Synergy of MODIS Deep Blue and Operational Aerosol Products with MISR and SeaWiFS

N. Christina Hsu and

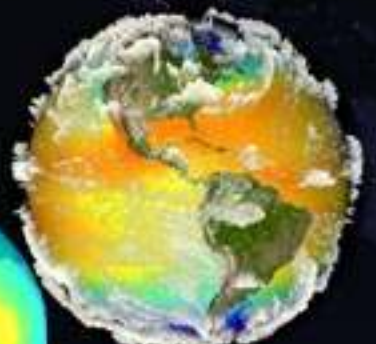
S.-C. Tsay, M. D. King, M.-J. Jeong

NASA Goddard Space Flight Center

Greenbelt, Maryland USA

NASA's Vision:
To improve life here,
To extend life to there,
To find life beyond.

- *Solar radiation is the sole large-scale source of diabatic heating that drives the weather & climate system on planet Earth.*
- *Terrestrial radiation keeps the planet in balance to make Earth habitable for all forms of life.*



- *Aerosols may play an important role in modifying solar and terrestrial radiation.*
- *Understanding that role is critical to understanding the energy balance that shapes our weather/climate.*

Understanding the role of aerosols means

Understanding how the properties of those aerosols…

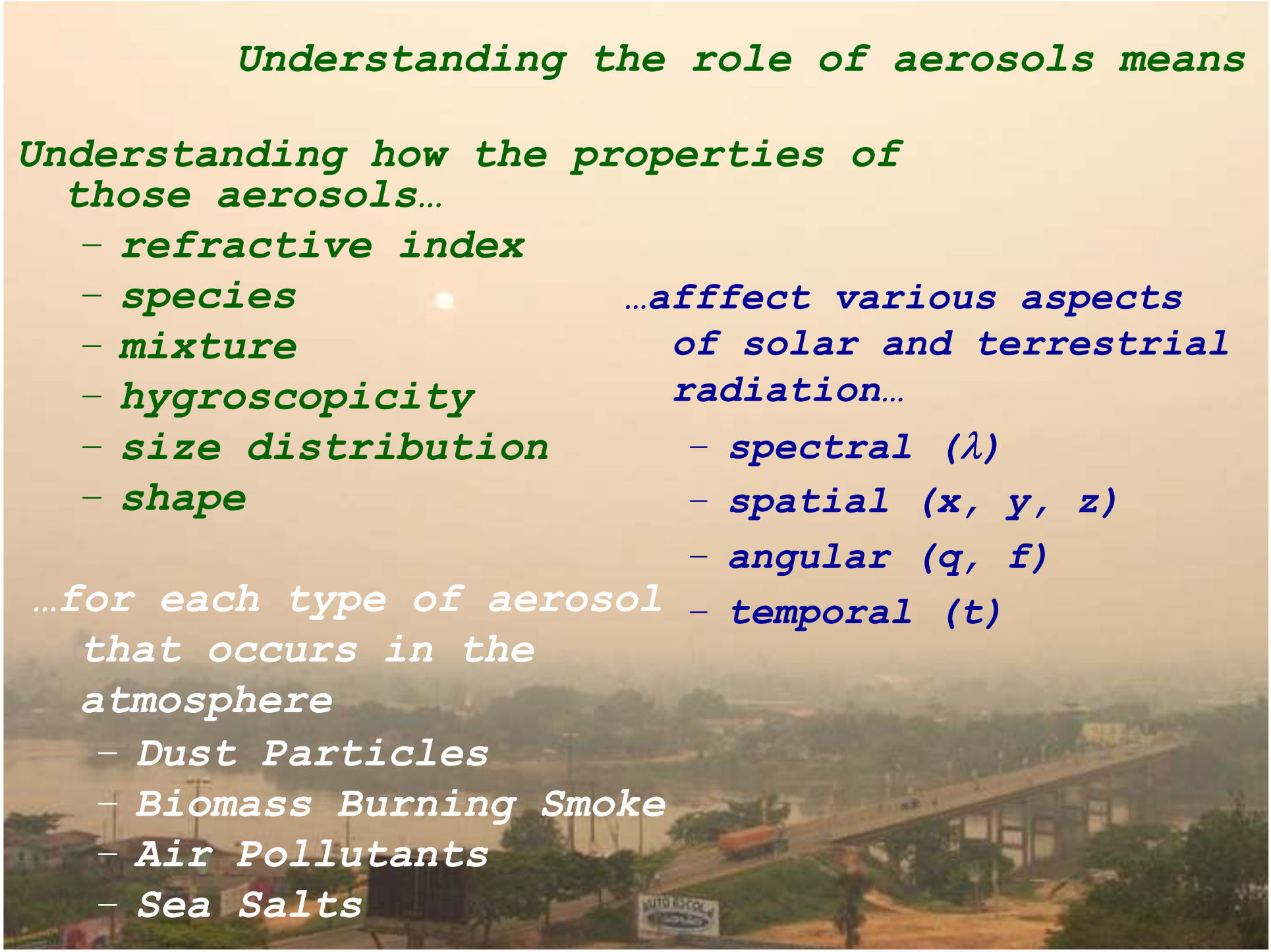
- *refractive index*
- *species*
- *mixture*
- *hygroscopicity*
- *size distribution*
- *shape*

…for each type of aerosol that occurs in the atmosphere

- *Dust Particles*
- *Biomass Burning Smoke*
- *Air Pollutants*
- *Sea Salts*

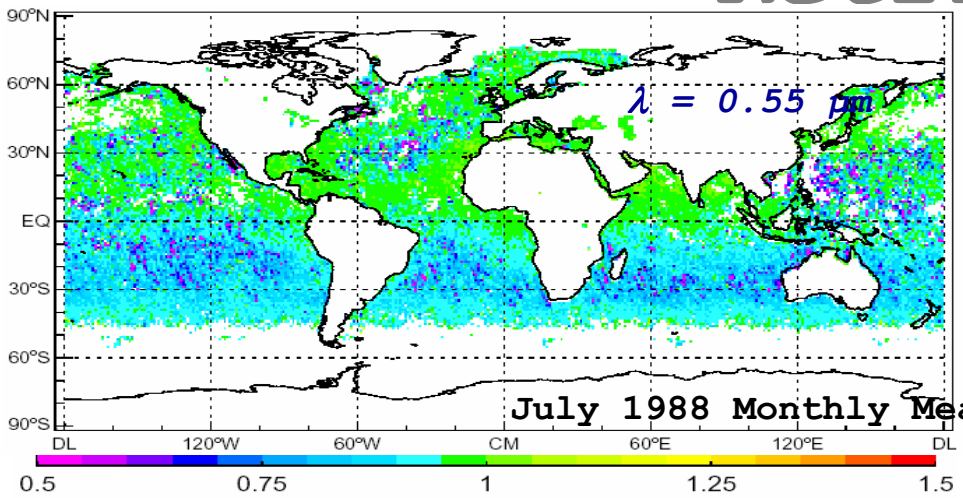
…affect various aspects of solar and terrestrial radiation…

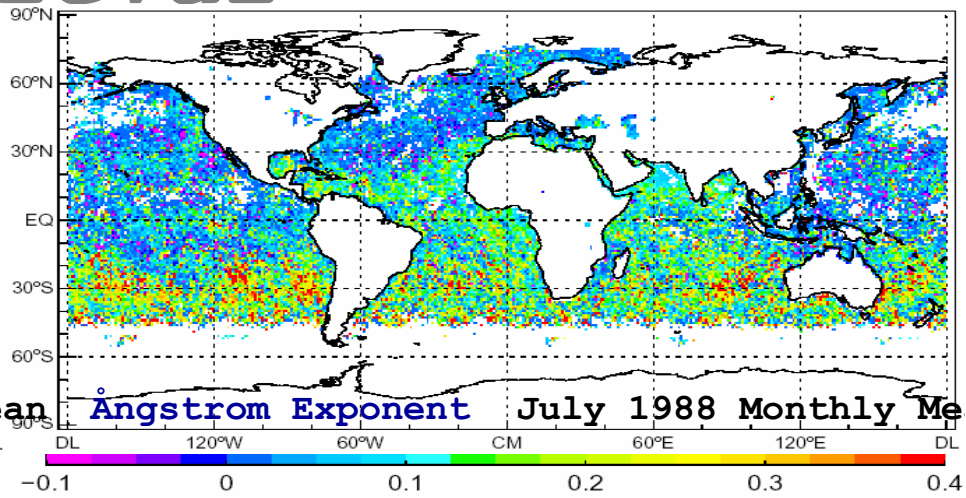
- *spectral (λ)*
- *spatial (x, y, z)*
- *angular (q, f)*
- *temporal (t)*



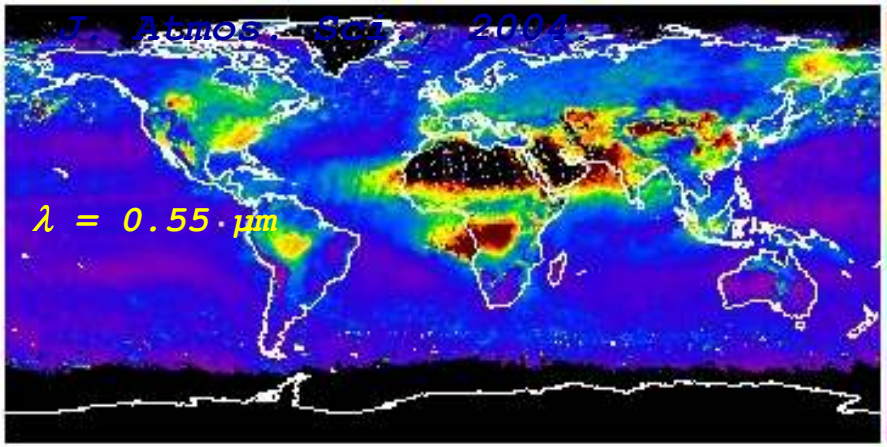
Aerosol Remote Sensing & Retrieval

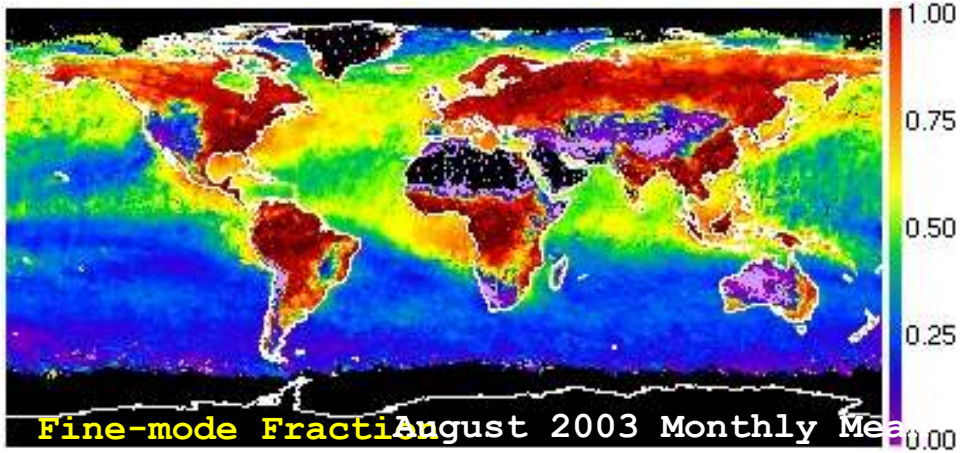
The early days of AVHRR, since 1983: Geogdzhayev, Mishchenko, et al., J. Atmos. Sci.,



