Collection 6 Algorithm Updates

MODIS Cloud Mask (MOD35)
and
Cloud Top Pressure (MOD06CT)

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Cloud Mask Updates

Status: Aqua delivered
Terra provisional pending final
L1b calibration

Use of NDVI background maps

Global 5 year means of 16-day NDVIs (Moody, et al.)

Define "desert" processing path (NDVI background < 0.3)

Define bands 1, 8 cloud test thresholds as functions of scattering angle and NDVI background; use band 8 (0.413 µm) for NDVI < 0.25

Define GEMI test thresholds as function of NDVI background in three ranges; use GEMI test for desert processing path only

Impacts:

greatly reduces the fraction of pixels processed as "desert"

reduces the frequency of clear-sky restorals (cloudy -> clear); however, this means more "probably clear" results in very arid regions when conditions are actually clear; *users should consider both "confident clear" and "probably clear" to be clear*

decreases numbers of "probably cloudy" and "probably clear" results in vegetated regions under conditions of clear skies;
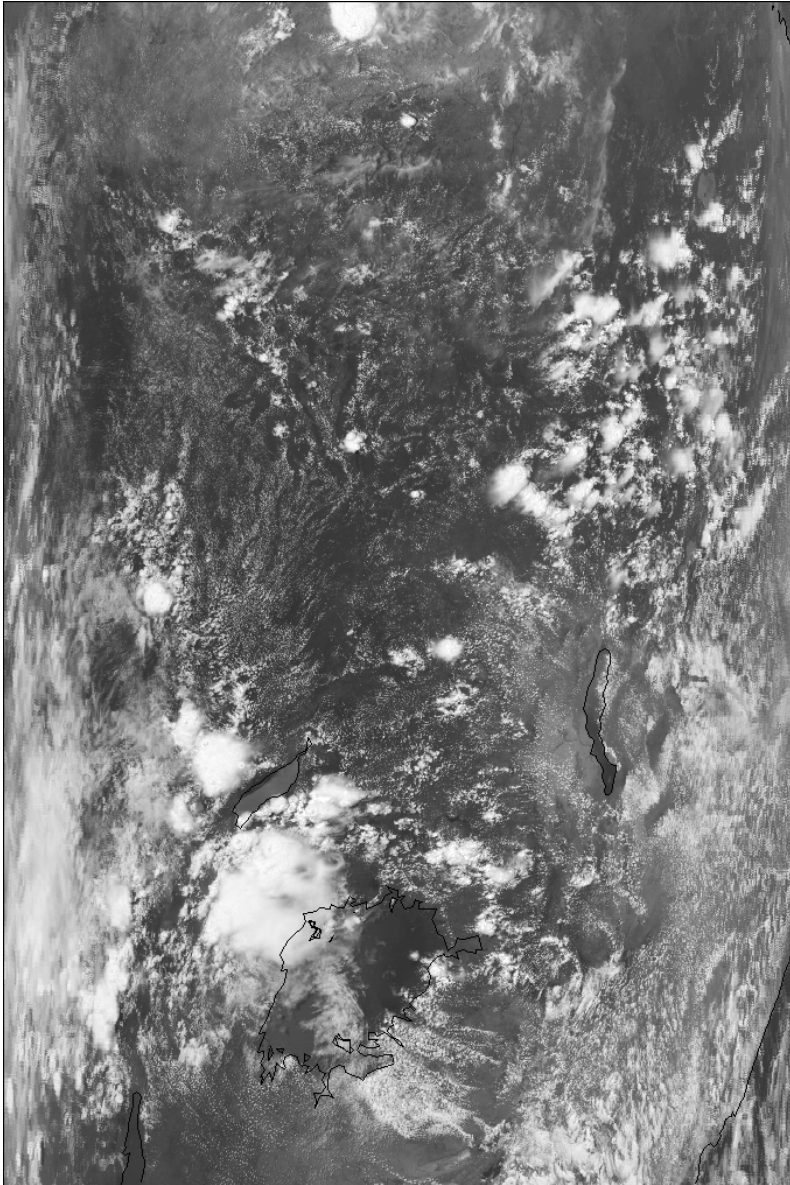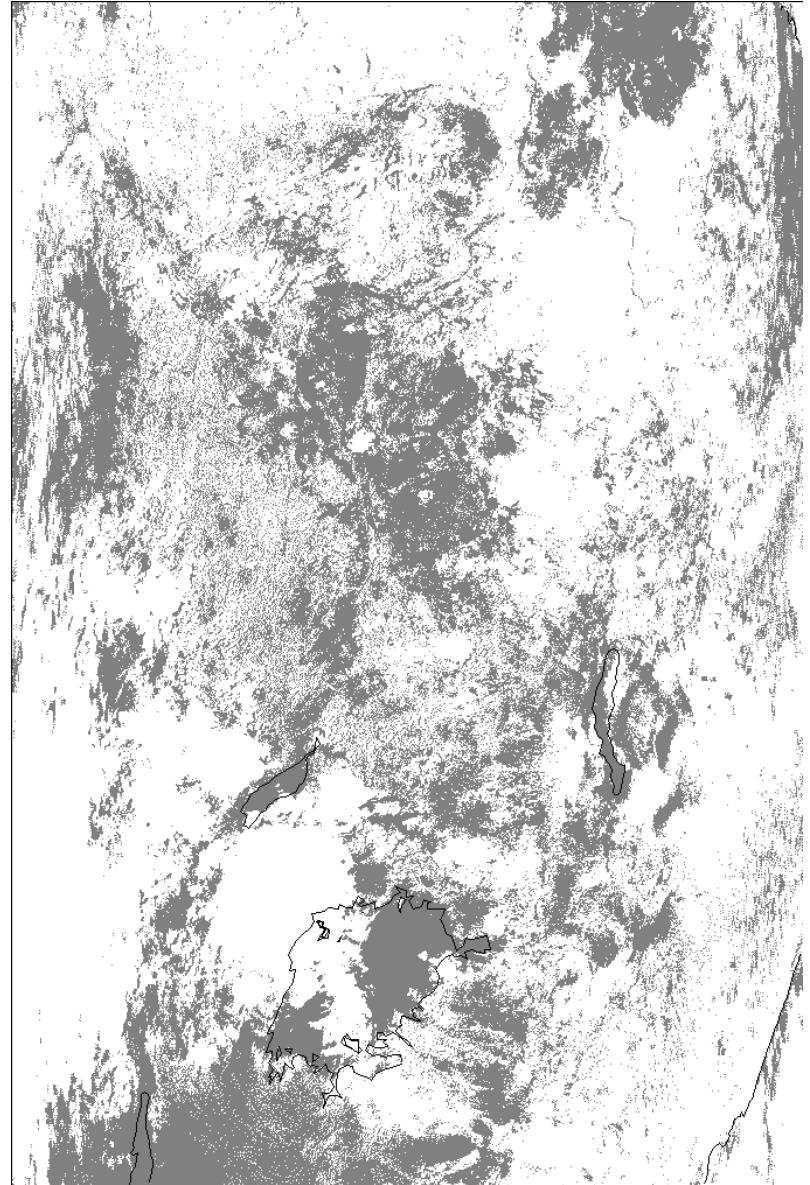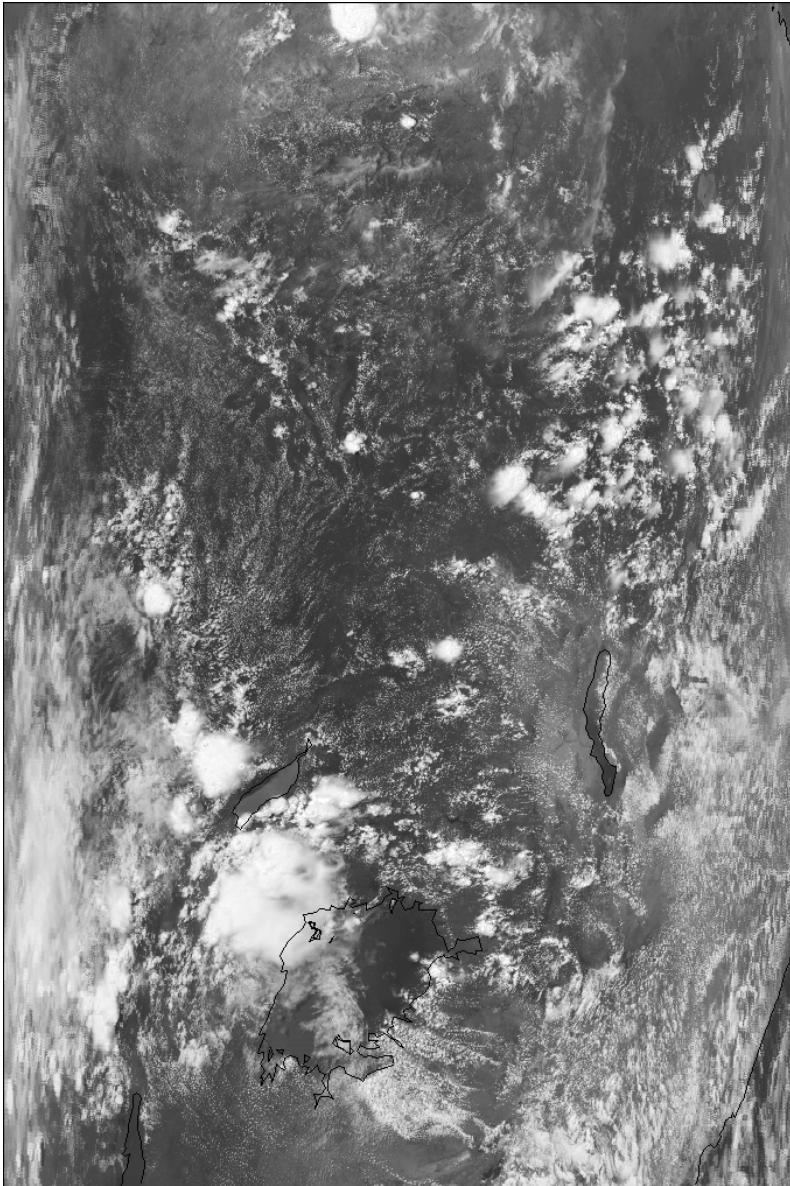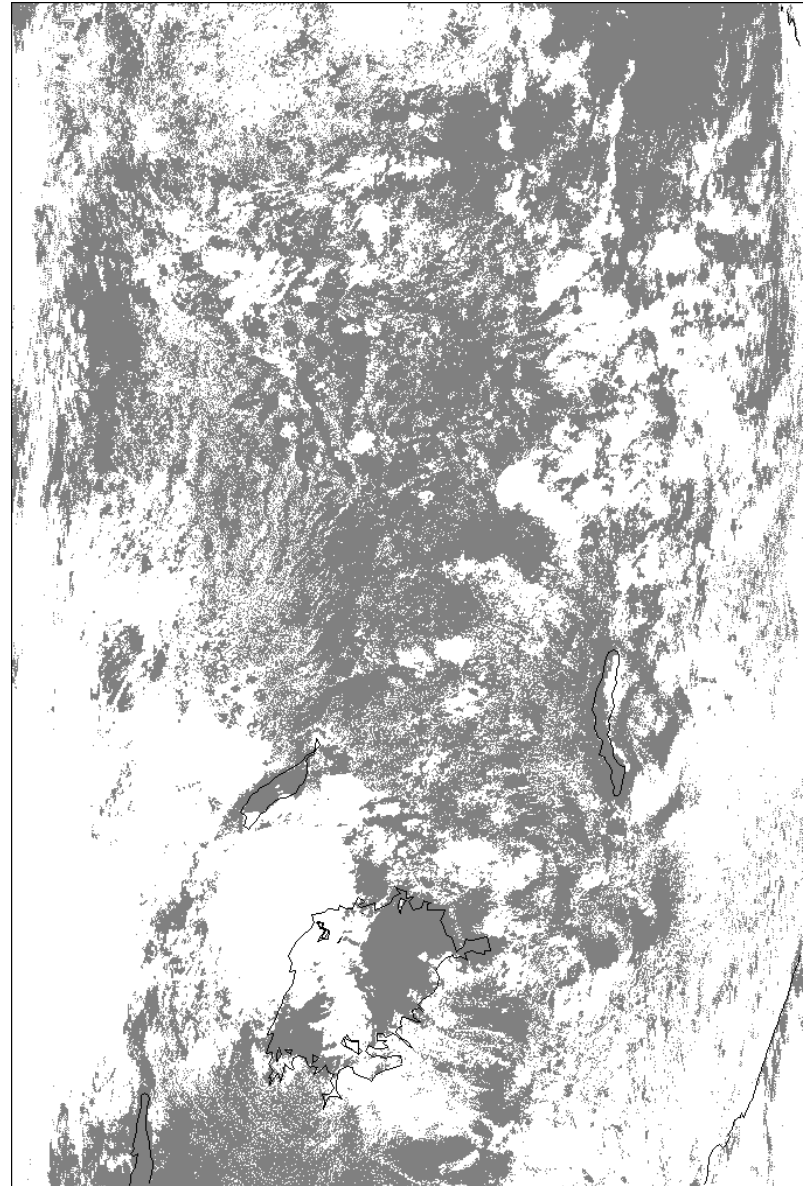
MODIS Band 1   Collection 5 Visible Cloud Test

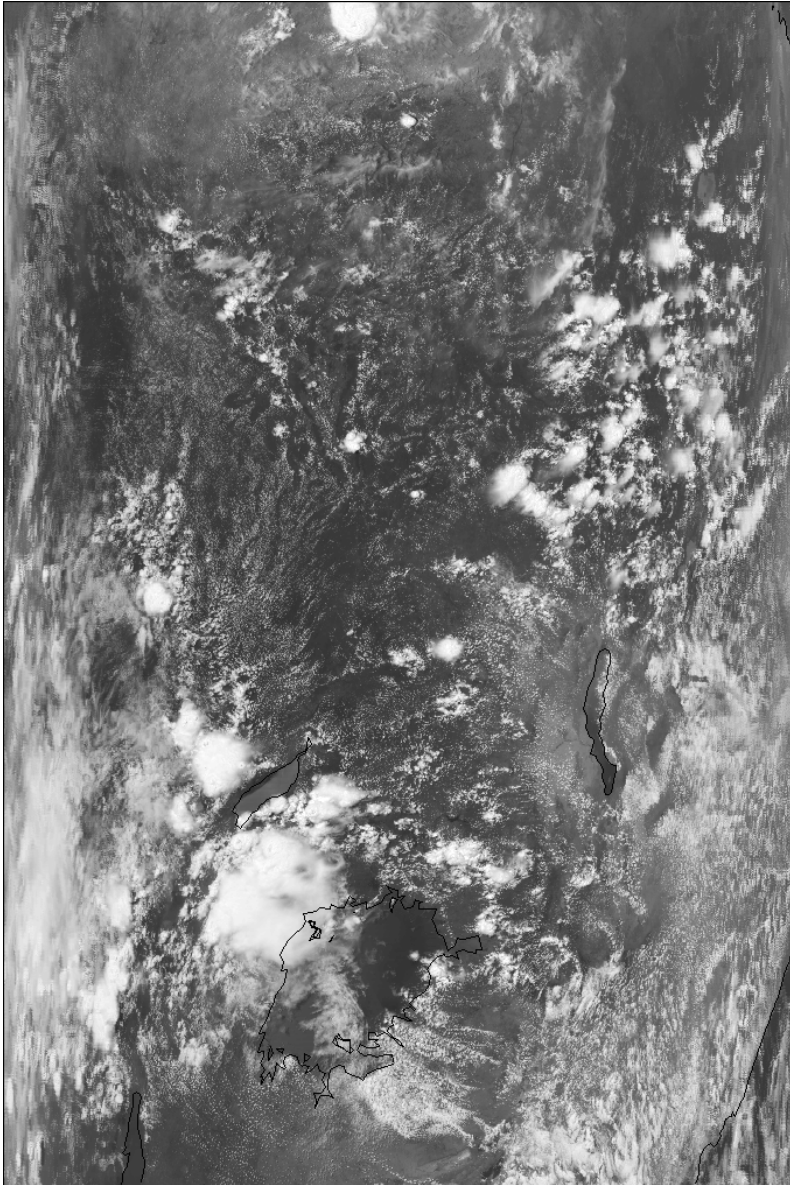**Aqua MODIS 2006240 at 11:20 UTC**
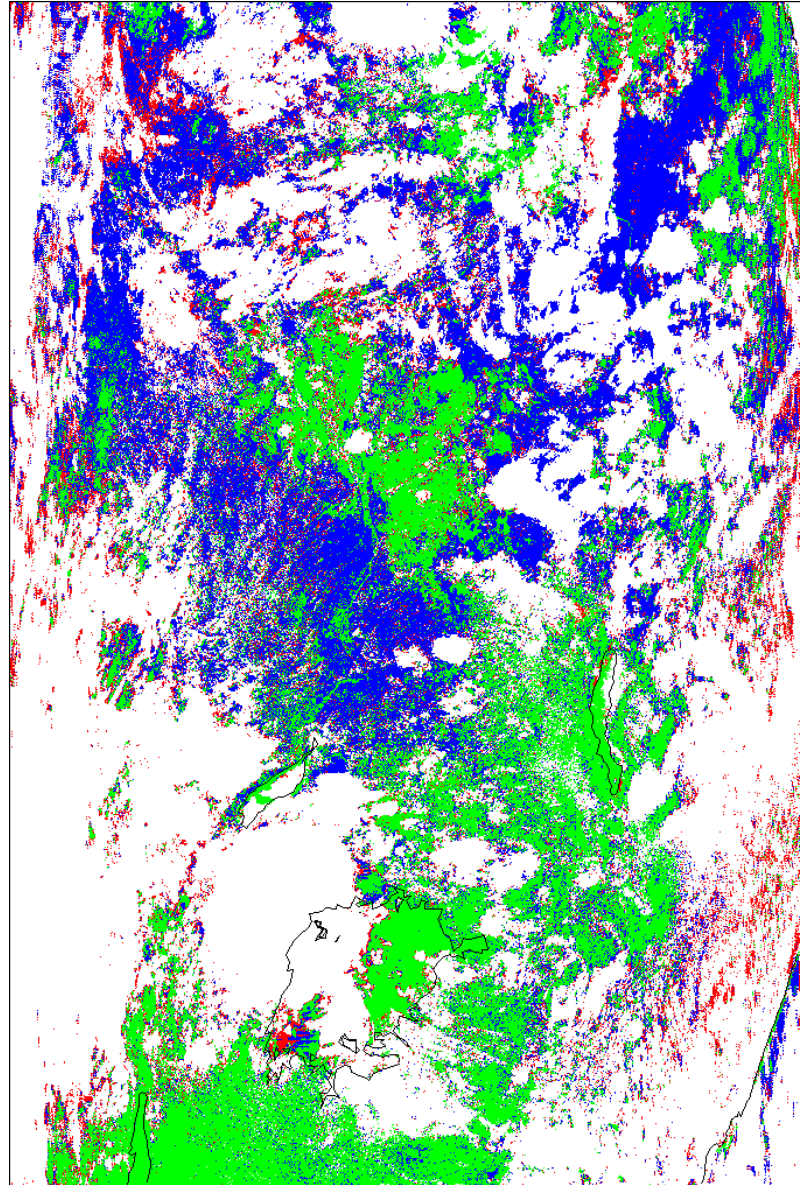
MODIS Band 1   Collection 6 Visible Cloud Test

Aqua MODIS 2006240 at 11:20 UTC

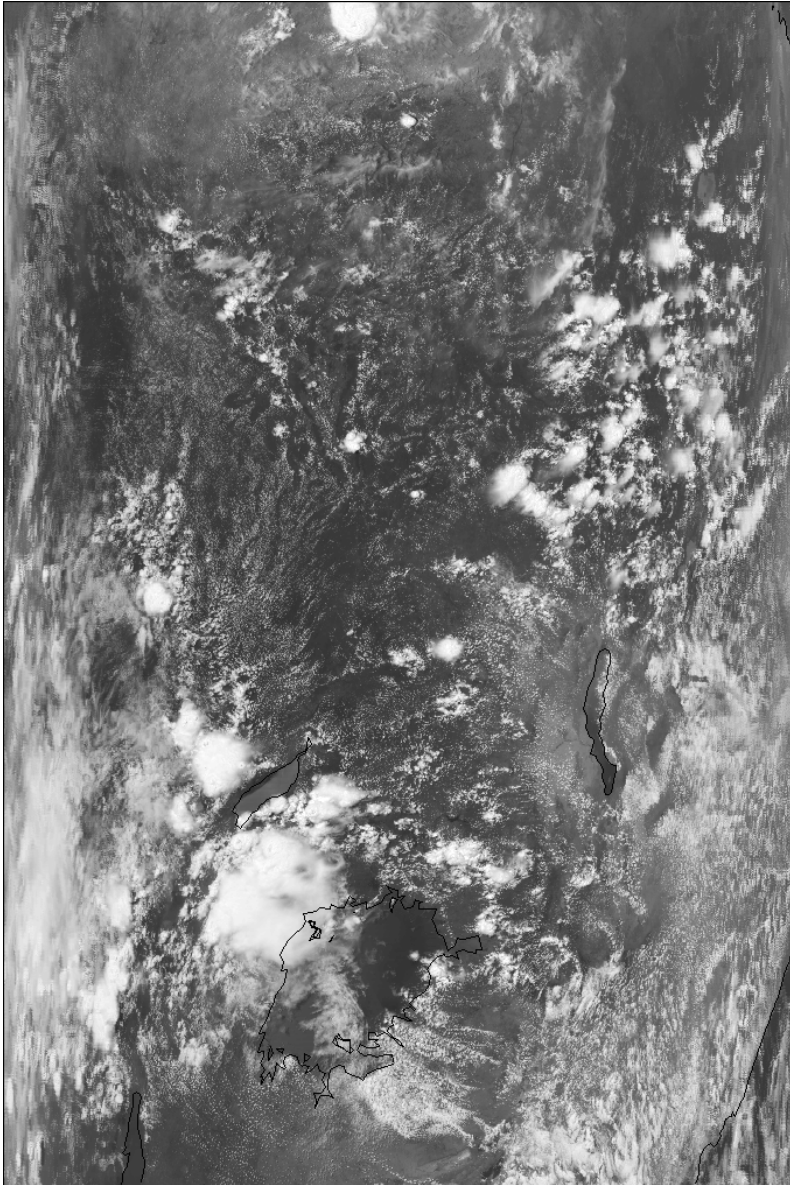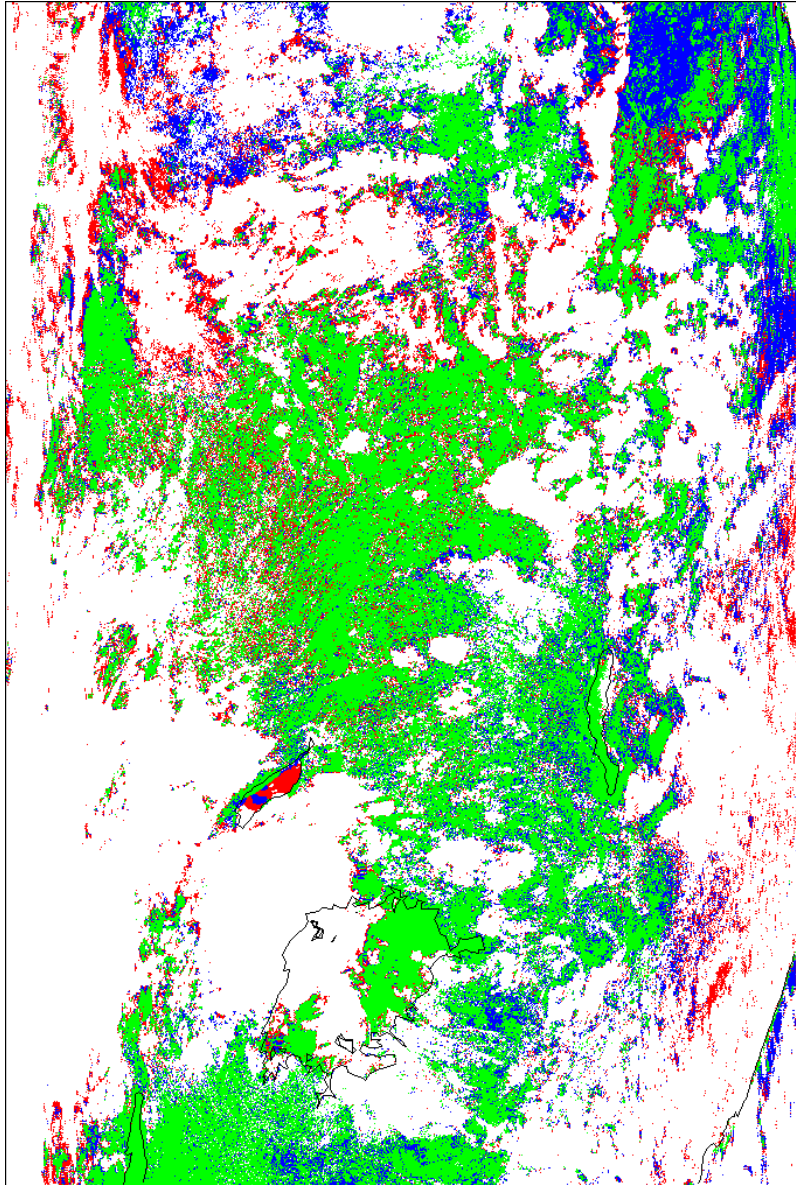G-conf. clear, B-prob. clear, R-prob. cloudy, W-conf.cloudy

