MODIS Atmospheric Science Products: Radiances, Cloud Detection, Cloud Properties, and Atmospheric Profiles

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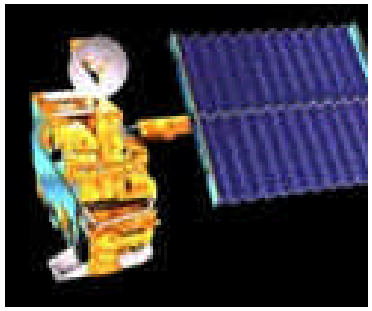
University of Wisconsin
CIMSS

inter-calibration
cloud mask
cloud properties
ozone and moisture
direct broadcast

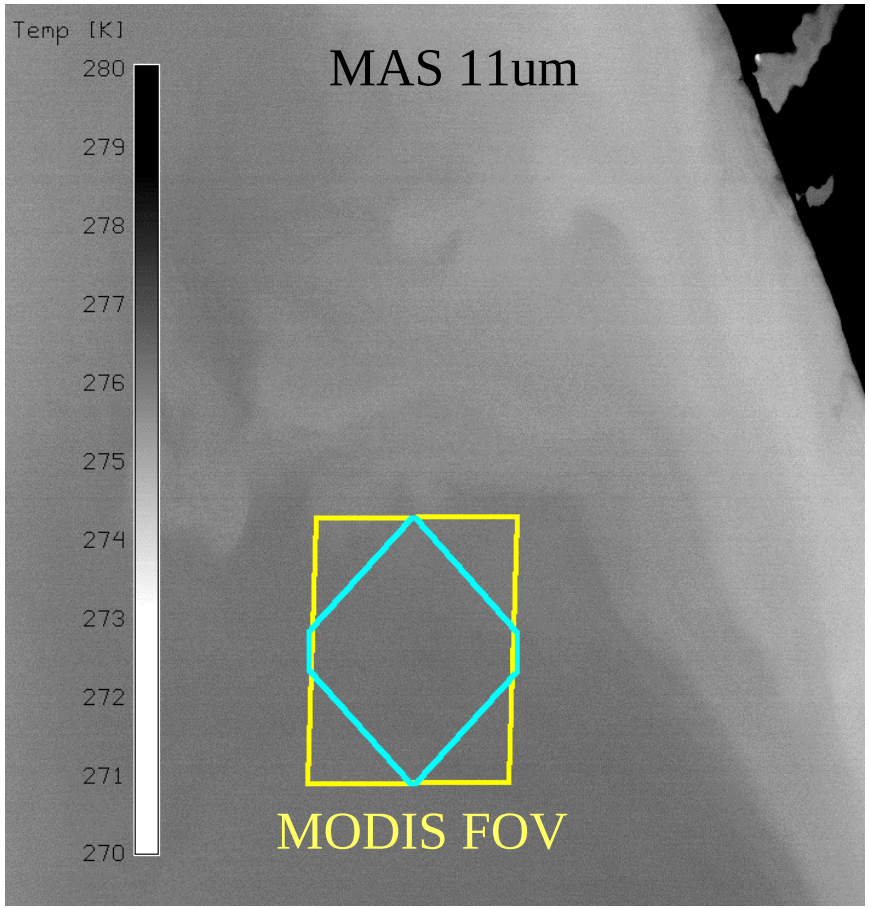
MODIS IR Cal/Val from ER-2 Sep 2000

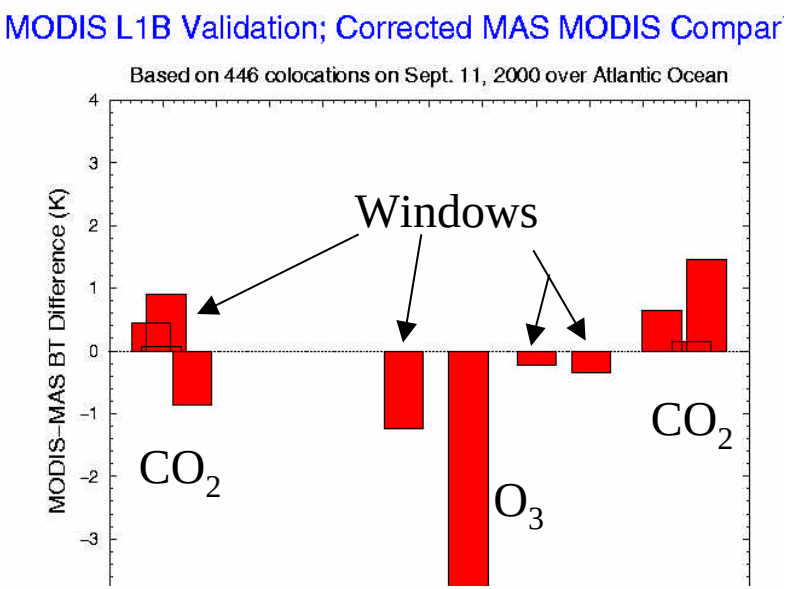


MAS
S-HIS

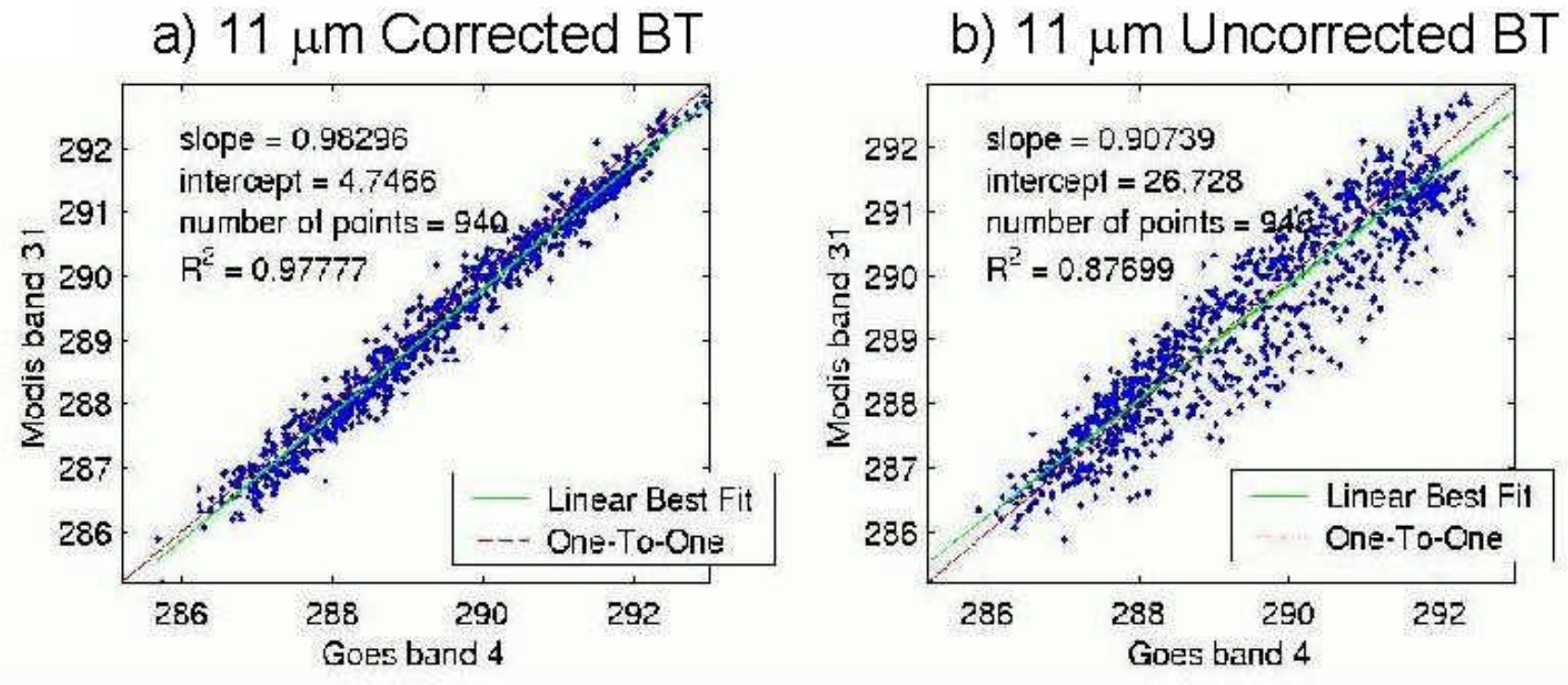
Purpose: Validate MODIS L1B

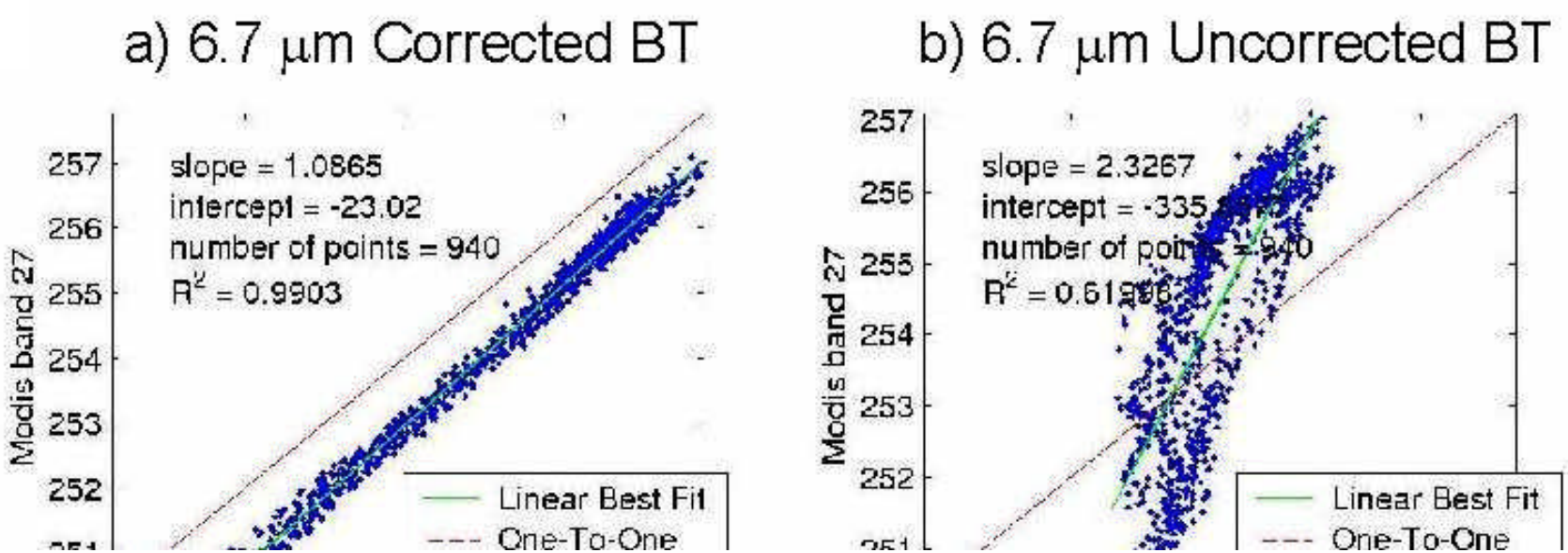
- Transfer S-HIS cal to MAS
- Collocate MODIS FOV on MAS
- Remove spatial, spectral and viewing geometry dependencies





MODIS and GOES IRW and H2O Comparisons





Detecting Clouds (IR)

IR Window Brightness Temperature Threshold and Difference Tests

IR tests sensitive to sfc emissivity and atm PW, dust, and aerosols
BT11 < 270
BT11 + aPW * (BT11 - BT12) < SST
BT11 + bPW * (BT11 - BT8.6) < SST
    aPW and bPW determined from lookup table as a function of PW
BT3.9 - BT11 > 12 indicates daytime low cloud cover
BT11 - BT12 < 2 (rel for scene temp) indicates high cloud
BT11 - BT6.7 large neg diff for clr sky over Antarctic Plateau winter

CO2 Channel Test for High Clouds

BT13.9 < threshold (problems at high scan angle or high terrain)

Detecting Clouds (vis)

Reflectance Threshold Test

r.87 > 5.5% over ocean indicates cloud
r.66 > 18% over vegetated land indicates cloud

Near IR Thin Cirrus Test

r1.38 > threshold indicates presence of thin cirrus cloud
ambiguity of high thin versus low thick cloud (resolved with BT13.9)
problems in high terrain

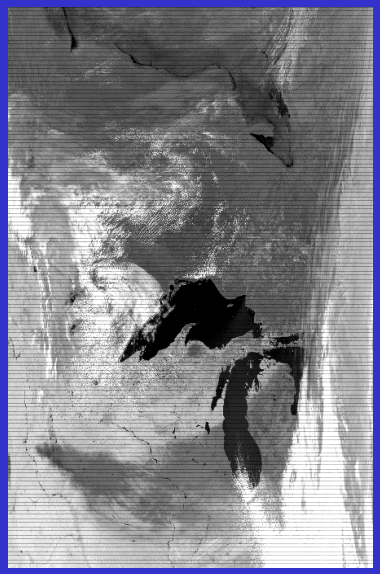
Reflectance Ratio Test

r.87/r.66 between 0.9 and 1.1 for cloudy regions
must be ecosystem specific

Snow Test

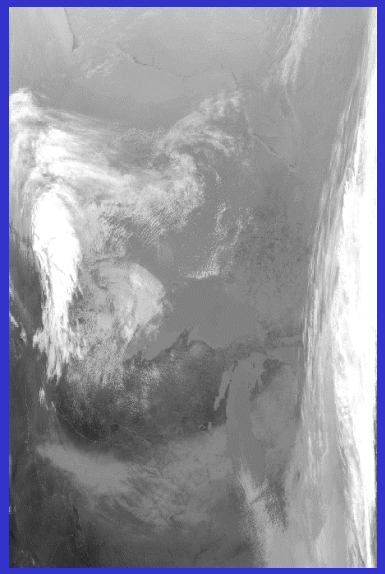
NDSI = [r.55-r1.6]/ [r.55+r1.6] > 0.4 and r.87 > 0.1 then snow

1.6 µm image

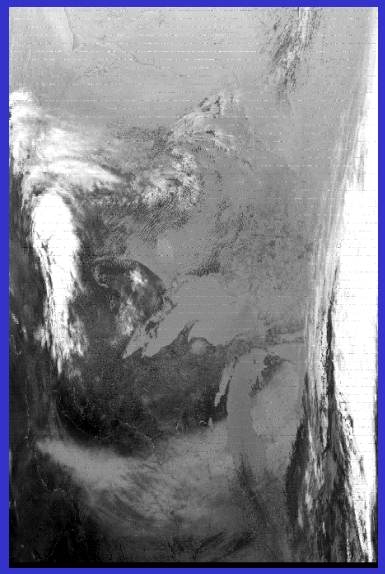


0.86 µm image

11 µm image



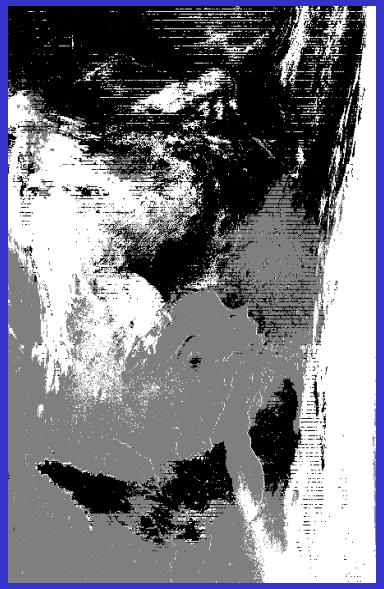
3.9 µm image



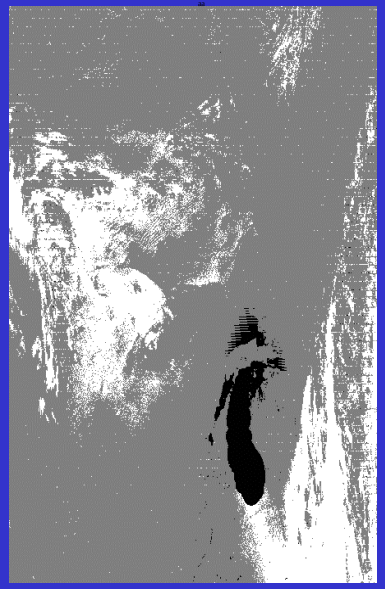
cloud mask

Snow test
(impacts choice of
tests/thresholds)

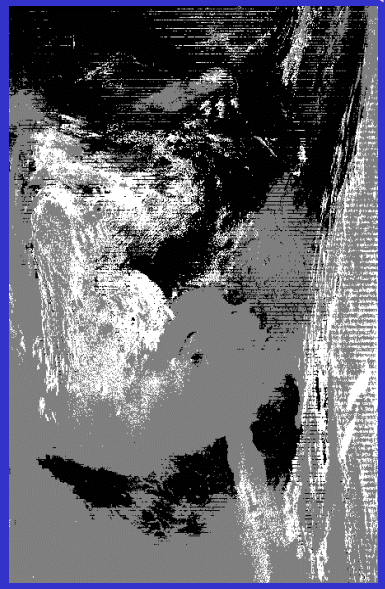
VIS test
(over non-snow
covered areas)



3.9 - 11 BT test
for low clouds



11 - 12 BT test
(primarily for
high cloud)

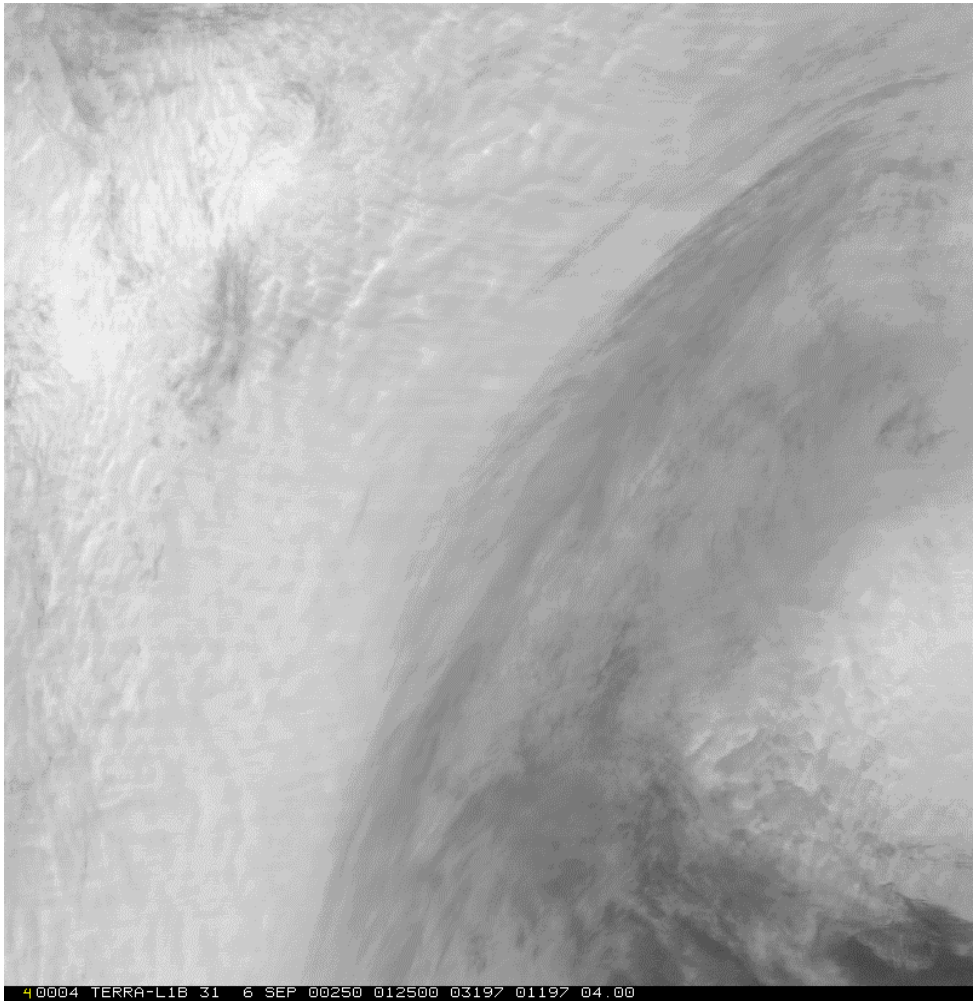


13.9 µm
high cloud test
(sensitive in cold regions)