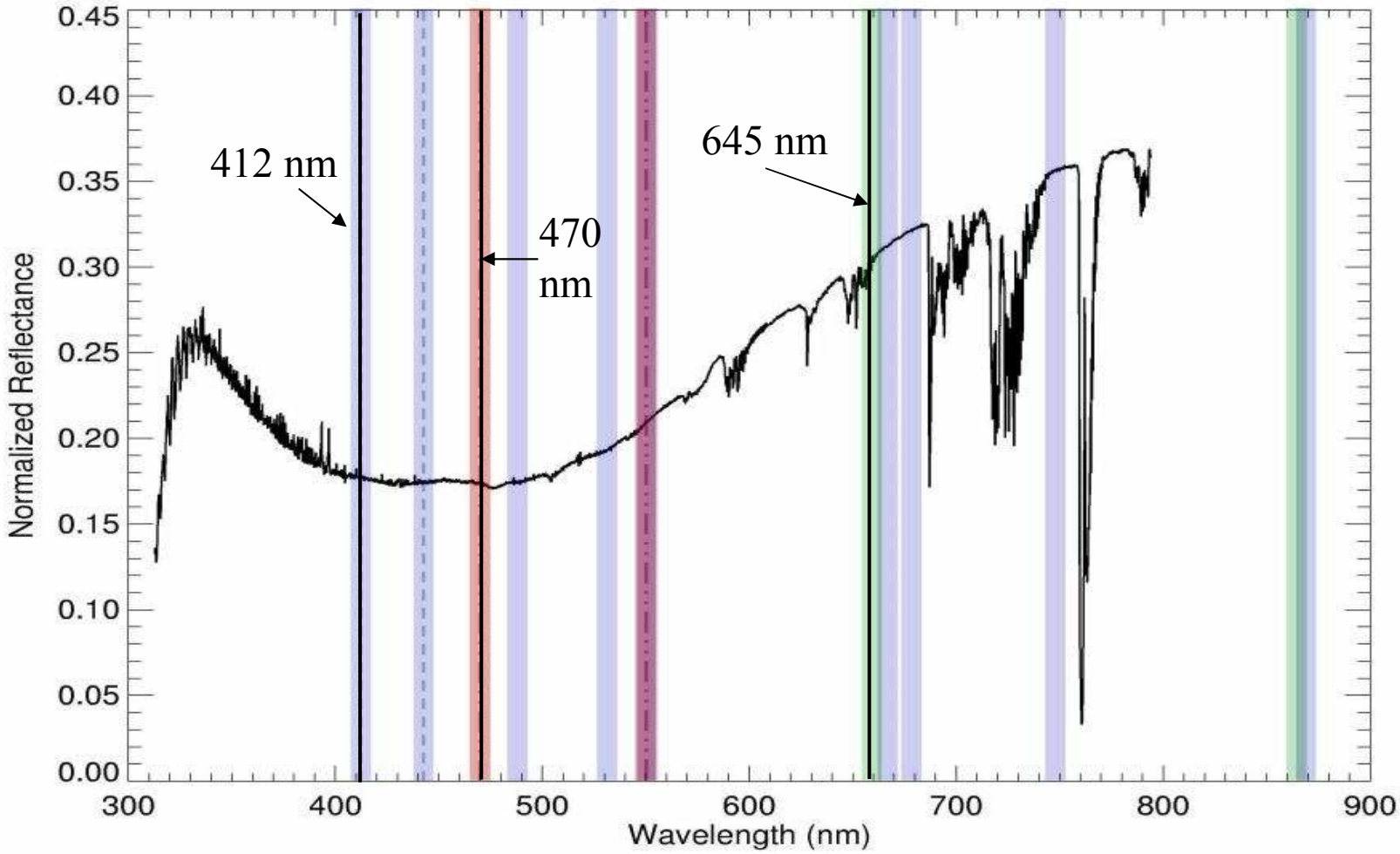


The current days of MODIS, since 2000: Remer, Kaufman, Tanré, et al.,





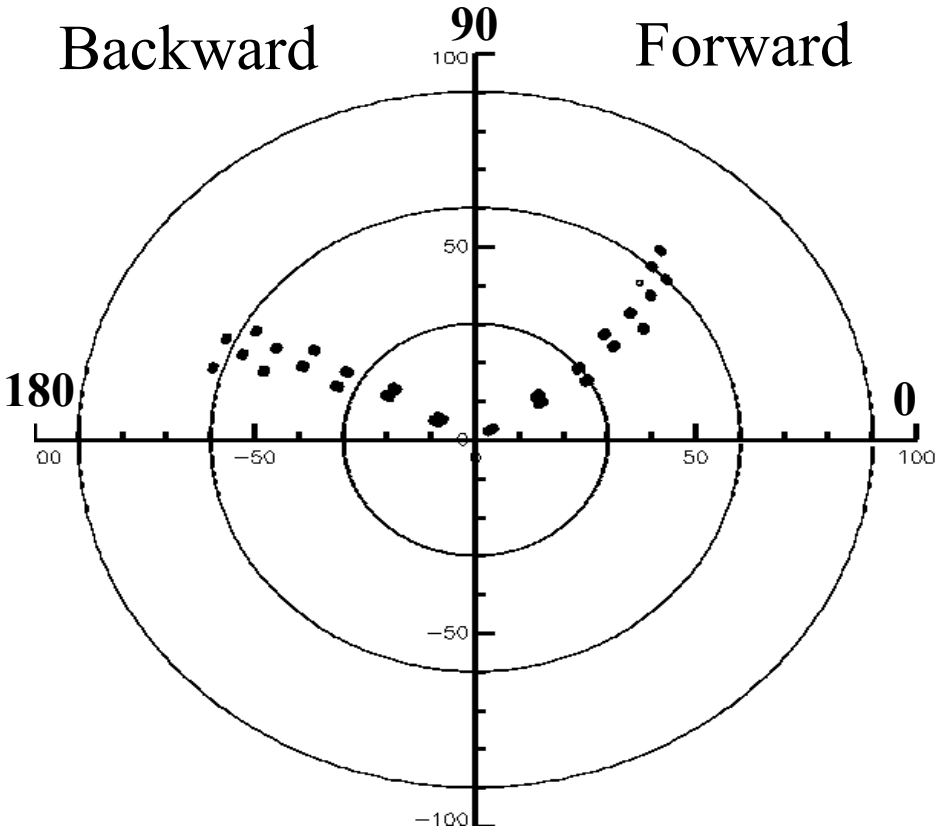
Visible & NIR Bands: superimposed on the GOME spectral reflectance taken over the Sahara MODIS



