University of Wisconsin-Madison MODIS Team

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Smith, Kathy Strabala, David Tobin…

and thanks to the Atmosphere PEATE

MODIS Science Team Meeting
April 29- May 1, 2013

Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin - Madison

Algorithms and Activities

- Cloud Mask
- Cloud Top Phase
- Cloud Top Pressure (temperature)
- Atmospheric Profiles
- Calibration
- Direct Broadcast

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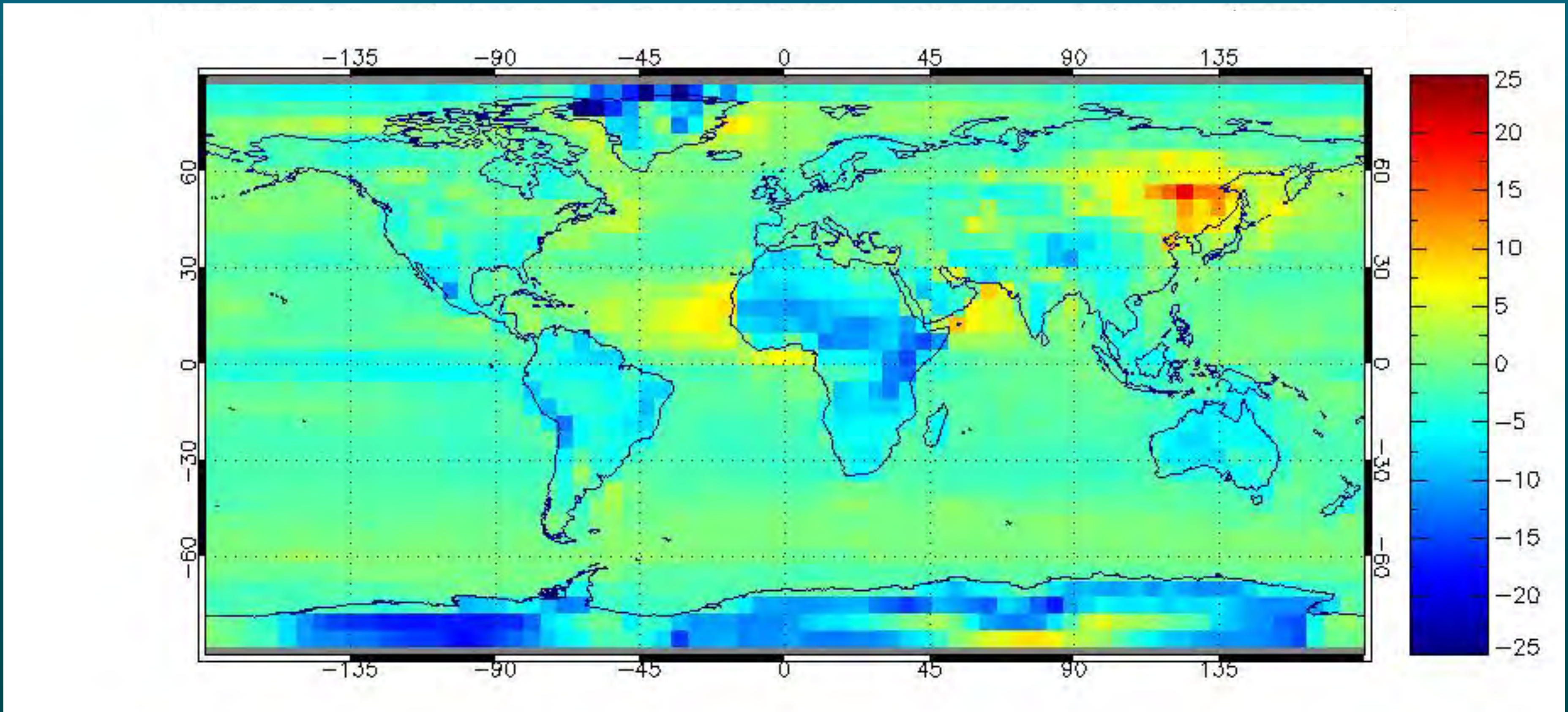
MODIS Cloud Mask

Comparison with CALIOP – total record

Category	Hit Rate (%)	False Alarms (%)	Missed Clouds (%)
Global – All	92.9	3.7	3.4
60S-60N	95.2	3.8	1.0
Global Day	95.5	2.7	1.8
60S-60N Day	96.2	3.0	0.8
Global Night	90.7	4.5	4.8
60S-60N Night	94.2	4.7	1.1
60S-60N Water Day	96.1	3.4	0.5
60S-60N Water Night	94.2	5.0	0.8
60S-60N Land Day	96.6	1.8	1.7
60S-60N Land Night	94.3	4.0	1.7
Desert Day	97.0	0.7	2.3
Desert Night	94.9	3.2	1.9

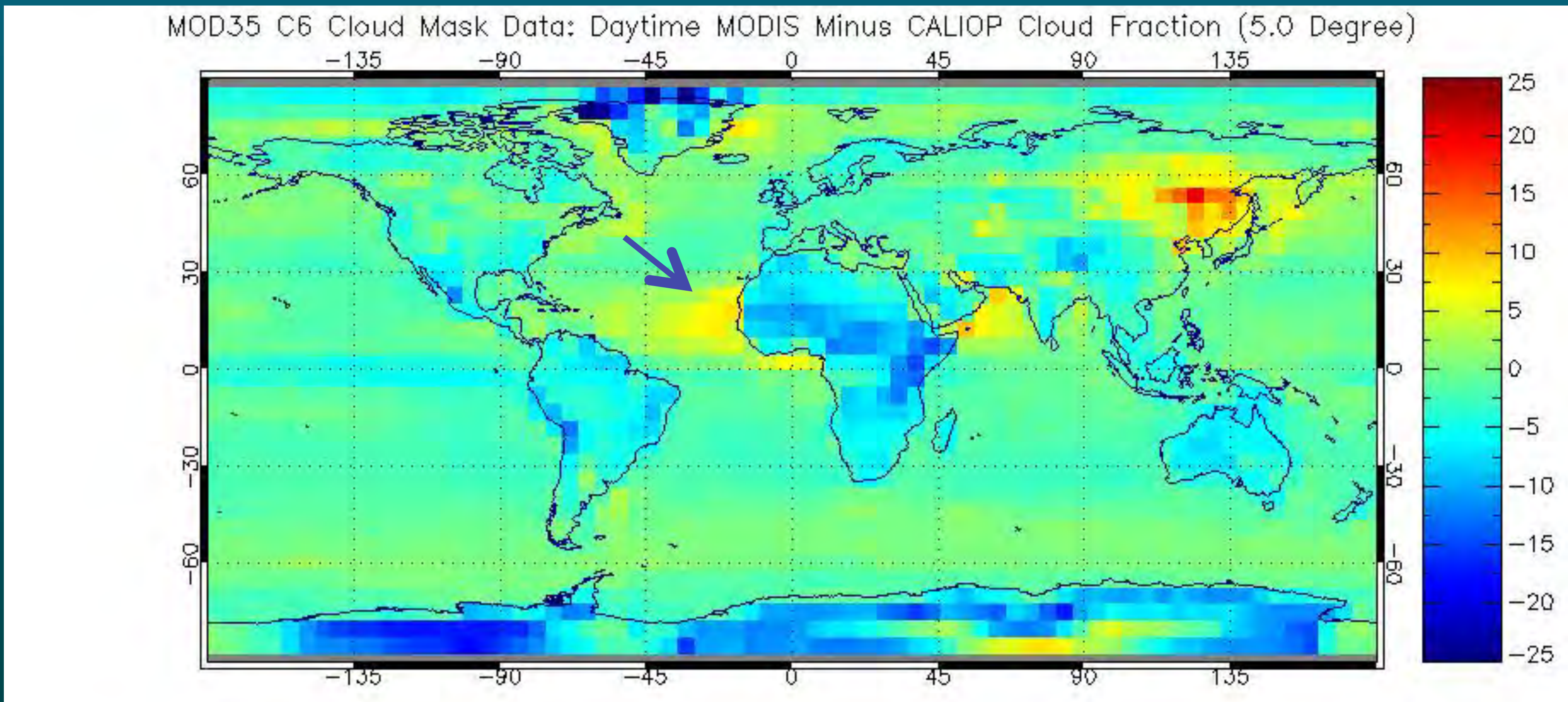
Cloud Detection by MOD35

- MODIS – CALIOP cloud frequency (%)

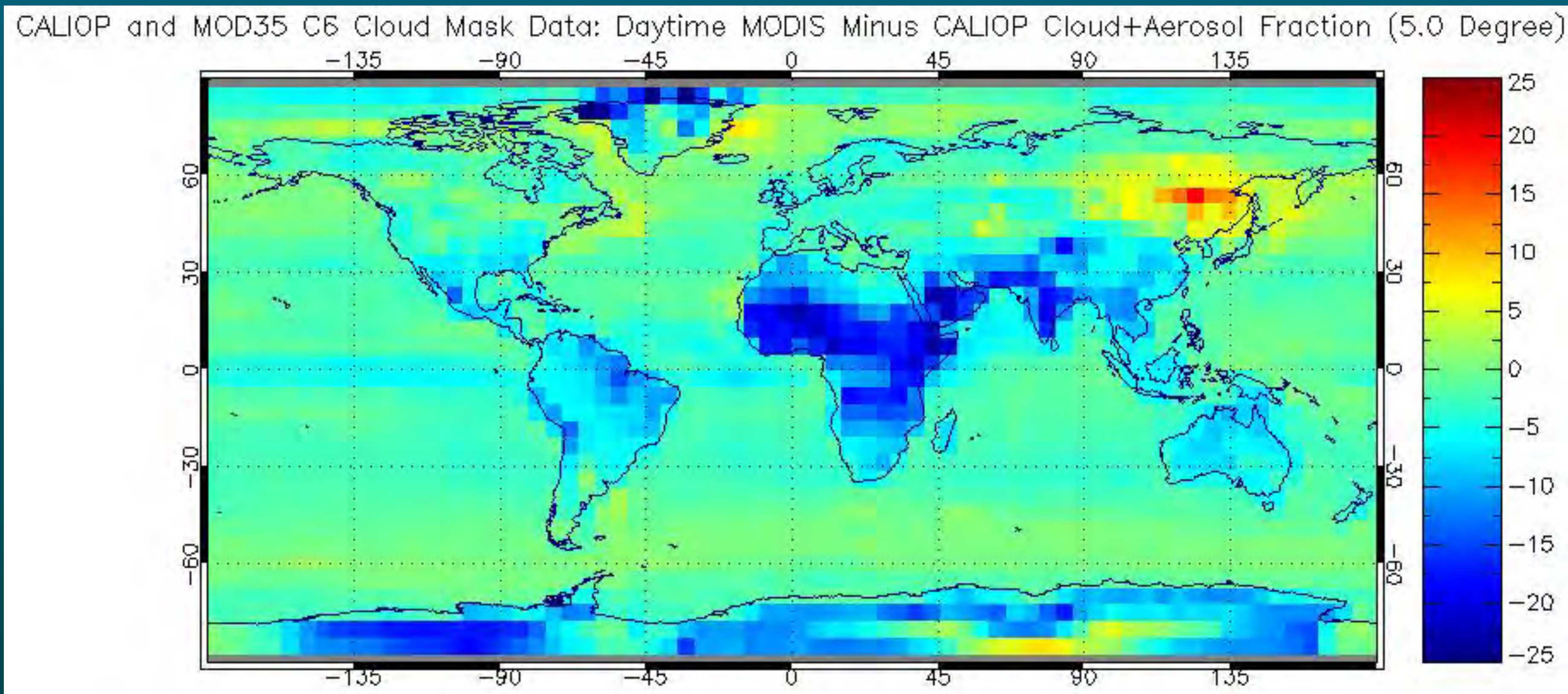


R. Frey

Daytime 5-degree mean MODIS cloud fractions minus daytime 5-degree mean CALIOP cloud fractions.



