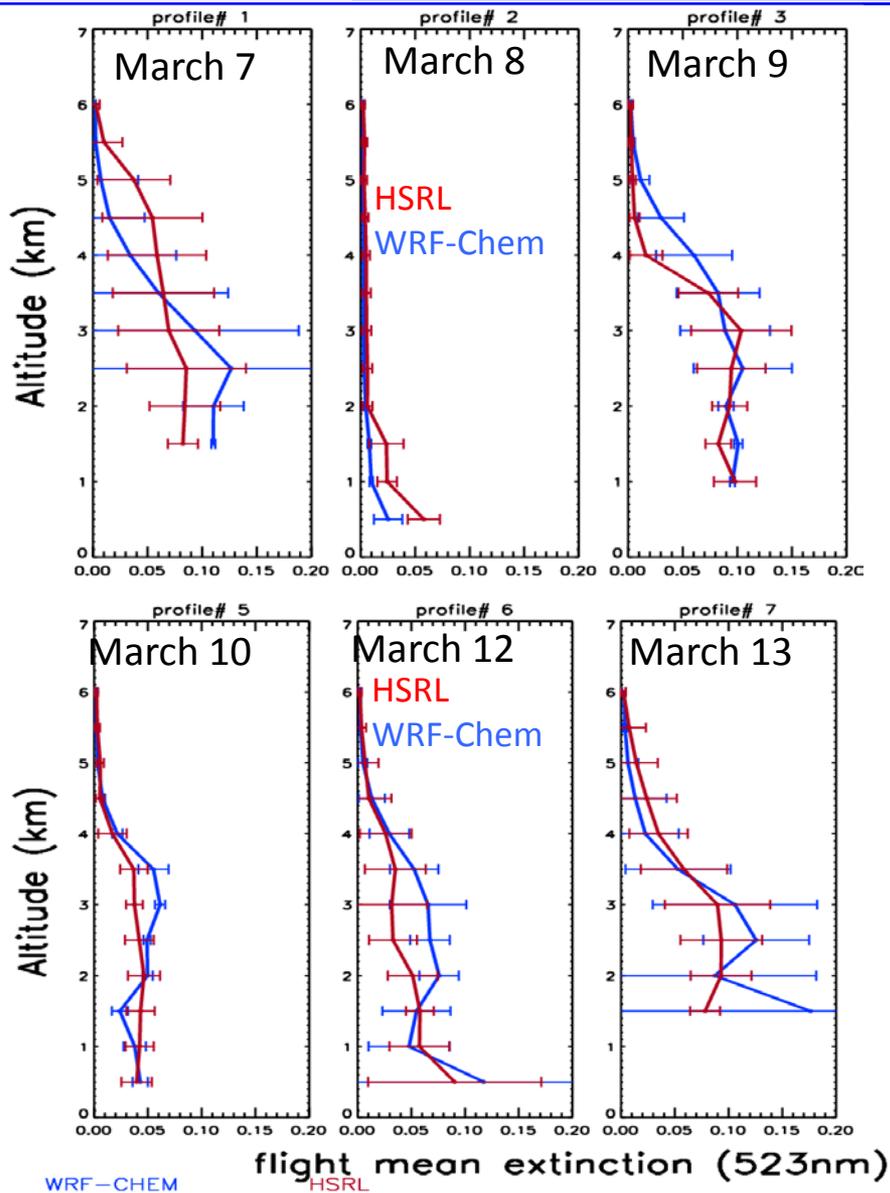
HSRL



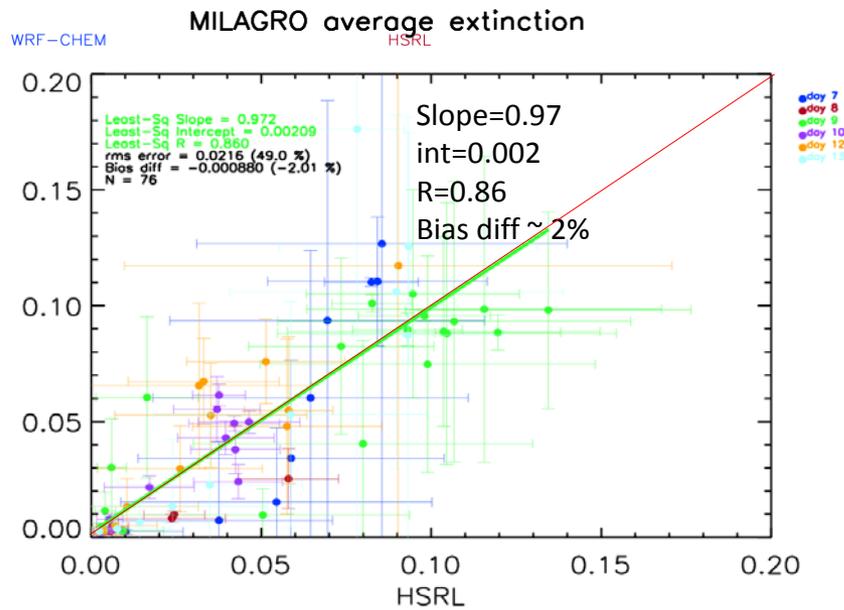
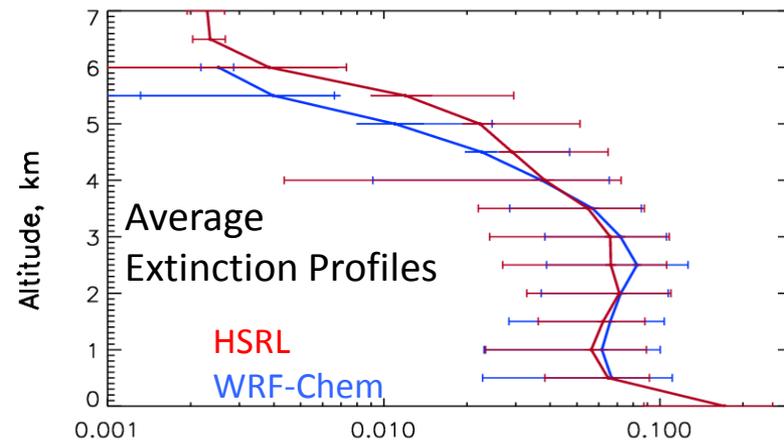
WRF-Chem

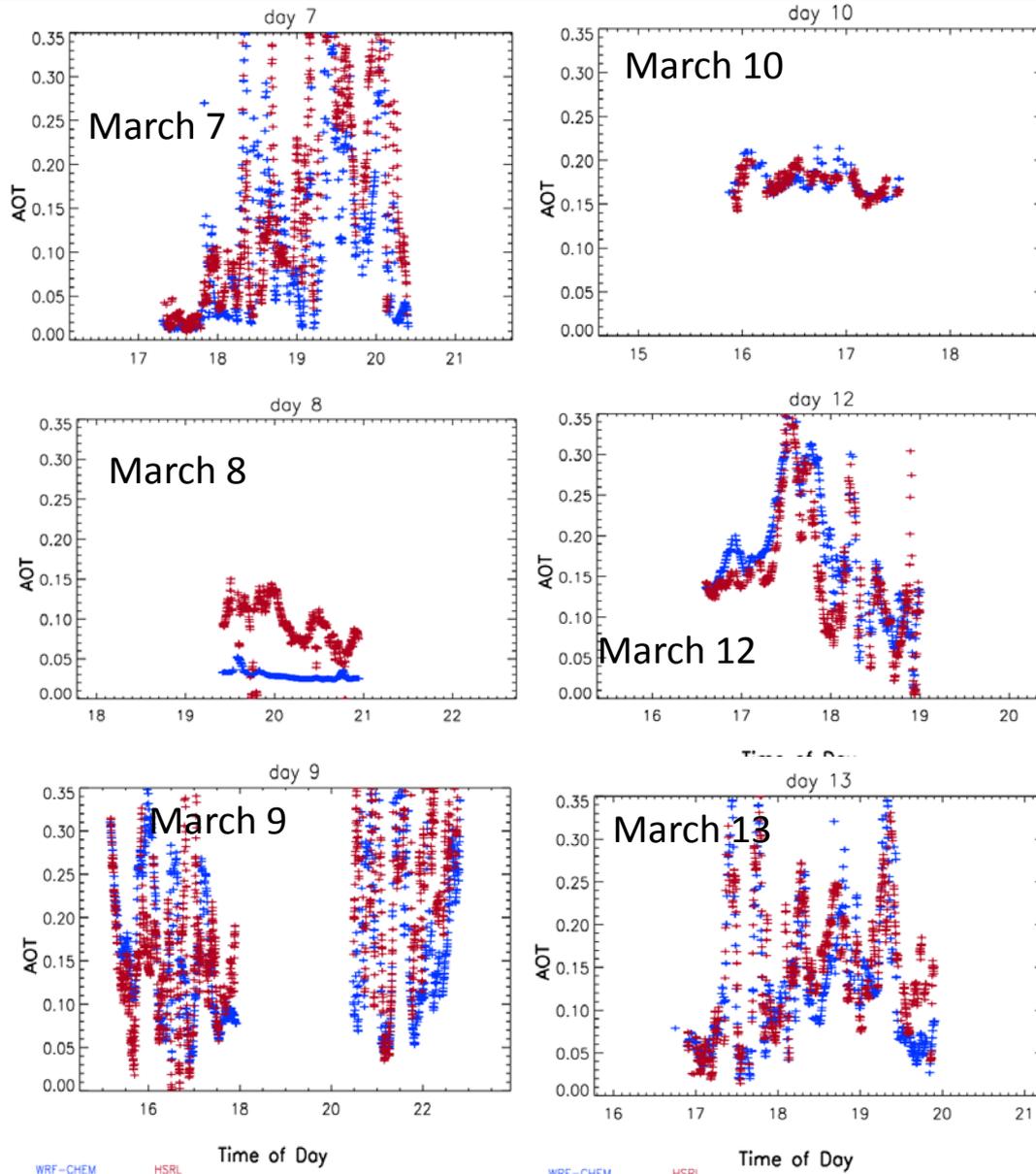


WRF-Chem (Jerome Fast – PNNL)



WRF-Chem aerosol extinction profiles in very good overall agreement with HSRL





WRF-Chem aerosol optical thickness in very good overall agreement with HSRL

Overall Summary

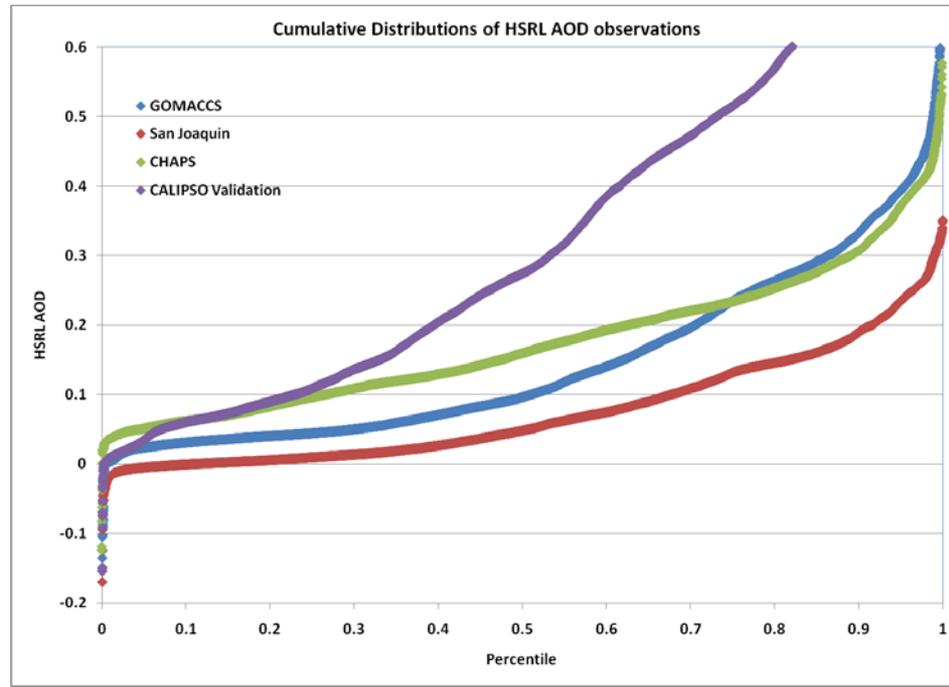
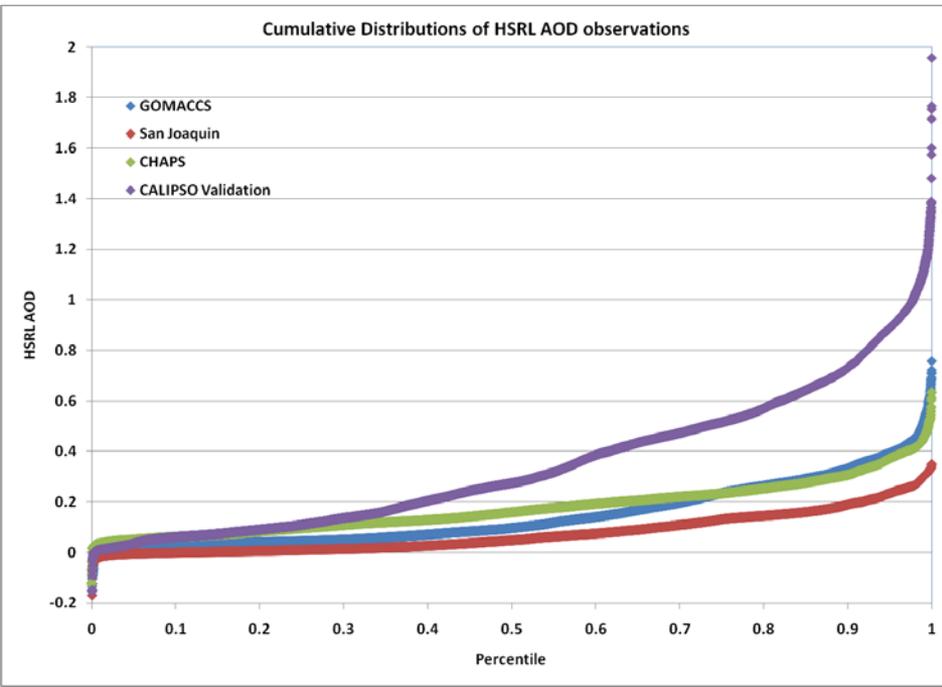
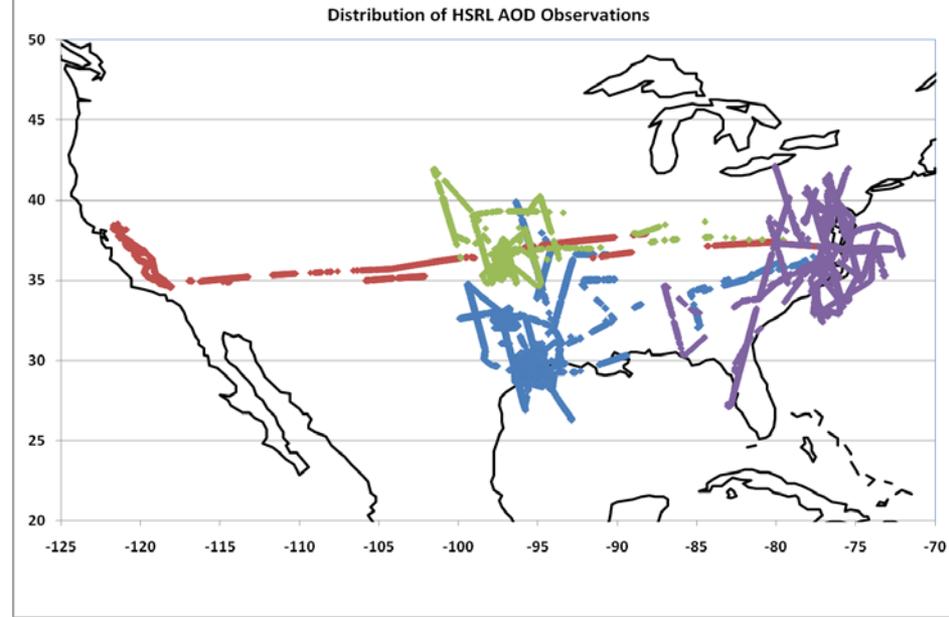
- Performance varies with location
- WRF-chem overestimates backscatter and extinction over Gulf and coast - perhaps too much model dust?
- Some fine scale layers only crudely represented by model
- Some differences between measured and modeled PBL growth rate



