Cloud Optical & Microphysical Properties

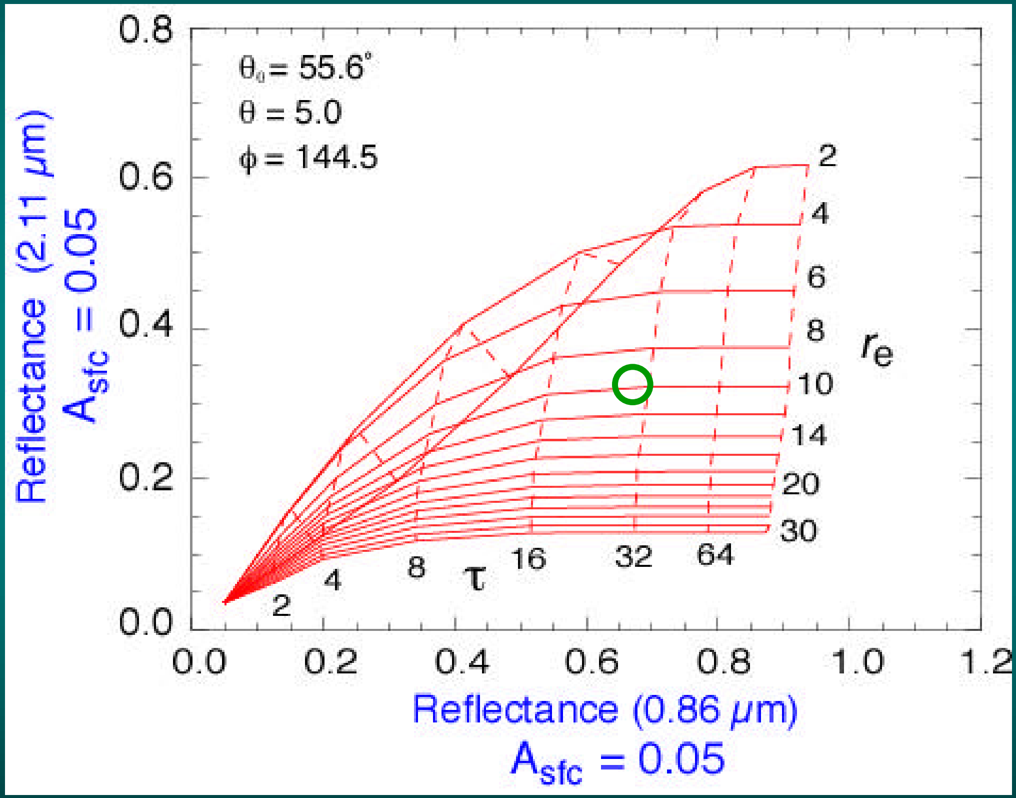
(M. D. King, S. Platnick, M. Gray, E. Moody, et al. – NASA GSFC, UMBC)

- Optical thickness, particle size (effective radius), and water path
- 1 km spatial resolution, daytime only, liquid water & ice clouds
- Solar reflectance technique, VIS through MWIR
  - Water nonabsorbing bands: 0.65, 0.86, 1.24 µm
  - Water absorbing bands: 1.6, 2.1, 3.7 µm
- Land, ocean, and snow/sea ice surfaces
  - Land surface: 0.65 µm
  - Ocean surface: 0.86 µm
  - Snow/ice surfaces: 1.24 µm
- MODIS 1st satellite sensor with all useful SWIR, MWIR bands

Retrieval of τ_c and r_e

- 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



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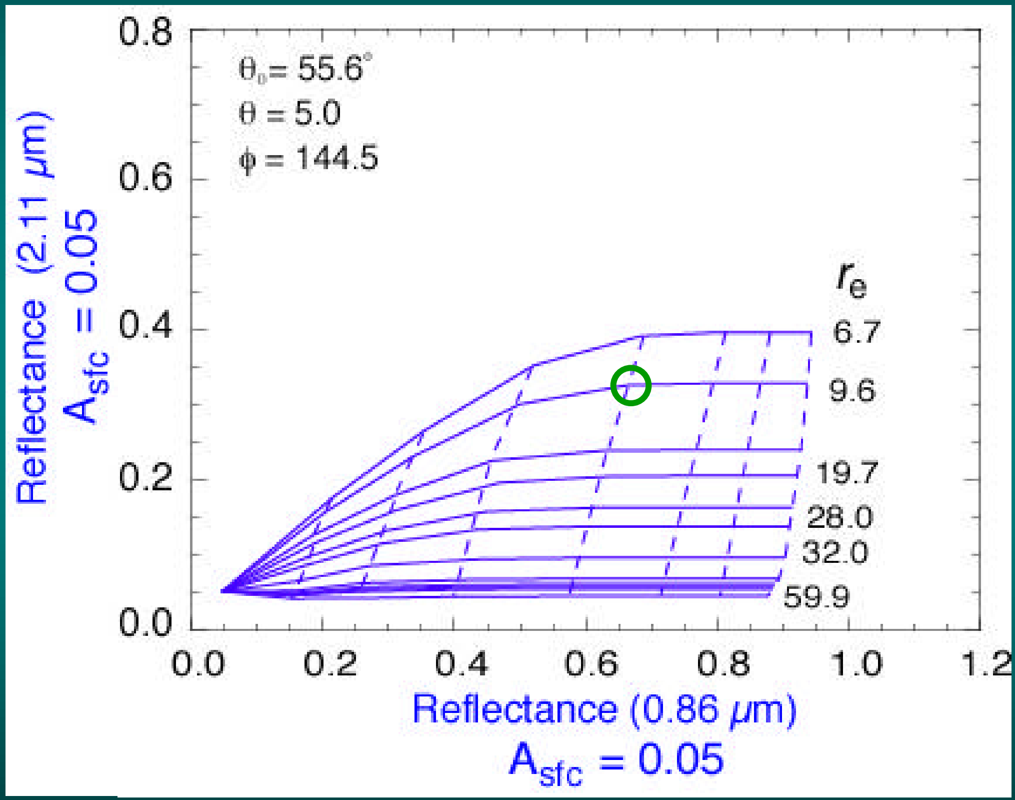
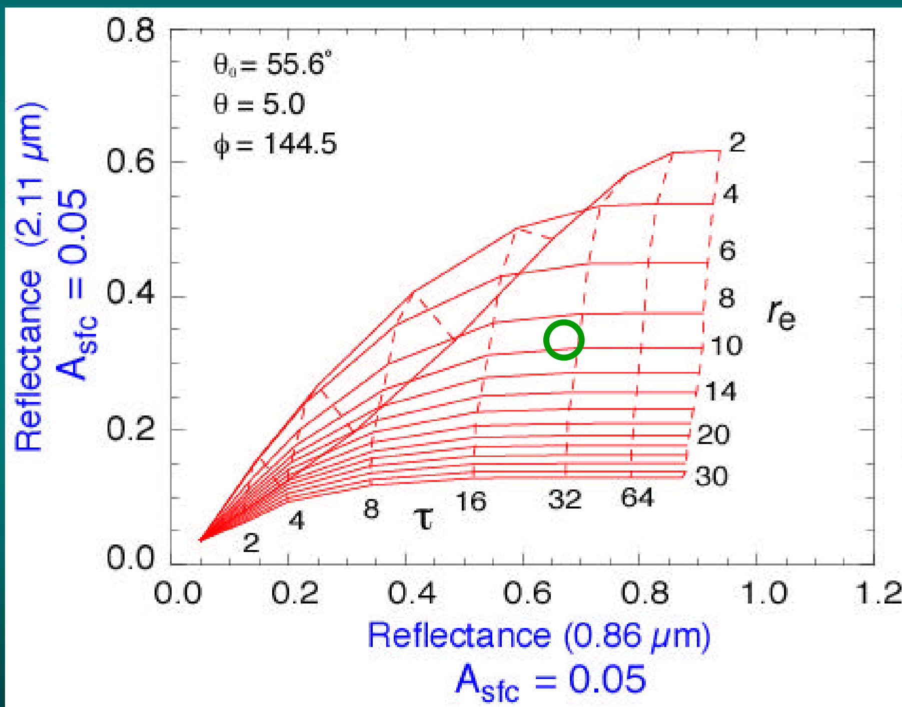
Ice Clouds - ocean surface

