The Atmospheres Team PEATE: Status and Issues

Bryan A. Baum
Robert Holz, Rich Frey, Paul Menzel
Liam Gumley...

Space Science and Engineering Center
University of Wisconsin-Madison

Andrew Heidinger and Michael Pavolonis

NOAA/NESDIS

Steve Platnick and Christina Hsu

NASA GSFC

and many others

MODIS-VIIRS Science Team Mtg
May 14-16, 2008

NPP Cloud/Aerosol Science Goals

Assess NGST cloud/aerosol Environmental Data Records (EDRs)

Assess ability of NGST EDRs to be Climate Data Records (CDRs)

Bring our experience in operational processing of satellite data and cal/val to the effort

Want high quality EDRs, but need to balance product latency (need results quickly) with algorithm complexity (tends to increase processing time)

Maintain (or exceed) expectations of various user communities

Considerations for accurate aerosol/cloud CDRs

Attention to details, such as

orbital drift

calibration

trace gases changing concentration over time

spectral shifts between successive instruments for channels of the "same" nominal wavelength

improvements in forward RT models

improvements/changes in ancillary data
- updates in meteorological gridded products
- global 1-km albedo and emissivity maps now available

sampling (treatment of temporal/spatial data gaps)

sensor-specific issues
- out of band response
- spectral response functions
- instrument idiosyncracies

PATMOS-x: AVHRR-based Cloud Climatology

The AVHRR Pathfinder Atmospheres Extended (PATMOS-x) Project is the climate component to CLAVR-x; the operational AVHRR cloud processing system within NESDIS

PATMOS-x provides a significant upgrade to the original PATMOS project of the 1990's

Produces a full suite of cloud macrophysical and microphysical properties from 1981 to present

PATMOS-x can process the entire Level-1b record in roughly 2 months. Reprocessing is initiated as algorithm and calibration improvements warrant. A new reprocessing will be done this summer.

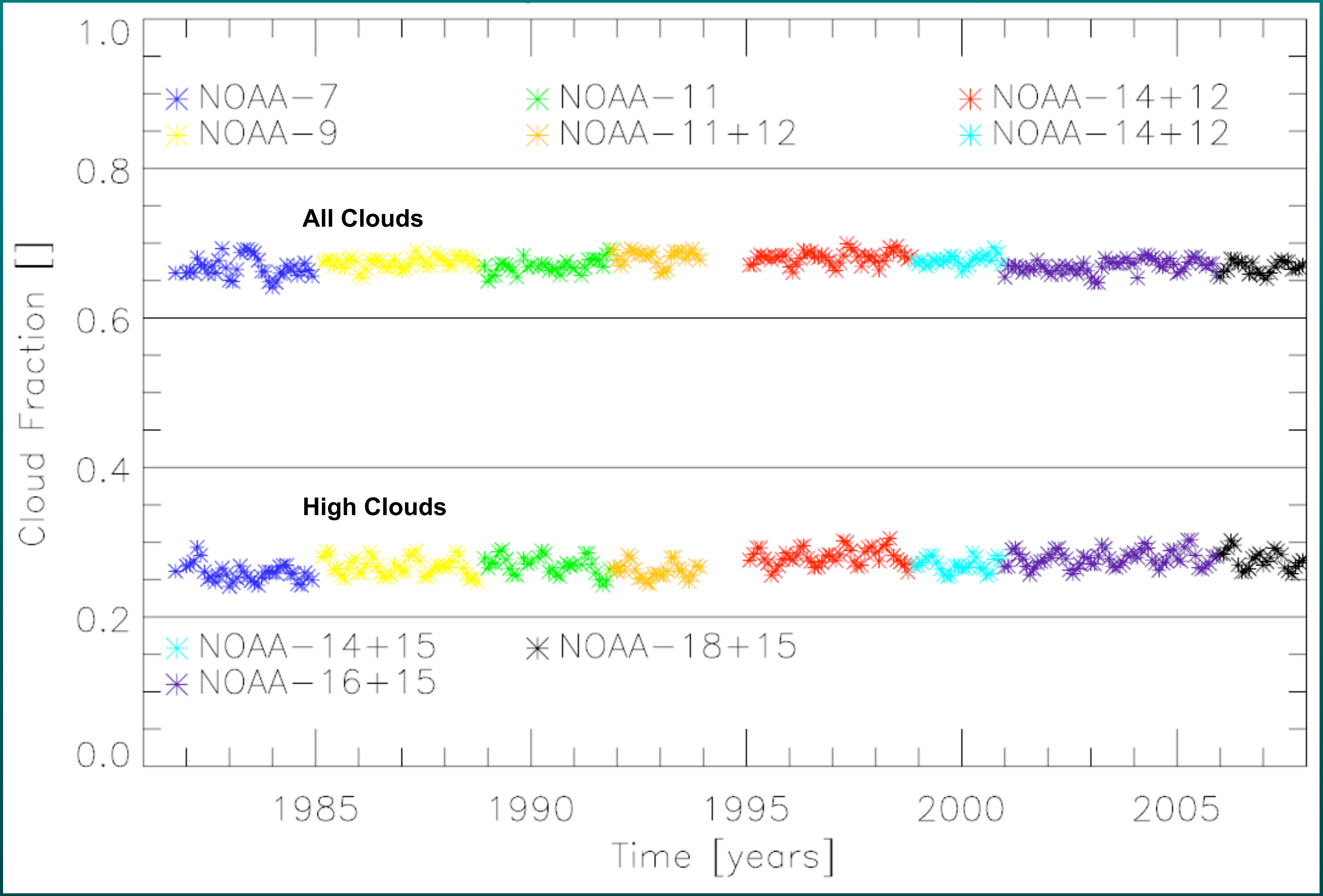
Uses improved AVHRR radiometric and geolocation methods developed in NESDIS

PATMOS-x employs a split-window approach that derives cloud temperature, emissivity and β, a microphysical index from the 11 and 12 μm observations.

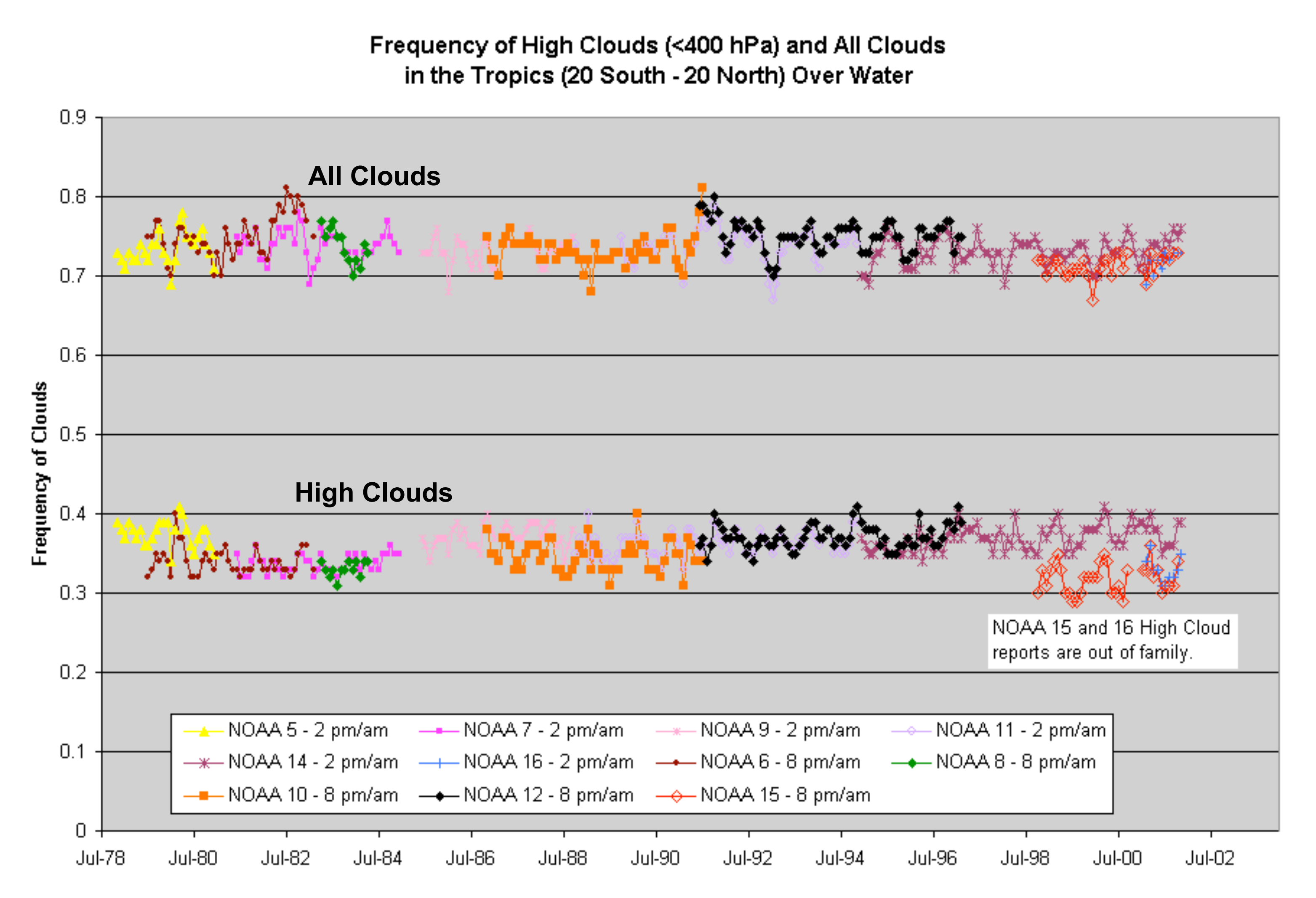
This method provides consistent day/night performance so properties are derived 4 times per day (since 1991) and this reduces sensitivity to orbital drift.