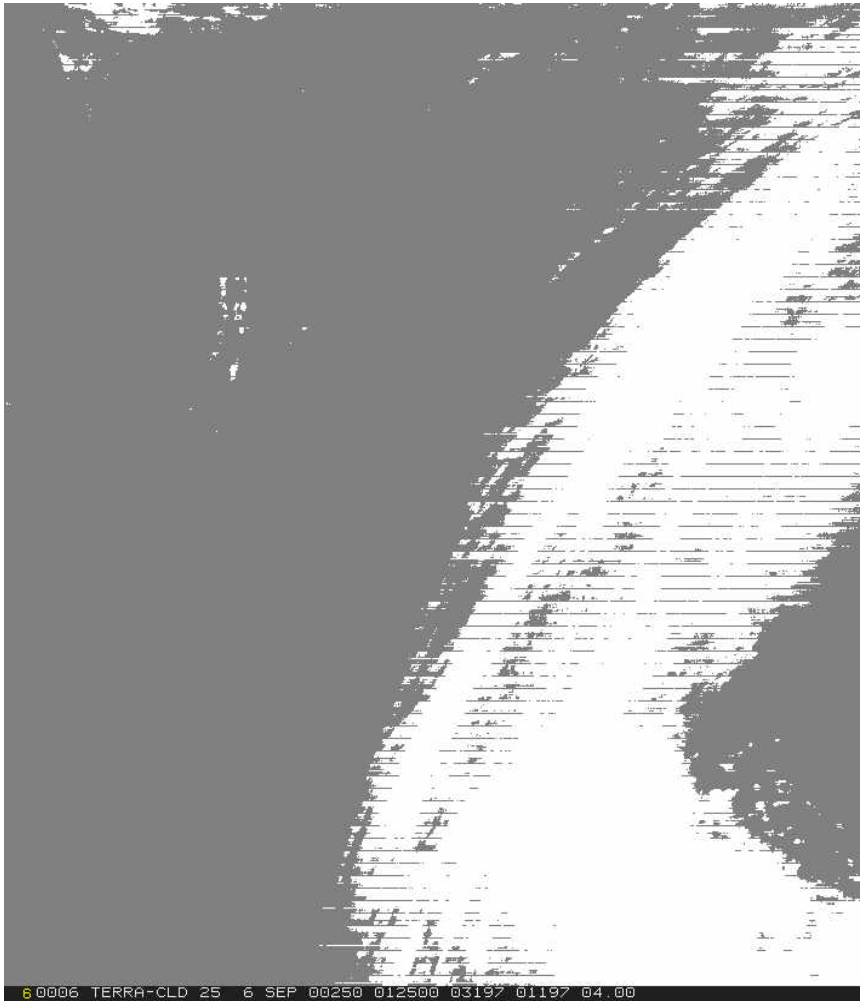
MODIS cloud mask example

(**confident clear** is green, **probably clear** is blue, **uncertain** is red,)

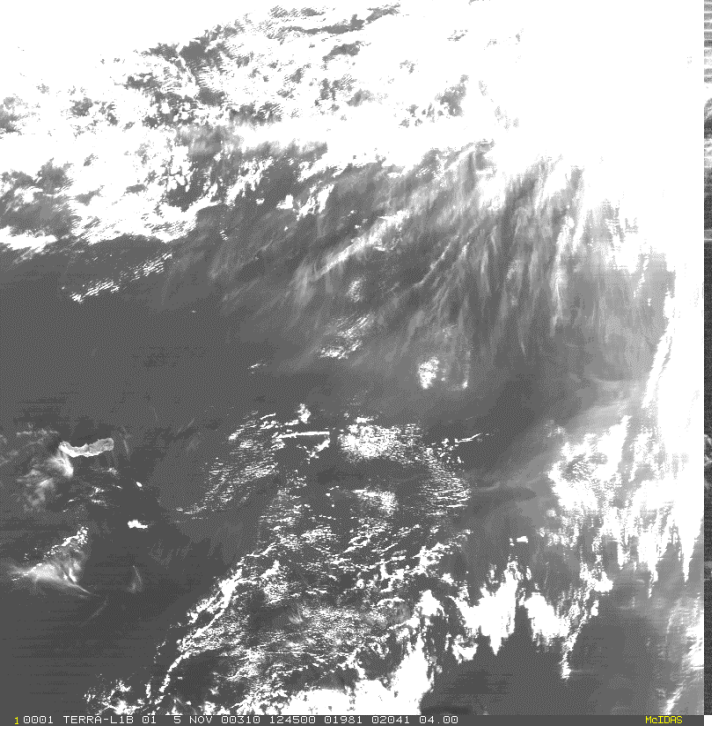
6.7-11 µm BTD Test helping Cloud Mask in Polar Regions



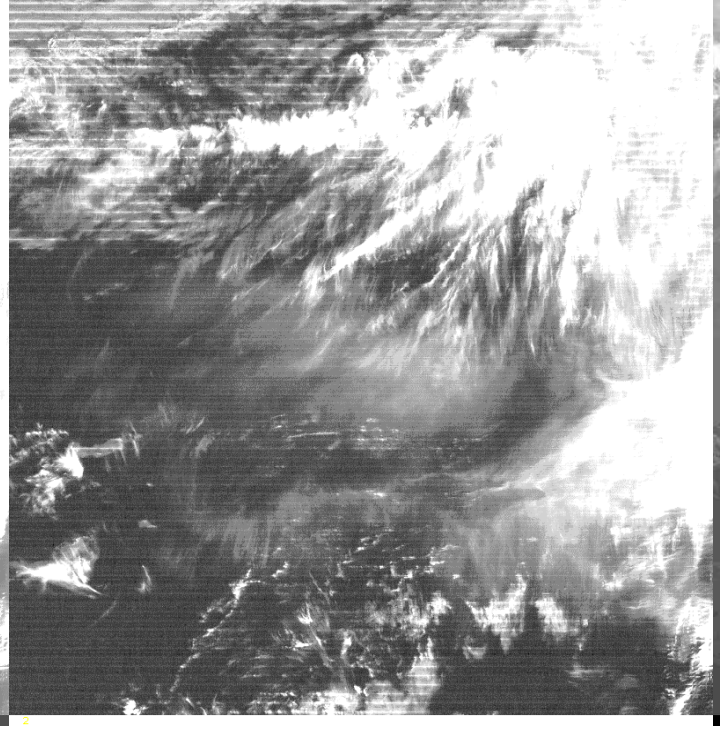
MODIS 11 µm image of Antarctic near the South Pole. Warmer temperatures are darker. Brightness temperatures vary from approximately 190K to 245K. Clear areas are lighter (colder).



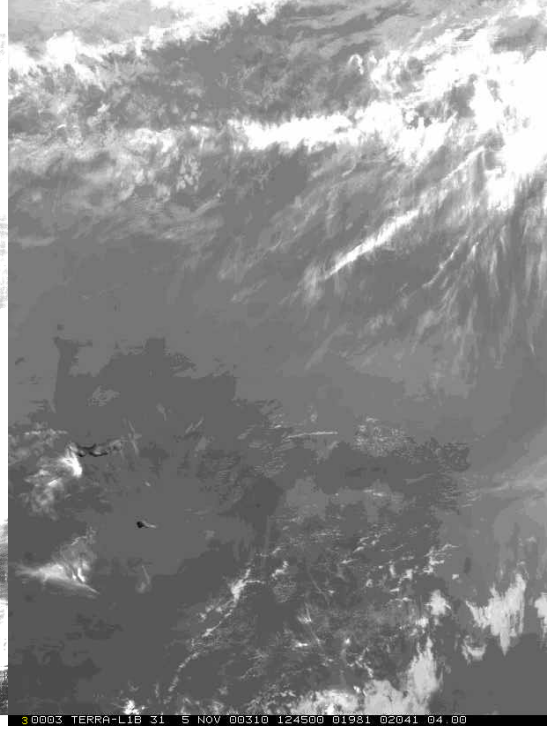
Operational MODIS cloud mask image. Clouds are indicated in white..



VIS

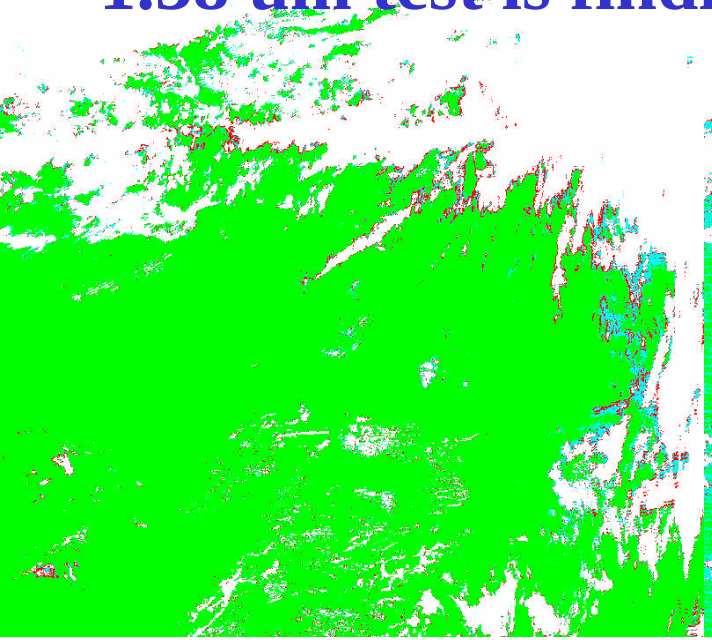


1.38

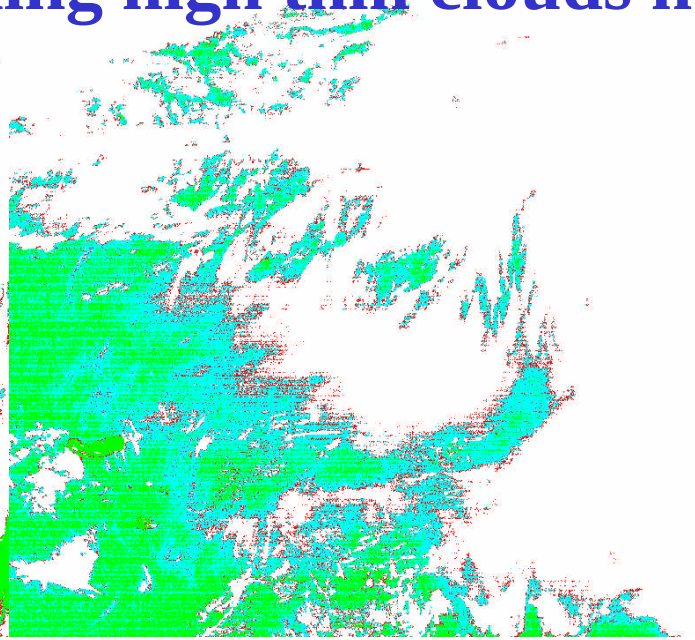


IRW

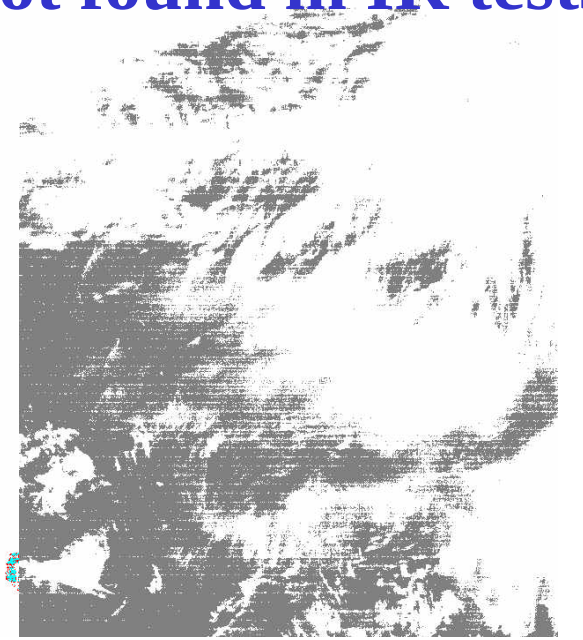
1.38 um test is finding high thin clouds not found in IR tests



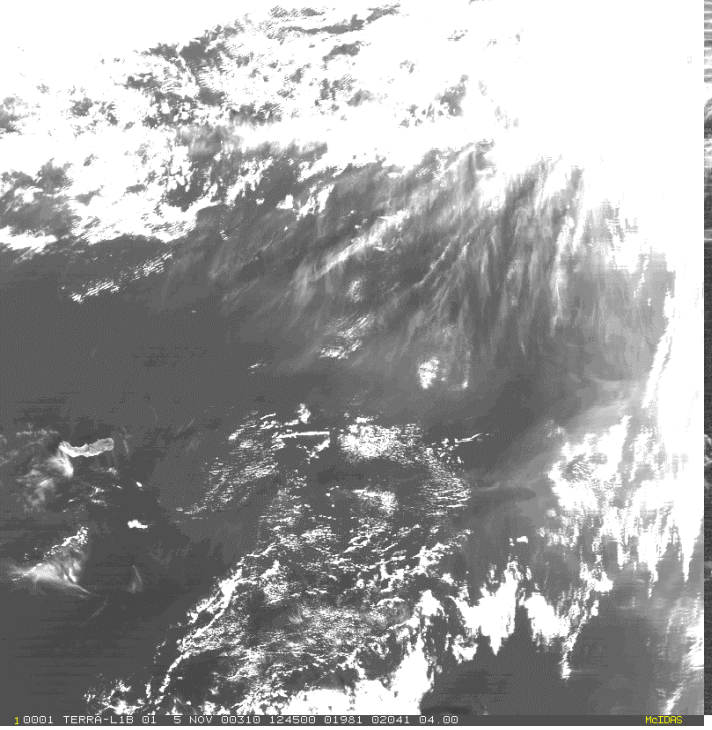
org cld msk



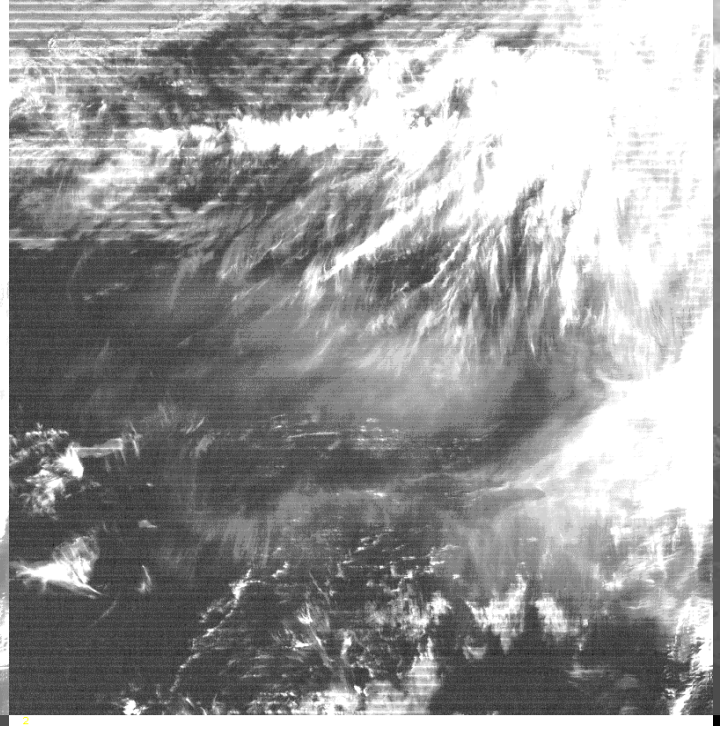
adj cld msk



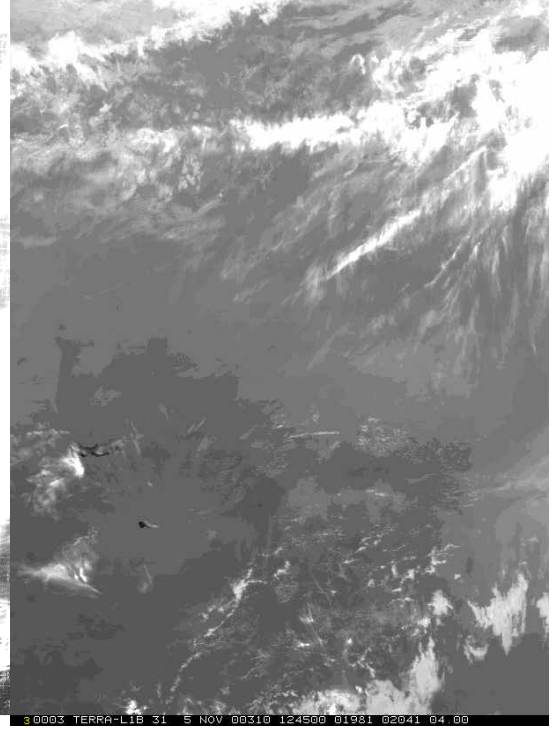
1.38 cld msk



VIS



1.38



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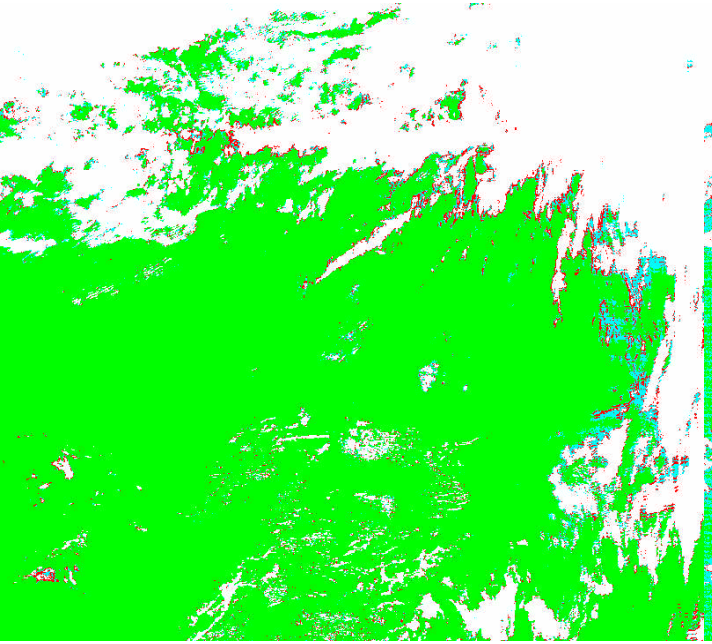
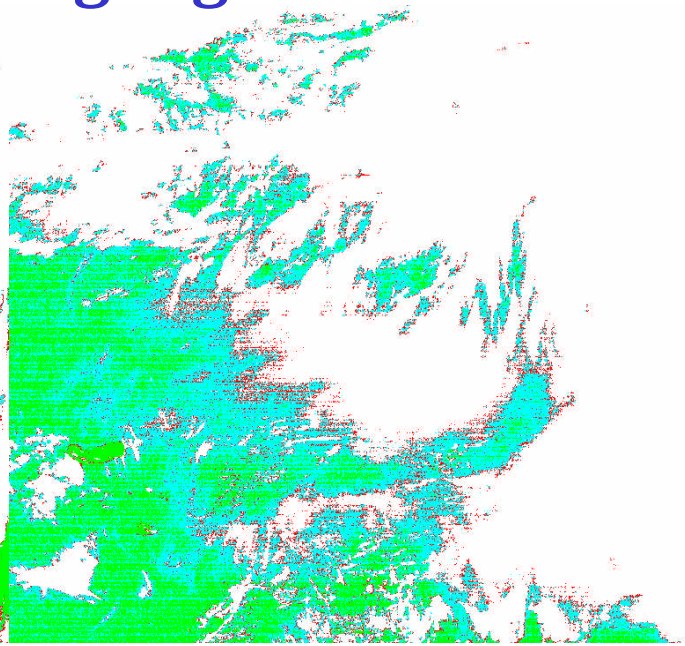
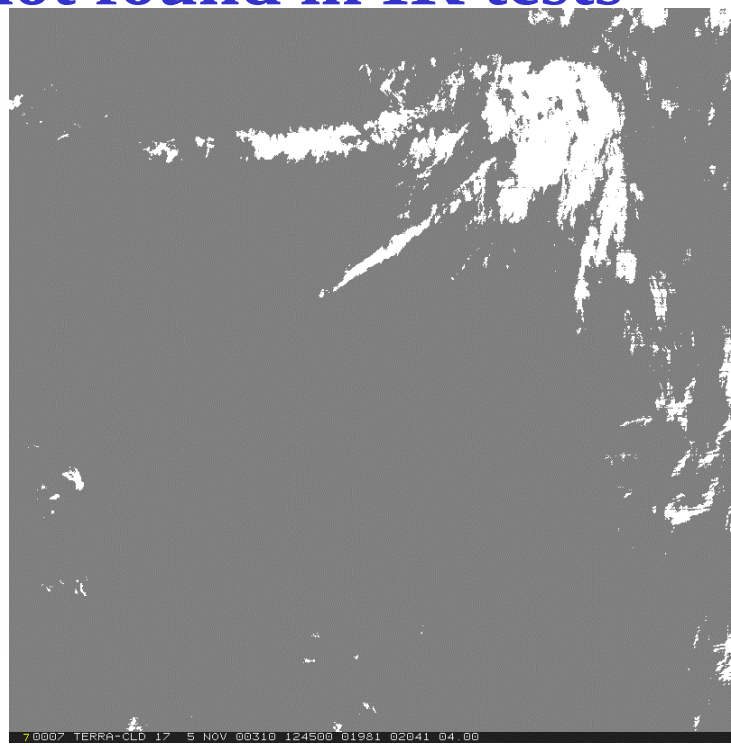
1.38 um test is finding high thin clouds not found in IR tests



