Spatial & Temporal Distribution of Clouds as Observed by MODIS onboard the Terra and Aqua Satellites

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➢ MODIS atmosphere products
- Examples from Aqua
  - ✓ Cloud fraction
  - ✓ Cloud top properties
  - ✓ Cloud optical & microphysical properties
- Probability density functions
  - ✓ Marginal
  - ✓ Joint

➢ Status and plans
- Collection 5.1
- Collection 6

Gridded Level-3 Joint Atmosphere Products
(M. D. King, S. Platnick, P. A. Hubanks – NASA GSFC)

- Daily, 8-day, and monthly products (97, 255, 255 MB)
  - 20-25% of the size of these products in Collection 4
  - Files contain more SDSs, but are stored with internal hdf compression
- 1° ´ 1° equal angle grid
- Statistics
  - Mean, standard deviation, minimum, maximum
  - QA mean, QA standard deviation
  - Cloud fraction, pixel counts
  - Log mean, log standard deviation (useful for cloud inhomogeneity studies)
  - Mean uncertainty, QA mean uncertainty
  - Marginal probability density functions for cloud properties
    - ✓ Histogram counts, confidence histograms
  - Joint probability density functions
    - ✓ Joint histograms between various cloud properties (e.g., cloud optical thickness vs cloud top pressure)
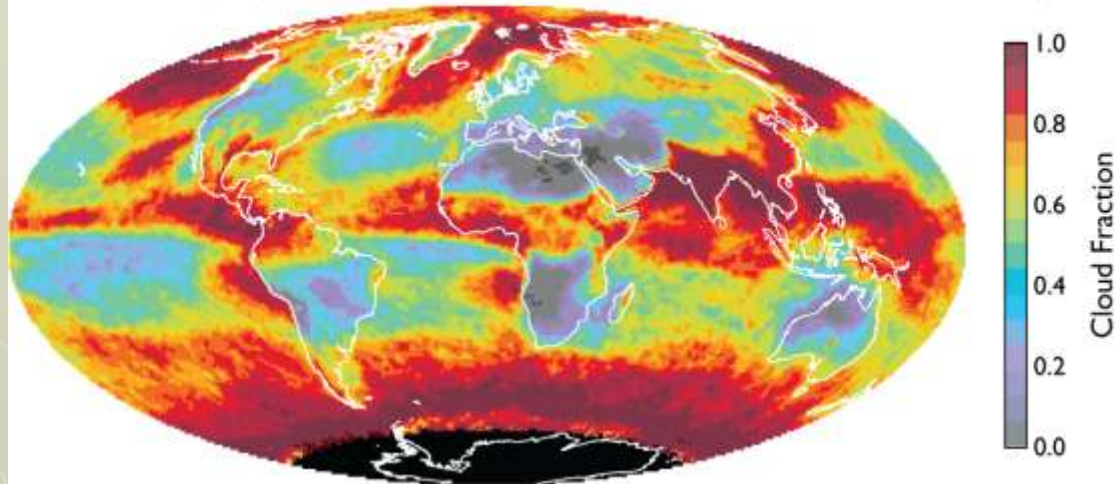
Monthly Mean Cloud Fraction
(S. A. Ackerman, R. A. Frey et al. – Univ. Wisconsin)
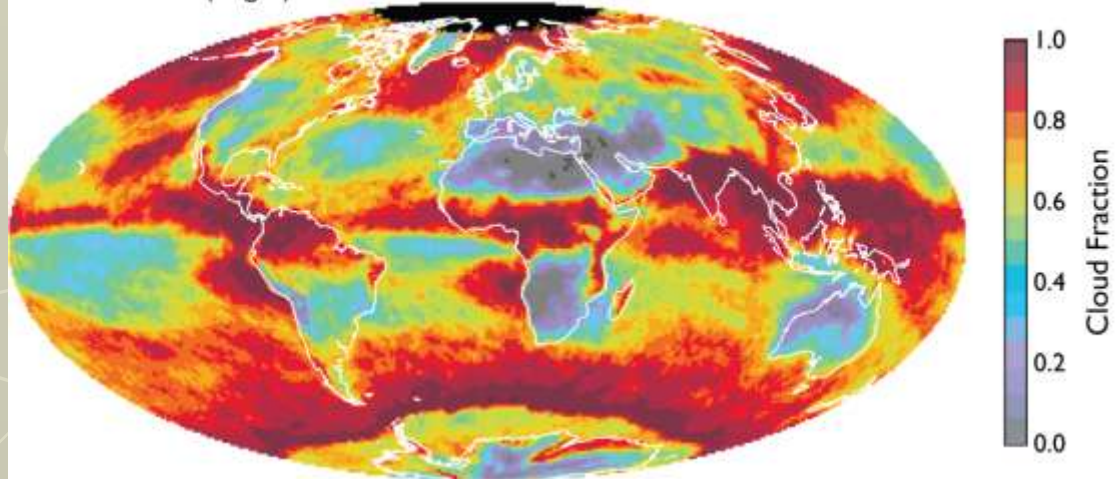
Aqua/MODIS
- ➢ Cloud fraction similar during day and night (in Collection 5)
  - – High cloud amount
    - ✓ Roaring 40s
    - ✓ ITCZ
    - ✓ North Atlantic
    - ✓ Indonesia and western tropical Pacific
  - – Low cloud amount
    - ✓ Subtropical gyres over the ocean
    - ✓ Deserts
    - ✓ Antarctica
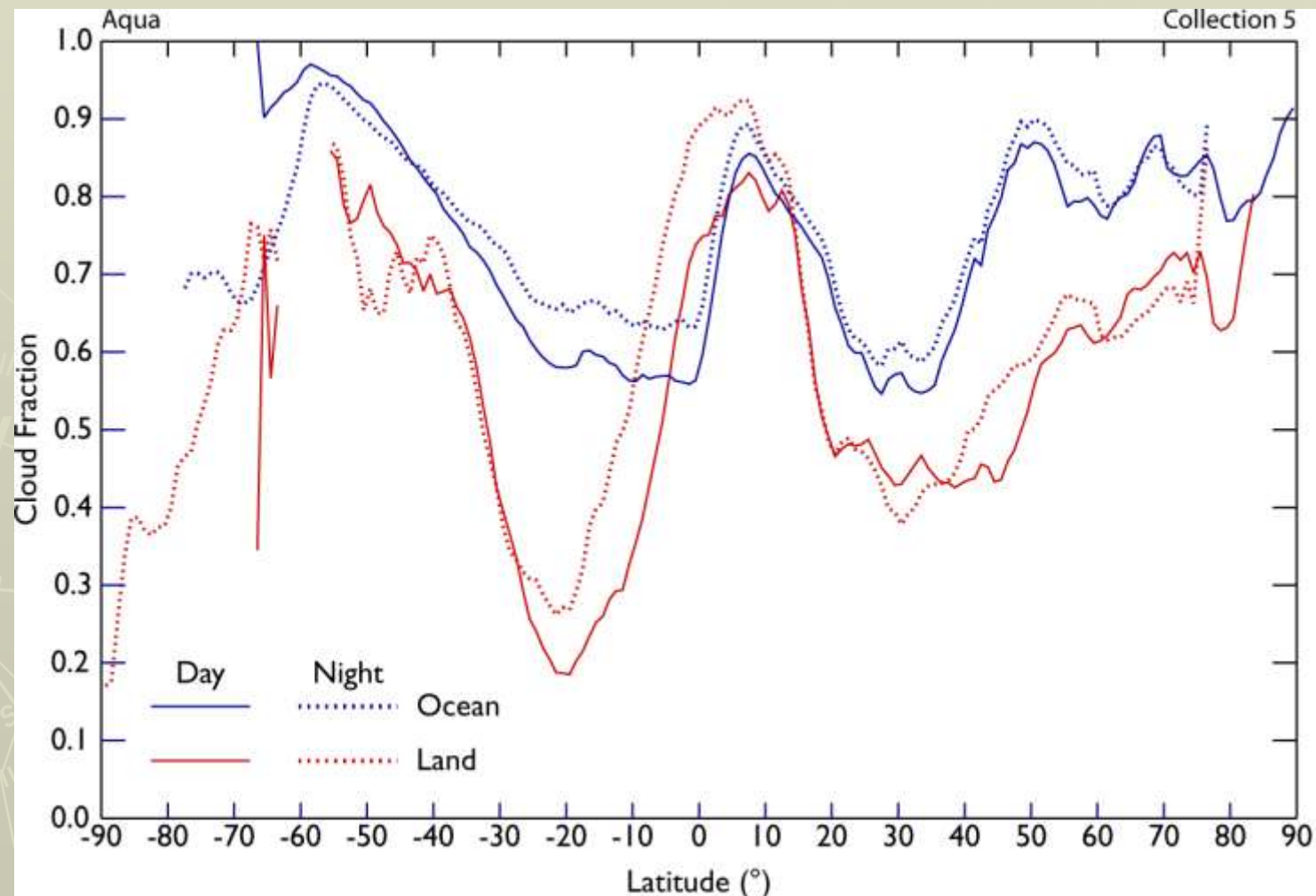   - ✓ Greenland