Employs a 1D-VAR approach that provides estimates of error characteristics

PATMOS-x V4 Total and High Cloud Fraction Time Series: 1981-2007



HIRS/2-HIRS/3 Total and High Cloud Fraction Time Series: 1978-2002



Wylie, D., D.L. Jackson, W.P. Menzel, and J.J. Bates, 2005: Trends in Global Cloud Cover in Two Decades of HIRS Observations. J. Climate, **18**, 3021–3031.

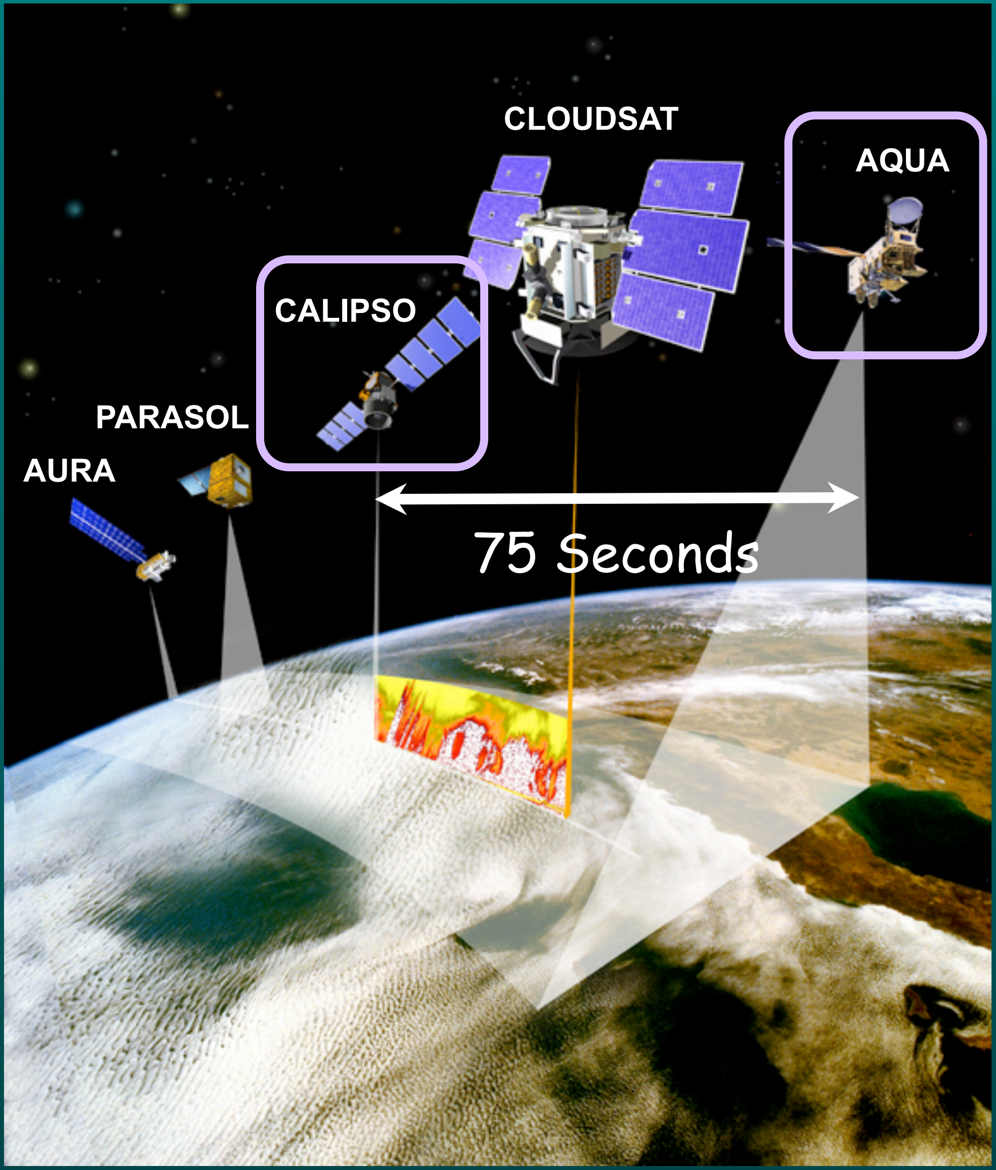
Intercomparison of CALIOP and Aqua Data

CALIOP data: about 80 m resolution

MODIS cloud products at both 1 & 5 km

Process goes like this:

1. Determine mechanics of how to link observations from two different spaceborne platforms (i.e., Aqua and CALIPSO)
2. Link viewing geometry to obtain correspondence between observations
3. Strip out the appropriate data products (may mean multiple granules)
4. Build matchup files



Goal: Continuous improvement in cloud/aerosol products

Strategy for product improvement:

- develop protocols for instantaneous parameter comparisons

- prioritize problem regions

- team collaborates to perform detailed investigation

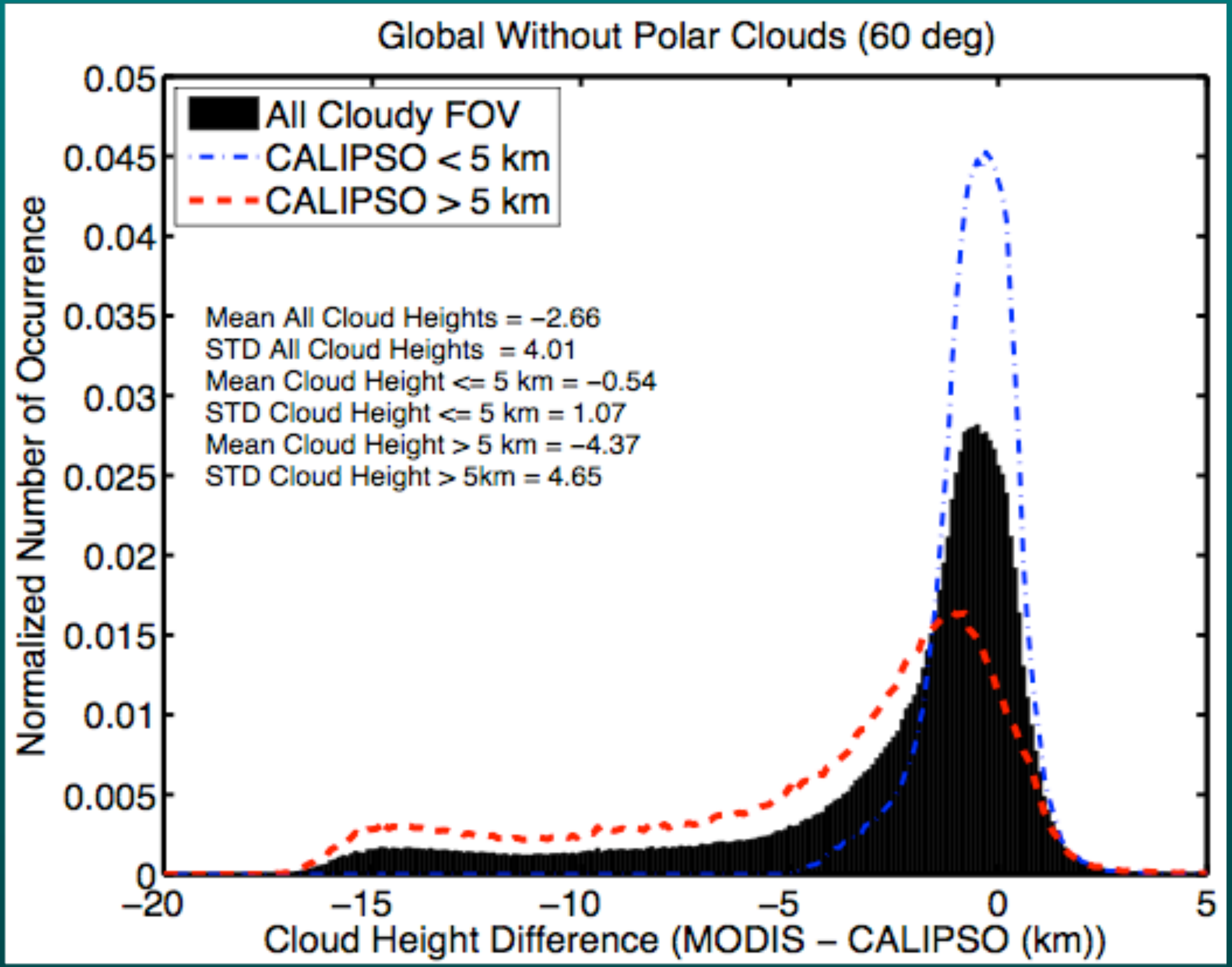
- develop and test solutions efficiently

