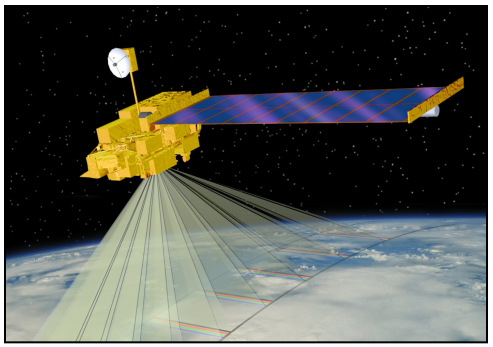
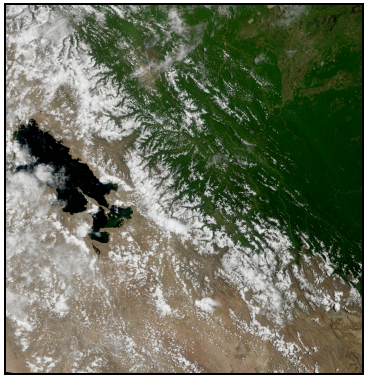
MODIS Products

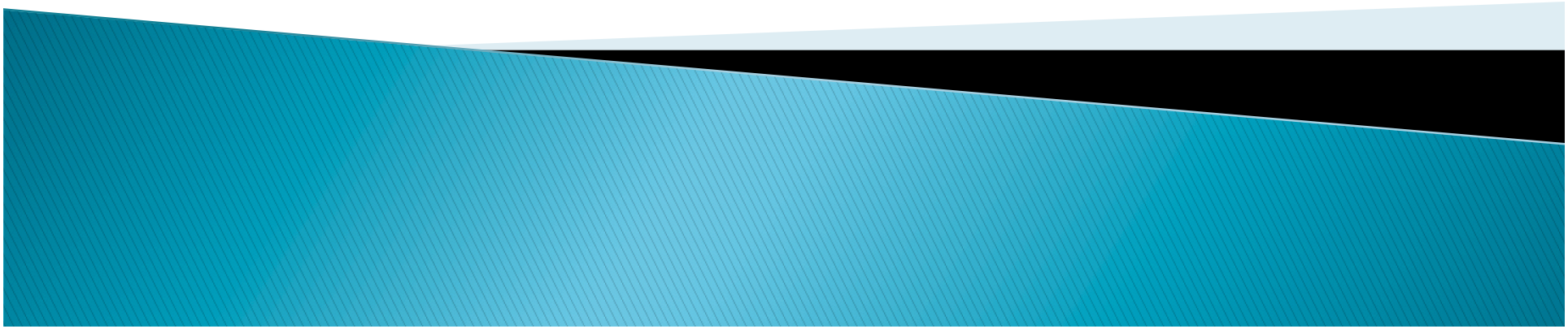
2011 IMAPP Training Workshop: Satellite Direct Broadcast for Real-Time Environmental Applications
ECNU, China
3 June 2011
Part 3



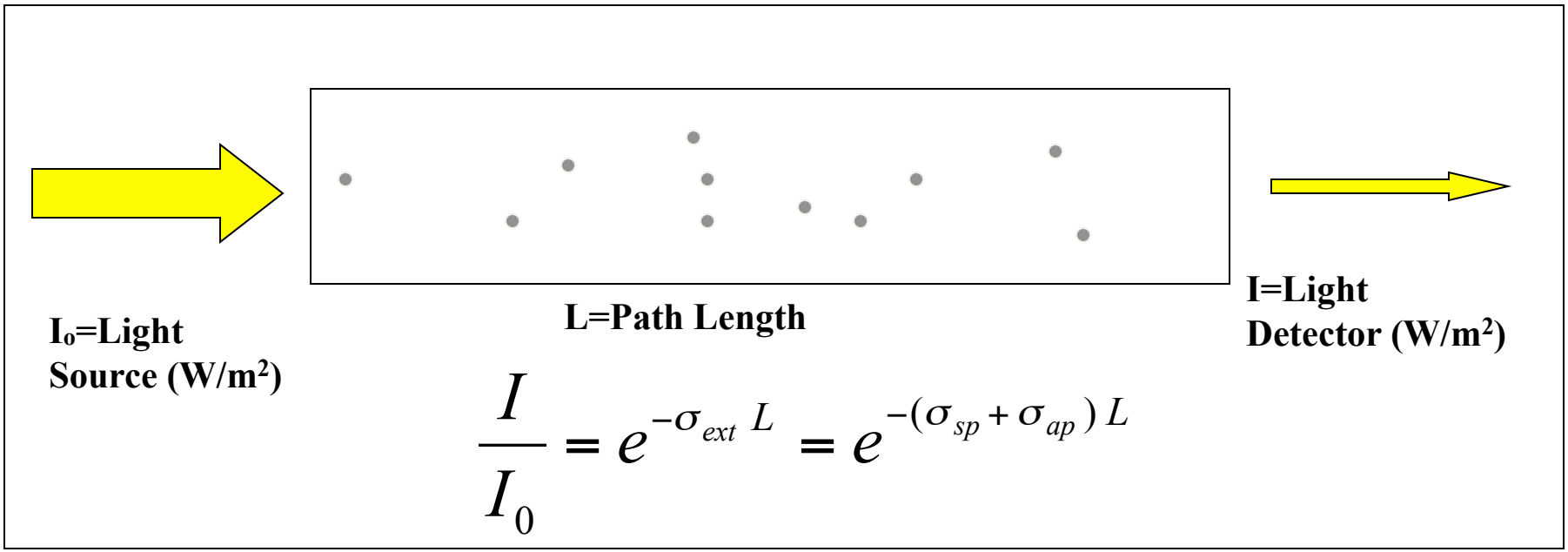


Kathleen Strabala
Cooperative Institute for Meteorological Satellite Studies
Space Science and Engineering Center
University of Wisconsin-Madison

MODIS Aerosol Product (MOD04)



Scattering and Absorption of Light by Aerosols



$$\frac{I}{I_0} = e^{-\sigma_{ext} L} = e^{-(\sigma_{sp} + \sigma_{ap}) L}$$

$$\tau = (\sigma_{sp} + \sigma_{ap}) * L \qquad \varpi = \sigma_{sp} / (\sigma_{sp} + \sigma_{ap})$$

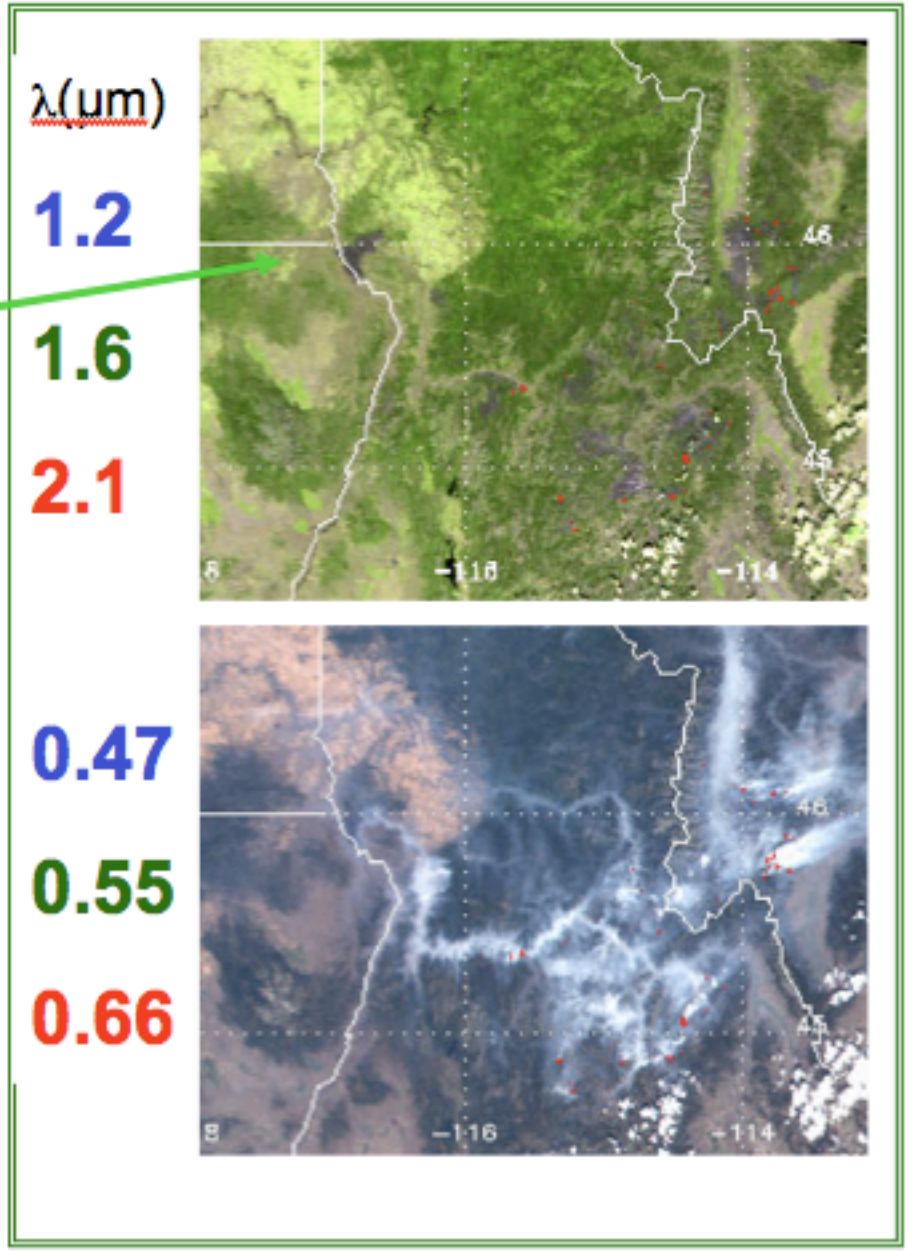
The quantity L is called the density weighted path length. $\sigma_{ext(\lambda)}$ L is a measure of the cumulative depletion that the beam of radiation has experienced as a result of its passage through the layer and is often called the optical depth τ_λ.