MODIS Band 1

Collection 5 Cloud Mask

Aqua MODIS 2006240 at 11:20 UTC

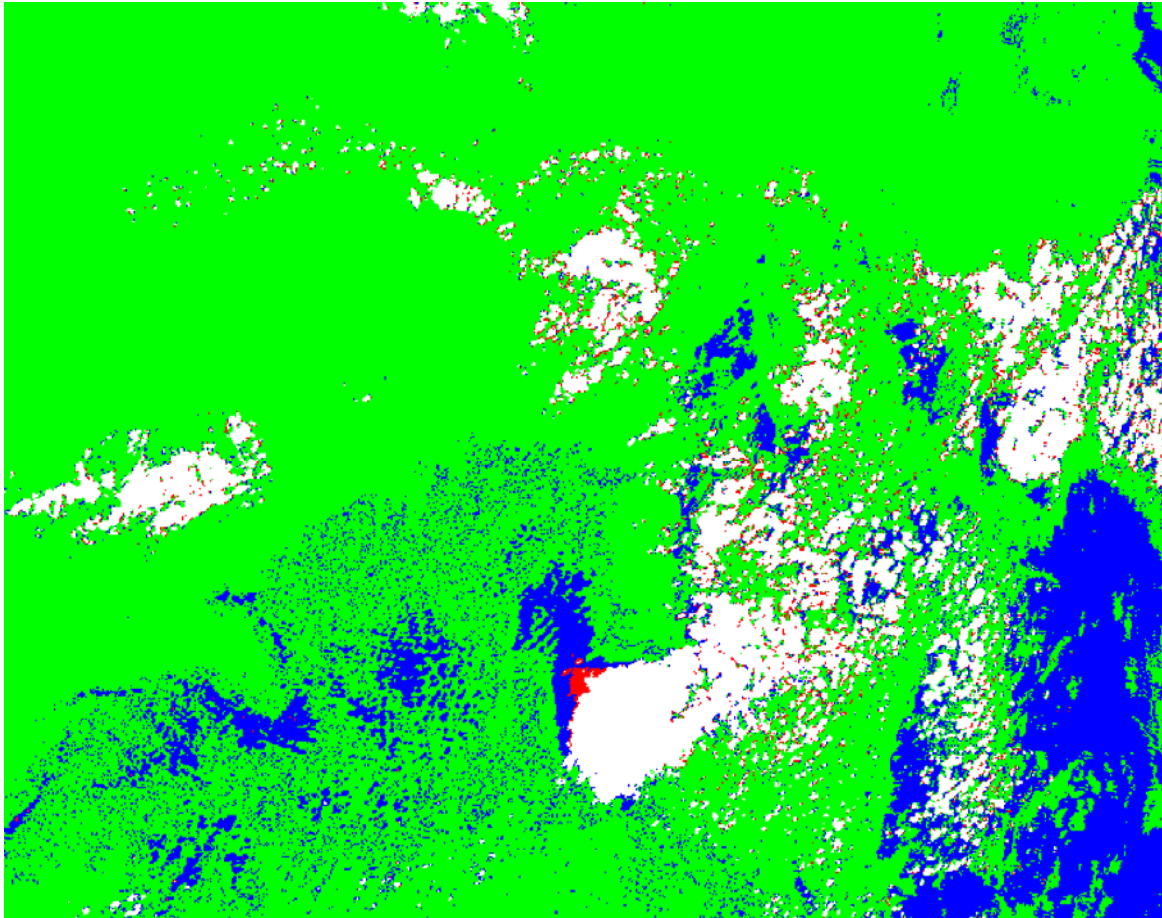G-conf. clear, B-prob. clear, R-prob. cloudy, W-conf.cloudy

MODIS Band 1

Collection 6 Cloud Mask

Aqua MODIS 2006240 at 11:20 UTC

Added cloud adjacency flag
includes probably cloudy, cloudy, and adjacent pixels

MODIS Collection 6 Cloud Mask

Aqua MODIS 2006240 at 13:05 UTC

cloud mask bit #12 …
may be used as a "cloudy plus probably cloudy plus adjacent pixel mask"

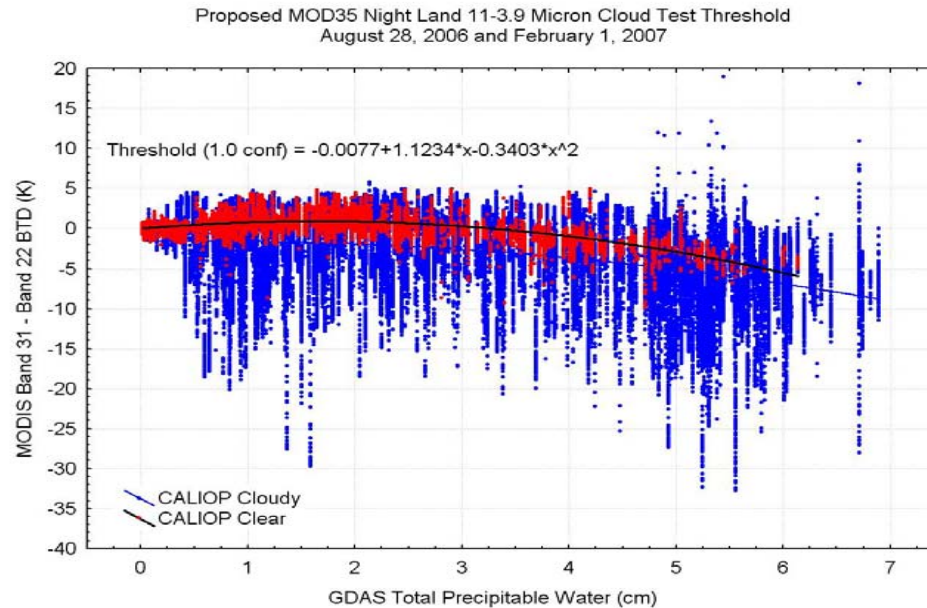**MOD35 Collection 6 Cloud Adjacency Flag**

Aqua MODIS 2006240 at 13:05 UTC

Made land night 11-3.9 um BTD test thresholds a function of total precipitable water
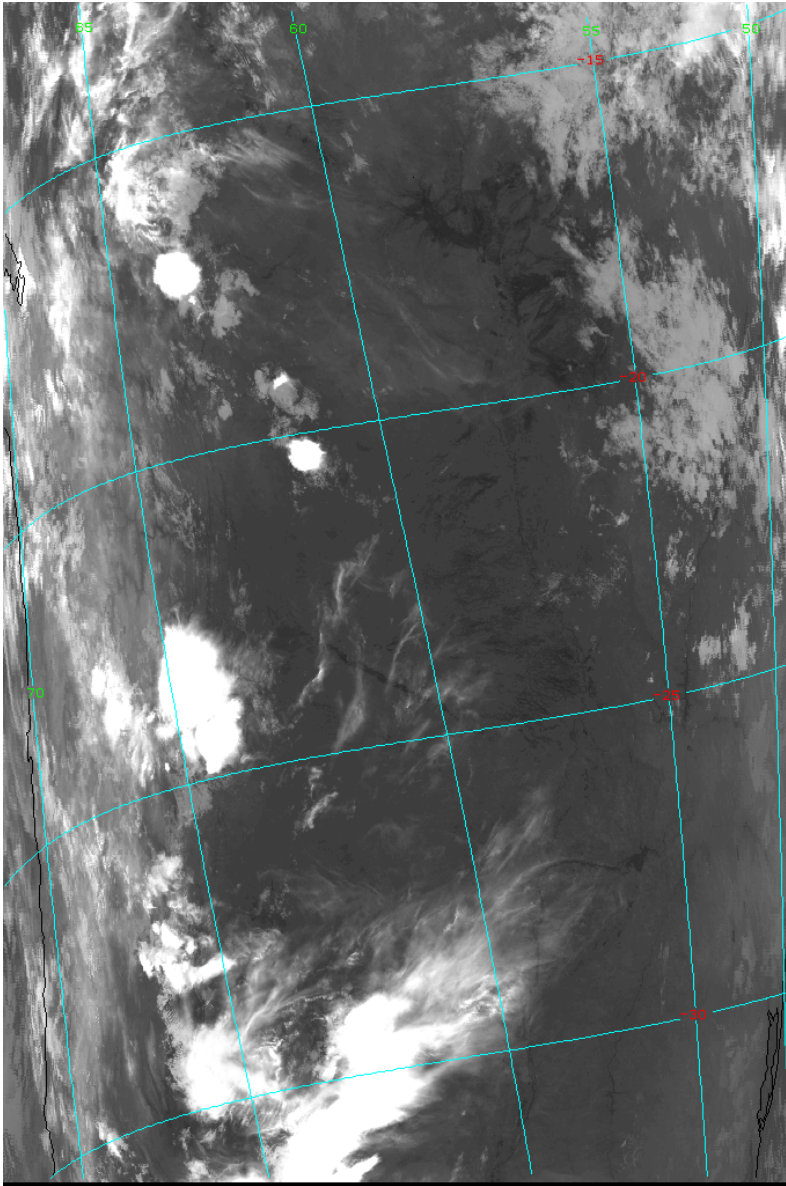
Thresholds are from regression between MODIS BTDs and GDAS TPW, using CALIOP to define clear pixels
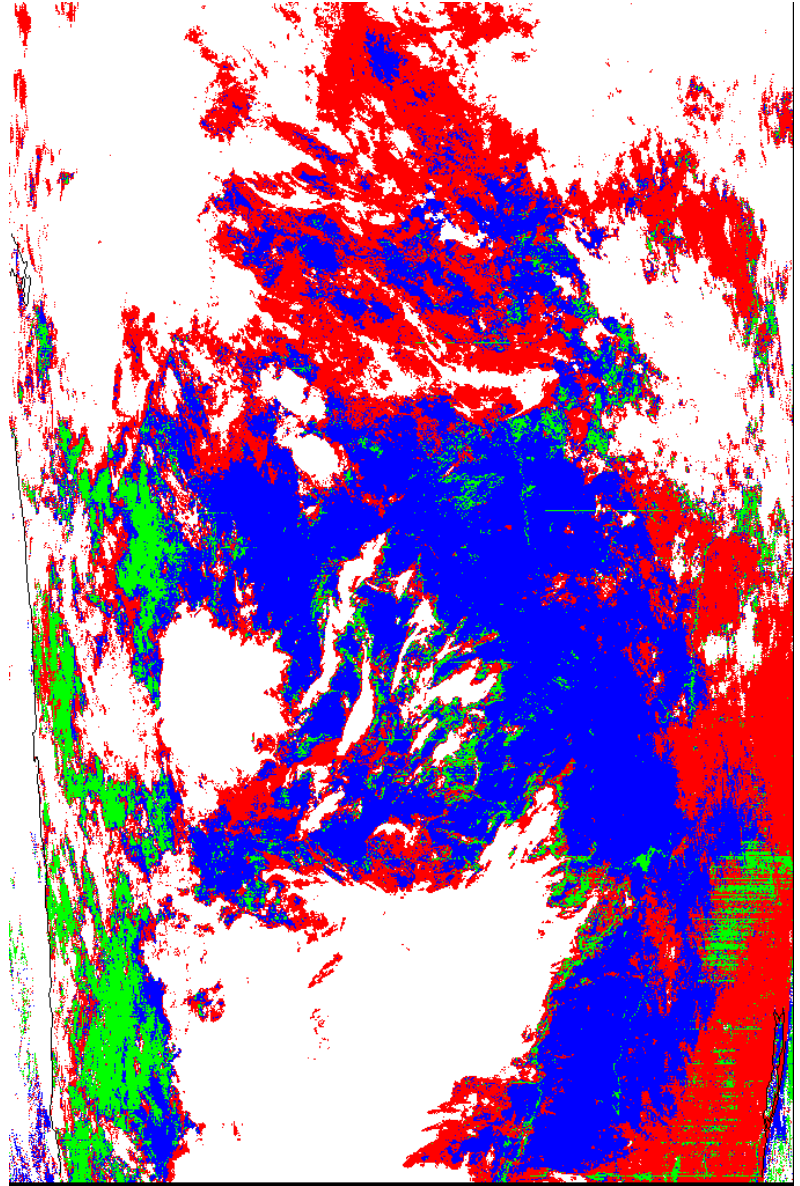
Impacts:
Reduces number of "probably cloudy" results in clear sky conditions especially in humid tropical locations such as the Amazon Basin
Enhances detection of transmissive cirrus

Proposed MOD35 Night Land 11-3.9 Micron Cloud Test Threshold
August 28, 2006 and February 1, 2007

Threshold (1.0 conf) = -0.0077+1.1234*x-0.3403*x^2

MODIS Band 31 - Band 22 BTD (K)

CALIOP Cloudy
CALIOP Clear

GDAS Total Precipitable Water (cm)

G-conf. clear, B-prob. clear, R-prob. cloudy, W-conf.cloudy
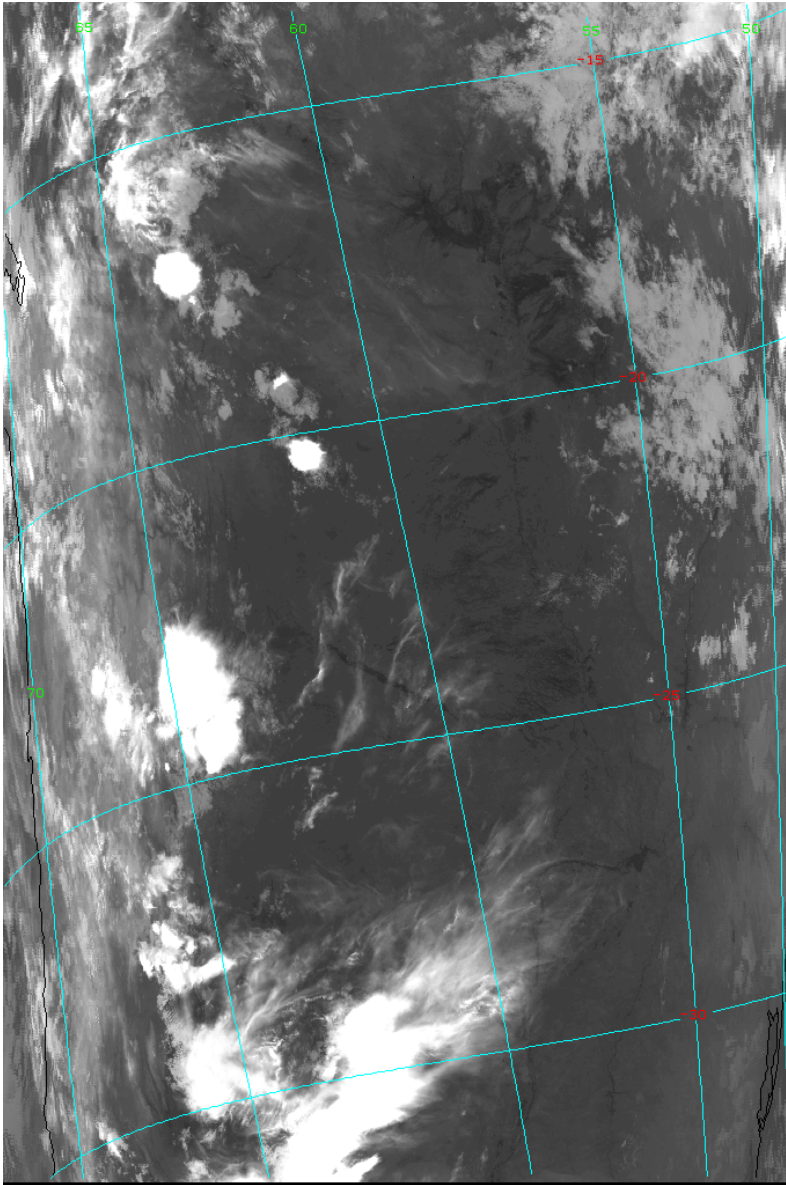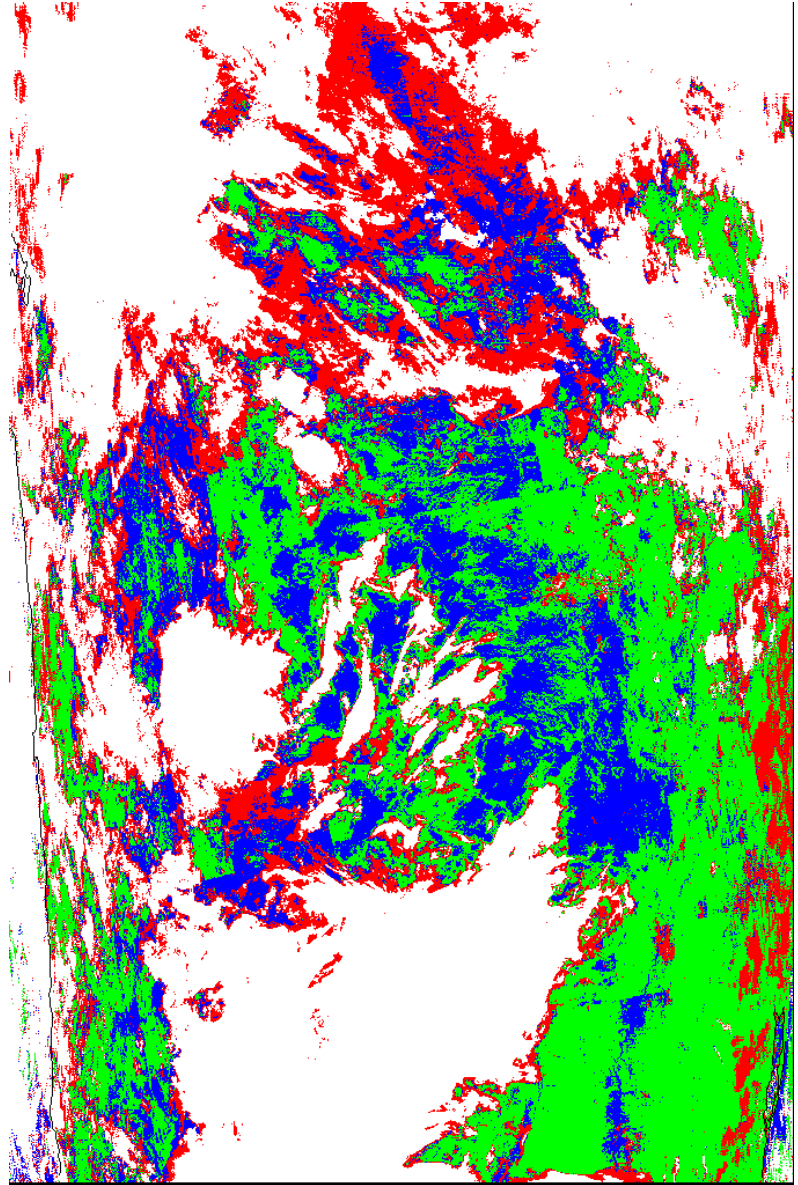
MODIS Band 20

Collection 5 Cloud Mask

Aqua MODIS 2008049 at 05:20 UTC Brazil, Argentina

G-conf. clear, B-prob. clear, R-prob. cloudy, W-conf.cloudy

MODIS Band 20

Collection 6 Cloud Mask

Aqua MODIS 2008049 at 05:20 UTC

Added night ocean 11-3.9 um BTD test

Thresholds are from regression between MODIS BTDs and GDAS TPW, using CALIOP to define clear pixels

Impacts:
More clouds detected with new test as opposed to the old version; enhances detection of transmissive cirrus; kept old test to detect "low-emissivity" marine stratus;

Aqua MODIS 11-3.9 Micron Brightness Temperature Differences
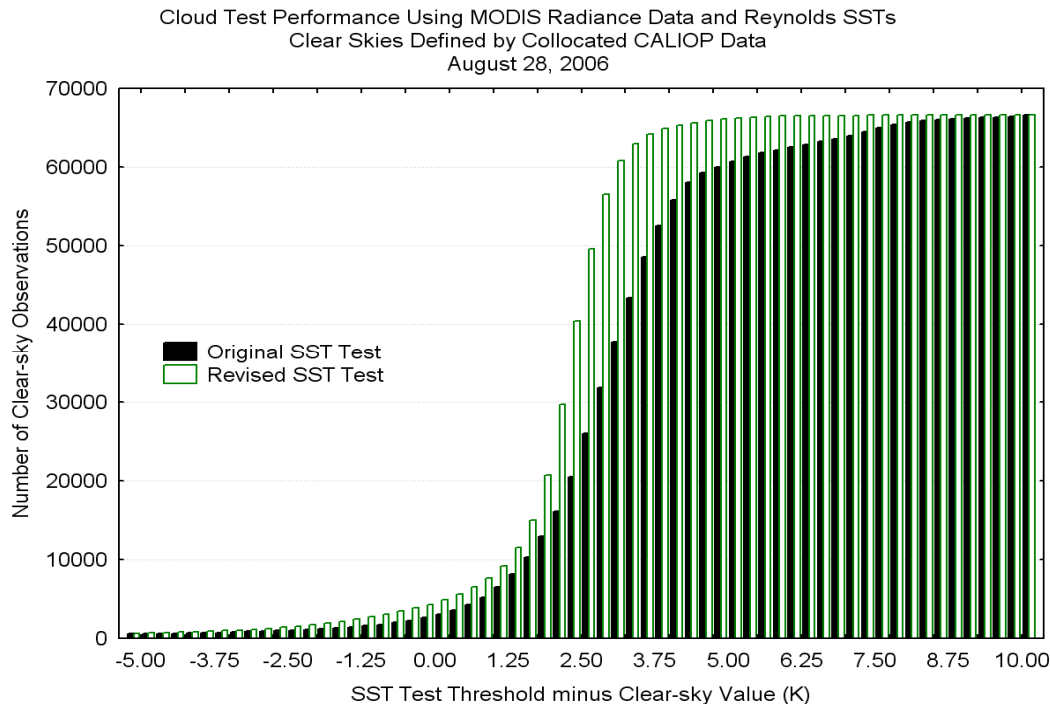Night Ocean from August 28, 2006
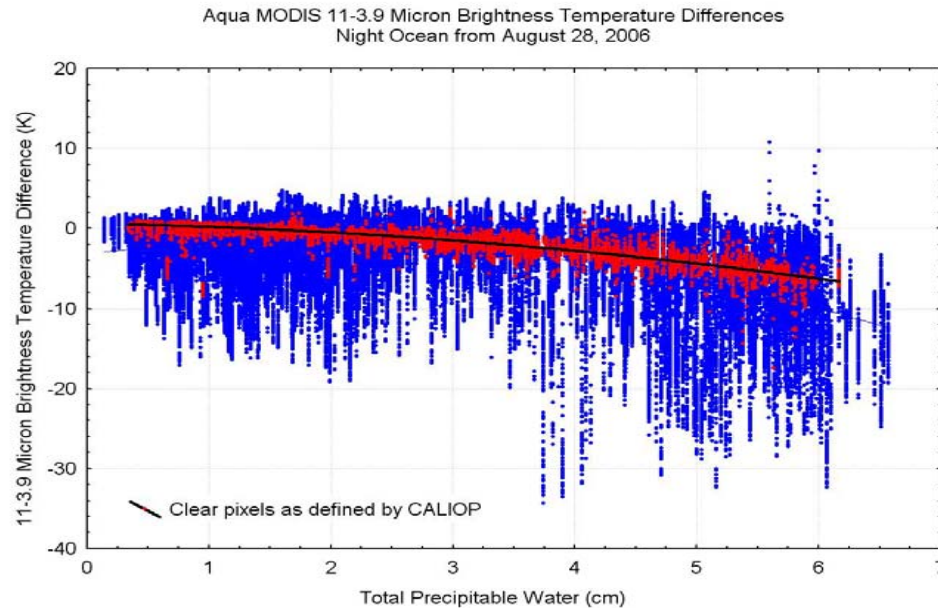
New surface temperature test for oceans

Calculates bulk SST directly from observations, tests against ancillary data
value

Impact:
Better discriminates between clear skies and low clouds in moist, tropical
regions such as the tropical western Pacific

Cloud Test Performance Using MODIS Radiance Data and Reynolds SSTs
Clear Skies Defined by Collocated CALIOP Data
August 28, 2006

Eliminated tri-spectral test in ocean scenes; replaced with simple 8.6-11 um BTD threshold test

Impact:
   Eliminates many "probably cloudy" and "probably clear" results
      in clear-sky conditions, especially in moist tropical locations

_____

Additional tests for non-cloud obstructions

"GOES_R" dust algorithm (day, night, land, water)
Thick smoke/aerosol test for daytime water surfaces

Impact:
   More optically thick non-cloud obstructions are detected

Shadows test (bit 10) has been eliminated; replaced with daytime ancillary snow cover (NISE) flag

Impact:

Intended for users needing an indication of surface snow/ice regardless of cloud coverage. The snow/ice background flag in bit 5 only indicates a processing path through the algorithm and does not indicate snow/ice in the presence of thick clouds.

———————

Adjusted Terra polar night 7.2-11 μm and 11-3.9 μm BTD cloud test thresholds

Impact:

The Terra changes were necessary to account for changes in Terra L1b calibrated radiances.

