University of Wisconsin Participation in IDEA (Infusing Satellite Data into Environmental Applications)
http://idea.ssec.wisc.edu

Kathleen Strabala
Cooperative Institute for Meteorological Satellite Studies
Space Science and Engineering Center
University of Wisconsin - Madison

And a cast of thousands

Tony Wimmers, Steve Ackerman, Jerry Robaidek, Scott Bachmeier, James Szykman,
John White, Brad Pierce, Jassim Al-Saadi, Doreen Neil,
Chieko Kittaka, Allen Chu, Lorraine Remer, Liam Gumley, and Elaine Prins

MODIS Atmosphere Group Meeting
March 24, 2005

IDEA: NASA-EPA-NOAA partnership to improve air quality assessment, management, and prediction by infusing (NASA) satellite measurements into (EPA, NOAA) analyses for public benefit.
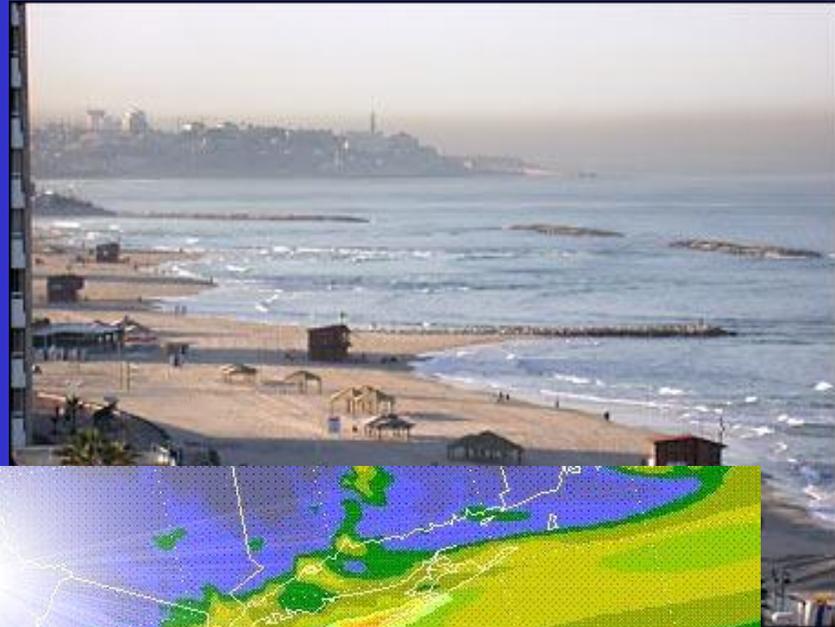
IDEA (Infusing satellite data into environmental air quality applications)

Part of NASA Earth Science Enterprise (ESE) Applications Program strategy to demonstrate practical uses of NASA sponsored observations from remote sensing systems and predictions from scientific research.

NASA MODIS - EPA AIRNow
Data Fusion Demonstration
Improving Air Quality Index (PM 2.5) Forecasting

What: Near-Real-Time Data Fusion of MODIS AOD and EPA AIRNow Data (Through NOAA bent pipe)

- Provides daily pseudo-synoptic view of aerosol loading across North America at a 10 km x 10 km spatial scale (MOD04_L2 product – Dr. Chu, Dr. Remer)

- Regional transport influences

- Natural event influences

- Re-circulation influences

When: Late August through September 2003

Who: NASA LaRC and GSFC

CIMSS/SSEC Univ. Of Wisc.-Madison & NOAA/NESDIS/ORA

US EPA OAR/OAQPS

Select group of Air Quality Forecasters

Objective: Prototype a near-real-time product for Air Quality Forecasters

Goal: Improve accuracy of next day $PM_{2.5}$ AQI forecast during large aerosol events

Summary of IDEA Demonstration

- Successfully achieved goal.
  - Fusion and delivery of multiple input data sets in near-real-time.
  - Selected group of forecasters routinely used the products to gain an understanding of large scales aerosol events.

- Timeliness of satellite data an issue in forecast cycle.
  - Implementation of MODIS AOD Direct Broadcast will help.

CIMSS PARTICIPATION
Near-Realtime Production Using UW-Madison Direct Broadcast Data

Reasons for CIMSS involvement:

- X-band direct broadcast production of MODIS products – timeliness aids forecasts

- Direct broadcast reception centrally located

- Experience with running and transitioning operational products

- Familiarity with MODIS products
    - Science Team Members and Associates
    - IMAPP – International MODIS/AIRS Processing Package