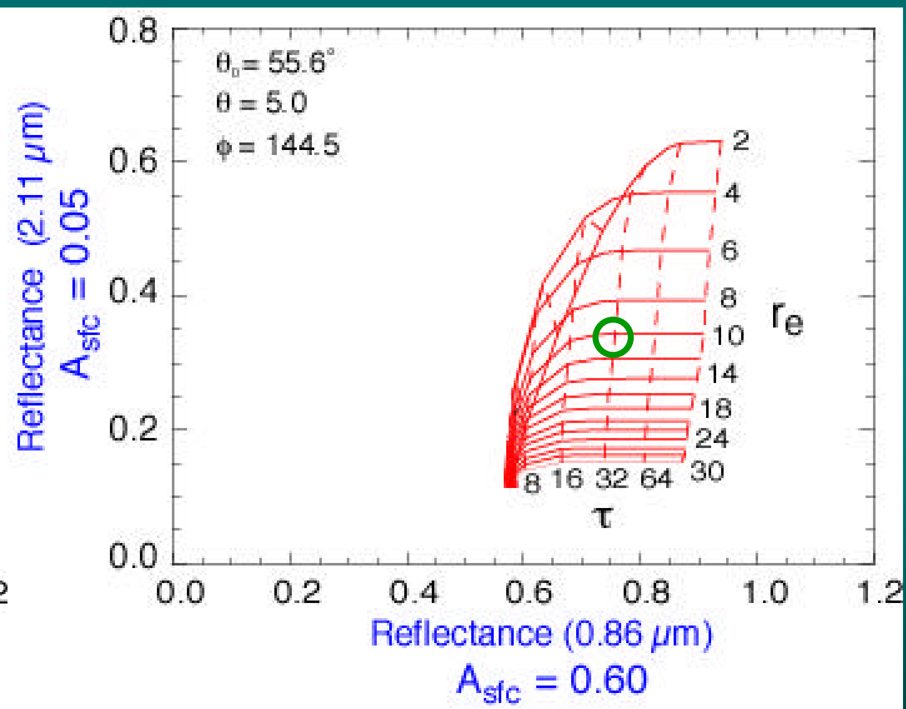


Cloud Optical & Microphysical Properties Retrieval Example

Liquid Water Clouds - ocean surface



Liquid Water Clouds - ice surface



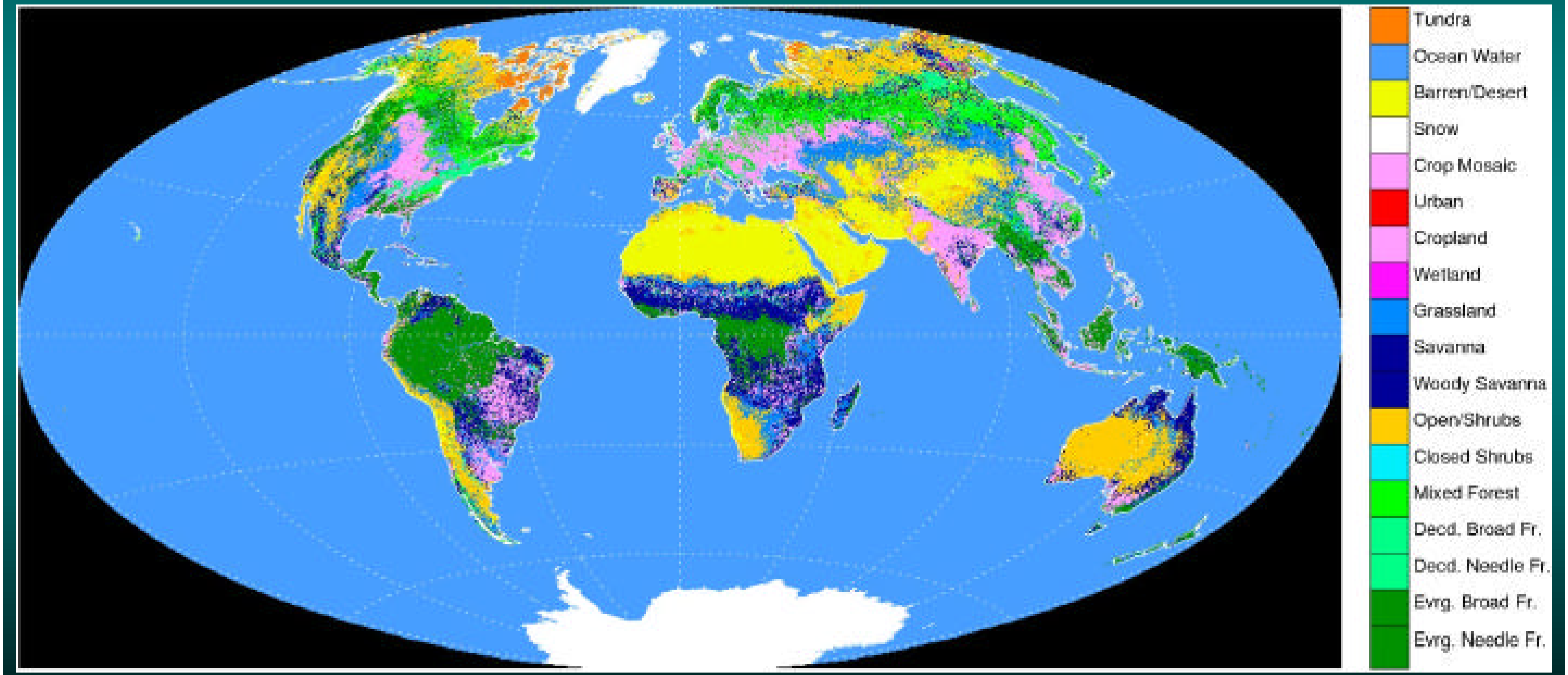
Cloud Optical & Microphysical Properties

- Critical input
  - Cloud mask
    - » to retrieve or not to retrieve?
  - Cloud thermodynamic phase
    - » use liquid water or ice libraries?
  - Surface albedo
    - » for land, ancillary information regarding snow/ice extent (NISE data set)
  - Atmospheric correction
    - » requires cloud top pressure, ancillary information regarding atmospheric moisture & temperature (e.g., NCEP, DAO, other MODIS products)
  - 3.7 µm emission (band contains both solar and emissive signal)
    - » need cloud top temperature, ancillary for surface temperature (e.g., from NCEP, DAO, ...)

Ecosystem Map

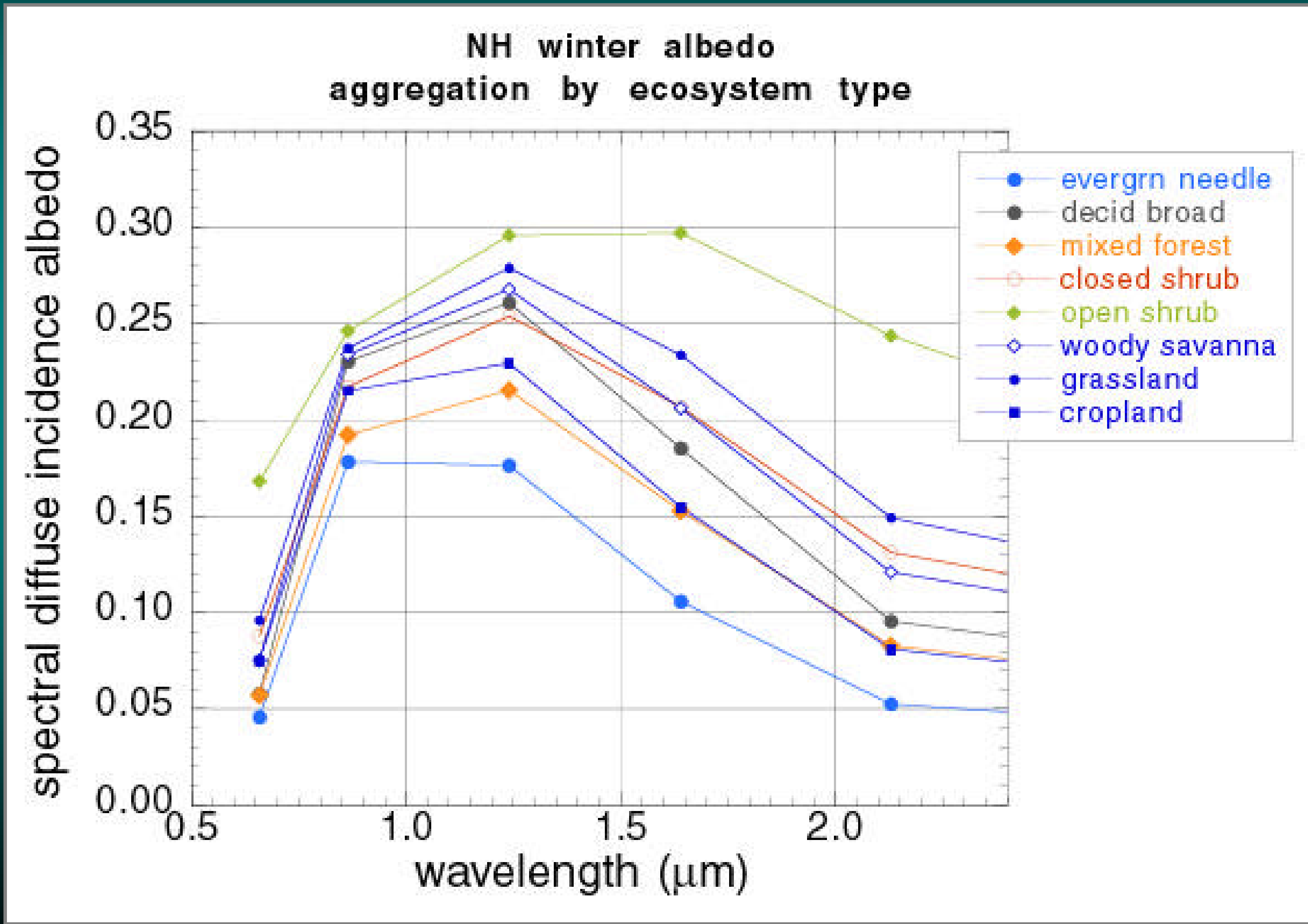
(A. H. Strahler, C. B. Schaaf, et al. – Boston University)

MOD12 (IGBP ecosystem classification) + USGS water + tundra



Surface Albedo

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



Albedo Movies

Loops through bands 0.65, 0.86, 1.24, 1.64, 2.1, and 3.7 µm

Loops through seasonal equinox and solstice, progressing from Julian days 91, 173, 293, 356