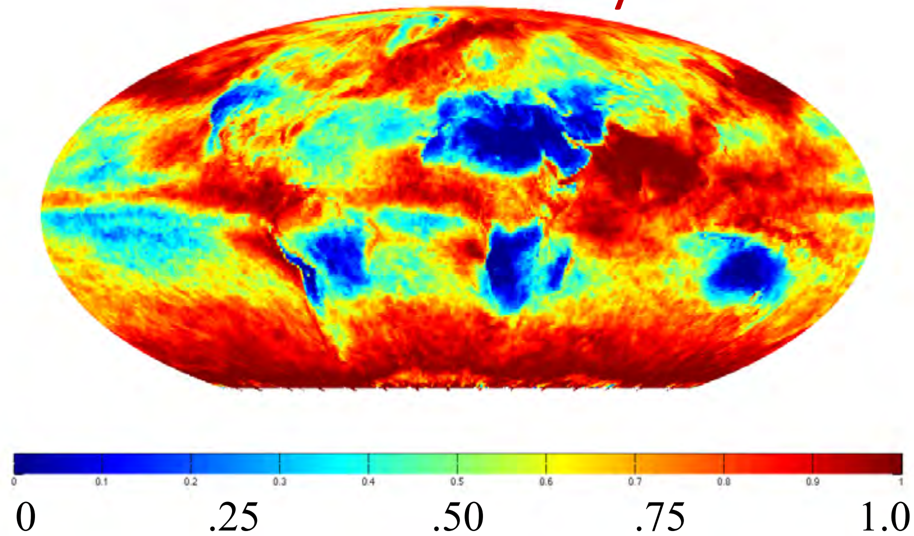
Daytime 5-degree mean MODIS cloud fractions minus daytime 5-degree mean CALIOP cloud plus aerosol fractions (AOD > 0.3)



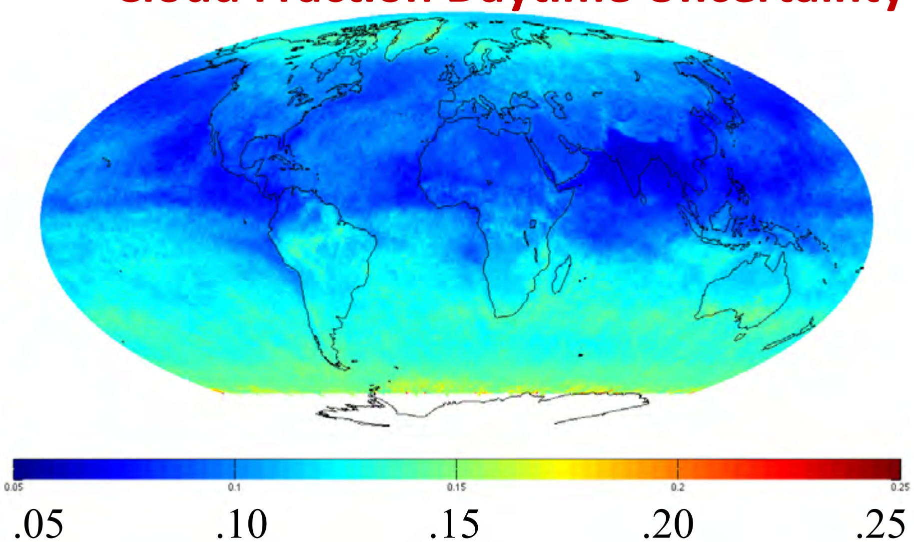
Cloud Fraction Uncertainty- July 2008

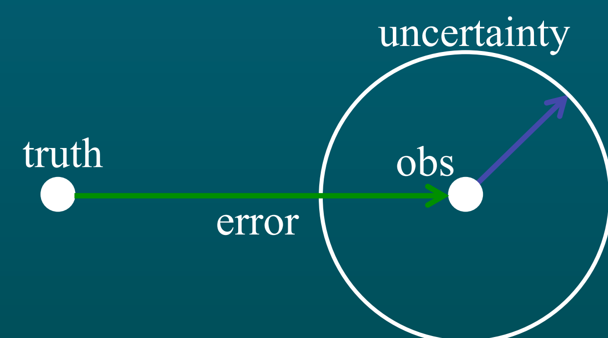
- Uncertainties increase for oblique solar angles, increased cloud heterogeneity and related to surface type.

Cloud Fraction Daytime



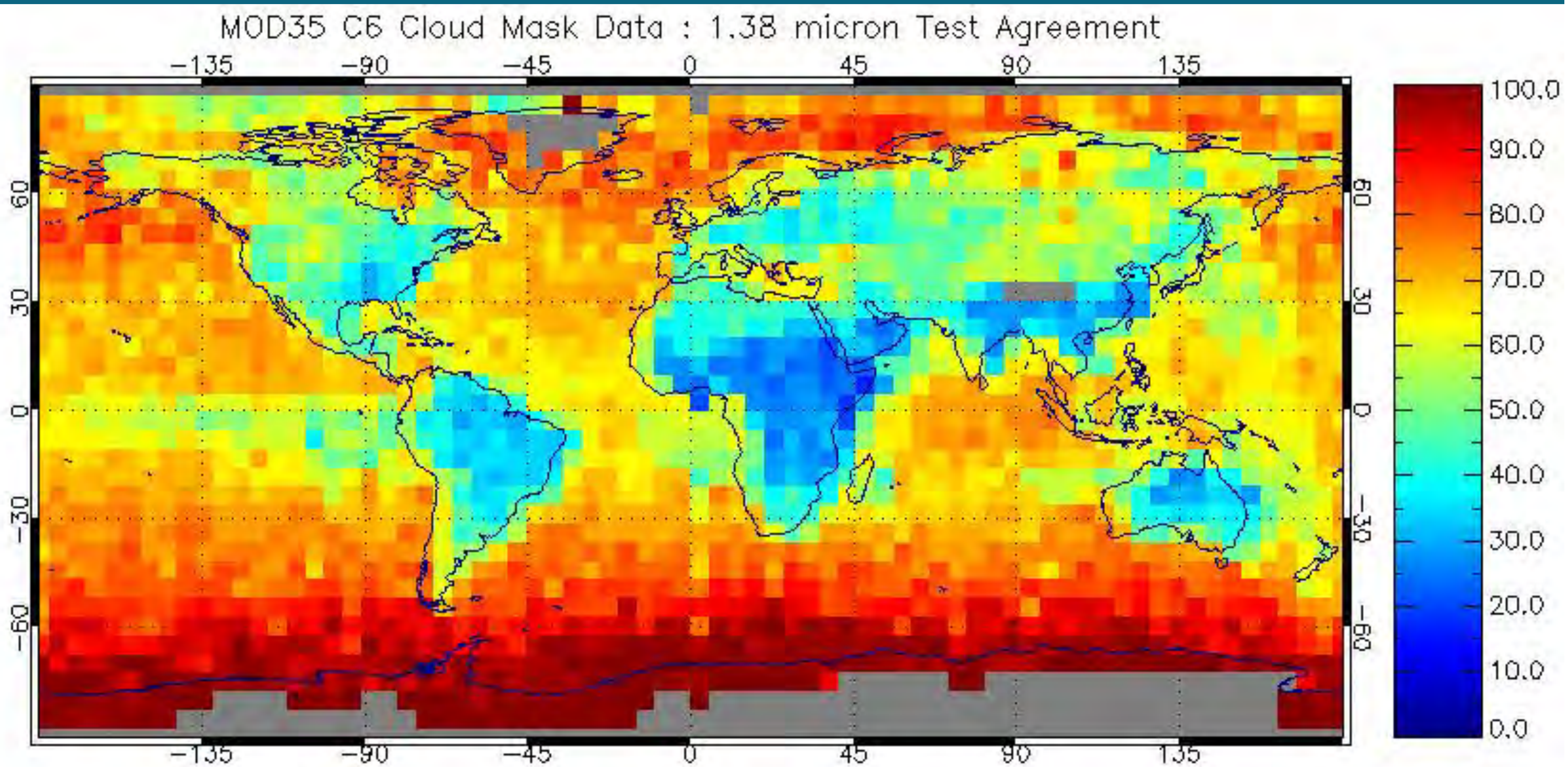
Cloud Fraction Daytime Uncertainty





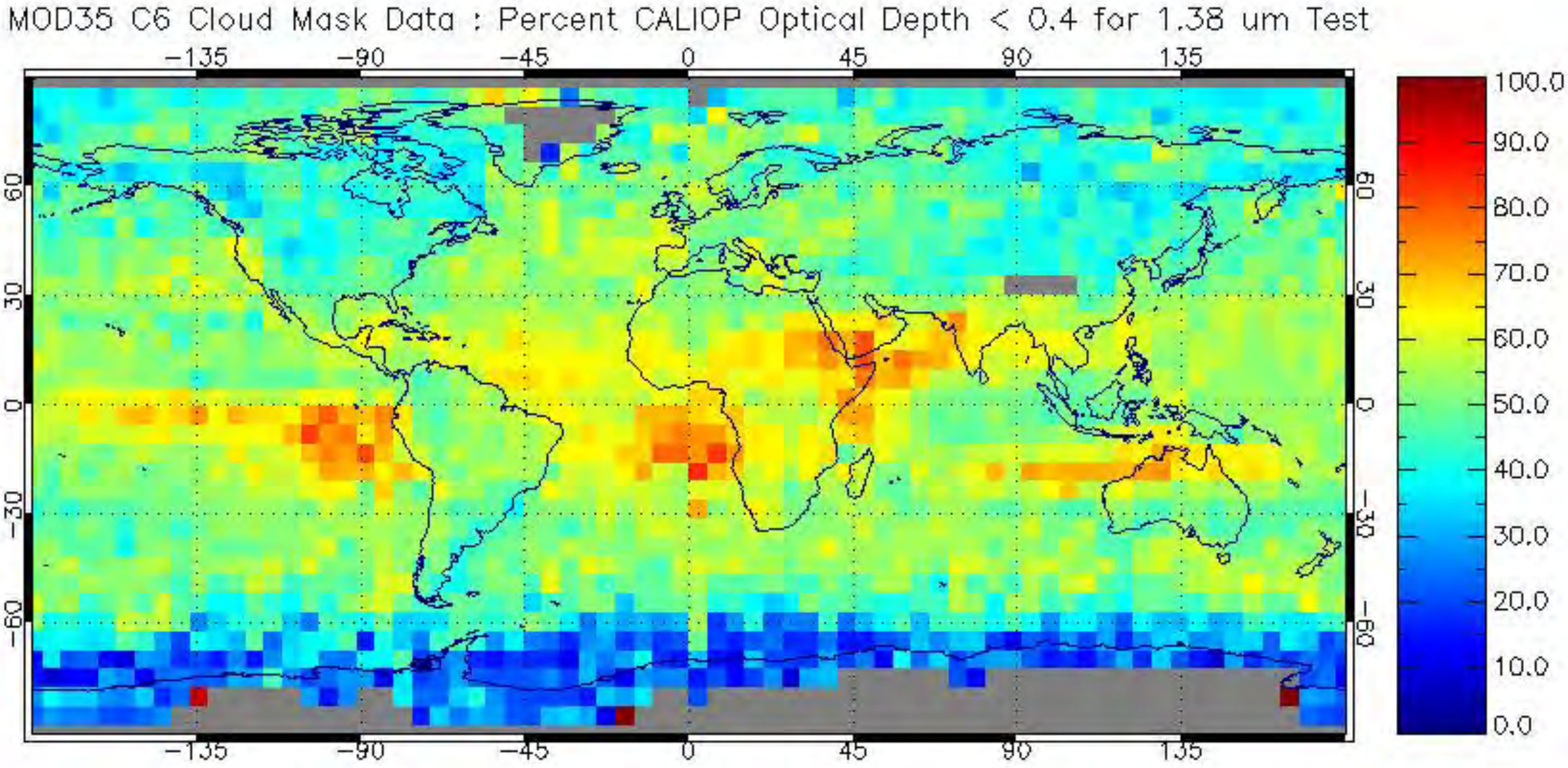
The uncertainty is not concerned with how close to the truth we are but with how well we know the observation

The map shows agreement for **single layer** clouds higher than **8 km** and where the 1.38 test was performed.