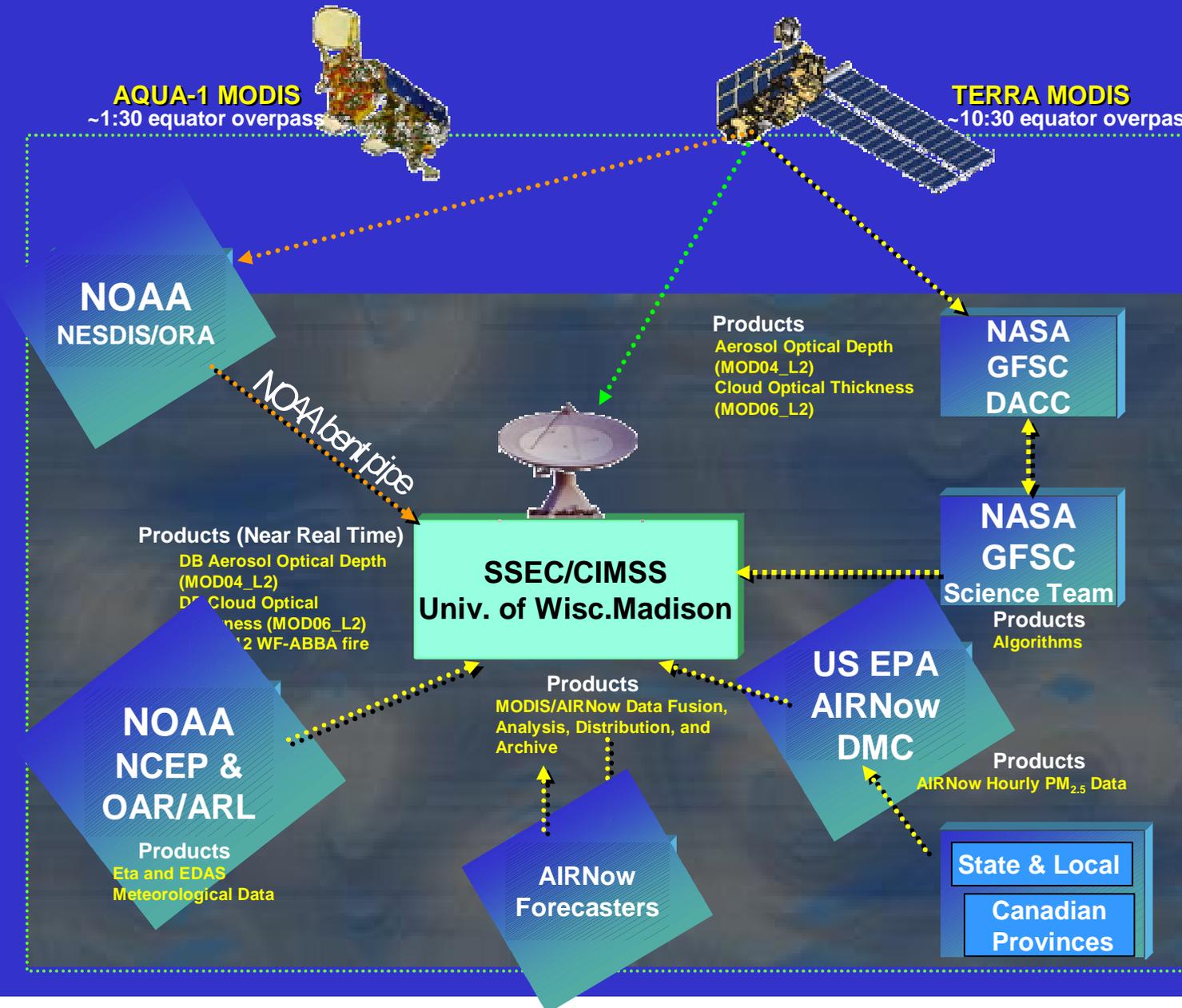- Aerosol scientists, forecasters and visualization experts present

CIMSS PARTICIPATION
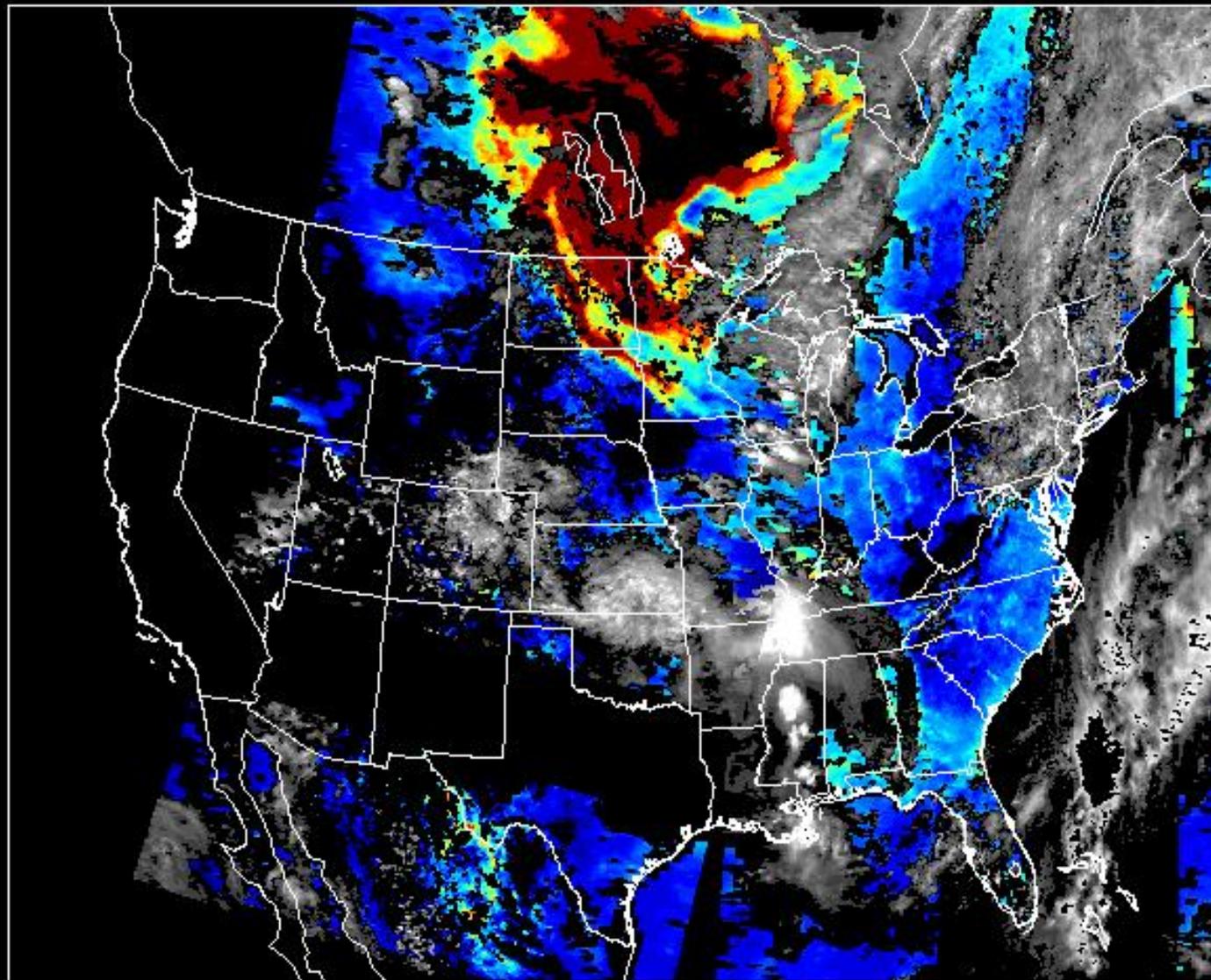## Funded To Produce IDEA Products for the 2004 Fire Season At UW-Madison

