Towards an Integrated Observing System for Air Quality Decision Making

Doreen Neil
Senior Research Scientist
Deputy Program Manager, Air Quality Applications
NASA

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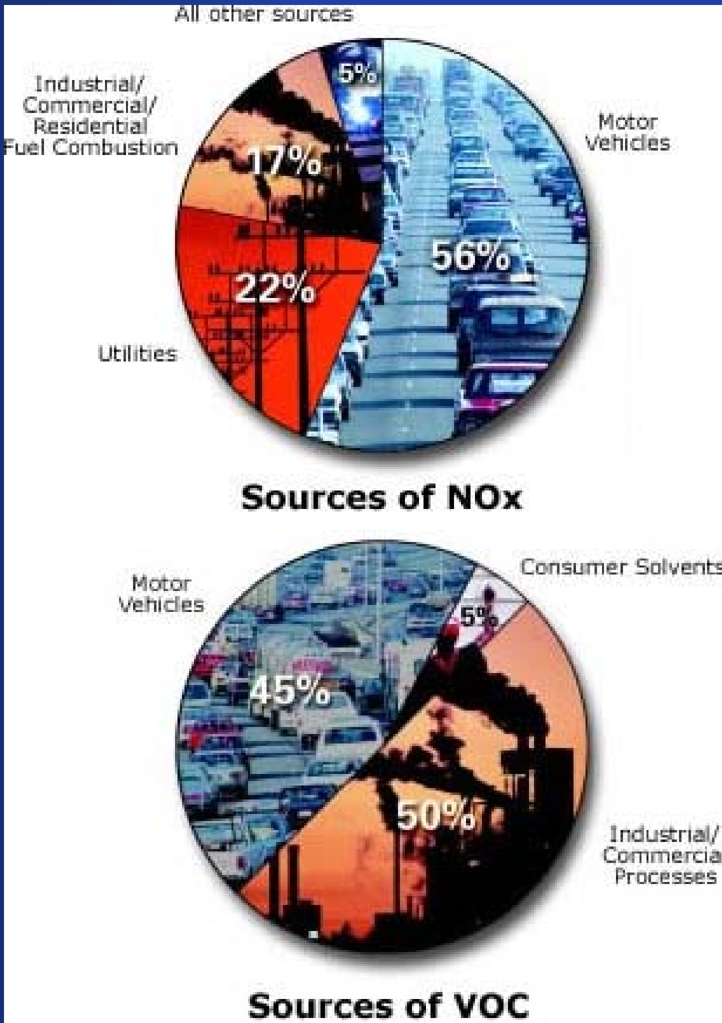
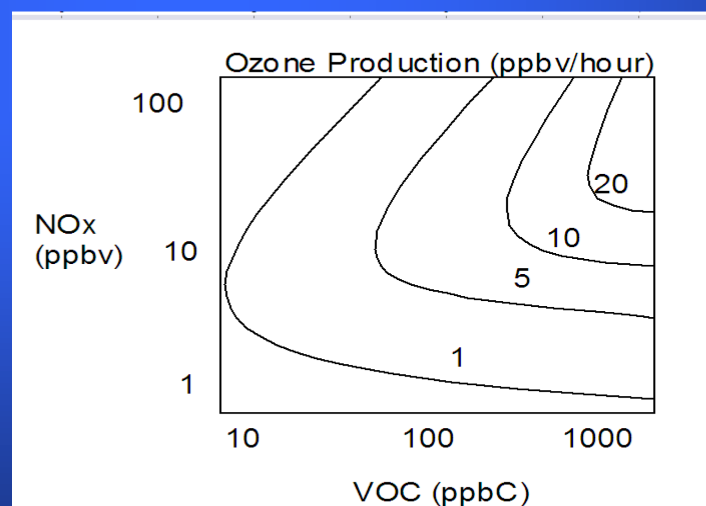
Air Quality is largely defined by the abundance of ***Aerosols*** and ***Ozone*** at Earth's surface



Particles contribute to haze, such as this brown haze over Boston.

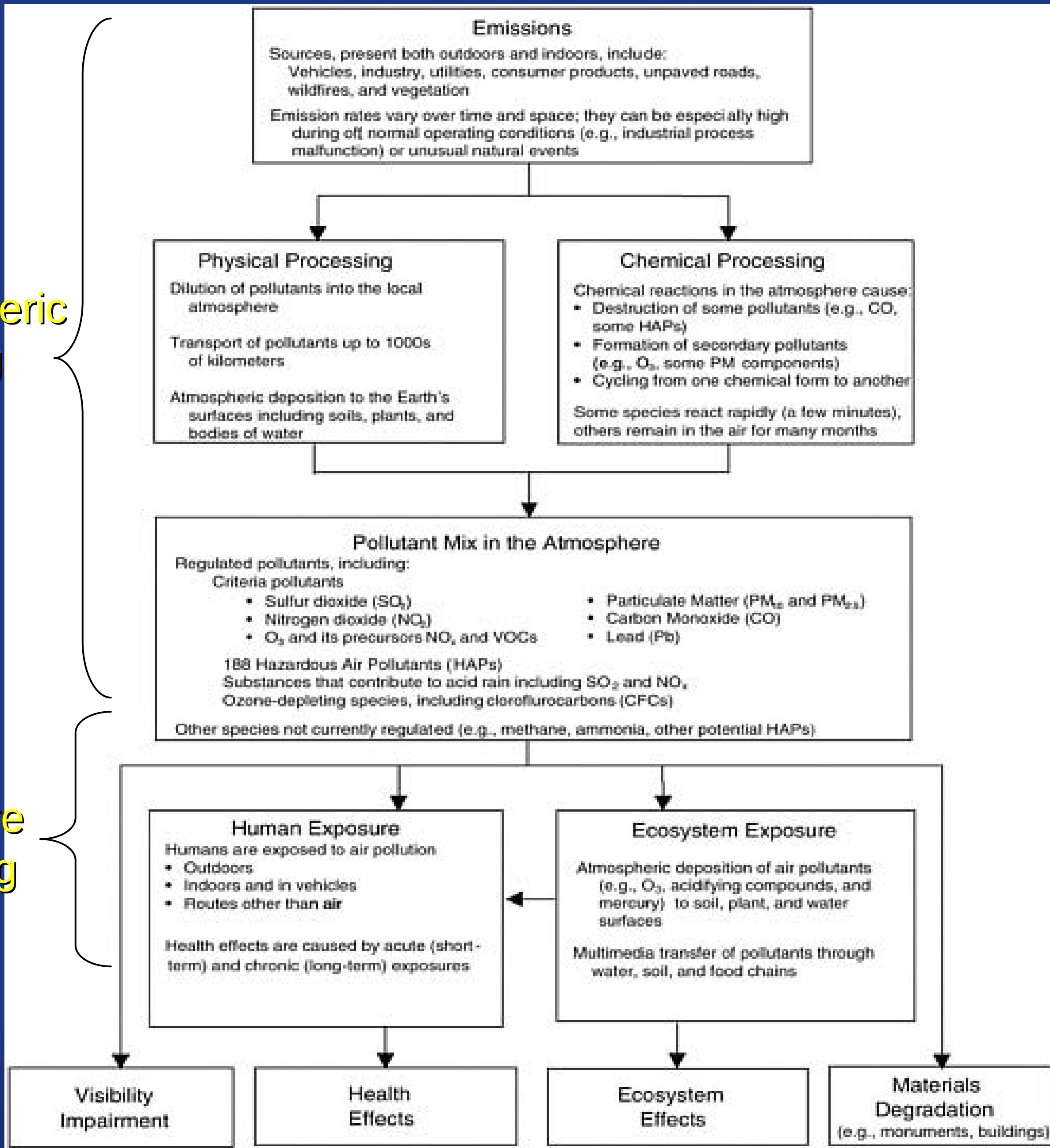


Ground-level ozone, a primary ingredient in smog, forms when volatile organics (VOCs) and Nitrogen Oxides (NO_x) react chemically in the presence of sunlight.

