



Air Quality Monitoring and Smoke

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Collaborators/Acknowledgements

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Why is Air Quality Important?

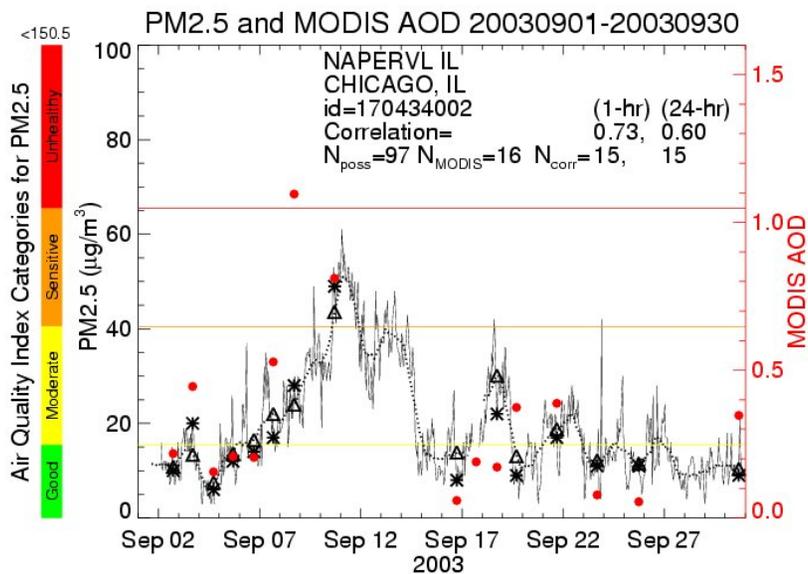
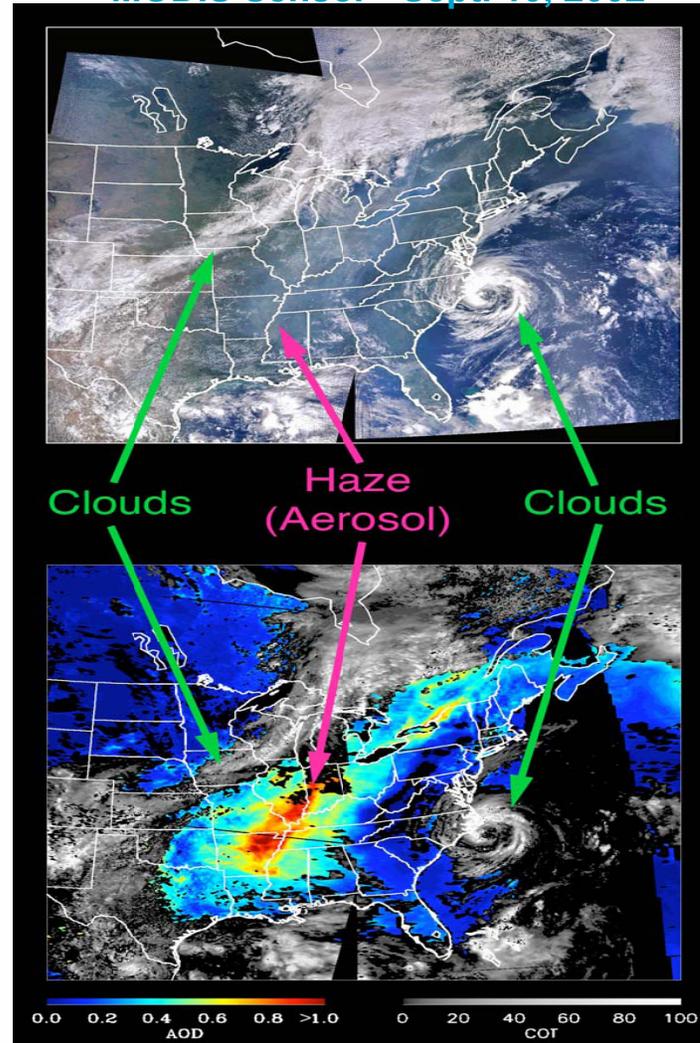
- **Aerosols (PM_{2.5})**
 - Induce respiratory diseases and cancer
 - Reduce visibility
 - Impacts Climate
- **Impacts of Poor Air Quality on Society**
 - 146 million+ people in the US live in areas with poor air quality⁺
 - 60,000 Death per annual (mean)^{*}
 - \$143 Billion Cost per annual (mean)^{**}

MODIS AOD/PM2.5 time series

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

The screenshot shows the IDEA website interface. At the top, there is a header with the IDEA logo and the text "Infusing satellite Data into Environmental Applications". Below the header, there is a "Latest Forecast Discussion" section with a message from CK dated 20040317 2:40PM. The main content area is divided into several sections:

- Forecast Trajectories for MODIS Aerosol Optical Depth, Cloud Optical Thickness and 48 hour Air Parcel:** Includes a map showing trajectories over the US and a "View latest" button.
- Regional Summary Plots of MODIS Aerosol Optical Depth and Cloud Optical Thickness:** Includes a map showing regional data and a "Select Region" button.
- National Correlation Map between PM_{2.5} and MODIS Aerosol Optical Depth:** Includes a map showing correlation across the US and a "View latest" button.
- Time-series between MODIS Aerosol Optical Depth and PM_{2.5} 24hr concentrations:** Includes a line graph showing the relationship between PM_{2.5} and MODIS AOD over time, with a "Select Site" button.

At the bottom, there is an "About IDEA..." section and a "Contact info:" section with contact details for Jim Szykman and Doreen Neil.

Infusing satellite Data into Environmental Applications (IDEA)

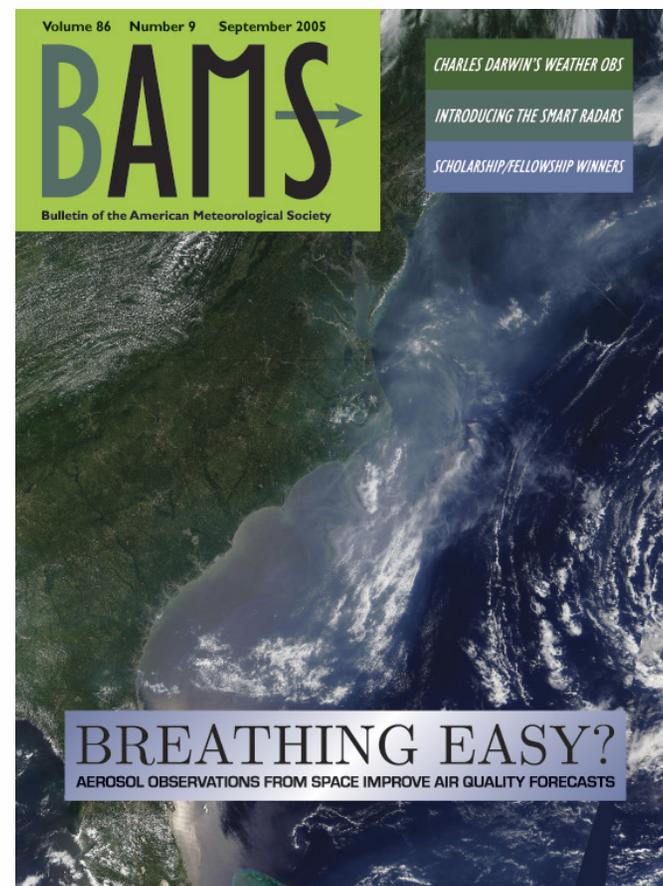
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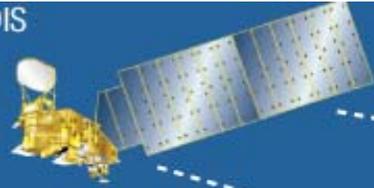
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AQUA-1 MODIS

Terra MODIS

Direct Broadcast



Products

- Aerosol Optical Depth (MOD04_L2)
- Cloud Optical Thickness (MOD06_L2)



NASA, GFSC, DACC



NASA, GFSC, Science Team

Products Algorithms

Products (Near Real Time)

- DB Aerosol Optical Deth (MOD04_L2)
- DB Cloud Optical Thickness (MOD06_L2)

SSEC/CIMSS Univ. of Wisc. Madison (MIPPS)



NOAA OAR/ARL

Products EDAS Forecast Data



US EPA AIRNow DMC

NASA LaRC

Products MODIS/AIRNow Data Fusion Site Static Data

State & Local Canadian Providences



AIRNow Forecasters

Products AIRNow Hourly PM_{2.5} Data

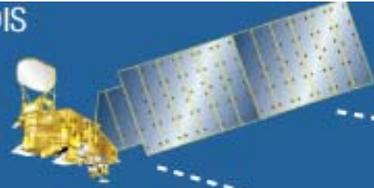
Terra & Aqua Satellite Direct Broadcast of MODIS instrument data via commercially available ground station



AQUA-1 MODIS

Terra MODIS

Direct Broadcast



Products

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SSEC/CIMSS
Univ. of Wisc.
Madison (MIPPS)



