Early Results from the MODIS Atmosphere Algorithms

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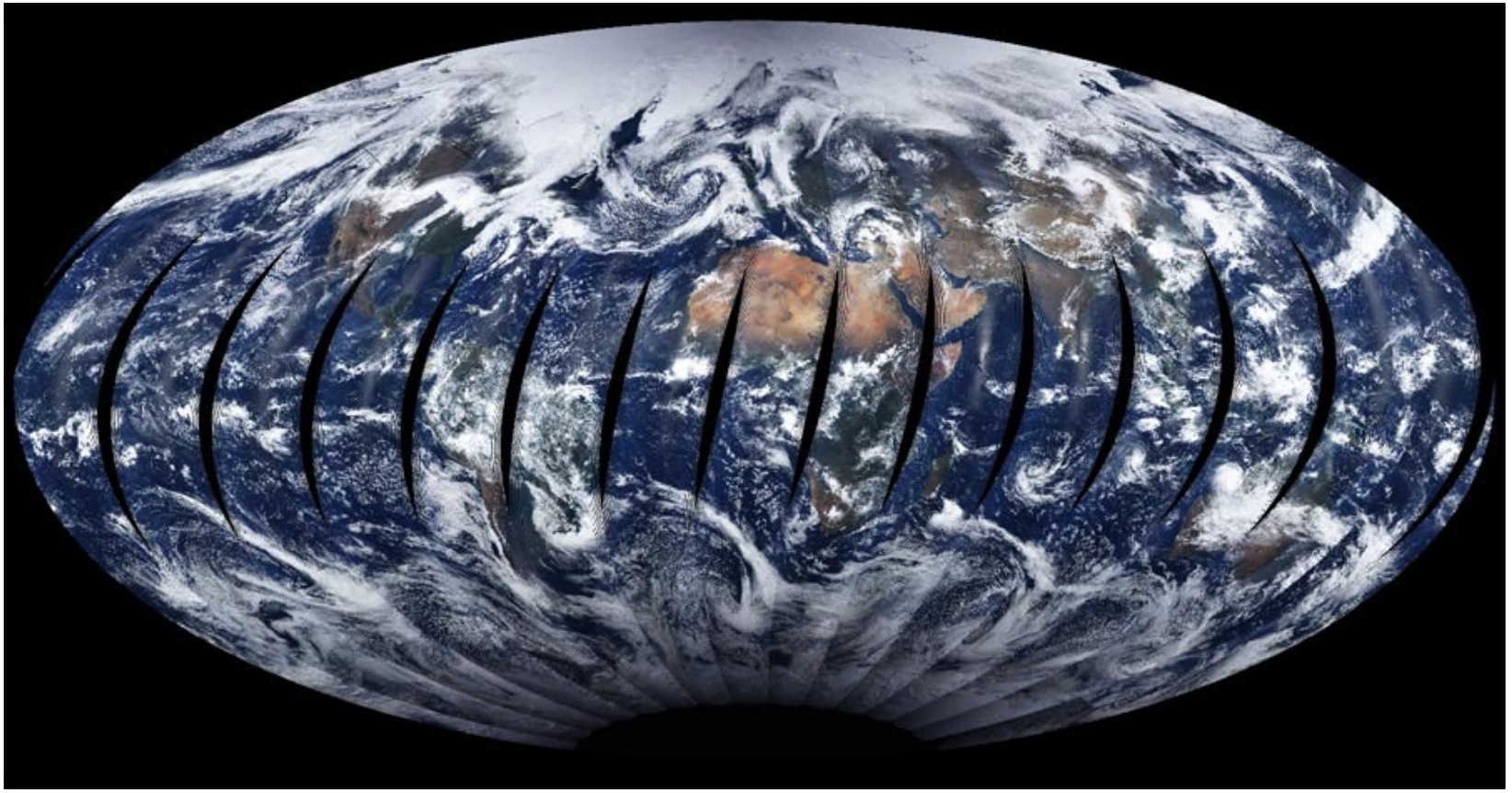
Outline

- ❏ MODIS atmosphere products
- ❏ Granule level (5 min.) product examples
- ❏ Global examples
- ❏ Summary

Global Level-1B Composite Image

R = 0.65 µm
G = 0.56 µm
B = 0.47 µm

April 19, 2000



MODIS Atmosphere Products

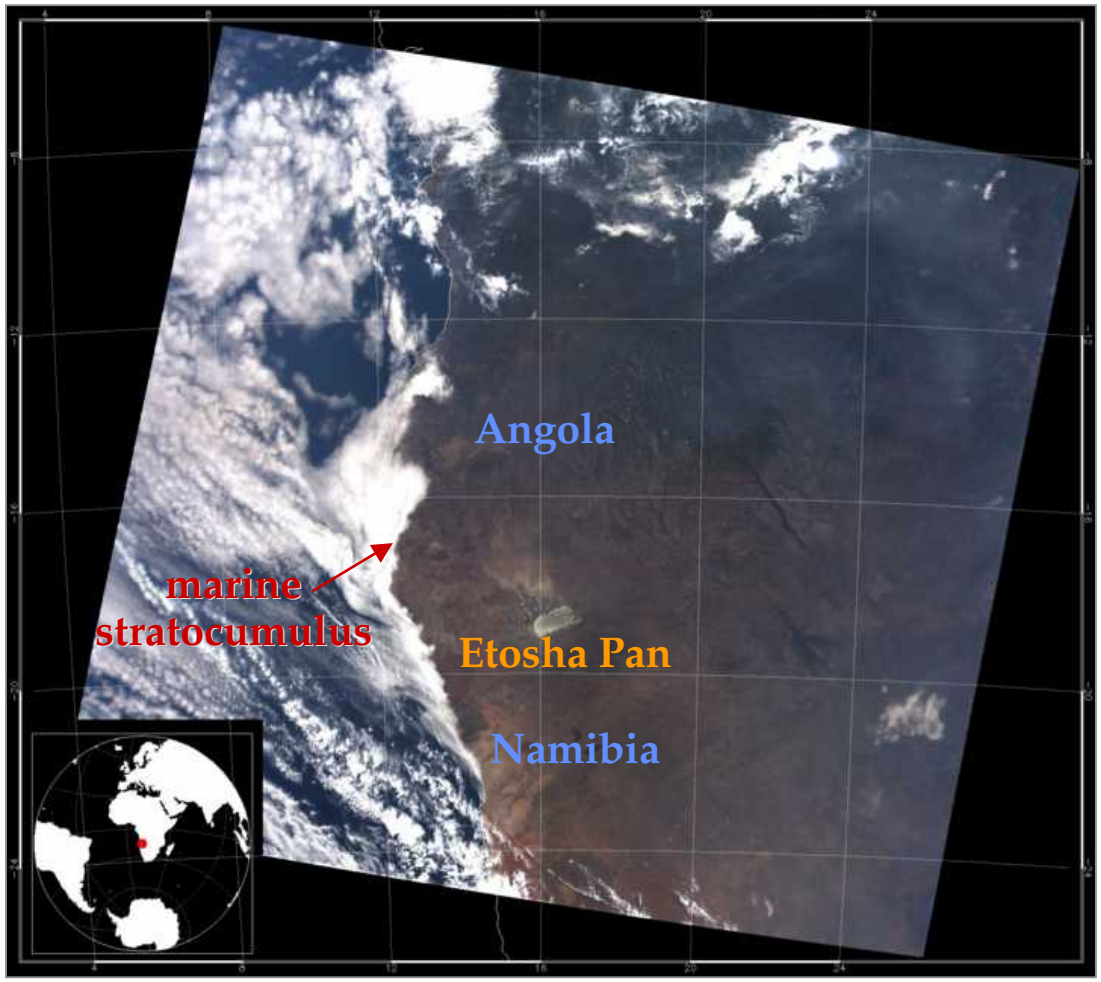
- Pixel-level (level-2) products
  - Cloud mask for distinguishing clear sky from clouds (288 @ 47.4 MB/file)
  - Cloud radiative and microphysical properties (288 @ 44.6 MB/file)
    - » Cloud top pressure, temperature, and effective emissivity
    - » Cloud optical thickness, thermodynamic phase, and effective radius
    - » Thin cirrus reflectance in the visible
  - Aerosol optical properties (144 @ 10.5 MB/file)
    - » Optical thickness over the land and ocean
    - » Size distribution (parameters) over the ocean
  - Atmospheric moisture and temperature gradients (288 @ 32.3 MB/file)
  - Column water vapor amount (288 @ 12.7 MB/file)
- Gridded time-averaged (level-3) atmosphere product
  - Daily, 8-day, and monthly products (409.2, 781.9, 781.9 MB)
  - $1° \times 1°$ equal angle grid
  - Mean, standard deviation, marginal probability density function, joint probability density functions
- http://modis-atmos.gsfc.nasa.gov

Cloud Mask

- MODIS cloud mask uses multispectral imagery to indicate whether the scene is clear, cloudy, or affected by shadows
- Cloud mask is input to rest of atmosphere, land, and ocean algorithms
- Mask is generated at 250 m and 1 km resolutions
- Mask uses 17 spectral bands ranging from 0.55-13.93 µm (including new 1.38 µm band)
  - 11 different spectral tests are performed, with different tests being conducted over each of 5 different domains (land, ocean, coast, snow, and desert)
  - temporal consistency test is run over the ocean and at night over the desert
  - spatial variability is run over the oceans
- Algorithm based on radiance thresholds in the infrared, and reflectance and reflectance ratio thresholds in the visible and near-infrared
- Cloud mask consists of 48 bits of information for each pixel, including results of individual tests and the processing path used
  - bits 1 & 2 give combined results (confident clear, probably clear, probably cloudy, cloudy)

