MODIS Atmospheric Profiles

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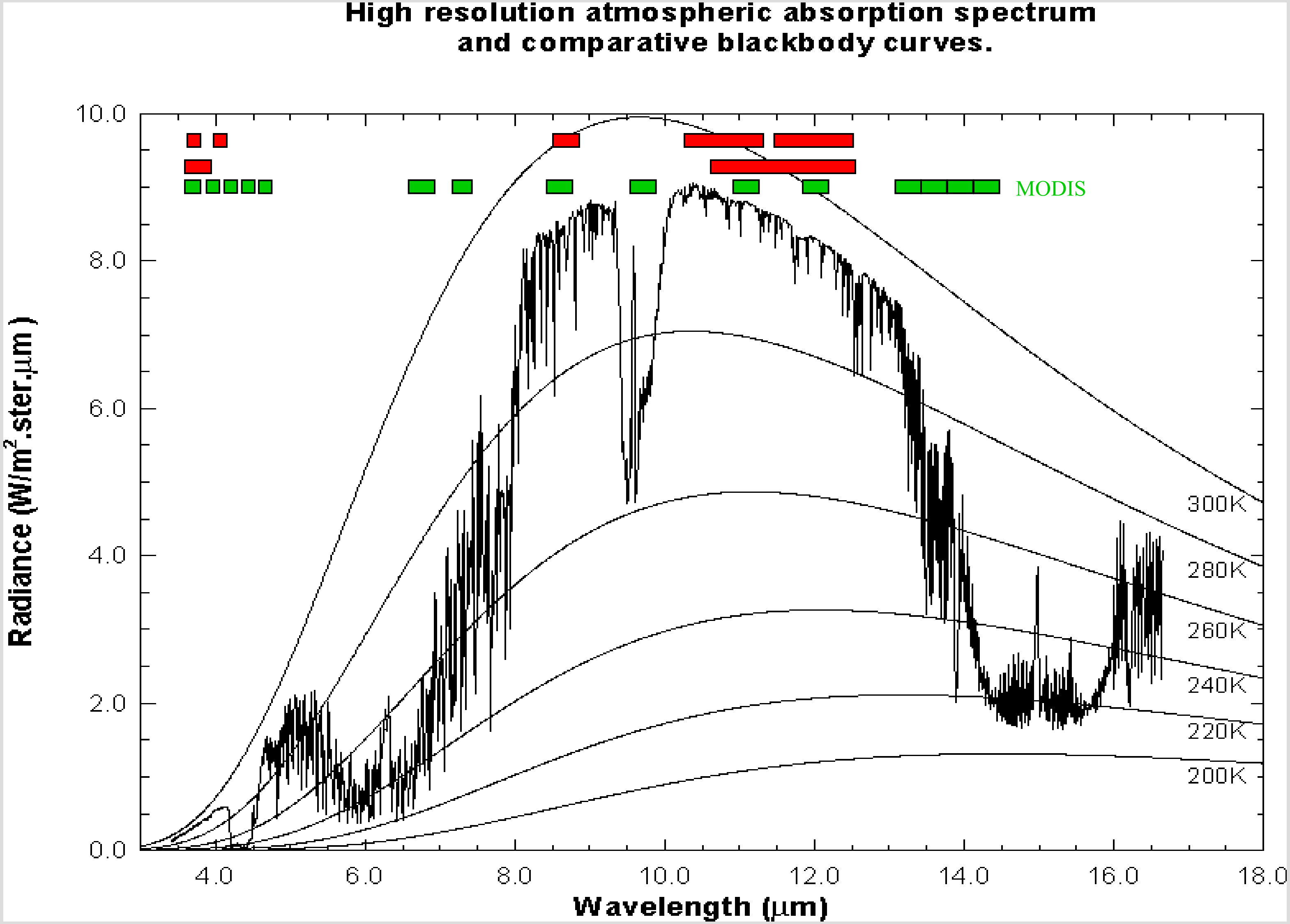
MOD07 Developer

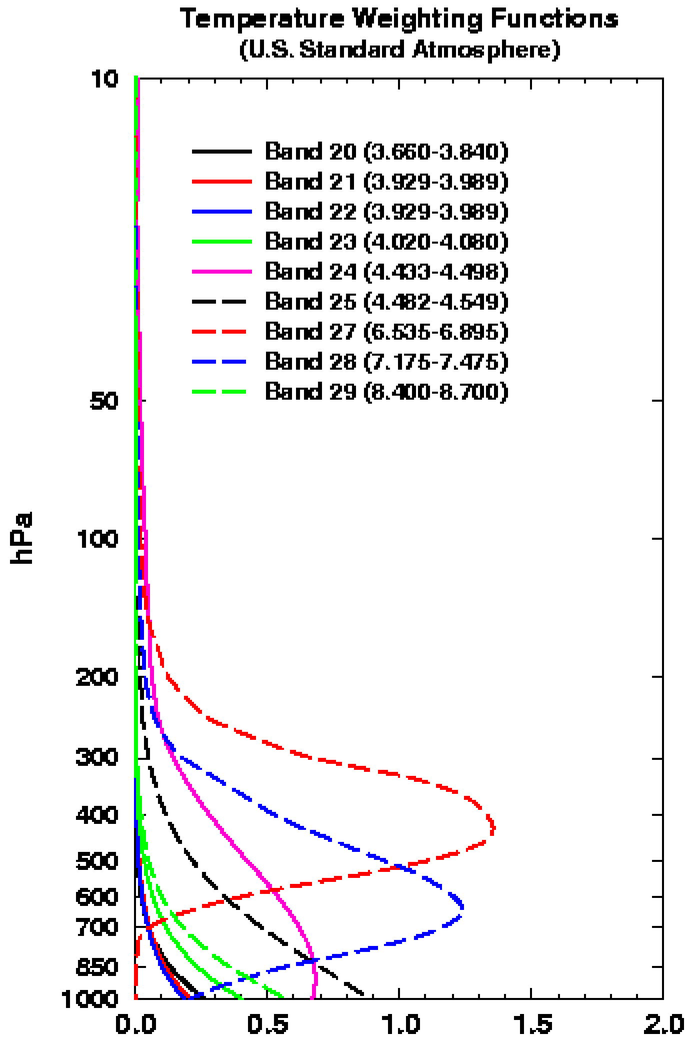
- Retrievals are performed in 5x5 FOV (approximately 5km resolution) clear-sky radiances over land and ocean for both day and night.
- Algorithm is a statistical regression and has the option for a subsequent nonlinear physical retrieval.
- Regression predictors include MODIS infrared radiances from bands 25, 27-36 (4.4 - 14.2mm).
- Clear sky determined by MODIS cloud mask (MOD35).