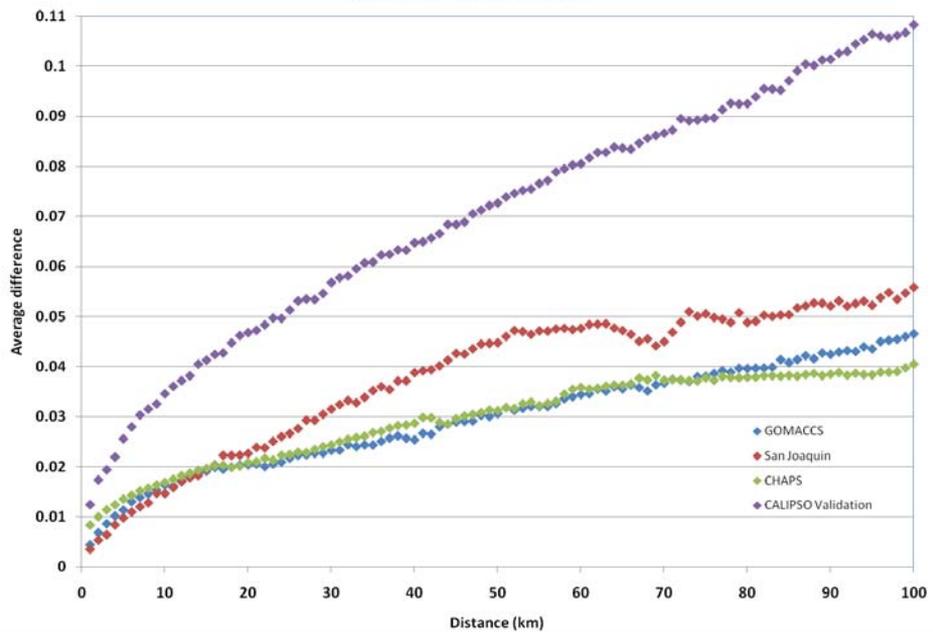
Spatial Variability in AOD based on HSRL observations

CALIPSO Validation flights encountered substantially higher AODs. Structure functions ($q=1$) were performed for each set of flights as well as for the CALIPSO validation flights only for $AOD > 0.5$ (roughly the upper quartile of data).

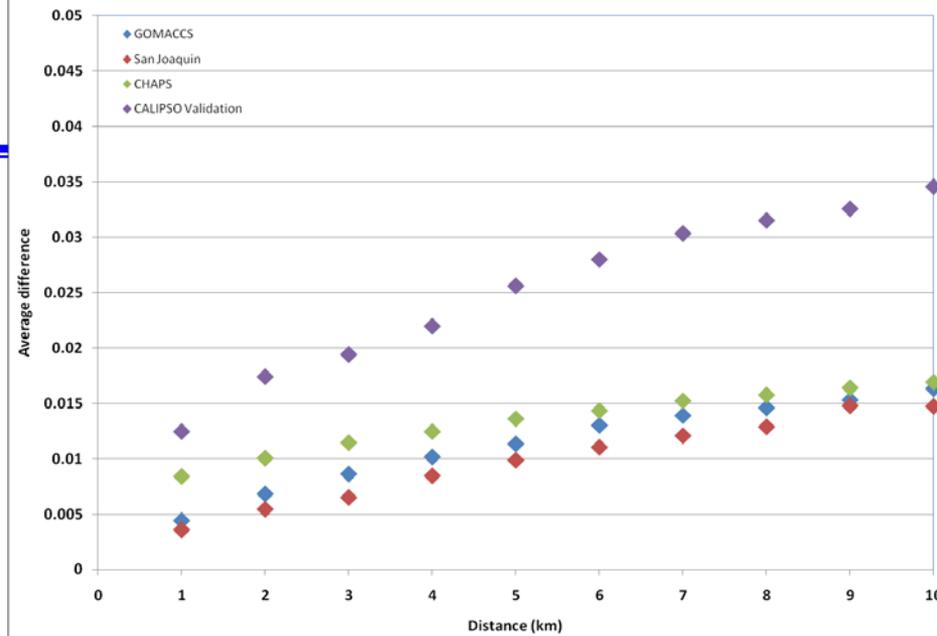
Results shown on following slide.



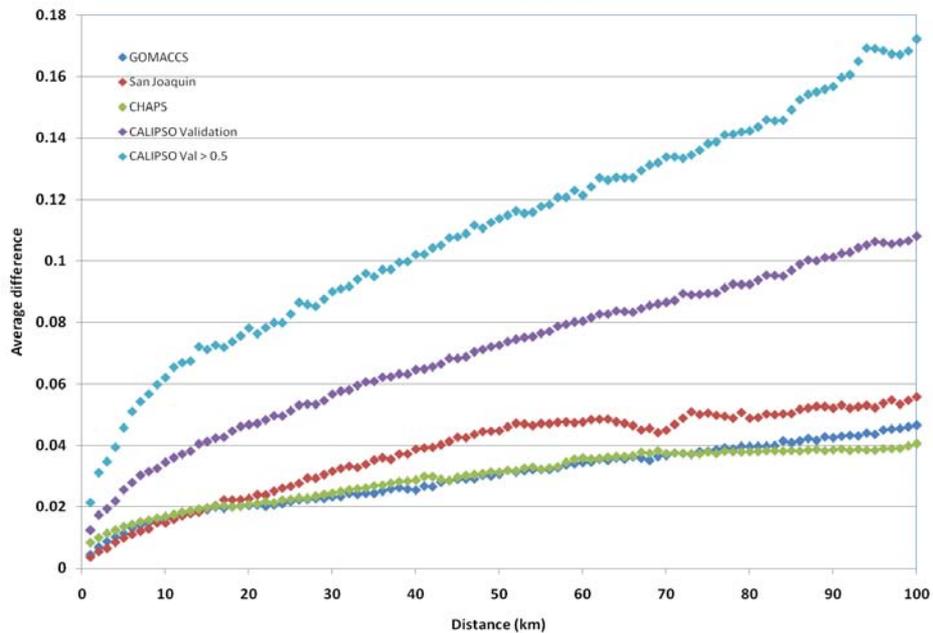
HSRL AOD Observations



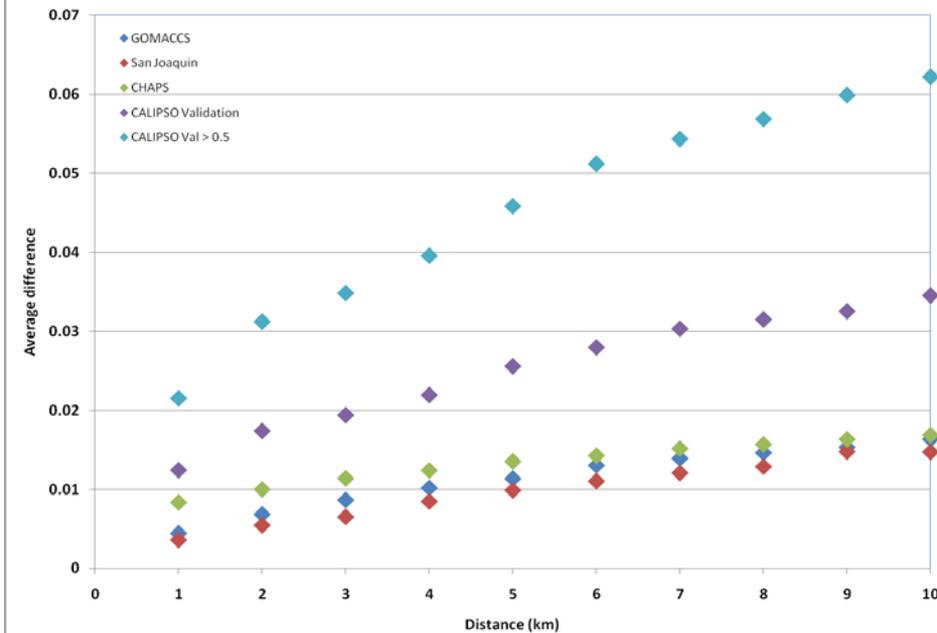
HSRL AOD Observations



HSRL AOD Observations



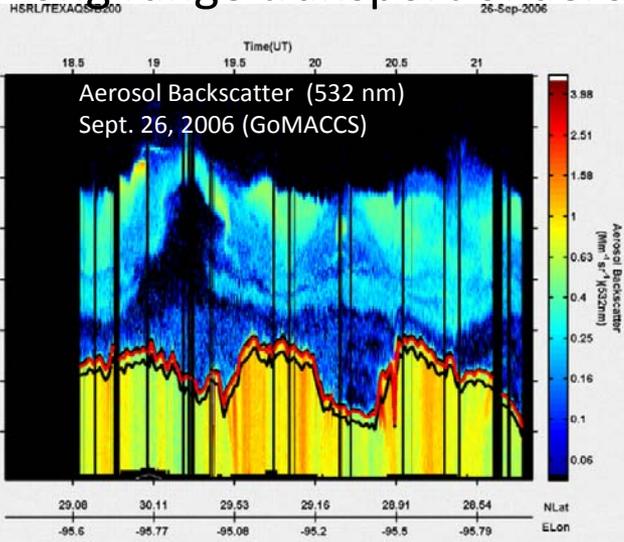
HSRL AOD Observations



Planetary Boundary Layer (PBL) Height Retrievals and AOT from High Spectral Resolution Lidar (HSRL)



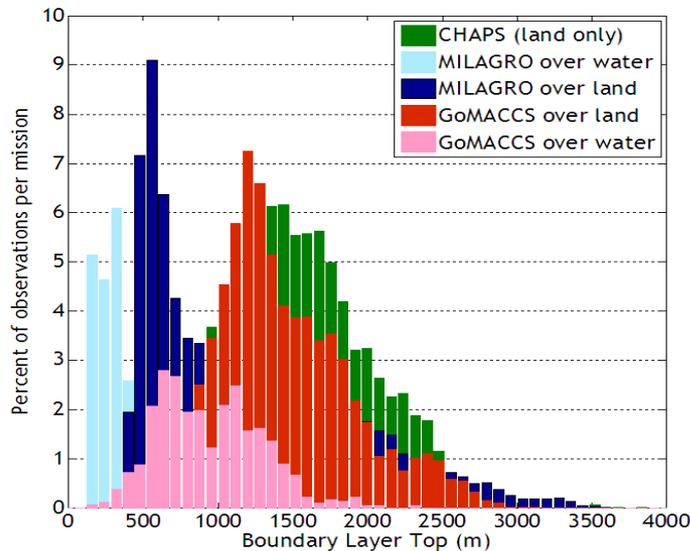
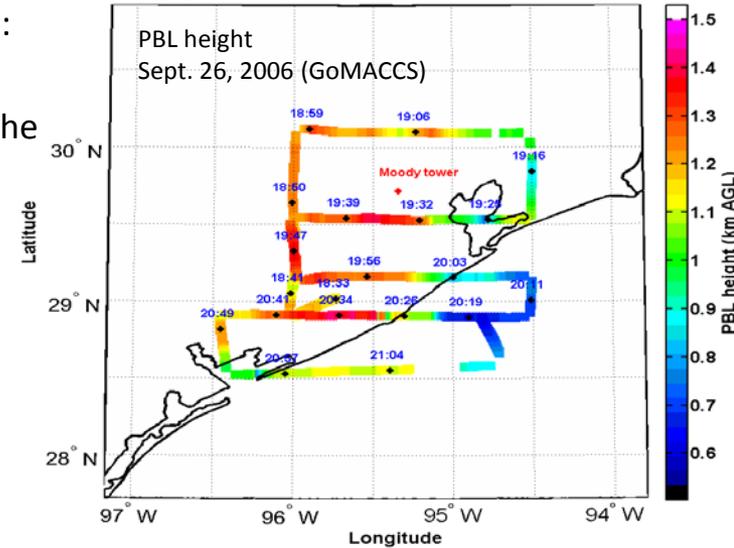
Long range transport of aerosols depends on whether aerosols injected above PBL



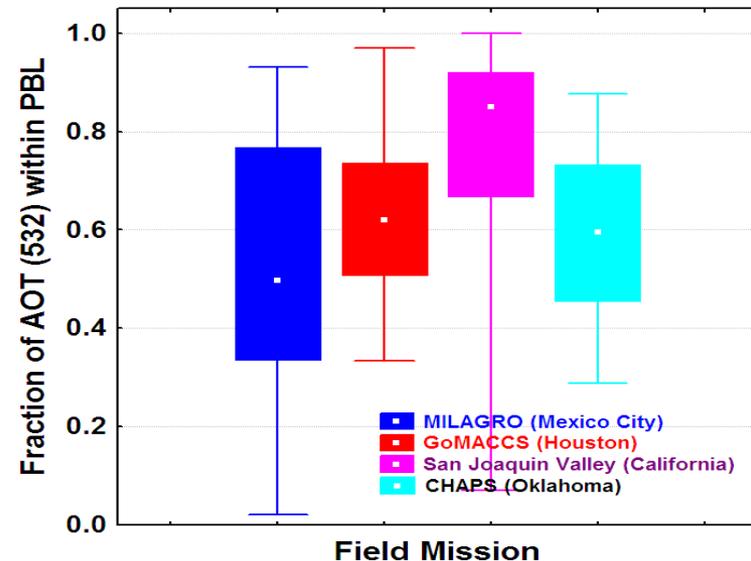
HSRL data used to determine:

