

Remote Sensing of Cloud Optical and Microphysical Properties Using MODIS Data

MODIS Direct Broadcast, 8 July 2001
Quebec Forest Fires

Bryan A. Baum
NASA Langley Research Center

M. D. King
NASA Goddard Space Flight Center

S. Platnick, M. Gray, E. Moody, P. Hubanks

Topics:

- Retrieval of cloud optical/microphysical properties
- Global and regional analyses
- Status



*MODIS Science Team Meeting
July, 2002*

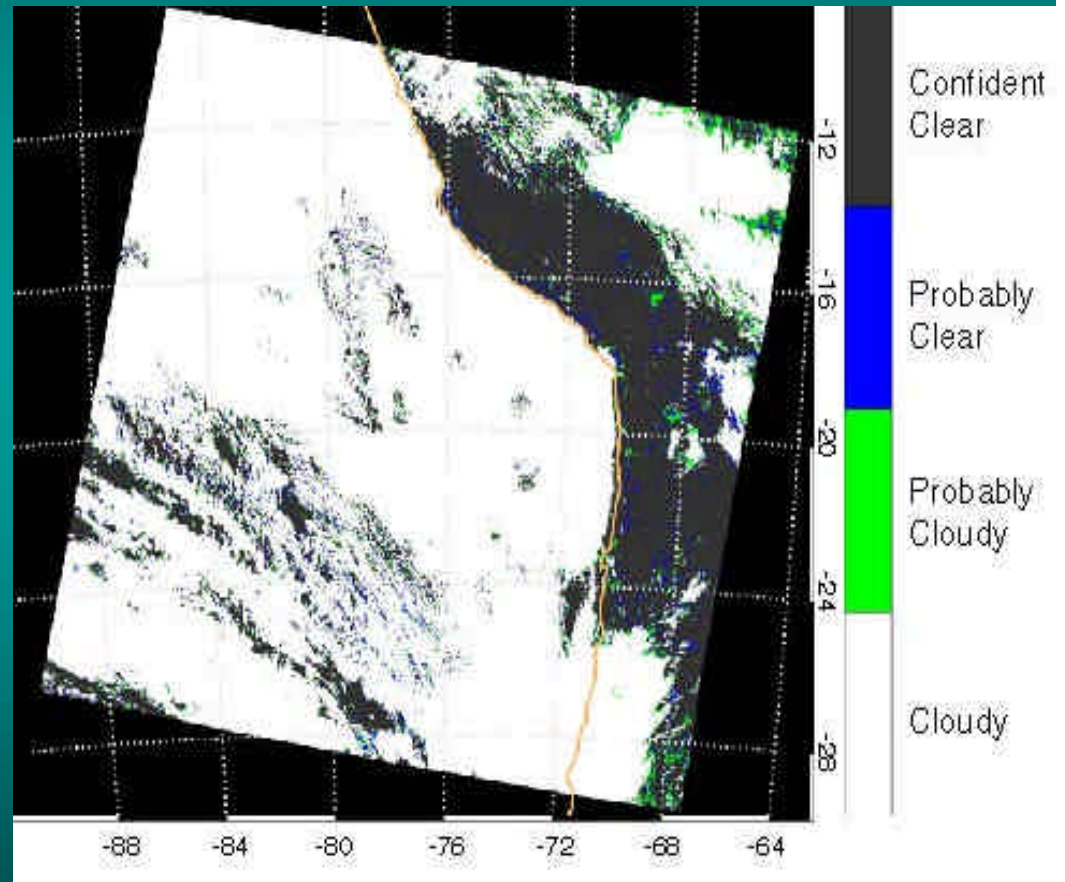
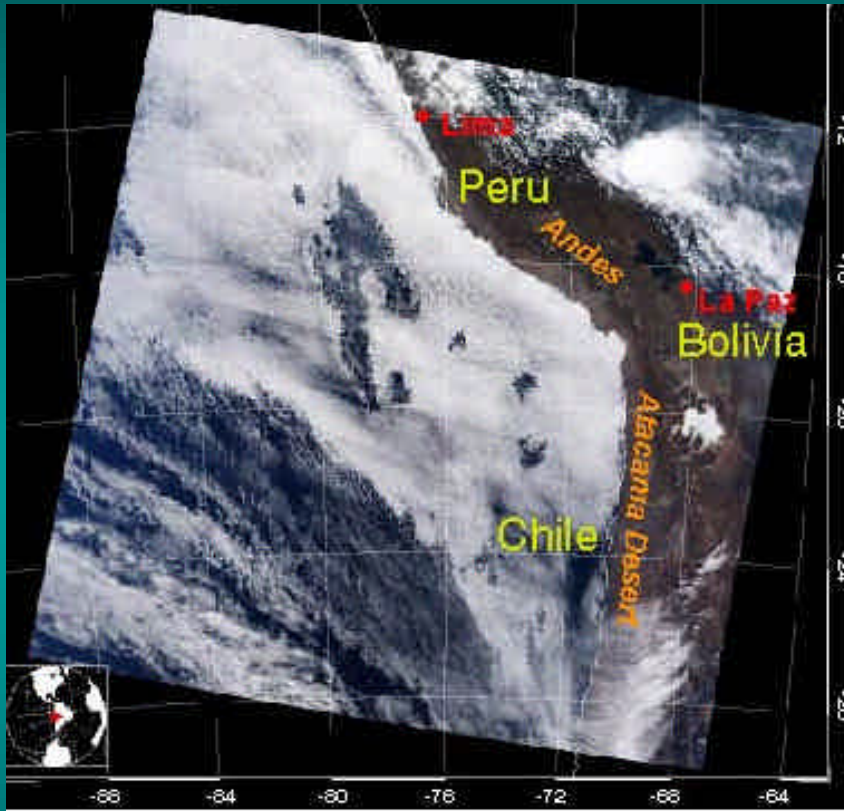


Cloud Clearing

- ❑ Based on multispectral threshold tests from 17 spectral bands ranging from 0.55-13.93 μm (including new 1.38 μm band)
- ❑ 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)
- ❑ Cloud mask is input to rest of atmosphere, land, and ocean algorithms
- ❑ Recent improvements for Version 4 (and upcoming reprocessing effort)
 - ❑ - semi-arid land (less uncertain in clear-sky regions)
 - ❑ - sunglint (better discrimination between low clouds and clear sky)
- ❑ Provided at both 0.25 km and 1 km spatial resolution



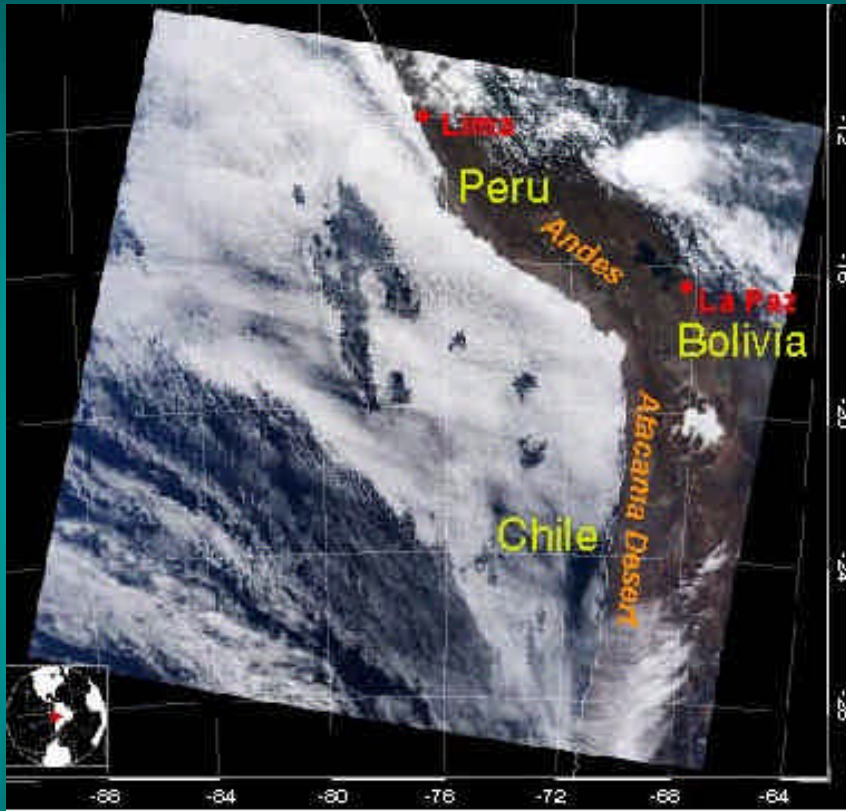
Operational Cloud Products



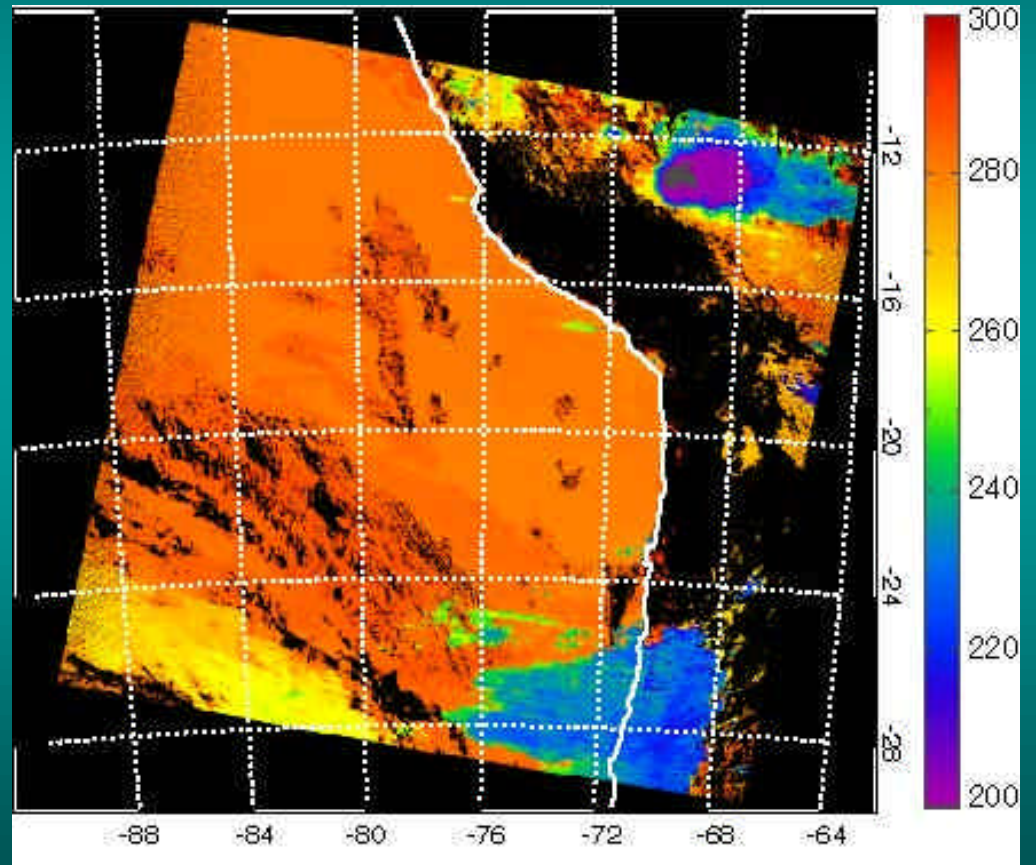
Platnick et al, 2002: The MODIS cloud products: Algorithms and examples from Terra. Submitted to *IEEE Transactions on Geoscience and Remote Sensing (TGRSS)*