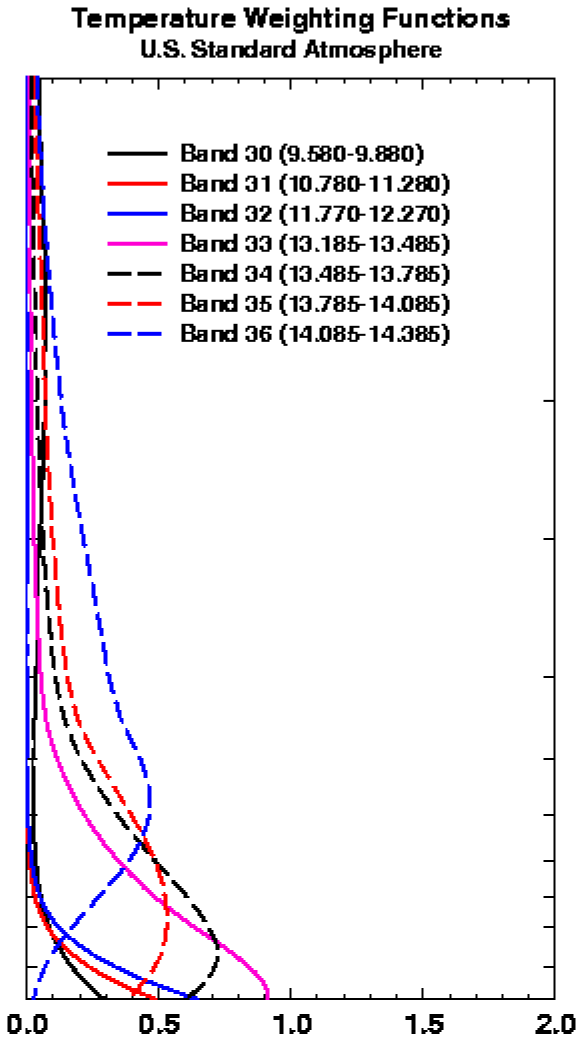
MODIS IR Bands
Spectral Position



MODIS IR Bands

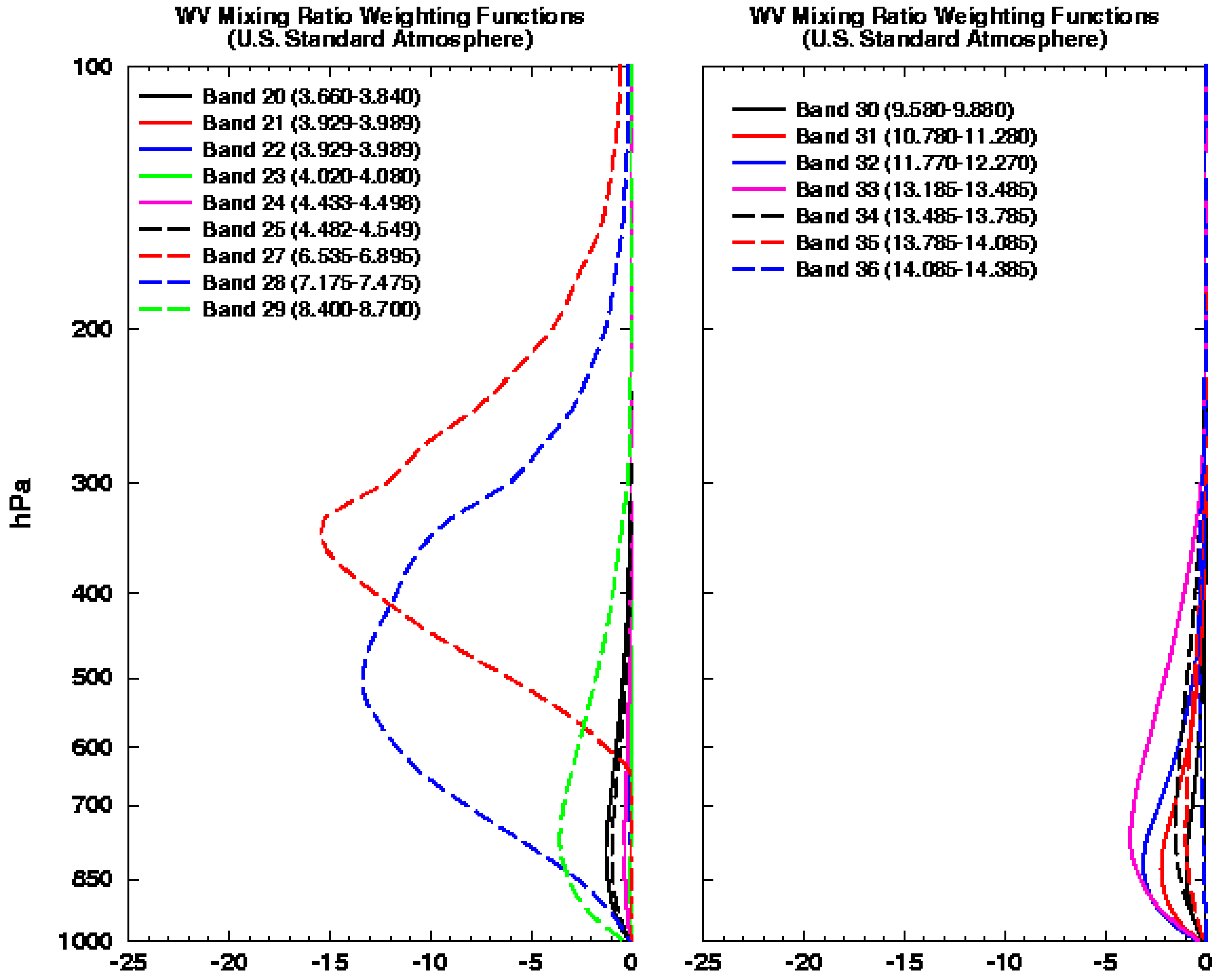
Profile Sensitivity - Temperature





MODIS IR Bands

Profile Sensitivity – Water Vapor



Atmospheric Profile Output

- Atmospheric precipitable water vapor (total, high - 250 hPa to 700 hPa, and low- 920 hPa to the surface)
- Profiles of temperature and moisture (20 levels)
- Total column ozone
- Stability indices (lifted index, total totals)
- Surface Skin Temperature

Algorithm Discussion

RTE (no scattering) in LTE

$$R_\upsilon = \varepsilon_{\upsilon s} B_{\upsilon s}(T_s)\, \tau_s(p_s) - \int_0^{ps} B_\upsilon(T(p))\, d\tau_\upsilon(p)$$
$$+ r_{\upsilon s}\, \tau_\upsilon(p_s) \int_0^{ps} B_\upsilon(T(p))\, d\tau^*_\upsilon(p)$$
$$+ R_\upsilon^{sun}\, \tau_\upsilon^{1+\sec\theta}(p_s)\, r_{\upsilon s}^{sun}$$

***R*…radiance, *υ*…wavenumber, *s*…surface, *p*…pressure, *sun*…solar,**

***T*…temperature, *B*…Planck function, ε …emissivity,*r*…reflectivity,**

τ…level to space transmittance, θ...local solar zenith angle

τ*…level to surface transmittance [$\tau^* = \tau_\upsilon(p_s)/\tau_\upsilon(p)$]

Algorithm Discussion - continue

R is measured by MODIS for λ = 4.4 - 14.2μm (R_{25}, R_{27}, … R_{36})

R can be considered a nonlinear function of the atmospheric properties including T, q, ozone, surface pressure, skin temperature, and emissivity.

We can infer a statistical regression relationship using calculated radiances from a global set of radiosonde profiles and surface data.

Relationship is inverted to retrieve atmospheric properties from observed MODIS radiances.

Algorithm Discussion - continue

Global radiosondes: data set drawn from NOAA-88, TIGR-3, ozonesondes, ECMWF analyses, desert radiosondes containing 15000+ global radiosonde profiles of temperature, moisture, and ozone used for training data set.

RT model: Radiance calculations for each training profile are made using a 101 pressure layer transmittance model. MODIS instrument noise is added to calculated spectral band radiances.

- **Radiosonde temperature-moisture-ozone profile / calculated MODIS radiance pairs are used to create the statistical regression relationship.**

Bias corrections are applied to the observed MODIS radiances to account for forward model error, spectral response uncertainty, and calibration error.

MODIS Land – Sea Classified Retrievals

•New BT zones:

Land	Zone 1:	< 272,	1978 profiles	(< 275)
	Zone 2:	272-287,	2538 profiles	(269-290)
	Zone 3:	287-296,	2807 profiles	(284- 299)
	Zone 4:	296-350,	2226 profiles	(293-353)
Ocean	Zone 1:	< 283.5,	2214 profiles	(< 286.5)
	Zone 2:	283.5-293,	2900 profiles	(280.5-296)
	Zone 3:	293-350,	2437 profiles	(290-353)

OLD BT 11μm ZONES	
Zone 1:	< 245 K
Zone 2:	245-269 K
Zone 3:	269-285 K
Zone 4:	285-294 K
Zone 5:	294-300 K
Zone 6:	300-310 K
Zone 7:	> 310 K

AIRS Clear-Sky Regression Retrieval

- Single FOV Eigenvector Regression Retrieval of T, q, T_s, TPW, O_3, and ε_s under clear conditions

Regression Model $X = C\ Y^T$

Least squares regression solution $C = X\ Y\ (Y^T\ Y)^{-1}$

X…Atmospheric State, C…Coefficients, Y…Measurements

- Preparation of representative trainingsets
- Forward Model Calculations using SARTA
- Application of BT/scanang-classification scheme
- Retrieval Validation/Comparison: ECMWF analysis, global RAOBs, MODIS and GOES Retrievals, L2 Standard Product

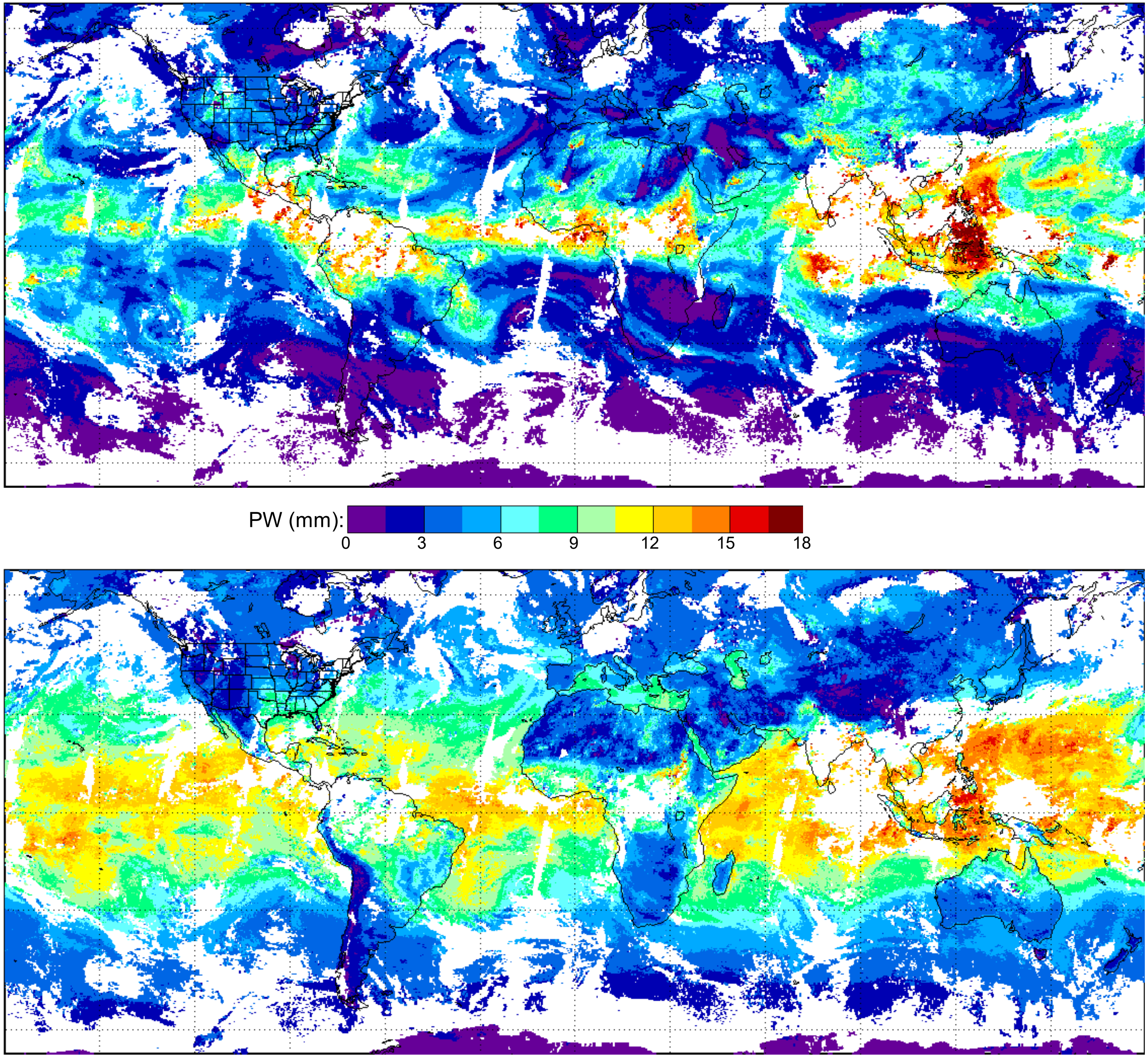
→ TIGR3 & Noaa88 & ECMWF & special desert and polar cases
→ Ecosystem assigned to each point to get realistic surface pressure, surface skin temperature and surface emissivity.

