

Ice Cloud Radiance Simulations with MODIS and AIRS: Implications for MODIS Collection 6 Cloud Products

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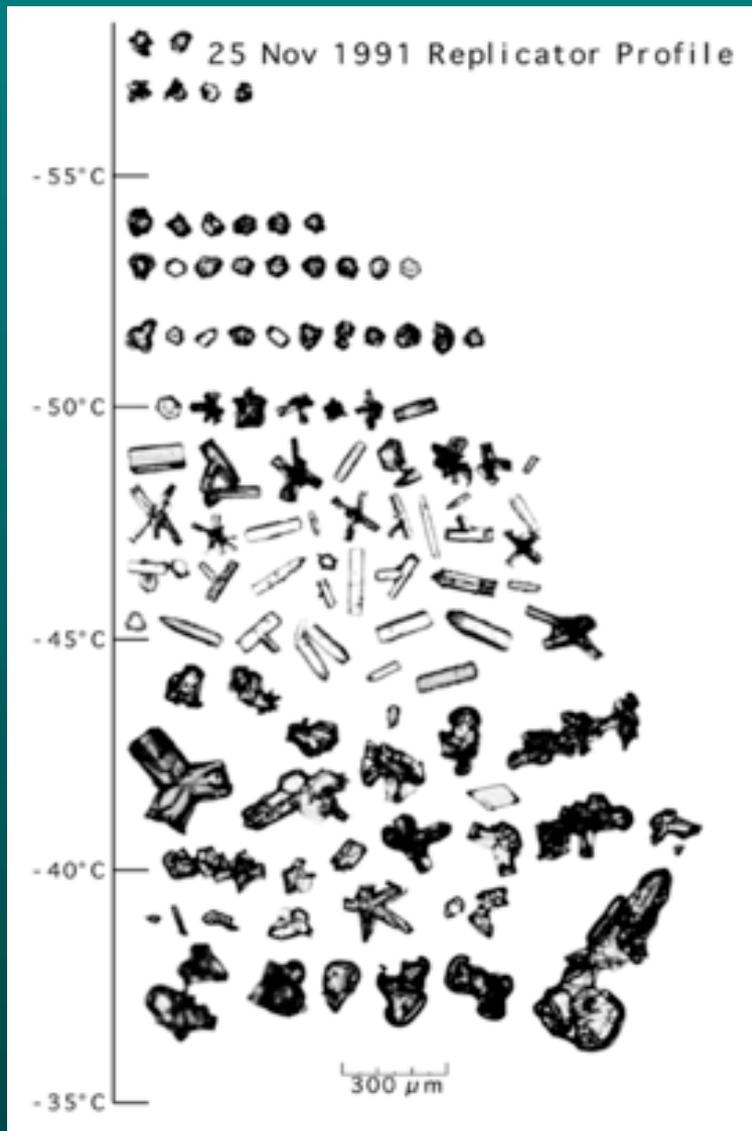