NOAA
OAR/ARL

Products
EDAS Forecast Data



US EPA
AIRNow DMC

NOAA
NESDIS

Products
MODIS/AIRNow Data
Fusion Site Static Data

State & Local
Canadian
Providences



AIRNow
Forecasters

Products
AIRNow Hourly
PM_{2.5} Data

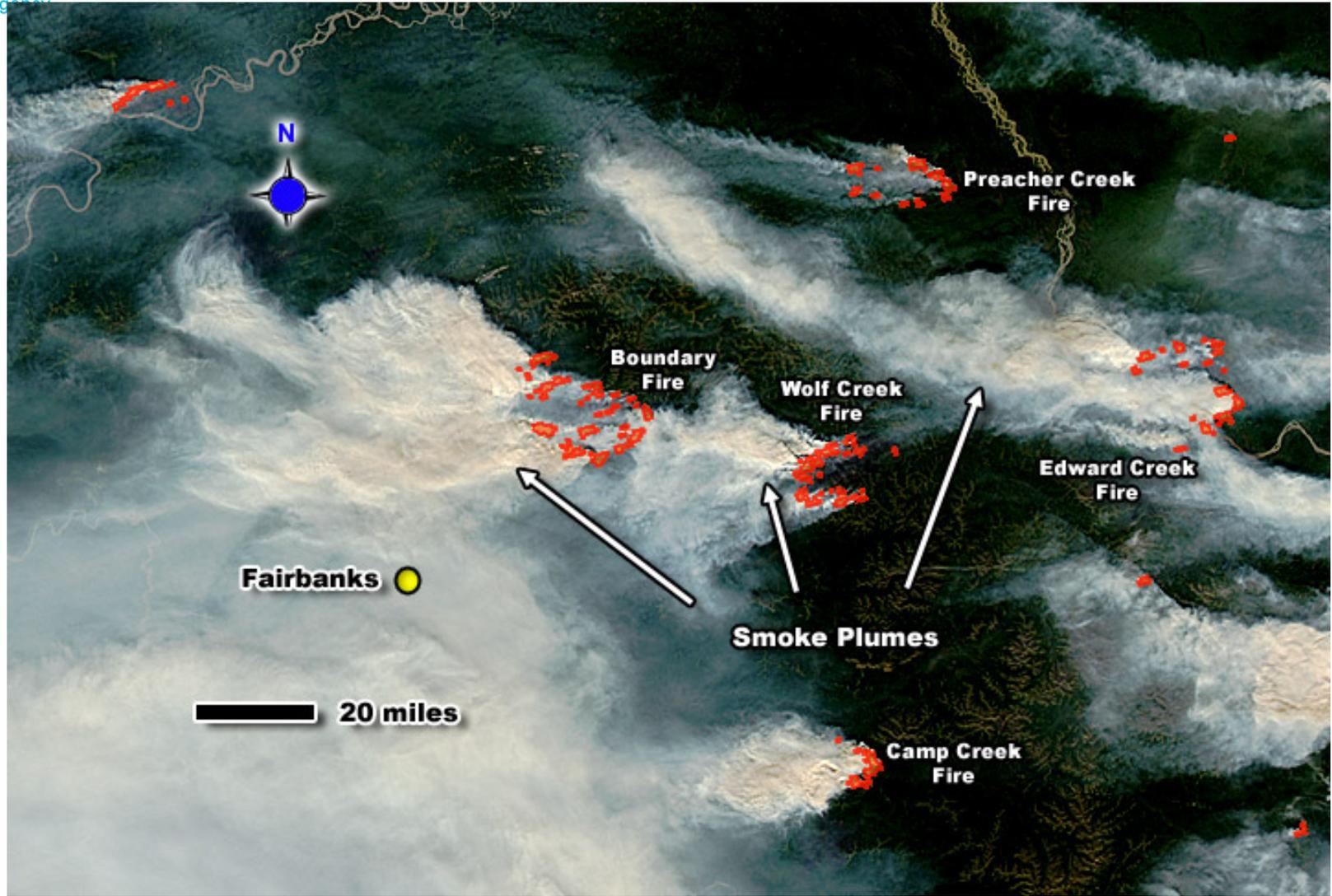
Terra & Aqua
Satellite Direct
Broadcast of MODIS
instrument data via
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able ground station