Cloud Top Pressure (MOD06CT) Updates

Status: Aqua delivered

        Terra pending - final changes related to
         use of "spectral shifts"

Refinements in the C6 Cloud Top Pressure Algorithm
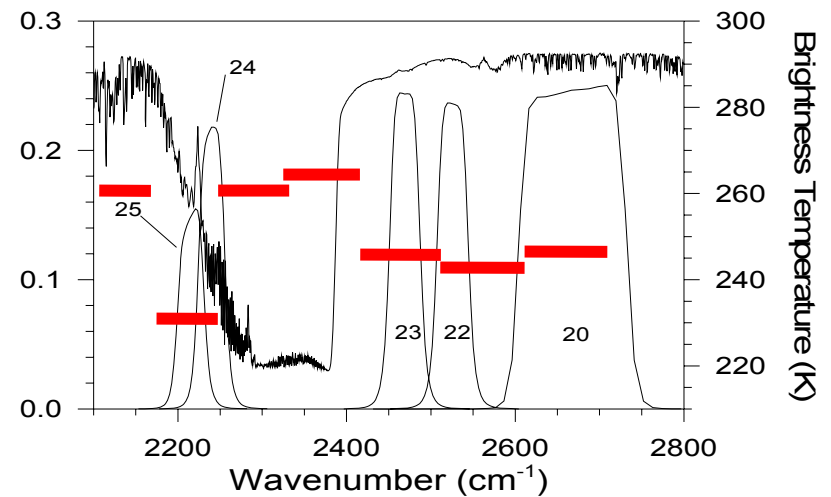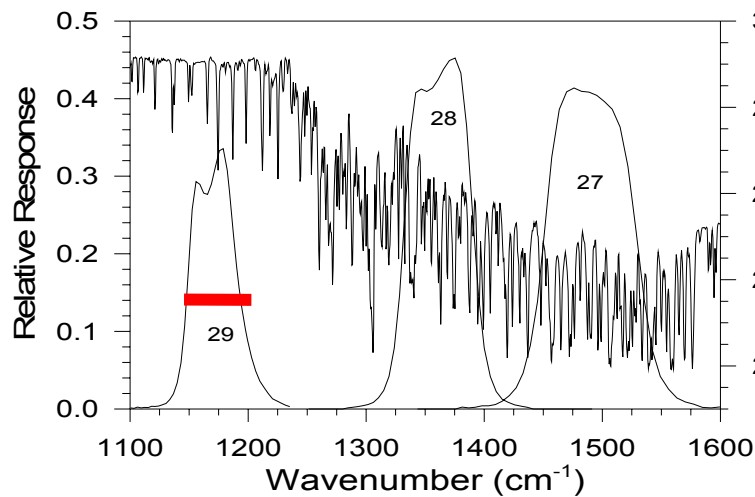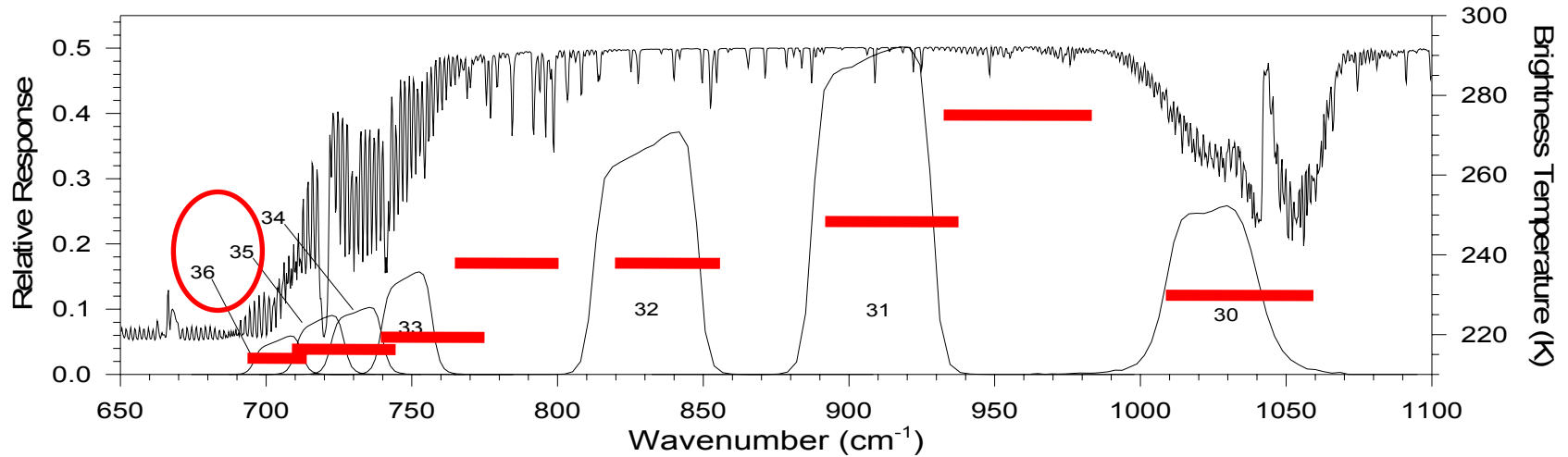
1) Increased cloud sensitivity in the CO2-slicing alg. (clear vs. cloudy thresholds)

2) Use GDAS ozone between 10 and 100 hPa to update climatological profiles

3) Algorithm must converge at pressure levels at or below the tropopause

4) Limit CO_2-slicing to ice clouds using cloud emissivity ratios

5) "Top down" use of CO_2 bands with low cloud height retrieval limits

6) For oceanic low clouds (IRW), use apparent 11 µm BT lapse rate
   CTH = (calc. 11 um BT – observed 11 um BT) / apparent lapse rate

   apparent LRs are monthly, 1-degree zonal means of observed cloudy BT minus calculated clear-sky BT; height of clouds from collocated CALIOP data

7) *** Use AIRS/MODIS–derived spectral shifts in forward model calculations

8) Implement 1-km cloud top pressure algorithm
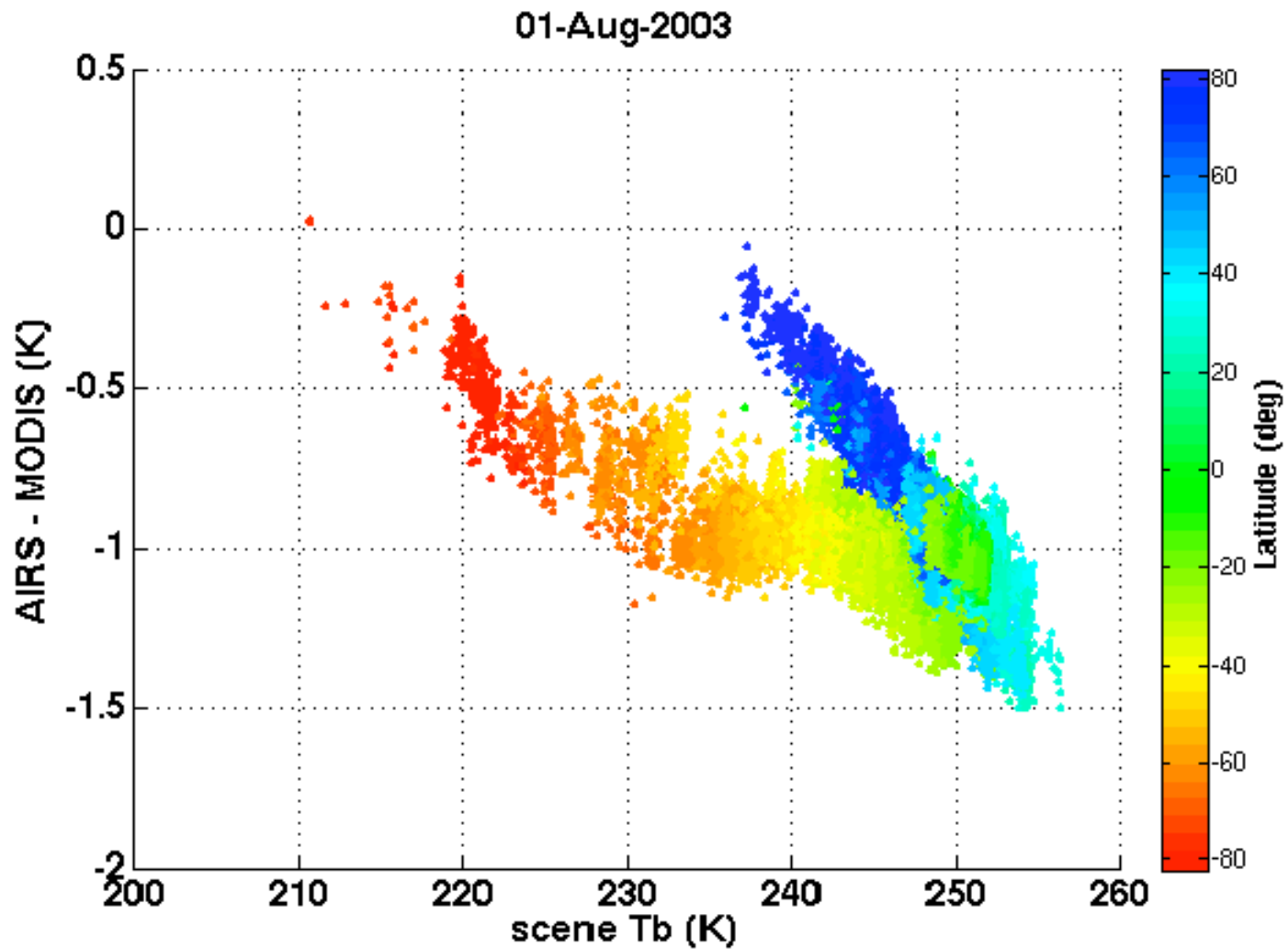
MODIS IR Spectral Bands

MODIS Spectral Response Functions and FASCOD3P Brightness Temperature Spectrum at HIS Resolution (U.S. Standard Atmosphere; 0-30km)

Aqua Band 35

01-Aug-2003

CO_2-slicing equation:

$$\text{LHS} = \frac{R_{cld}(\lambda_1) - R_{clr}(\lambda_1)}{R_{cld}(\lambda_2) - R_{clr}(\lambda_2)} = \frac{N\varepsilon(\lambda_1) \int^{pcld} \tau(\lambda_1)dB(\lambda_1)\,dp}{N\varepsilon(\lambda_2) \int^{pcld} \tau(\lambda_2)dB(\lambda_2)\,dp} = \text{RHS} + \text{Error}$$

where λ_1 and λ_2 are MODIS bands 34/33, 35/34, or 36/35

In Collection 5, subtracted:

0.33, 0.50, 0.75 mw/m2*str*ν-1 (Aqua)
0.66, 1.00, 1.50 mw/m2*str*ν-1 (Terra)

from LHS for bands 34-36, respectively.

MODIS IR Spectral Bands

MODIS Spectral Response Functions and FASCOD3P Brightness Temperature Spectrum at HIS Resolution (U.S. Standard Atmosphere; 0-30km)

Aqua Band 35

Aqua Band 35
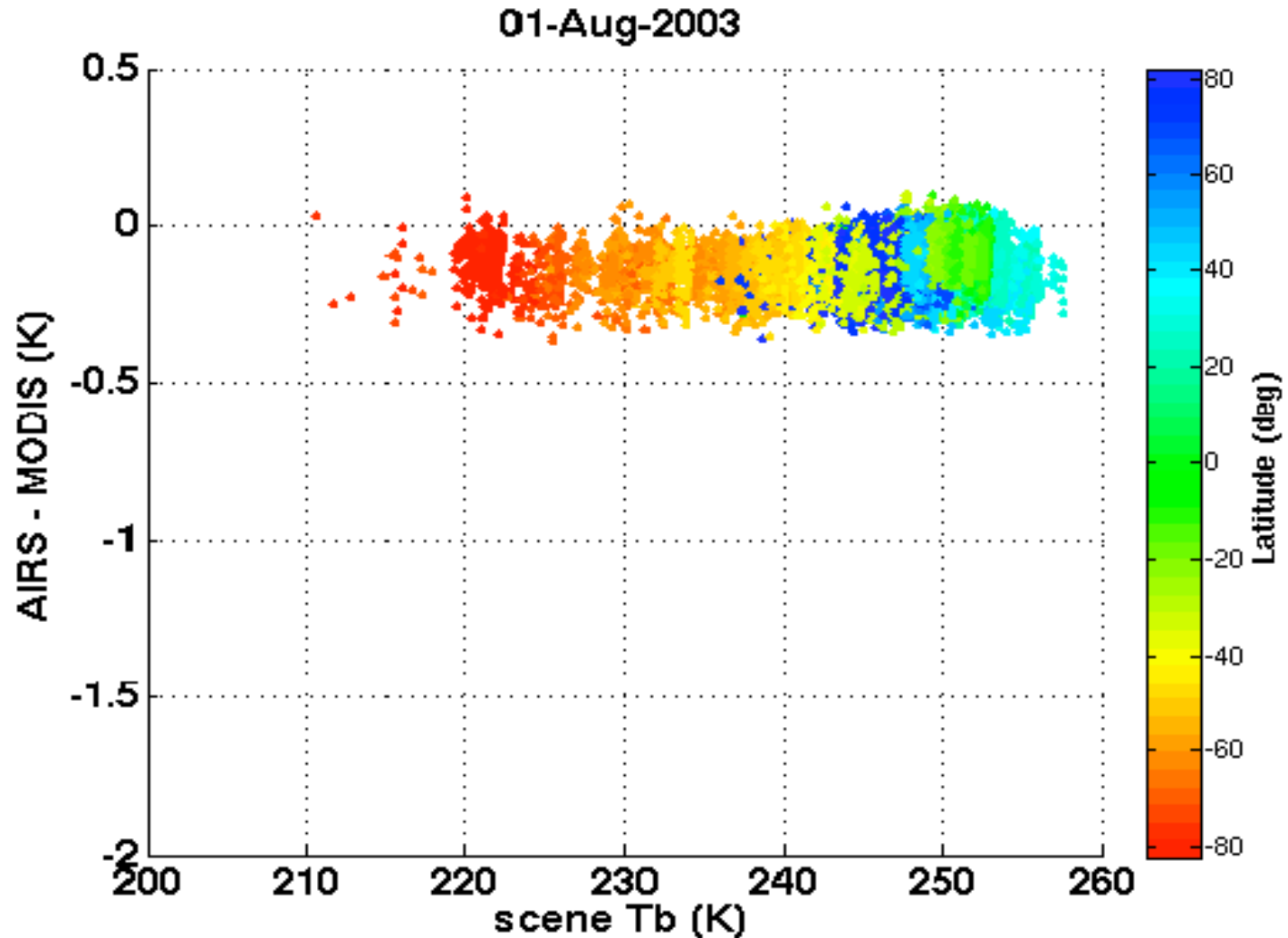
Tobin, David C.; Revercomb, Henry E.; Moeller, Christopher C. and Pagano, Thomas S. *Use of Atmospheric Infrared Sounder high-spectral resolution spectra to assess the calibration to Moderate resolution Imaging Spectroradiometer on EOS Aqua*. Journal of Geophysical Research, Volume 111, 2006, doi:10.1029/2005JD006095.

IASI vs. Terra MODIS TEB Comparisons

- Apply AIRS-Aqua MODIS derived spectral shifts in IASI-Terra MODIS SNO comparisons.

- Spectral shift equation is:
  RSRnew = RSRold + Shift (wavenumber units)

- Shape of RSR does not change, only central wavenumber.

2009 SNOs: IASI - Aqua MODIS Band 35 Det 5 MS 1
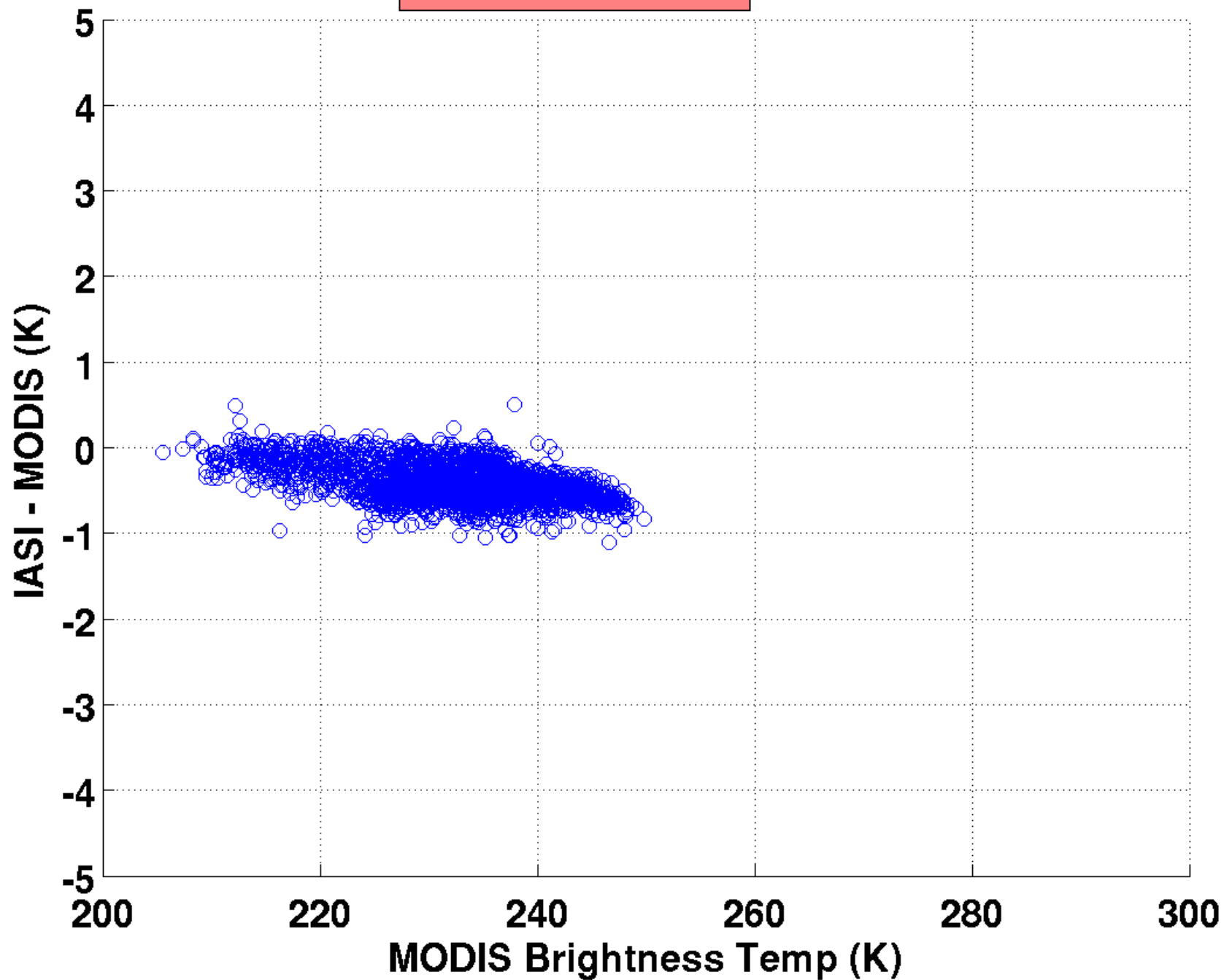
2009 SNOs: IASI - Aqua MODIS Band 35 Det 5 MS 1
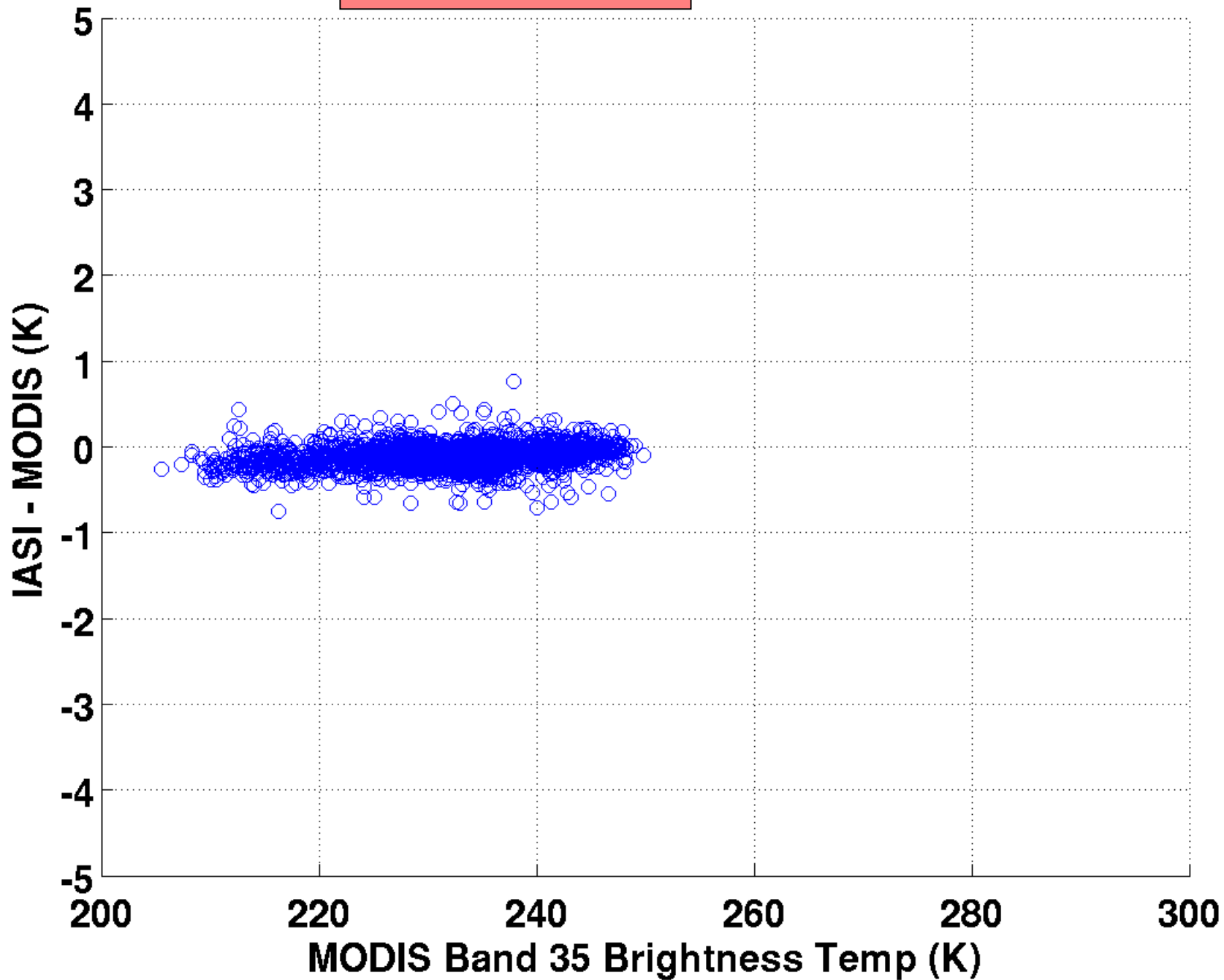
2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 1
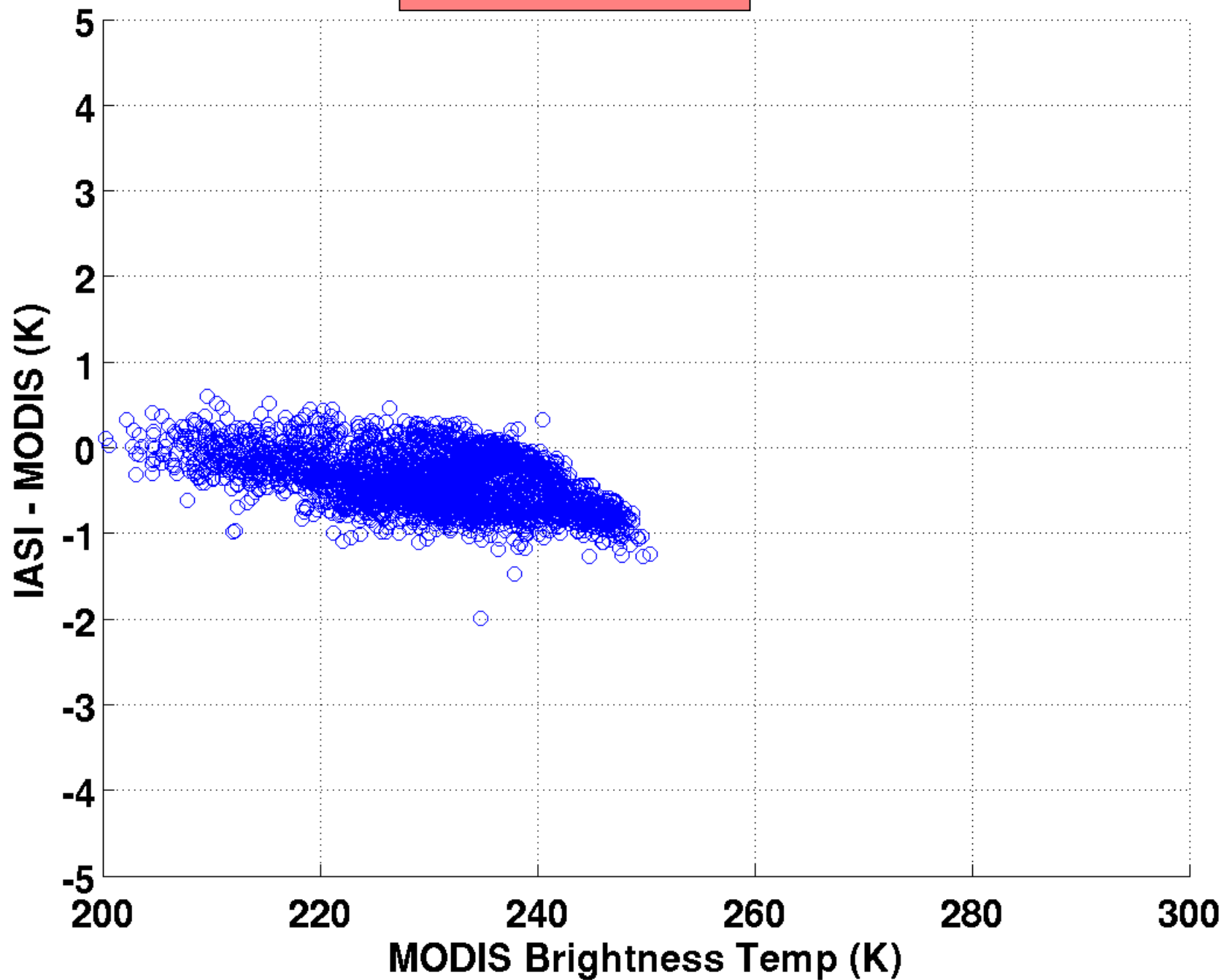
2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 1
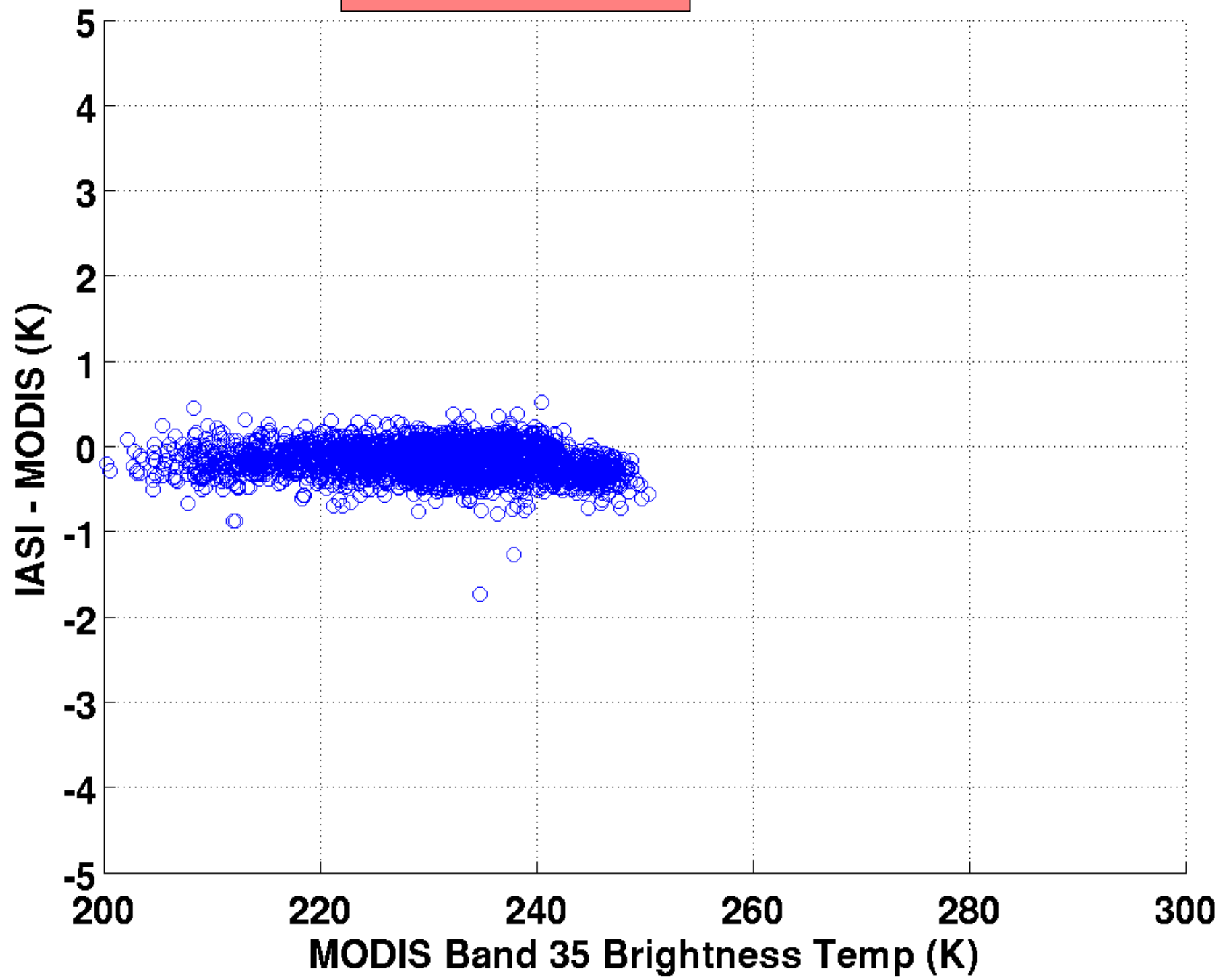
Spectral Shifts Applied