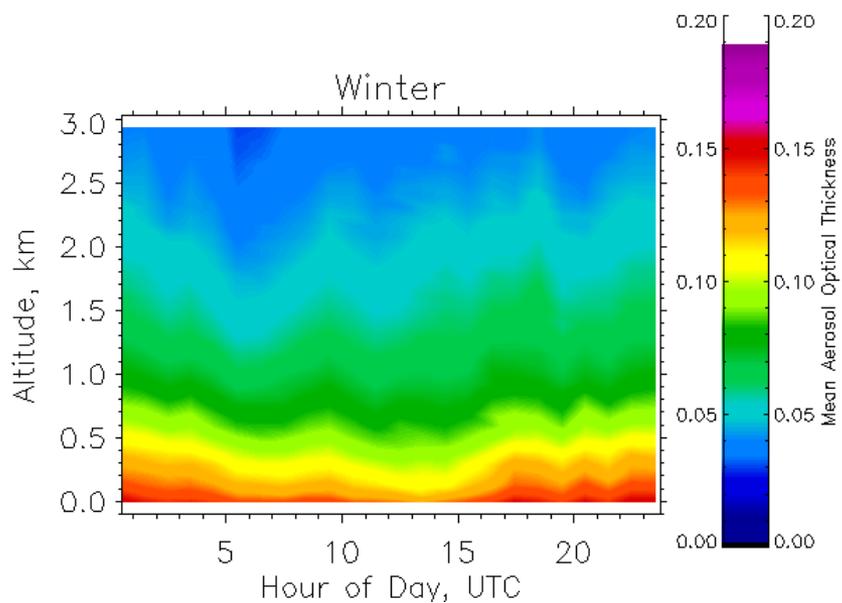
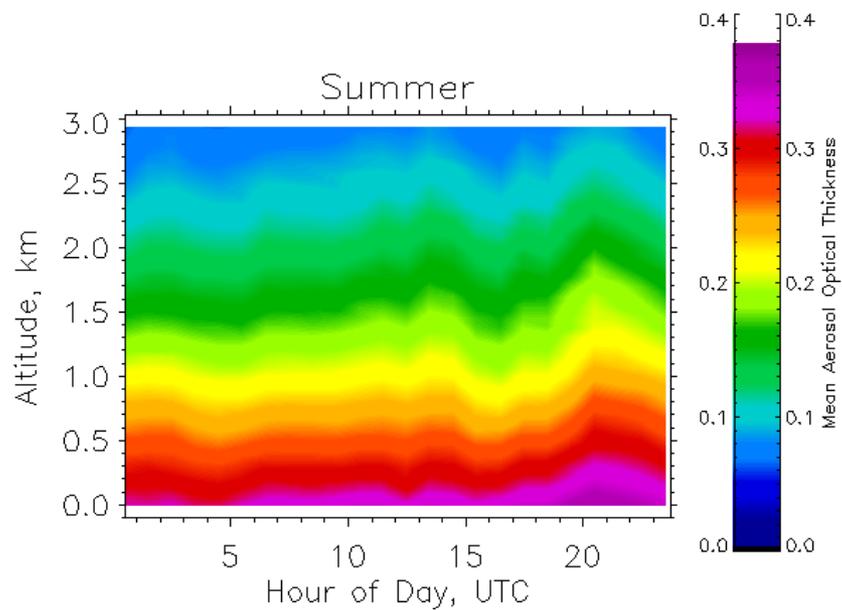
- PBL height
- Upper and lower limits of the backscatter transition (i.e. entrainment) zone
- Fraction of aerosol optical thickness within PBL

NASA Langley B200 King Air TexAQS/GoMACCS September 26, 2006



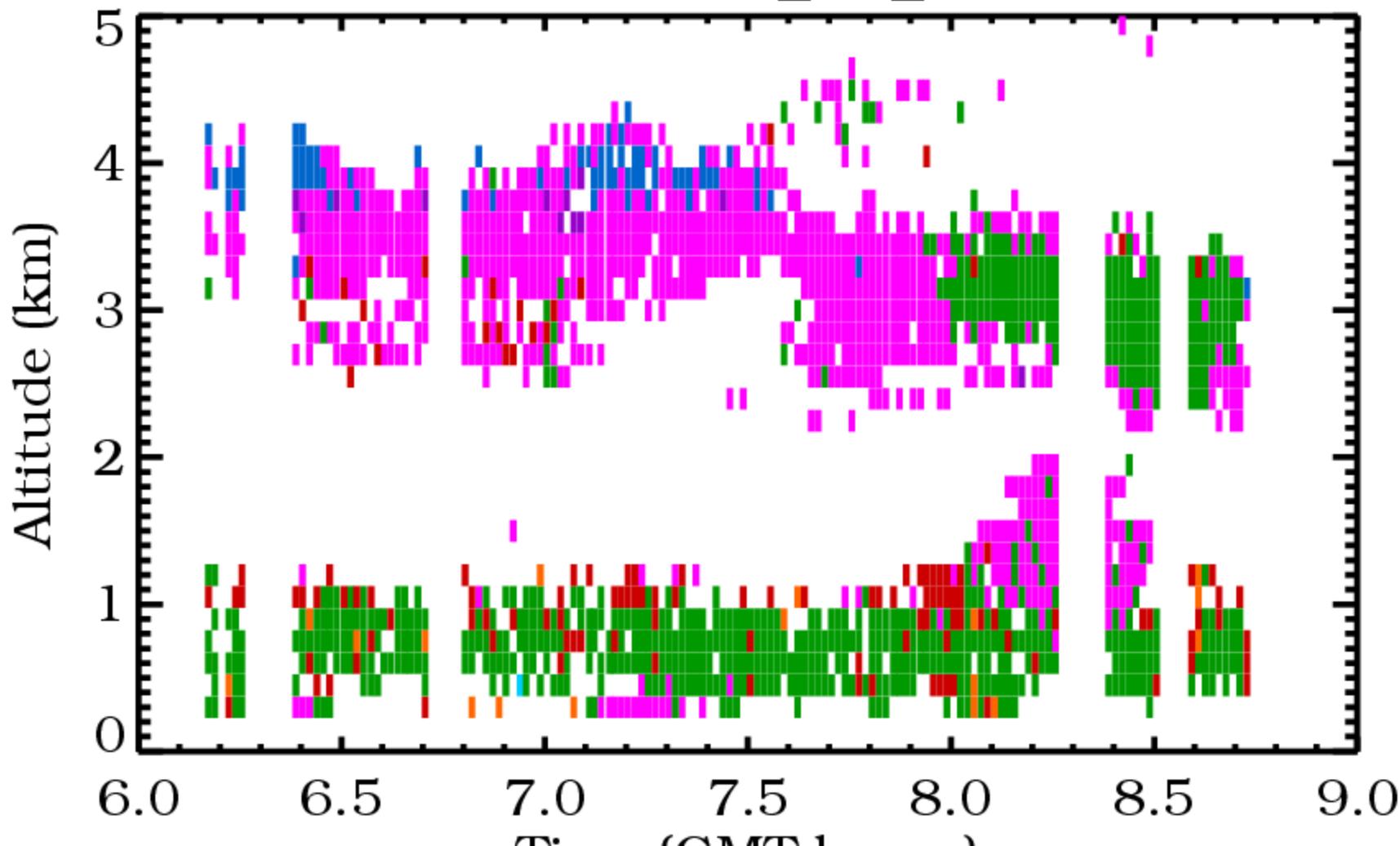
- PBL heights over water significantly lower than PBL heights over land
- Large fraction (40-50%) of AOT above PBL during MILAGRO, GoMACCS, CHAPS
- Most (80-90%) of AOT within PBL during San Joaquin Valley Mission
- HSRL PBL heights now routinely requested by other investigators







20100415_L1_sub

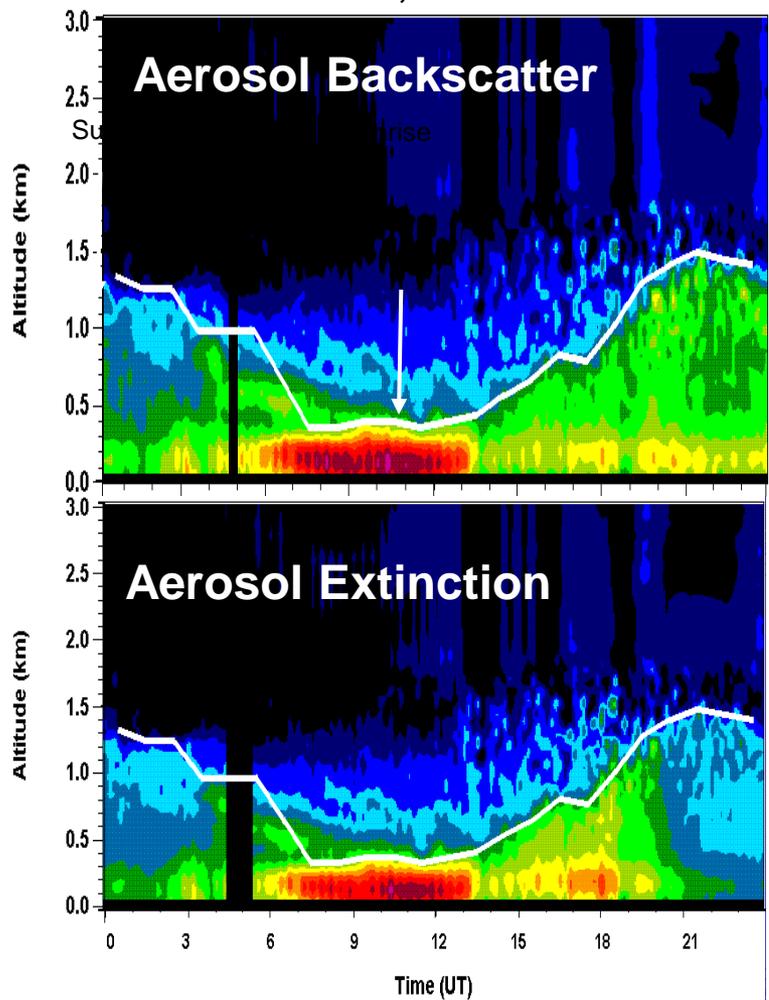


DOE SGP Raman Lidar PBL Height Retrievals

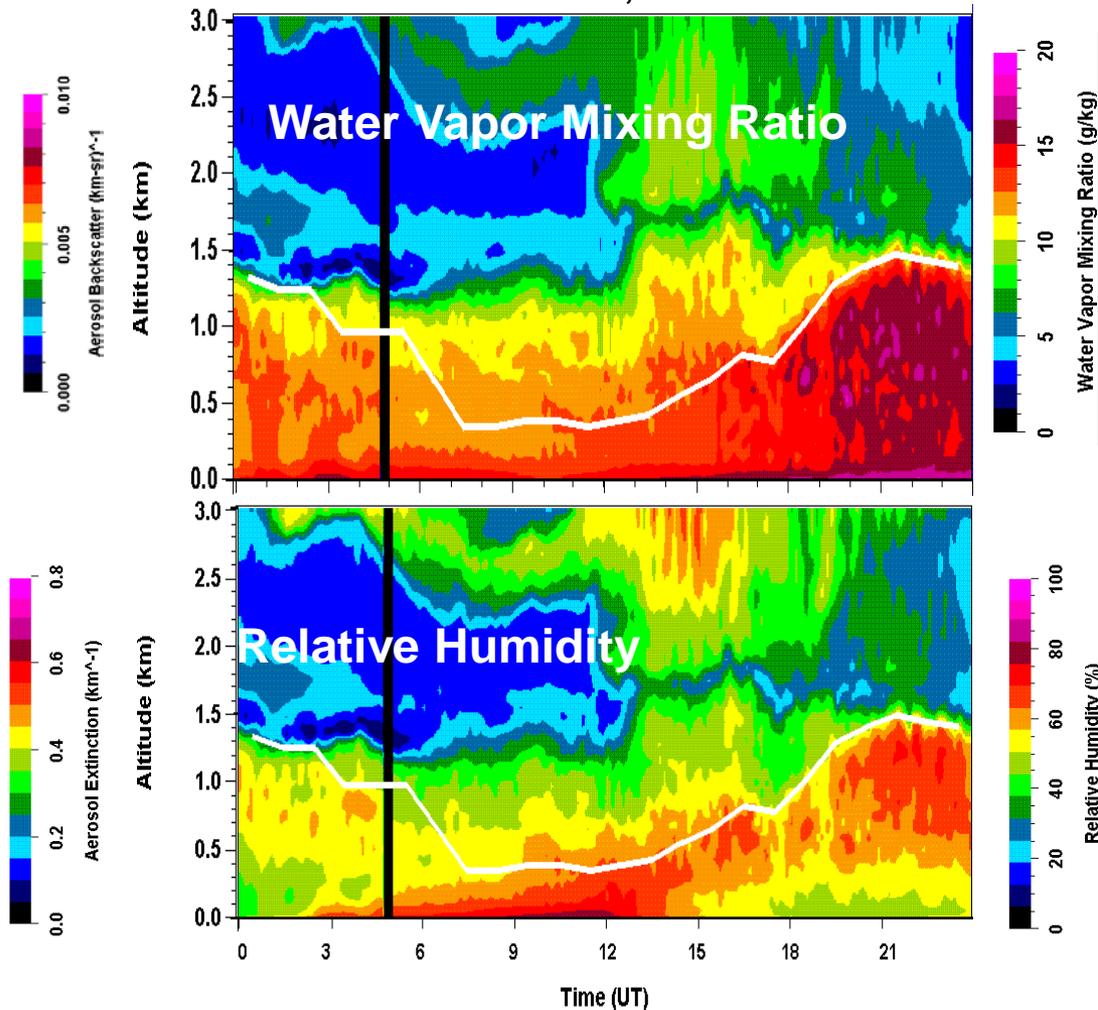


- DOE SGP Raman Lidar (Oklahoma) operates 24/7 measuring water vapor and aerosols
- Raman lidar data used to determine PBL height and aerosol and water vapor distributions