Alaskan Fire Complexes

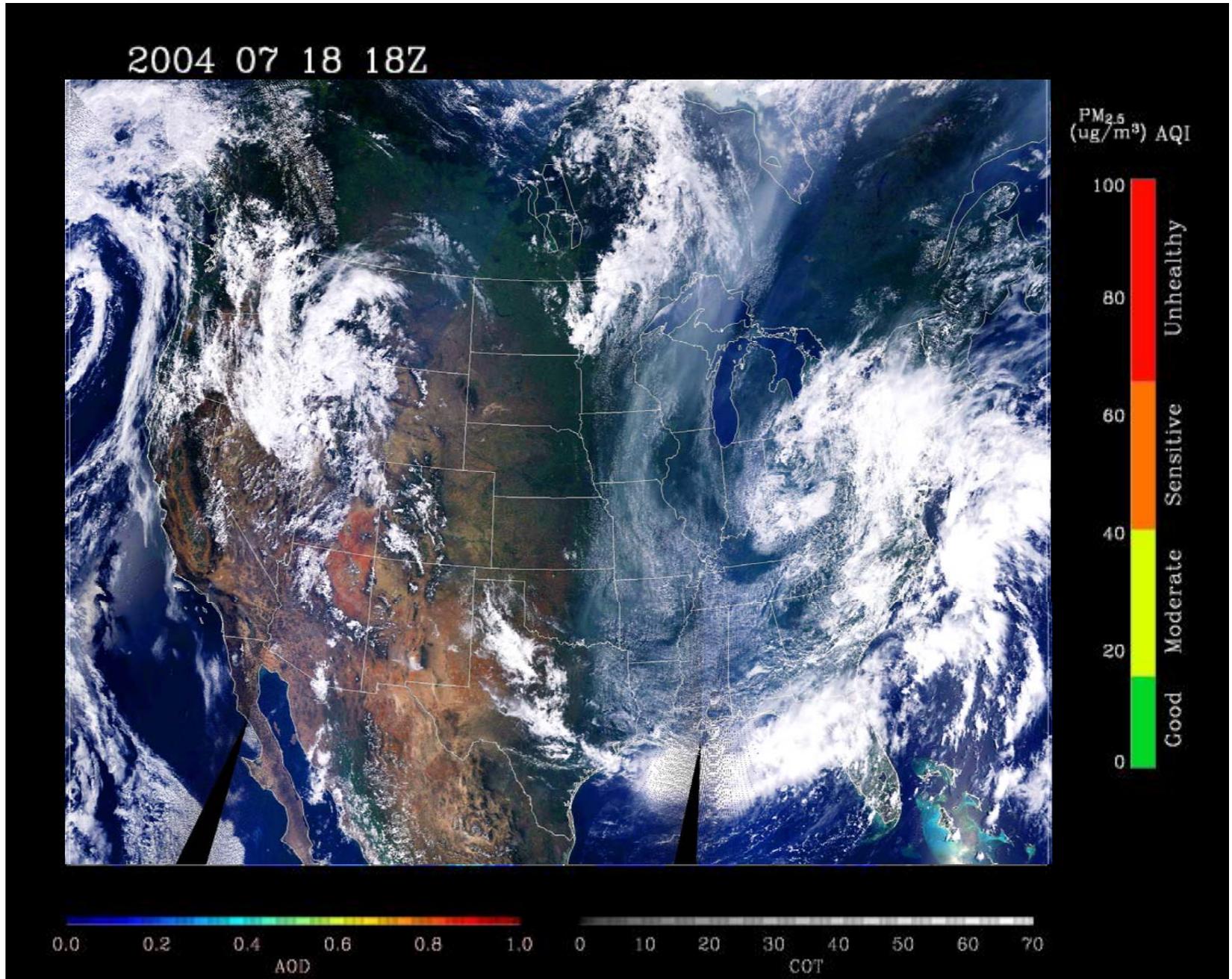
June 30, 2004



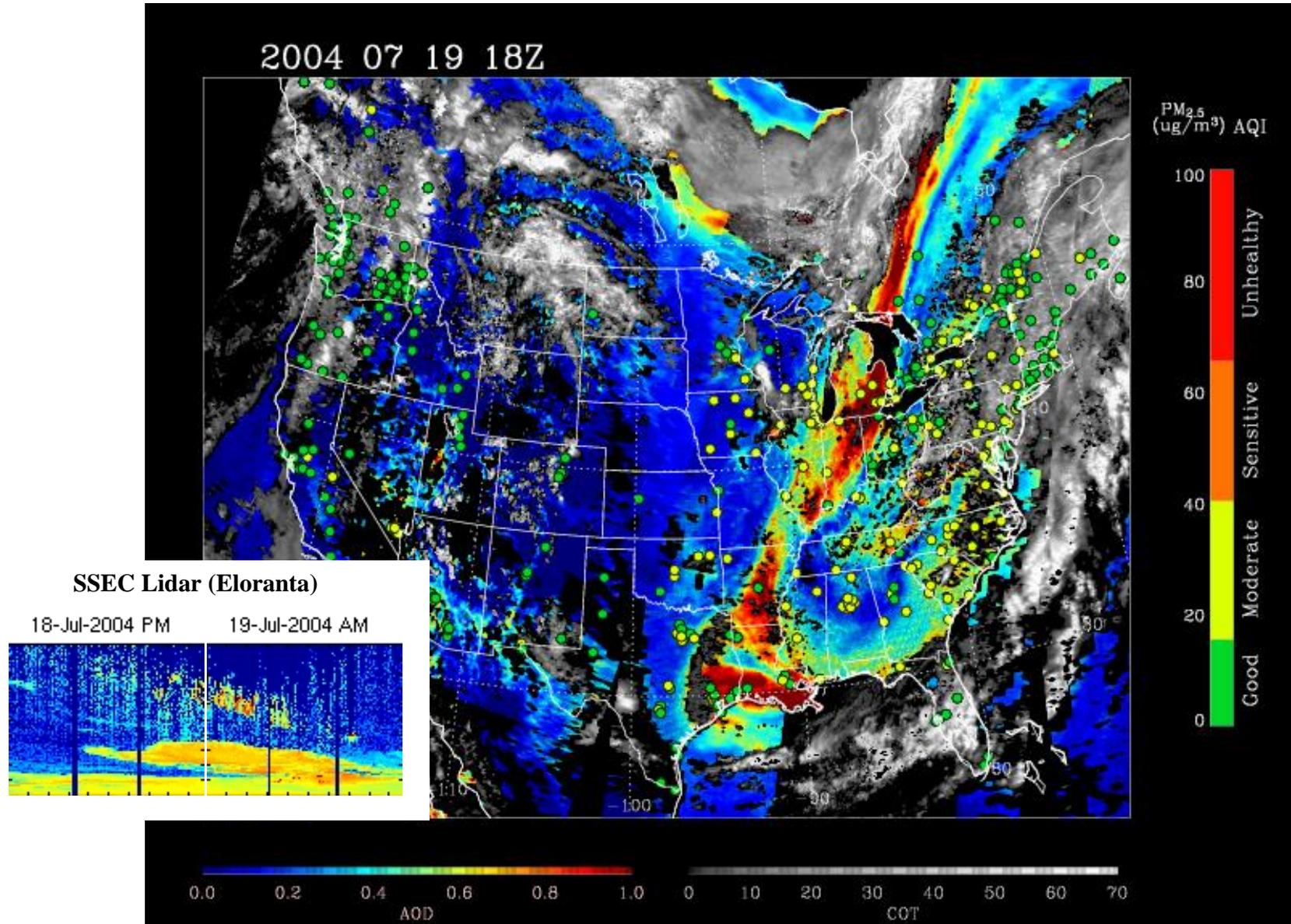
Data source: NASA-MODIS-Aqua

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

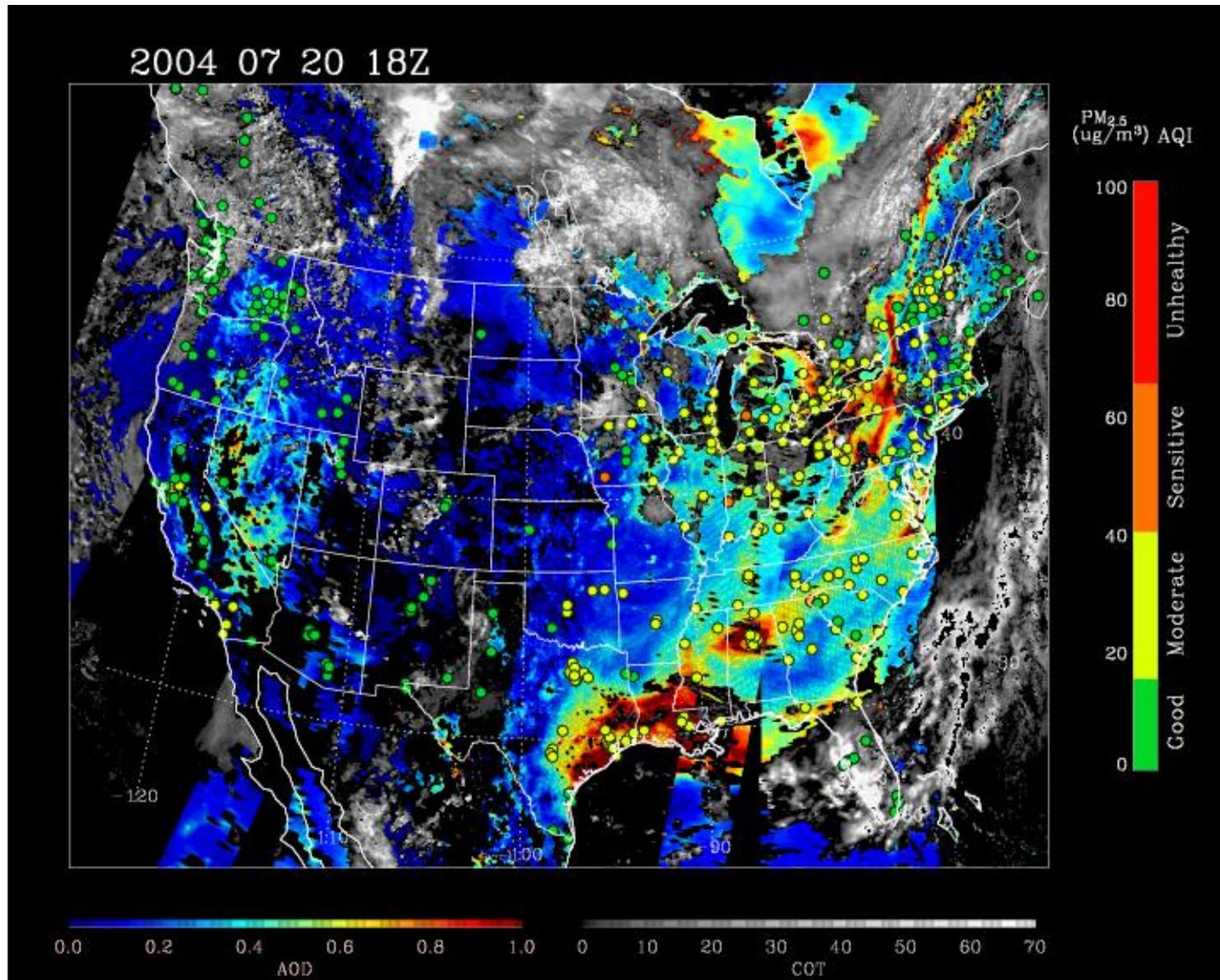
18 July 2004 Smoke from Alaskan/Yukon Fires Over U.S.

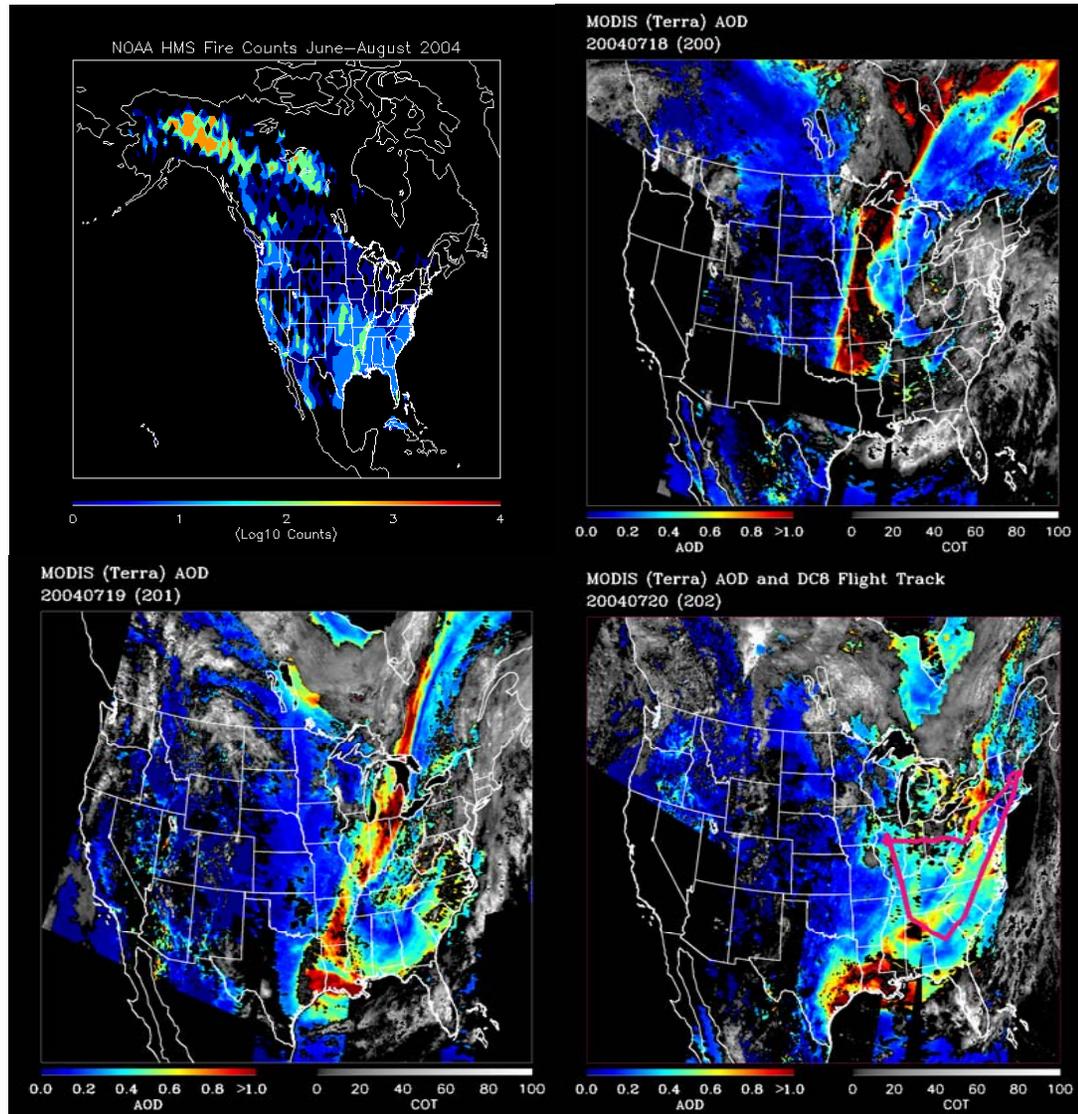


19 July 2004 Smoke from Alaskan/Yukon Fires Impact U.S.



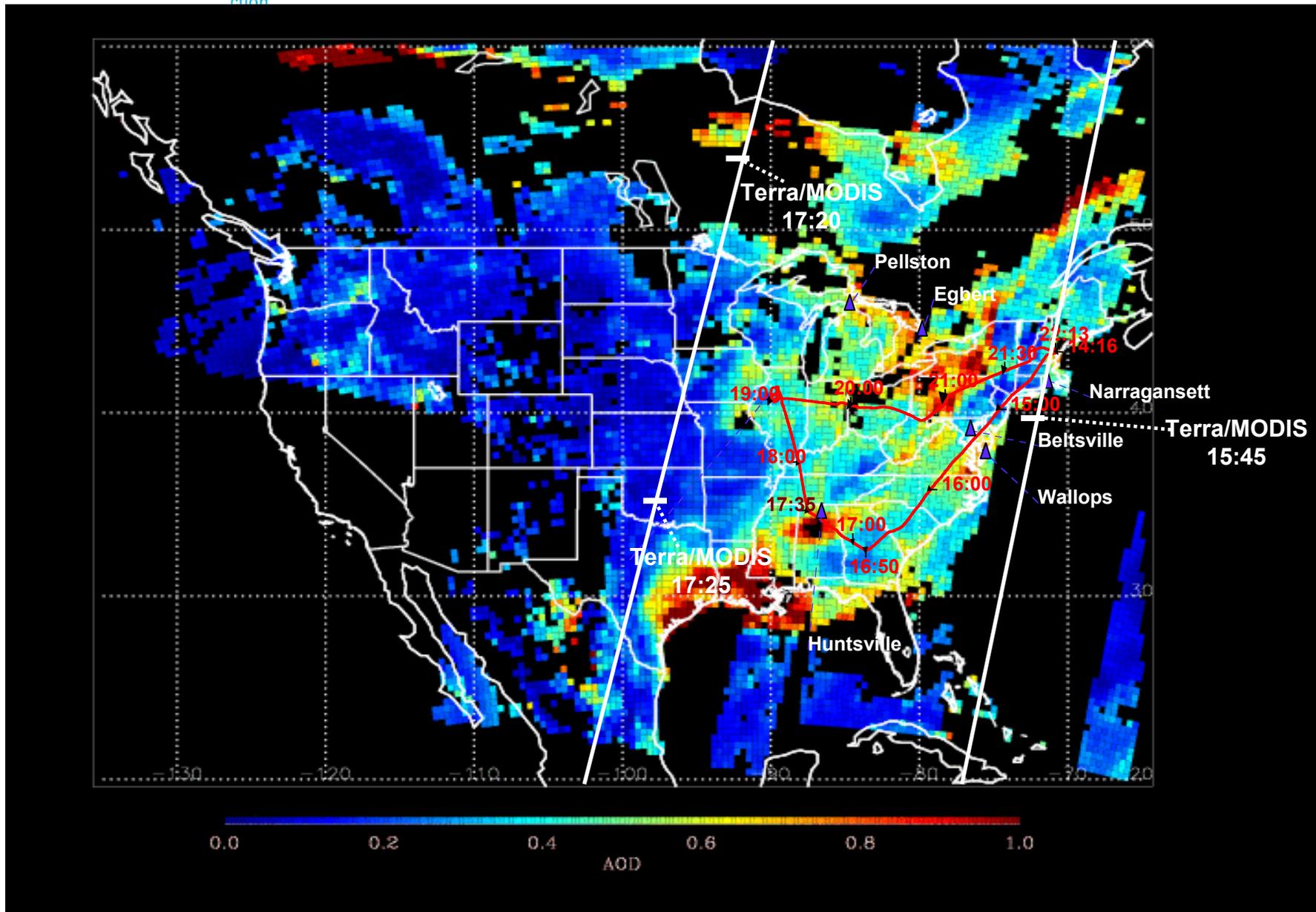
20 July 2004 Smoke from Alaskan/Yukon Fires Impact U.S.