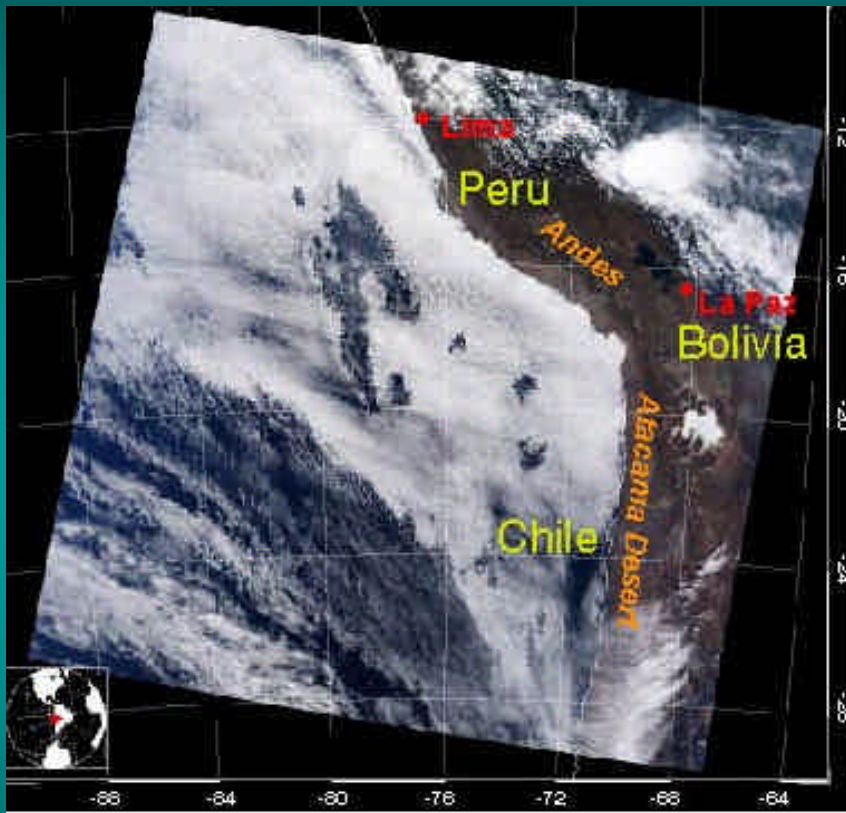
Cloud Temperature



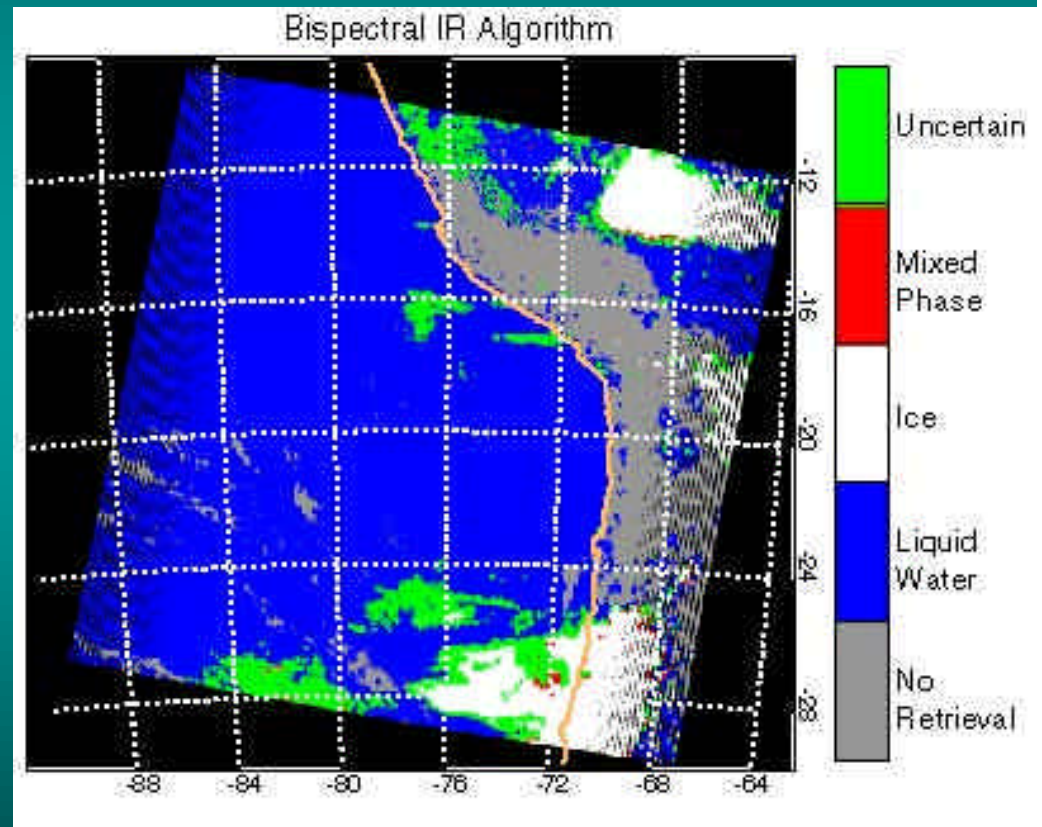
18 July 2001



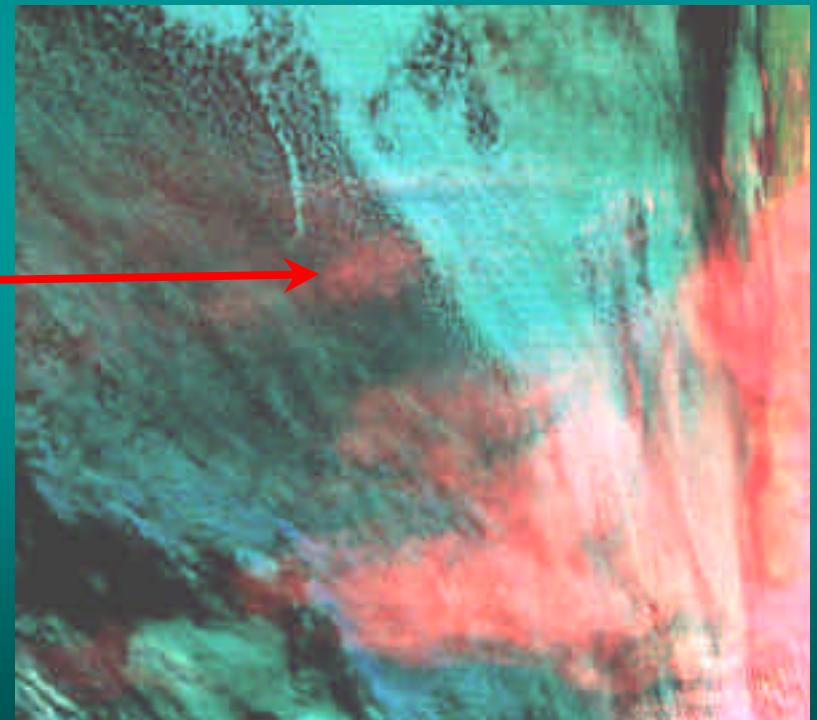
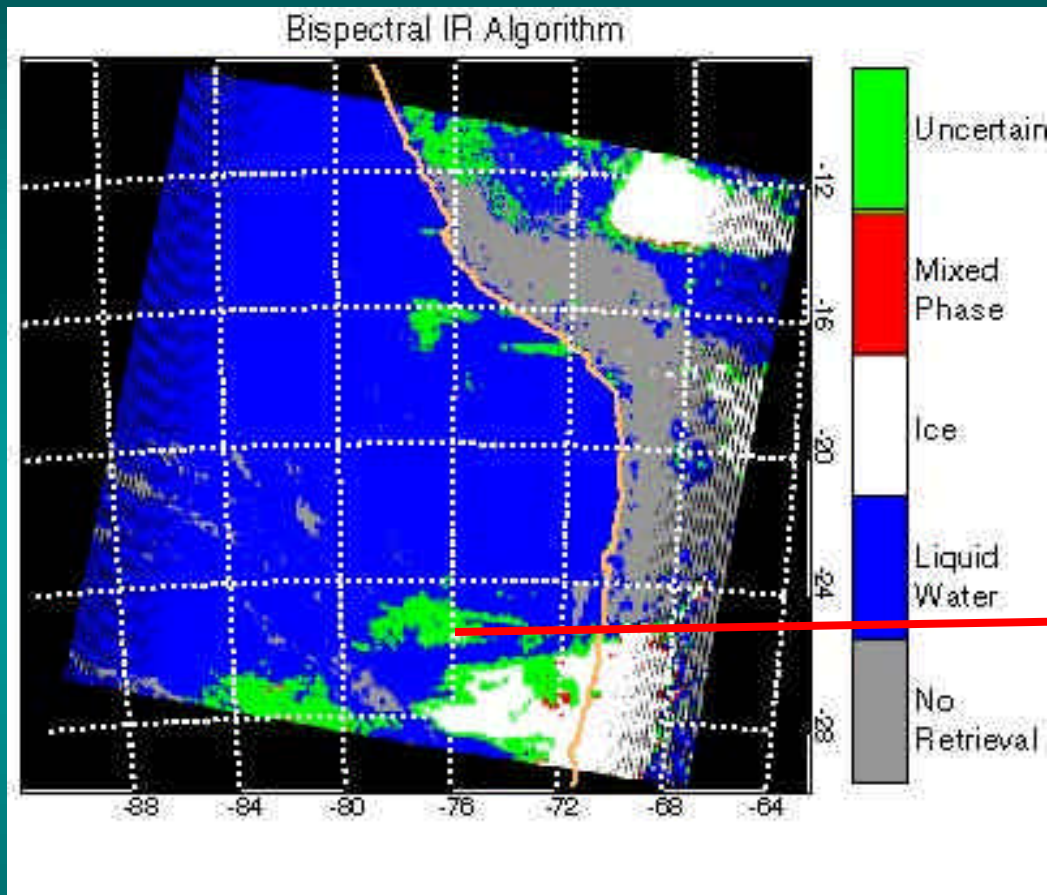
Infrared Cloud Phase



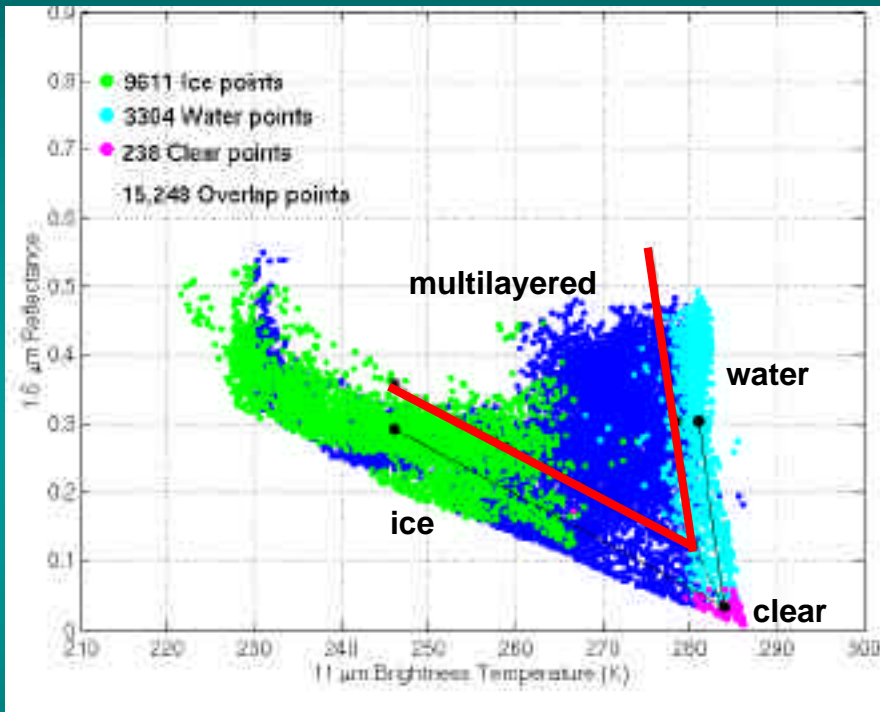
18 July 2001



Multilayered Clouds



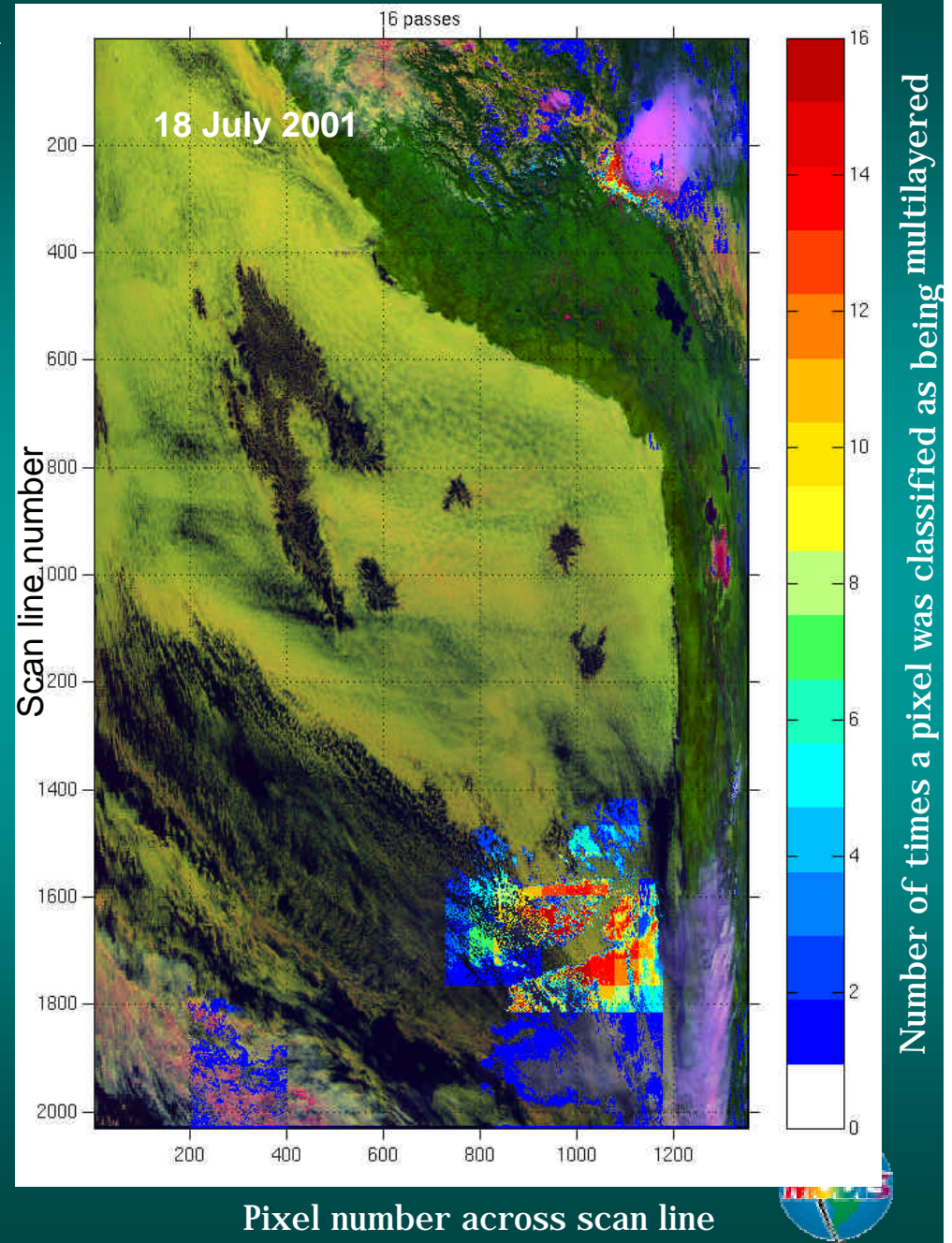
Daytime Multilayered Cloud Detection



Scatterplot for 200 x 200 pixel array

Pixels are analyzed multiple times (except around edges of granule) by staggering the array over the scene

Nasiri and Baum, 2002: Daytime Multilayered Cloud Detection using MODIS Data. In preparation.

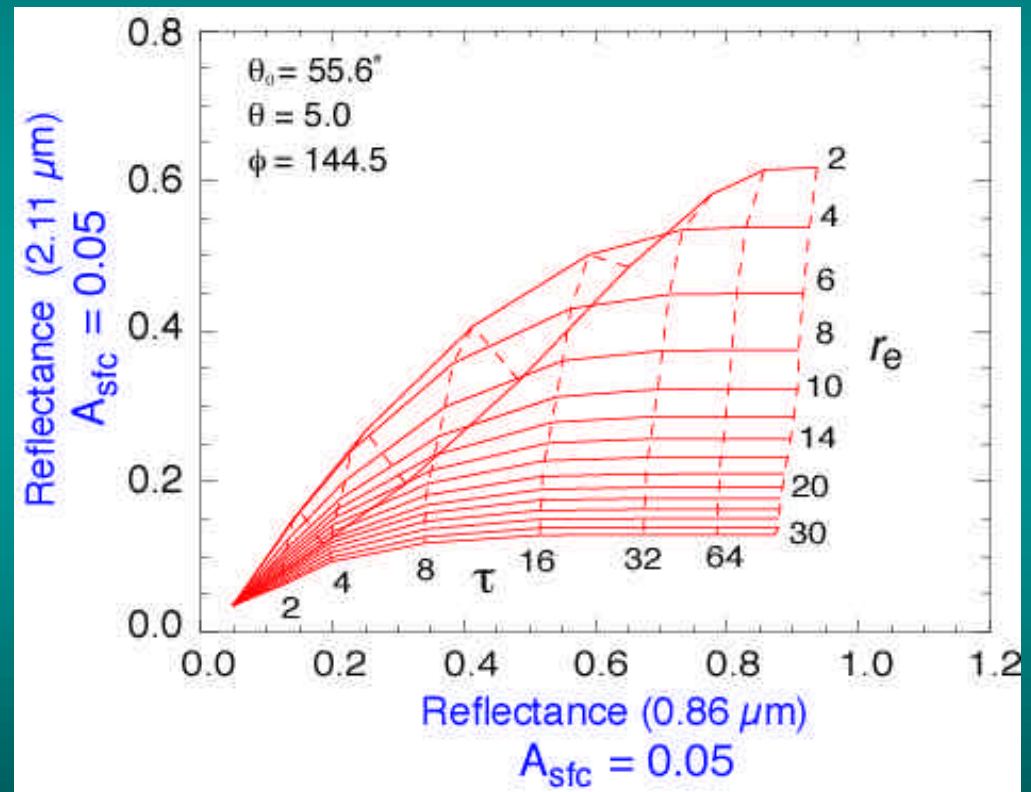


Retrieval of Optical Thickness and Particle Size

(M. D. King and S. Platnick)