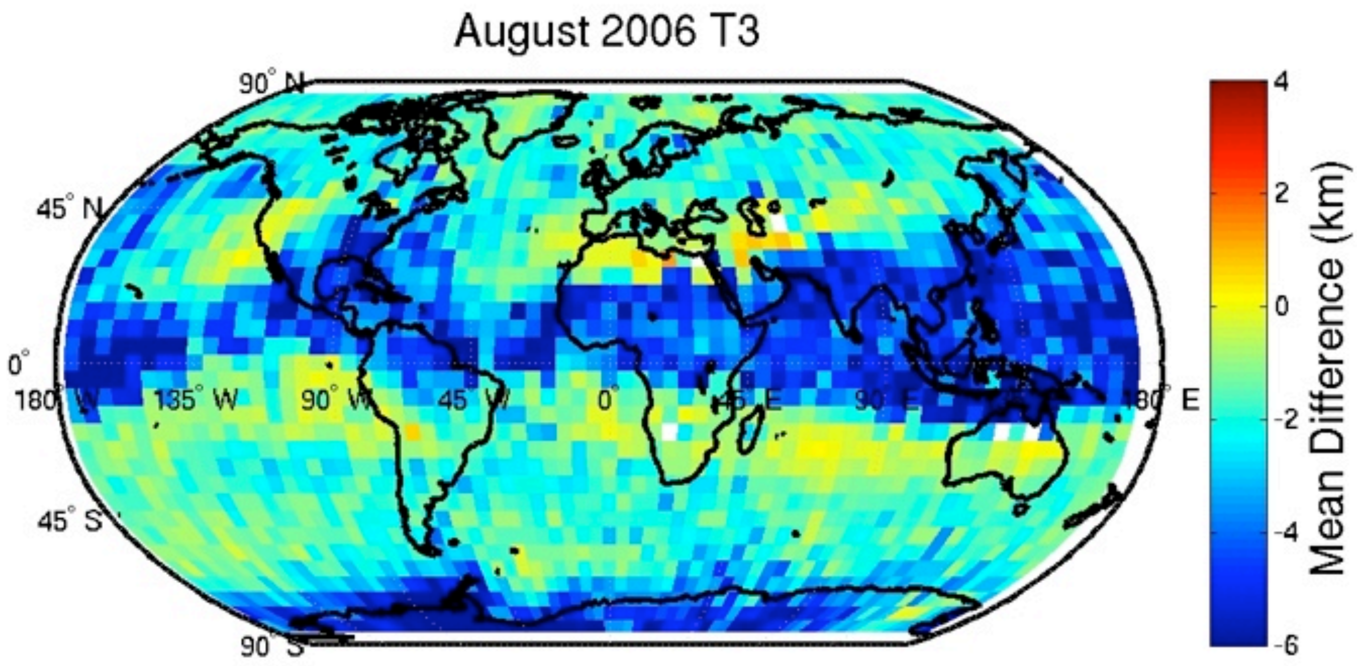
- test proposed solutions on global data and quantify improvement

Recent paper by Holz et al: Global MODIS cloud detection and height evaluation using CALIOP. In press, J. Geophys. Res.

SSEC

Sorting out the CALIOP-MODIS Matches





August 2006 T3
90° N
45° N
0°
45° S
90° S
180° W
135° W
90° W
45° W
0°
45° E
90° E
180° E
Mean Difference (km)
4
2
0
-2
-4
-6

Issues with Transition from EOS to NPP

Heritage algorithms are not "static"

MODIS cloud top property software is about 10 years old, and is showing its age

A goal is to have 1-km cloud-top properties, but current operational code is unwieldy and major changes to the structure are impractical

We need to investigate NGST algorithm performance and compare directly to heritage approaches

Given the time and funding constraints, we need to adopt a different approach

The PEATE offers a new paradigm

NPP Atmosphere PEATE at SSEC

PEATE: Product Evaluation and Test Element

- Supports NPP Science Team evaluation of standard VIIRS (Raw, Sensor, and Environmental) Data Records

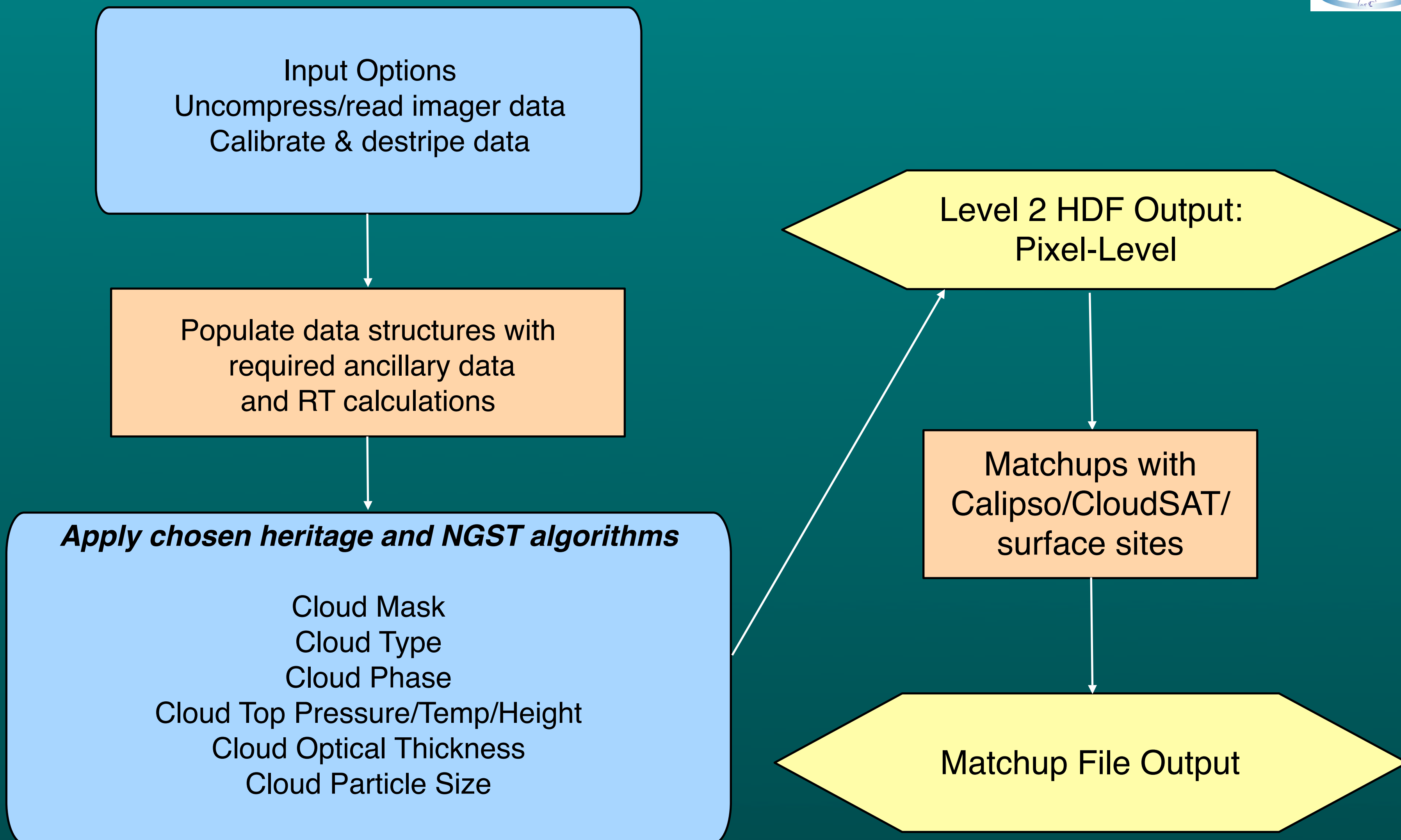
- Current implementation is a Linux cluster (combination of dual- and quad-core compute nodes)

- Serves as a building block for constructing decadal, multi-satellite climatology of cloud properties

- Facilitates the development of measurement-based multi-mission satellite retrieval algorithms and software

- Uses available validation data for rapid pre- and post-launch assessment of NPP EDRs and SDRs

Low Earth Orbiter Cloud Algorithm Testbed: LEOCAT



To give an idea of PEATE processing times

Average processing times for different stages in the processing of one MODIS granule (5 minutes of data):

1. Data transfer to compute node (~10 sec)
2. Uncompress the MYD01 (Level 1) data (33 sec)
3. Geolocation (34 sec)
4. Calibration (76 sec)
5. Destripe IR bands + 1.38-micron band (3 sec)
6. Operational MODIS cloud mask (70 sec)
7. Operational MOD06 cloud-top pressure (46 sec)
8. Operational MOD06 optical properties (360 sec, daytime only)
9. Collocation with CALIPSO (~10 sec)
10. Compare CALIPSO product to MODIS product (~20 sec)
11. Store data products and matchup files (~2 sec)