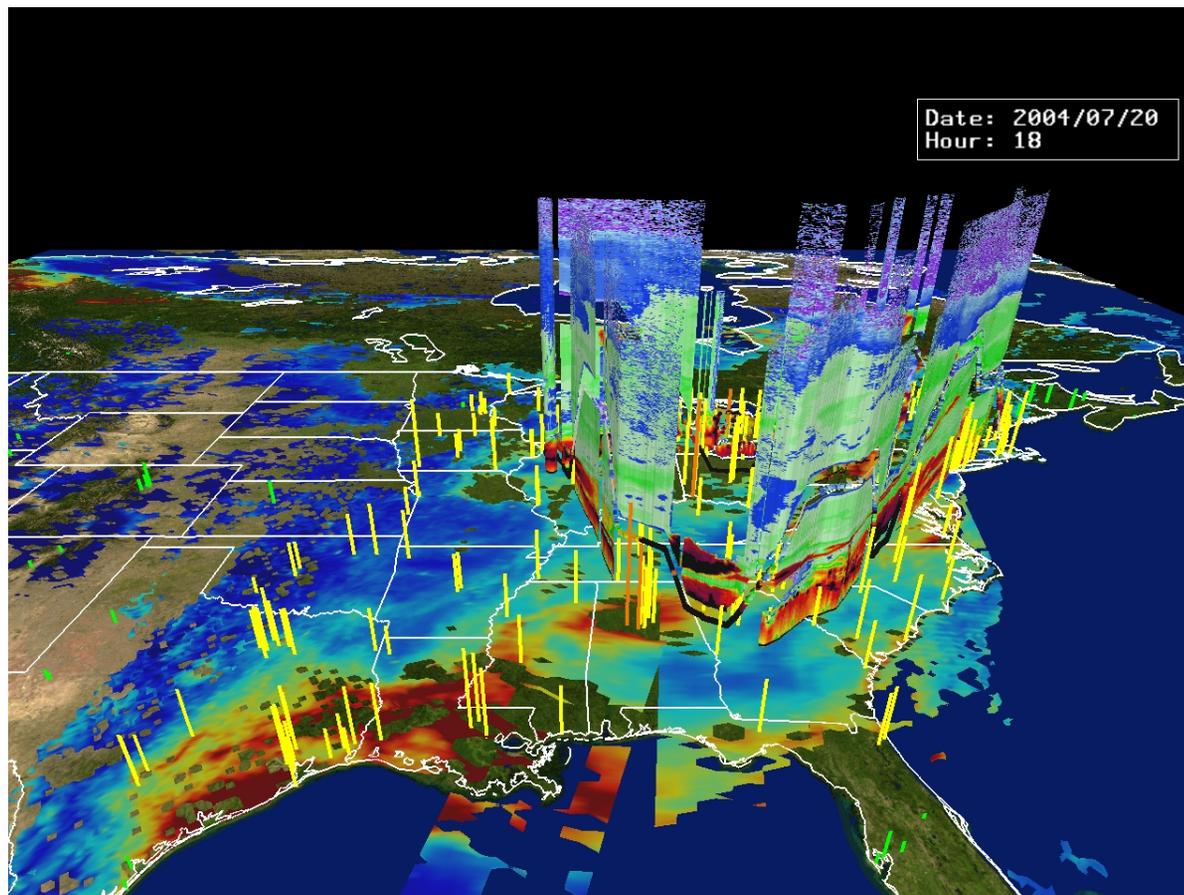


NASA LaRC DIAL DC-8 Track (Flight 10) July 20, 2004

ction

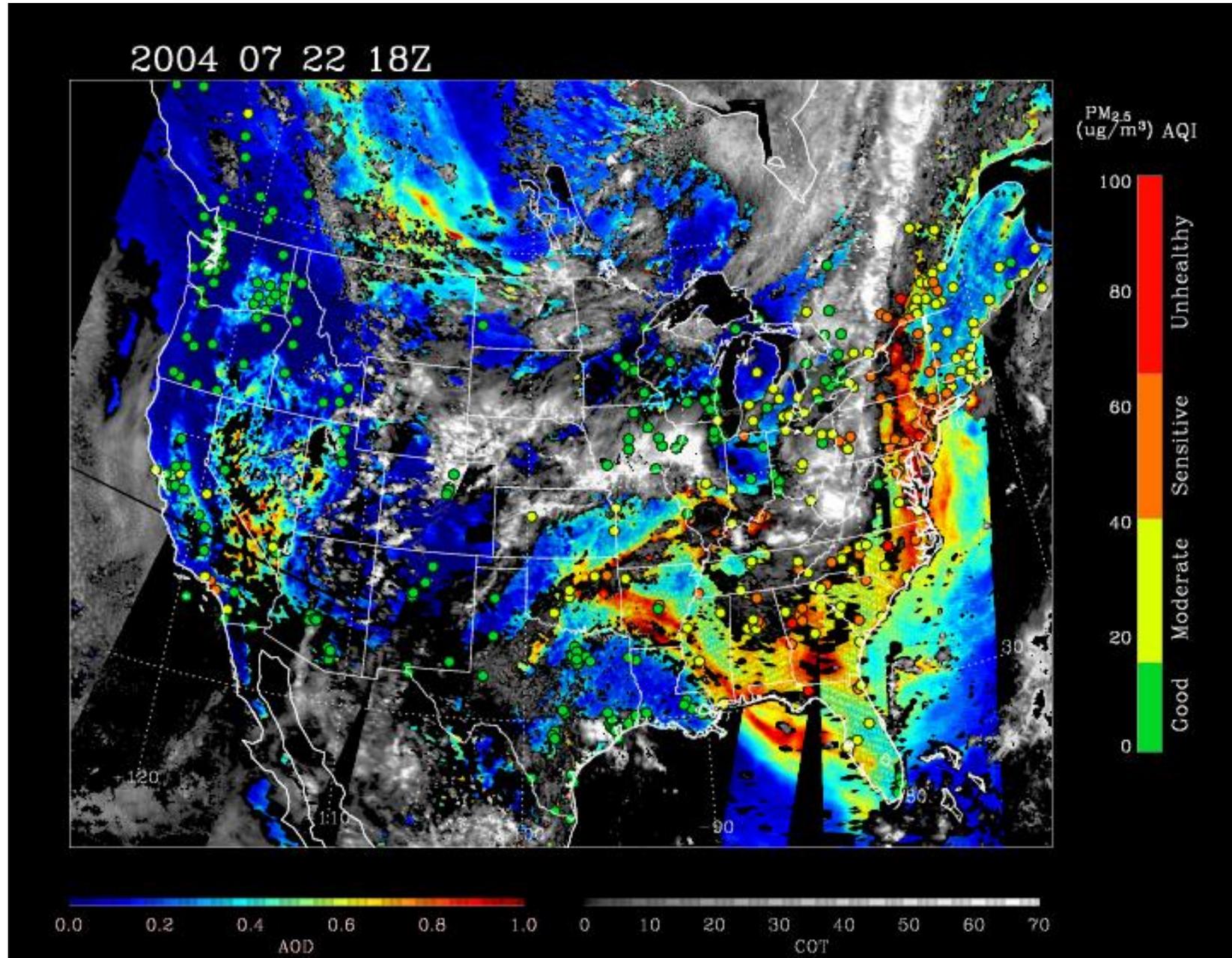


An Integrated Picture of Aerosols in SE United States on July 20, 2004 Helps Show the Evolution of The Largest Aerosol Pollution Event during Summer 2004



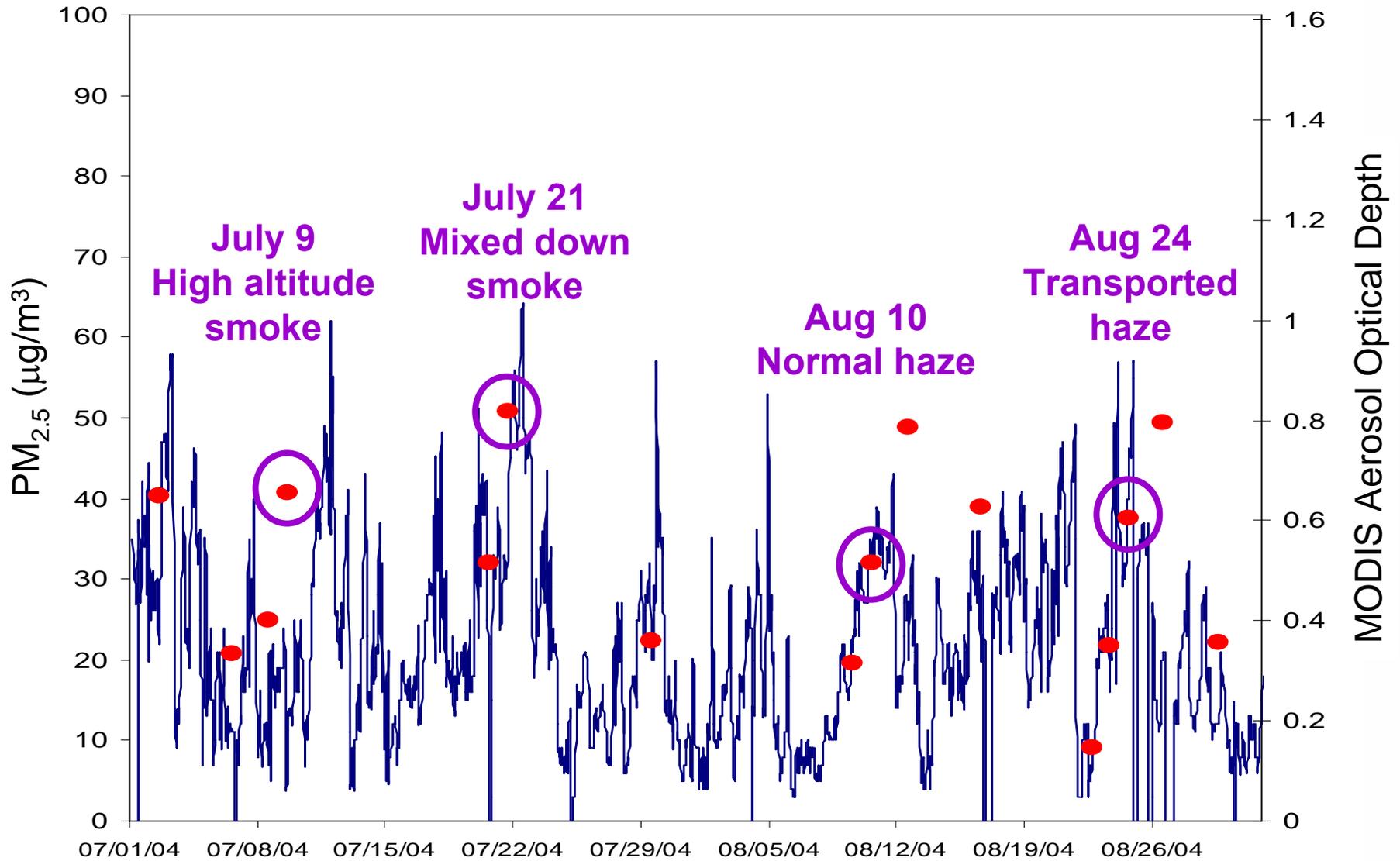
NASA's DC-8 LIDAR and In-situ Aerosol Measurements during the ICARTT field campaign overlaid with NASA MODIS AOD and EPA AIRNow ground based measurements.

