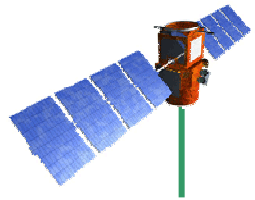
Use of NASA Three Dimensional Air Quality System (3D-AQS) Remote Sensing Data for Air Quality Forecasting

Amy K. Huff
703-875-2975
huffa@battelle.org
Battelle Memorial Institute

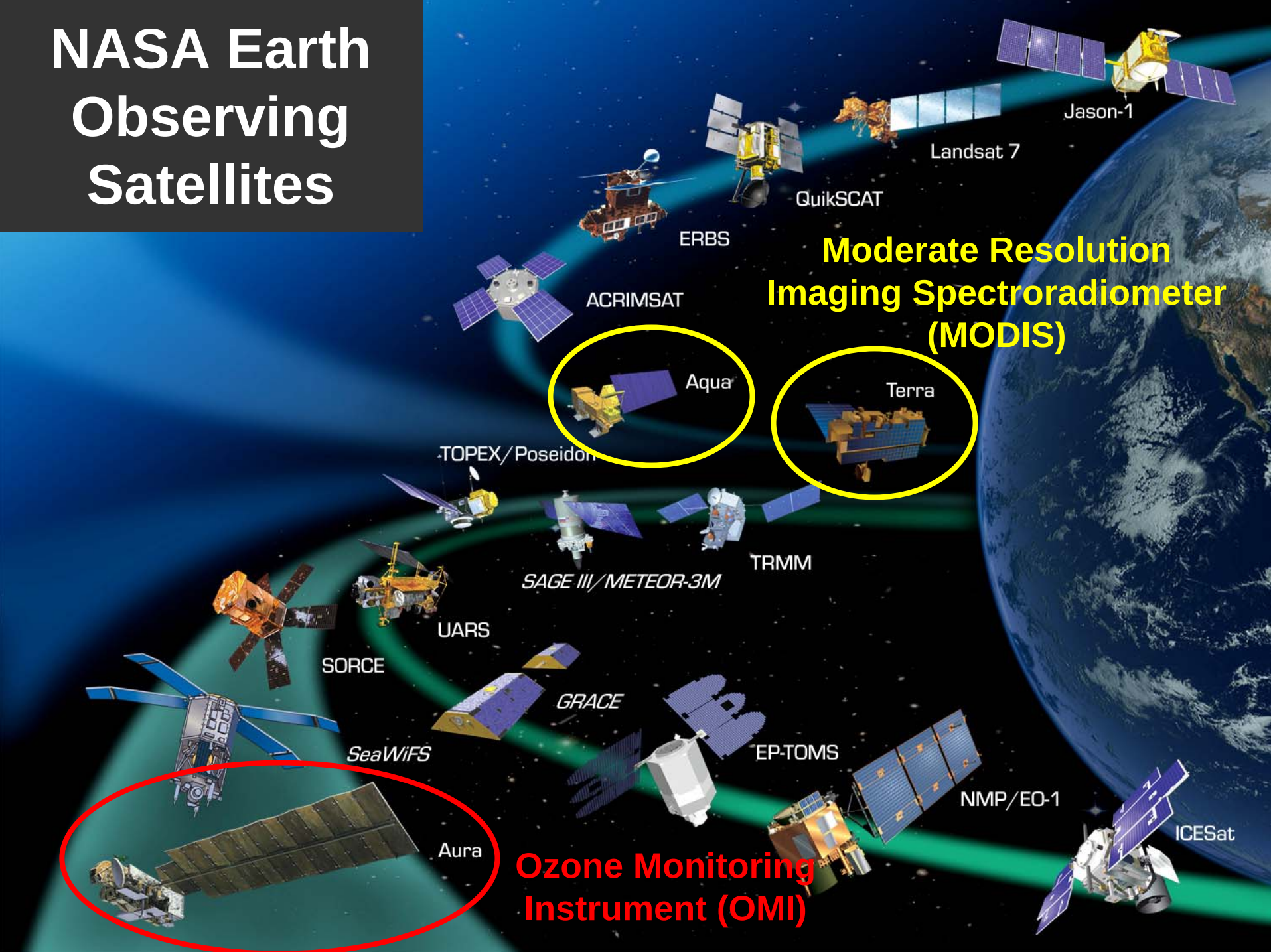
Jill Engel-Cox
Battelle Memorial Institute

Raymond M. Hoff
University of Maryland, Baltimore County

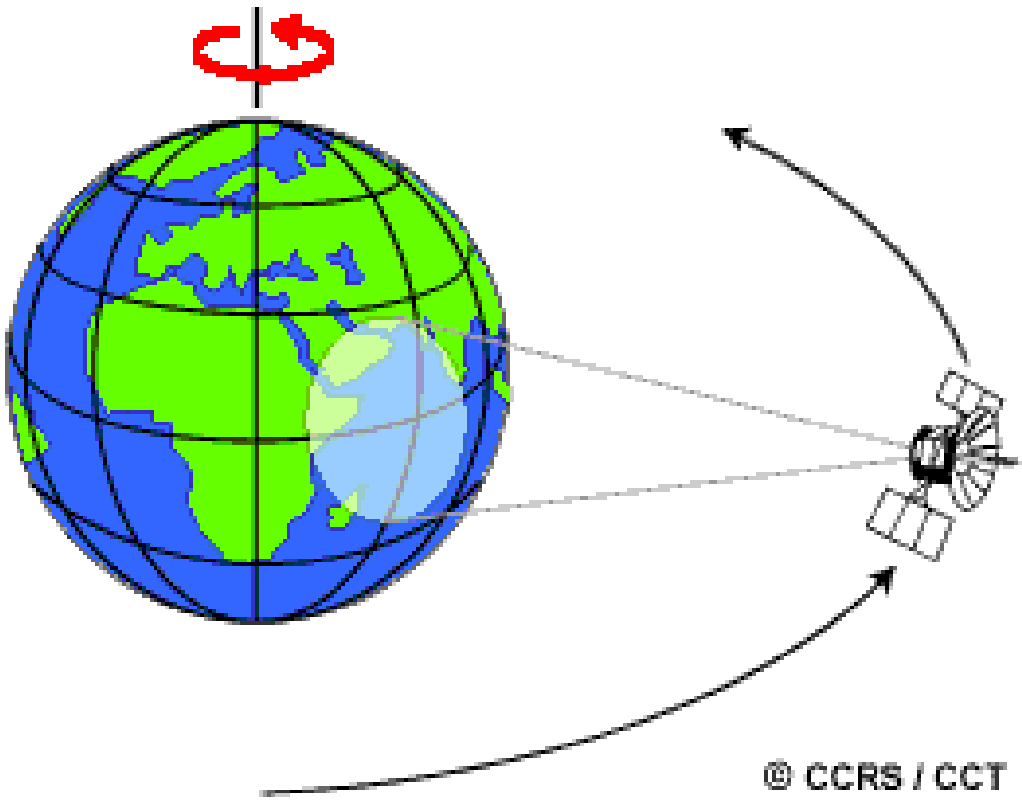
Why Use Remote Sensing Data for Air Quality Forecasting?



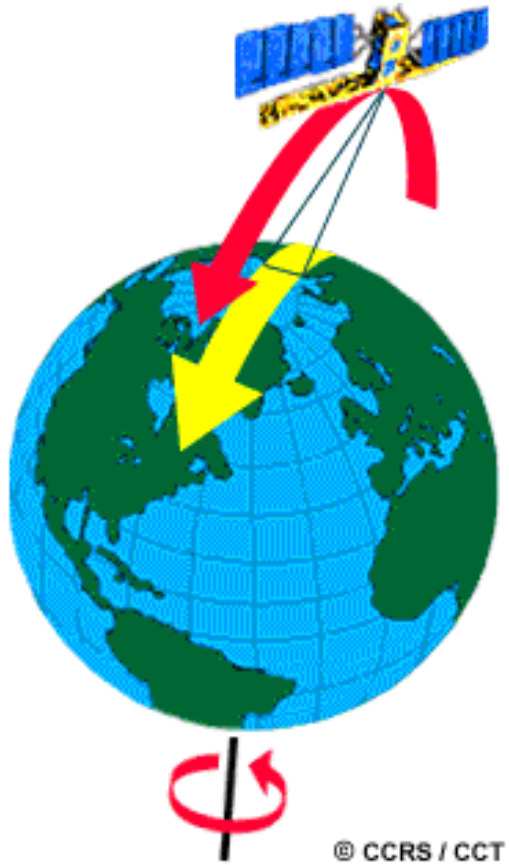
- Information about the horizontal transport of pollutants on the mesoscale and synoptic scale
- Advance warning of impending air quality events, especially fires and dust storms
- Air quality information in areas where there are no ground-based monitors
- Information about vertical distribution and transport of particulates in the atmosphere
- A quick and easy way to keep track of the “big picture” of national air quality
- Provides visual appeal: “snapshots” of air quality


NASA Earth Observing Satellites
Jason-1
Landsat 7
QuikSCAT
ERBS
ACRIMSAT
Moderate Resolution Imaging Spectroradiometer (MODIS)
Aqua
Terra
TOPEX/Poseidon
TRMM
SAGE III/METEOR-3M
UARS
SORCE
GRACE
SeaWiFS
EP-TOMS
NMP/EO-1
ICESat
Aura
Ozone Monitoring Instrument (OMI)

Types of Satellite Orbits

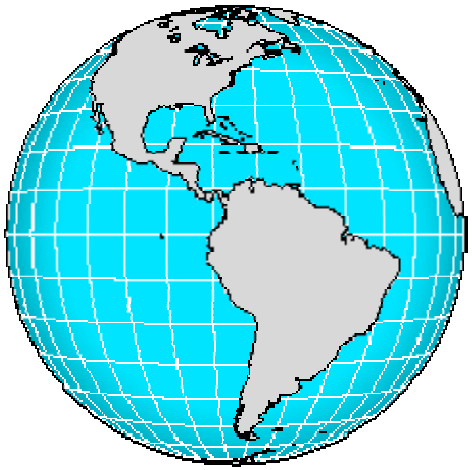


Geostationary
38,500 km

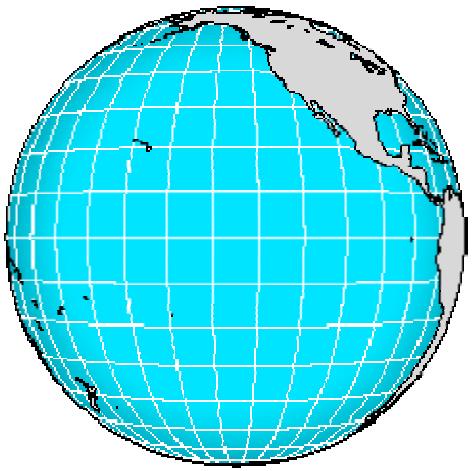


Polar Orbiting
700 – 800 km

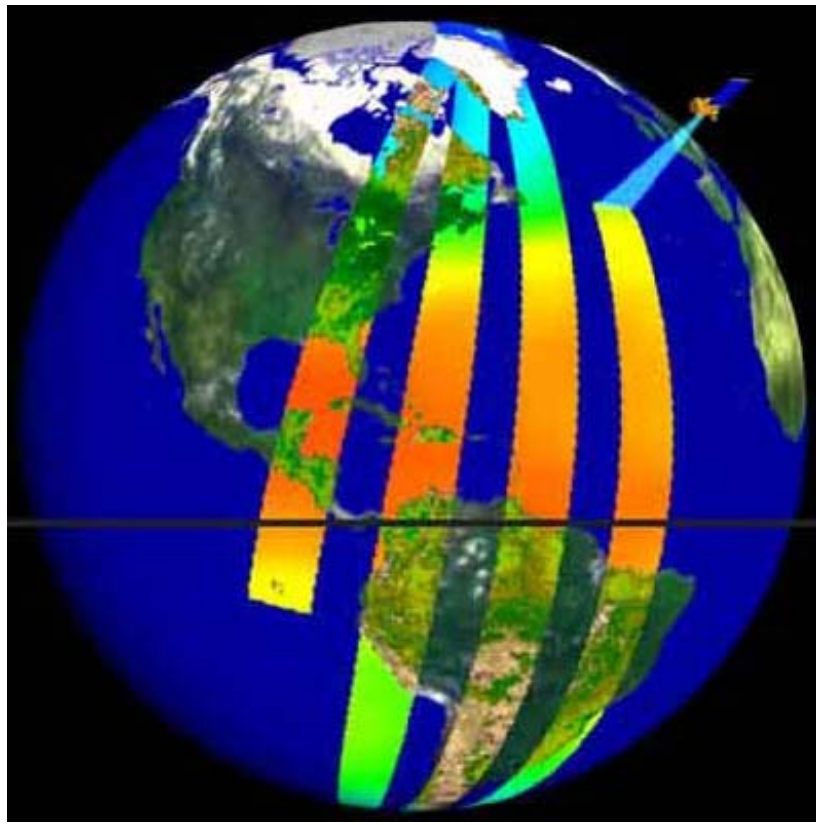
A Satellite's Orbit Determines its Temporal Resolution



GOES-East



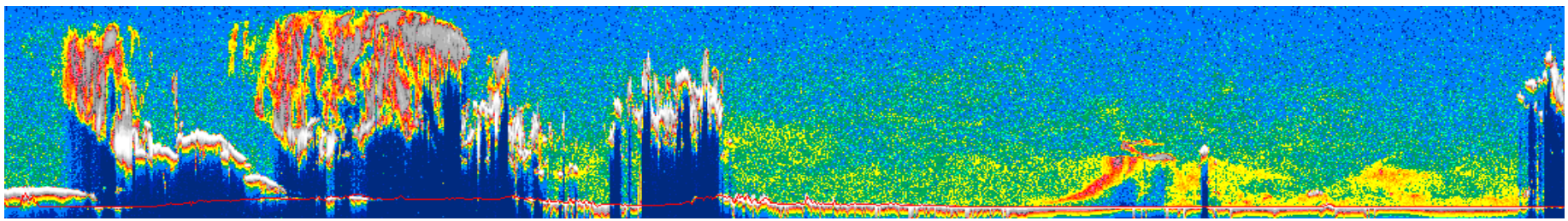
GOES-West



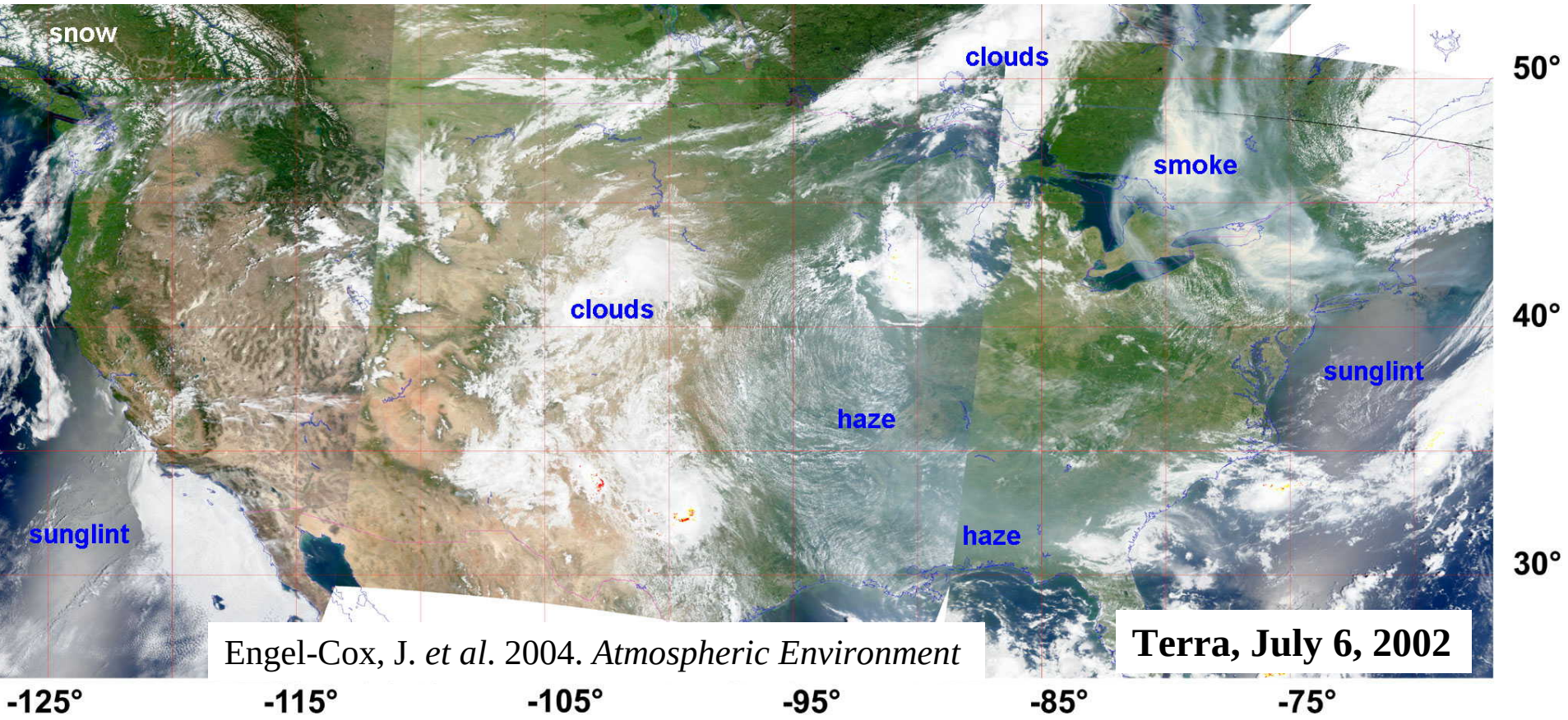
Terra (MODIS)
Aqua (MODIS)
Aura (OMI)

Categories of 3D-AQS Remote Sensing Data for Air Quality Forecasting

- True Color Images
- Aerosol Optical Depth (AOD)
- OMI Tropospheric Column Measurements
- LIDAR (LIght Detection and Ranging)