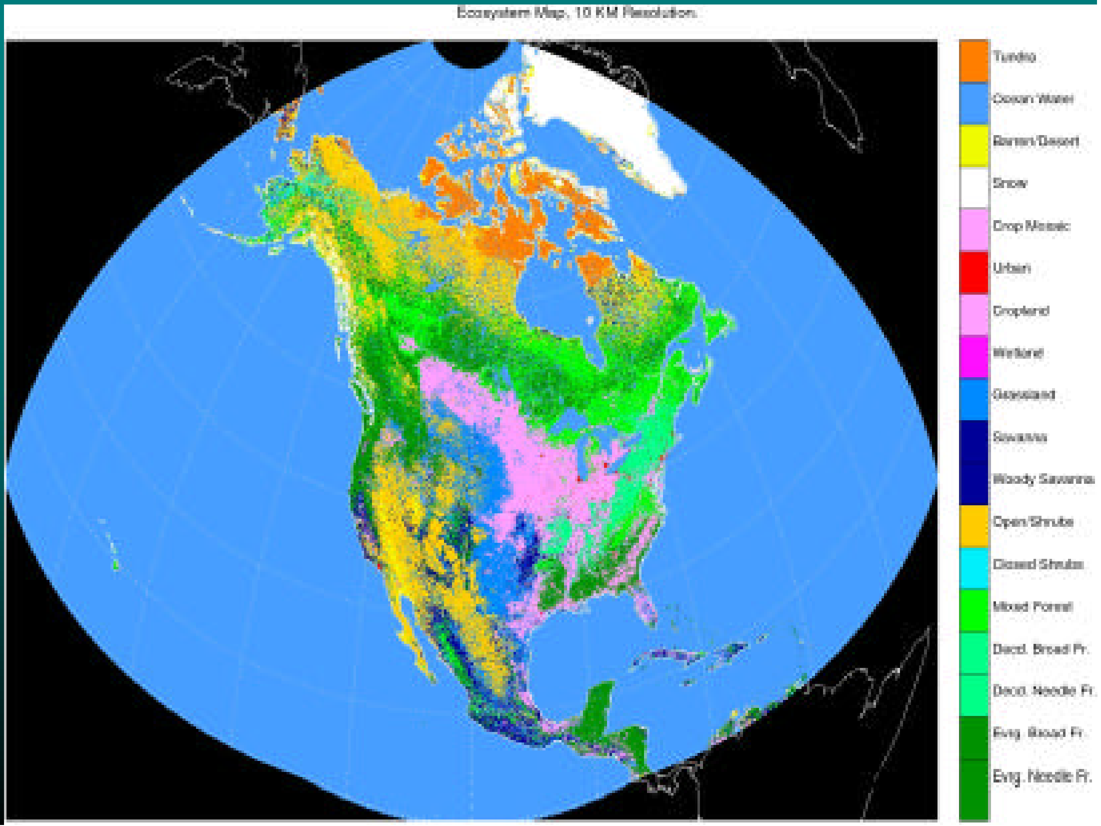
Ecosystem Color Scheme

Pink = Crops

Green = Trees

Yellows = Barren/Deserts

Blues = Savannas



Atmospheric Correction

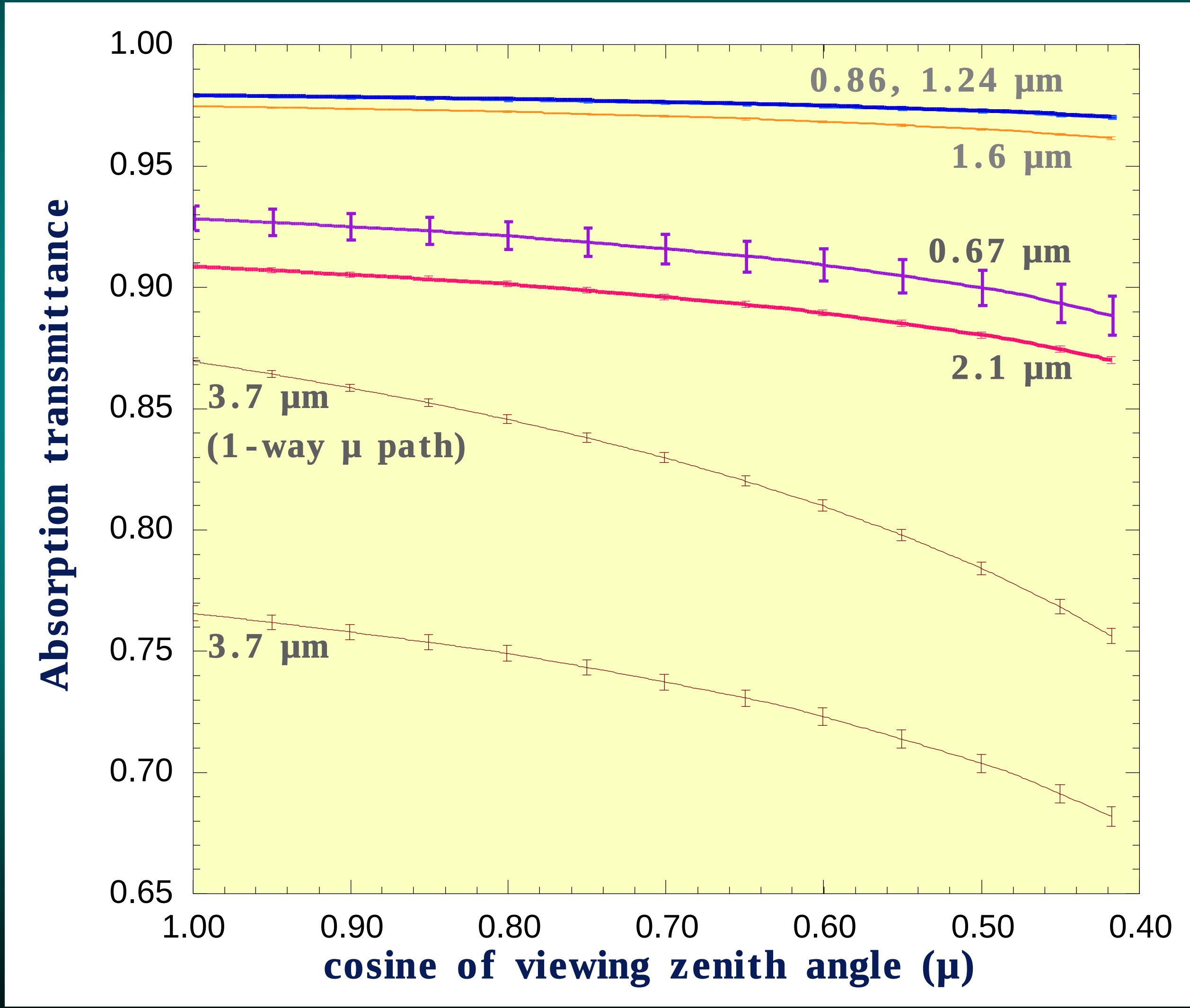
- Cloud library calculations give cloud-top quantities (no atmosphere)
  - atmosphere included during retrieval
- Rayleigh scattering
  - iterative approach applied to 0.65 µm band only (used over land)
  - important for thin clouds and for any clouds with large solar/view angle combinations
- Atmospheric absorption
  - Well-mixed gases a function of p_c, water vapor absorption a function of profile; both a weak function of temperature
  - Assume above-cloud column water vapor amount the primary parameter, vapor profile of minor consequence
  - Library calculations made at a variety of p_c, above-cloud column water amounts (scaled from various water vapor and temperature profiles), geometries
    - » using *MODTRAN 4.0* with scripts for 2-way transmittance calculations
  - requires cloud top pressure, and ancillary information regarding atmospheric moisture (currently using NCEP)

Two-way Atmospheric Path Transmittance $(1/\mu + 1/\mu_0)$

p_c = 900 hPa

w = 2.0 g-cm^{-2} above-cloud precipitable water

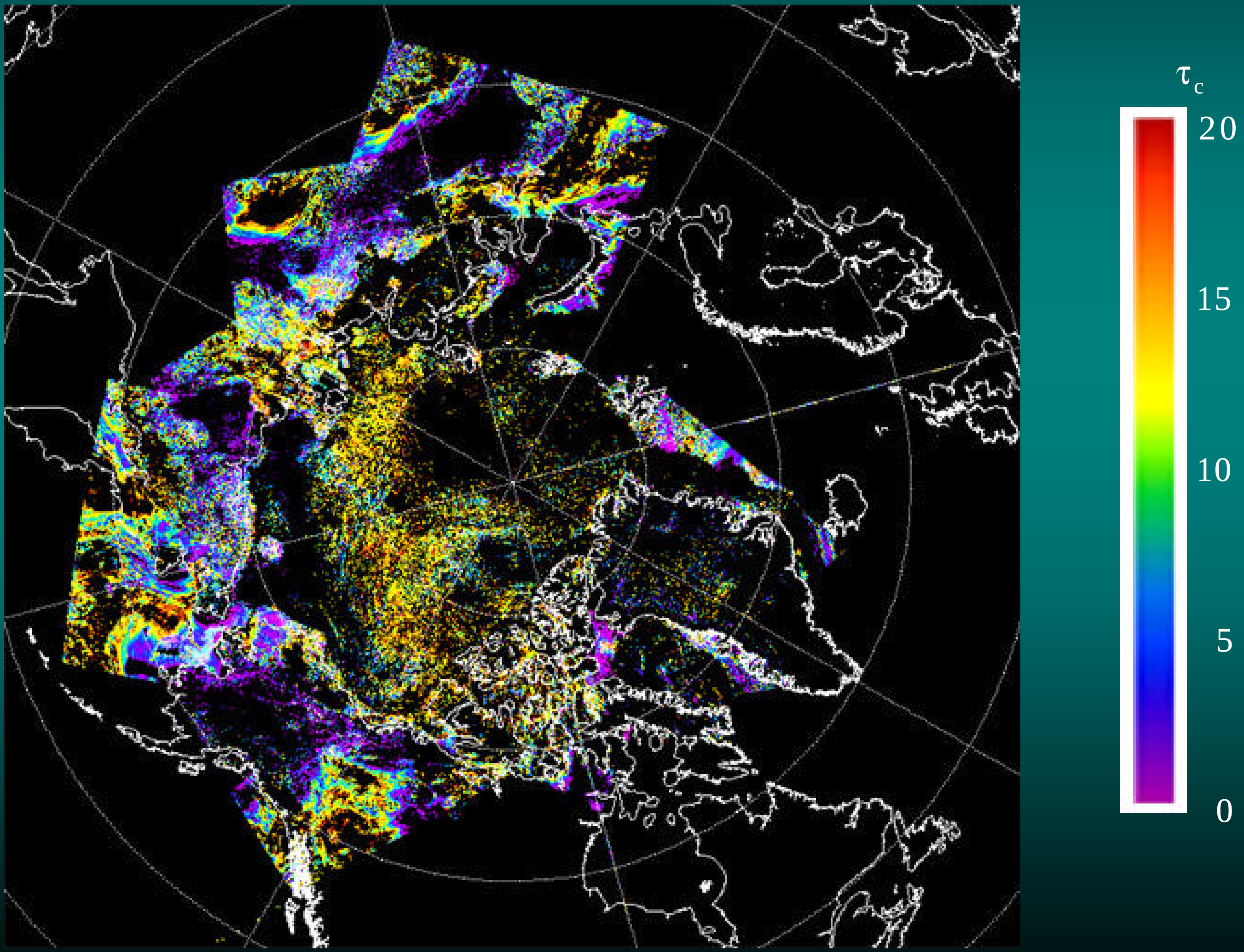
μ_0 =0.8



Cloud Optical Thickness in the Arctic:

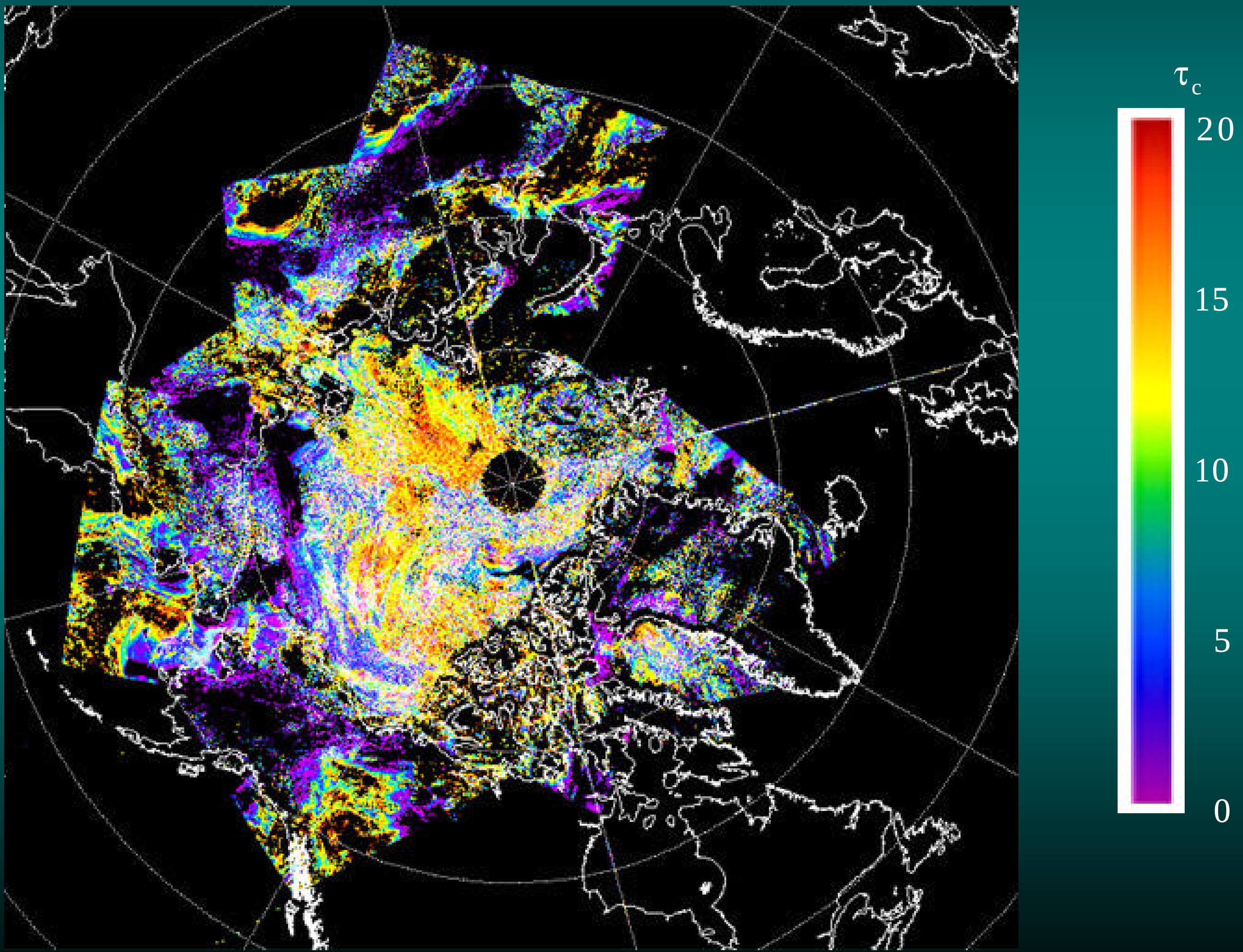
Provisional Production Code (edition 3)