org cld msk

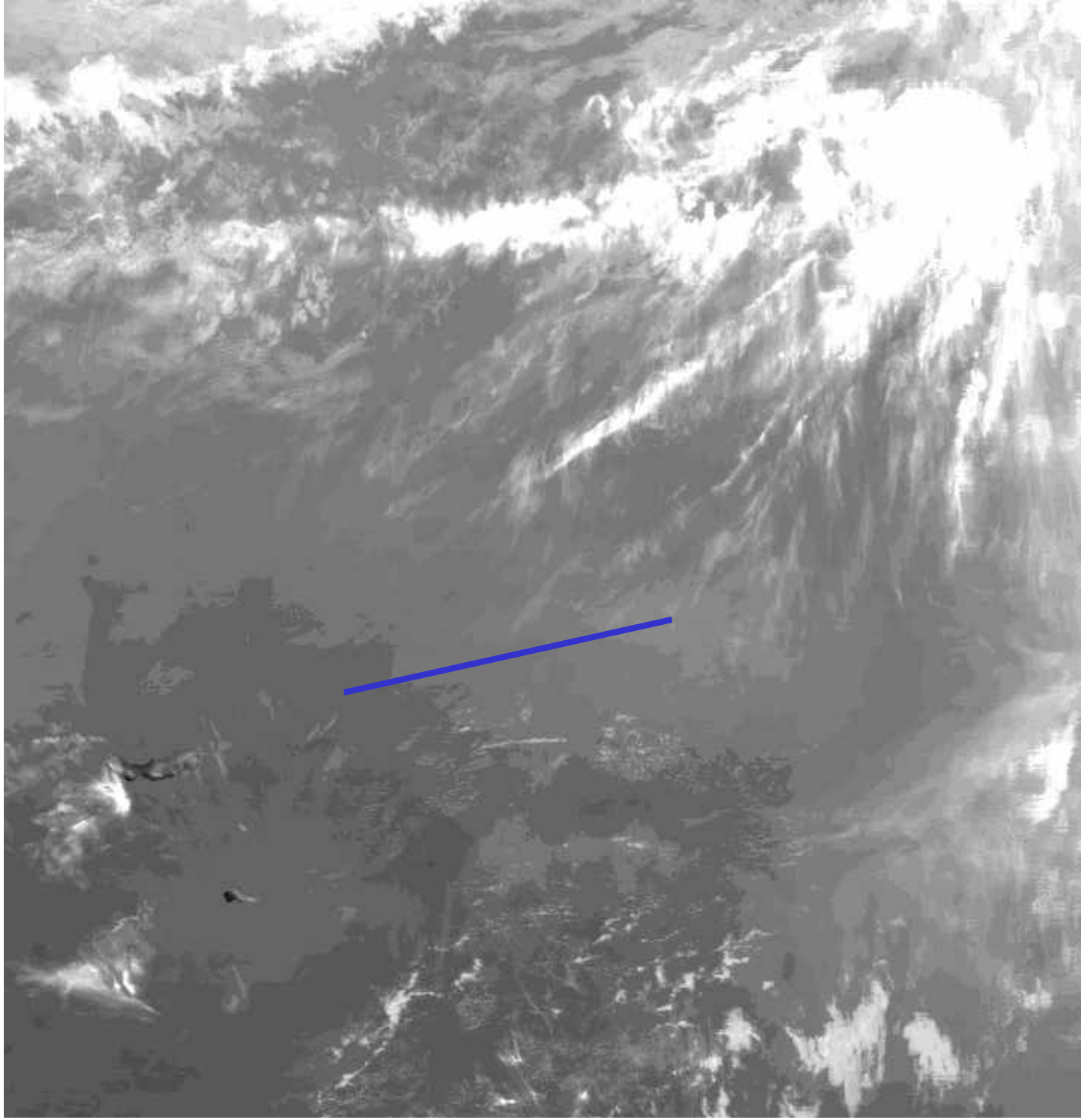


adj cld msk

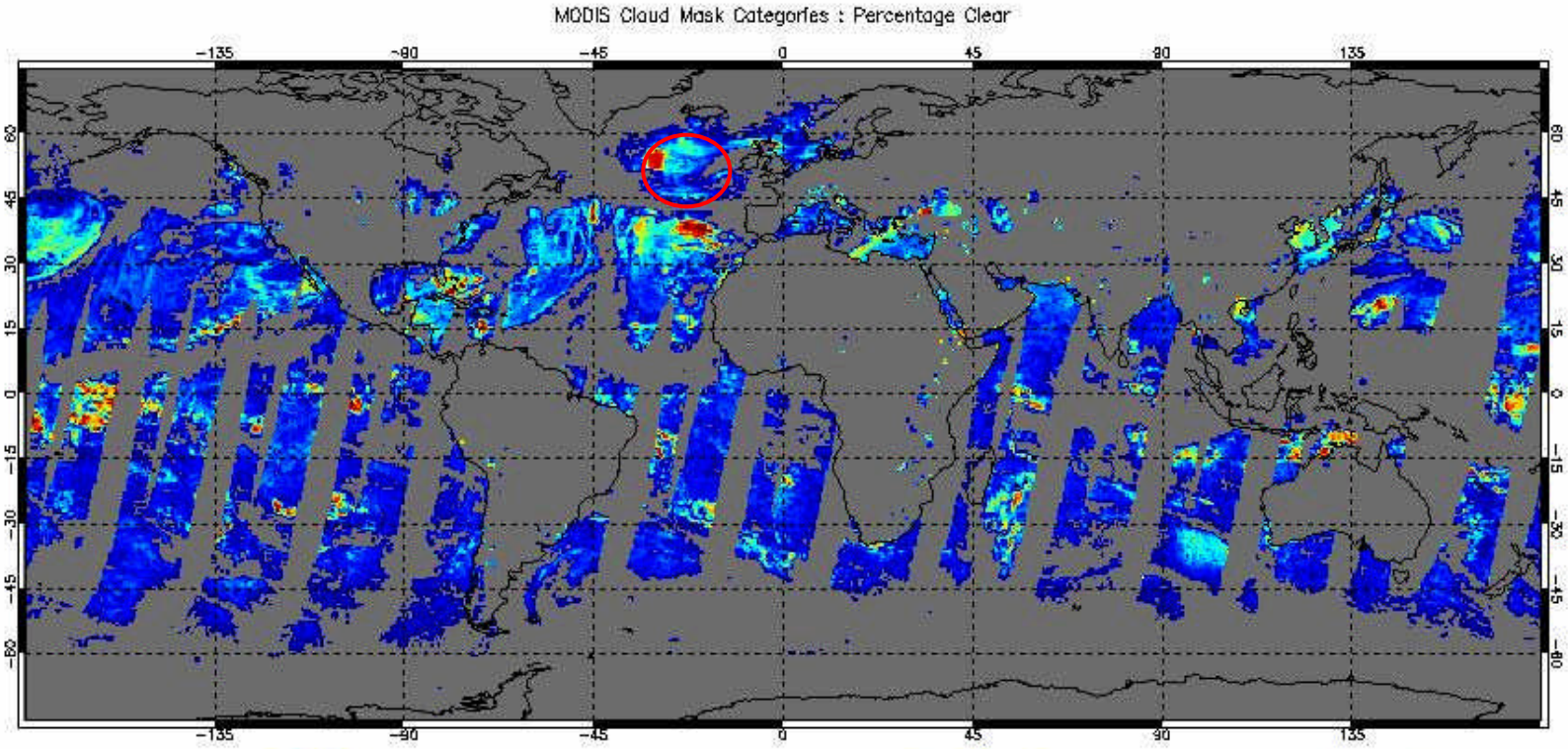


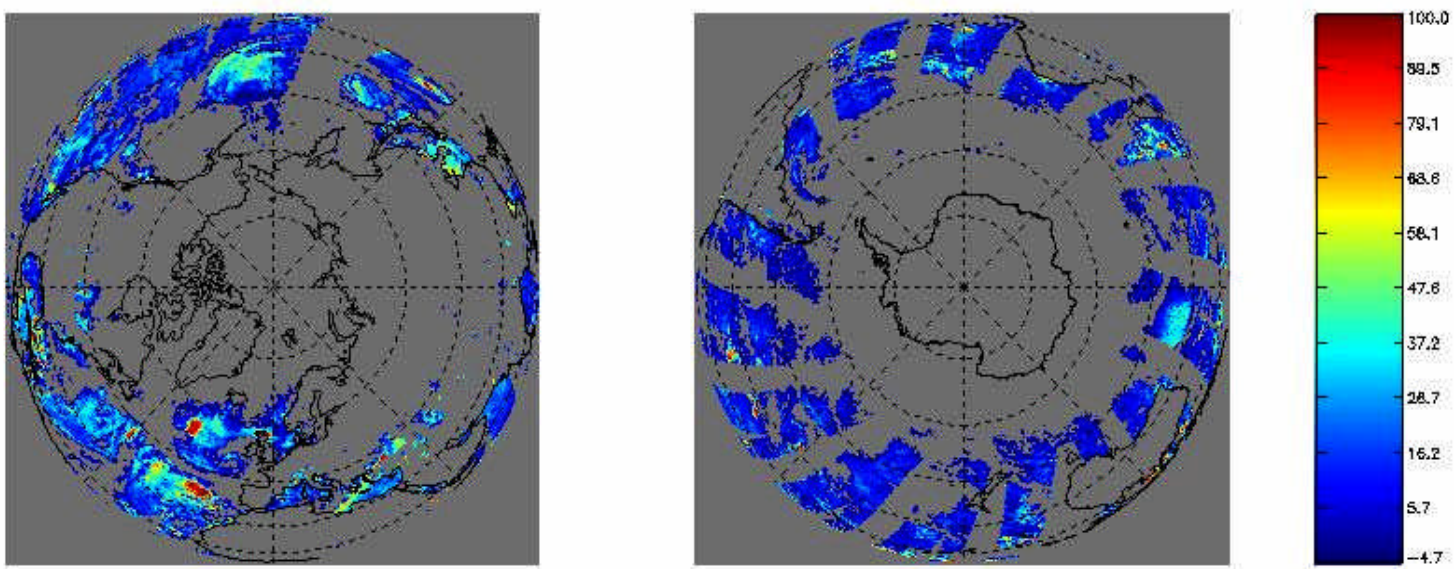
tri-spectral cld msk

Is 3 K gradient SST or clouds?



Impact of 1.38 um cloud detection
Difference in % Clear-sky (original - modified cloud mask)





confidence of clear-sky > 99%

MODIS cloud mask algorithm was updated 29 September 2000

Major changes were:

* Added sun-glint test based on 3.75-11 um difference in bit #26. In severe sun-glint, confidence of clear sky is uncertain if IR tests do not indicate cloud.

* Over land, bit #26 helps find clear in daytime desert when no IR cloud test indicates cloud, and the 11 um brightness temperature is higher than a given threshold.

* Added checks for cloudy pixels misidentified as snow.

* Added 11 um variability (standard deviation over 3x3 pixel region) test to find warm low clouds over nighttime ocean in bit #27.

* Added "suspended dust test" over daytime land in bit #28 when 11 - 12 is negative.

* No shadow determinations are attempted in coastal regions.

* Various cloud test thresholds were adjusted.

Pending changes are:

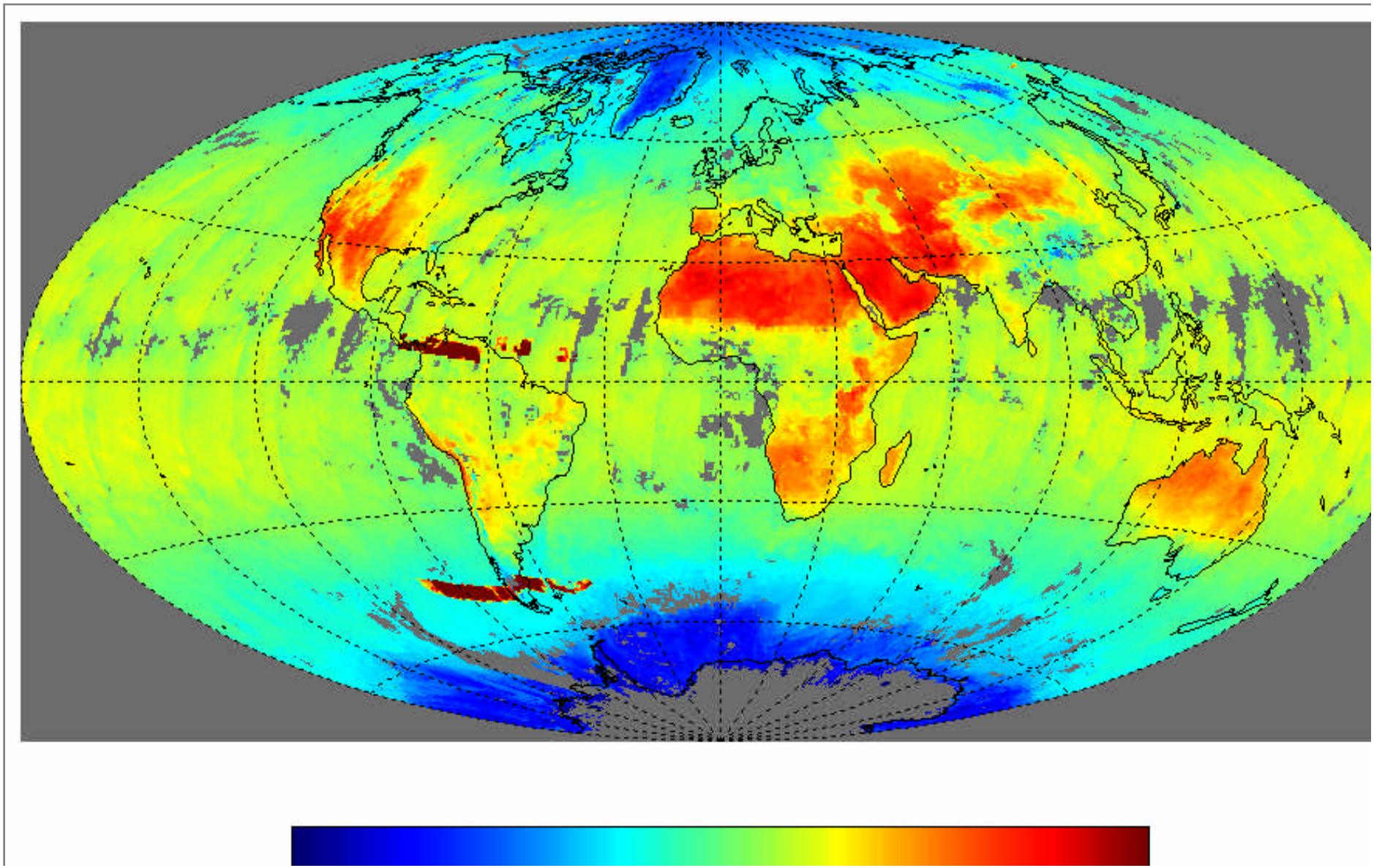
* Elevation check to assist in mountains

* Expanding Antarctic cloud checks (too bright for current thresholds)

* Mitigating striping problems (especially over Sahara)