Total: ~ 10 min/granule daytime [2030 or 2040 scans/granule, 1354 pixels/scan: ~2.7 million pixels/granule]
~ 5 min/granule nighttime

For one month of data:

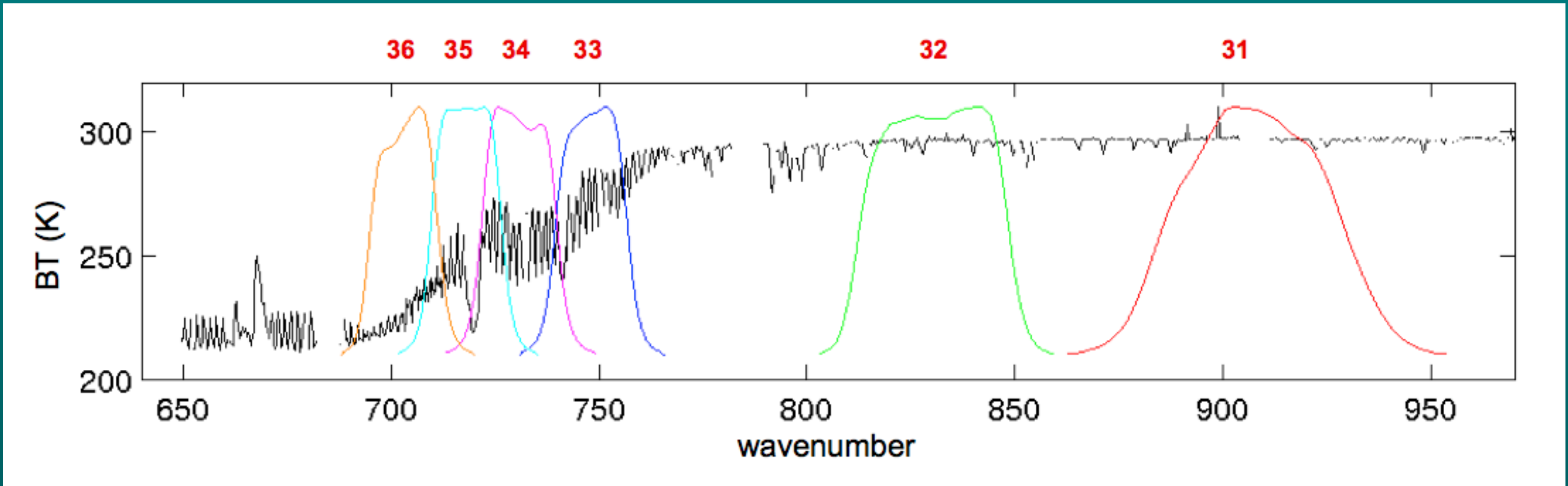
288 granules per day for 30 days = 8640 granules

Given 126 CPUs in our cluster: 8640/126 = ~69 granules per CPU

~36 granules x 10 min/granule (daytime) + 33 granules x 5 min/granule (nighttime) = ~9 hours

Result: ~ 9 hours to process a month of MODIS data and co-locate with CALIPSO
(which is about 80x real time)

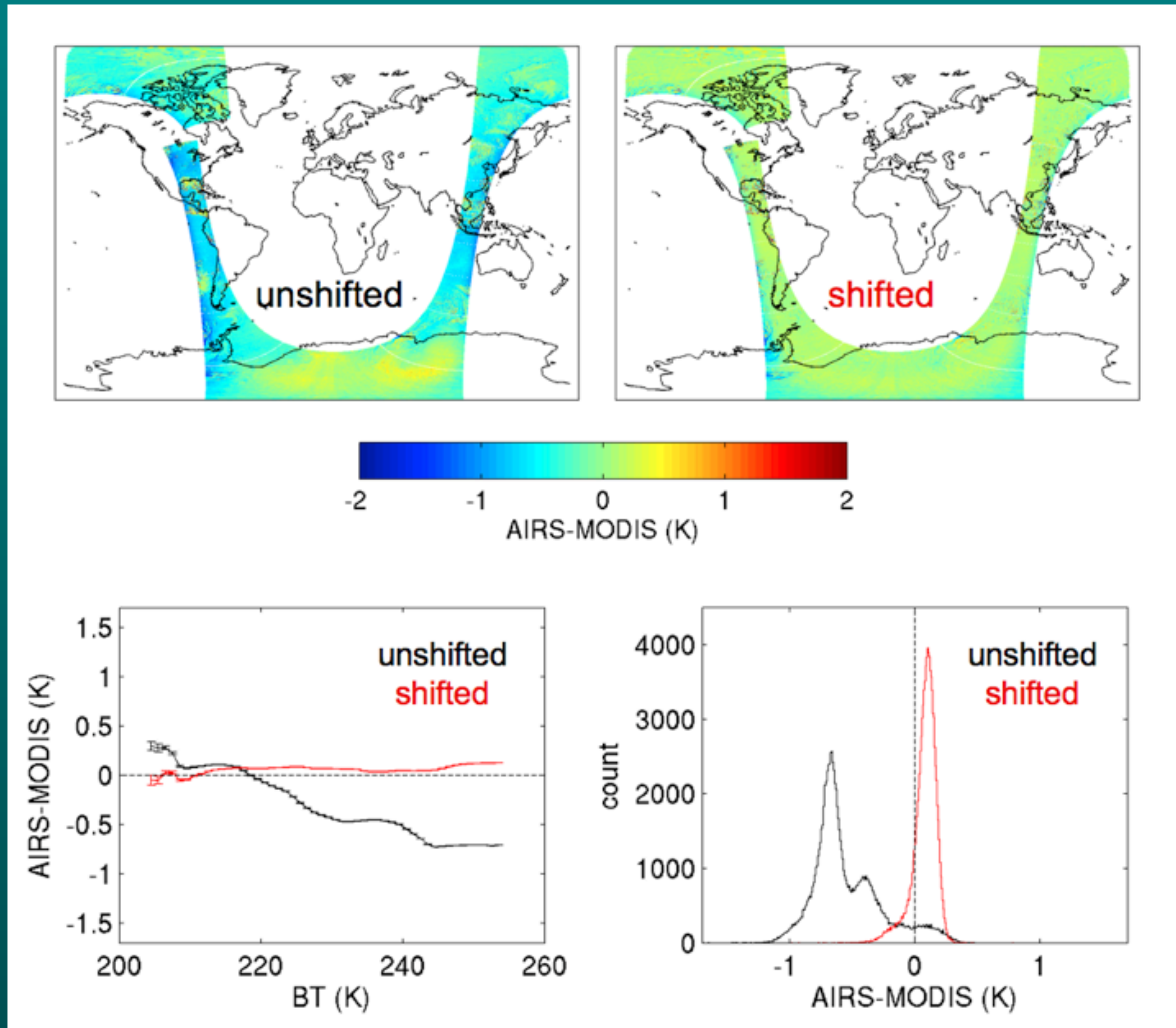
Evaluation of MODIS Spectral Response Functions Using AIRS



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 μm), 32 (12 μm), 33 (13.3 μm), 34 (13.6 μm), 35 (13.9 μm), and 36 (14.2 μm).