June 2, 2001



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

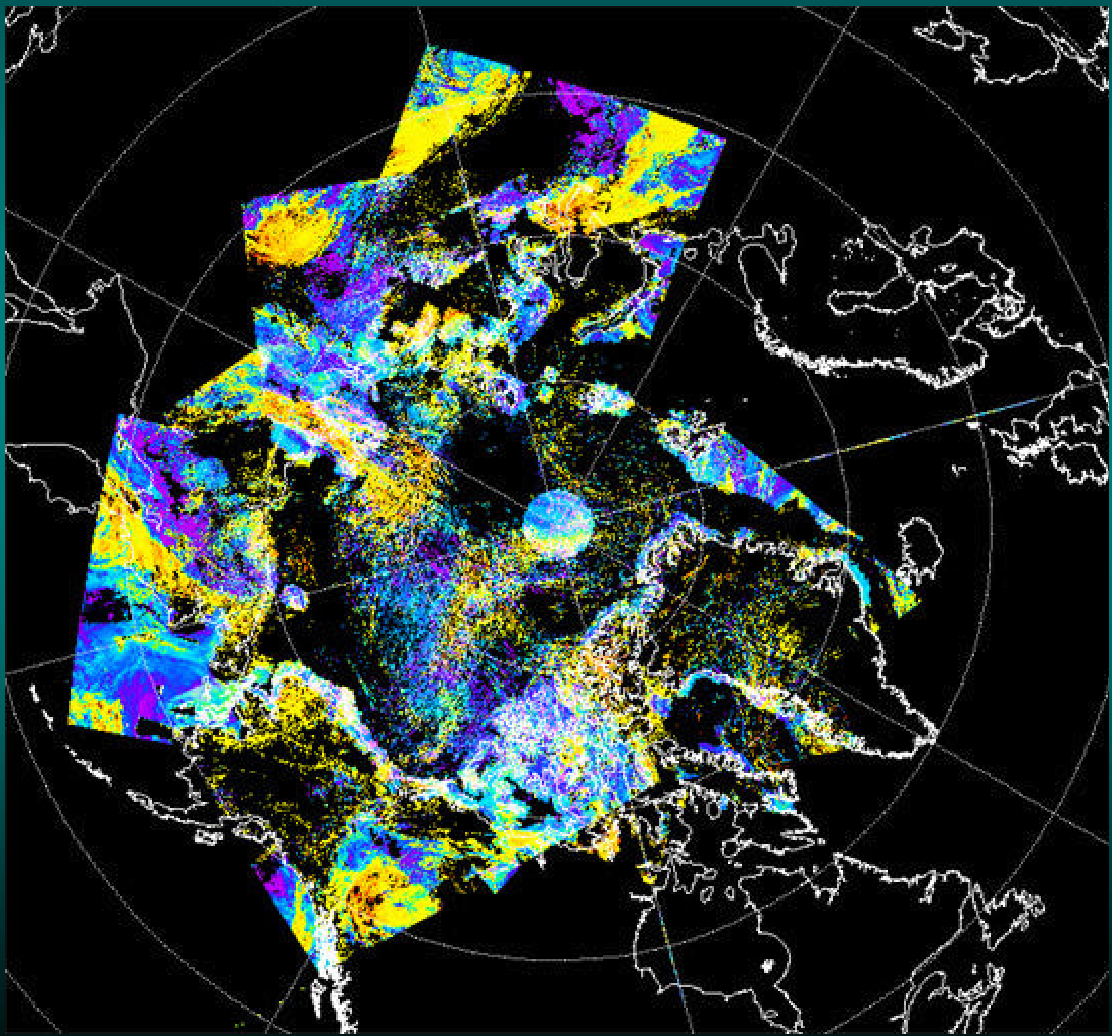
June 2, 2001

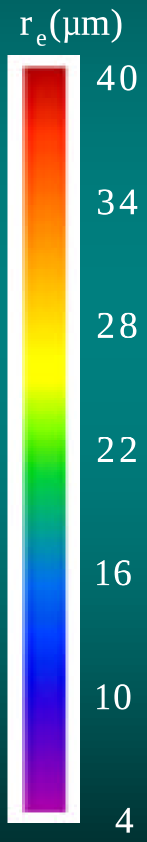


Cloud Effective Radius in the Arctic:

Provisional Production Code (edition 3)

June 2, 2001





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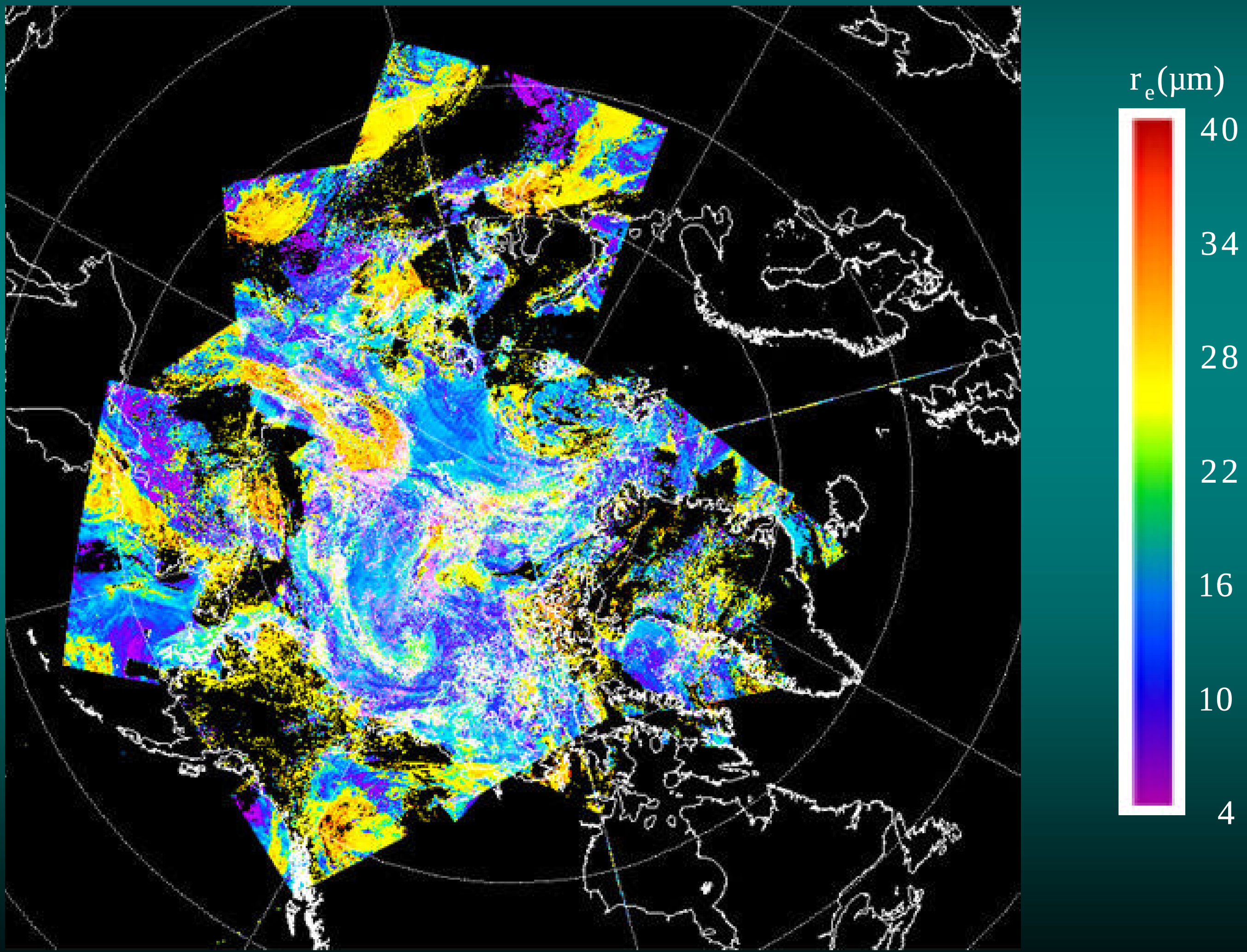