Band	Terra Shift (cm-1)	Aqua Shift (cm-1)
24	0	0
27	+4	+4
28	+2	0
29	0	0
30	+1	0
34	0.8	0.8
35	0.8	0.8
36	1.0	1.0

Aqua

Terra

Terra MODIS from Equatorial Pacific on August 28, 2006 at 23:15 UTC

Vanuatu

`10001 TERRA-TOP 2 28 AUG 06240 231500 00001 00001 06.66`

`10010 TERRA-TOP 6 28 AUG 06240 231500 00001 00001 06.66`
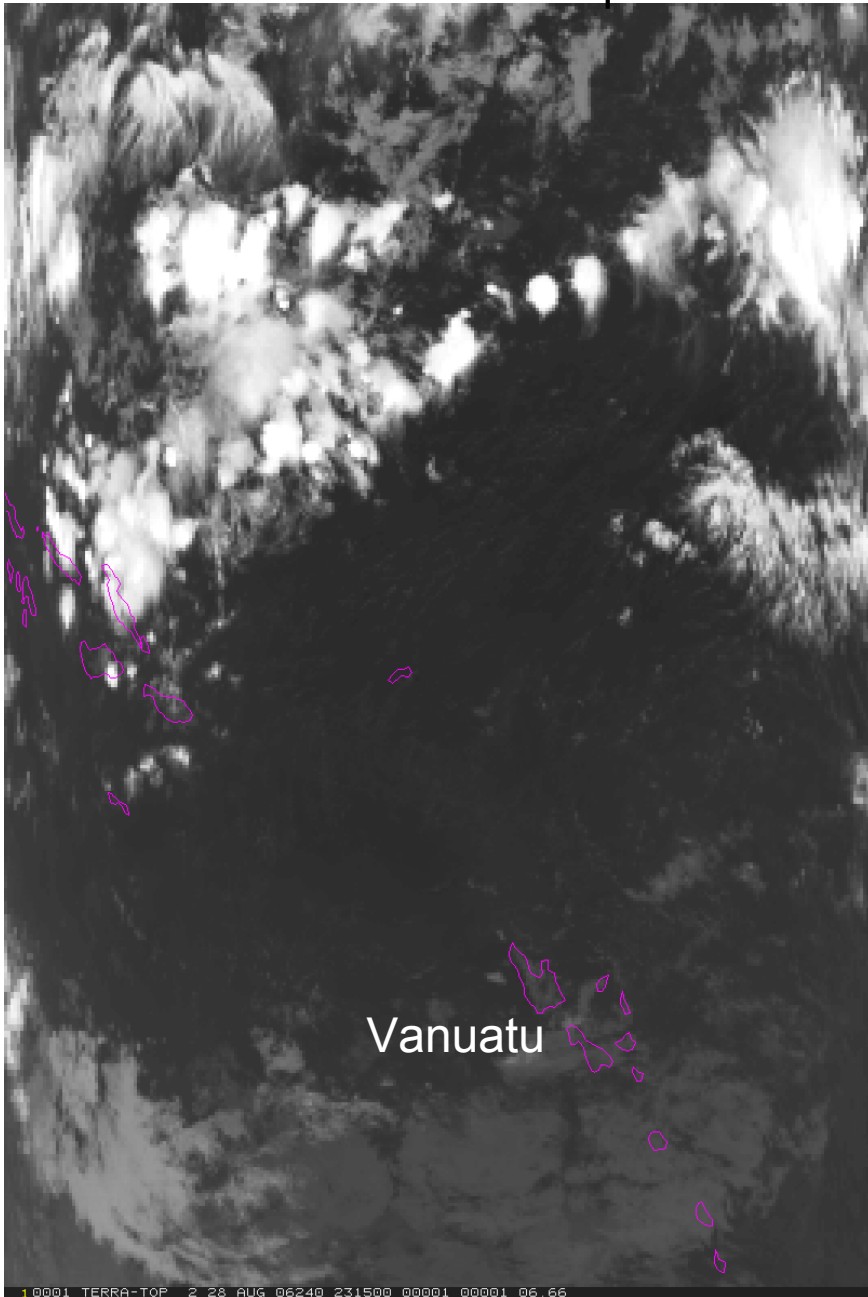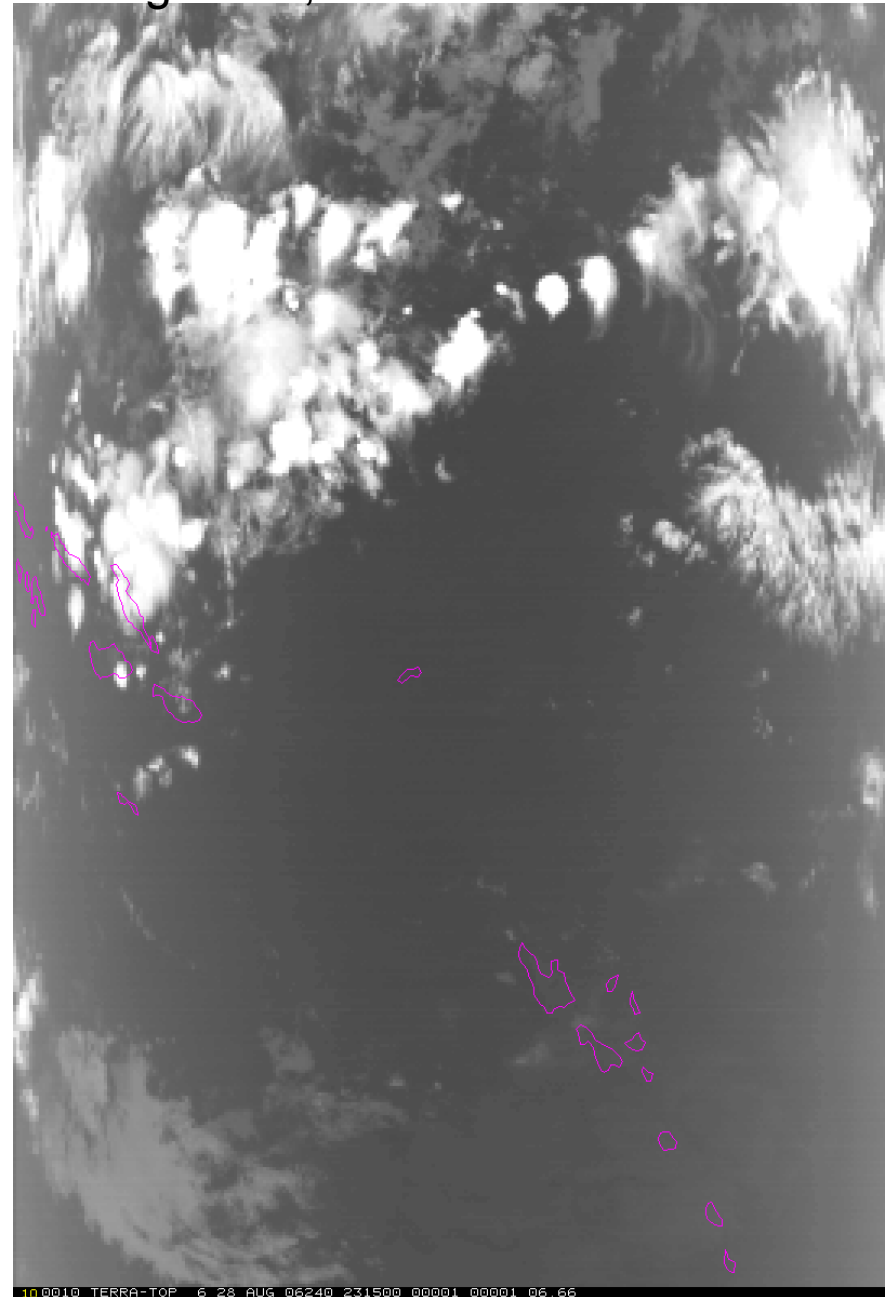
Band 31

Band 35

Terra MODIS from Equatorial Pacific on August 28, 2006 at 23:15 UTC
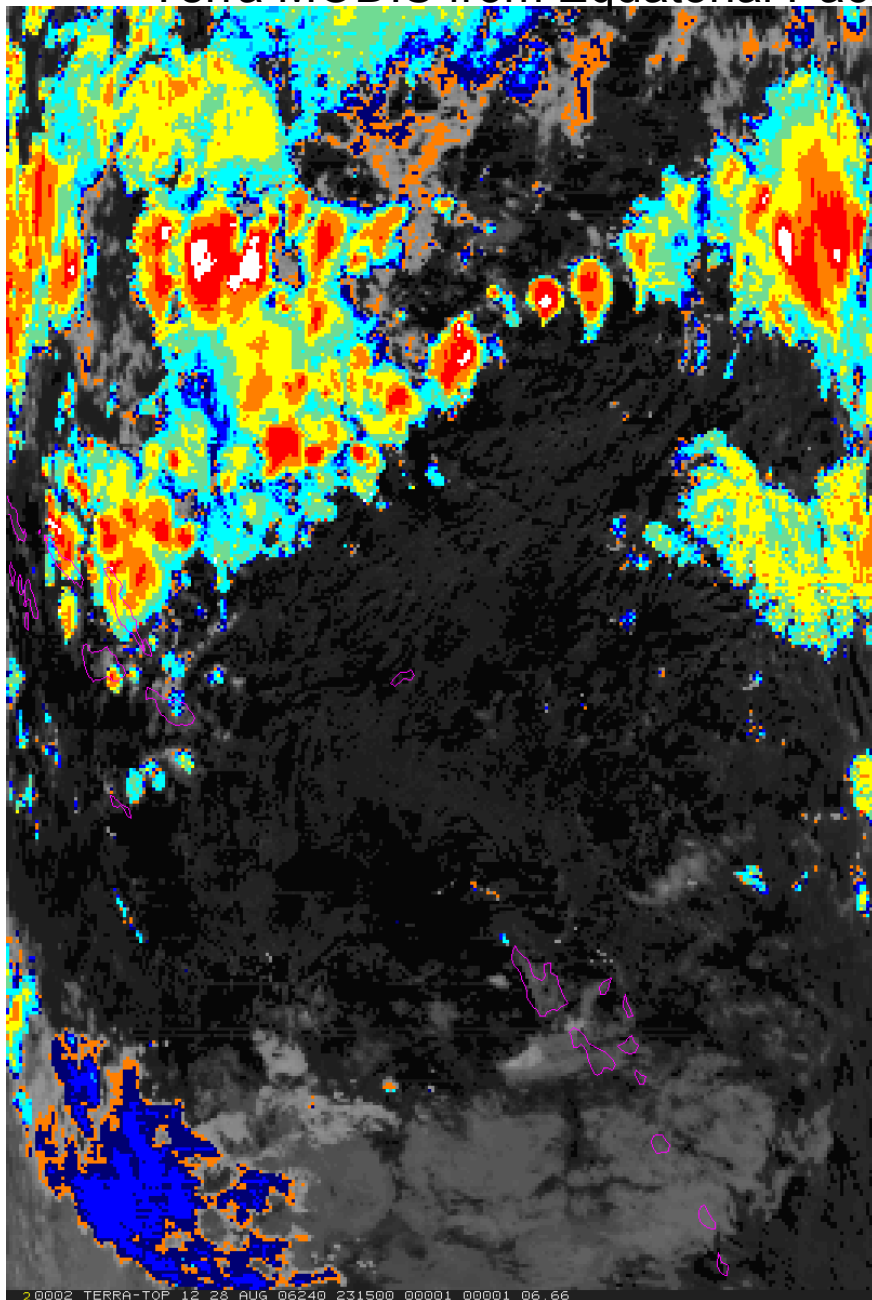
Collection 5 Cloud Top Pressure
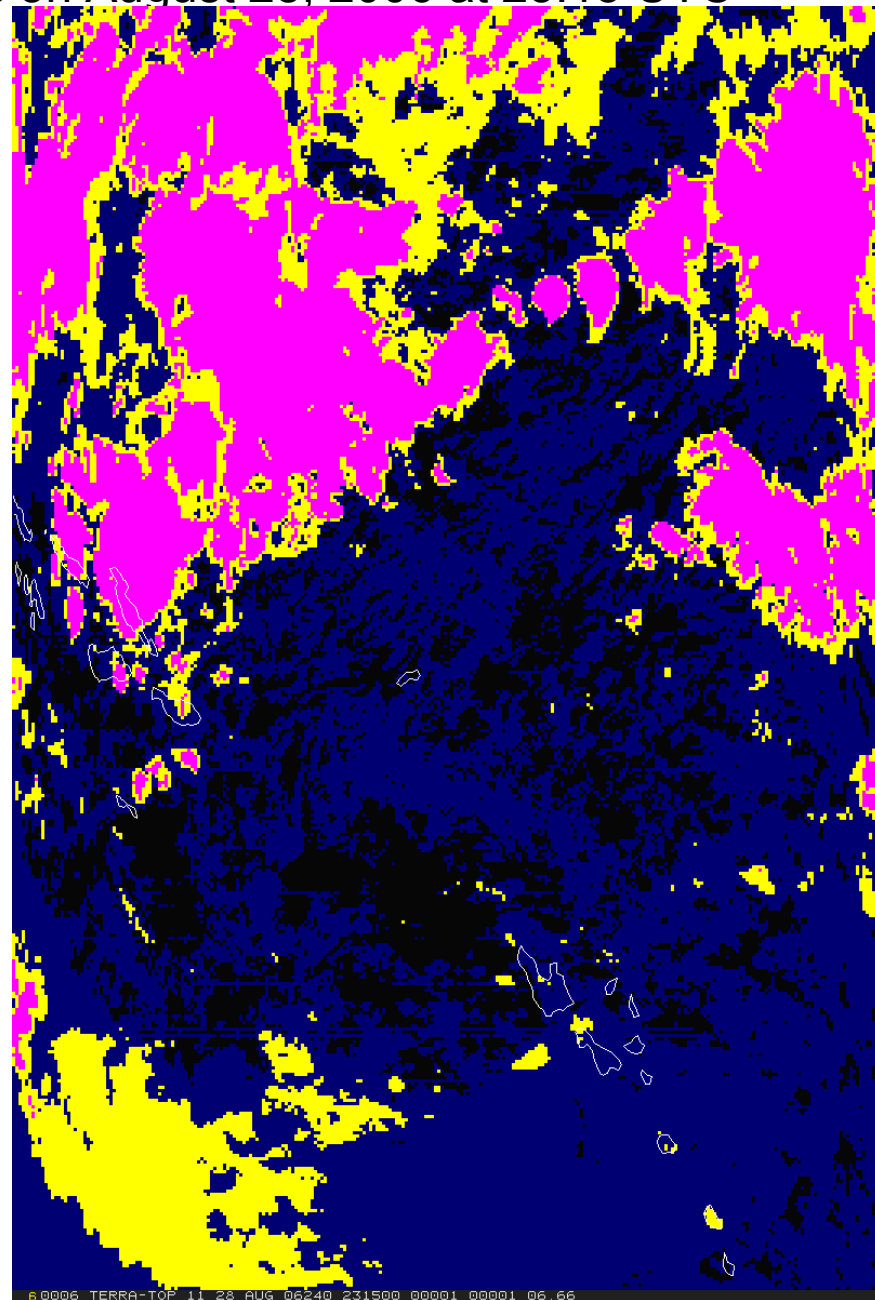
Collection 5 Retrieval Band Pairs

Terra MODIS from Equatorial Pacific on August 28, 2006 at 23:15 UTC
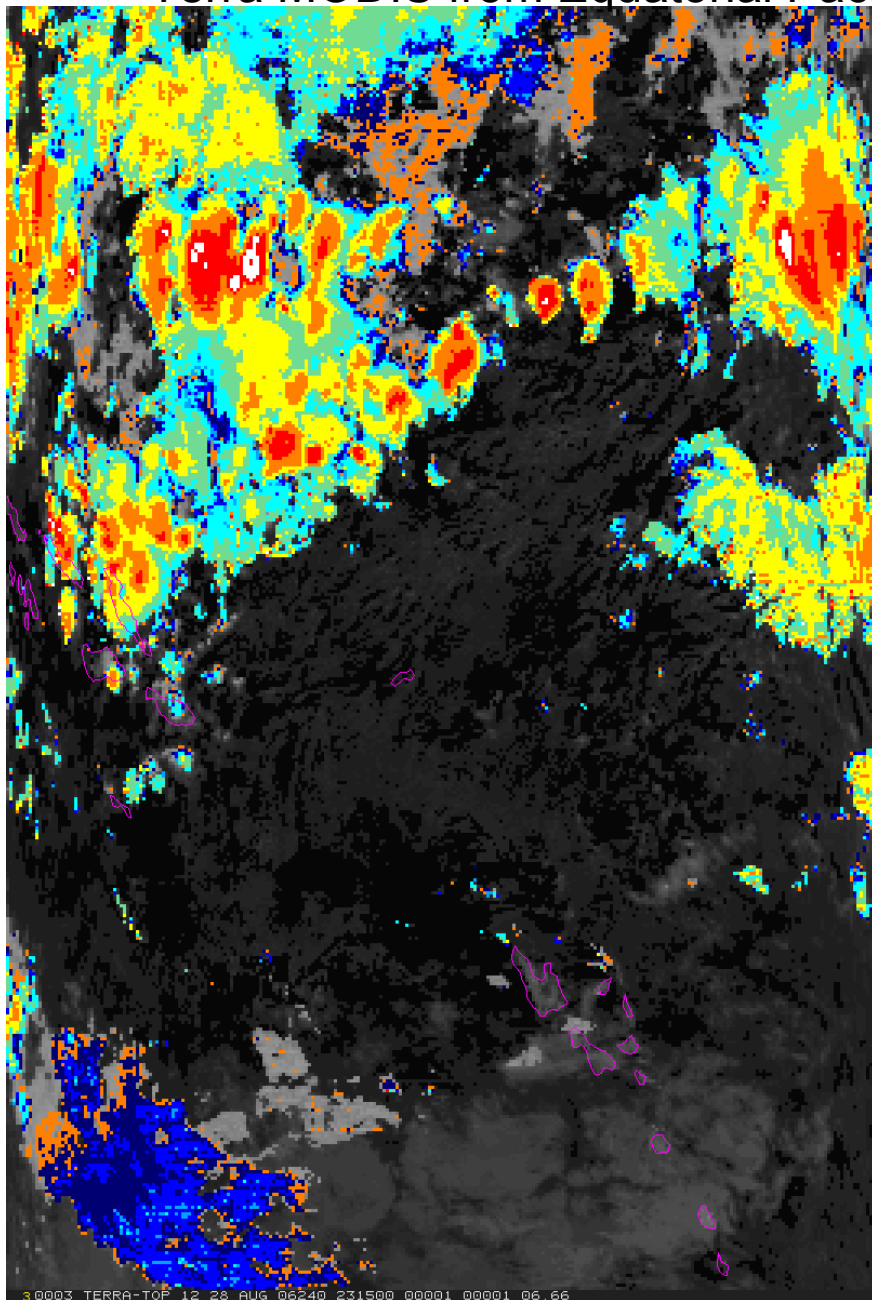
C6 CTP w/no Spectral Shifts
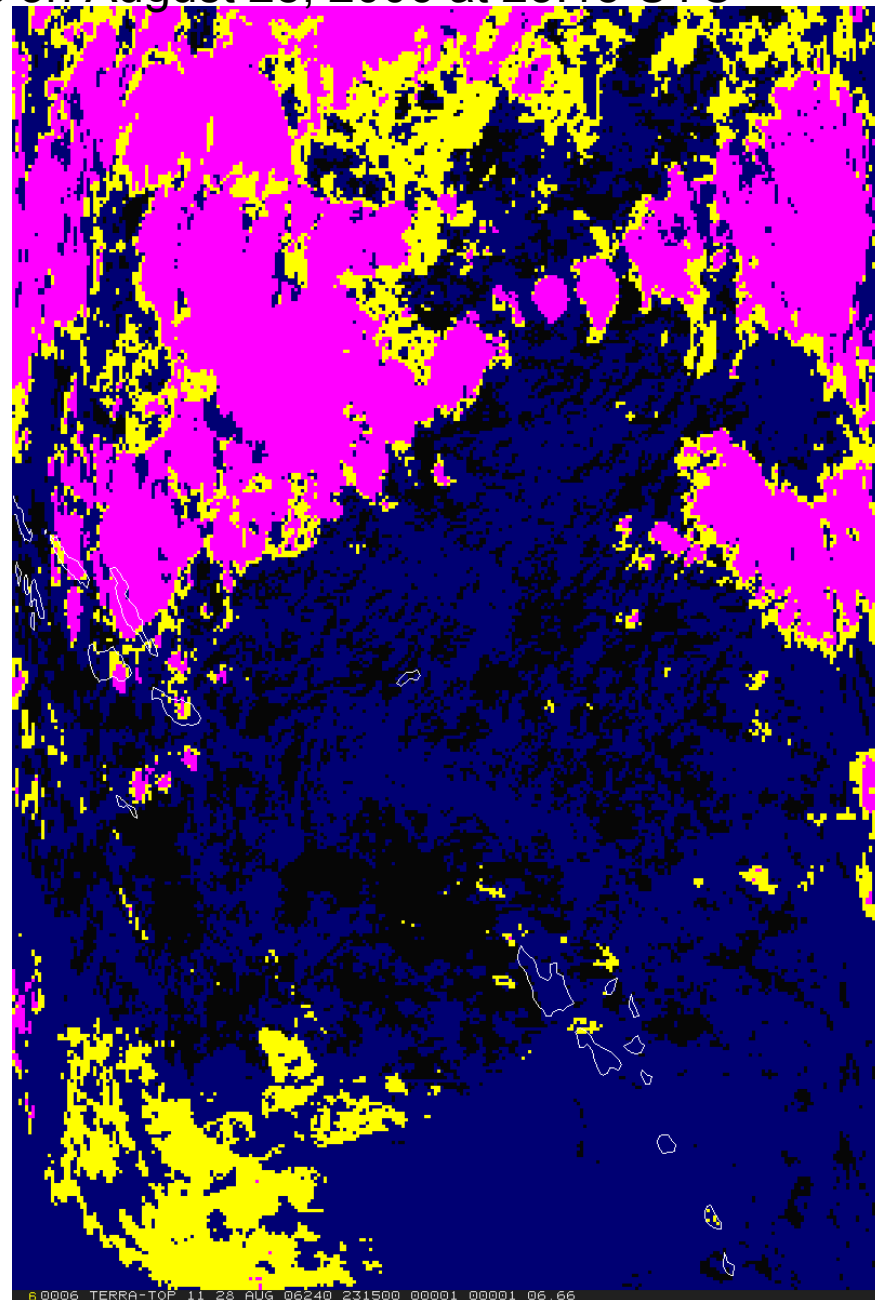
C6 Ret. Bands w/no Spectral Shifts