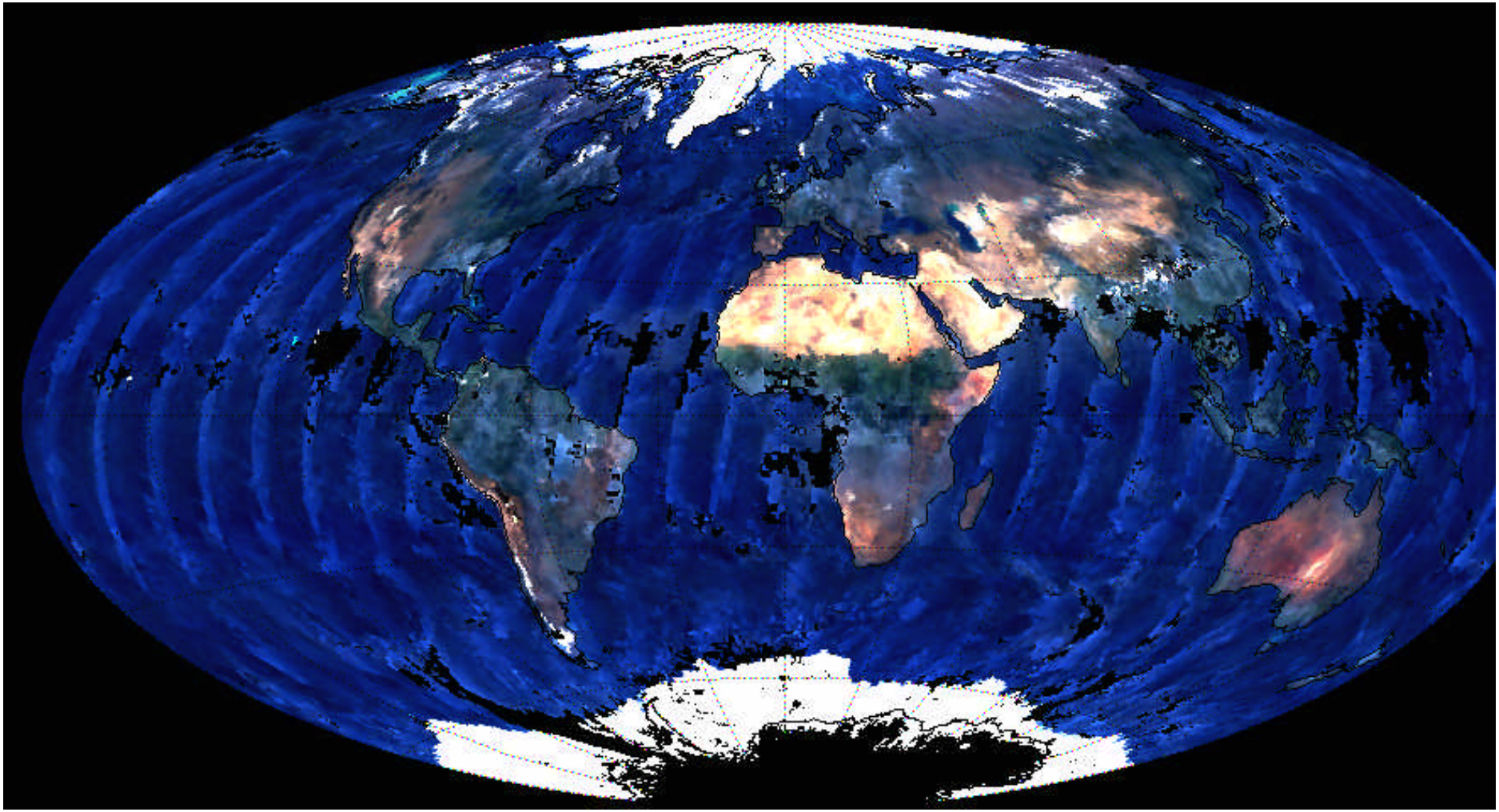
MODIS 5-8 September 2000

Band 31 (11.0 µm) Daytime Clear sky Brightness Temperature



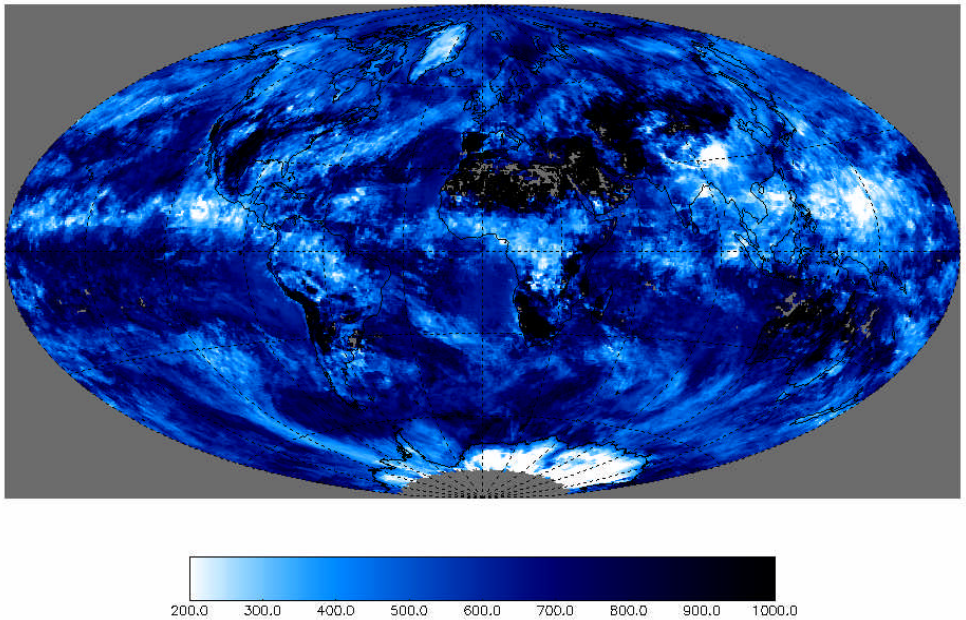
MODIS 5-8 September 2000

Band 1, 4, 3 (R/G/B) Daytime Clear sky Reflectance Composite

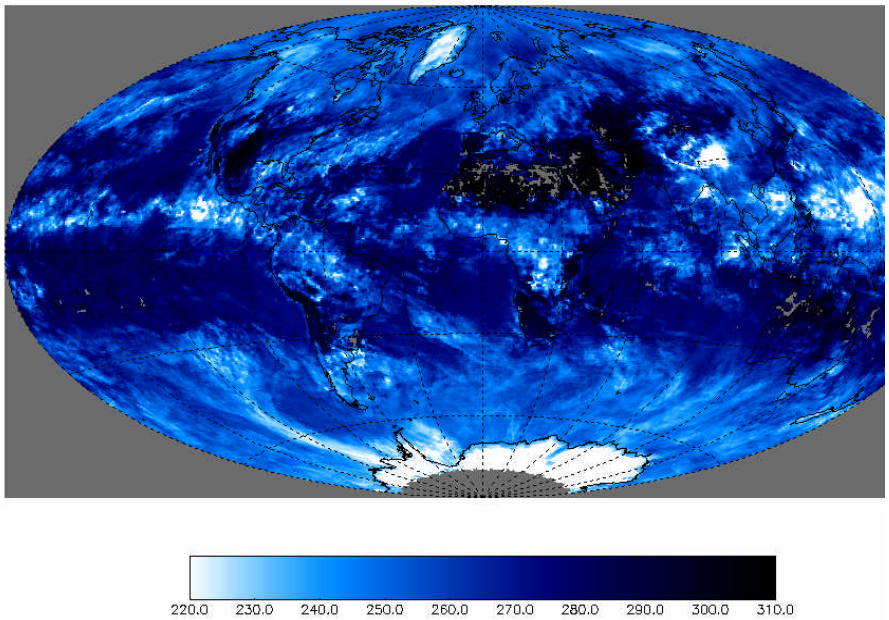


MODIS 5-8 September 2000

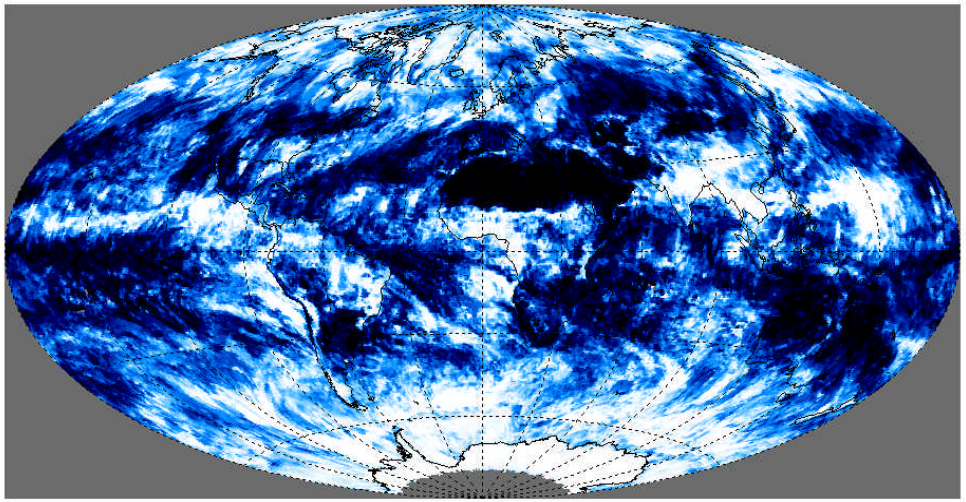
Cloud top Pressure



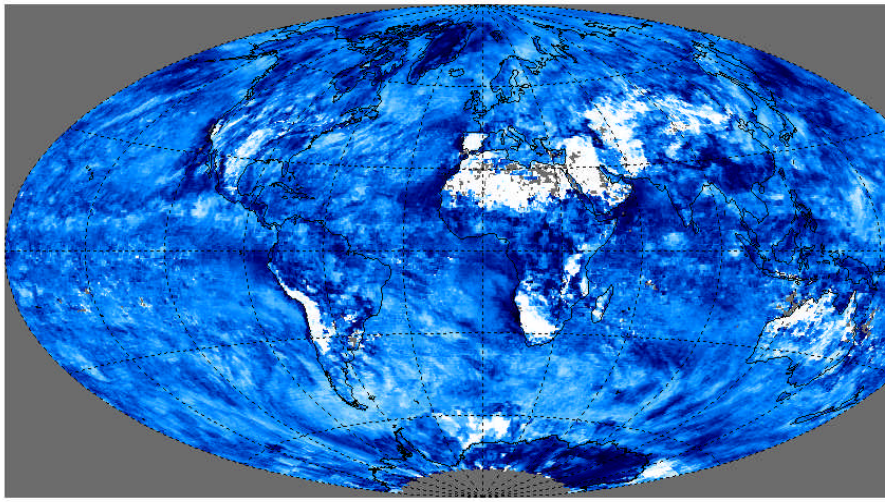
Cloud top Temperature



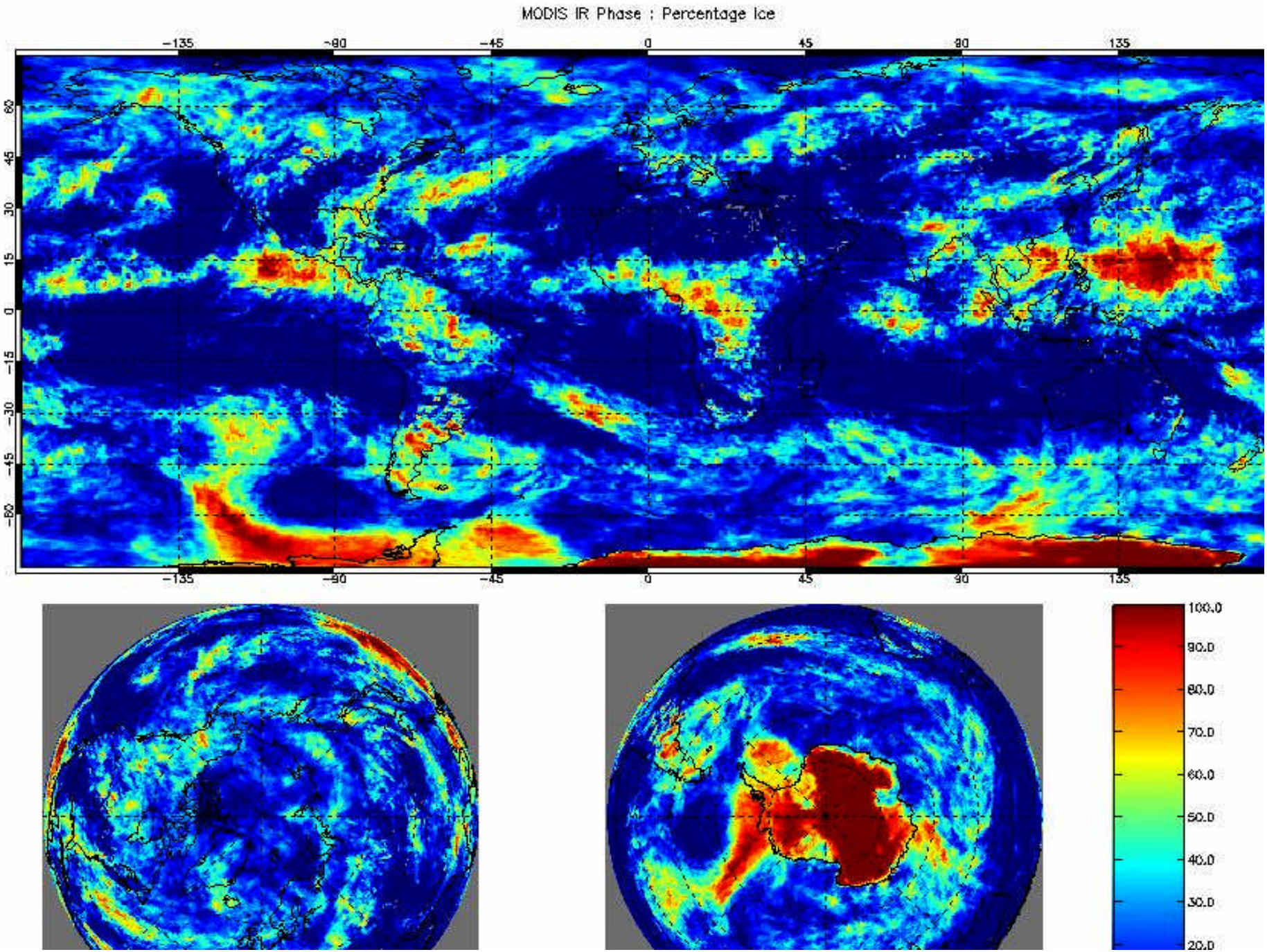
Cloud Fraction



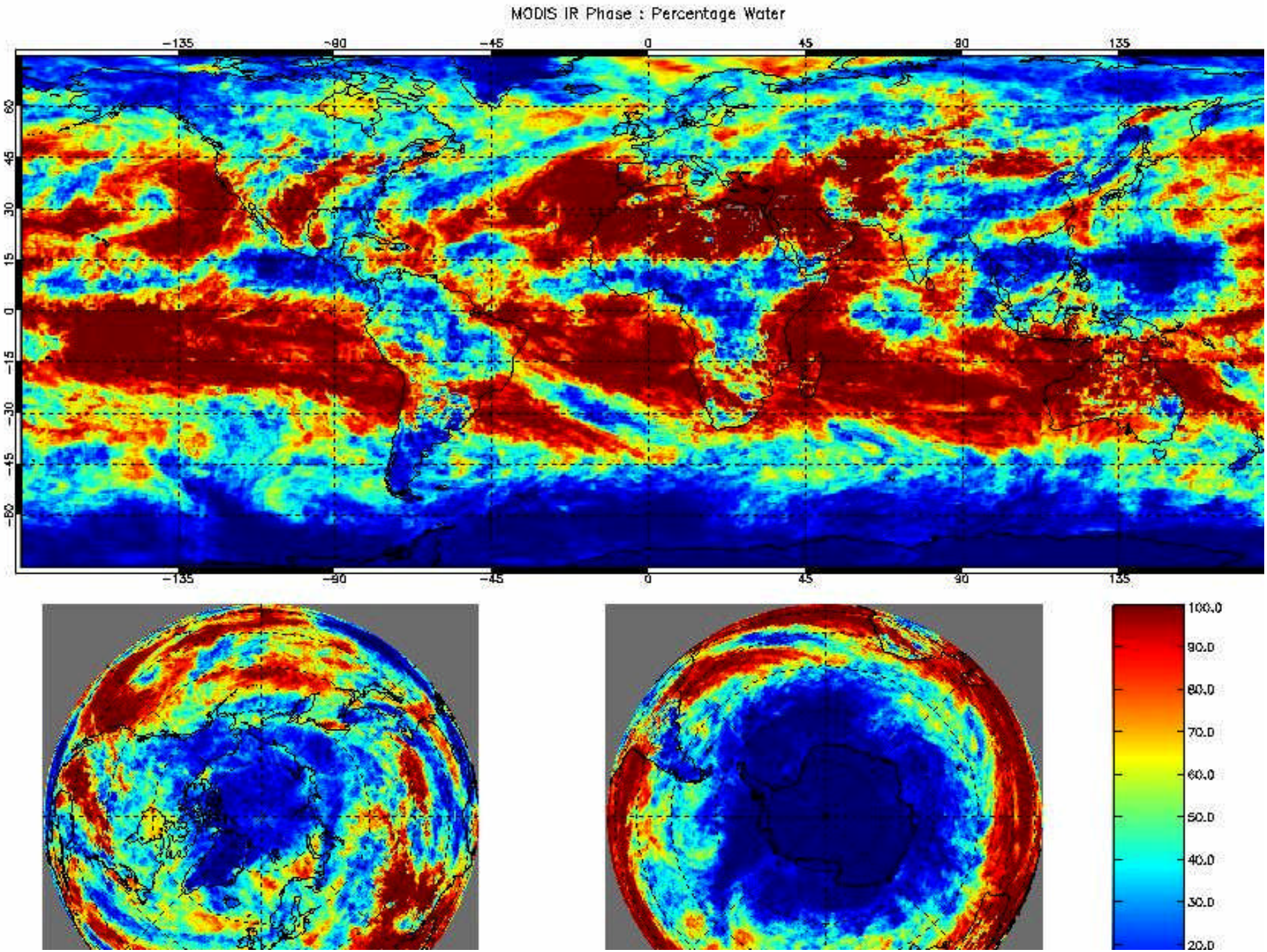
Cloud Effective Emissivity



MODIS 2000/09/05-08 Percentage Ice Cloud

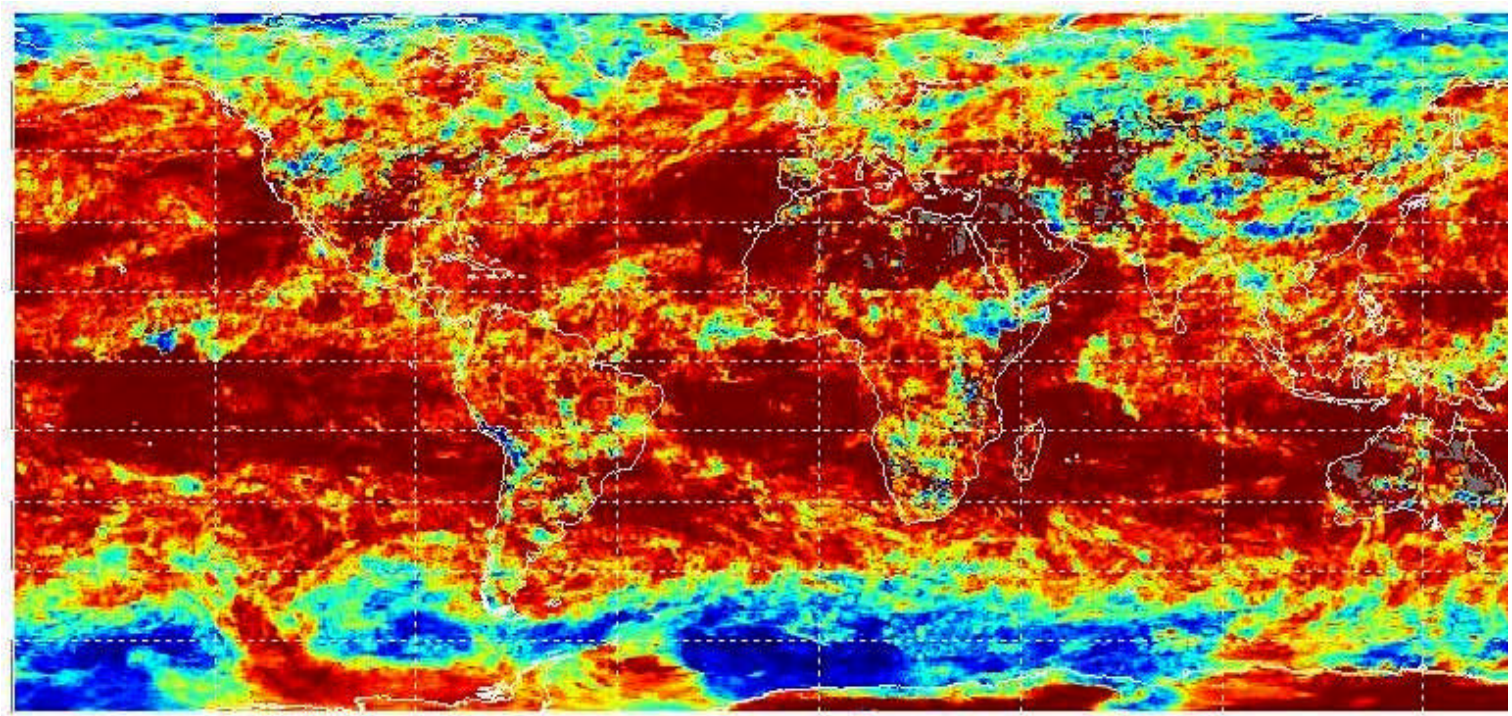


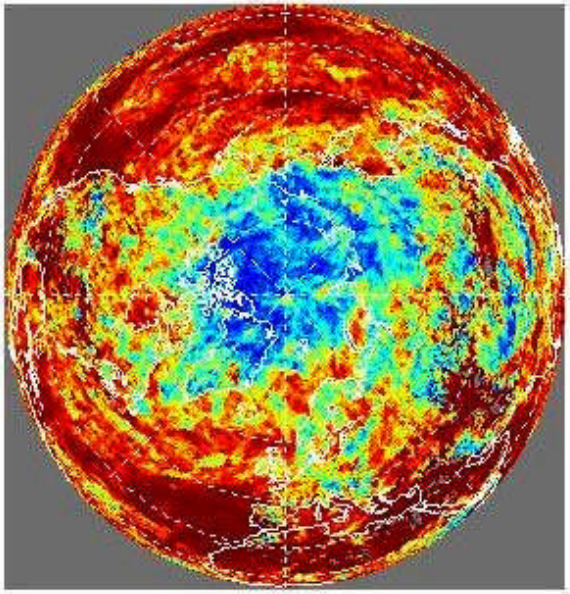
MODIS 2000/09/05-08 Percentage Water Cloud