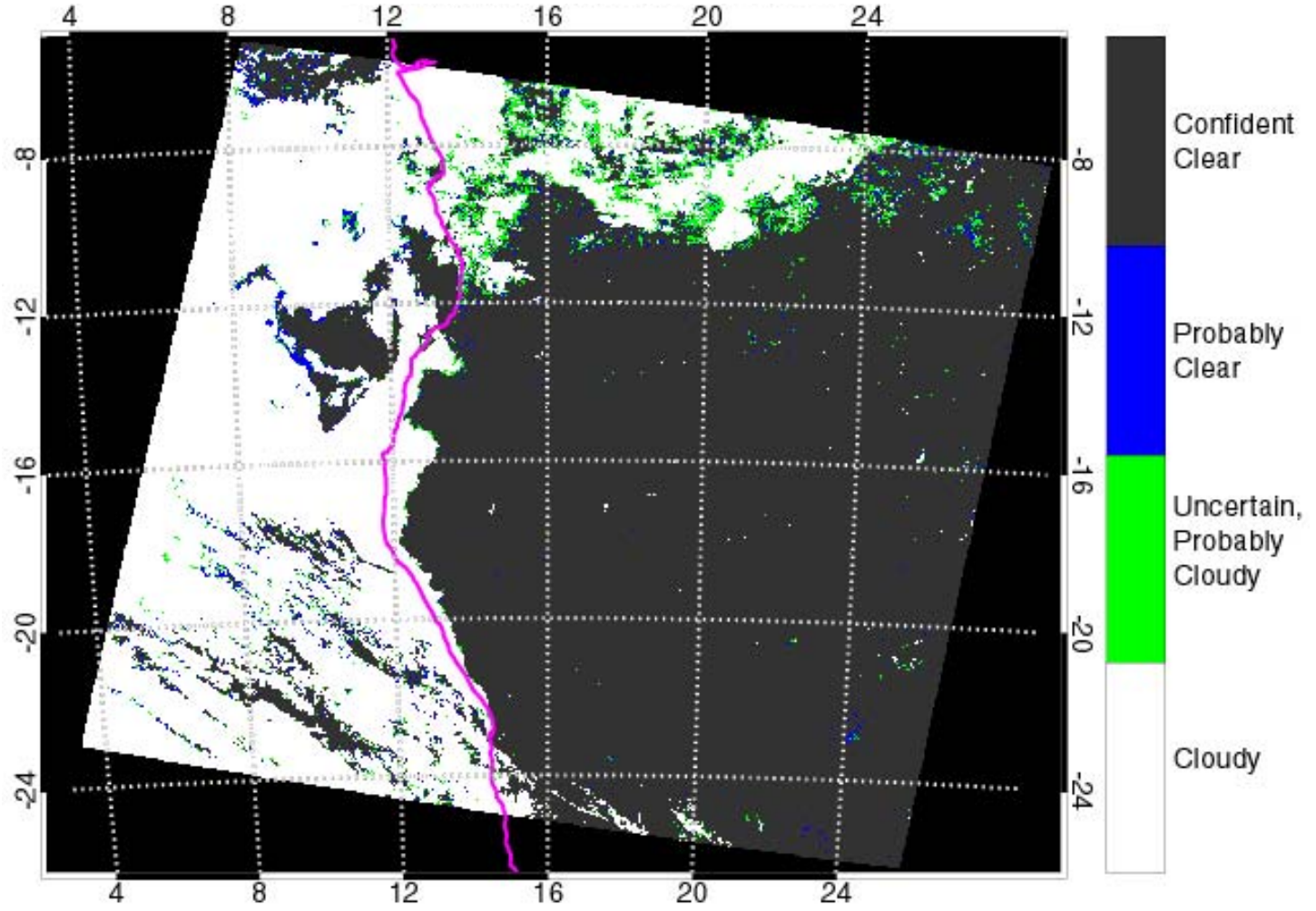
Level-1B Image of Namibian Stratus during SAFARI 2000

September 13, 2000



Red = 0.65 µm
Green = 0.56 µm
Blue = 0.47 µm

Level-1B Image of Namibian Stratus

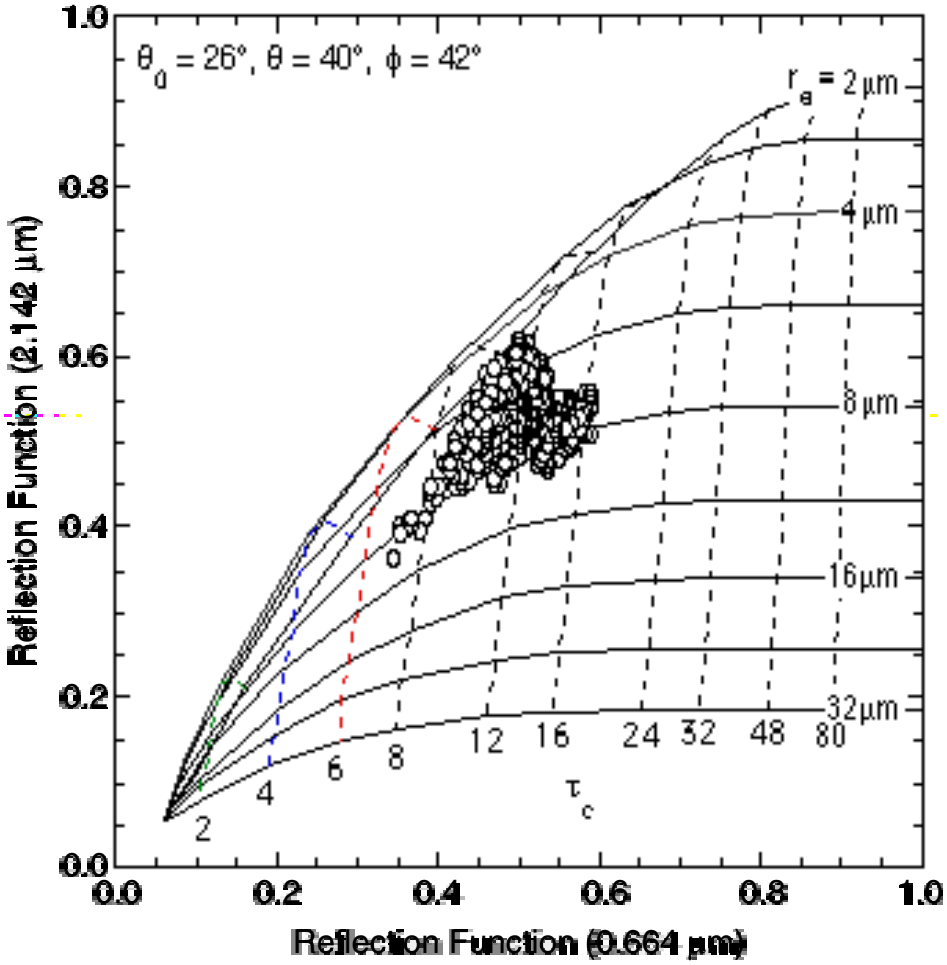


Cloud Properties

- **Twelve MODIS bands are utilized to derive cloud properties**
  - **0.65, 0.86, 1.24, 1.38, 1.64, 2.13, 3.75, 8.55, 11.03, 12.02, 13.34, and 13.64 µm**
  - **Visible and near-infrared bands**
    - » **daytime retrievals of cloud optical thickness and effective radius**
    - » **1.6 µm band will be used to derive thermodynamic phase of clouds during the daytime (post-launch)**
  - **Thermal infrared bands**
    - » **determination of cloud top properties, including cloud top altitude, cloud top temperature, and thermodynamic phase**

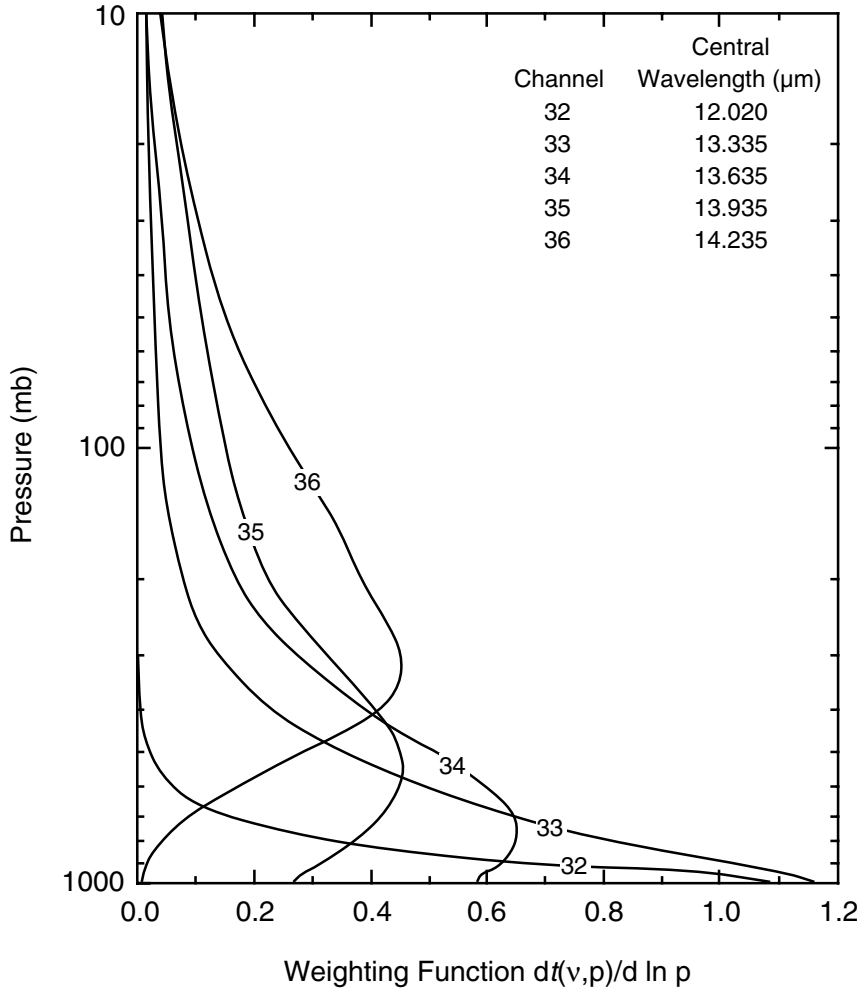
Retrieval of τ_c and r_e

- The reflection function of a nonabsorbing band (e.g., 0.66 µm) is primarily a function of optical thickness
- The reflection function of a near-infrared absorbing band (e.g., 2.14 µm) is primarily a function of effective radius
  - clouds with small drops (or ice crystals) reflect more than those with large particles
- For optically thick clouds, there is a near orthogonality in the retrieval of τ_c and r_e using a visible and near-infrared band