Wide Spectral Range makes land retrieval possible

- **Mid-IR is used to observe the surface brightness**
- **Then aerosol is derived from estimated surface reflectance in the visible and actual reflectance**

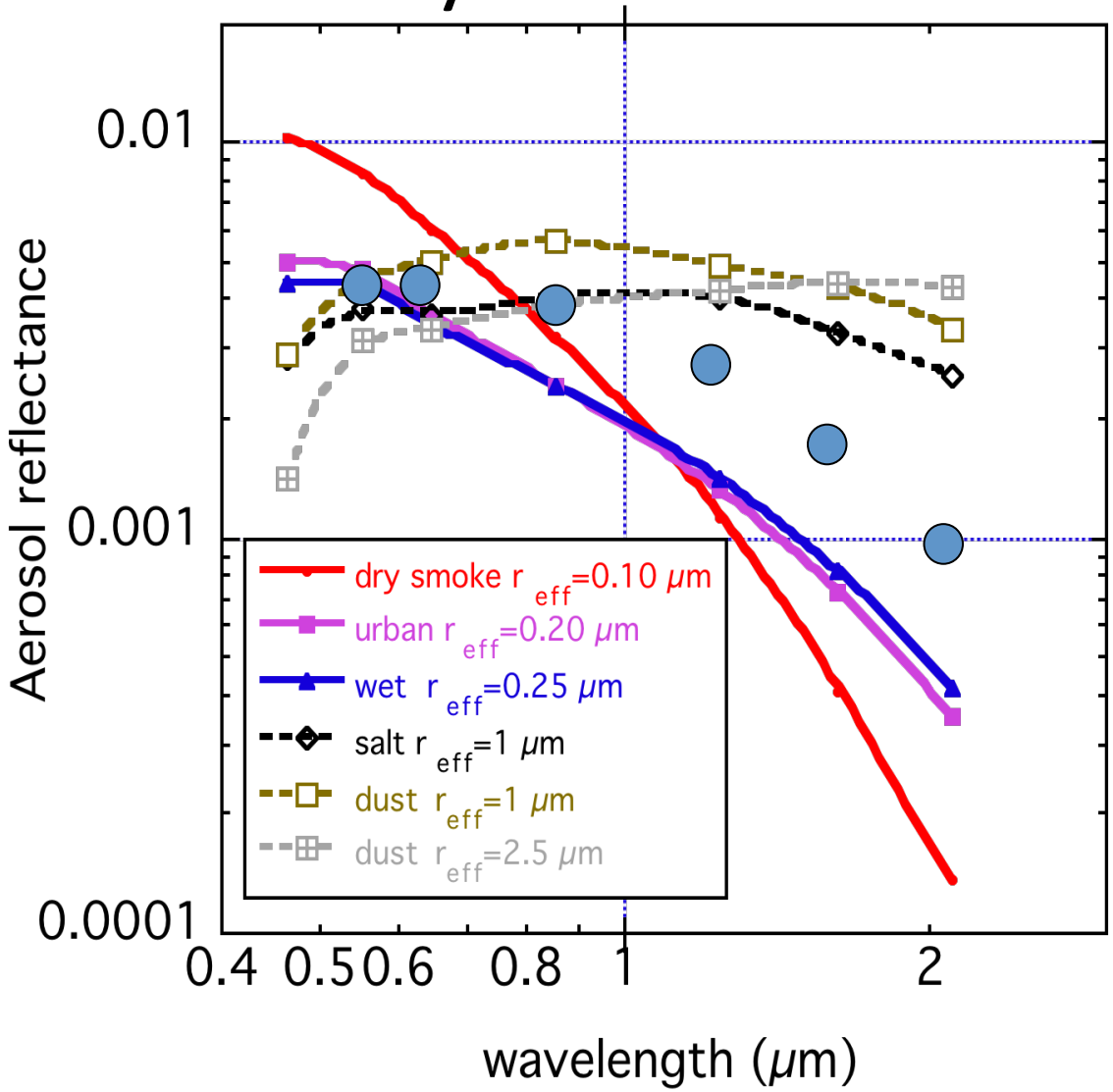
$t_{0.66} \sim [r^*_{0.66} - 0.5r^*_{2.1}]$

$t_{0.47} \sim [r^*_{0.47} - 0.25r^*_{2.1}]$



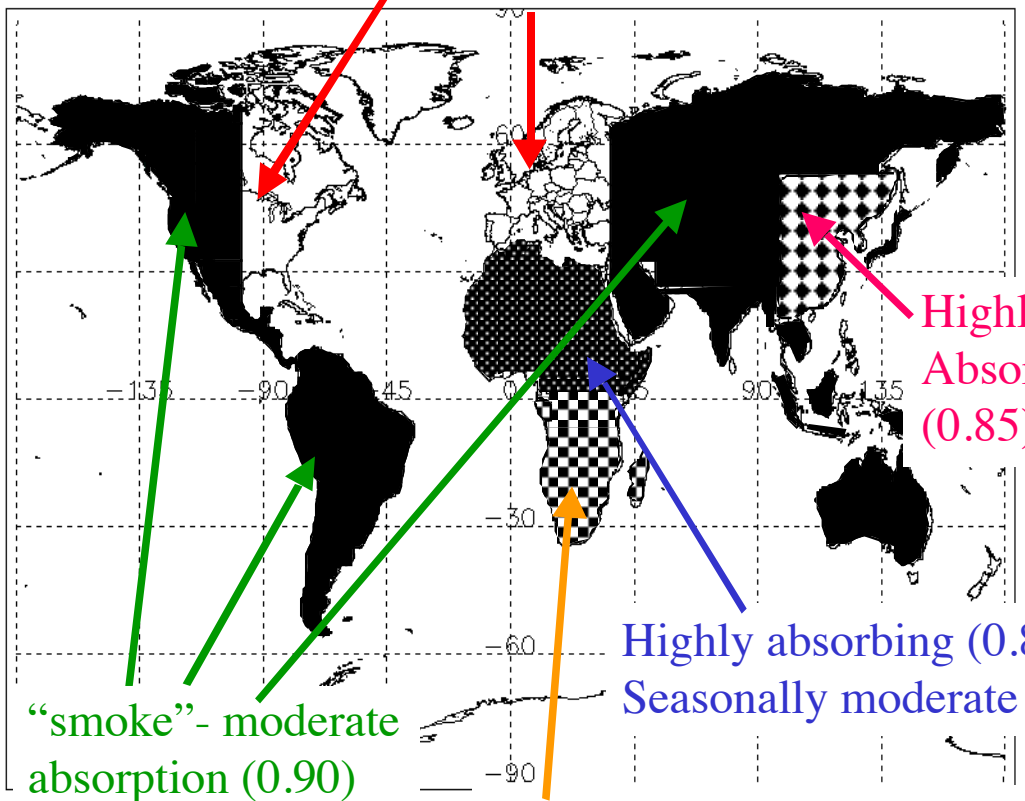
Yoram Kaufman

Getting A Best Fit for the Observations Match Theory and Observations

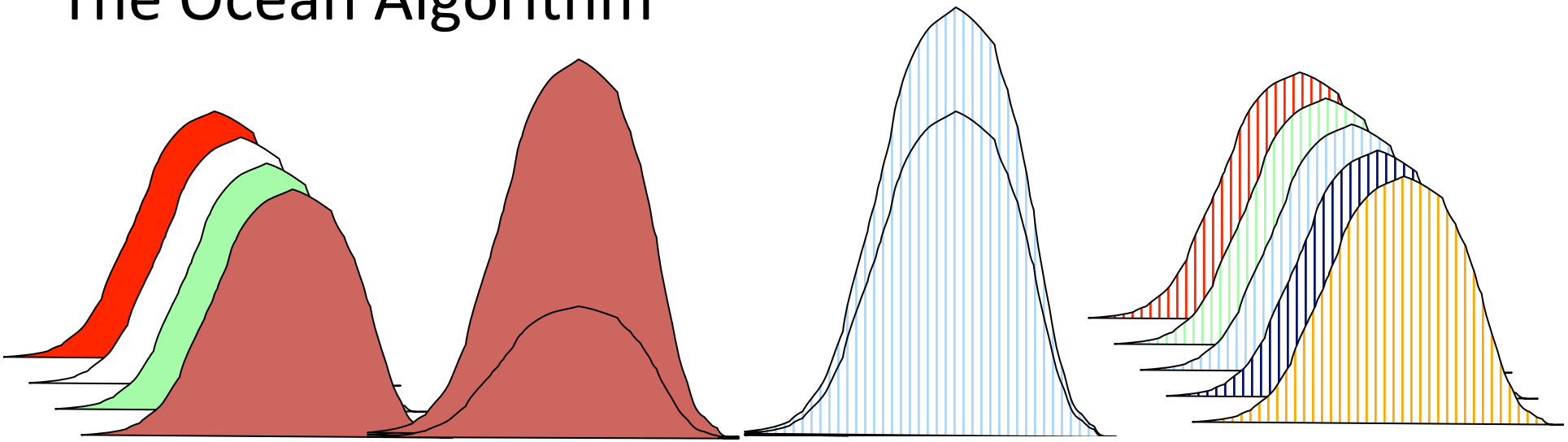


3 non-dust models
plus dust
Set by geography and
season

Models are dynamic f(τ)