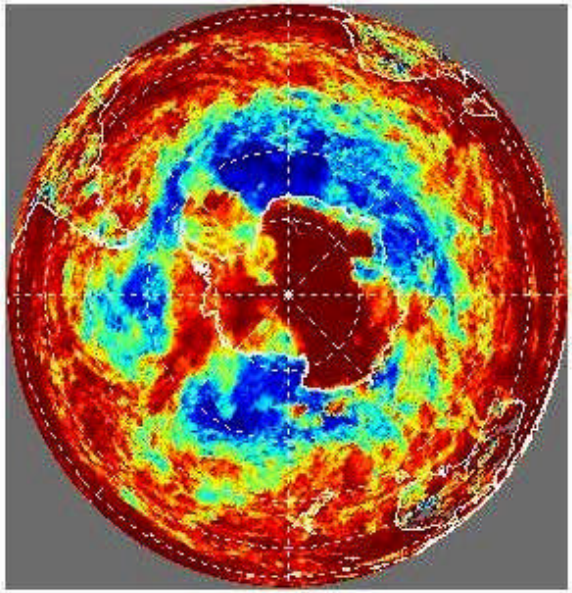


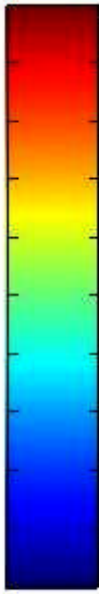
% of time cloud phase is either ice or water (mixed or uncertain phase excluded)

5-8 Sep 2000 nighttime-only



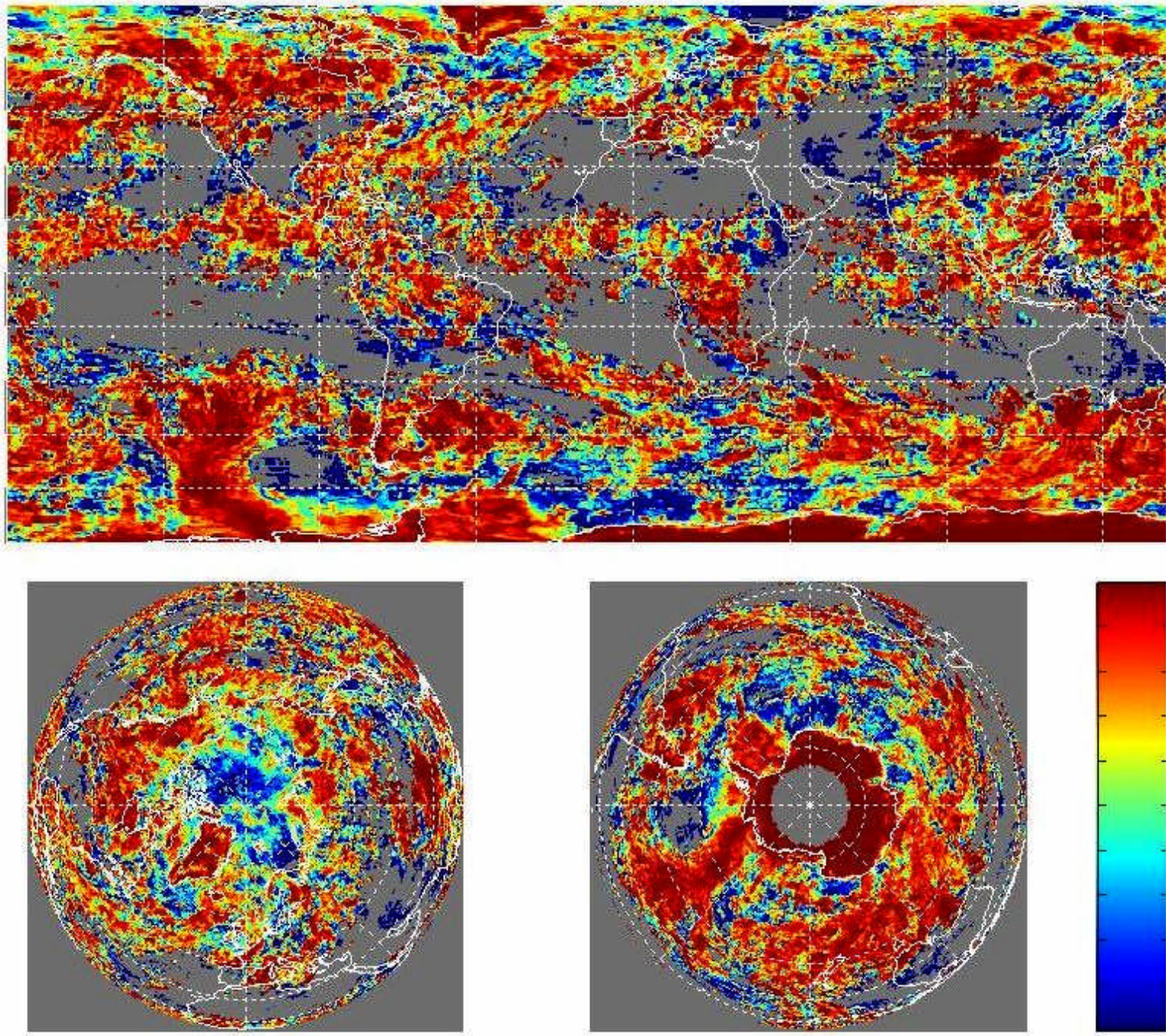






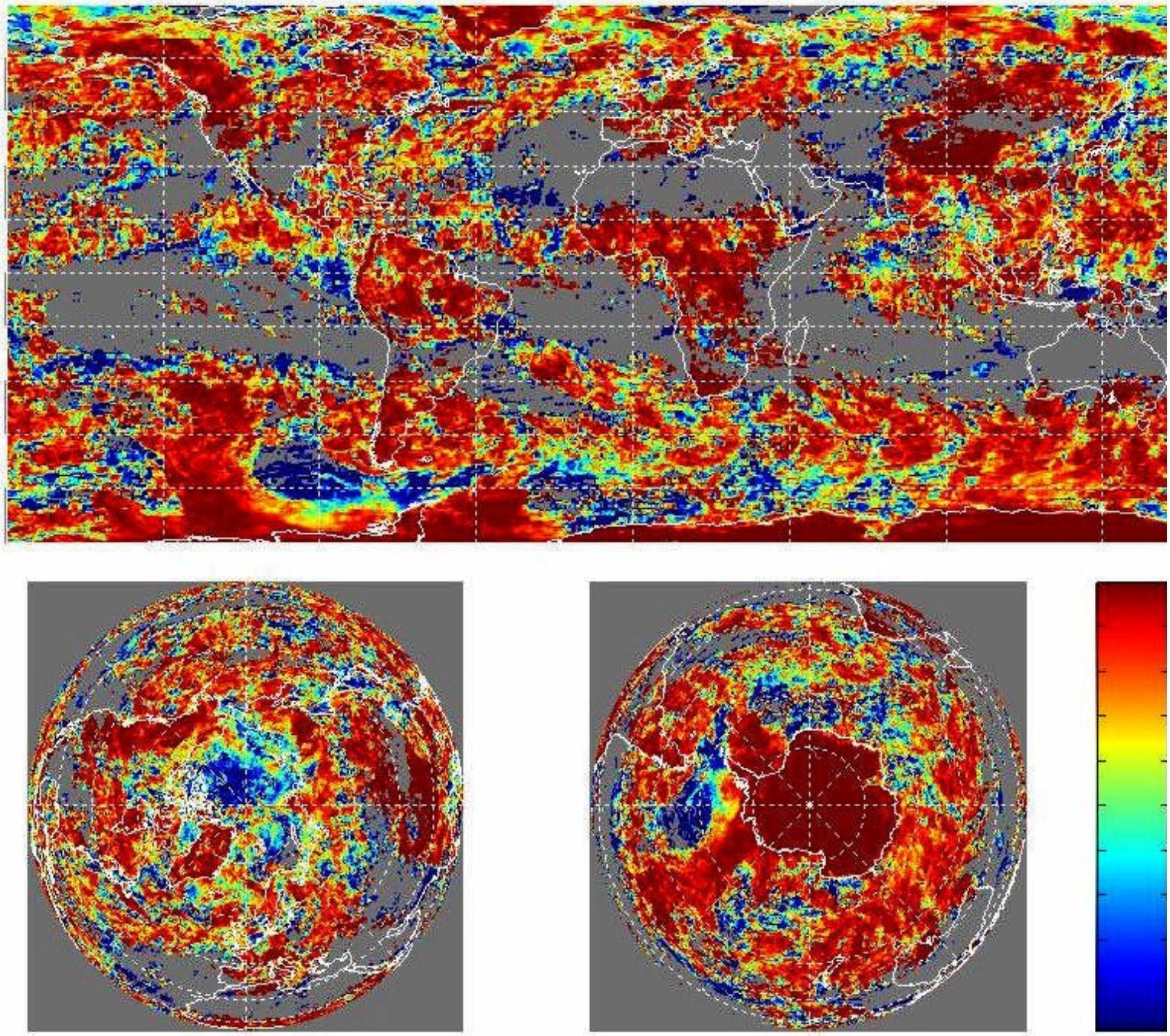
Correlation of ice cloud with $T_c < 243K$

5-8 Sep 2000 daytime-only



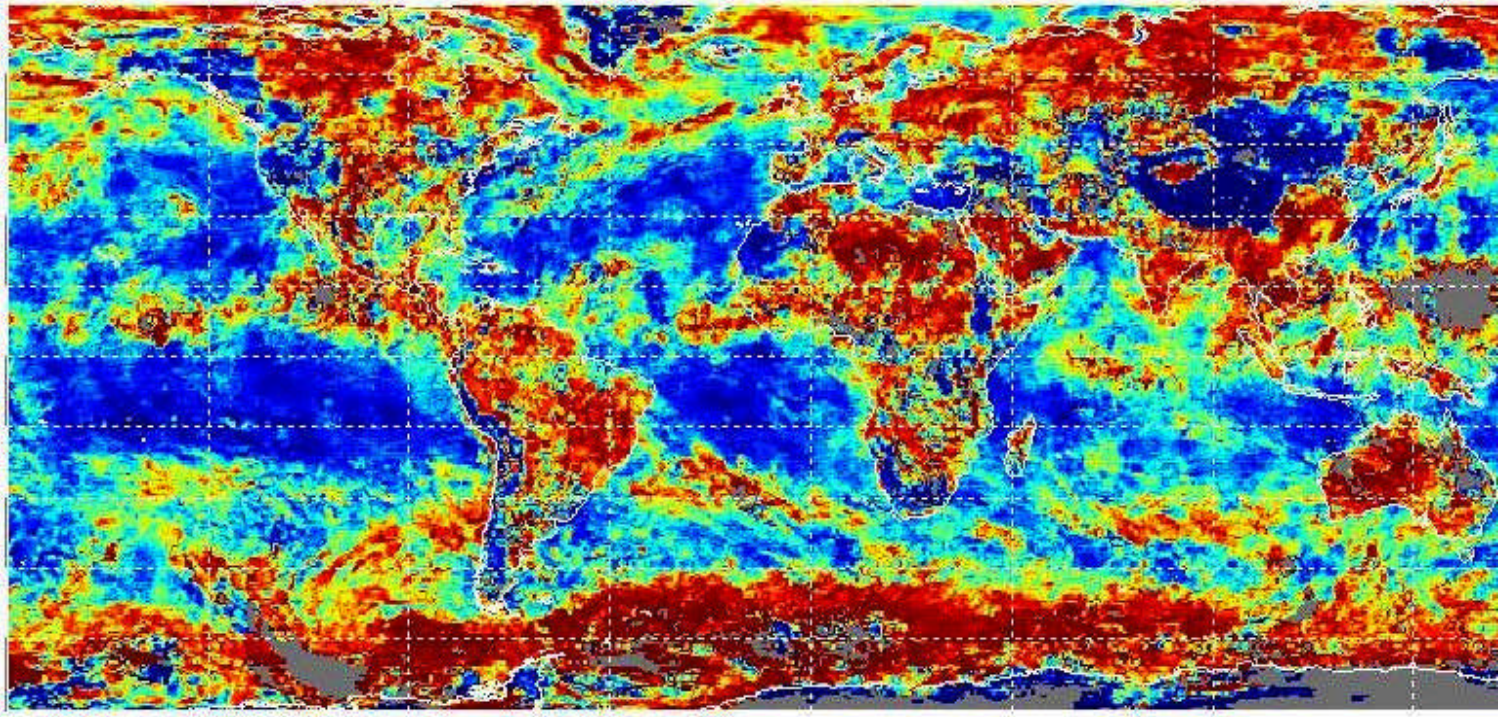
Correlation of ice cloud with $T_c < 243K$

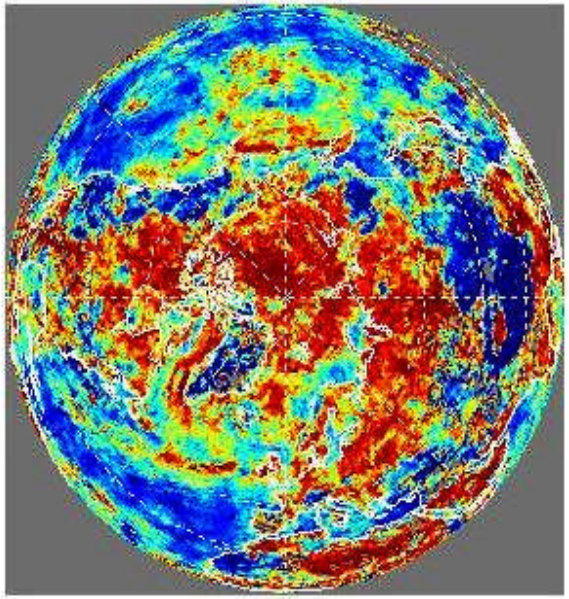
5-8 Sep 2000 night-time-only

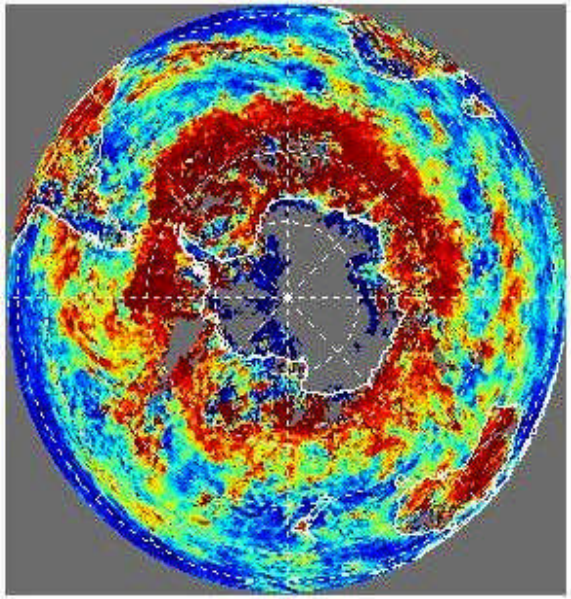


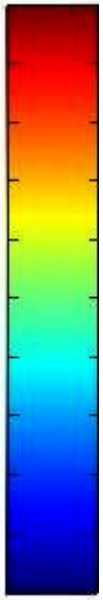
Correlation of water phase with $243K<T_c<273K$