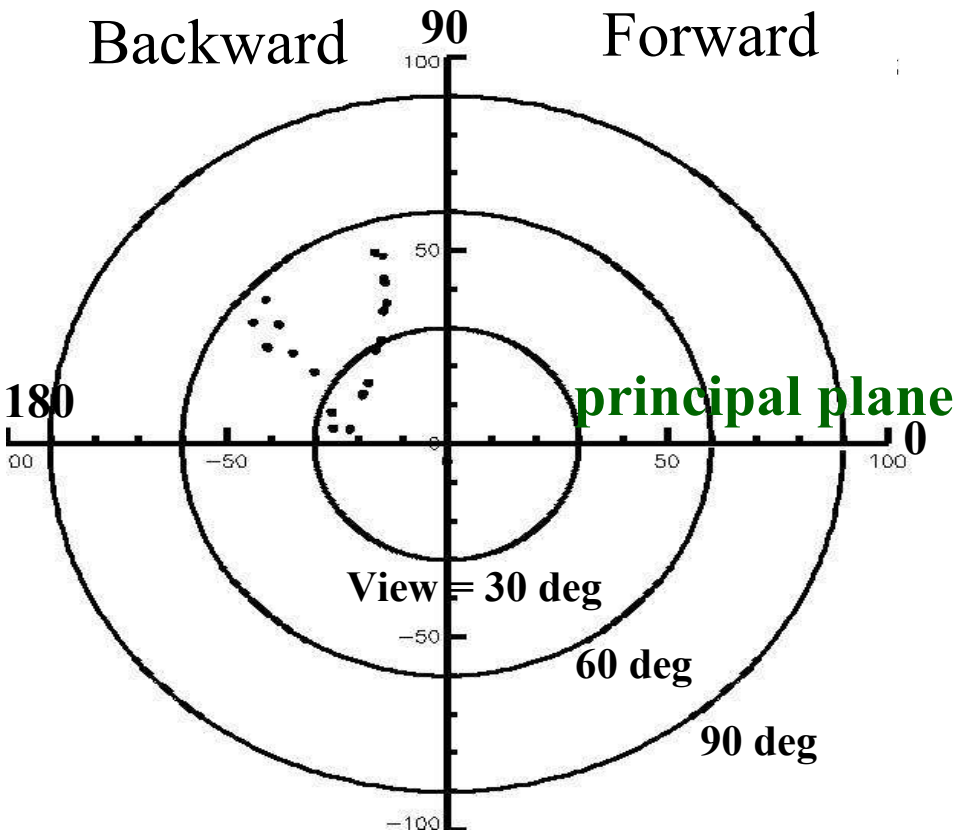
Viewing Geometry Differences

View Angle vs. Relative Azimuth Angle

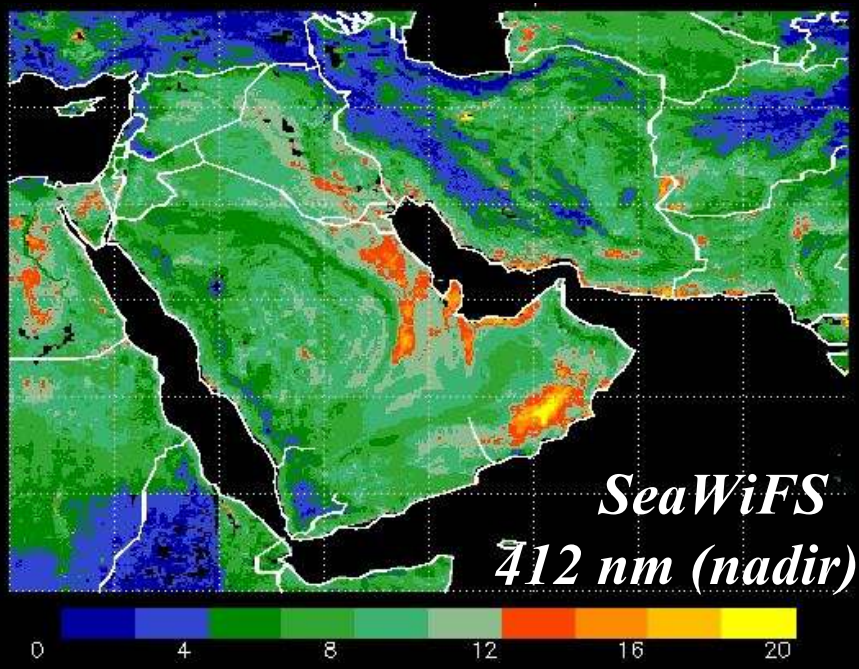
Aqua

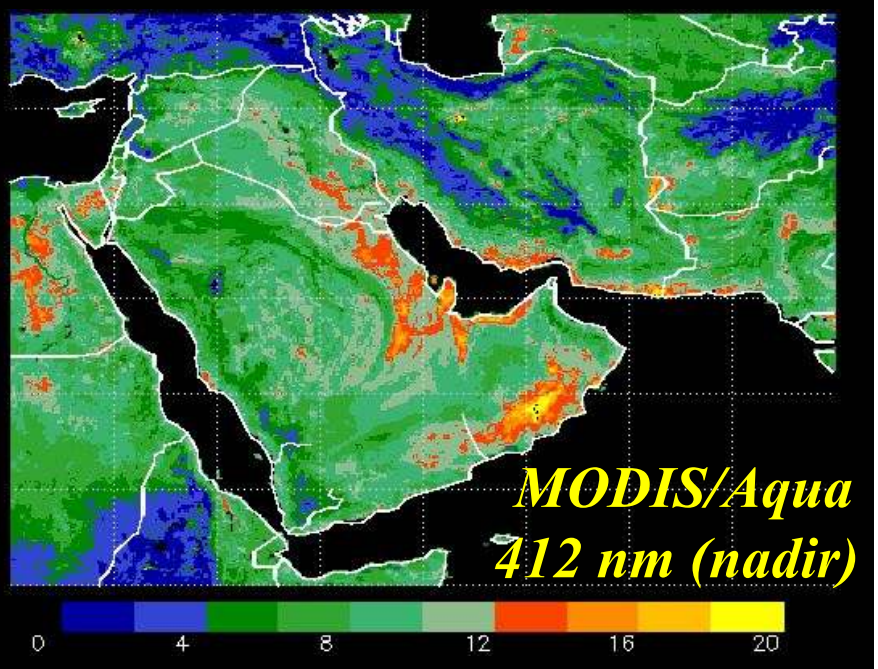


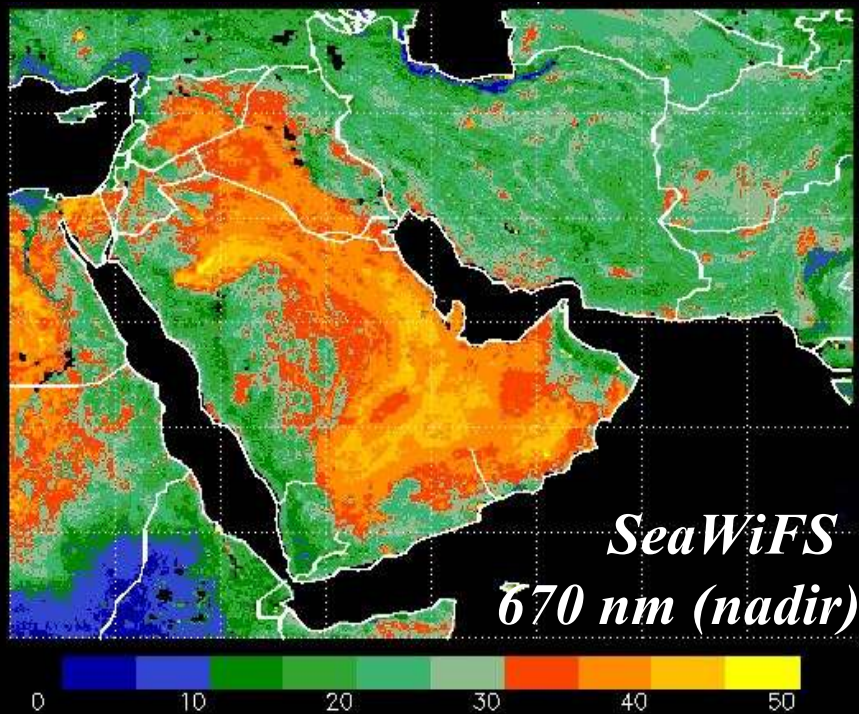
SeaWiFS

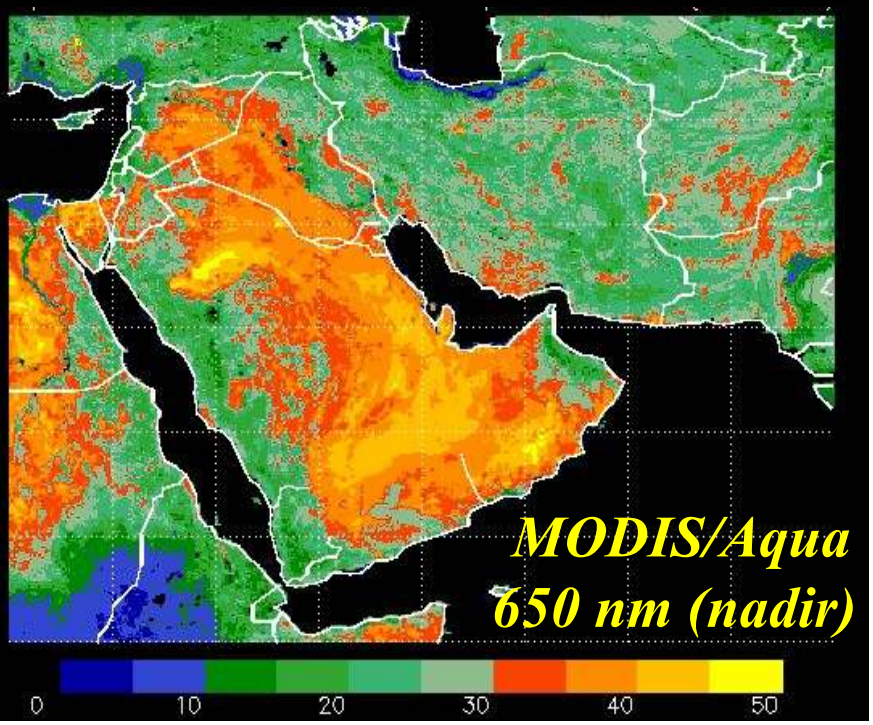


Surface Reflectance Data Base - Sep 2004

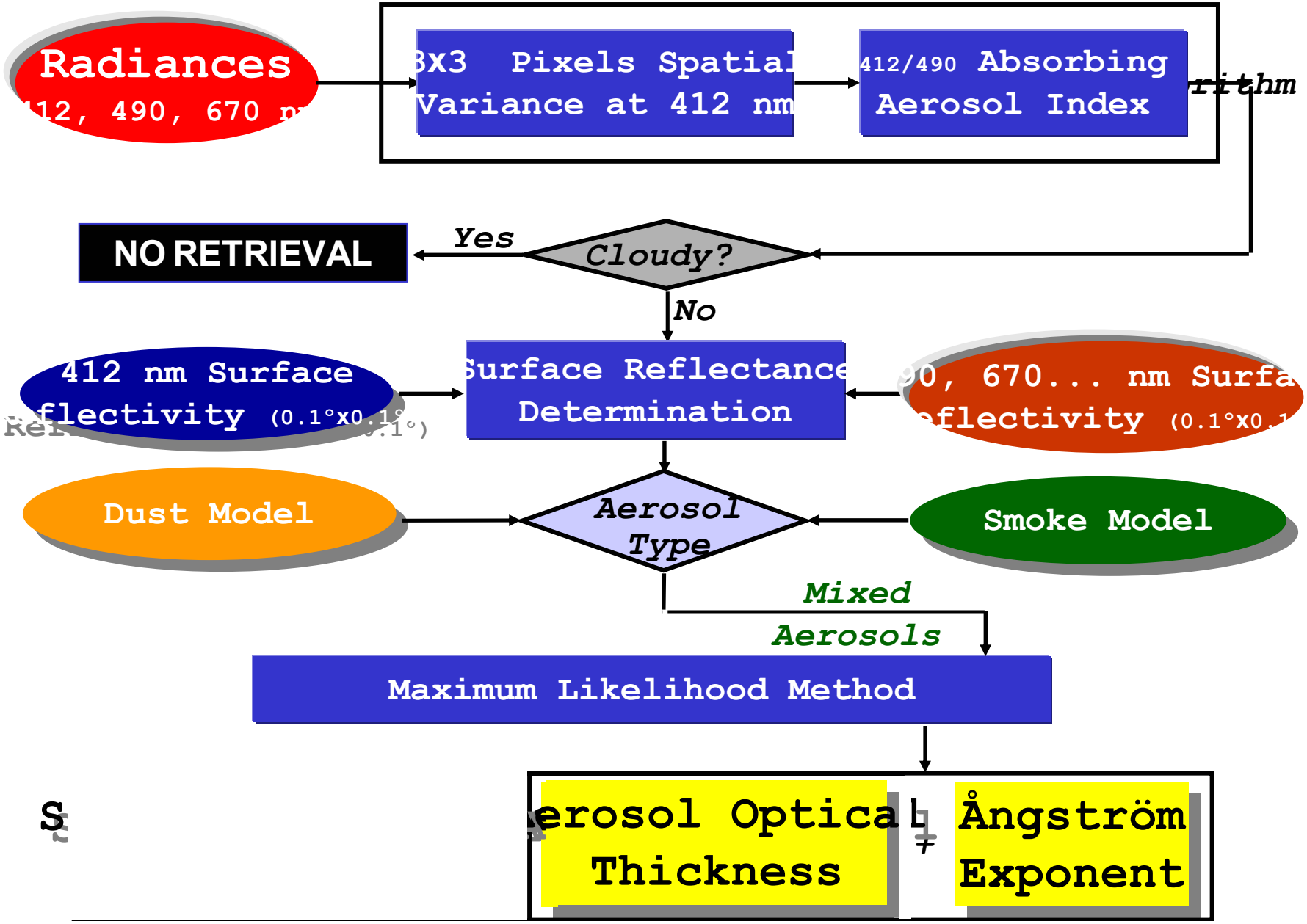




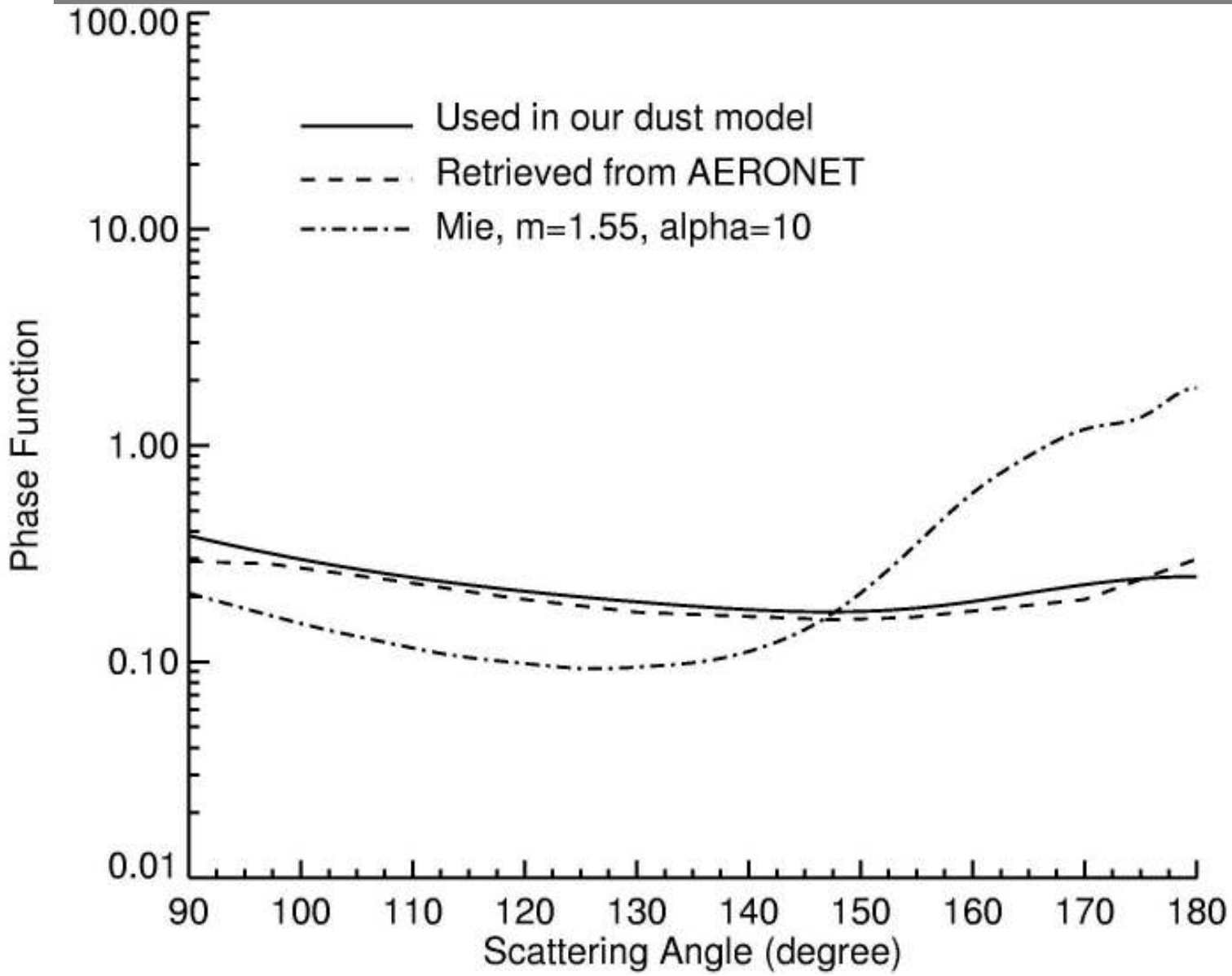




Flowchart for Deep Blue Algorithm

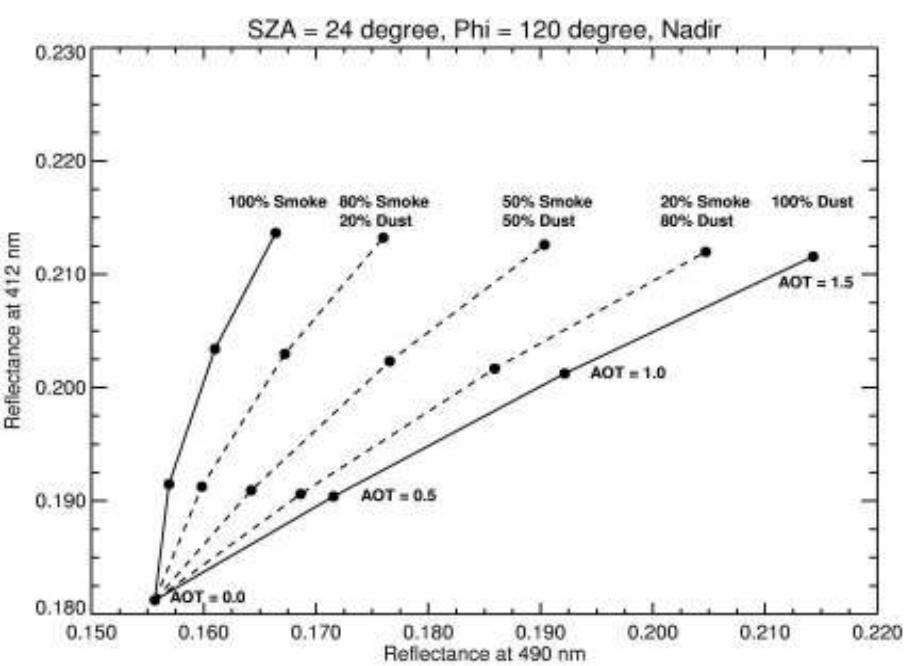


Phase Function for Dust Model



The aerosol characteristics used to generate the simulated radiances in these two figures are shown below

Aerosol Model	τ_{412}/τ_{470}	τ_{490}/τ_{470}	Refractive Index 412 nm	Refractive Index 490 nm	ω_0 412 nm	ω_0 490 nm
Dust	1.00	1.00	1.55 – 0.020i	1.55 – 0.008i	0.91	0.96