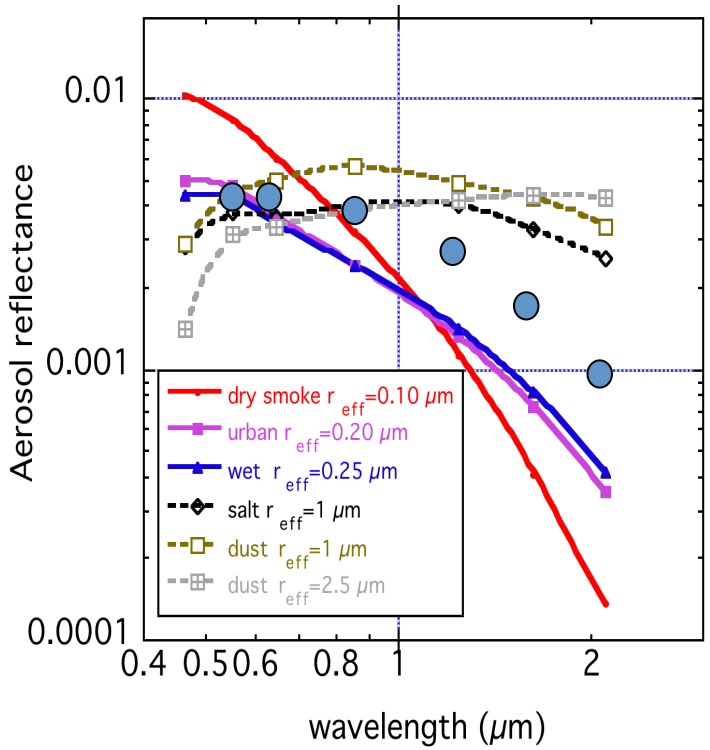


The Ocean Algorithm

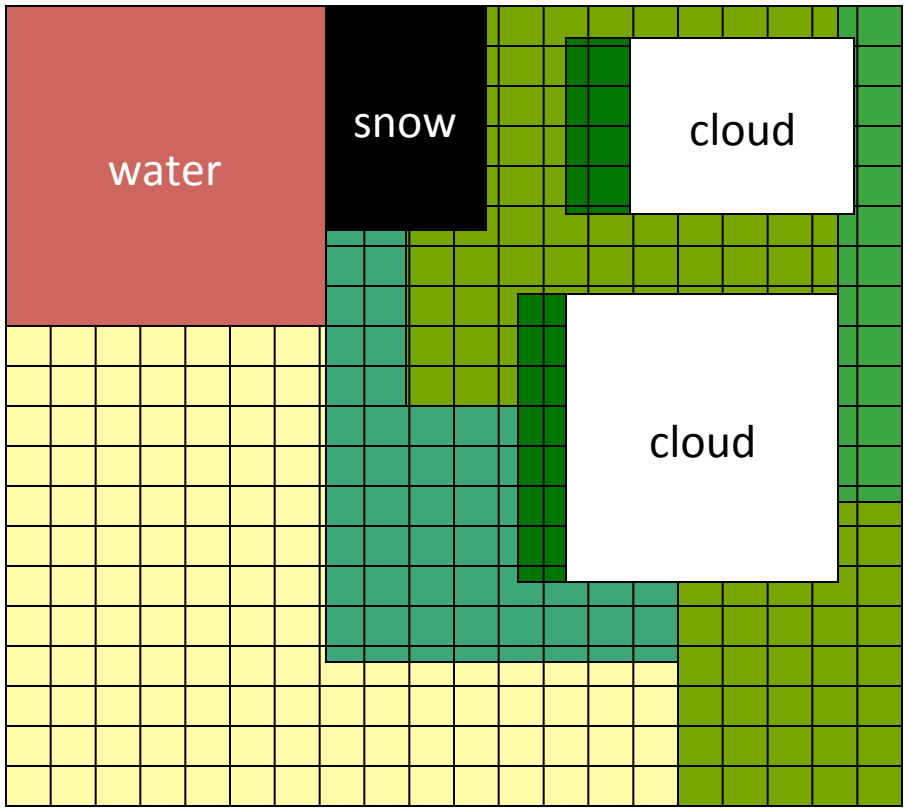


Choice of 4 fine modes
and 5 coarse modes

In order to minimize
$(\rho_{meas} - \rho_{LUT})$ over 6 wavelengths



MODIS Over Land Algorithm
20 x 20 pixels at 500 m resolution
(10 km at nadir)



400 total
- 56 water

344
- 24 snow

320
- 55 cloud

265
-116 “bright”

149 “good”

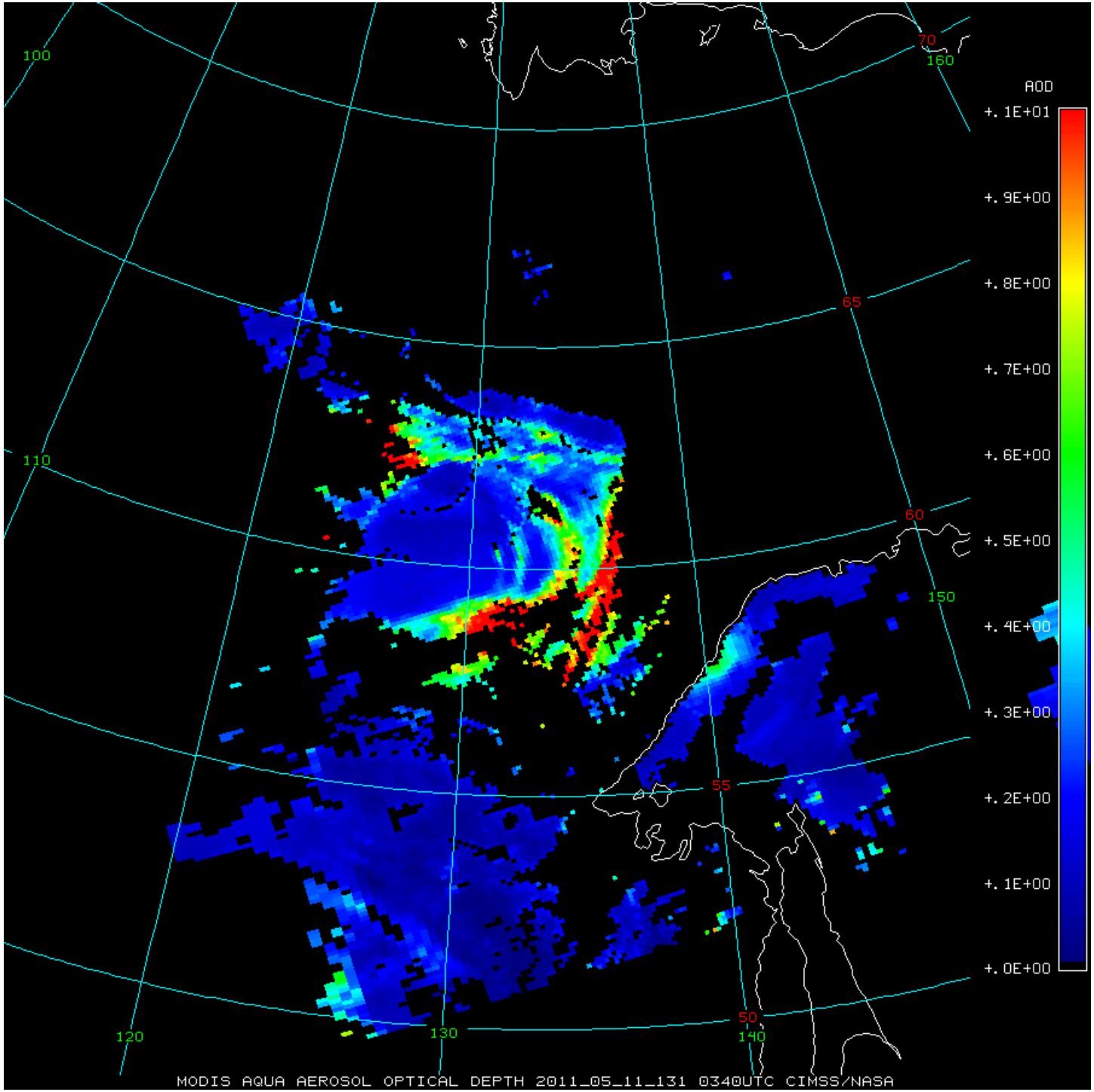
Discard brightest 50% and darkest 20% of the 149 good pixels.

