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Air Quality Monitoring and Smoke

Health Breakout Session
GEO-UIC Meeting
August 1-3, 2007
Washington, DC

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United States Environmental Protection Agency
Office of Research and Development, National Exposure Research Laboratory, Environmental Sciences Division

August 6, 2007

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Why is Air Quality Important?

- **Aerosols ($PM_{2.5}$)**
  - Induce respiratory diseases and cancer
  - Reduce visibility
  - Impacts Climate

- **Impacts of Poor Air Quality on Society**
  - 146 million+ people in the US live in areas with poor air quality[+]
  - 60,000 Death per annual (mean)*
  - $143 Billion Cost per annual (mean)**

[+] USEPA 2004;*Science 289, 2000; **American Lung Assoc. 2001

MODIS AOD/PM2.5 time series

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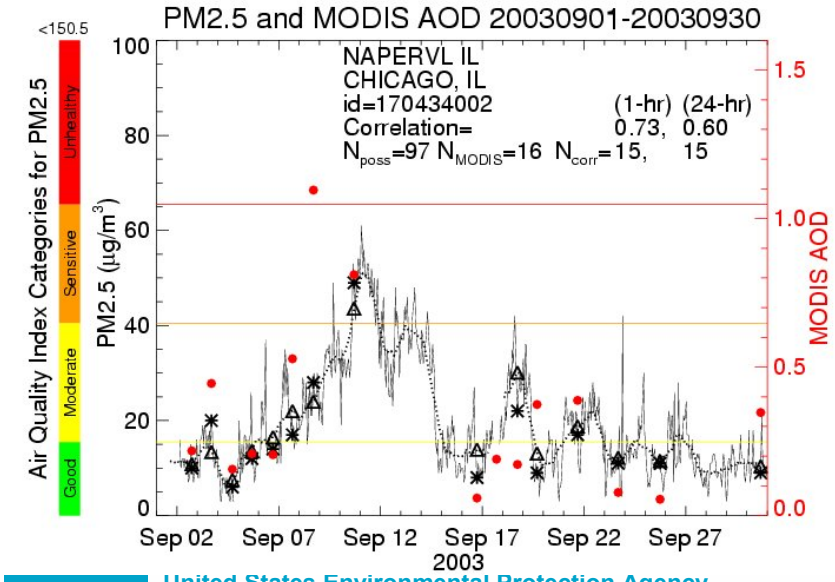
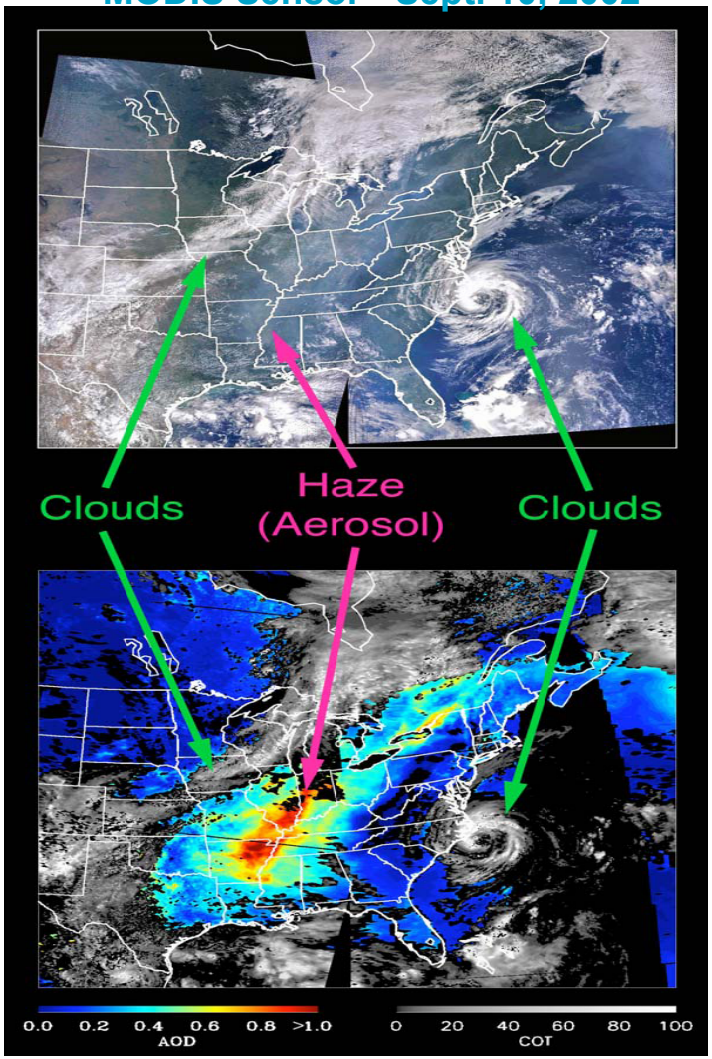
MODIS AOD shows strong correlations with PM2.5 mass concentrations during large scale aerosol events (US EPA, 2003 and Engel-Cox, J. et. al. 2004).

MODIS AOD estimate correct AQI level >90% (regional AL study) (Wang, J., S. Christopher, 2003).



Visible Image vs. Atmospheric Reterivals
MODIS Sensor - Sept. 10, 2002



Infusing satellite Data into Environmental Applications (IDEA)

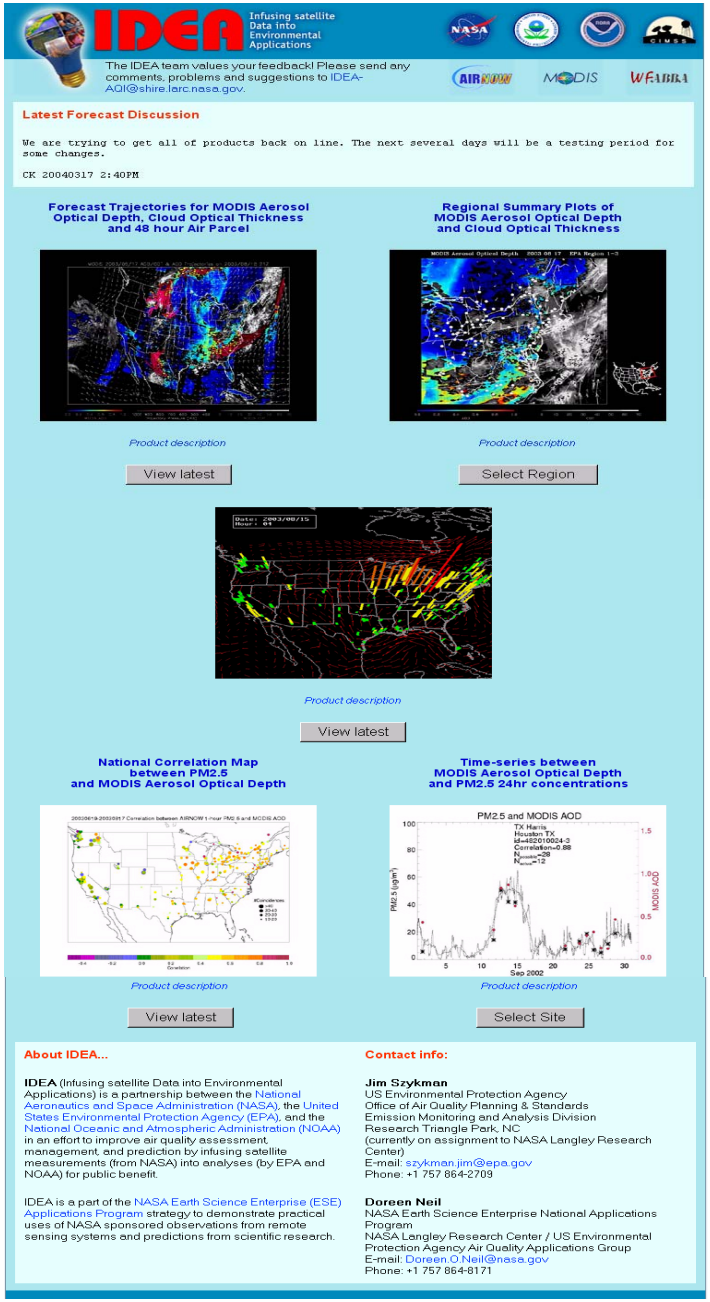
A joint NASA-NOAA-EPA initiative:

Objective - Prototype a near-real-time MODIS trajectory forecast product using MODIS direct broadcast aerosol optical depth over CONUS.

Goal - Improve accuracy of next day $PM_{2.5}$ Air Quality Index (AQI) by providing pseudo-synoptic aerosol observations and trajectory forecast during large aerosol events.

- *EPA, NOAA, NASA, University Researchers, and Air Quality Forecasters prototyped a system demonstrated during Summer 2003.*
- *Pseudo-operational System implemented at CIMSS May 2004. Forecast tool for AQ forecasters through direct link with AIRNow-TECH.*
- *Currently in pre-operational mode at NESDIS, scheduled to become operational in 2007.*

Benefit - Enable improved mitigation of health effects caused by episodes of poor air quality