Smoke	1.30	0.92	1.55 – 0.022i	1.55 – 0.026i	0.90	0.89

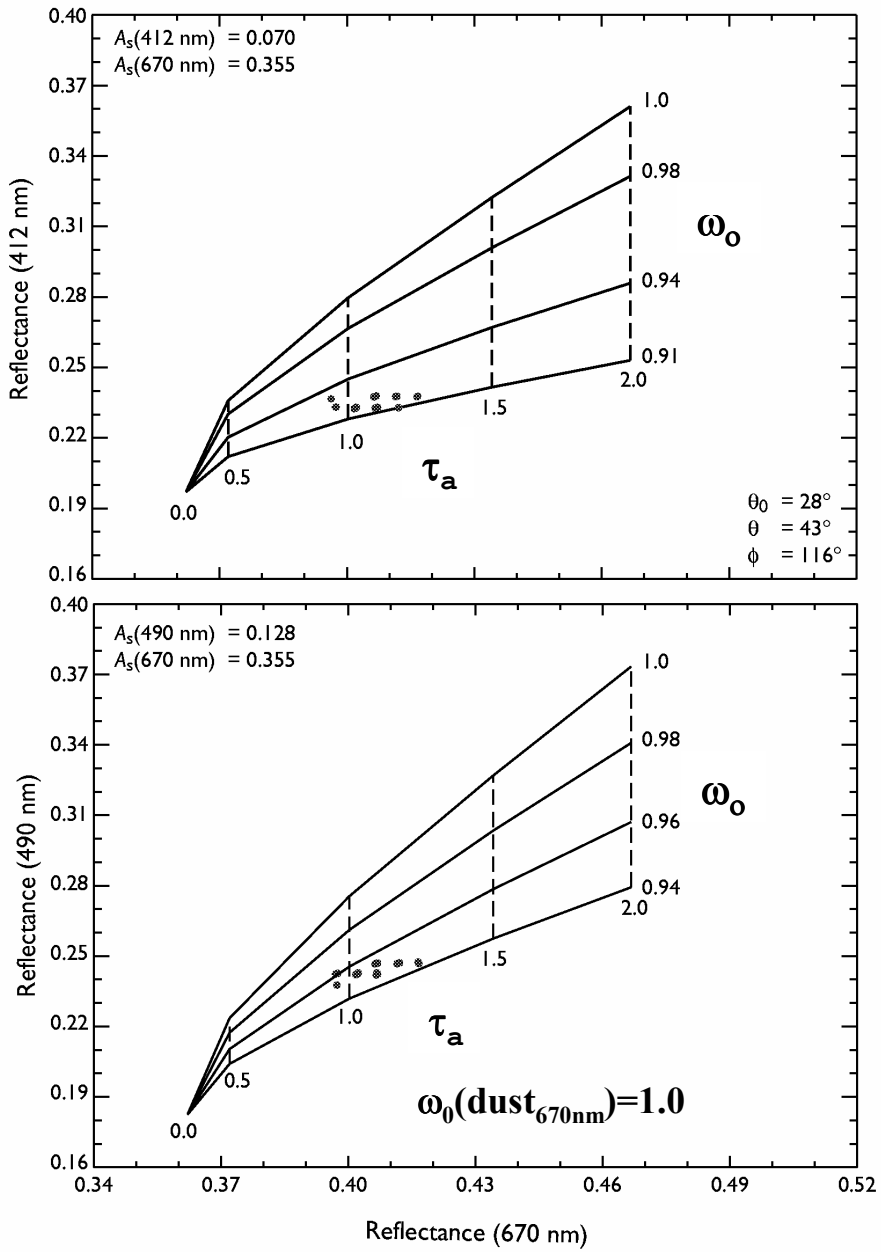


In areas of mixed aerosol types, we linearly mix radiances from the dust aerosol model, R^{dust}, with those from the smoke aerosol model, R^{smoke}

$$= aR^{dust} + (1-a)R^{smoke}$$

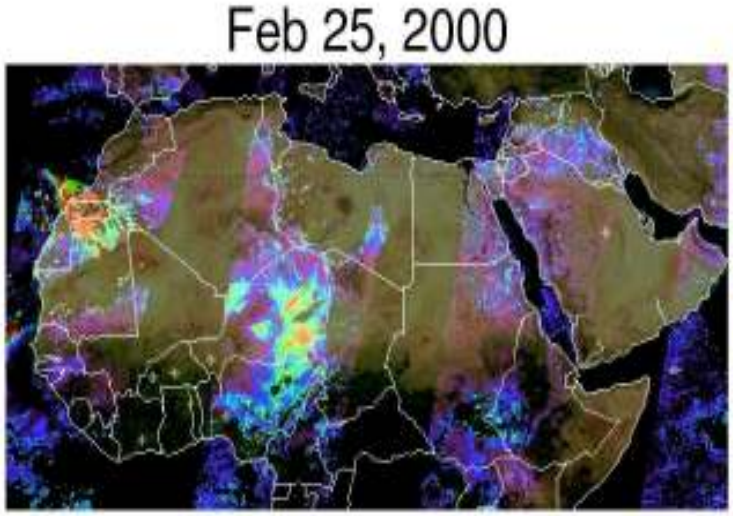
Gaussian distribution with a peak at 3 km and a width of 1 km was assumed

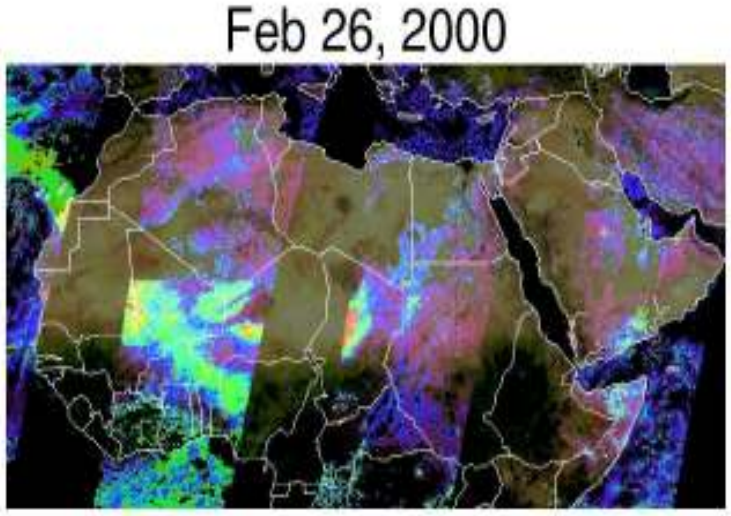
Deep Blue Algorithm for SeaWiFS/MODIS

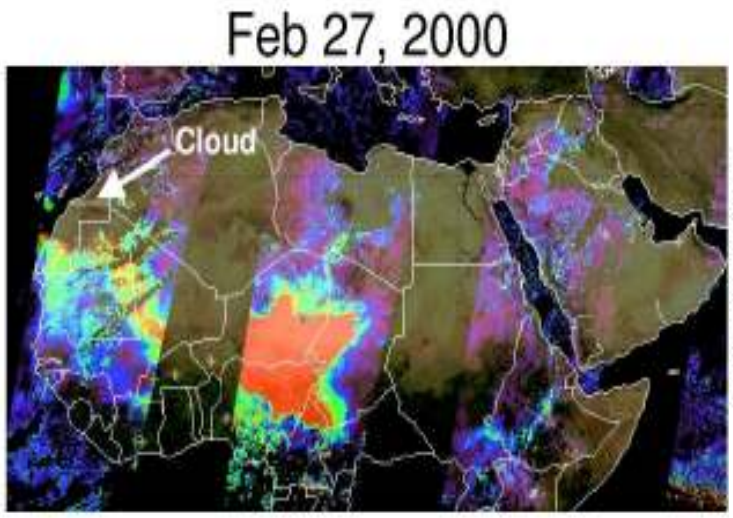


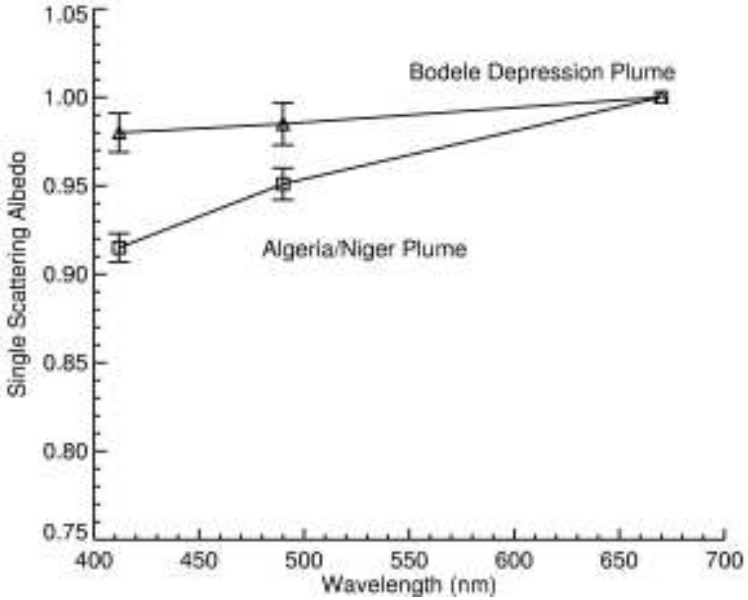
- Utilize solar reflectance at λ = 412, 490, and 670 nm to retrieve aerosol optical thickness (τ_a) and single scattering albedo (ω_o).
- Less sensitive to aerosol height, compared to UV methods.
- Works well on retrieving aerosol properties over various types of surfaces, including very bright desert.