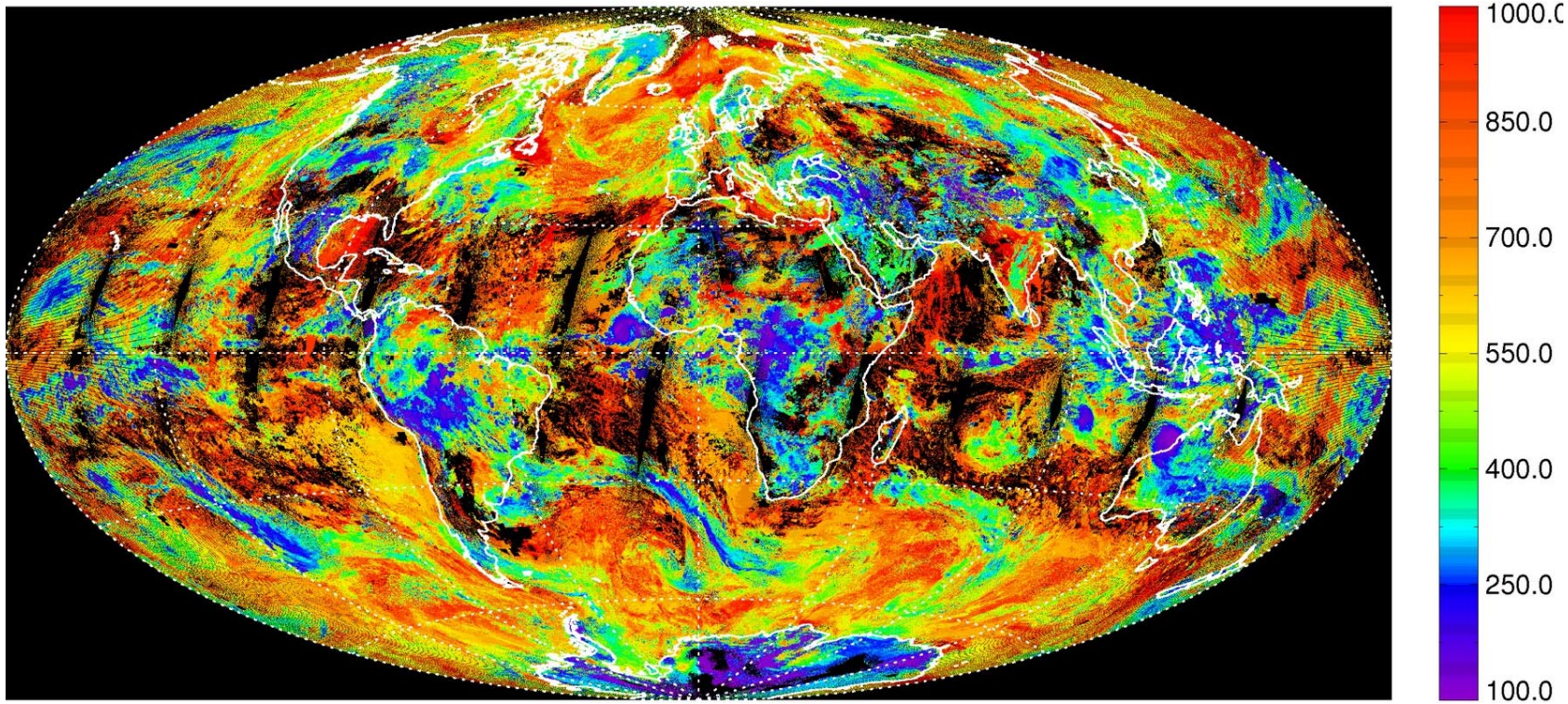
Weighting Functions for CO_2 Slicing

- CO_2 slicing method
  - ratio of cloud forcing at two near-by wavelengths
  - assumes the emissivity at each wavelength is same, and cancels out in ratio of two bands
- The more absorbing the band, the more sensitive it is to high clouds
  - technique the most accurate for high and middle clouds
- MODIS will be the first sensor to have CO_2 slicing bands at high spatial resolution (5 km)
  - technique has been applied to HIRS data for ~20 years