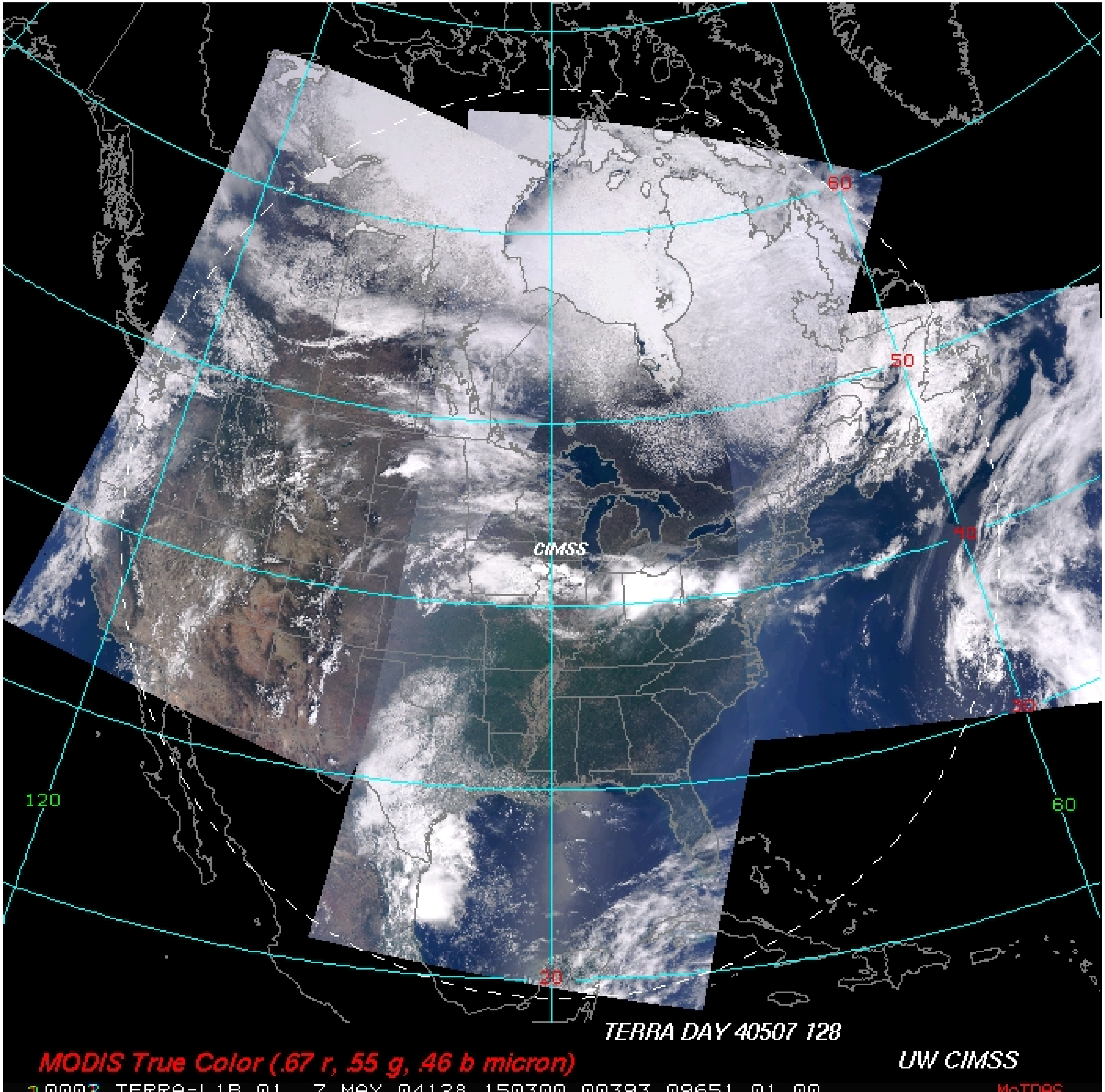
Class	BT@1000 cm^{-1} training	BT@1000 cm^{-1} observations
1	BT ≤ 260	BT ≤ 255
2	250<BT≤270	255<BT≤265
3	260<BT≤280	265<BT≤275
4	270<BT≤290	275<BT≤285
5	280<BT≤300	285<BT≤295
6	290 < BT	295 < BT

11 scanning angles θ
with
$\sec(\theta)=1 + \Delta * i$
i=0,1,2,…10 and $\Delta = 0.0524$