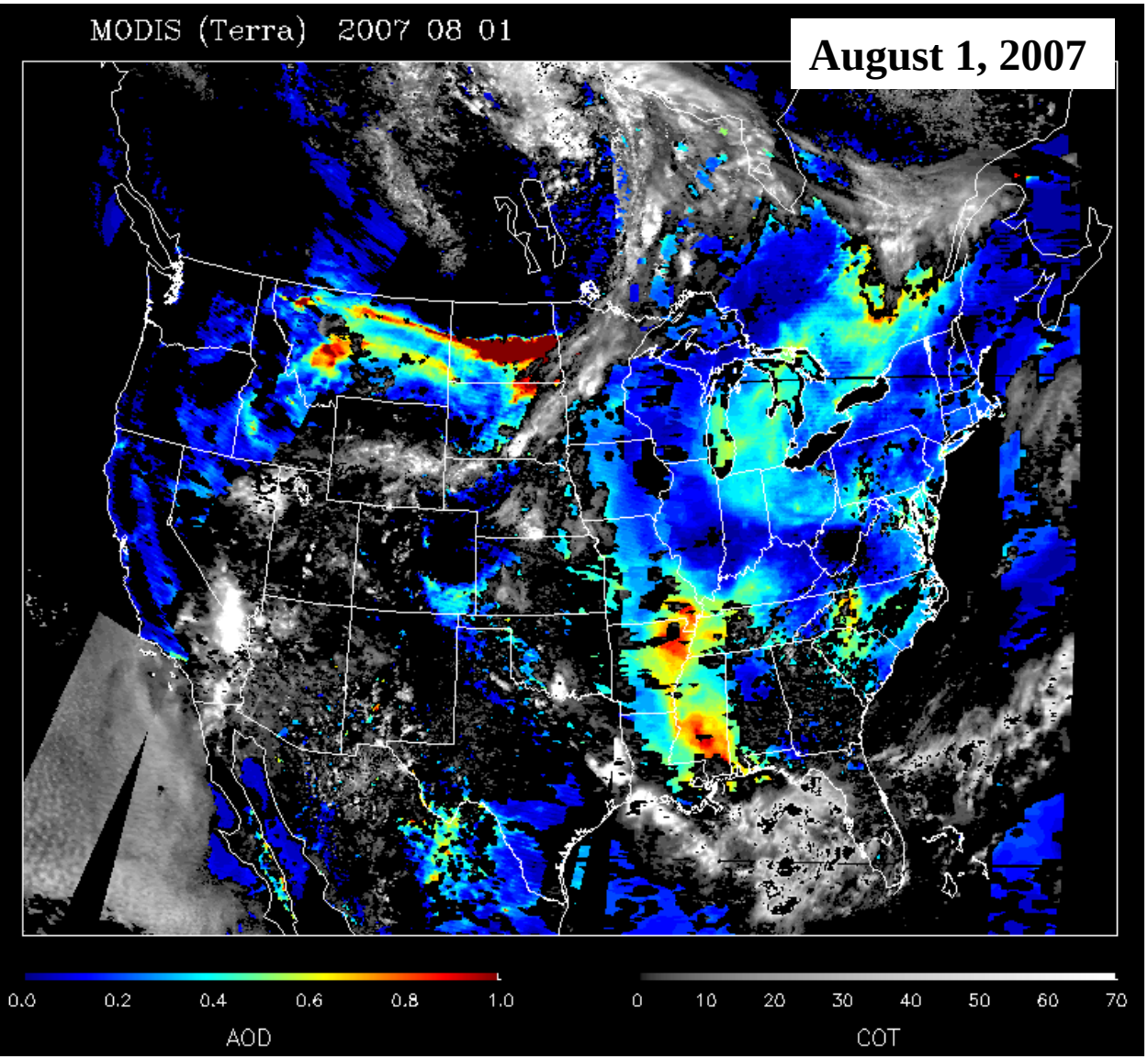


MODIS True Color Image



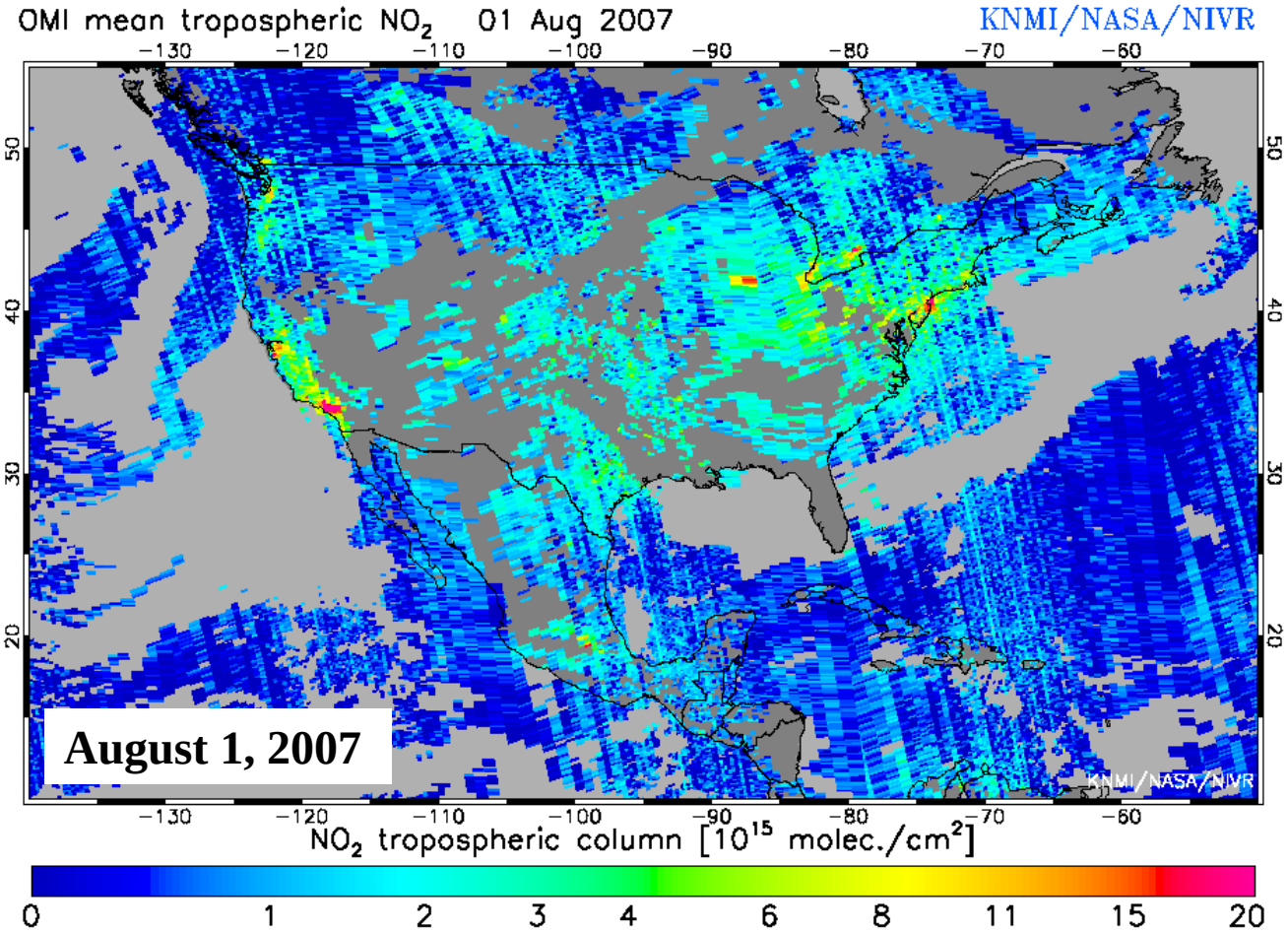
- A True Color Image is NOT a picture!
- Image using Red-Green-Blue bands of instrument
- Terra = ~10:30 AM local time overpass
- Aqua = ~1:30 PM local time overpass

Aerosol Optical Depth (AOD)



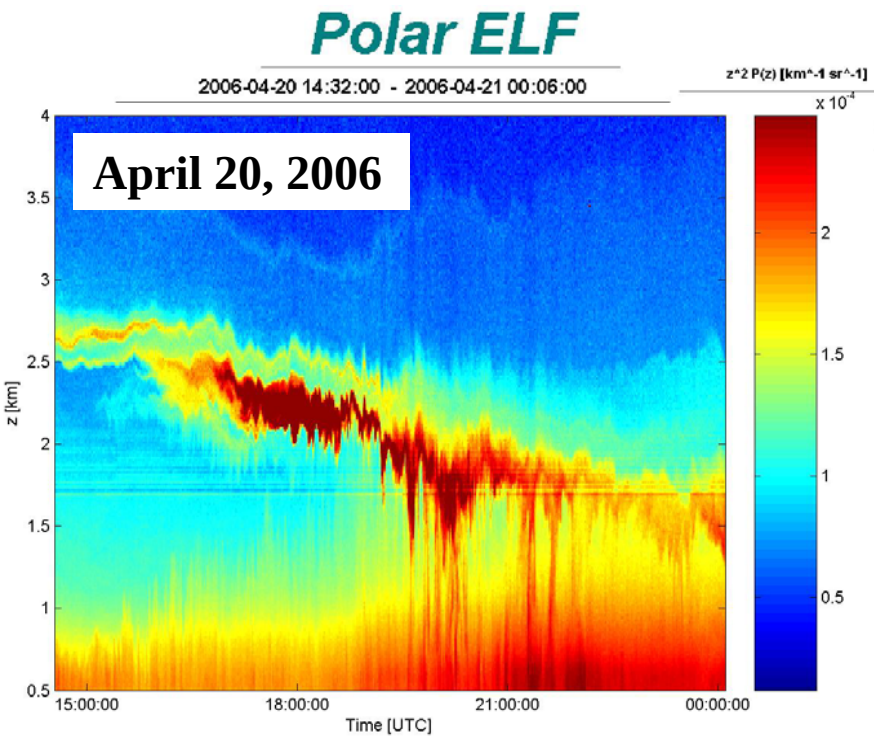
- AOD is a measure of the extinction and scattering of light by particles in a total column from the satellite to the ground
- AOD is proportional to particulate concentration
- AOD is dimensionless; values typically range from 0 (clear, no haze) to 1 (very hazy, smoky, or dusty) in the US
- Clouds block the measurement of AOD!

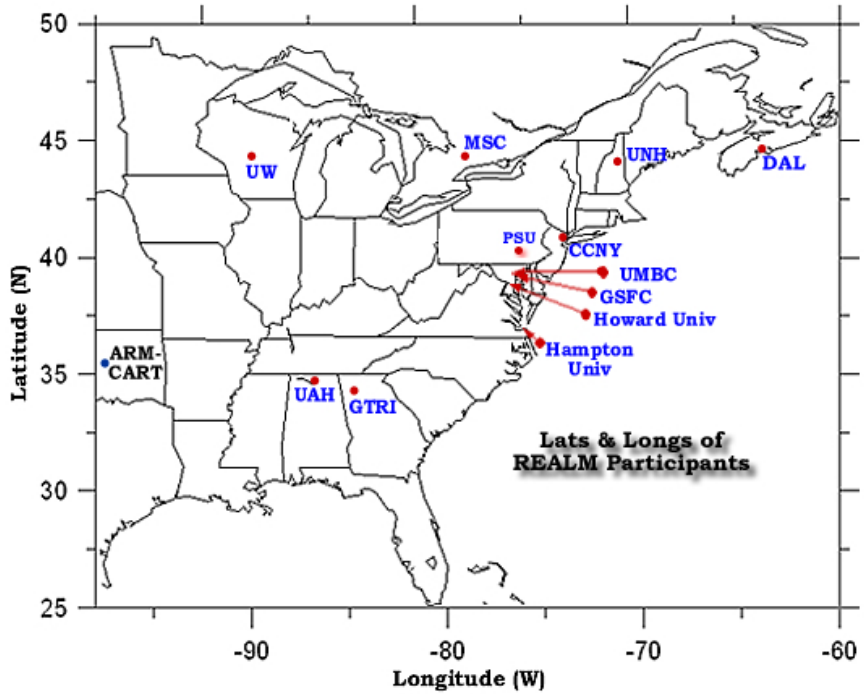
OMI Tropospheric Column NO_2



- Daily measurement of NO_2 at ~1:30 PM LST
- Column measurement, not surface – use for qualitative applications
- 2 products:
  - KNMI "Real Time"
  - NASA Standard
- Clouds block the measurement of OMI NO_2!

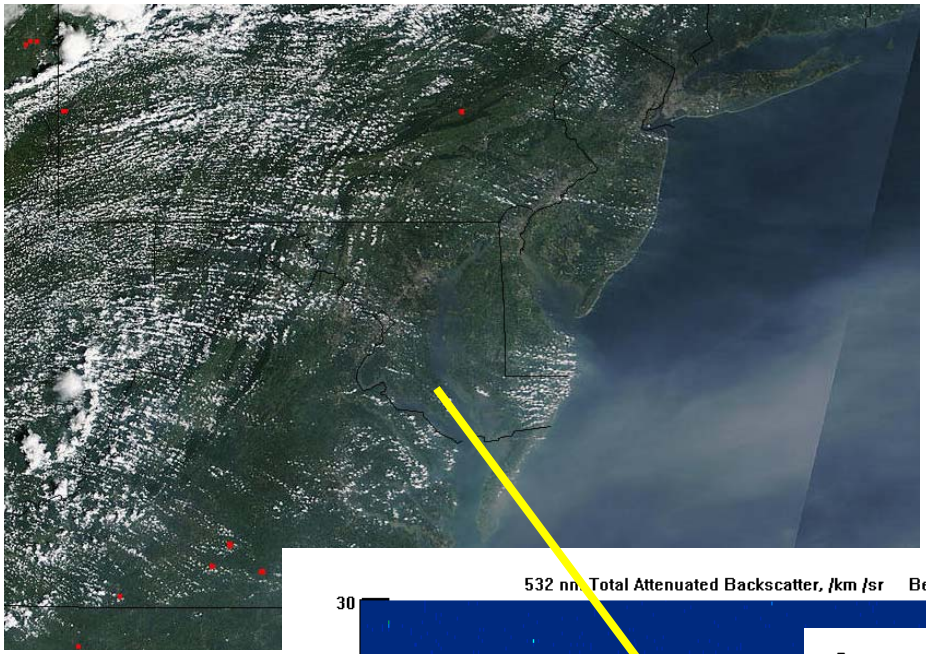
LIDAR Aerosol Extinction Profile

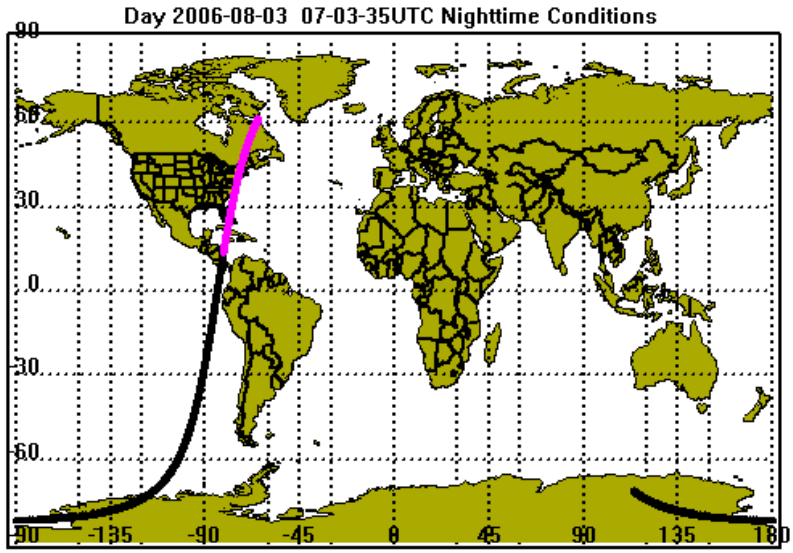


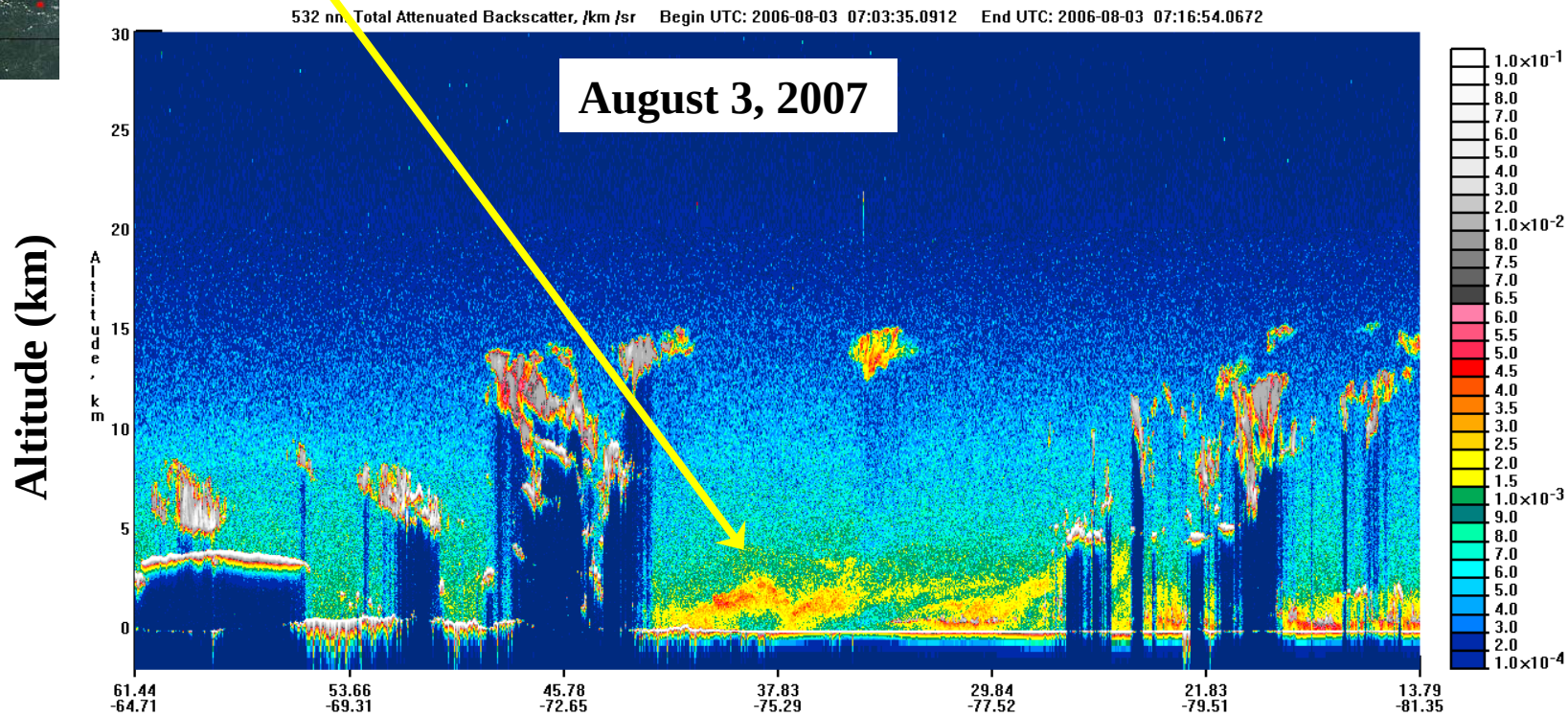


- Information about the vertical distribution of particles
- 2 sources: ground-based (REALM) and satellite (CALIPSO)
- Weaknesses: interference from clouds and limited spatial coverage
- Many REALM participants do not have data on a regular basis
- CALIPSO data are not available in real time