5-8 Sep 2000 night-time-only





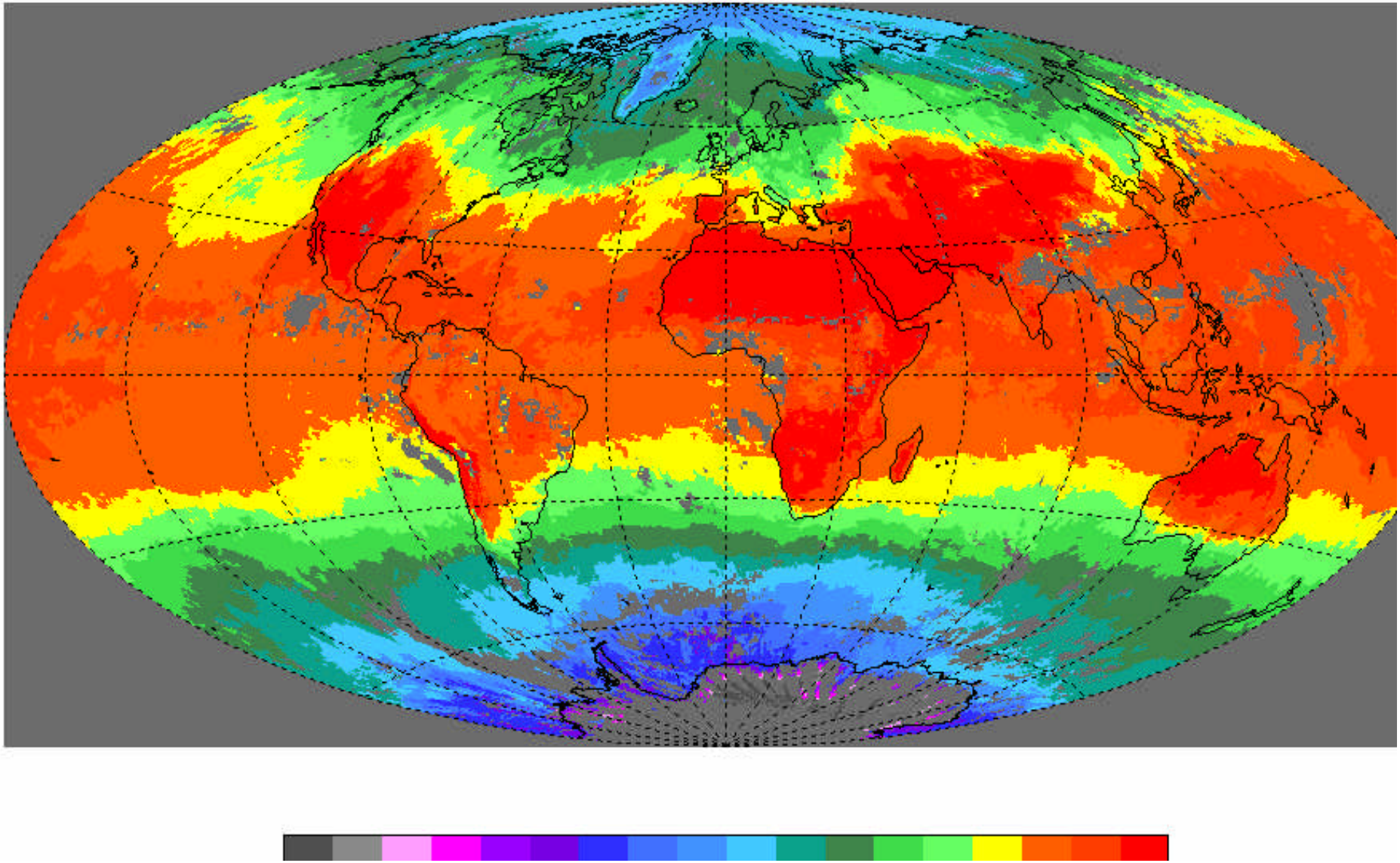




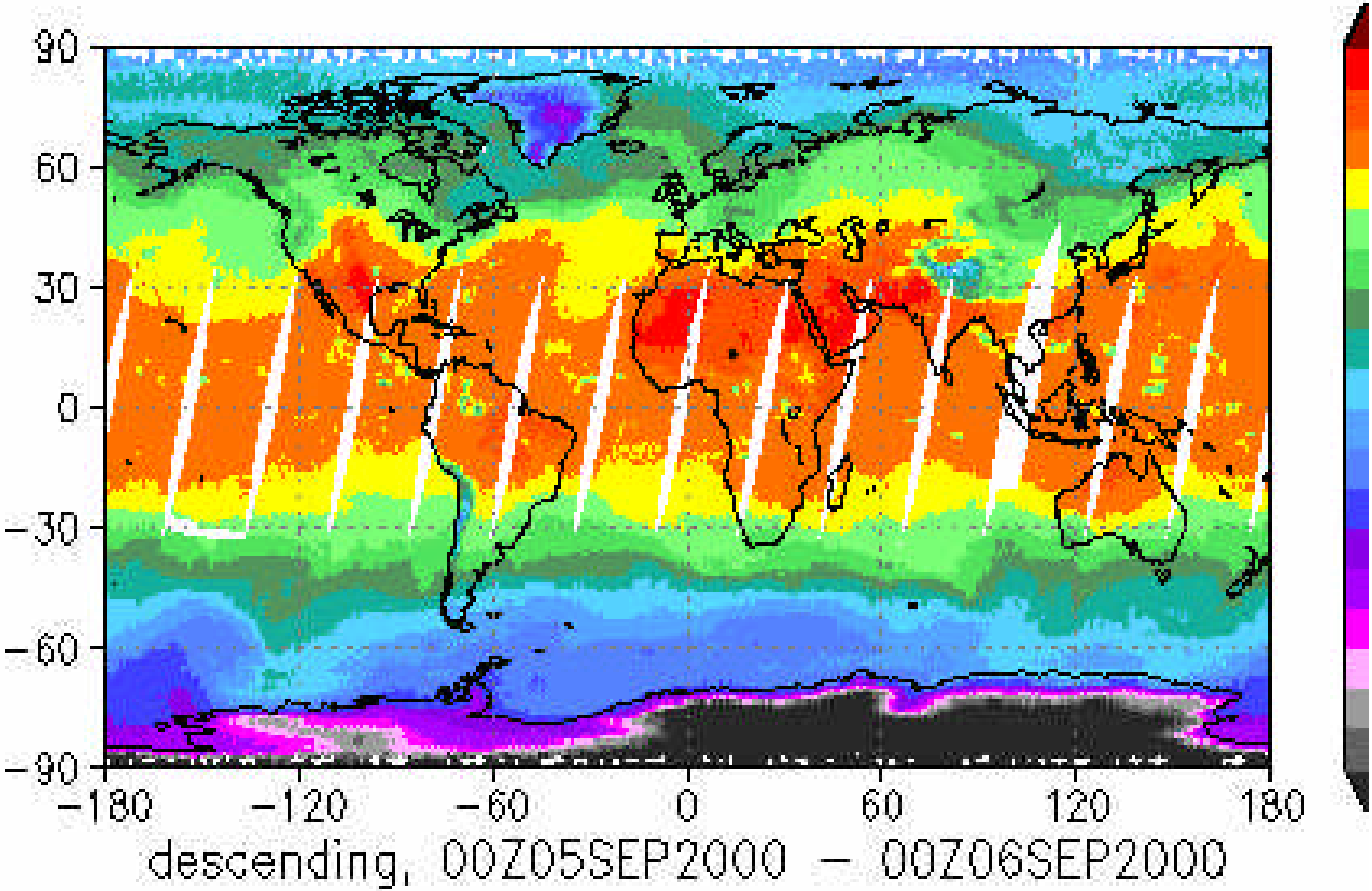
MODIS cloud phase determinations are revealing interesting patterns; first ever global day/night ice/water cloud determinations; validations pending

MODIS 2000/09/05-08

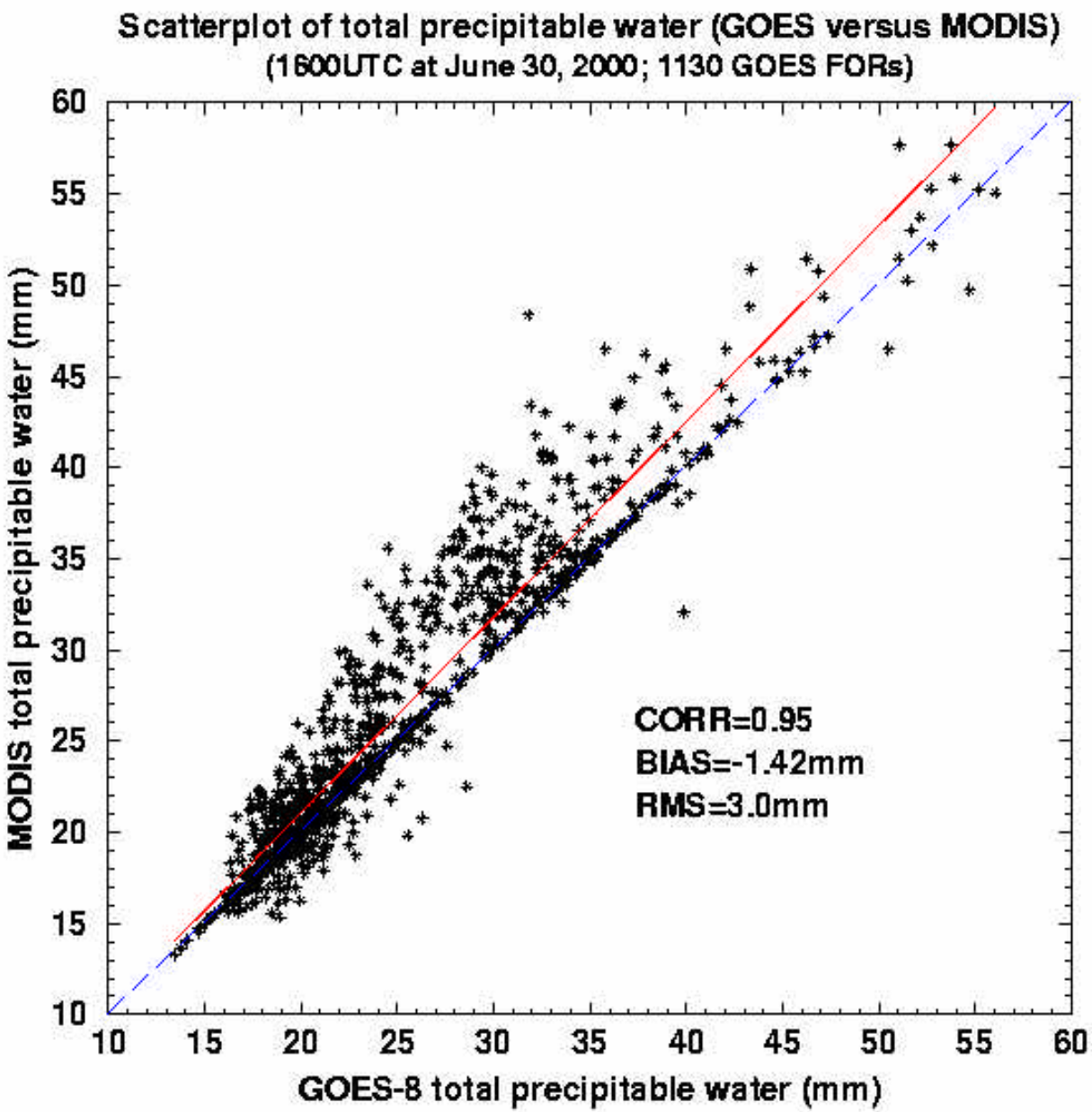
Daytime 850 hPa Temperature (K) for 4 days



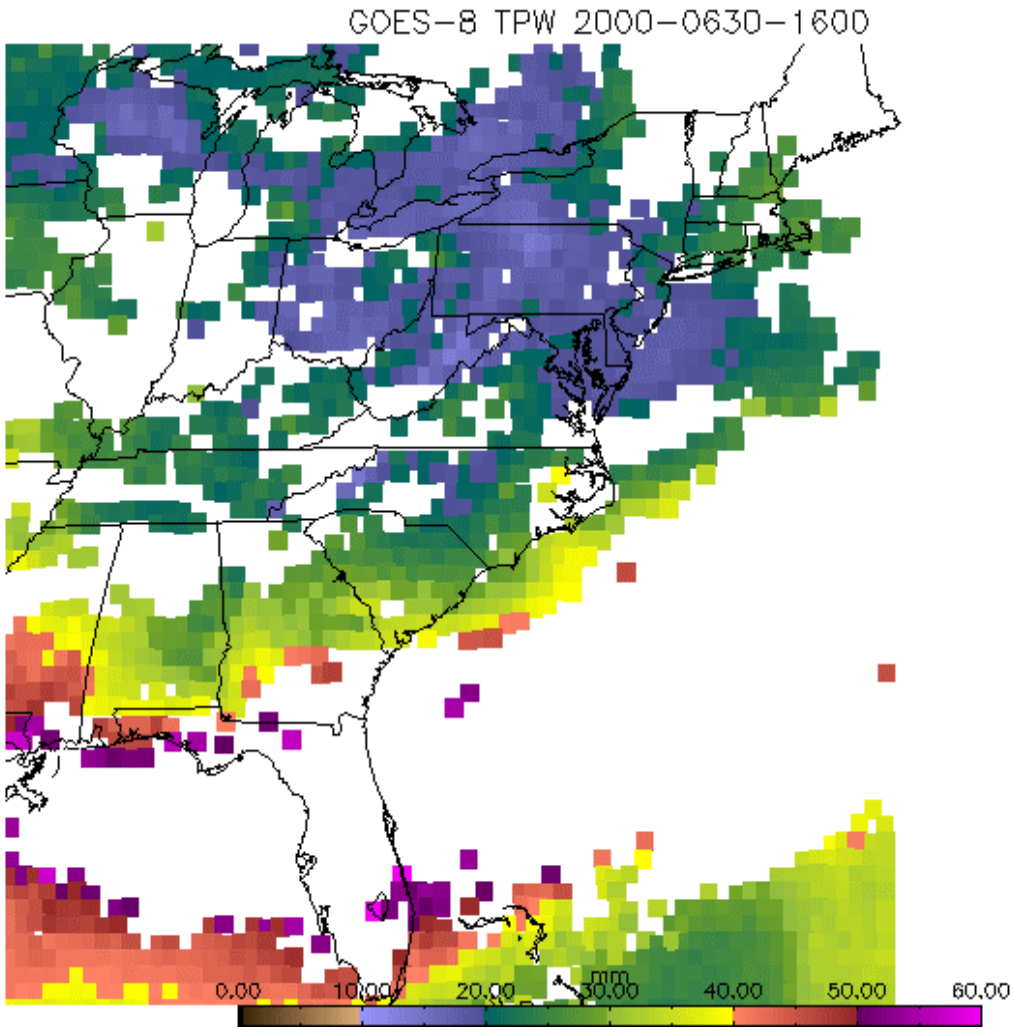
NOAA-15 AMSU-A 2000/09/05
Daytime 850 hPa Temperature (K) for one day

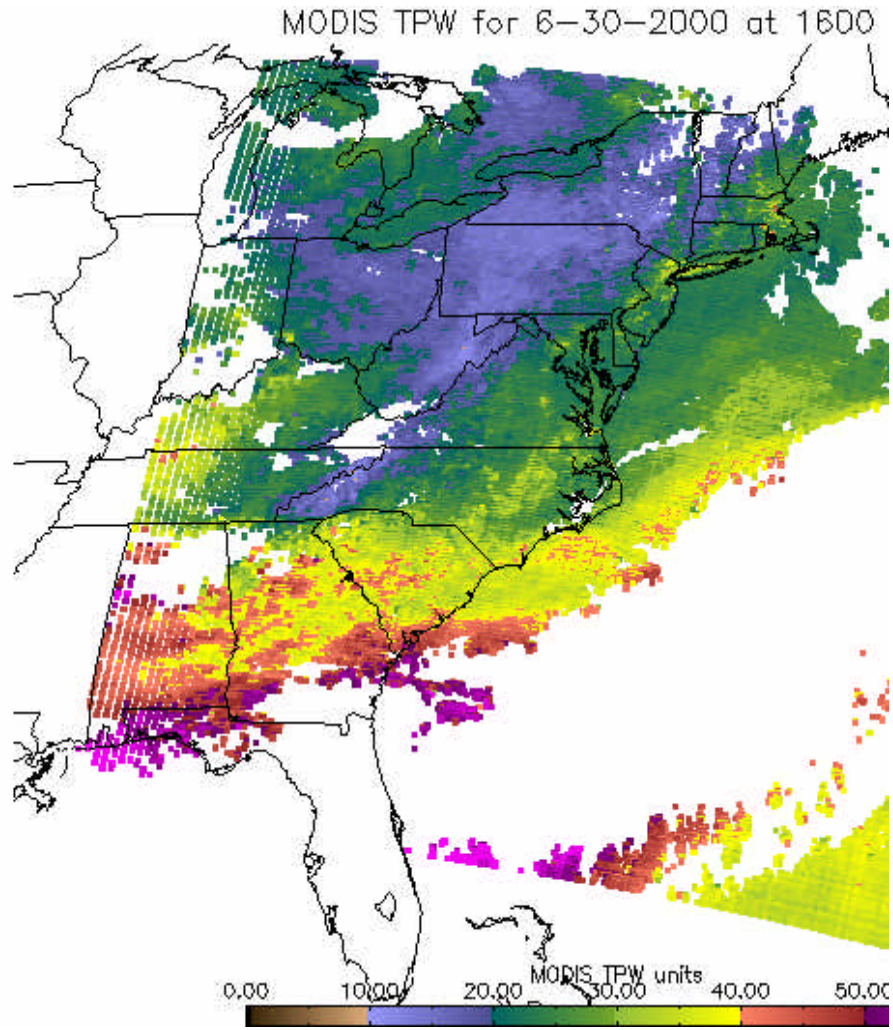


MODIS total precipitable water vapor shows a wet bias wrt GOES; bias 1.5 mm and rms of 3 mm; bias will be removed after more validation



GOES vs. MODIS 2000/06/30 1600 UTC
Total Precipitable Water (mm)