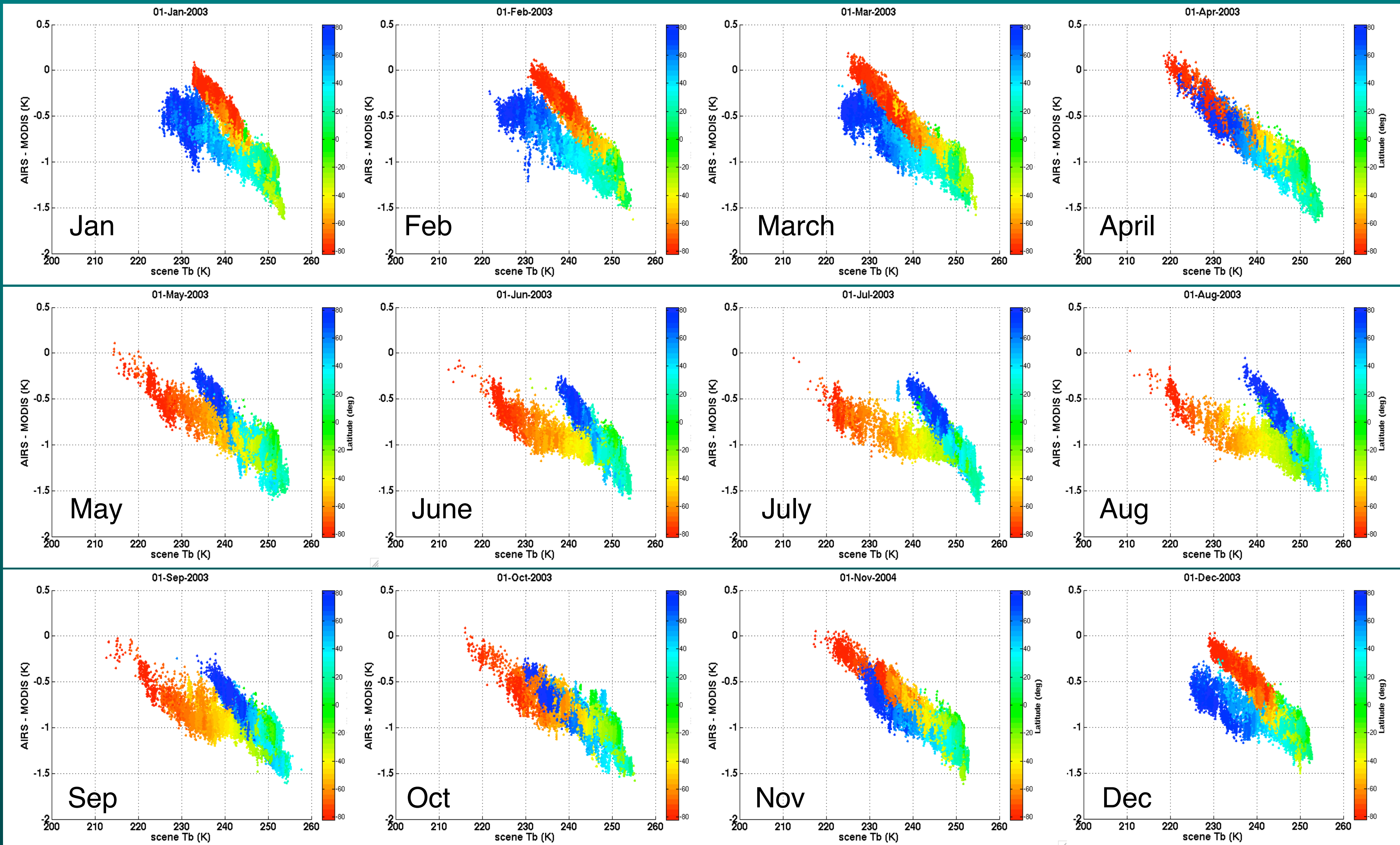
Tobin, D. C., H. E. Revercomb, C. C. Moeller, and T. S. Pagano, 2006: Use of Atmospheric Infrared Sounder high-spectral resolution spectra to assess the calibration of Moderate resolution Imaging Spectroradiometer on EOS Aqua. J. Geophys. Res., 111, D09S05, doi:10.1029/2005JD006095.

AIRS minus MODIS Comparison: 13.9 microns



MODIS Band 35 (13.9 μm) brightness temperature differences using the nominal detector averaged MODIS SRF and using the SRF shifted by +0.8 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.

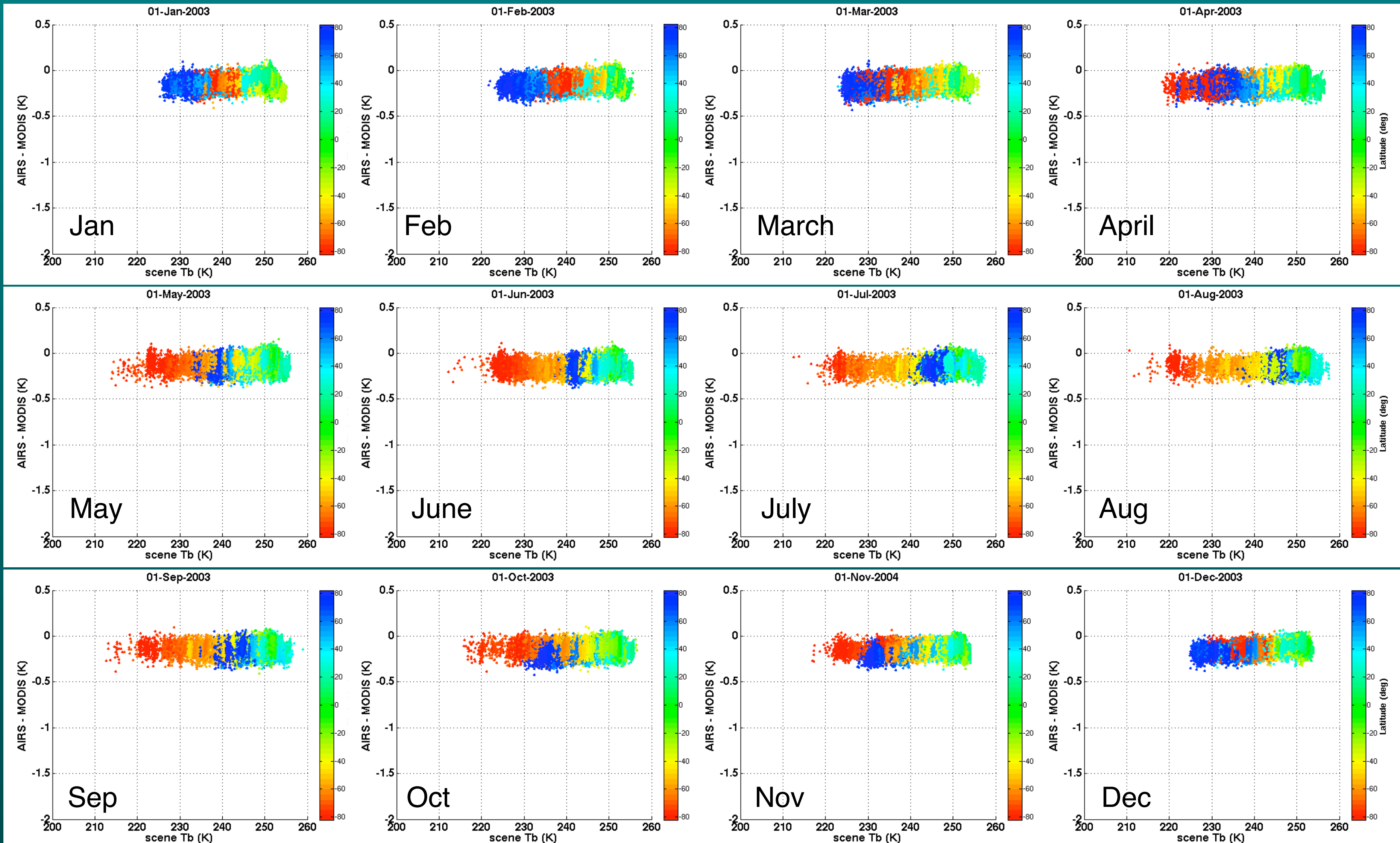
AIRS minus MODIS, Band 35 (13.9 microns)



Recent test processed global MODIS/AIRS radiance data for 1st day of each month since launch

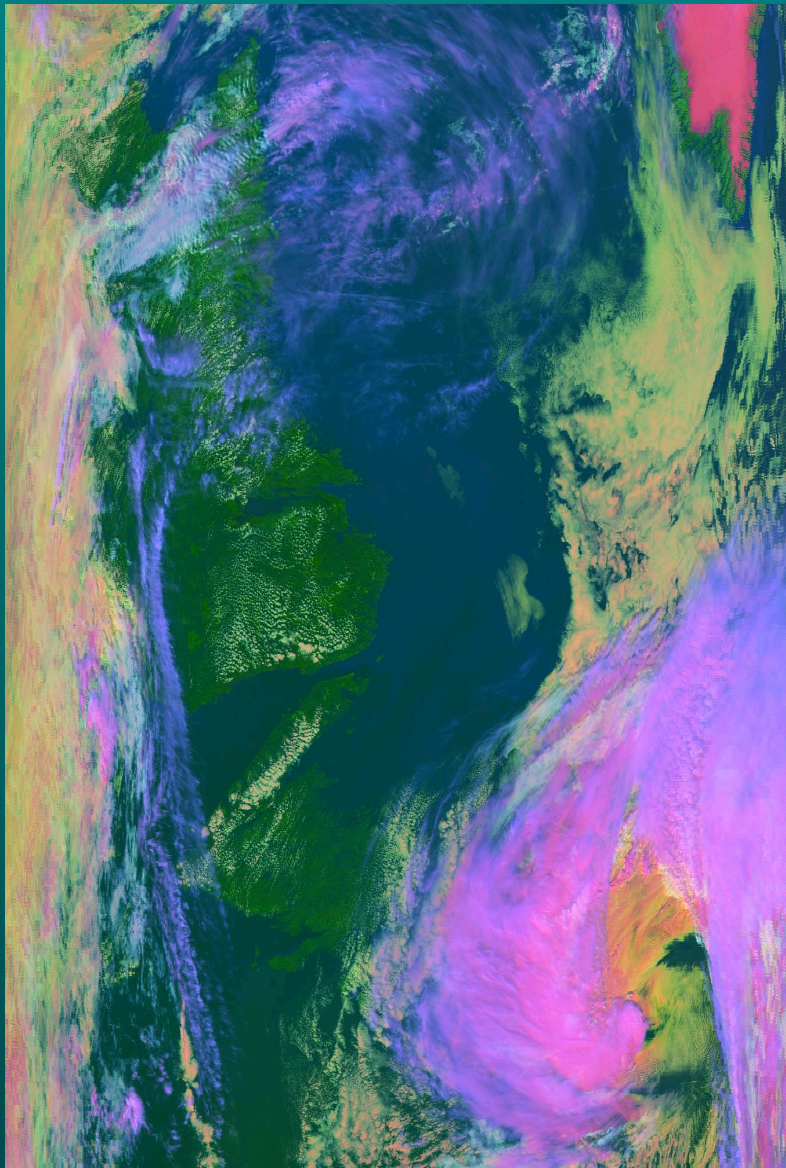
Provides a way to monitor IR band calibration over time