Terra MODIS from Equatorial Pacific on August 28, 2006 at 23:15 UTC
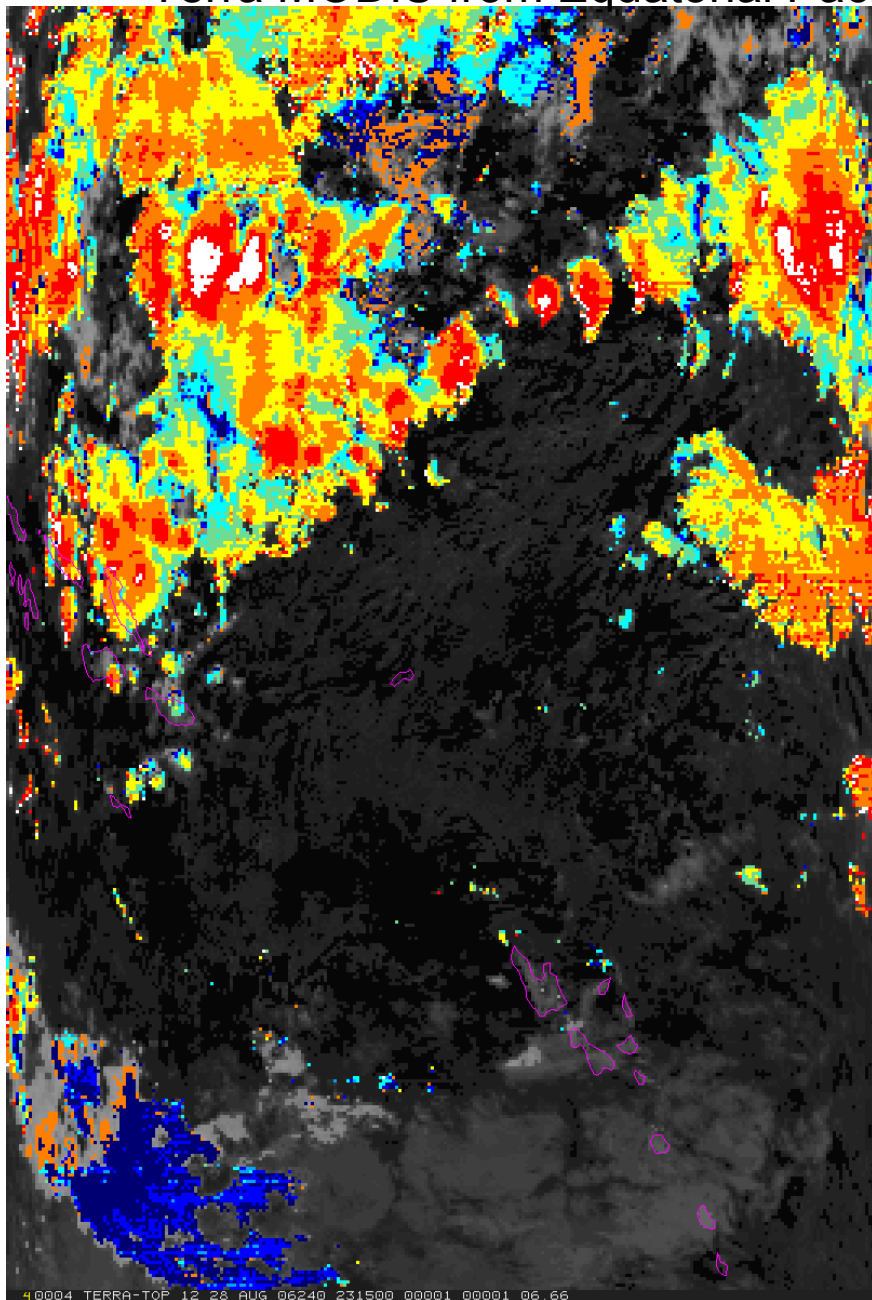
C6 CTP with Spectral Shifts Applied
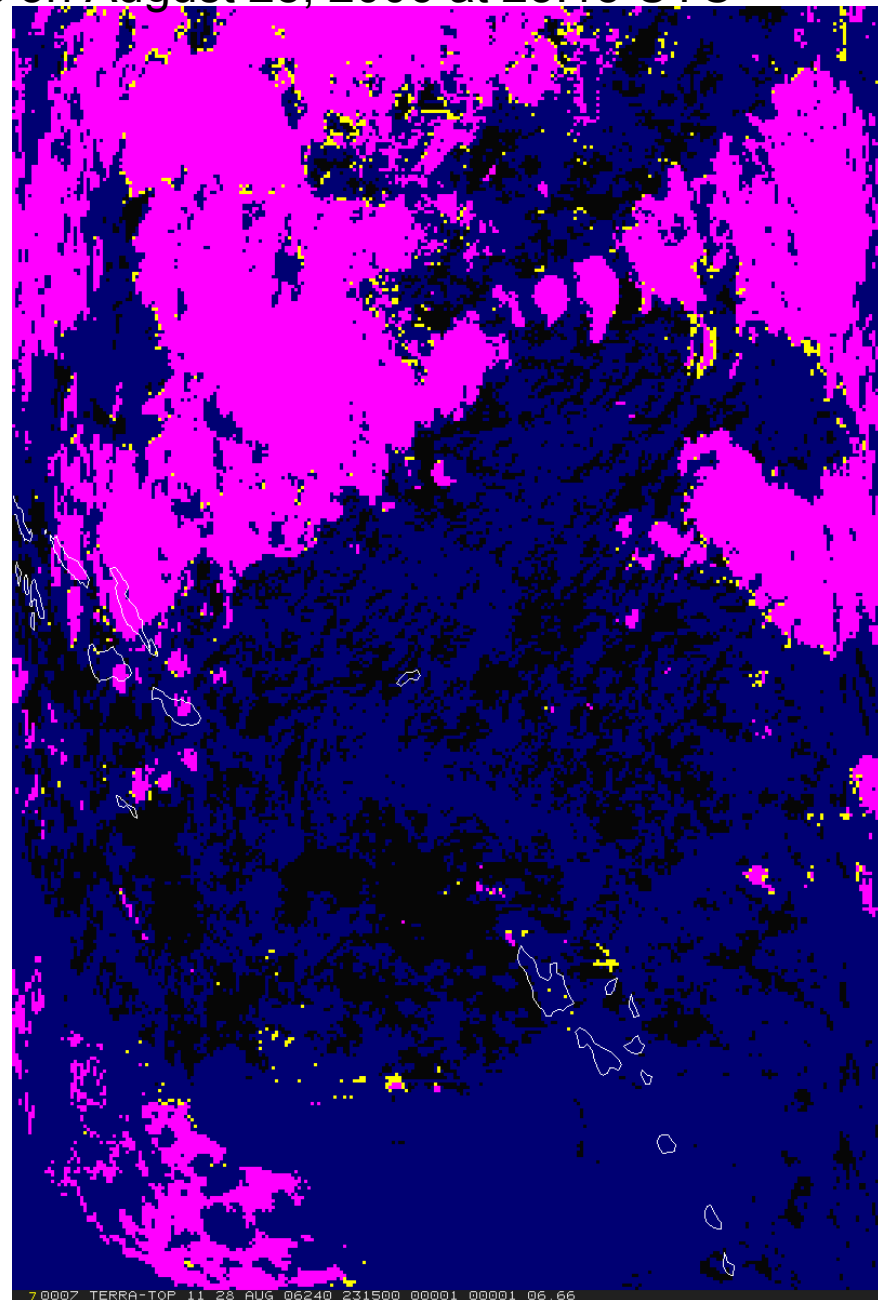
C6 Ret. Bands with Spectral Shifts Applied

MODIS Mean CTP from Band 36/35 Retrievals
August 28, 2006
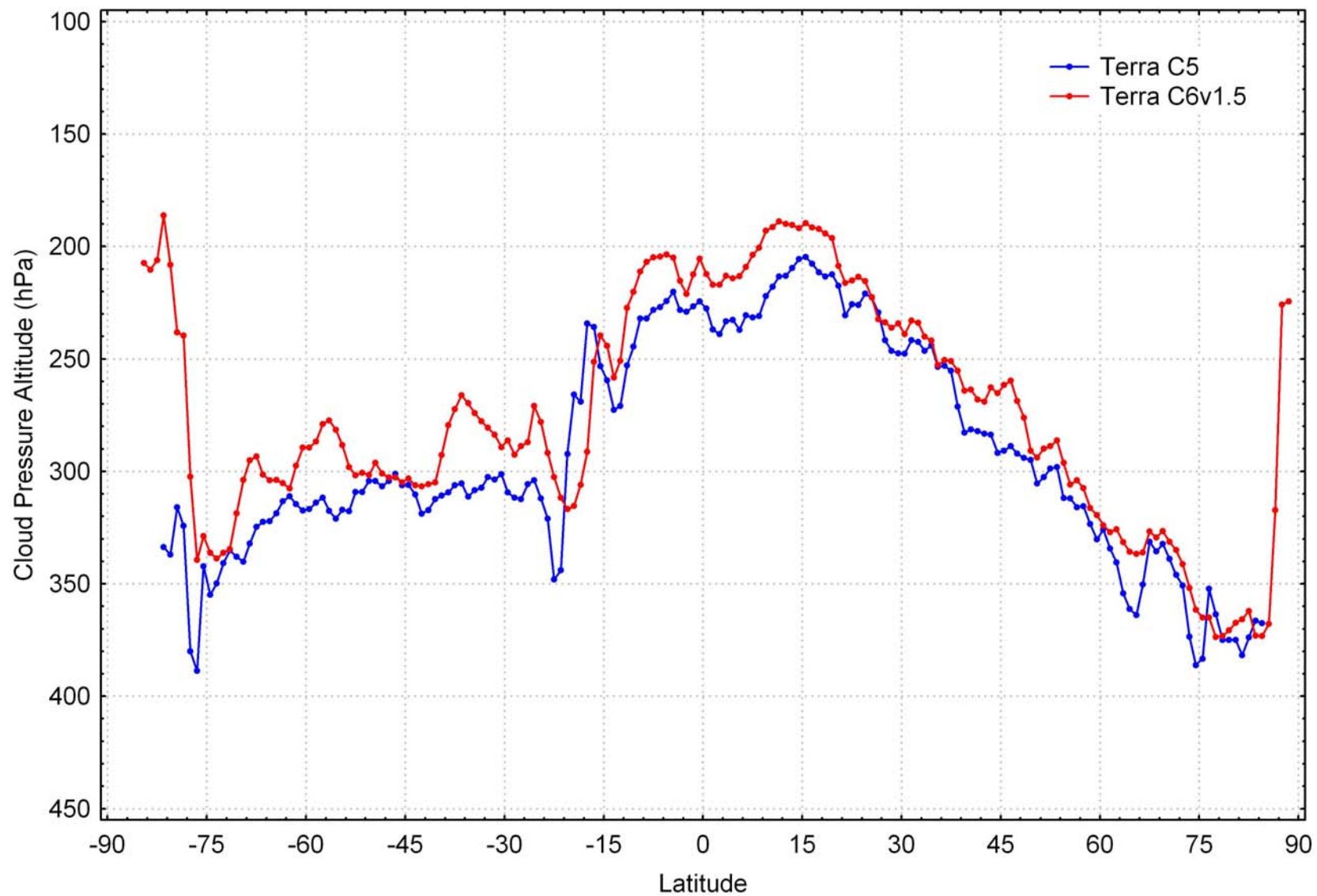
MODIS Mean CTP from Band 35/33 Retrievals
August 28, 2006
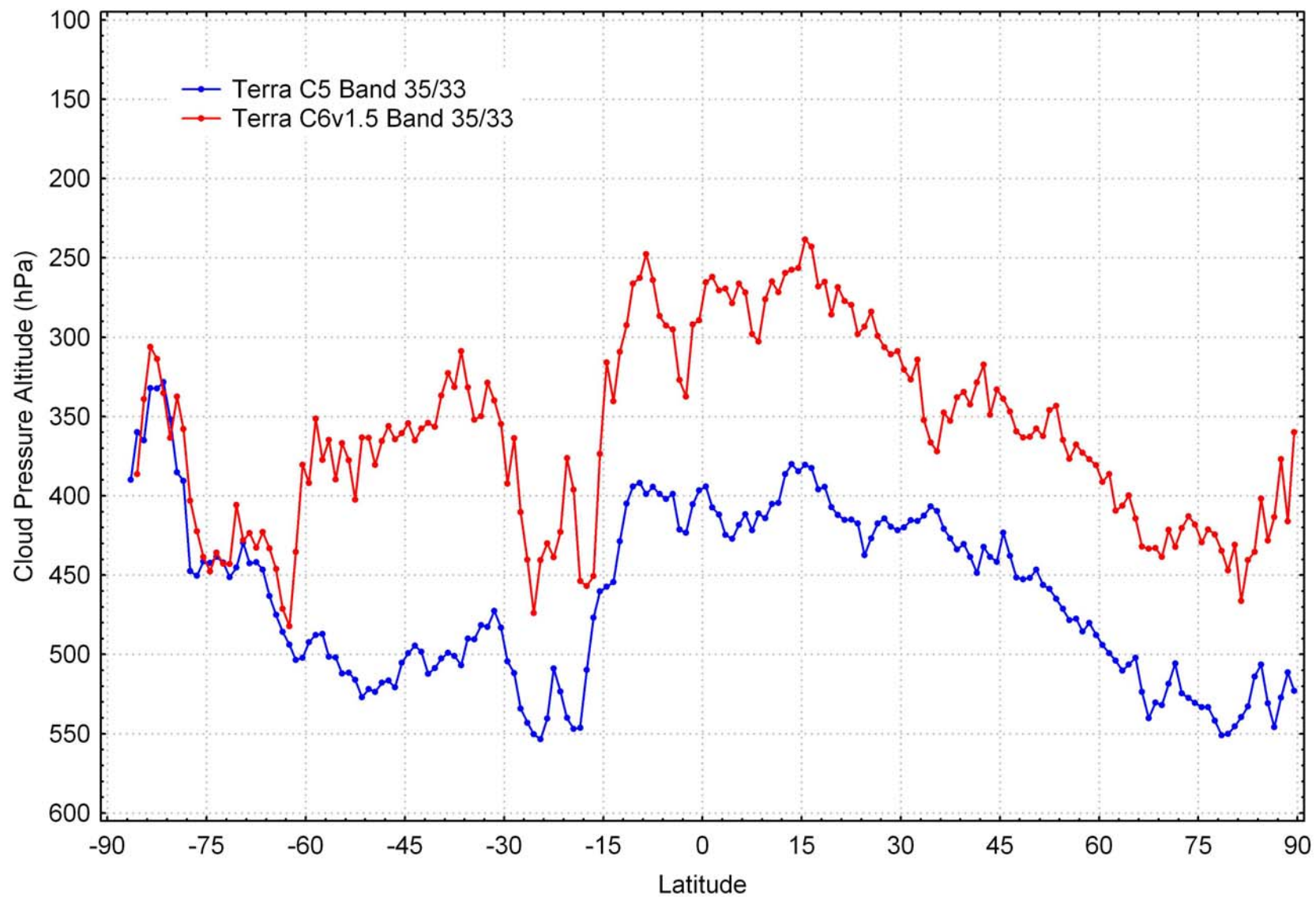
MODIS Frequency of High Clouds
CTP < 440 hPA
August 28, 2006
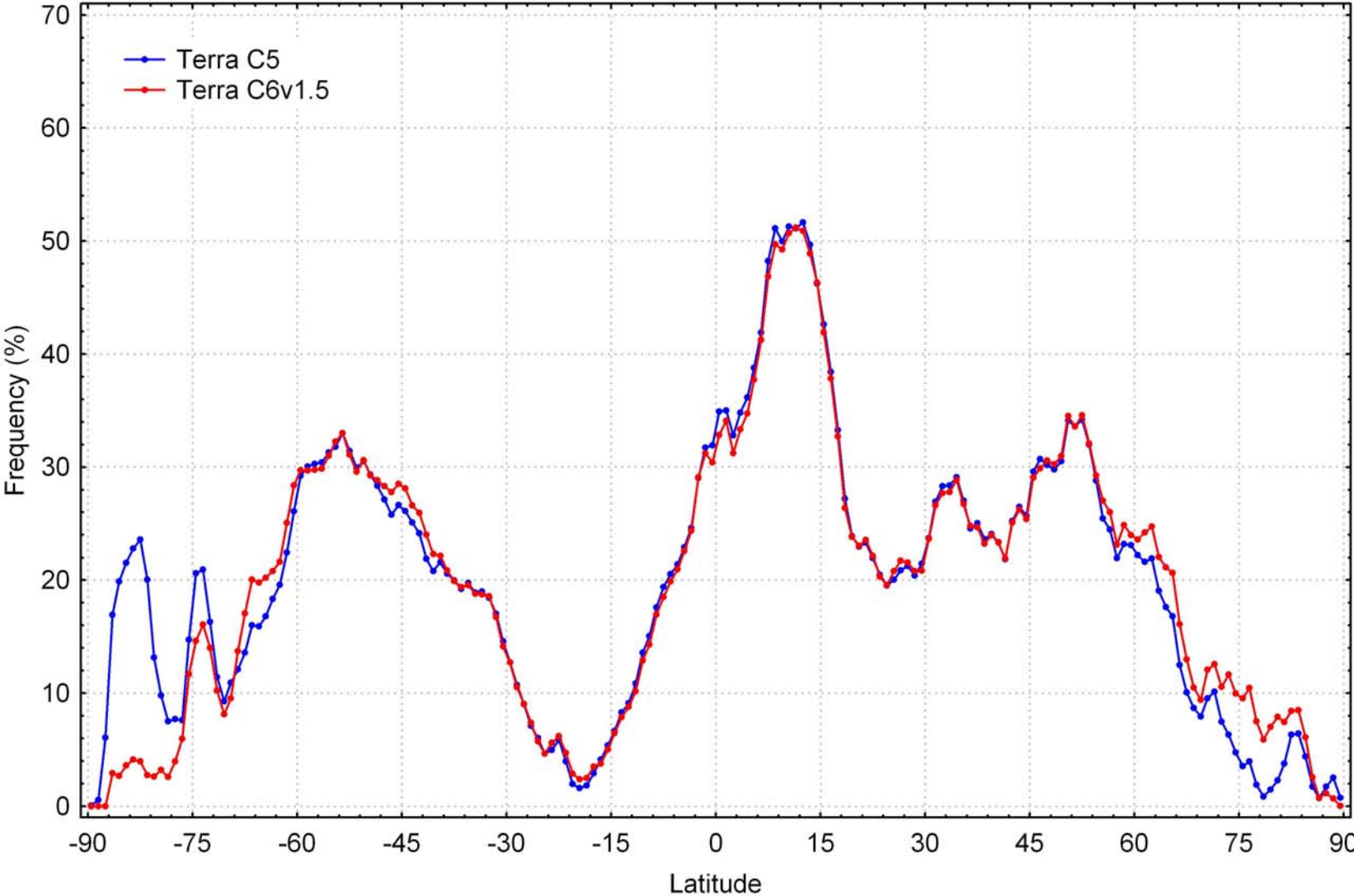
MODIS Frequency of Middle Clouds
CTP Between 440 and 680 hPa
August 28, 2006
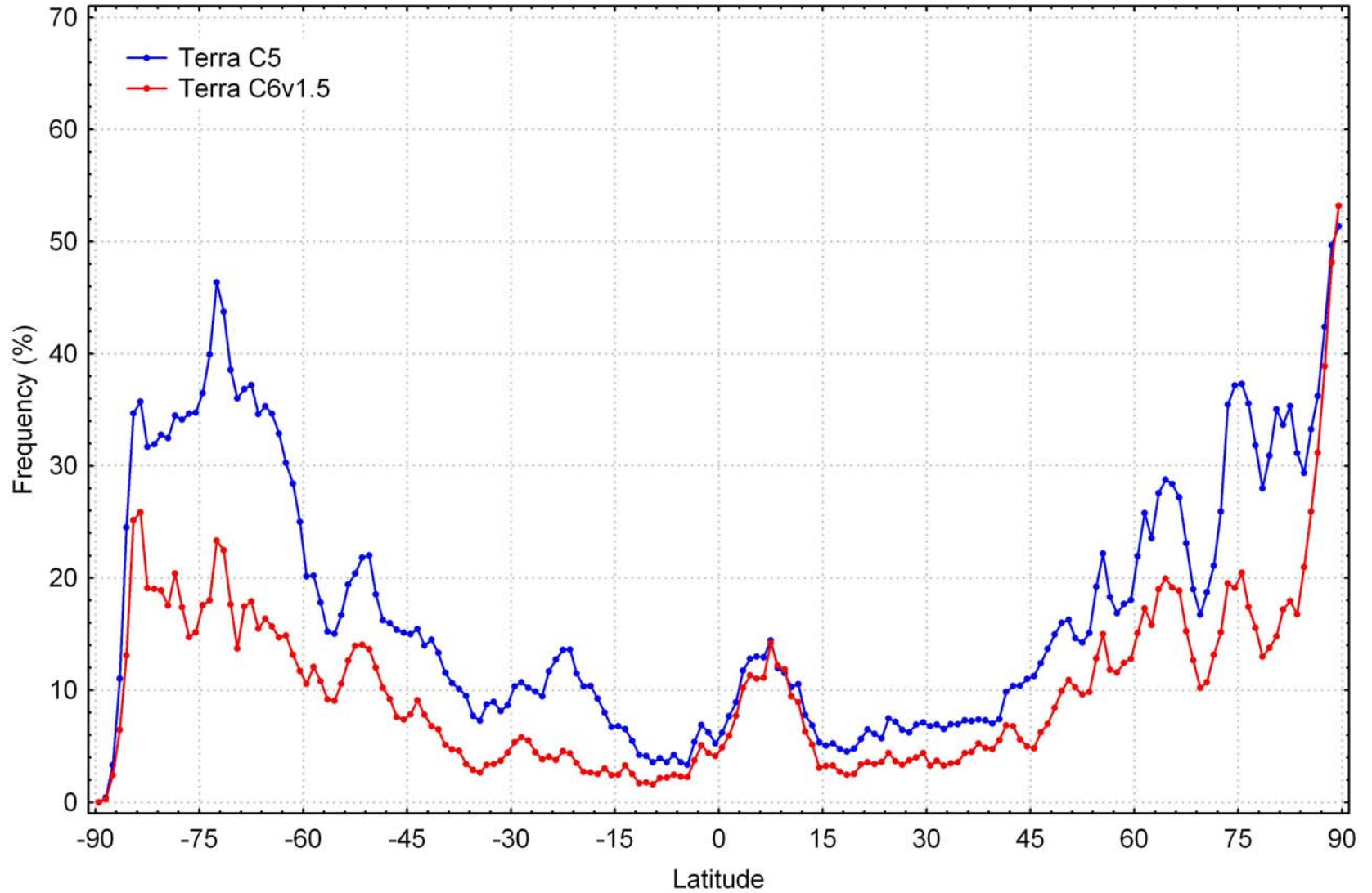
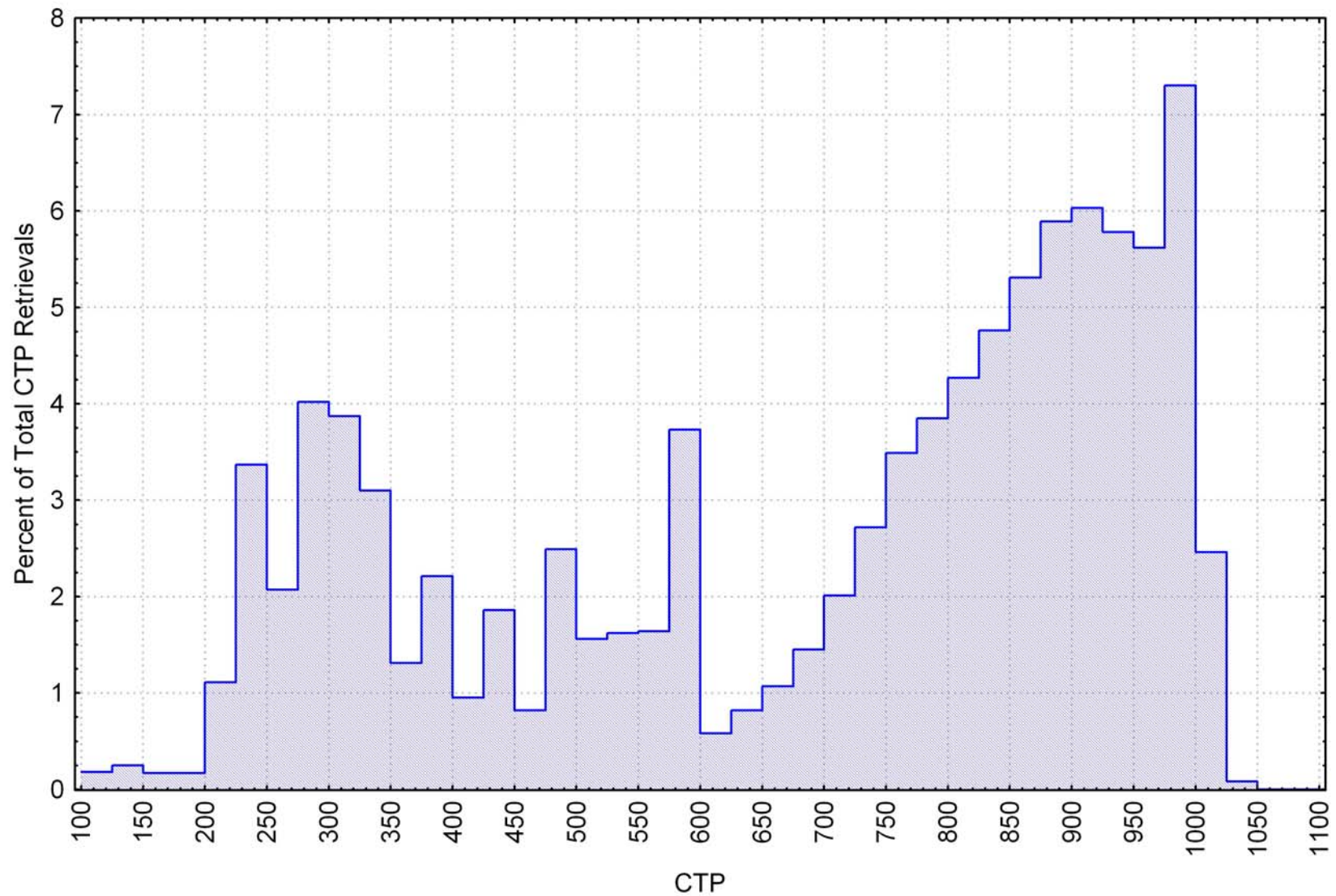MODIS Frequency of Low Clouds
CTP > 680 hPa
August 28, 2006
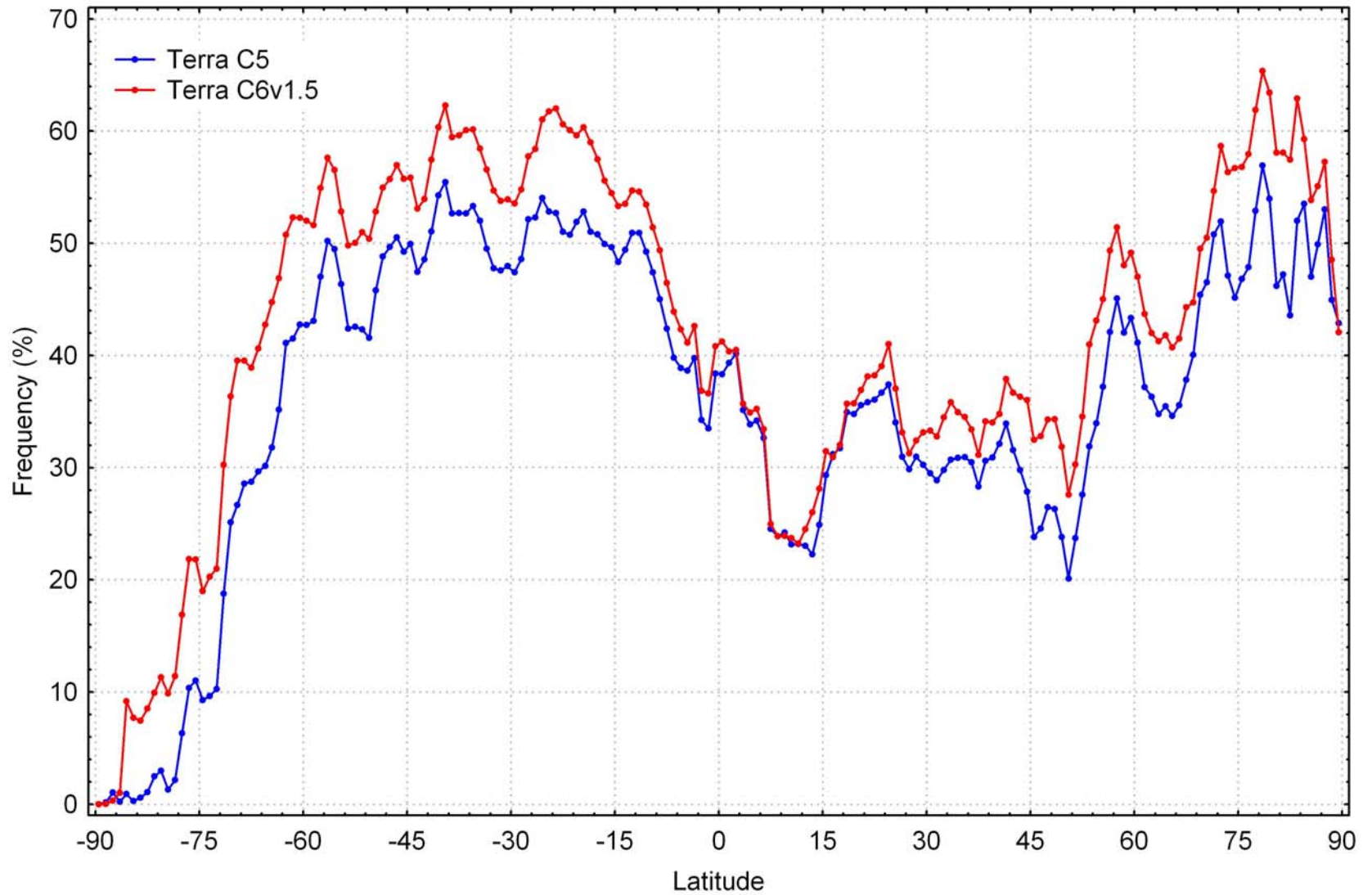
Summary of Terra Collection 5 vs. Collection 6 Comparisons:

1) Overall, frequency of CO_2-slicing retrievals is down, but reasonable.

2) However, the mean cloud top height of CO_2-slicing retrievals is higher.

3) Frequency of high clouds is about the same, but mean cloud top height is higher (#2).

4) Fewer mid-level clouds, more low-level clouds.

Distribution of MODIS Terra Collection 5 Cloud Top Pressure Retrievals
28 August 2006
20S-90S Latitude

Distribution of MODIS Terra C6v1.5 Cloud Top Pressure Retrievals
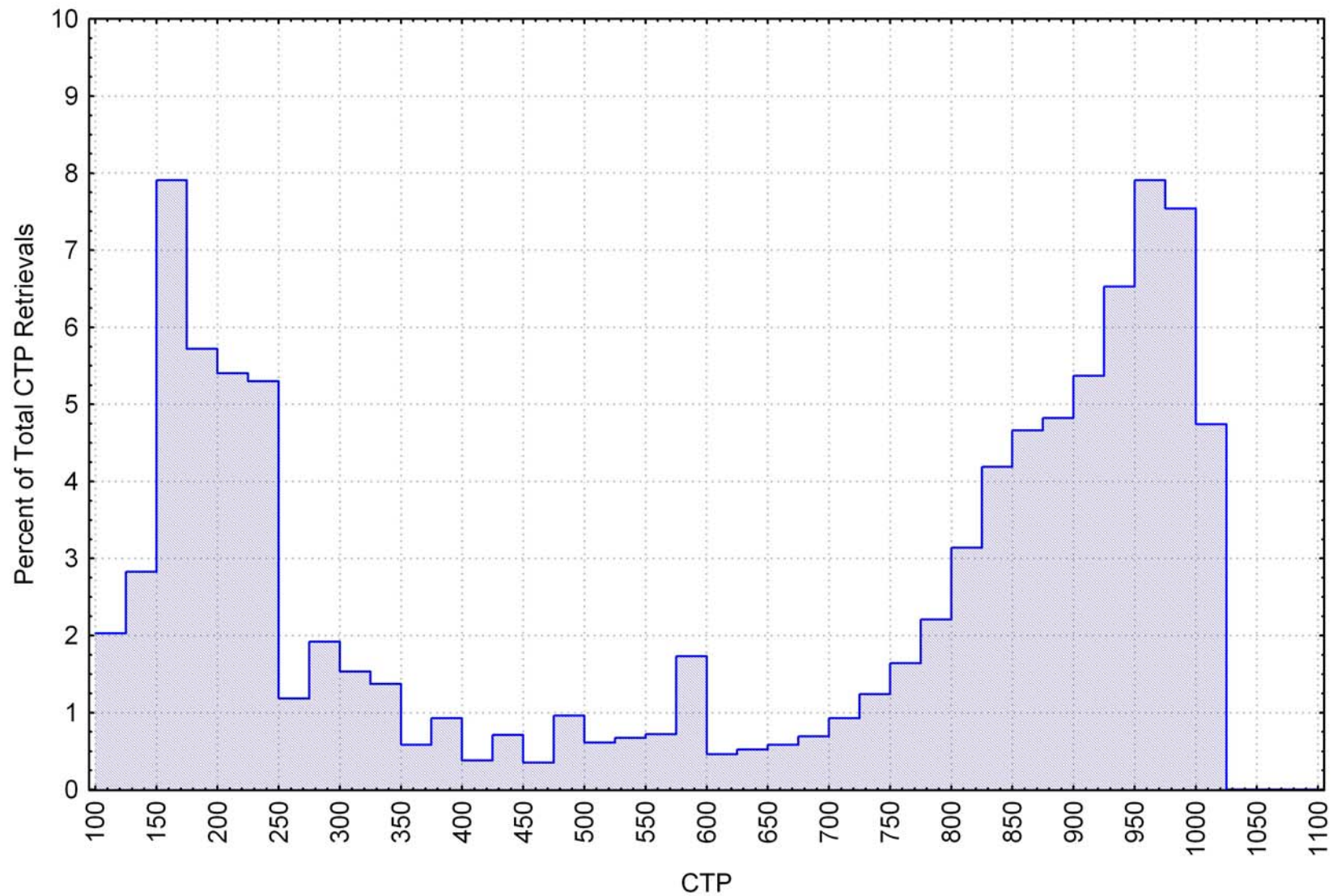28 August 2006
20S-90S Latitude

Distribution of MODIS Aqua Collection 6 Cloud Top Pressure Retrievals
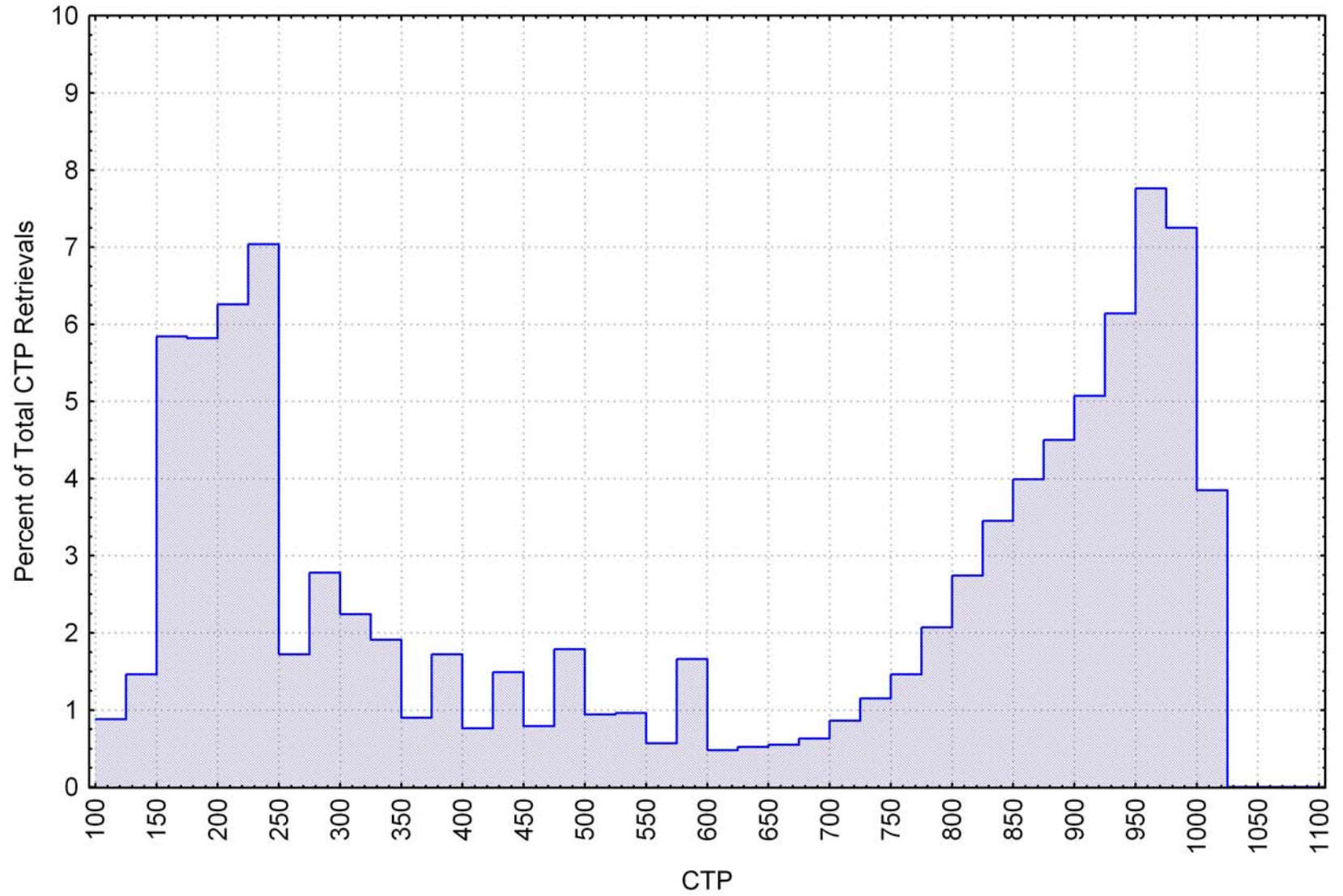28 August 2006
20S-90S Latitude

Distribution of MODIS Terra Collection 5 Cloud Top Pressure Retrievals
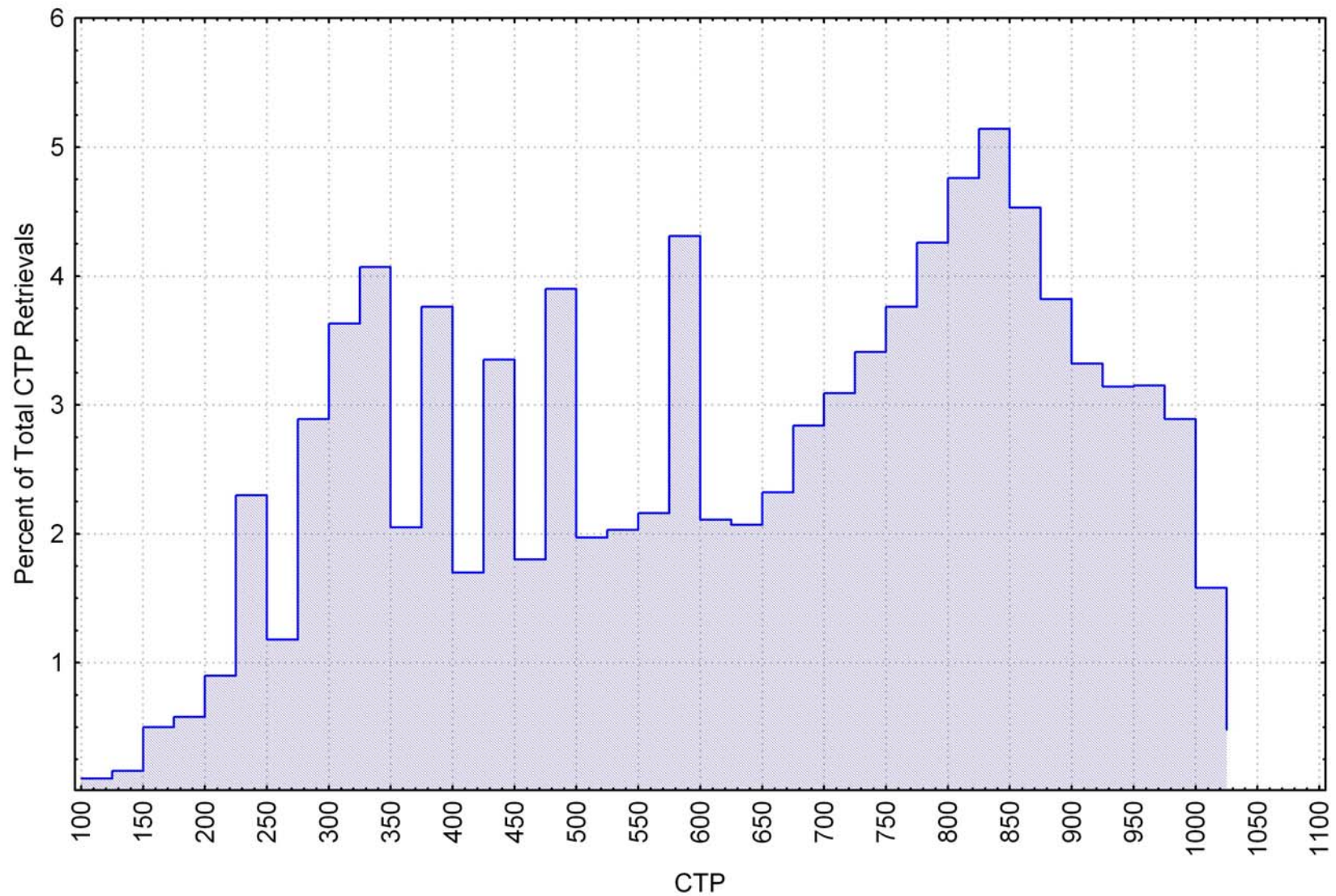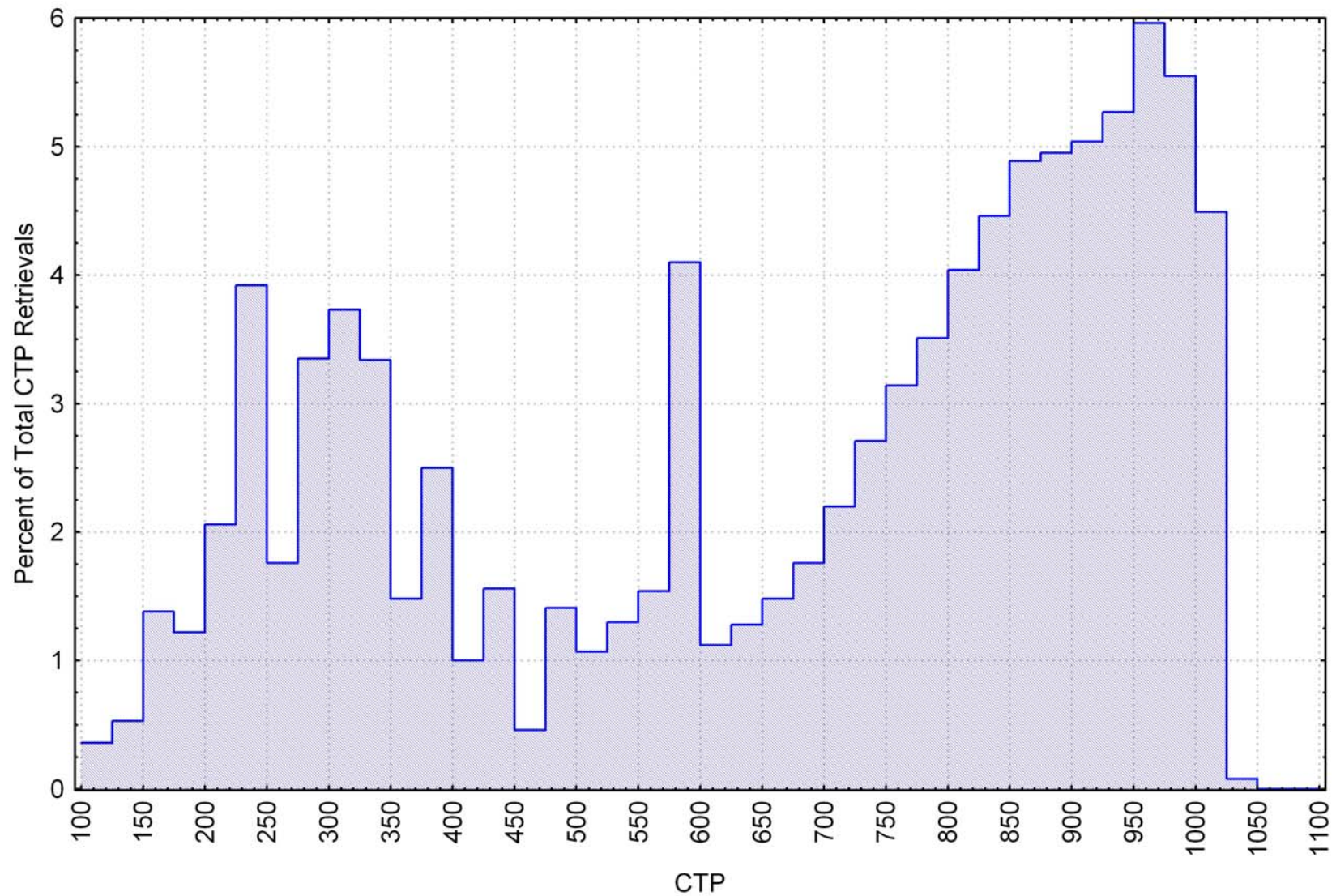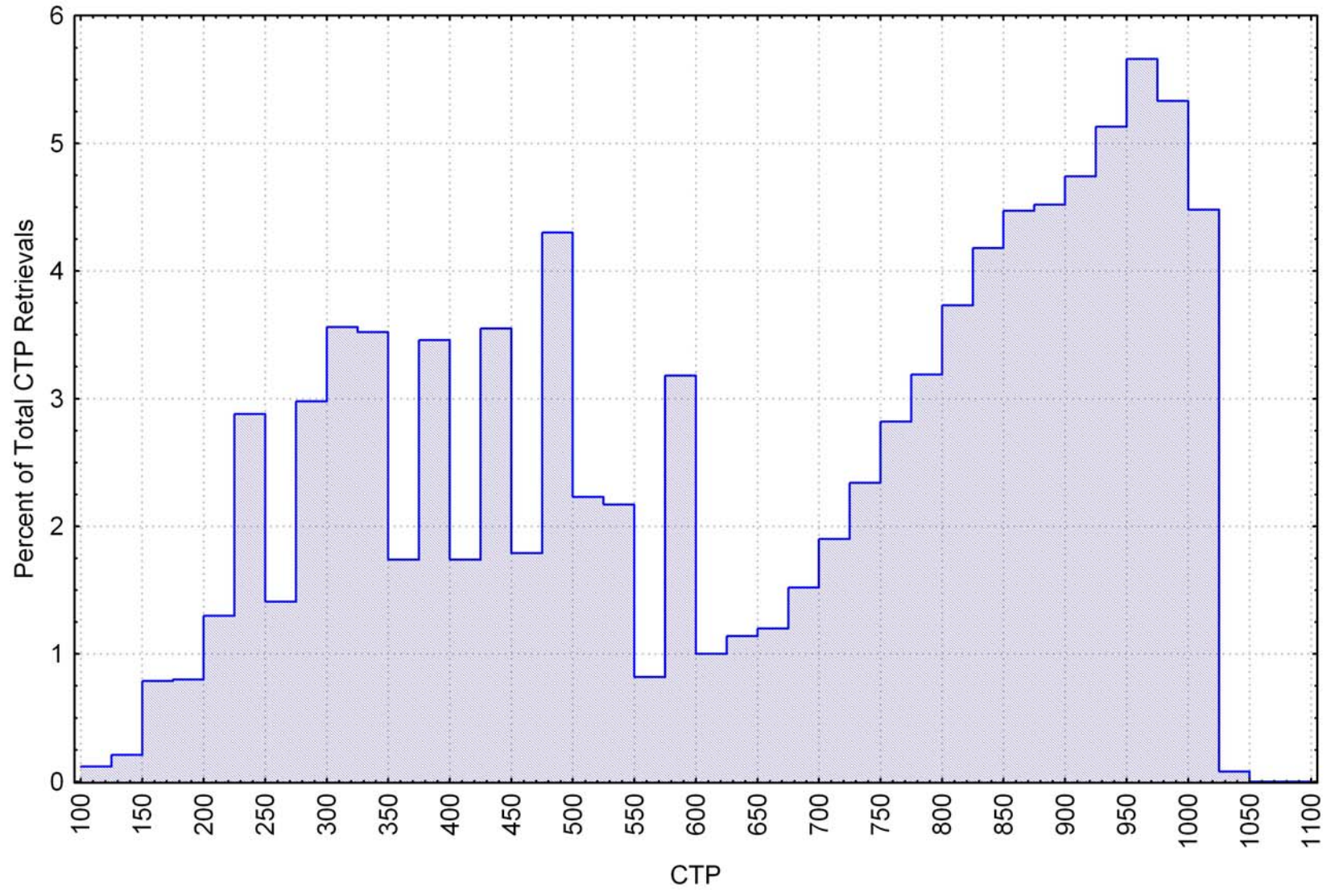28 August 2006
20S-20N Latitude