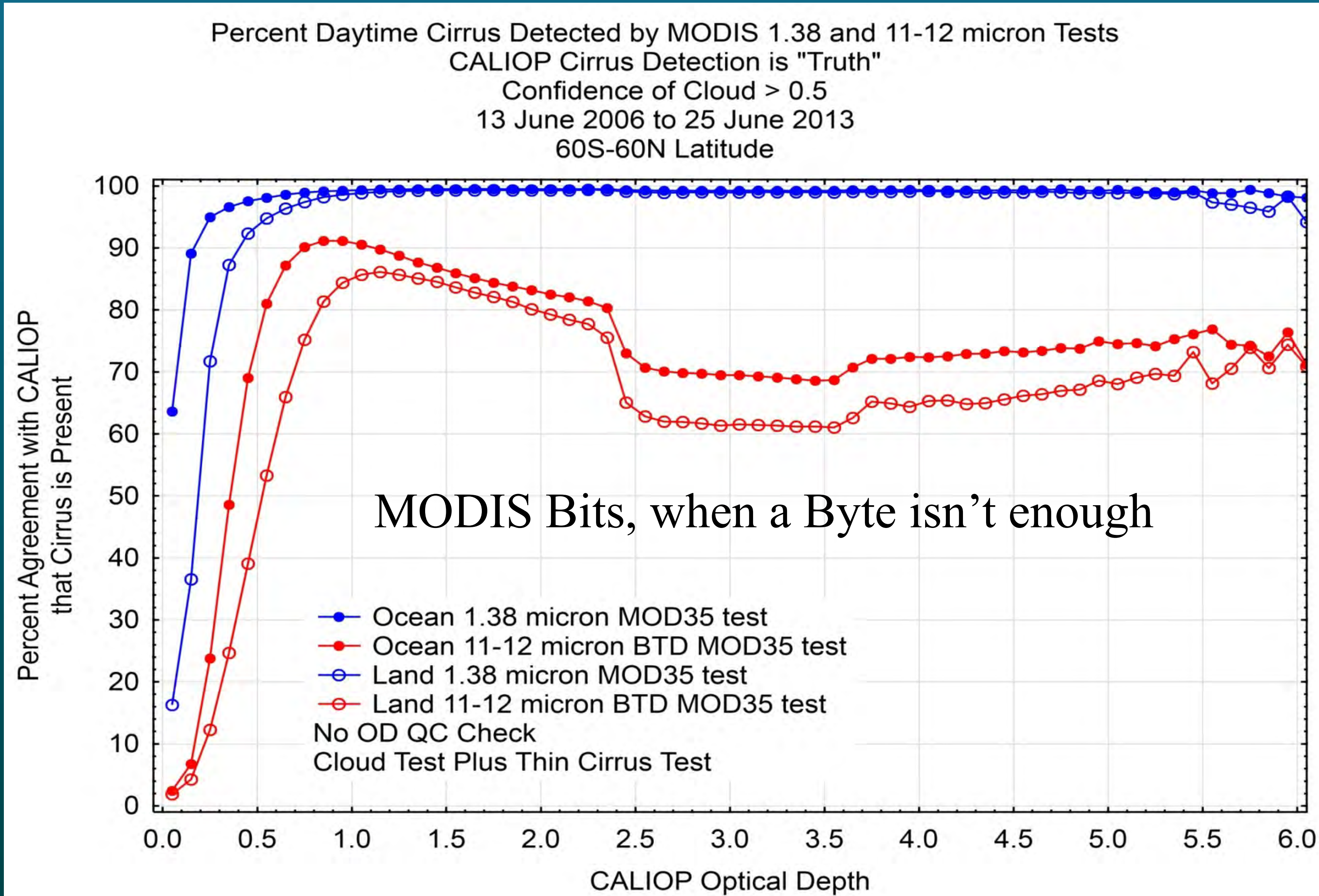
CALIOP QC=<4 Issues with frequency of occurrence of these clouds

If the 1.38 test is performed, and CALIOP has a single layer cloud above 8 km, this is the percent of those clouds that have an OD <. 4 according to CALIOP.



CALIOP QC=<4

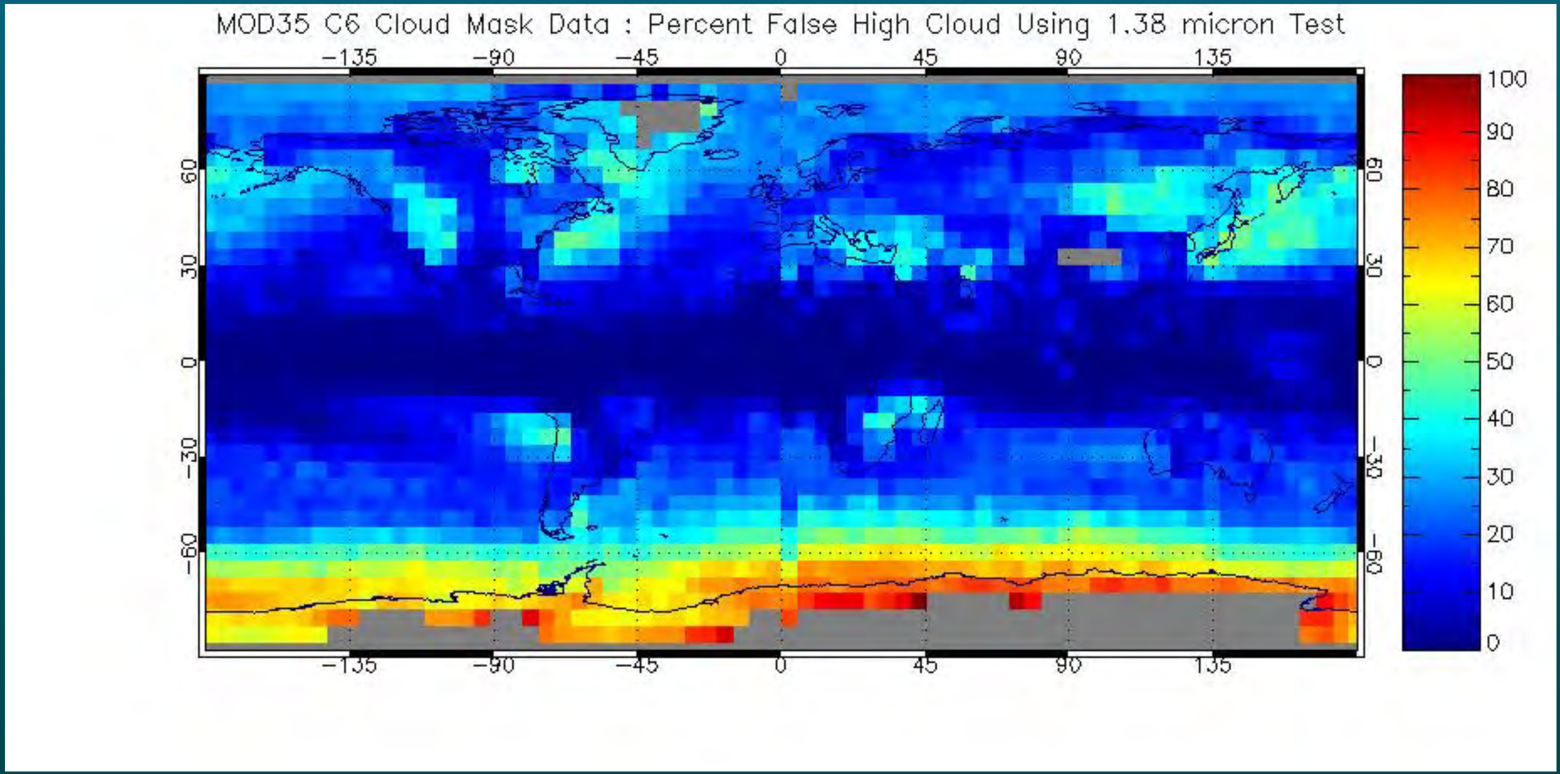
Cirrus Detection by MOD35



R. Frey

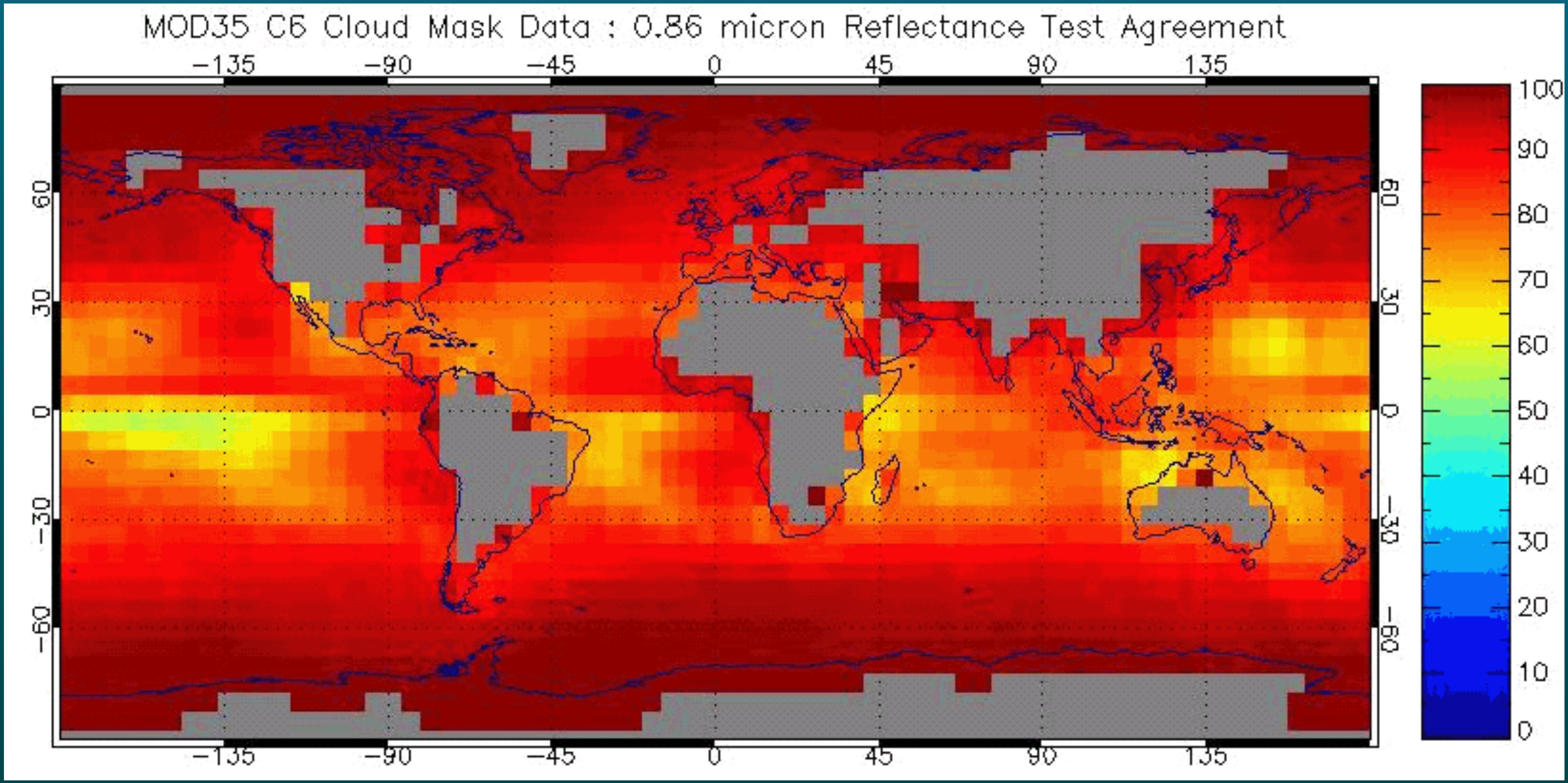
1.38 µm test detects clouds when CALIPO cloud top < 5000 m high.

Percent False high Cloud using 1.38 micron test – a function of water vapor amount



The map shows agreement with CALIOP of .86 micron reflectance test bit results.