Science of Air Quality

Atmospheric Modeling

Exposure Modeling



Inverse Modeling – Top Down Constraints on Emission Sources

Data Assimilation - Constraints on vertical distribution, loading and composition

Model Verification – Characterize process errors and uncertainties

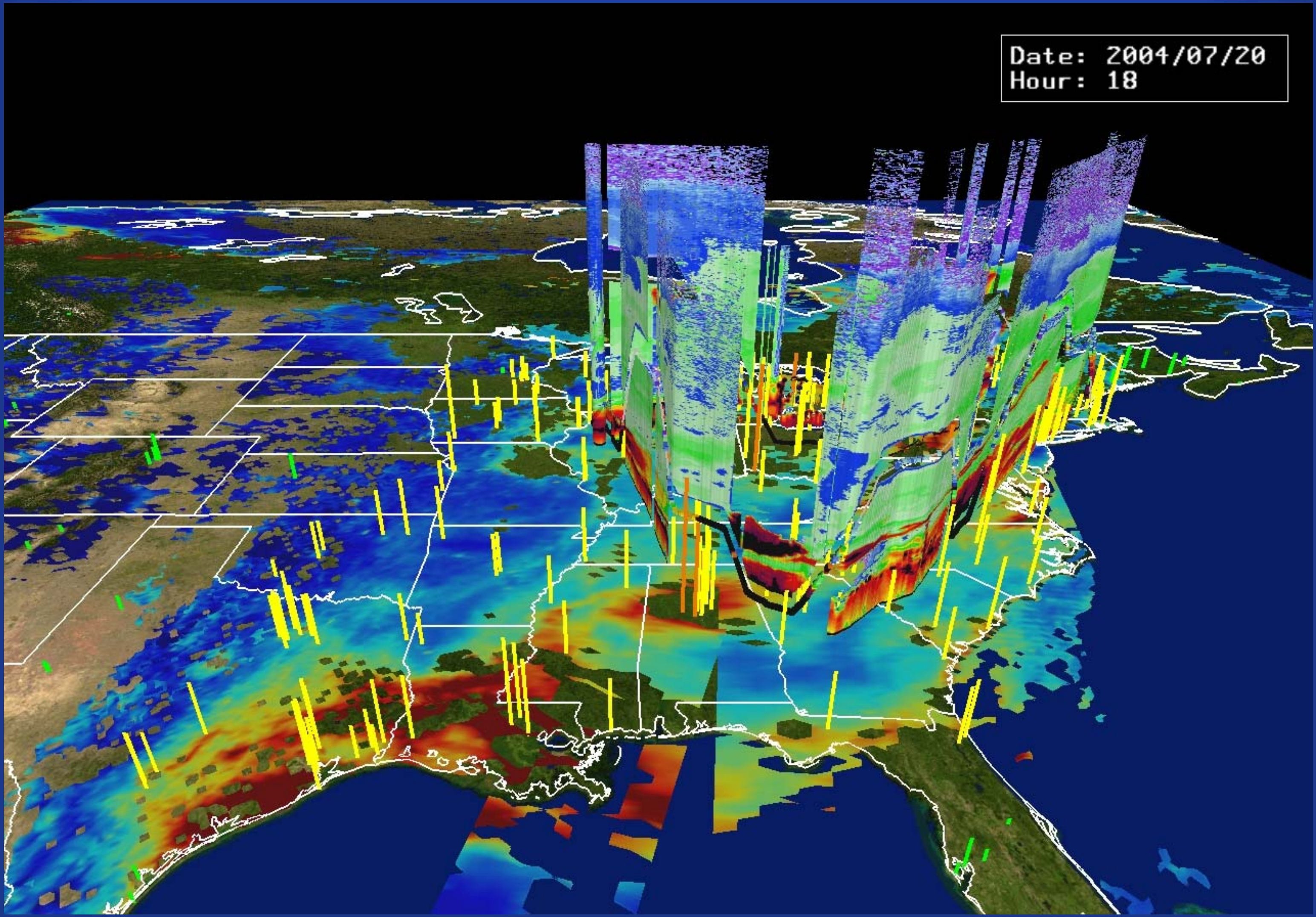
Best Estimate of Spatial Distribution of Loading and Composition

Source: Air Quality Management in the United States, NRC 2004

Climate Change- Air Quality link

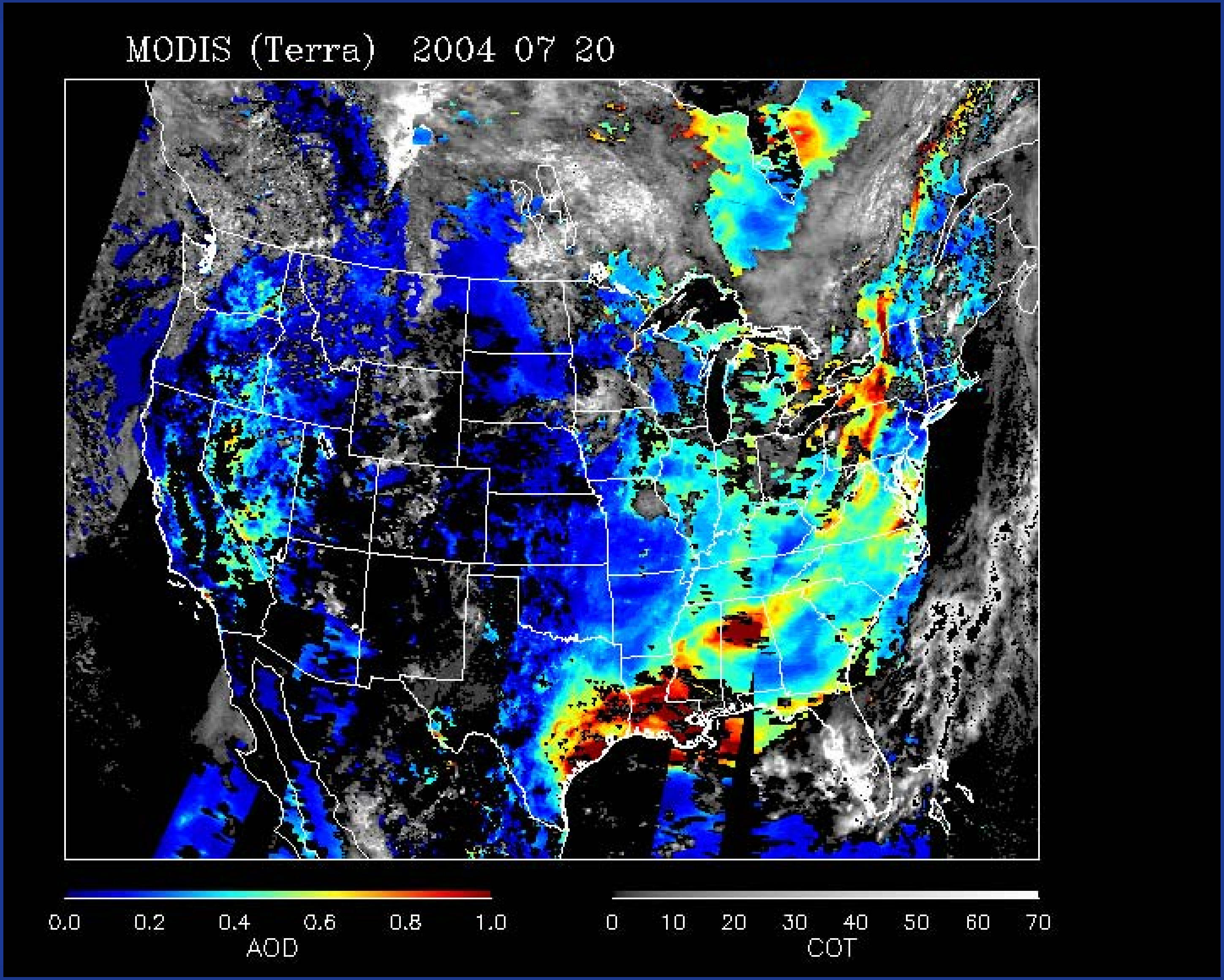
- Most obvious link is through aerosol
  - Climate change is being seen in boreal regions through increased frequency and emissions of boreal forest fires– smoke aerosol, chemical constituents. Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment 2004.
  - Climate change may affect the frequency and intensity of photochemical pollution events in North America- photochemically produced aerosol. Source: Effects of future climate change on regional air pollution episodes in the United States, Mickley et al., 2004.
  - Increasing photochemical events also produce ozone, a greenhouse gas.