Sounder Science Team Mtg
October 13-16, 2009

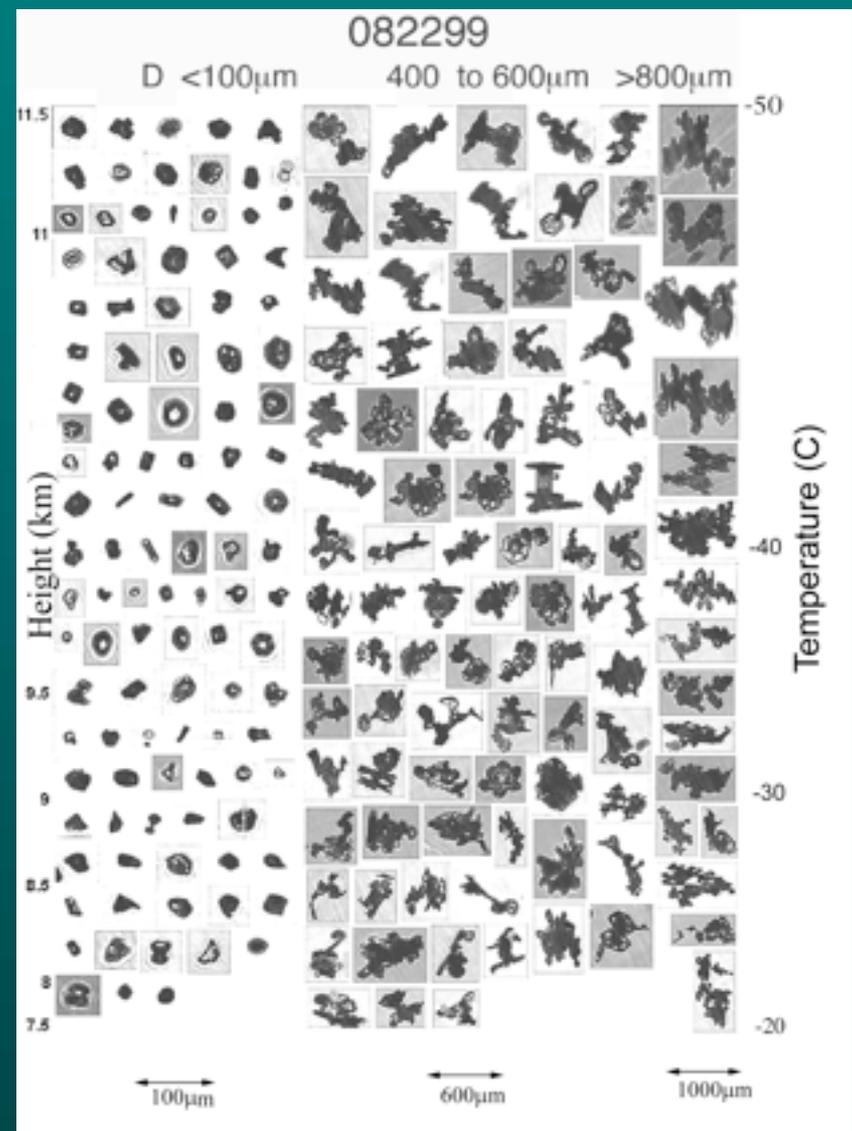


Ice Cloud Particle Habits

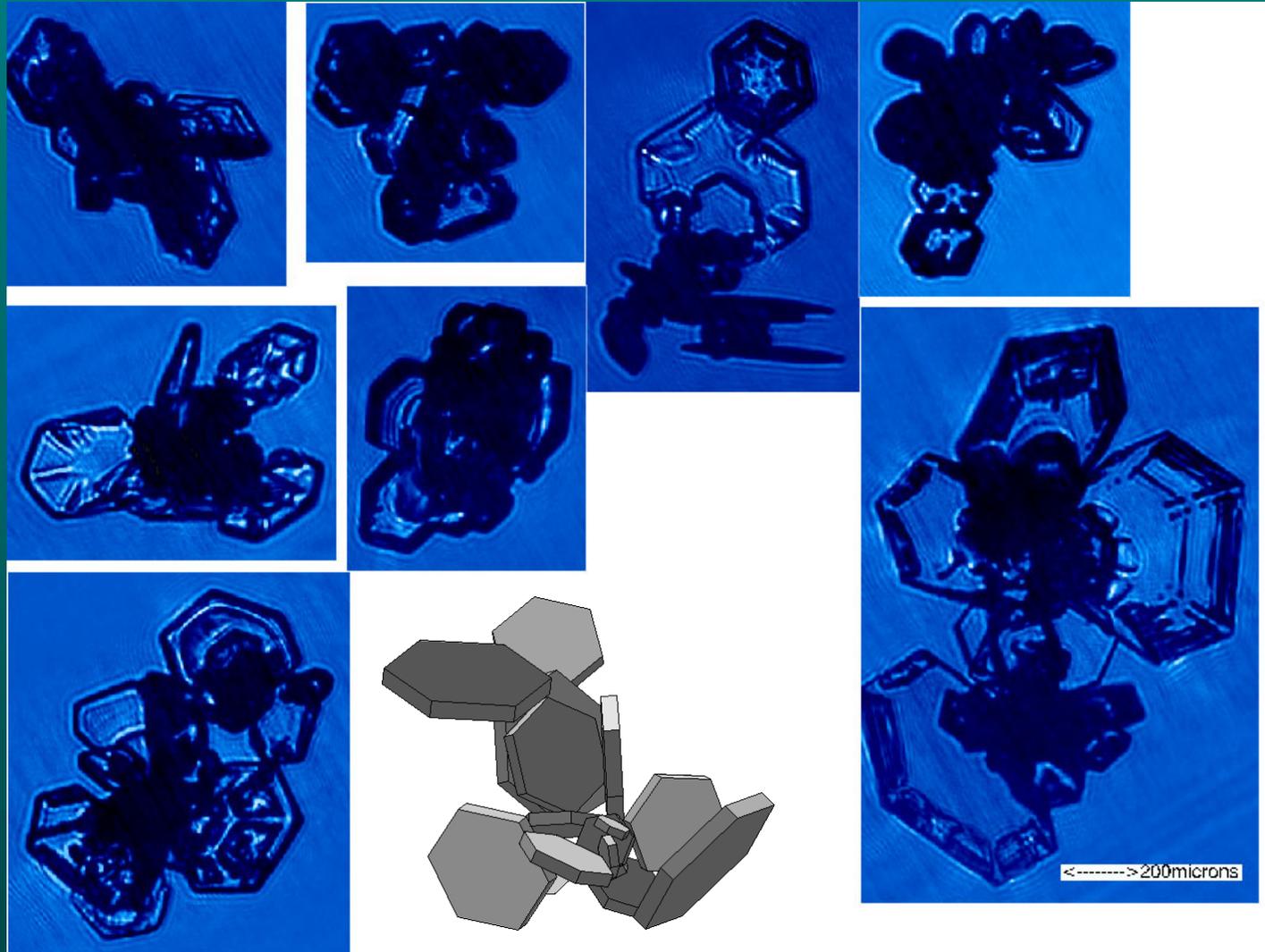
Synoptic Cirrus



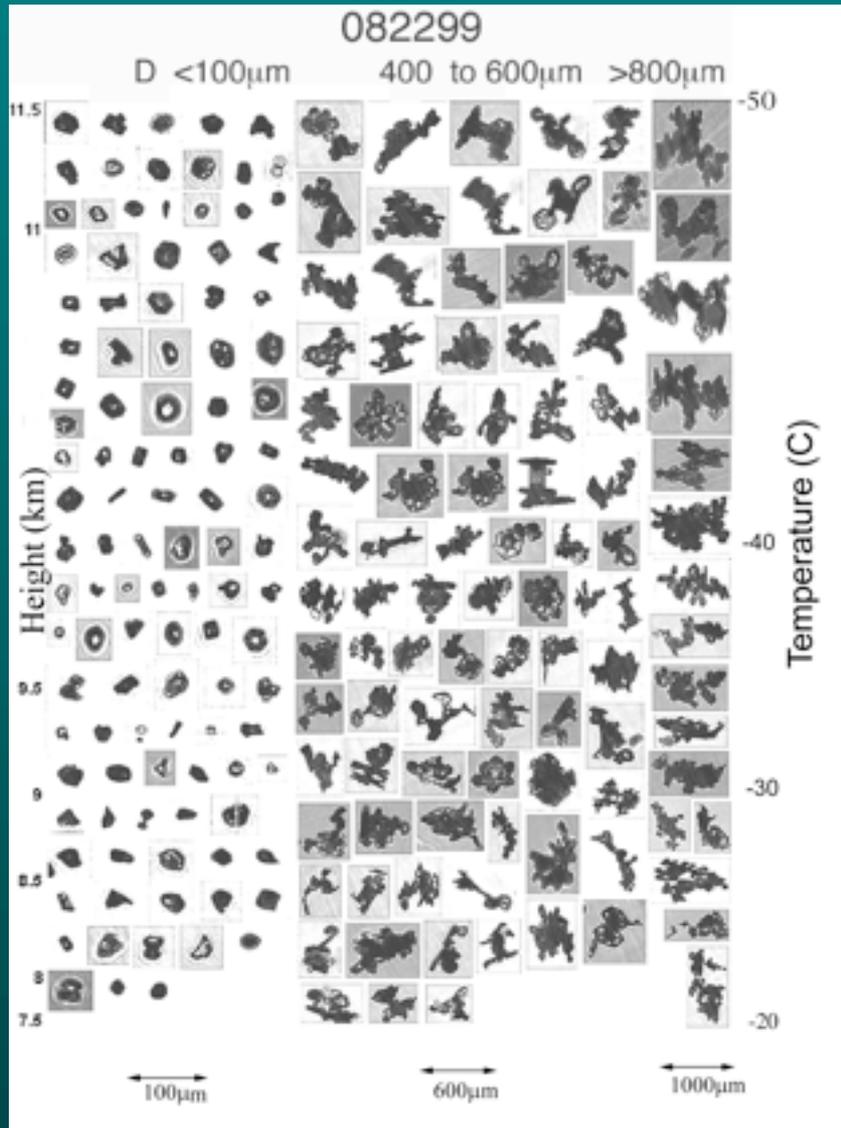
Tropical Cirrus



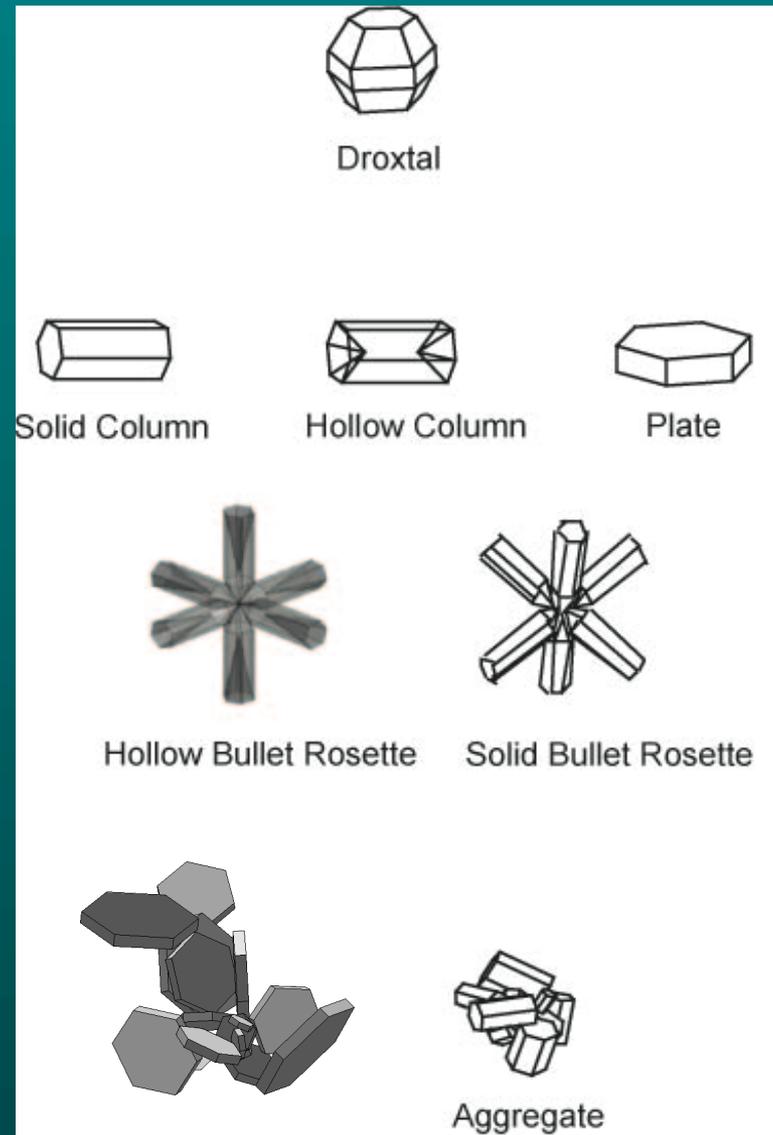
New Aggregate Under Development: Plates rather than Columns



Ice Cloud Particle Habits



Simulated Particle Habits



Summary of Improvements to Bulk Optical Models

No spectral gaps from UV to Far-IR

New ice particle single scattering libraries will include:

- a. new habits, e.g., hollow bullet rosette and aggregate of plates
- b. both roughened and smooth particles
- c. full phase matrix
- d. increased resolution in particle size
- e. host of improvements to light scattering calculations
- f. updated ice index of refraction (Warren and Brandt, JGR, 2008)
- g. different (hopefully more sensible) ice particle habit mixture
- h. models will include same properties as before except for delta-transmission energy

Microphysical data available from many new missions; use of new instrumentation and methods
(now have about 13,000 individual PSDs; current version used about 1100 PSDs)

Microphysical data from 2D-C (and similar probes) reprocessed to mitigate contribution of shattered ice particles

Will build models for each individual imager, no longer a generic imager such as AVHRR

Assessment of the quality of MODIS cloud products from radiance simulations

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¹Seoul National University ²Texas A&M University ³University of Wisconsin-Madison

Basic Info: January 2007; Ocean only, 60°N to 60°S

Products used: MYD06 for MODIS; AIRS2RET for AIRS; 2B-GEOPROF (CloudSat/Calipso)

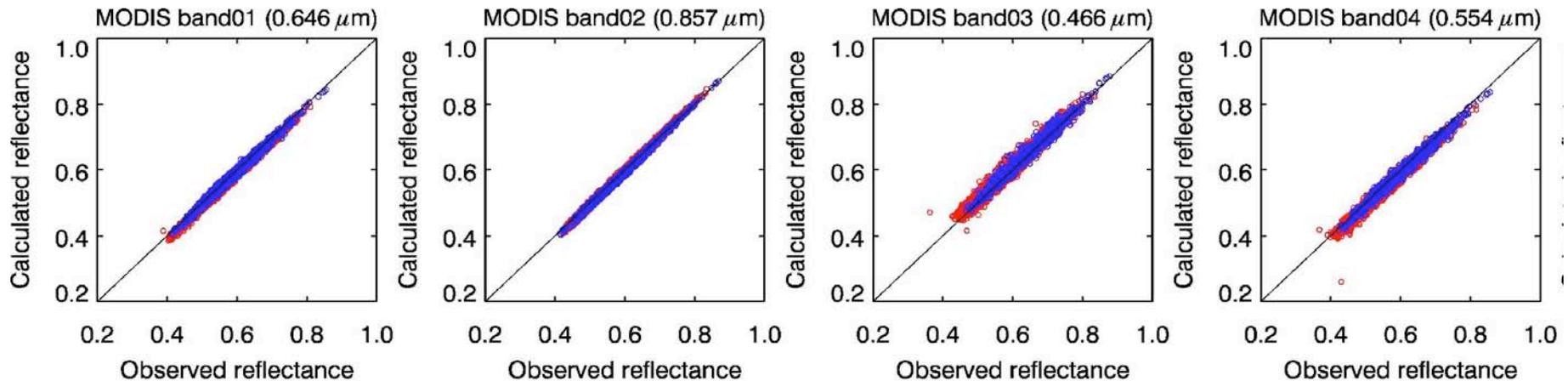
For a given CloudSat pixel, closest MODIS, AIRS, Calipso pixels are chosen within 0.1°, 0.5°, and 0.1°

RT model: SBDART (Santa Barbara DISORT Atmospheric Radiative Transfer) model

SW Bands (MODIS Bands 1, 2, 3, and 4)

• Ice clouds

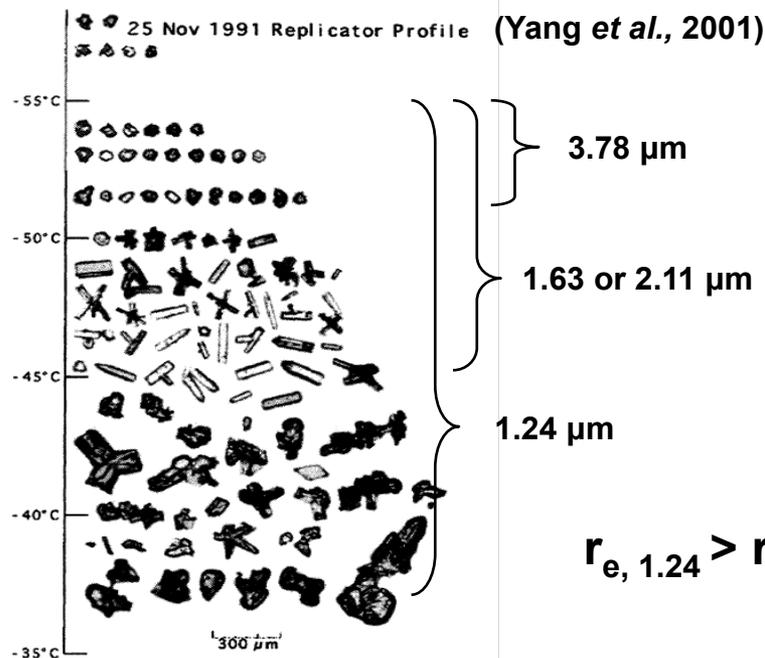
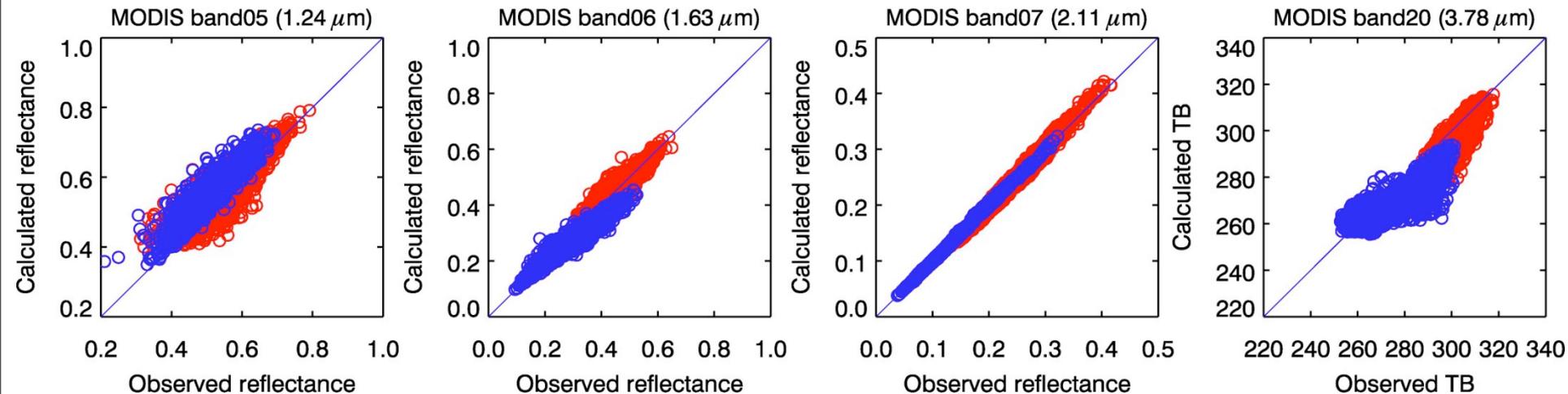
• Water clouds



Ham, S. H., B. J. Sohn, P. Yang, and B. A. Baum, 2009: Assessment of the quality of MODIS cloud products from radiance simulations. *J. Appl. Meteor. Clim.*, 48, 1591-1612.

SWIR/NIR Bands (Bands 5, 6, 7, and 20)