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

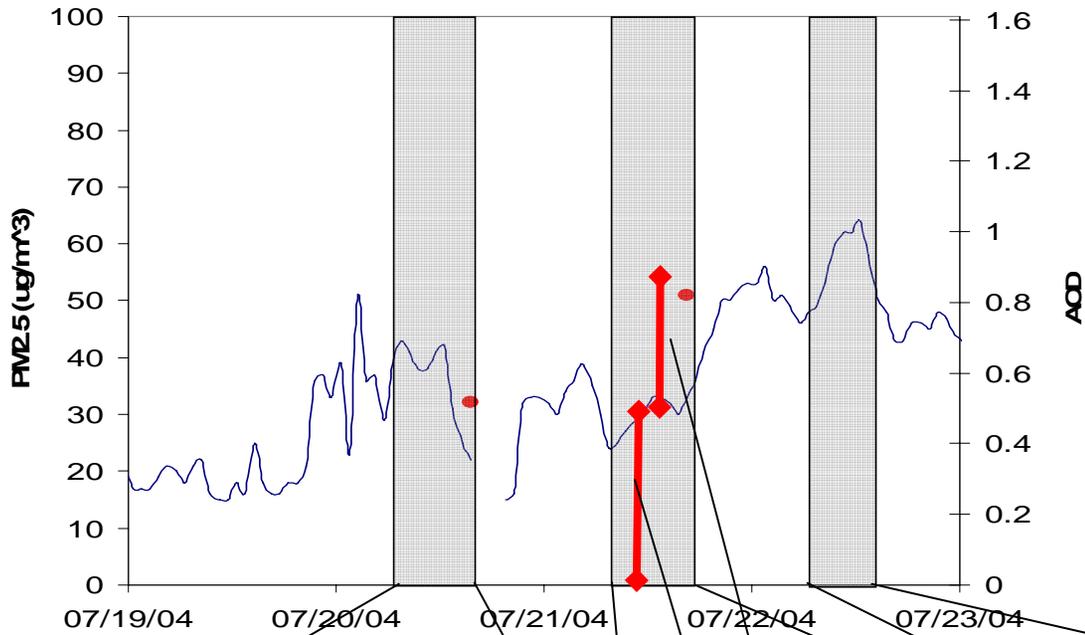


Baltimore, MD Summer 2004

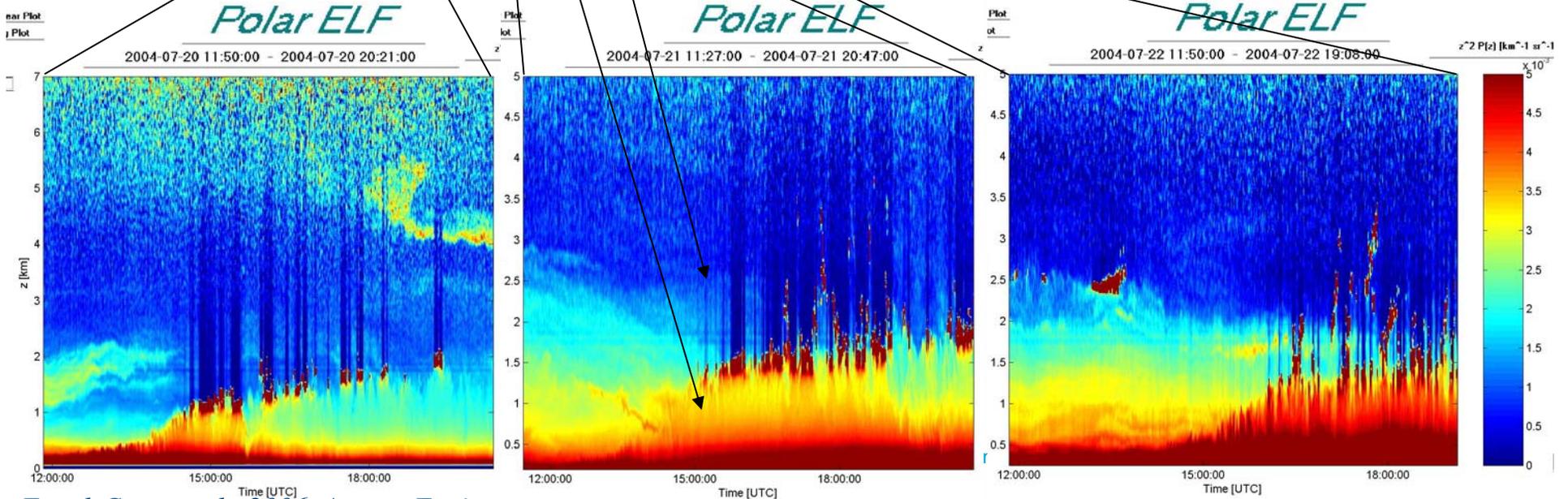
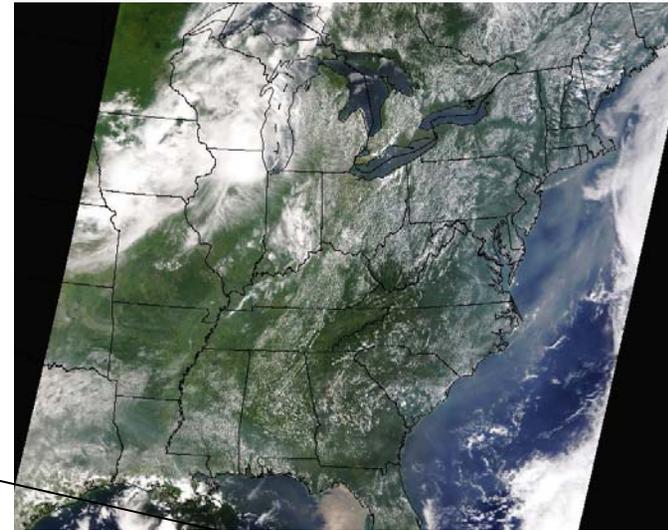
— Old Town TEOM
• MODIS AOD



Old Town (Baltimore) — PM2.5
 ● MODIS



Smoke mixing in Maryland 20-22 July 2004

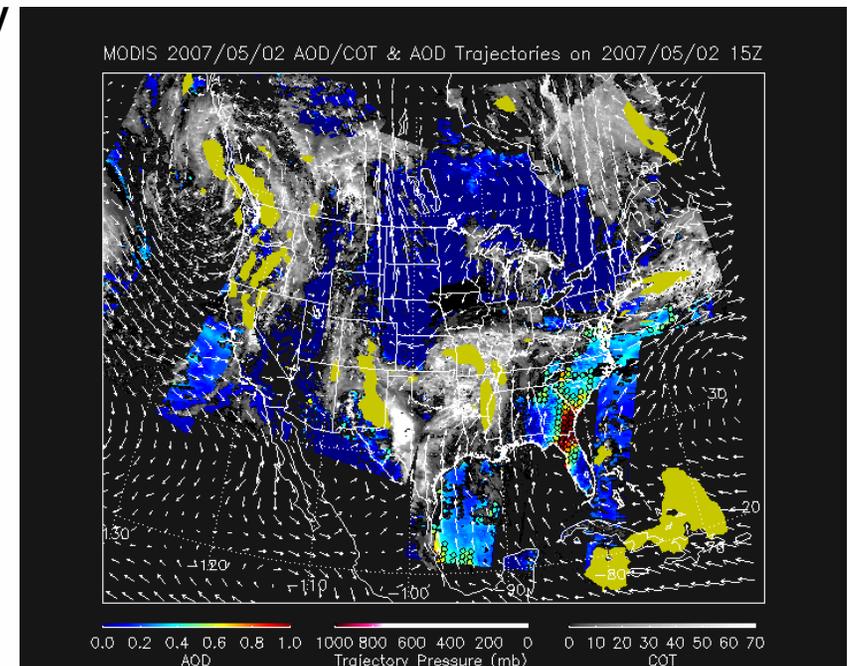


Engel-Cox, et. al., 2006, Atmos. Environ.