An Integrated Picture of Aerosols in SE United States
July 20, 2004 a variety of measurements show the evolution of the largest aerosol pollution event during Summer 2004

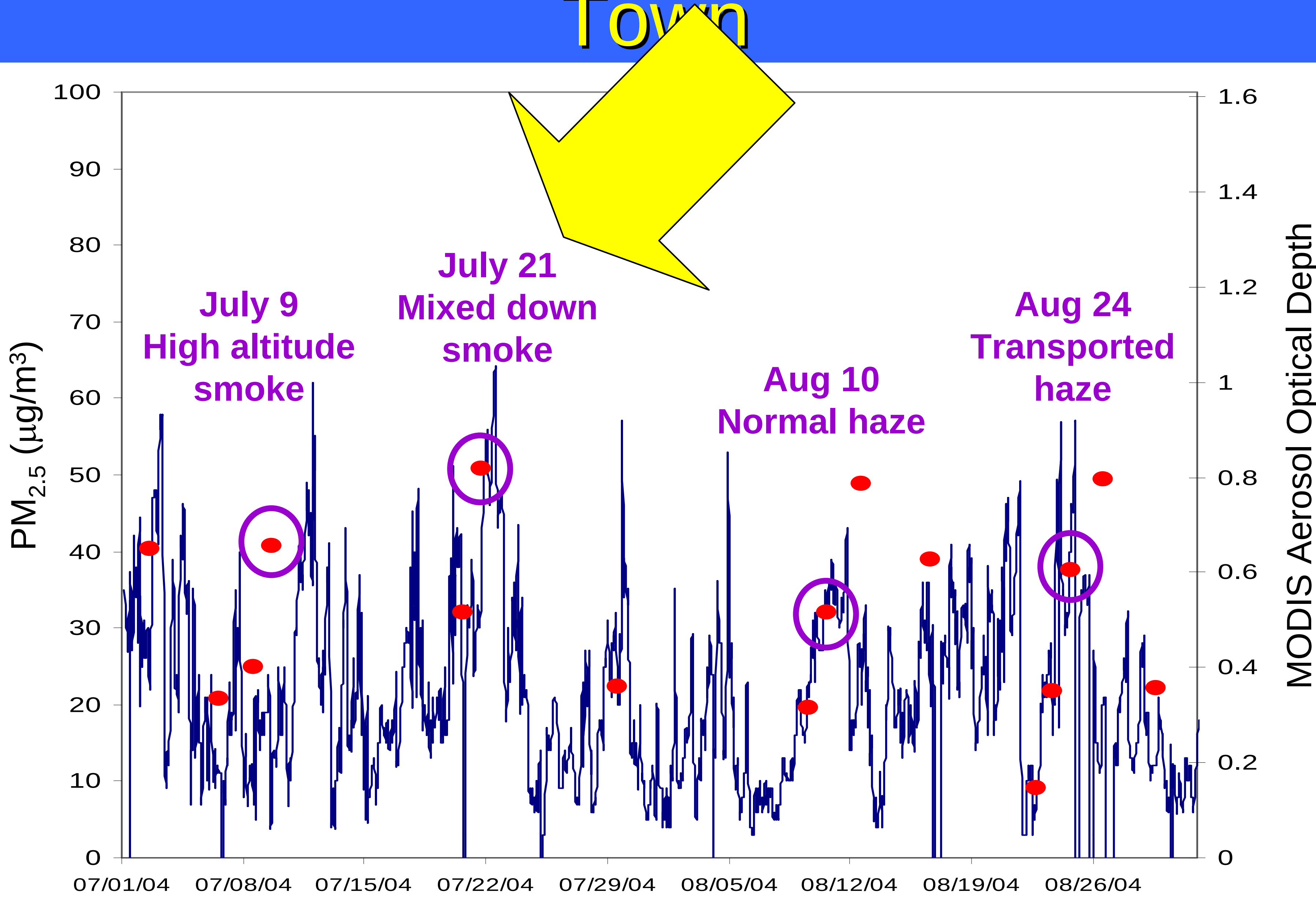


NASA's DC-8 LIDAR and In-situ Aerosol Measurements during the ICARTT field campaign with NASA MODIS AOD and EPA AIRNow ground based measurements..

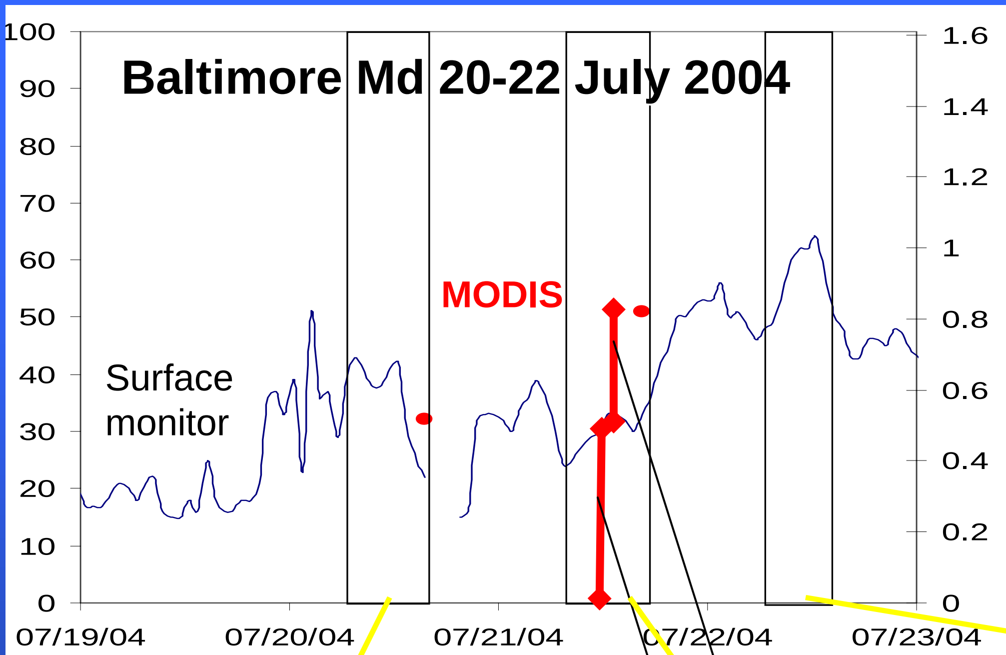
MODIS Aerosol Optical Depth (AOD) measurements