Cloud Fraction (Day) — Aqua

Cloud Fraction (Night)

Zonal Mean Cloud Fraction
(S. A. Ackerman, R. A. Frey et al. – Univ. Wisconsin)

July 2006

Time Series of Cloud Fraction during the Daytime
(M. D. King, S. Platnick et al. – NASA GSFC)
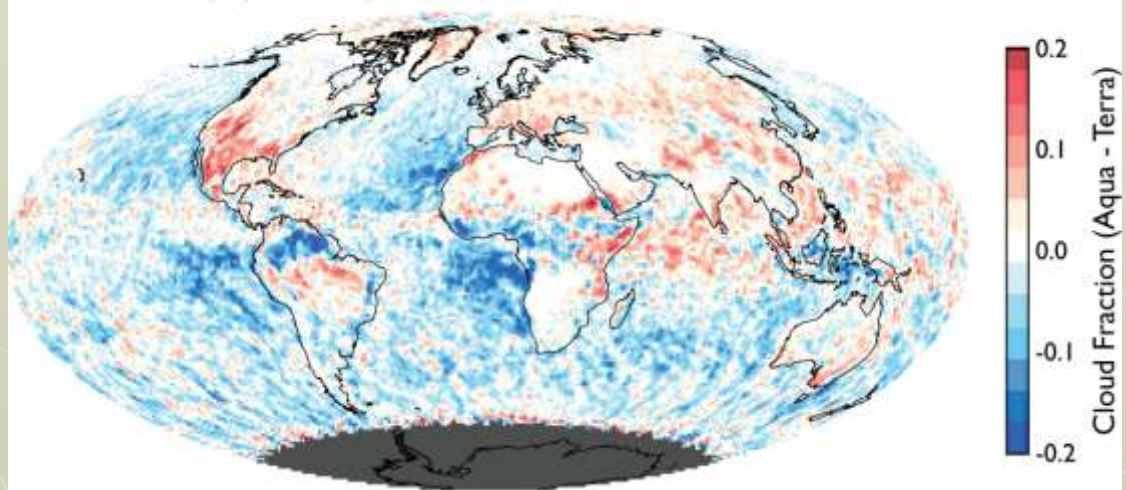
July 2002 – January 2007
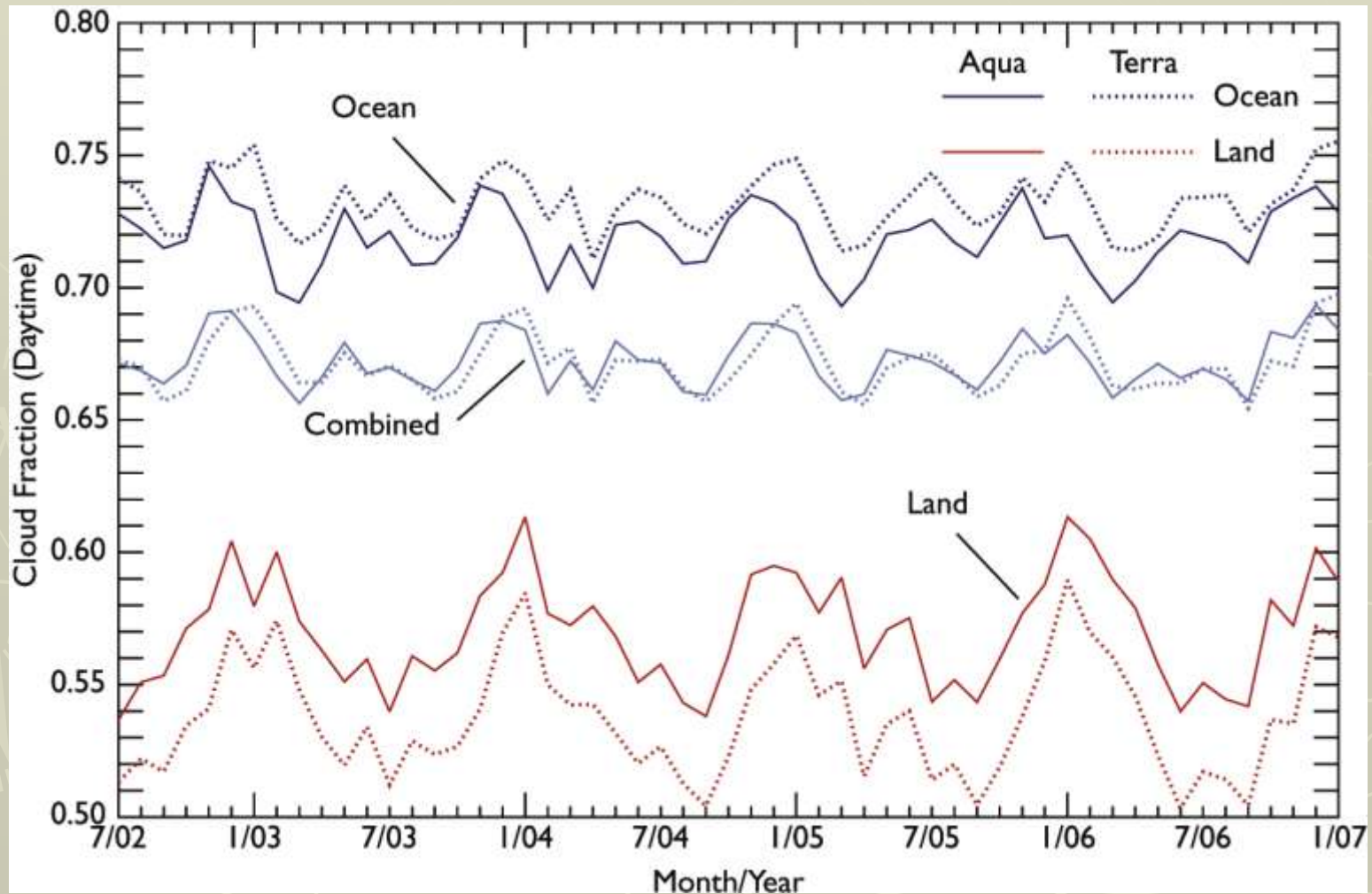
Aqua Cloud Fraction – Terra Cloud Fraction
(M. D. King, S. Platnick et al. – NASA GSFC)

- Terra
  - Higher over oceans than land
    - ✓ Marine stratocumulus
- Aqua
  - Higher over land than ocean
    - ✓ Interior continents
    - ✓ Desert southwestern US
    - ✓ Australia
  - Higher over ocean than land
    - ✓ Northern Indian Ocean

Cloud Fraction (Aqua - Terra)