Broken clouds or possibly single-layer thin cirrus



Cloud Detection by MOD35

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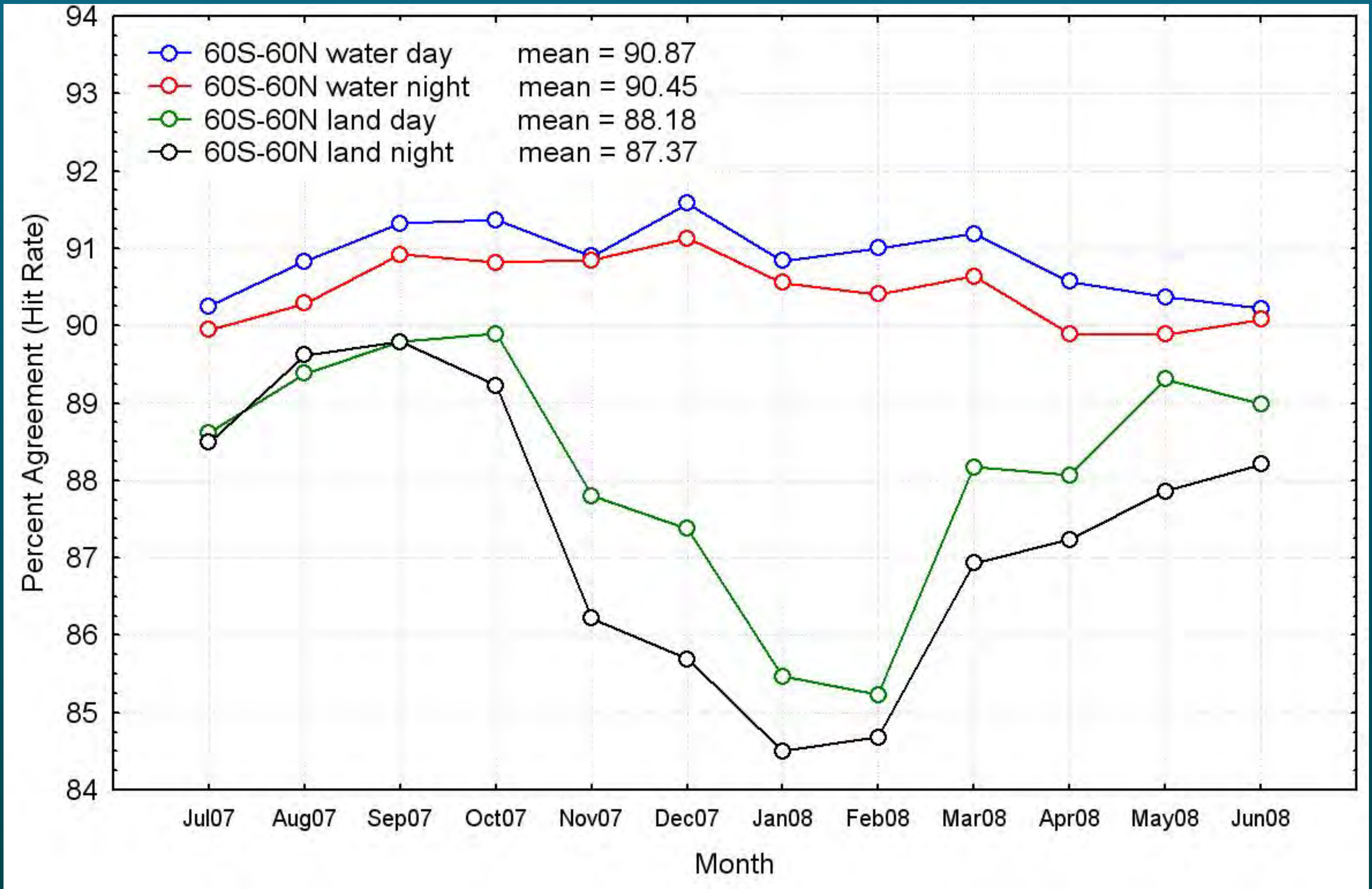

R. Frey

MODIS Cloud Mask

- Continue comparison and validation with collocated CALIOP
- Assigning uncertainty
- Assess individual tests via the MOD35 bits
- Regional studies continue as do anomaly studies

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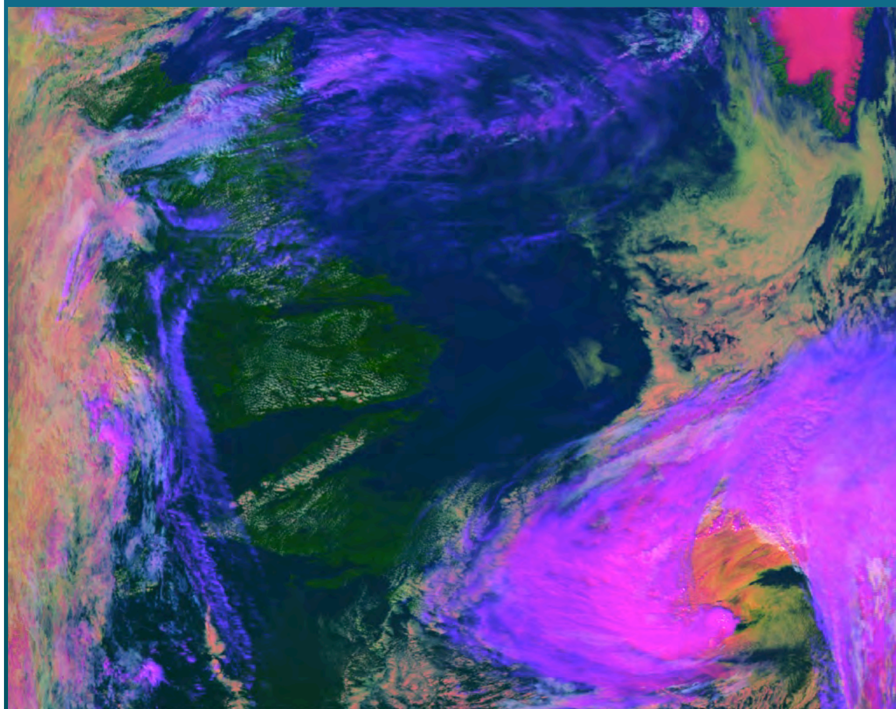
Beta ratios used for C6 IR phase tests

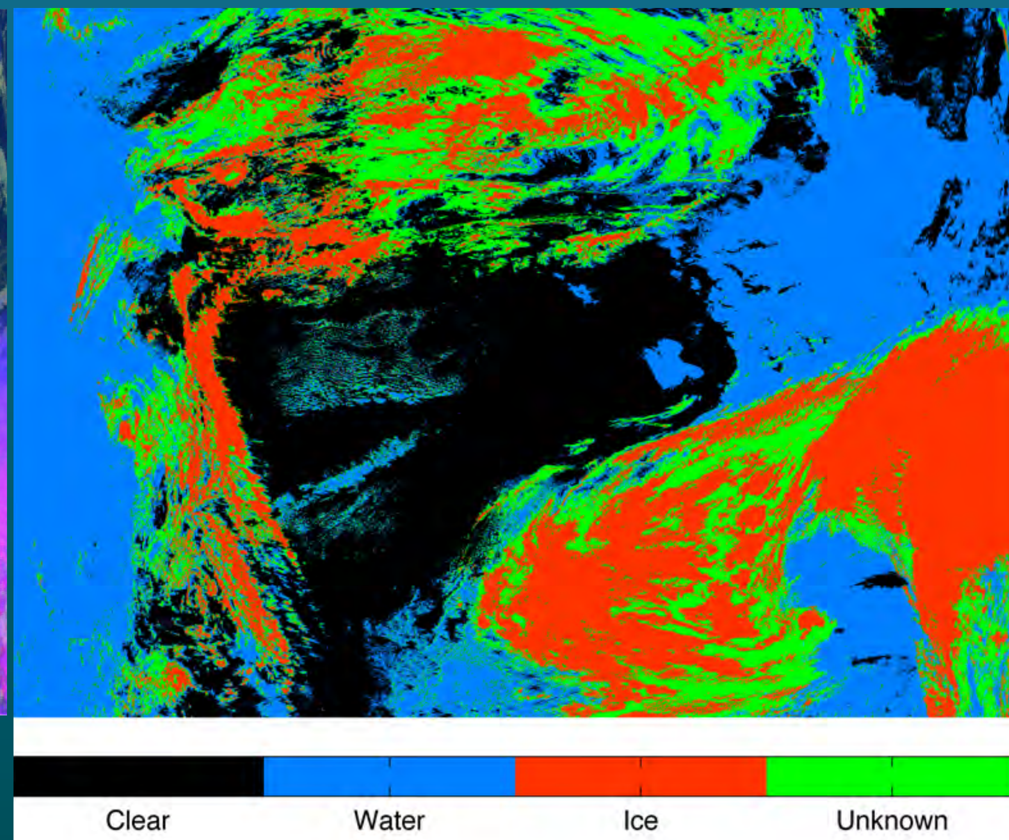
8.5/11: has the most sensitivity to cloud phase

11/12: sensitive to cloud opacity; implementation of this pair helps with optically thin clouds (improves phase discrimination for thin cirrus)

7.3/11: sensitive to high versus low clouds; helps with low clouds (one of the issues was a tendency for low-level water clouds to be ringed with ice clouds as the cloud thinned out near the edges)

MODIS IR Phase for a granule on 28 August, 2006 at 1630 UTC Over N. Atlantic Ocean between Newfoundland and Greenland





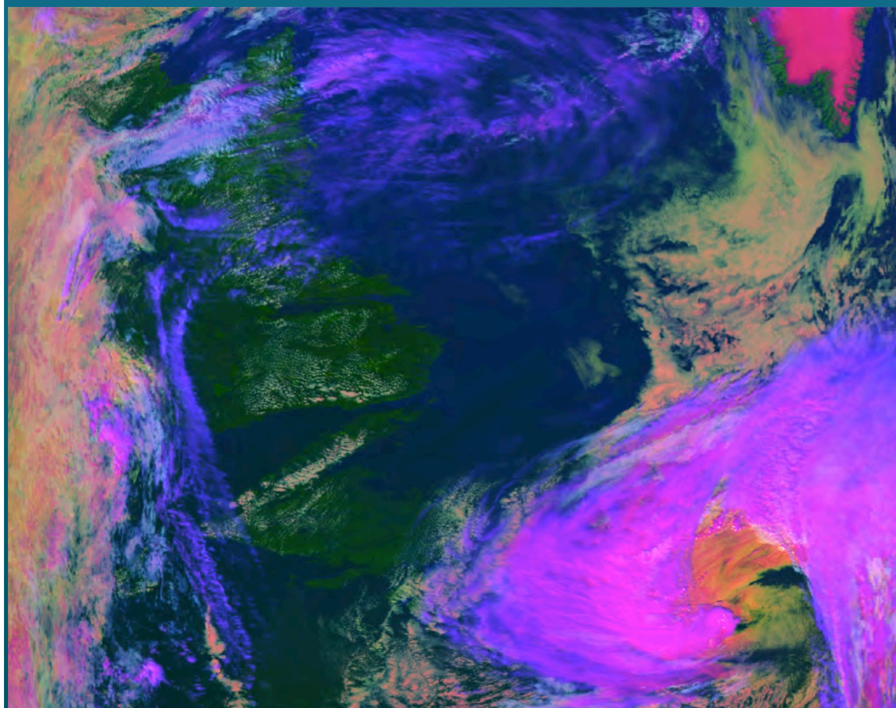
False color image
Red: 0.65 μ m; Green: 2.1 μm; Blue: 11 μ m

Thin cirrus: blue
Opaque ice clouds: pink
Water clouds: white/yellow
Snow/ice: magenta (Southern tip of Greenland)
Ocean: dark blue
Land: green

Collection 5 algorithm but with uncertain and mixed phase pixels combined into "uncertain" category

Baum

MODIS IR Phase for a granule on 28 August, 2006 at 1630 UTC Over N. Atlantic Ocean between Newfoundland and Greenland