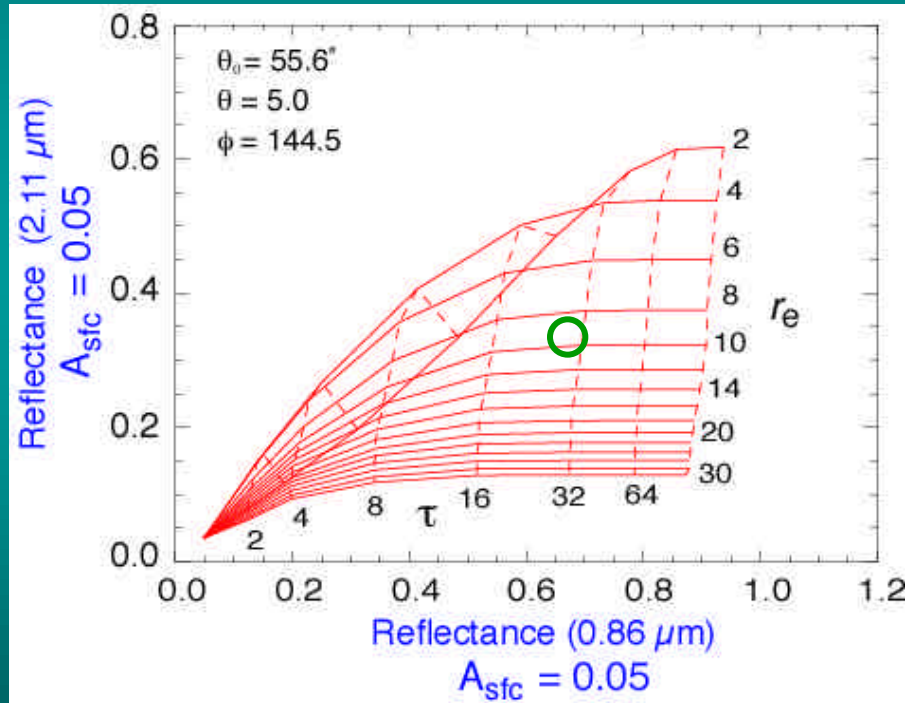
- The reflection function of a nonabsorbing band (e.g., 0.86 μm) is primarily a function of optical thickness
- The reflection function of a near-infrared absorbing band (e.g., 2.14 μm) is primarily a function of effective radius
 - clouds with small drops (or ice crystals) reflect more than those with 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

Liquid Water Clouds - ocean surface

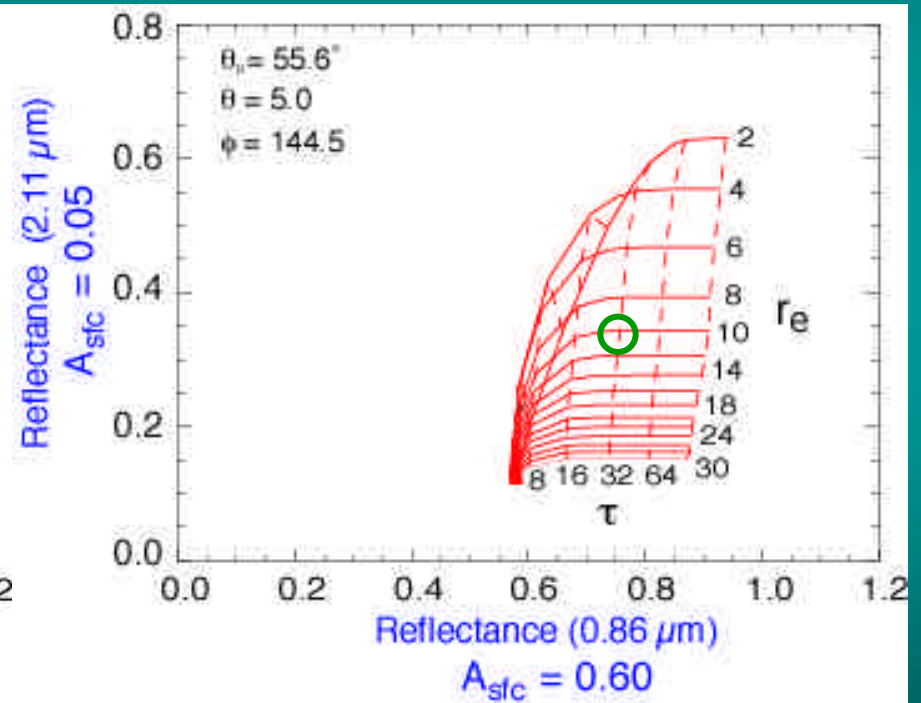


Cloud Optical & Microphysical Properties Retrieval Example

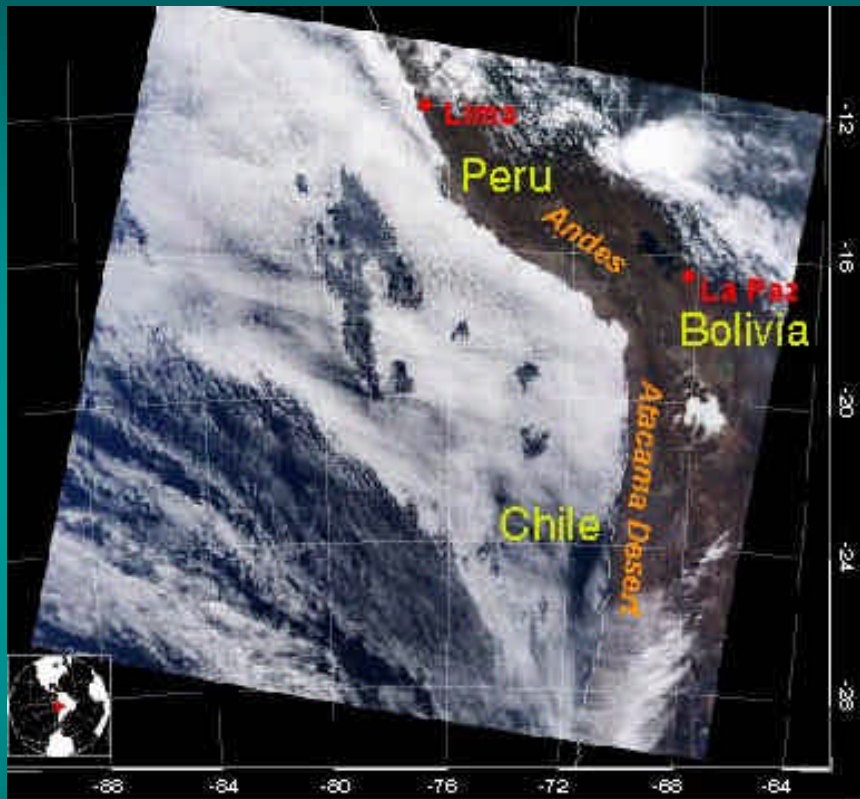
Liquid Water Clouds - ocean surface



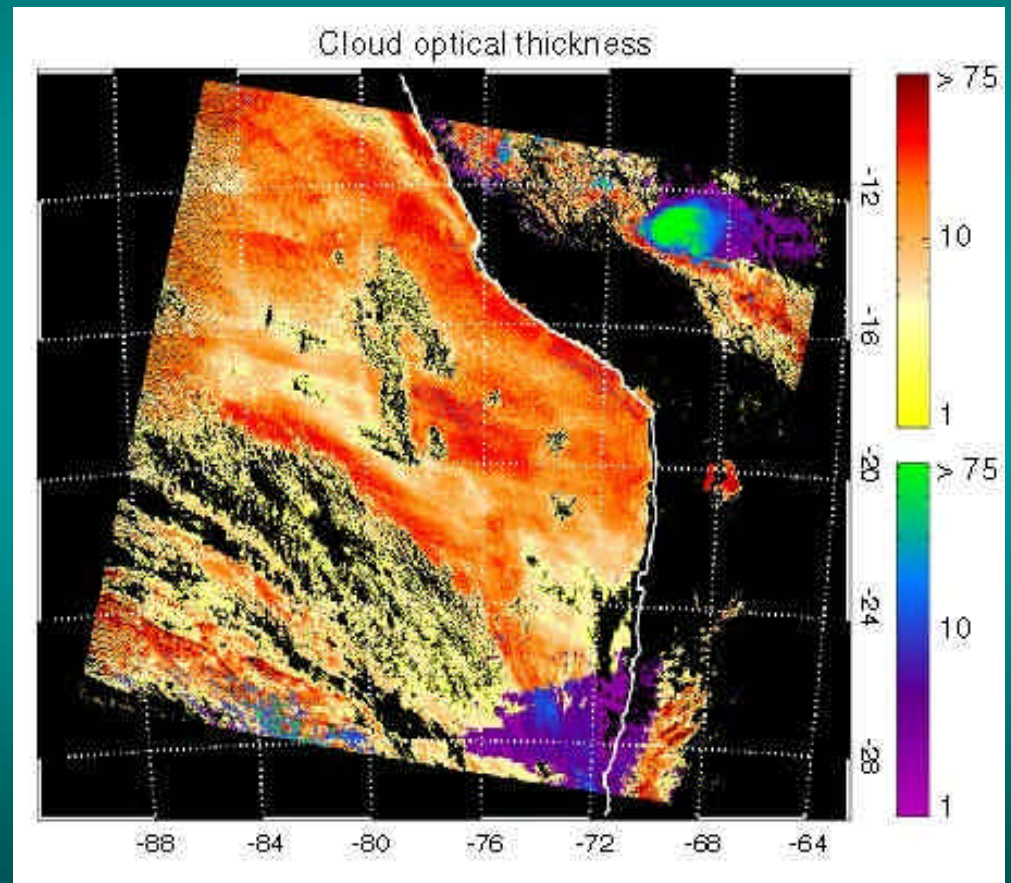
Liquid Water Clouds - ice surface



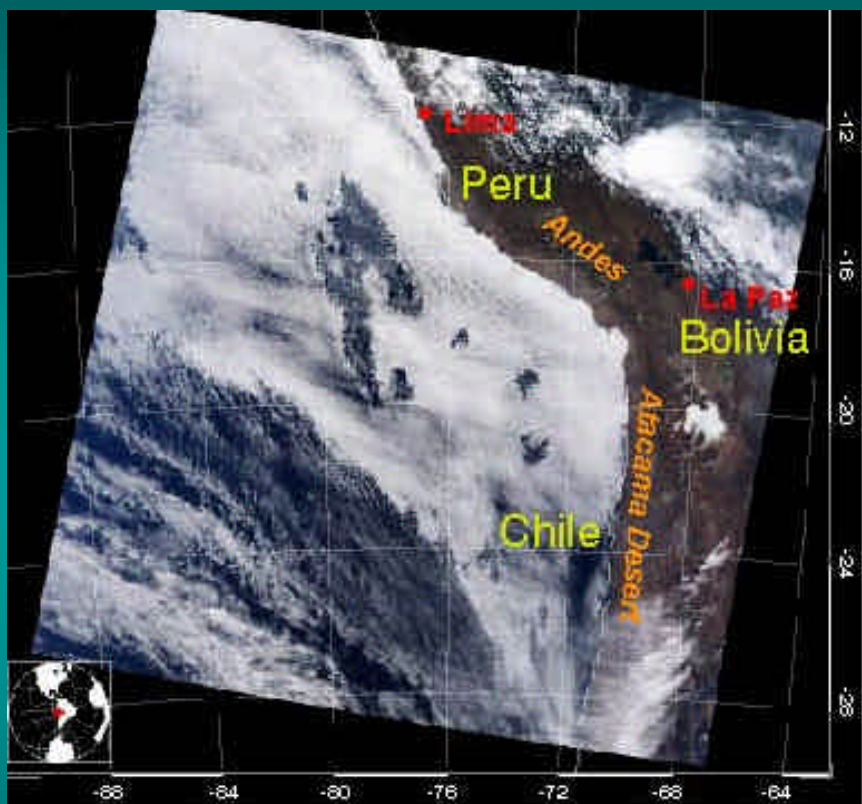
Cloud Optical Thickness



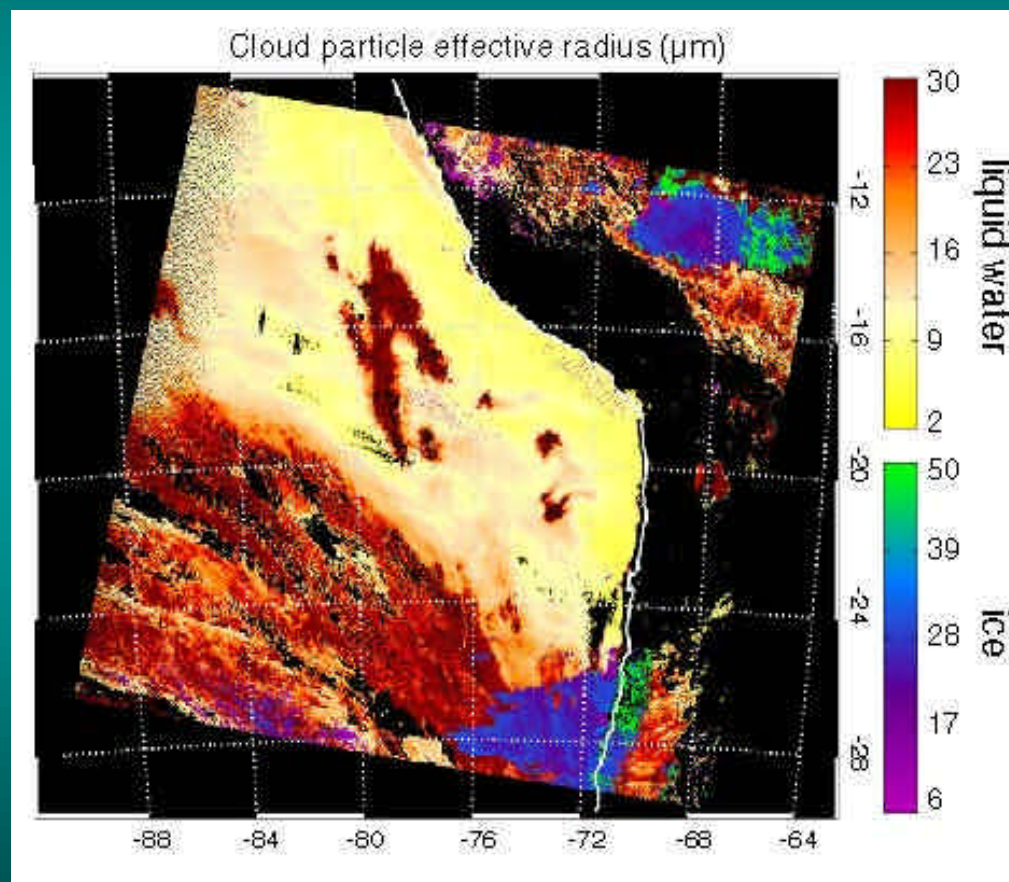
18 July 2001



Cloud Particle Size



18 July 2001



Recent Improvements for Collection 4 Code Delivery

New high resolution surface albedo map based on MOD43.

New cloud phase decision algorithm that merges results from the IR (8.5 and 11 μm) and decision tree (based on cloud mask) approaches.

Serious algorithm problems solved (polar retrievals, use of pre-calculated cloud property libraries).