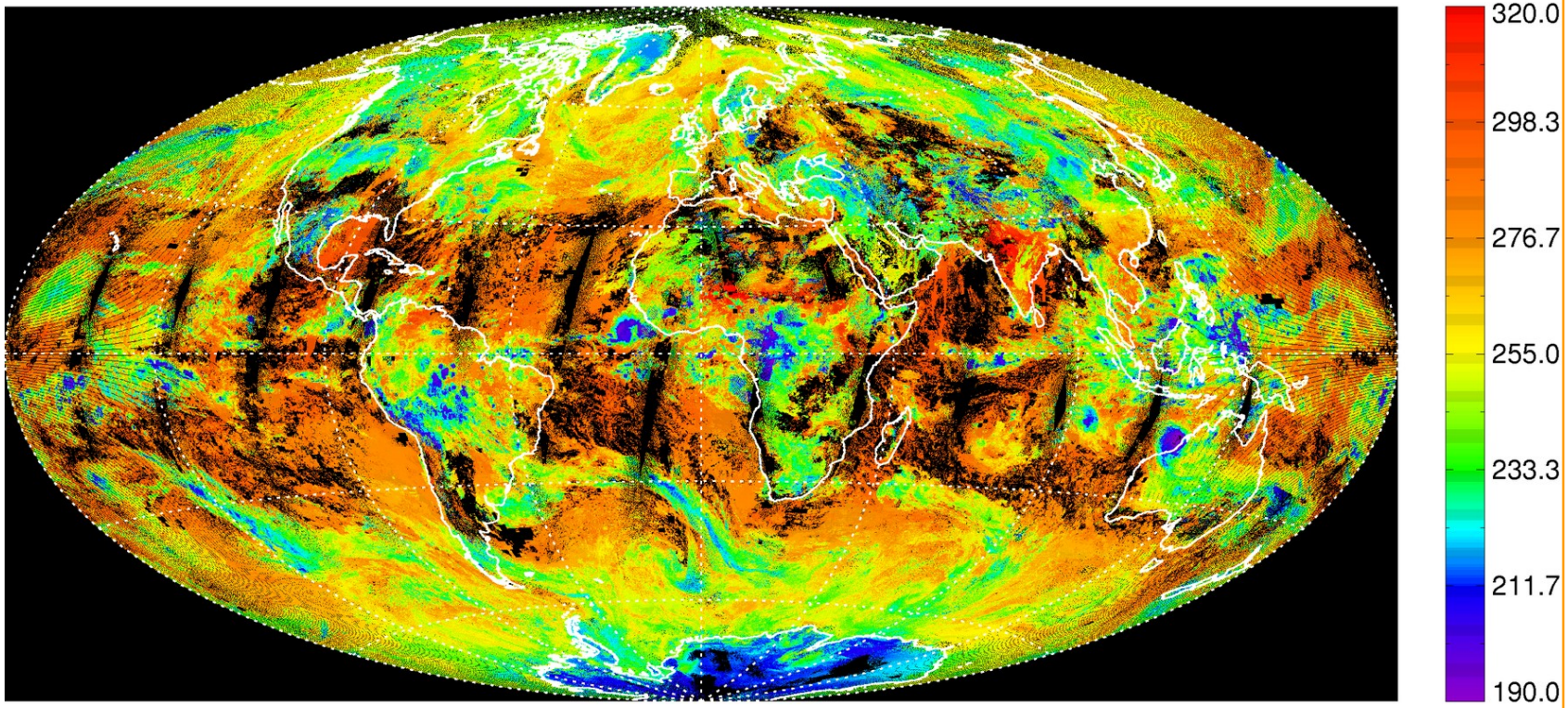
Cloud Top Pressure

April 19, 2000

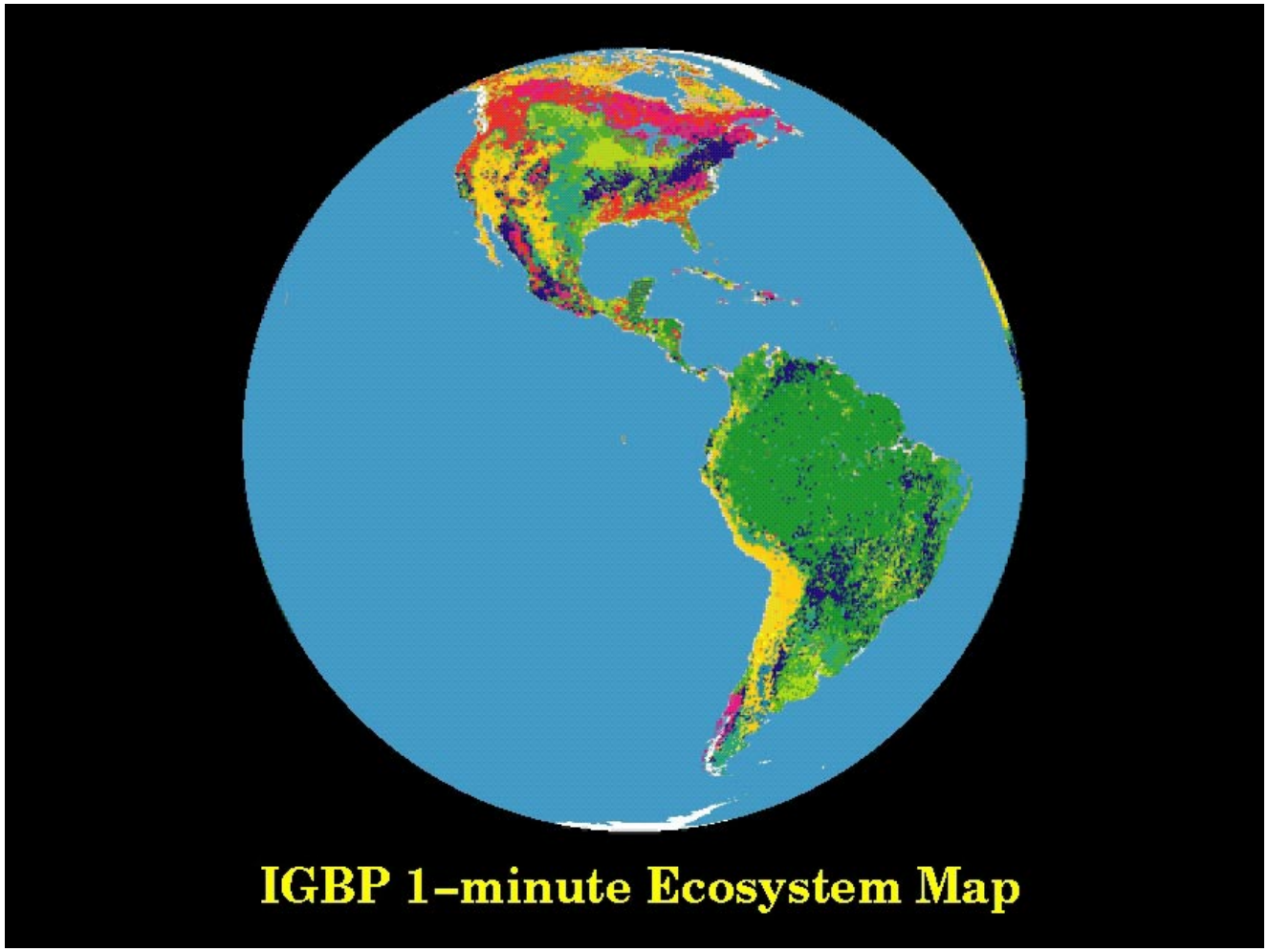


Cloud Top Temperature

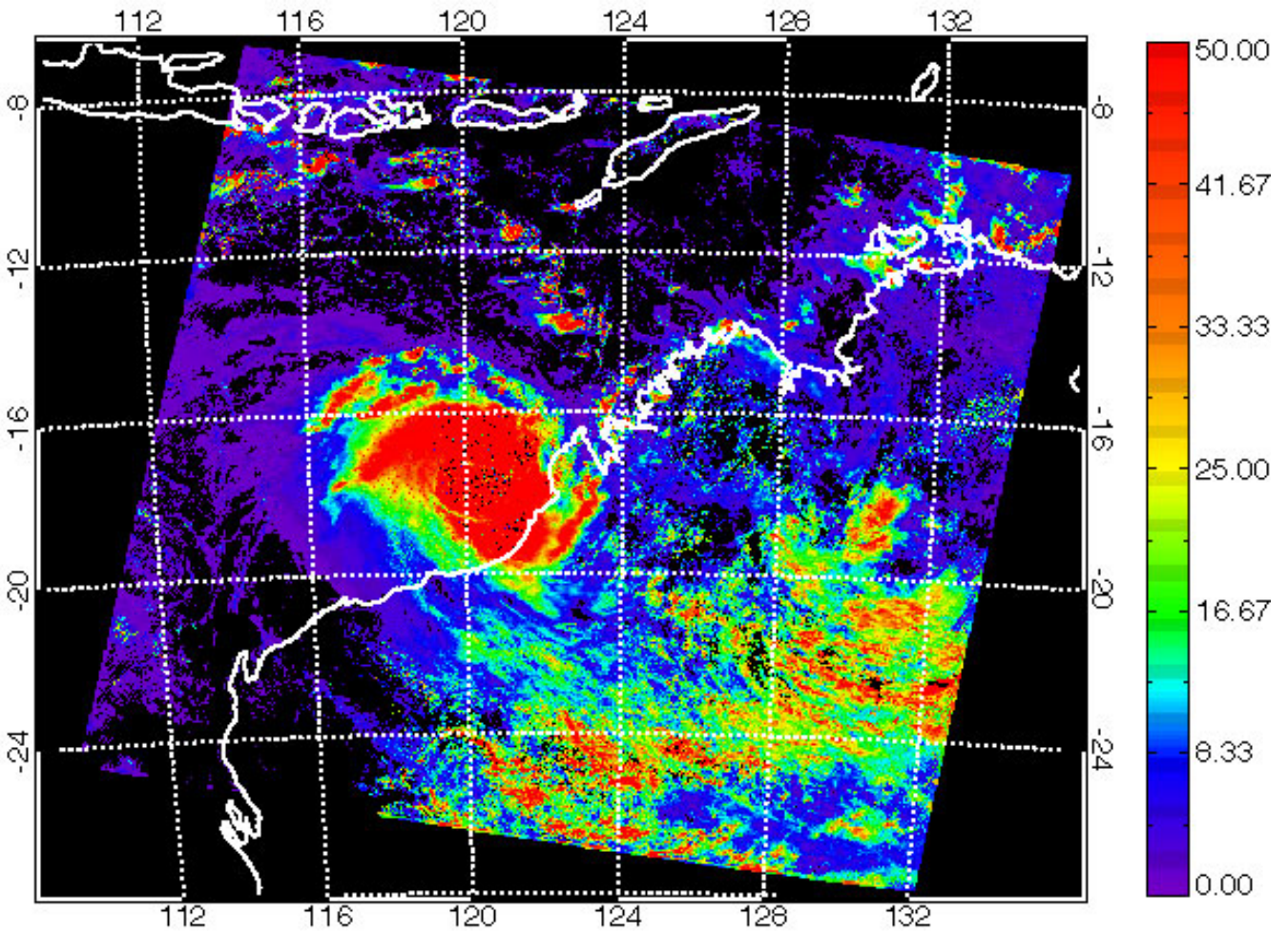
April 19, 2000



Ecosystem Map

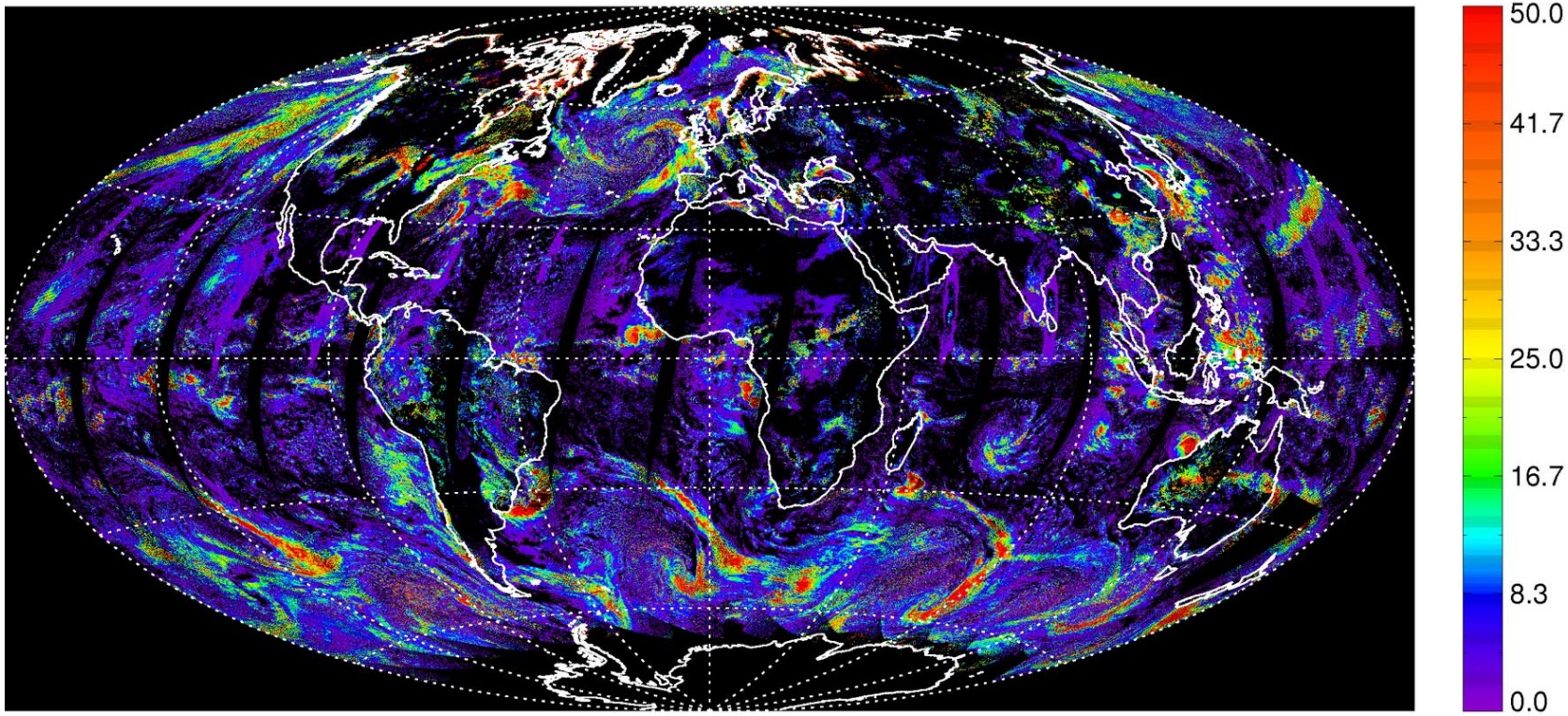


Cloud Optical Thickness



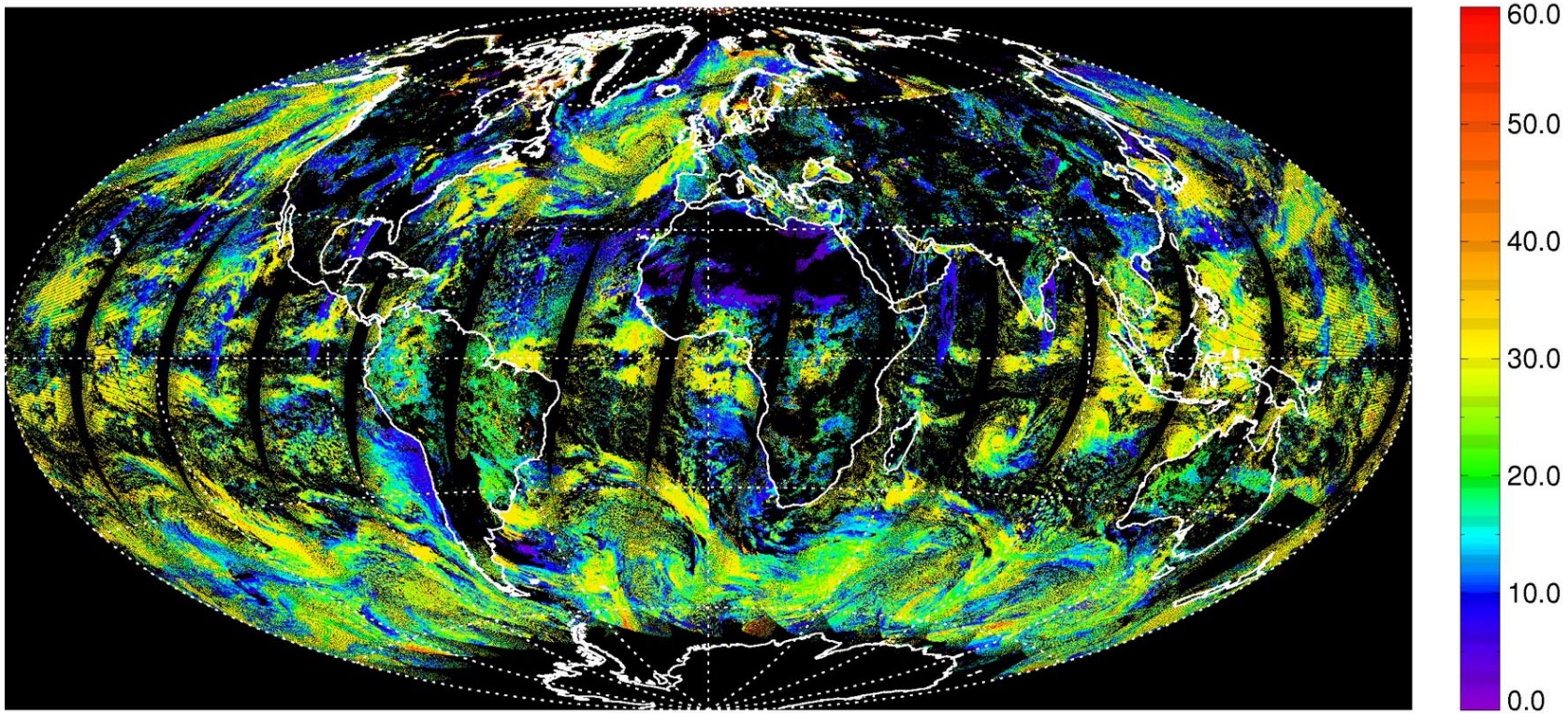
Cloud Optical Thickness

April 19, 2000