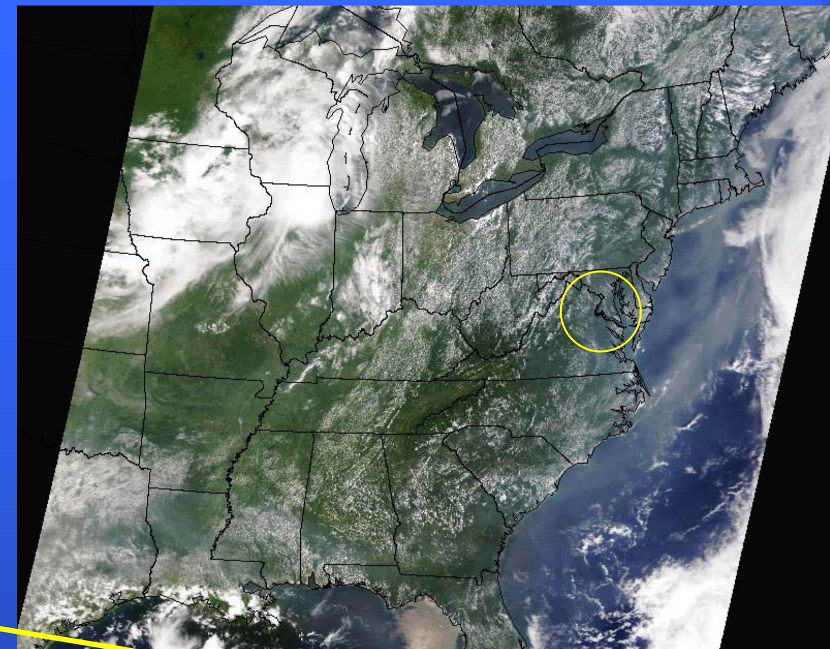


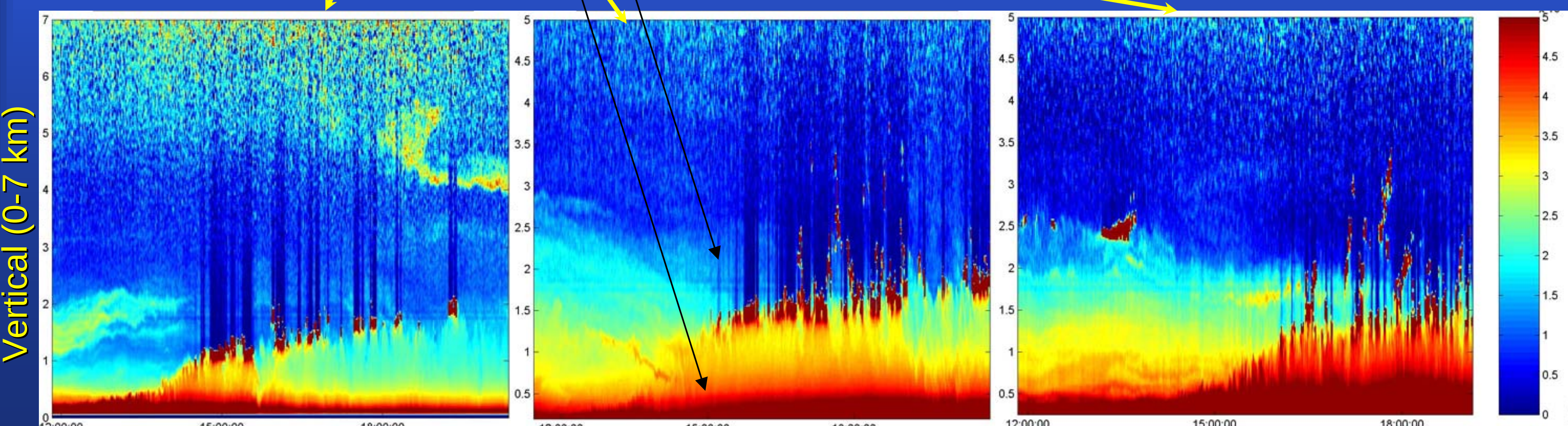
The Summer of 2004: Baltimore Old Town



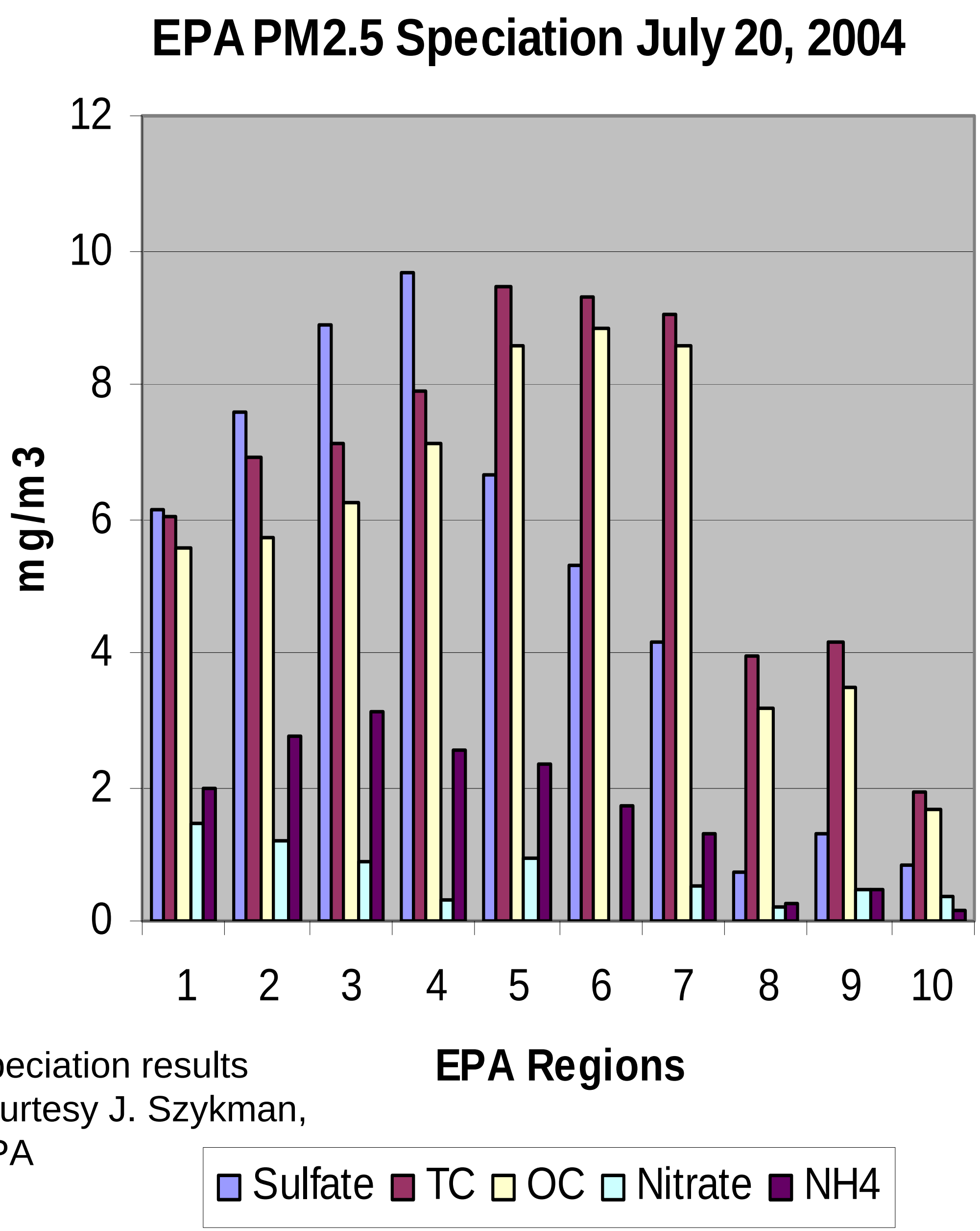
Smoke mixing with sulfate aerosol



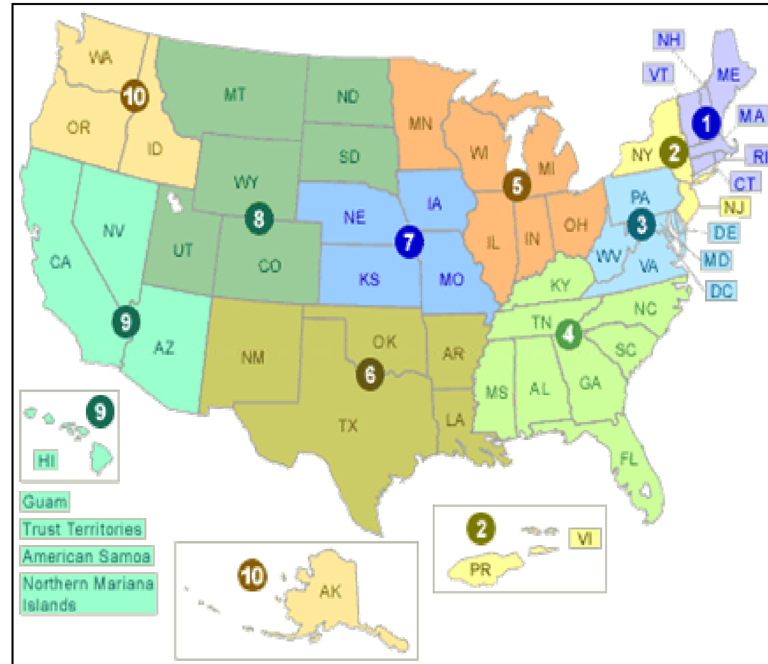


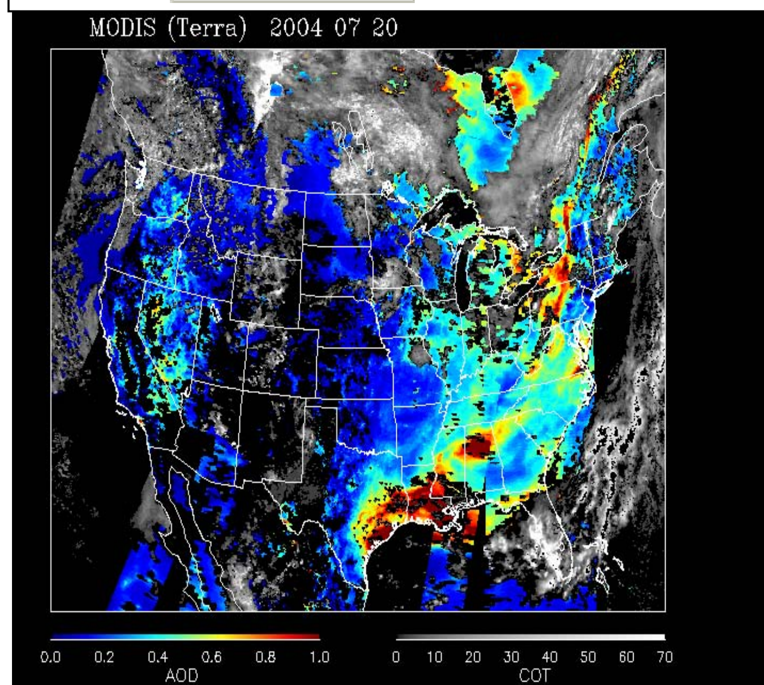


24 hours of surface based aerosol lidar measurements during three separate days