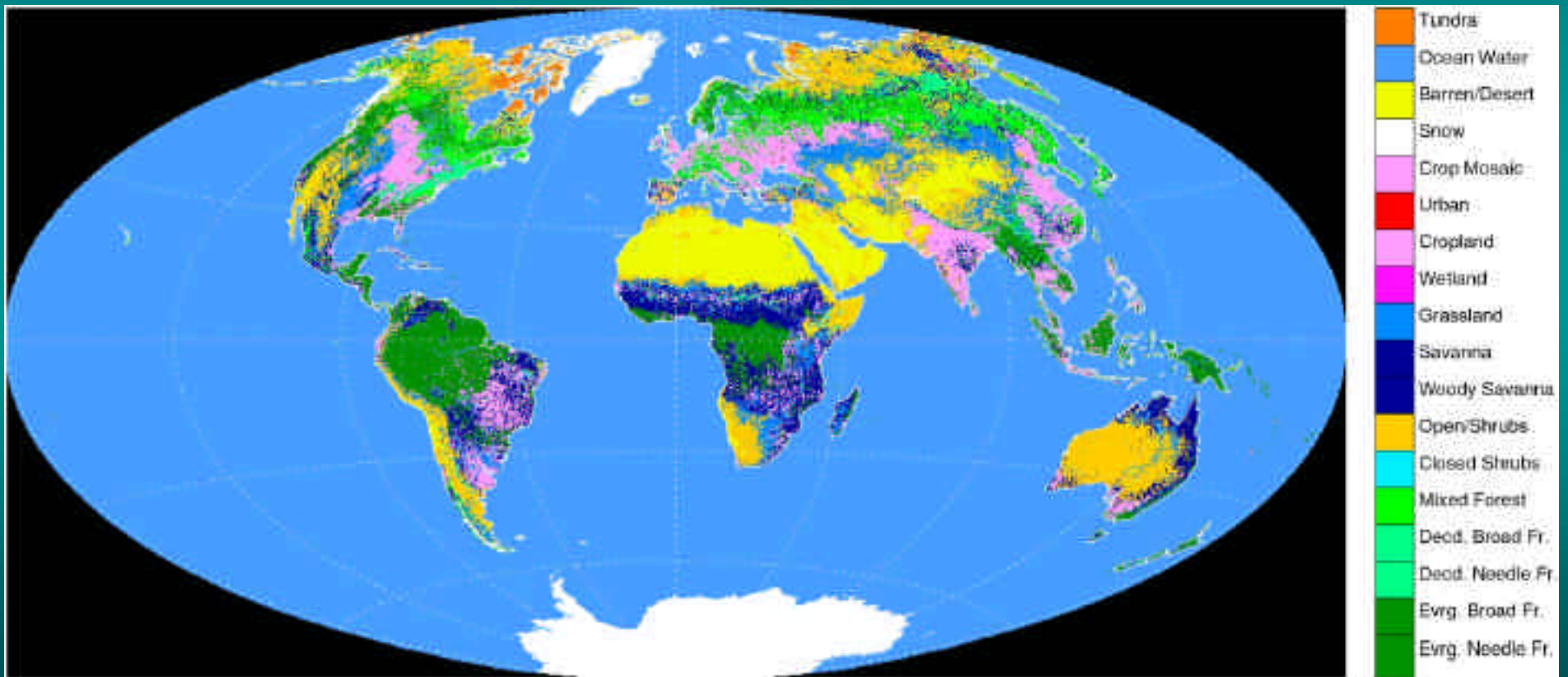
Large reduction in number of unsuccessful retrievals.



Ecosystem Map

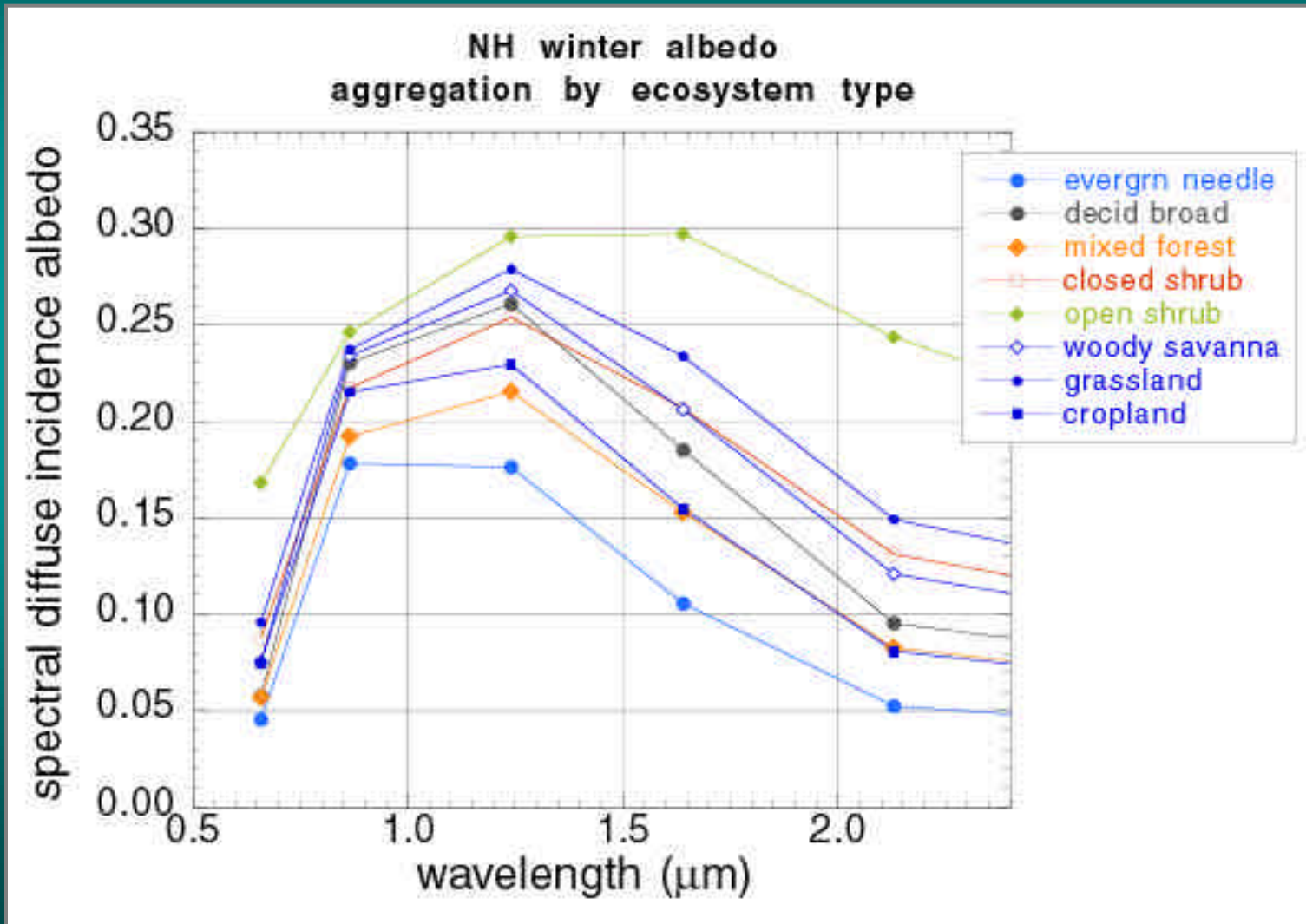
(A. H. Strahler, C. B. Schaaf, et al. – Boston University)

MOD12 (IGBP ecosystem classification) + USGS water + tundra



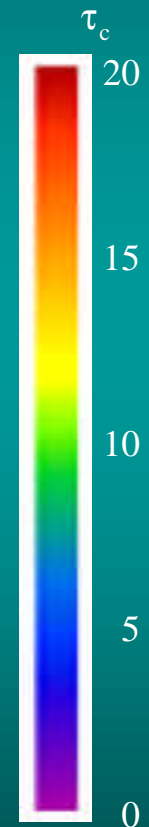
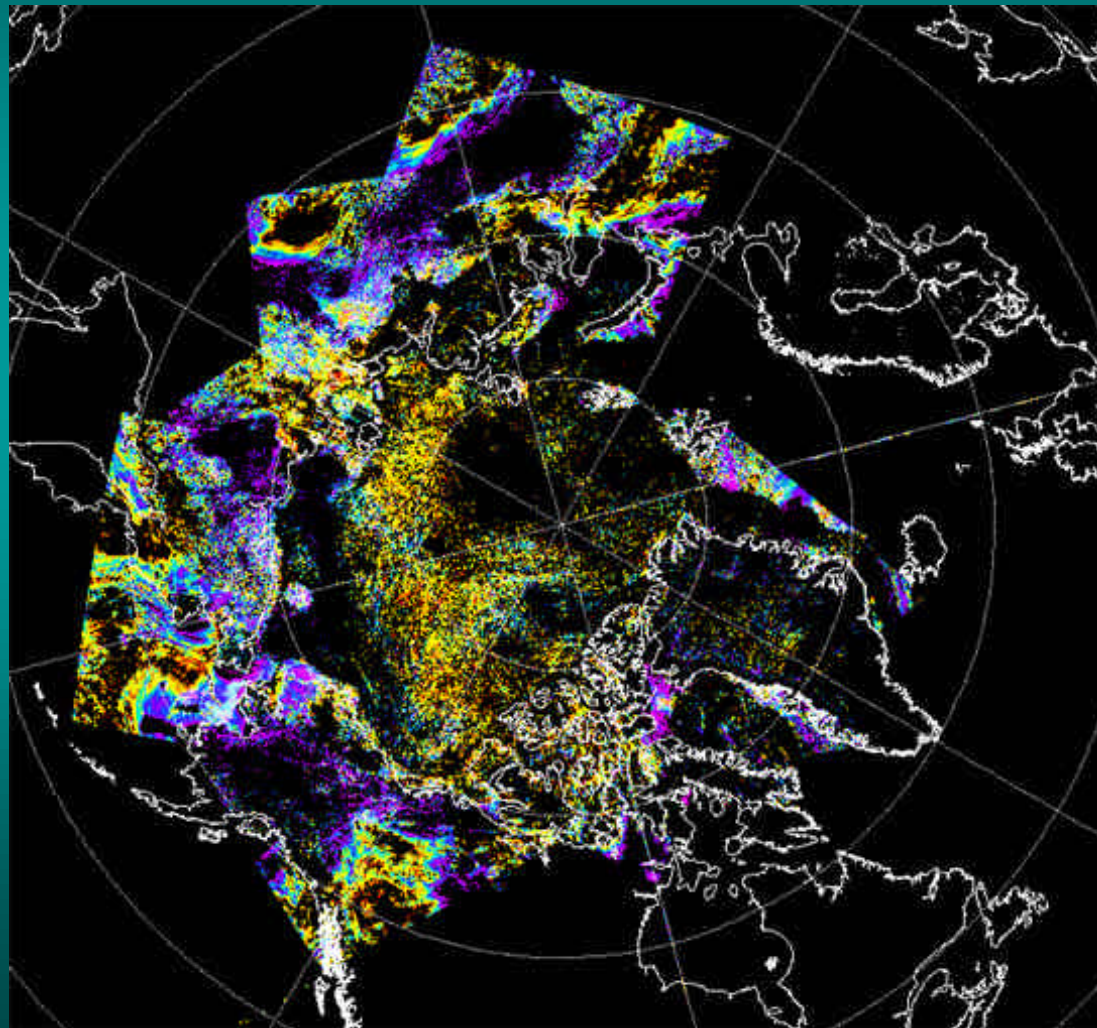
Surface Albedo

Surface albedo = ecosystem + MOD43 (Strahler, Schaaf et al.) aggregation



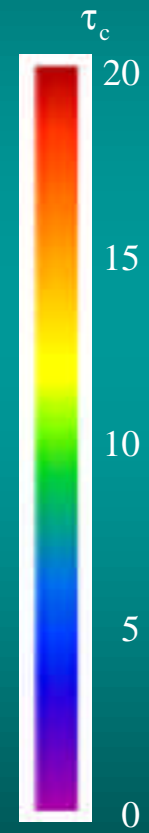
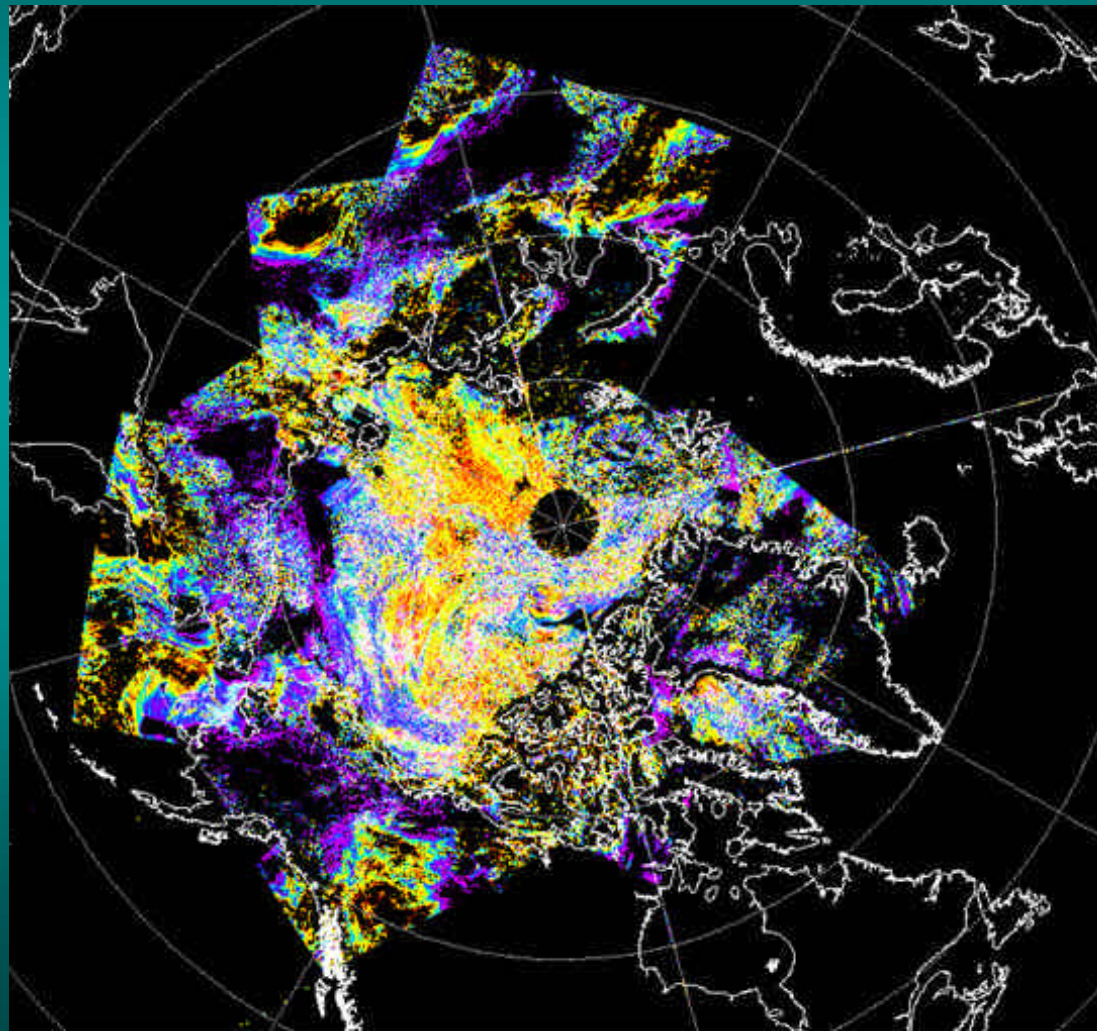
Cloud Optical Thickness in the Arctic: Provisional Production Code (edition 3)