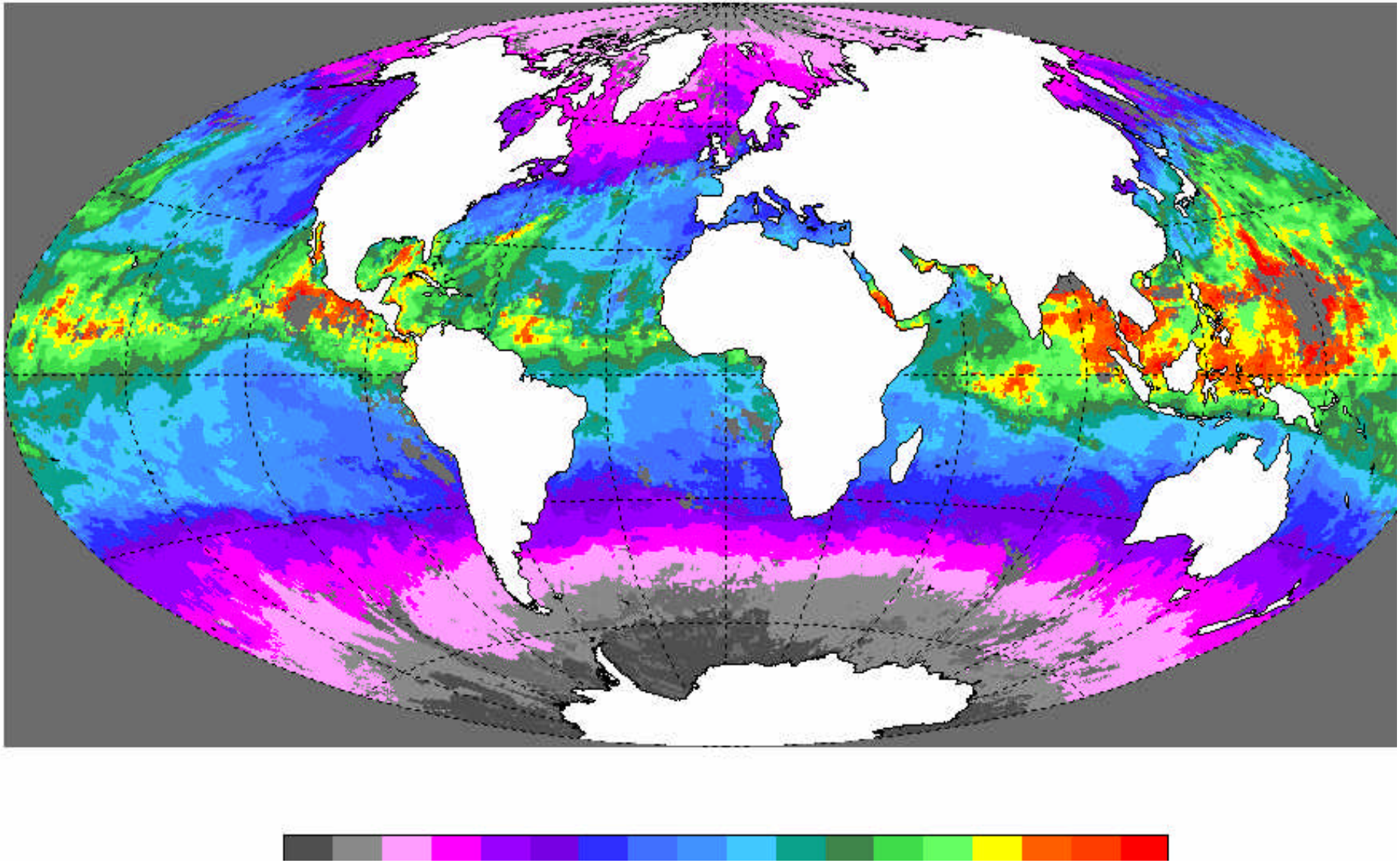




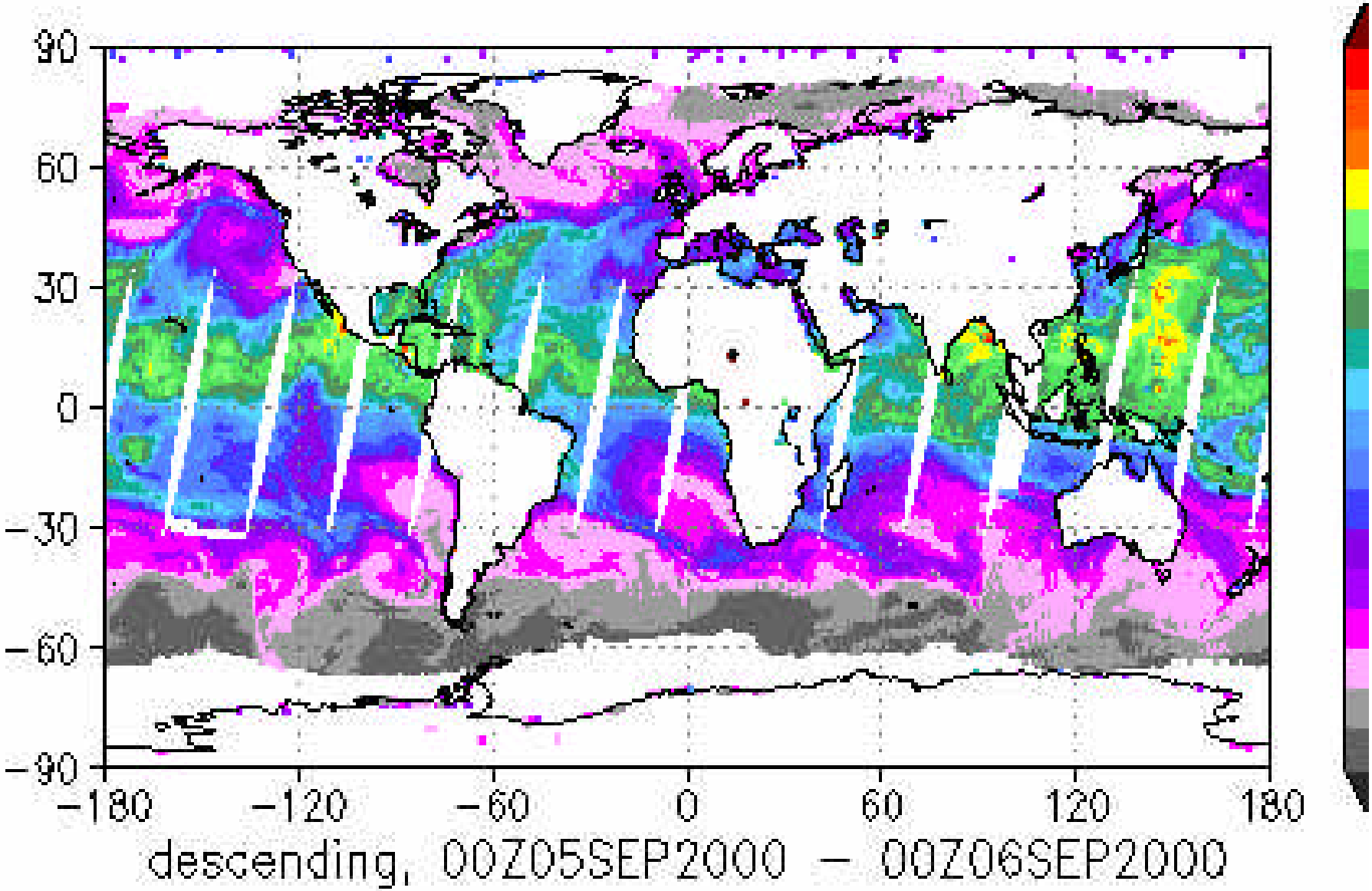
MODIS 2000/09/05-08

Daytime Total Precipitable Water (cm)

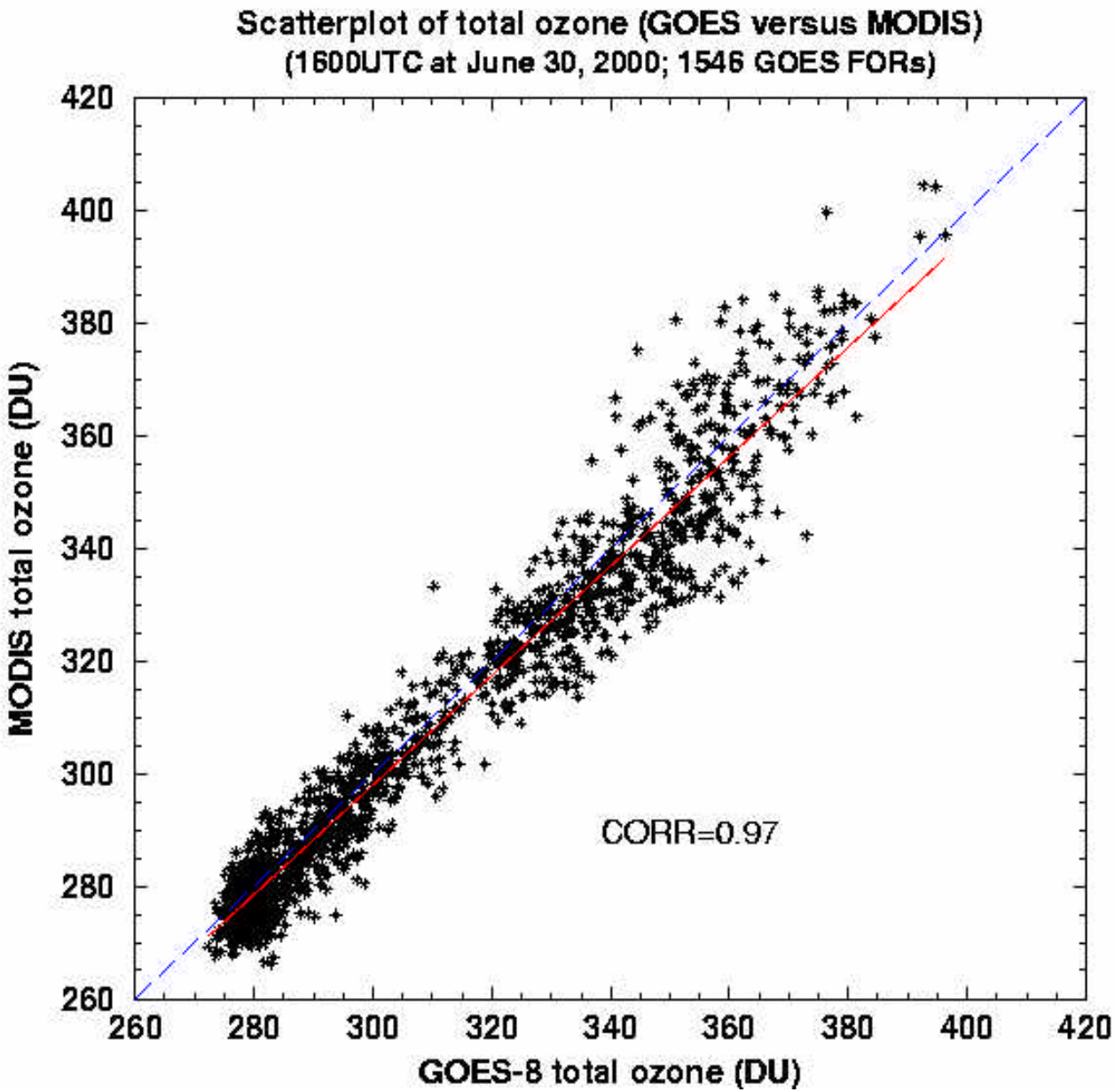
values over land not shown to facilitate comparison with AMSU



NOAA-15 AMSU-A 2000/09/05
Daytime Total Precipitable Water (mm)

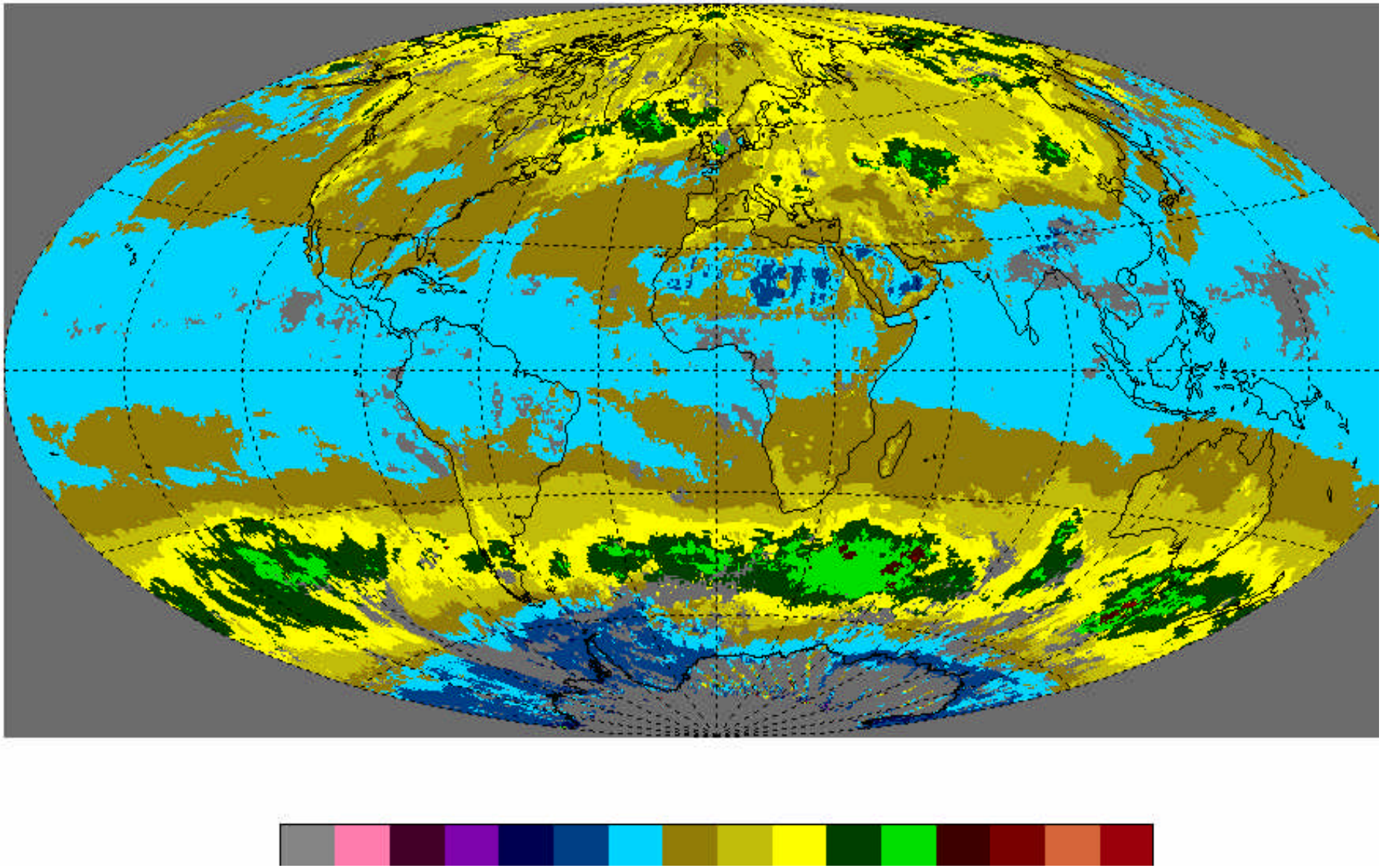


MODIS ozone is very close to the GOES ozone (over North America); rms of about 10 Dobsons; polar extreme ozone values will be improved

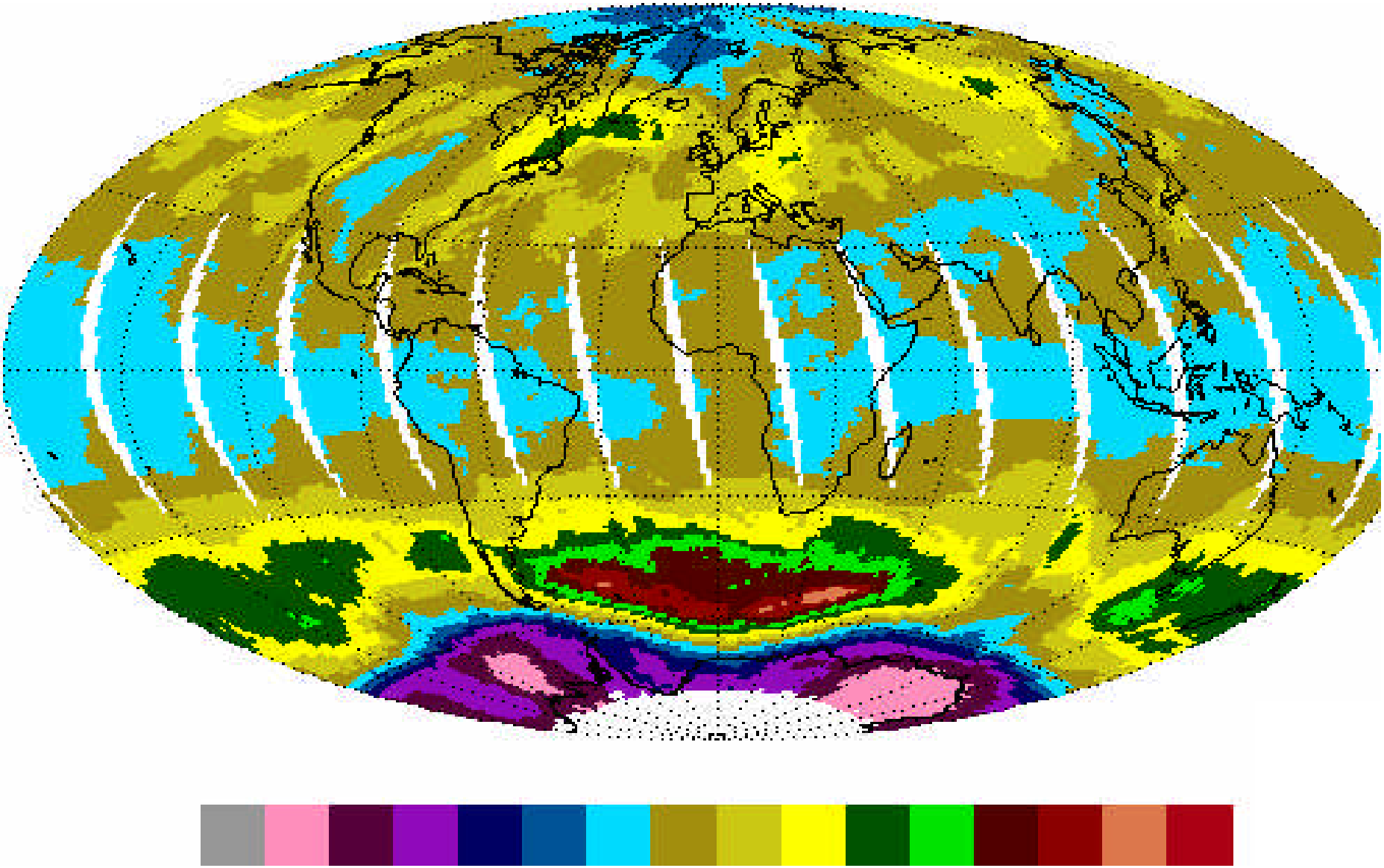


MODIS 2000/09/05-08

Daytime Total Ozone (Dobsons)



Earth Probe TOMS 2000/09/05
Total Ozone (Dobsons)

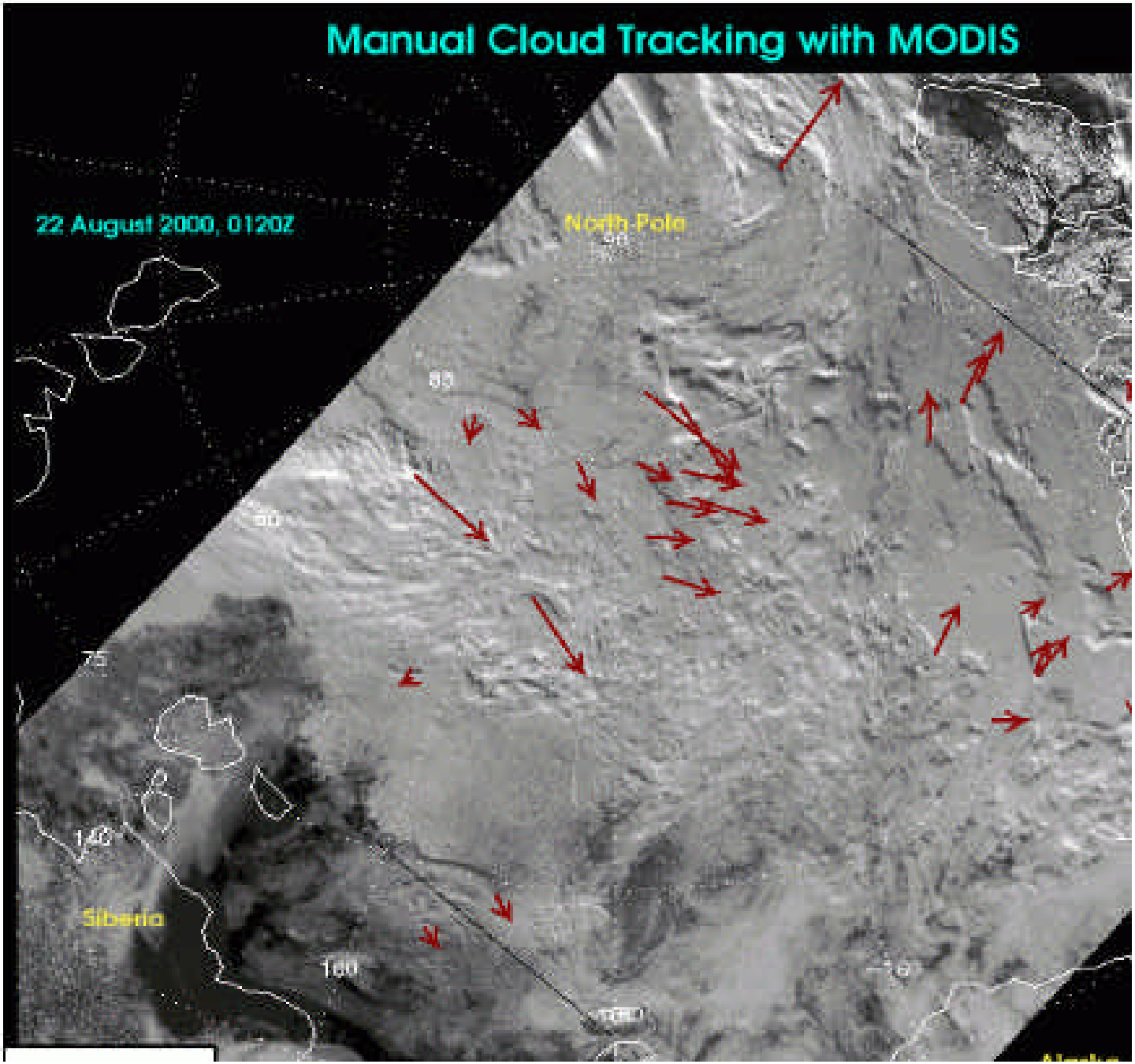


MODIS is being used to track polar atmospheric motions

MODIS Polar Winds

As the first step in a proof–of–concept clouds were tracked manually. The figure shows MODIS band 1 (visible) data for three 5–minute granules over the western Arctic.