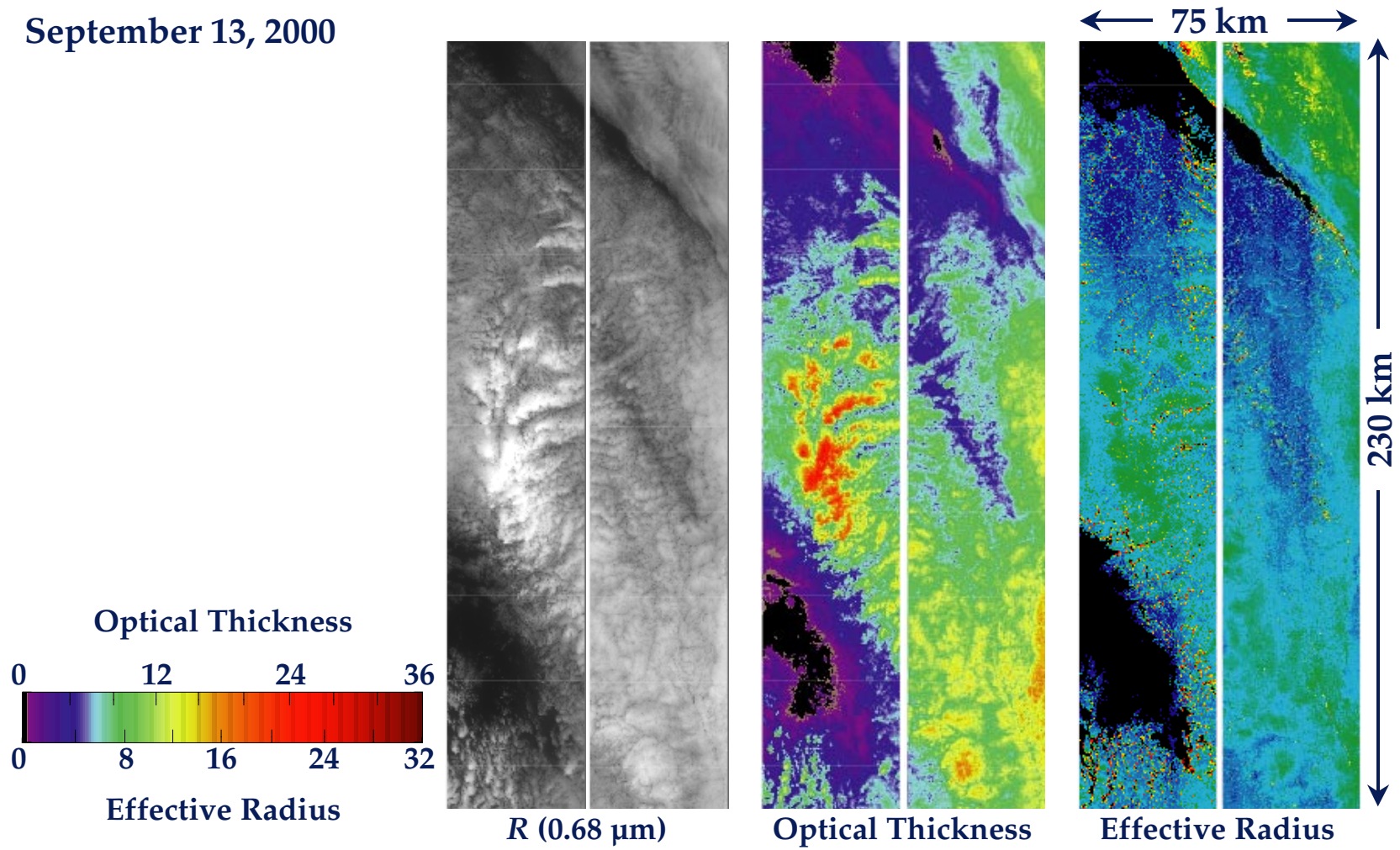
Cloud Effective Radius

April 19, 2000



MODIS Airborne Simulator Analysis of Namibian Stratus during SAFARI 2000

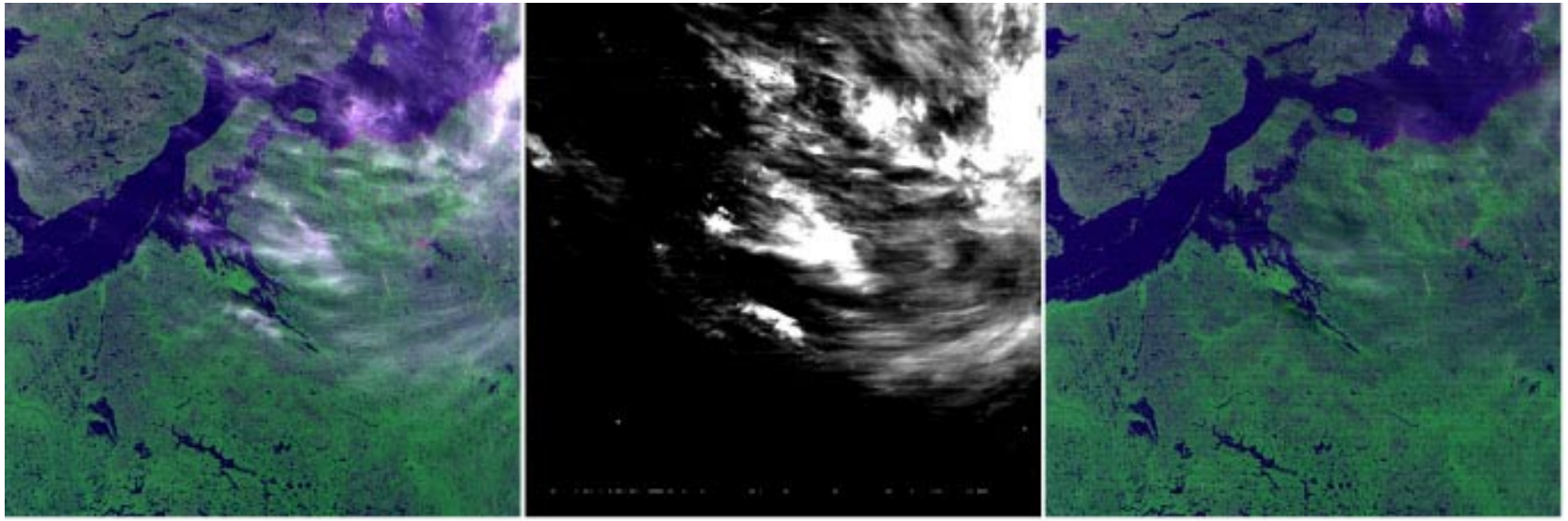
September 13, 2000



Correction of Imagery for Thin Cirrus

Canada
September 2, 2000

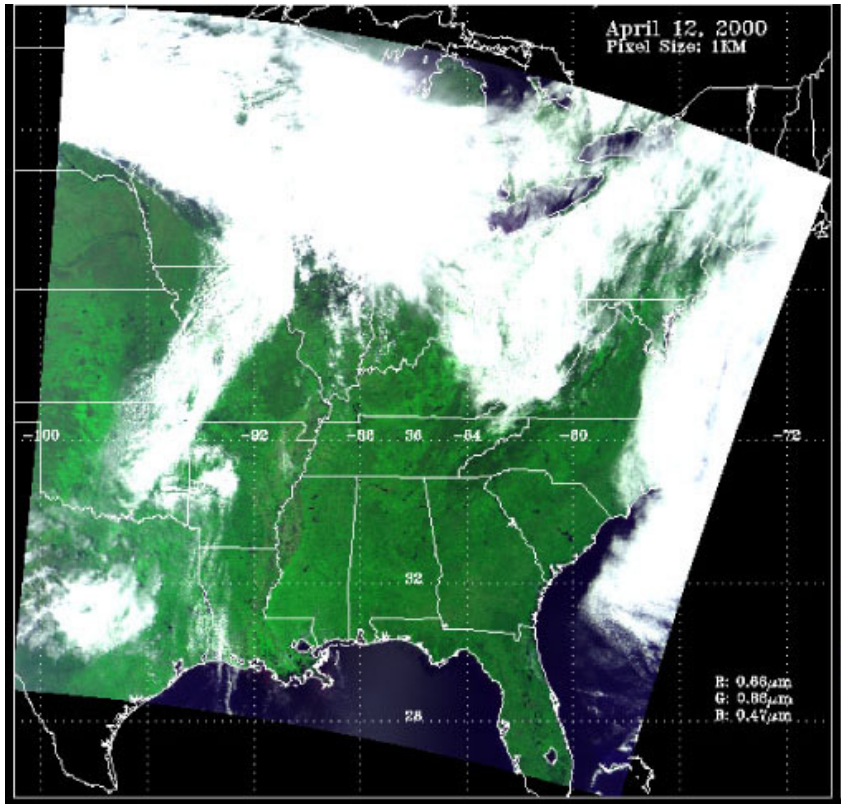
Uncorrected Image | **Cirrus Image (1.38 µm)** | **Cirrus Corrected Image**