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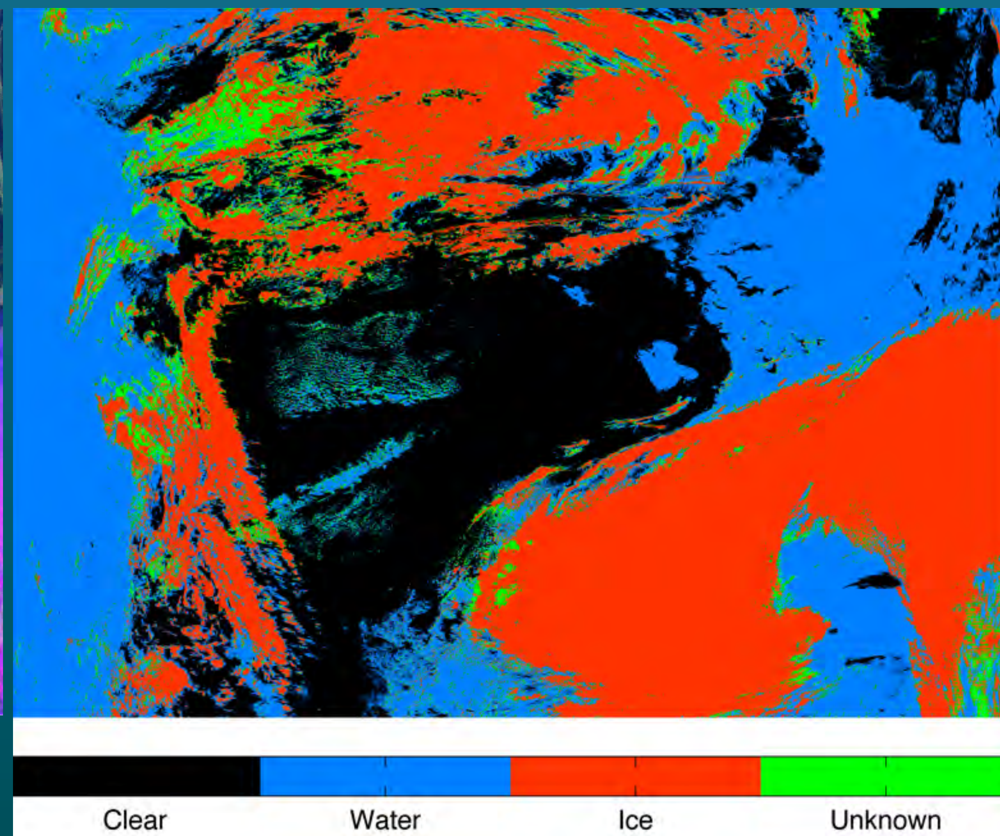
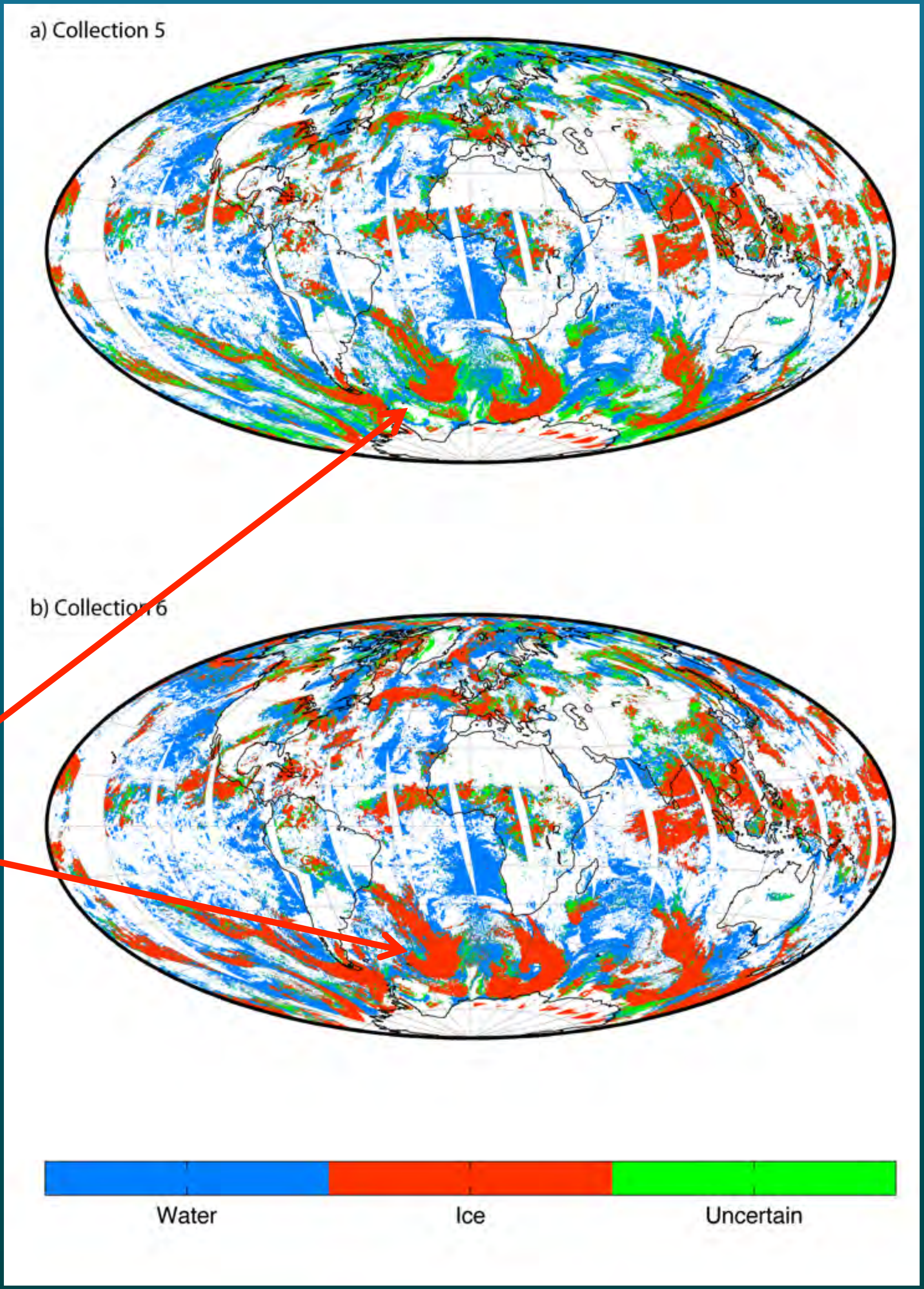


Collection 6 algorithm:
Propose 3 categories, deleting mixed phase since there is no justification for this category

Baum

C5 (top) versus C6 (bottom) cloud phase comparison

(less uncertain)



Baum

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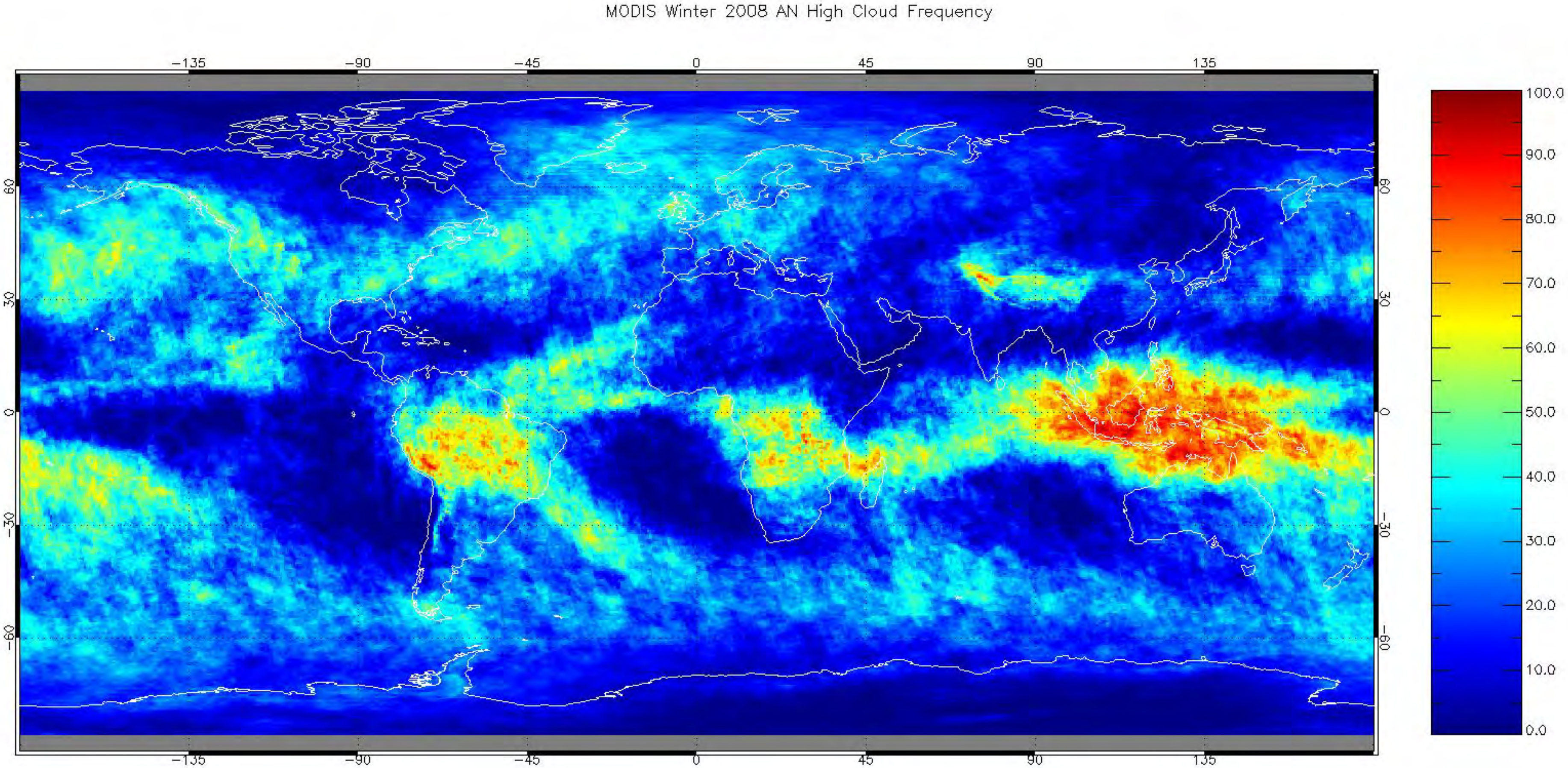
MODIS DJF 2008 AN (60S-60N Day) High Cloud Frequency