CALIPSO Aerosol Extinction Profile







MODIS Direct Broadcast at SSEC

http://eosdb.ssec.wisc.edu/modisdirect/

MODIS Direct Broadcast at SSEC 2008/04/02 (day 093) Aqua Historical Search What's New

Terra - April 02, 2008 

		Start UTC	End UTC	Quicklook	Browse Images
1	Predicted	02:52:10	03:03:40		
	Actual	02:51:39	03:03:39		Graphical, Text Only, Coverage
2	Predicted	04:29:20	04:41:40		
	Actual	04:28:50	04:41:40		Graphical, Text Only, Coverage
3	Predicted	14:53:30	14:56:40		
	Actual	14:53:00	14:56:40		Graphical, Text Only, Coverage
4	Predicted	16:27:40	16:40:20		
	Actual	16:27:10	16:40:20		Graphical, Text Only, Coverage
5	Predicted	18:06:00	18:16:40		
	Actual	No pass found for this time			

Information current as of April 4, 2008 20:21:05 UTC

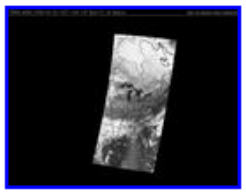
Orbital Tracks | Download Data | Software | Products | Gallery | Credits | About MODIS | Contact Us | SSEC Home

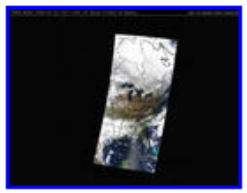
MODIS Direct Broadcast at SSEC

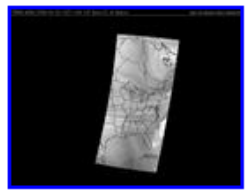
http://eosdb.ssec.wisc.edu/modisdirect/

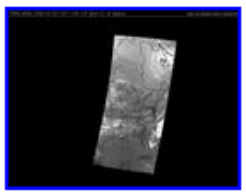
Continental

All Regions


Band 1

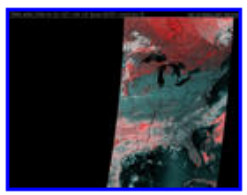

Composite 1/4/3

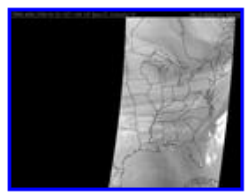

Band 27


Band 31

Continental US


Band 1


Band 02,07,07


Band 27

Atchafalaya Bay LA hi-res

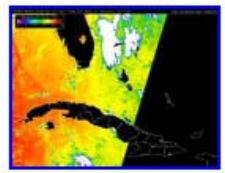

Composite 1/4/3

Atlanta GA hi-res


Composite 1/4/3

Bahamas and Cuba


Composite 1/4/3


Band 31

Buffalo NY


Composite 1/4/3

Cancun Mexico hi-res


Composite 1/4/3

Chicago IL hi-res


Composite 1/4/3

Florida Keys hi-res


Composite 1/4/3

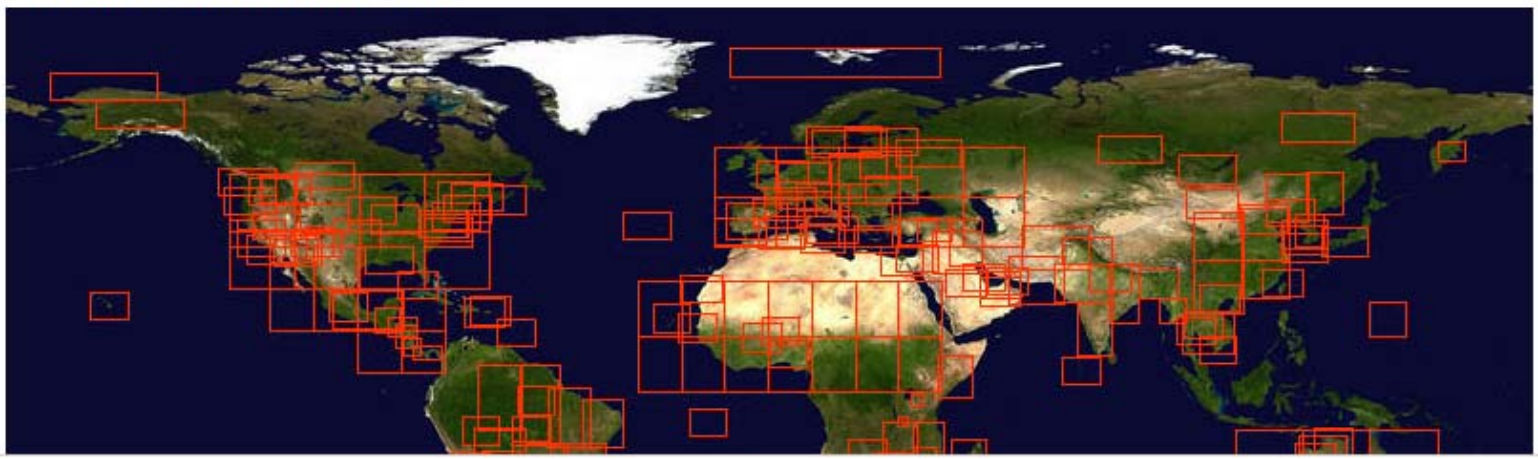
MODIS Rapid Response System - Subsets

http://rapidfire.sci.gsfc.nasa.gov/subsets/

Subsets

This page contains a number of image subsets that are automatically generated in near-real-time for various applications users. Most subsets are available as true-color images. Some additional band combinations may be be available for specific applications. Geographic areas can be selected from the maps or from the list below. For each geographic area the archive imagery is available online.
Subsets for a few projects can also be accessed through these specific URLs:
http://rapidfire.sci.gsfc.nasa.gov/aeronet
http://rapidfire.sci.gsfc.nasa.gov/fas
http://rapidfire.sci.gsfc.nasa.gov/servir
http://rapidfire.sci.gsfc.nasa.gov/jason
http://rapidfire.sci.gsfc.nasa.gov/uae

Select a subset:
(click on the map or pick from the list below)



MODIS Rapid Response System - Subsets

http://rapidfire.sci.gsfc.nasa.gov/subsets/

Date: 2008/093 - 04/02

Go back to the main page

MODIS Terra
True color

Pixel size:
2km | 1km | 250m

MODIS Terra
721

Pixel size:
2km | 1km | 250m

MODIS Terra
NDVI

Pixel size:
2km | 1km | 250m

MODIS Aqua
True color

Pixel size:
2km | 1km | 250m

MODIS Aqua
721

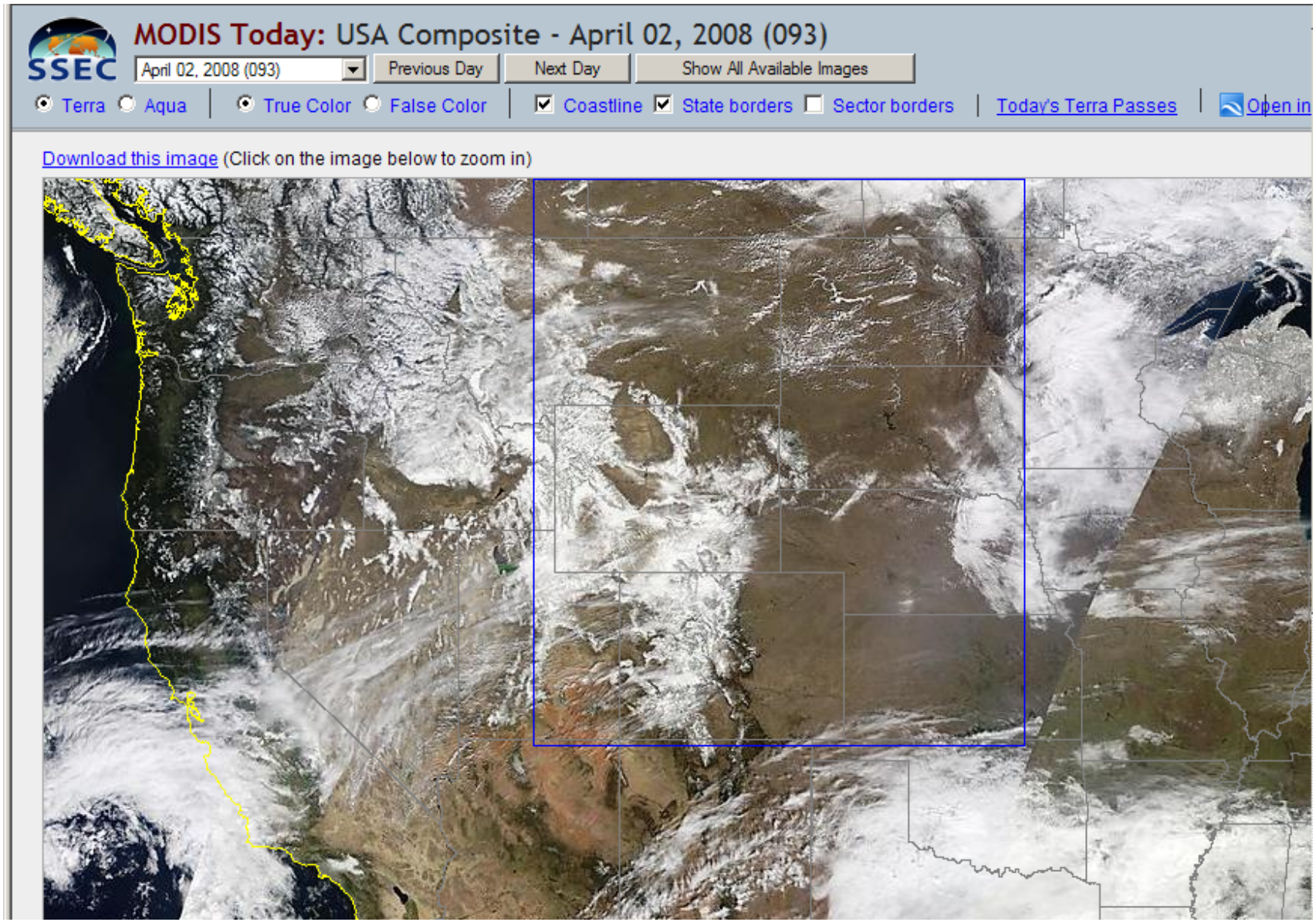
Pixel size:
2km | 1km | 250m

MODIS Aqua
NDVI

Pixel size:
2km | 1km | 250m

CCMIS/SSEC MODIS Today: USA Composite

http://www.ssec.wisc.edu/modis-today/



IDEA at NOAA (Developed by NASA)

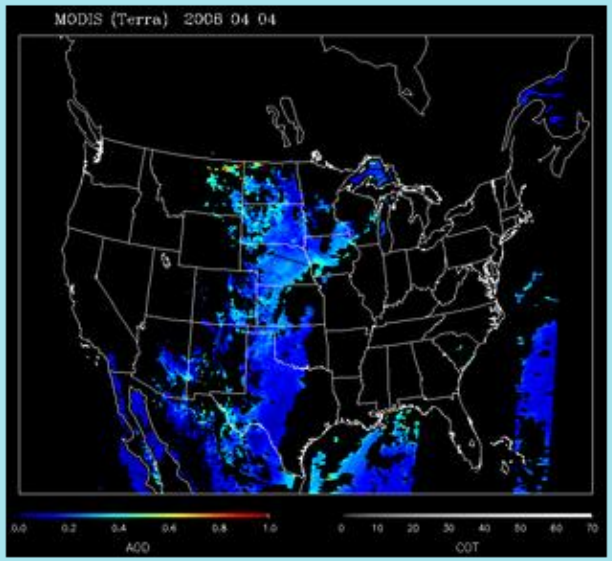
http://www.star.nesdis.noaa.gov/smcd/spb/aq/

IDEA
Infusing satellite Data into Environmental Applications

We value your feedback! Please send any comments, problems and suggestions to the IDEA Team.

MODIS | GASP

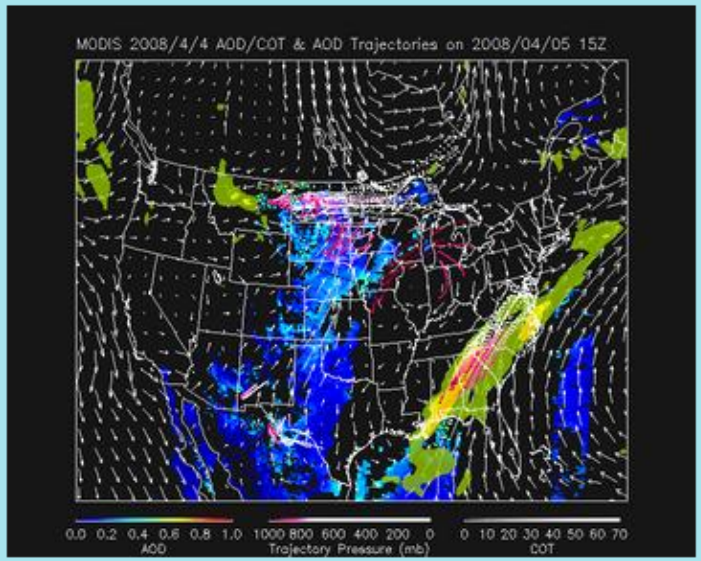
Regional plots of MODIS aerosol optical depth (AOD) and cloud optical thickness