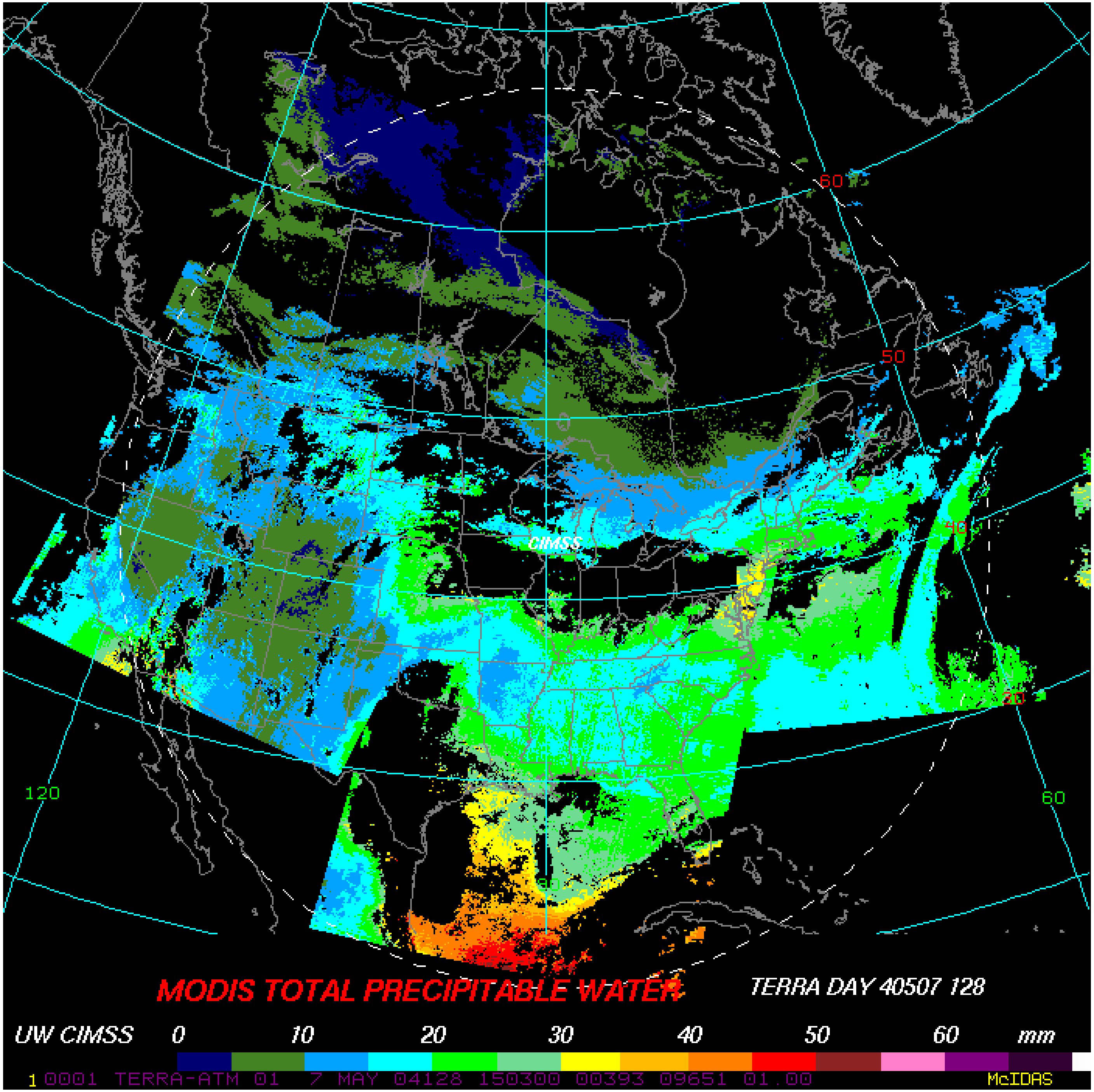
PW High
700-300 hPa

PW Low
920 hPa - sfc



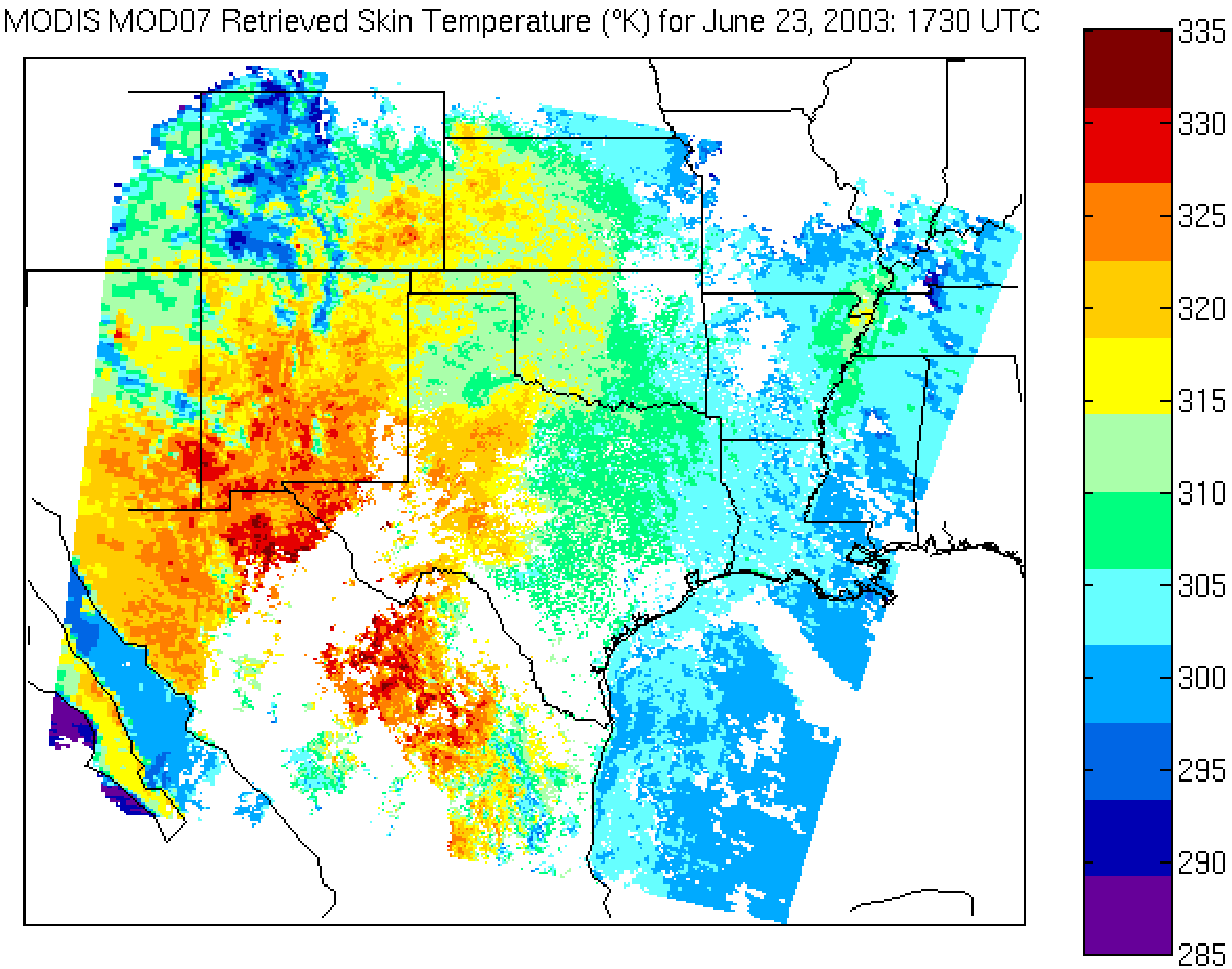


60
50
40
30
20
120
60
CIMSS
TERRA DAY 40507 128
MODIS True Color (.67 r, .55 g, .46 b micron)
UW CIMSS
2 0002 TERRA-L1B 01 7 MAY 04128 150300 00393 09651 01.00
McIDAS

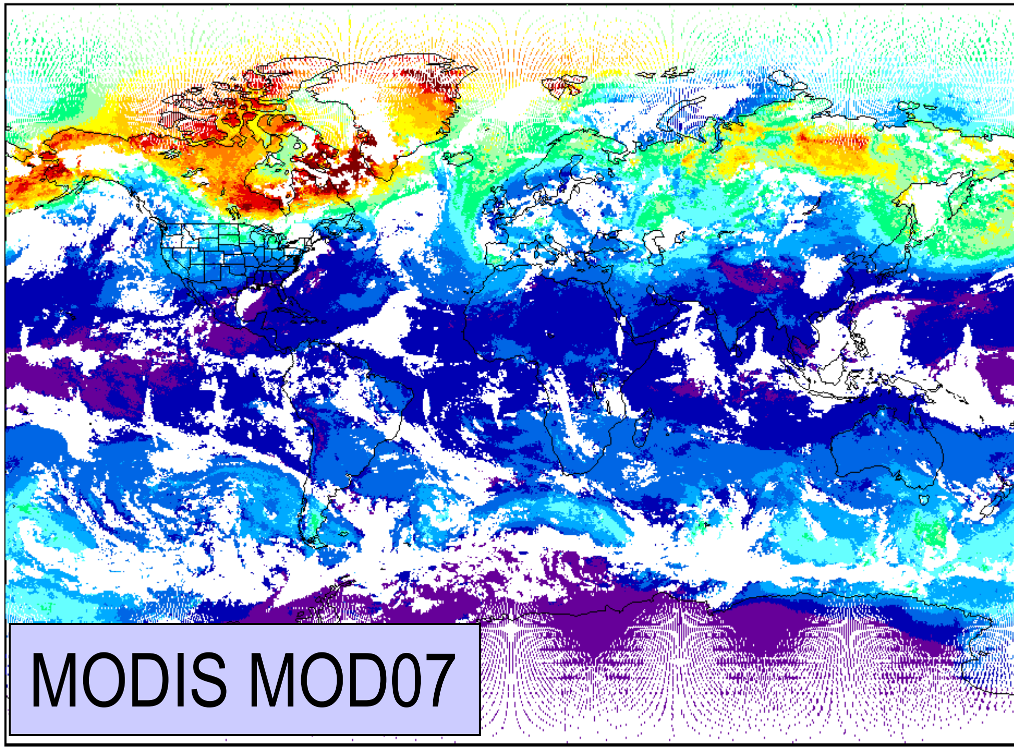


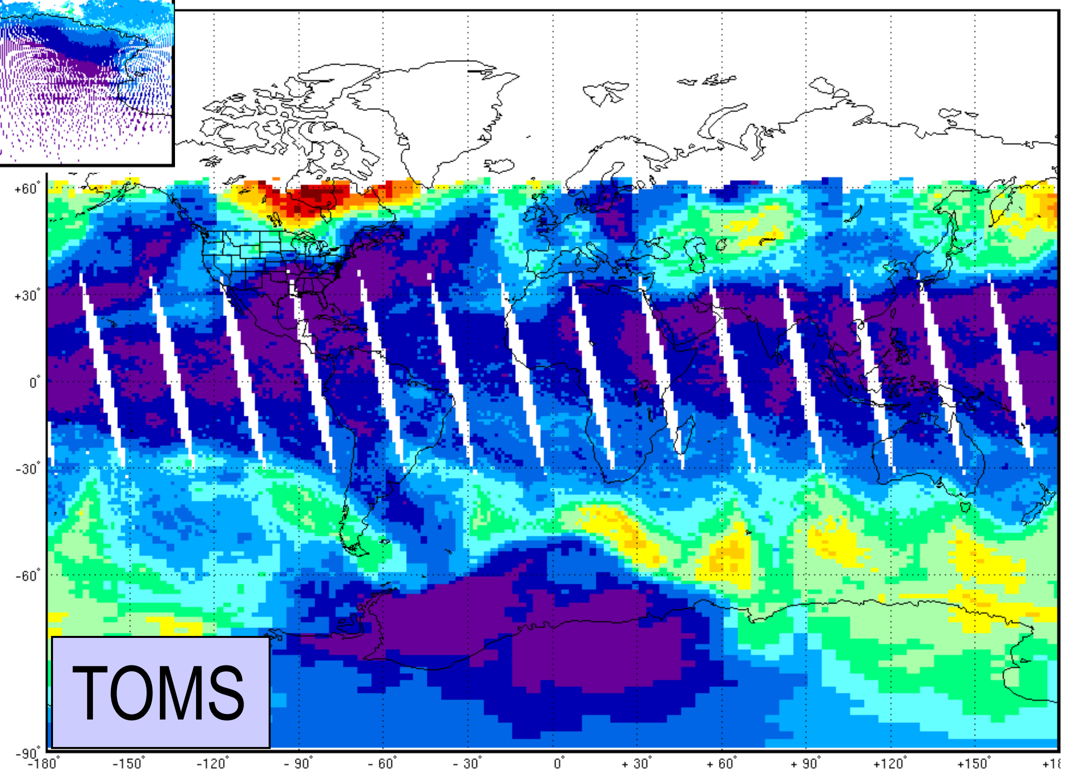
60
50
40
30
120
60
CIMSS
MODIS TOTAL PRECIPITABLE WATER
TERRA DAY 40507 128
UW CIMSS
0
10
20
30
40
50
60
mm
1 0001 TERRA-ATM 01 7 MAY 04128 150300 00393 09651 01.00
McIDAS