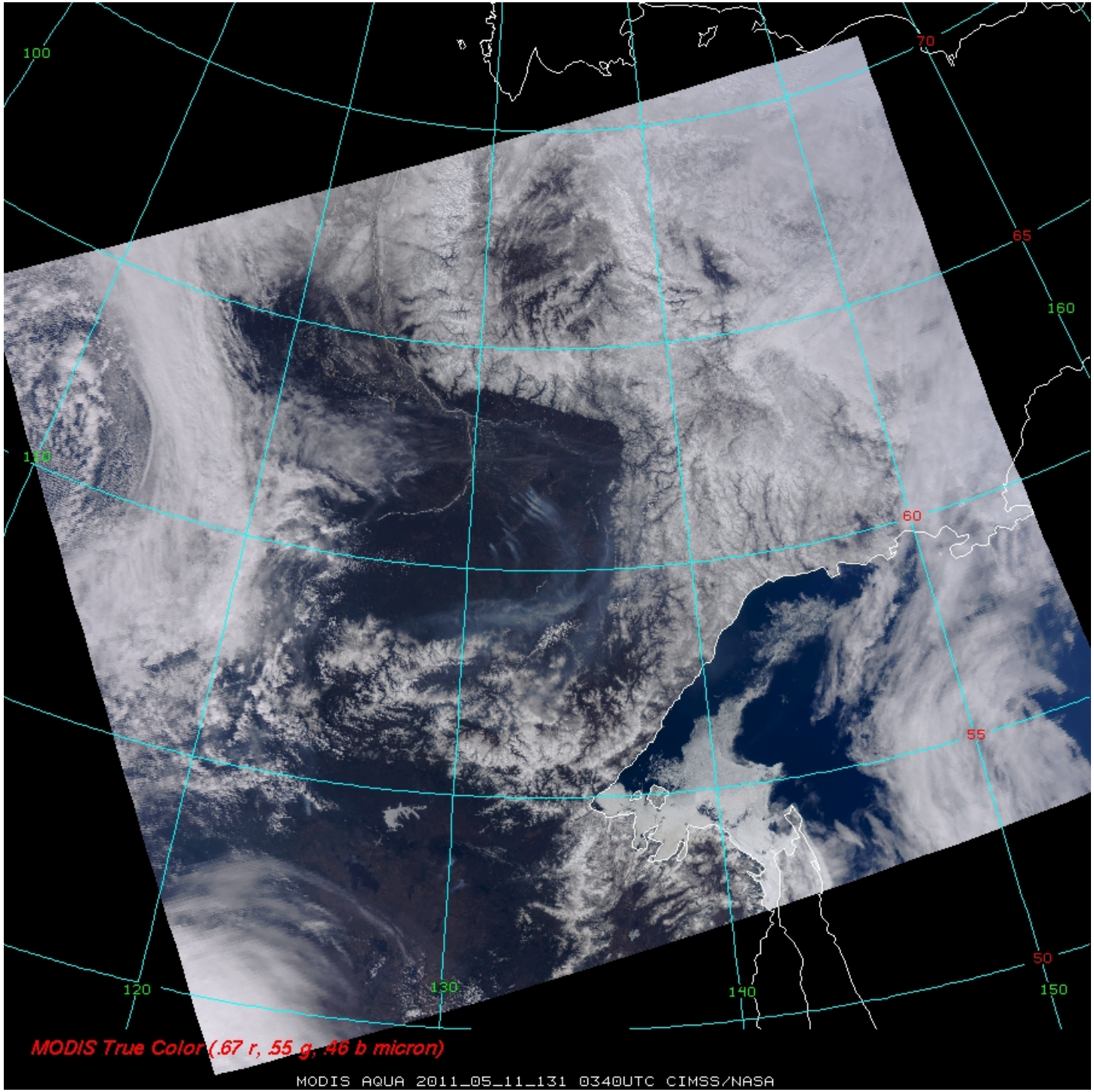
44 pixels

MOD04 Key Output Parameters

10x10 pixel (1km) resolution

- Optical_Depth_Land_And_Ocean –
  Aerosol Optical Thickness (AOT) at 0.55 microns for both ocean (best) and land (corrected)
- Optical_Depth_Ratio_Small_Land_And_Ocean - Ratio of small mode optical depth to total at 0.55 microns
- Corrected_Optical_Depth_Land (3 bands) - Corrected optical thickness at 0.47, 0.55, and 0.66 microns
- Effective_Optical_Depth_Average_Ocean (7 bands) - AOT at seven bands for average solution at .47, .55, .66, .86, 1.2, 1.6 and 2.1 microns


AOD
+.1E+01
+.9E+00
+.8E+00
+.7E+00
+.6E+00
+.5E+00
+.4E+00
+.3E+00
+.2E+00
+.1E+00
+.0E+00
100
110
120
130
140
150
160
70
65
60
55
50
MODIS AQUA AEROSOL OPTICAL DEPTH 2011_05_11_131 0340UTC CIMSS/NASA


100
70
65
160
110
60
55
50
120
130
140
150
MODIS True Color (.67 r, .55 g, .46 b micron)
MODIS AQUA 2011_05_11_131 0340UTC CIMSS/NASA

How does the DB product differ from the NASA archived product?

- Not HDFEOS (Straight HDF4)
- DB version includes 4 arrays only
- No Deep Blue algorithm included

Collection 6 (before the end of the year) will include:

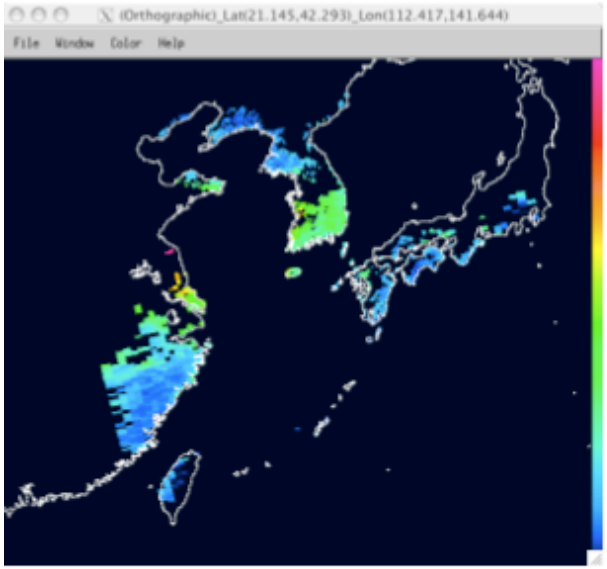
- One product that includes the best retrieval for the pixel
- Ocean/Land or Deep Blue
- 1 km retrieval

MODIS Aerosol Products

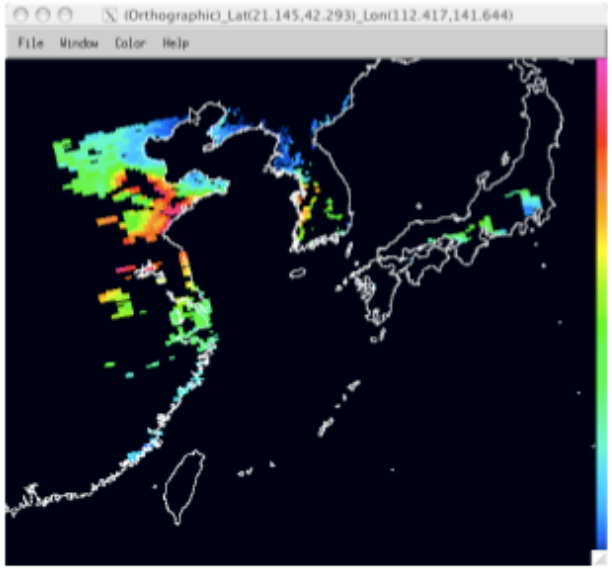
Three Separate Algorithms

Land

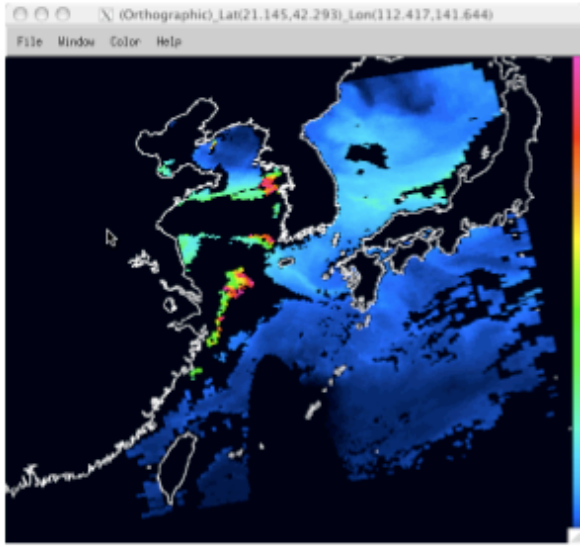
Dark Target



Deep Blue



Ocean

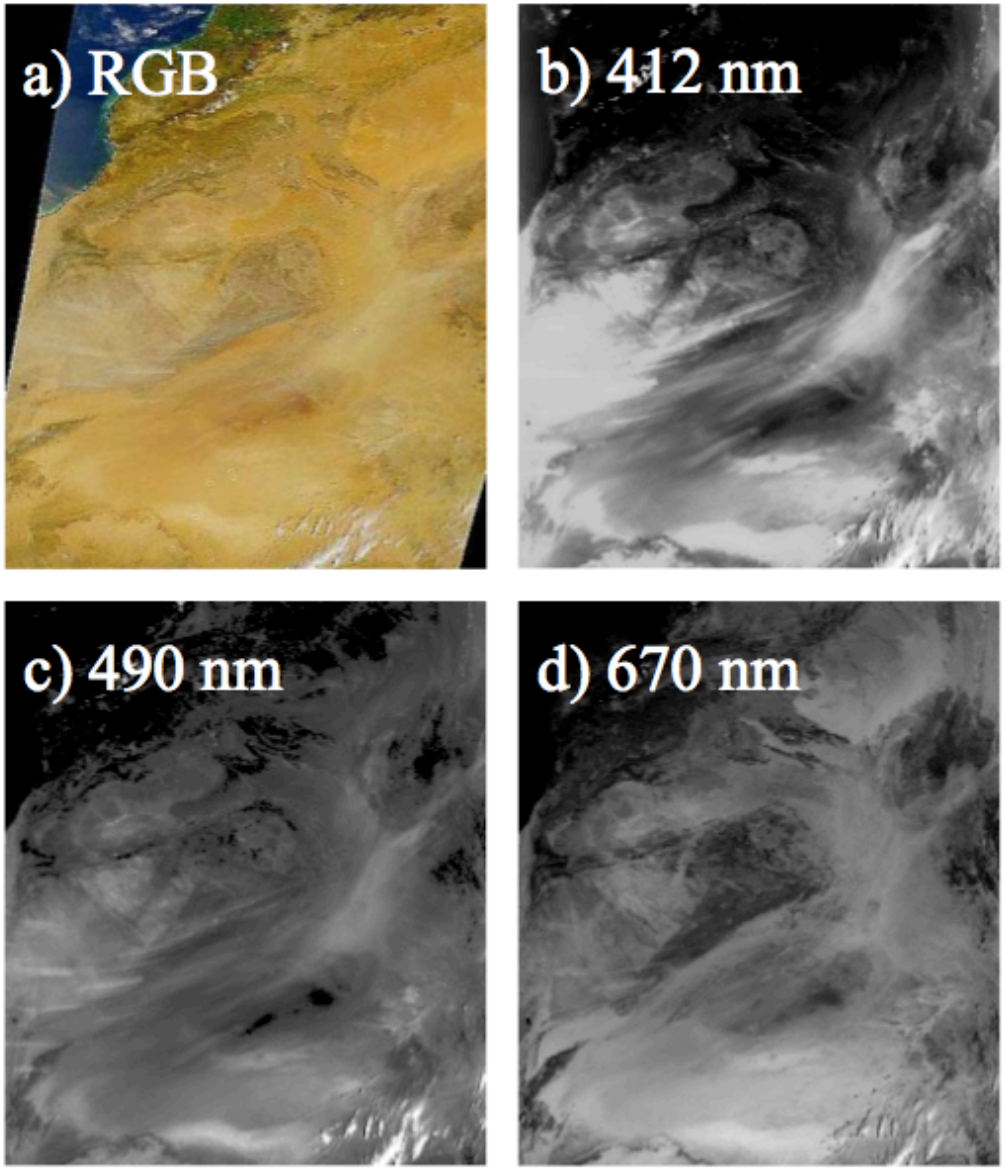


Richard Kleidman

The Deep Blue Advantage

- **Deep Blue uses information from blue channels, where the surface is darker**
  - **412nm, 470nm, 650nm (MODIS bands 8, 3, 1)**

Saharan Desert - Feb. 10, 2001



Thin narrow dust plumes were seen clearly at 412 nm reflectance image, but not discernible at 670 nm image.