Level-2 Global Cloud Images

True Color Image

Cloud Mask

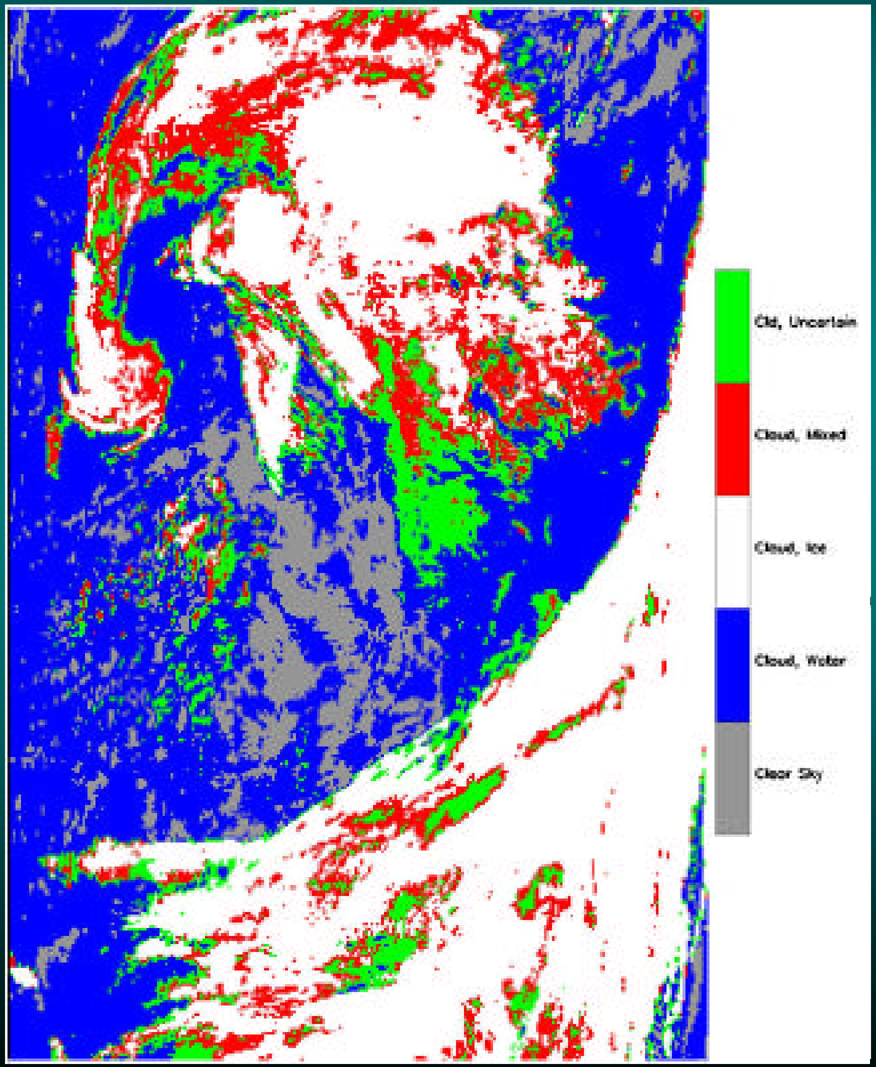
Land Classification

Cloud Optical Thickness

Cloud Effective Radius

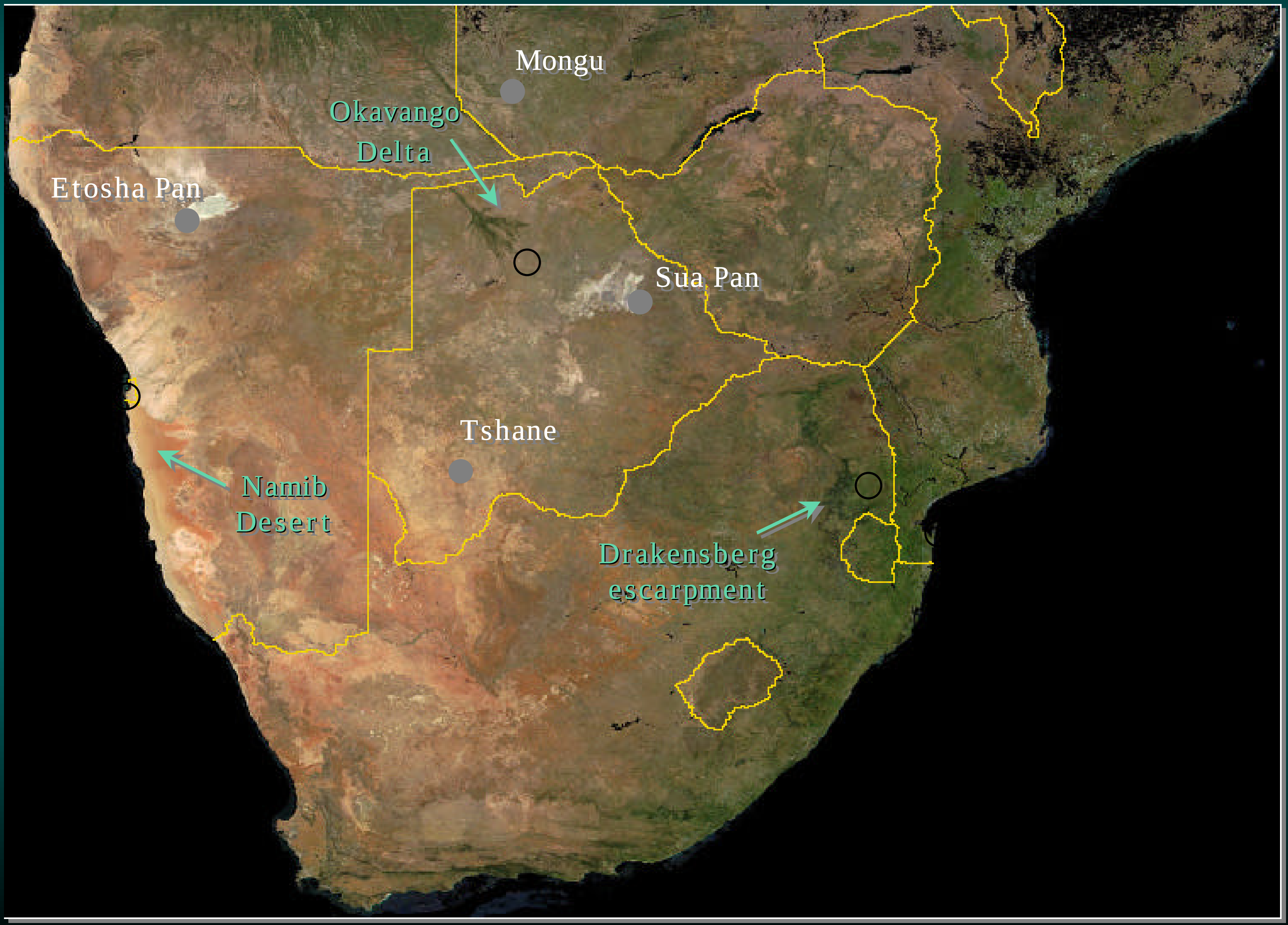
Cloud Top Temperature

Bispectral Phase



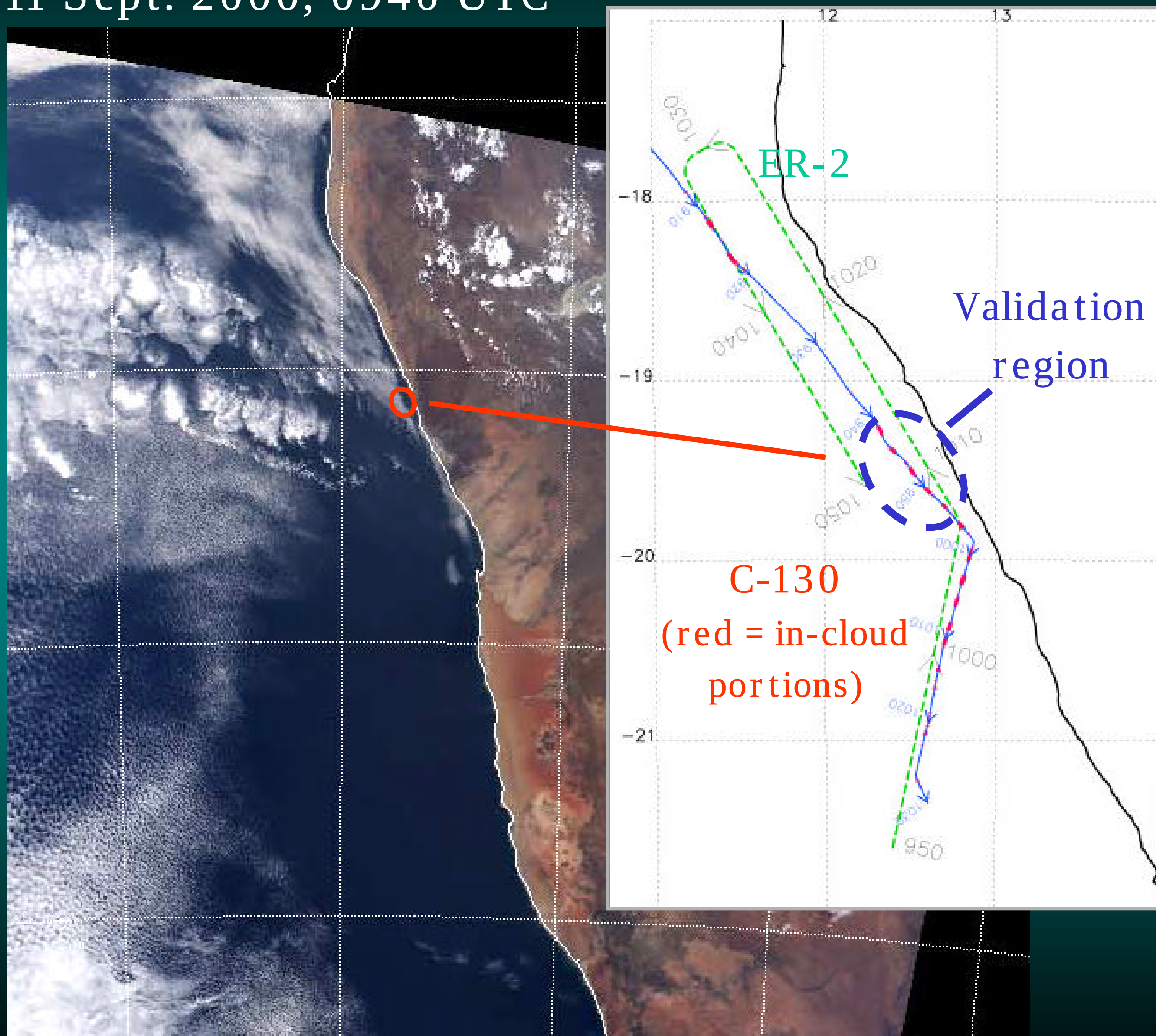
October 1, 2001

SAFARI 2000 Core Sites



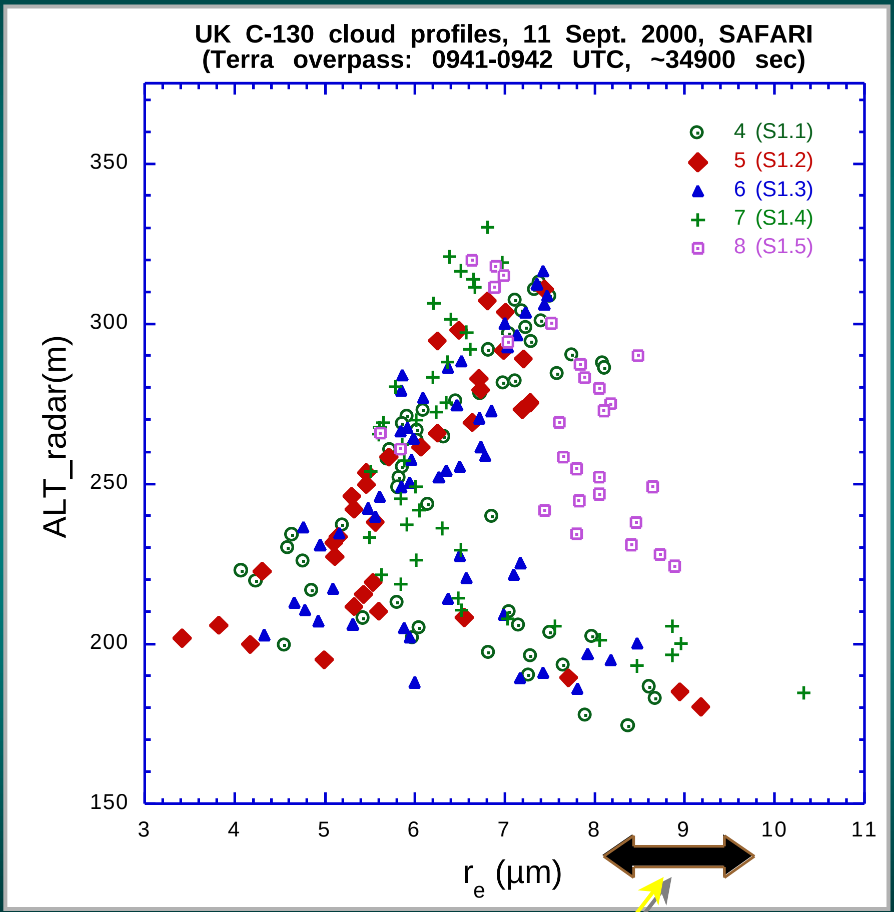
MODIS true color
11 Sept. 2000, 0940 UTC