June 2, 2001



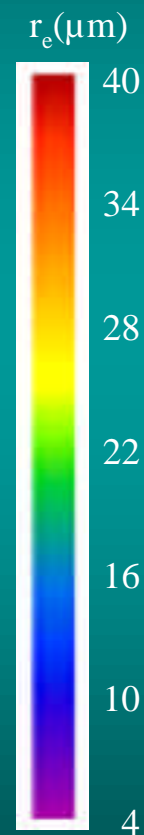
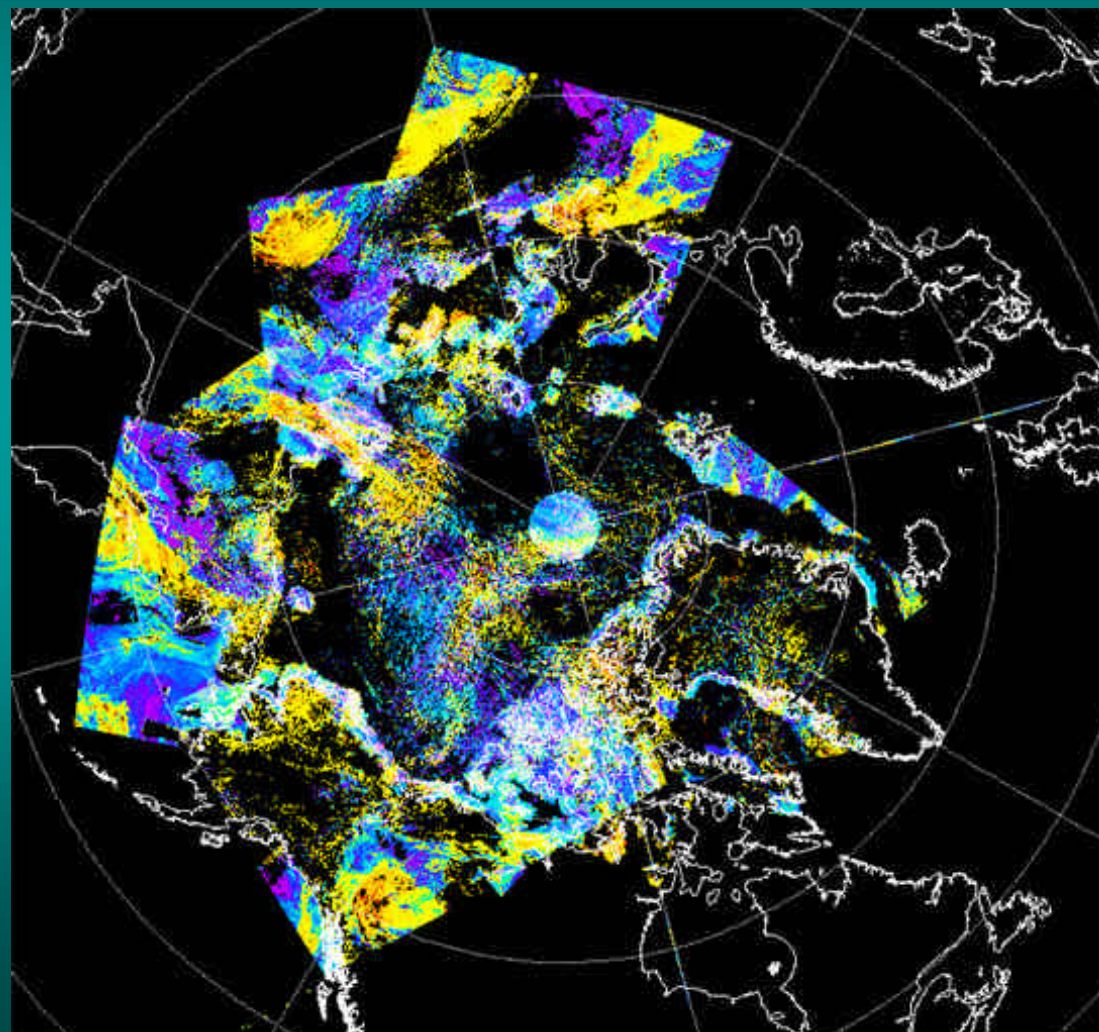
Cloud Optical Thickness in the Arctic: Provisional Production Code (new correction)

June 2, 2001



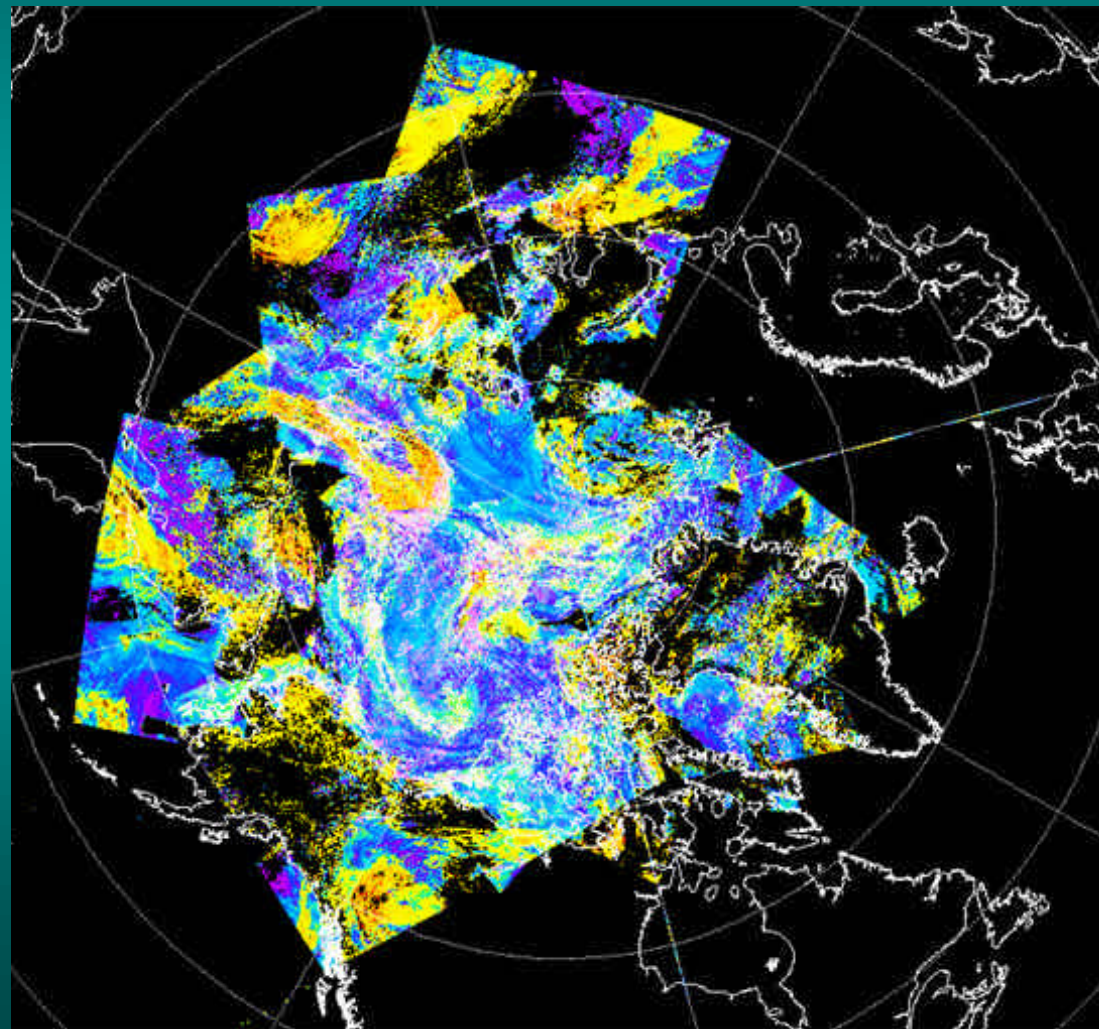
Cloud Effective Radius in the Arctic: Provisional Production Code (edition 3)

June 2, 2001



Cloud Effective Radius in the Arctic: Provisional Production Code (new correction)

June 2, 2001



Global Cloud Retrievals

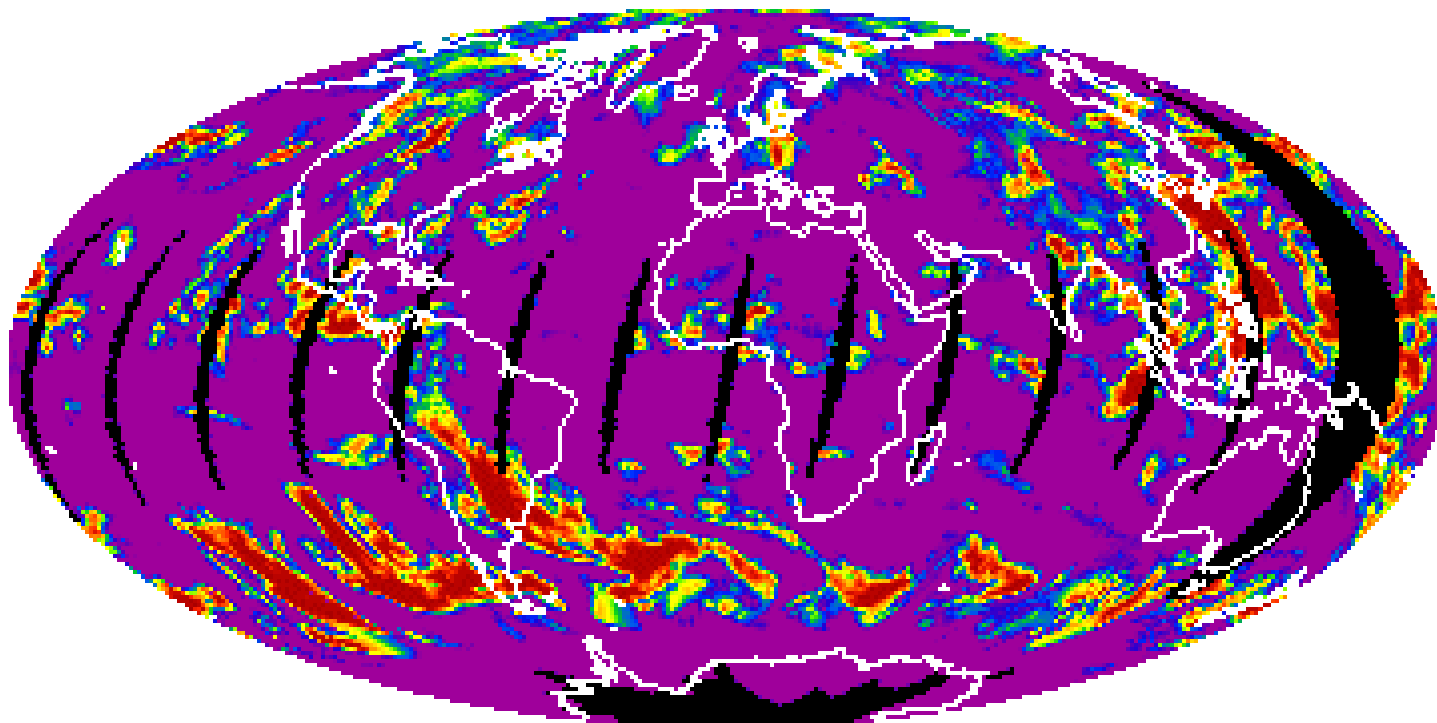
Global cloud optical/microphysical properties being derived for both Terra and Aqua data

What follows are comparisons between identical Terra and Aqua cloud parameters for July 4, 2002.



Cloud_Fraction_Ice

04Jul2002



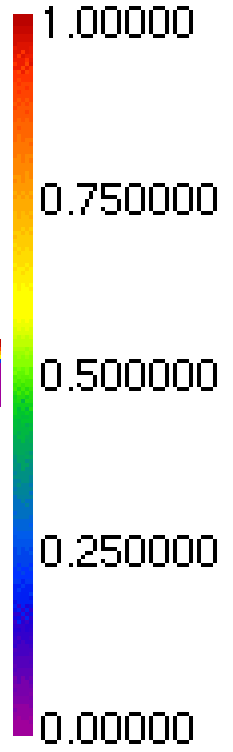
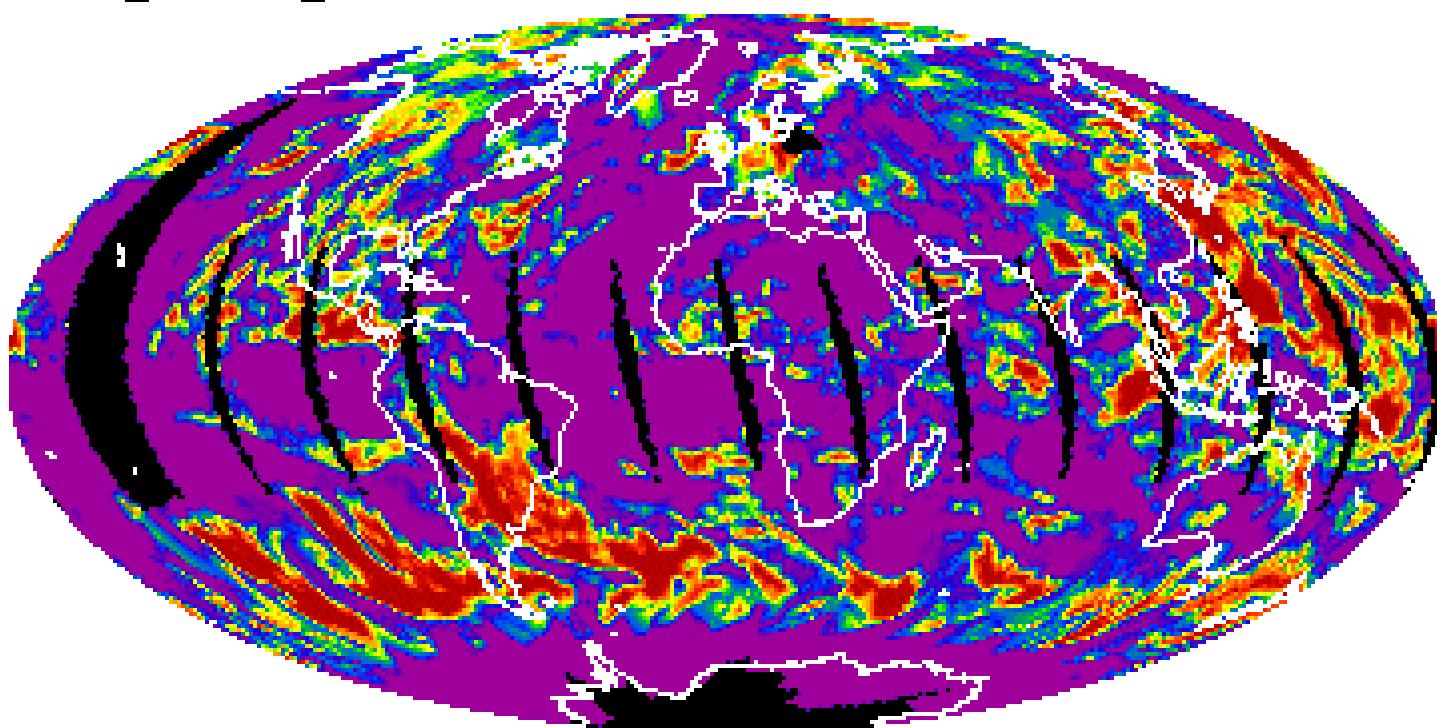
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*name



