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

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

July 2006

Liquid Water Cloud
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
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

July 2006
Zonal Mean Cloud Top Pressure
(W. P. Menzel, R. A. Frey et al. - Univ. Wisconsin)

July 2006

[Graph showing the zonal mean cloud top pressure for ocean and land, with pressure on the y-axis and latitude on the x-axis.]
Monthly Mean Cloud Optical Thickness
(M. D. King, S. Platnick et al. - NASA GSFC)

July 2006
Aqua (QA Mean)

- Liquid water clouds
  - Marine stratocumulus $\tau_c \sim 15$
  - 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
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
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

C5 w/out Restoral
\( \langle \tau_{\text{no CSR}} \rangle = 7.3 \) (-15%)

C5 operational
\( \langle \tau_{\text{oper}} \rangle = 8.6 \)
Marginal Histograms of Cloud Effective Radius
South Atlantic Ocean

Terra
March 30 - April 6, 2005
MODIS $\tau_c$ vs $r_e$ Joint Histograms
Liquid Water Clouds over Ocean
32° -40° N, 117° -125° W
June 2005
ISCCP-like $\tau_c$ vs $p_c$ Joint Histograms

50° N-50° S
Terra
August 2001
MODIS $\tau_c$ vs $p_c$ Joint Histograms
Ice Clouds

50° N-50° S
Terra
August 2001
MODIS $\tau_c$ 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**