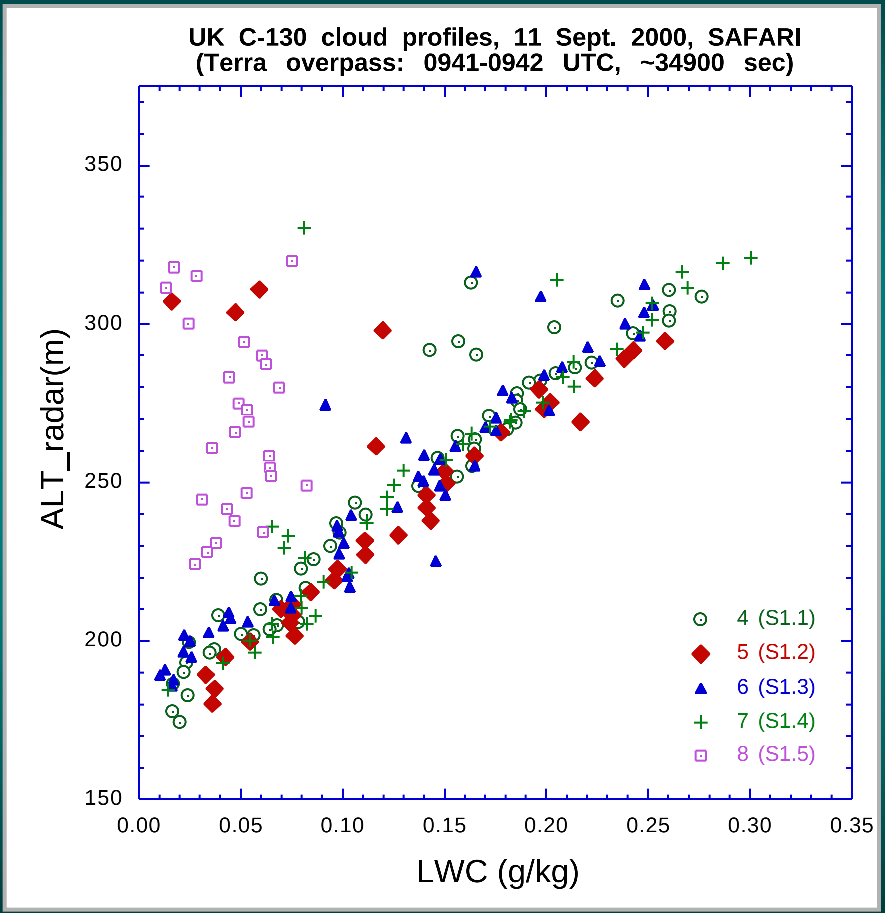
ER-2, C-130
ground tracks



UK C-130 in situ droplet radius, liquid water content

11 Sept. 2000, 0941-0953 UTC (S. Osborne, Met Office)

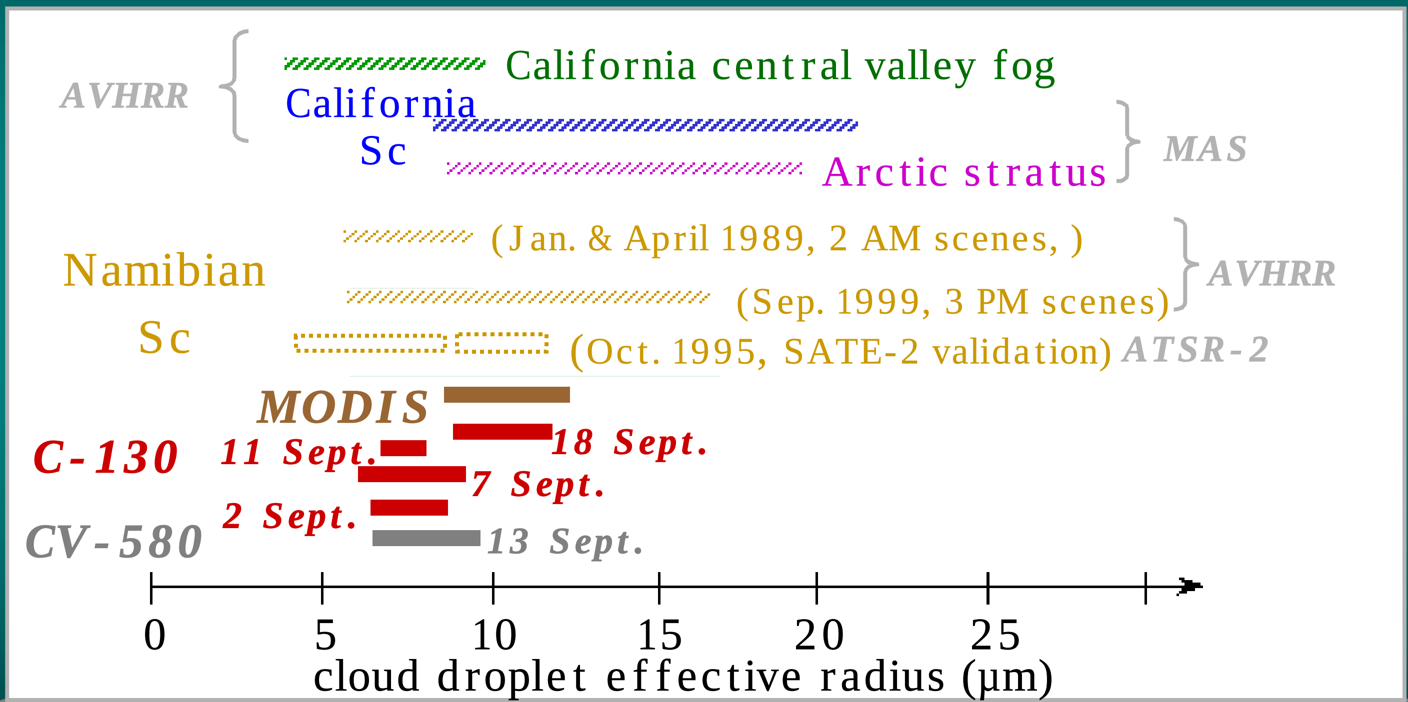




MODIS droplet size retrievals

optical thickness: C-130 ≈ 5, MODIS ≈ 3±1

Previous + SAFARI 2000 Namibian Sc studies

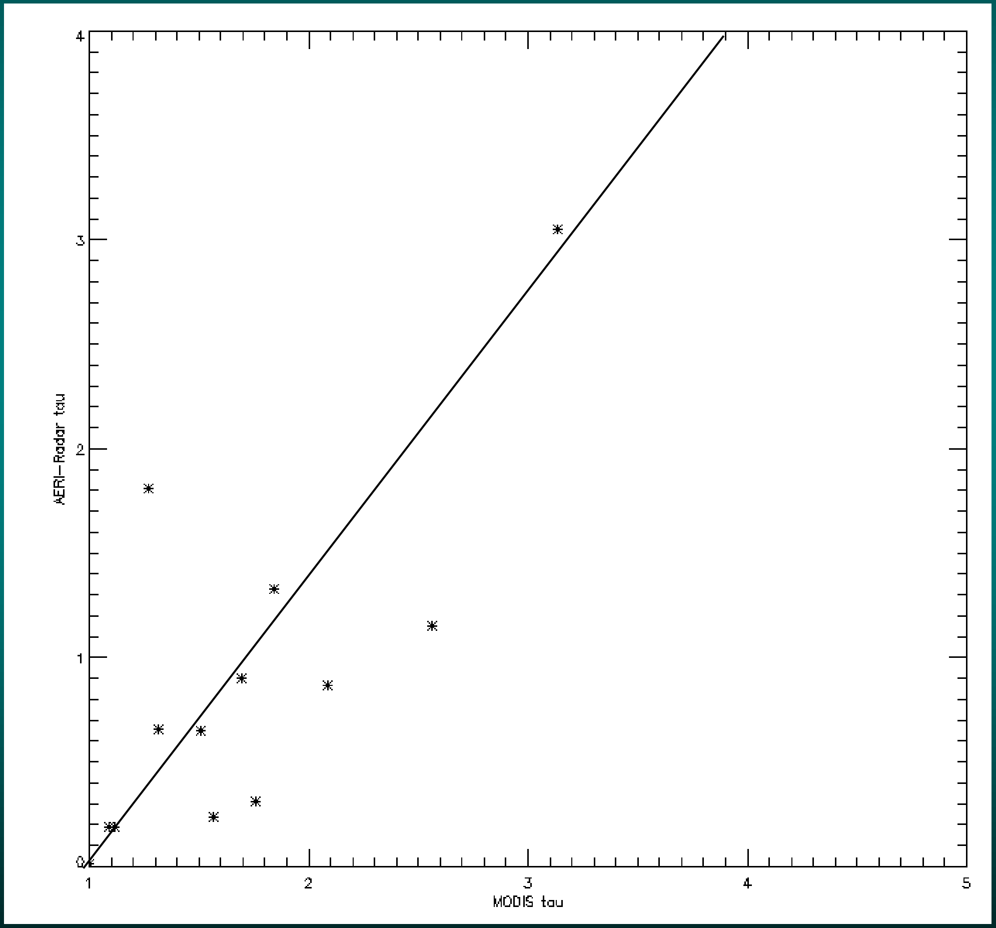


Namibian Sc often have significantly smaller droplet sizes than other regimes? Or lack the larger droplet sizes of other regimes? A difference in CCN concentrations? If so, why?

Comparison of Visible Optical Thickness

(G. G. Mace, S. Bensen, K. Sassen – University of Utah)

Retrieved Optical Thickness



MOD06 Optical Thickness

Gridded Level-3 Joint Atmosphere Products

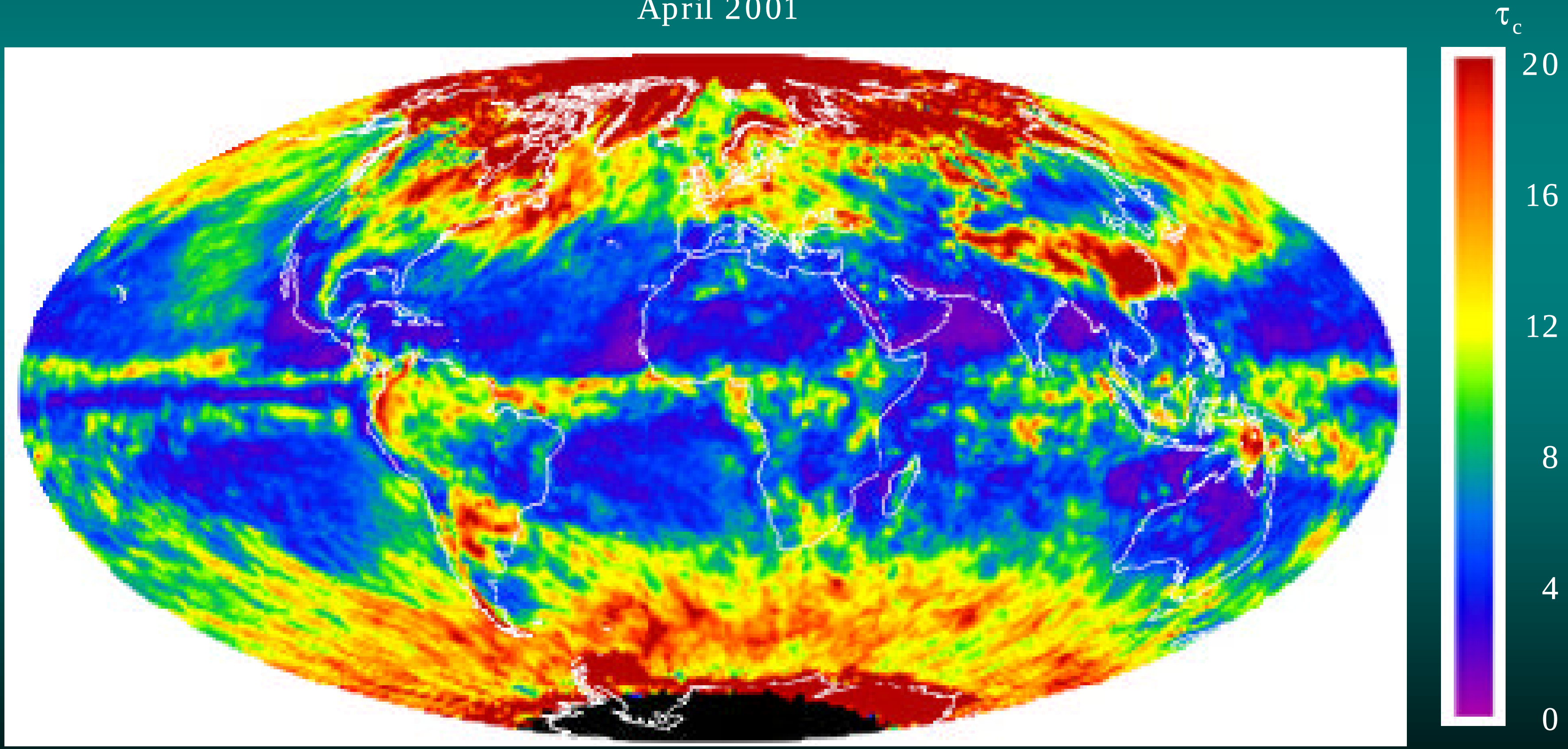
(M. D. King, S. Platnick, P. A. Hubanks, et al. – NASA GSFC, UMBC)