Cloud_Fraction_Ice

04 Jul 2002



MODIS/Aqua

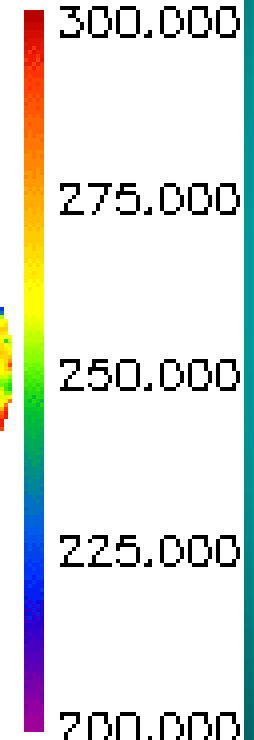
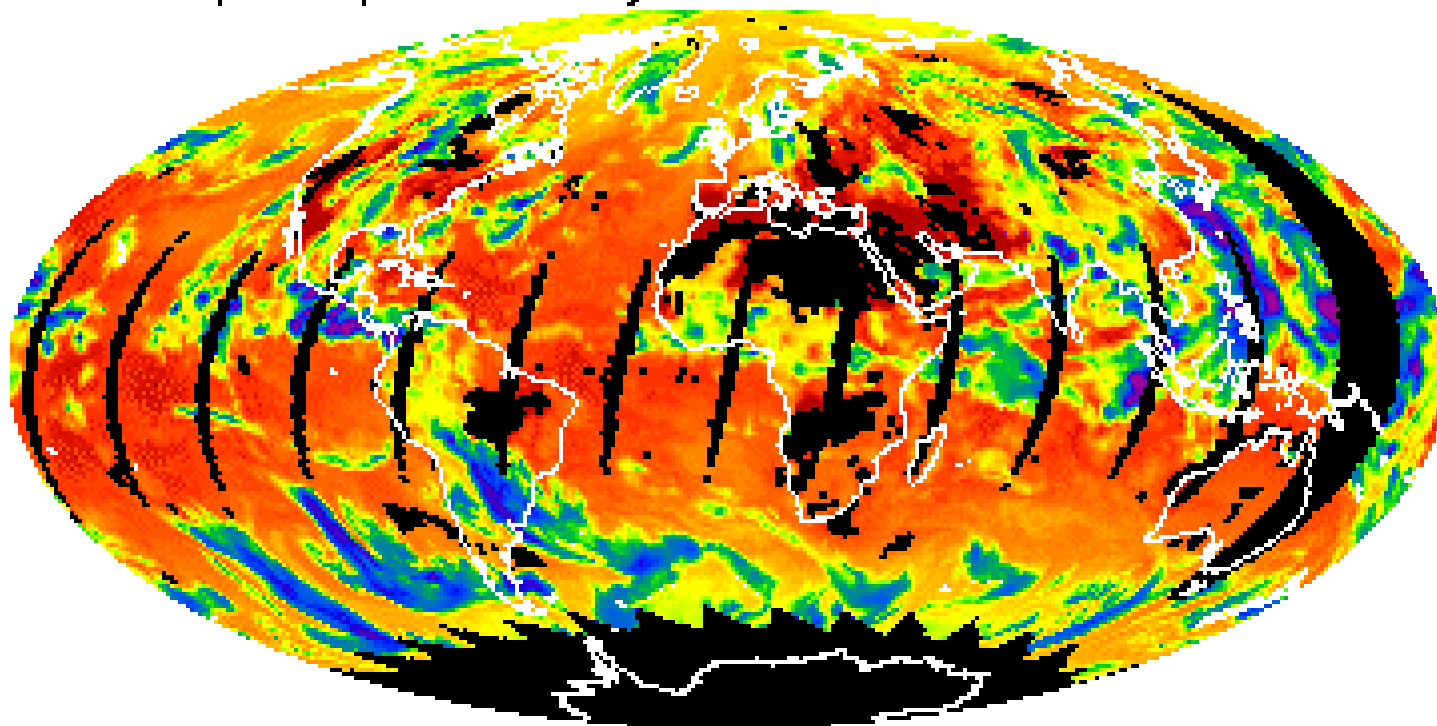
MYD08_D3.A2002185.003.2002189030600.hdf

*none



Cloud_Top_Temperature_Day_Mean

04 Jul 2002



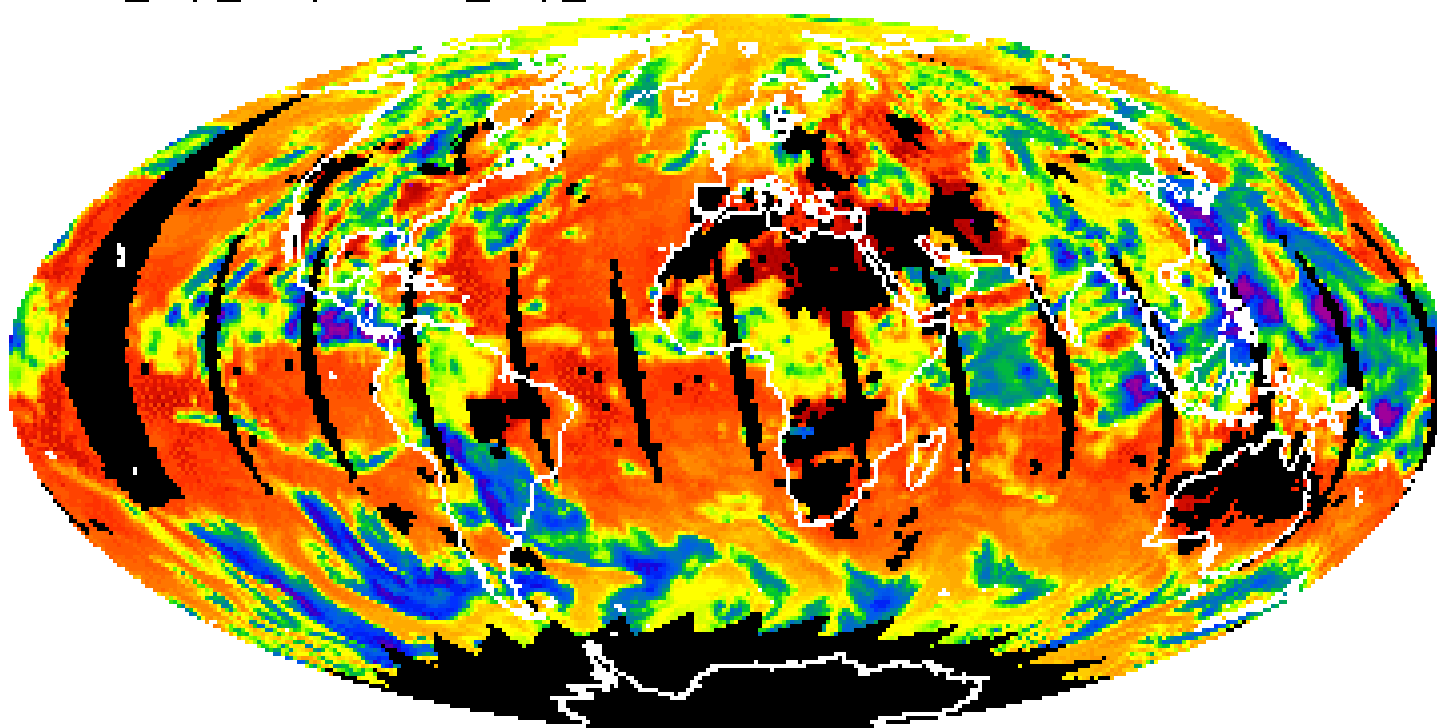
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*Degree Kelvin



Cloud_Top_Temperature_Day_Mean

04 Jul 2002



MODIS/Aqua

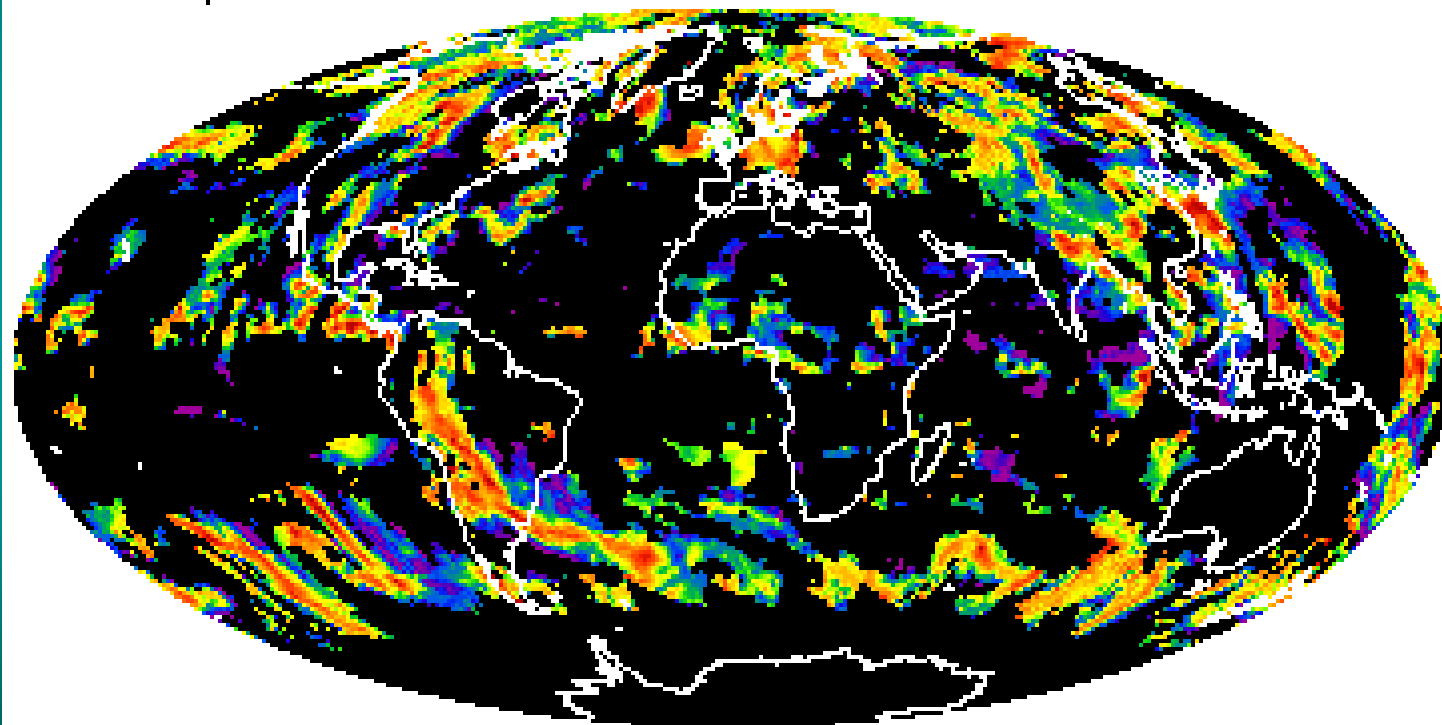
MYD08_D3.A2002185.003.2002189030600.hdf

* Degrees Kelvin



Cloud_Optical_Thickness_Ice_Mean

04Jul2002



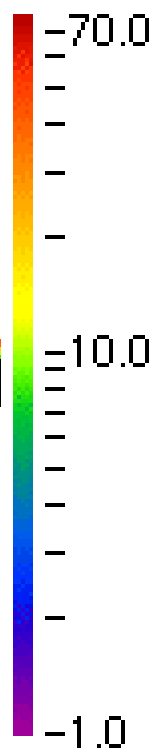
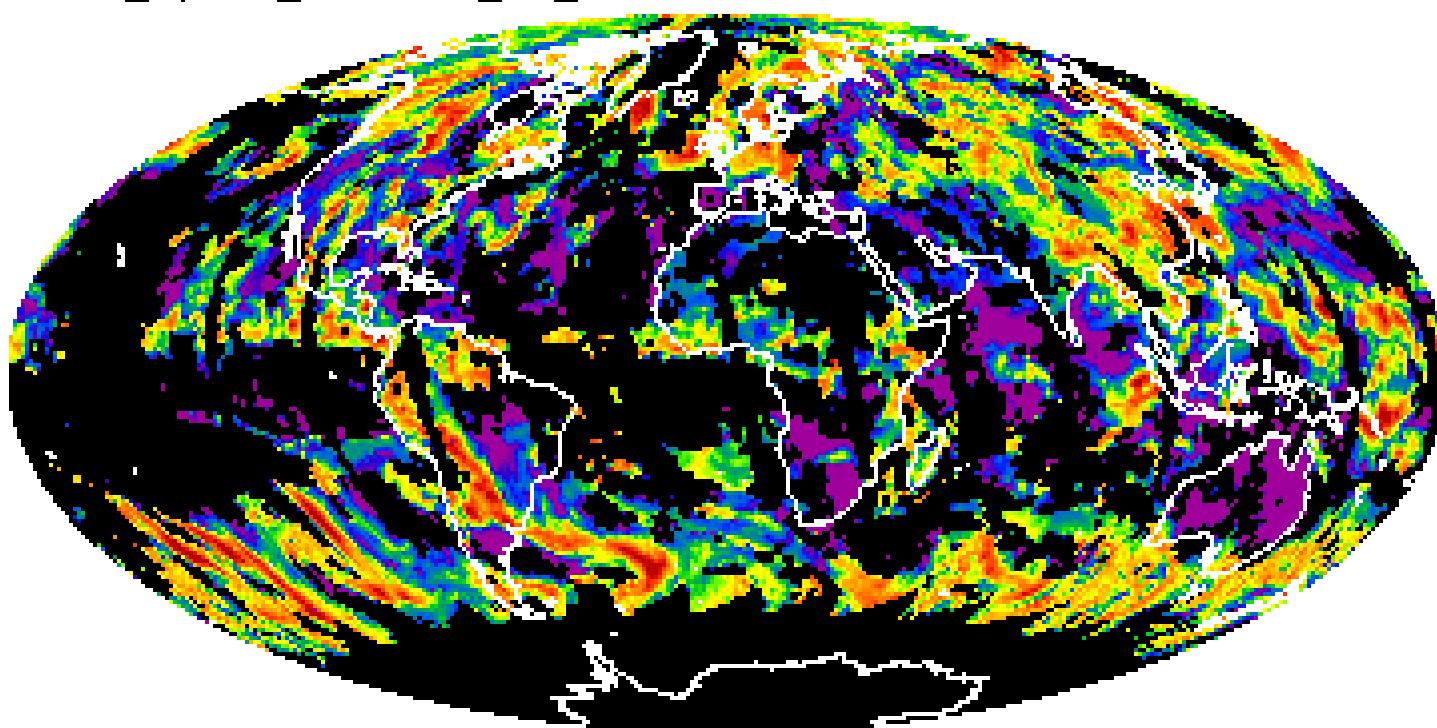
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*name