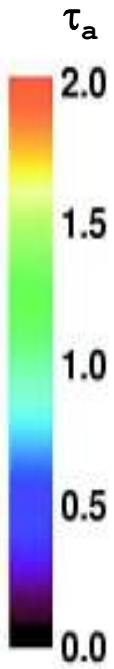
Aerosol Optical Thickness Retrieved from Deep Blue Algorithm: Dust plumes in Africa





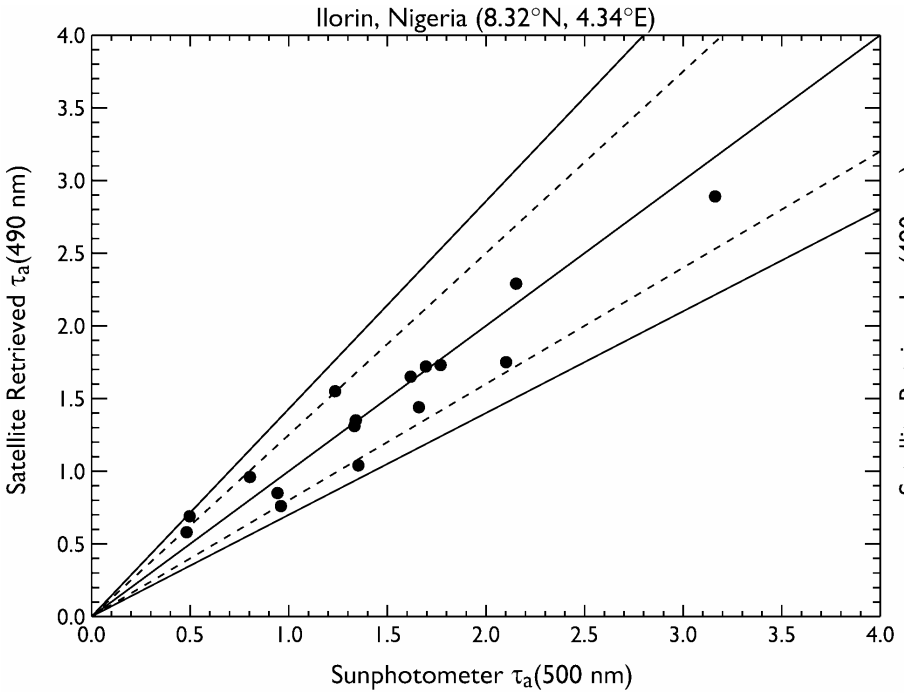




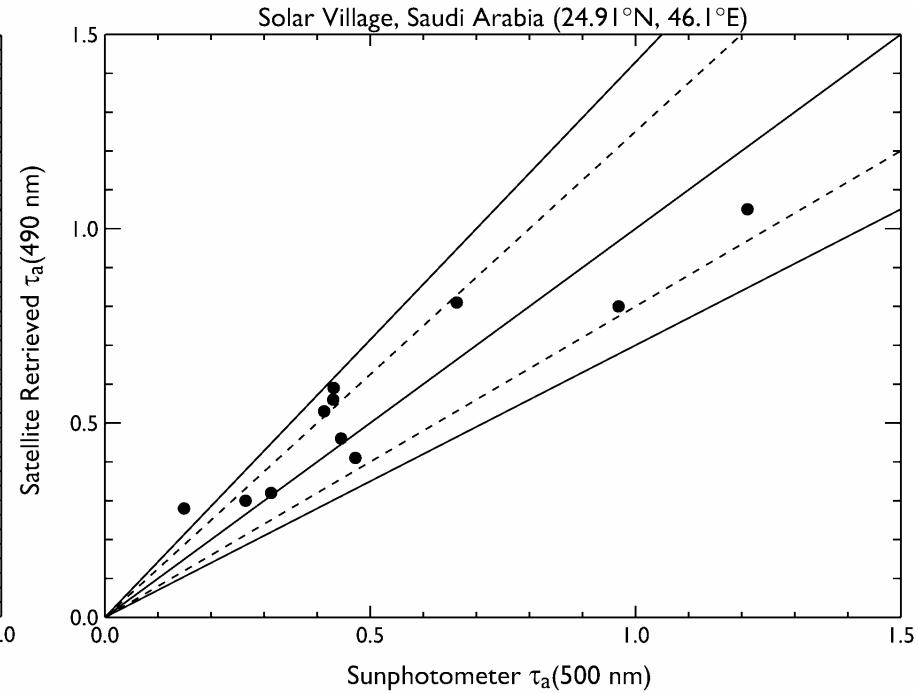


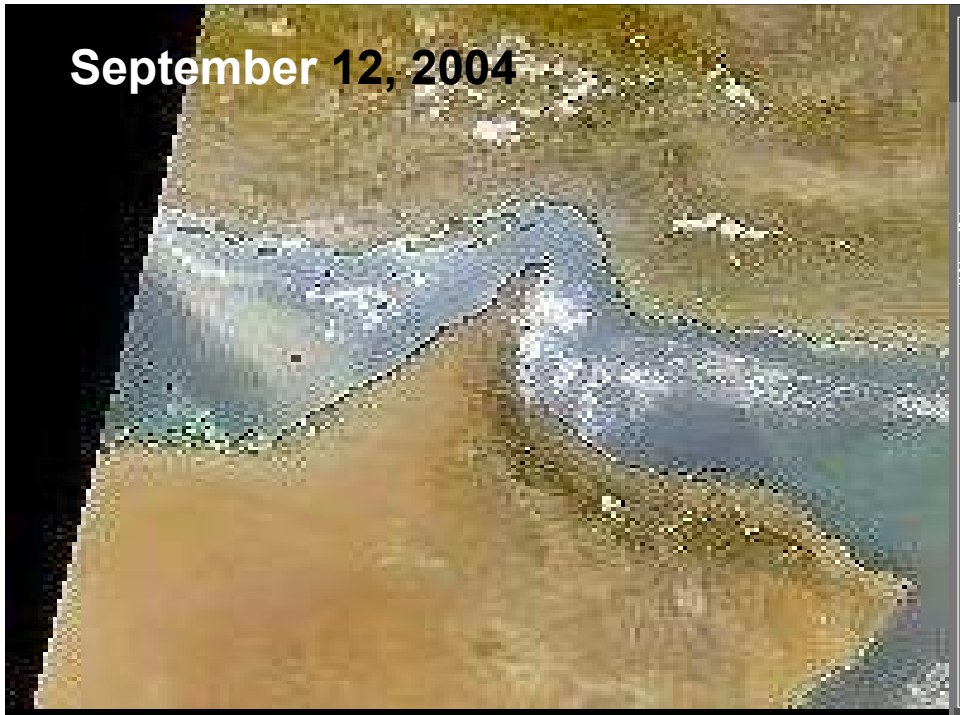
Validation: Comparisons with AERONET Aerosol Optical Thickness