Zonal Mean Cloud Fraction by Phase
(M. D. King, S. Platnick et al. – NASA GSFC)
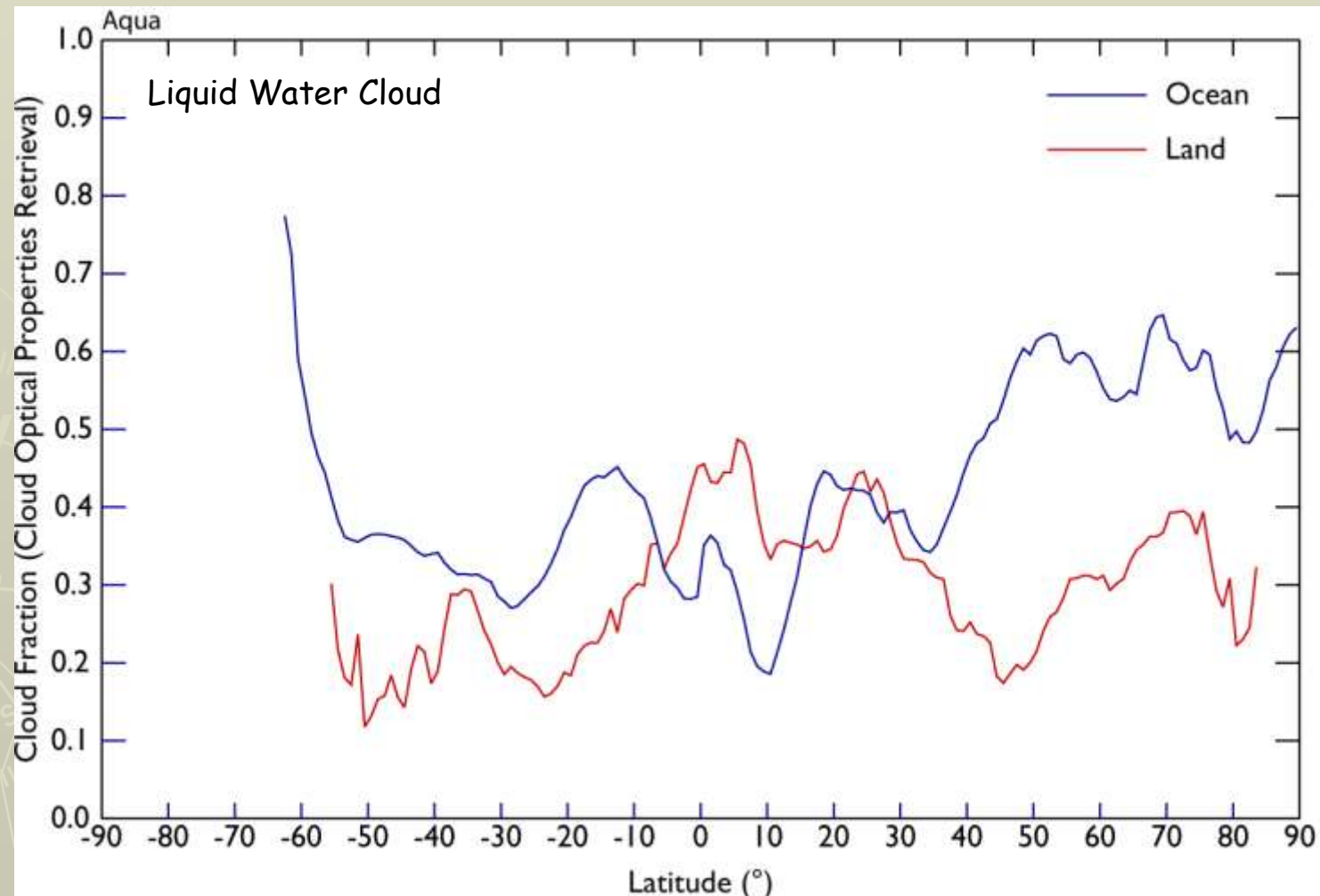
July 2006

Zonal Mean Cloud Fraction by Phase
(M. D. King, S. Platnick et al. – NASA GSFC)
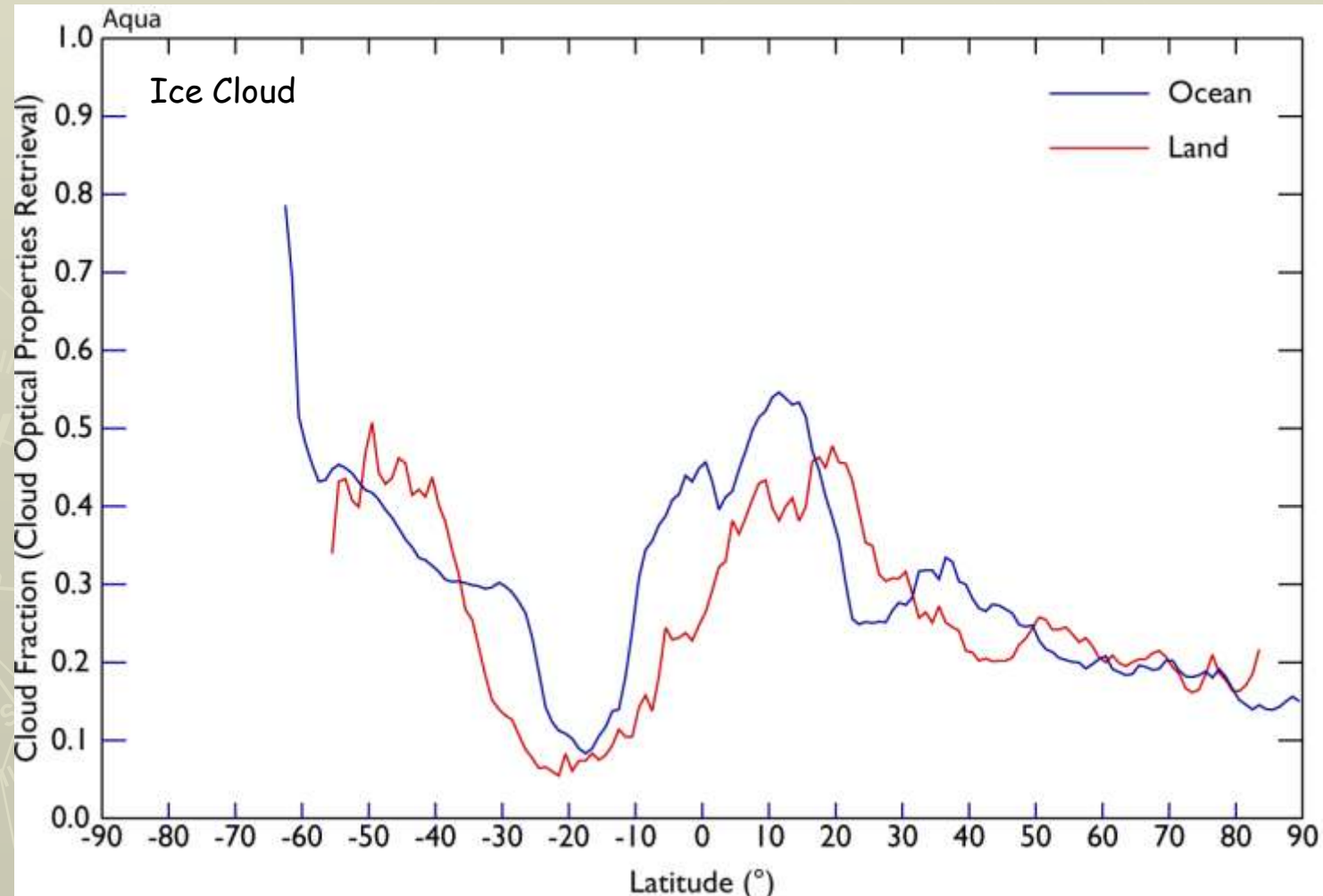
July 2006

Aqua Cloud Fraction – Terra Cloud Fraction
(M. D. King, S. Platnick et al. – NASA GSFC)

July 2006
- ➢ Liquid Water Clouds
  - Terra
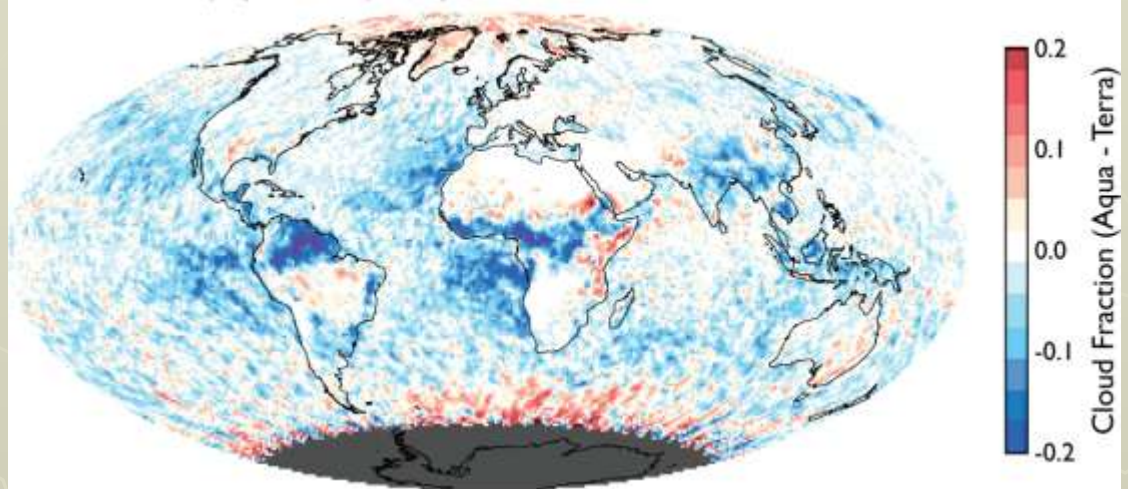   - ✓ Greater over oceans
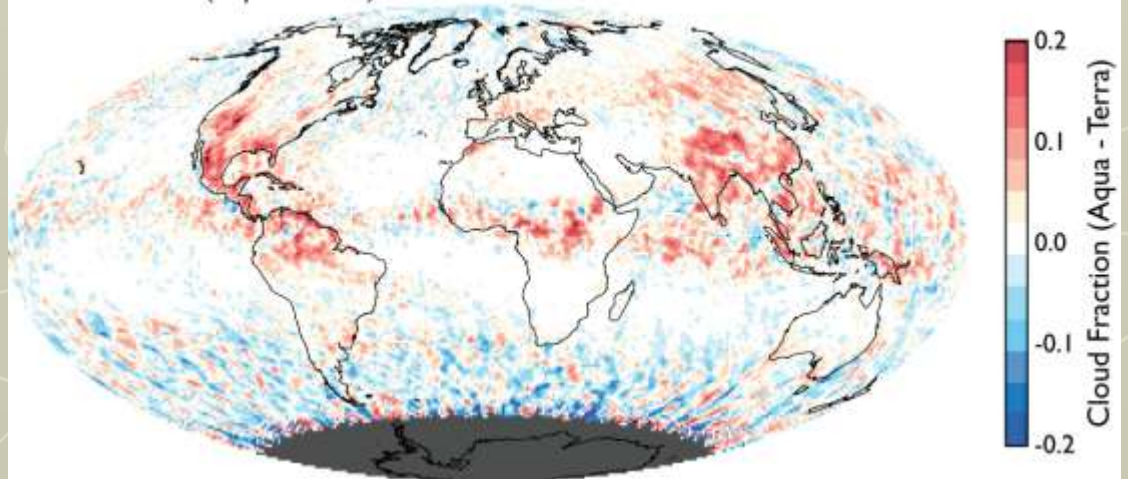   - ✓ Greater over northern Amazonia
- ➢ Ice Clouds
  - Aqua
    - ✓ Greater over continents
    - ✓ Greater over ITCZ