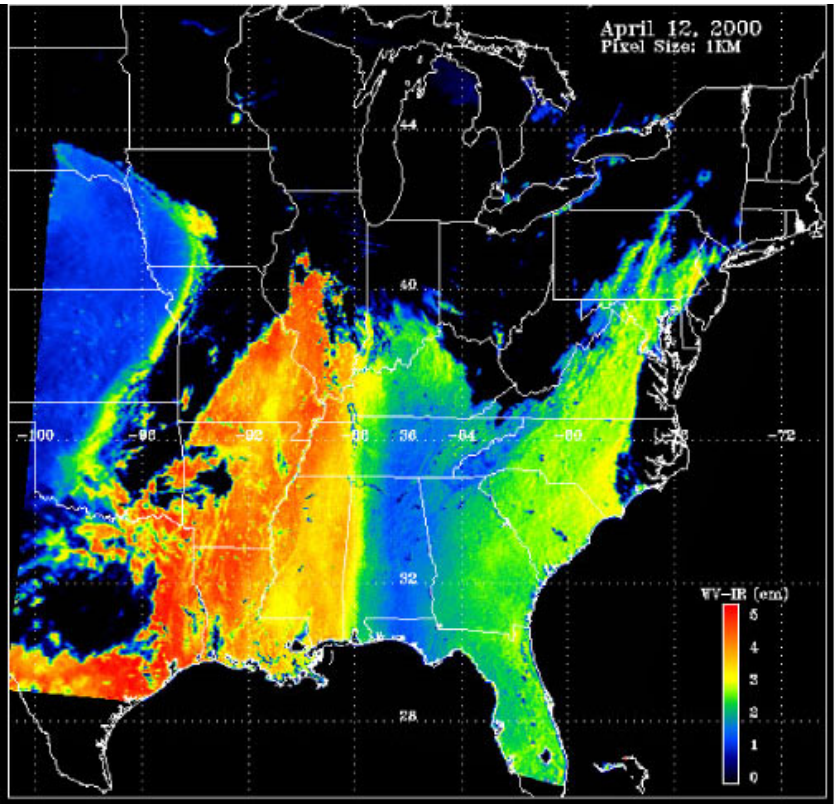
Atmospheric Water Vapor

April 12, 2000

R: 0.65, G: 0.86, B: 0.46

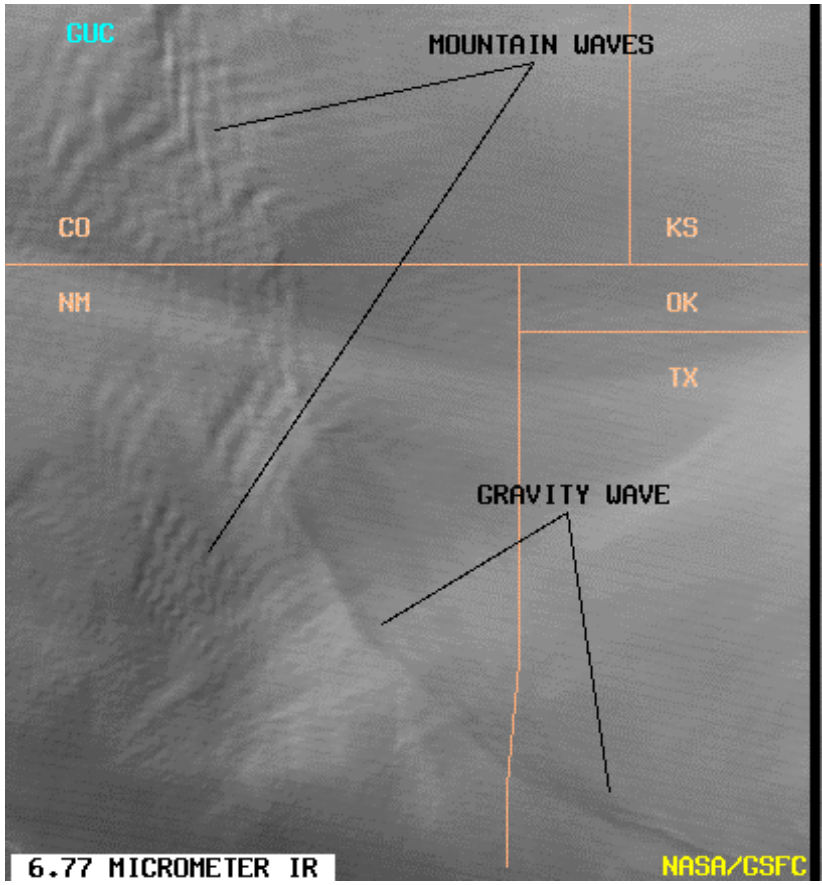


Precipitable Water Vapor (cm)

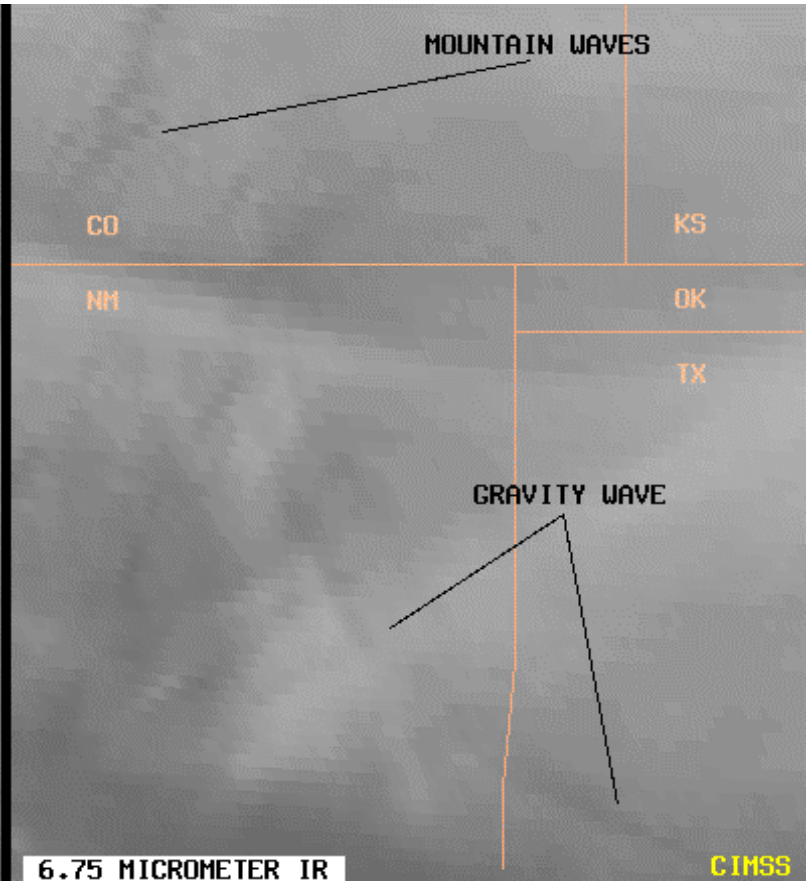


MODIS Reveals Atmospheric Moisture Details As Never Seen Before

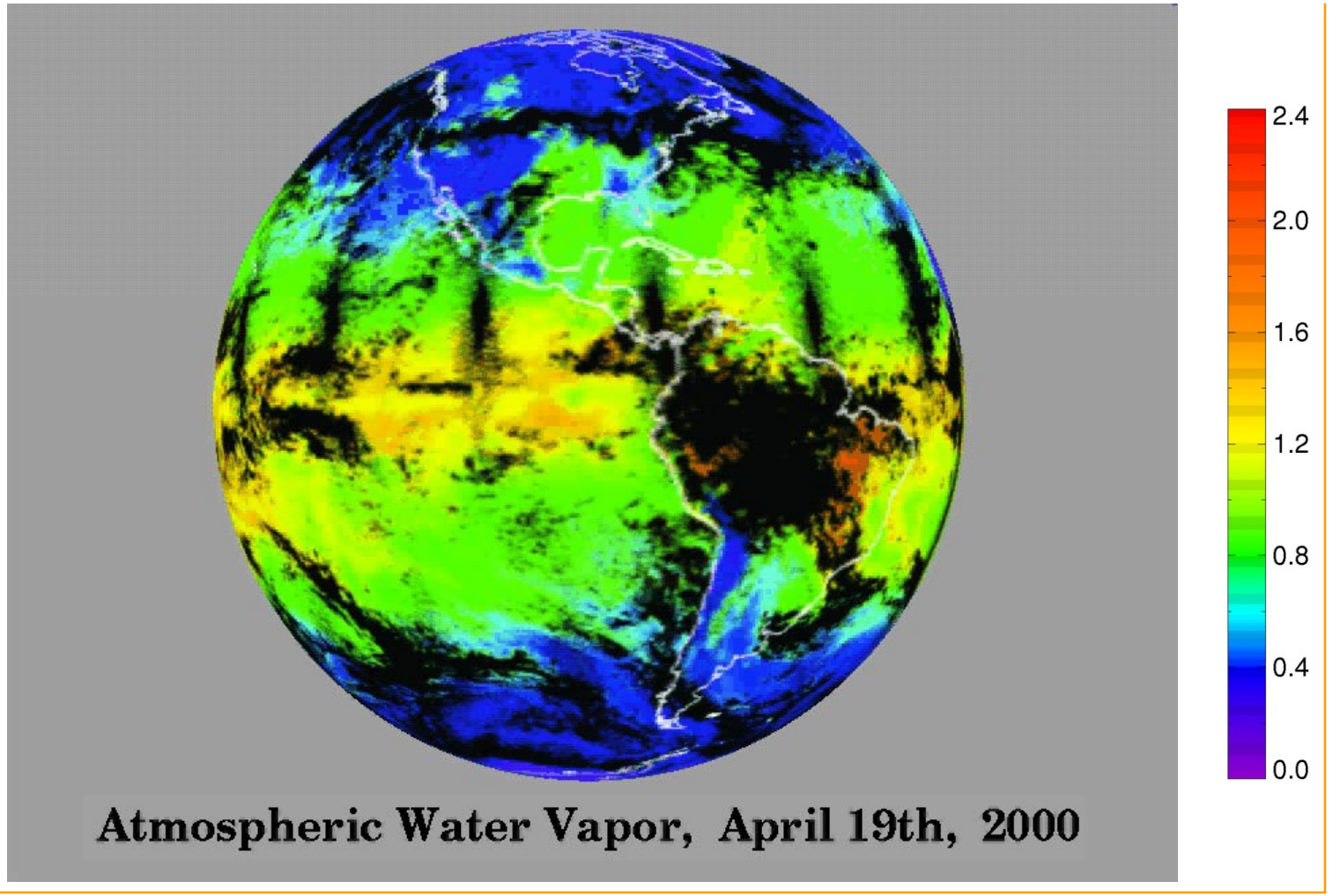
MODIS Water Vapor (1 km)



GOES-8 Water Vapor (4 x 8 km)