Select Region

Product description

48-hour aerosol trajectory forecast, with model winds and precipitation

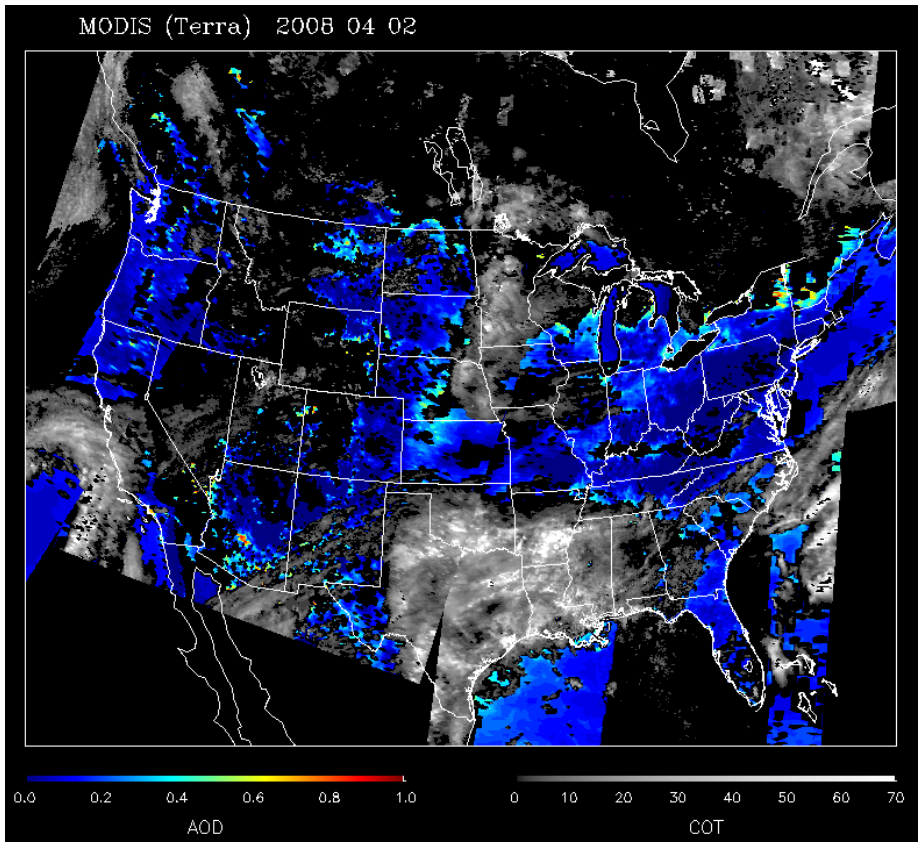


View latest

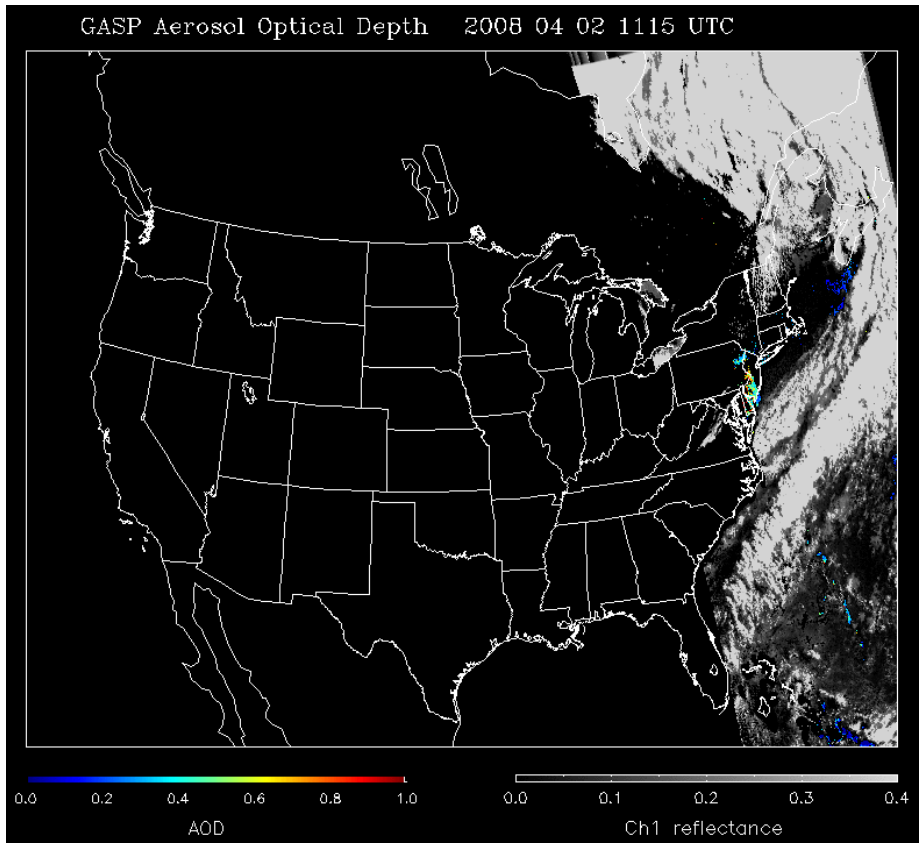
Product description

IDEA at NOAA

http://www.star.nesdis.noaa.gov/smcd/spb/aq/



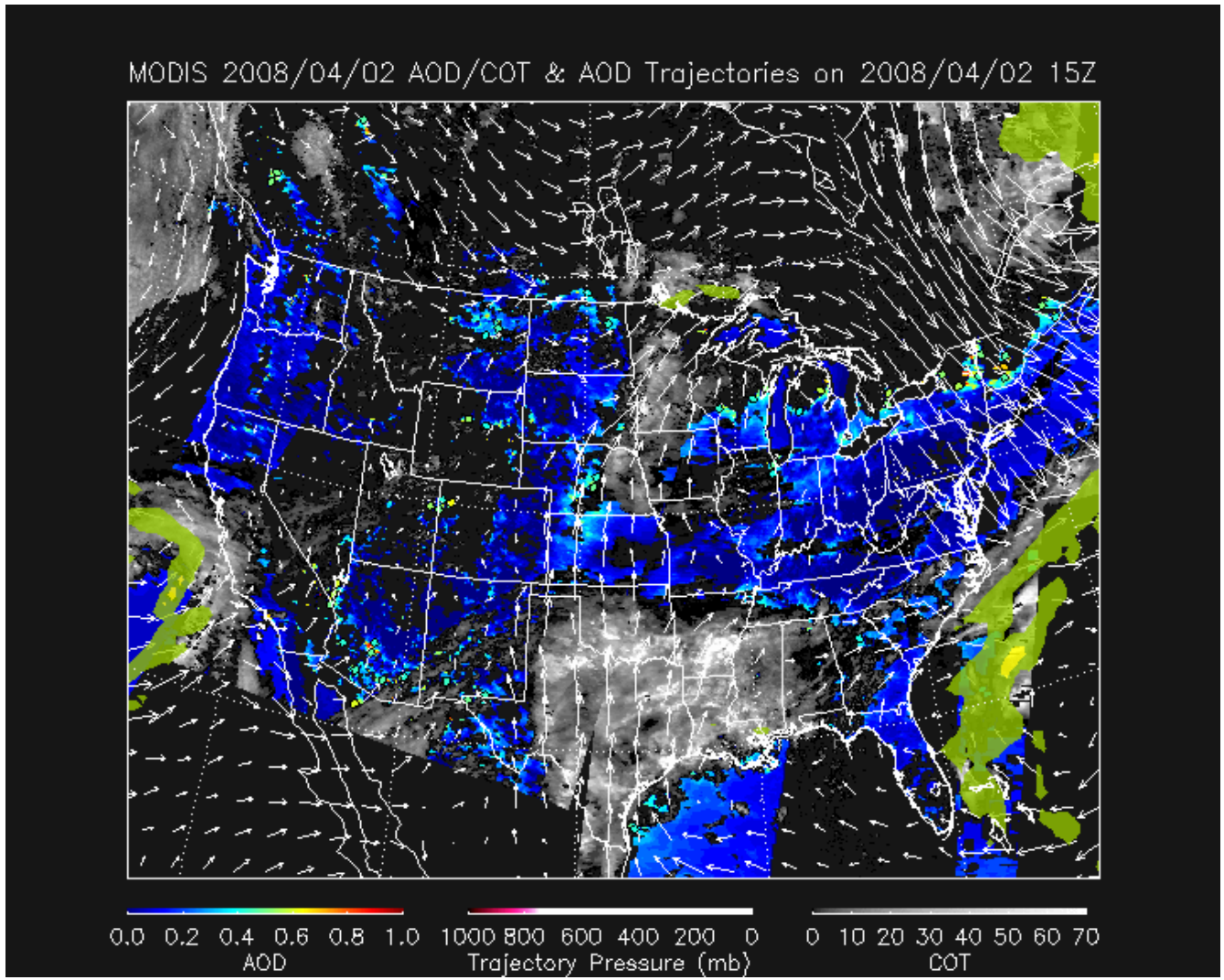
MODIS AOD



GASP AOD animation

IDEA at NOAA

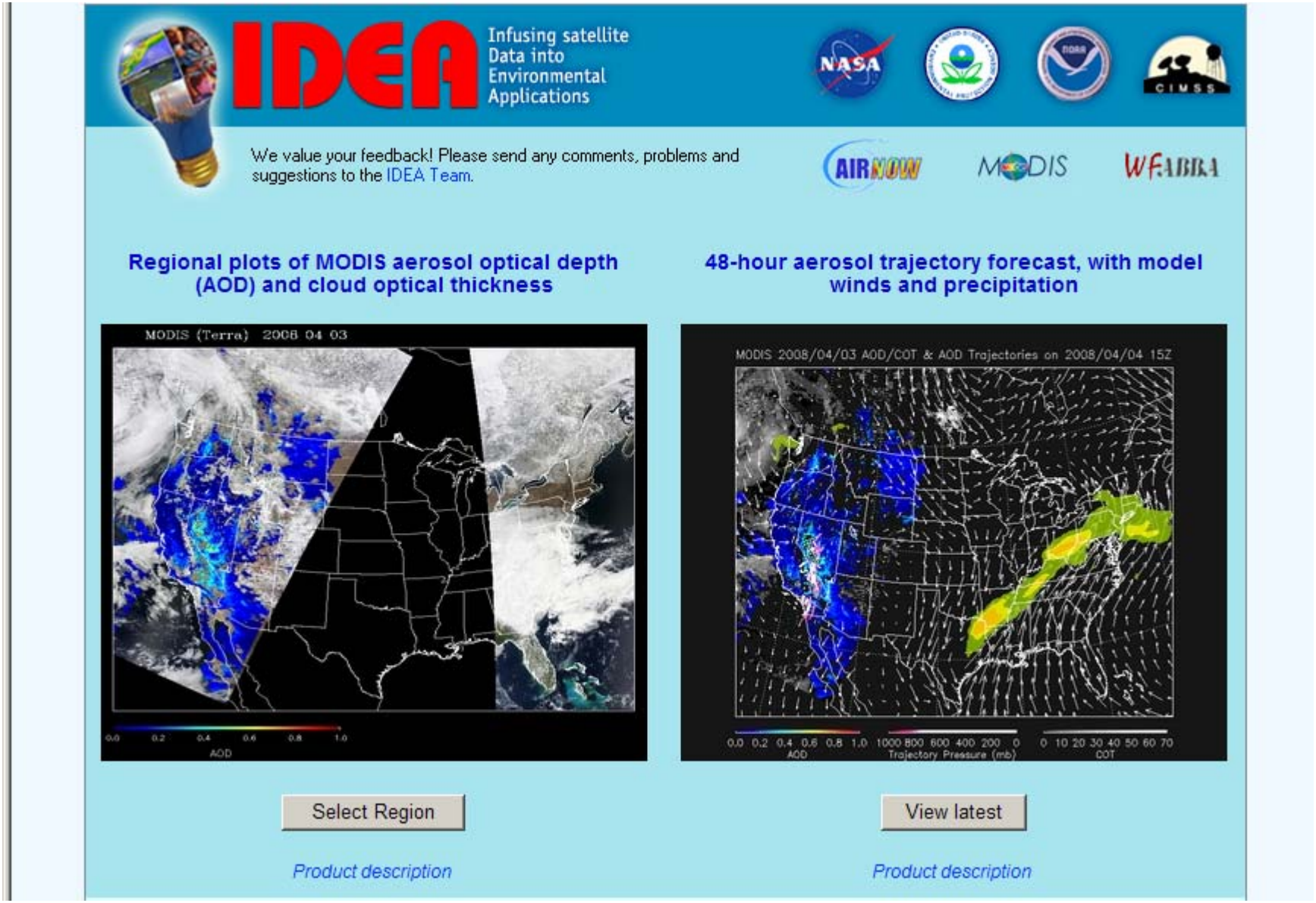
http://www.star.nesdis.noaa.gov/smcd/spb/aq/