- Ice clouds
- Water clouds

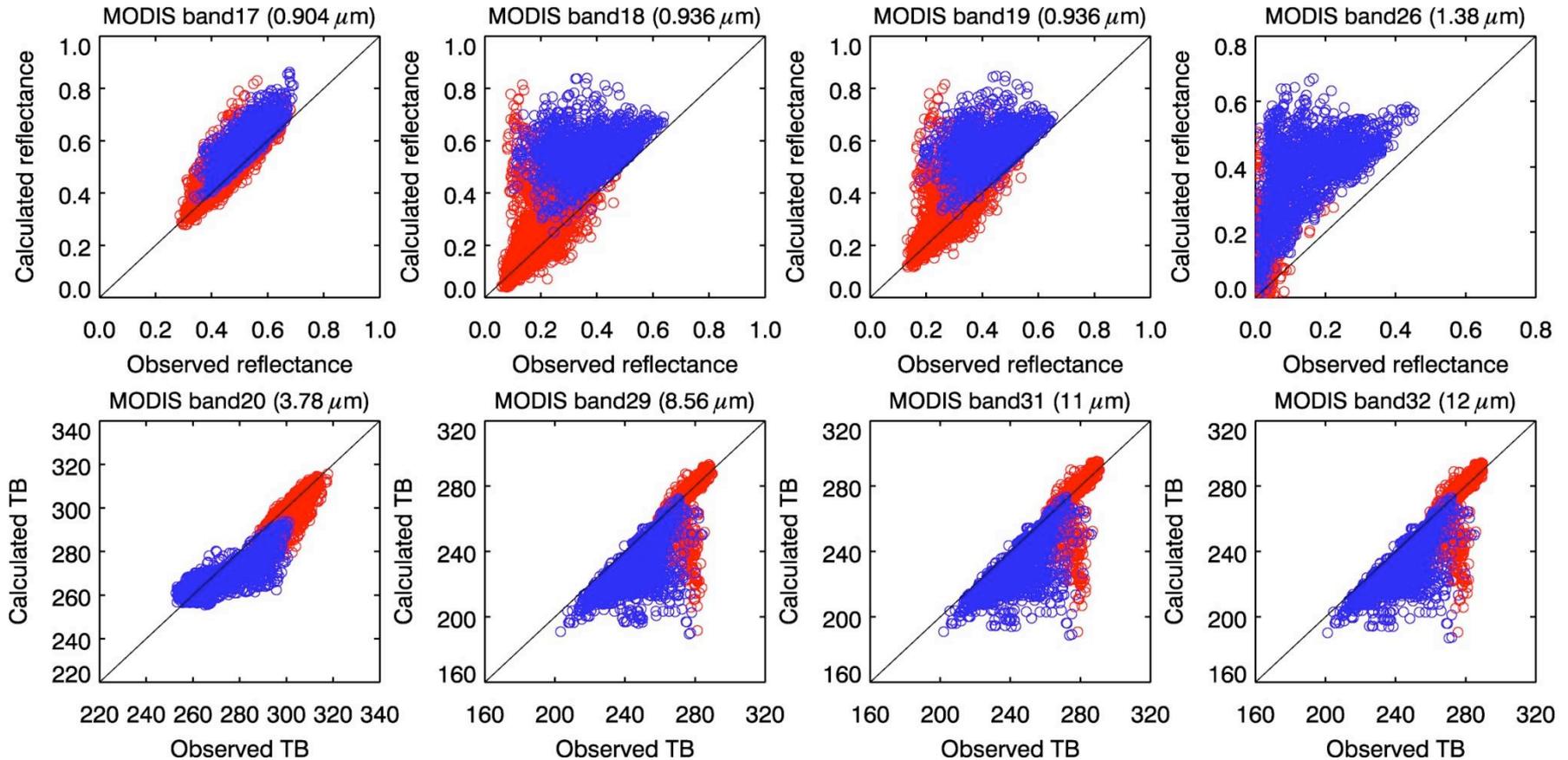


$$r_{e, 1.24} > r_{e, 2.11} > r_{e, 3.78}$$

WV and Window Bands

• Ice clouds

• Water clouds

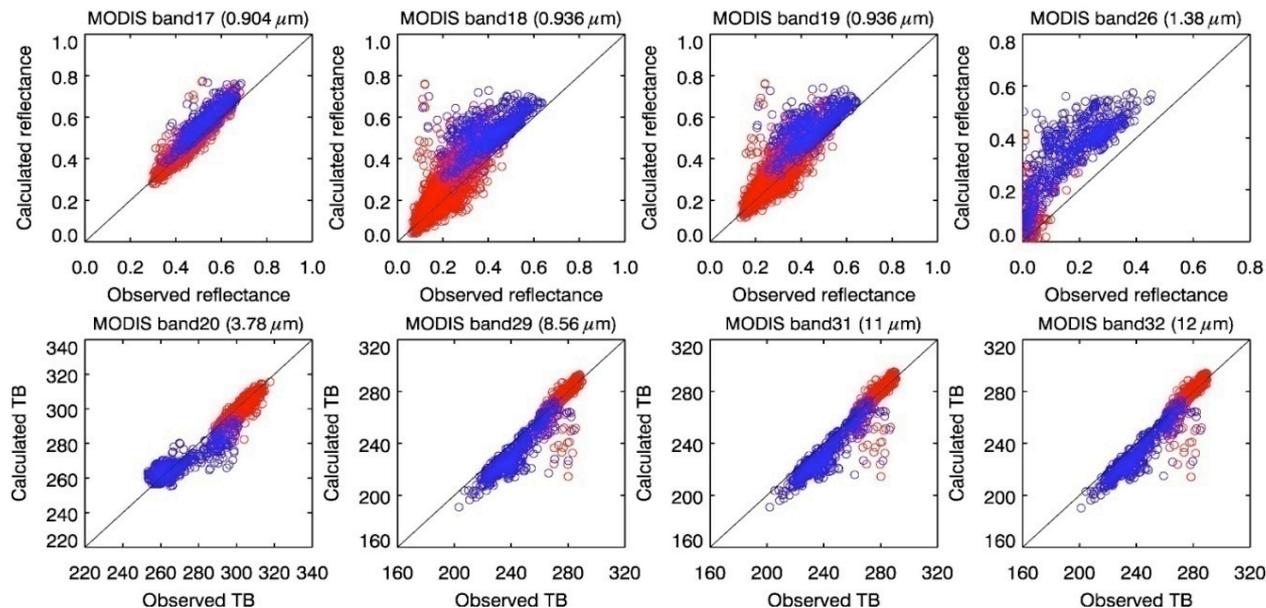


- Large overestimation for WV band radiances.
- Large underestimation for window band radiances

Influence of multilayered clouds: Simulations Based on MODIS CTP

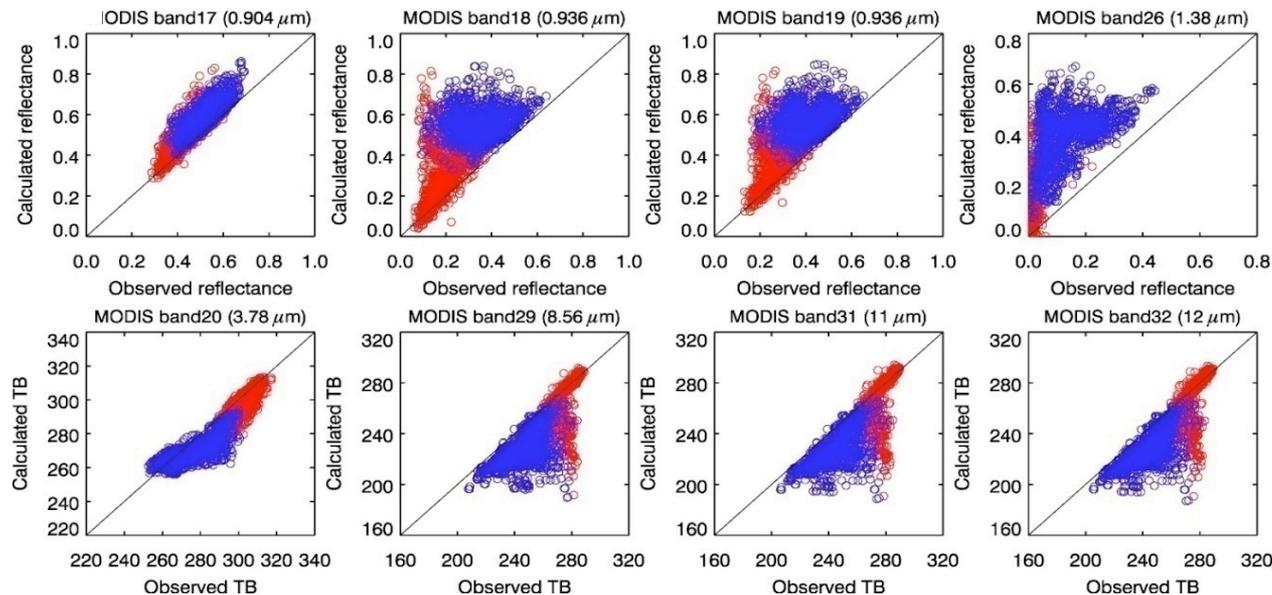
Single-layer clouds

Ice clouds Water clouds



Multilayered clouds

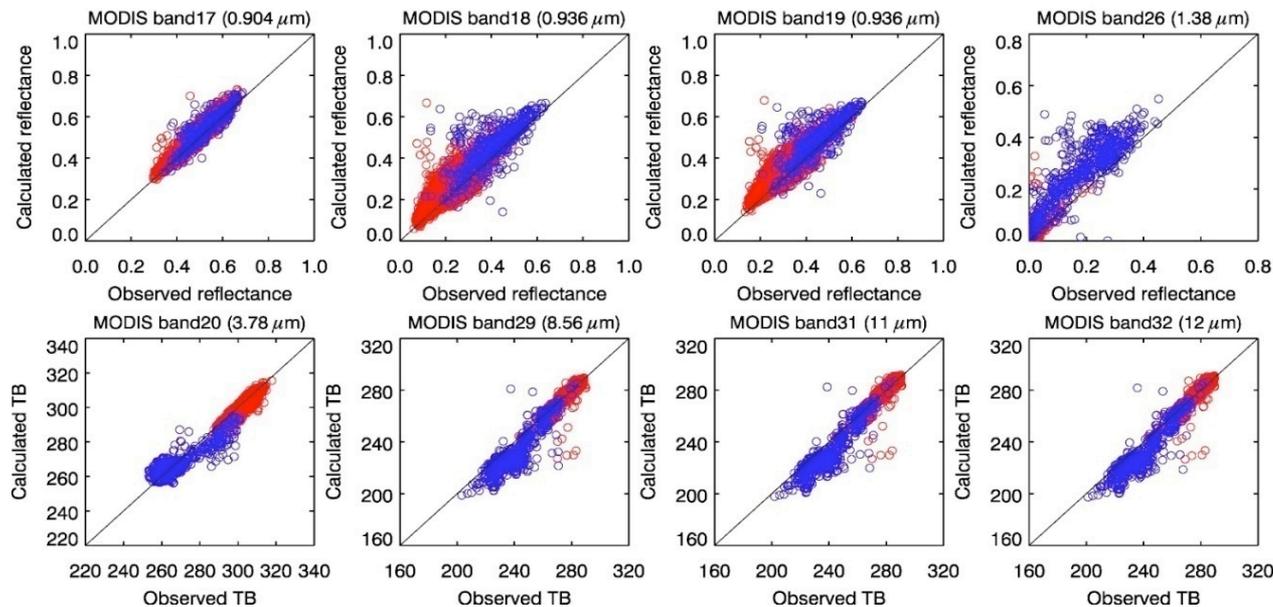
From MODIS-AIRS-
CloudSat-CALIPSO
collocated pixels



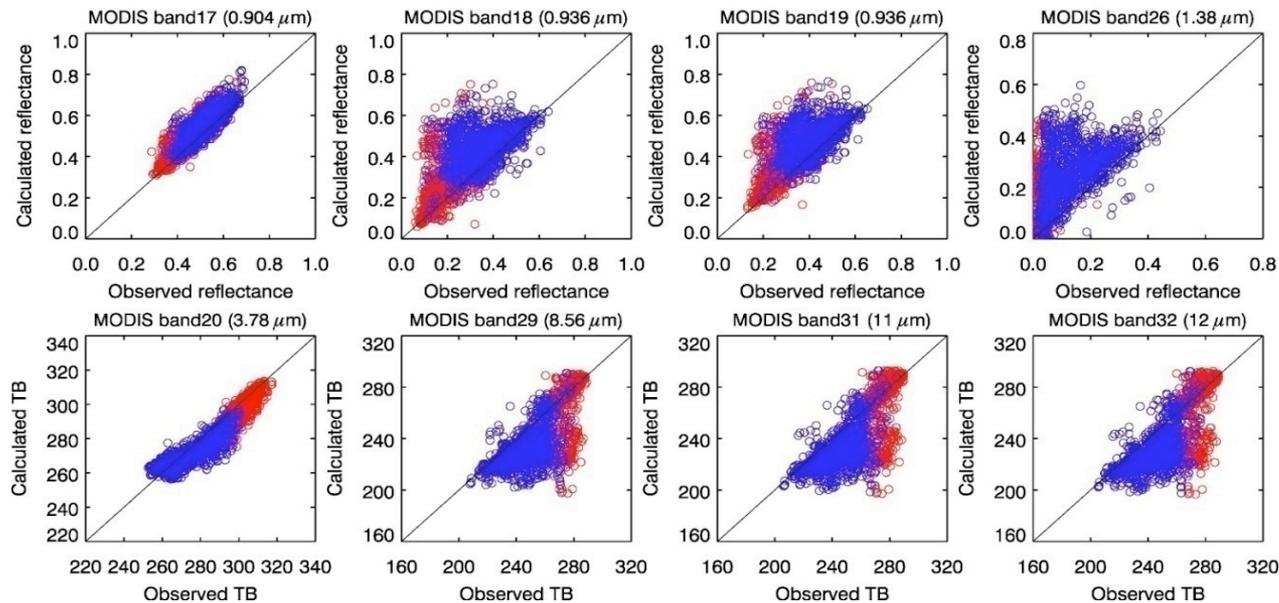
Improvement from use of CloudSat cloud heights