Al-Saadi et. al., September 2005, *Bulletin of American Meteorological Society*

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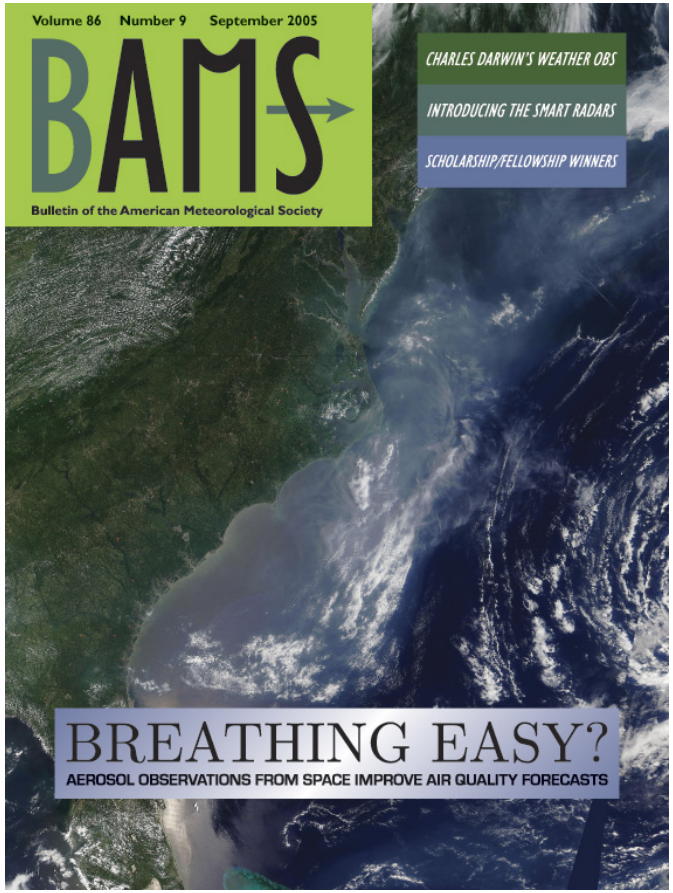
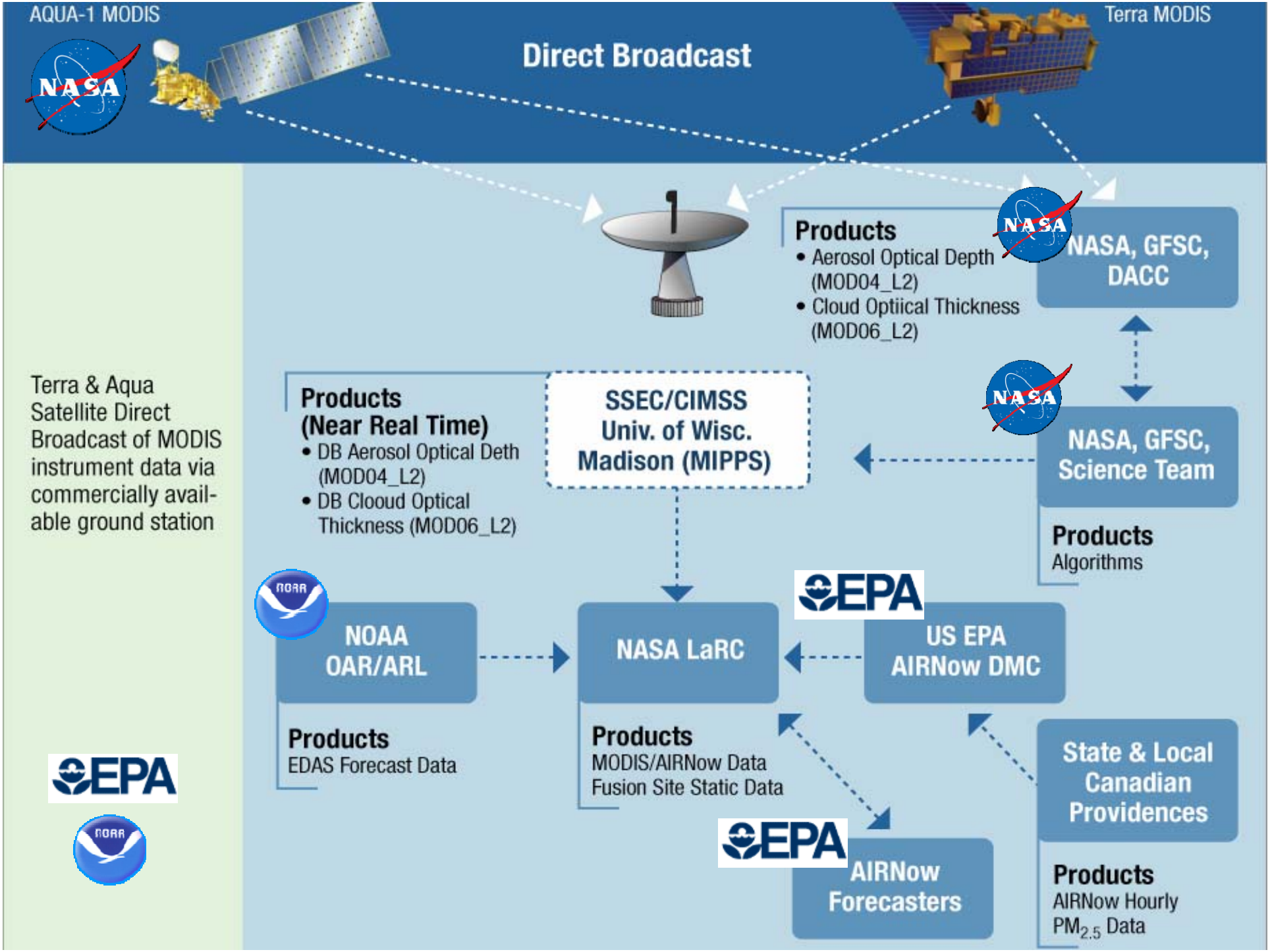
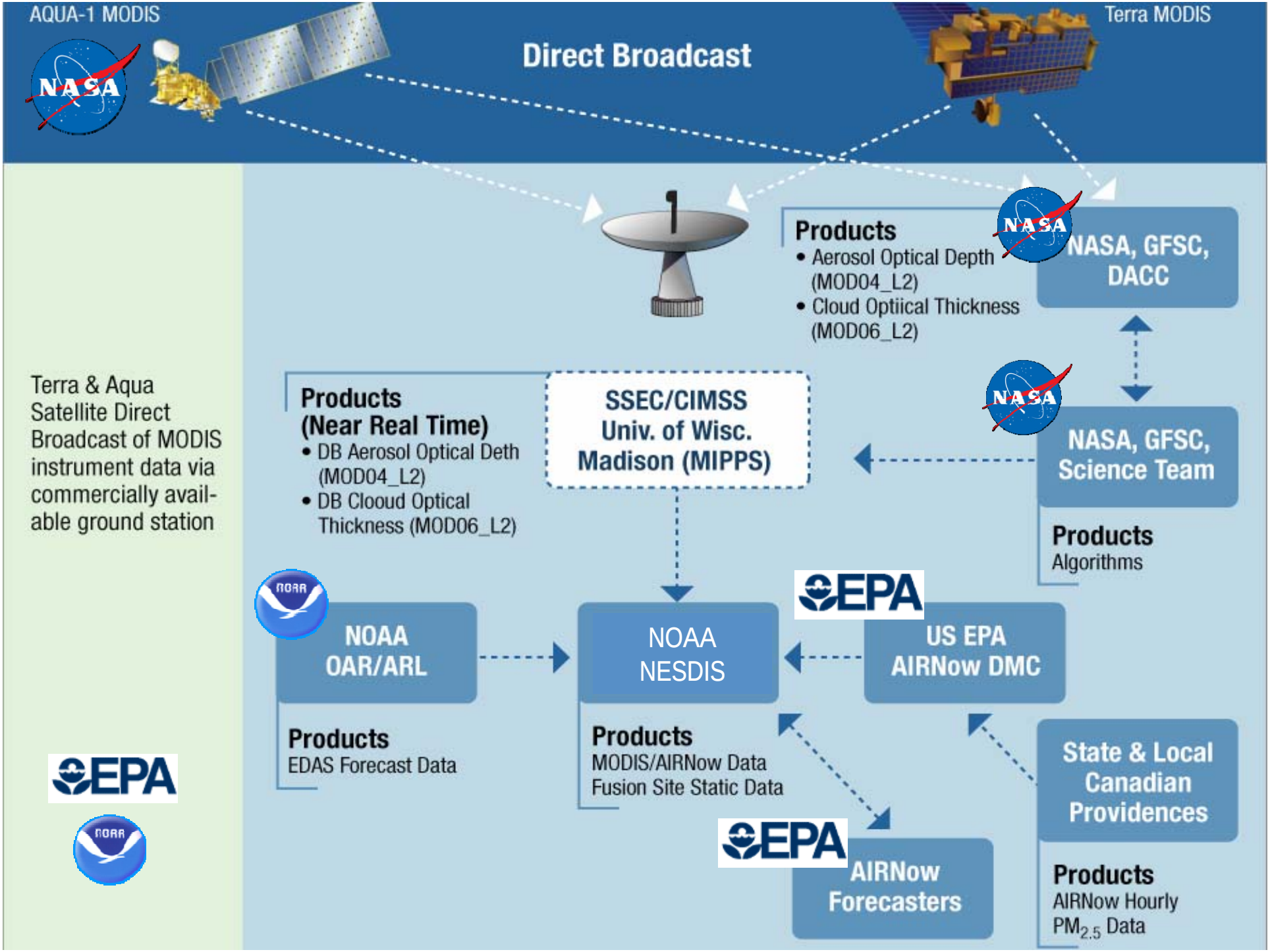


Al-Saadi et. al., September 2005, *Bulletin of American Meteorological Society*





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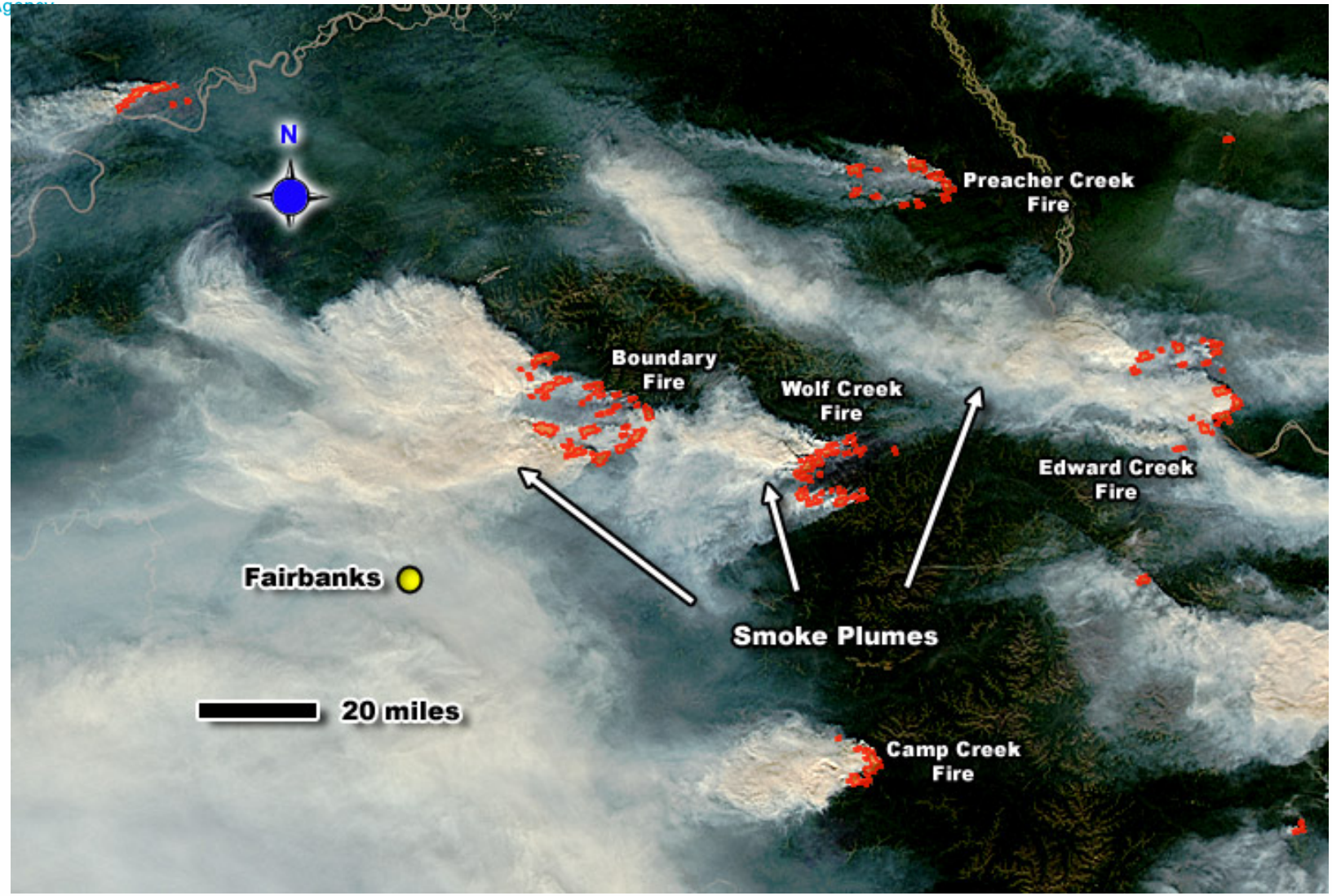
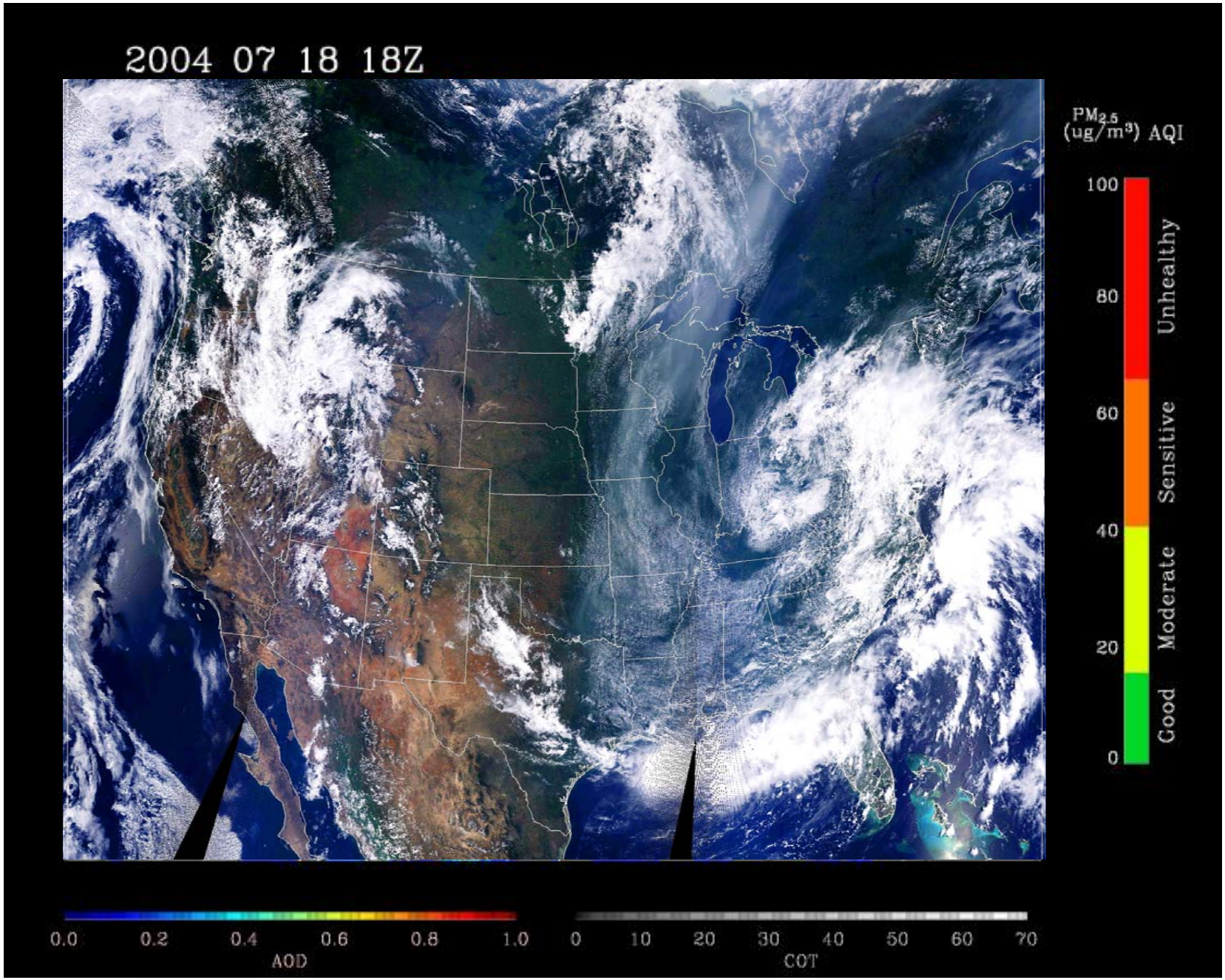
Alaskan Fire Complexes
June 30, 2004