48-Hour Aerosol Trajectory Forecast

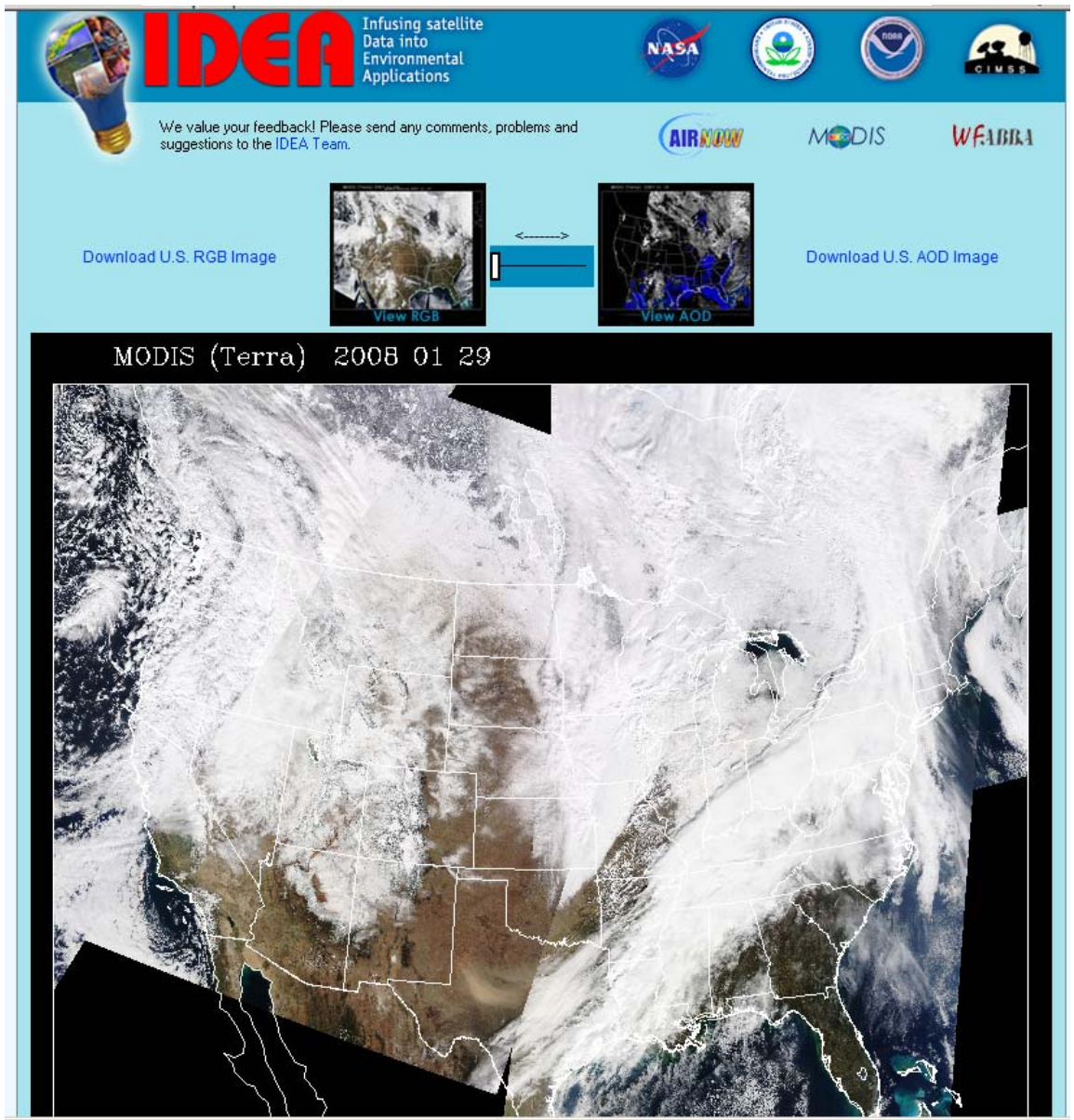
IDEA at the University of Wisconsin

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

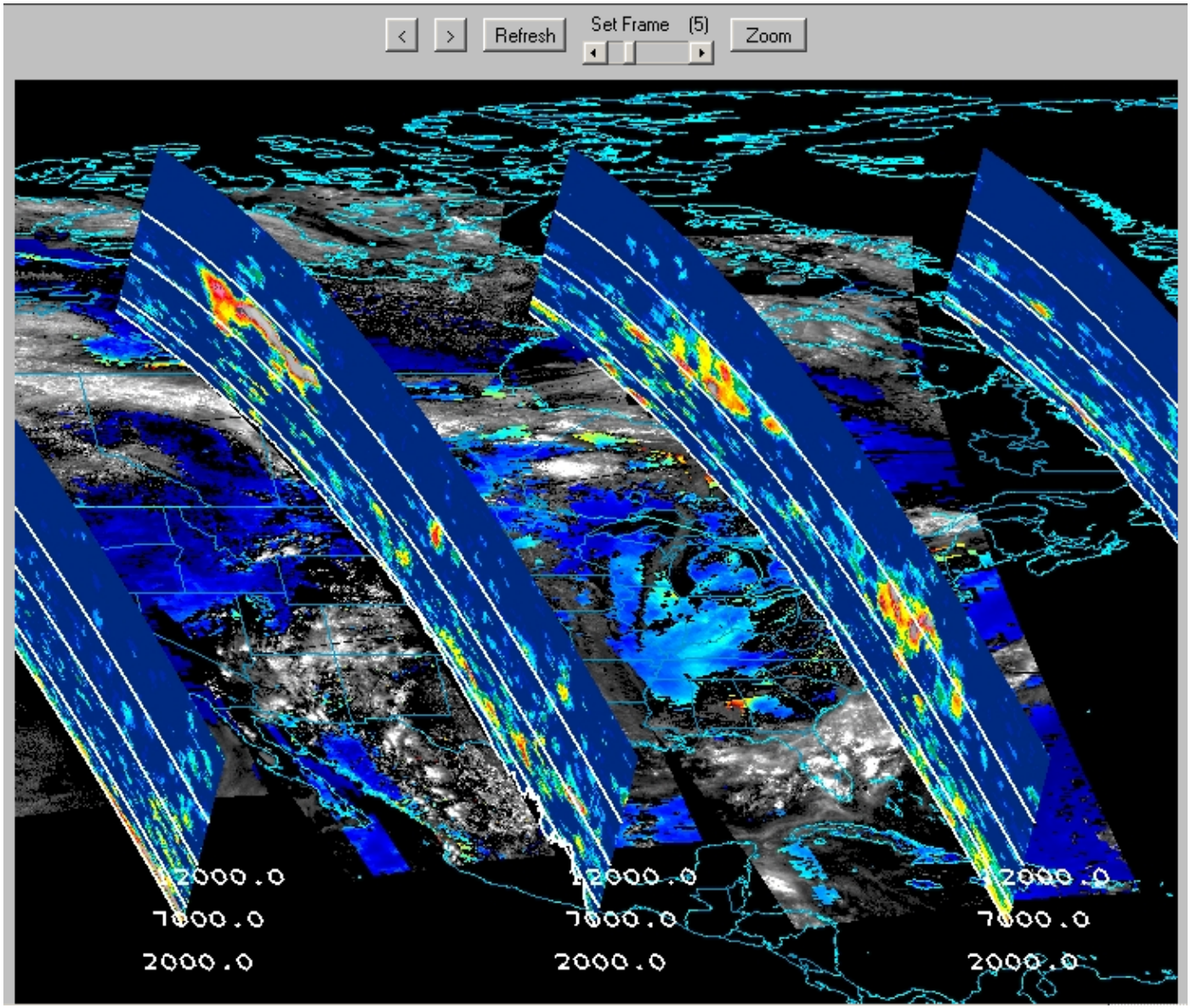


IDEA at the University of Wisconsin

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



Coming Soon: a New 3-D Visualization Tool



Tony Wimmers, SSEC

U.S. Air Quality - The Smog Blog
http://alg.umbc.edu/usaq

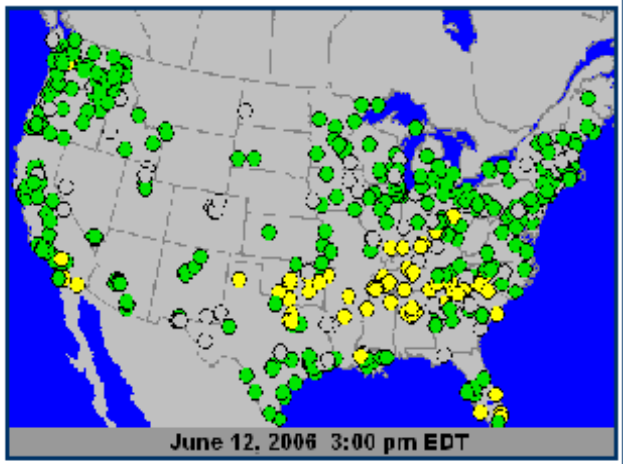
U.S. Air Quality
The Smog Blog

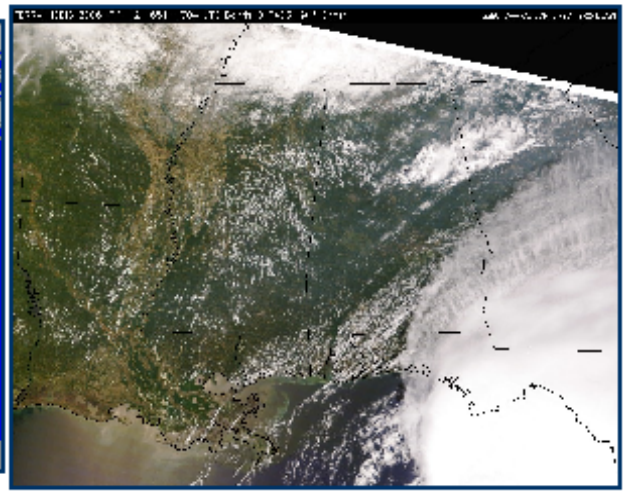
UMBC
AN HONORS UNIVERSITY IN MARYLAND

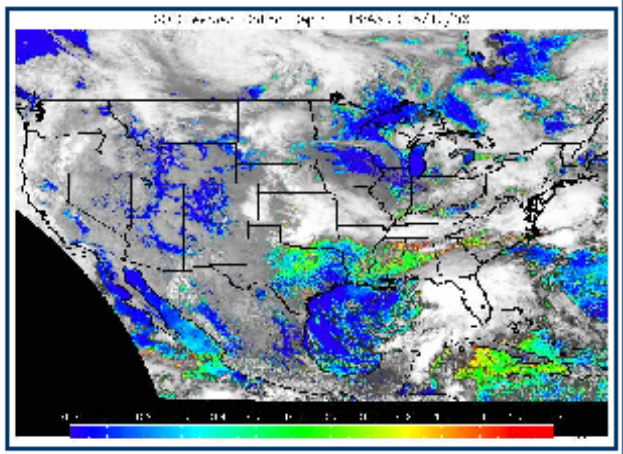
June 12, 2006

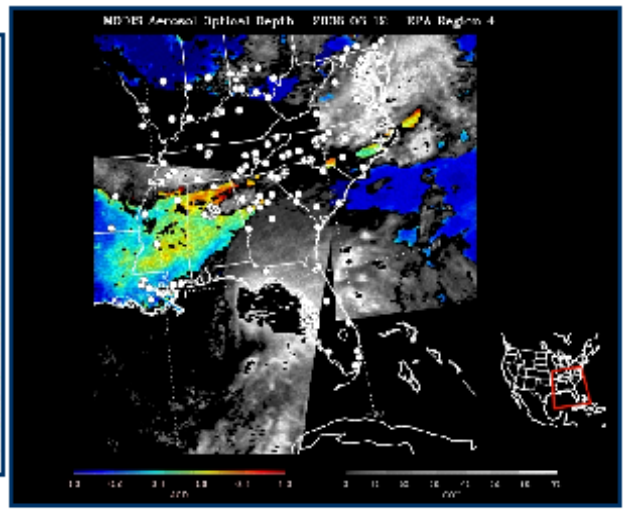
MODERATE AQI IN THE SOUTH

Particulate Matter measurements remain moderate (AQI is code yellow) in the South. Tropical Storm Alberto (source: NOAA OSEI) is also visible in today's satellite images, which is likely contributing to the aerosol load over the south (also mentioned by Jill in yesterday's post). Both GASP and IDEA show the intensity of aerosols; AOD reached unity in some places.









About U.S. Air Quality

USAQ is a daily diary of air quality in the U.S. using information from NASA satellites, ground-based lidar, EPA monitoring networks, and other monitors. Interpretation and analysis is provided by the staff of the University of Maryland, Baltimore County Atmospheric Lidar Group.

Search

Search this site:

Search

Recent Entries

- Moderate AQI in the South
- Southern haze and Alberto, the first named Atlantic storm
- Hazy in Louisiana
- CALIPSO comes alive!
- Still hazy in the east
- Moderate AQI Continues...
- Moderate AQI in the East

Index & Links

Main Data Sources

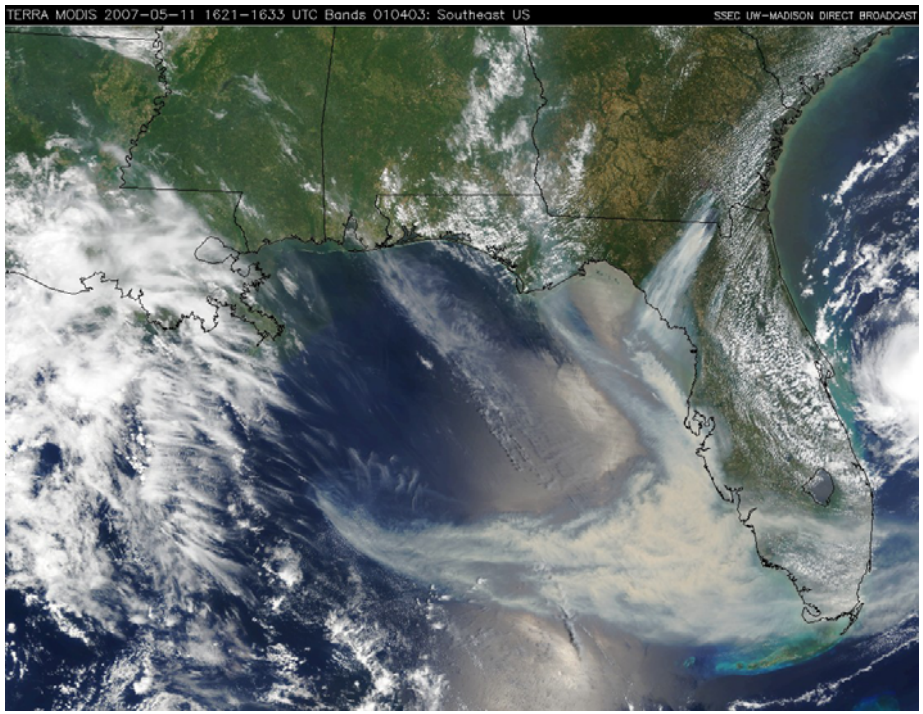
- UW MODIS Direct
- NASA MODIS Rapidfire Browse / Subsets
- EPA AirNow / ParticlesNow
- NASA/EPA/NOAA/UW IDEA
- NOAA NESDIS GASP
- NASA OMI Ozone and Aerosol
- NOAA Hazard Mapping System Fire and Smoke Product
- Baltimore-DC Air-Watch.net

Image Interpretation Help Files

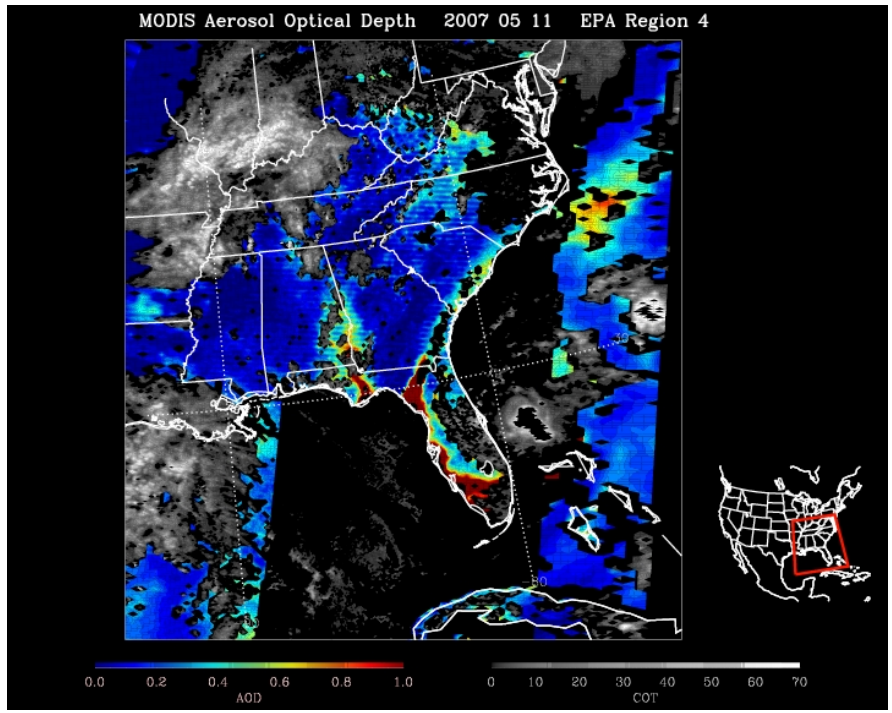
- MODIS Red Green Blue Image (MODIS Direct)
- MODIS Red Green Blue Image (Rapidfire)
- MODIS Aerosol Optical Depth (IDEA)
- GOES Aerosol/Smoke Product (GASP)
- Air Quality Index Fine Particles (AQI PM2.5)
- Hazard Mapping System Fire and Smoke Product (HMS)
- UMBC Polar ELF LIDAR Product