Speciation results courtesy J. Szykman, EPA





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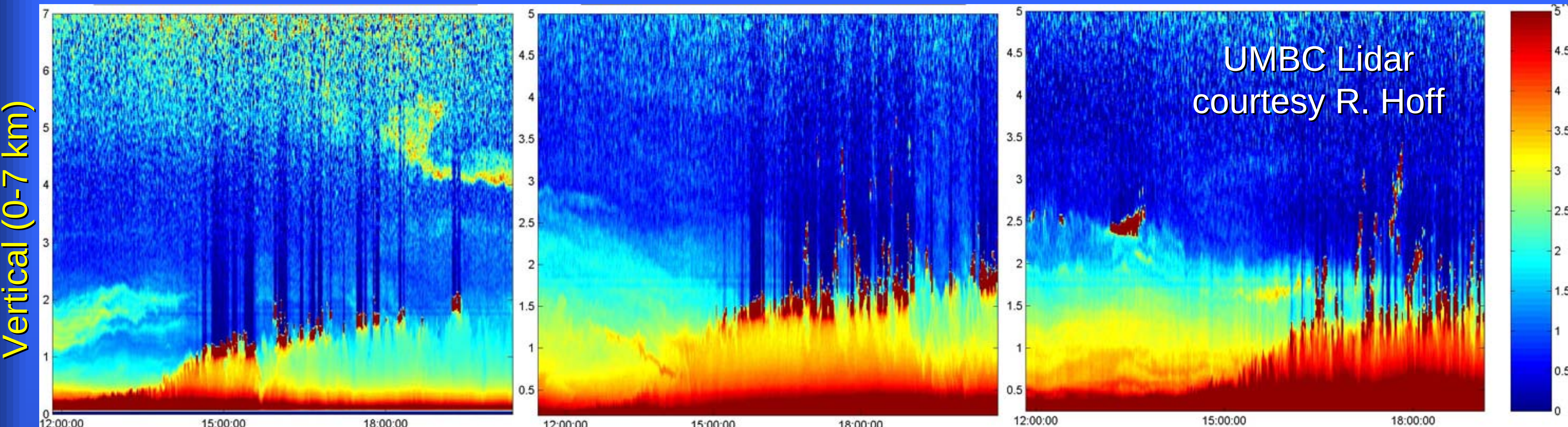

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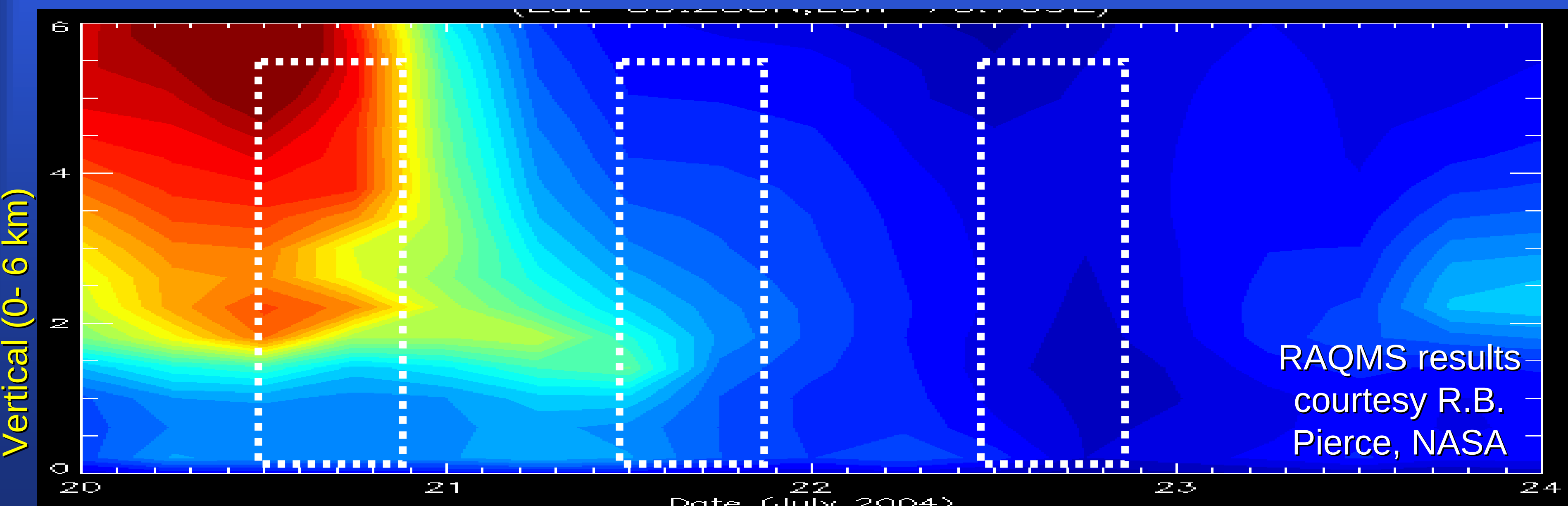
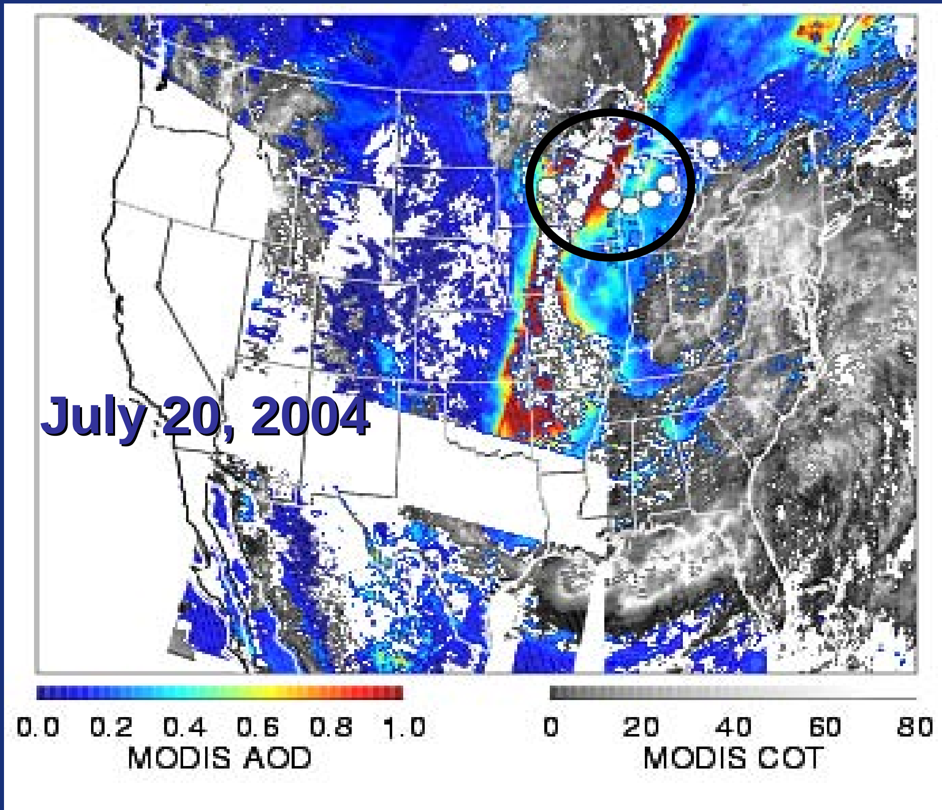
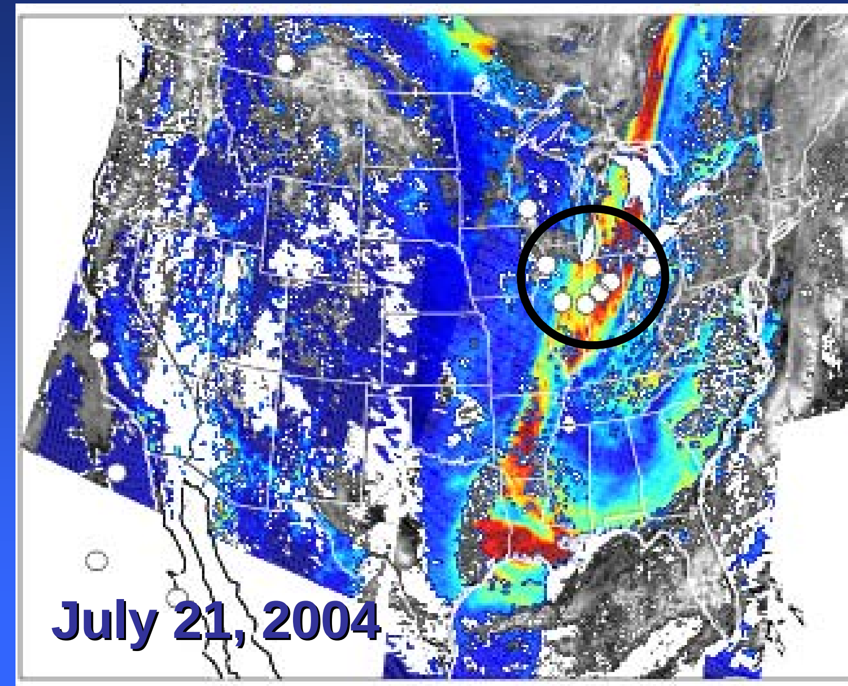
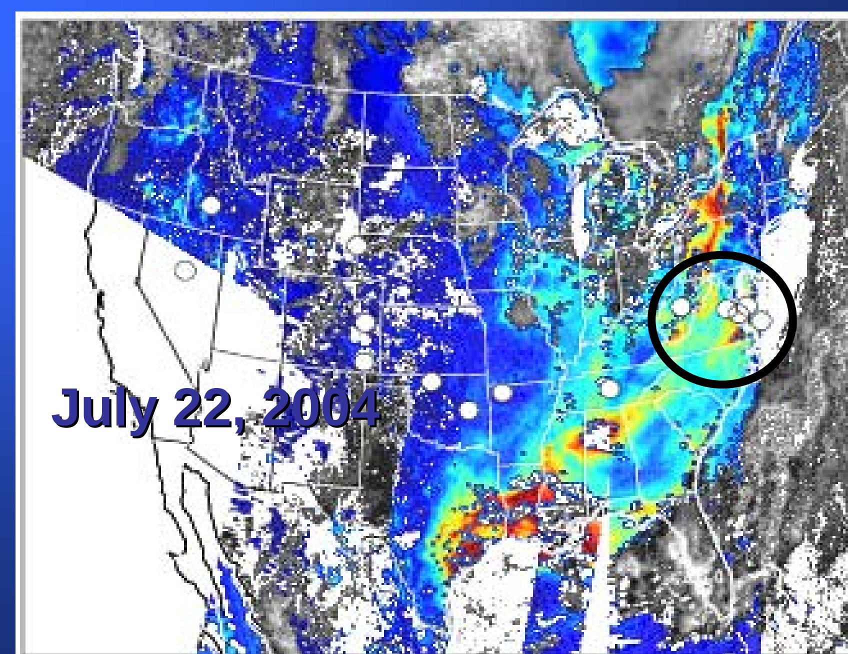