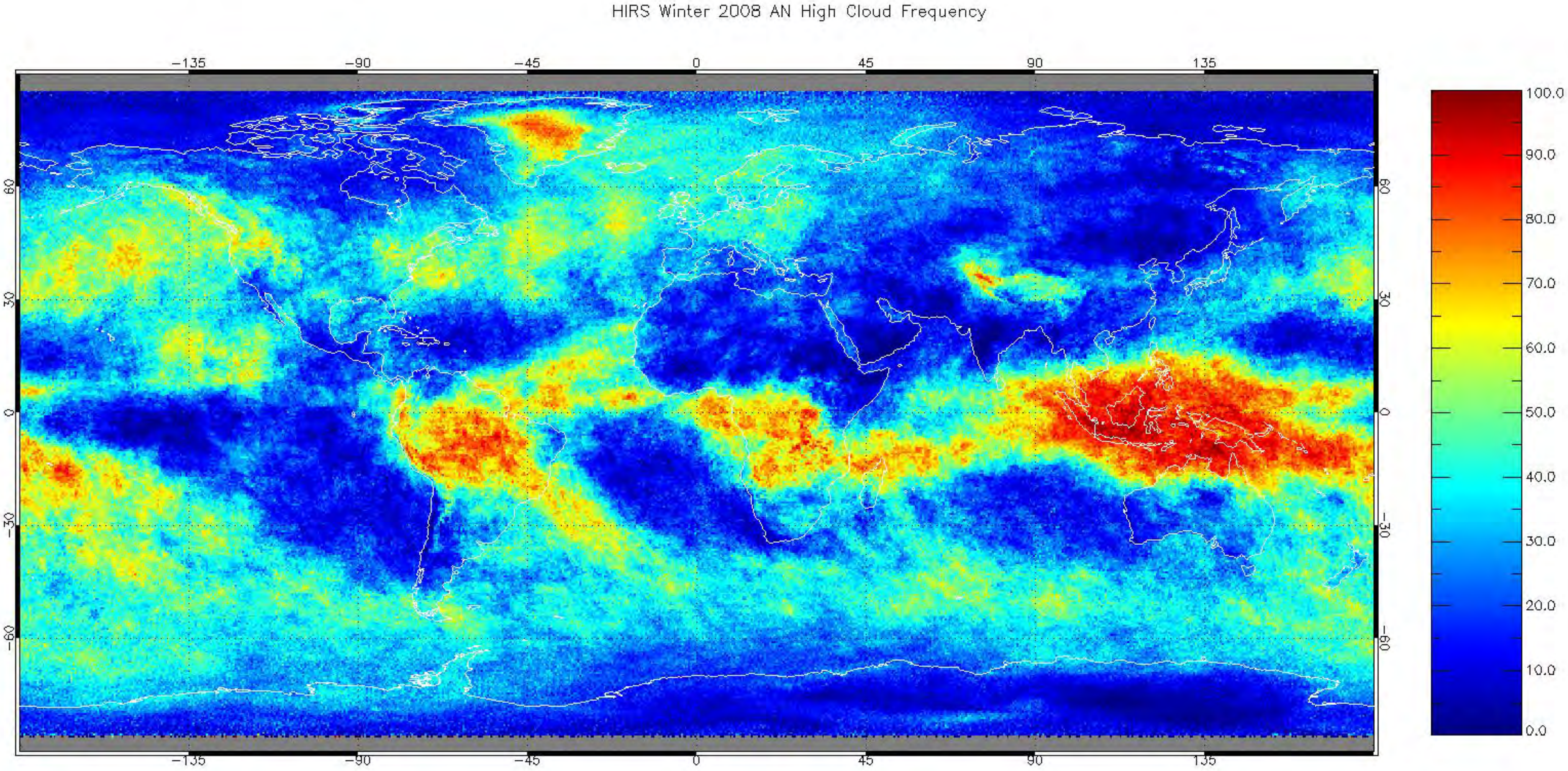
CTP < 440 hPa



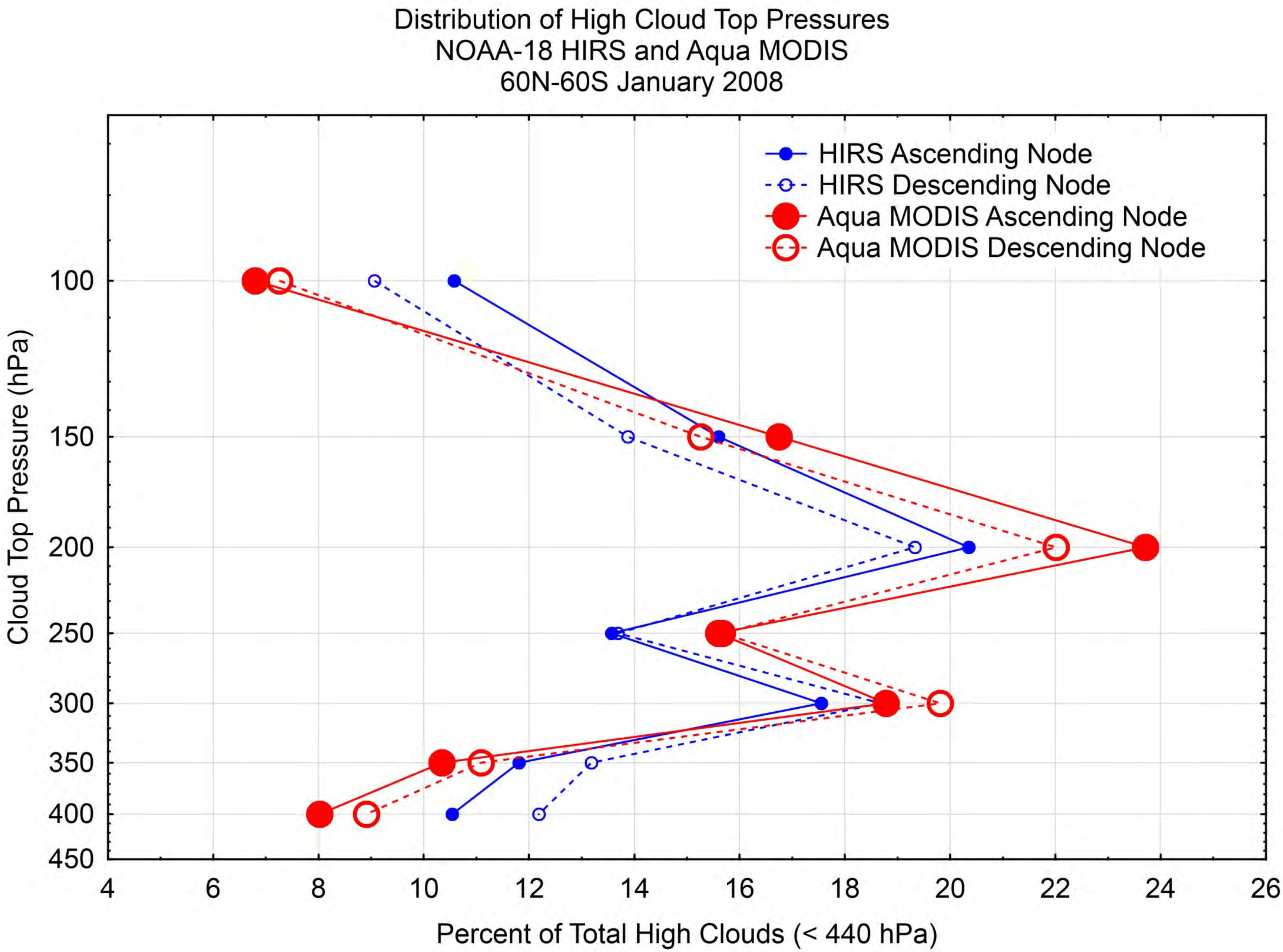
Menzel

HIRS DJF 2008 AN (60S-60N Day) High Cloud Frequency

CTP < 440 hPa



Menzel



Distribution of High Cloud Top Pressures
NOAA-18 HIRS and Aqua MODIS
60N-60S January 2008
HIRS Ascending Node
HIRS Descending Node
Aqua MODIS Ascending Node
Aqua MODIS Descending Node
Cloud Top Pressure (hPa)
100
150
200
250
300
350
400
450
4
6
8
10
12
14
16
18
20
22
24
26
Percent of Total High Clouds (< 440 hPa)

CO_2-slicing Algorithm Differences

Low Cloud Filters

HIRS uses PATMOS-x (AVHRR) cloud phase

more than 75% water clouds in a HIRS IFOV not permitted

MODIS uses emissivity 11/12 µm “beta” ratios

beta < 0.95 not permitted

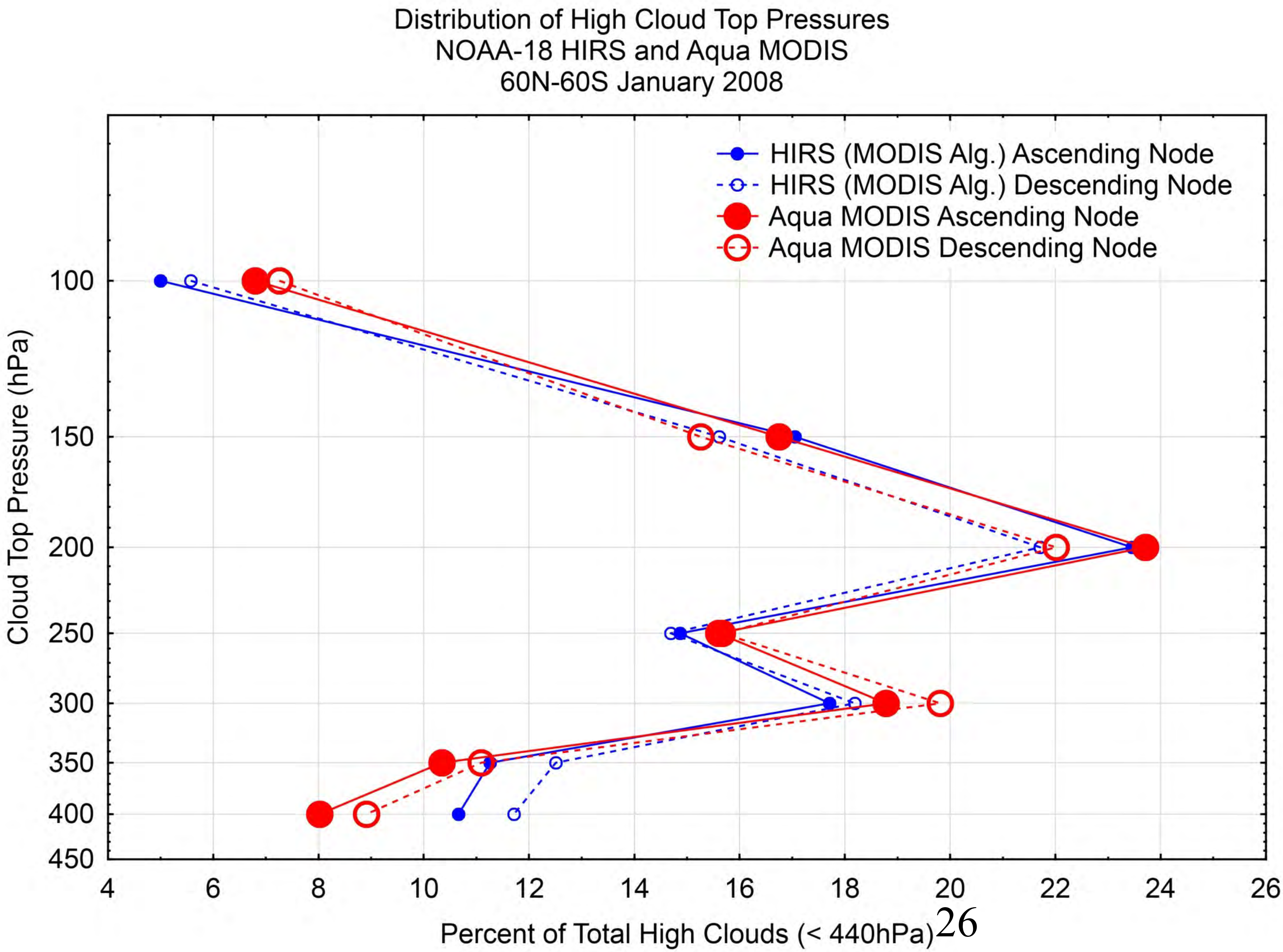
HIRS “second chance” high clouds

A HIRS detected high cloud overrides PATMOS-x cloud mask

Does not exist in the MODIS algorithm

Algorithm Sensitivity -> $(I_\lambda^{clr} - I_\lambda) > \Delta$

HIRS clear minus cloudy radiance difference threshold is $0.5\ W/m^2*str*cm^{-1}$


Distribution of High Cloud Top Pressures
NOAA-18 HIRS and Aqua MODIS
60N-60S January 2008
HIRS (MODIS Alg.) Ascending Node
HIRS (MODIS Alg.) Descending Node
Aqua MODIS Ascending Node
Aqua MODIS Descending Node
Cloud Top Pressure (hPa)
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6
8
10
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14
16
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22
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Percent of Total High Clouds (< 440hPa)

MODIS – HIRS Comparison

HIRS radiance data is being processed with MODIS CO_2-slicing algorithm

A one-year comparison between HIRS and Aqua MODIS shows high cloud frequency distribution is geographically very similar but with a consistent bias of about +12% HIRS relative to MODIS; a little higher in the tropics

More high transmissive clouds detected by HIRS relative to Aqua MODIS due to necessary decreased sensitivity thresholds (higher ΔR) for MODIS; may point to multiple detector issues on MODIS

Aqua MODIS cloud data is well characterized by comparisons to CALIOP lidar (A-train);