Richard Kleidman

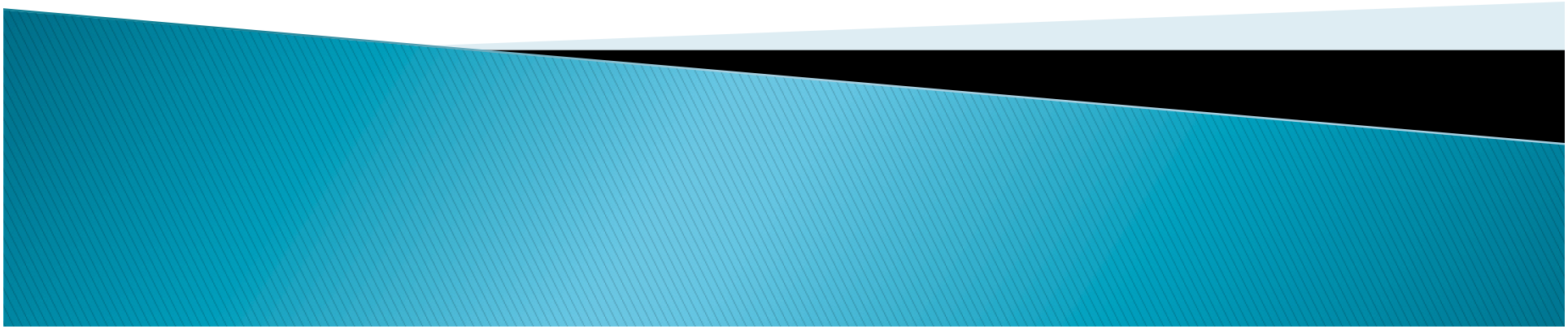
References

Levy, R. C., L. A. Remer, and O. Dubovik, 2007: Global aerosol optical properties and application to Moderate Resolution Imaging Spectroradiometer aerosol retrieval over land. J. Geophys. Res., 112, D13210

Levy, R. C., L. Remer, S. Mattoo, E. Vermote, and Y. J. Kaufman, 2007: Second-generation algorithm for retrieving aerosol properties over land from MODIS spectral reflectance. J. Geophys. Res., 112, D13211, 22 pages.

Remer, L. A., Y. J. Kaufman, D. Tanre, S. Mattoo, D. A. Chu, J. V. Martins, R-R. Li, C. Ichoku, R. C. Levy, R. G. Kleidman, T. F. Eck, E. Vermote, & B. N. Holben, 2004: The MODIS Aerosol Algorithm, Products and Validation. Journal of Atmospheric Sciences, 64, 4, 947-973.

What is IDEA?



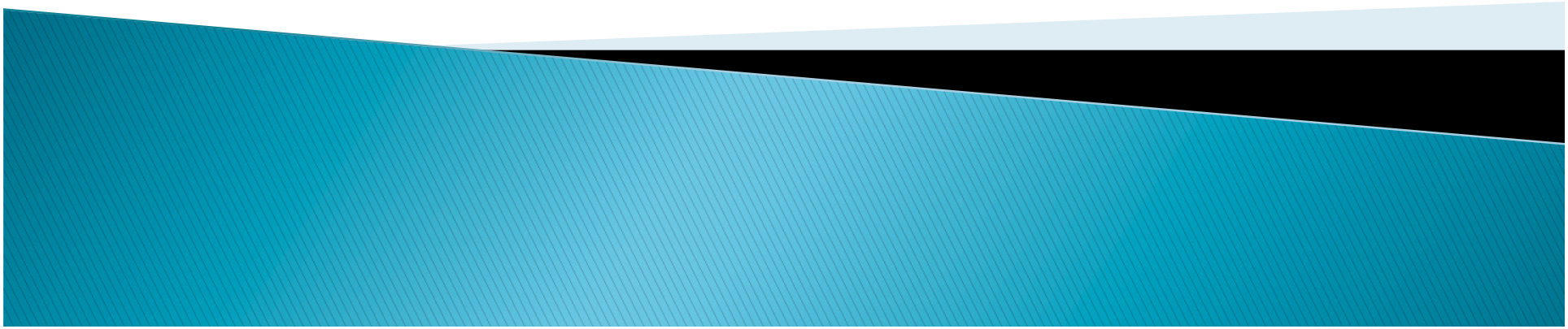
IDEA: NASA-EPA-NOAA partnership to improve air quality assessment, management, and prediction by infusing (NASA) satellite measurements into (EPA, NOAA) analyses for public benefit.

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.

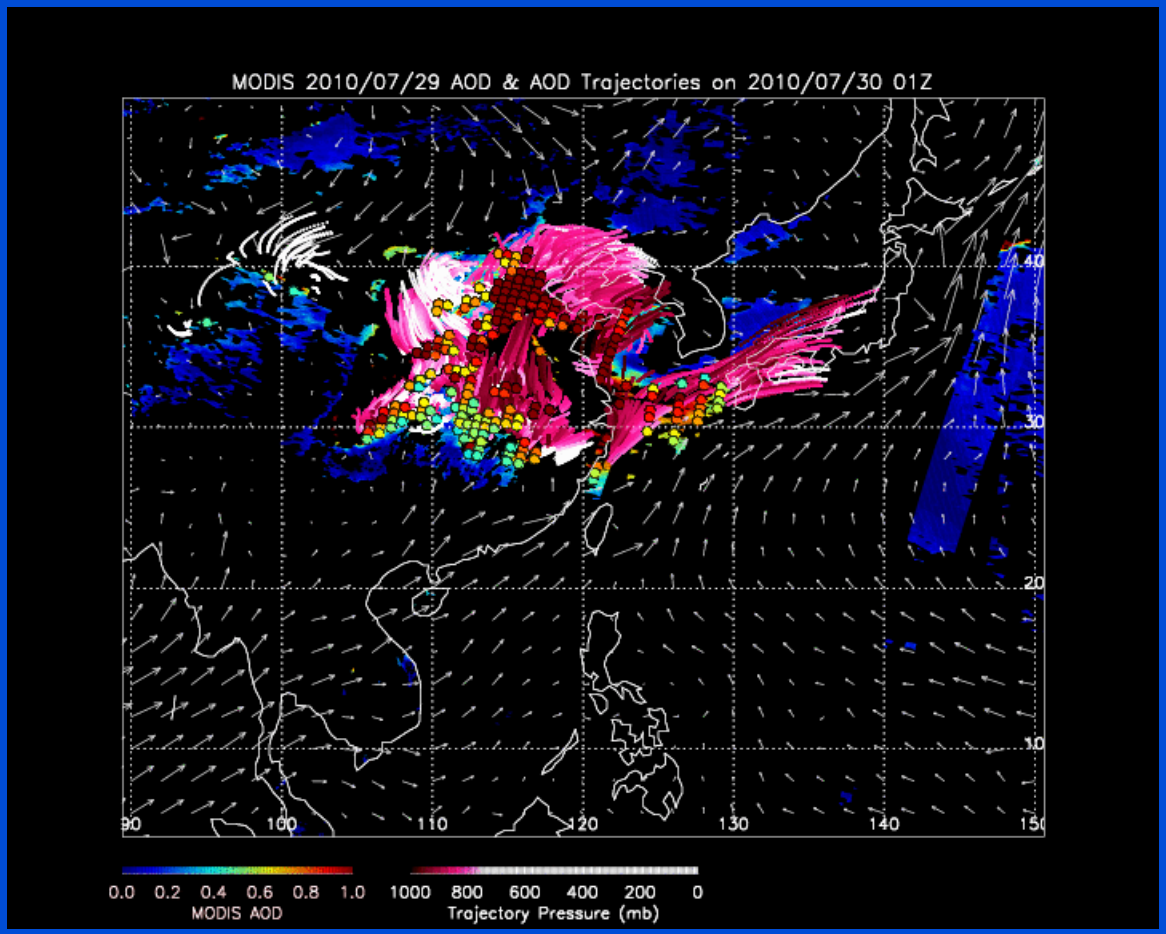
Simple IDEA-I Tutorial

Brad Pierce



Trajectory Forecast

•The trajectory forecast animation displays the most important components of an aerosol forecasts