AIRS-MODIS, Band 35 with 0.8 cm^{-1} SRF shift



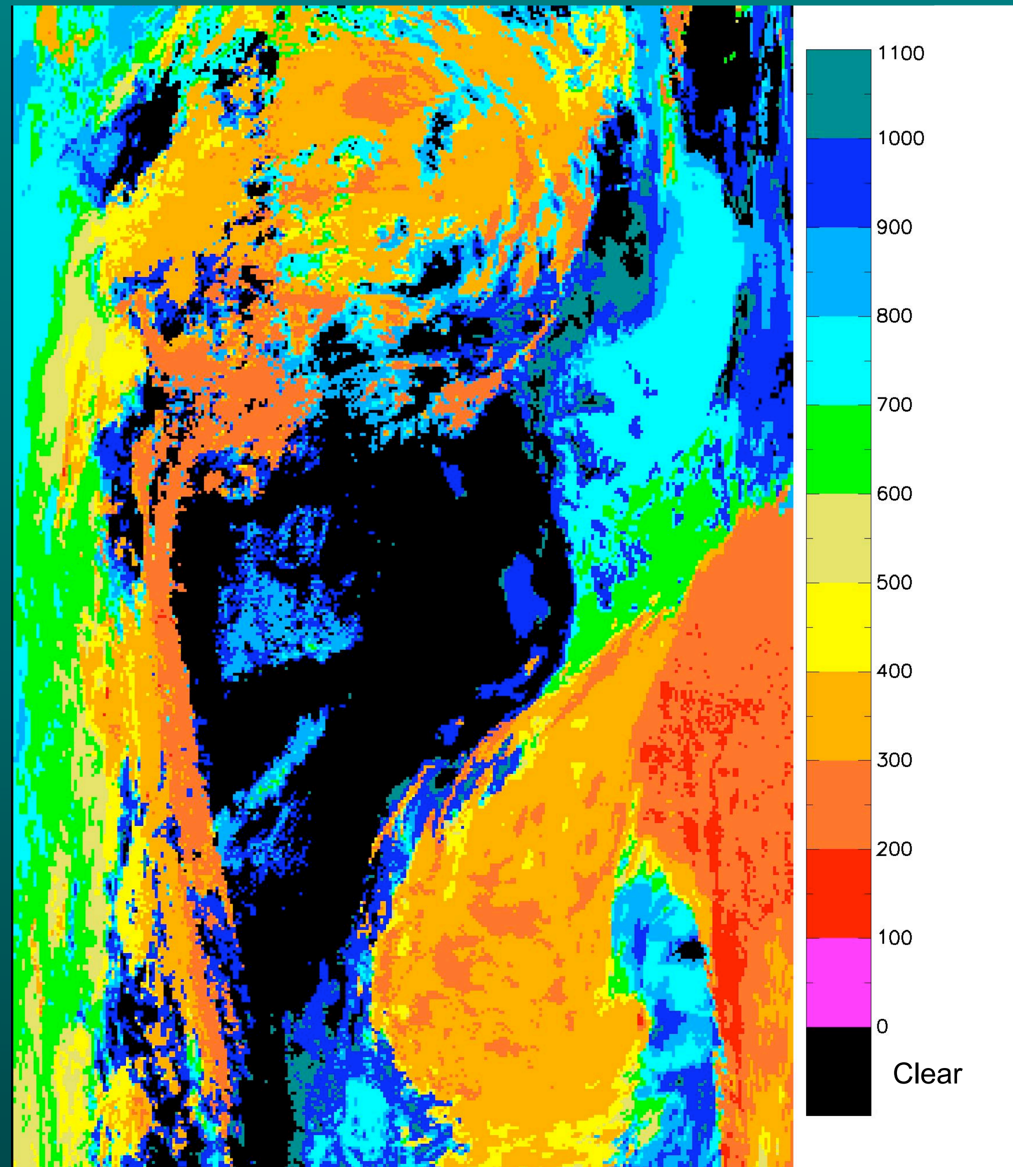
This process will be automated in the PEATE