Cloud targets were identified manually in this image and in the subsequent overpass about 1.5



Early Estimates of UW MODIS Product Quality

MODIS IR window radiances agree to within 1 C with GOES

Cloud mask has demonstrated advantages of new multispectral approach
sun glint, desert, and polar problems diminished

MODIS cloud top pressures compare well with HIRS;
aircraft validation is better than 50 mb.

MODIS cloud phase determinations are revealing interesting patterns;
first ever global day/night ice/water cloud determinations; validations pending.

MODIS tropospheric temperatures compare well with AMSU;
rms better than 1 C, both within 2 C of radiosonde observations

MODIS total precipitable water vapor shows a wet bias wrt GOES;
bias 1.5 mm and rms of 3 mm; bias will be removed after more validation.

MODIS ozone is very close to the GOES ozone (over North America);
rms of about 10 Dobsons; polar extreme ozone values will be improved

MODIS Direct Broadcast changes Madison skyline and CIMSS logo

CIMSS
1980-2000

CIMSS
Cooperative Institute for
Meteorological Satellite Studies

SSEC UW-Madison EOS Direct Broadcast

Goals:

Acquire and process MODIS and AIRS data from Terra and Aqua in near real-time.

Highlights:

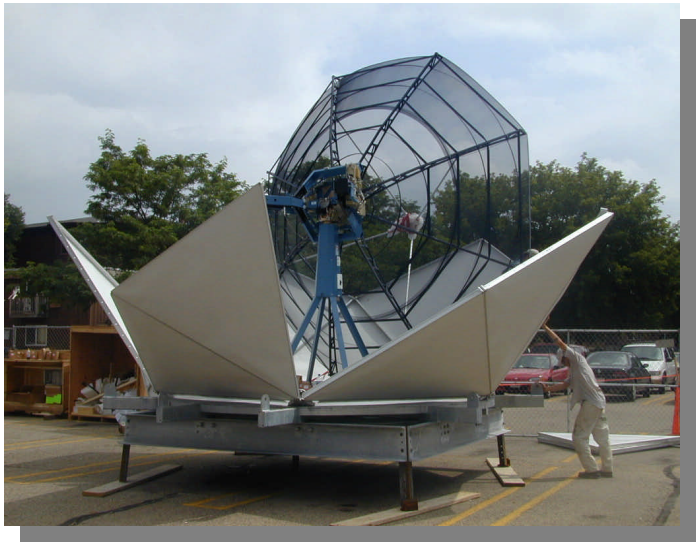
- SeaSpace auto-tracking 4.4 m antenna installed August 2000,
- 500 Terra passes (day and night) acquired as of January 20, 2001,
- Software for processing MODIS data released in May 2000,
- Automated processing to Level-1B is now operational at SSEC,
- Most recent 7 days of data and quicklooks will be available via FTP by end of January.

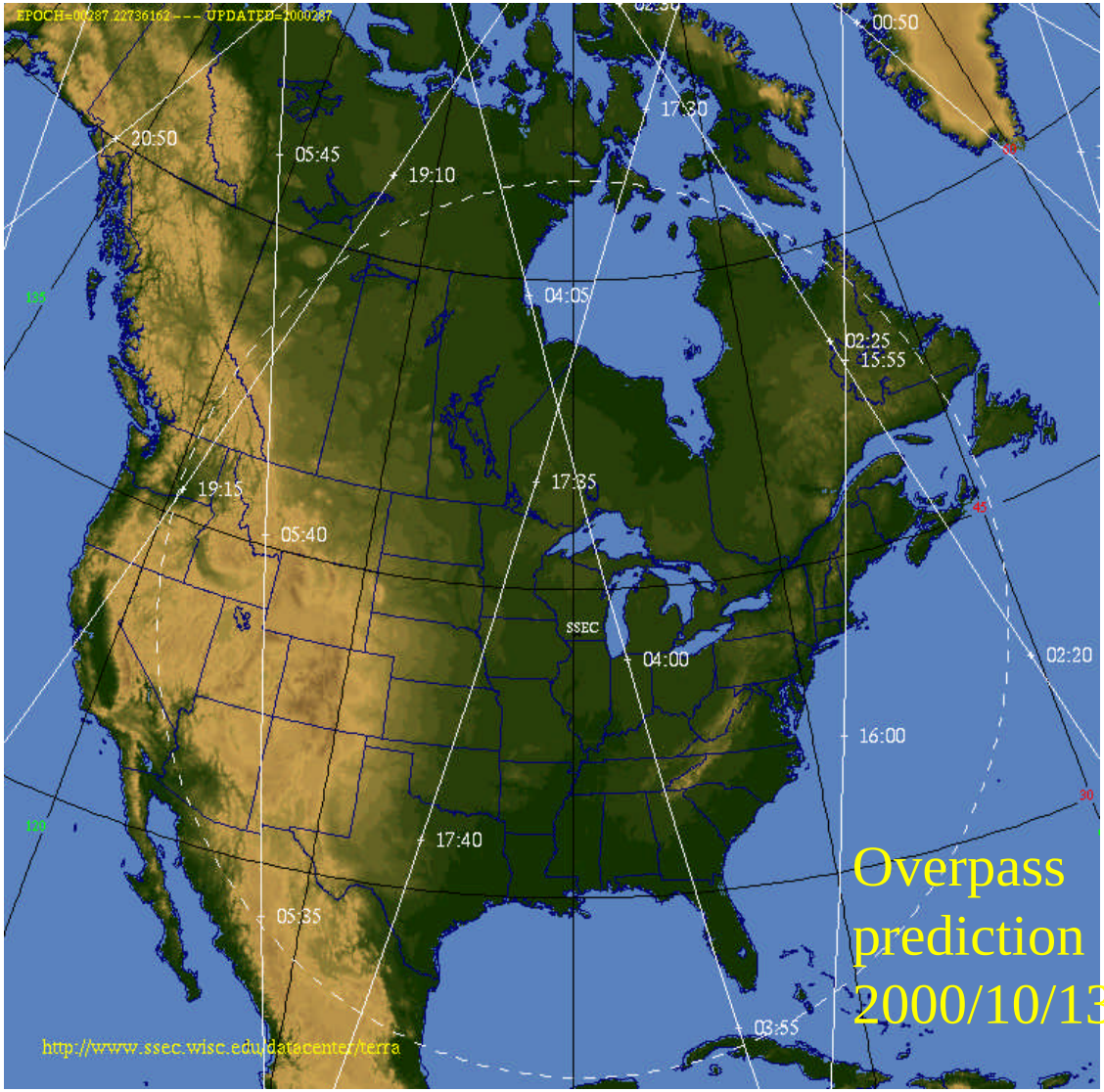
More Information:

http://cimss.ssec.wisc.edu/~gumley/IMAPP/IMAPP.html

UW-Madison EOS Direct Broadcast Groundstation

TeraScan SX-EOS 4.4 m antenna: First pass acquired 2000/08/18





Overpass prediction 2000/10/13

Antenna installed 5 August 2000

International MODIS/AIRS Processing Package

Goal:

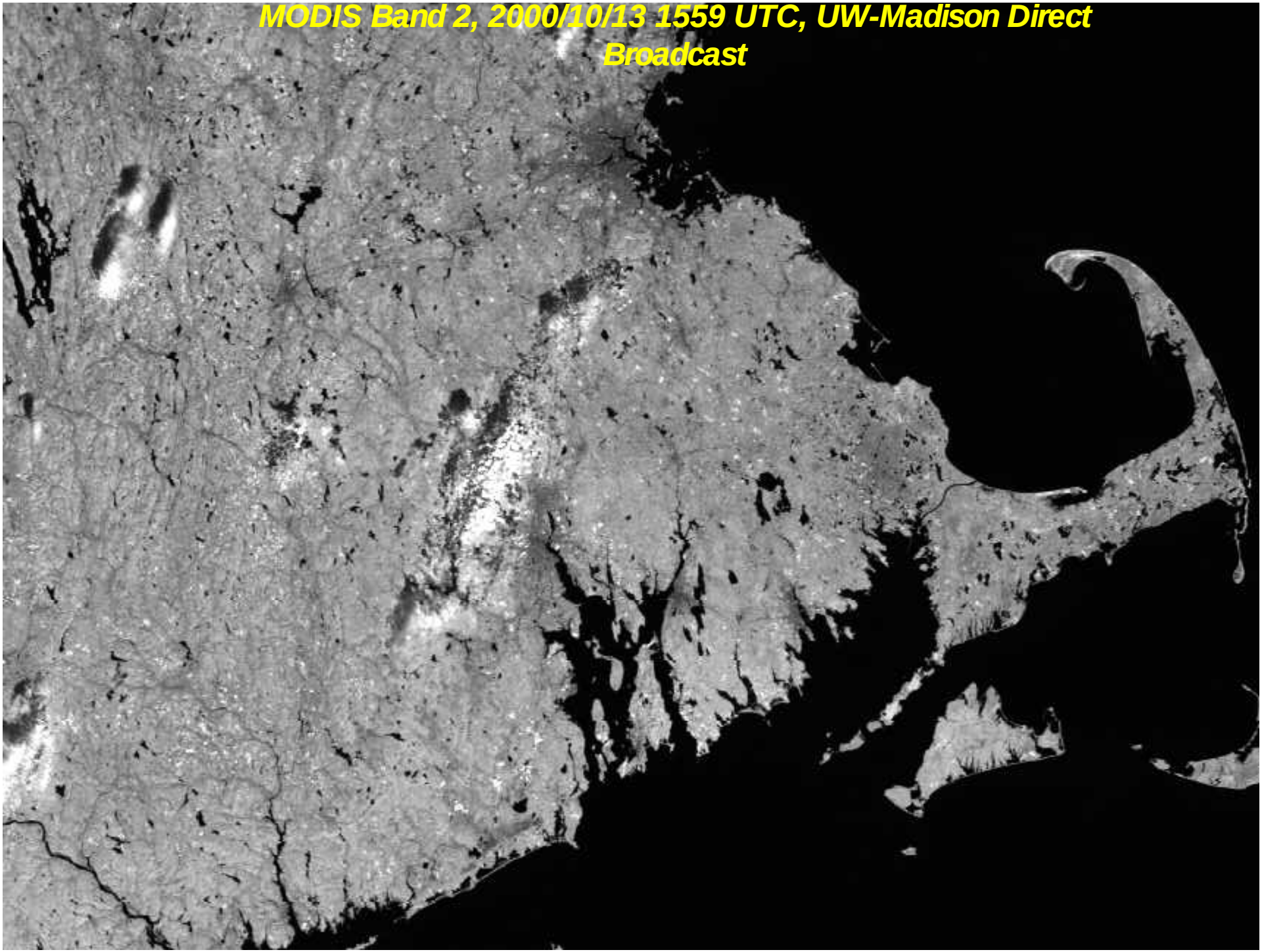
Transform direct broadcast Level-0 data to Level-1B. Generate selected Level-2 products (e.g. cloud mask, atmospheric profiles).

Features:

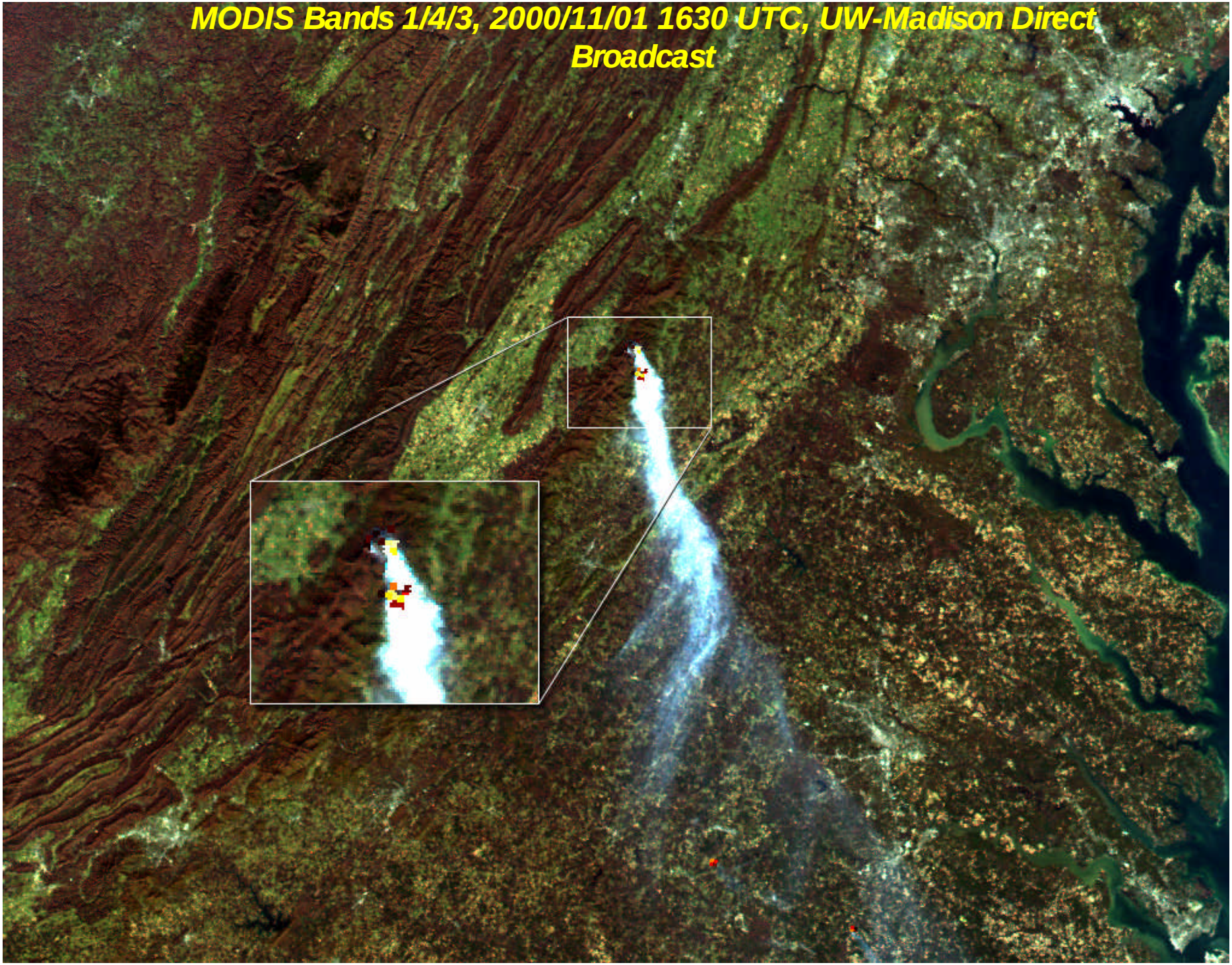
- Platforms include IRIX, Solaris (Ultra, x86), AIX, HP-UX, Linux,
- The only toolkit required is NCSA HDF 4.1r3,
- Downlinked or definitive ephemeris/attitude data may be used,
- Available at no cost; licensed under GNU GPL,
- Version 1.1 released November 1, 2000,
- Version 1.2 (B-side calibration, mis-registration fix) in testing.

Available from:

http://cimss.ssec.wisc.edu/~gumley/IMAPP/IMAPP.html

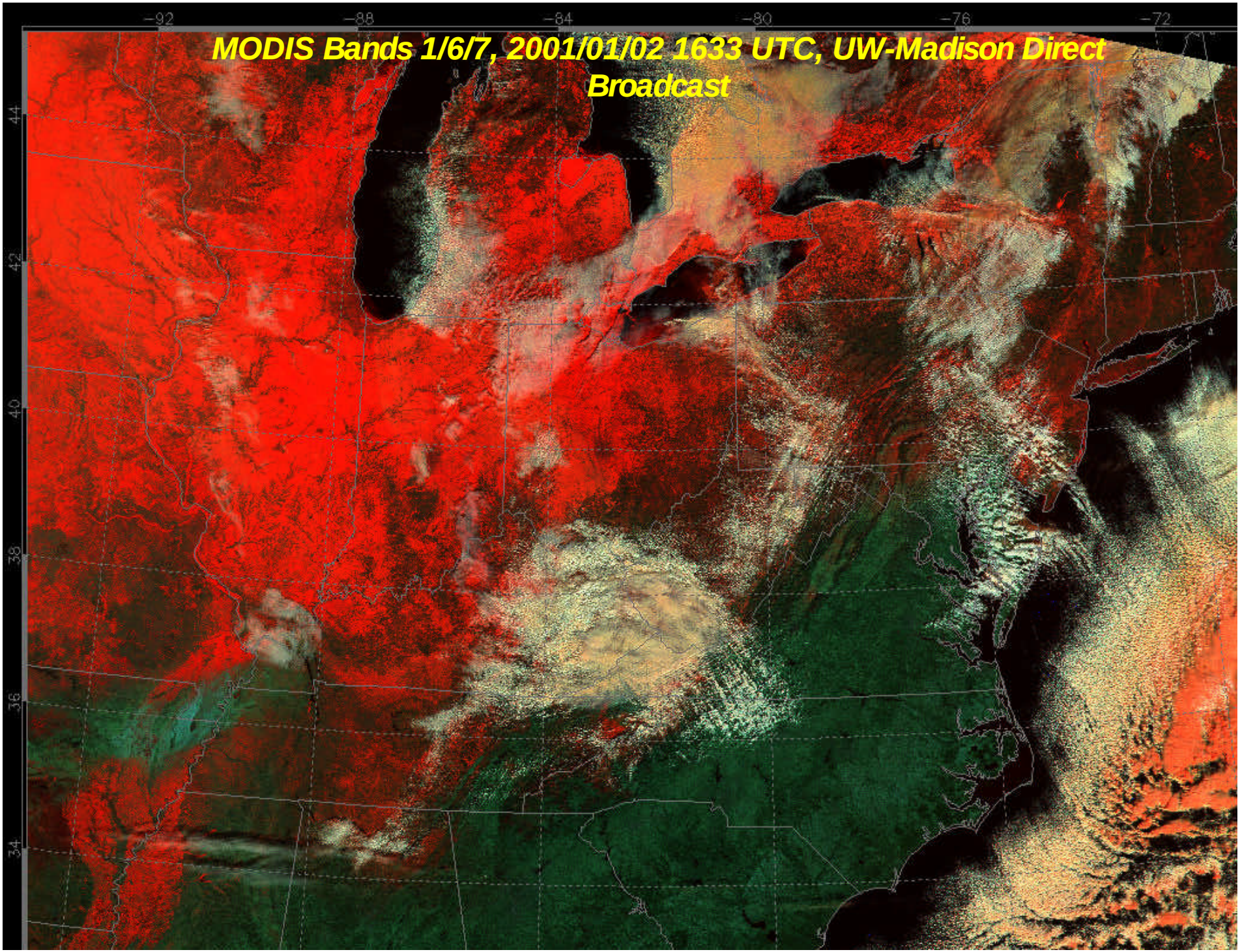


Boston and Cape Cod, MA; Providence, RI



Fires in Shenandoah National Park, VA

Band 21



Snow (red), land (green), clouds (white)

UW MODIS atmospheric investigations

1 km WV
IR cal comparison with MAS and GOES
1.38 um thin cirrus detection
multi-spectral cloud mask
cloud heights with CO2 slicing
cloud phase with tri-spectral window
TPW and Ozone with sounding channels
polar winds

UW MODIS QA

web site and links to data examples
http://cimss.ssec.wisc.edu/modis1/modis1.html

UW MODIS Direct Broadcast

International MODIS Processing Package V.1 (May 2000)
web site for quicklooks and real time data (Feb 2001)