Continuous modeled carbonaceous/total fine aerosol ratio during the period





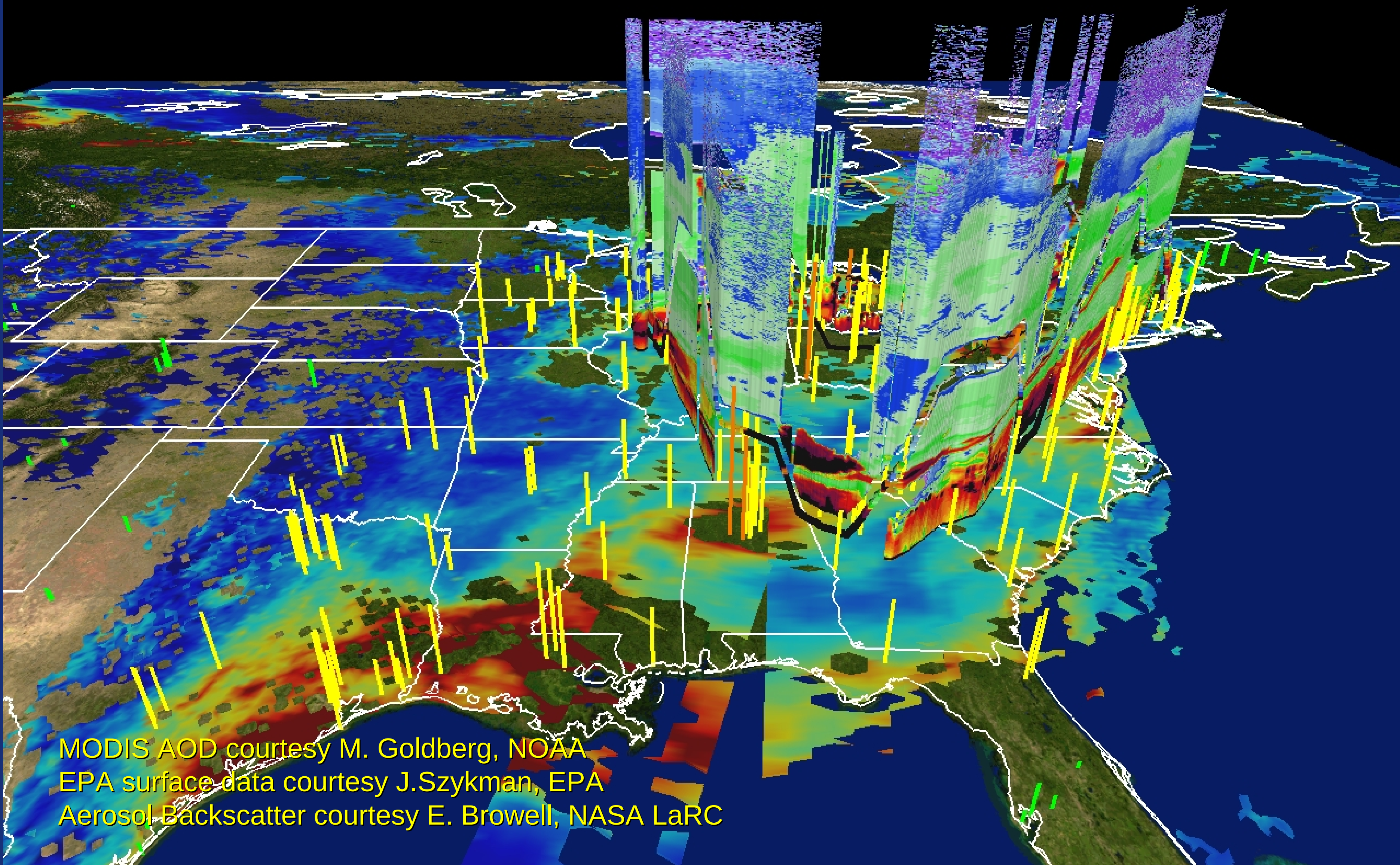


2-Day back trajectories initialized initialized below 1 km altitude at UMBC, with MODIS AOD and COT.

These results illustrate how back trajectories can be be used to link surface based lidar measurements, measurements, model predictions of aerosol composition, and satellite observations of aerosol loading to provide additional information for

Satellite (MODIS) Aerosol Optical Depth
EPA surface monitor $PM_{2.5}$
DIAL aerosol backscatter ratio

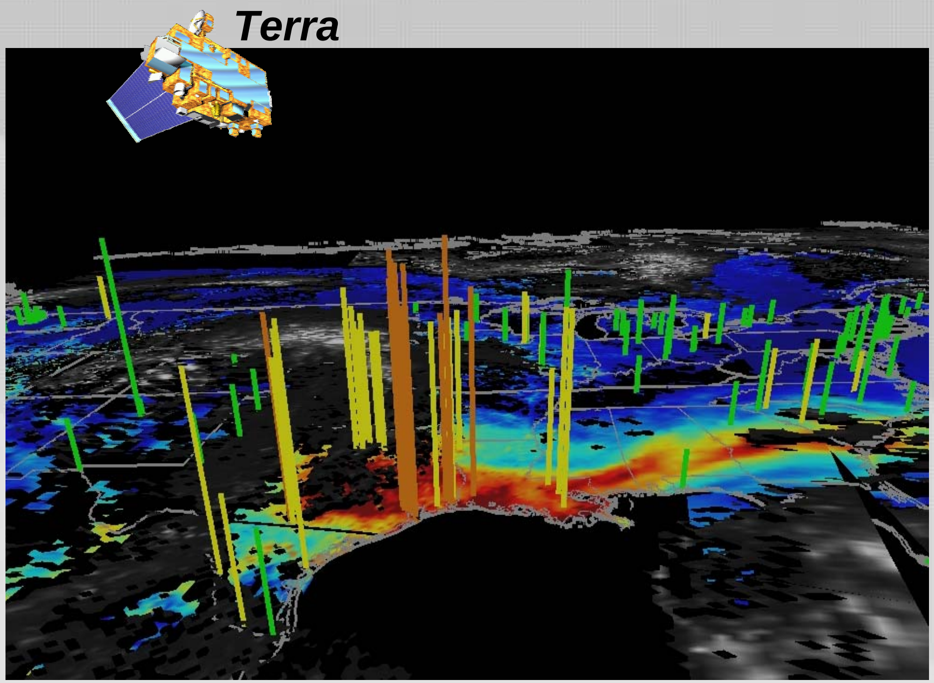
Date: 2004/07/20
Hour: 18



NASA LaRC Air Quality Applications: Successful Transition from Research to Operations

- IDEA, the first project conducted under NASA's Air Quality National Applications Program, creates a data fusion to support EPA's AirNOW next-day fine particle air quality forecasting.