Process:

- Installed most recent Baselined Version of Atmosphere Group Products MOD04 and MOD06OD

- Transferred IDL and Pearl Scripts from NASA Langley to UW Dell Linux boxes – operational and development. Scripts compiled and tested

- Automated the data gathering process and script execution

- Processed data sets automatically beginning April 2004

- Trajectory forecast products generated by 4:30 pm (Eastern Time Zone)

- Set up web log for forecasts and user feedbacks and comments

- Monitor site use (user statistics)

- Assisted with forecast discussions

- Adjusted site based upon feedback from EPA forecasters

IDEA Data Flow Diagram

Not a Simple Straightforward Accomplishment

AQUA-1 MODIS
~1:30 equator overpass

TERRA MODIS
~10:30 equator overpass

NOAA
NESDIS/ORA

NOAA bent pipe

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

NASA GFSC DACC

Products (Near Real Time)
DB Aerosol Optical Depth (MOD04_L2)
DB Cloud Optical Thickness (MOD06_L2)
L2 WF-ABBA fire

SSEC/CIMSS
Univ. of Wisc.Madison

NASA GFSC
Science Team
Products
Algorithms

NOAA NCEP & OAR/ARL

Products
Eta and EDAS Meteorological Data

Products
MODIS/AIRNow Data Fusion, Analysis, Distribution, and Archive

US EPA AIRNow DMC

Products
AIRNow Hourly $PM_{2.5}$ Data

AIRNow Forecasters

State & Local

Canadian Provinces

MODIS (Terra)   2004 07 16

0.0   0.2   0.4   0.6   0.8   1.0
AOD

0   10   20   30   40   50   60   70
COT

Air Quality Index for Particles

Index Values	Category	Cautionary Statements	PM$_{2.5}$ (ug/m^3)	PM$_{10}$ (ug/m^3)
0-50	Good	None	0-15.4	0-54
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion	15.5-40.4	55-154
101-150	Unhealthy for Sensitive Groups	Sensitive groups should reduce prolonged or heavy exertion	40.5-65.4	155-254
151-200	Unhealthy	Sensitive groups should avoid prolonged or heavy exertion; everyone else should reduce prolonged or heavy exertion	65.5-150.4	255-354
201-300	Very Unhealthy	Sensitive groups should avoid all physical activity outdoors; everyone else should avoid prolonged or heavy exertion	150.5-250.4	355-424