Infusing satellite Data into Environmental Applications (IDEA)

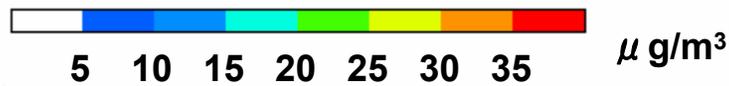
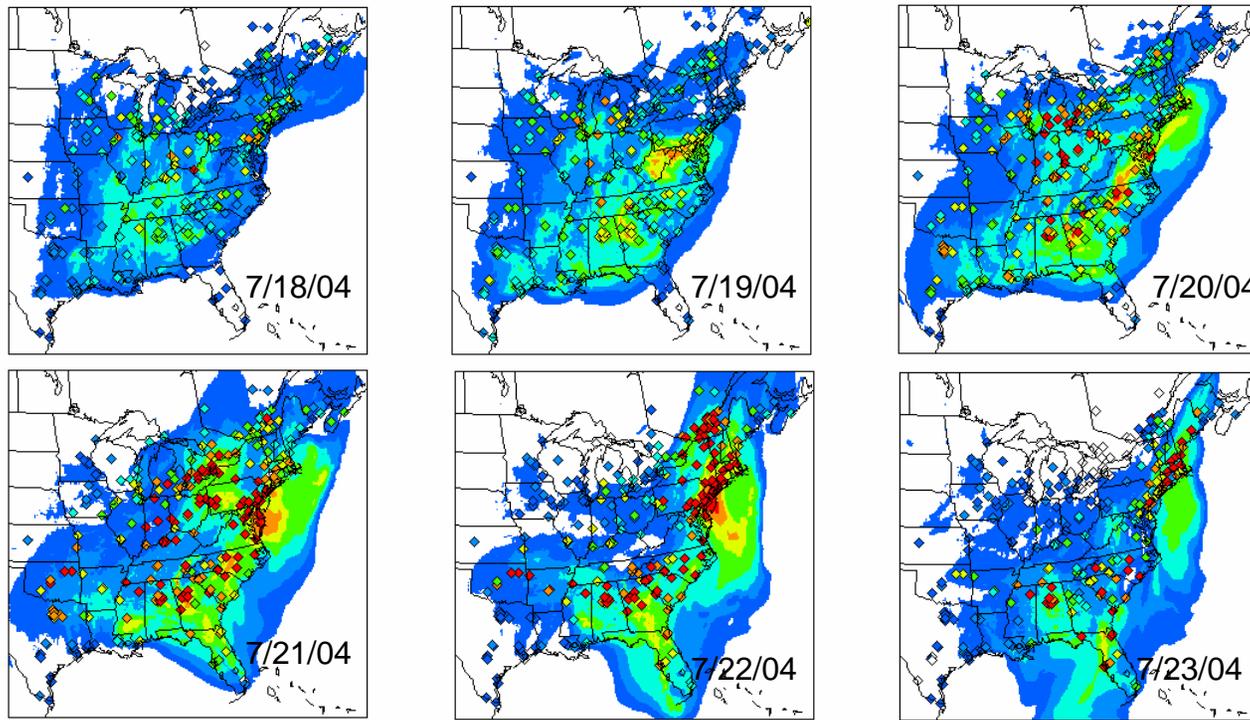
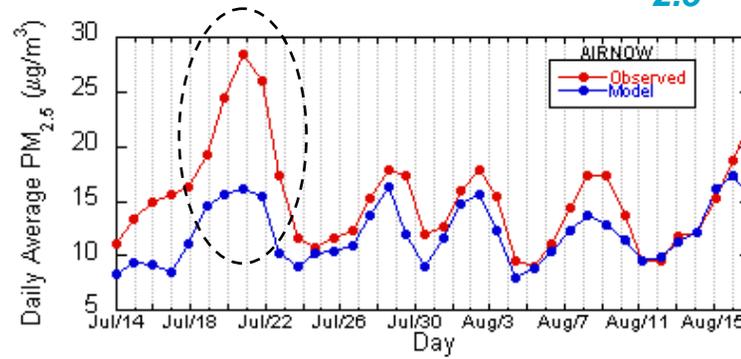
- **A joint NASA-NOAA-EPA initiative that is GEOSS relevant.**
- **Provides forecast guidance for surface air quality (PM_{2.5})**
 - Dust storms
 - Smoke from forest fires
 - Urban/industrial haze
- **Trajectories are initialized at locations with aerosol optical depth > 0.4 at 50, 100, 150, and 200mb 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

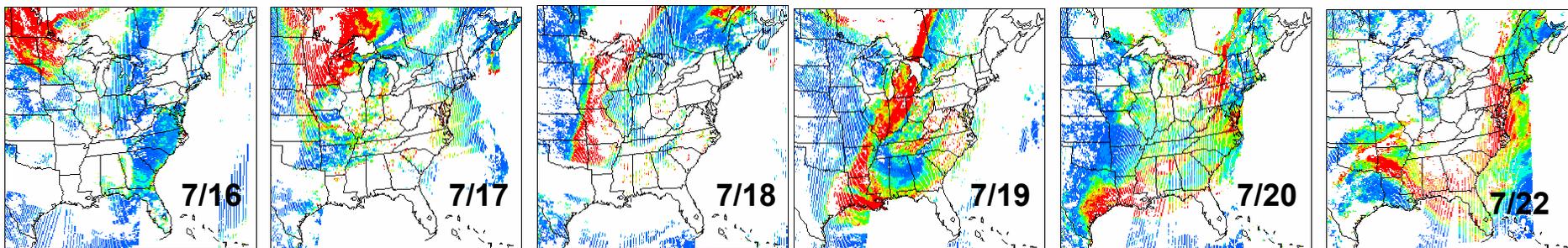
Eta-CMAQ PM_{2.5} Forecasts



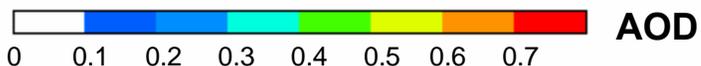
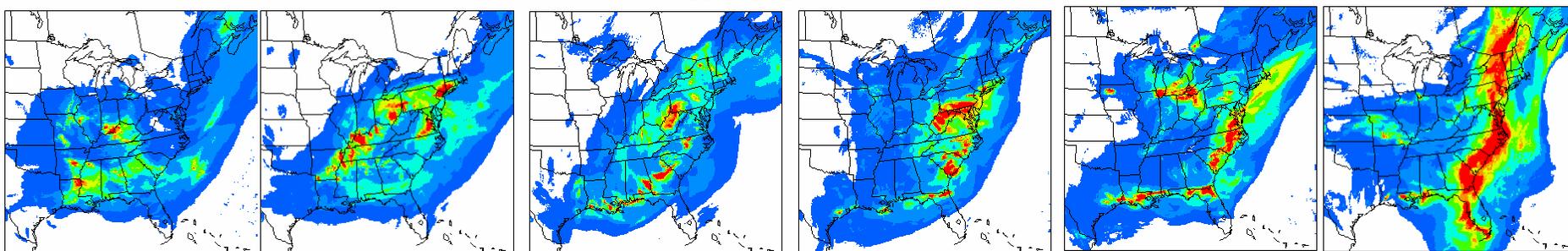
July 16-22, 2004: Evidence of Effects of Long Range Transport Originating from Outside the Modeled Domain

Evolution of Model and Observed Aerosol Optical Depth

MODIS



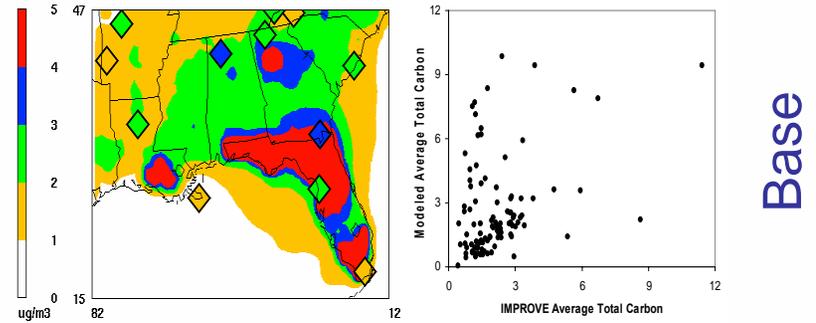
Model



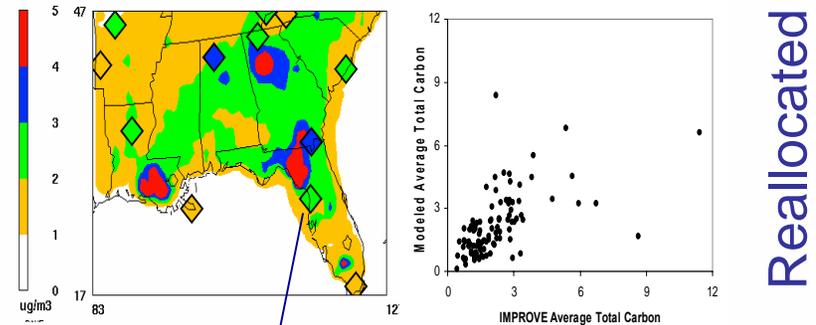
Transport from outside the domain influences observed PM concentrations which are grossly under-predicted during this period