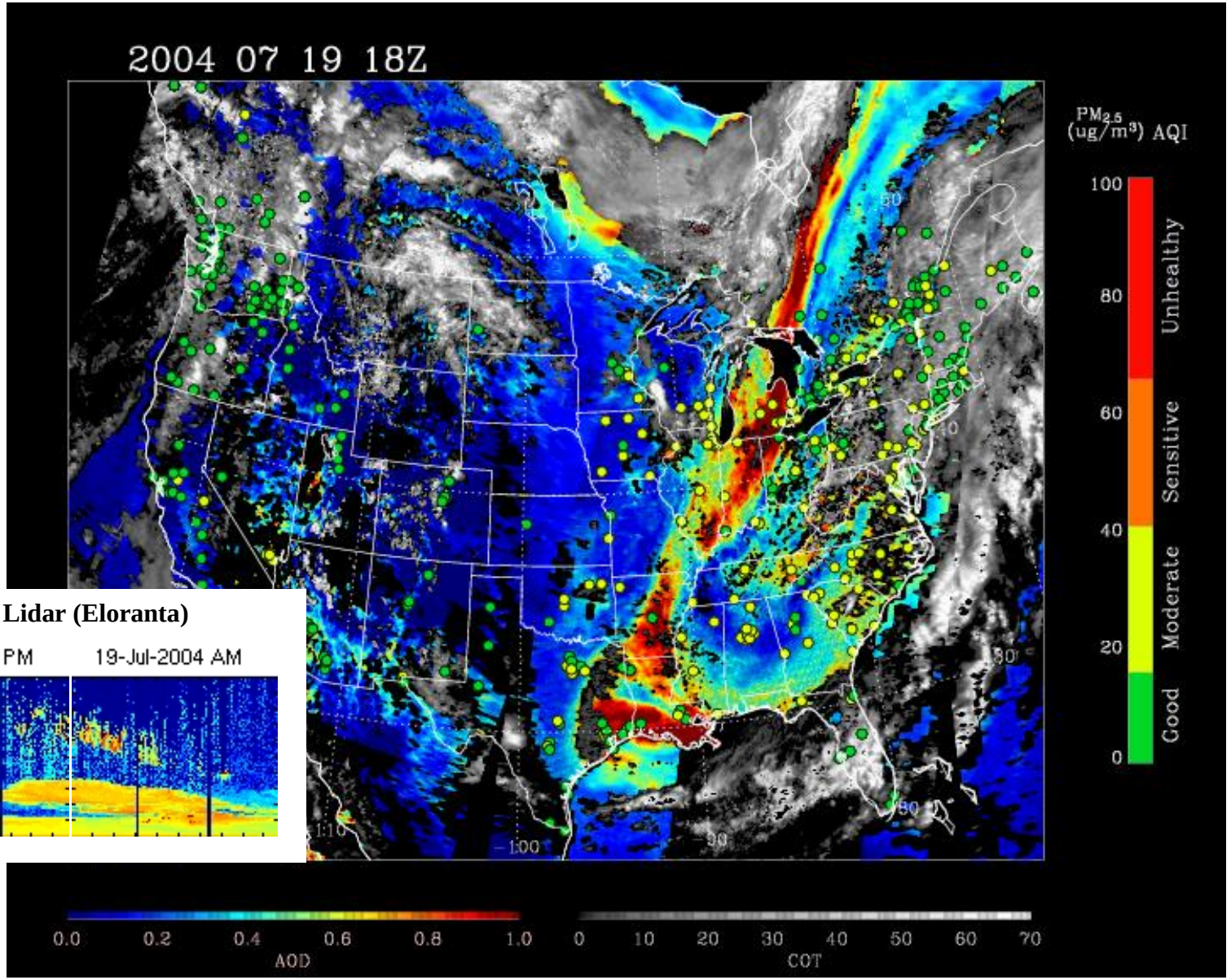


Data source: NASA MODIS-Aqua

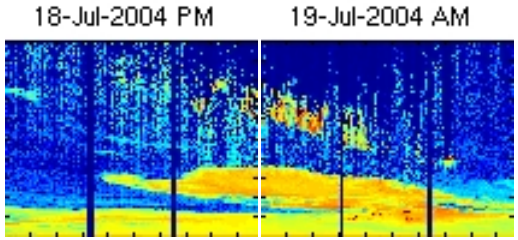
18 July 2004 Smoke from Alaskan/Yukon Fires Over U.S.



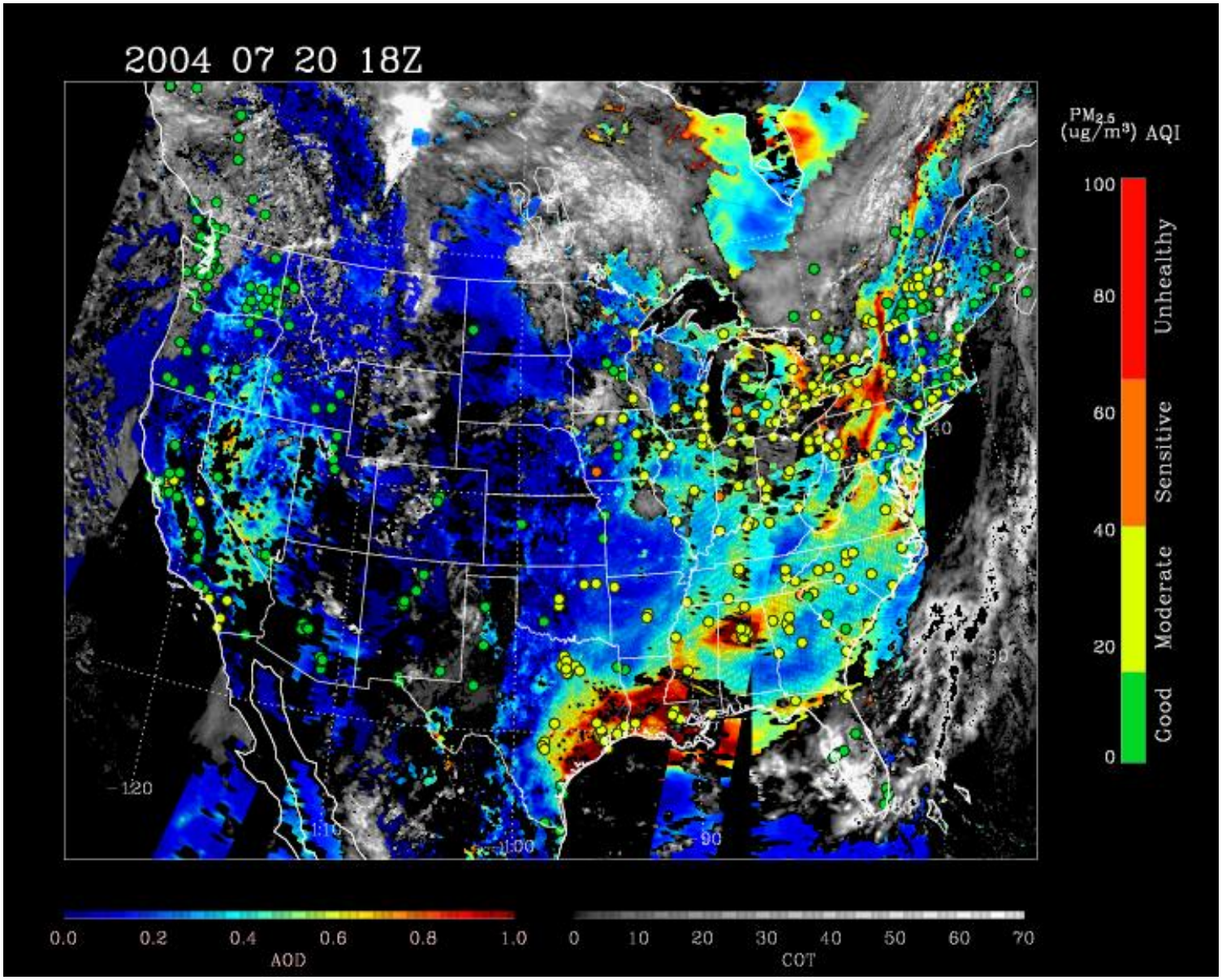
19 July 2004 Smoke from Alaskan/Yukon Fires Impact U.S.



SSEC Lidar (Eloranta)