Global Atmospheric Water Vapor



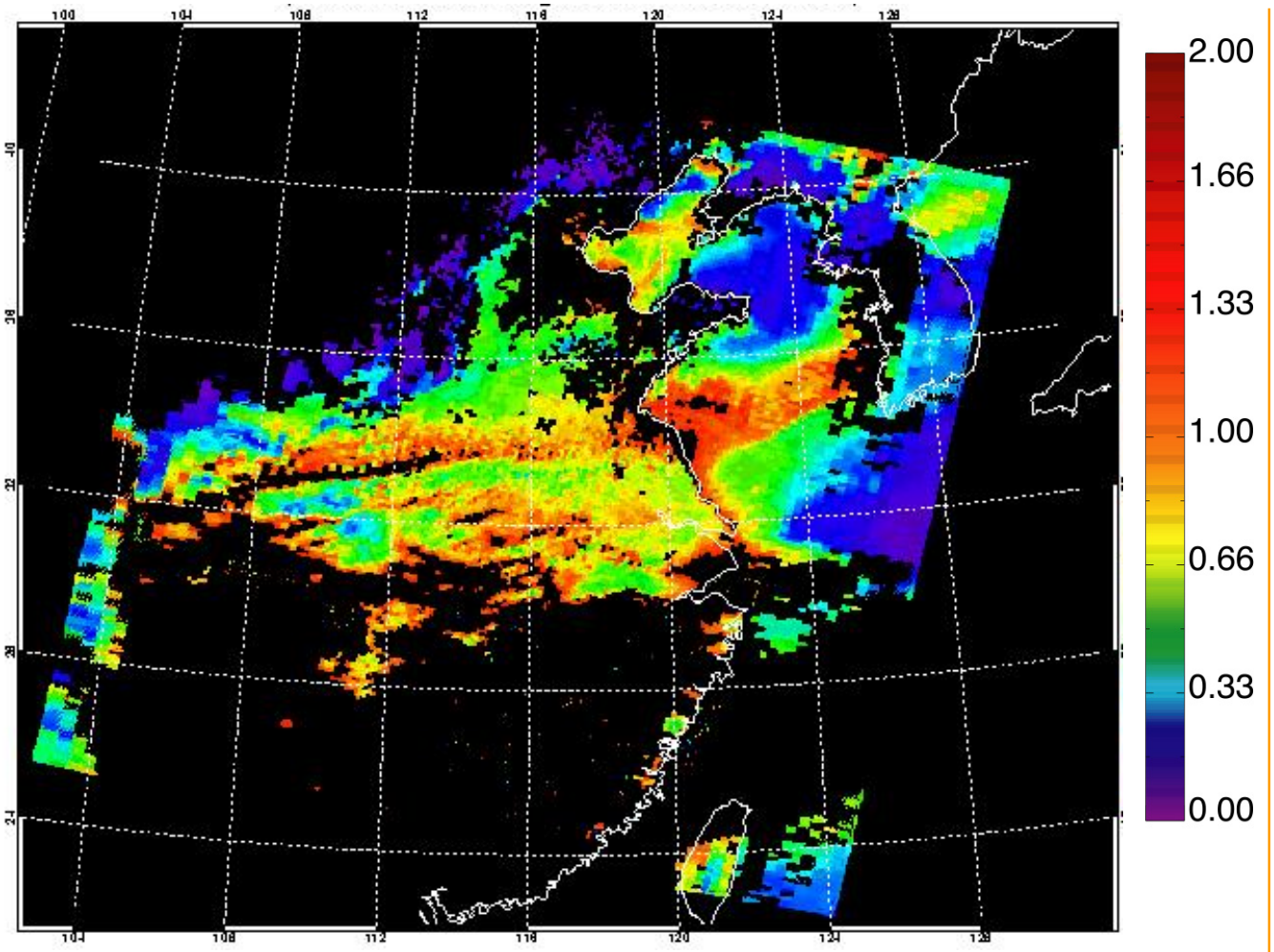
Aerosol Properties

- Seven MODIS bands are utilized to derive aerosol properties
  - 0.47, 0.55, 0.65, 0.86, 1.24, 1.64, and 2.13 μm
  - Ocean
    - » reflectance contrast between cloud-free atmosphere and ocean reflectance (dark)
    - » aerosol optical thickness (0.47-2.13 μm)
    - » size distribution characteristics (ratio between the assumed two log-normal modes, and the mean size of each mode)
  - Land
    - » dense dark vegetation and semi-arid regions determined where aerosol is most transparent (2.13 μm)
    - » contrast between Earth-atmosphere reflectance and that for dense dark vegetation surface (0.47 and 0.66 μm)
    - » enhanced reflectance and reduced contrast over bright surfaces (post-launch)
    - » aerosol optical thickness (0.47 and 0.66 μm)