Cloud_Optical_Thickness_Ice_Mean

04 Jul 2002



MODIS/Aqua

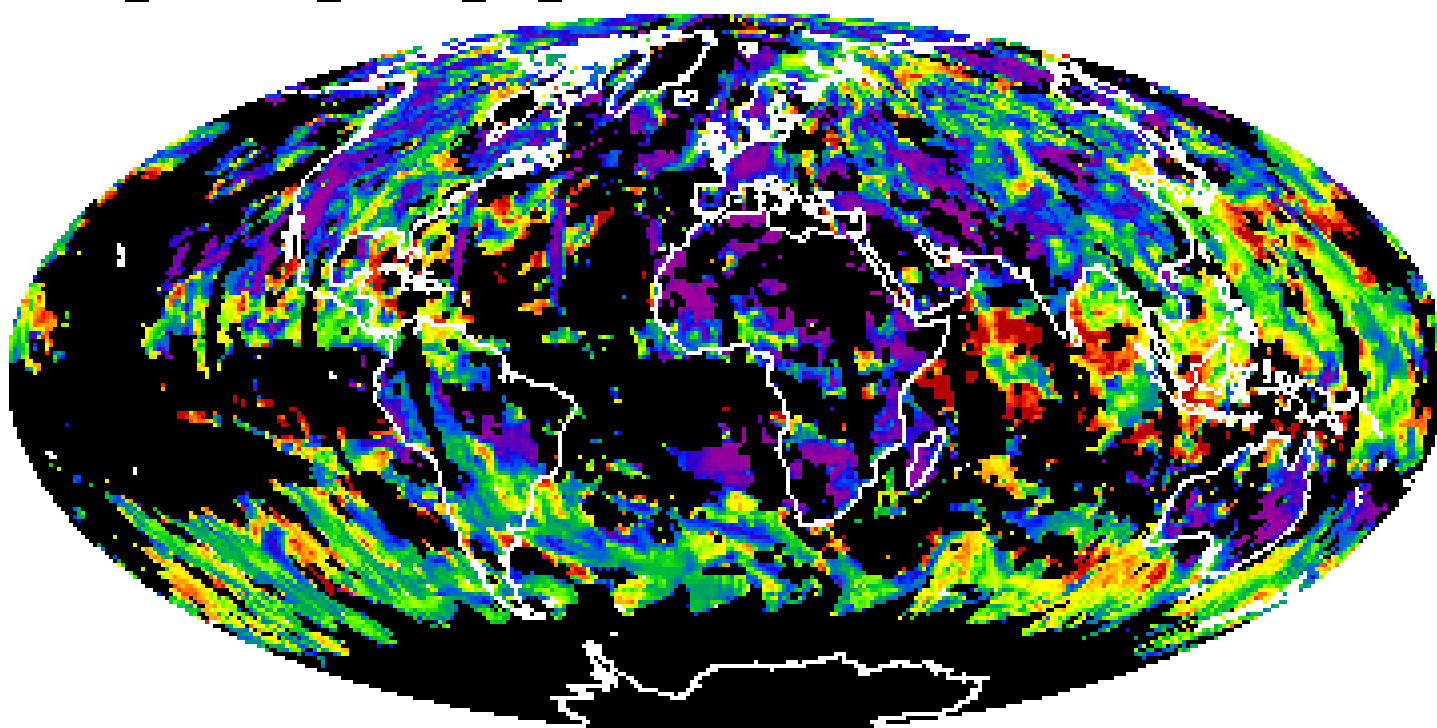
MYD08_D3.A2002185.003.2002189030600.hdf

*none



Cloud_Effective_Radius_Ice_Mean

04 Jul 2002



MODIS/Aqua

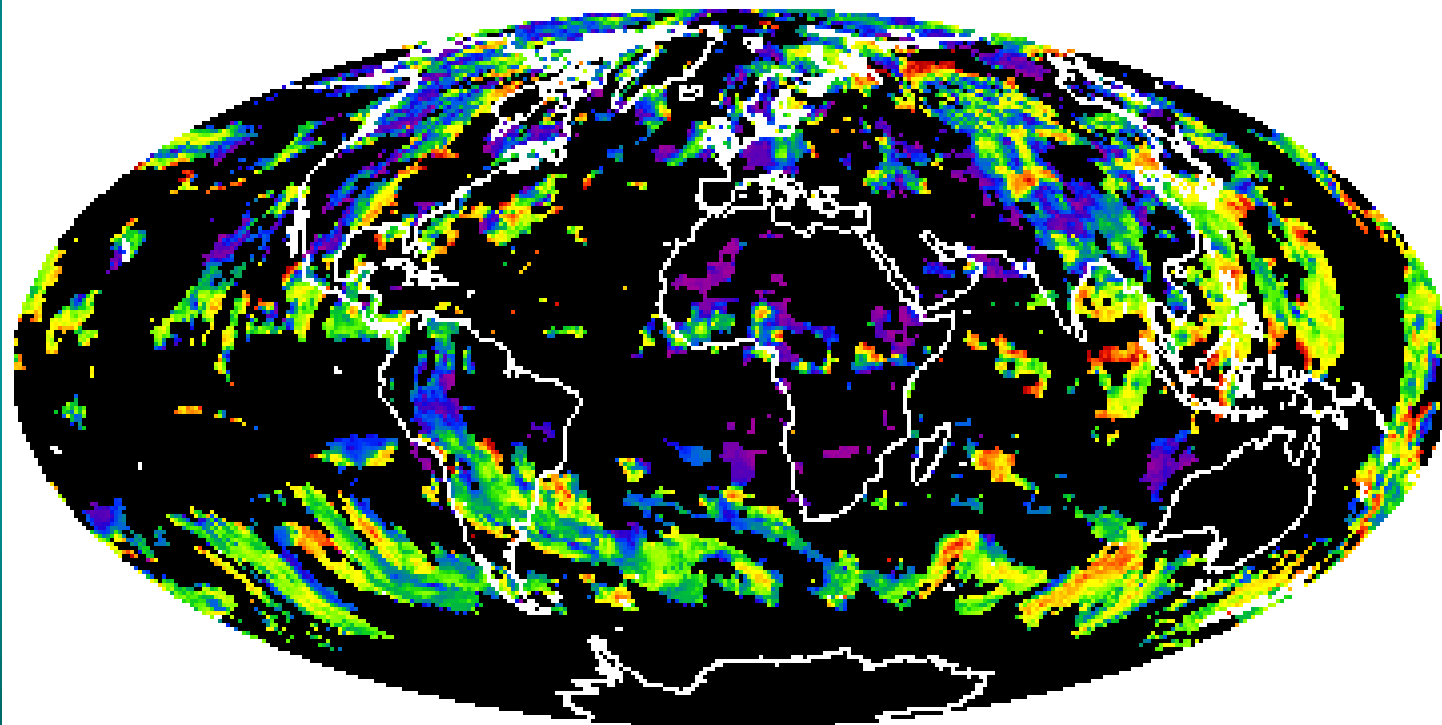
MYD08_D3.A2002185.003.2002189030600.hdf

*microns



Cloud_Effective_Radius_Ice_Mean

04Jul2002



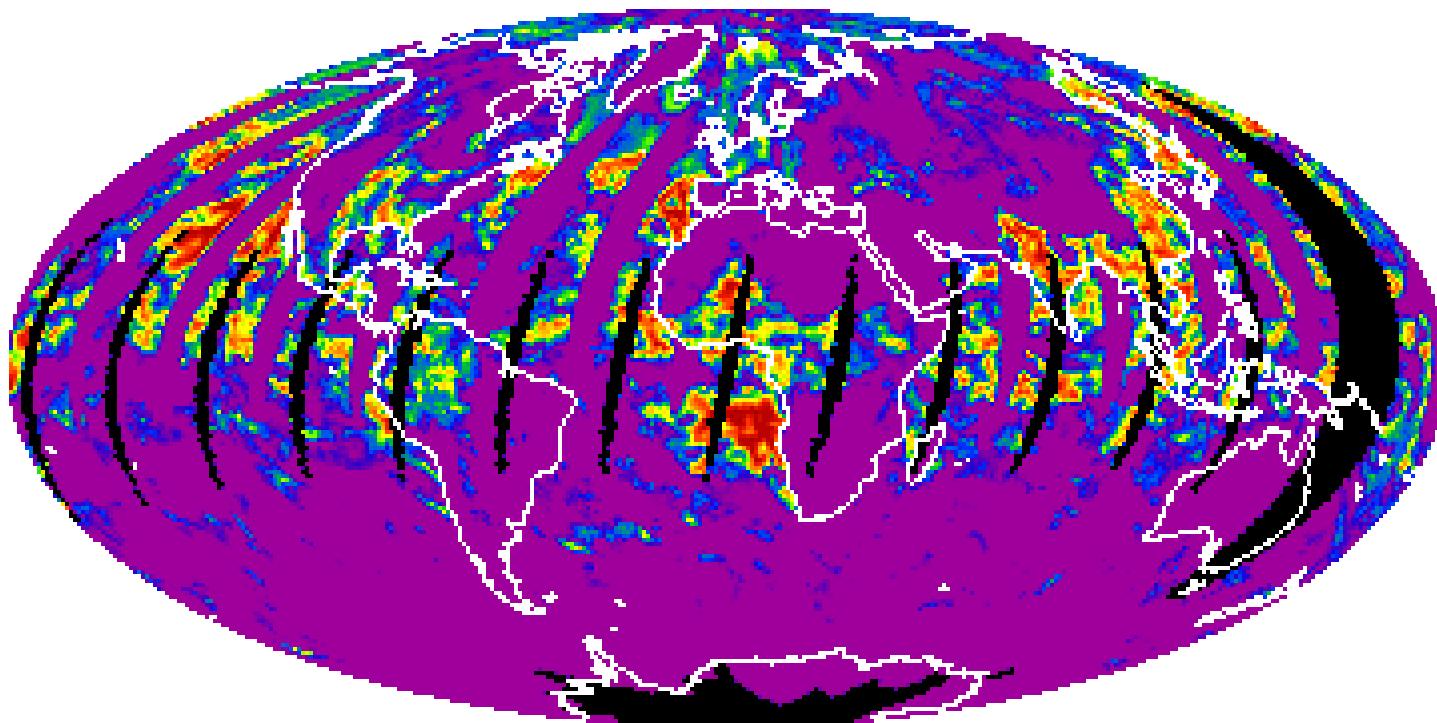
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*microns



Cloud_Fraction_Water

04Jul2002



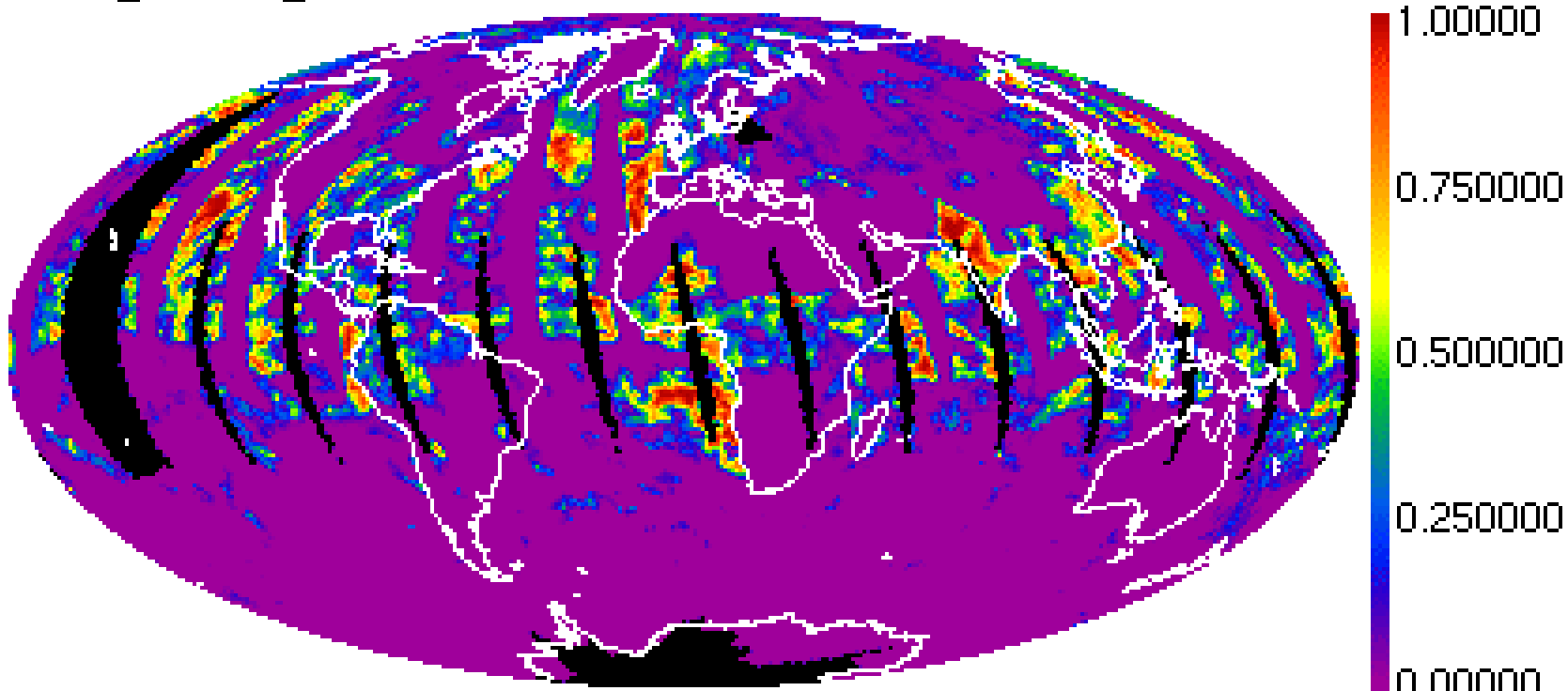
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*name