Single-layer clouds

Ice clouds Water clouds



Multilayered clouds

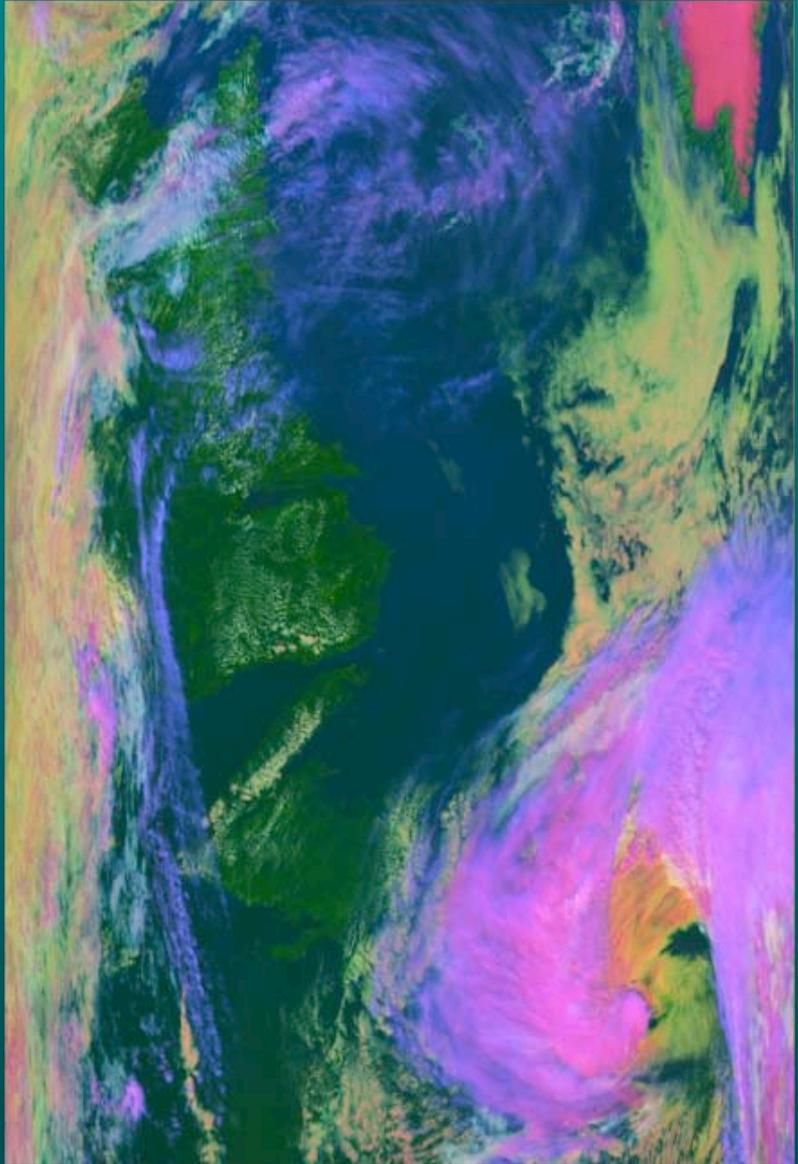


Game Changers for MODIS Collection 6

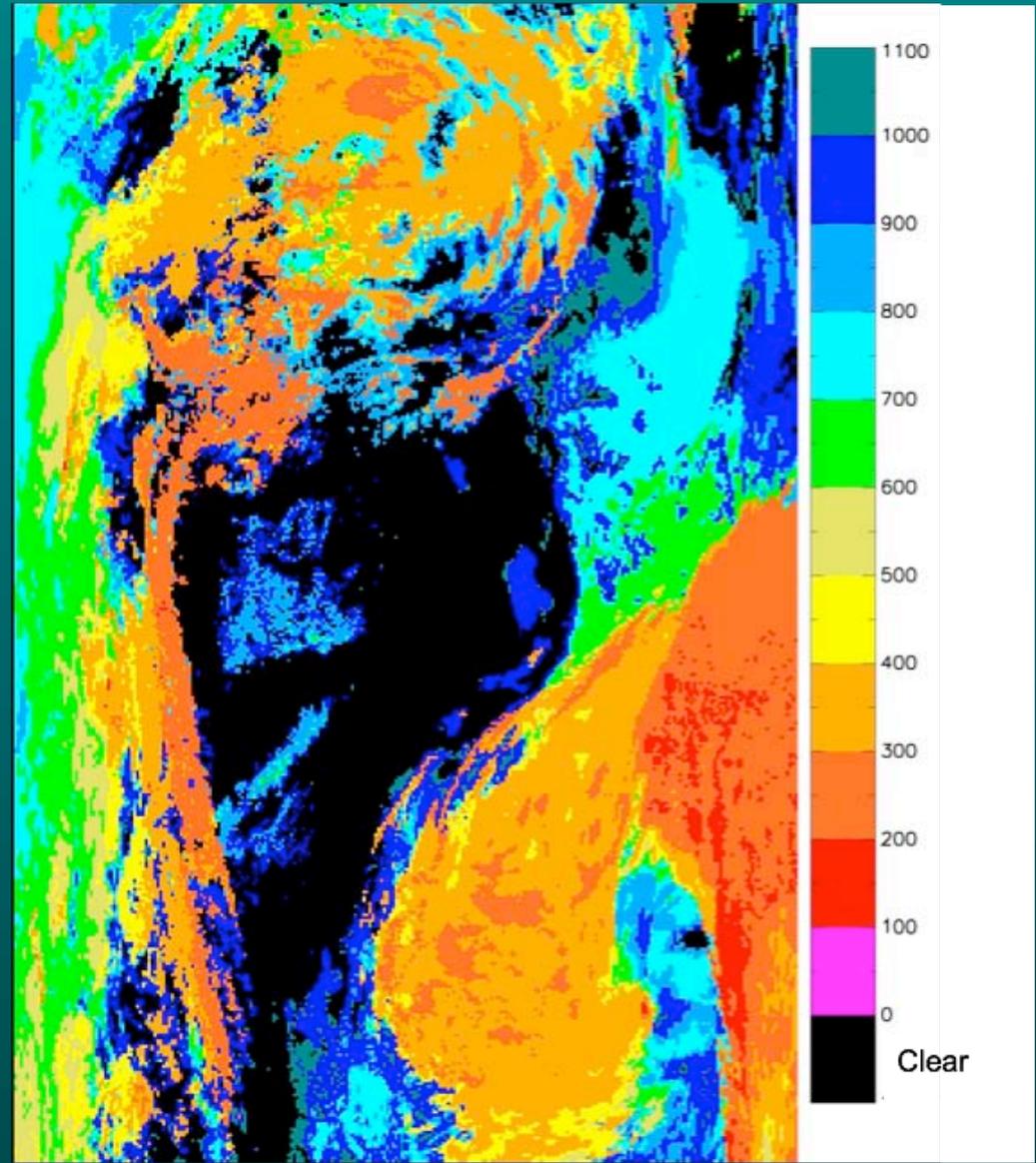
Out of a long list of changes, two stand out:

1. Use of CALIOP to compare with MODIS cloud heights
2. MODIS IR cal/val activity using AIRS

August 28, 2006; 1630 UTC, Aqua MODIS

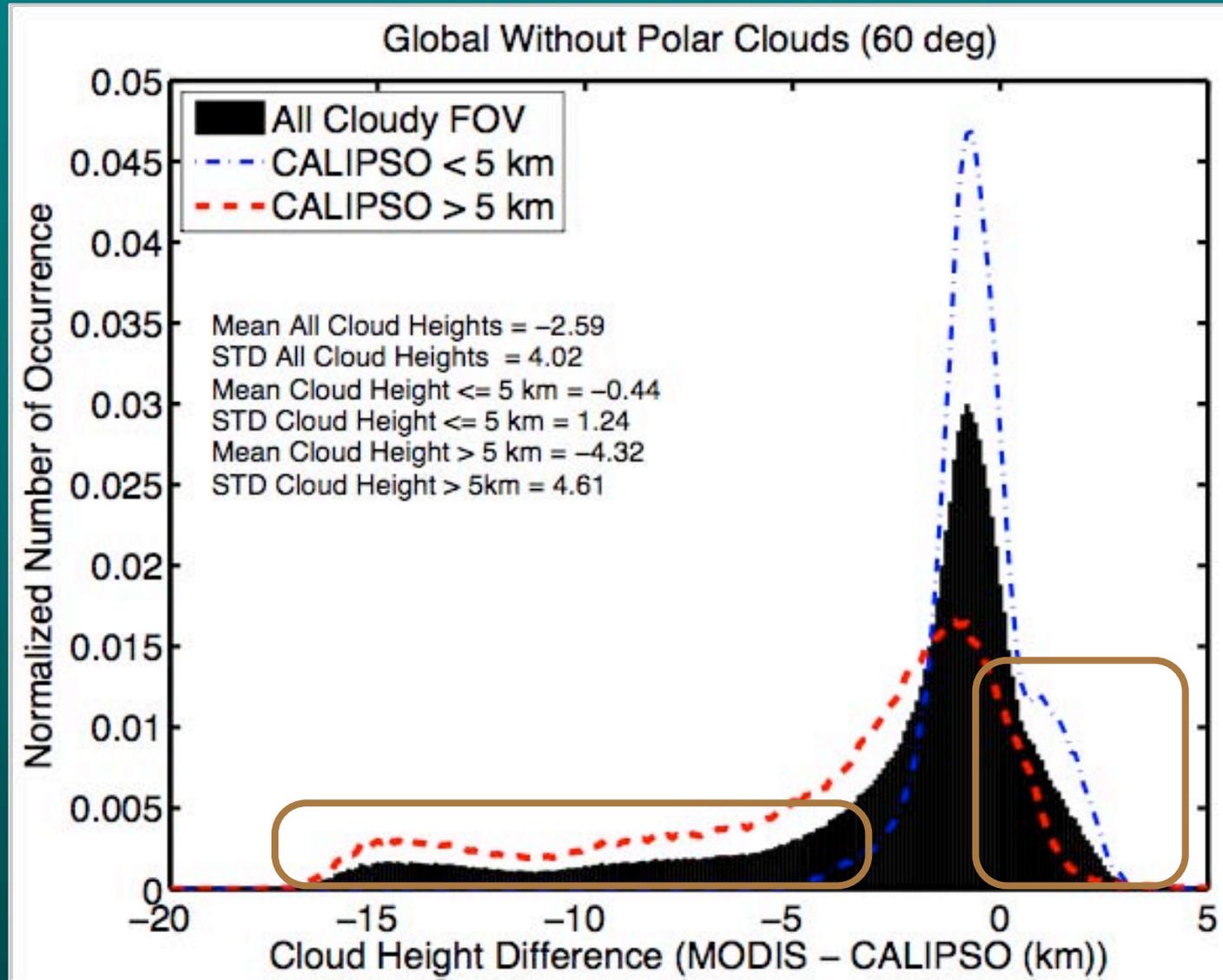


False color image
Red: 0.65 μm ; Green: 2.1 μm ; Blue: 11 μm

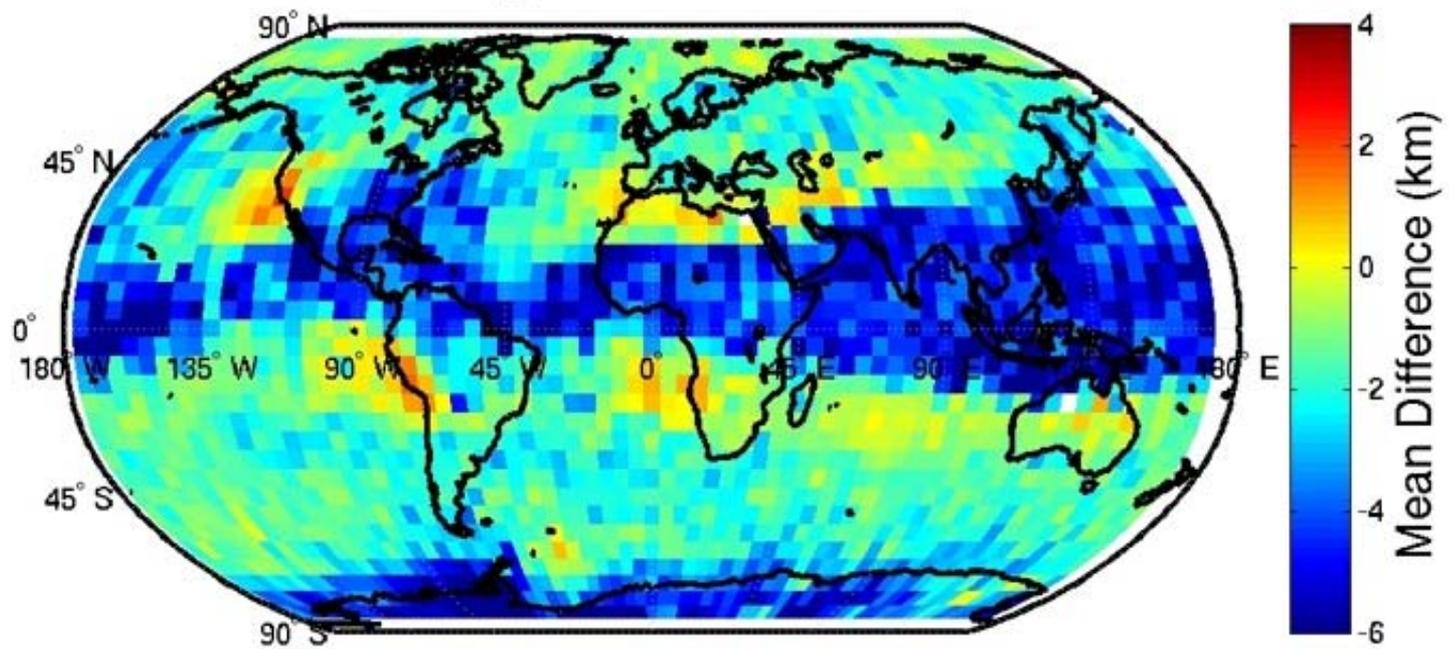


MODIS Collection 5 Cloud Top Pressures (hPa)
at 5 km resolution

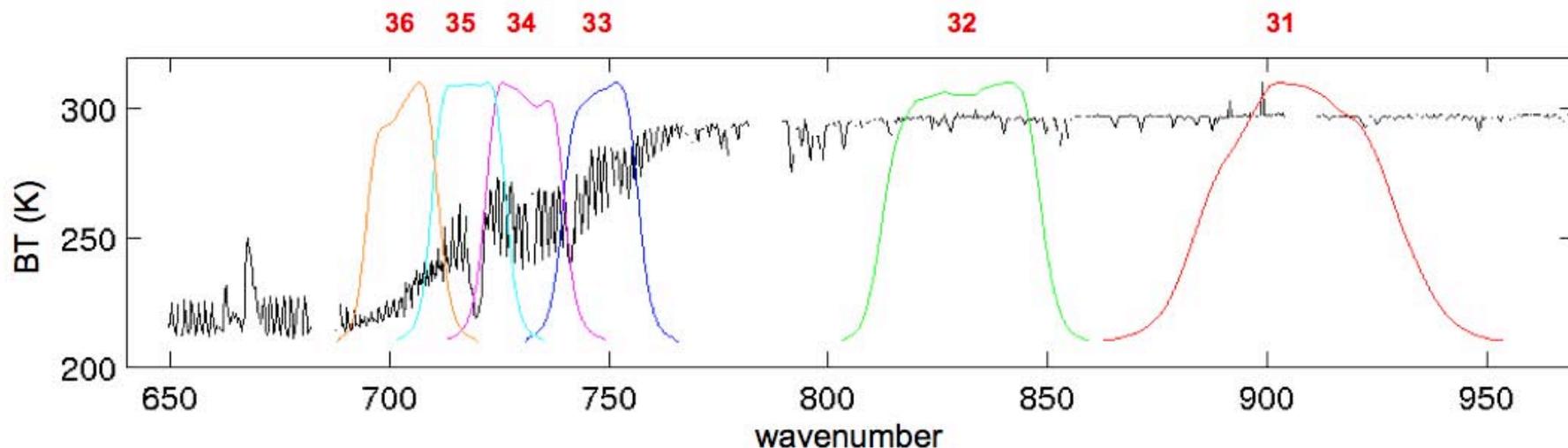
MODIS-CALIOP Matchups for August 2006



August 2006 DAAC



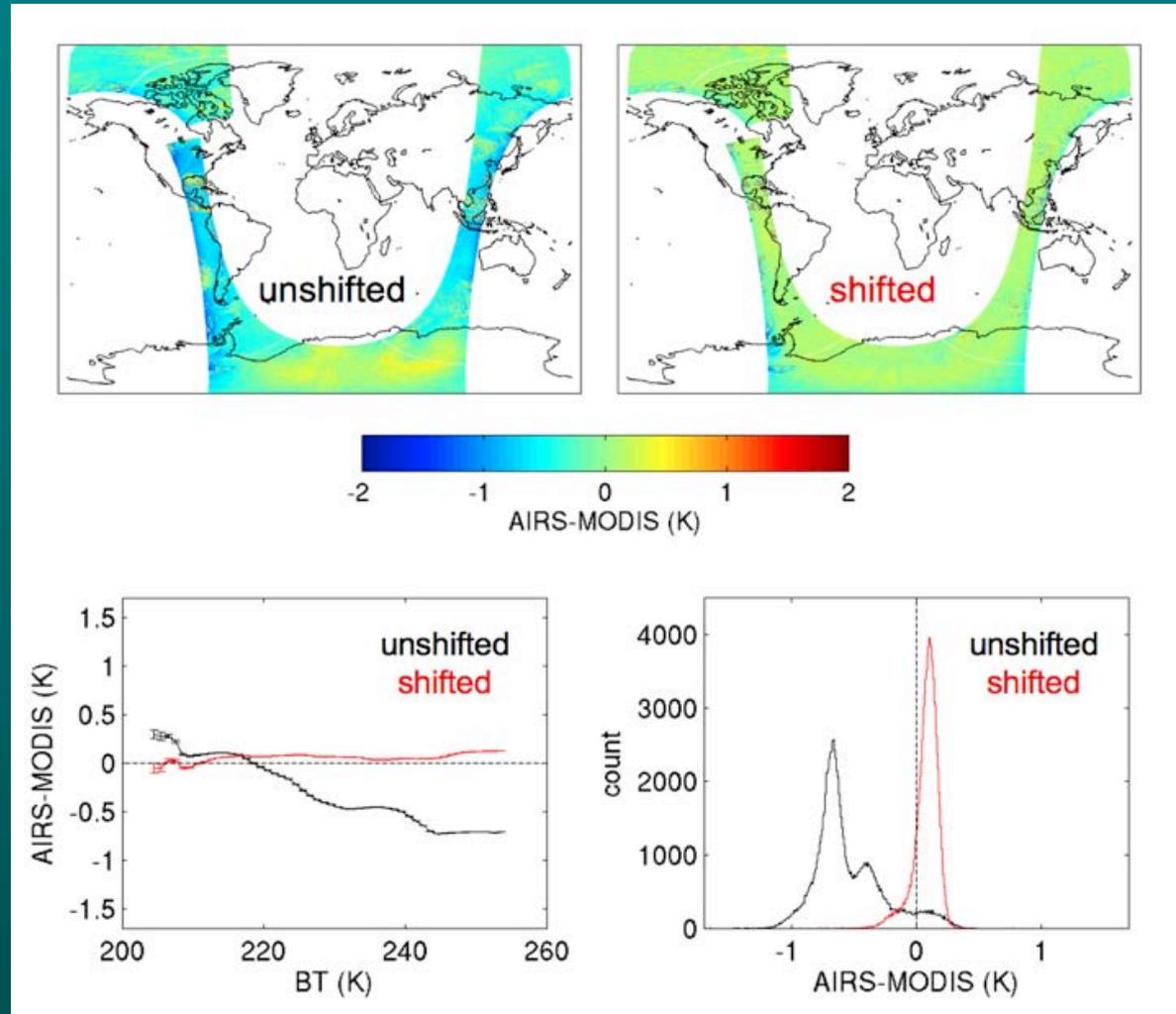
Evaluation of MODIS Spectral Response Functions Using AIRS



A sample AIRS brightness temperature spectrum (black line) collected on 18 February 2004 at ~0630 UTC off the east coast of Florida with the detector averaged Aqua MODIS spectral response functions (SRFs) overlaid. The MODIS spectral band numbers are noted along the top of the panel, with central wavelengths as follows: 31 ($11 \mu\text{m}$), 32 ($12 \mu\text{m}$), 33 ($13.3 \mu\text{m}$), 34 ($13.6 \mu\text{m}$), 35 ($13.9 \mu\text{m}$), and 36 ($14.2 \mu\text{m}$).

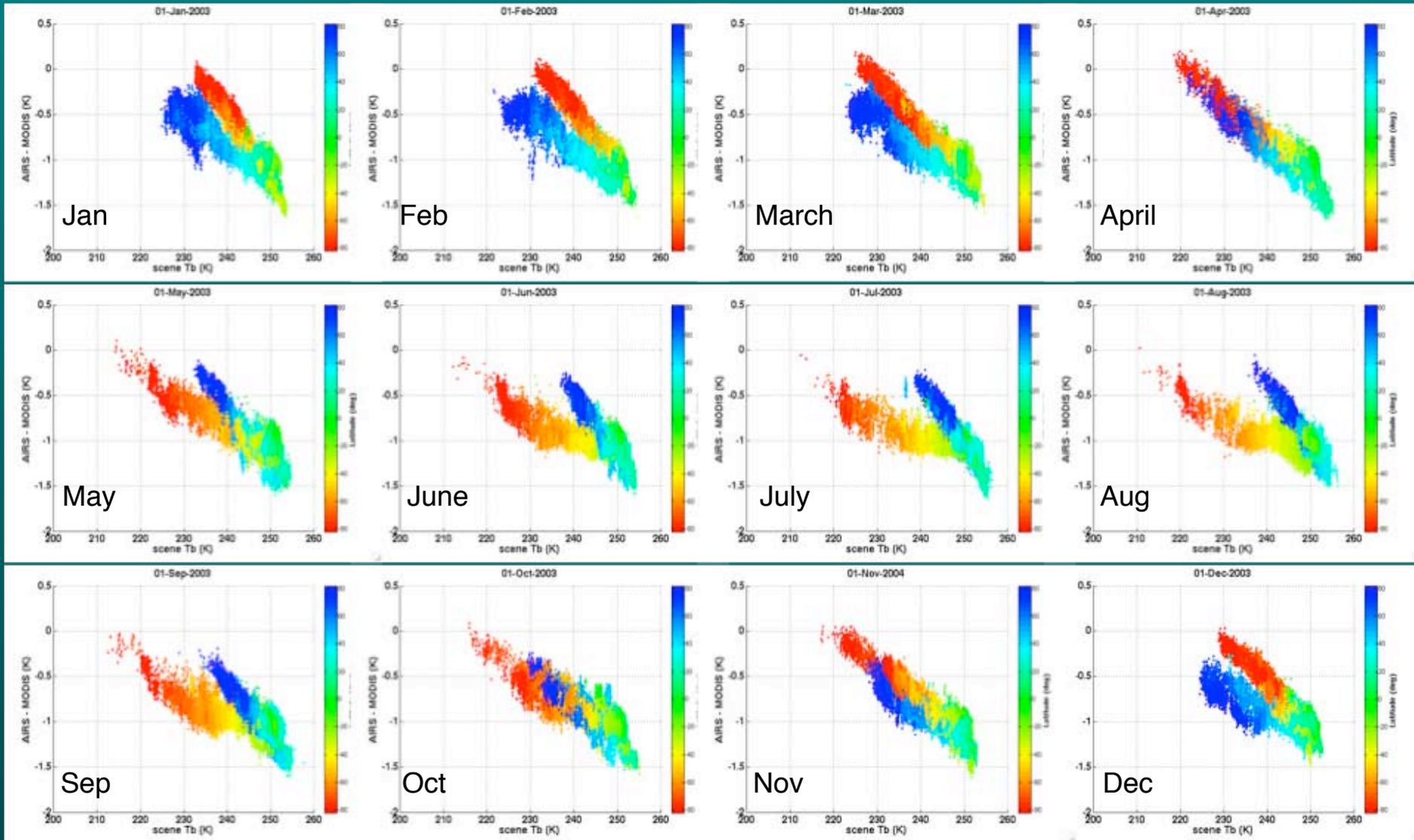
Tobin, D. C., H. E. Revercomb, C. C. Moeller, and T. S. Pagano, 2006: Use of Atmospheric Infrared Sounder high-spectral resolution spectra to assess the calibration of Moderate resolution Imaging Spectroradiometer on EOS Aqua. *J. Geophys. Res.*, 111, D09S05, doi:10.1029/2005JD006095.