- ➢ Aqua shows more ice clouds, especially over land
- ➢ Terra shows more liquid clouds, especially over ocean

Cloud Fraction (Aqua - Terra) – Liquid

Cloud Fraction (Aqua - Terra) – Ice

Monthly Mean Cloud Fraction by Phase
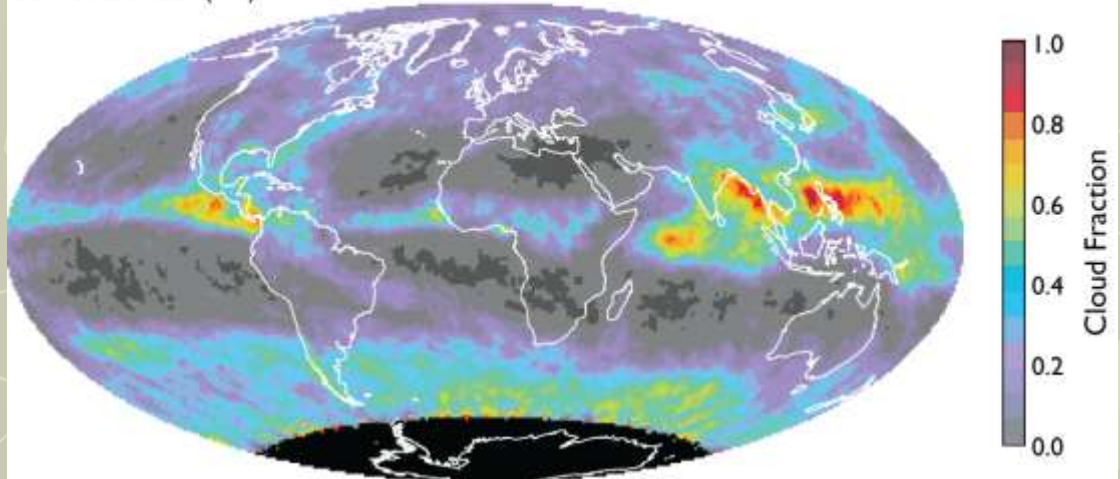## (M. D. King, S. Platnick et al. – NASA GSFC)

July 2006
Aqua

- Liquid water clouds
  - Marine stratocumulus regions
    - Angola/Namibia
    - Peru/Ecuador
    - California/Mexico
- Ice clouds
  - Tropics
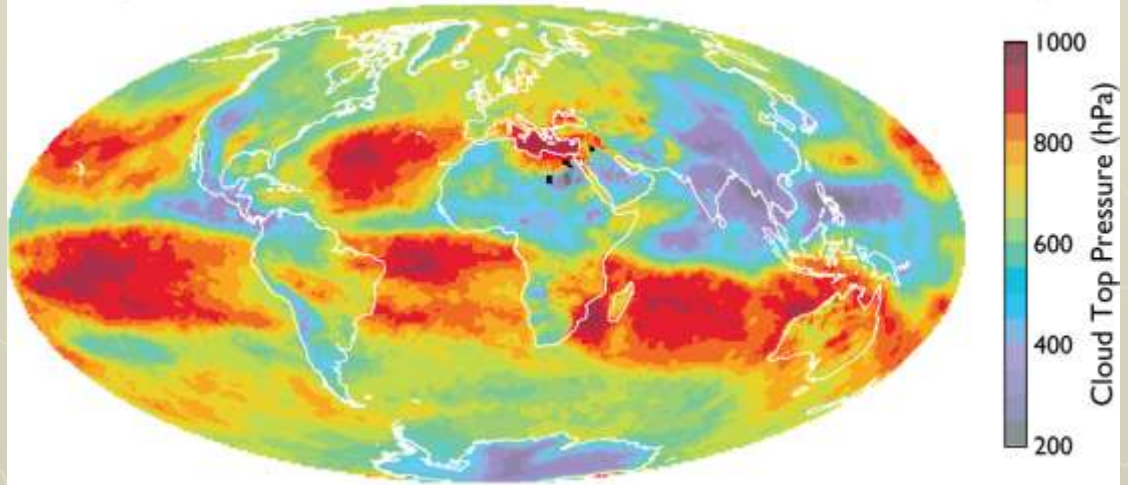   - Indonesia & western tropical Pacific
    - ITCZ
  - Roaring 40s
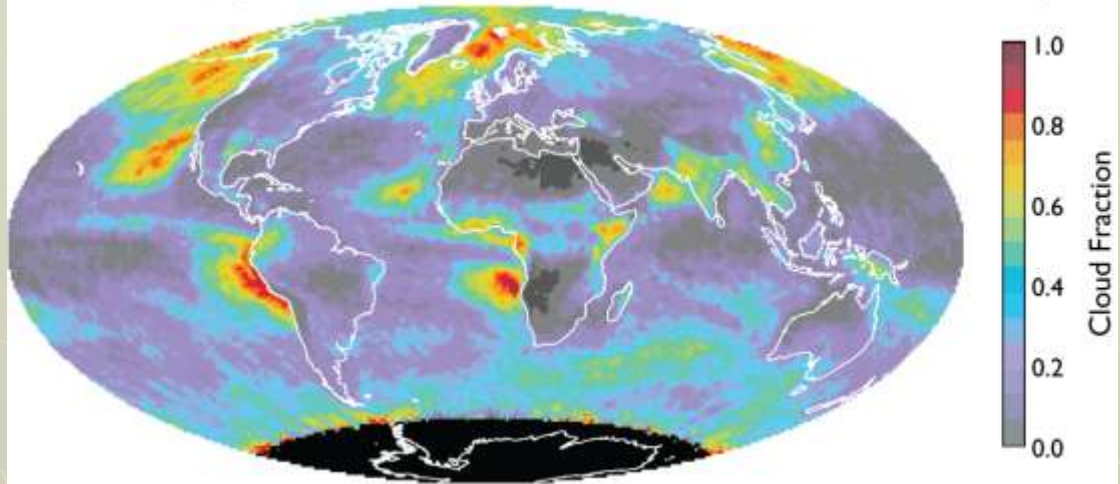
Monthly Mean Cloud Top Properties
(W. P. Menzel, R. A. Frey et al. – Univ. Wisconsin)

Aqua/MODIS

➢ Cloud top pressure and temperature low (high clouds)
  – ITCZ
  – Deserts
  – India and China land
  – Western tropical Pacific
  – Northern Indian Ocean
  – Greenland
  – Antarctica