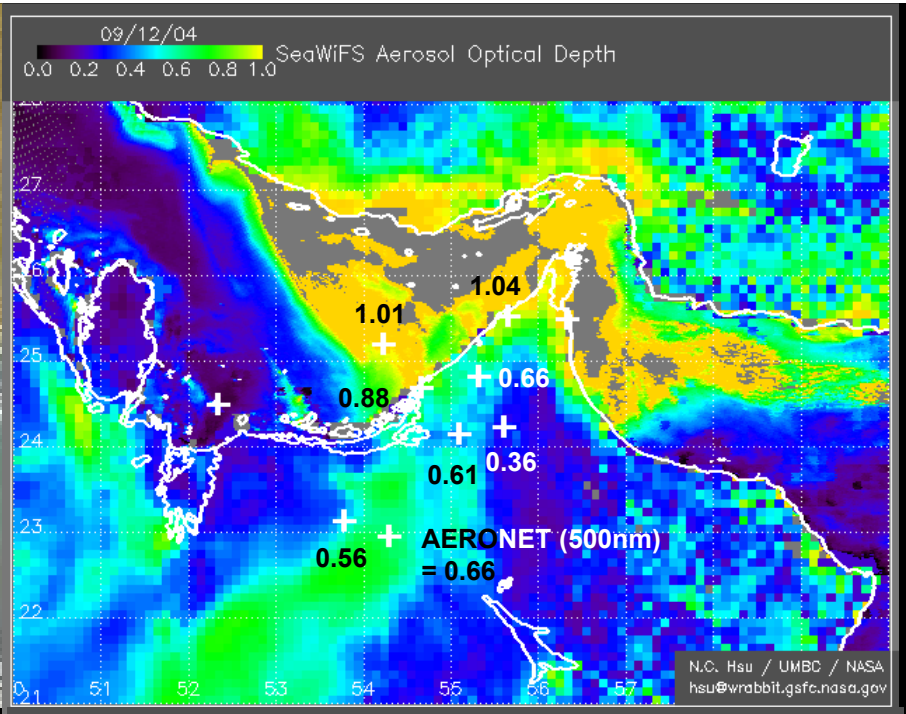
North Africa
February 2000

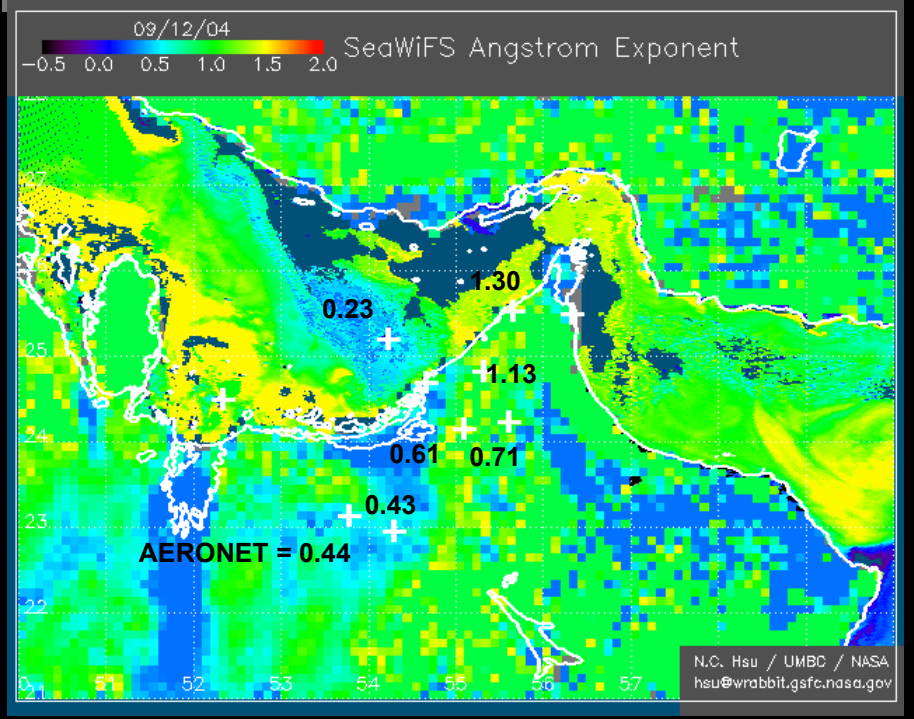


Arabian Peninsula
June - July 2000







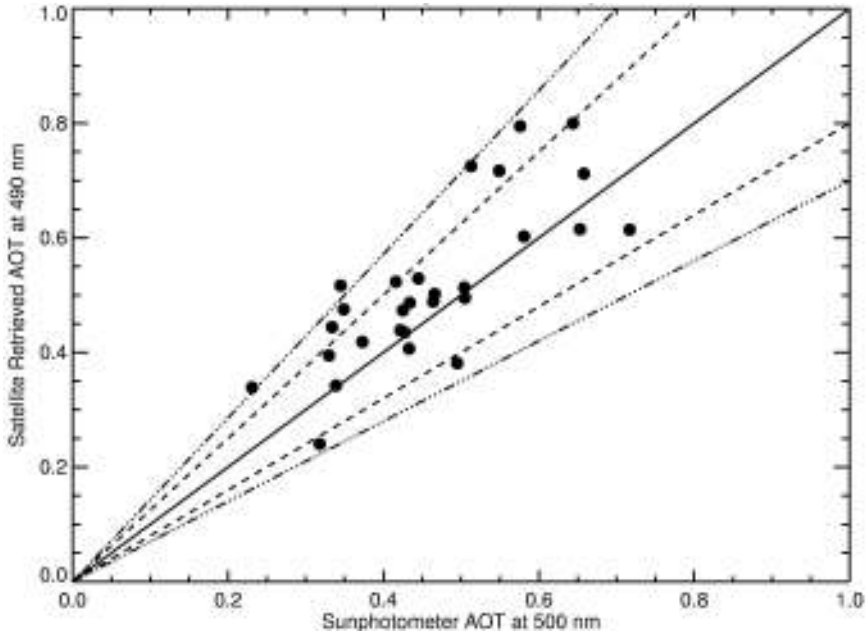


Deep Blue Algorithm

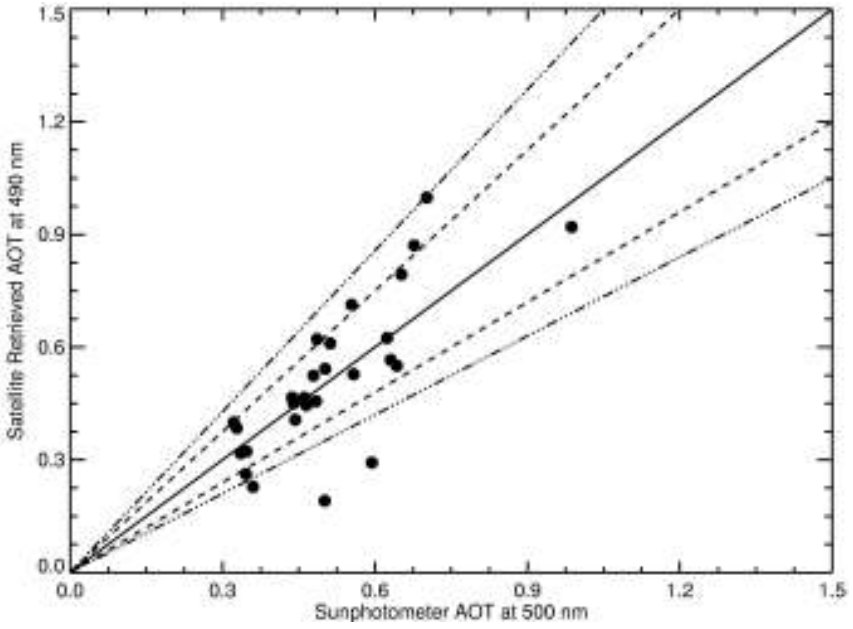
SeaWiFS retrieved aerosol optical thickness and Angstrom exponent showing a dust front pushing the air mass with small particle air pollution over both water and land on this day.