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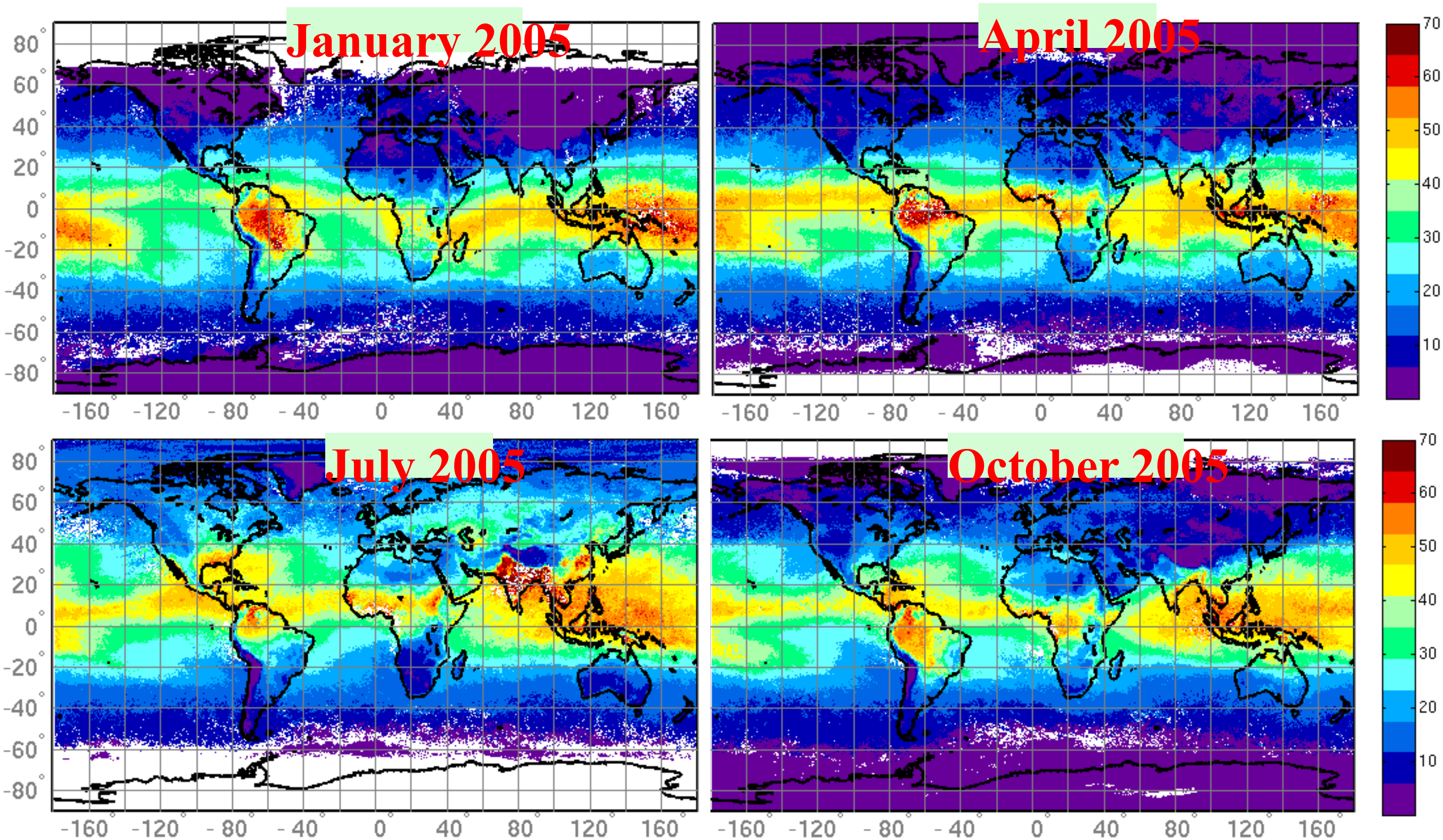
Global TPW Trends Inferred from 10 Years of HIRS Data (Poster)

- Comparing MODIS C6 and HIRS TPW trends
- HIRS Record extends from 1978 to the present
  - HIRS TPW (and UTH) is a statistical regression developed from the SeeBor data base (Borbas et al. 2005) that consists of geographically and seasonally distributed radiosonde, ozonesonde, and ECMWF ReAnalysis data. TPW are determined for clear sky radiances measured by HIRS (at 20km and later 10km resolution) over land and ocean both day and night. The retrieval approach is borrowed from MODIS (Seemann et al. 2003, Seemann et al. 2008).

(Borbas and Menzel)

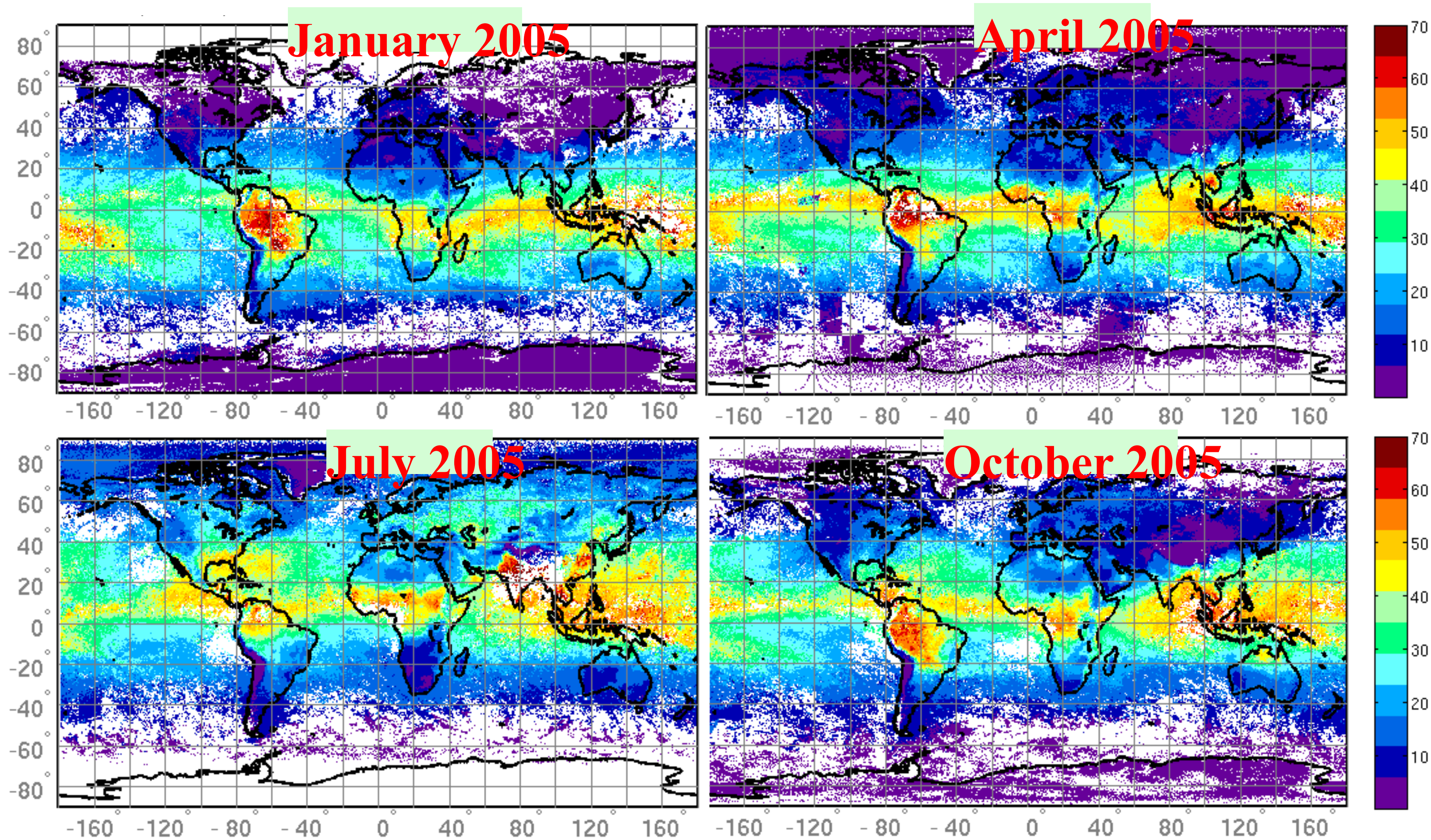
MOD07 monthly mean TPW (mm) (day)



M
M

(Borbas and Menzel)

N17/HIRS monthly mean TPW (mm) (day)

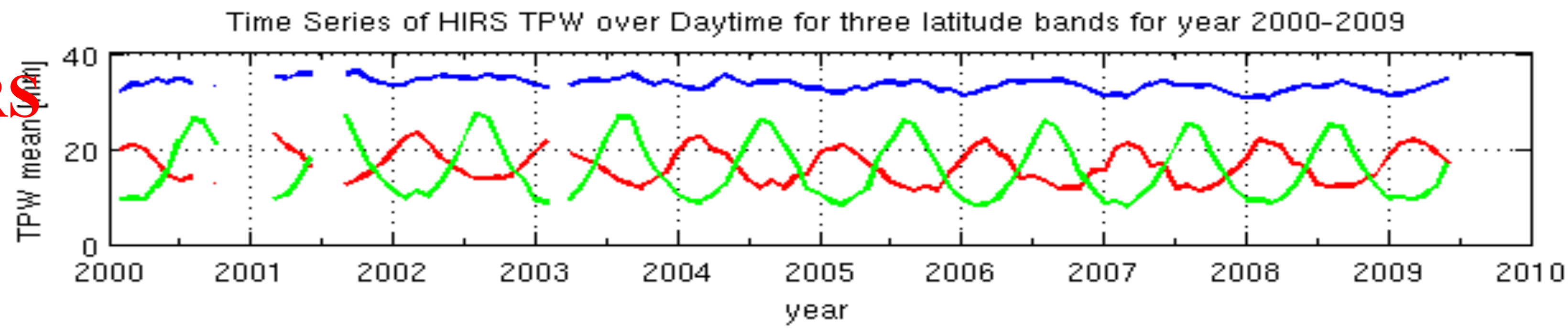


M
M

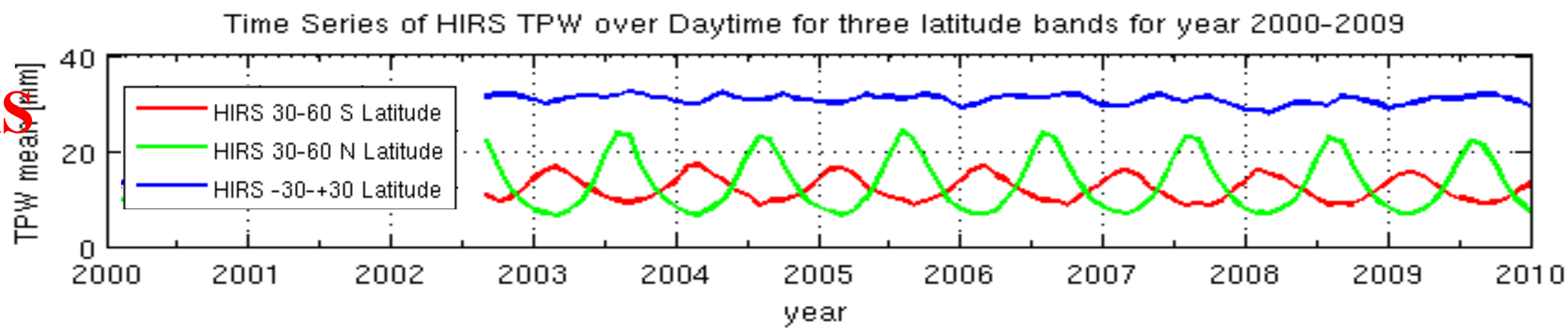
(Borbas and Menzel)

TPW Comparison (day)