➢ Cloud top pressure and temperature high (low clouds)
  – Central ocean gyres
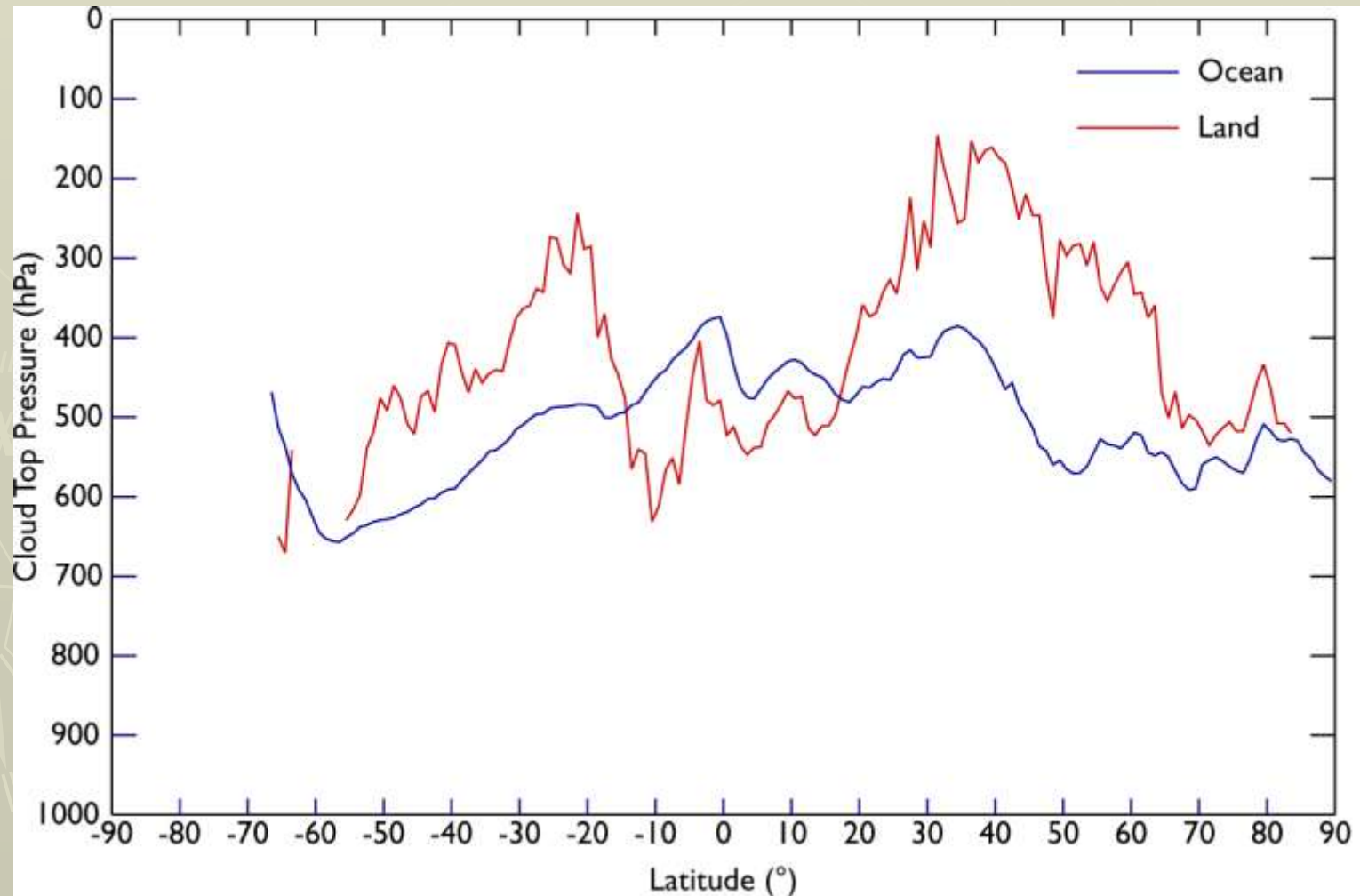 – Southern Indian Ocean
  – Western Europe
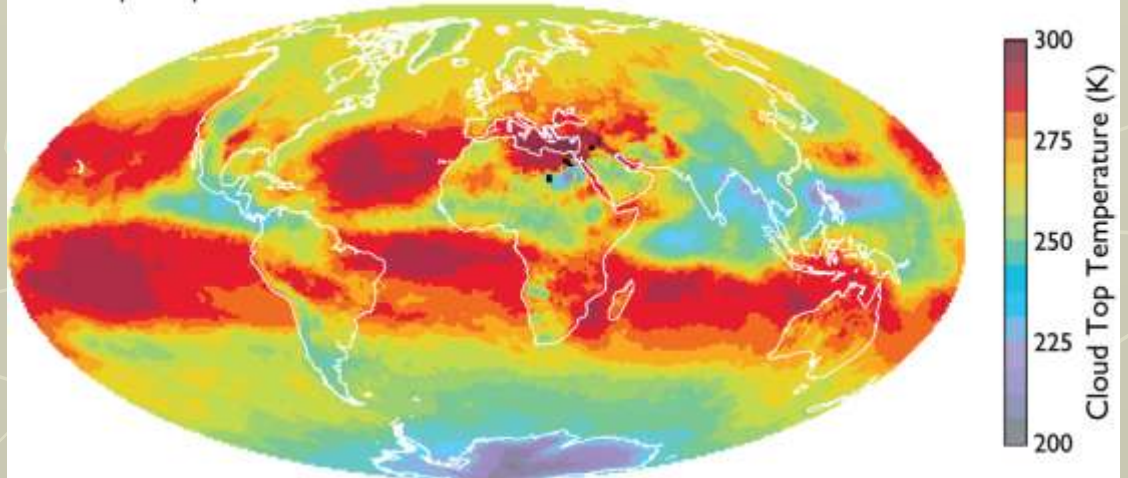
Zonal Mean Cloud Top Pressure
(W. P. Menzel, R. A. Frey et al. – Univ. Wisconsin)

July 2006

Monthly Mean Cloud Optical Thickness
(M. D. King, S. Platnick et al. – NASA GSFC)
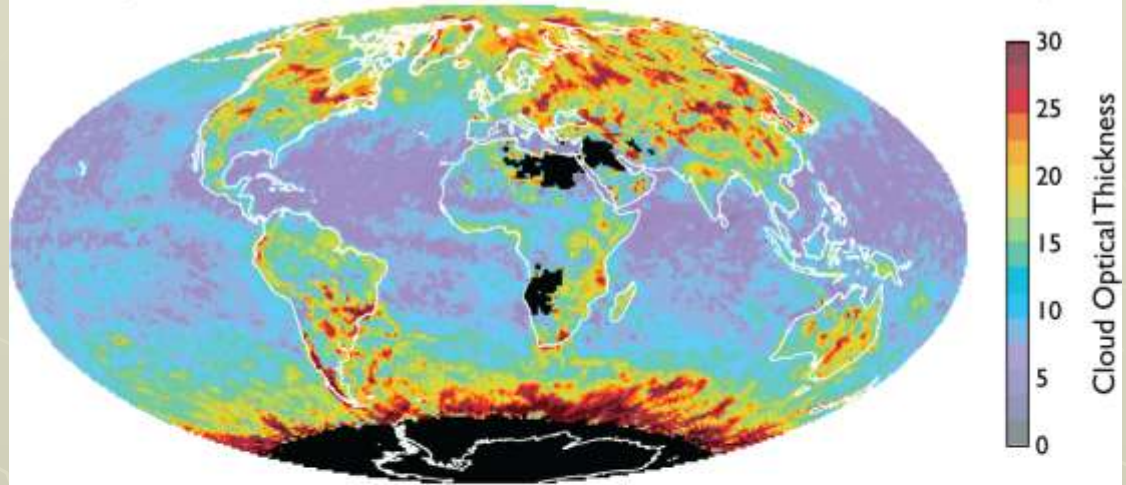
July 2006

Aqua (QA Mean)

➤ Liquid water clouds
  – Marine stratocumulus τ_c ~ 15
  – Higher optical thickness over land than ocean
    ✓ Cloud optical thickness ~5 in Indian Ocean
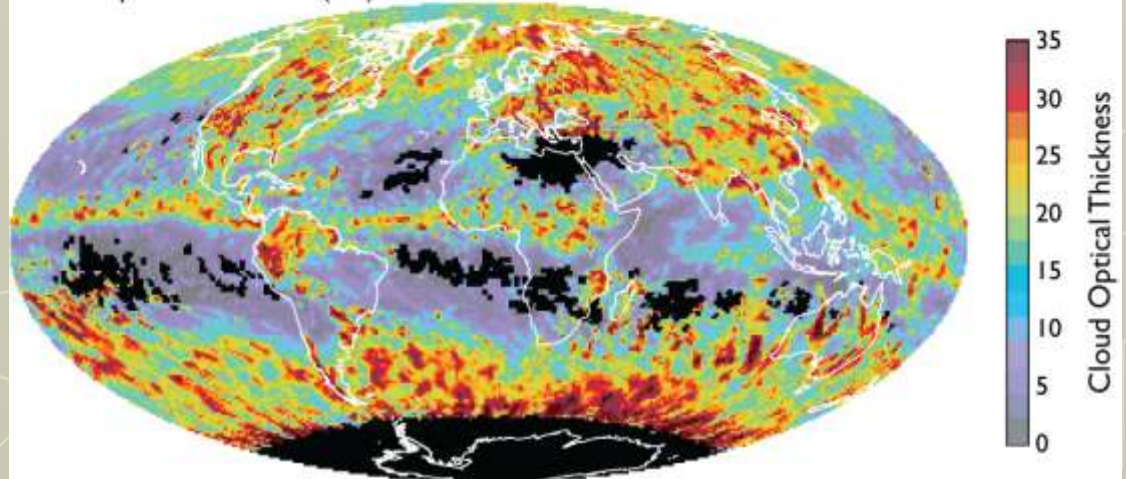 – High optical thickness around roaring 40s