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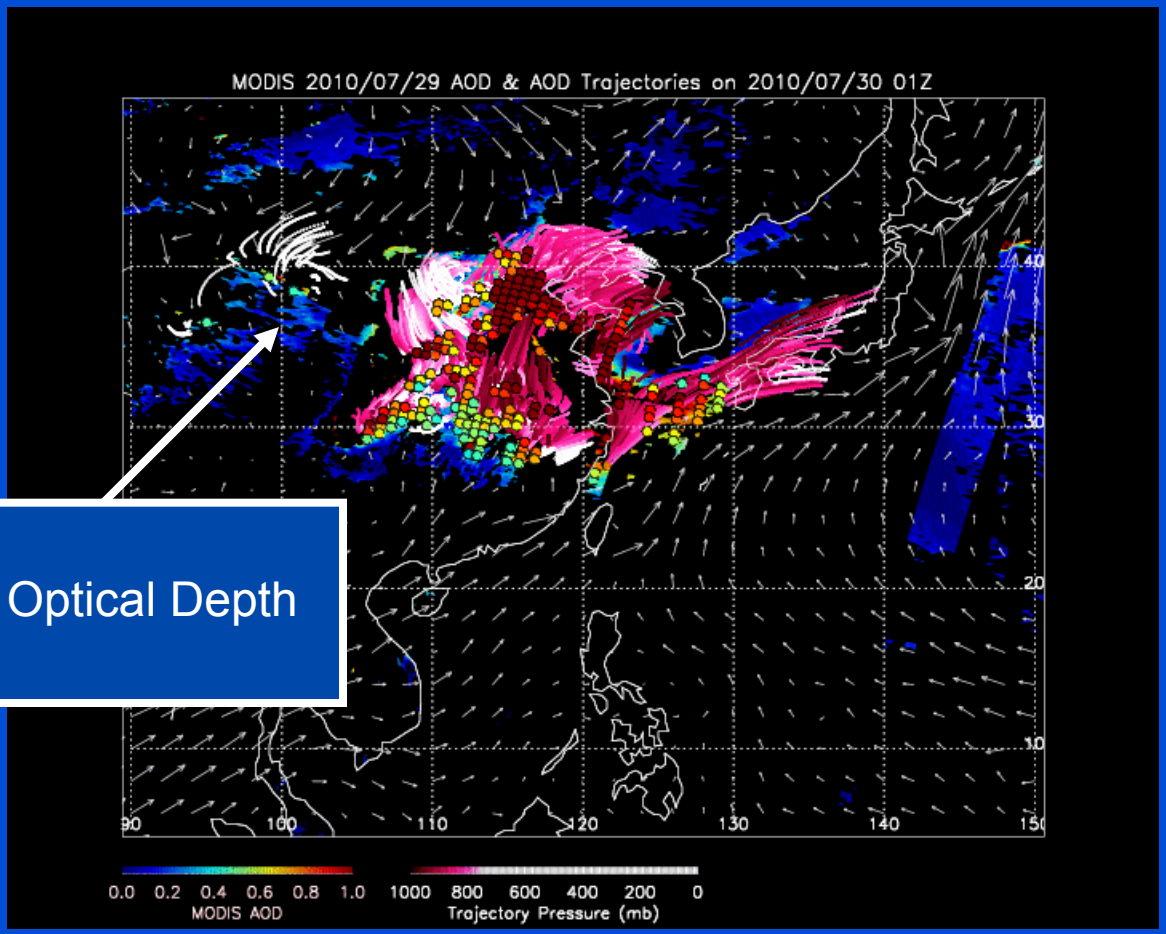
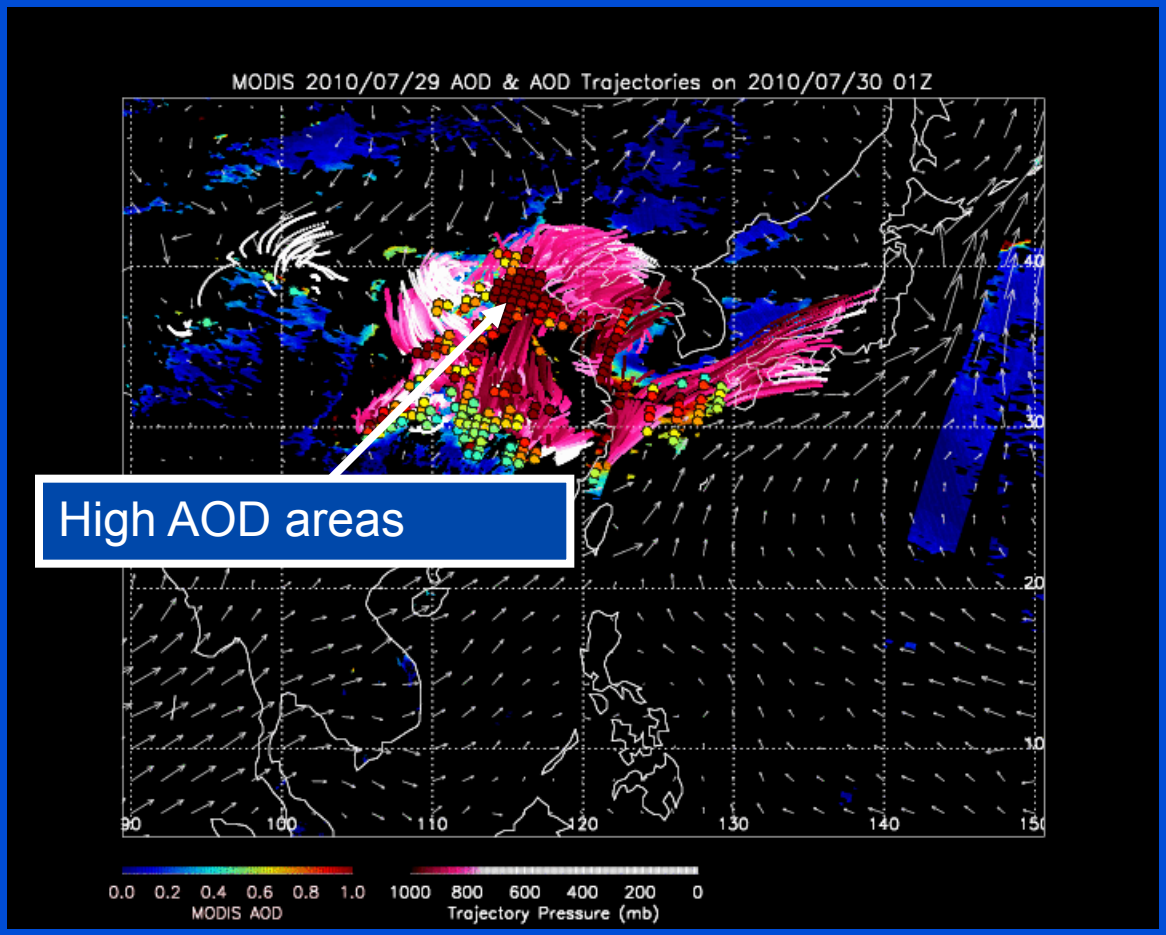


MODIS
Aerosol Optical Depth
(AOD)

Trajectory Forecast

- The trajectory forecast animation displays the most important components of an aerosol forecasts



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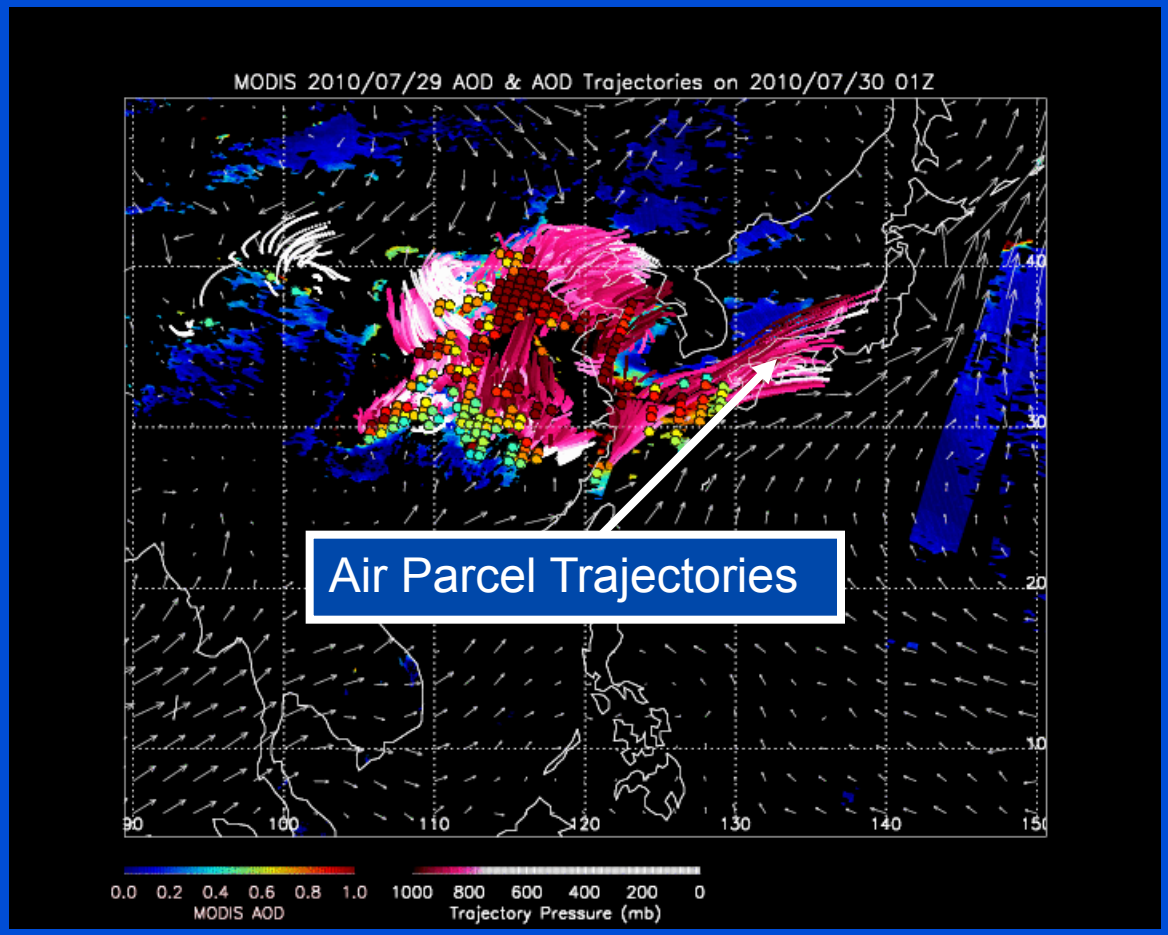
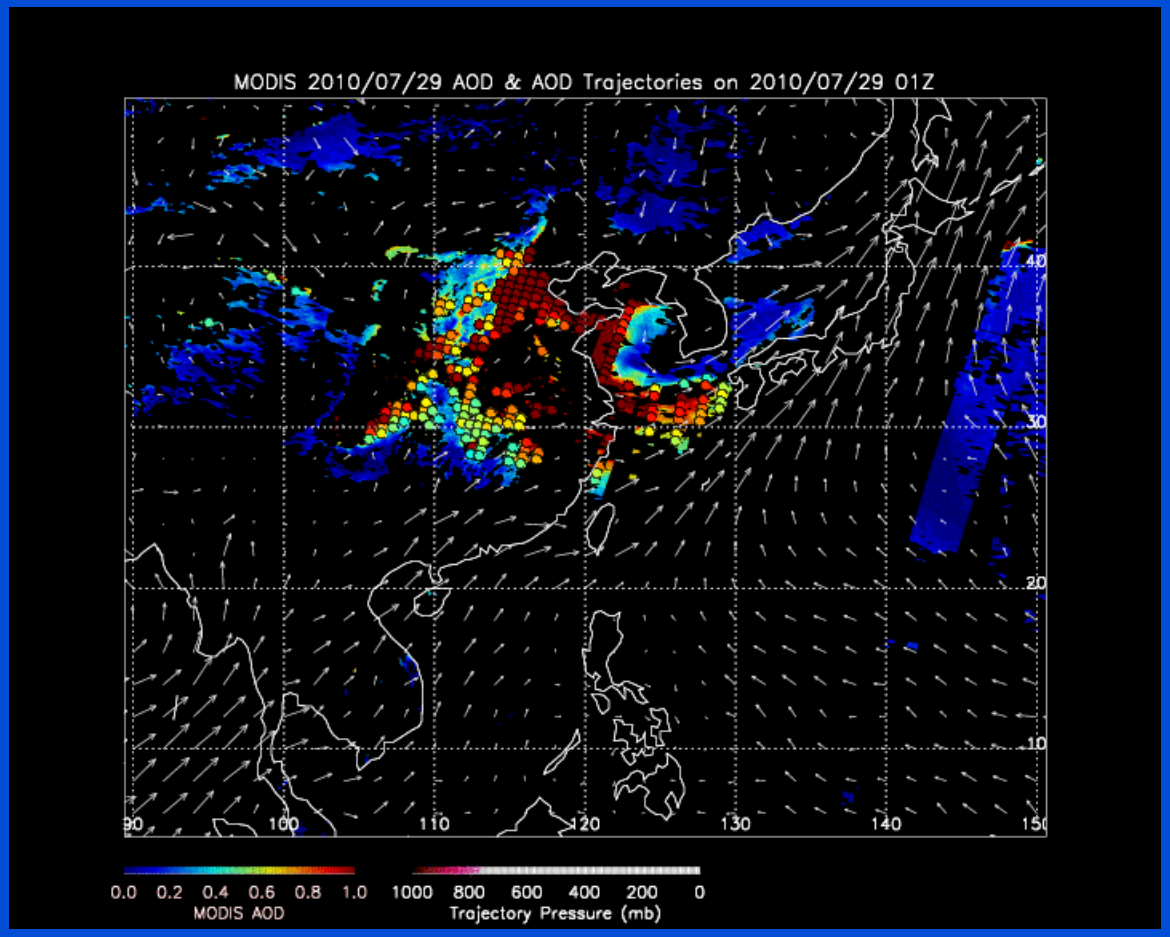