Terra

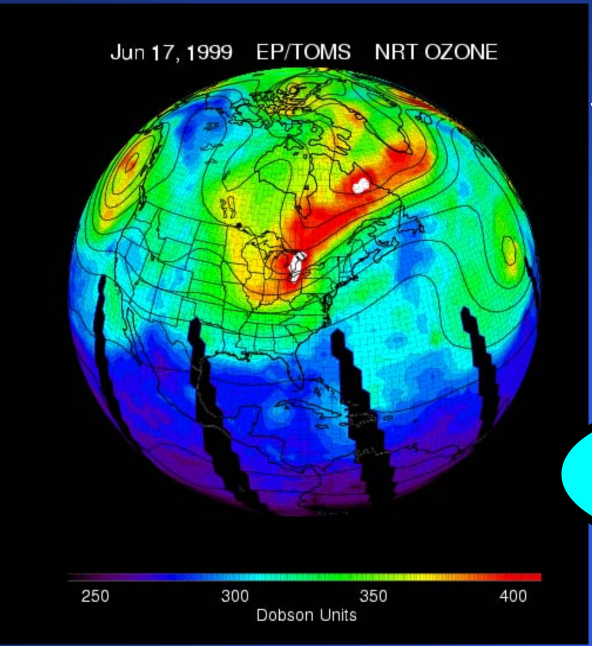


IDEA combines aerosol optical depth from NASA's MODIS, and EPA surface measurements of $PM_{2.5}$ with forward air parcel trajectories. IDEA provides next-day aerosol forecast guidance, and supports analysis of aerosol pollution events. http://idea.ssec.wisc.edu/index.php

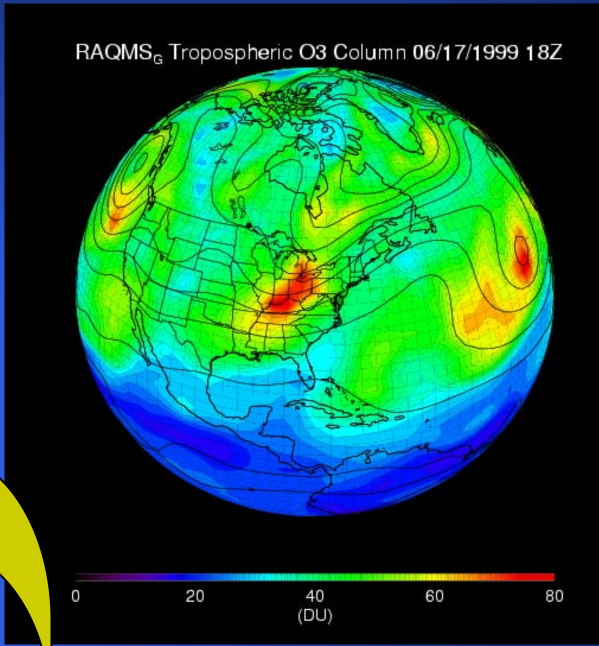
EPA submitted the coordinated User Request for operational production of IDEA to NOAA NESDIS in Aug. 2005.

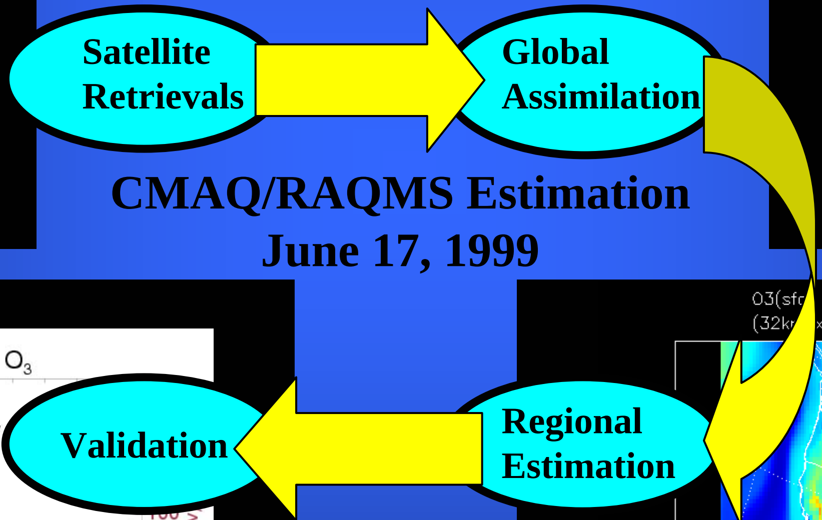
- IDEA prototype visualization demonstrated **Sept. 2003.**
- Benchmark Report **Nov. 2003** IBPD 4ESA1.1
- Transition to pre-operational status at UW-NOAA-NASA institute (CIMSS) **May 2004.**
- EPA conducted forecaster training at national conference **Feb 2005.**
- IDEA analysis used in US EPA's Clean Air Interstate Rule (CAIR) making **May 2005**.

Impact of assimilated Satellite Ozone Measurements on CMAQ Air Quality Assessment Modeling

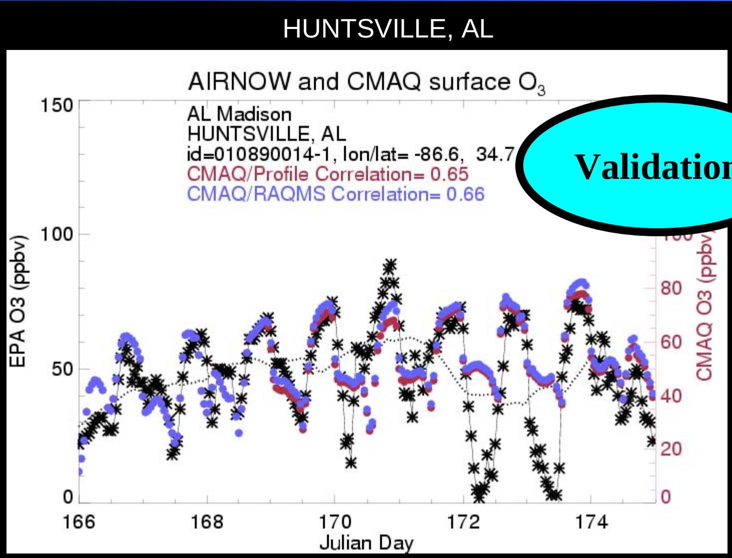


Collaborators: EPA/ORD (Ken Schere and Alice Gilliland) and the University of Houston (UH) Institute for Multidimensional Air Quality Studies (IMAQS) (Daewon Byun) using RAQMS global chemical analyses (R.B. Pierce) as lateral boundary conditions for the EPA CMAQ model.