AIRS minus MODIS Comparison: 13.9 microns



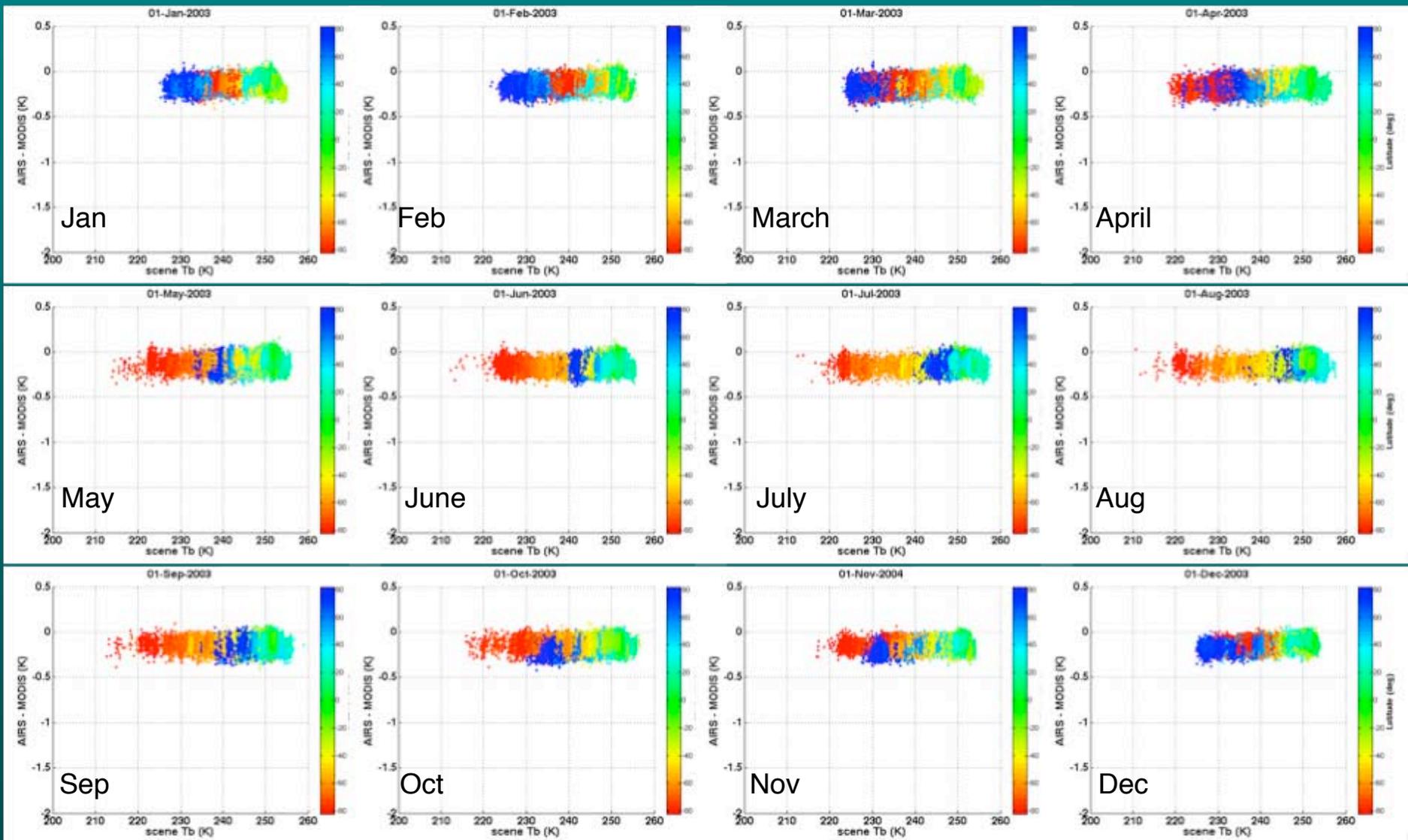
MODIS Band 35 ($13.9 \mu\text{m}$) brightness temperature differences using the nominal detector averaged MODIS SRF and using the SRF shifted by $+0.8 \text{ cm}^{-1}$ (15.5 nm) for one orbit on 6 September 2002. The panels are images of the brightness temperature differences without (left) and with (right) the shift.

AIRS minus MODIS, Band 35 (13.9 microns)



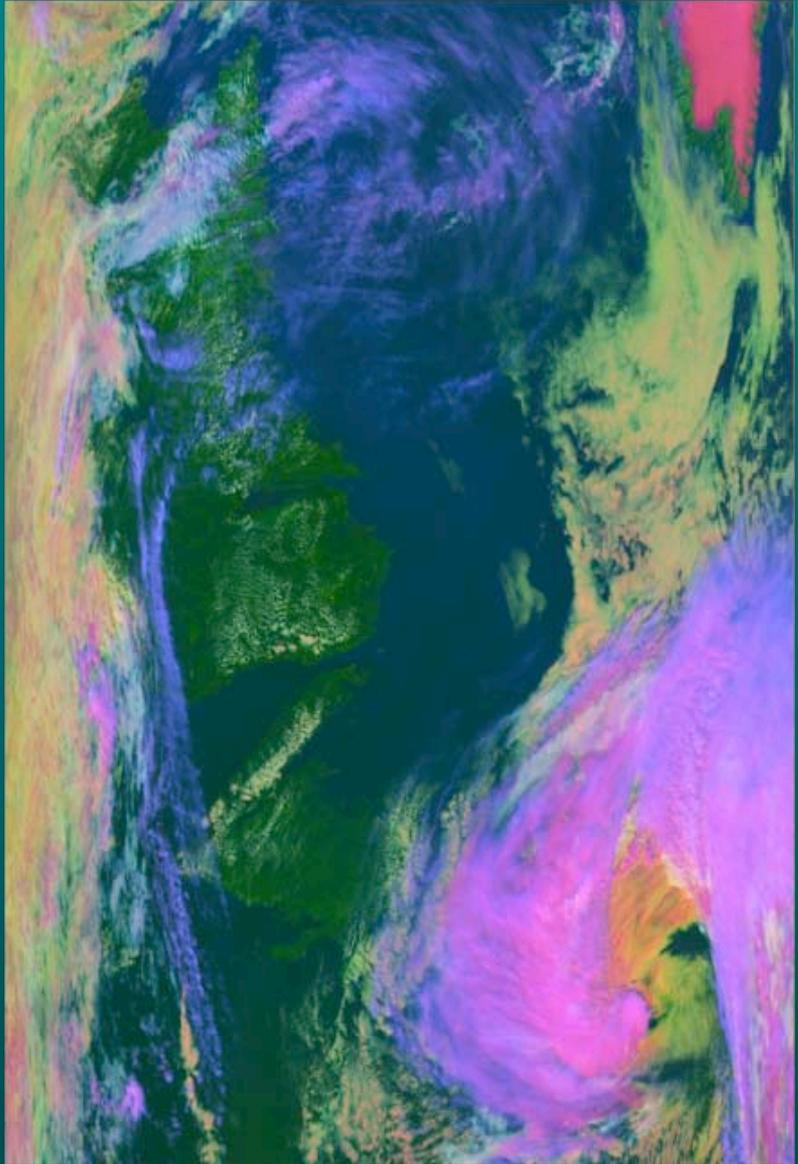
Recent test processed global MODIS/AIRS radiance data for 1st day of each month since launch
Provides a way to monitor IR band calibration over time

AIRS-MODIS, Band 35 with 0.8 cm⁻¹ SRF shift

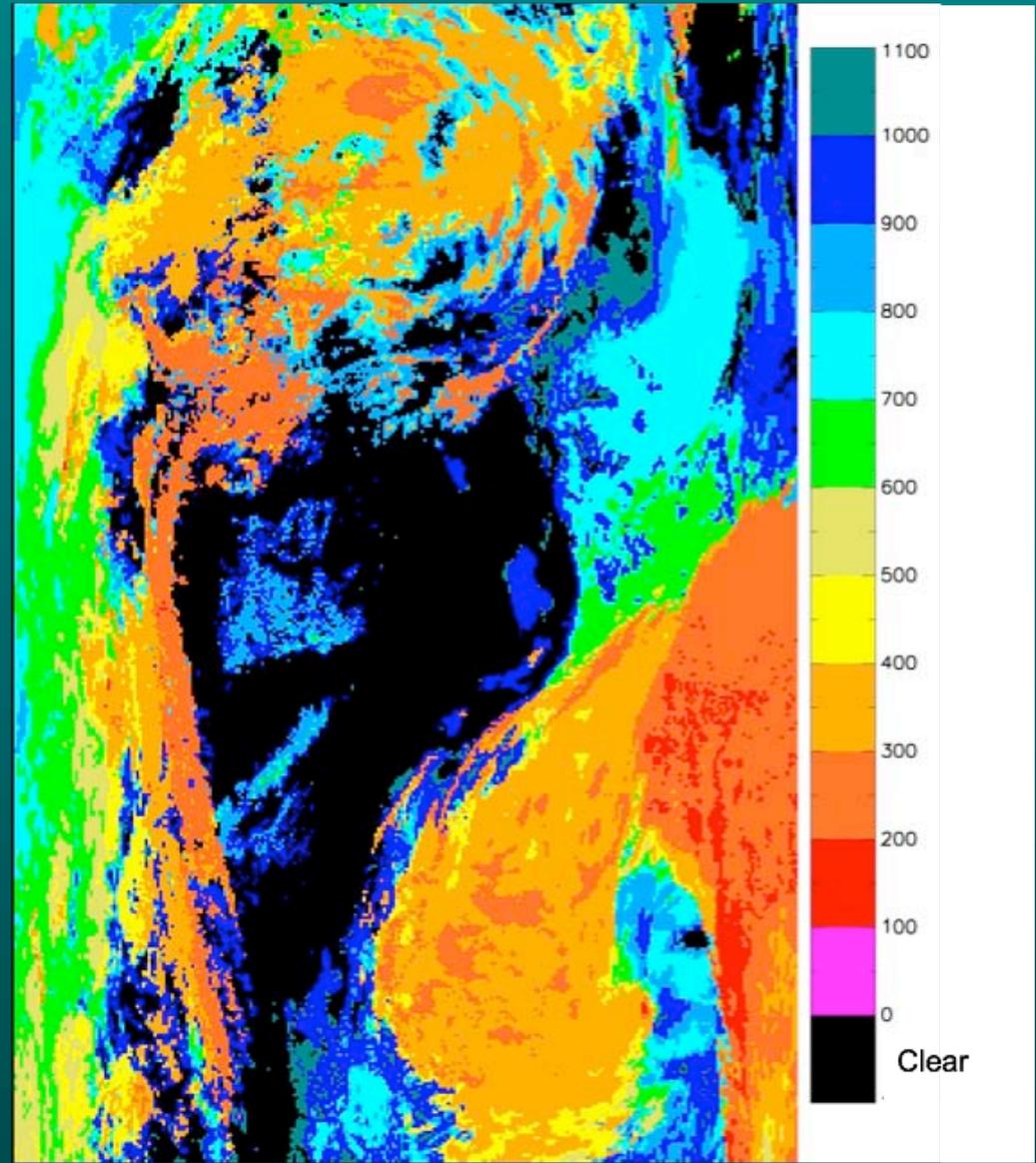


This process will be automated in the PEATE
Will be extended to METOP platform with IASI-AVHRR/HIRS