Trajectory Forecast - Initialization

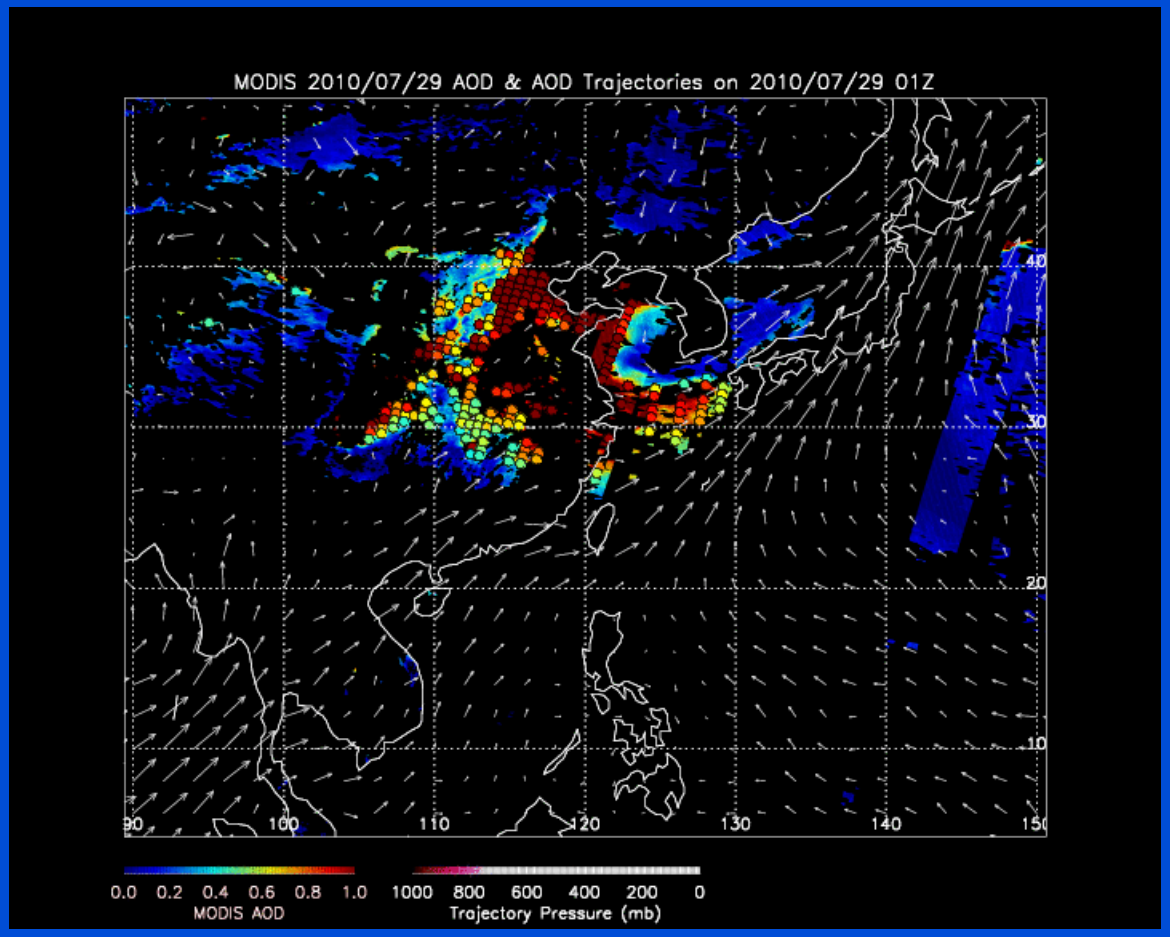
- The trajectory forecast begins when the MODIS overpass occurs

- High values of AOD (>0.4) are located and used to initialize the trajectories



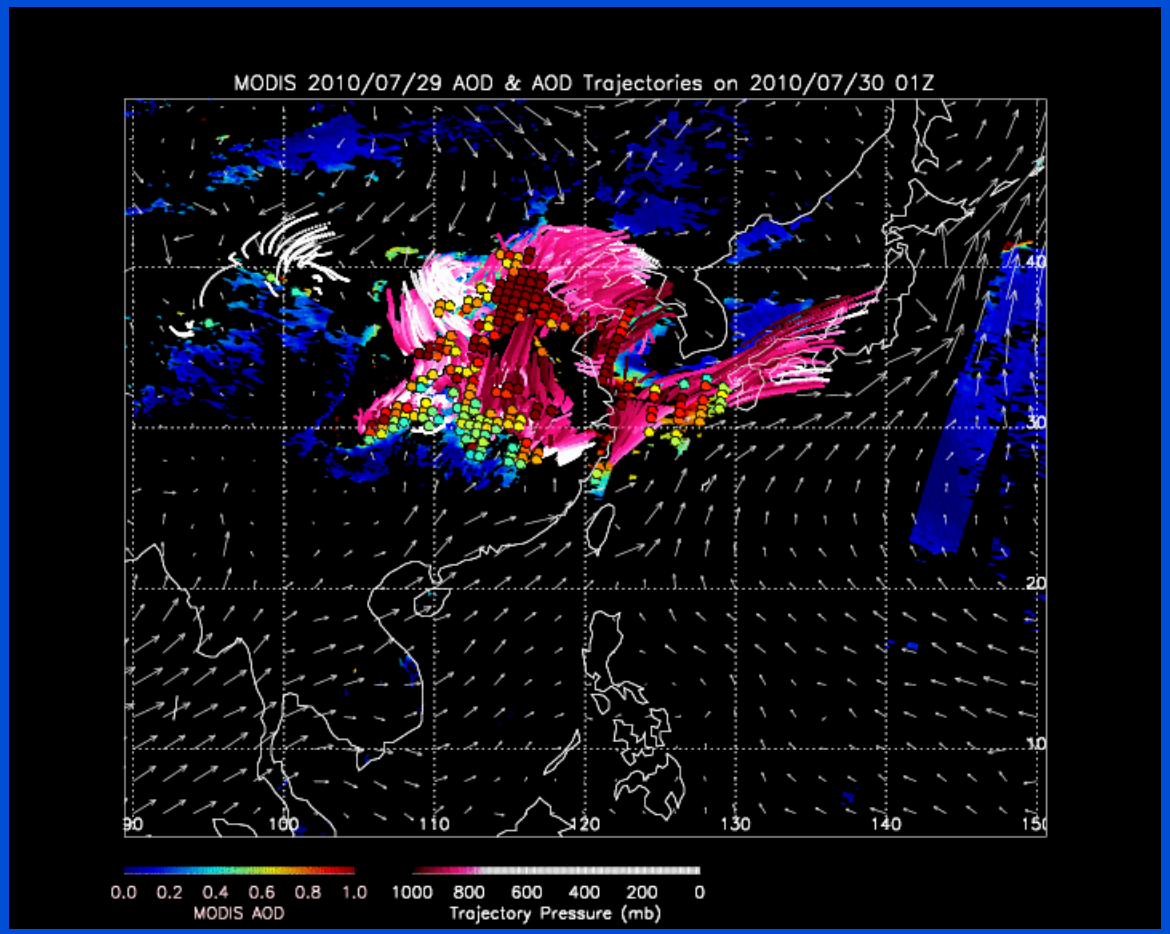
Trajectory Forecast - Initialization

- The high MODIS AOD values are determined by calculating mean AOD values on a 50kmx50km grid, or 5 pixels square



Trajectory Forecast

- The trajectories are initialized at the high AOD values at 50mb, 100mb, 150mb, and 200mb above the surface
- The air parcel trajectories are run using the 12Z NOAA/ NCEP GFS forecast data providing a 48hr forecast via trajectories
- The pressure levels of the trajectories are plotted in mb and colored to a magenta-white scale. White indicates that the air parcel no longer affects the surface