Other Links

Wildfires in Florida: May 11, 2007

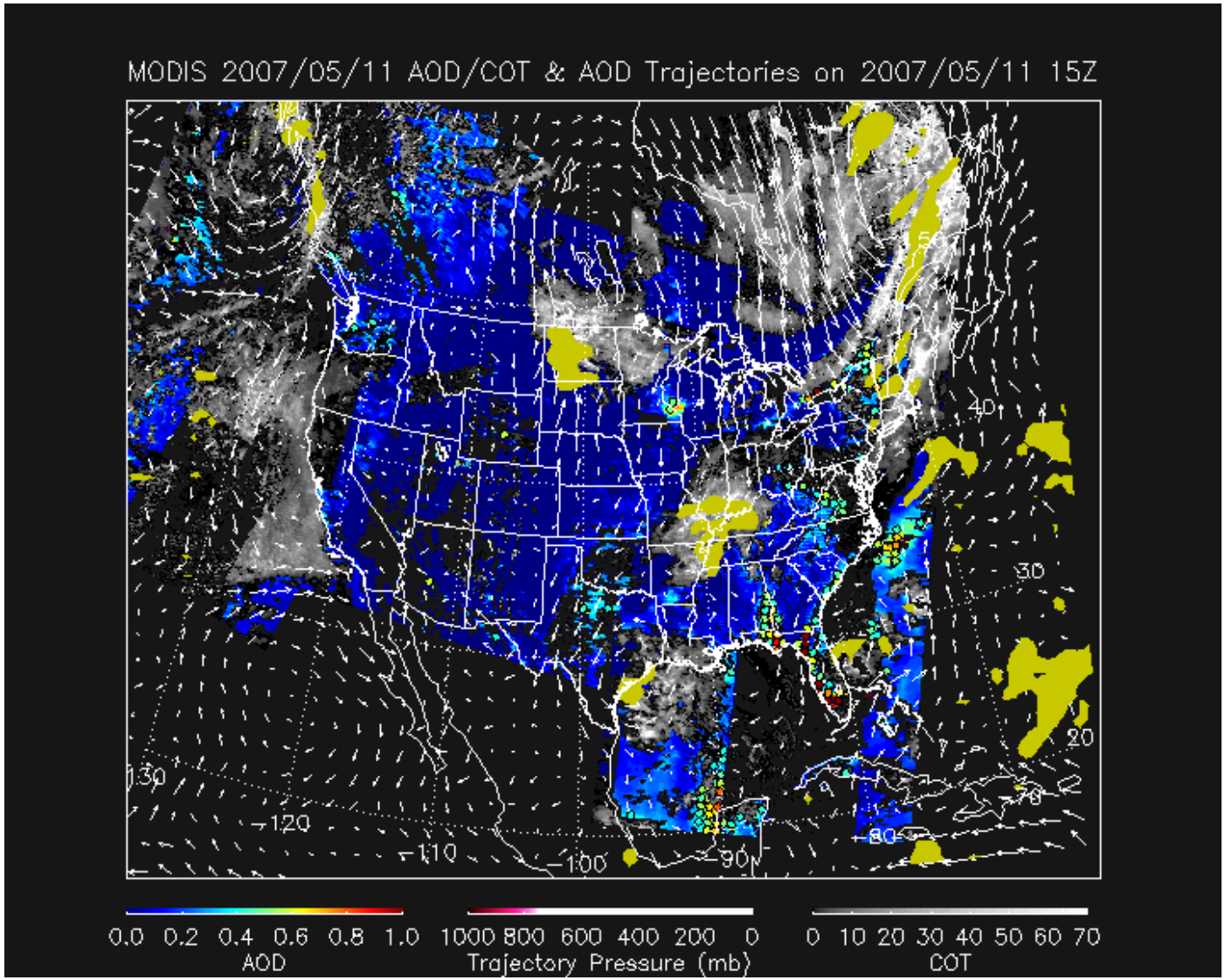


MODIS Direct Broadcast:
MODIS Terra True Color



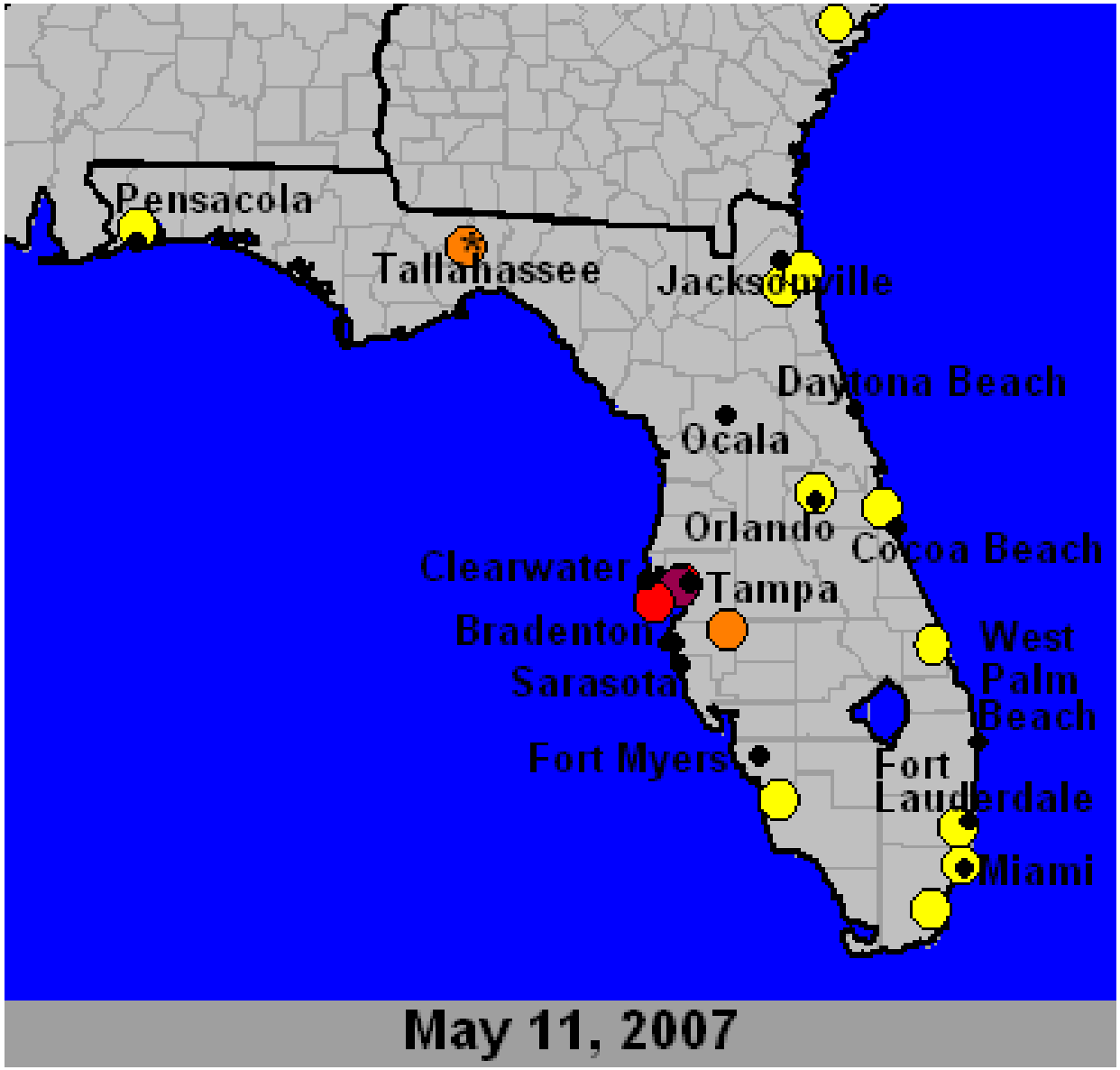
IDEA at UW:
MODIS AOD

48-Hr Aerosol Trajectory Forecast: May 11, 2007



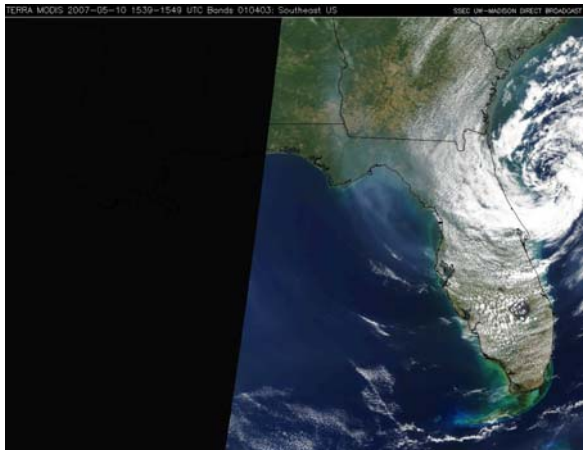
IDEA at UW

24-Hr Average $PM_{2.5}$ Observations

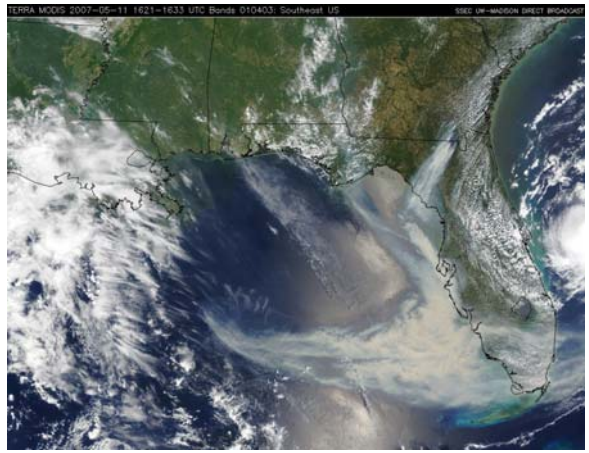


MODIS Terra True Color Time Series

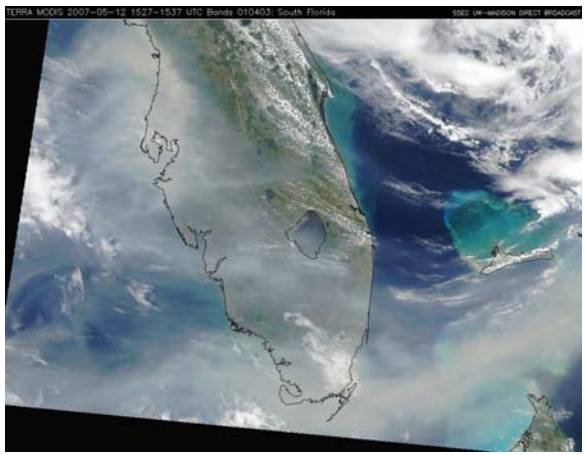
5/9/07



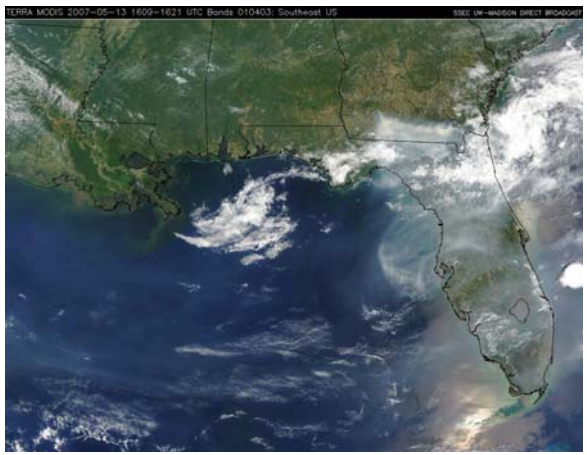
5/10/07



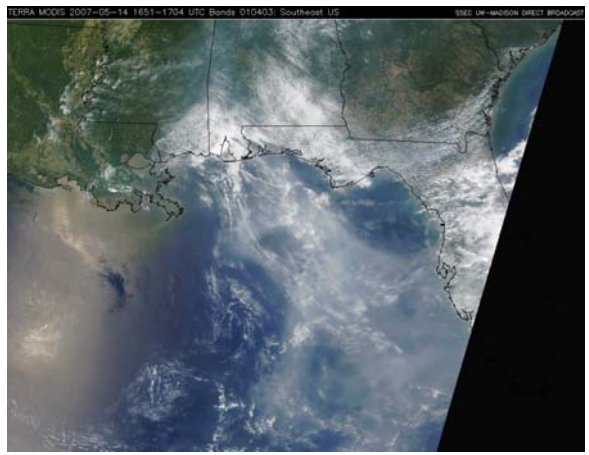
5/11/07



5/12/07

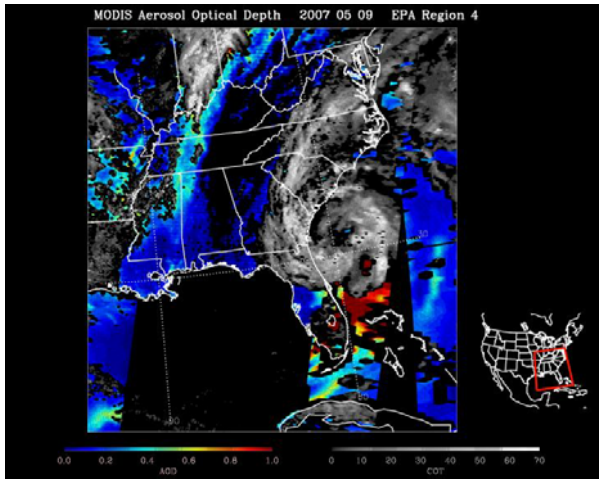


5/13/07

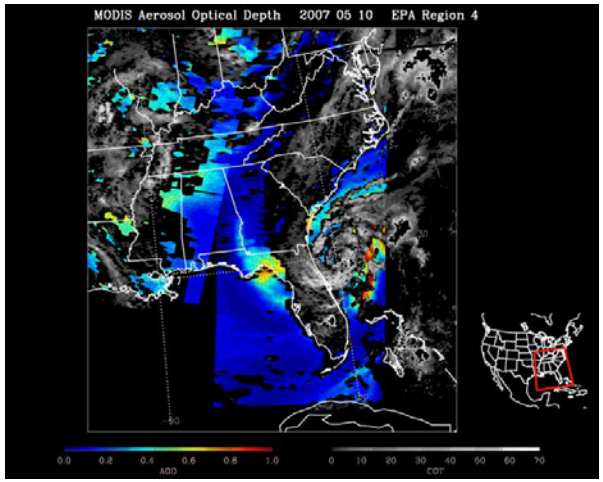


5/14/07

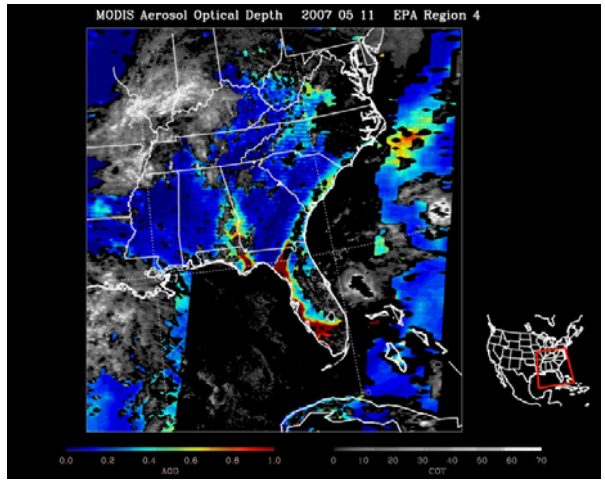
MODIS AOD Time Series



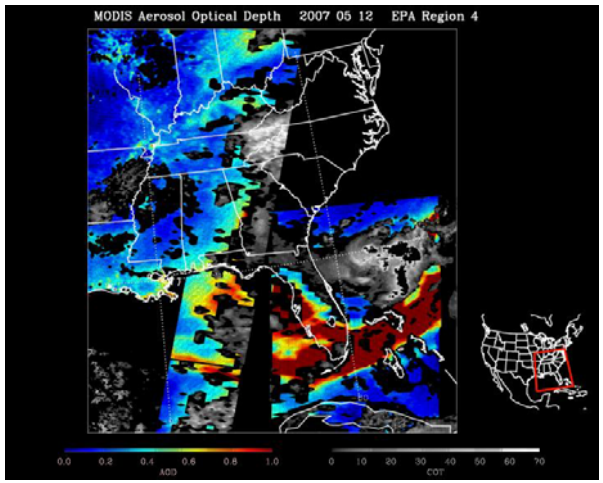
5/9/07



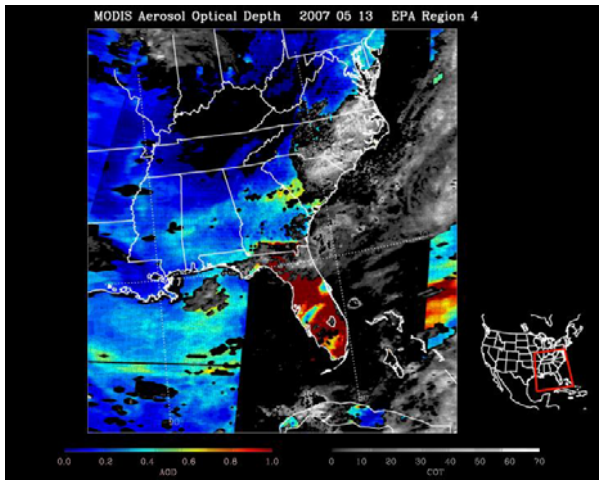
5/10/07



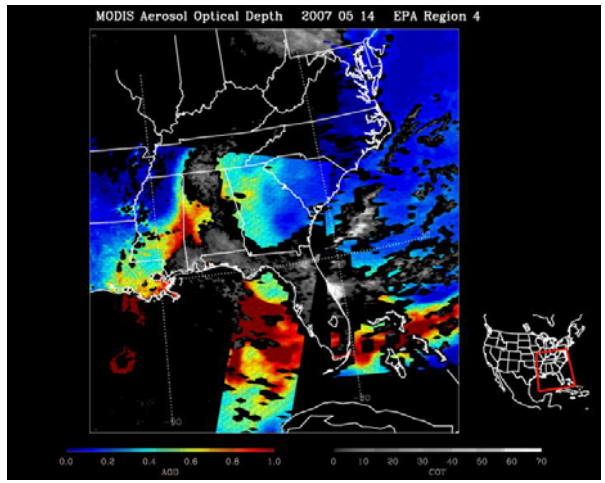
5/11/07



5/12/07

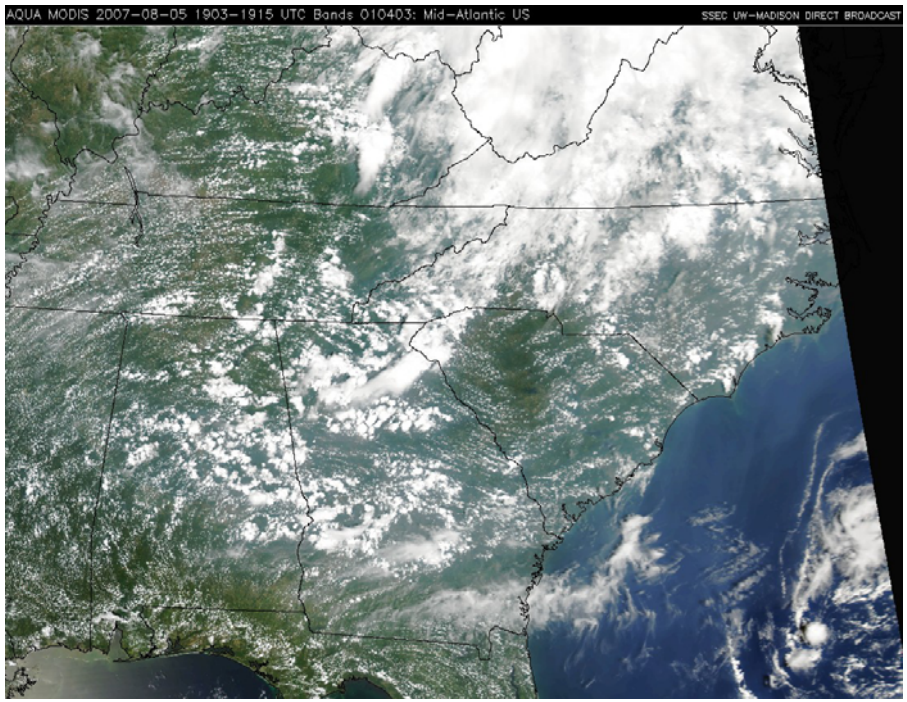


5/13/07

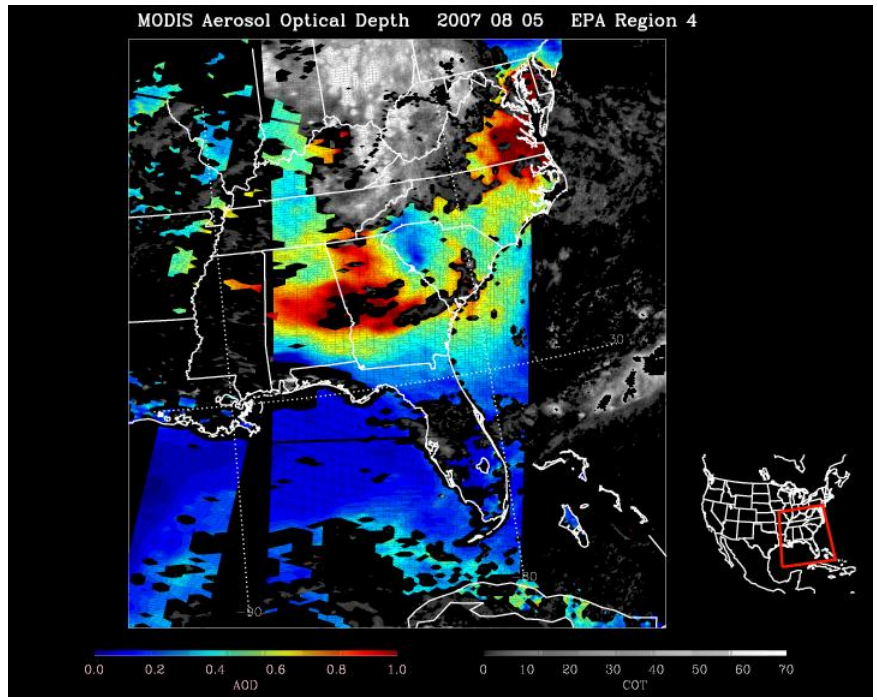


5/14/07

Haze in the Southeast: August 5, 2007

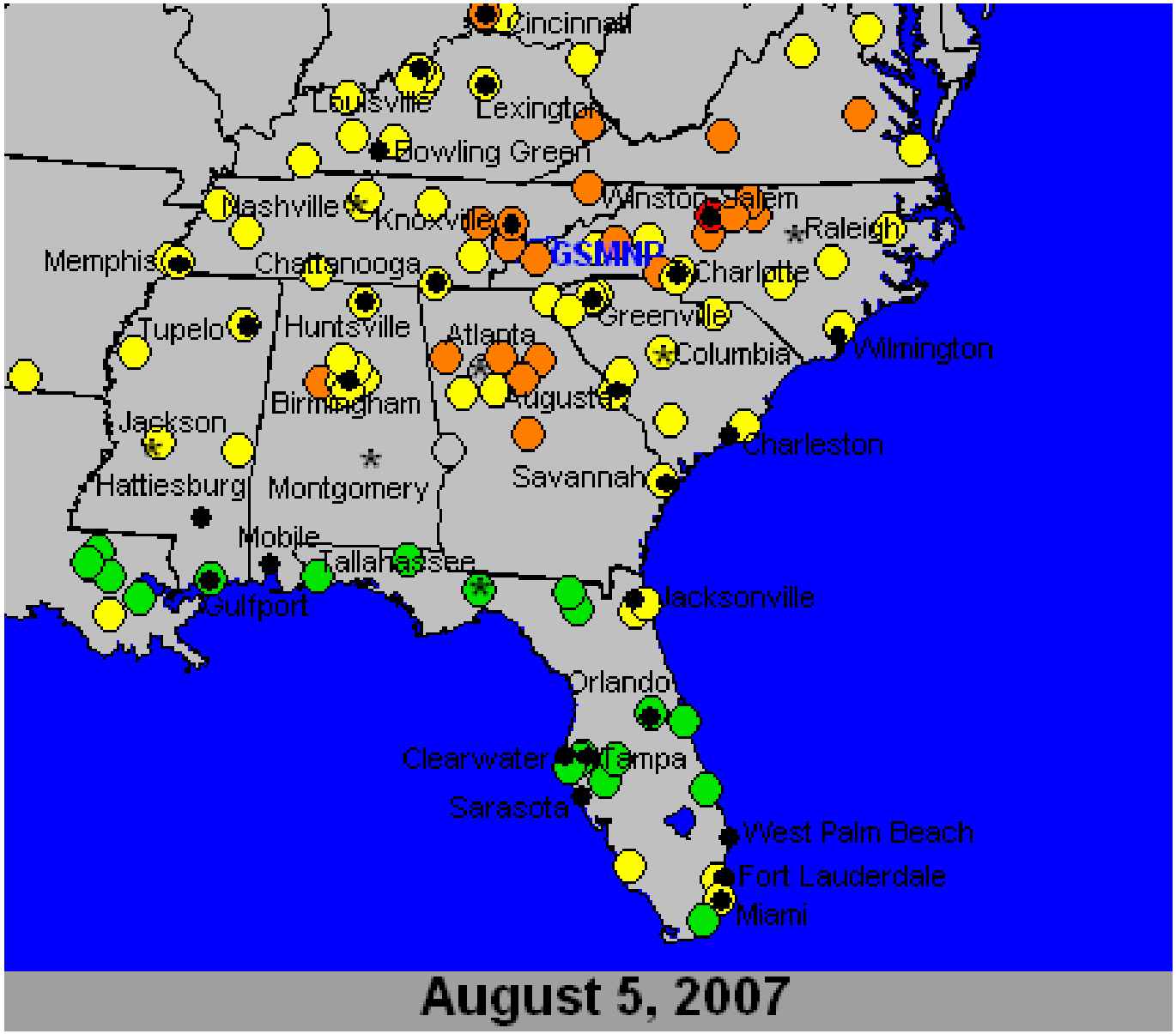


MODIS Direct Broadcast:
MODIS Aqua True Color

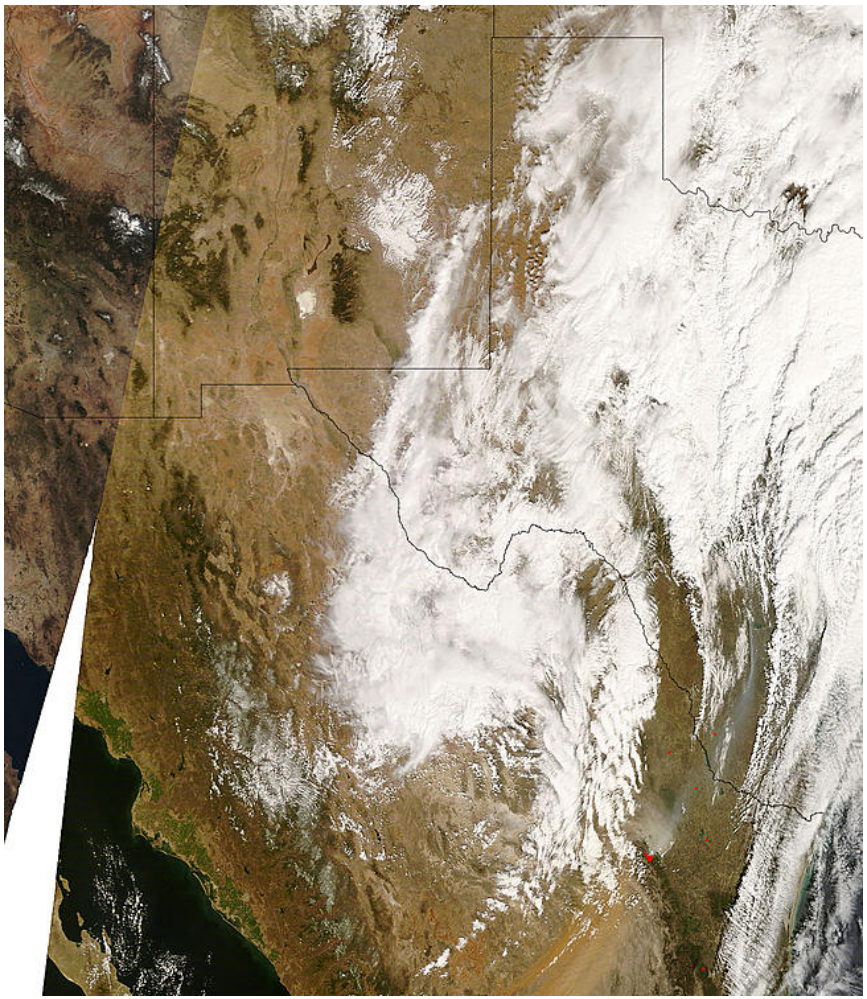