Cloud_Fraction_Water

04 Jul 2002



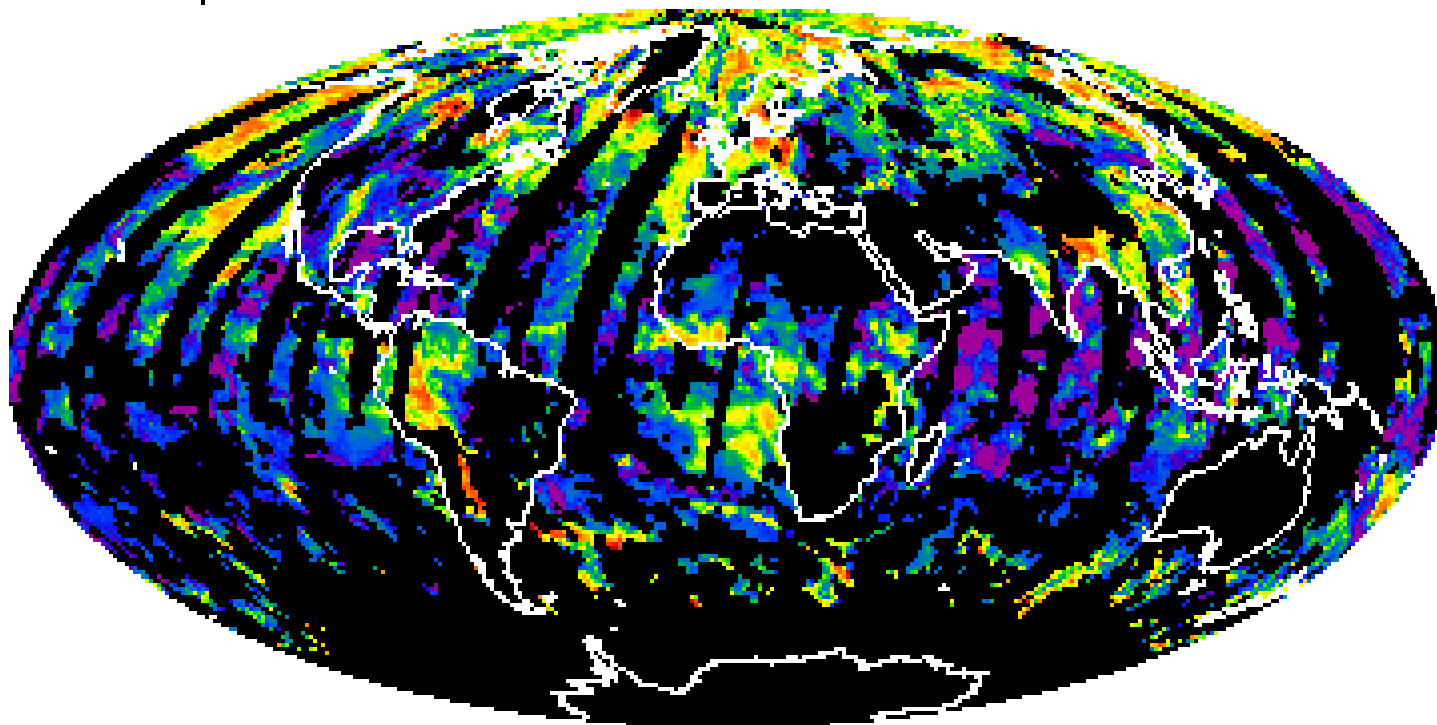
MODIS/Aqua

MYD08_D3.A2002185.003.2002189030600.hdf *none



Cloud_Optical_Thickness_Water_Mean

04Jul2002



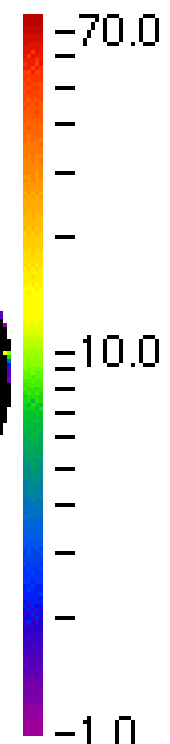
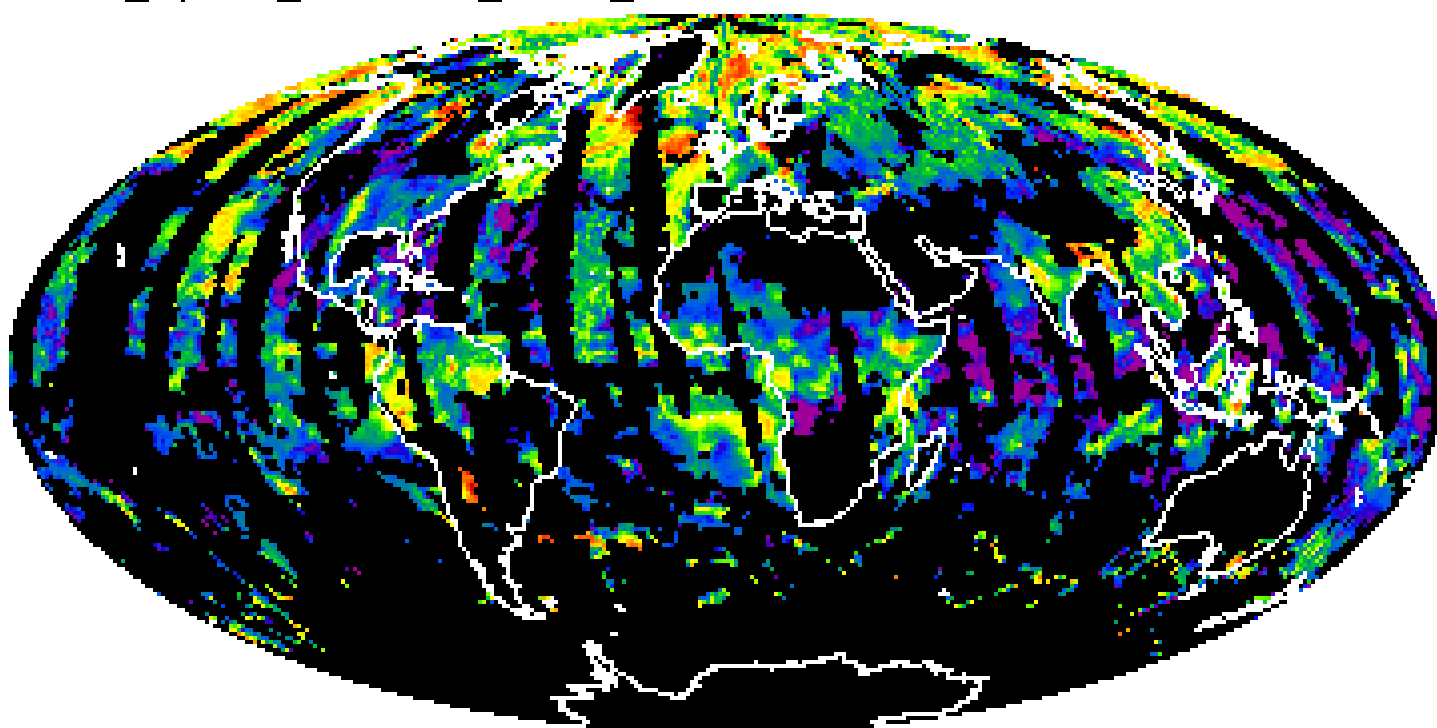
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*name



Cloud_Optical_Thickness_Water_Mean

04 Jul 2002



MODIS/Aqua

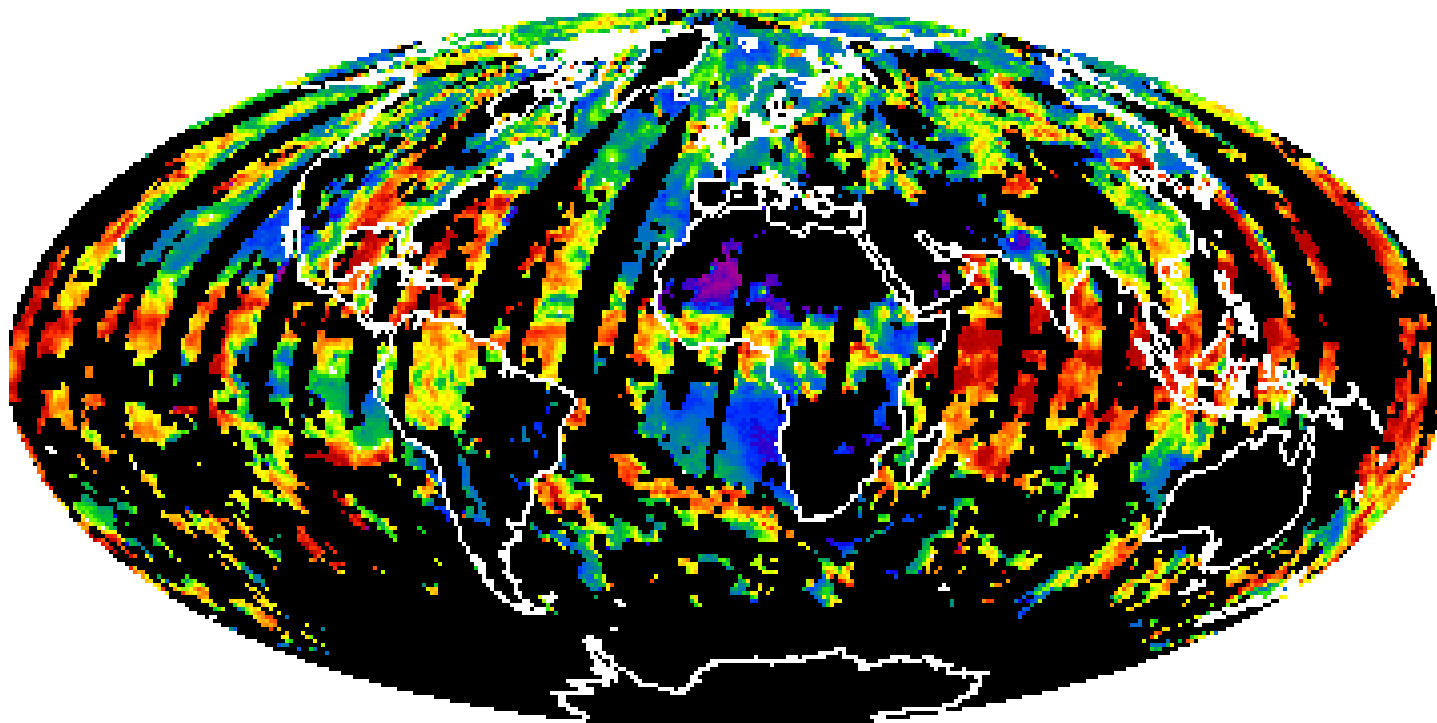
MYD08_D3.A2002185.003.2002189030600.hdf

*none



Cloud_Effective_Radius_Water_Mean

04Jul2002



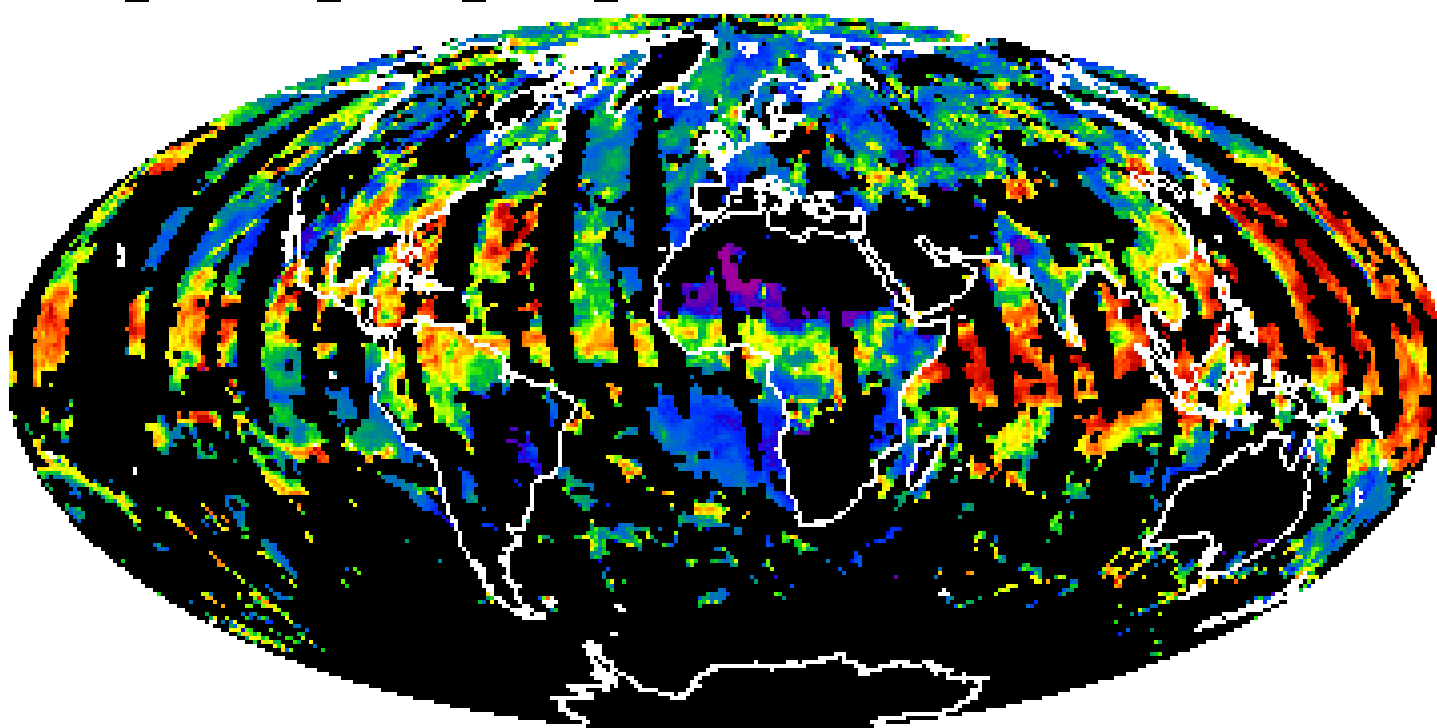
MODIS/Terra MOD08_D3.A2002185.003.2002187133212.hdf

*microns



Cloud_Effective_Radius_Water_Mean

04 Jul 2002



MODIS/Aqua

MYD08_D3.A2002185.003.2002189030600.hdf

*microns



Summary of Cloud Optical and Microphysical Property Products

Comparison of preliminary Aqua products to Terra products shows remarkable consistency and is thus encouraging.

Many improvements have been implemented for retrievals of cloud optical thickness and particle size. Major improvements include:

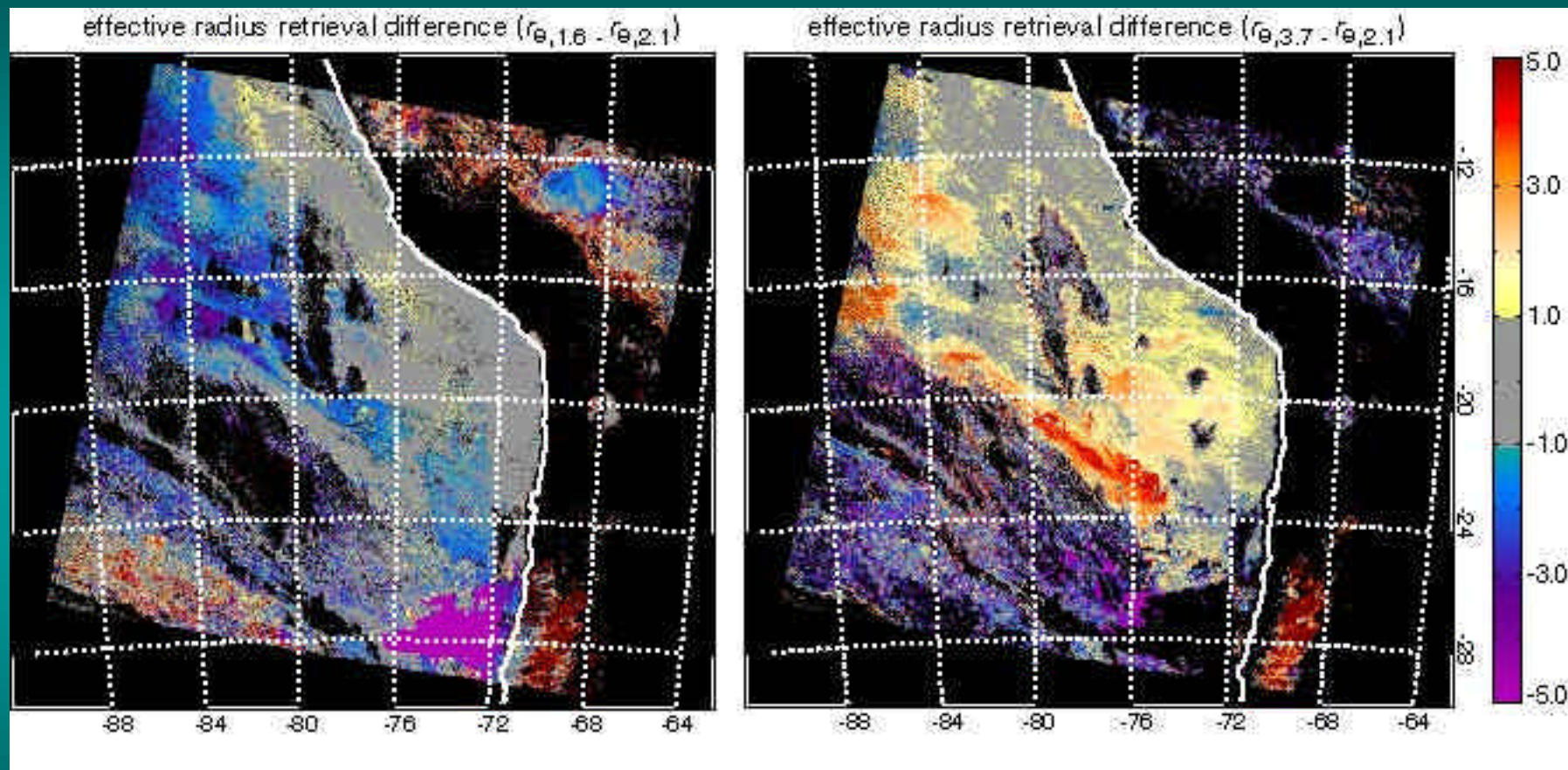
- polar regions
- cloud phase
- fewer unsuccessful retrievals
- use of MOD43 to improve characterization of multispectral surface reflectances

Highest priorities are

- 1. Mixed-phase clouds*
- 2. Multilayered clouds*
- 3. Better cloud phase discrimination*



Cloud Particle Size Comparison



Difference in particle effective radius (microns) relative to a retrieval using the 2.1 μm band. In general, the left panel shows similar sized or smaller liquid water radii when using the 1.6 μm band in place of the 2.1 μm band, in contrast to larger radii with the 3.7 μm band.