20 July 2004 Smoke from Alaskan/Yukon Fires Impact U.S.



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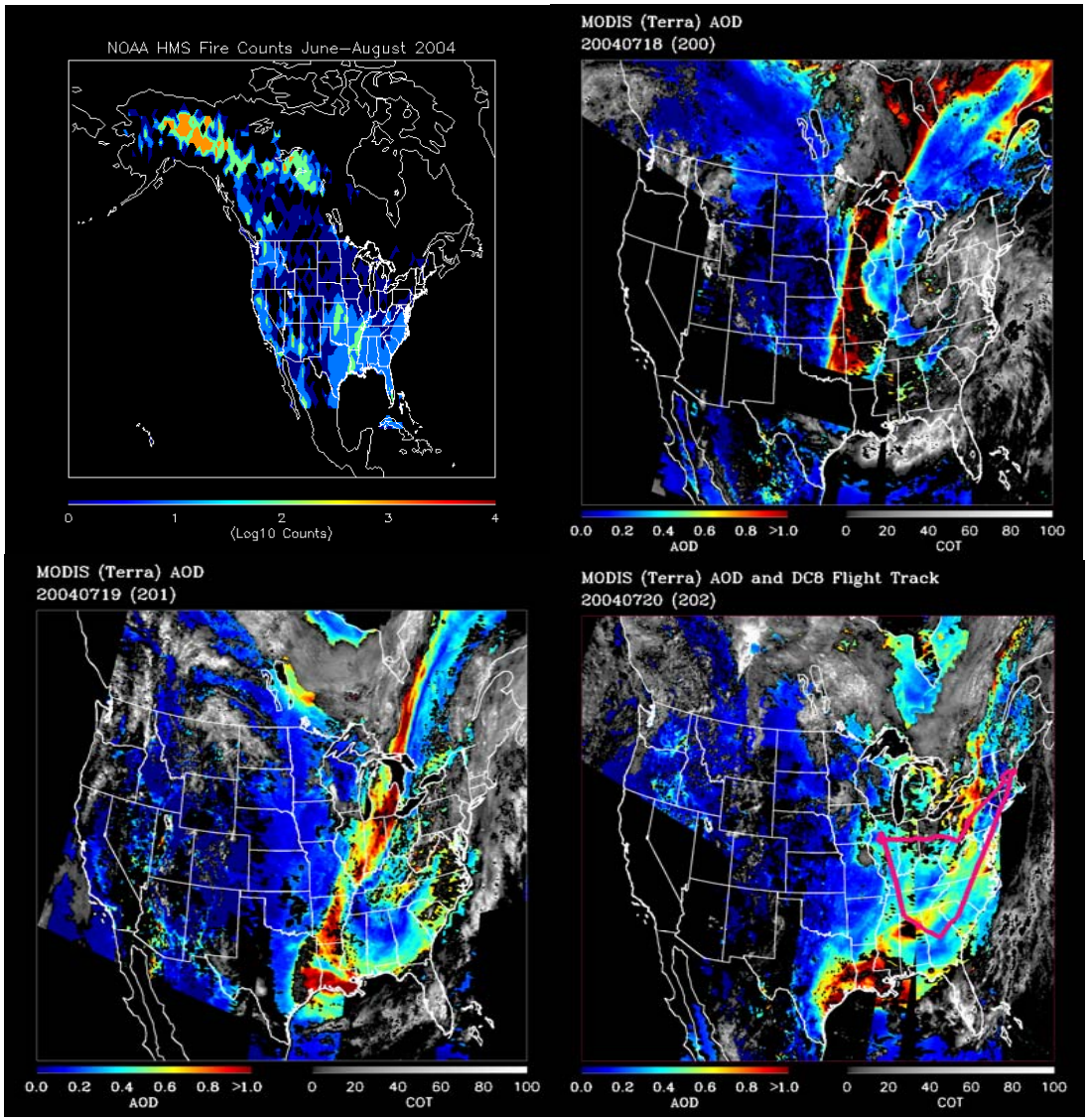
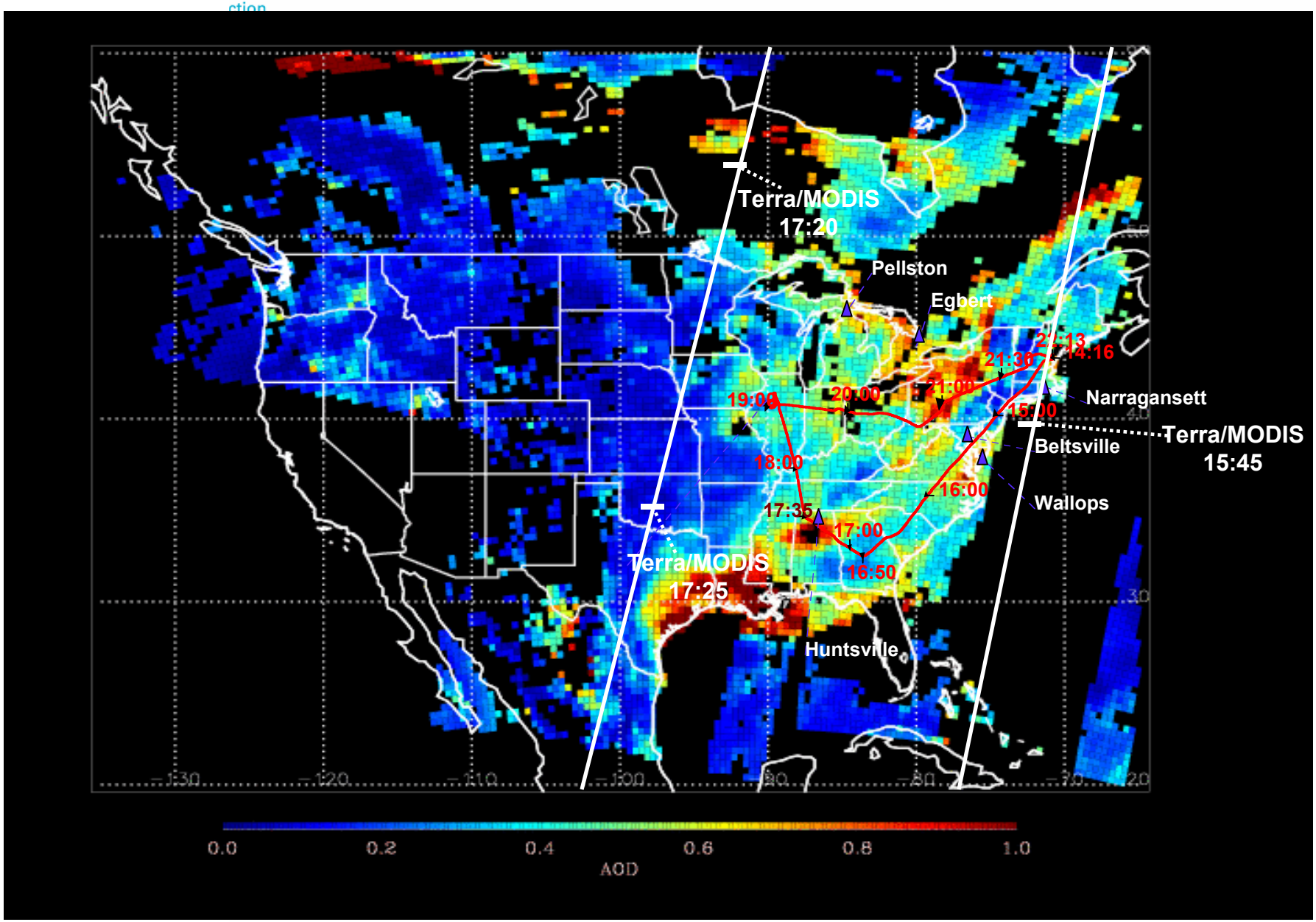
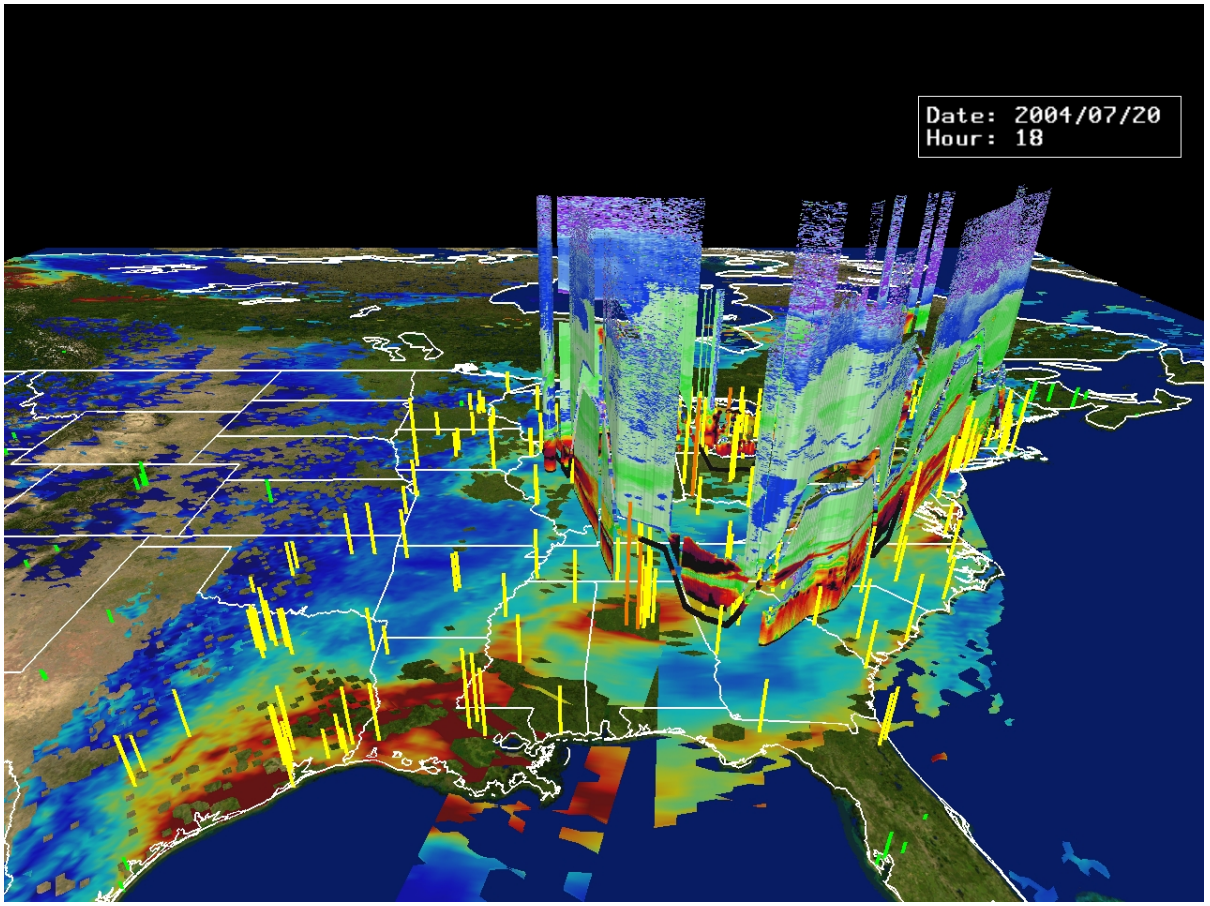


NASA LaRC DIAL DC-8 Track (Flight 10) July 20, 2004



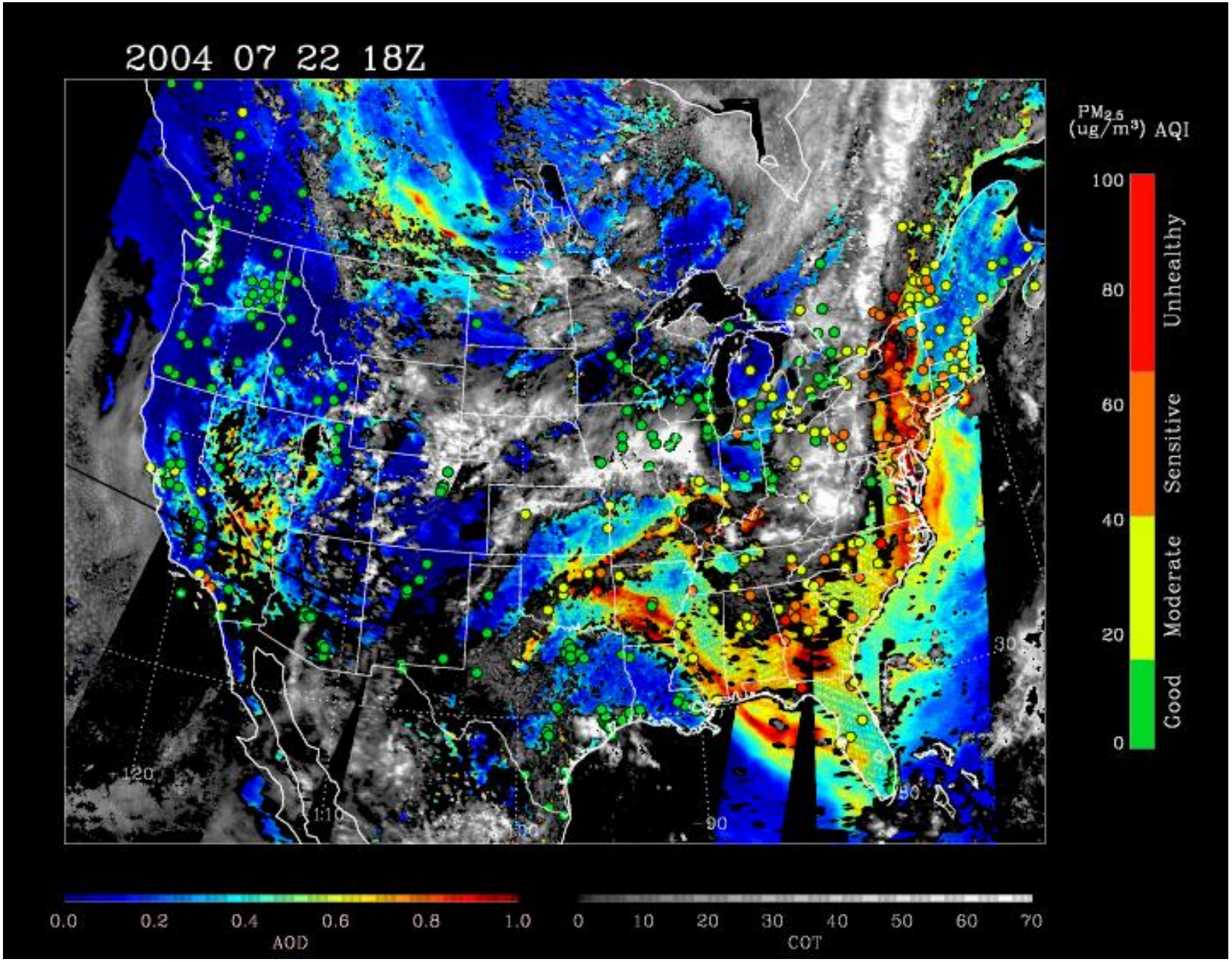
EPA United States Environmental Protection Agency