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

- 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

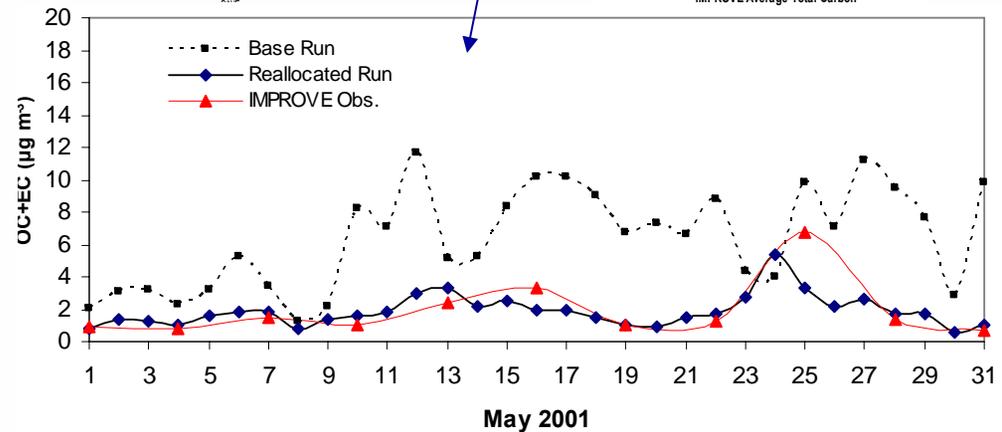


Base

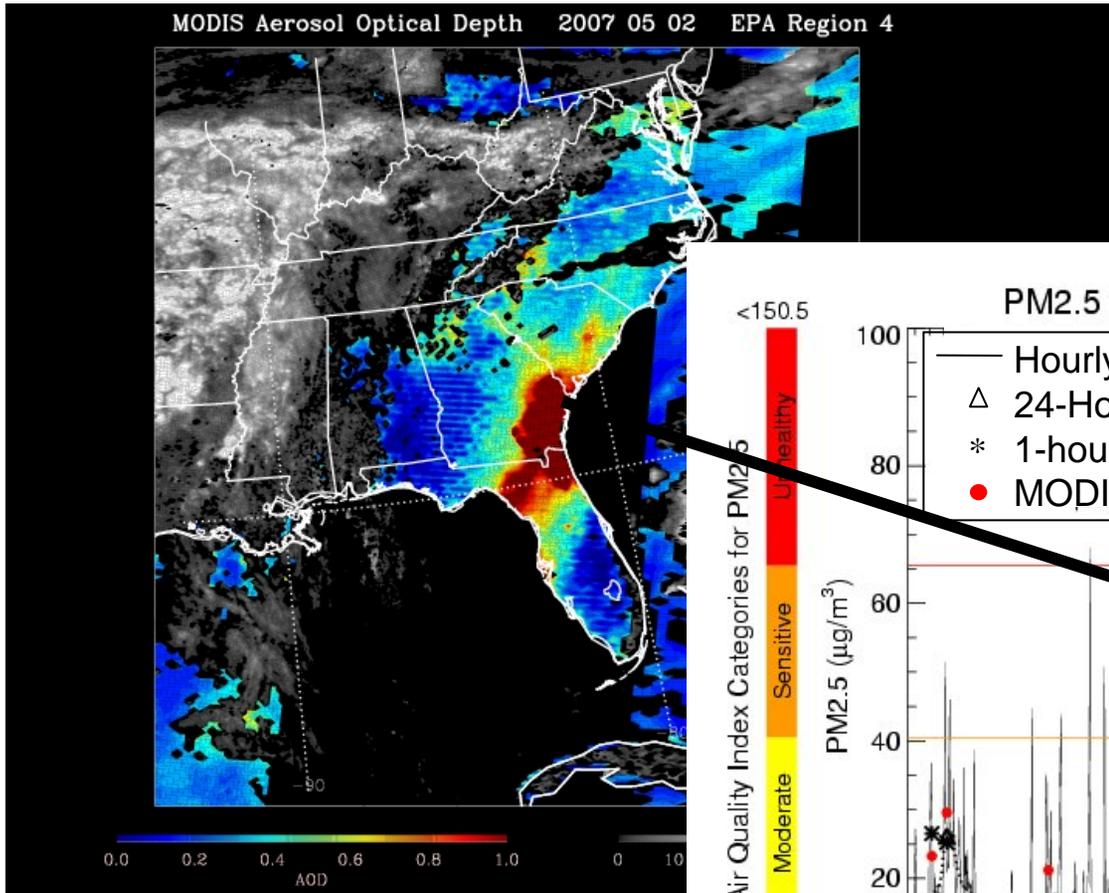


Reallocated

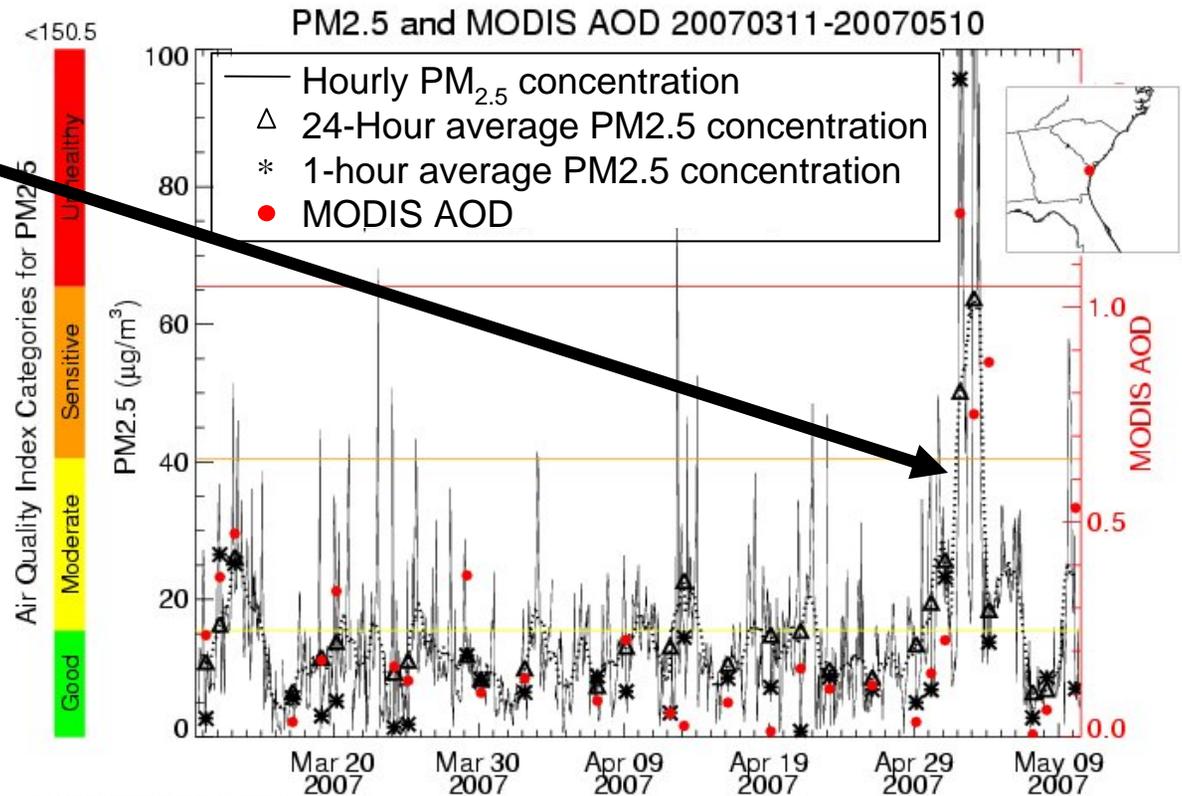
➔ Reallocation helps reduce bias and improves correlation in total carbon predictions



Satellite & Ground Measurements can help define spatial gradients

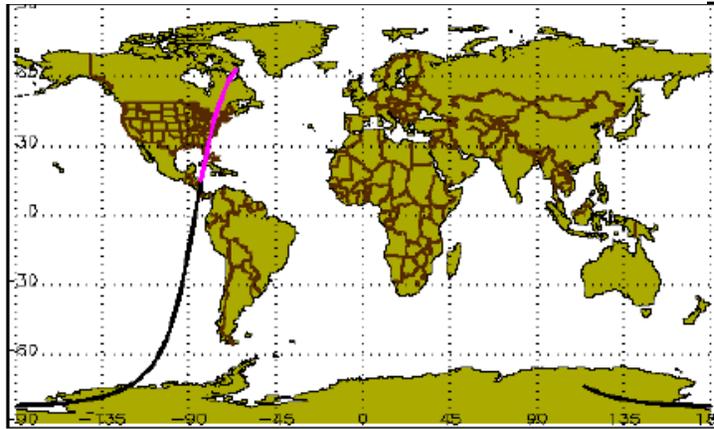


Savannah, Georgia USA

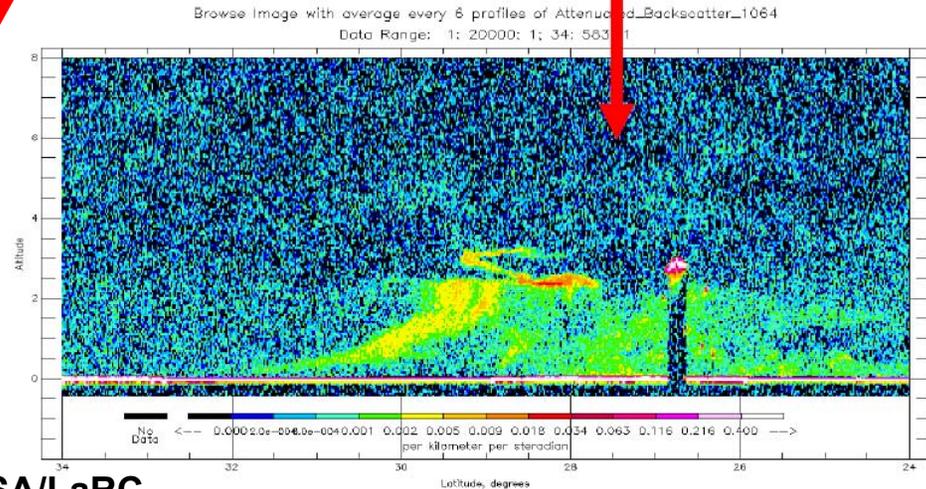
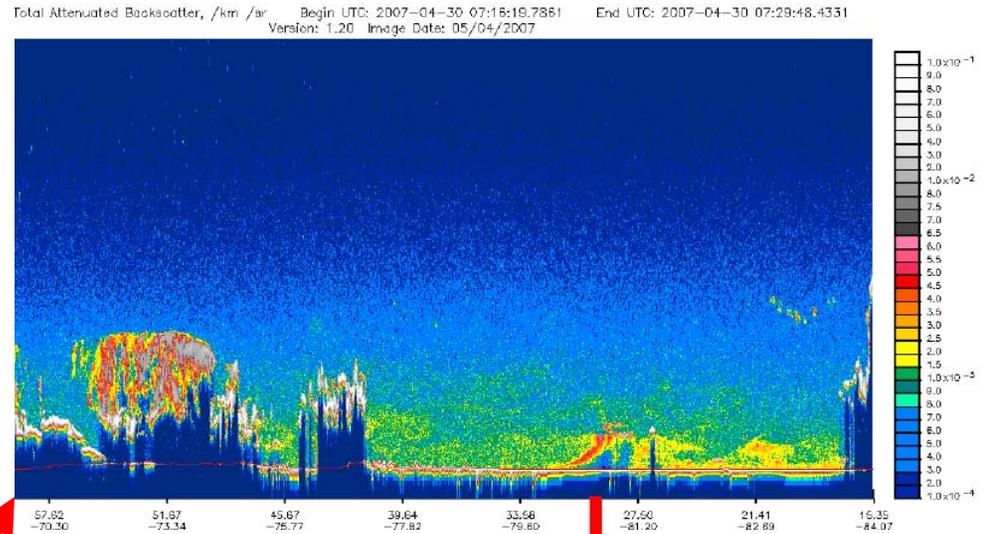