August 28, 2006; 1630 UTC, Aqua MODIS

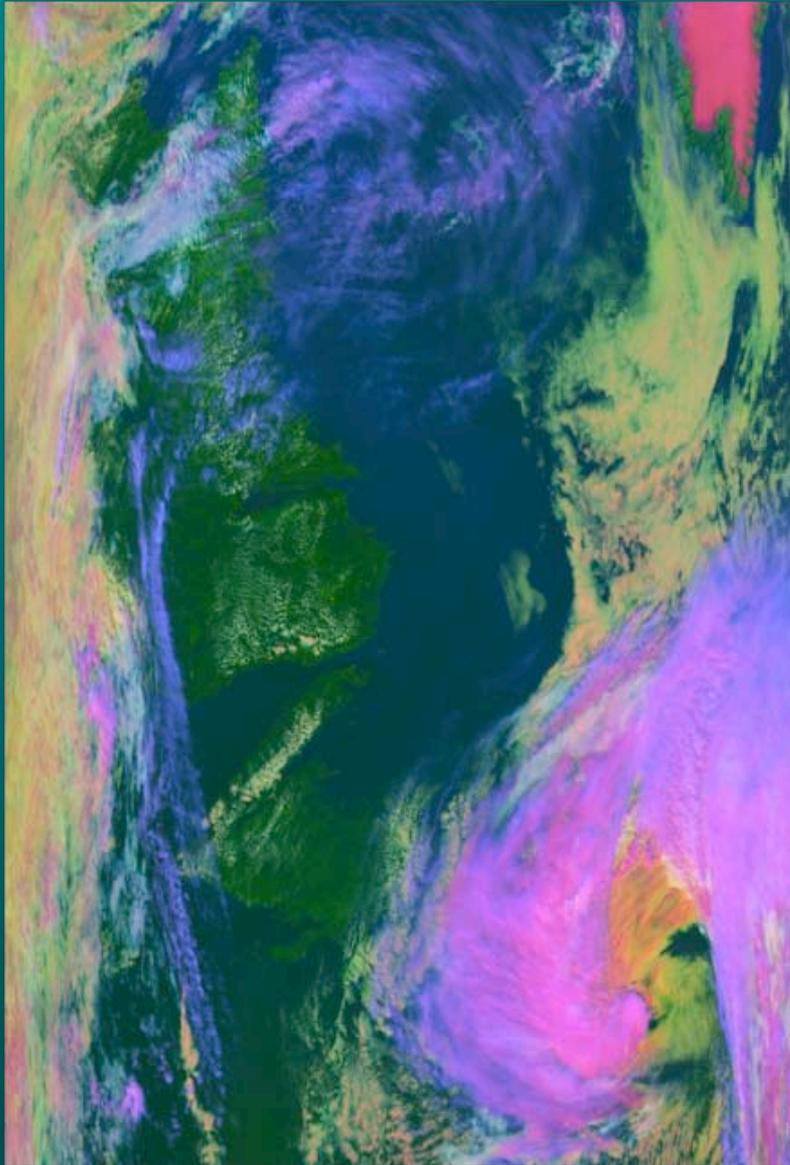


False color image
Red: 0.65 μm ; Green: 2.1 μm ; Blue: 11 μm

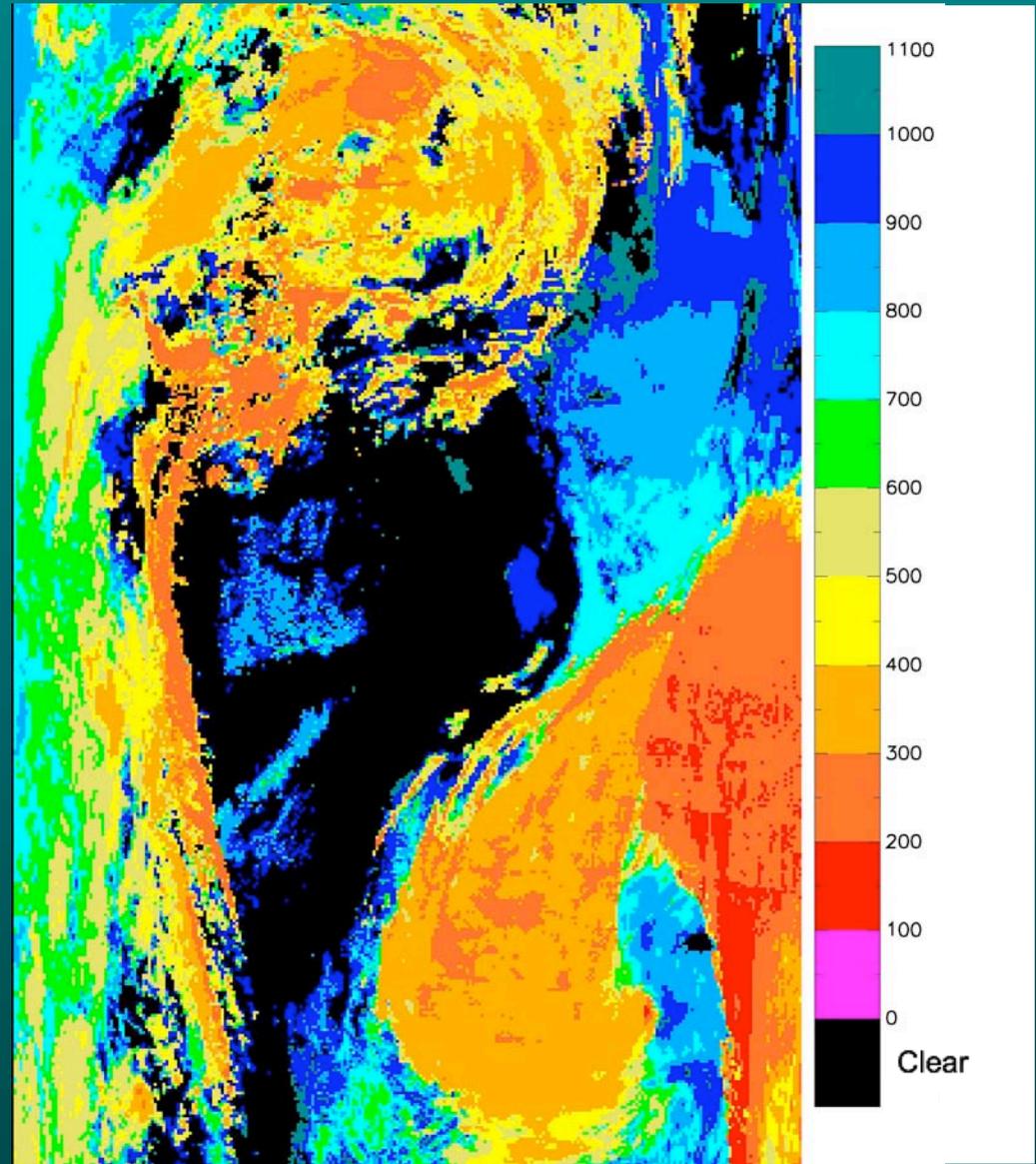


MODIS Collection 5 Cloud Top Pressures (hPa)
at 5 km resolution

August 28, 2006; 1630 UTC, Aqua MODIS

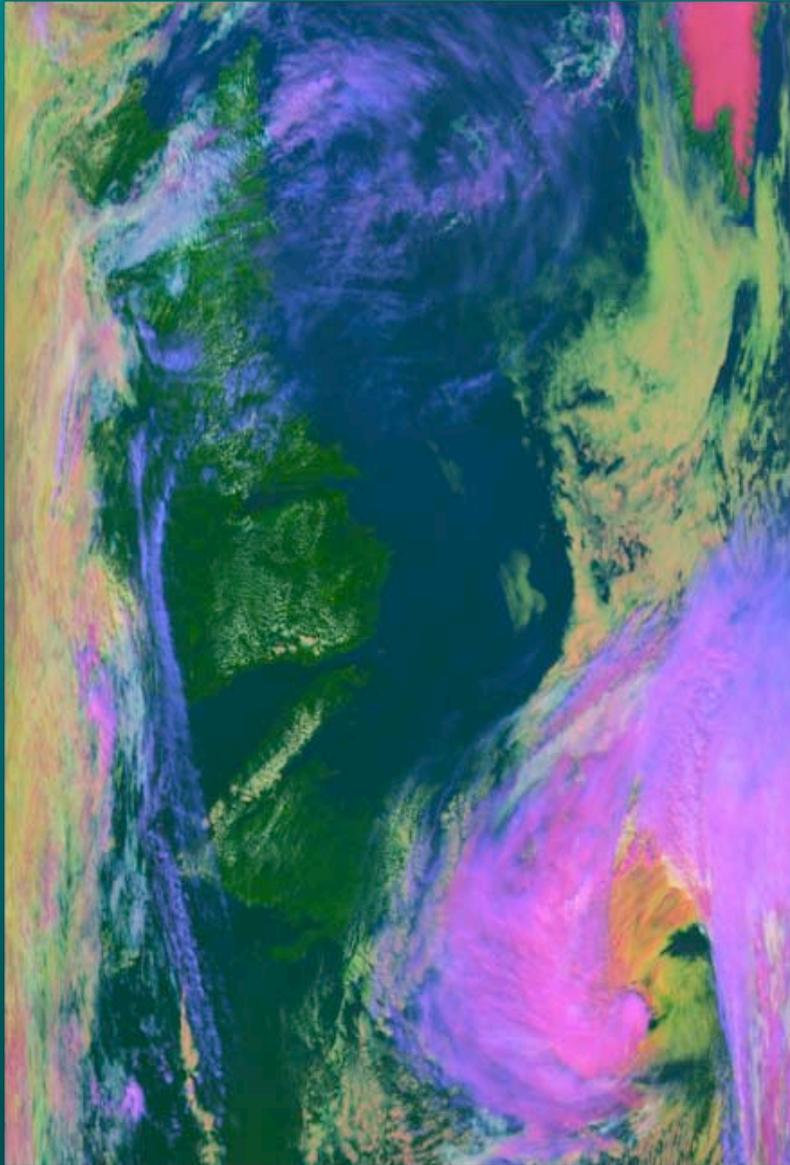


False color image
Red: 0.65 μm ; Green: 2.1 μm ; Blue: 11 μm

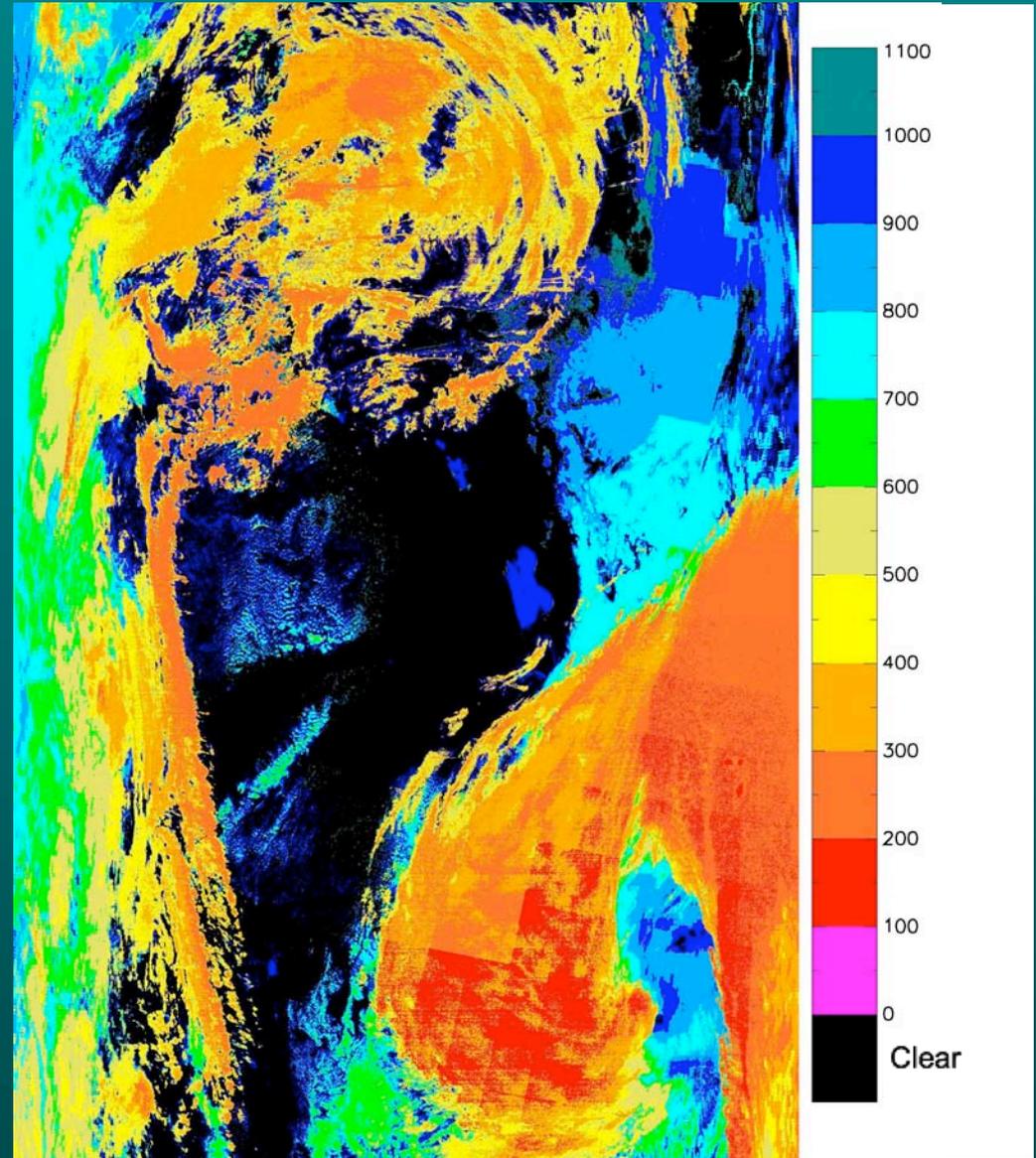


MODIS Pre-Collection 6 Cloud Top Pressures (hPa)
at 5 km resolution

August 28, 2006; 1630 UTC, Aqua MODIS

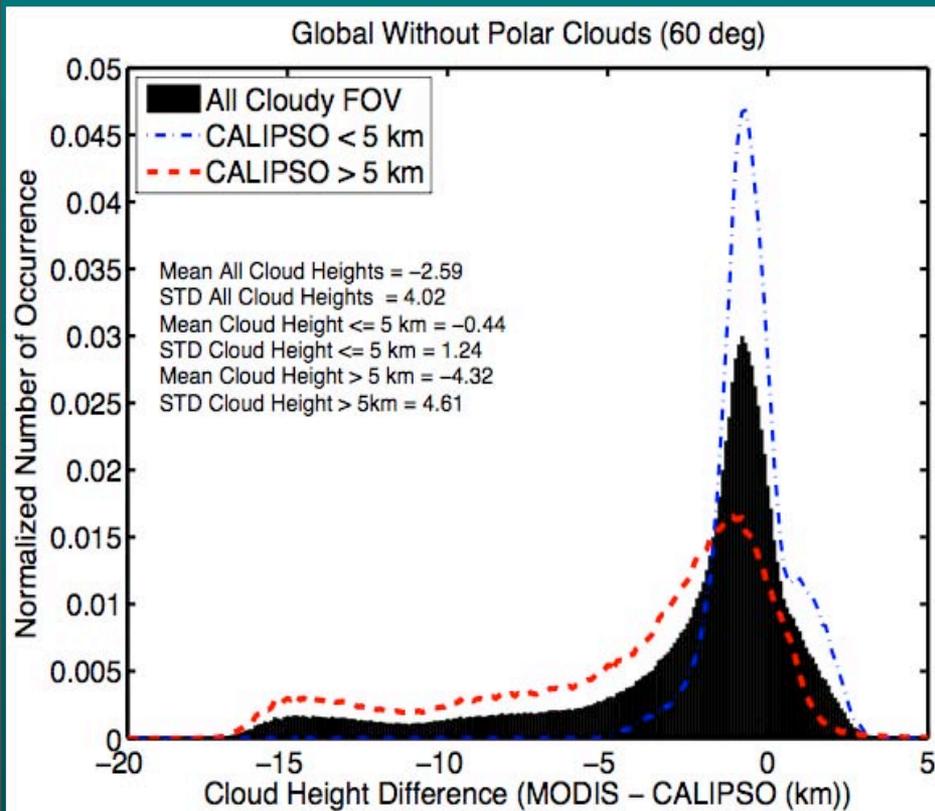


False color image
Red: $0.65 \mu\text{m}$; Green: $2.1 \mu\text{m}$; Blue: $11 \mu\text{m}$