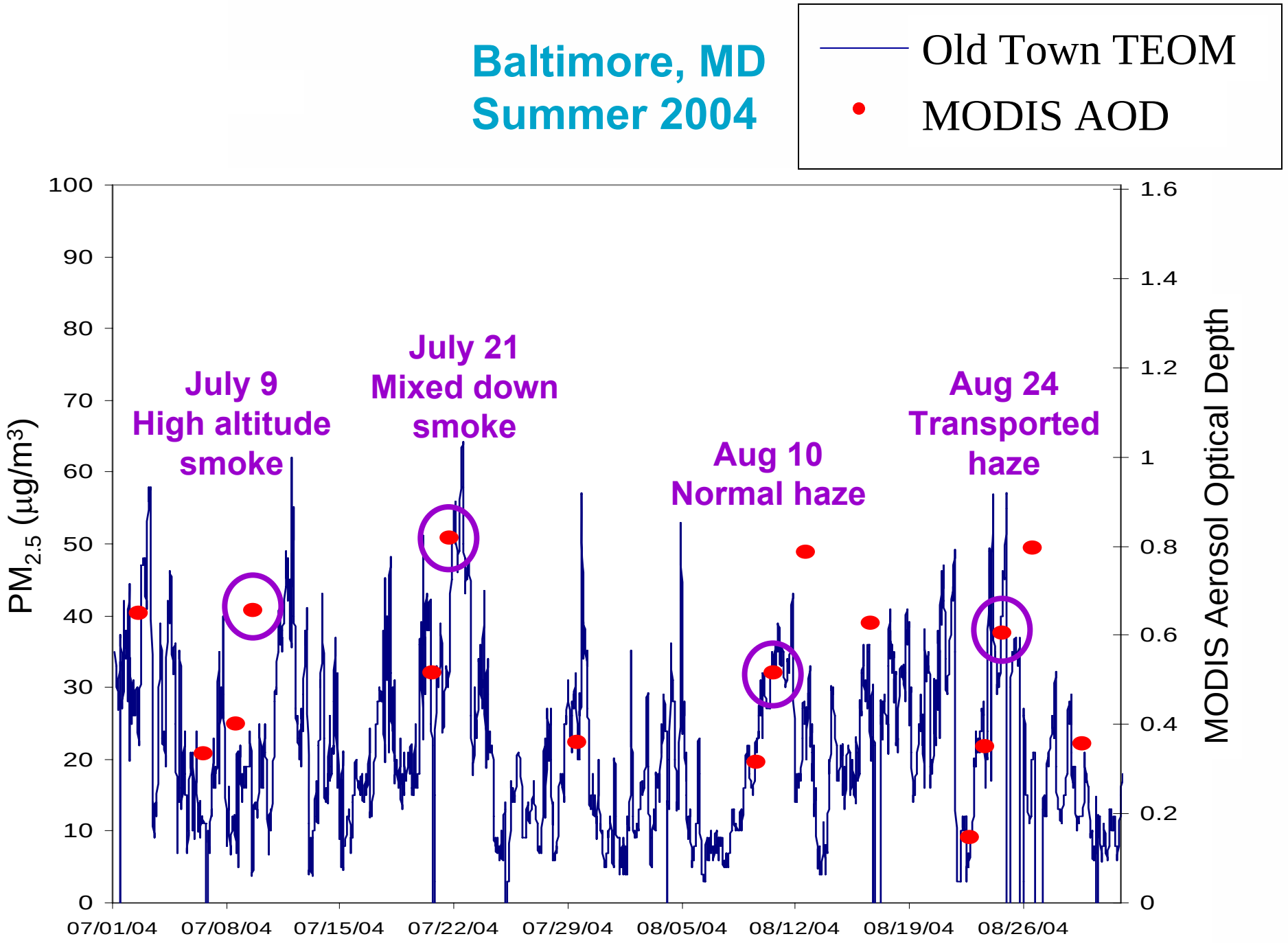
An Integrated Picture of Aerosols in SE United States on July 20, 2004 Helps Show the Evolution of The Largest Aerosol Pollution Event during Summer 2004



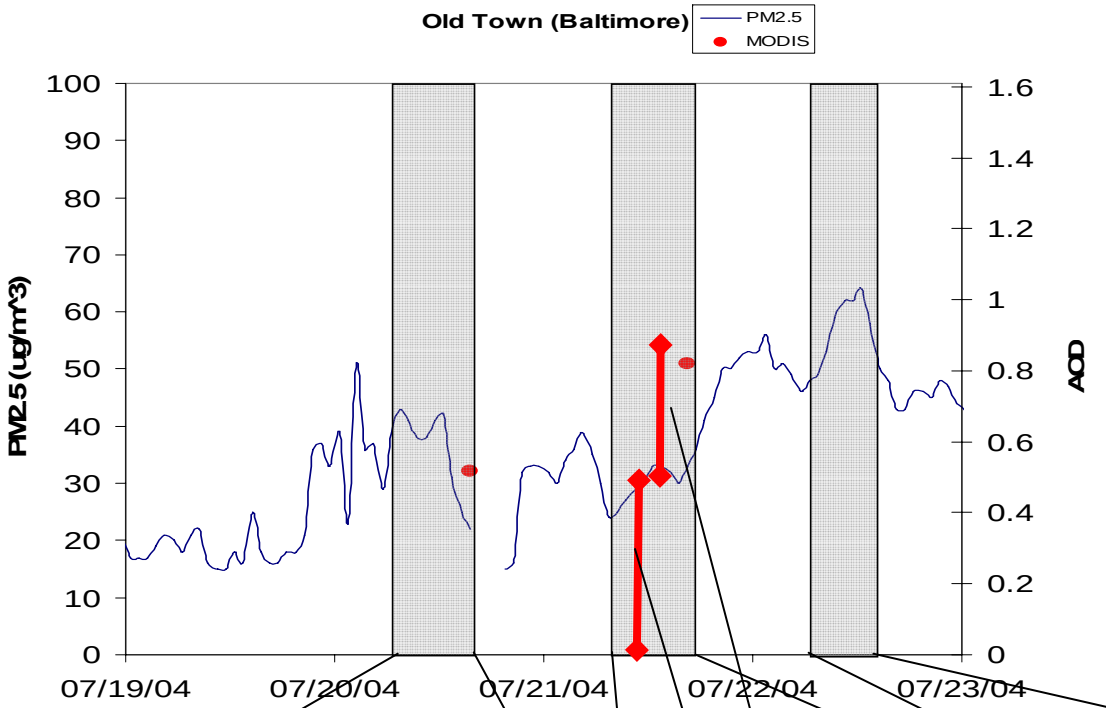
NASA's DC-8 LIDAR and In-situ Aerosol Measurements during the ICARTT field campaign overlaid with NASA MODIS AOD and EPA AIRNow ground based measurements.

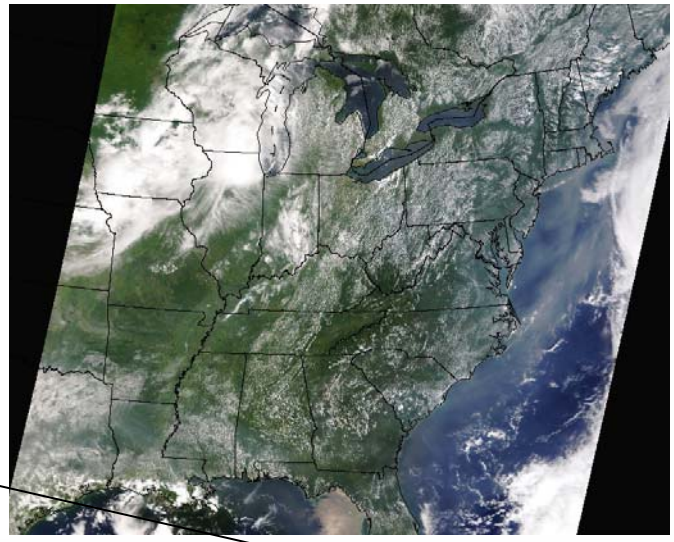
22 July 2004 Smoke from Alaskan/Yukon Fires Impact U.S.

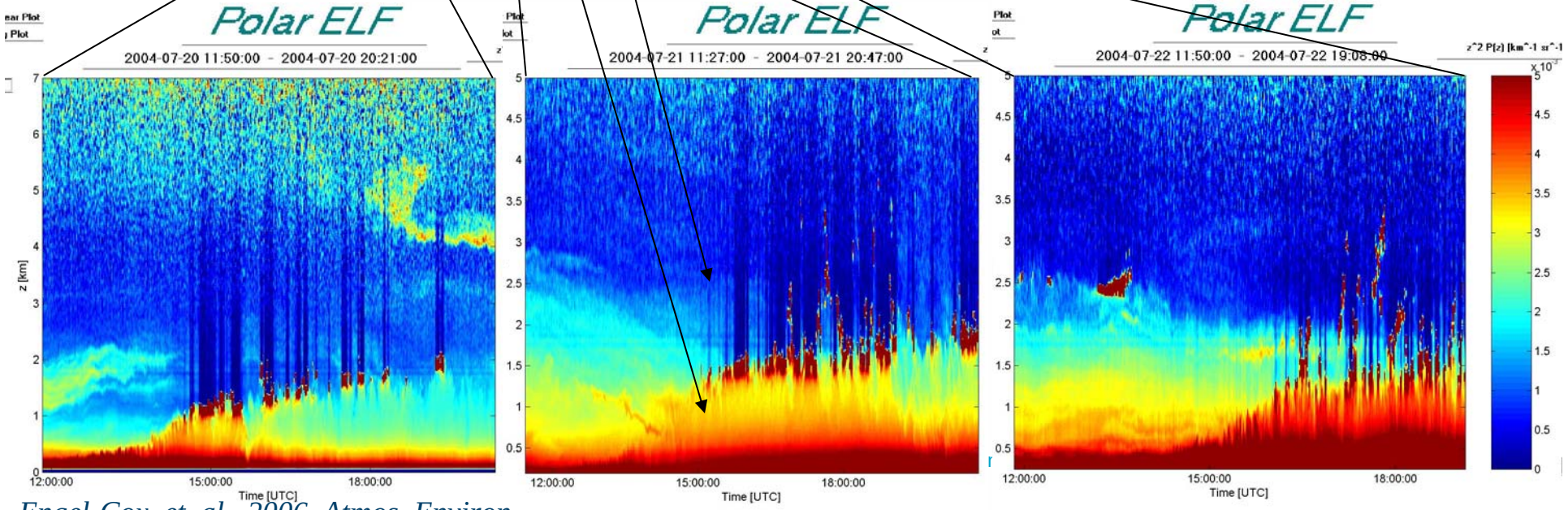




Smoke mixing in Maryland 20-22 July 2004







Engel-Cox, et. al., 2006, Atmos. Environ.

Infusing satellite Data into Environmental Applications (IDEA)

- **A joint NASA-NOAA-EPA initiative that is GEOSS relevant.**

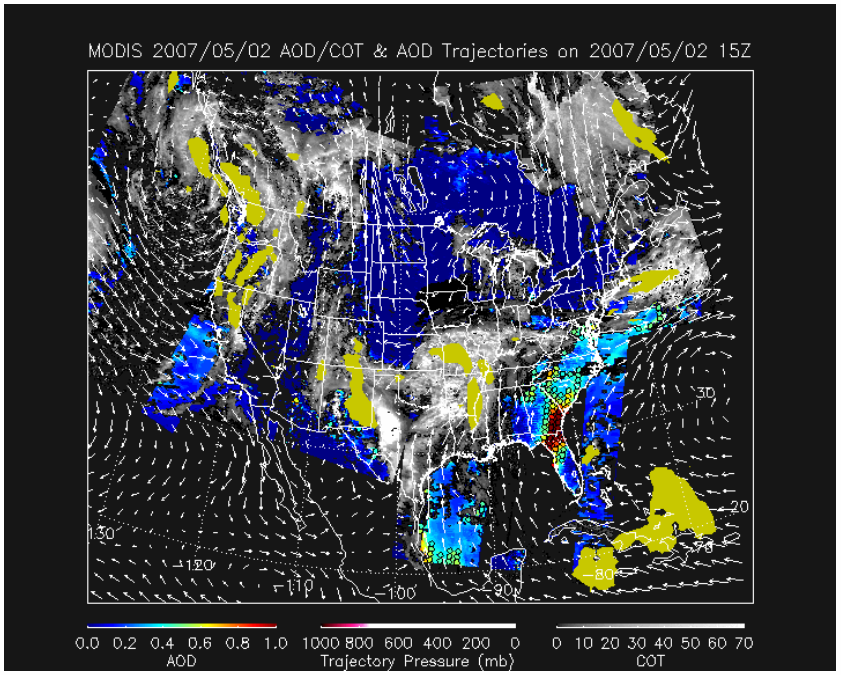
- **Provides forecast guidance for surface air quality (PM2.5)**
  - Dust storms
  - Smoke from forest fires
  - Urban/industrial haze

- **Trajectories are initialized at locations with aerosol optical depth > 0.4 at 50, 100, 150, and 200mb and run using 12Z NOAA/NCEP NAM forecast data providing 48 hr forecast**

- **System requirements**
  - Direct broadcast receiving station for satellite data
  - Trajectory model
  - Regional meteorological forecast model output
  - Algorithms to derive aerosol optical depth or related parameters
  - Surface mass aerosol monitors

- **System flexibility**
  - Easily adaptable to other regions of the globe
  - Easy to modify to input other satellite data

Forecast Product for May 2, 2007



48-hr trajectory forecast initialized with satellite (MODIS) observations of Aerosol Optical Depth. Pink color in the forecast trajectories indicates pollution will be closer to the ground