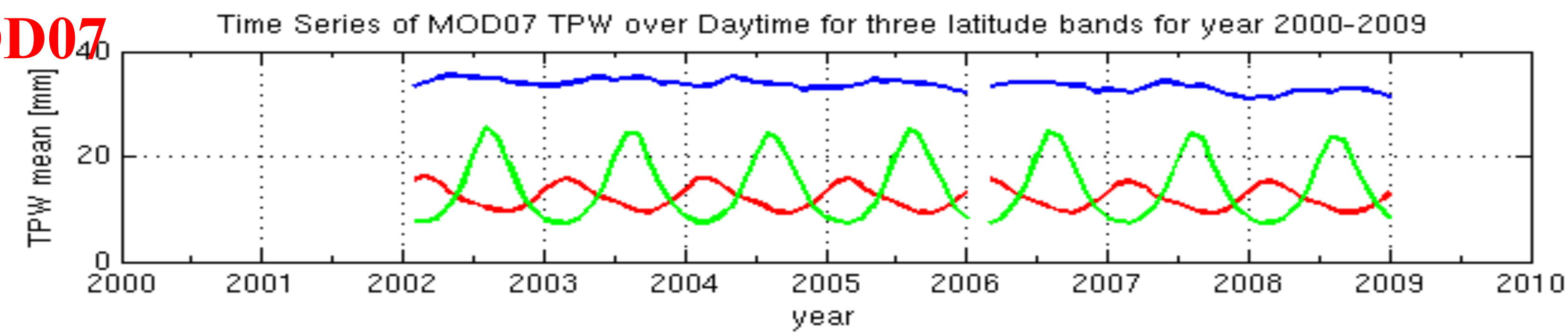
N15
HIRS



N17
HIRS



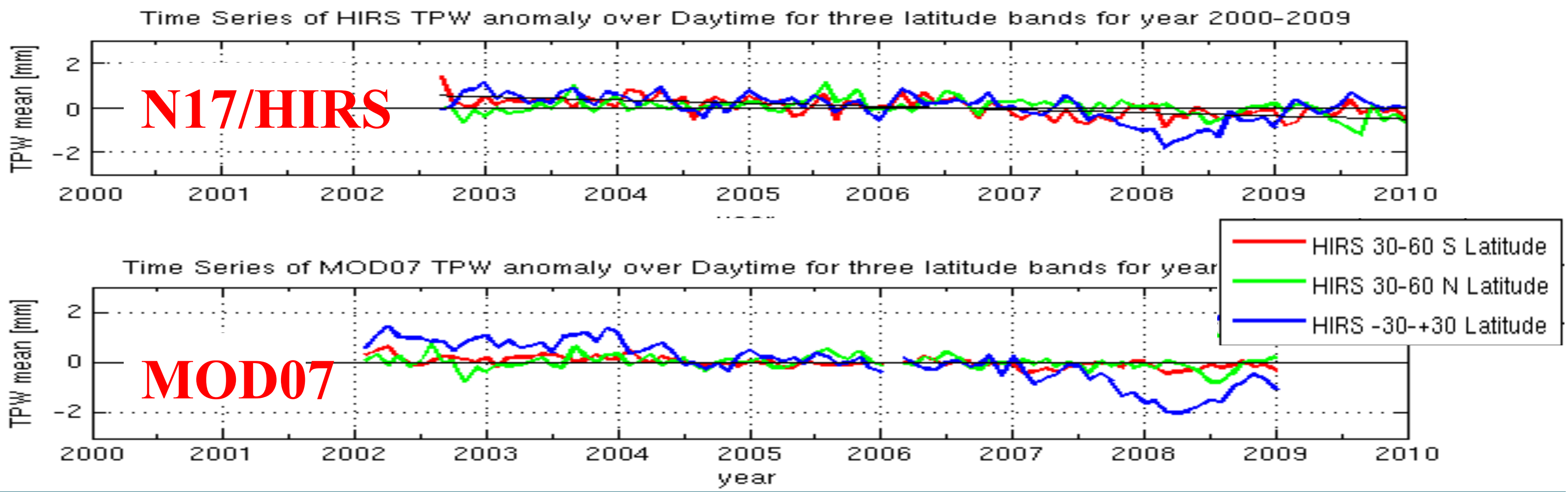
MOD07



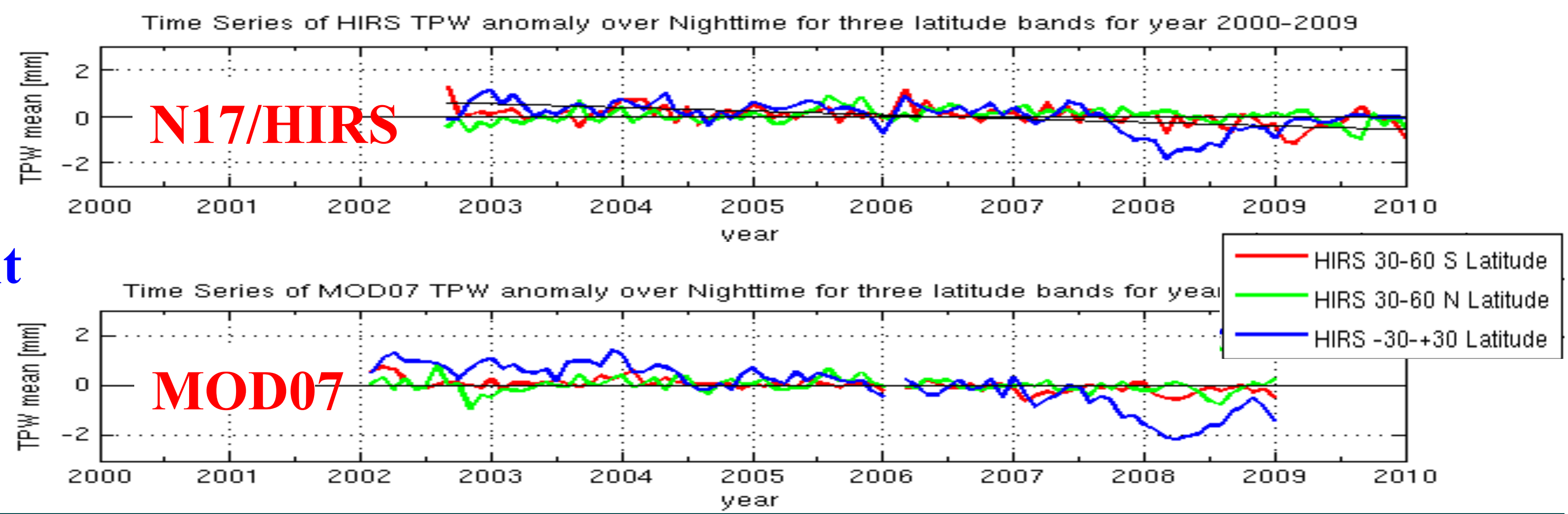
(Borbas and Menzel)

MOD07 and N17 TPW anomalies (day & night)

day



night



(Borbas and Menzel)

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IMAPP/CSPP Software Philosophy

Released software must:

- Create useful products for the DB community,
- Include up-to-date algorithms,
- Be pre-compiled for 32 and/or 64-bit Linux,
- Be easy to install and operate,
- Include test data for verification,
- Have prompt user support,
- Run efficiently on modest hardware.

Focus on IMAPP

International MODIS/AIRS Processing Package

Aqua and Terra support for the Direct Broadcast Community Funded by NASA since 2000

http://cimss.ssec.wisc.edu/imapp/

- 50 software packages released in 13 years
- More than 1700 registrants from 73 different countries
- 11 direct broadcast workshops held on 5 continents
- 16 MODIS related software packages
- 7 AIRS related software packages
- 4 AMSR-E software packages

IMAPP Software Suite

MODIS Atmosphere and Polar Products • Cloud mask • Cloud top pressure and temperature • Cloud optical depth and effective radius • Temperature and moisture profiles • Total precipitable water • Stability indices • Aerosol optical depth • Ice Surface Temperature • Snow Mask • Ice Cover and Ice Concentration • Inversion Strength and Inversion Depth **MODIS Land Products** • Land Surface Reflectance • BRDF **MODIS Image Software** • MODIS in Google Earth (true color) **AIRS Level 1B** • Calibrated and geolocated radiances and brightness temperatures (AIRS) • Calibrated and geolocated antenna temperatures (AMSU)	**AIRS Retrievals** • JPL 3x3 FOV • Dual Regression Single FOV **AIRS Utilities** • Collocating AIRS/MODIS utility • AIRS HDF to BUFR utility **AMSR-E Level 1B** • Calibrated and Geolocated Antenna Temperatures **AMSR-E Products** • Rain Rate, Soil Moisture, Snow Water Equilvalent **NWP Products** • Globally configurable regional numerical weather prediction model that assimilates MODIS DB products - DBCRAS **Aviation/Severe Weather Products** • Overshooting Tops Identification including turbulence and lightning potential **Complete DB Processing System** • VA for Mac, Windows and Linux

IMAPP Software Suite

Air Quality Forecast Product – IDEA-I

- 48 Hour Aerosol trajectory forecast
- Beta- Stratospheric Ozone Intrusions trajectory forecast

Visualization Tools

- Polar2Grid MODIS reprojection software including true color images

- COMING SOON

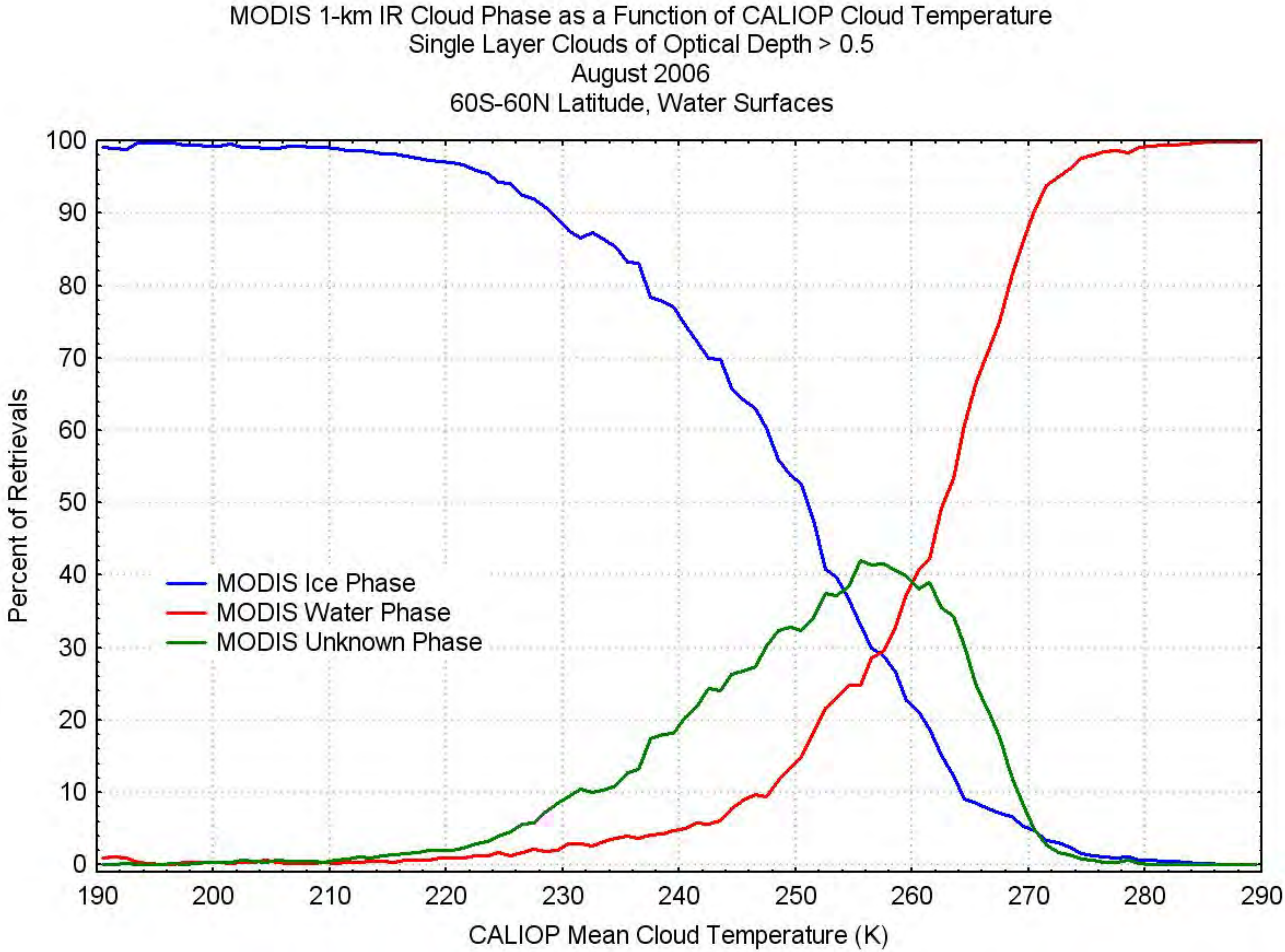
- MODIS Atmosphere Collect 6 Products
    - Wrapped operational algorithms, with standalone execution capability.

Web Mapping Service (wms)

- Display and share GeoTIFFs through a web browser
- Can readily display Polar2Grid VIIRS/MODIS Imagery

Summary

- C6 algorithms (cloud mask, IR cloud phase, cloud top and atmospheric profiles) have been updated, improvement has demonstrated and code delivered,
- Validation continues and methods of assigning uncertainty
- Science analysis continues, merging MODIS with HIRS data record (also AVHRR).



MODIS 1-km IR Cloud Phase as a Function of CALIOP Cloud Temperature
Single Layer Clouds of Optical Depth > 0.5
August 2006
60S-60N Latitude, Water Surfaces
Percent of Retrievals
CALIOP Mean Cloud Temperature (K)
MODIS Ice Phase
MODIS Water Phase
MODIS Unknown Phase
0
10
20
30
40
50
60
70
80
90
100
190
200
210
220
230
240
250
260
270
280
290

THANKS