June 12, 2001



June 12, 2001



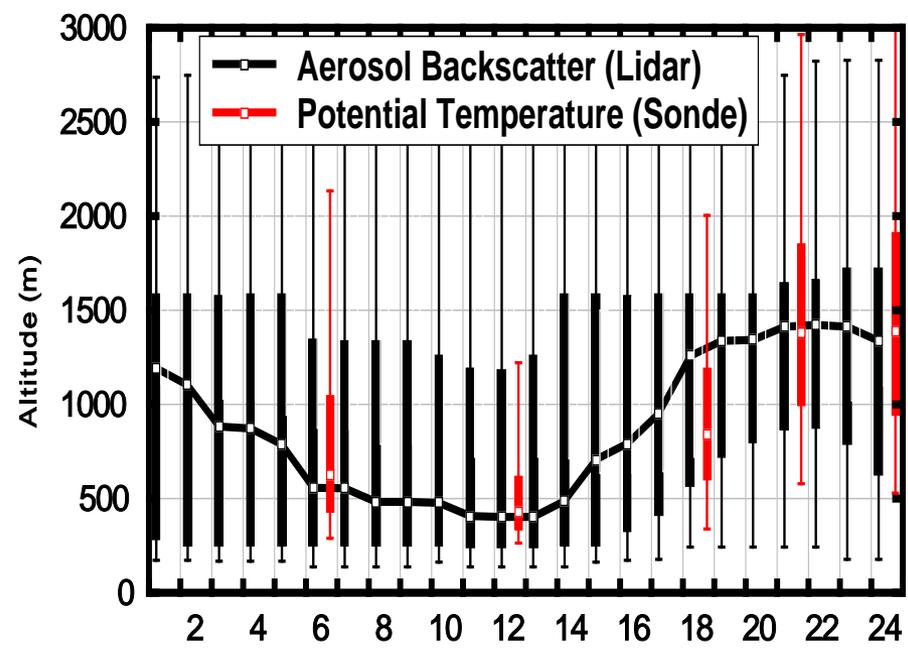
DOE SGP Raman Lidar PBL Height Retrievals

- PBL Height Methods:
 - Radiosonde - Potential temperature - (Heffter, 1980)
 - Raman Lidar - Aerosol backscatter, water vapor via Haar wavelet – (Brooks, 2003)
- Best agreement during afternoon, early evening

- Amount of AOT within PBL
 - varies with time of day
 - does not vary significantly with season or AOT
- Significant fraction of AOT (>25%) is above PBL

Boundary Layer Height (1998-2003)

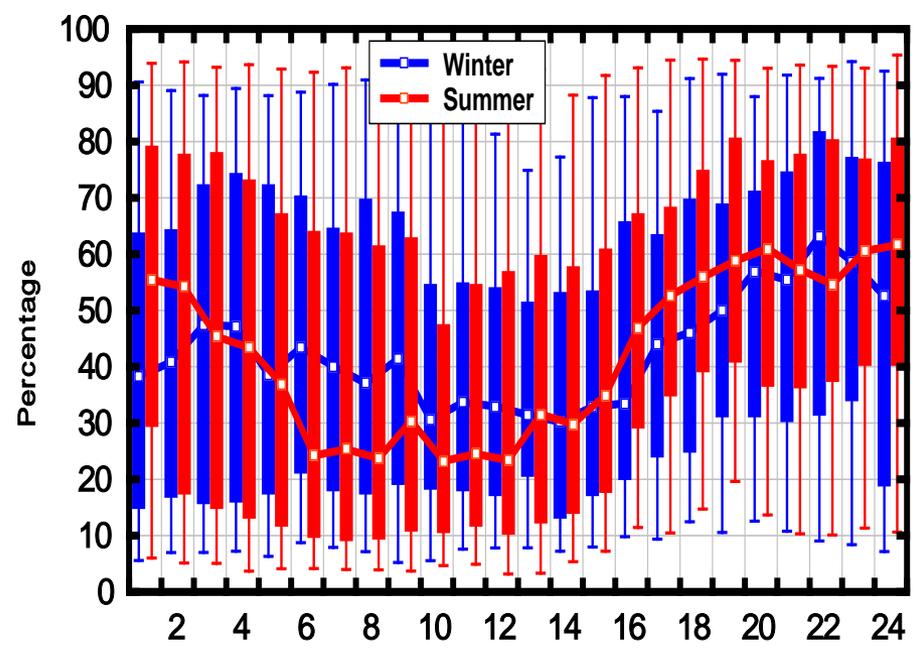
Median; Box: 25%, 75%; Whisker: 5%, 95%



Time (UT) Box Plot (copy of 01011998-12312003_aot_addv5.sta 59v*35976c)

Percentage of AOT below BL Height

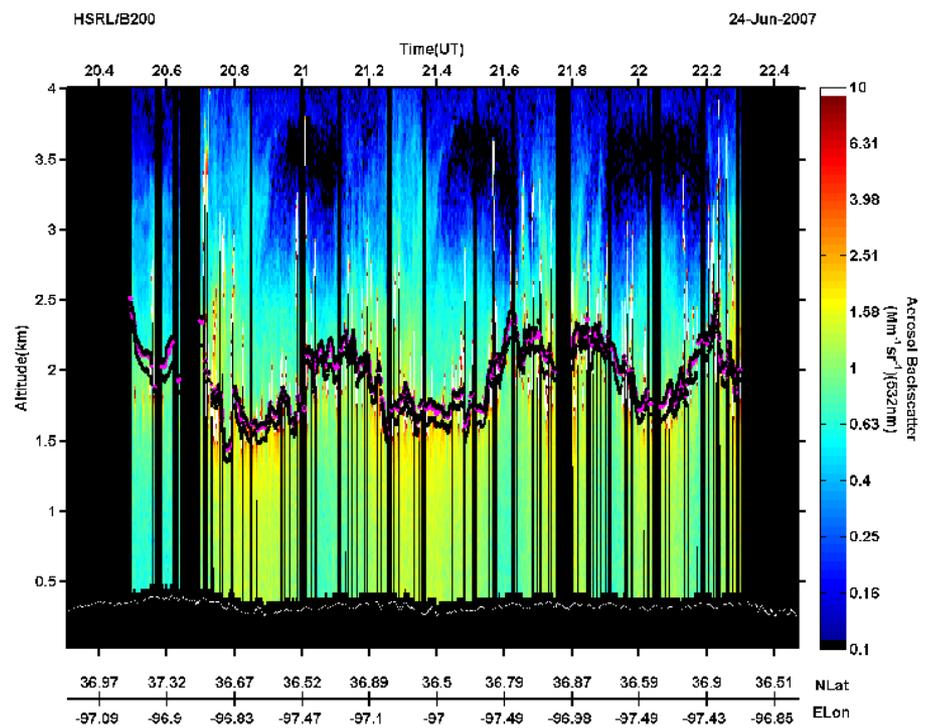
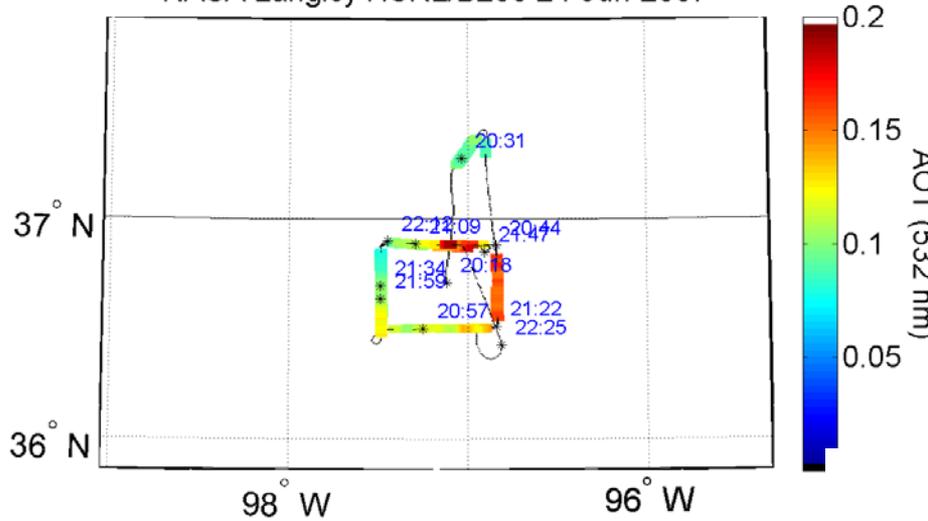
Median; Box: 25%, 75%; Whisker: 5%, 95%

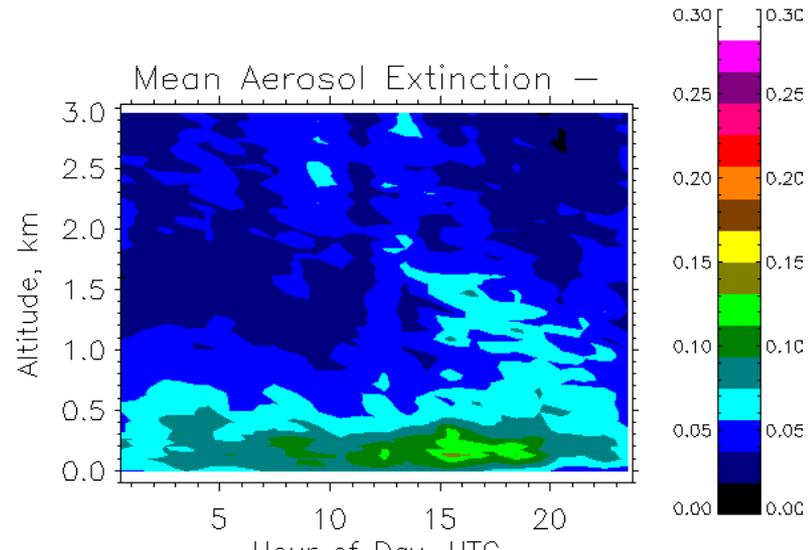
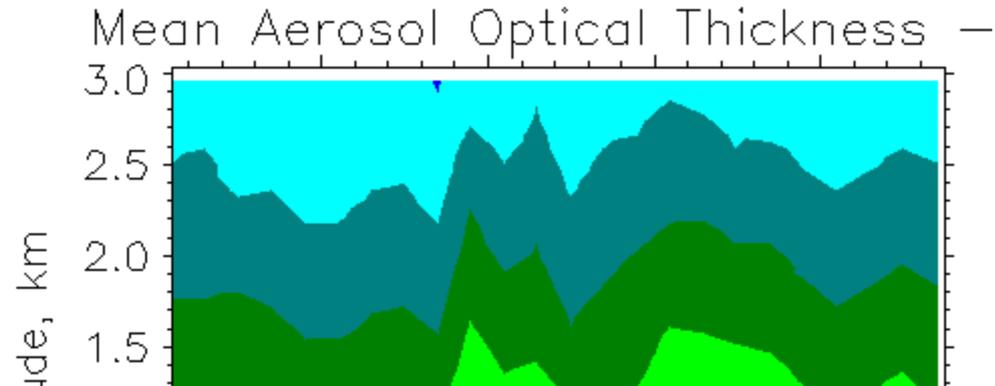
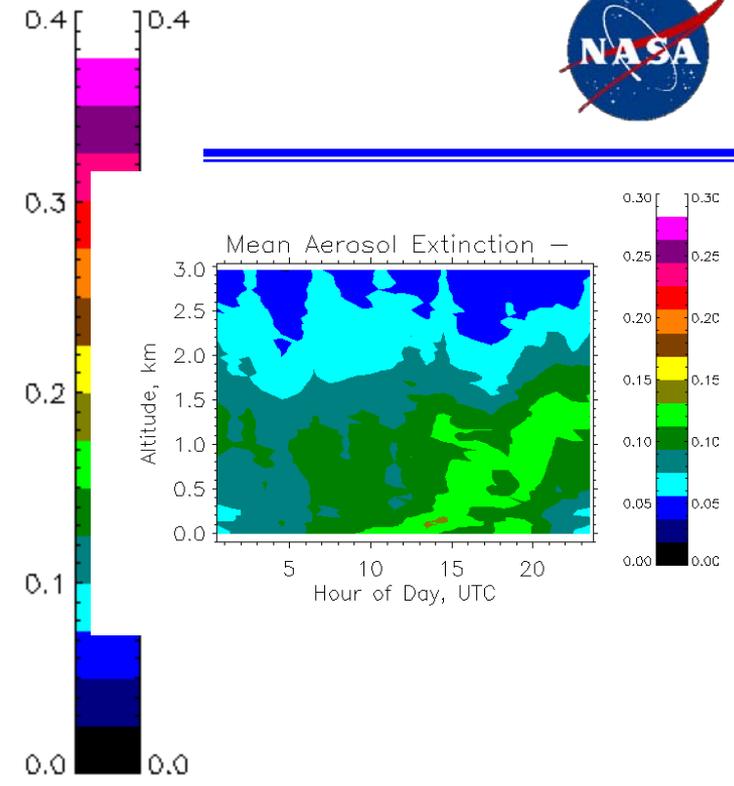
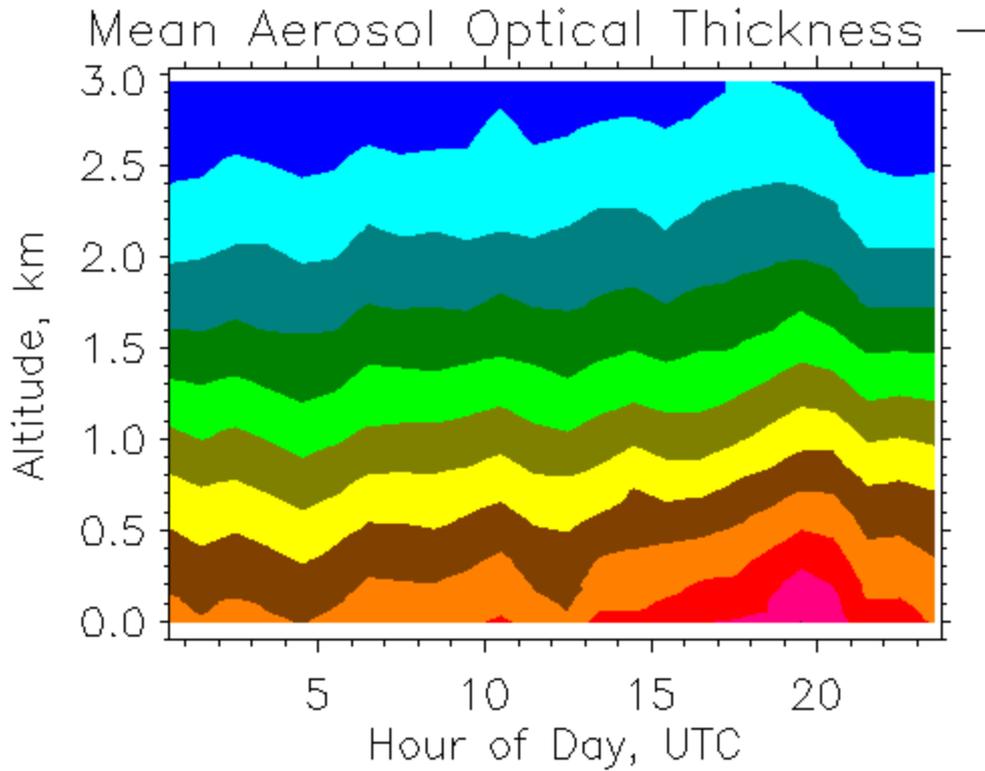