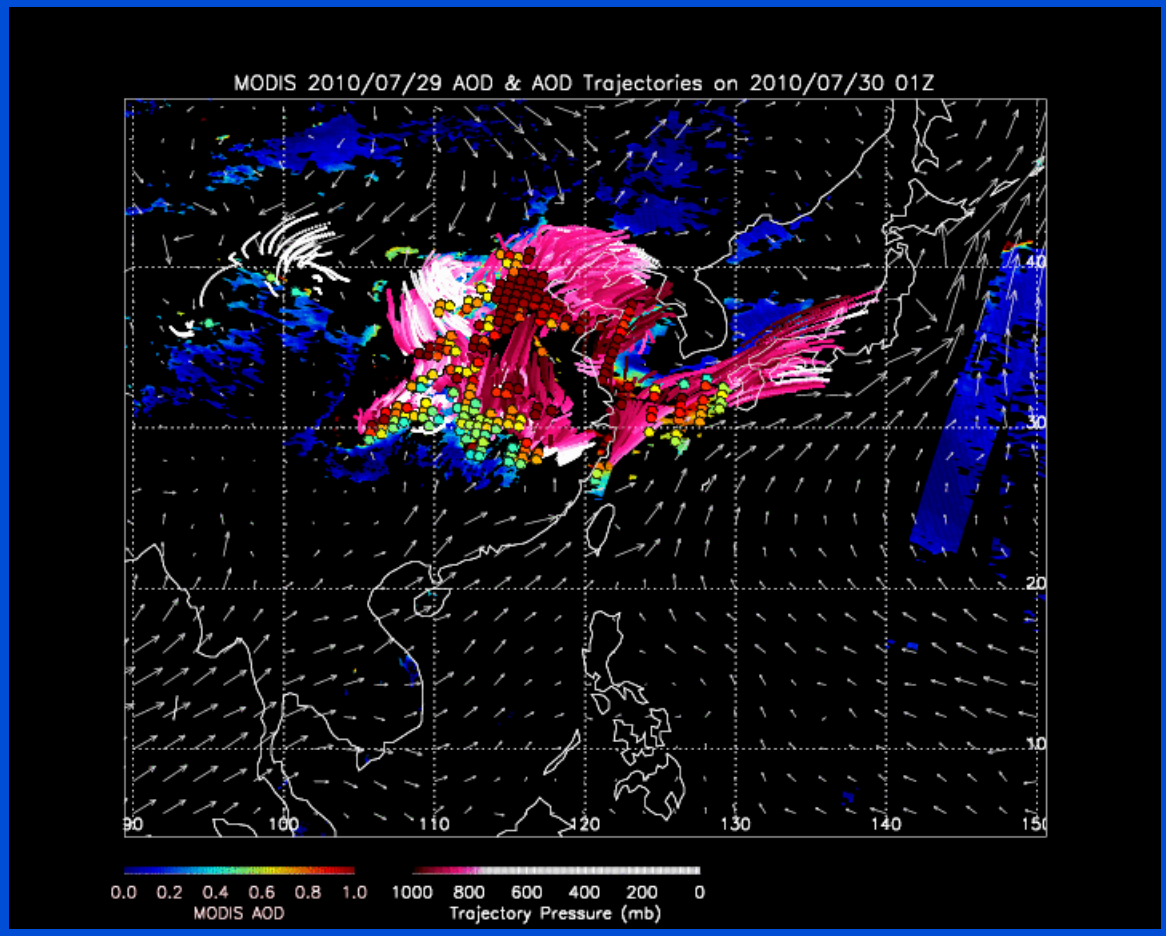


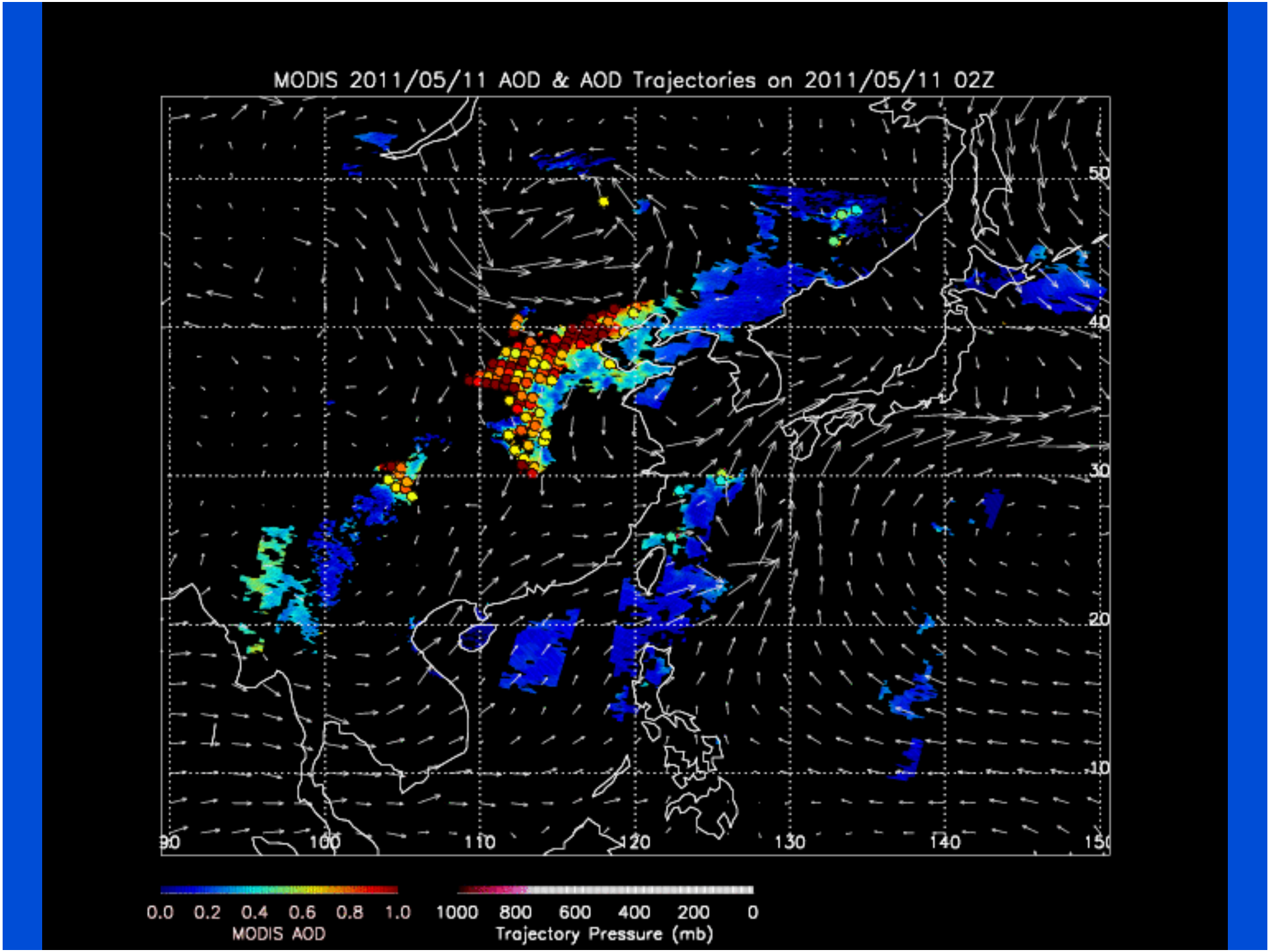
Trajectory Forecast

- The most recent 12 hours of the 48 hour forward trajectories are plotted at each frame of the animation.

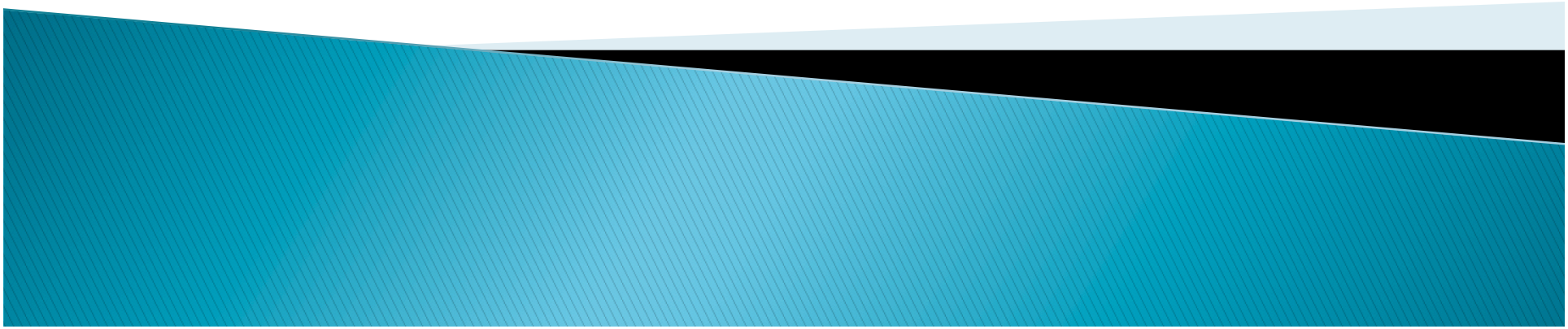
- The most recent day of MODIS data remains on the plot.

- The 850mb wind field vectors are plotted to show wind direction and speed.




MODIS 2011/05/11 AOD & AOD Trajectories on 2011/05/11 02Z
50
40
30
20
10
90
100
110
120
130
140
150
0.0 0.2 0.4 0.6 0.8 1.0
MODIS AOD
1000 800 600 400 200 0
Trajectory Pressure (mb)

IDEA-I Notes



References

- Al-Saadi, J. A. et al., 2005: Improving National Air Quality Forecasts with Satellite Aerosol Observations, BAMS, DOI:10.1175/BAMS-86-9-1249.

References continued

- R. Bradley Pierce, et. al, “Impacts of background ozone production on Houston and Dallas, Texas, air quality during the Second Texas Air Quality Study field mission”, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, D00F09, doi: 10.1029/2008JD011337, 2009
- R. Bradley Pierce and T. Duncan A. Fairlie, 1993 “Chaotic Advection in the Stratosphere- Implications for the Dispersal of Chemically Perturbed Air From the Polar Vortex”, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 98, NO. D10, PAGES 18,589-18,595.

Trajectory Model and .dat files

- Trajectory Model is included in the IDEA-I
  - GFS_traject_3d_v01.f

  Located in the /ideai/IMAPP_IDEA/Traject
- Trajectory forecast images are created from the daily trajectory forecast .dat files
  - Ex: traj_48hr_20110531.dat
- Dr. Bradley Pierce gave me information about how to read the .dat files using an IDL program. Ask, and I will give it to you.

Limitations

- Terra only retrievals
- Limitations of MOD04
  - Clouds
  - Bright surfaces
  - 10 km resolution
  - Aerosols too thick
- The time it takes to run the trajectory forecast is proportional to how much aerosols are found (~3 hours)