➤ Ice clouds
  – Larger in tropics (ITCZ)
  – High where deep convection occurs
    ✓ Congo basin
    ✓ Amazon basin
  – High optical thickness around roaring 40s
  – Higher over land than ocean

Cloud Optical Thickness (Liquid Water)   Aqua

Cloud Optical Thickness (Ice)

Monthly Mean Cloud Effective Radius
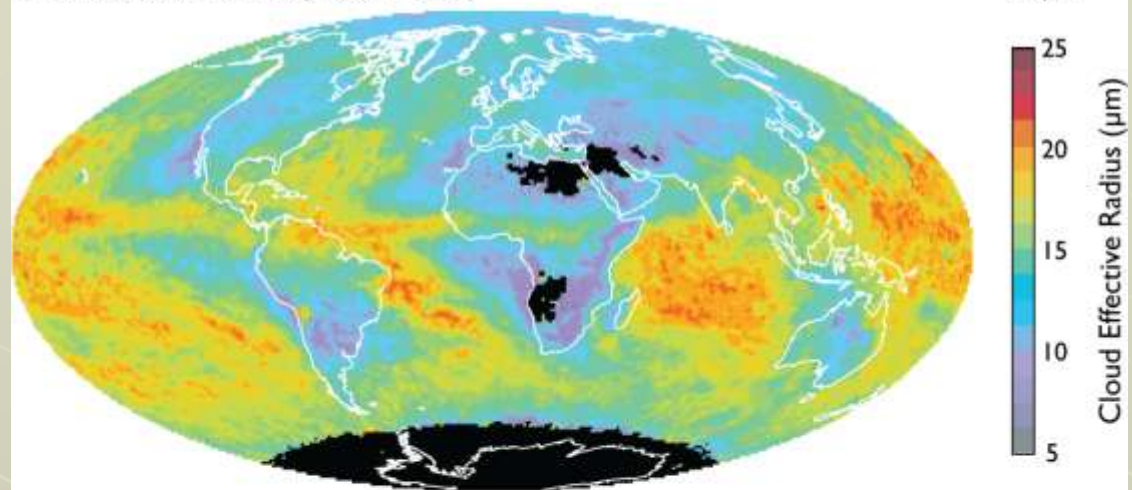## (M. D. King, S. Platnick et al. – NASA GSFC)

July 2006
Aqua (QA Mean)

➢ Liquid water clouds
- Larger drops in SH than NH
- Larger drops over ocean than land
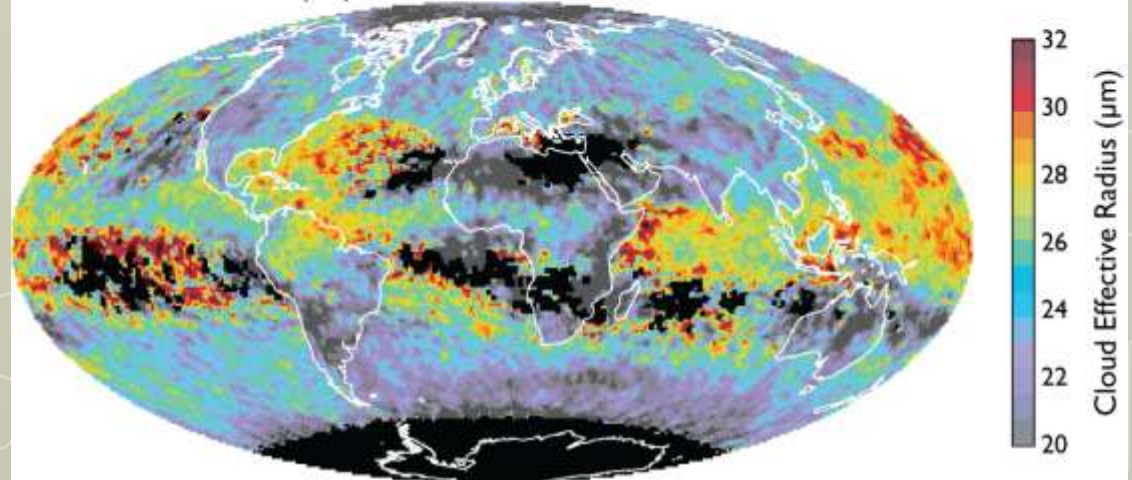 - ✓ Due to cloud condensation nuclei (aerosols)

➢ Ice clouds
- Larger in tropics than high latitudes
  - ✓ Anvils
- Small ice crystals at top of deep convection
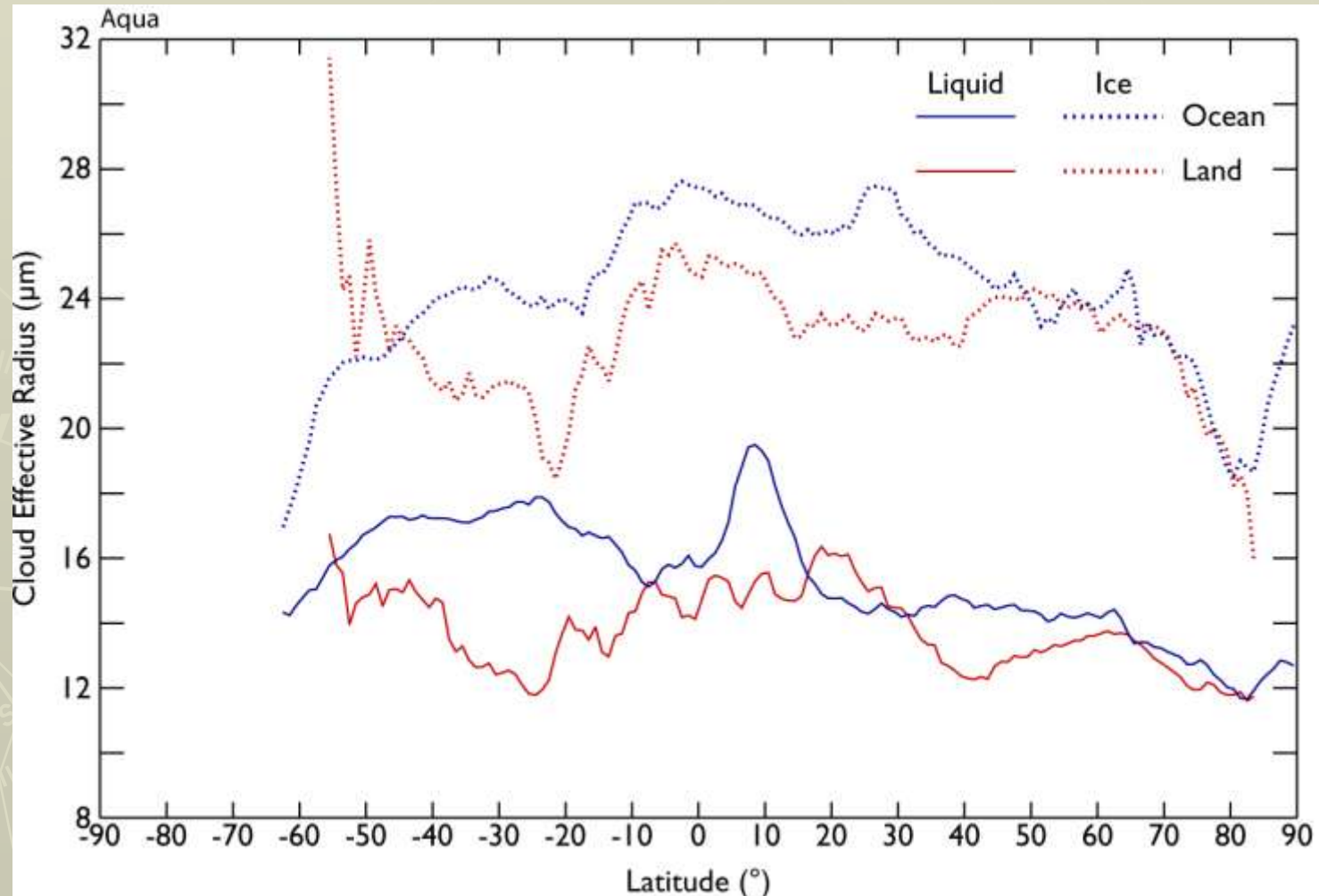