Validation During UAE2 Experiment August – September 2004

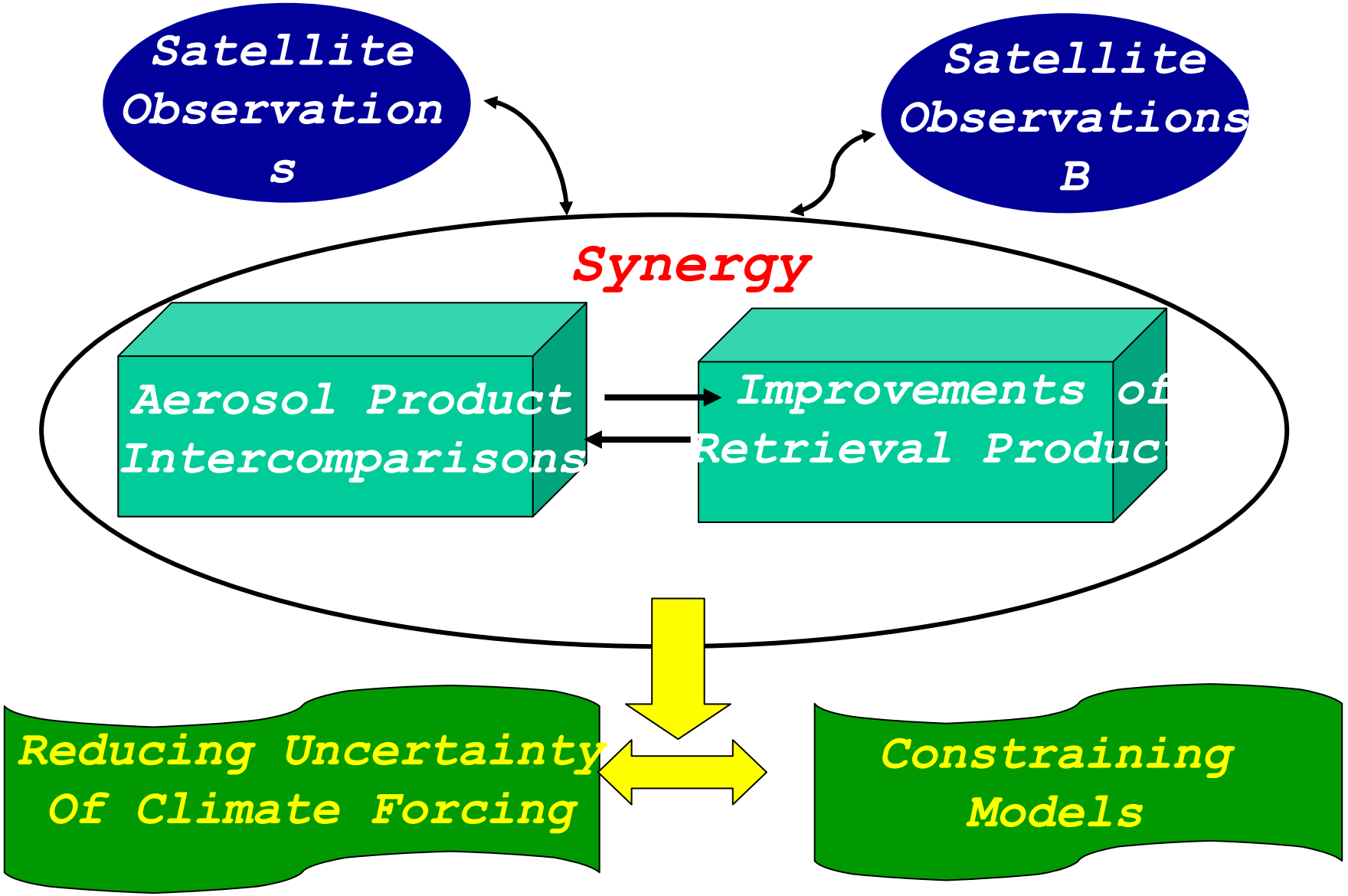
Harmim



Mezaira



Aerosol Observation Strategy

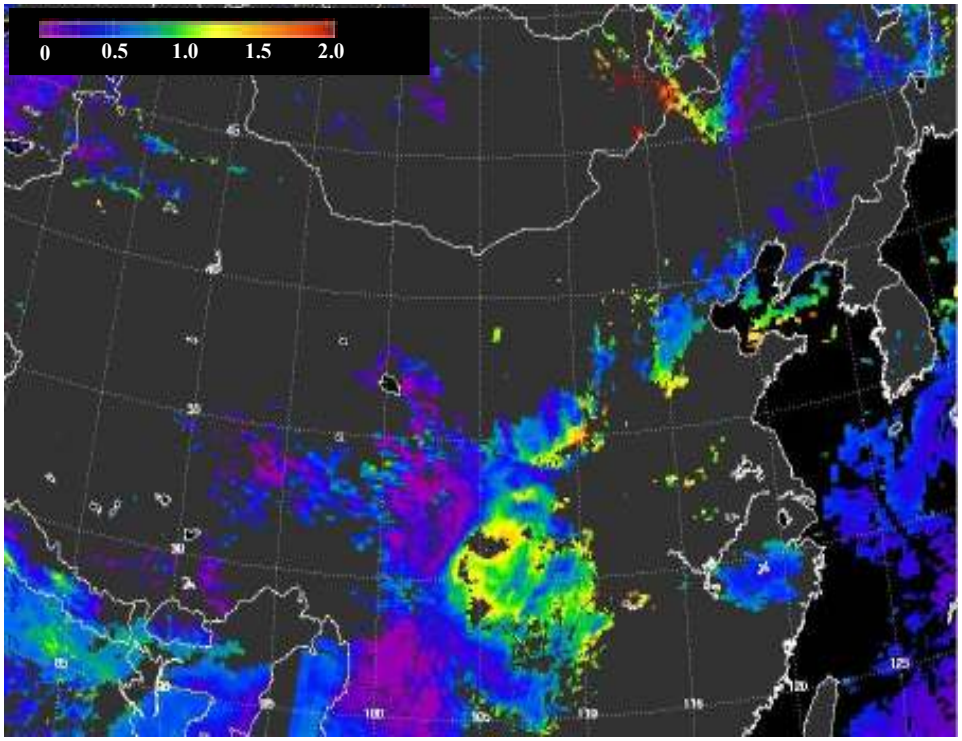


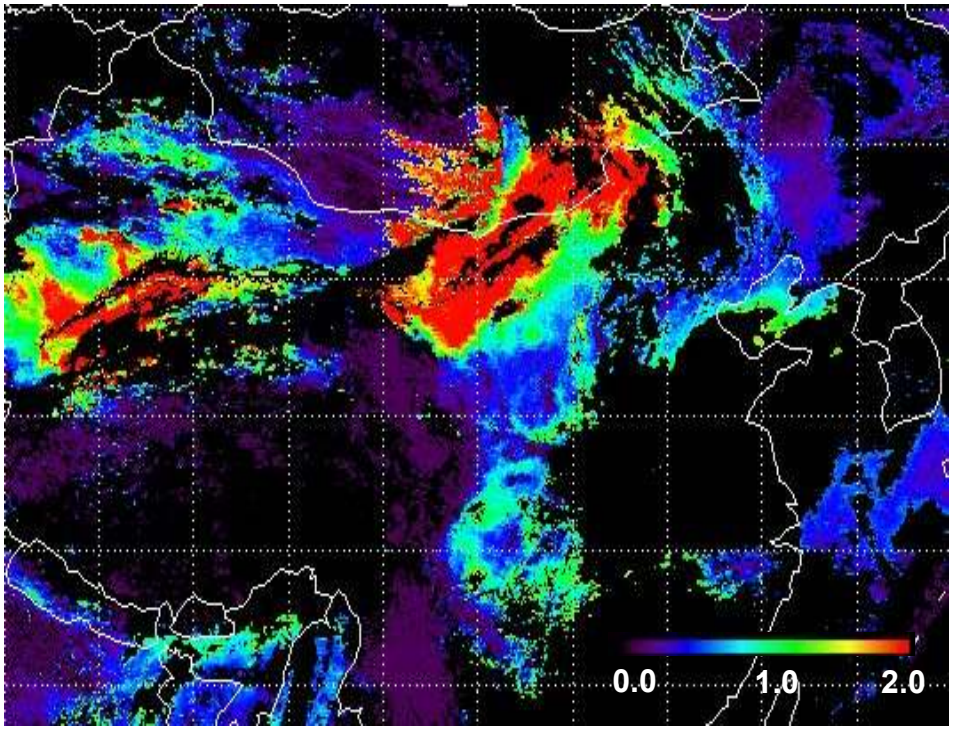
6 April 2001

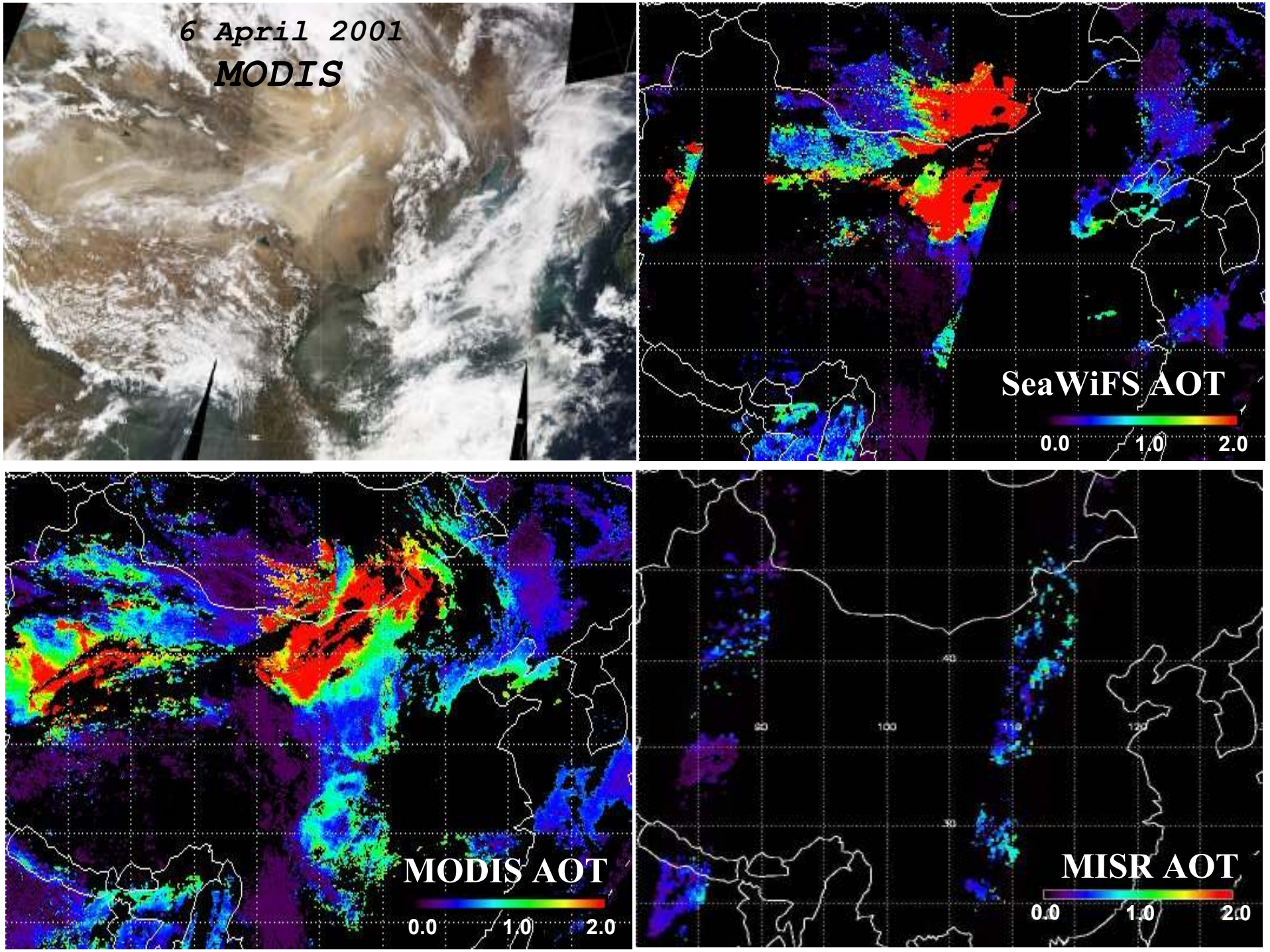
MODIS *Red*-*Green*-*Blue* with Rayleigh scattering removed

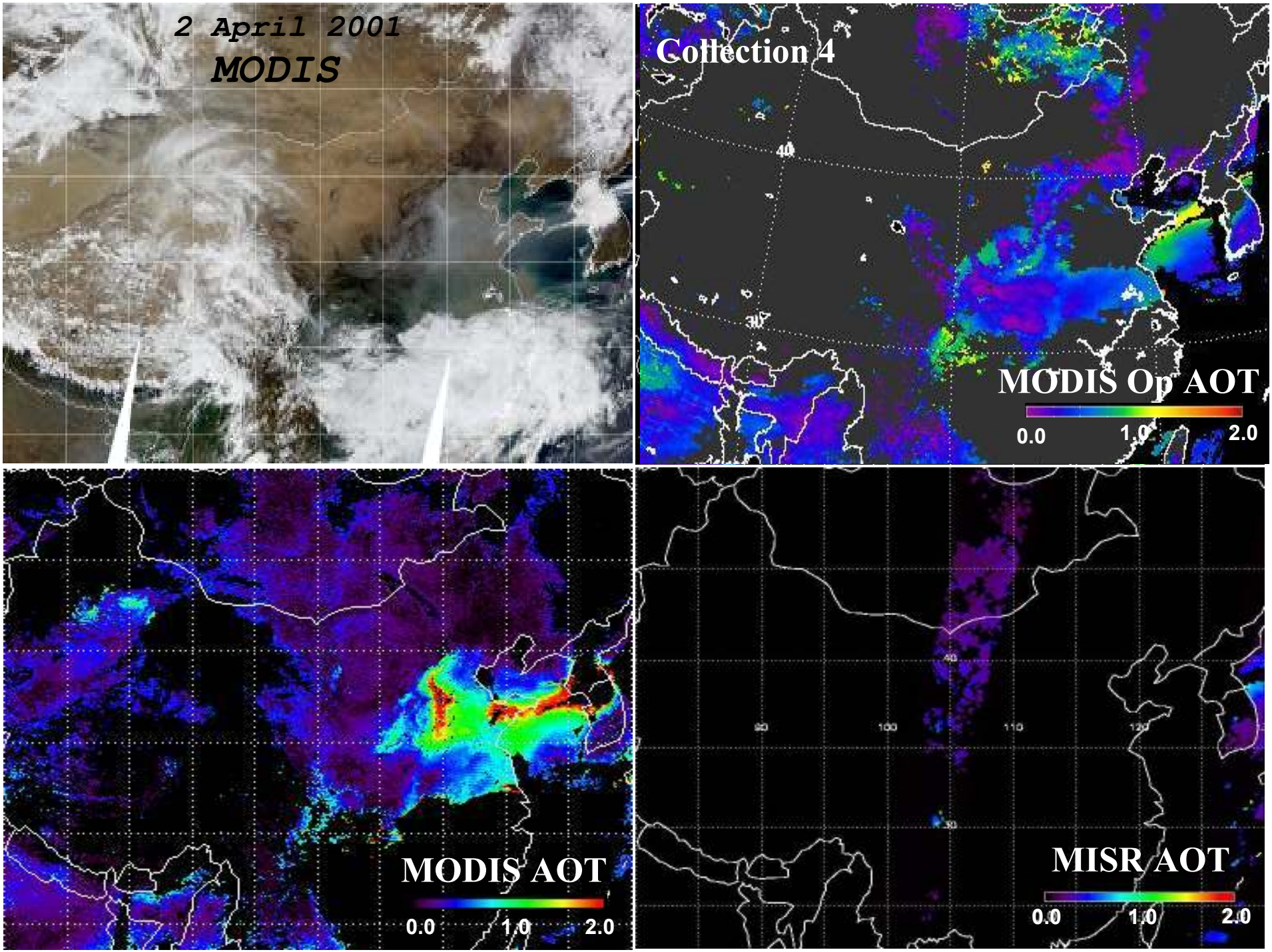
Current* MODIS *retrievals:
Aerosol Optical Thickness