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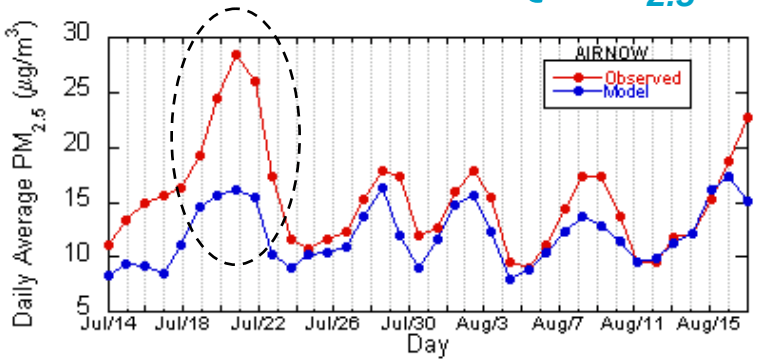
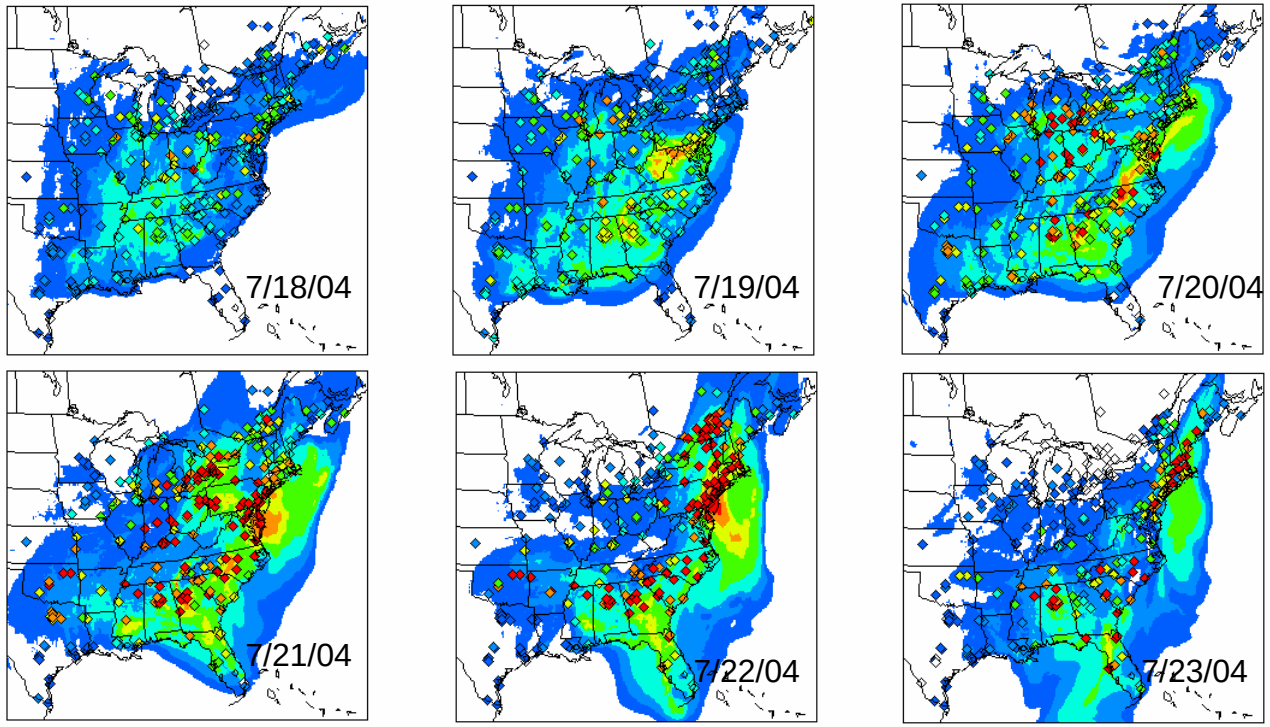
Eta-CMAQ $PM_{2.5}$ Forecasts





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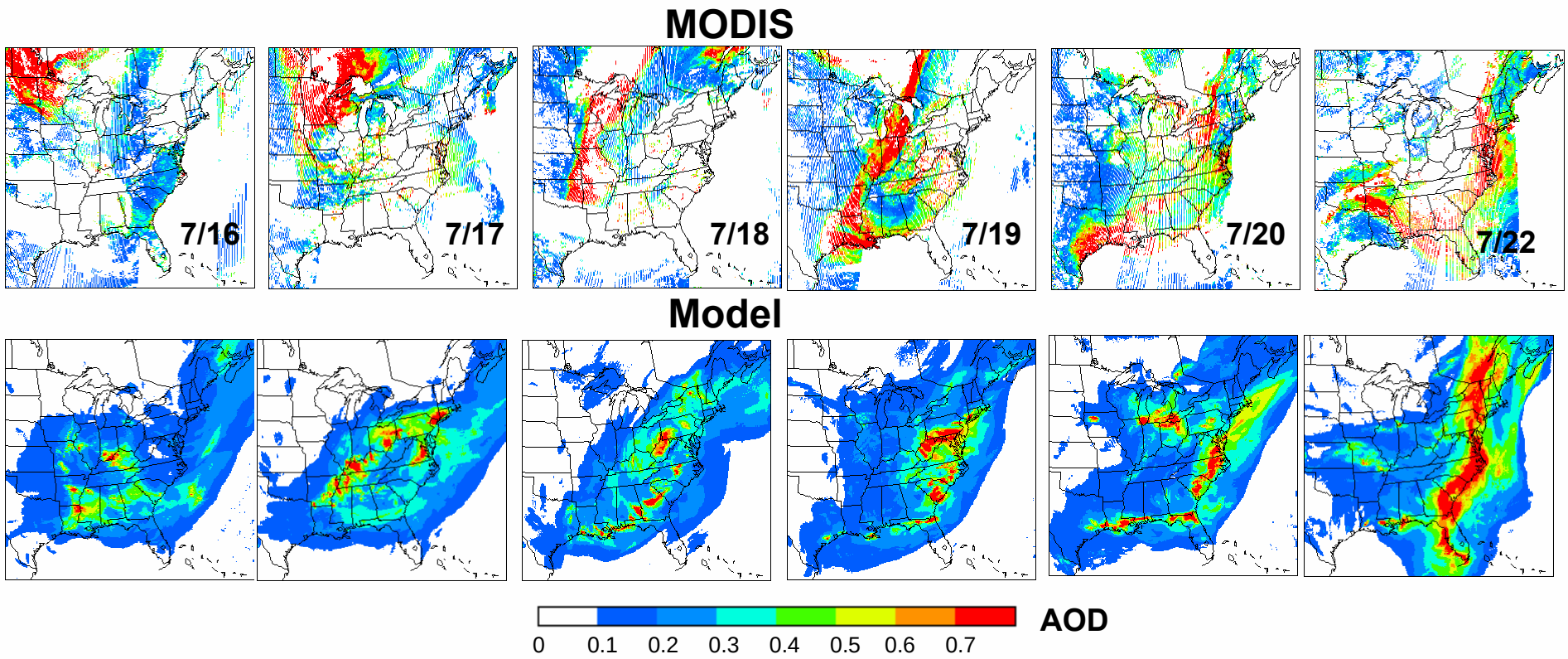
July 16-22, 2004: Evidence of Effects of Long Range Transport Originating from Outside the Modeled Domain

Evolution of Model and Observed Aerosol Optical Depth



Transport from outside the domain influences observed PM concentrations which are grossly under-predicted during this period

- Model picks up spatial signatures ahead of the front
- Under predictions behind the front (due to LBCs)

Improving Model Parameter Estimates Wildfire Emission Specification

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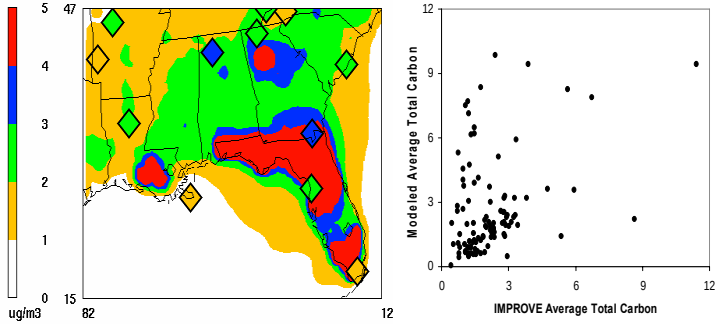
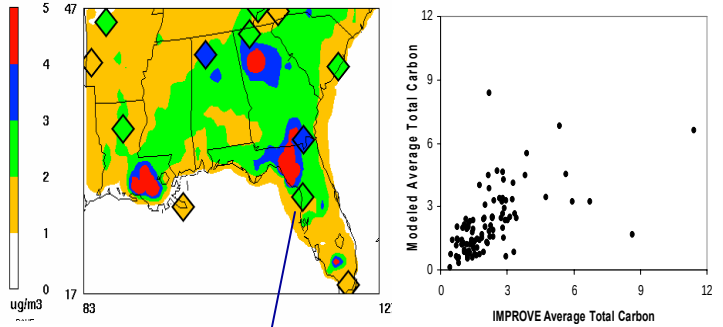
- Spatial allocation of emissions based on forest surrogates leads to unrealistic spatial distributions
- Reallocate NEI prescribed and wildfire emissions using MODIS Rapid Response Fire pixel count

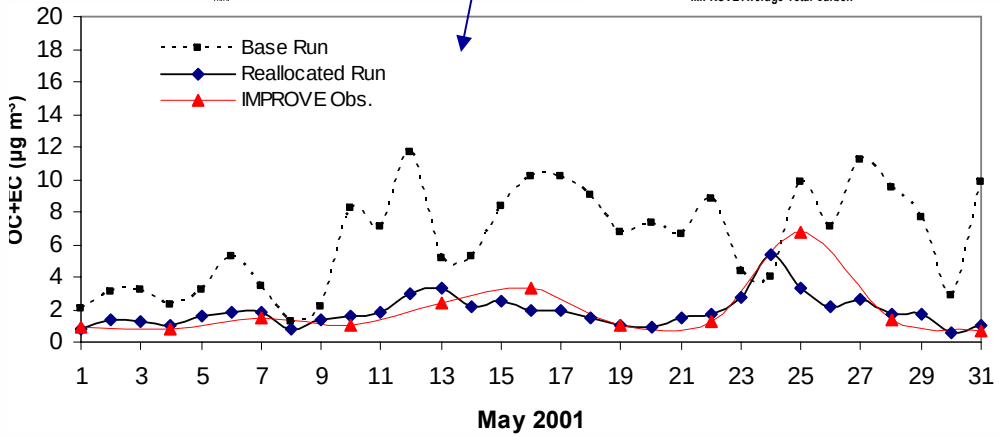
➡ Reallocation helps reduce bias and improves correlation in total carbon predictions