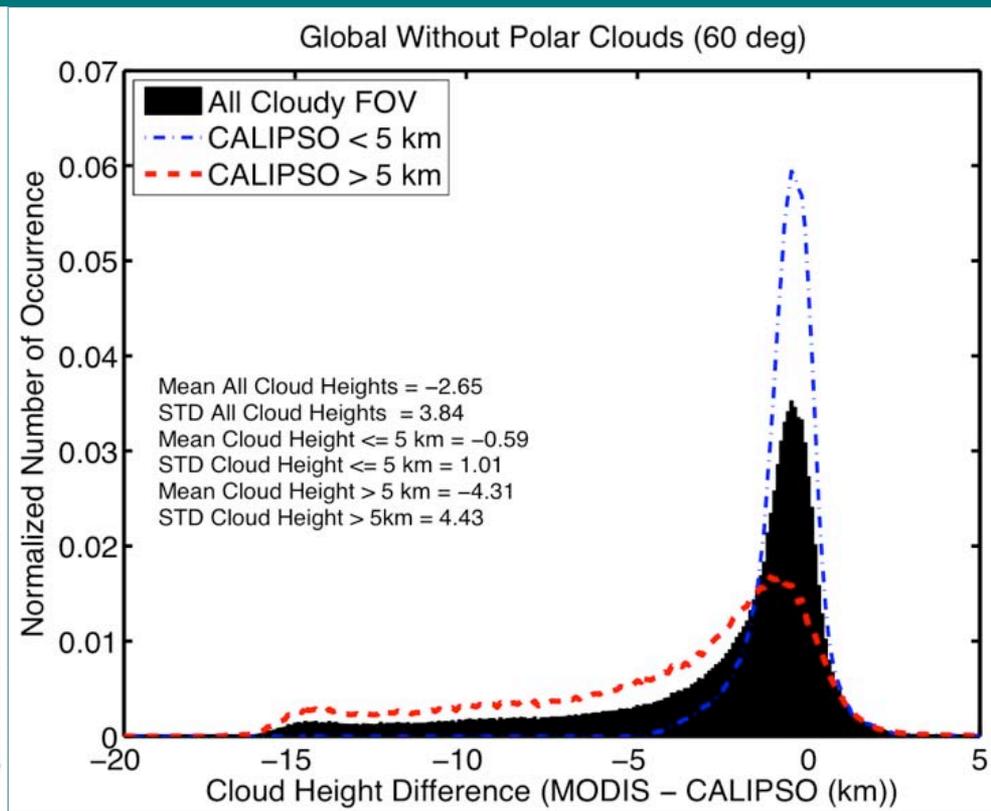


MODIS Cloud Top Pressures (hPa)
at 1 km resolution from LEOCAT

MODIS-CALIOP Matchups for August 2006



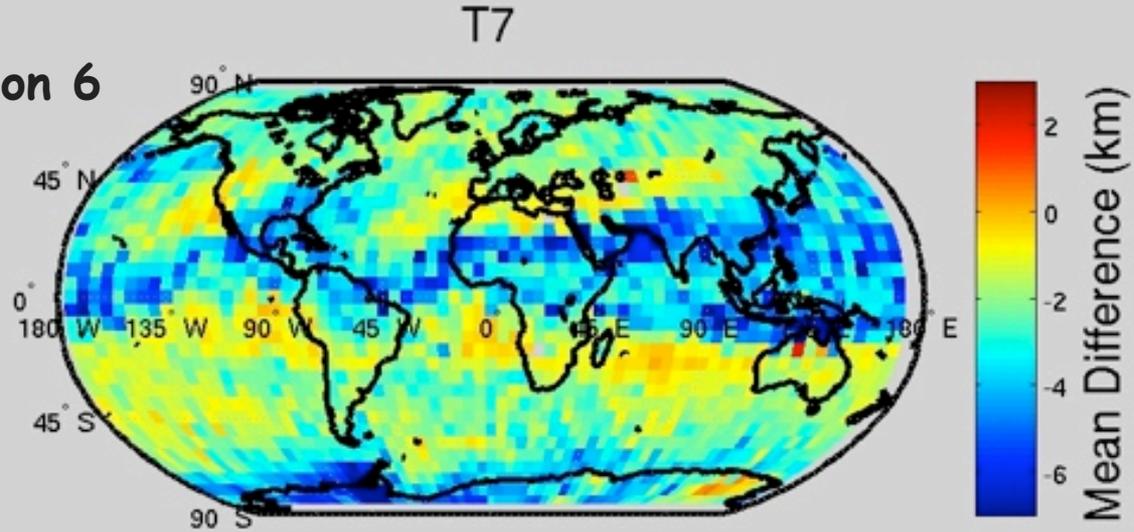
Collection 5



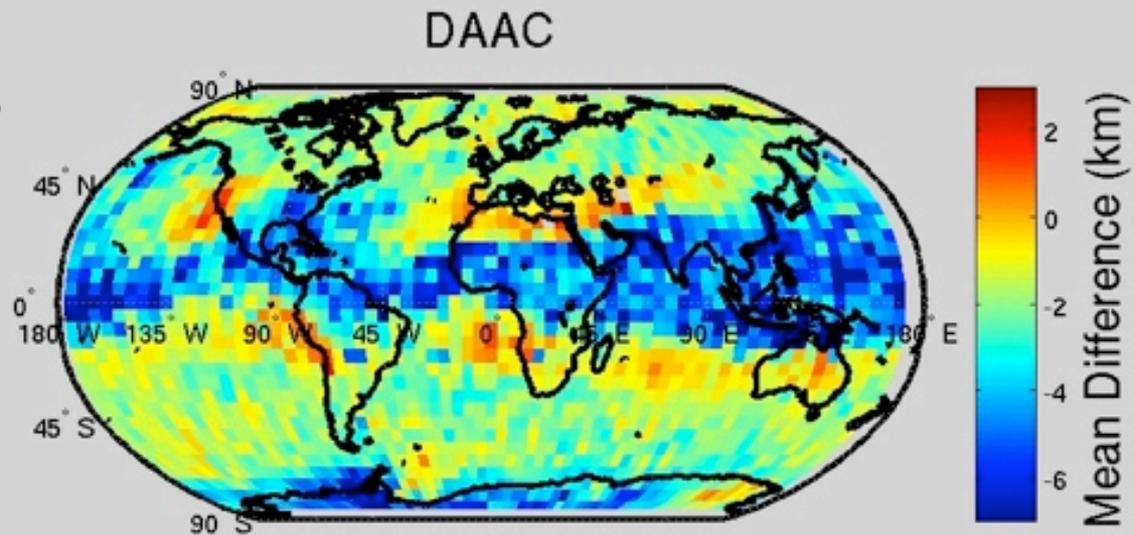
Pre-Collection 6

MODIS-CALIPSO Results for August 2006

Pre-Collection 6



Collection 5



In Summary...

MODIS Collection 6 (C6) cloud products showing improvement over C5 through

- a. intercomparison with CALIOP products
- b. IR cal/val using AIRS

In Collection 6, MODIS cloud-top properties will be provided at both 1- and 5-km resolution

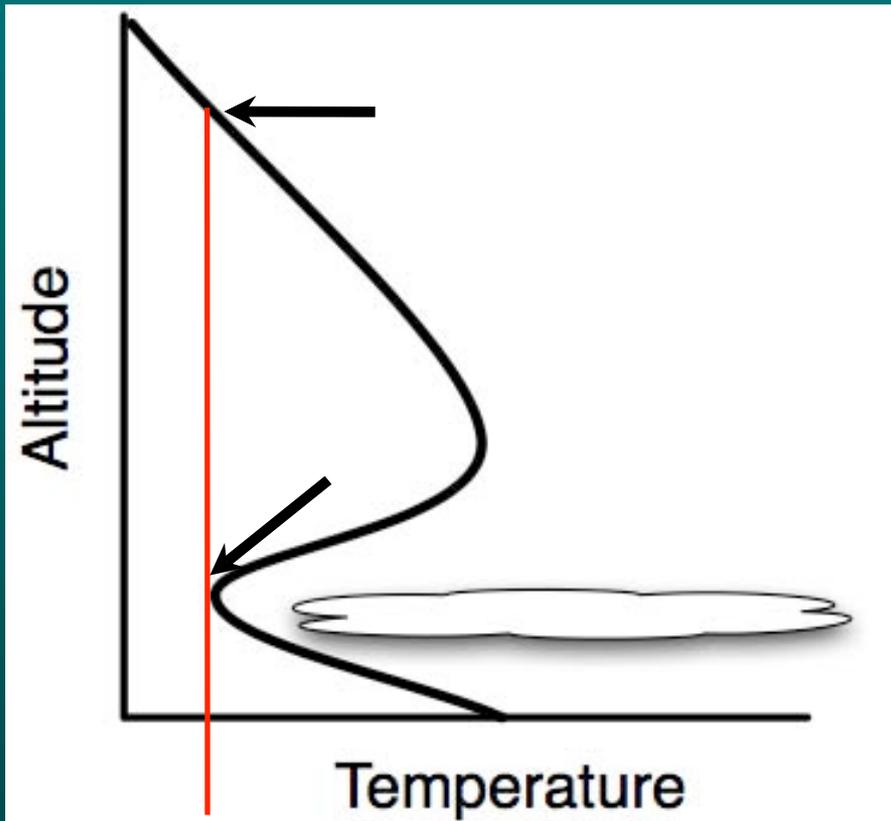
- RT calculations will be based on spectrally-shifted Aqua IR bands
- still unsure of what to do with MODIS-Terra IR cal/val
- low-level clouds will be lower compared to C5 (by about 100 hPa)
- more optically thin high clouds compared to C5

Next generation of ice bulk scattering models in the works:

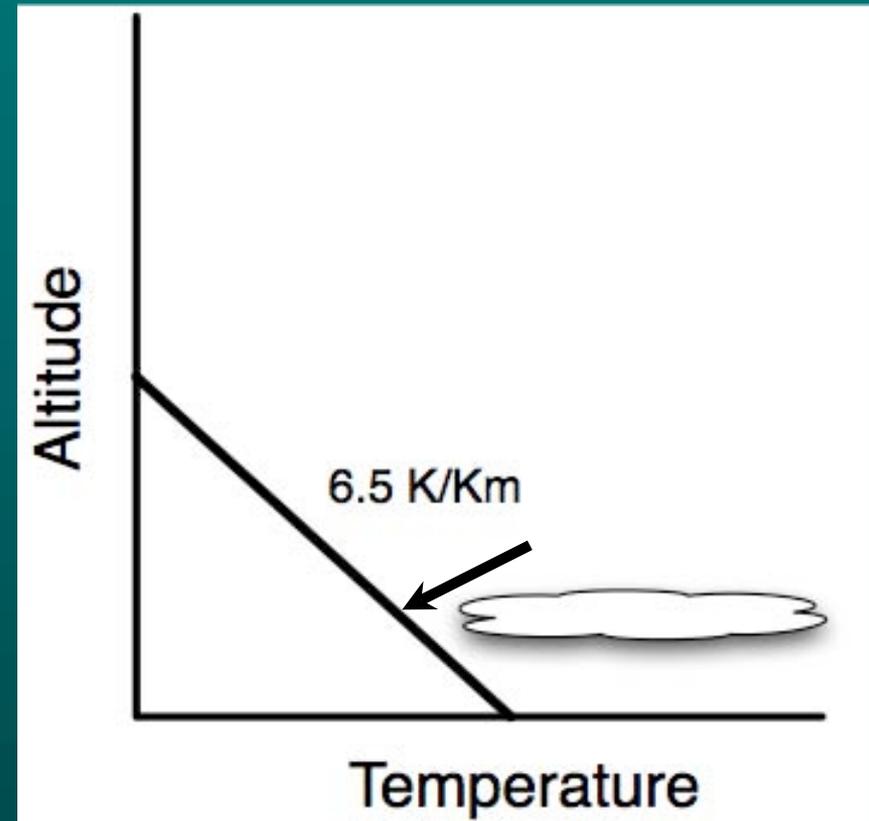
- surface roughening (smooth, moderately roughened, and severely roughened)
- hollow bullet rosettes and aggregates of plates
- based on new Warren and Brandt (JGR, 2008) ice index of refraction
- based on order of magnitude more discrete microphysical measurements
- in SW, no longer will have delta transmission term

Clouds in presence of temperature inversions

MODIS Collection 5



Modified



Minnis et al., Stratocumulus cloud properties derived from simultaneous satellite and island-based instrumentation during FIRE. *J. Appl. Meteor.*, 31, 317-339, 1992.

Zonal Mean Lapse Rates (surface to cloud tops < 3 km)
Computed from Collocated MOD06CT-1km and CALIOP 1-km Data