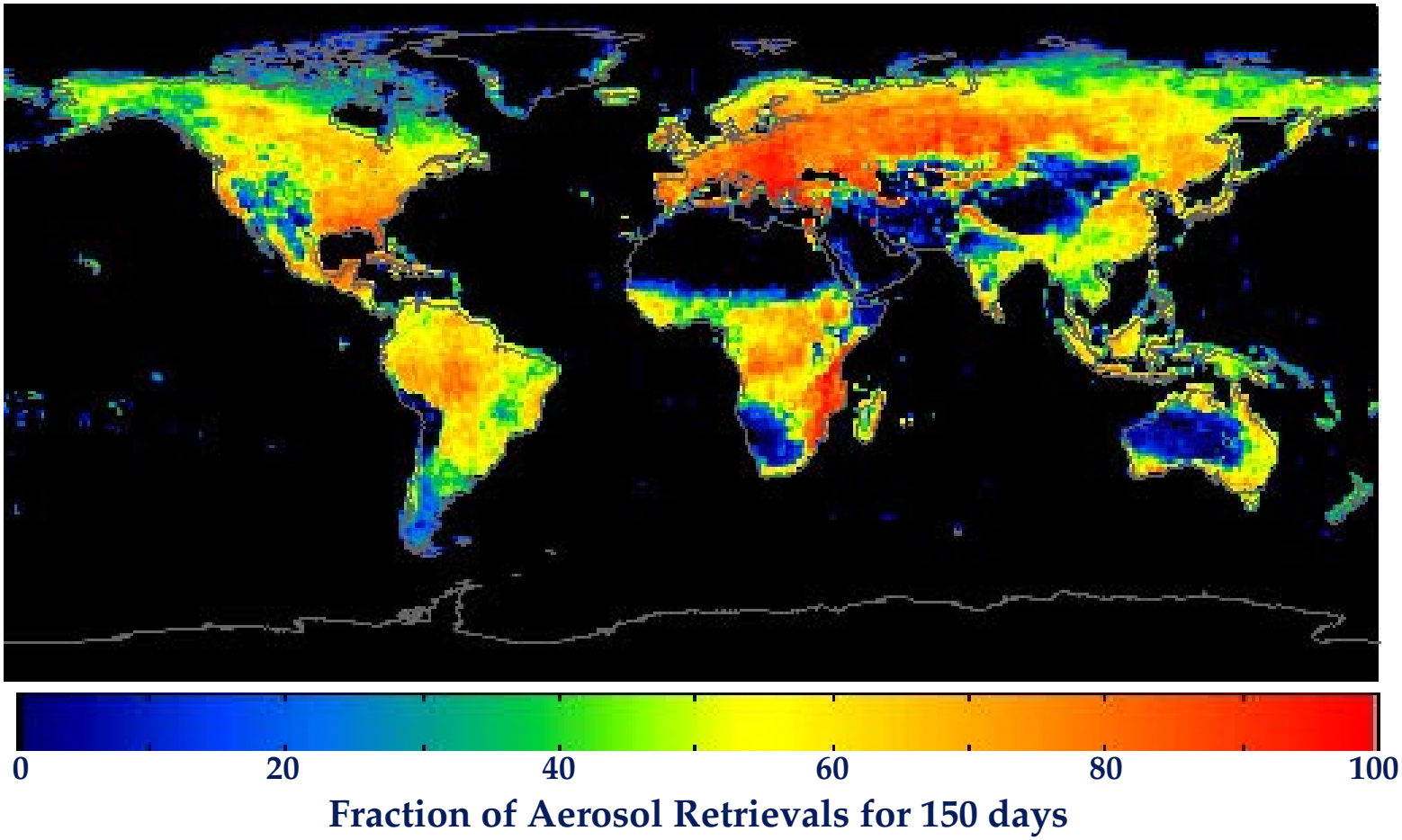
Aerosol Optical Thickness

April 7, 2000

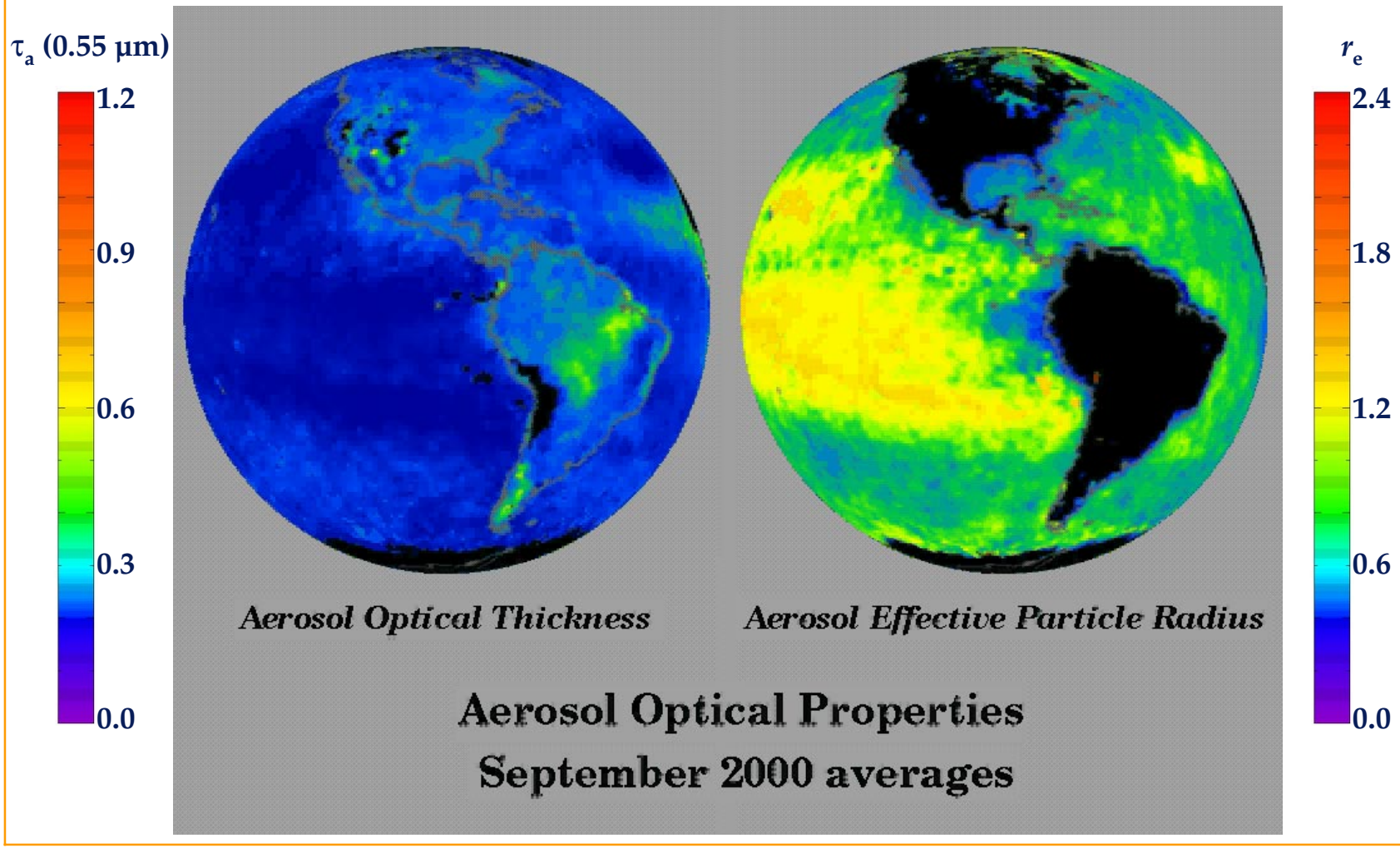
- **Dust outbreak over China**



Frequency of Aerosol Retrievals

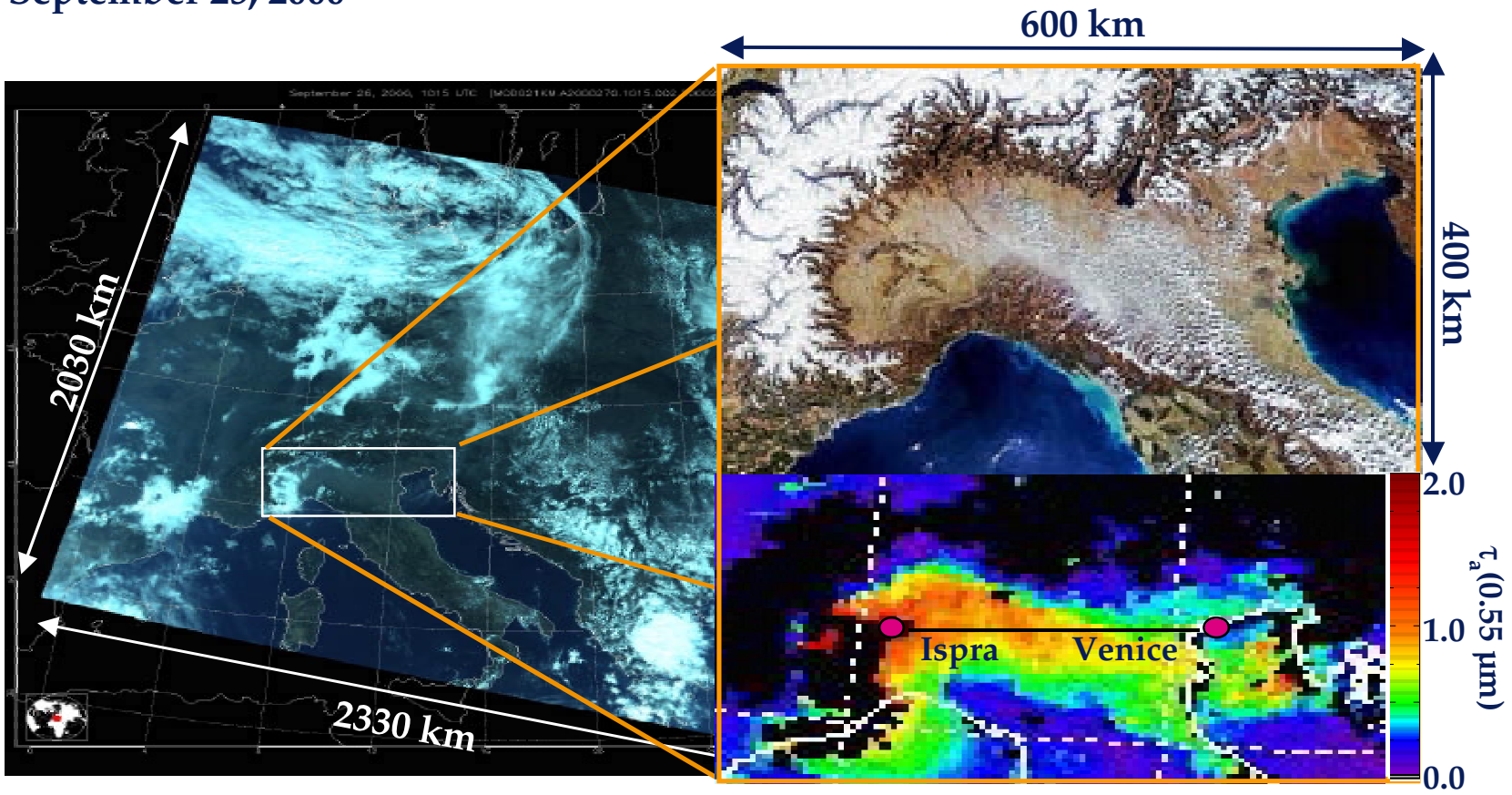


Aerosol Optical Thickness & Effective Radius

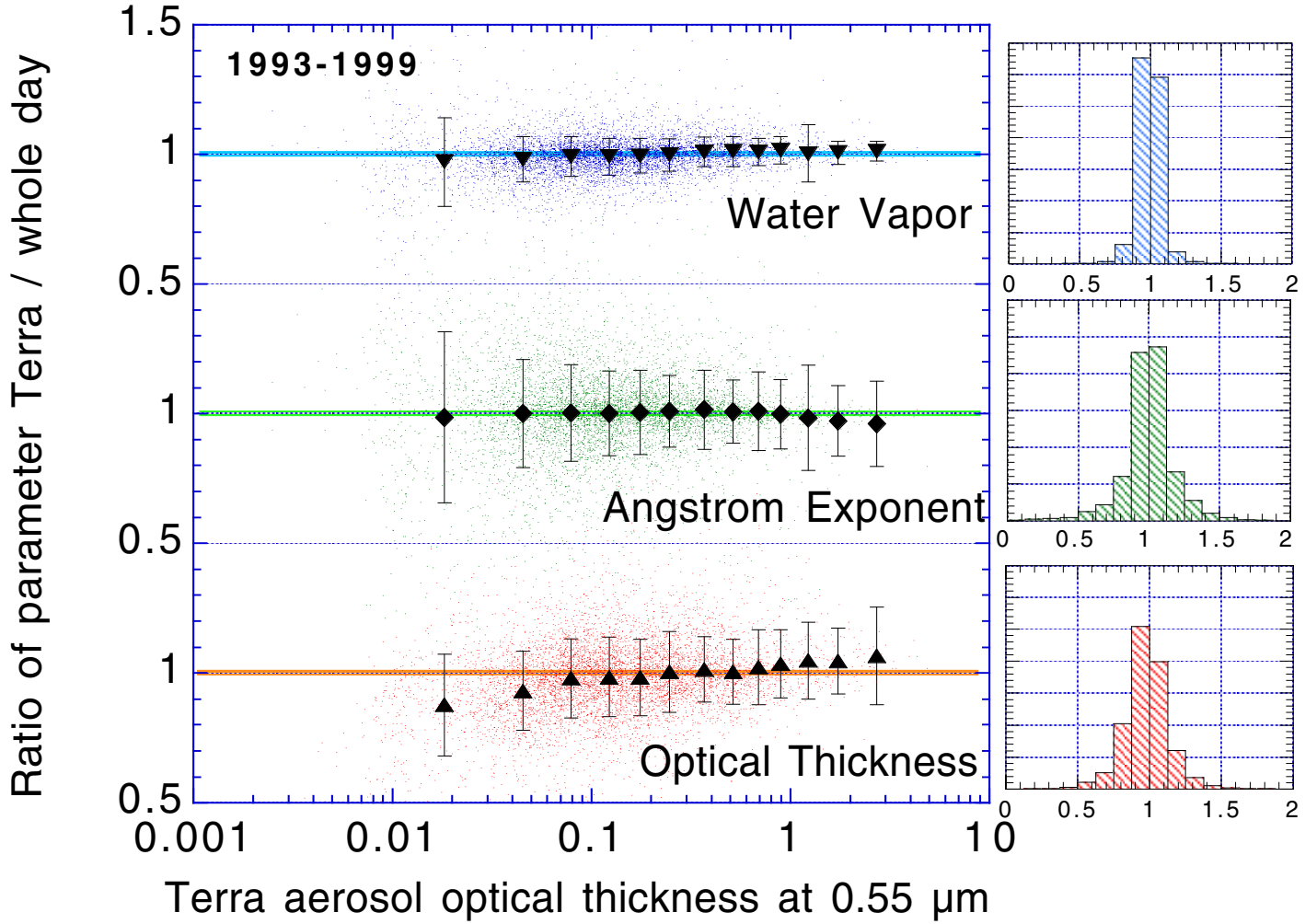


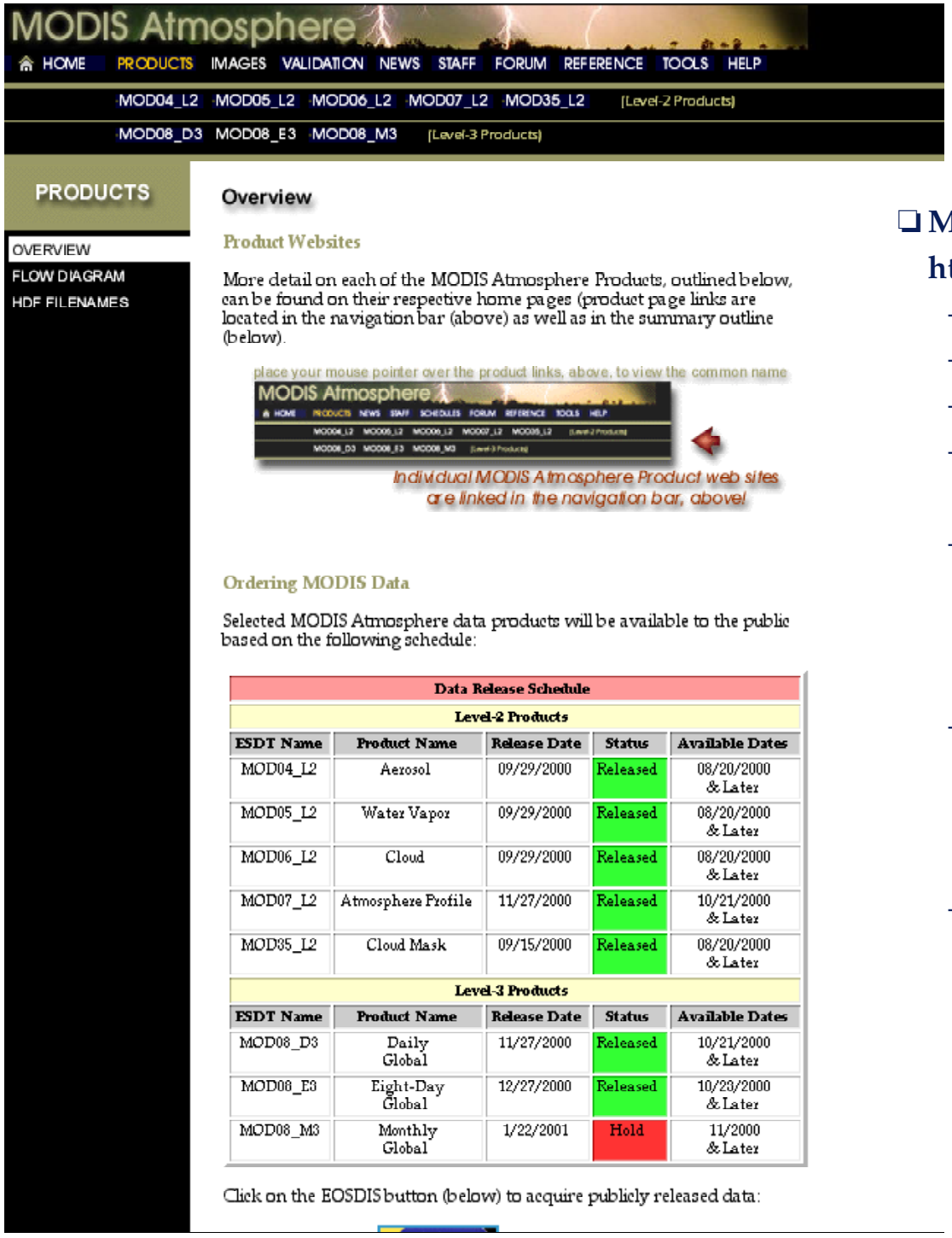
Continental to Regional Scale Pollution in Northern Italy

September 25, 2000



How Does Terra Aerosol Properties Compare to the Daily Cycle?





- MODIS Atmosphere Web site: http://modis-atmos.gsfc.nasa.gov
  - Images
  - Validation
  - News
  - Staff
    - » Resumes
  - References
    - » ATBDs
    - » Validation Plans
    - » Publications (pdf)
  - Tools
    - » Granule locator tools
    - » Spatial and dataset subsetting
    - » Visualization and analysis
  - Data products
    - » Format and content
    - » Grids and mapping
    - » Sample images
    - » Acquiring data

Summary

- MODIS provides an unprecedented opportunity for atmospheric studies
  - 36 spectral channels, high spatial resolution
- Comprehensive set of atmospheric algorithms
- Archive of pixel level retrievals and global statistics
- Validation activities are high priority (ground-based, in situ, aircraft, and satellite intercomparisons)