Base



Reallocated



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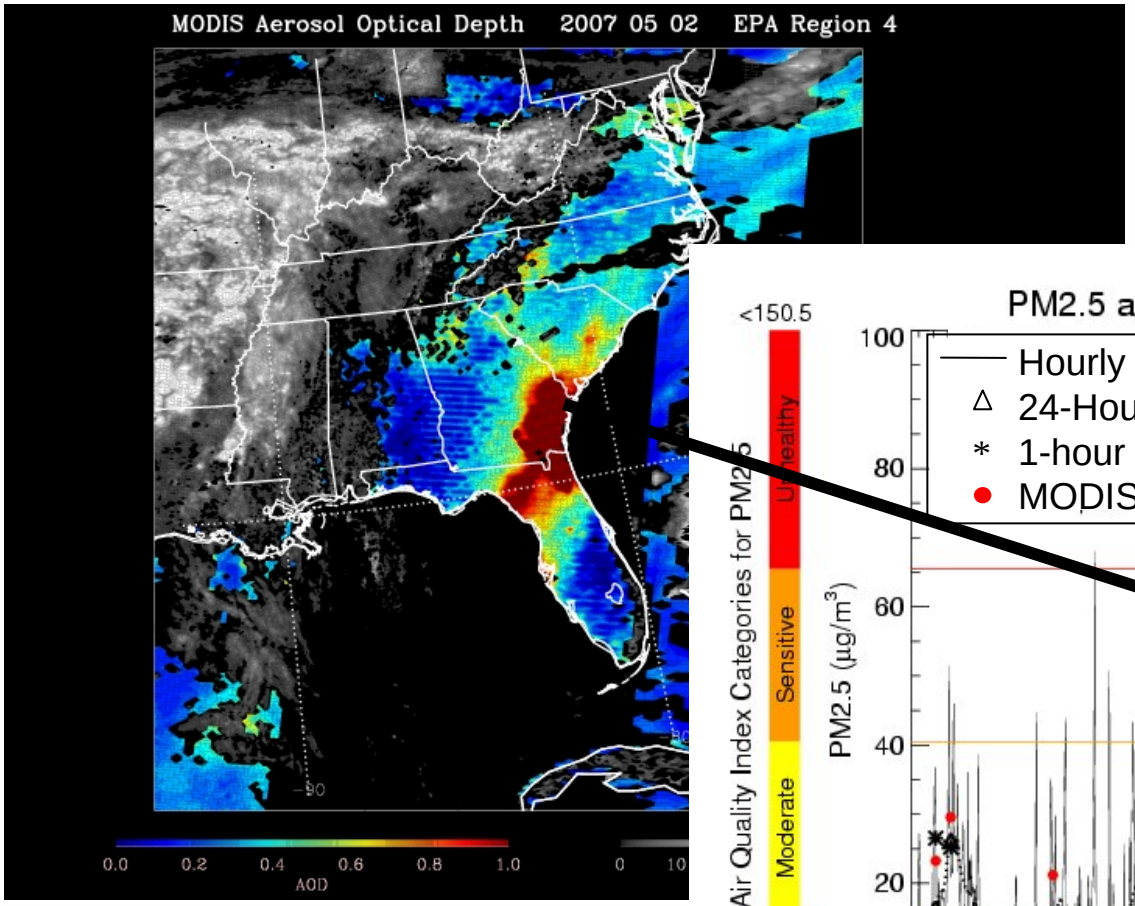
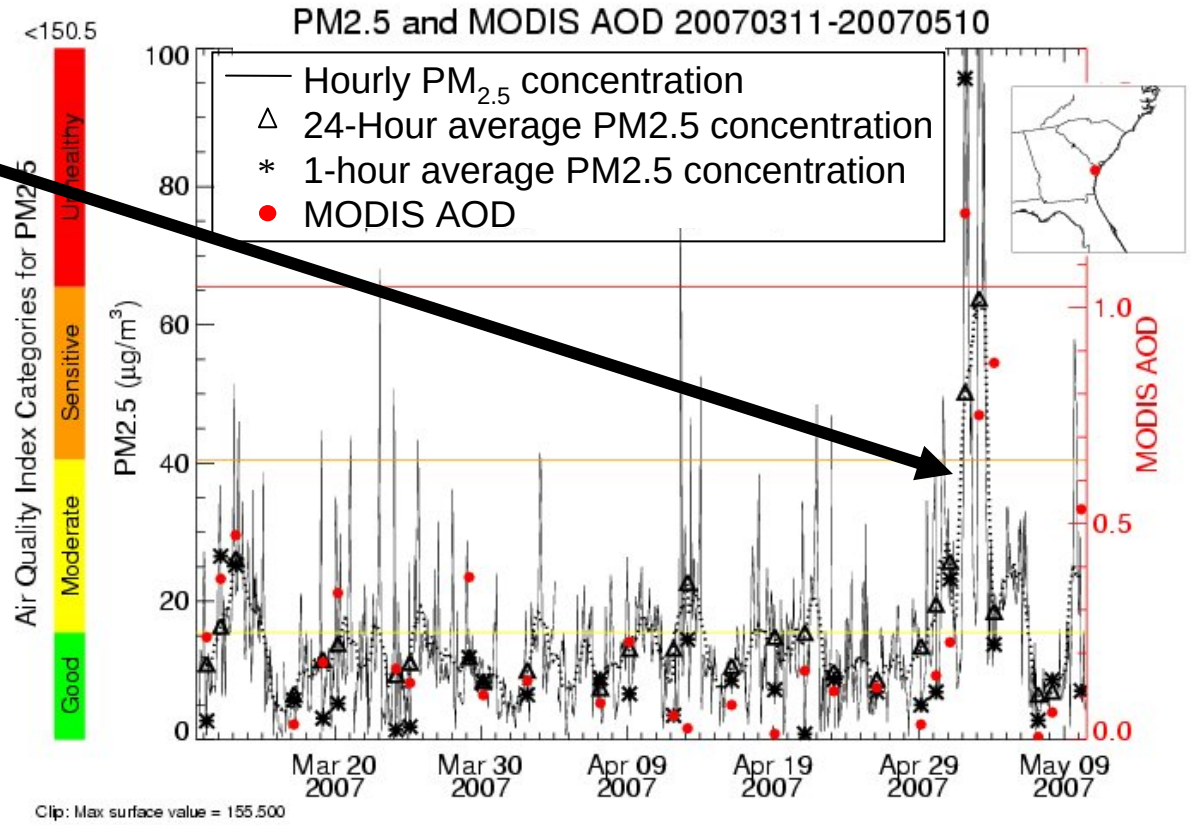
Satellite & Ground Measurements can help define spatial gradients



Savannah, Georgia USA



CALIPSO Measurements Capture Vertical Structure of Aerosols

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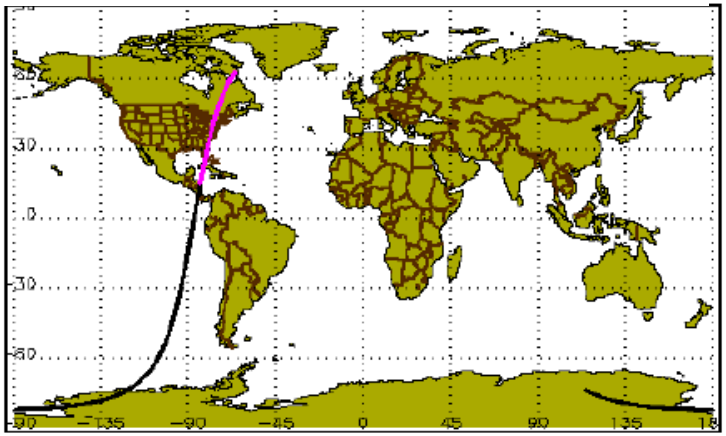
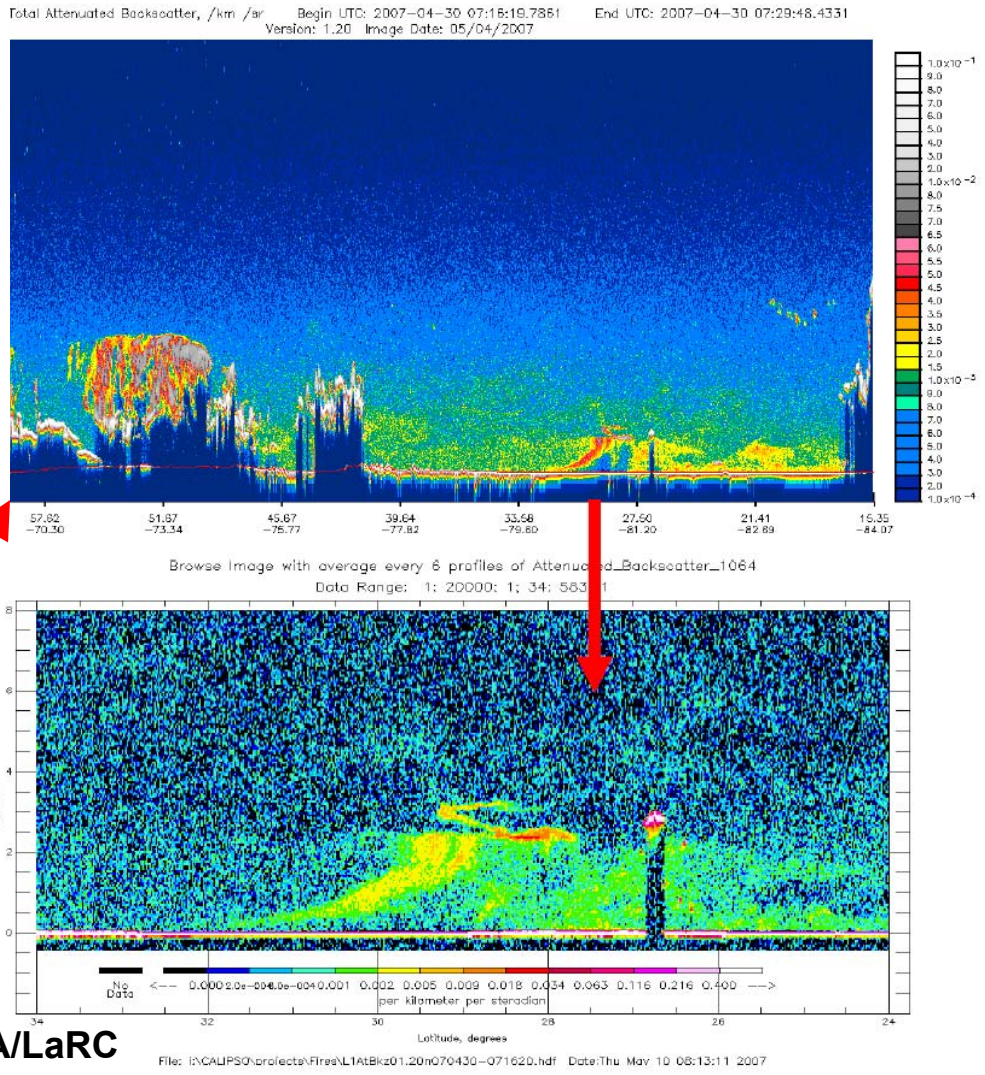
CALIPSO track is shown in pink





CALIPSO image April 30, 2007. Nighttime image, 532 nm total attenuated backscatter. The image shown begins at the top of the track. The plume height from the fire burning in Georgia is about 2.5 km, with a portion of the plume rising to about 3 km.

Credit: Dr. Dave Winker & Dr. Chip Trepte NASA/LaRC

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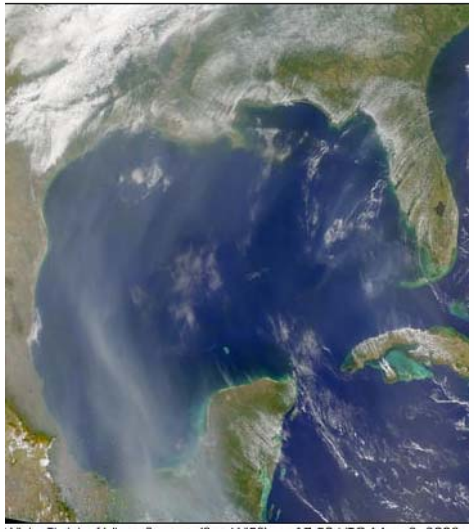
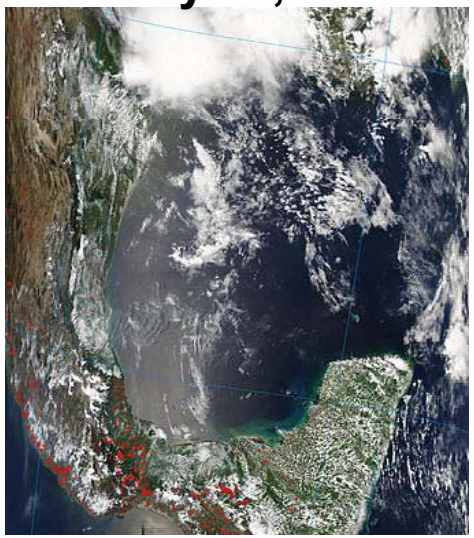
May 2, 2002