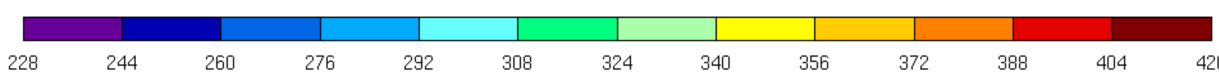
Surface Skin Temperature



Global Total Ozone (Dobson) for December 1, 2004

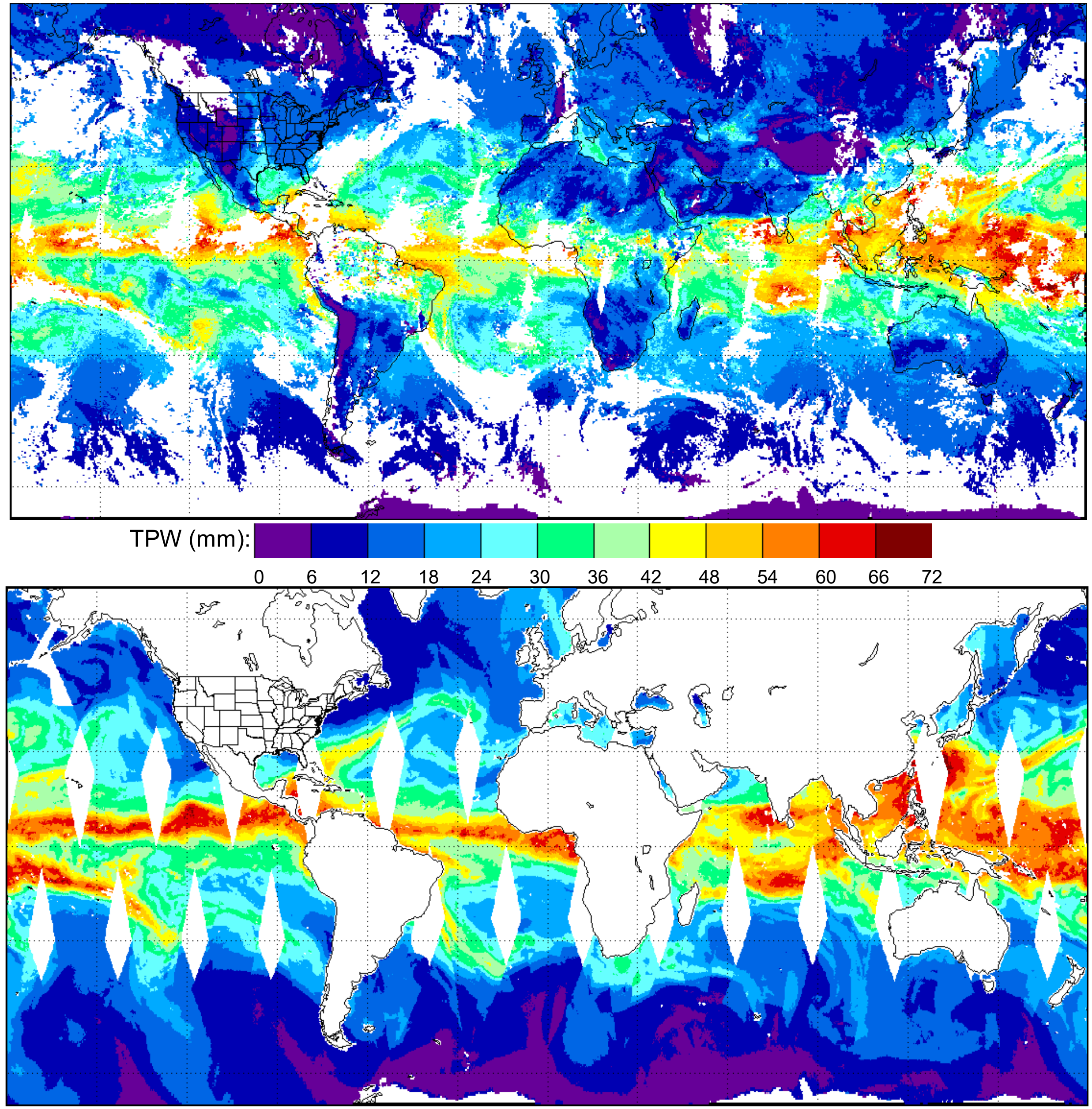






Global Total Precipitable Water Comparison 22 May 2002

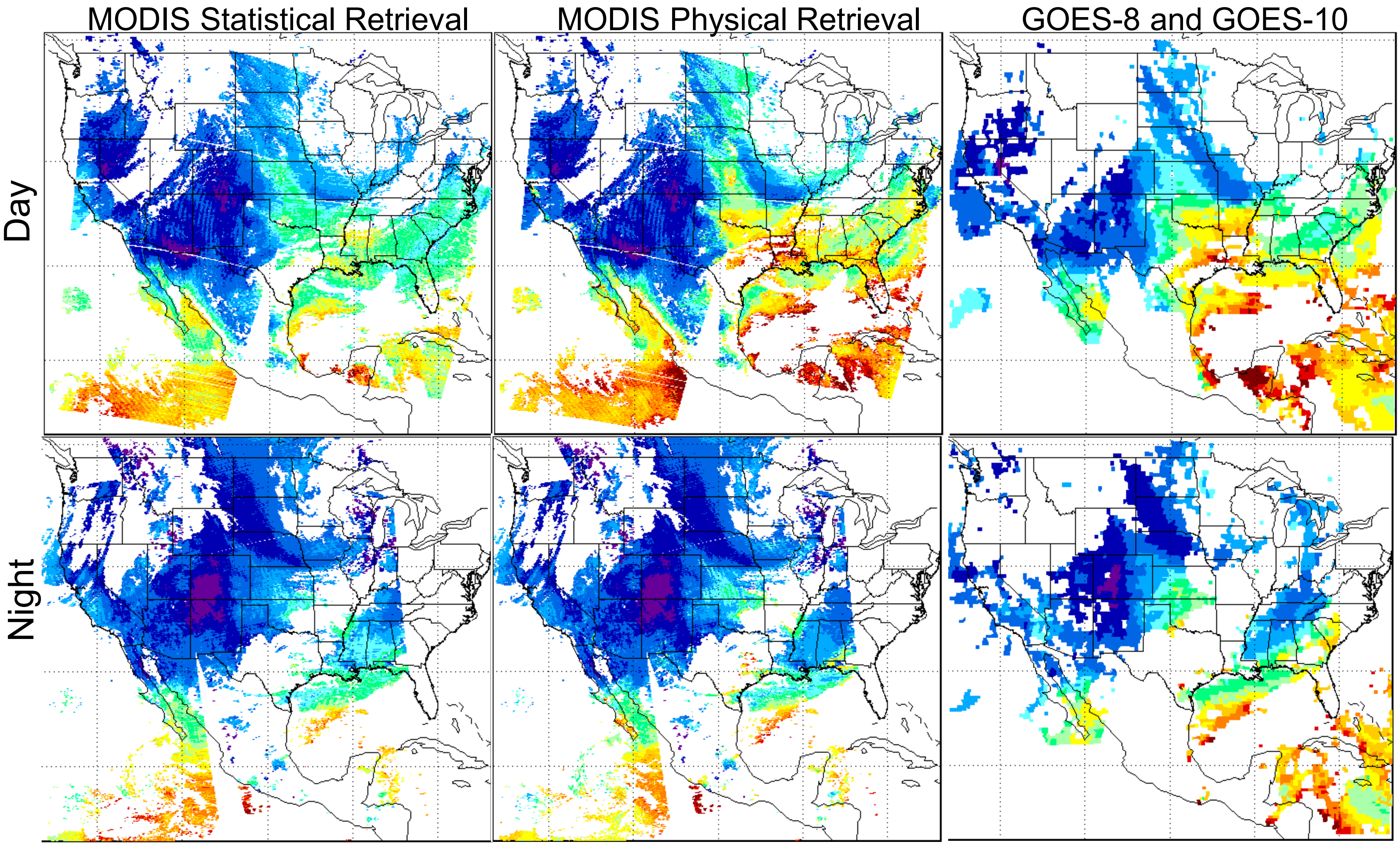
MODIS TPW



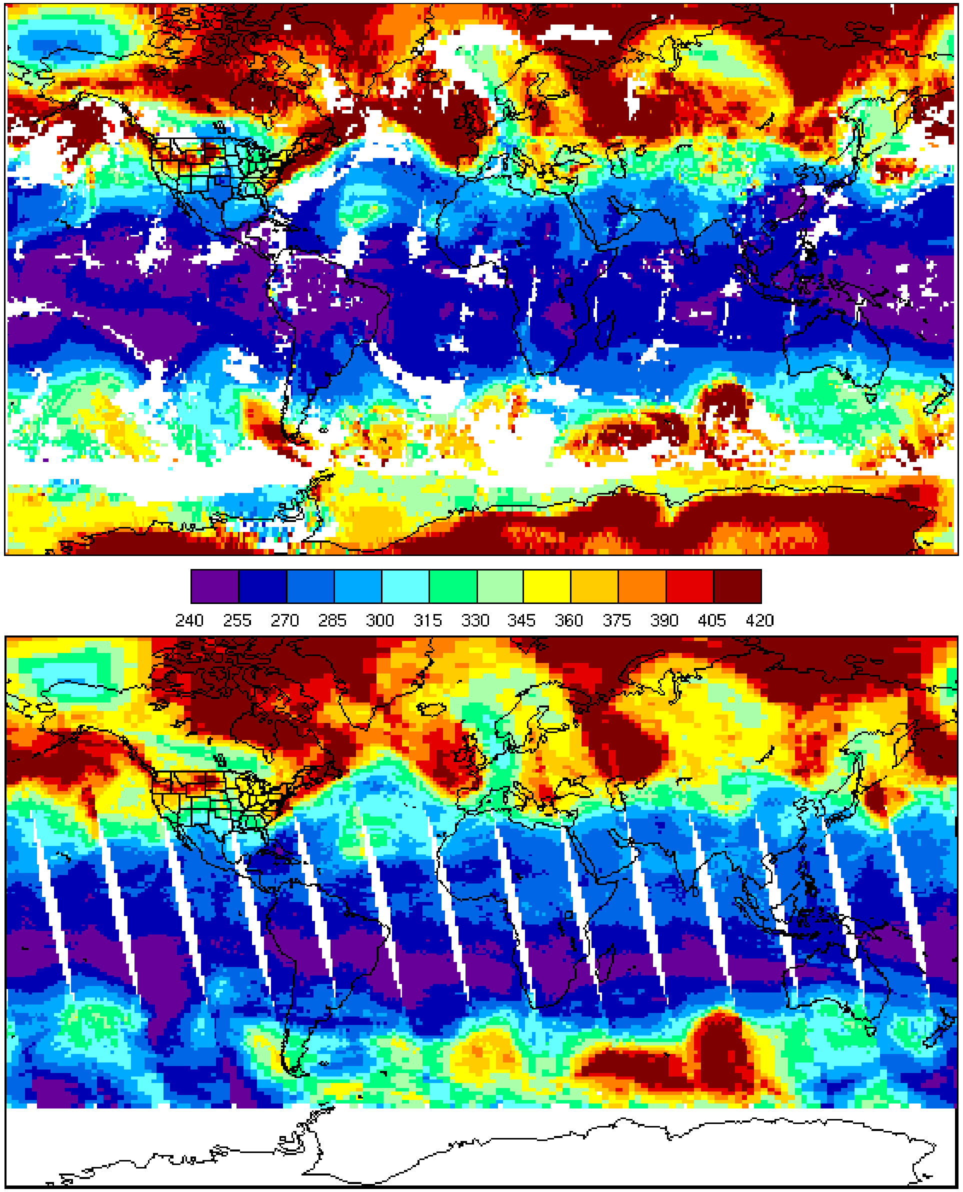
SSM/I f-14 TPW

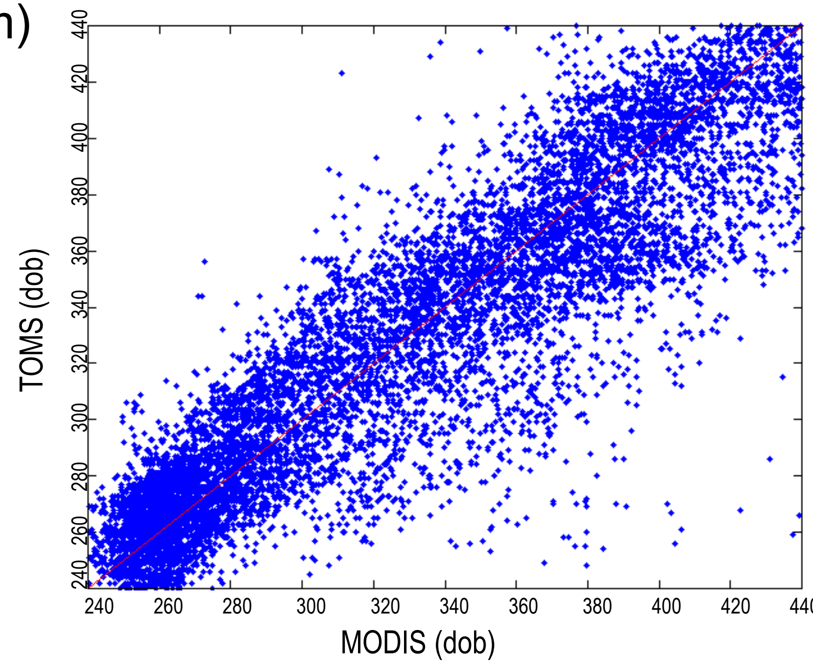
Ascending and descending passes were averaged

TPW (mm) for 2 June 2001 over North America