Cloud Effective Radius (Liquid Water) — Aqua
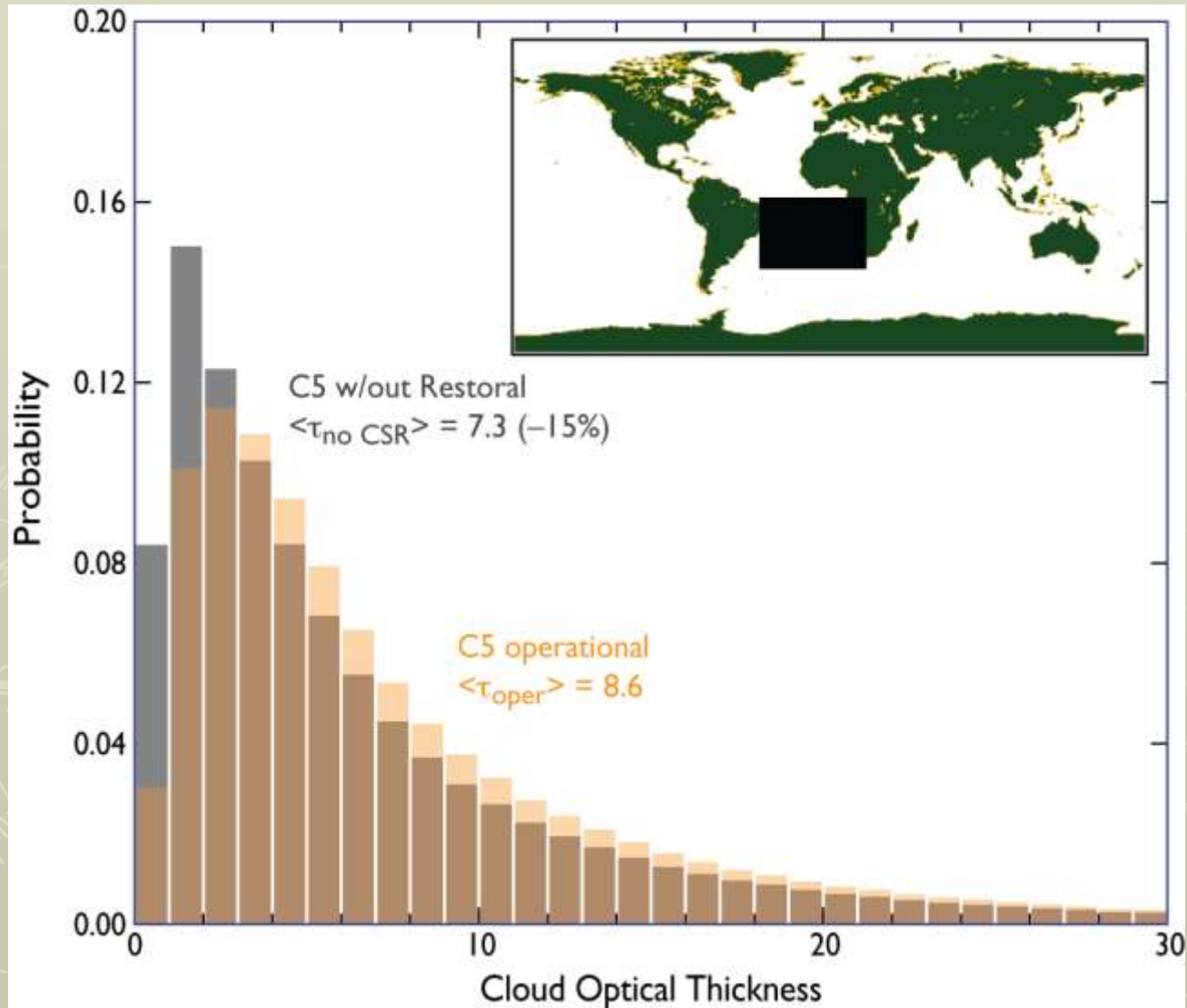
Cloud Effective Radius (Ice)

Zonal Mean Cloud Effective Radius
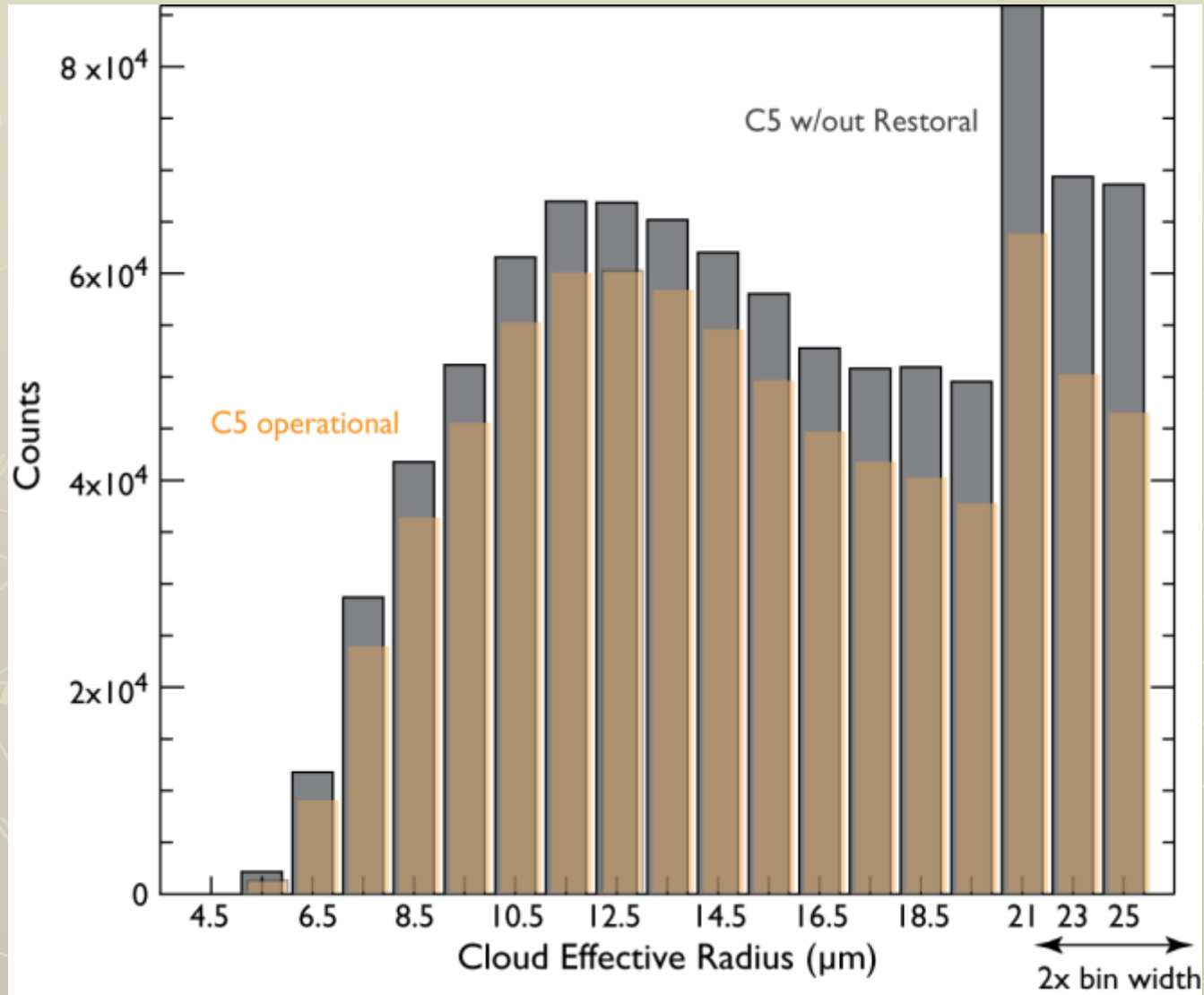## (M. D. King, S. Platnick et al. – NASA GSFC)