IDEA at NOAA:
MODIS AOD

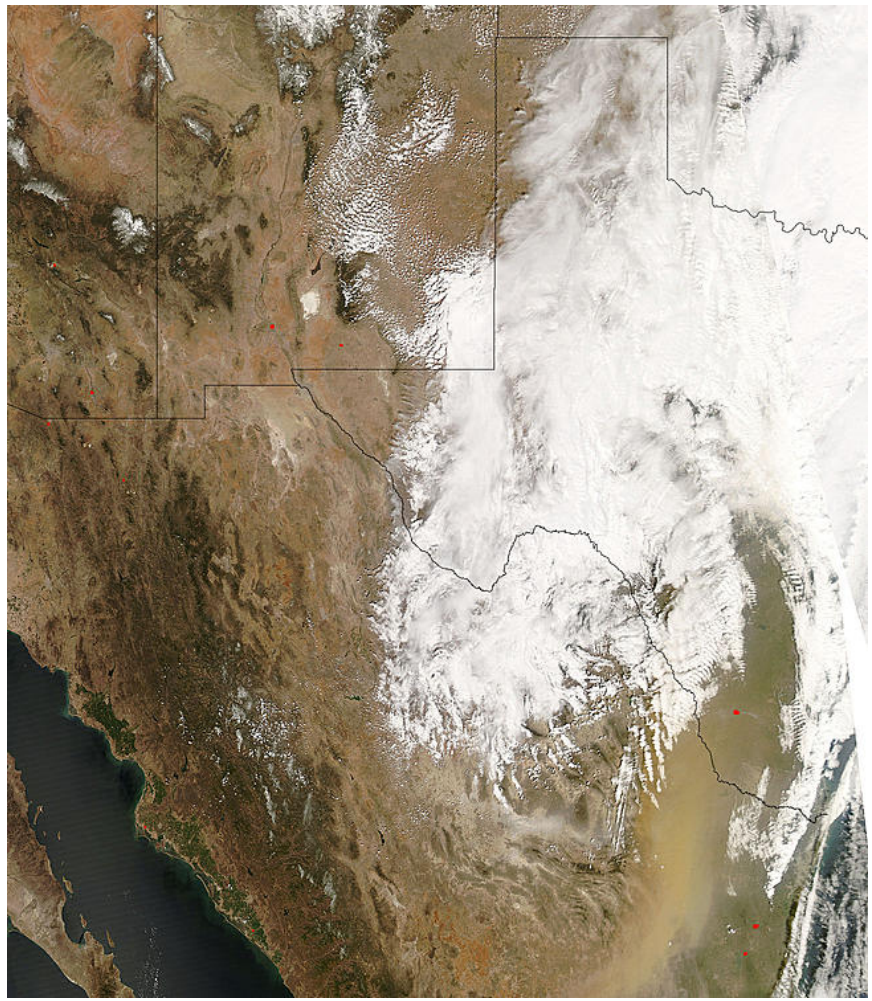
24-Hr Average $PM_{2.5}$ Observations



Dust and Smoke in South Texas: March 18, 2008

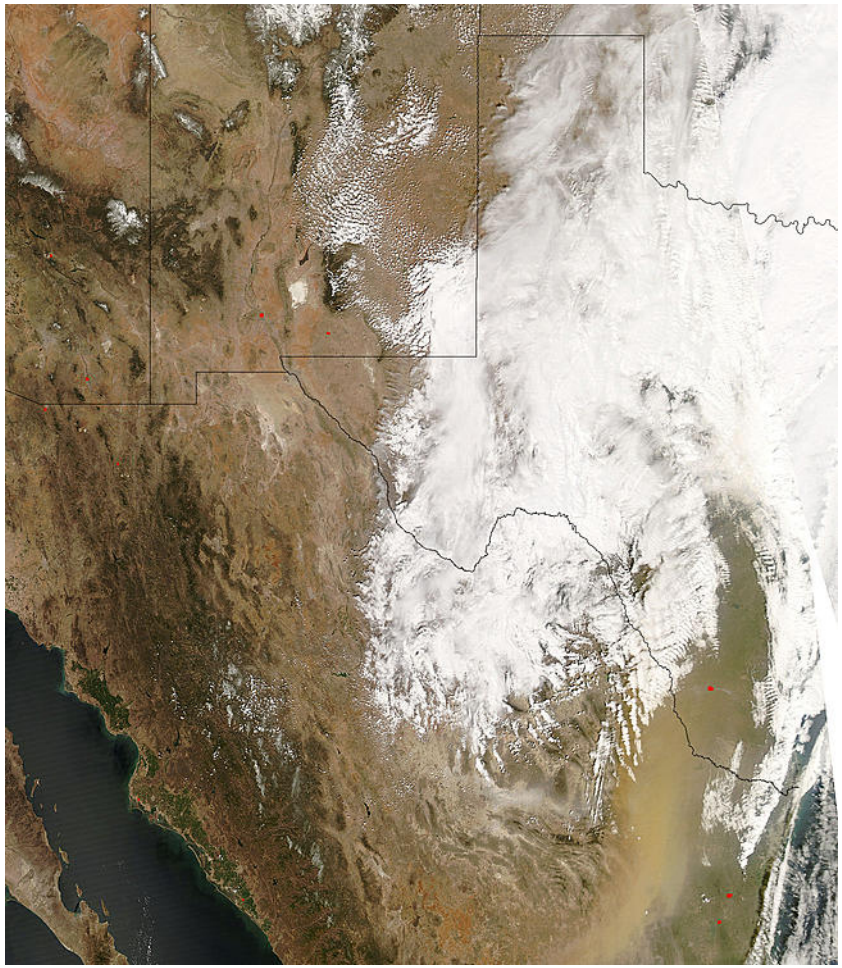


MODIS Rapid Response System:
MODIS Terra True Color

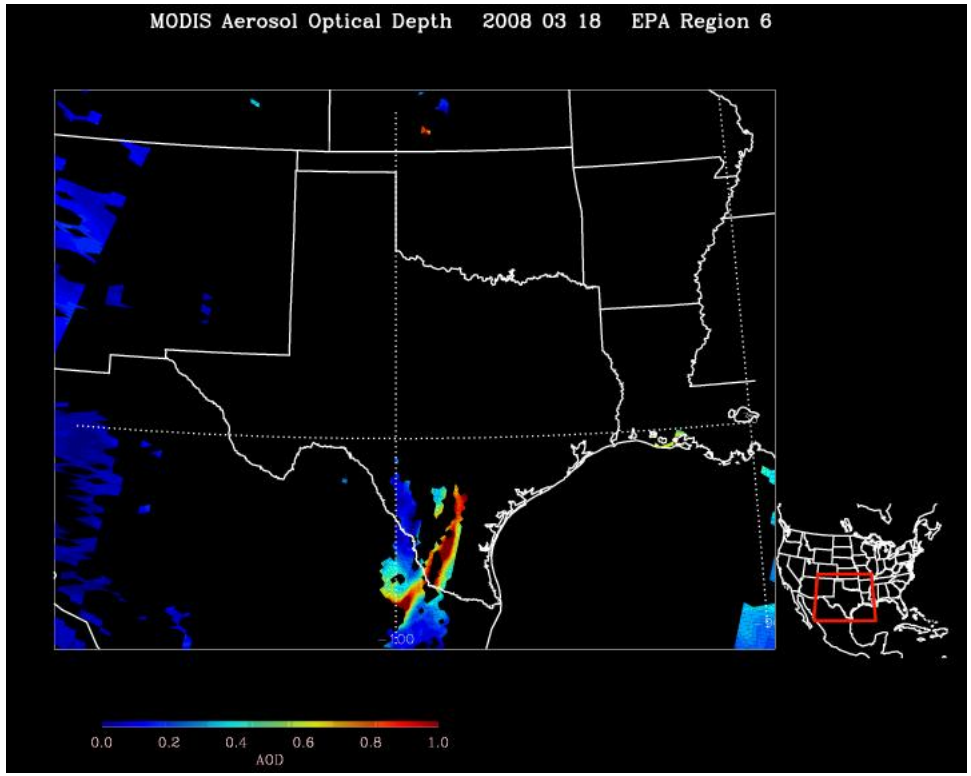


MODIS Rapid Response System:
MODIS Aqua True Color

Dust and Smoke in South Texas: March 18, 2008

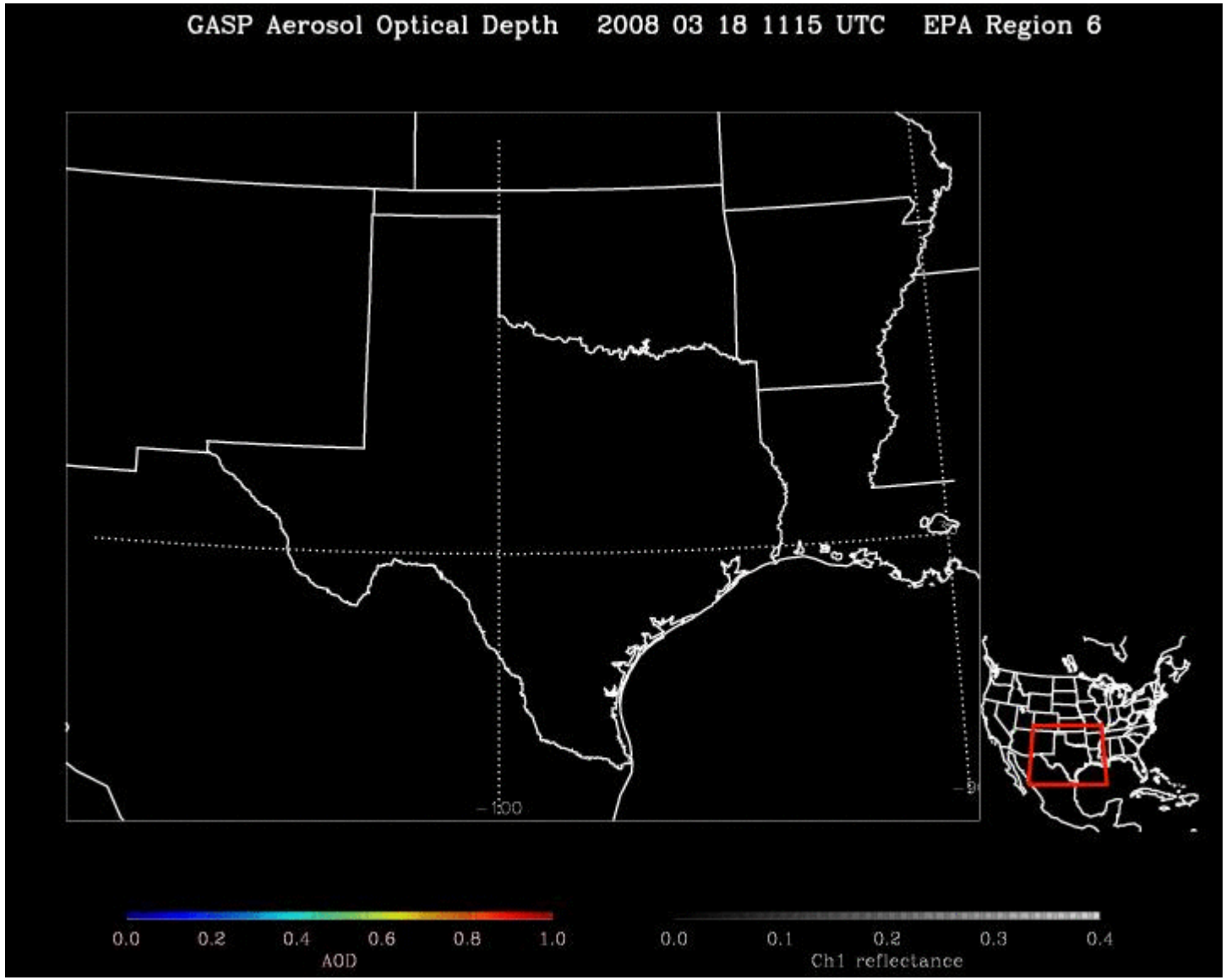


MODIS Rapid Response System:
MODIS Aqua True Color



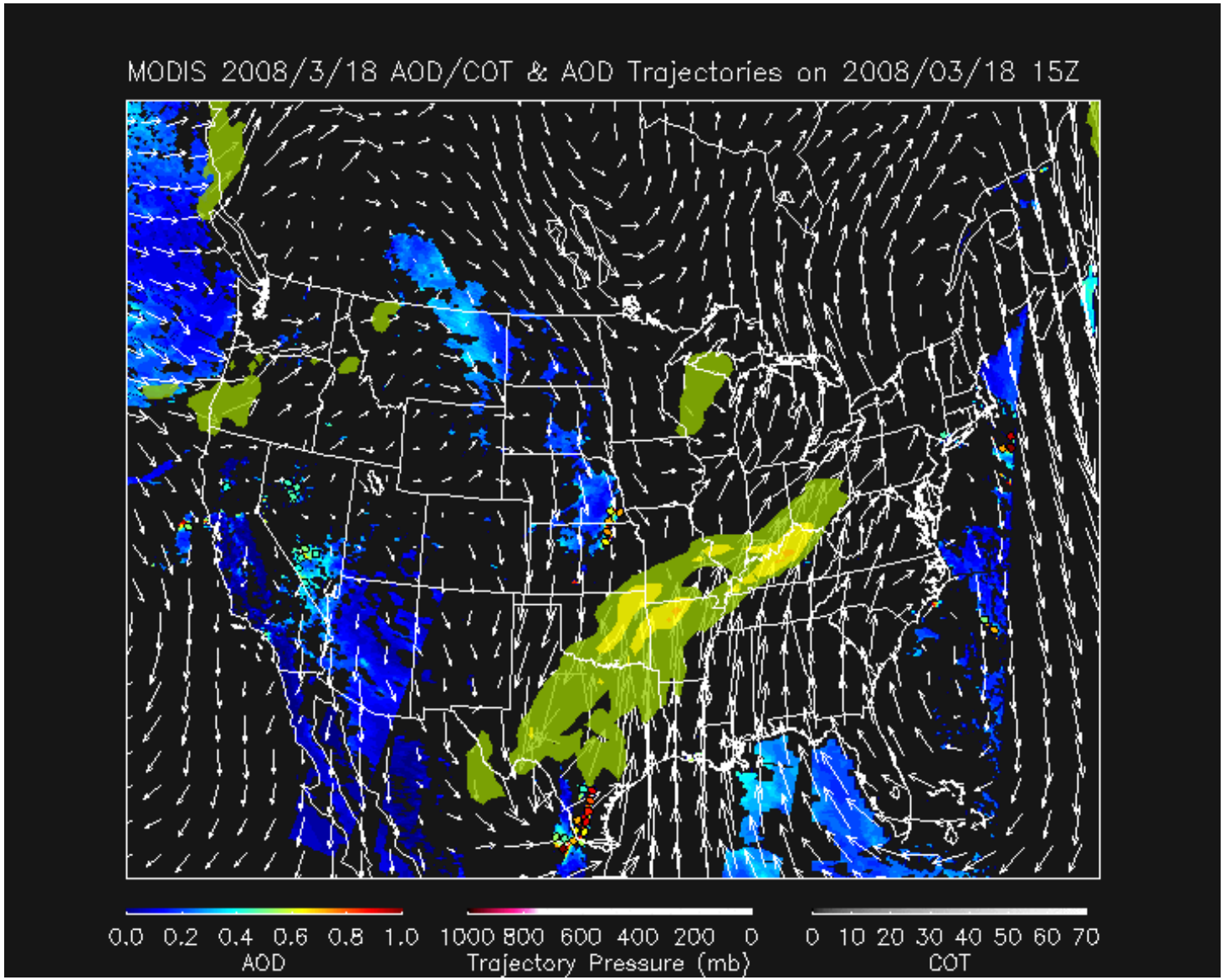
IDEA at NOAA:
MODIS AOD

GASP AOD Animation: March 18, 2008



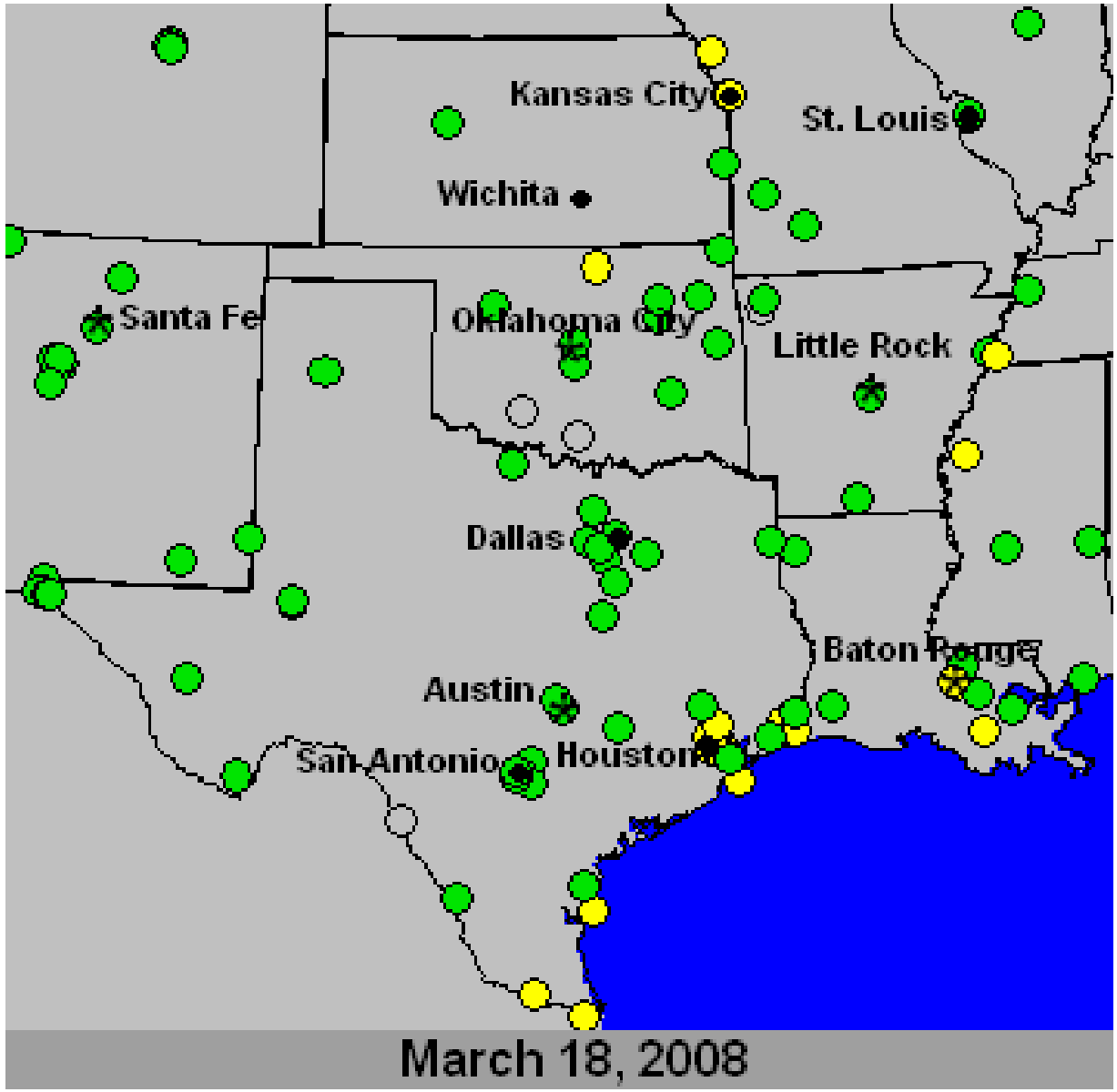
IDEA at NOAA

48-Hr Aerosol Trajectory Forecast: March 18, 2008

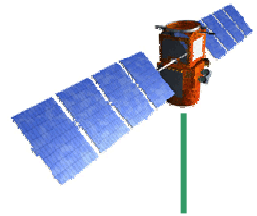


IDEA at NOAA

24-Hr Average $PM_{2.5}$ Observations



Tips for Using 3D-AQS Remote Sensing Data for Air Quality Forecasting



- Temporal resolution of polar-orbiting satellites: observations are made only 1-2 times per day.

  Solution: use geostationary satellite images (GASP AOD)

- Time lag for processing of images: real-time data are not always available by forecast deadlines.

  Solution: use images from the previous time period (e.g., yesterday's MODIS Aqua)