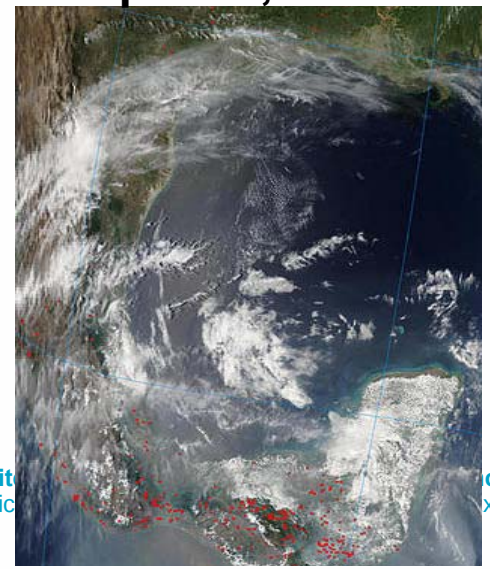


May 9, 2003

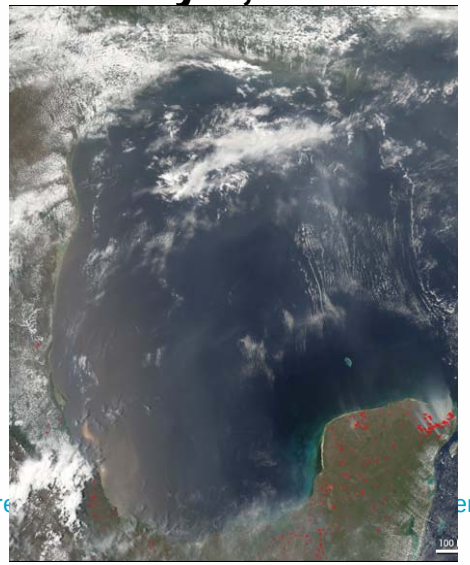
May 11, 2004



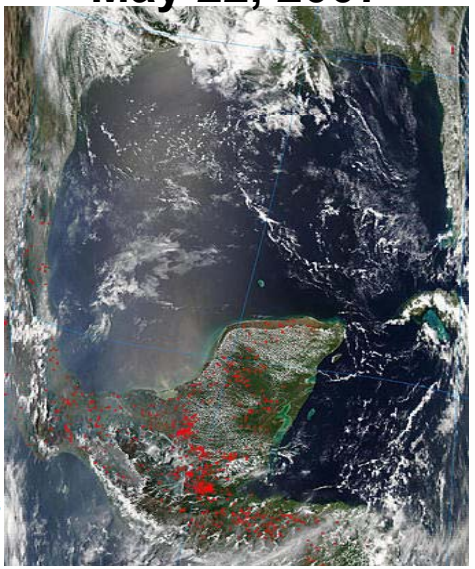
April 28, 2005



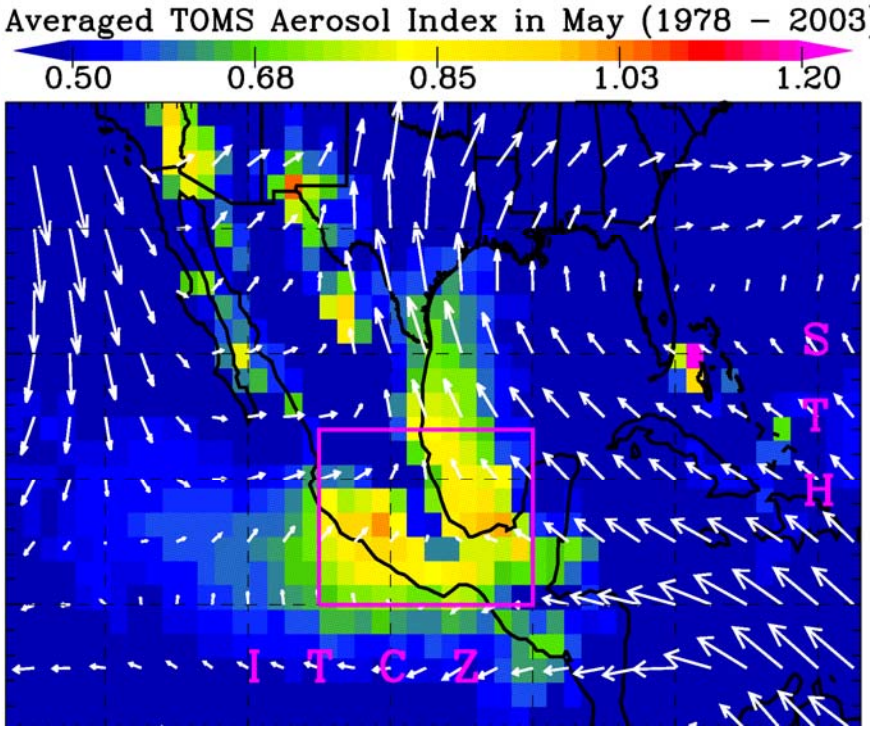
May 8, 2006



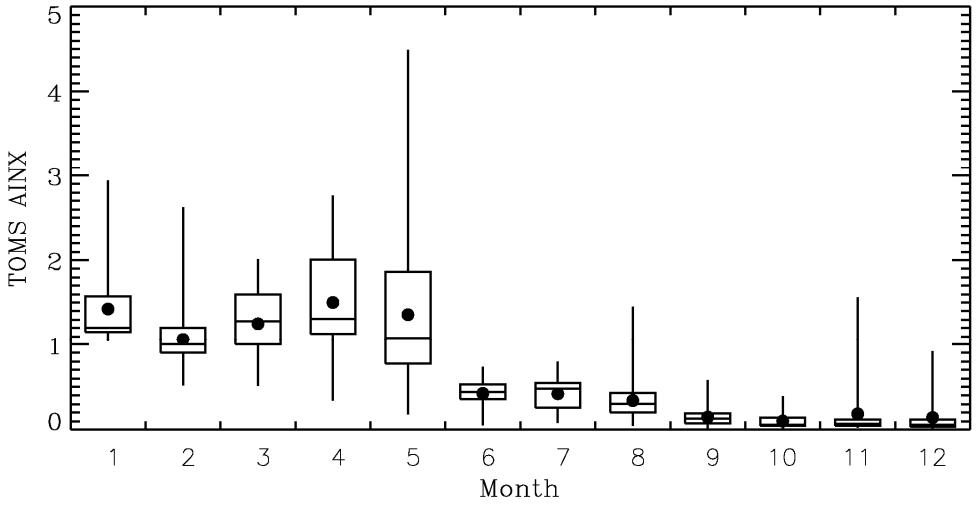
May 22, 2007



Spatial & Temporal Variations



Box-and-Whisker Plot of monthly TOMS aerosol index



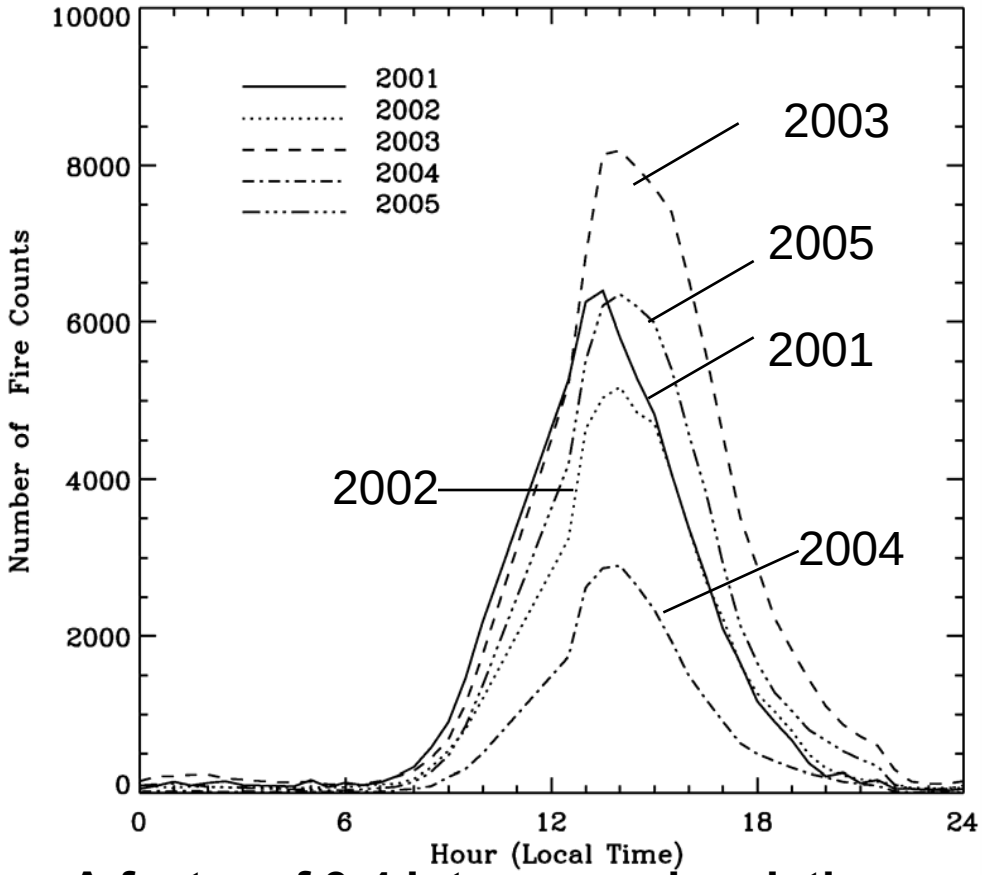
25 yrs statistics

Wang et al., 2006

- Two pathways: northward to U.S. and westward to the Pacific
- Inter-annul variation: bi-mode, mainly in Jan – May (dry season)

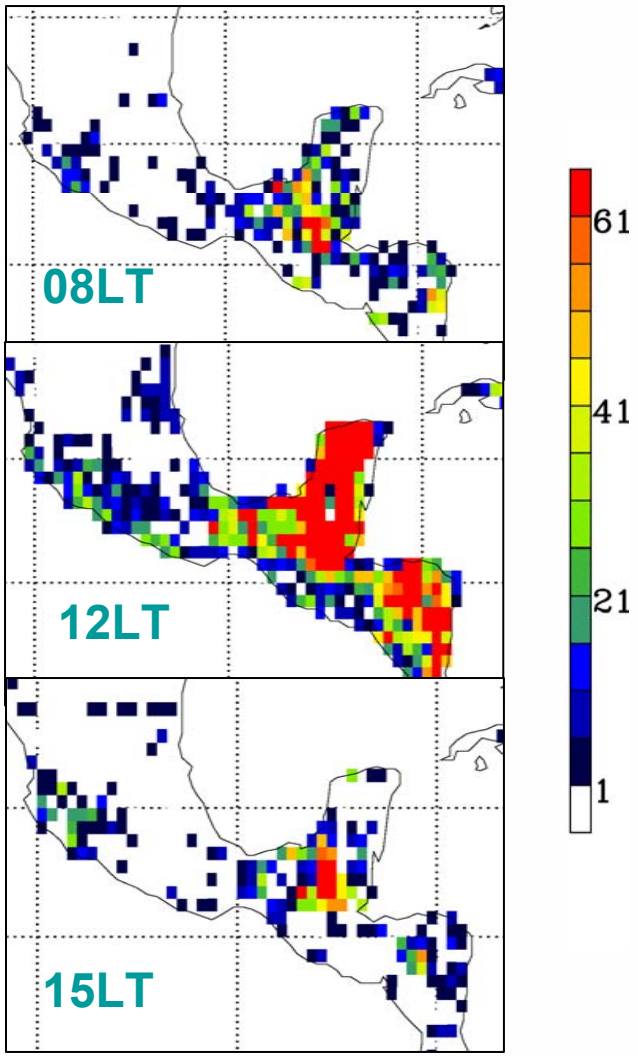
Diurnal & Intra-annual Variations

Fire counts by GOES in April & May



A factor of 3-4 intra-annual variation.
But diurnal variation pattern is similar.

of fire counts, Mar.-May, 2003



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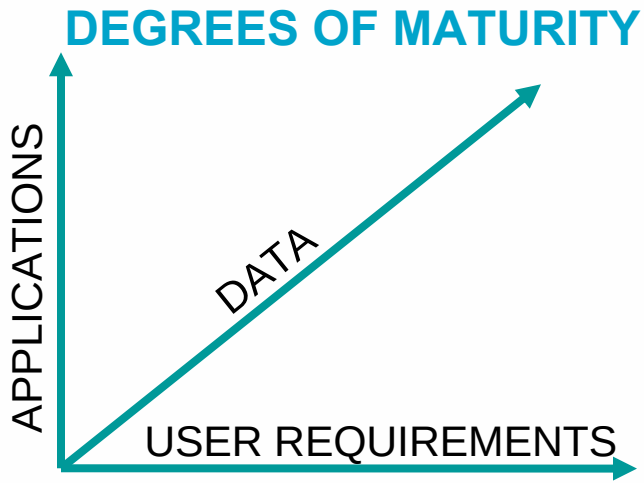
- Need a process within UIC to establish a connection between applications and users.
- Recognize existing processes to identify user requirements, (e.g., NOAA-CORL, IGOS-P Atmospheric Chemistry Theme Document, NCAR-Air Quality Workshop)
- GEO sponsored expert workshop under Health on Air Quality on user requirements, data, and applications.



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References

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- Wang, J., S.A. Christopher, U.S. Nair, J.S. Reid, E.M. Prins, **J. Szykman**, and J.L. Hand, Mesoscale modeling of Central American smoke transport to the United States, 1: "top-down" assessment of emission strength and diurnal variation impacts, *J. Geophys. Res.*, 11, D05S17, doi:10.1029/2005jd006720, 2006. Summary

- Engel-Cox, J., R. M. Hoff, R. Rogers, F. Dimmick, A. C. Rush, **J. J. Szykman**, J. Al-Saadi, D. A. Chu, and E. R. Zell, 2006. Integrating lidar and satellite optical depth with ambient monitoring for 3-dimensional particulate characterization. *Atmos. Environ., 40 (2006) 8056-8067*.

- Al-Saadi, **J., J. Szykman**, R. B. Pierce, C. Kittaka, D. Neil, D. A. Chu, L. Remer, L. Gumley, E. Prins, L.Weinstock, C. MacDonald, R. Wayland, F. Dimmick and J. Fishman, 2005. Improving National Air Quality Forecasts with Satellite Aerosol Observations. *Bull. Am. Met. Soc.* 86, 1249–1261.

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