Clip: Max surface value = 155.500

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

May 2, 2002



May 9, 2003



May 11, 2004



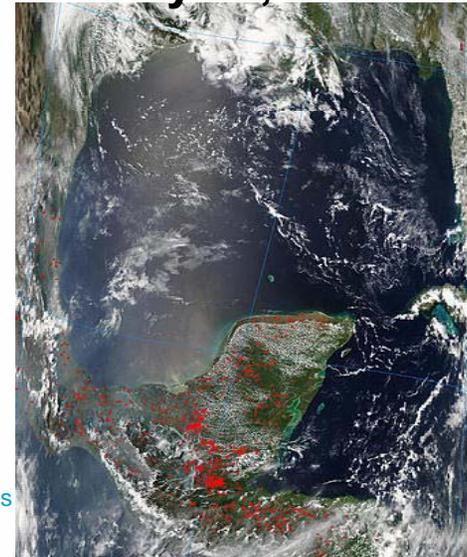
April 28, 2005



May 8, 2006

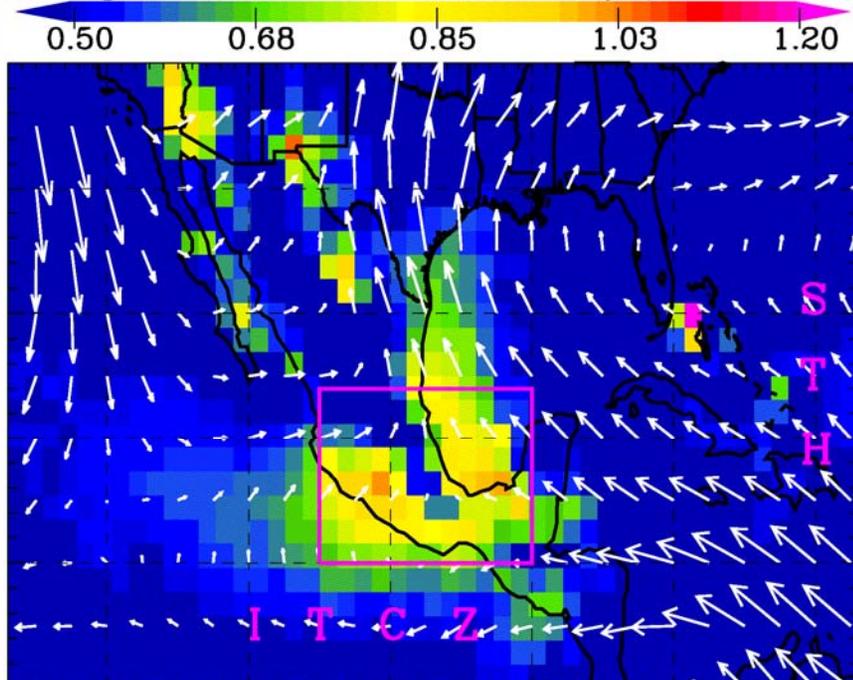


May 22, 2007

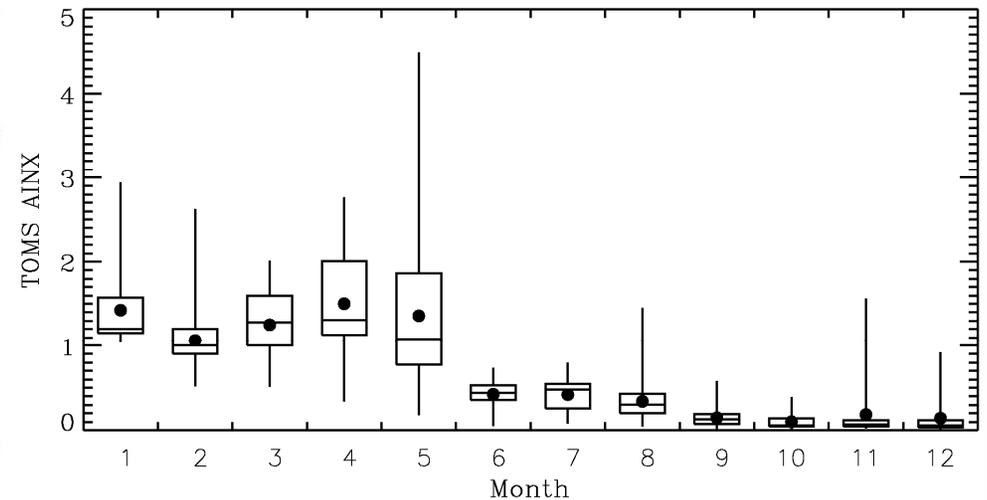


Spatial & Temporal Variations

Averaged TOMS Aerosol Index in May (1978 – 2003)



Box-and-Whisker Plot of monthly TOMS aerosol index



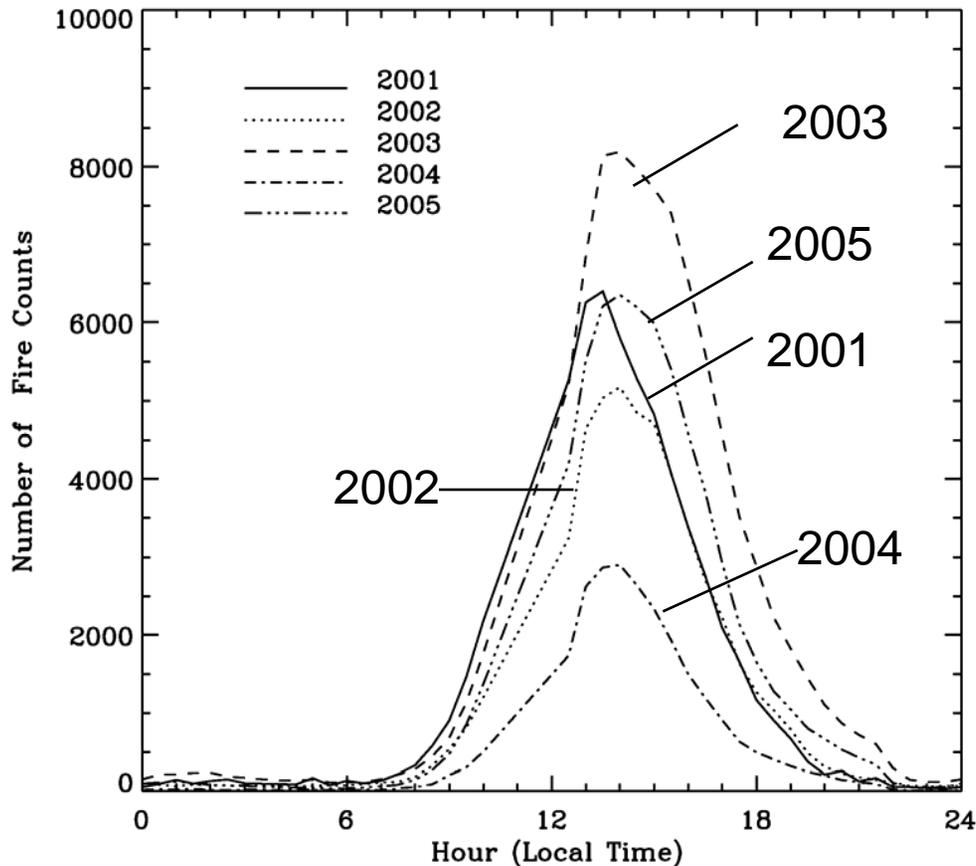
25 yrs statistics

Wang et al., 2006

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

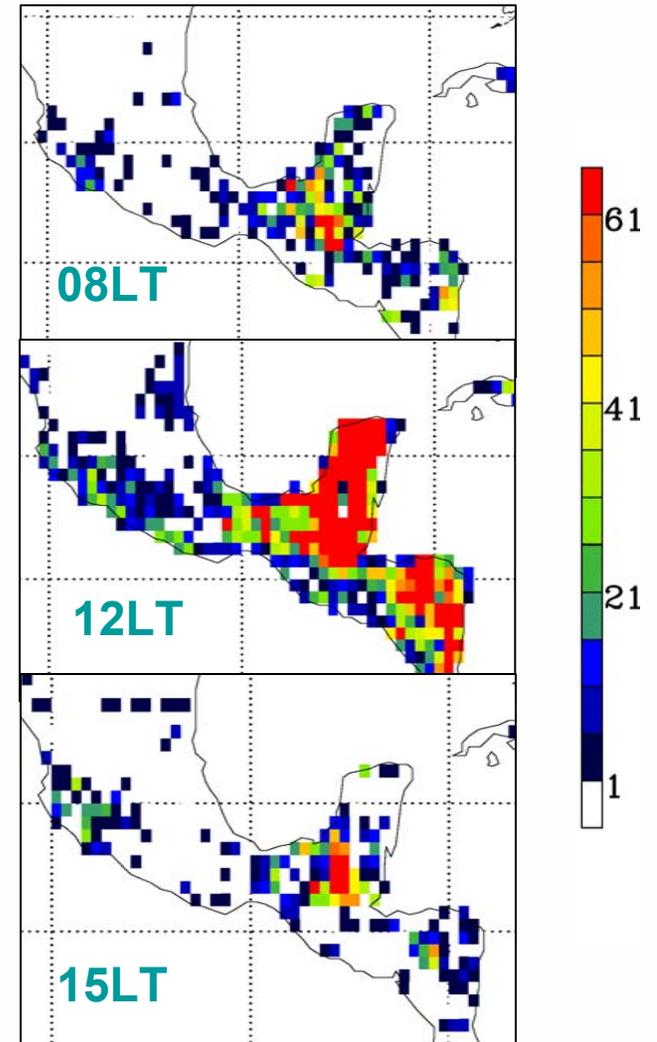
Diurnal & Intra-annual Variations

Fire counts by GOES in April & May

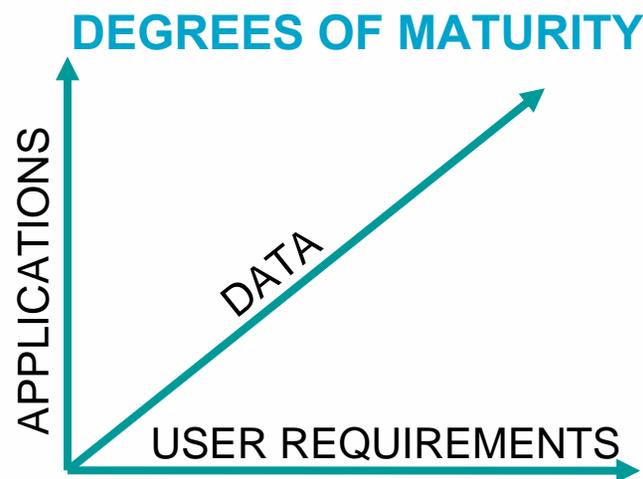


**A factor of 3-4 intra-annual variation.
But diurnal variation pattern is similar.**

of fire counts, Mar.-May, 2003



- 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.



References

- Wang, J., and S.A. Christopher, 2006: Mesoscale modeling of central American smoke transport to the United States, 2: Smoke regional radiative impacts on surface energy budget and boundary layer evolution, *J. Geophys. Res.*, doi:10.1029/2005JD006720, 111, D14S92, doi:10.1029/2005JD006416, 2006.
- 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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