Will be extended to METOP platform with IASI-AVHRR/HIRS

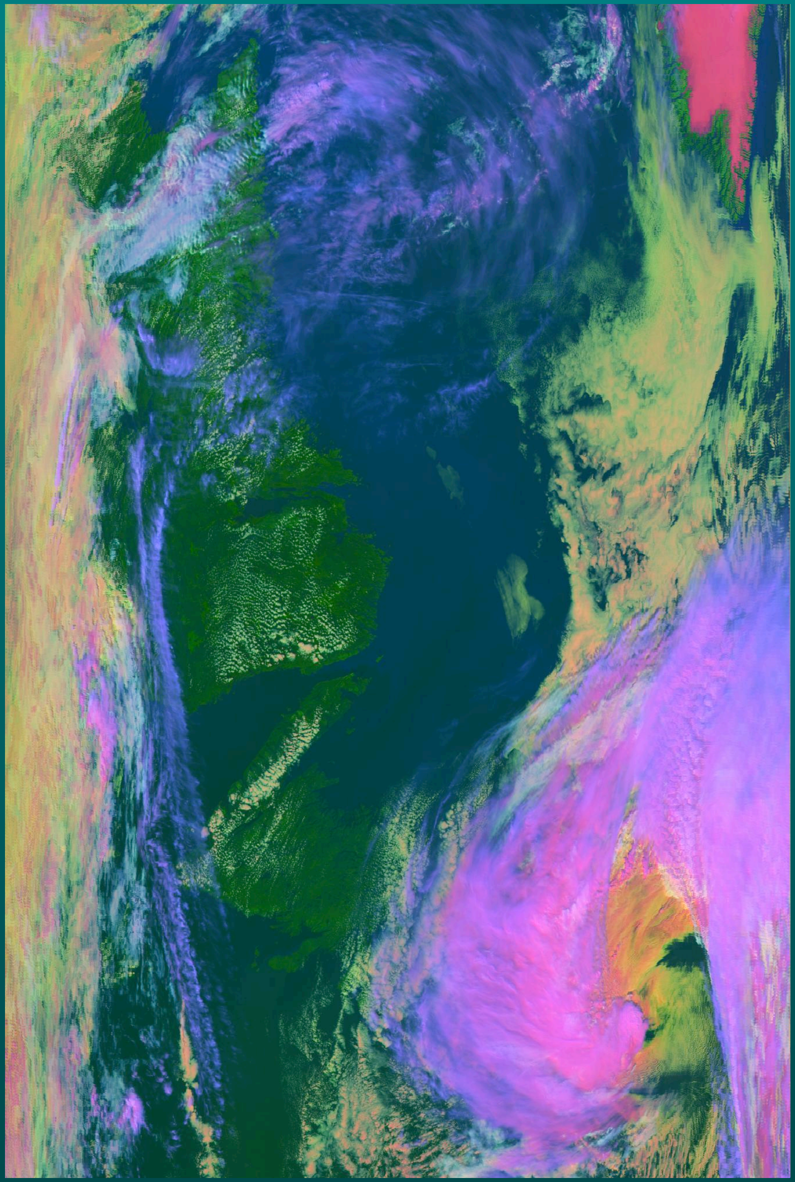


False color image

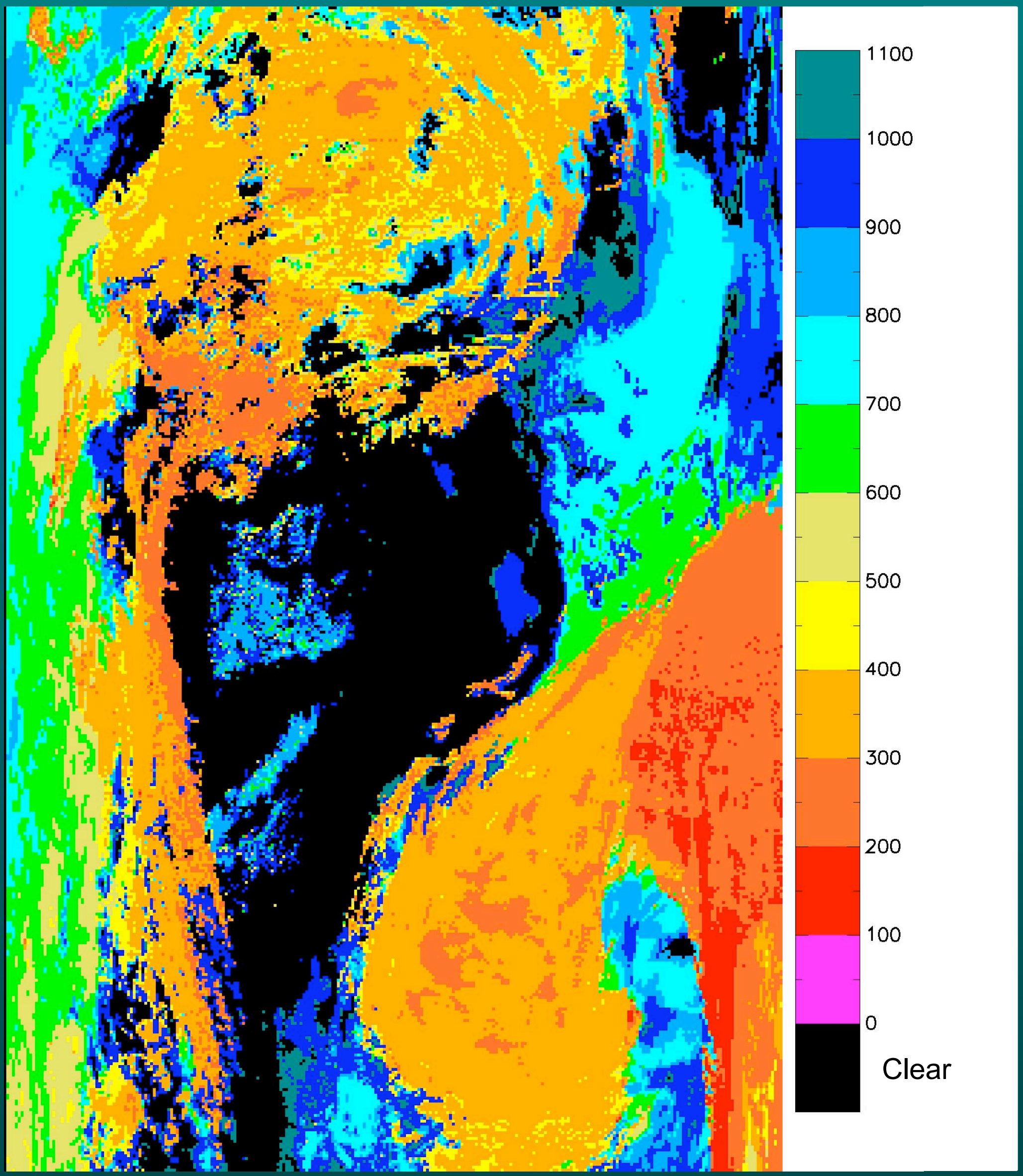
Red: 0.65 μm; Green: 2.1 μm; Blue: 11 μm



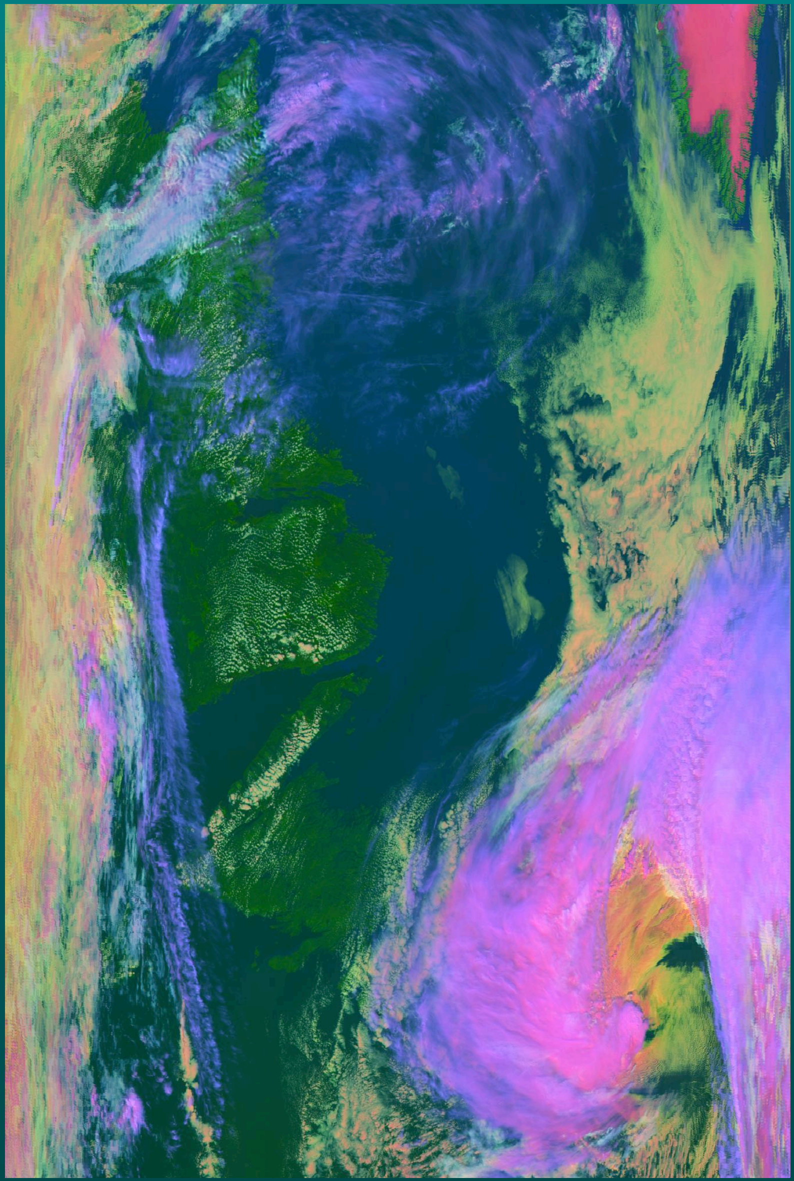
MODIS Collection 5 Cloud Top Pressures (hPa) at 5 km resolution



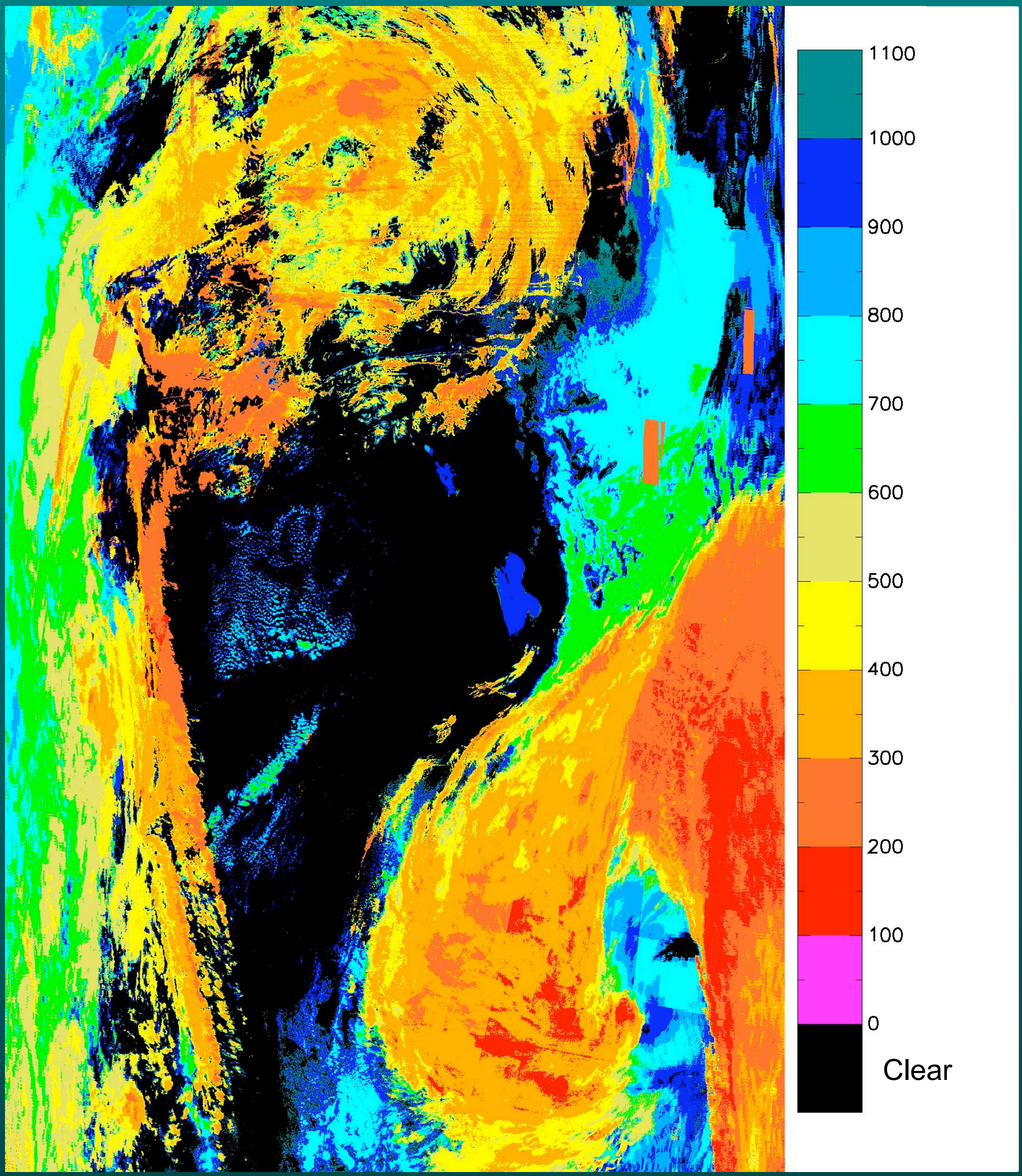
False color image
Red: 0.65 μm; Green: 2.1 μm; Blue: 11 μm