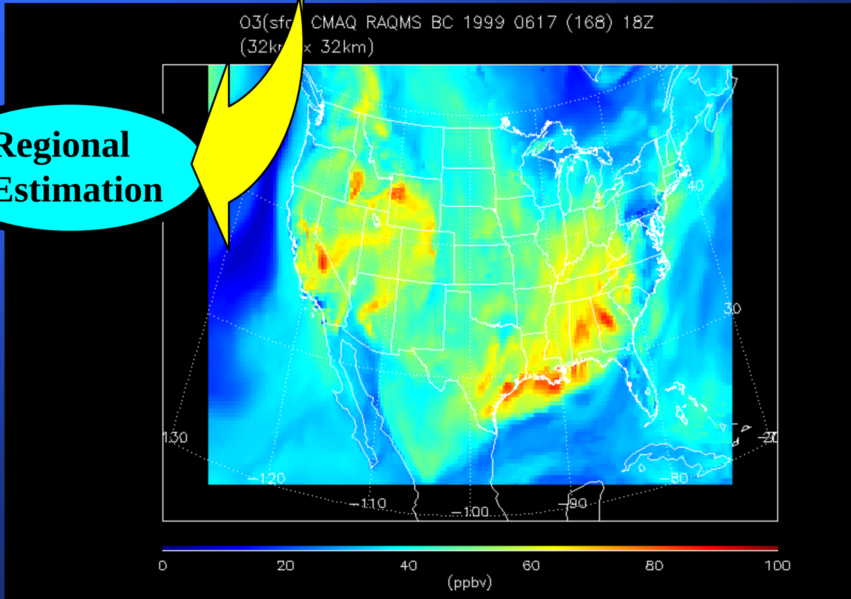




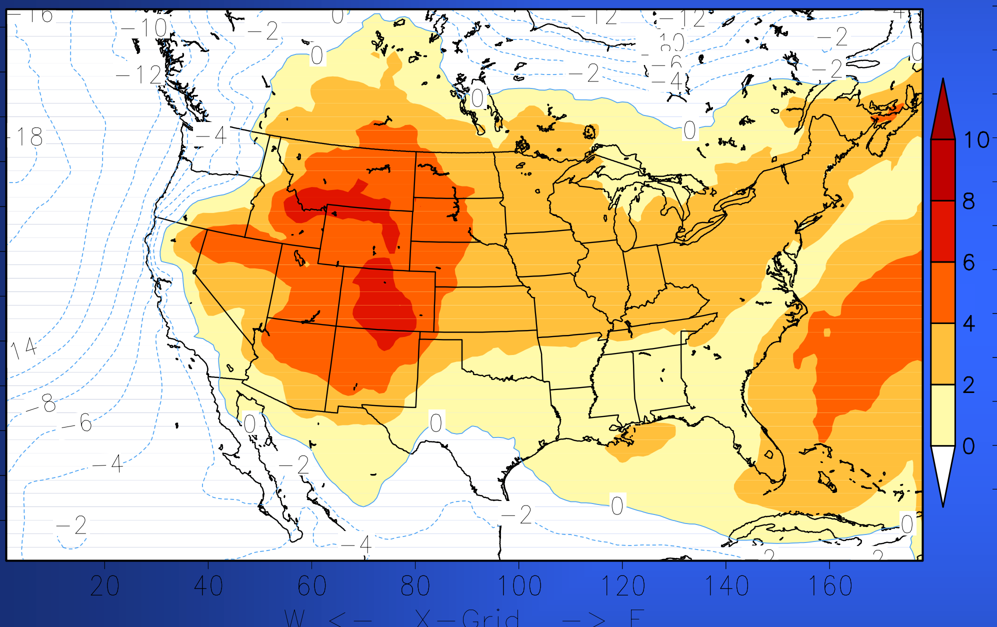
CMAQ/RAQMS Estimation
June 17, 1999



CMAQ surface Ozone Vs AIRNow

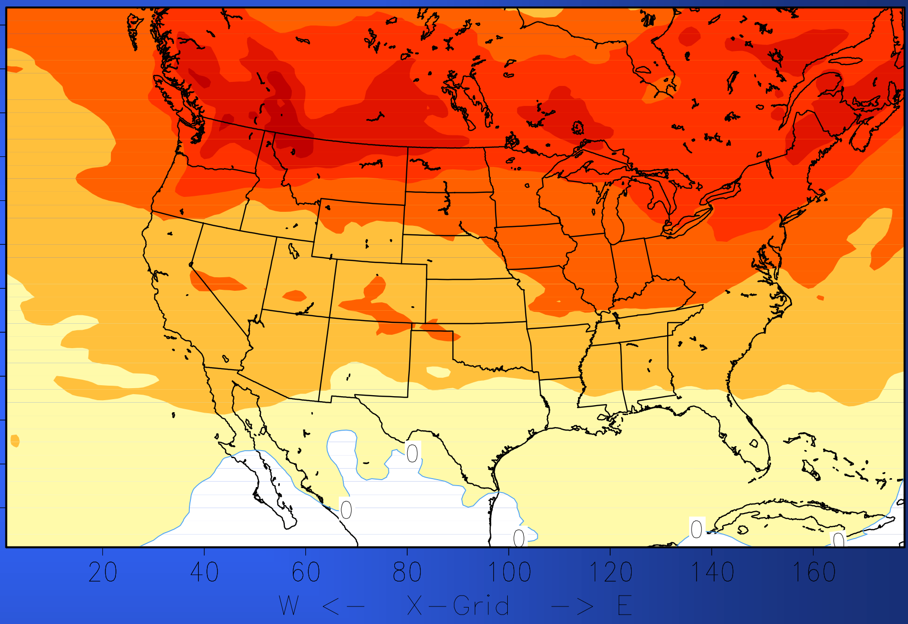


Mean Ozone Differences (ppbv) in CMAQ with and without time-varying globally assimilated boundary conditions



Surface ozone difference

(Moderate,but large in western states)



Upper tropospheric ozone difference

(significant over most of US)

Analysis from Benchmark Report, NASA LaRC

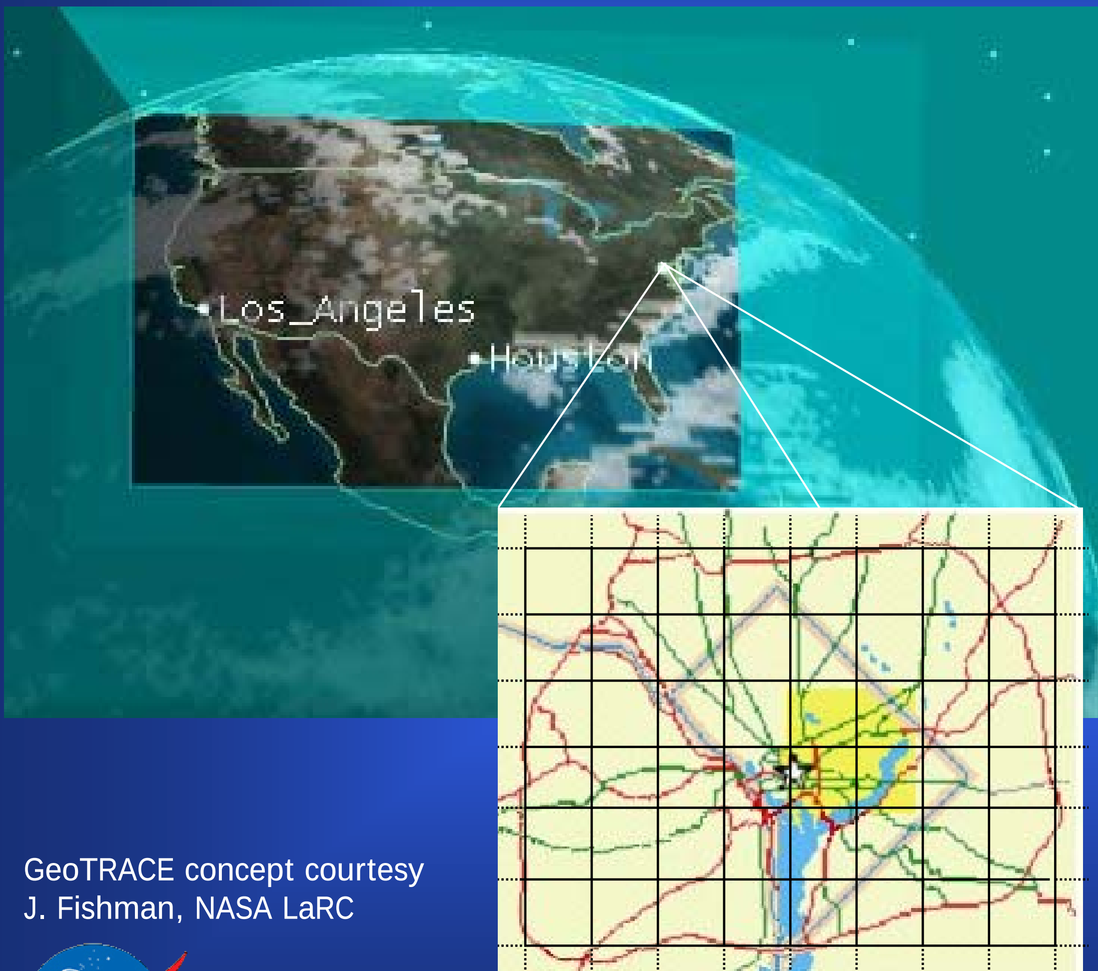
Lessons learned:
Air Quality Science to Decision Support

- "Sound science" is valued in public decision making. Partners look to NASA to "certify" the science.
- Many applications products are a sort of "level 4" product in NASA-speak, combining data from multiple instruments and models, and often including existing partner products.
- Partners will use NASA data, models, and analysis when their application is developed "scientist-to-scientist".
- Prototyping is important- outside the NASA community, decision makers find it difficult to imagine what can be done. Show them.
- Near real time delivery, frequency of sampling, and continuity of the data stream are valuable features to users. Give them what they need.
- CEOS/IGACO and GEOSS are the way forward.

Air Quality prediction, assessment, and management is a is a complex problem!

- Air Quality Goal: ubiquitous, near-surface atmospheric composition distributions every hour, every day.
- An integrated observing system comprises process studies (model results), source/point data, global observations, and time-resolved observations.
- The pieces of such an integrated observing system for criteria pollutants are substantially in place, except for the time-of-day-resolved observations, the last piece in the puzzle.

GeoTRACE Mission Concept: Time-resolved Tropospheric Chemistry



Washington DC: 48 pixels within the I-95 beltway

- GeoTRACE measures tropospheric columns of chemically linked gases: O_3, aerosols, CO, CH_2O, NO_2, and SO_2.
- Measurements every hour across the entire continent at the same time.
- Geostationary obit provides continuous access to the continental domain (5000 km x 5000 km, e.g., N. America).
- 3-5 km horizontal resolution.
- “Staring” enables high S/N measurements.

GeoTRACE concept courtesy J. Fishman, NASA LaRC