- Daily, 8-day, and monthly products (474.8, 883.2, 883.2 MB)
- 1° ×1° equal angle grid
- Mean, standard deviation, marginal probability density function, joint probability density functions

Cloud Optical Thickness

Level-3 Monthly

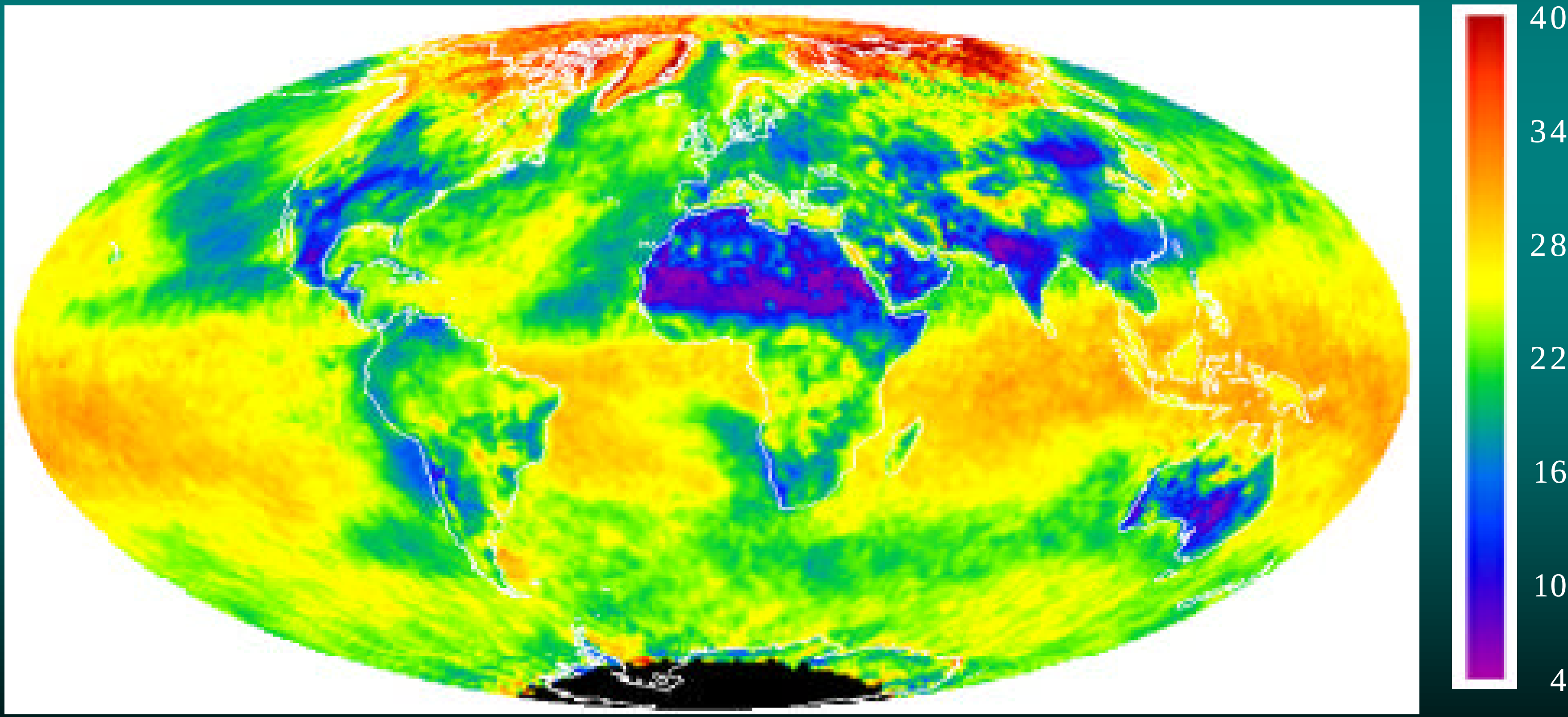
April 2001



Cloud Effective Particle Radius

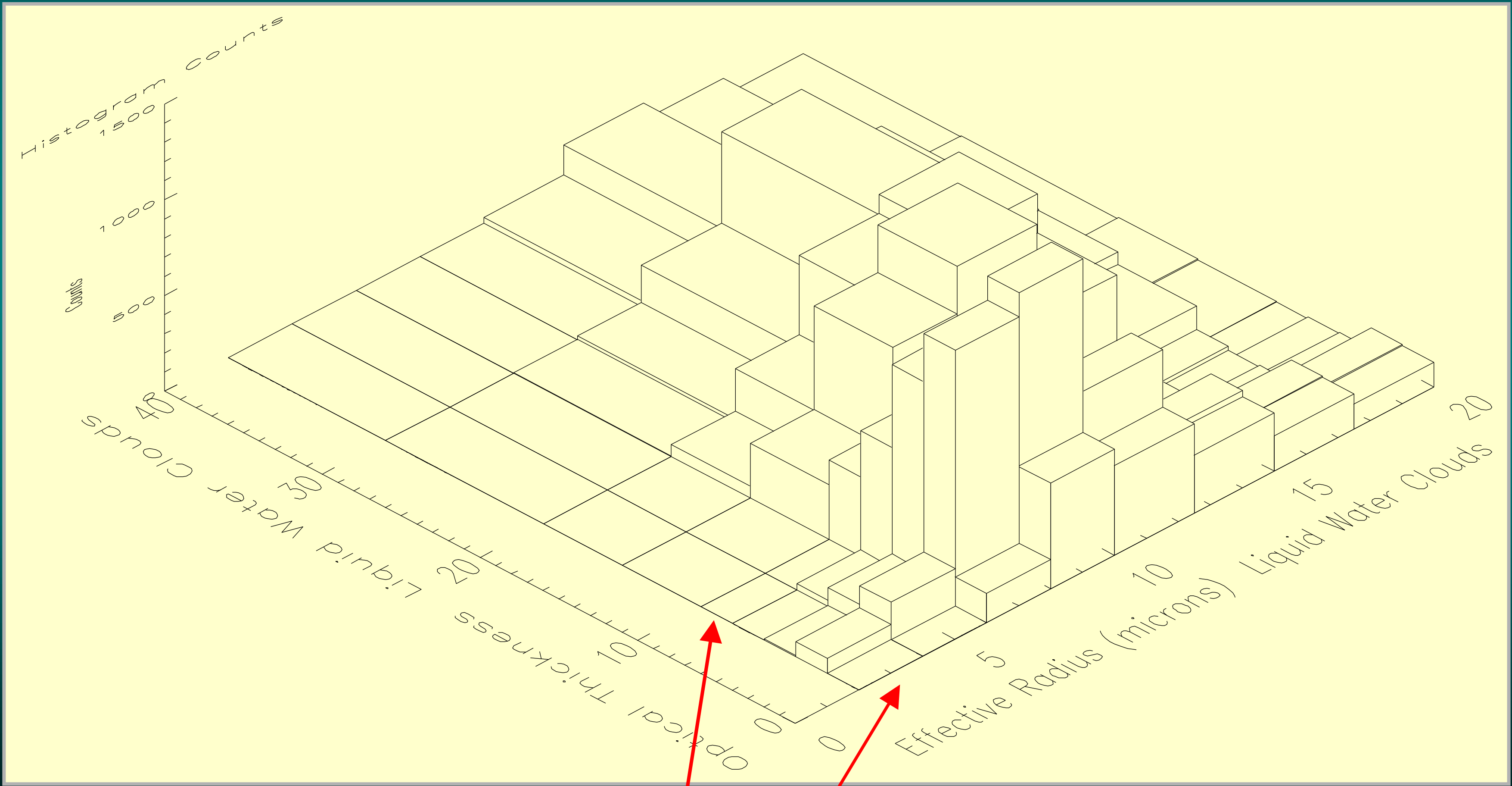
Level-3 Monthly

April 2001



MODIS L3 aggregation from 6°x 6° grid off **Namibian** coast

liquid water clouds



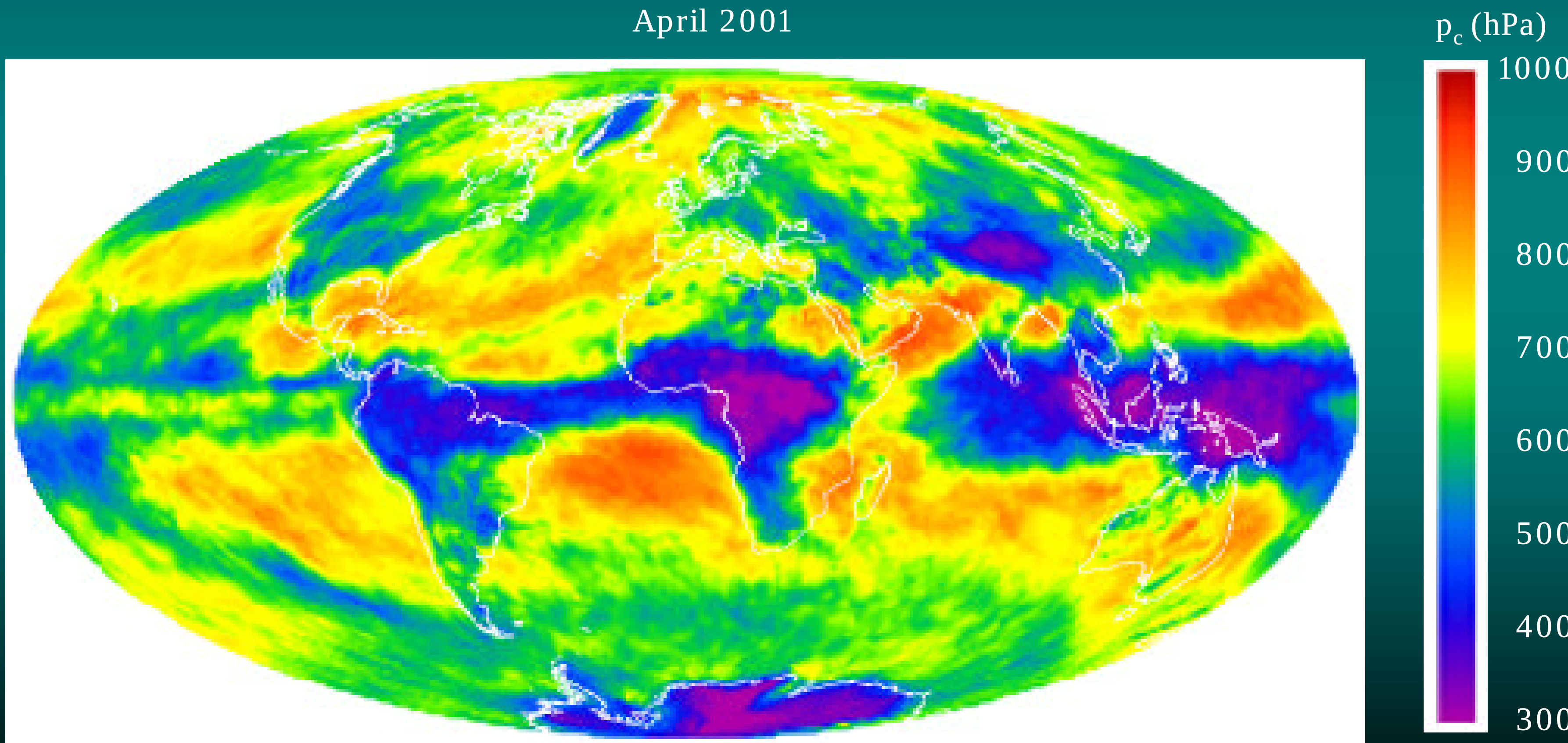
L3 product bin sizes (liquid water clouds)

Cloud Top Pressure

(W. P. Menzel, R. Frey, K. Strabala, L. Gumley, et al. – NOAA NESDIS, U. Wisconsin/CIMSS)