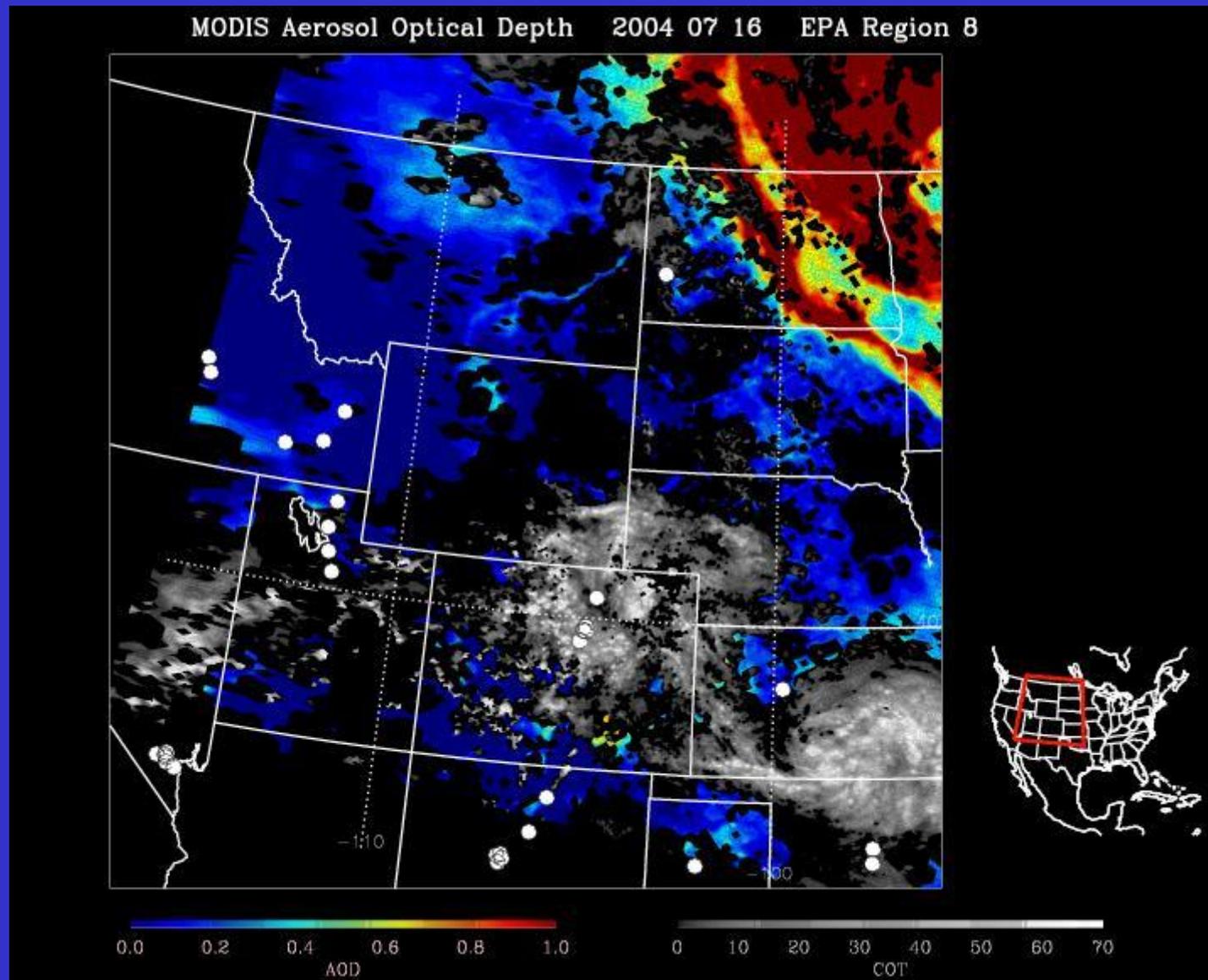Terra MODIS true color image 17 July 2004
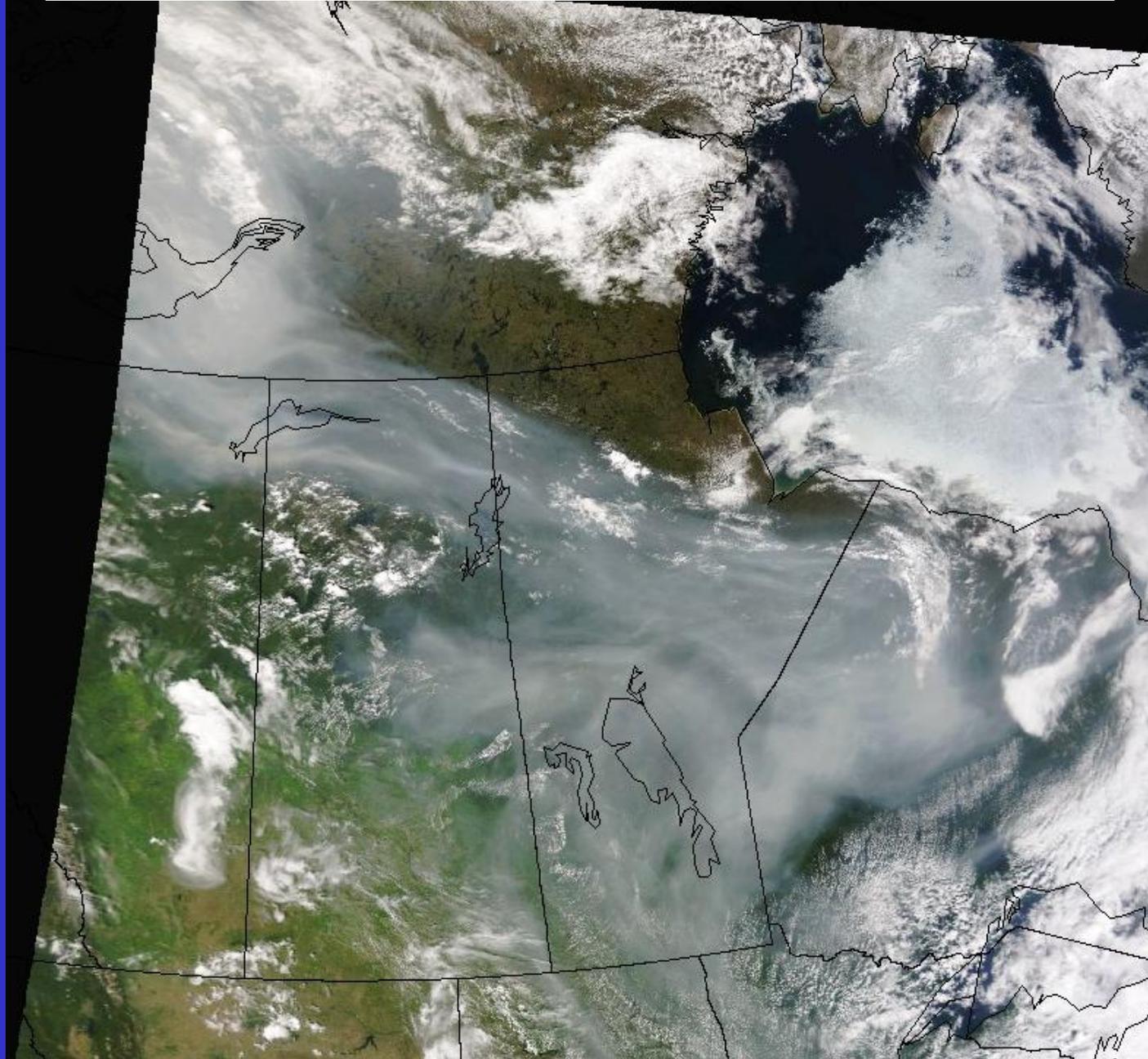
IDEA
Forecast Tool Products

(Example from July 2004 Aerosol Outbreak)

- Regional Summary Plots of MODIS Aerosol Optical Depth and Cloud Optical Thickness

- MODIS Aerosol Optical Depth 48 hour Trajectories Forecast

- Composite PM2.5/MODIS Aerosol Optical Depth Data Fusion 3-day Animation

- Time-series between MODIS Aerosol Optical Depth and PM2.5 (1hr and 24hr) Mass Concentration