Time (UT) Box Plot (copy of 01011998-12312003_aot_addv5.sta 60v*35976c)

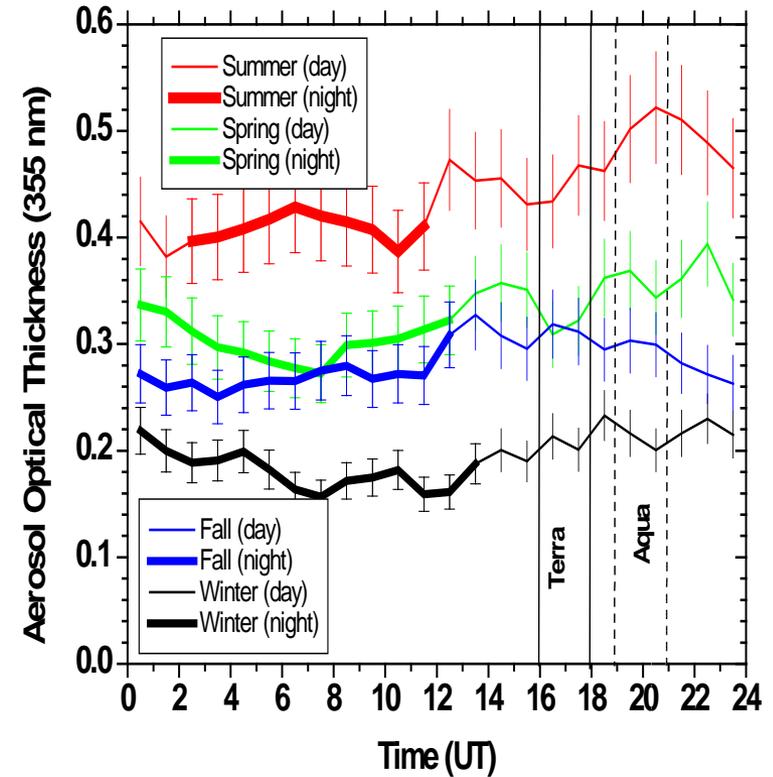
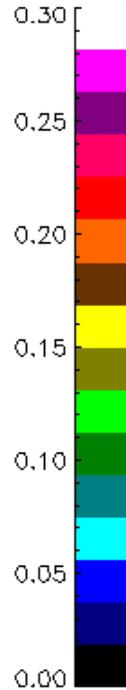
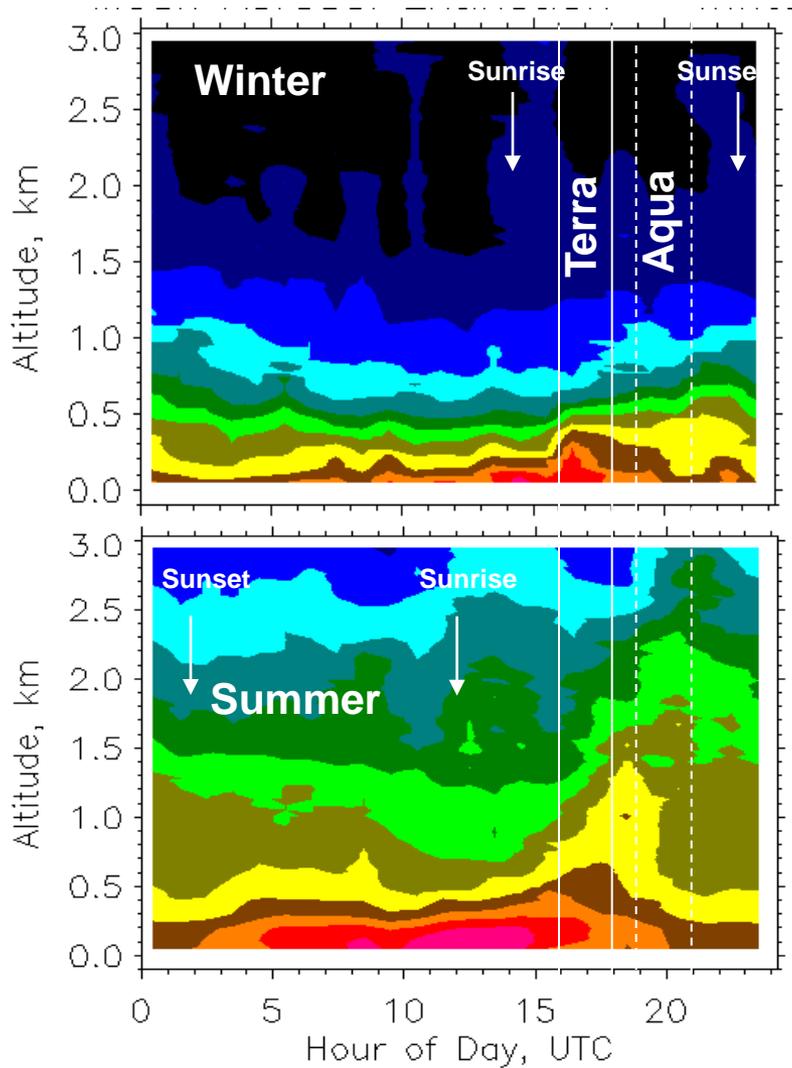


NASA Langley HSRL/B200 24-Jun-2007

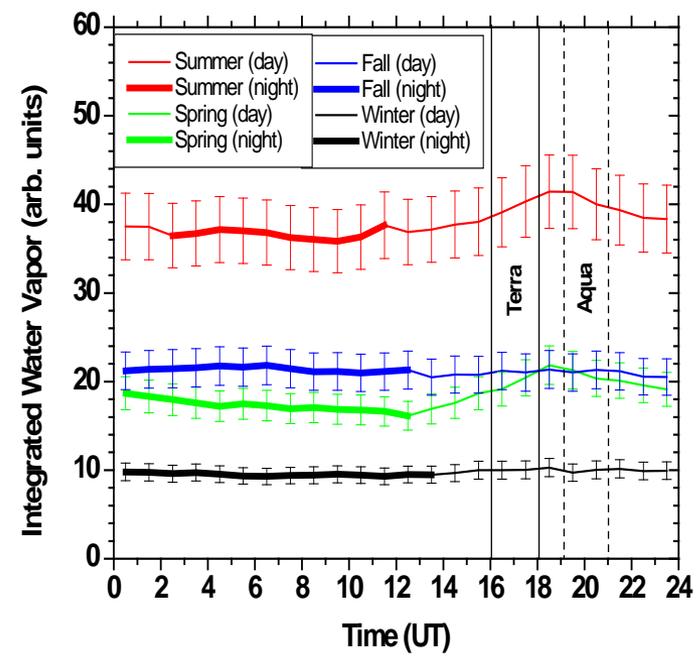
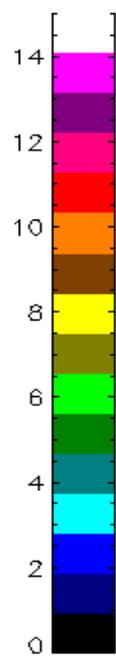
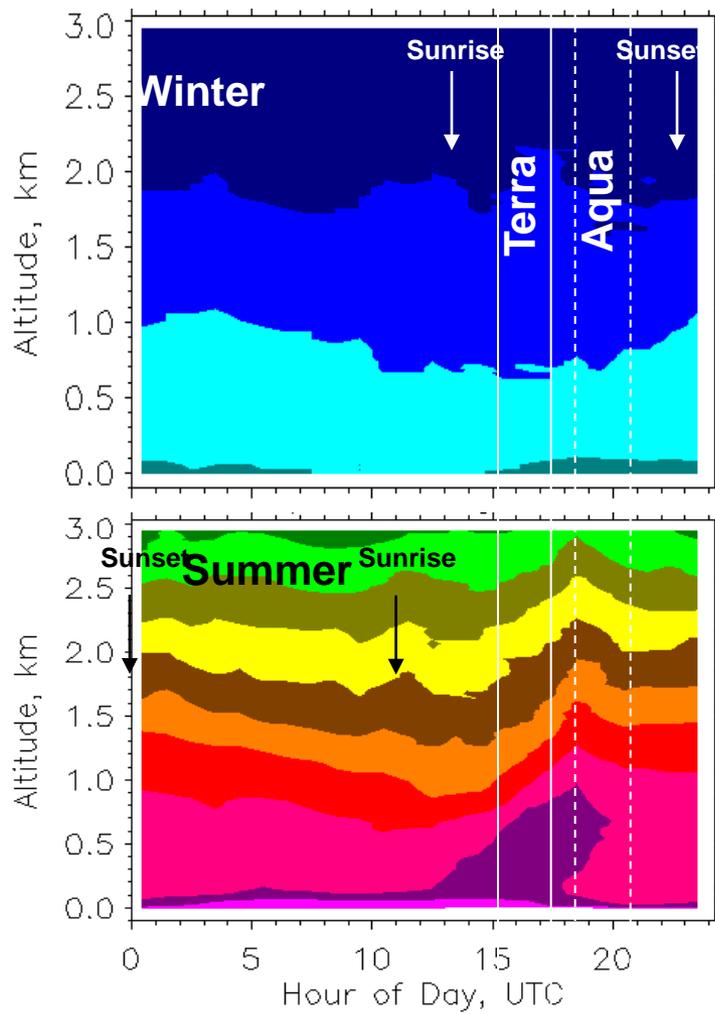




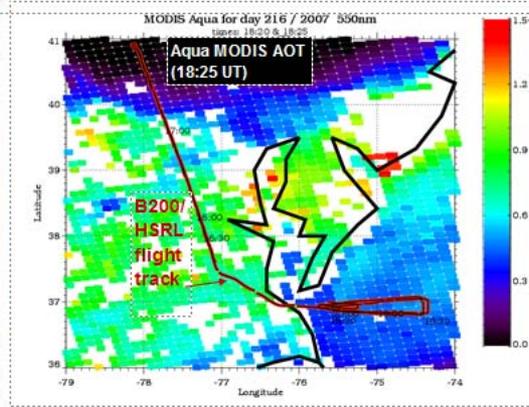
Average Diurnal Variation of Aerosol Extinction Profiles and AOT



Average Diurnal Variation of Water Vapor Profiles



HSRL Measurements used to evaluate satellite retrievals of aerosol optical depth – August 4, 2007

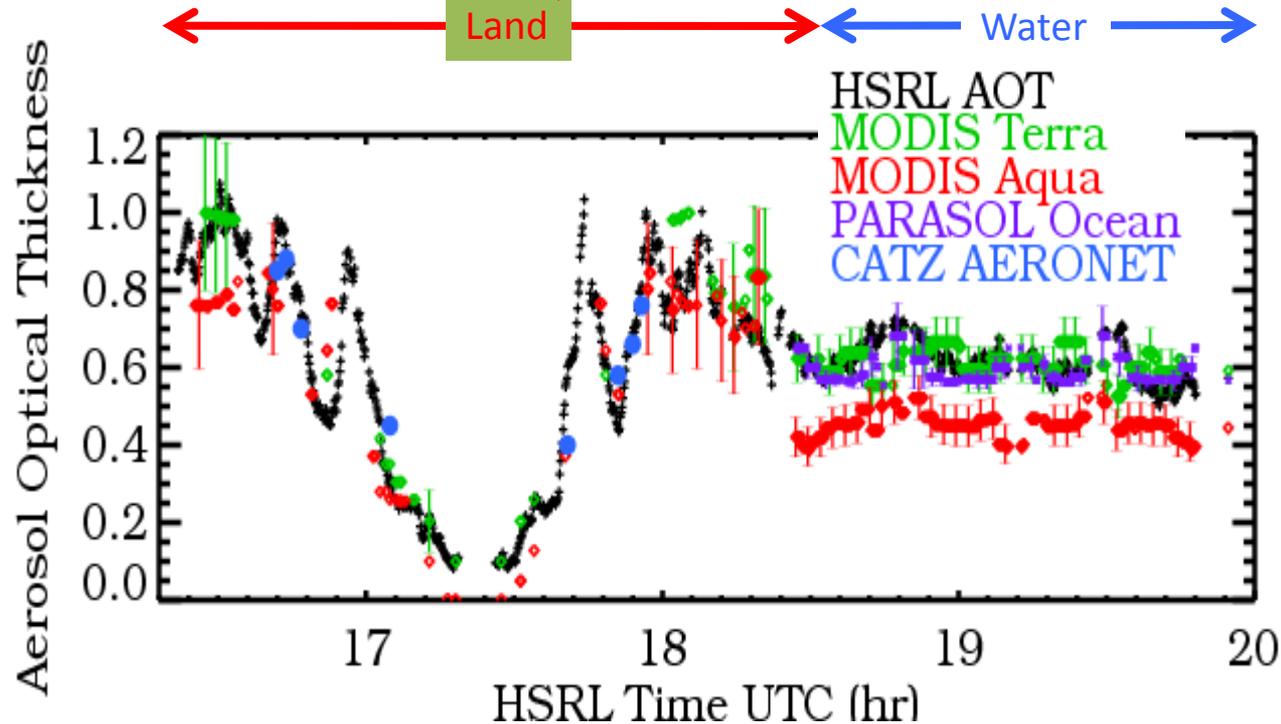
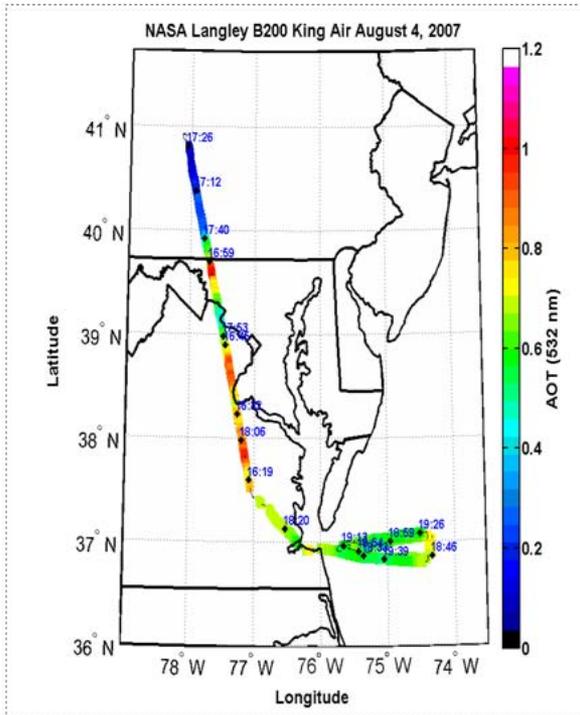