Distribution of MODIS Terra C6v1.5 Cloud Top Pressure Retrievals
28 August 2006
20S-20N Latitude

Distribution of MODIS Aqua Collection 6 Cloud Top Pressure Retrievals
28 August 2006
20S-20N Latitude

Distribution of MODIS Terra Collection 5 Cloud Top Pressure Retrievals
28 August 2006
20N-90N Latitude

Distribution of MODIS Terra C6v1.5 Cloud Top Pressure Retrievals
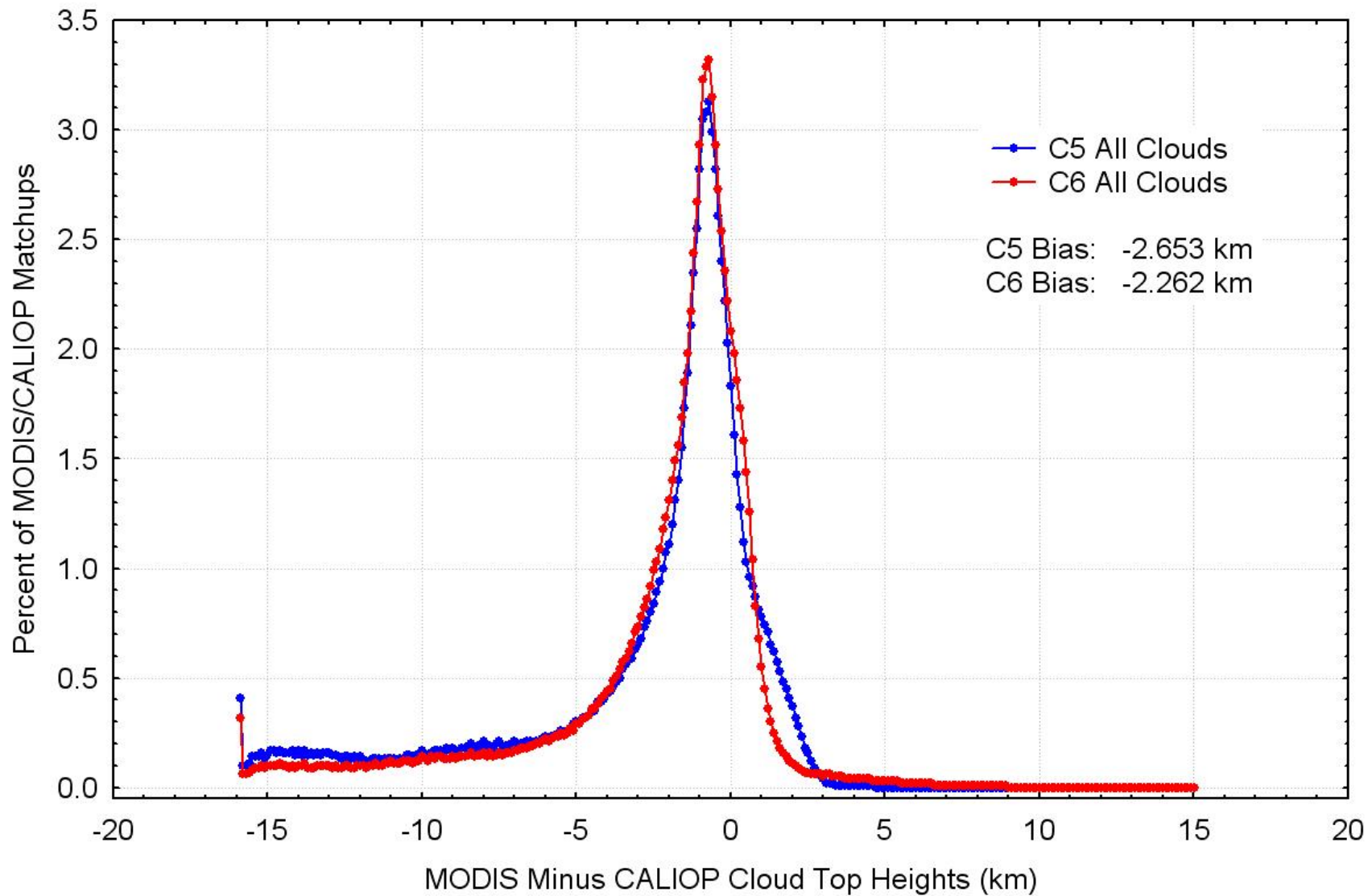28 August 2006
20N-90N Latitude

Distribution of MODIS Aqua Collection 6 Cloud Top Pressure Retrievals
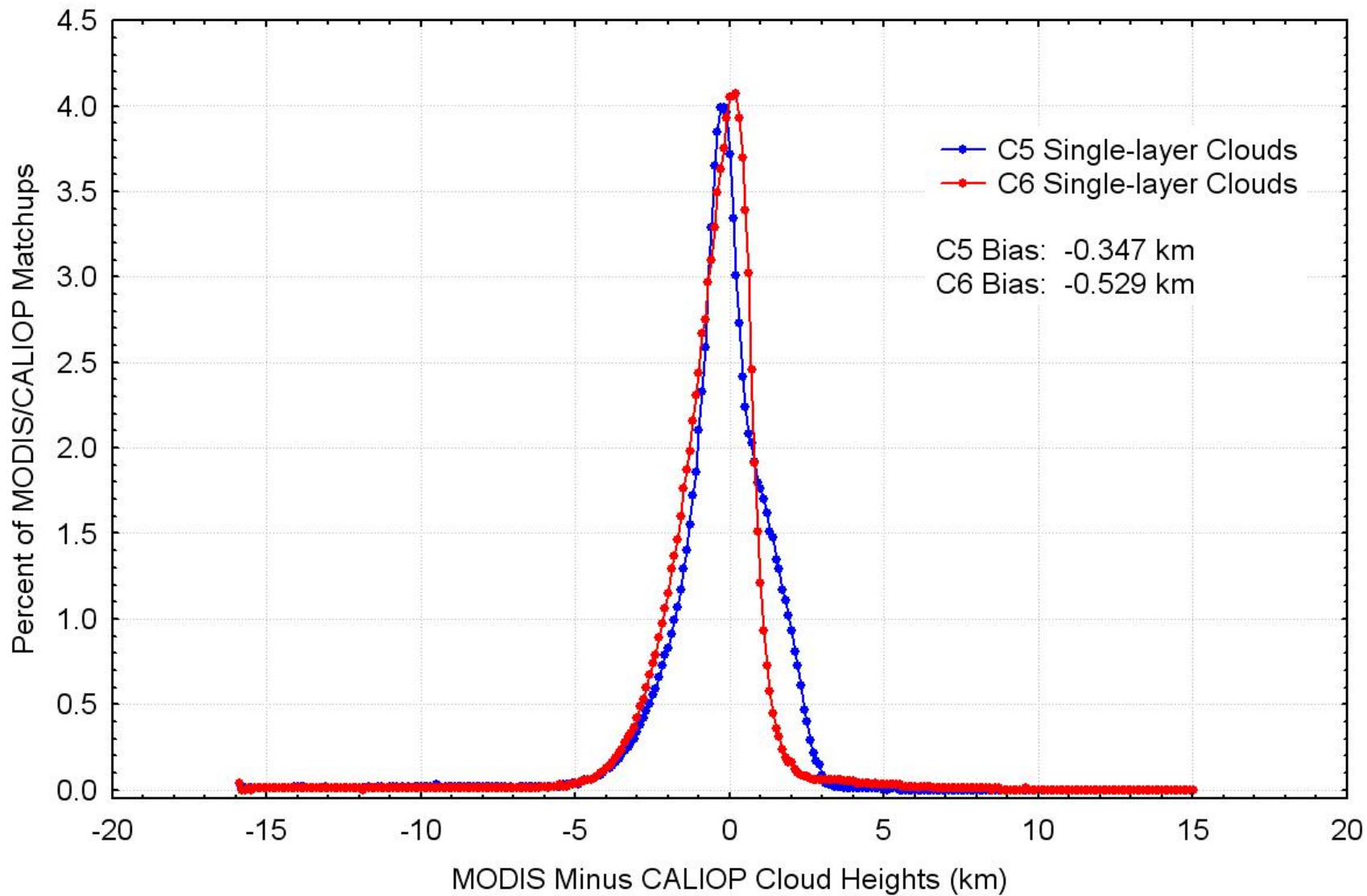28 August 2006
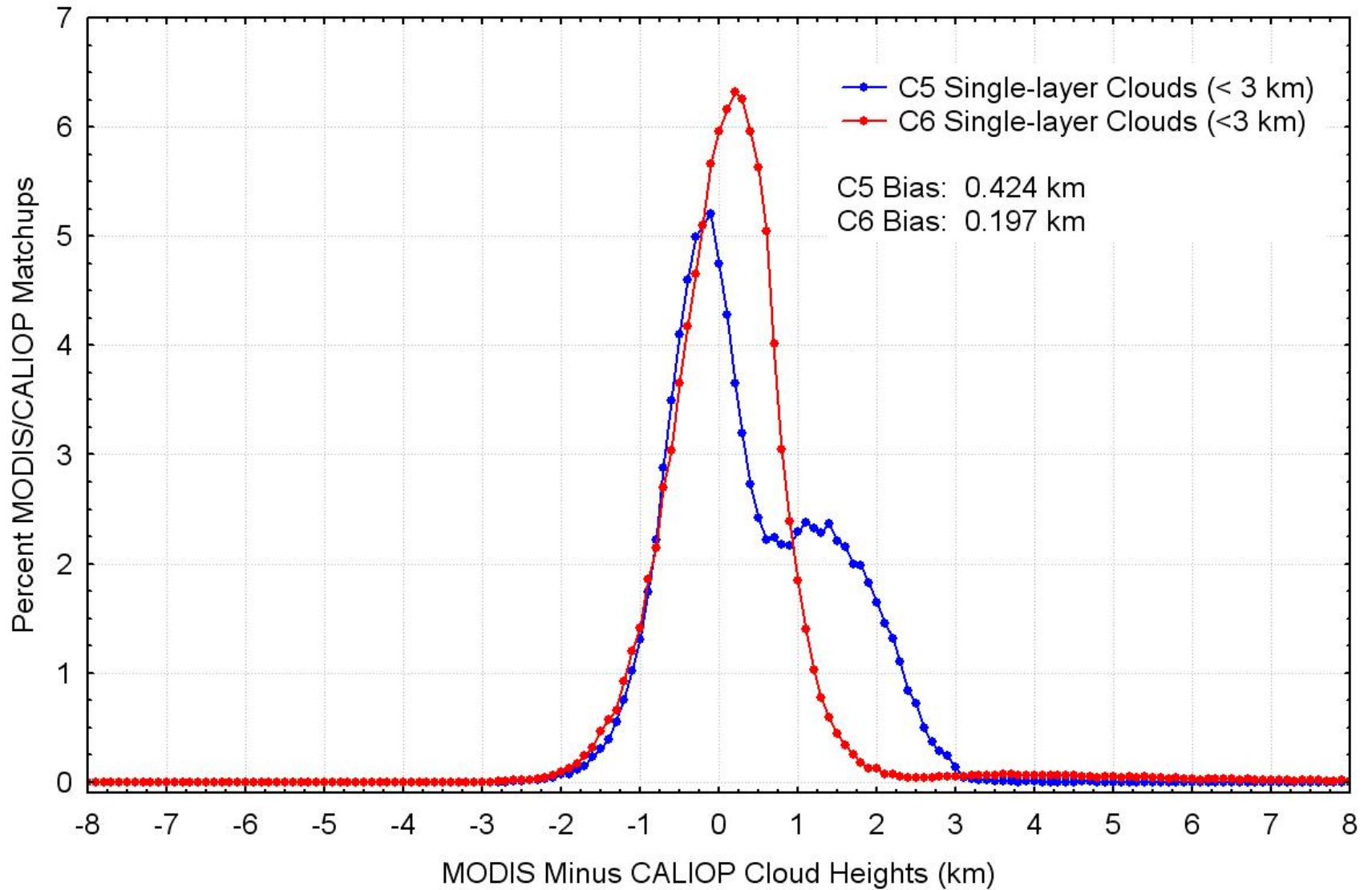20N-90N Latitude

Backup Slides

Aqua MOD06CT and CALIOP Cloud Heights
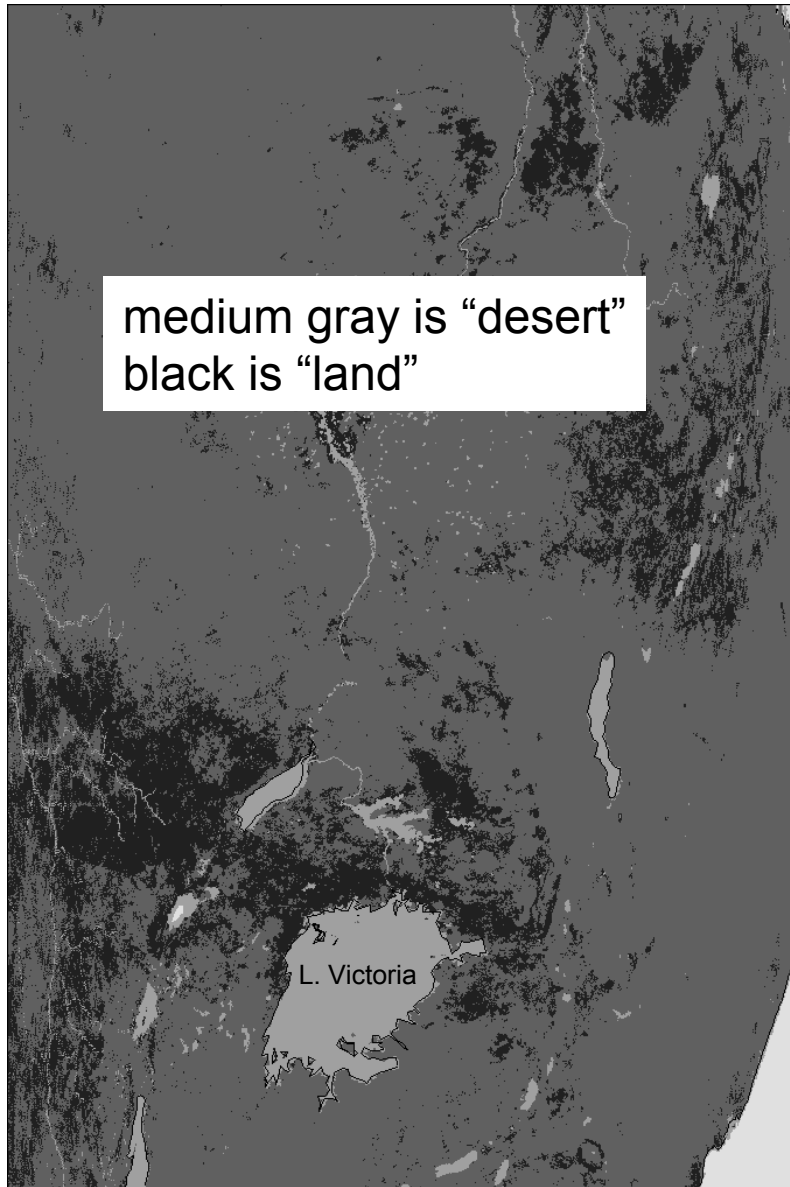August 2006
60S-60N
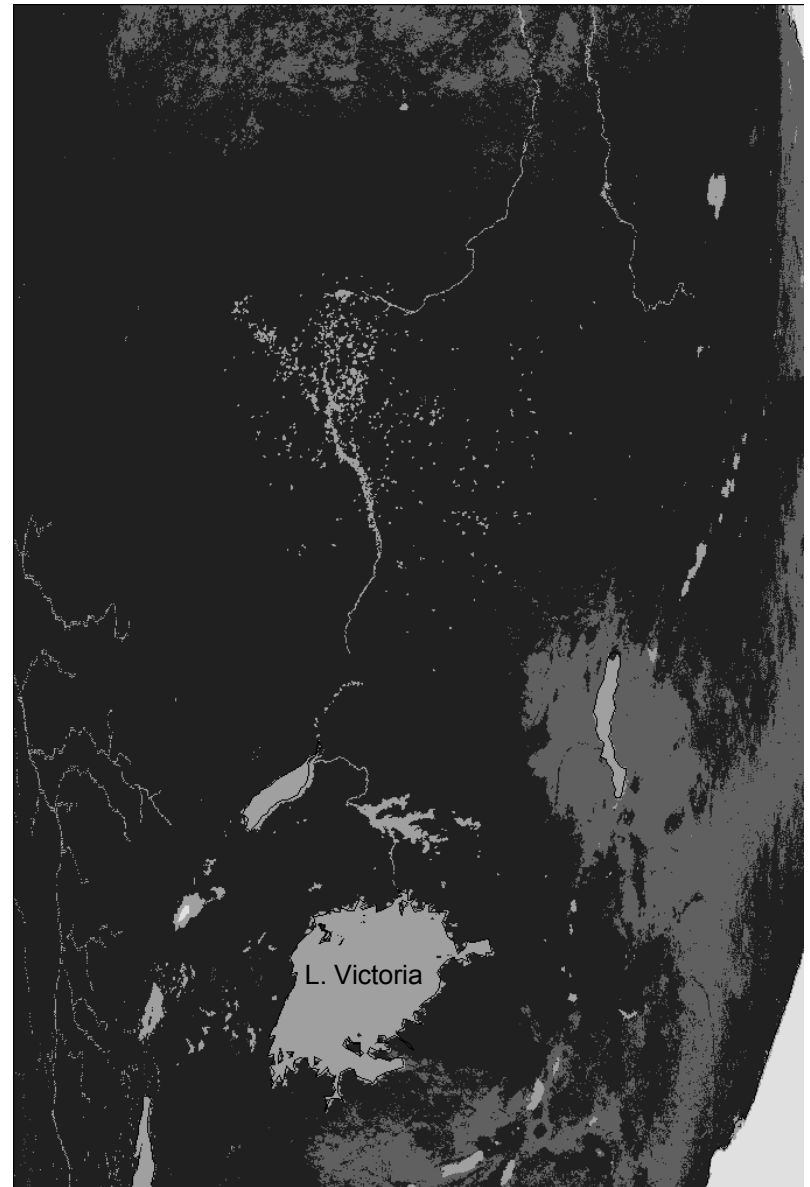
Aqua MOD06CT and CALIOP Cloud Heights
August 2006
60S-60N

Aqua MOD06CT and CALIOP Cloud Heights
August 2006
60S-60N

C5 Single-layer Clouds (< 3 km)
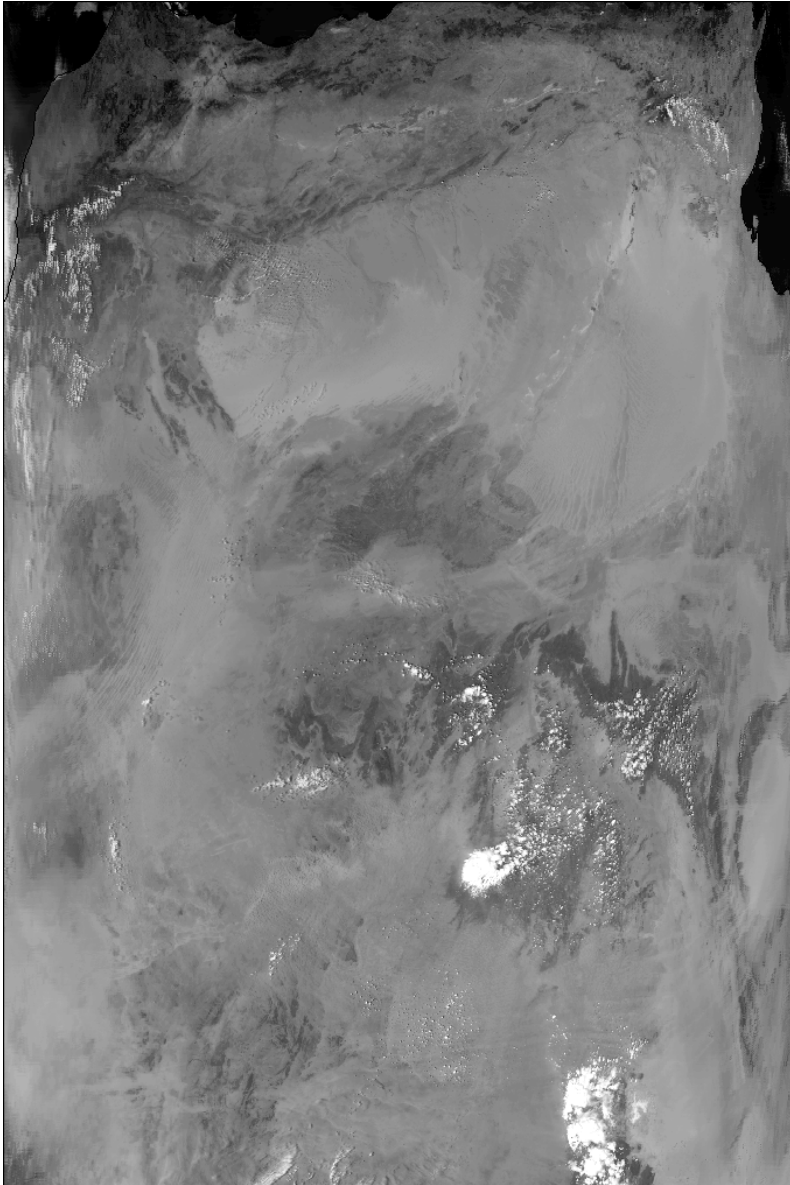C6 Single-layer Clouds (<3 km)

C5 Bias: 0.424 km
C6 Bias: 0.197 km

Percent MODIS/CALIOP Matchups

MODIS Minus CALIOP Cloud Heights (km)

MOD35 Processing Path

medium gray is "desert"
black is "land"