- Gaps in data sometimes occur: images aren't there when you need them.

  Solution: consult multiple internet delivery systems

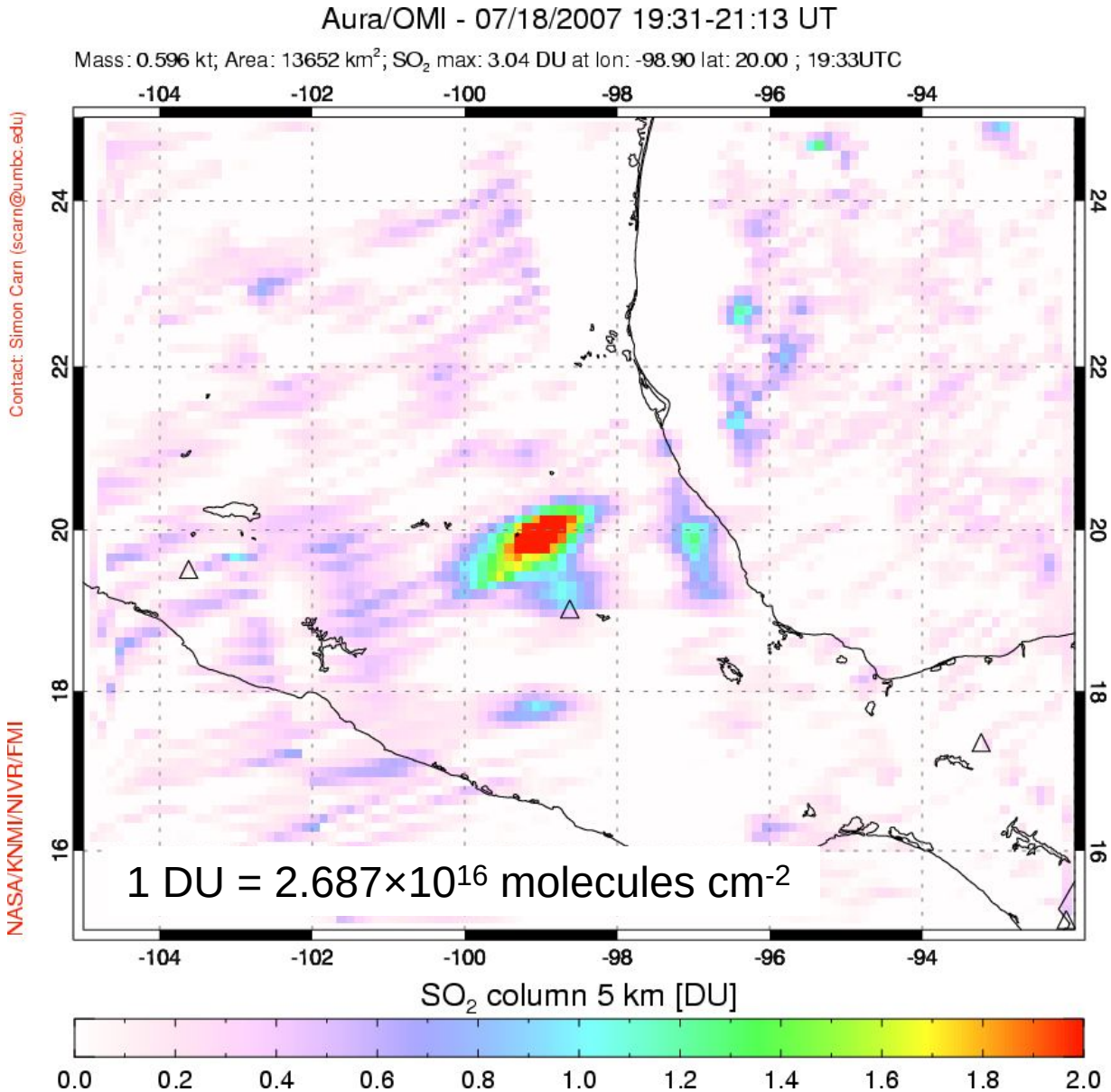
- Lack of specificity about some pollutants: best for $PM_{2.5}$, still qualitative for NO_2, sketchy for O_3.

  Solution: become involved and provide feedback to the 3D-AQS team! The air quality community drives continuous improvements to remote sensing tools!

Acknowledgements

- Lawrence Friedl and NASA Applied Sciences
- Ray Hoff and the entire 3D-AQS team
- Tony Wimmers

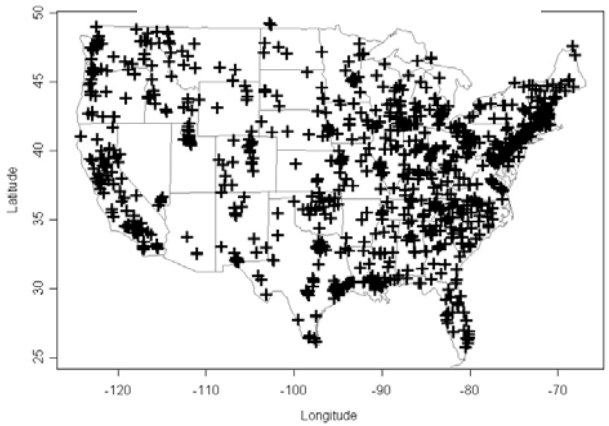
OMI Tropospheric Column SO_2



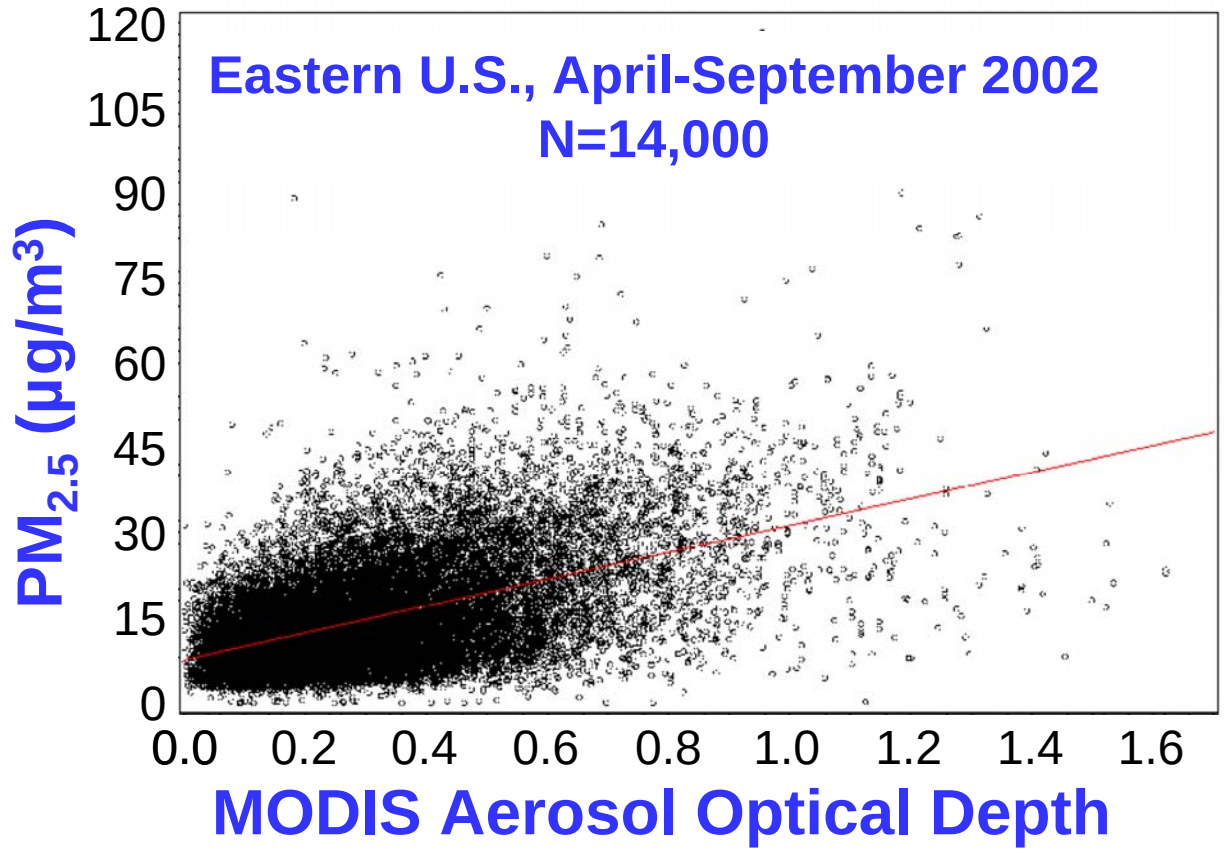
- Daily measurement of SO_2 at ~1:30 PM LST
- Column measurement, not surface – use for qualitative applications
- May not be accurate at altitudes < 2 km
- Images only available for volcanic regions
- Clouds, aerosols, and ozone block the measurement of OMI SO_2!

$PM_{2.5}$ Concentrations are Proportional to AOD

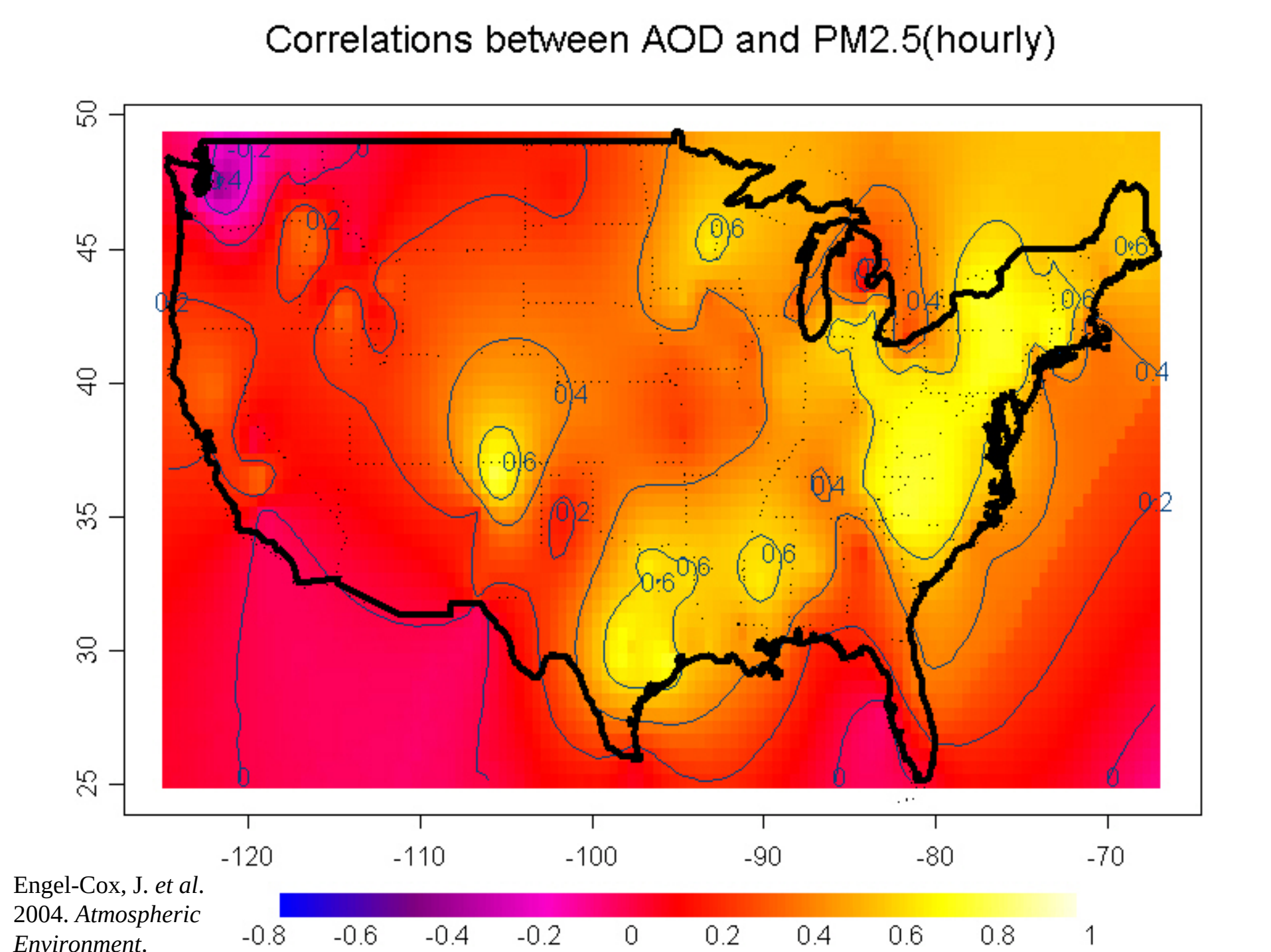
Urban Monitors



Rural Monitors



Engel-Cox, J. *et.al*. 2004. *Atmospheric Environment*



Engel-Cox, J. *et al*. 2004. *Atmospheric Environment*.