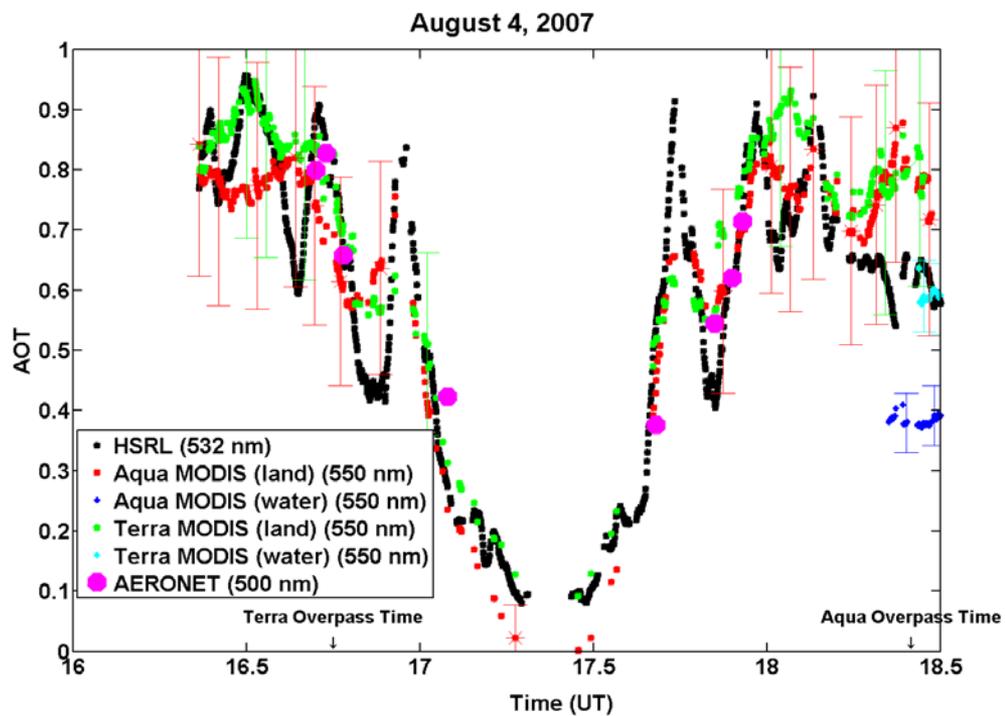
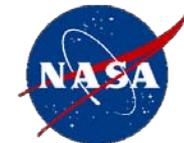
AOT Over land:

- Terra and Aqua MODIS, HSRL, and AERONET agree

AOT over water:

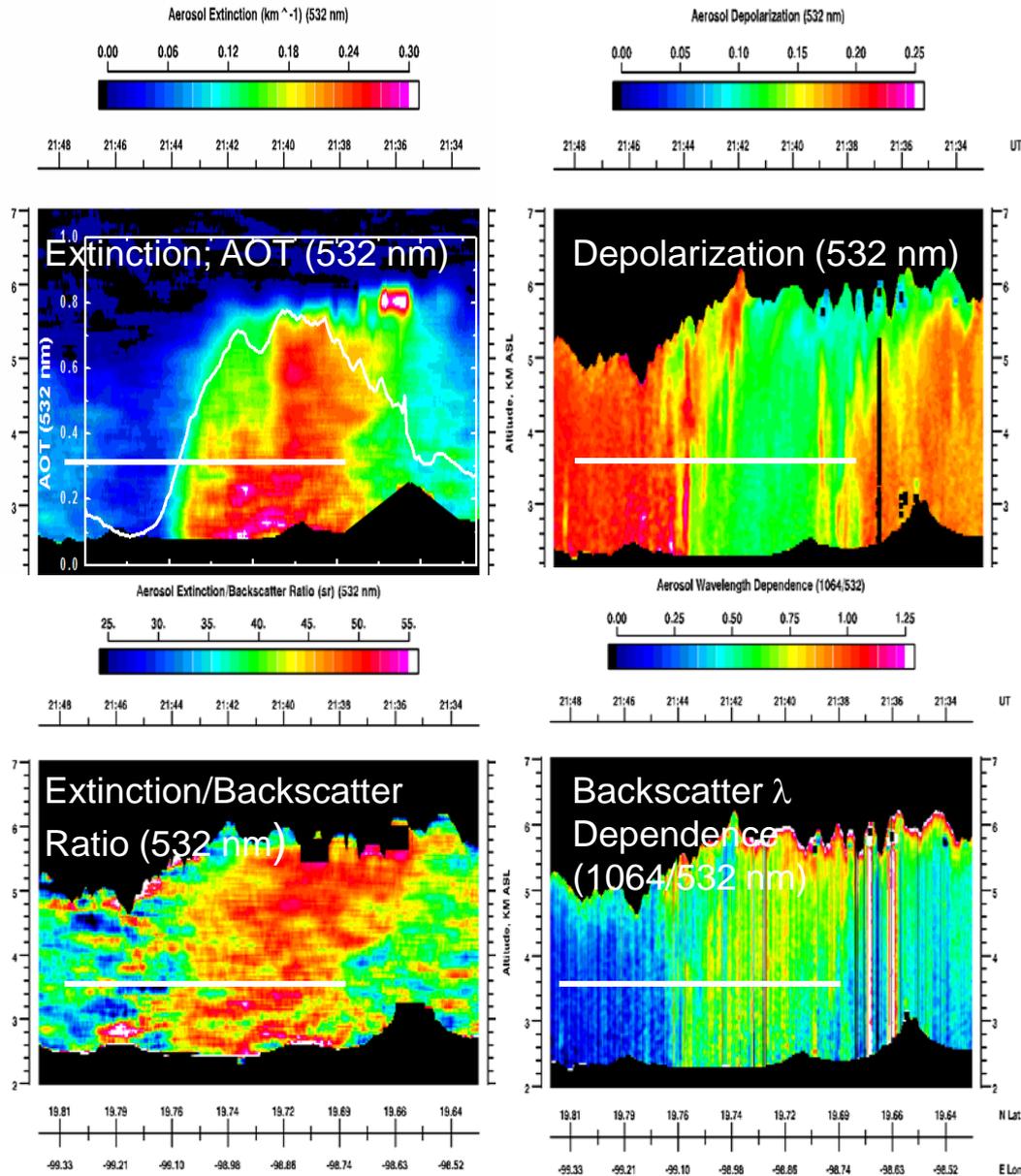
- Terra MODIS , PARASOL, and HSRL agree
- Aqua MODIS AOT about 0.2 (33%) low



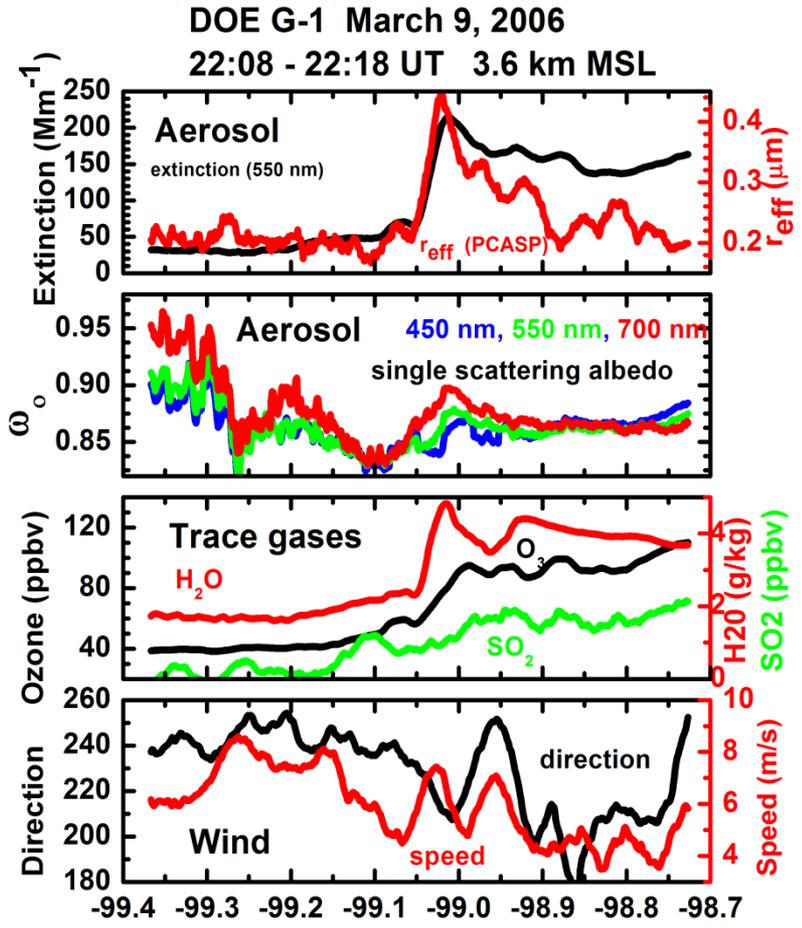




Characterizing aerosol optical properties/type Providing vertical context for G-1 in situ measurements



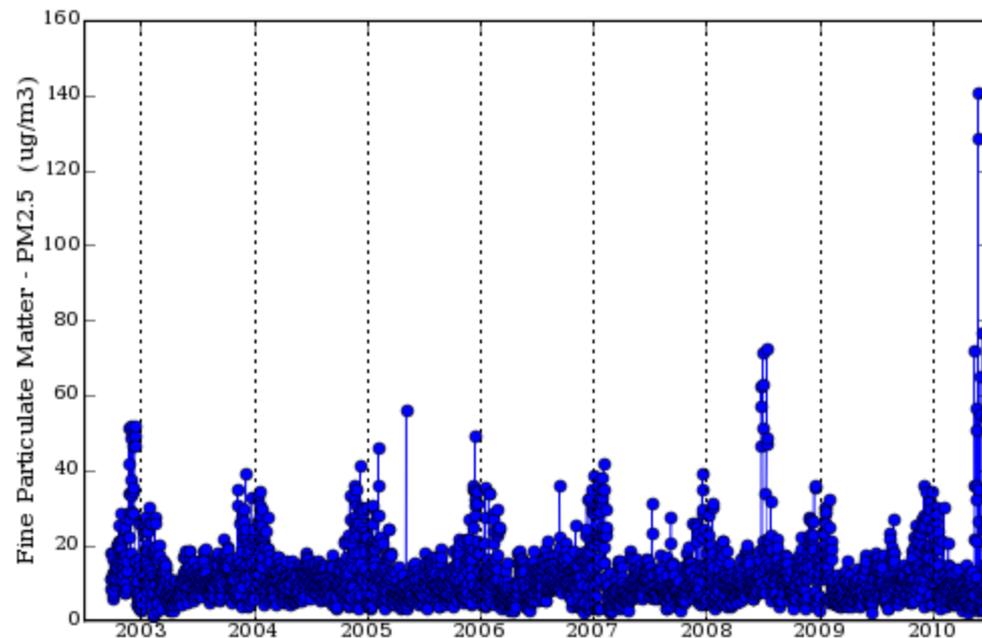
NASA King Air & DOE G-1 coordinated flight – March 9, 2006



PRELIMINARY DATA



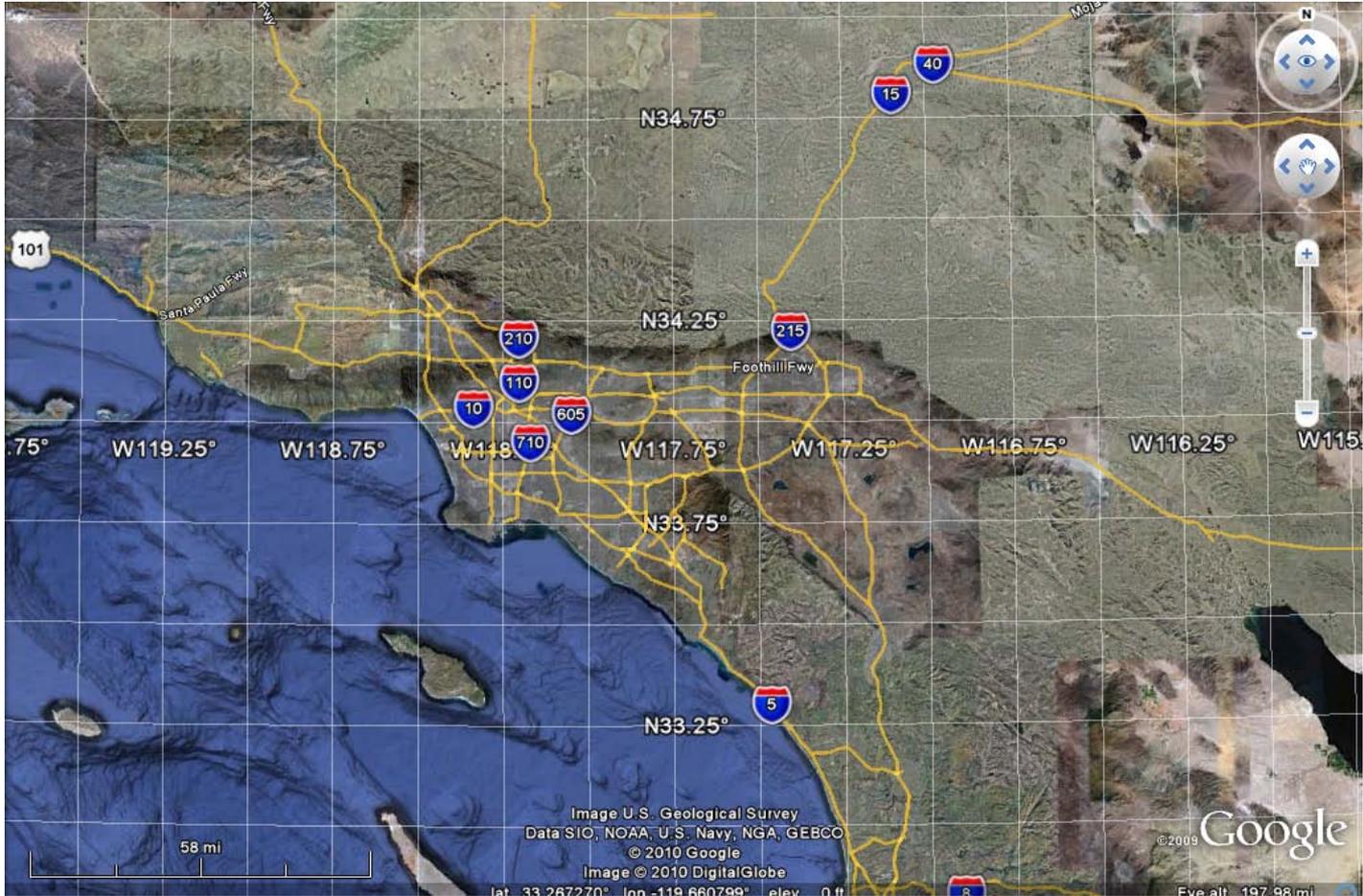
Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 122W-121W, 38N-38N)