July 2006

Marginal Histograms of Cloud Optical Thickness
South Atlantic Ocean

Terra
March 30 –
April 6, 2005

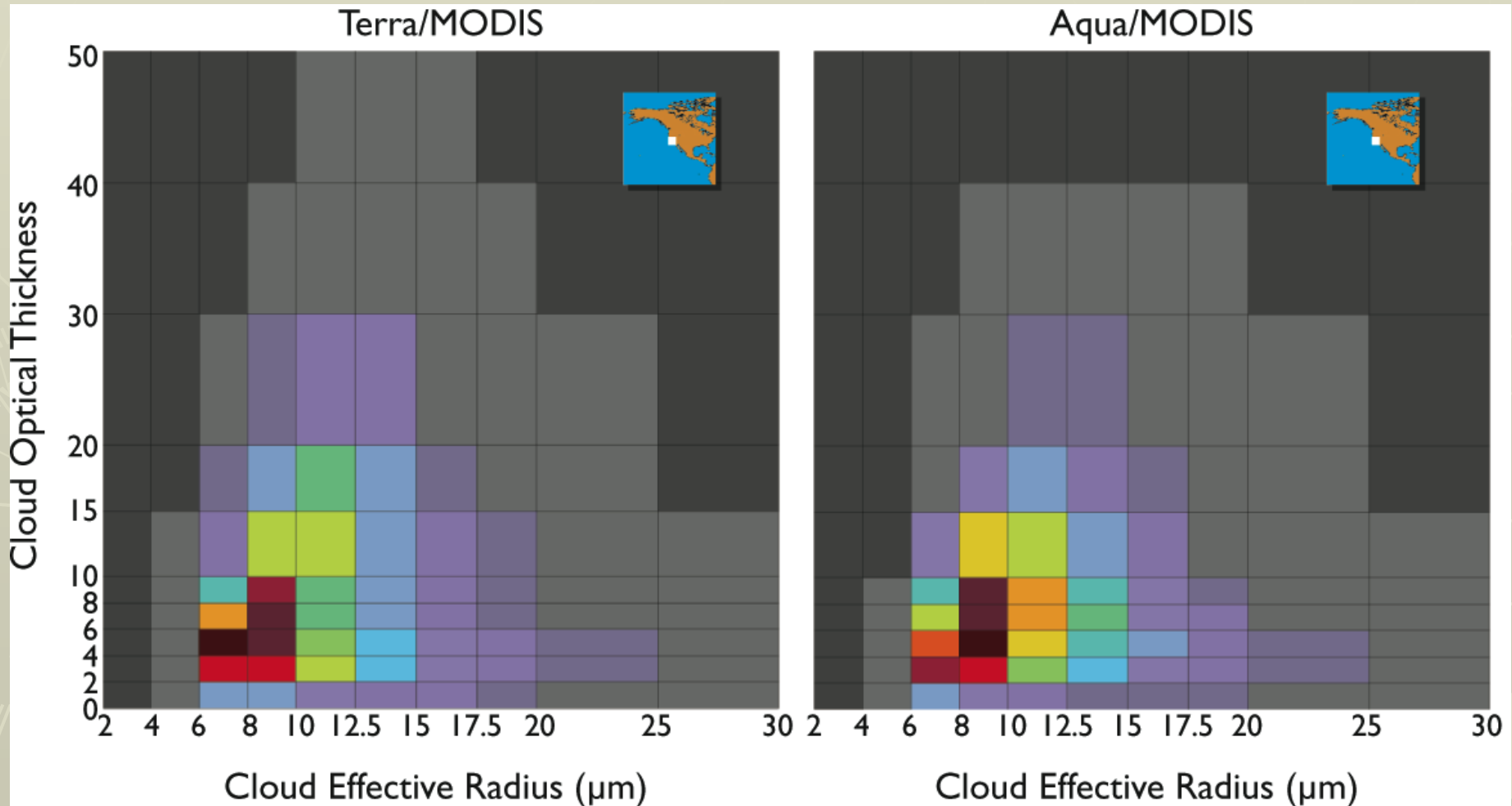# Marginal Histograms of Cloud Effective Radius
South Atlantic Ocean

Terra
March 30 –
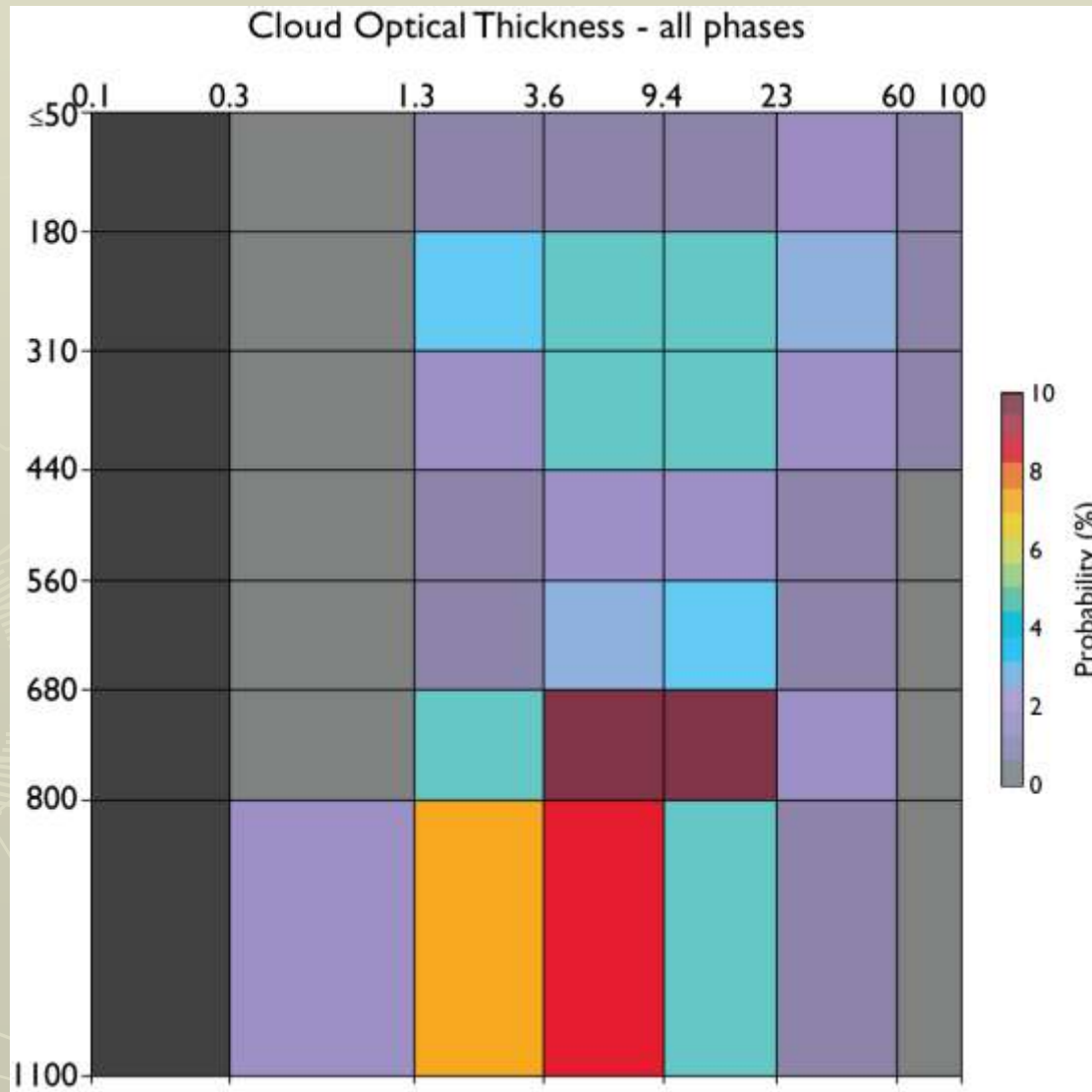April 6, 2005

MODIS τ_c vs r_e Joint Histograms
Liquid Water Clouds over Ocean

32° -40° N, 117° -125° W
June 2005

ISCCP-like τ_c vs p_c Joint Histograms

Cloud Optical Thickness - all phases

MODIS τ_c vs p_c Joint Histograms
Ice Clouds

50° N-50° S
Terra
August 2001

Cloud Optical Thickness - ice phase

MODIS τ_c vs p_c Joint Histograms
Liquid Water Clouds

50° N-50° S
Terra
August 2001

Status and Plans for Collection 6

➢ Terra and Aqua
  – MODIS atmosphere products (descriptions, level-1b and level-3 browse imagery, documentation, contact information, tools for working with and ordering data…)
    ✓ modis-atmos.gsfc.nasa.gov
  – Data available for browse (level-1 and atmosphere level-2 and level-3) and ordering at Level 1 and Atmosphere Archive and Distribution System (LAADS)
    ✓ ladsweb.nascom.nasa.gov
➢ Plans for the future
  – Collection 5.1 enhancements and reprocessing
    ✓ Atmosphere reprocessing of Aqua to begin on May 21, 2008 (beginning of Aqua around July 4, 2002 to August 2007) and complete in September 21, 2008
    ✓ Atmosphere reprocessing of Terra to begin on September 16, 2008 (beginning of Terra around February 24, 2000 to August 2007) and complete in February 2009
      » To include Deep Blue aerosol algorithm
  – Collection 6 enhancements and processing
    ✓ Atmosphere initial delivery of code in November 2008 for initial testing
    ✓ Atmosphere processing of Terra and Aqua to begin in February 2009