- National Correlation Map between PM2.5 and MODIS Aerosol Optical Depth

- Daily Forecast Discussion and Blog

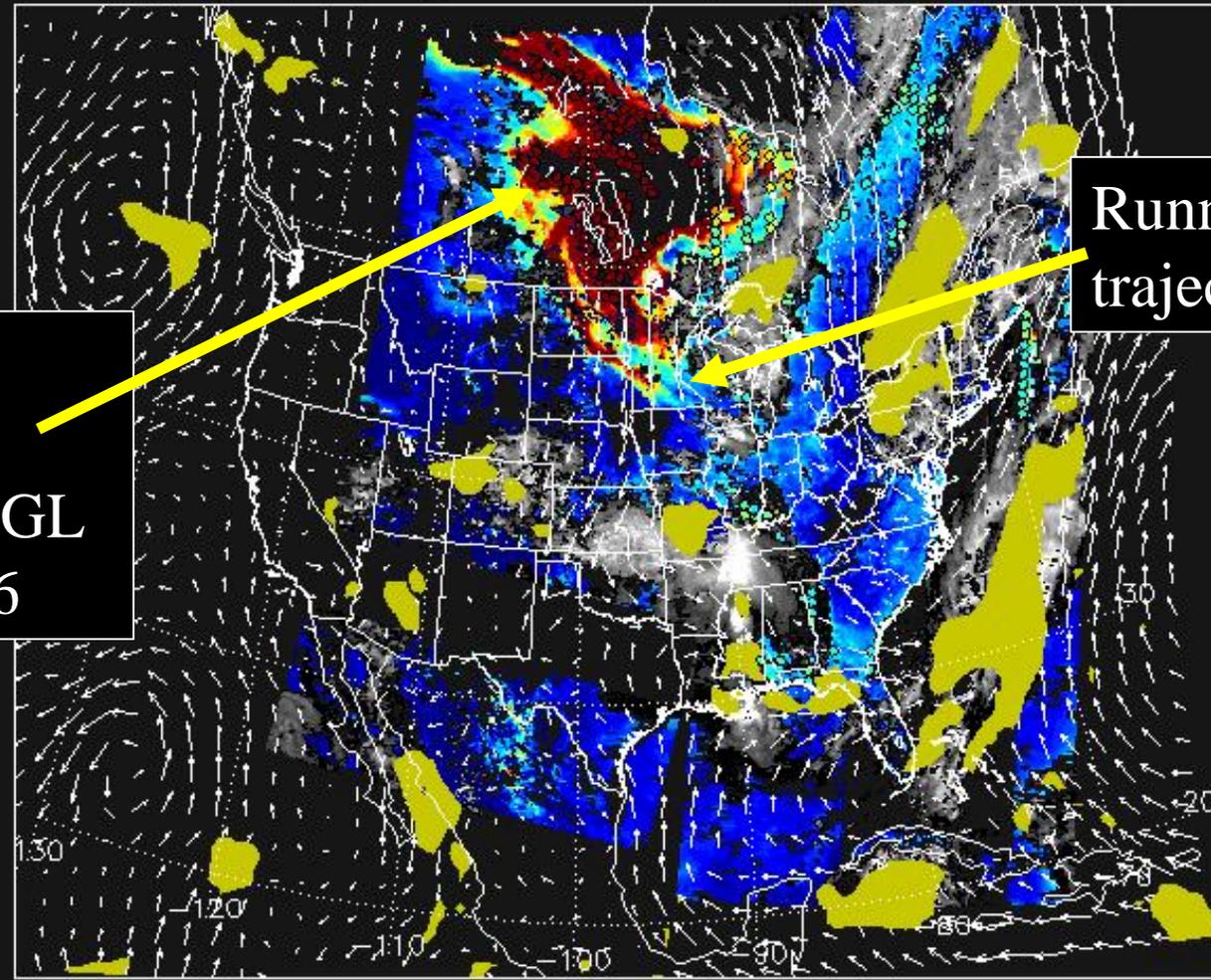# Regional Summary Plots of MODIS Aerosol Optical Depth and Cloud Optical Thickness

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MODIS Aerosol Optical Depth 48 hour Air Parcel Forecast Trajectories (16 July 2004)

MODIS 2004/07/16 AOD/COT & AOD Trajectories on 2004/07/16 15Z

Running 12-hour trajectory path

Trajectories initialized at 50-200 mb AGL for AOD >0.6

0.0 0.2 0.4 0.6 0.8 1.0
AOD

1000 800 600 400 200 0
Trajectory Pressure (mb)