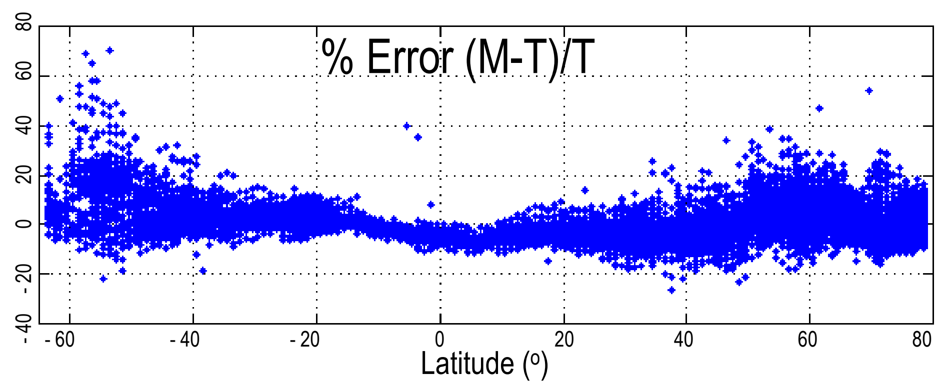


Total Ozone from MODIS (top) and TOMS (bottom)
May 22, 2002

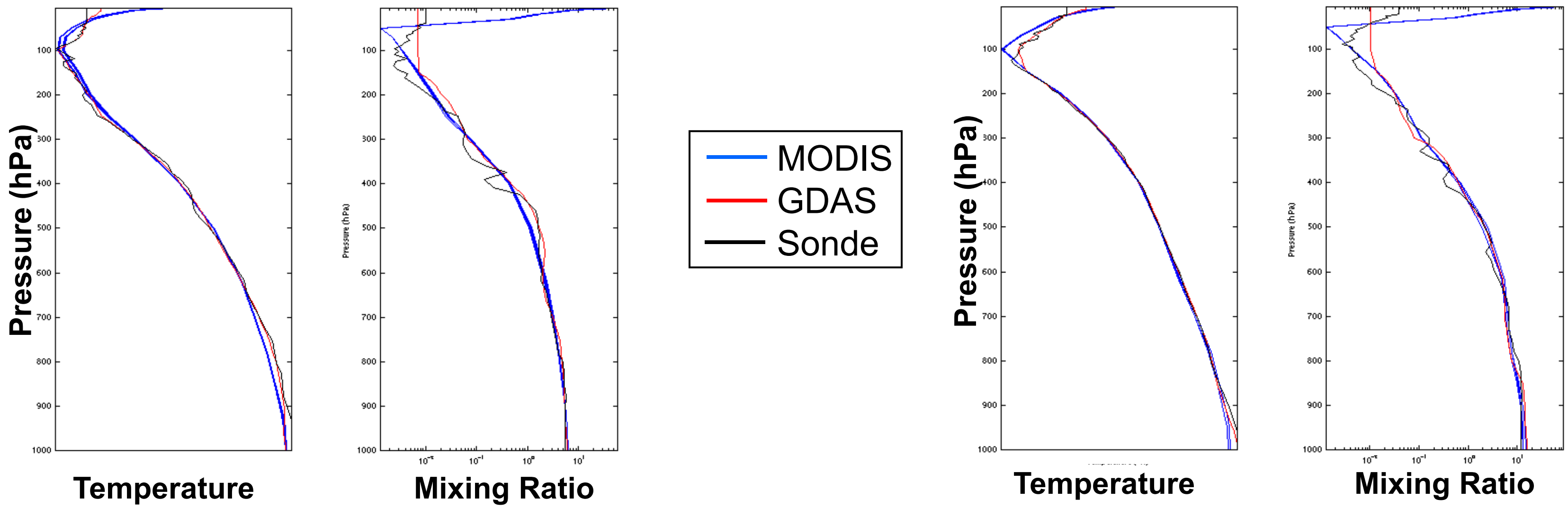




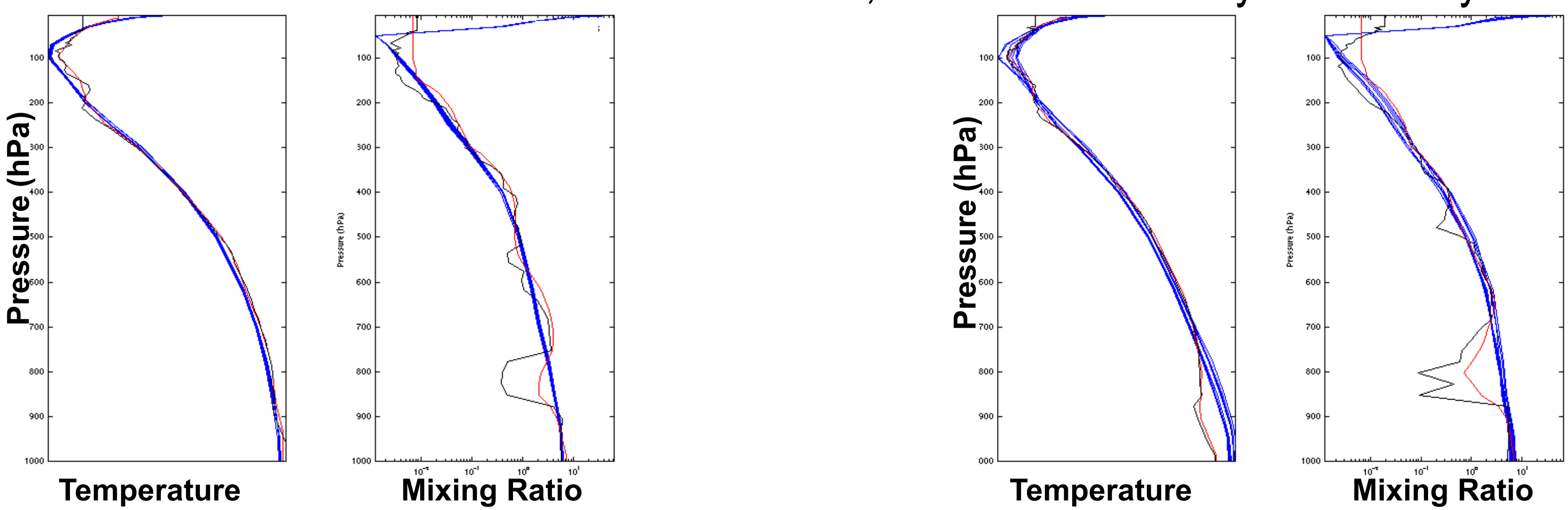
Mean difference MODIS - TOMS = 4.4 dob
RMS = 27.4 dob
mean abs % error: abs(M-T)/T = 5.9%
N = 10,614



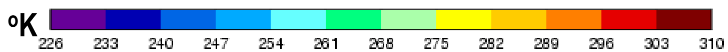
MODIS profiles agree well with radiosondes and NCEP-GDAS when the atmospheric temperature and moisture is fairly smooth and monotonic:

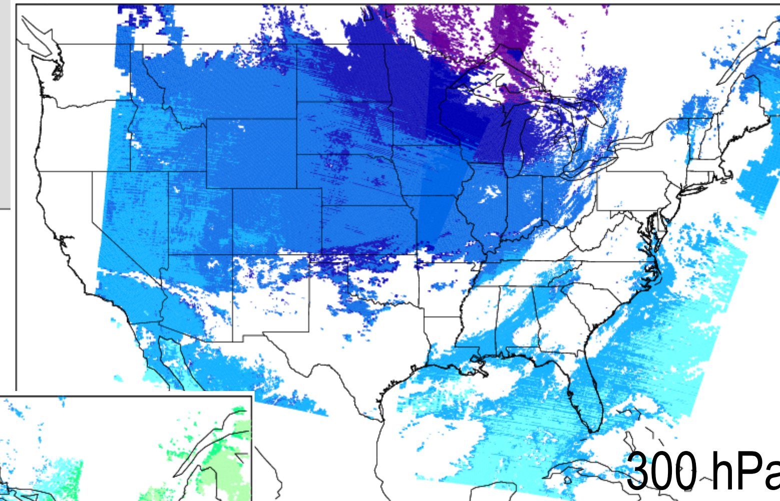


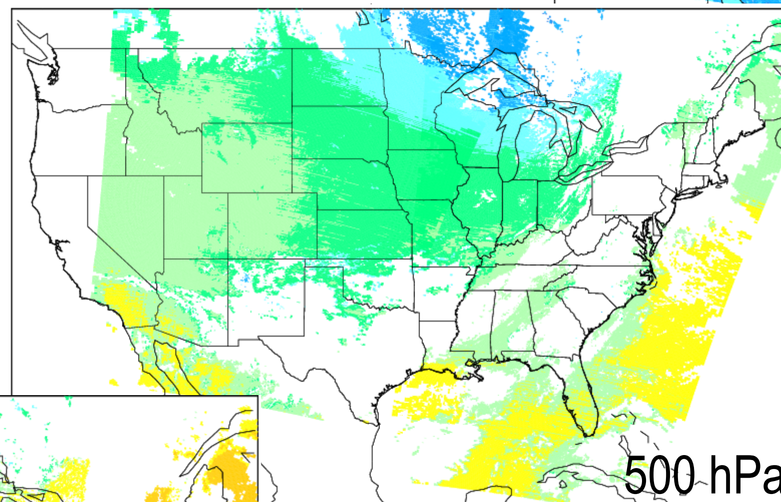
But not so well with smaller-scale features, such as isolated dry or moist layers:

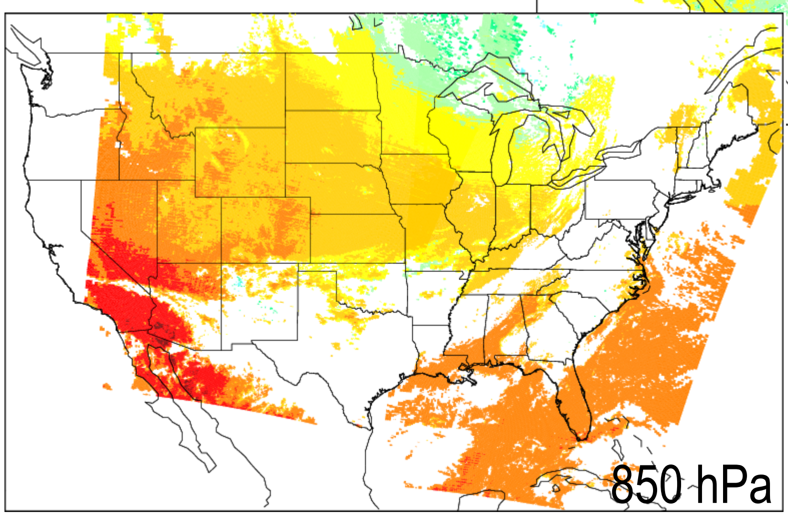


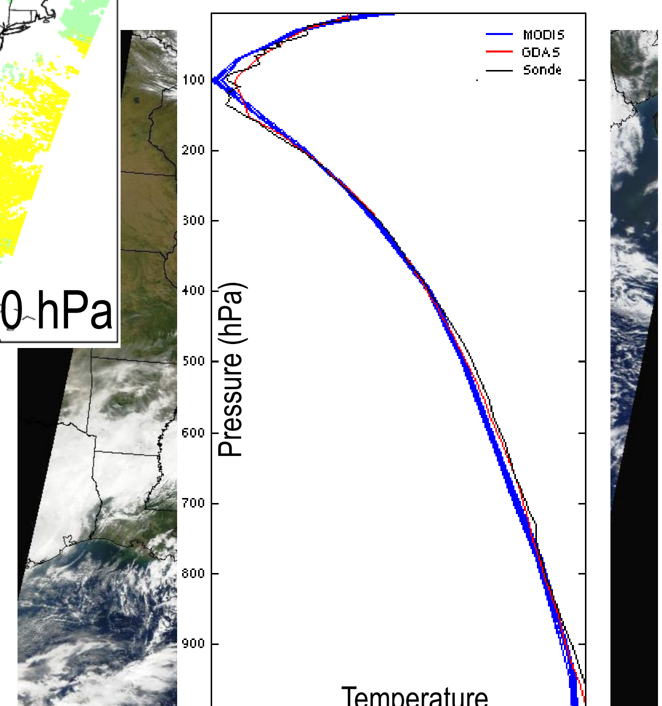
Isobaric Surfaces/Profiles of Temperature
13 October 2002
Terra MODIS direct broadcast



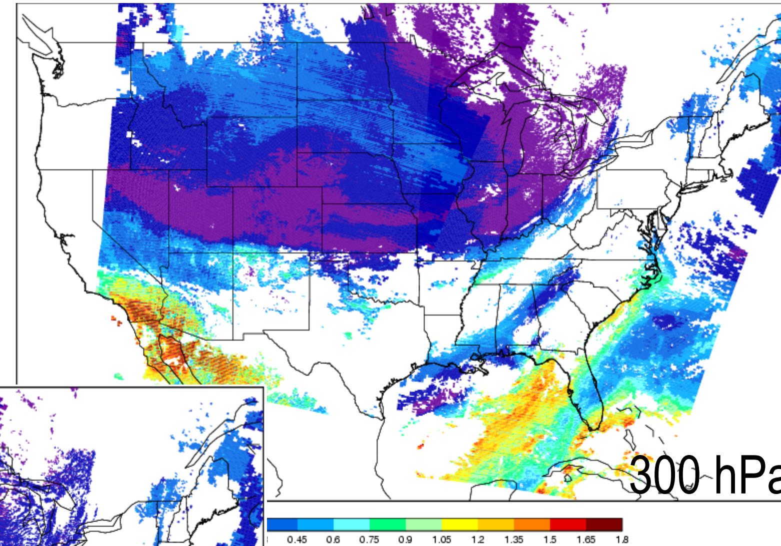


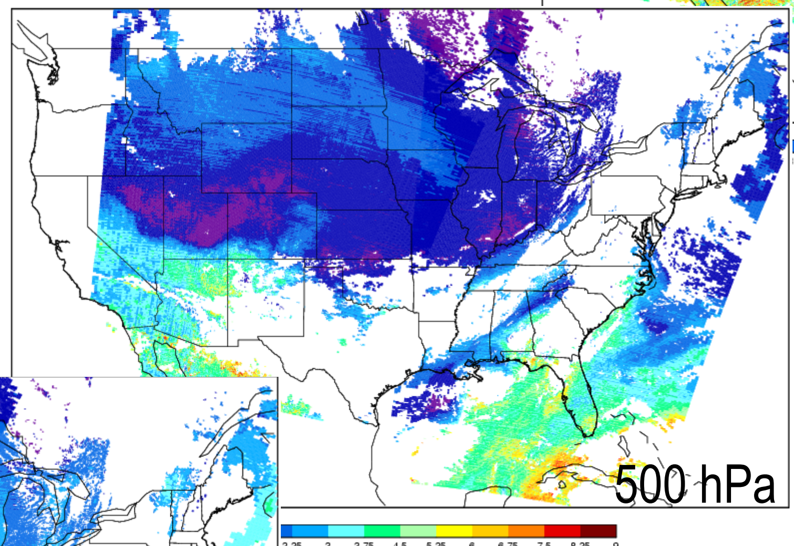


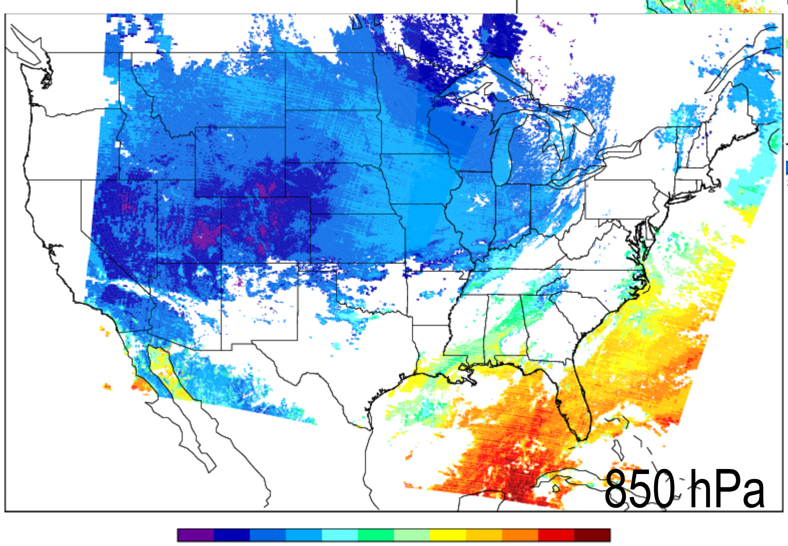


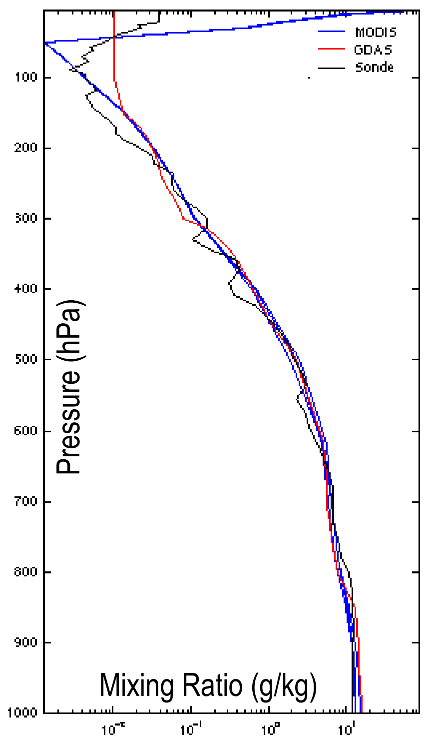


Isobaric Surfaces/Profiles of Moisture
13 October 2002
Terra MODIS direct broadcast