L. Victoria

L. Victoria

Collection 5
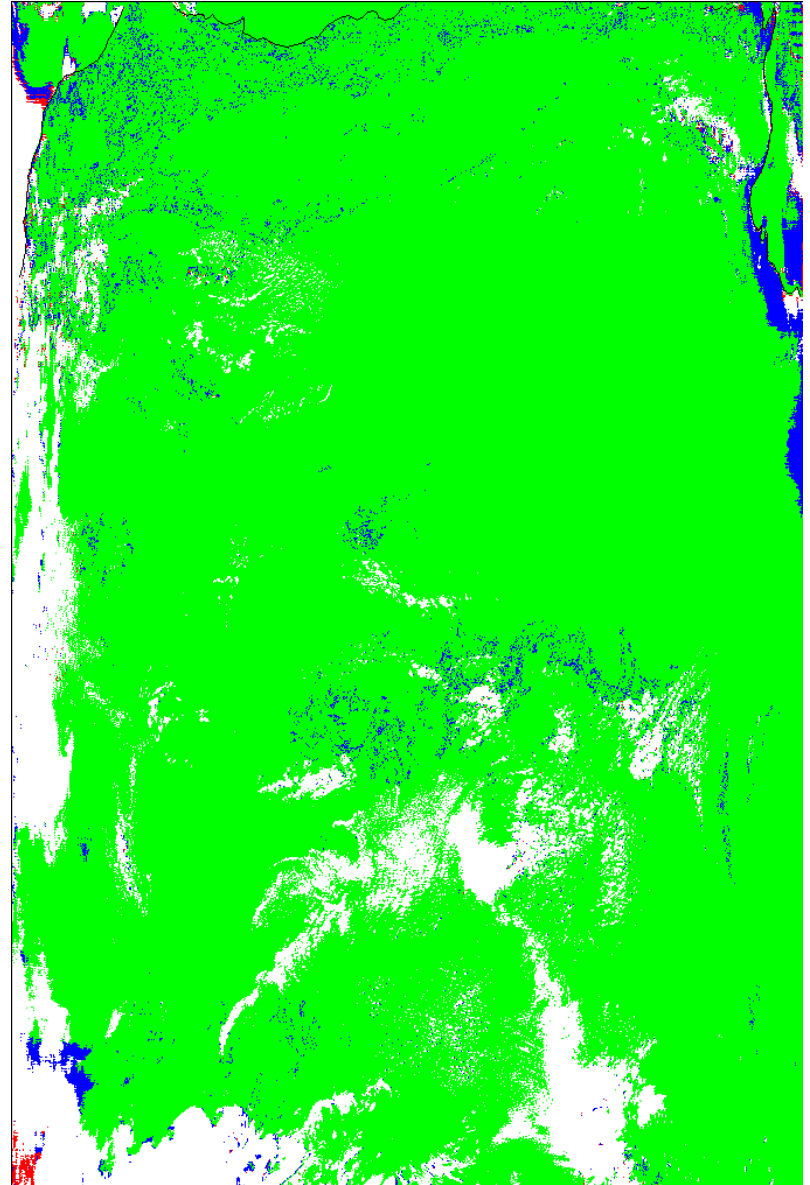
Collection 6

Aqua MODIS 2006240 at 11:20 UTC East Africa

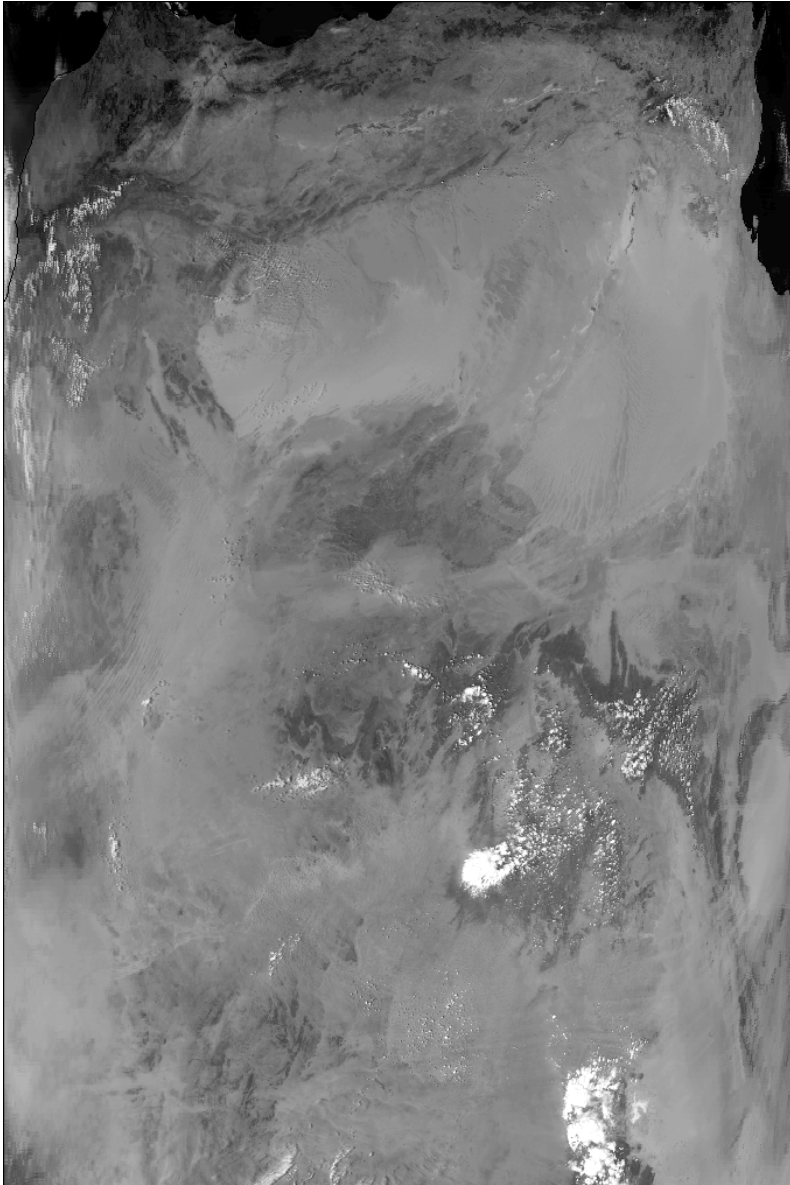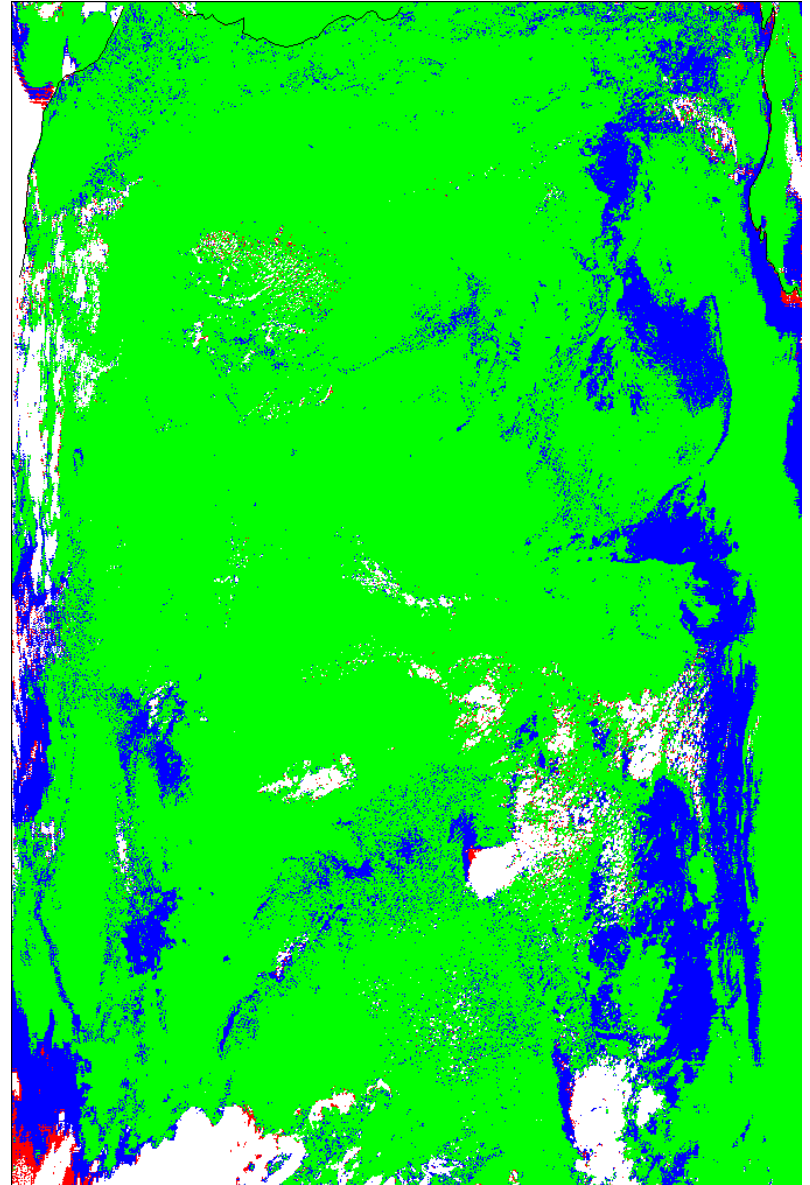G-conf. clear, B-prob. clear, R-prob. cloudy, W-conf.cloudy

MODIS Band 1

Collection 5 Cloud Mask

Aqua MODIS 2006240 at 13:05 UTC

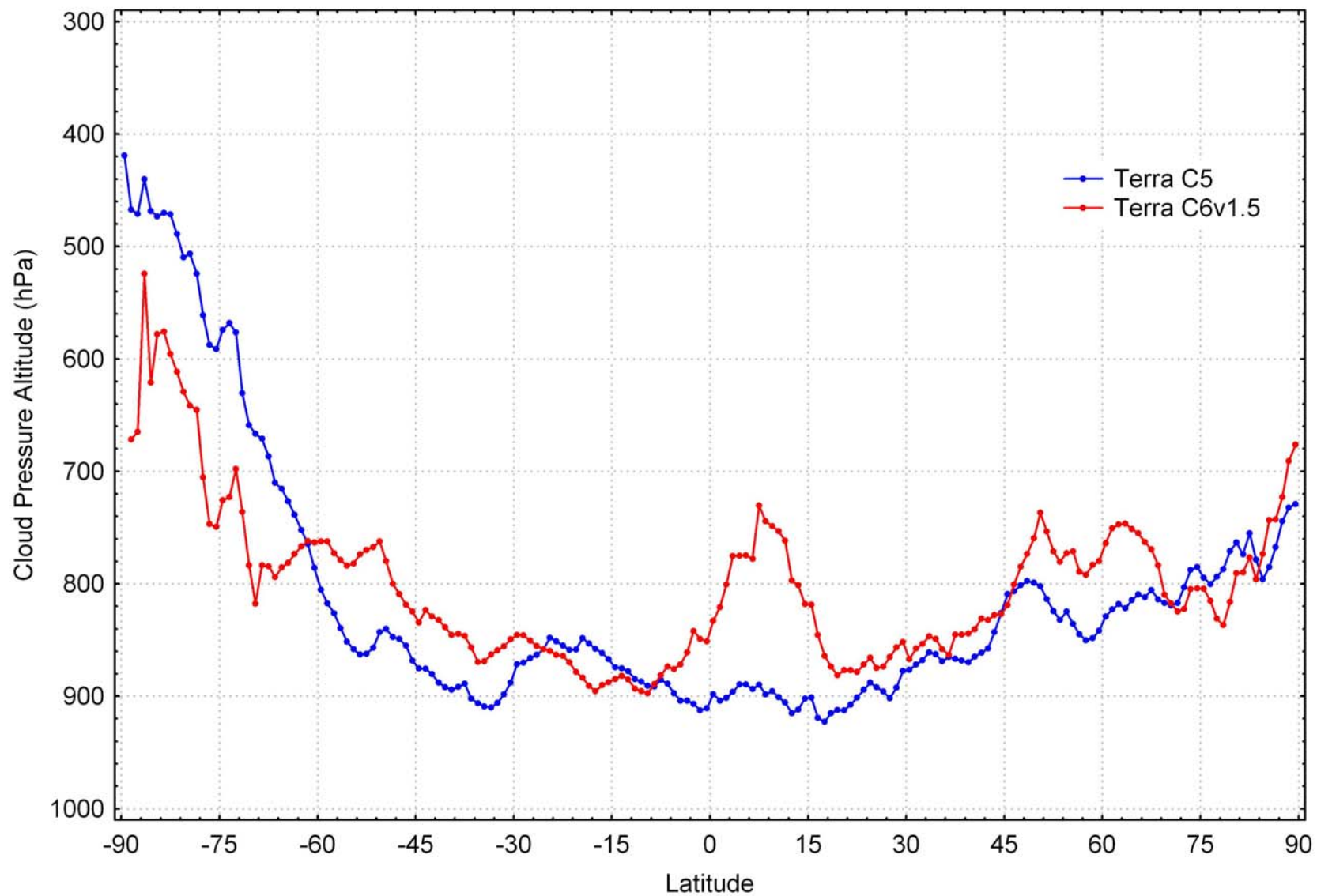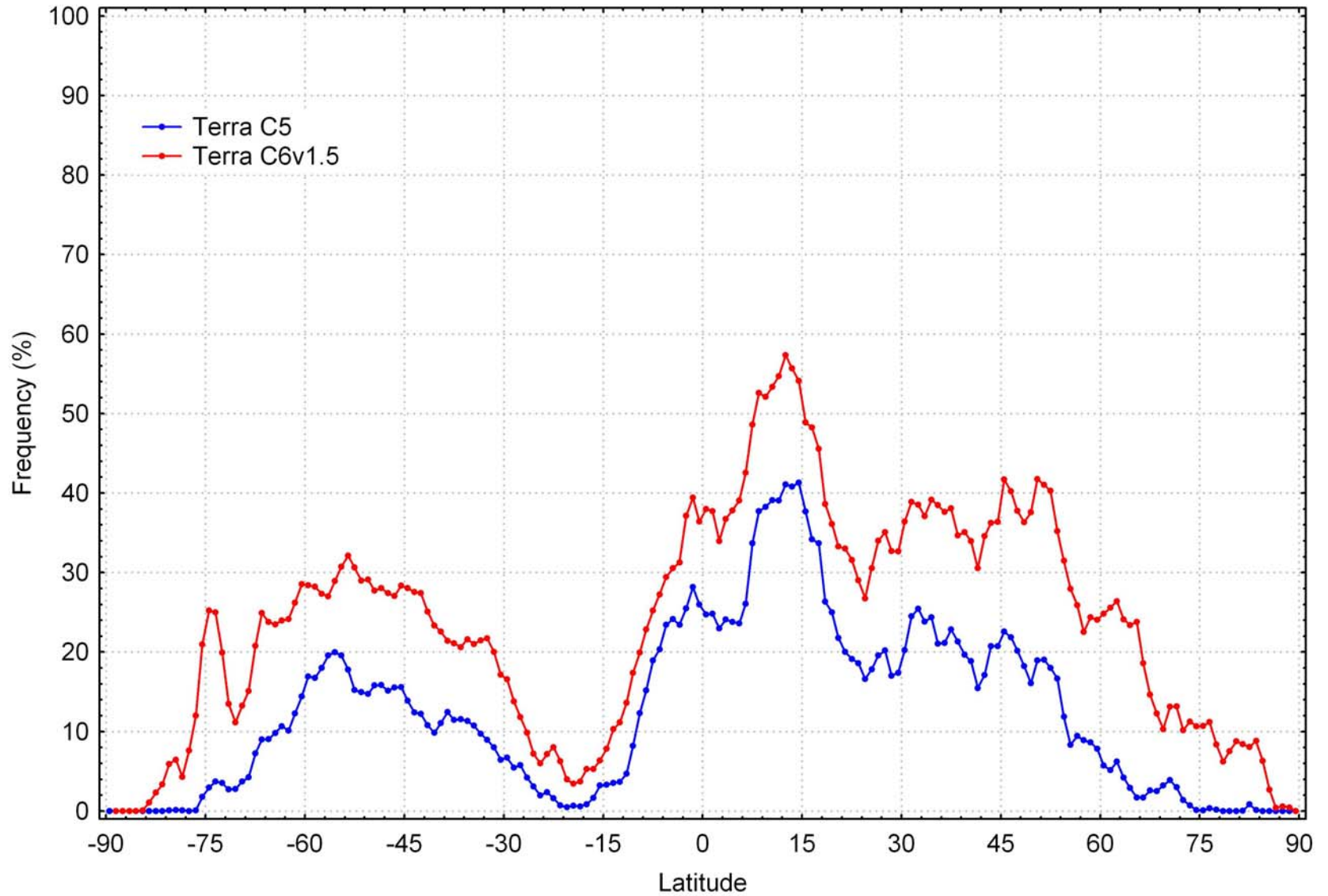G-conf. clear, B-prob. clear, R-prob. cloudy, W-conf.cloudy

MODIS Band 1
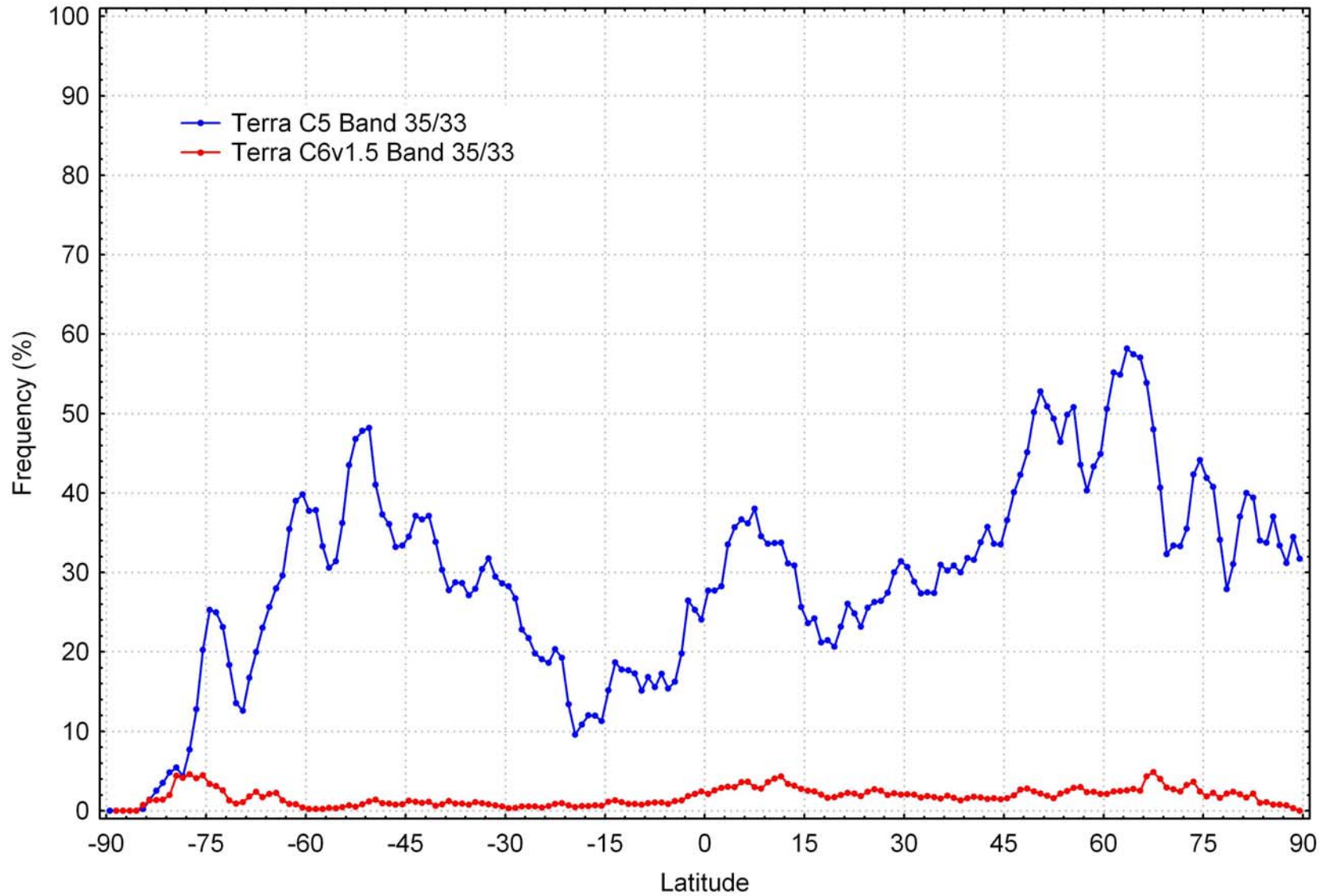
Collection 6 Cloud Mask

Aqua MODIS 2006240 at 13:05 UTC

MODIS Mean CTP from IR Window Retrievals
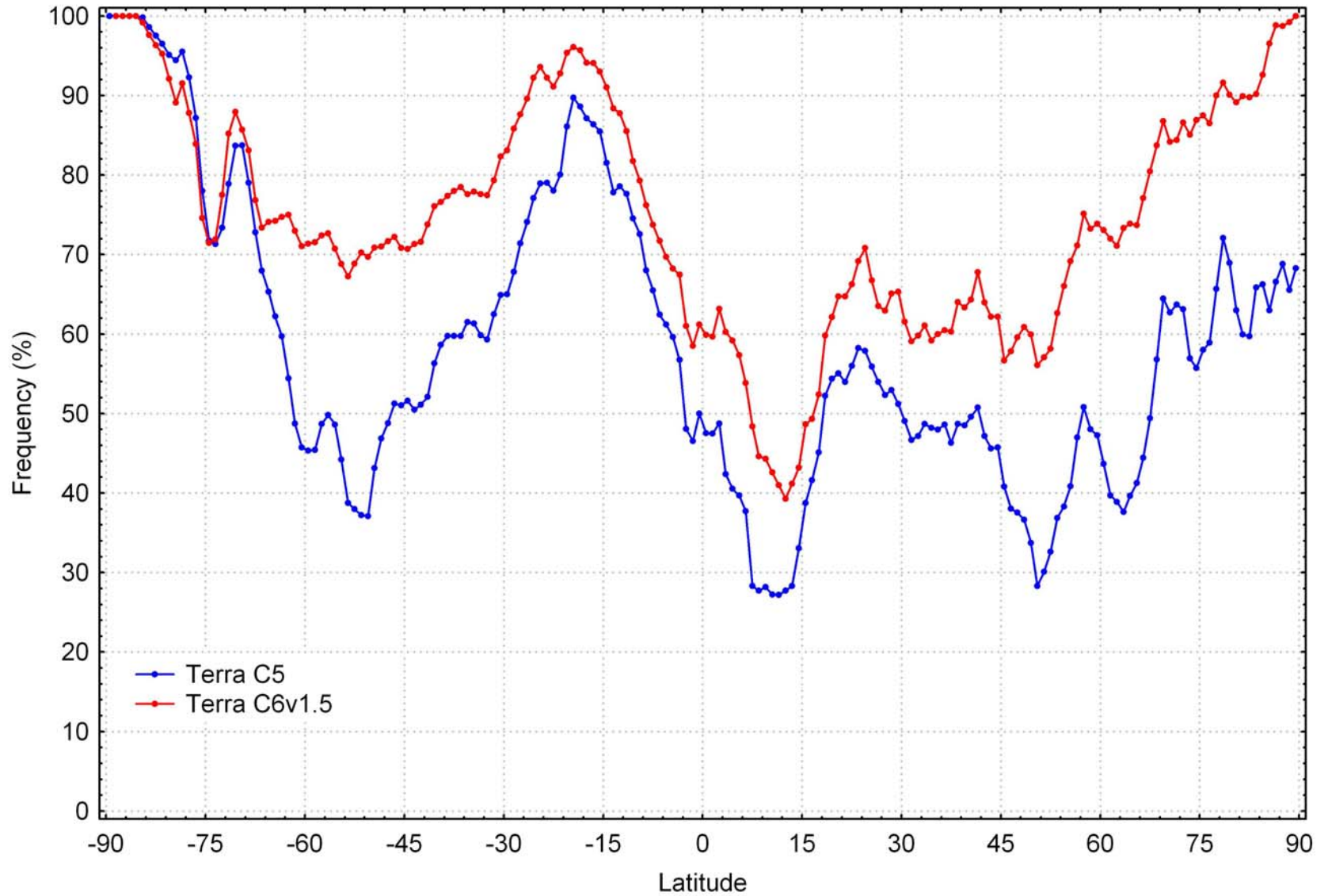August 28, 2006

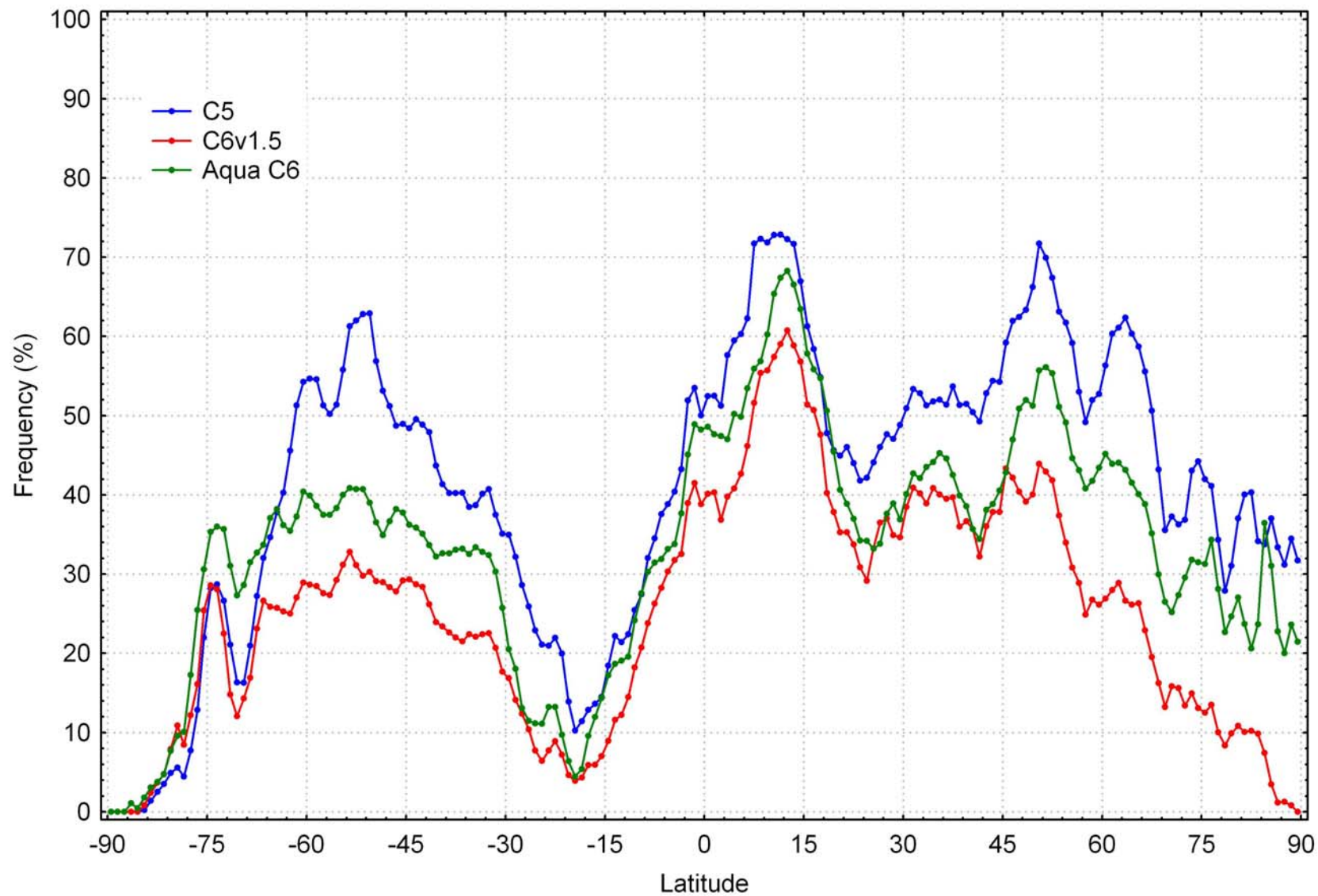MODIS Frequency of Band 36/35 CTP Retrievals
August 28, 2006

MODIS Frequency of Mid CO_2 Band CTP Retrievals
August 28, 2006

MODIS Frequency of IR Window CTP Retrievals
August 28, 2006

MODIS Zonal Frequency of CO$_2$ Slicing Retrievals
August 28, 2006

Aqua MOD06CT and CALIOP Cloud Heights
August 2006
60S-60N

High Thin Clouds (CALIOP detects surface signal)
C5 Single-layer Clouds (> 8 km)
C6 Single-layer Clouds (>8 km)

C5 Bias: -2.791 km
C6 Bias: -2.314 km