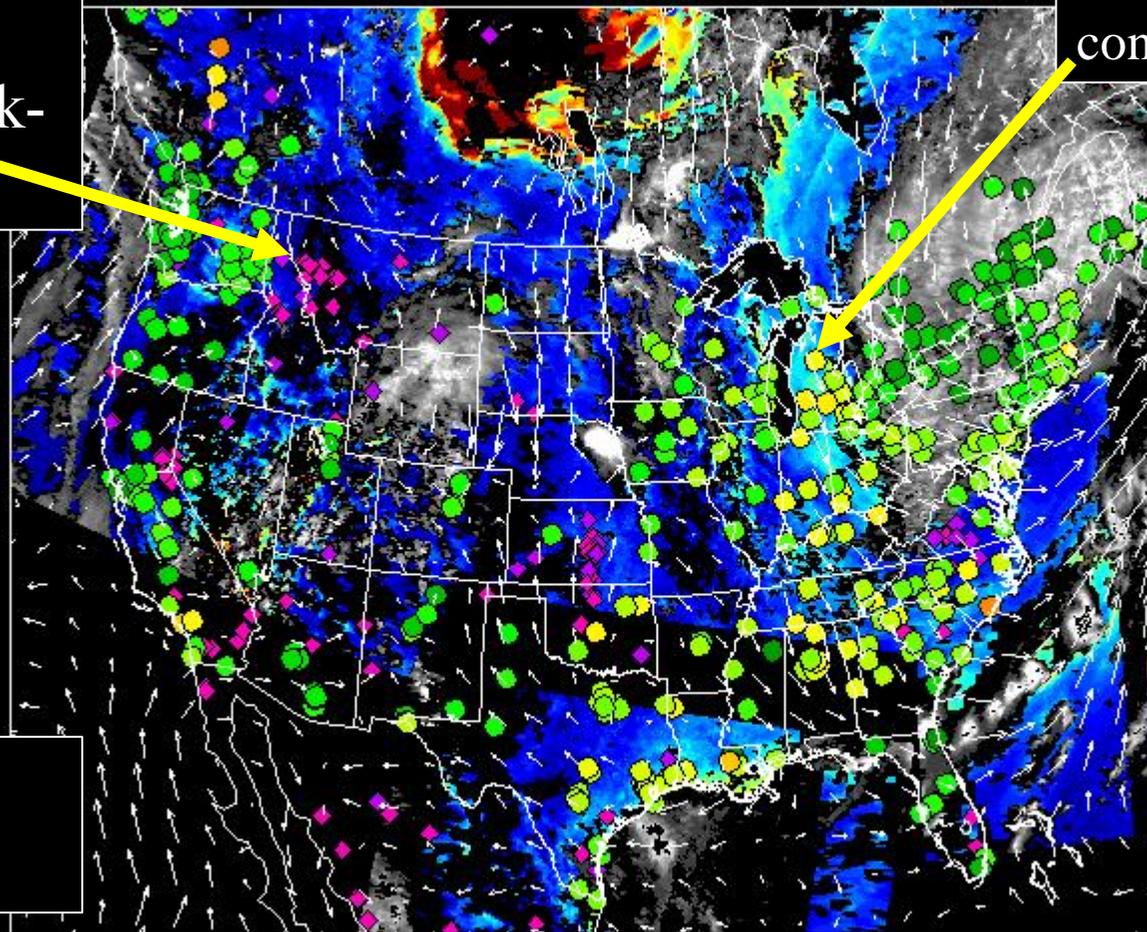0 10 20 30 40 50 60 70
COT

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Half-hourly WF-ABBA Fire Locations (pink-purple)