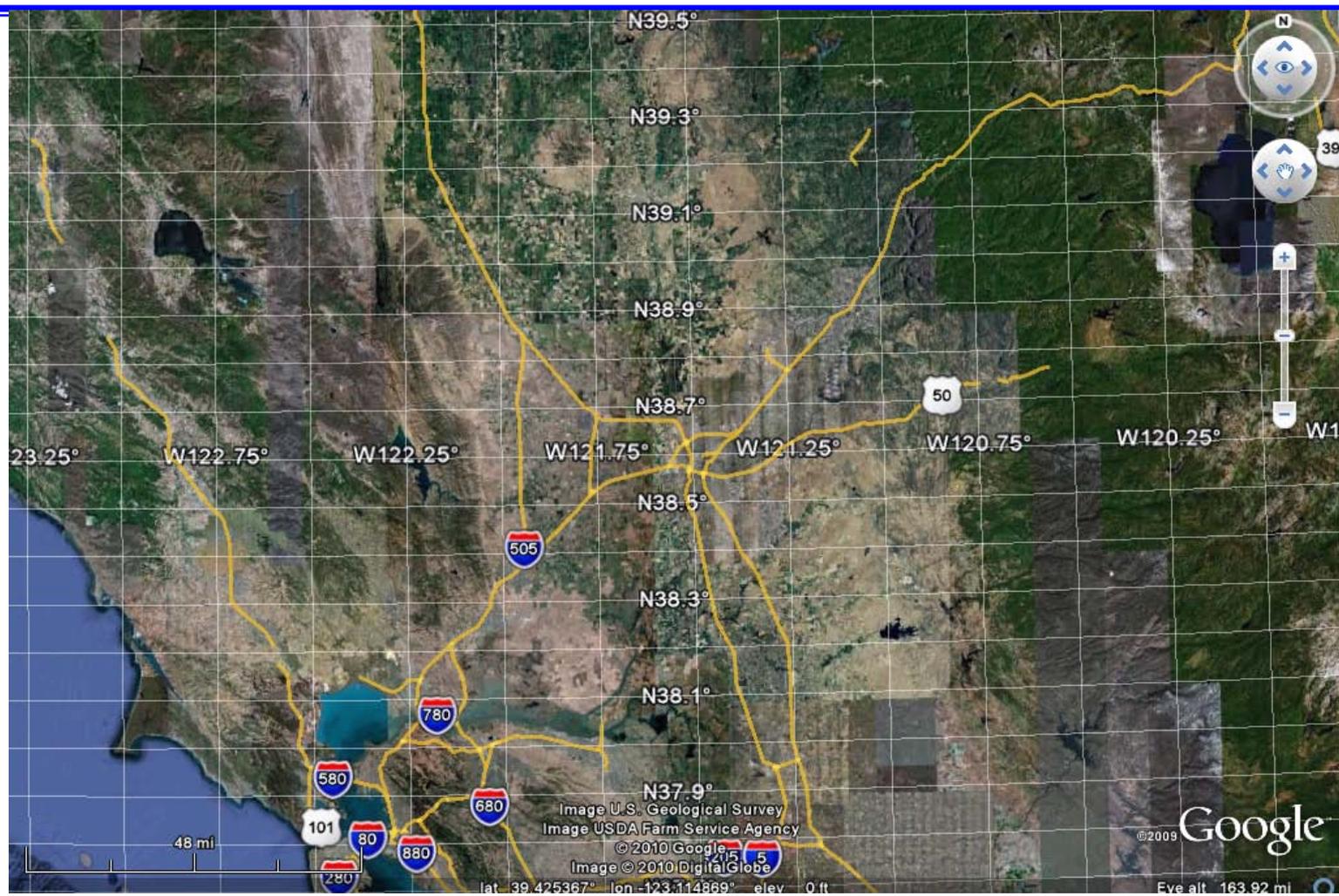


Cursor Coordinates: -121.57935, 38.93456

United States United States United States

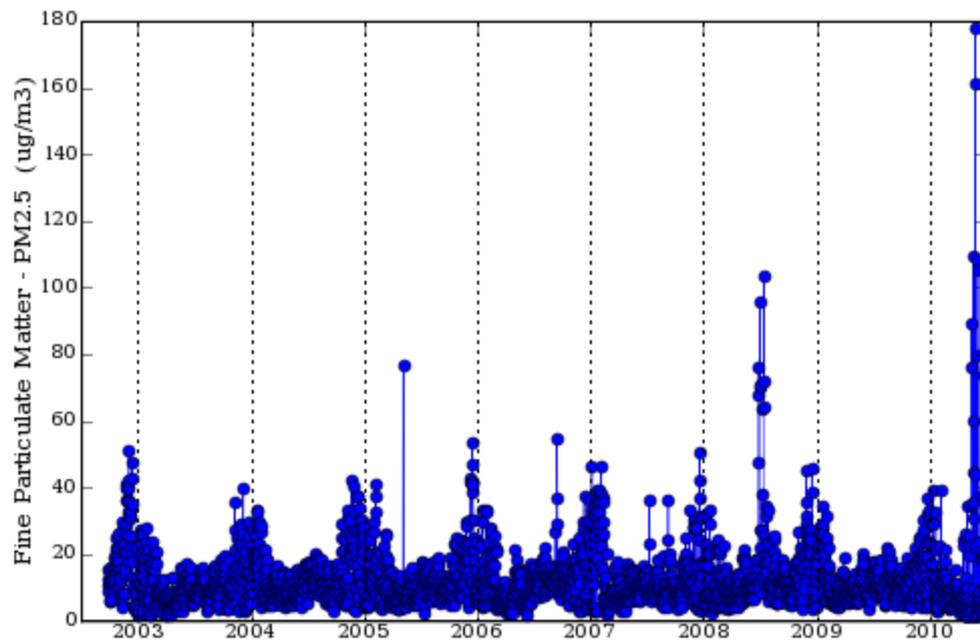
Area of Interest: West: -122.296209 North: 38.92357520 South: 38.53630713 East: -121.782598 Update Map







Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 122W-120W, 38N-39N)



Spatial

Cursor Coordinates: 0.00000, 0.00000

Area of Interest: West: -122 North: 39 South: 38 East: -120.5 Update Map

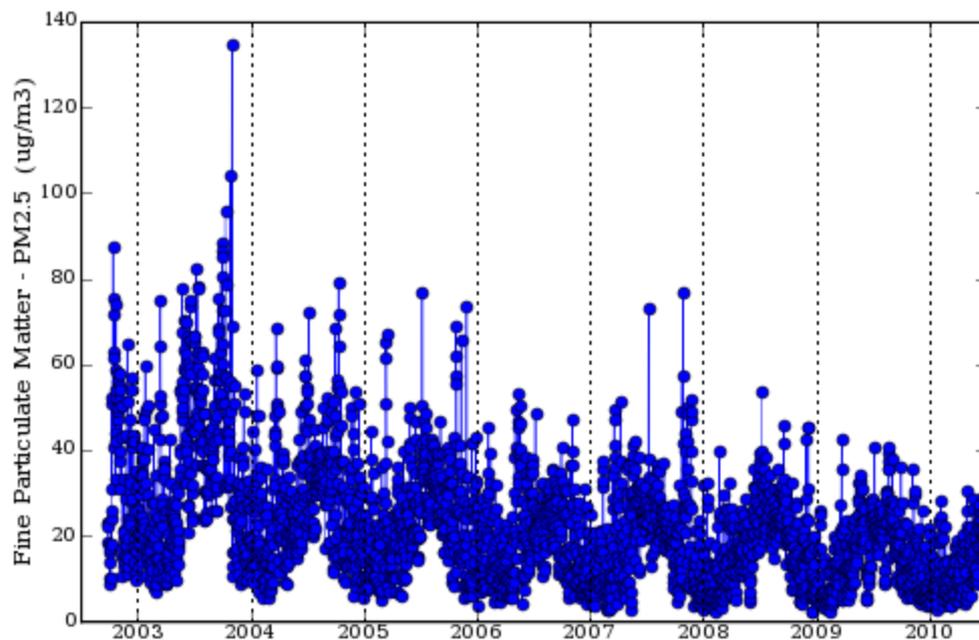
Temporal

Begin Date Year 2002 Month Jul Day 1 (Date Begin: 01 Jan 2000)

End Date Year 2010 Month Jun Day 28 (Date End: 29 Jun 2010)

The date ranges for the various Aerosol Parameters will depend on their sources (e.g Measurement or Model). These date ranges can be found next to the Data Product type in the grey blocks above.

Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 119W-117W, 33N-34N)



Spatial

Cursor Coordinates: -116.48663, 33.88190

Area of Interest: West: -119 North: 34.5 South: 33.5 East: -117 Update Map

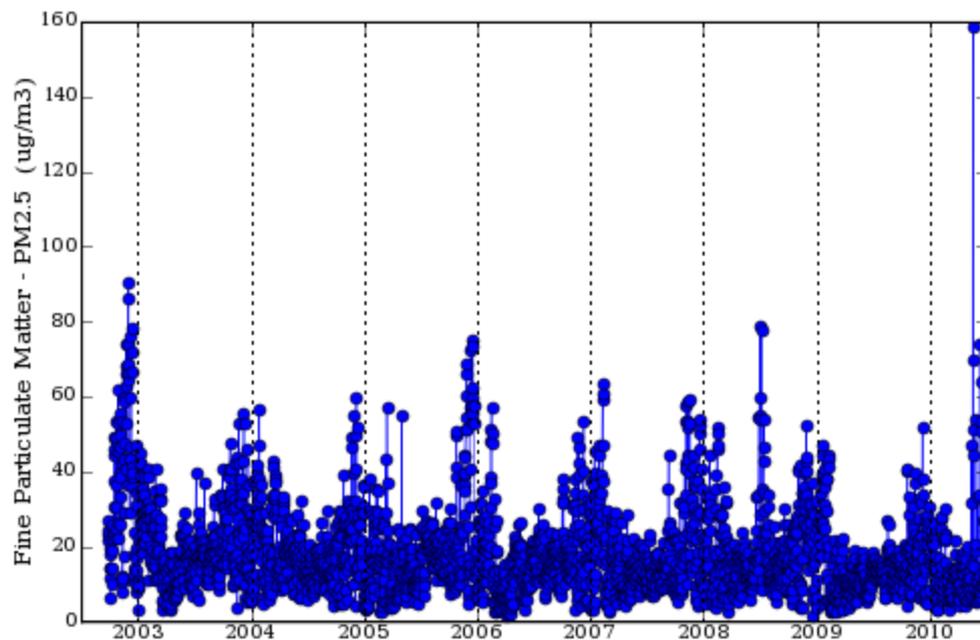
Temporal

Begin Date Year 2002 Month Jul Day 1 (Date Begin: 01 Jan 2000)

End Date Year 2010 Month Jun Day 28 (Date End: 29 Jun 2010)

The date ranges for the various Aerosol Parameters will depend on their sources (e.g Measurement or Model). These date ranges can be found next to the Data Product type in the grey blocks above.

Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 120W-118W, 35N-37N)



Spatial

Cursor Coordinates: 0.00000, 0.00000

Area of Interest: West: -120.25 North: 37 South: 35.25 East: -118.75 Update Map

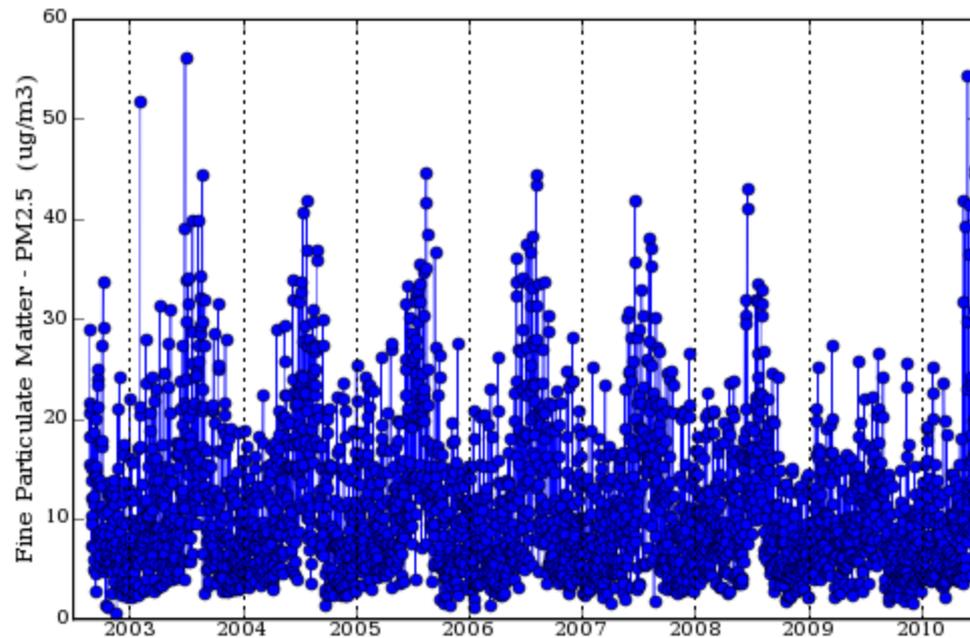
Temporal

| | | | | | | | |
|------------|------|------|-------|-----|-----|----|---------------------------|
| Begin Date | Year | 2002 | Month | Jul | Day | 1 | (Date Begin: 01 Jan 2000) |
| End Date | Year | 2010 | Month | Jun | Day | 28 | (Date End: 30 Jun 2010) |

The date ranges for the various Aerosol Parameters will depend on their sources (e.g Measurement or Model). These date ranges can be found next to the Data Product type in the grey blocks above.



Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 77W-76W, 38N-39N)



Spatial

Cursor Coordinates: -77.77504, 38.59188

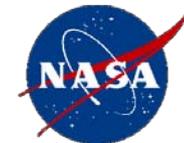
Area of Interest: West: -77.6 North: 39.6 South: 38.6 East: -76 Update Map

Temporal

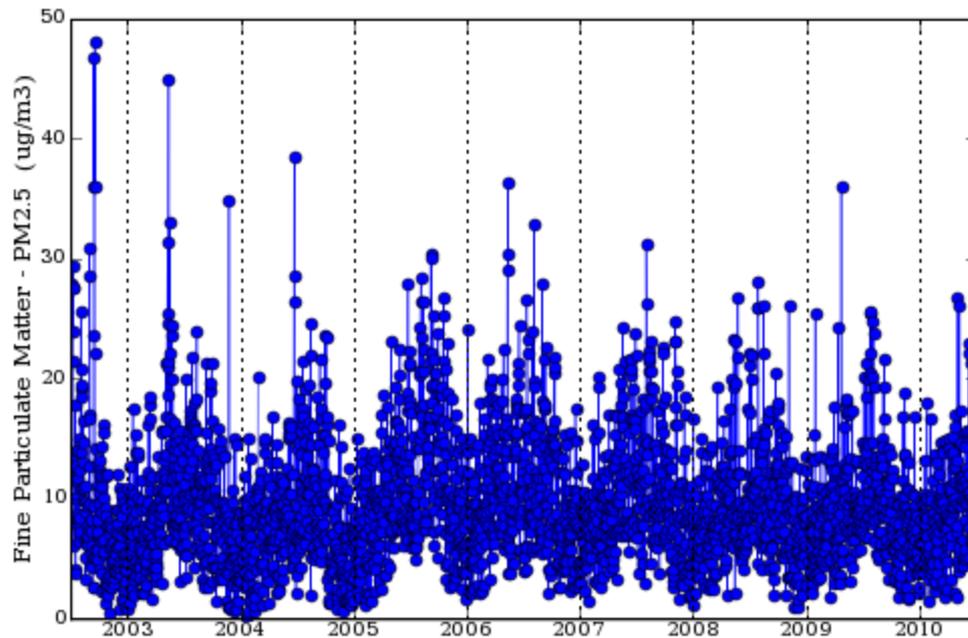
Begin Date Year 2002 Month Jul Day 1 (Date Begin: 01 Jan 2000)

End Date Year 2010 Month Jun Day 28 (Date End: 02 Jul 2010)

The date ranges for the various Aerosol Parameters will depend on their sources (e.g Measurement or Model). These date ranges can be found next to the Data Product type in the grey blocks above.



Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 96W-94W, 29N-30N)



Spatial

Cursor Coordinates: -95.05495, 29.57516

Area of Interest: West: -96 North: 29.2 South: 29.2 East: -94.5 Update Map

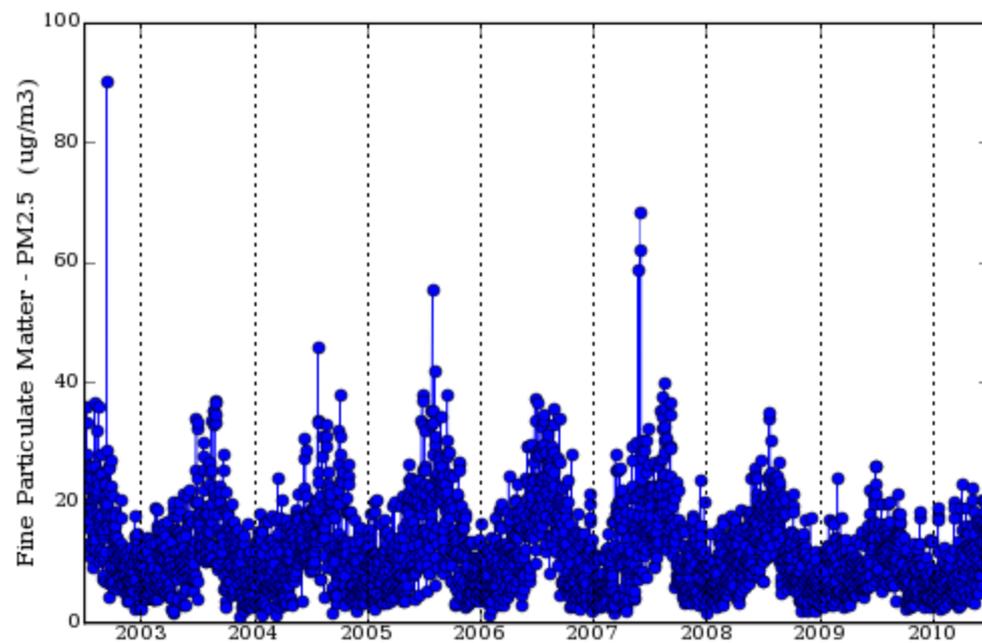
Temporal

Begin Date Year: 2002 Month: Jul Day: 1 (Date Begin: 01-Jan-2000)

End Date Year: 2010 Month: Jun Day: 28 (Date End: 02-Jul-2010)

The date ranges for the various Aerosol Parameters will depend on their sources (e.g. Measurement or Model). These date ranges can be found next to the Data Product type in the gray blocks above.

Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 85W-83W, 33N-34N)



Spatial

Cursor Coordinates: 0.0000, 0.0000

West: 83.0000 East: 85.0000

Area of Interest: West: -85.25 North: 34.3 South: 33.3 East: -83.25 Update Map

Temporal

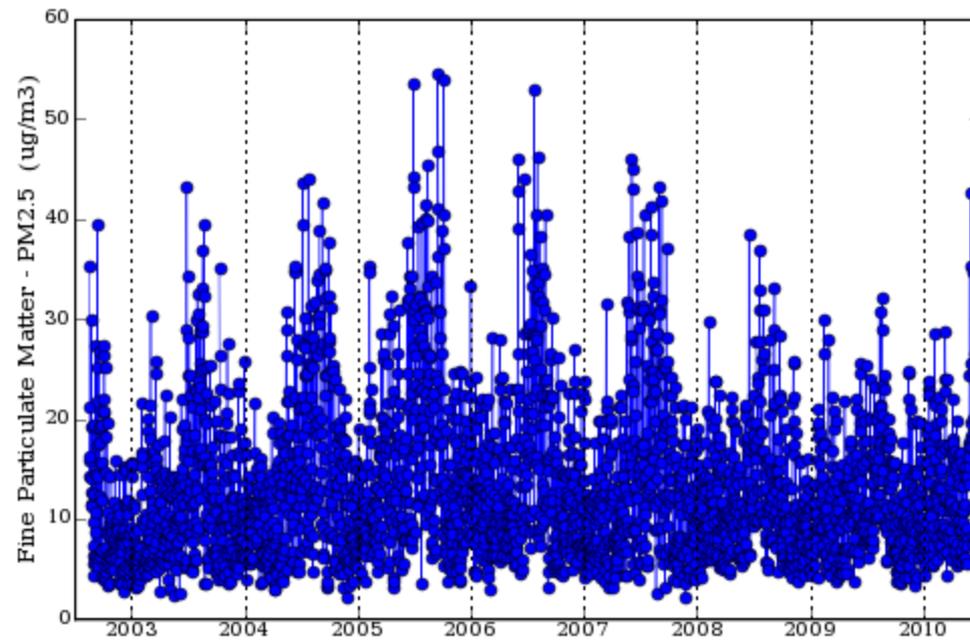
Begin Date Year: 2002 Month: Jul Day: 1 (Date Begin: 01 Jan 2000)

End Date Year: 2010 Month: Jun Day: 28 (Date End: 02 Jul 2010)

The date ranges for the various Aerosol Parameters will depend on their sources (e.g. Measurement or Model). These date ranges can be found next to the Data Product type in the grey blocks above.



Area-Averaged Time Series (AIRNOW_PM.001) (Region: 82W-79W, 39N-41N)



Refine Constraints [Top]

Spatial

Cursor Coordinates: -78.87982, 41.23829

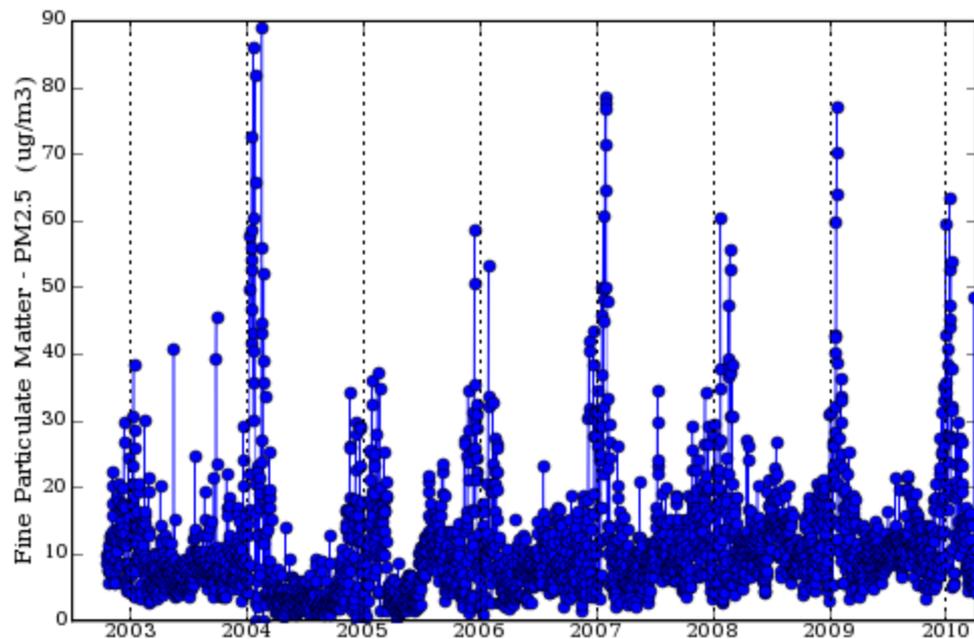
Area of Interest: (West) -82 (East) -79 (North) 41.75 (South) 39.75 Update Map

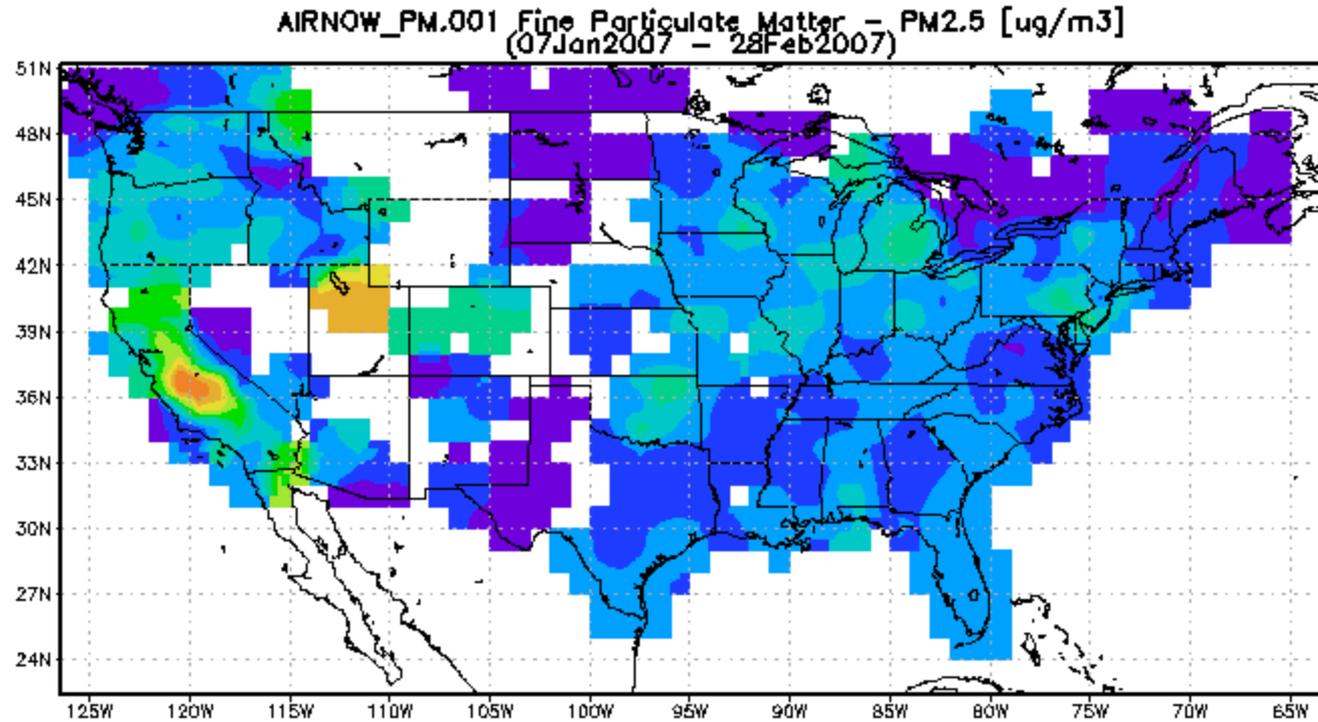
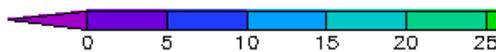
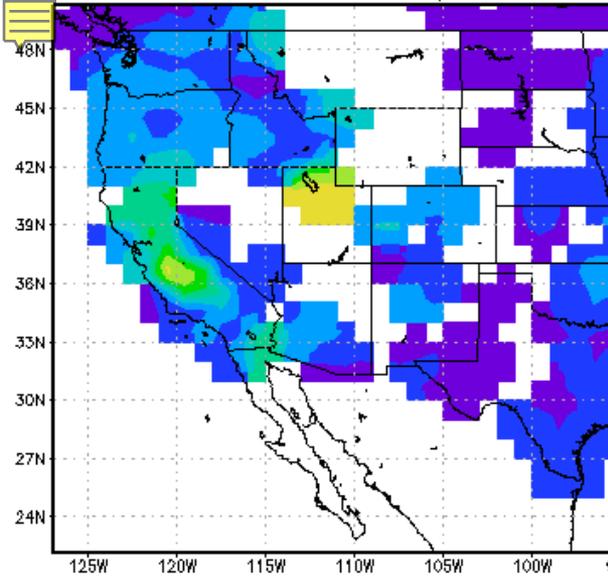
Temporal

Begin Date Year: 2002 Month: Jul Day: 1 (Date Begin: 01 Jan 2000)
End Date Year: 2010 Month: Jul Day: 22 (Date End: 03 Jul 2010)

The date ranges for the various Aerosol Parameters will depend on their sources (e.g. Measurement or Model). These date ranges can be found next to the Data Product type in the grey boxes above.

Area-Averaged Time Series (AIRNOW_PM.001)
(Region: 112W-111W, 39N-41N)





AIRNOW_PM.001 Fine Particulate Matter
(01Feb2007 - 28Feb2007)