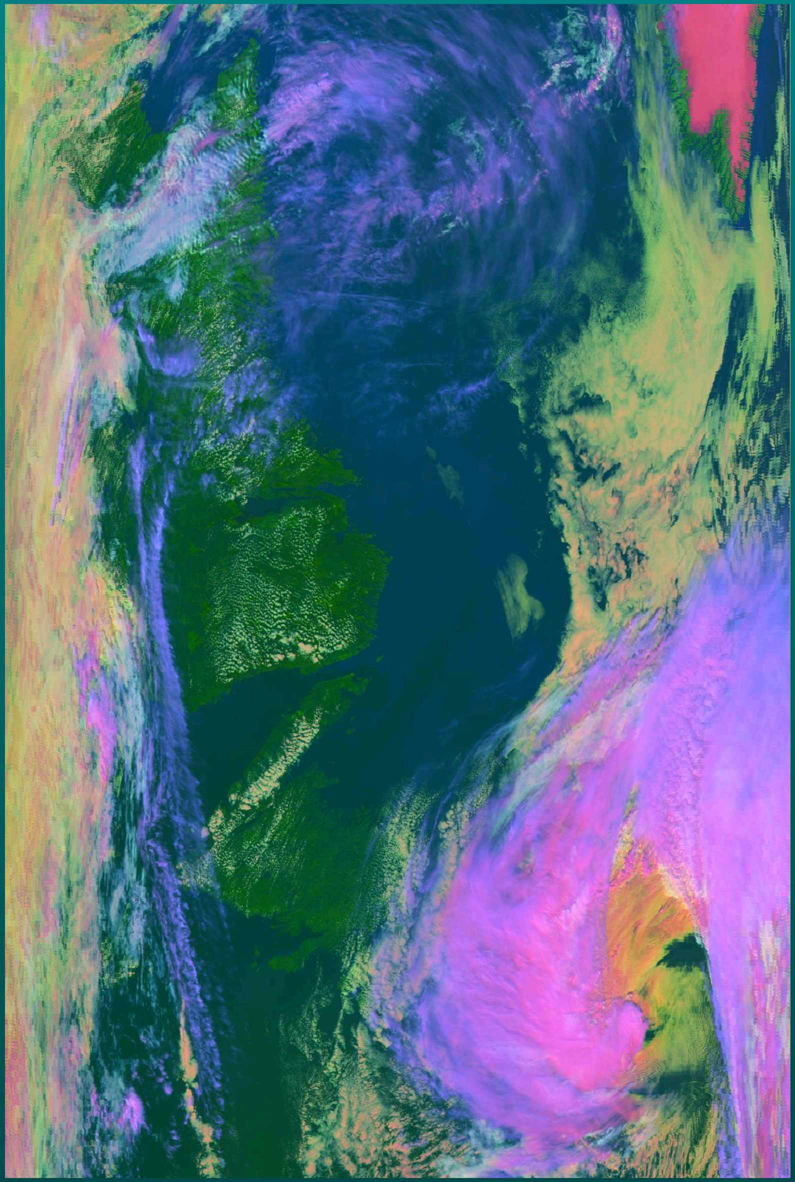
MODIS Pre-Collection 6 Cloud Top Pressures (hPa) at 5 km resolution



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

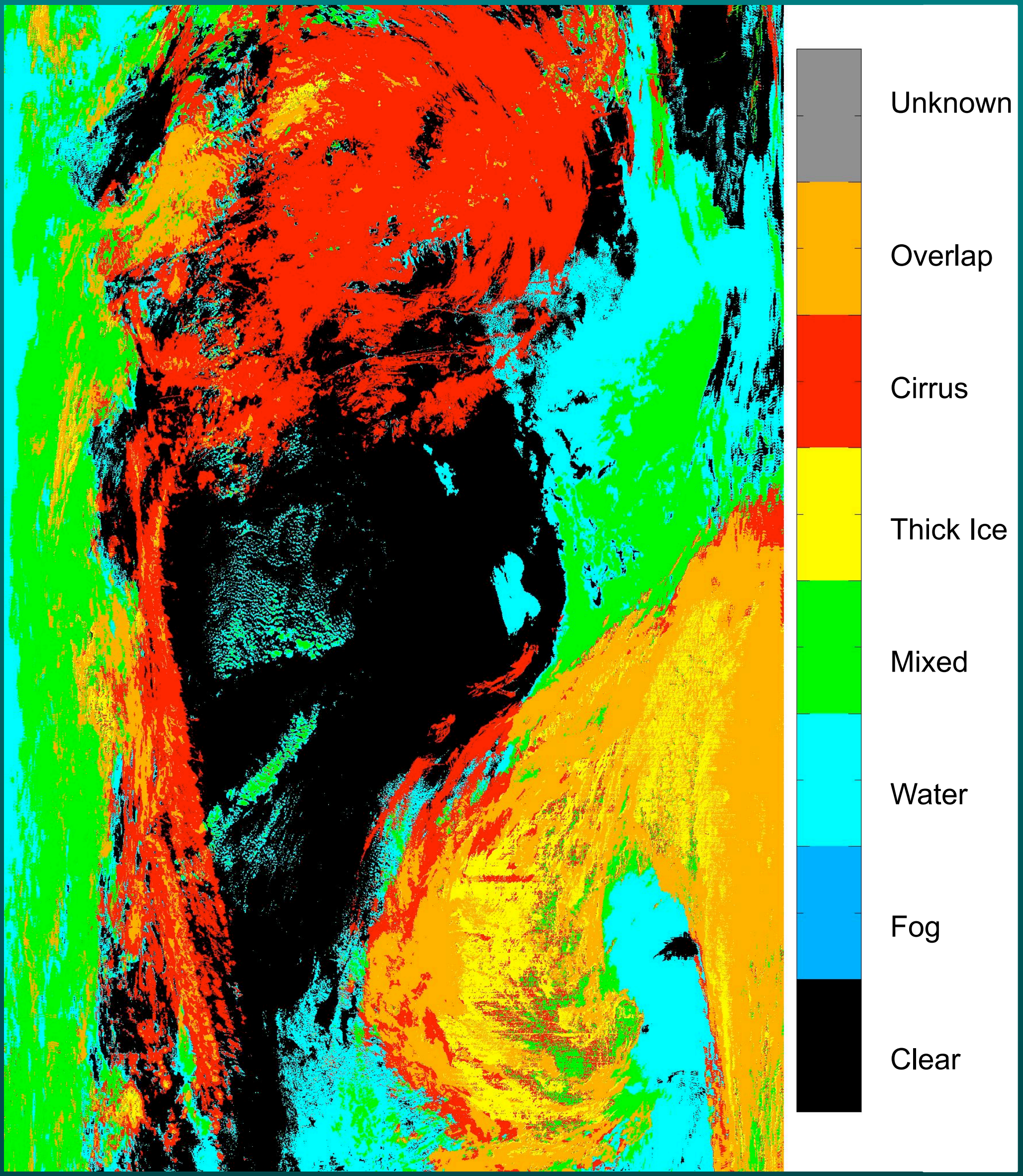


MODIS LEOCAT Cloud Top Pressures (hPa)
at 1 km resolution



False color image

Red: 0.65 μm; Green: 2.1 μm; Blue: 11 μm



Cloud Type: Implemented in PATMOS-x and VIIRS

Pavolonis et al., JAMC, 2005, Vol 44, 804-826.

Status of MODIS Code Transition to the Atmosphere PEATE

MODIS Cloud Mask (MOD35) - transitioned

VIIRS Cloud Mask developed from MOD35, leaving out MODIS bands not on VIIRS

NGST Cloud Mask - transitioned

Other NGST cloud/aerosol products will be implemented in LEOCAT in 2008

MOD06 Cloud Top Properties

- Collection 5 code transitioned (5 km resolution)
- Pre-Collection 6 code under development (5 km resolution)
- Being transitioned to LEOCAT (1 km resolution)

MOD06 Optical Properties - MODIS Collection 5 algorithm implementation underway/ undergoing global testing

MOD04 Aerosols:

- NGST aerosol algorithm implementation is imminent
- MODIS Collection 5 algorithm implementation underway
- Evaluation of MODIS and NGST aerosol algorithm performance is planned through use of ground-based AERONET observations as well as with Calipso

In Summary...

The PEATE is already proving quite useful to the MODIS and NPP cloud/aerosol team

Issues are being illuminated from a variety of ongoing cal/val efforts but resolution may not always be straightforward

Climate data records require multiple passes through at least major portions of the data record

Approach adopted at UW provides capability to prototype and test algorithm modifications, as well as investigate impact of sensor issues on the products

Post-launch cal/val efforts should be closely linked to the pre-launch efforts, both in terms of involving the same people/expertise and the technical issues

Progress depends on collegiality, mutual respect, and communication, given a team committed to collaboration and transparency

SSEC