Level-3 Monthly

April 2001

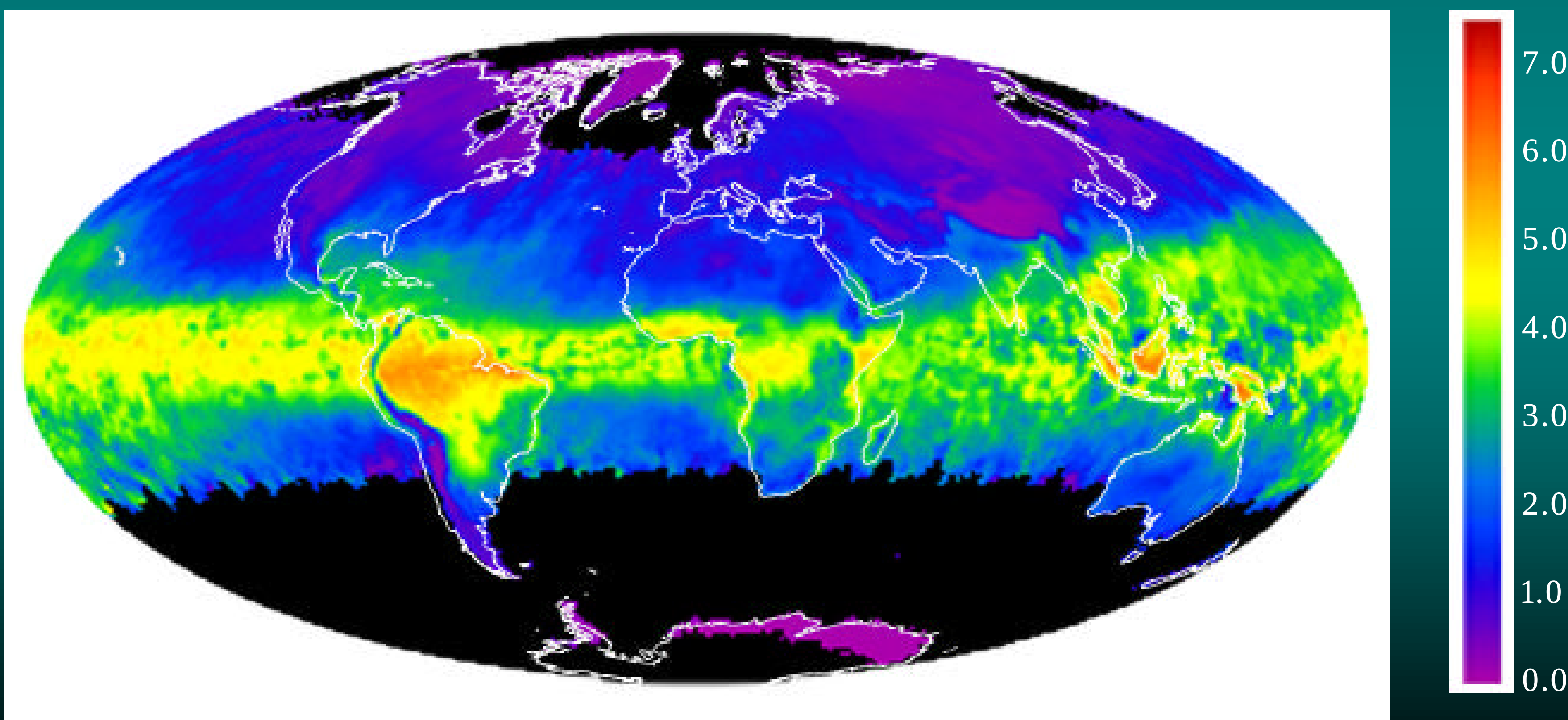


Precipitable Water over Land & Sunglint

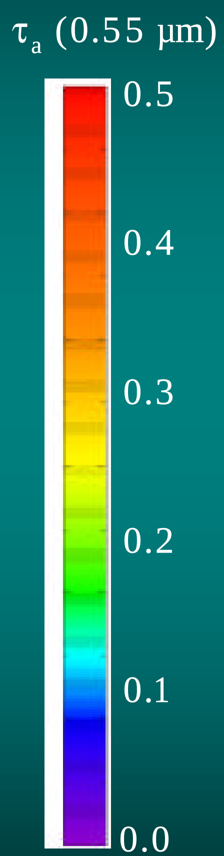
(B. C. Gao, et al. – Naval Research Laboratory)

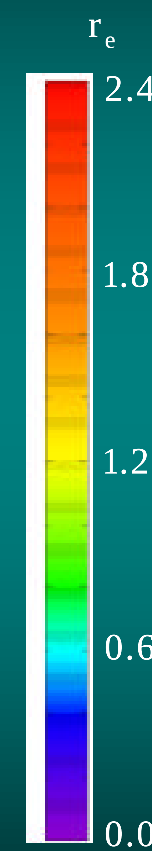
Level-3 Monthly

April 2001



MODIS Aerosol Optical Thickness & Effective Radius



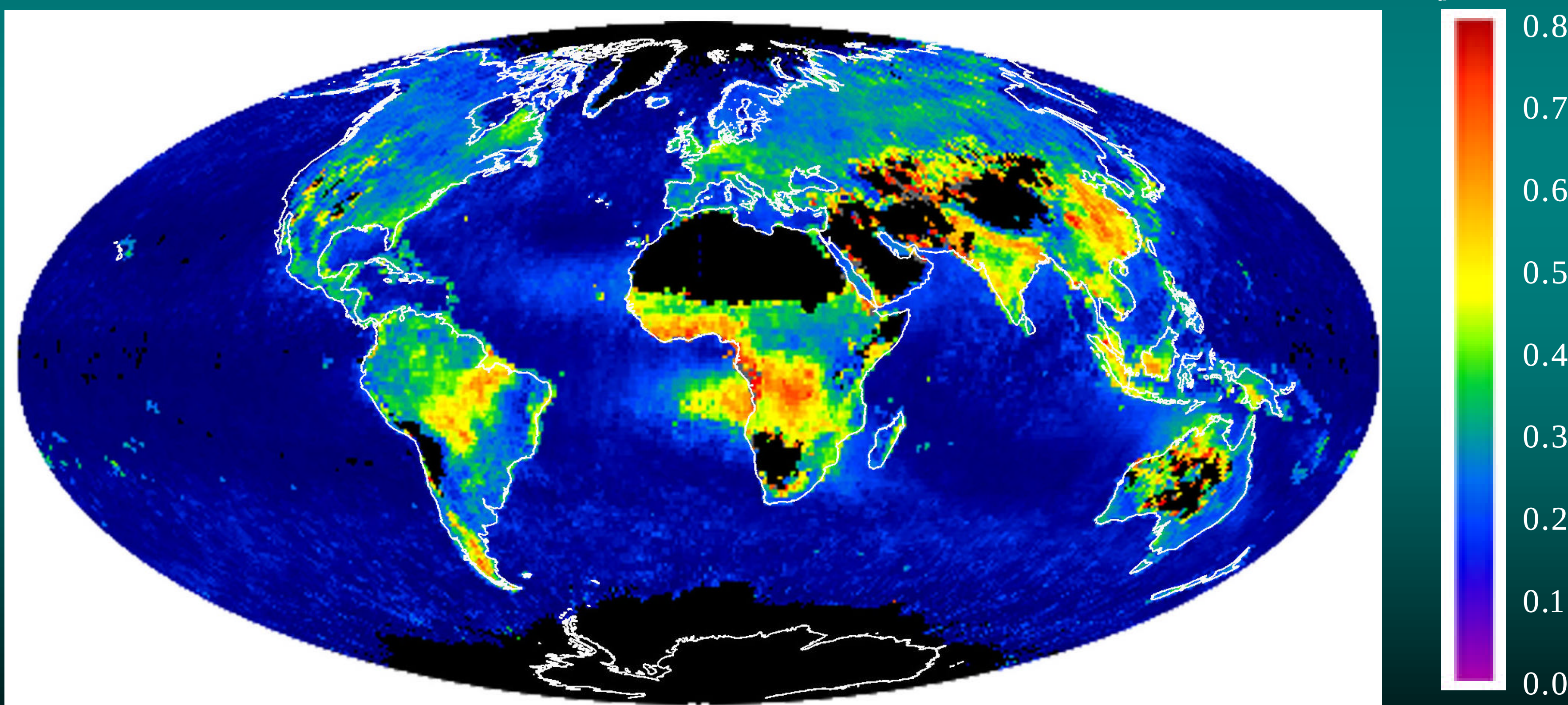


Aerosol Optical Thickness (fine mode)

(Y. J. Kaufman, D. Tanré, L. A. Remer, D. A. Chu. – NASA GSFC, CNES/USTL)

Level-3 Monthly

September 2000



Aerosol Optical Thickness (coarse mode)

(Y. J. Kaufman, D. Tanré, L. A. Remer, D. A. Chu. – NASA GSFC, CNES/USTL)

Level-3 Monthly

September 2000