New* MODIS *Deep Blue:
Aerosol Optical Thickness

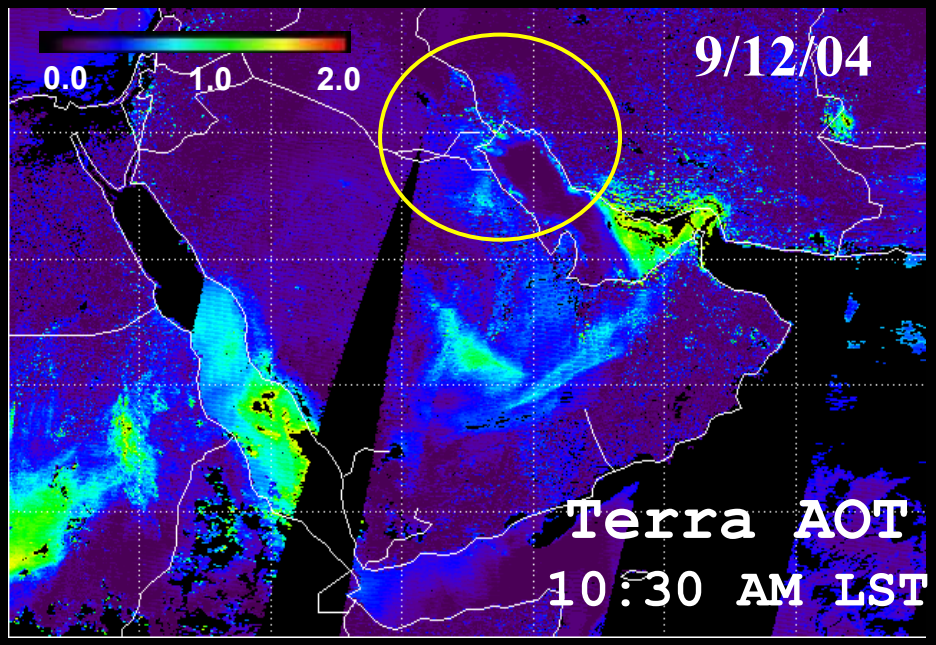


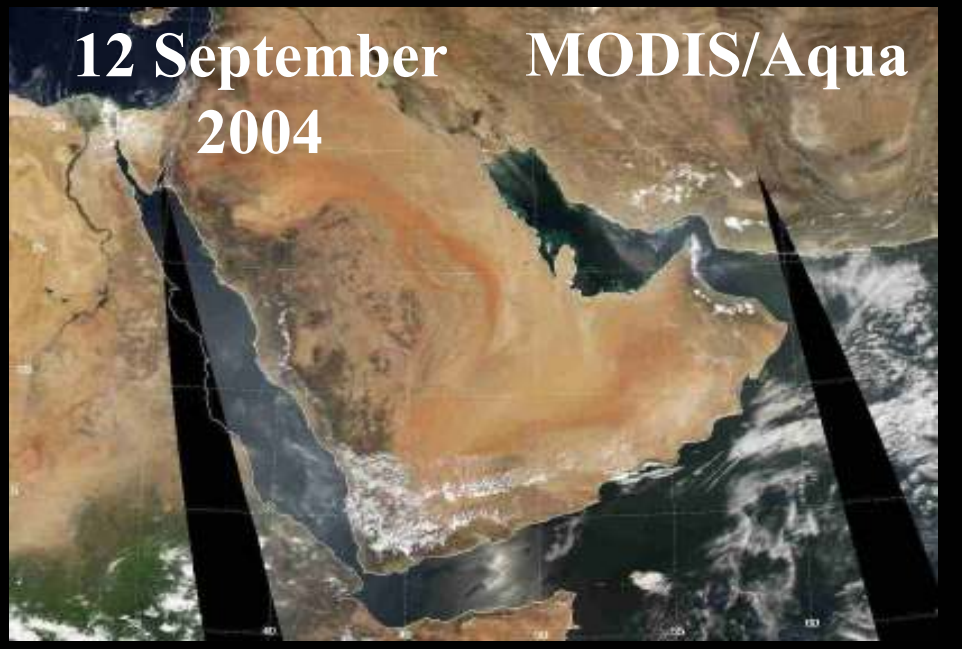


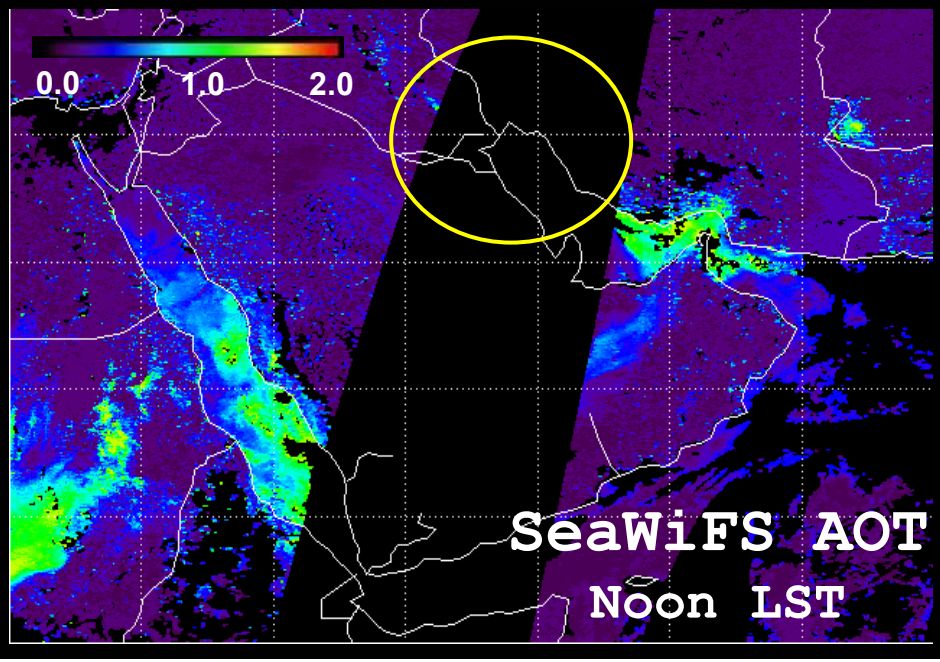

6 April 2001
MODIS
SeaWiFS AOT
0.0
1.0
2.0
MODIS AOT
0.0
1.0
2.0
MISR AOT
0.0
1.0
2.0

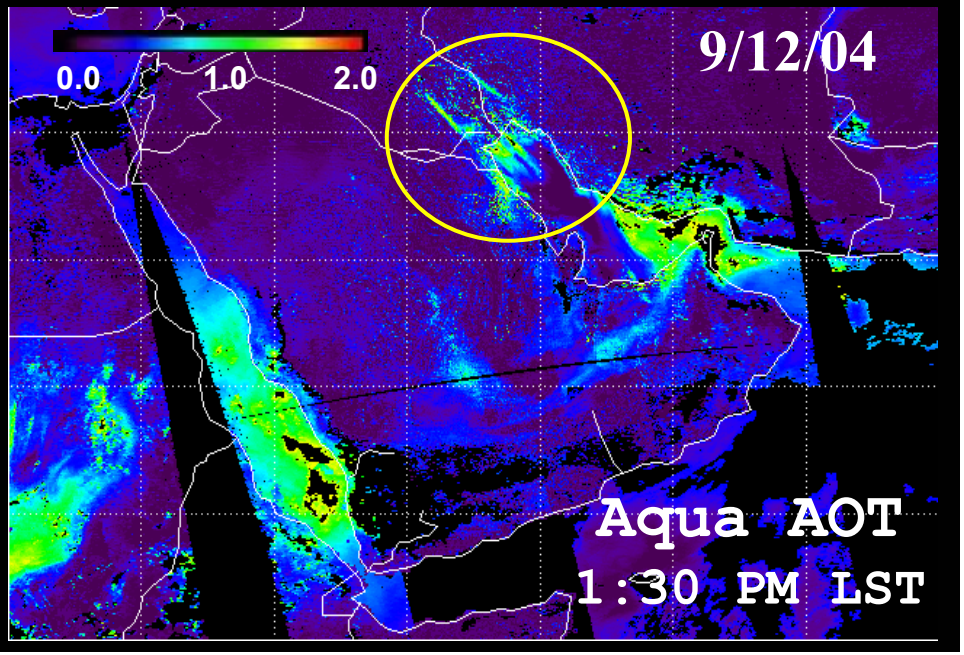

2 April 2001
MODIS
Collection 4
40
30
MODIS Op AOT
0.0
1.0
2.0
MODIS AOT
0.0
1.0
2.0
40
90
100
110
120
30
MISR AOT
0.0
1.0
2.0

Tracking Movements and Evolutions of Aerosol Plumes



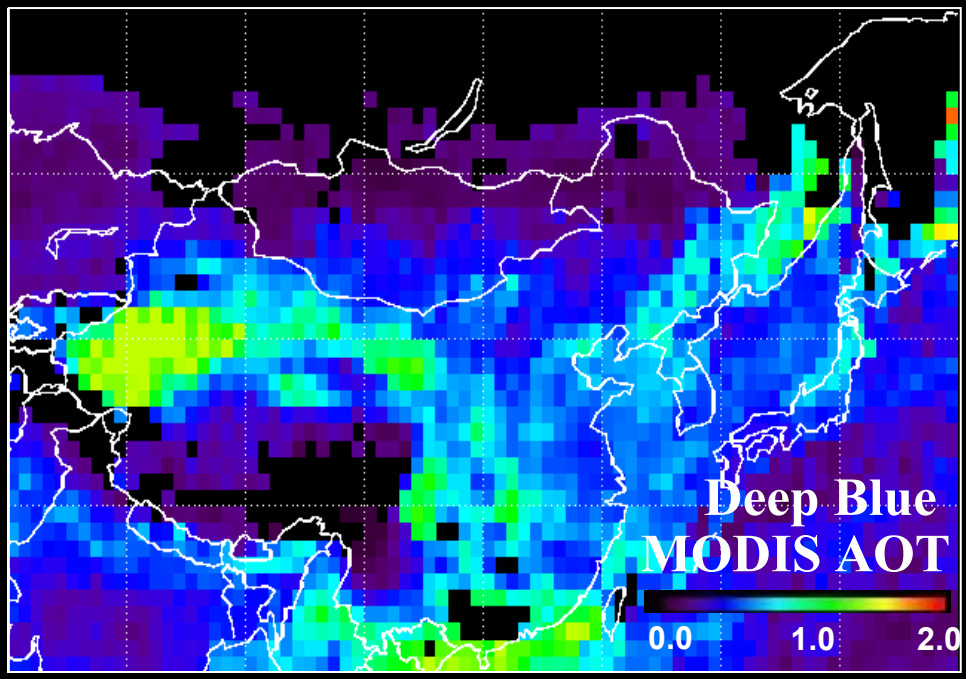


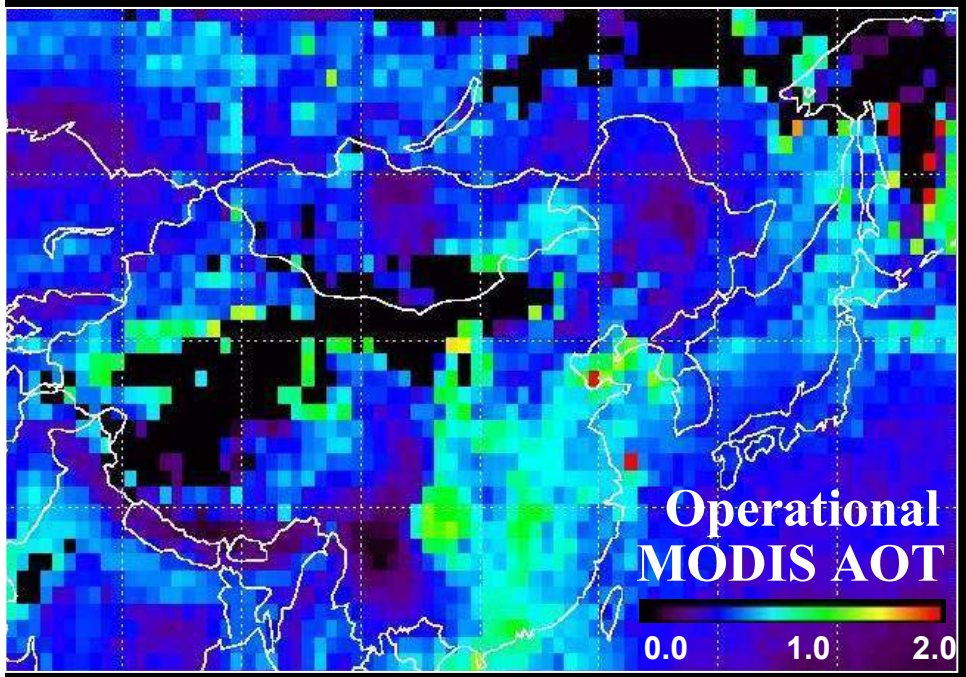


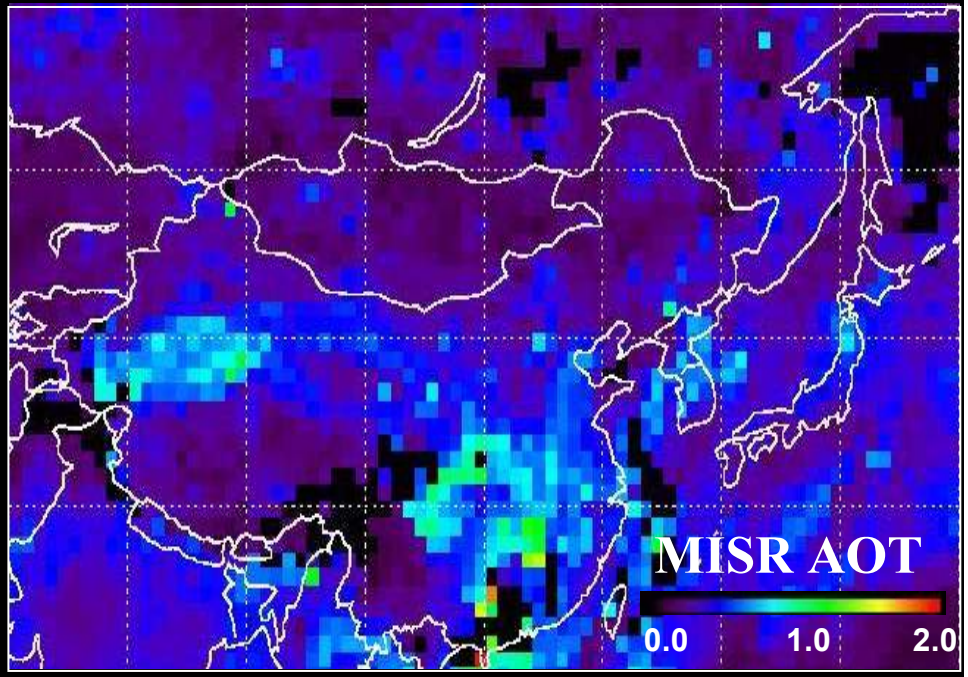


Intercomparisons of April 2001 Monthly Mean AOT Over East Asia

- *Large Daily Variability in AOT*
- *Frequent Presences of Clouds*







Summary

- *Deep Blue algorithm* provides aerosol *optical thickness*, *Angstrom exponent* and *single scattering albedo* for both land and water.

- Compared *well* with AERONET aerosol products:
  - Separate dust *well* from other anthropogenic sources
  - Aerosol optical thickness agree with AERONET values within 10-20% over water and 20-30% over deserts

- *Deep Blue algorithm* successfully applied to SeaWiFS and MODIS: *evolution* (spatial & temporal) of aerosols can be studied for the first time over deserts using one consistent algorithm.

Summary (continued)

***Current Issues** in Aerosol Product Synergy:*

- ***Presences of Clouds**: requires careful selection in geolocation to conduct intercomparisons;*

- ***Variability of Aerosol Loading**: requires spatial coverage;*

- ***Accurate and Consistent Calibration** across each individual sensors.*