In-situ continuous $PM_{2.5}$ mass concentration data

850 mb EDAS wind fields

IDEA
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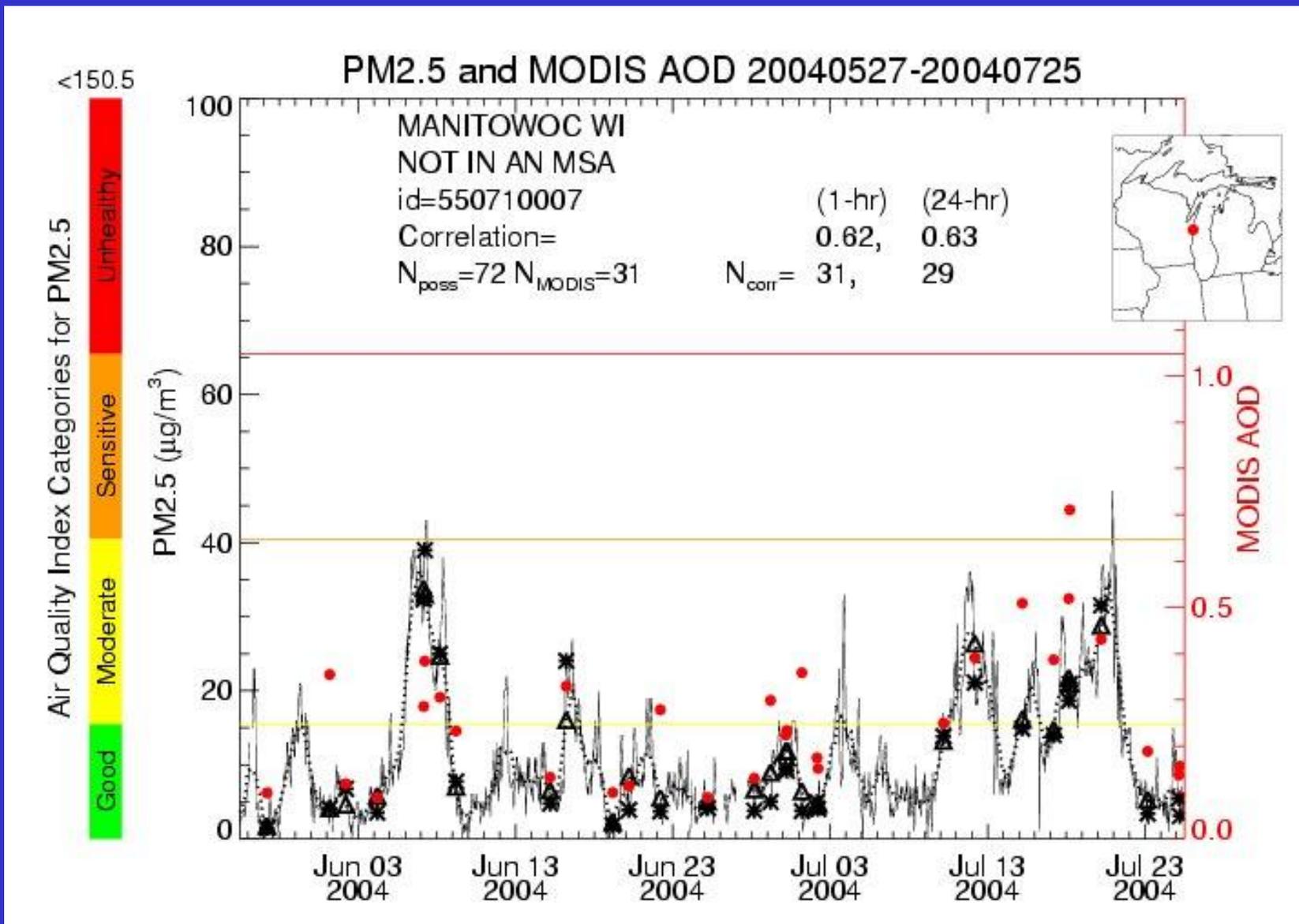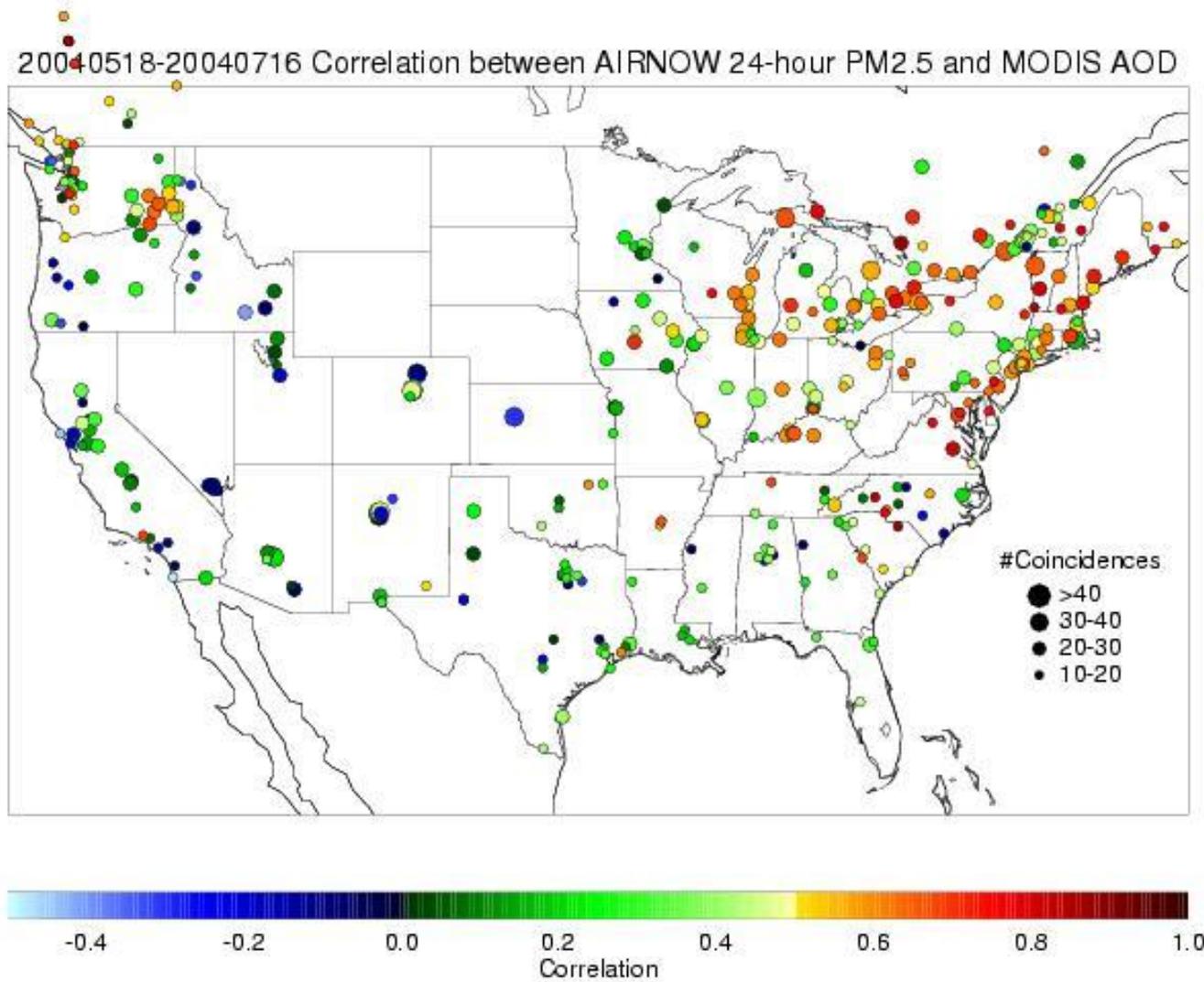
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National Correlation Map between PM2.5 Mass Concentration and MODIS Aerosol Optical Depth

20040518-20040716 Correlation between AIRNOW 24-hour PM2.5 and MODIS AOD

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IDEA Forecast Discussions

Latest Forecast Discussion - July 17, 2004

9:44 PM EDT

MODIS AOD image shows extensive coverage of aloft smoke plume (AOD > 1 resulting from AlaskaYukon fires) in the mid-western states from N. Dakota to
the northern Oklahoma and reaching as far as northern Wisconsin, and northwestern Iowa. The trajectory model predicts that smoke plume in the boundary layer begins to move northeasternward, partly due to the developing low over mid-Atlantic states. The northern branch plumes moves to the east Canada but at higher altitude (500 mb).

Haze (AOD ~0.6) from the southeast moves out to the mid-Atlantic Ocean.

Elevated AOD is continuously seen in the eastern Washington state.

More
allenc 09:44 PM EDT | Comments (2)

7:22 AM EDT

MODIS continues to show elevated AOD (~0.5-0.6) in the mid-western states (Wisconsin, Michigan, Ohio, Illinois), as a result of smoke origated from Alaska/Yukon fires. AIRNow surface sights show moderate AQI associated with this smoke plume.
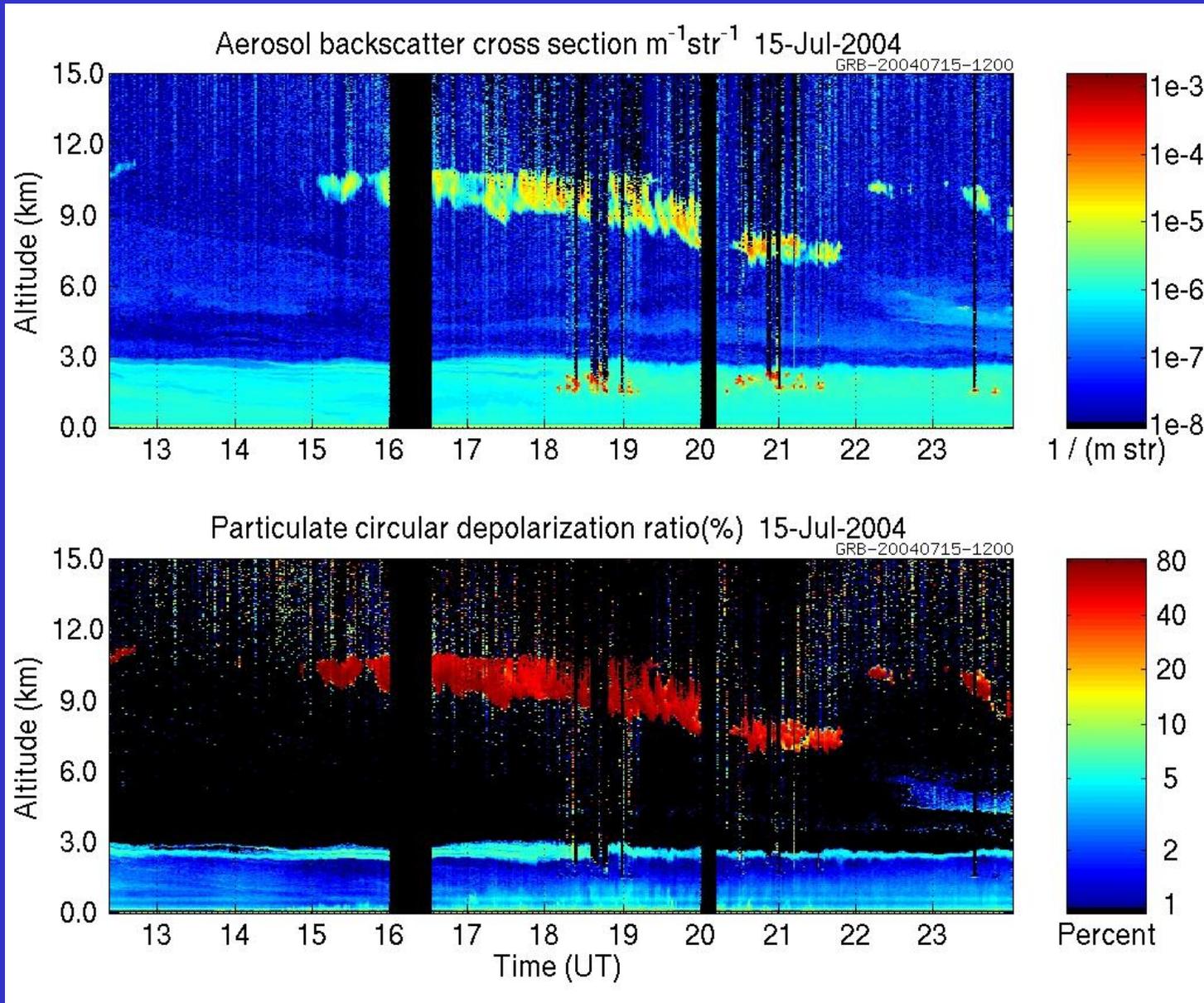
MODIS shows very high AOD from main smoke plume now entering North Dakota/South Dakota SE Minnesota. Trajectory initialization within the main smoke plume over central Canada assumes that the smoke is within the lowest 250mb (BL) which is likely not true for this region (plume more likely aloft based on rapid transport of plume around the southern edge of upper level trough.

Impact on midwestern and NE AQI dependent on whether plume remains aloft
or gets entrained within BL. Smoke has been has been observed by UW Madison's lidarWisconsin Lidar
, showing a layer around 3 km (~ 1 km thick) on 07/15.

More
bradp 07:22 AM EDT | Comments (4)

UW High Spectral Resolution Lidar

Aerosol backscatter cross section m⁻¹str⁻¹ 15-Jul-2004

Particulate circular depolarization ratio(%) 15-Jul-2004

IDEA Web Site Conclusions
User Feedback

Successfully demonstrated the utility of producing and combining multi-source products for improving Air Quality forecasts.

Comments compiled by John White (EPA) and Jim Szykman (LaRC):

"I try to check the IDEA web site daily as it is helpful for PM2.5 forecasting. I particularly use the animated 48-hour trajectory forecast. It would be nice if it were possible for the user to stop the animation at specific times since it runs continuously. Each morning I also read the forecast discussion that comes out the previous evening. It might be nice if the forecast discussion was moved to the morning since it would be timelier for forecasters. It is an excellent product."

I think we should make it a priority to migrate the IDEA graphical products into the AniS applet as soon as possible, to allow a higher level user control andd interactivity -- it sounds like they (the users) would appreciate such an improvement. -Jim

Web Site JAVA Trajectory Forecast Example

http://idea.ssec.wisc.edu/

IDEA Project Future Goals

CIMSS Work Statement for March – September 2005:

- Continuation of current generation of derived air quality products

- Incorporate Terra data from Oregon State University Direct broadcast station for coverage further west and north

- Add MODIS AOD/COT images at high resolution for direct visual comparison with MODIS true color images

- Create training materials for education and outreach
  - Present VISITview session to state and local forecast agencies in June

- Begin the process of transitioning operational IDEA production to NOAA

VISITview® Example

VISITview® is a teletraining and real-time collaboration tool developed for the National Weather Service VISIT program to meet the needs of science training of their forecasters.