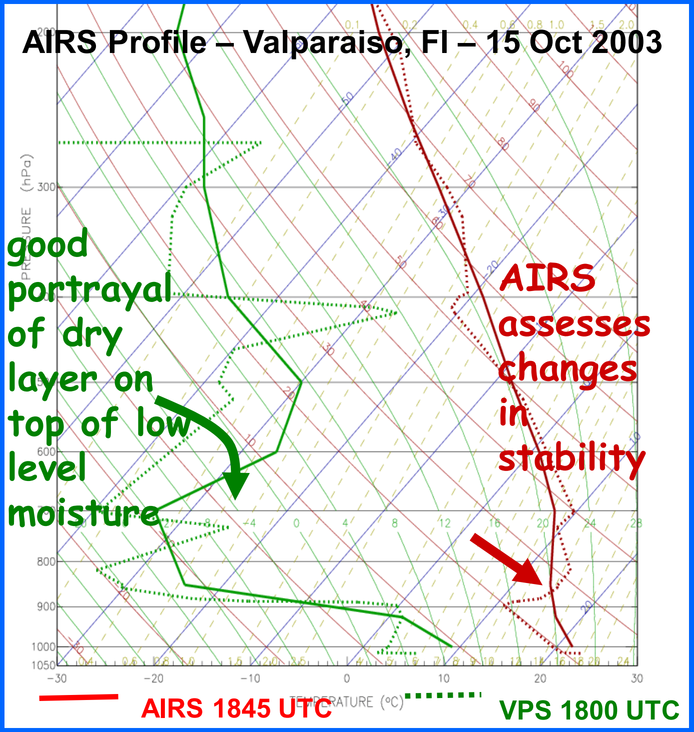






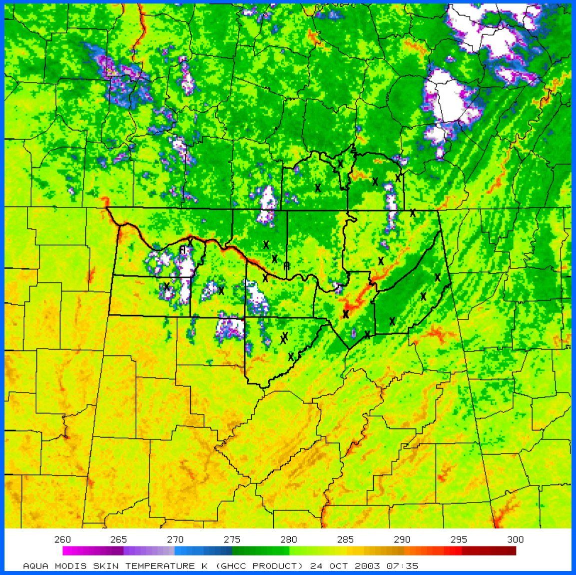
Earth Science Enterprise
National Aeronautics and Space Administration

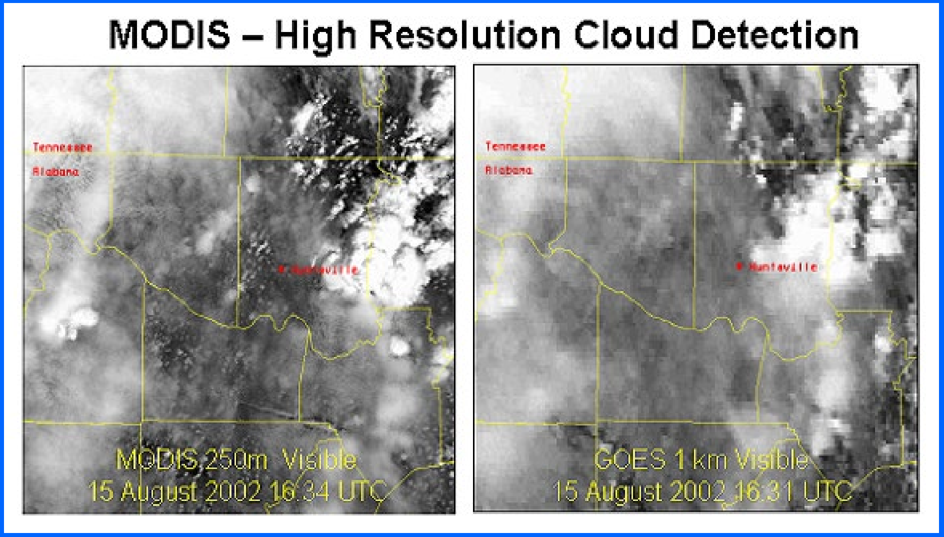
EOS Products



AIRS profiles will map **temperature** and **moisture** gradients and help diagnose asynoptic **changes in** atmospheric **stability**.

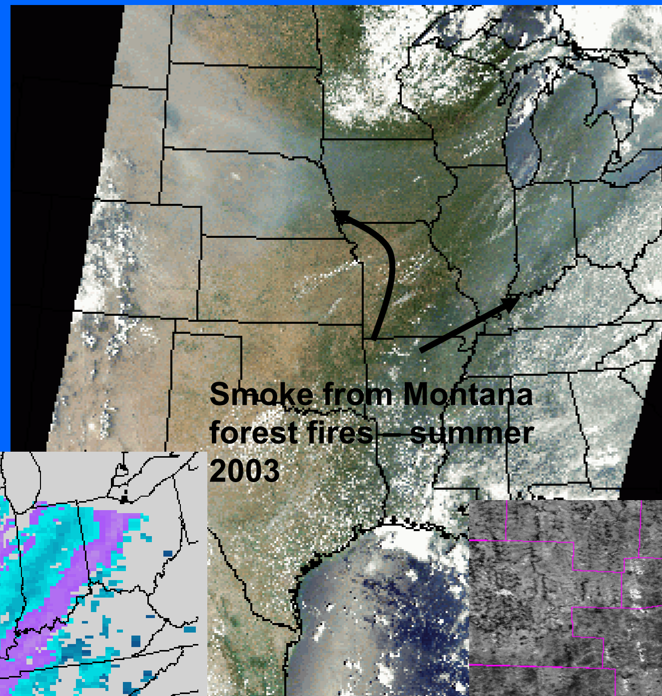
MODIS land surface temperatures are used in **forecasting morning low temperatures** and in IFPS validation.



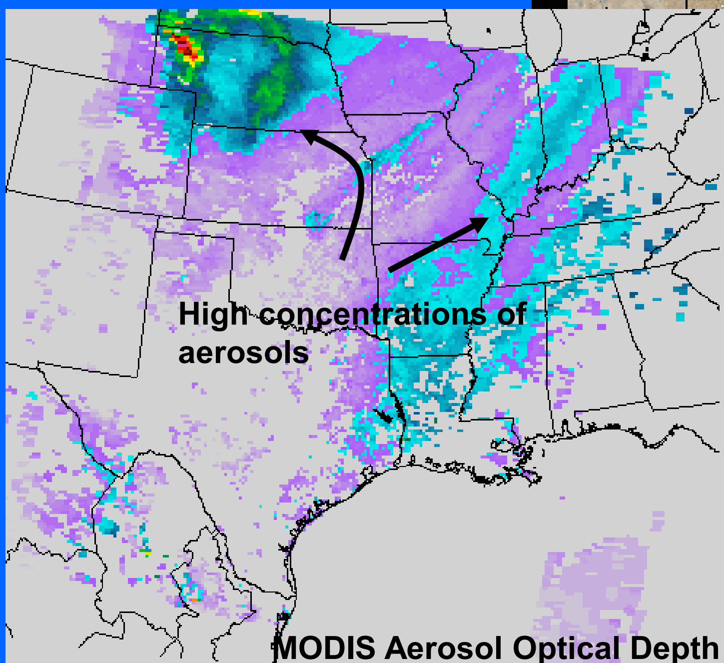


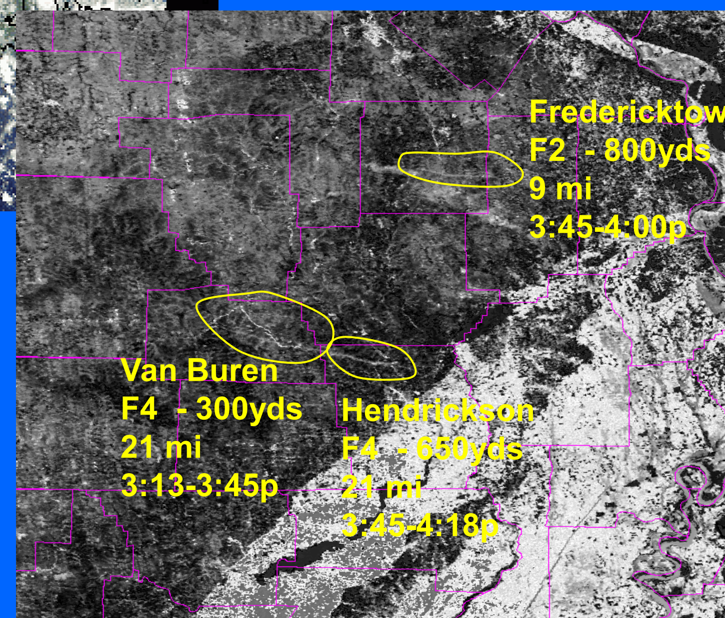
EOS Products

Color composite imagery and aerosol optical depth derived from MODIS can identify regions of restricted visibility with significant impact on aviation .



MODIS 250m visible and color composite imagery can detect tornado damage tracks and help in storm intensity assessment.





Some aspects of AIRS Sounding Retrieval and their impact on IMAPP Products

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Space Applications Centre (ISRO), INDIA

ABSTRACT

As a part of International MODIS/AIRS Processing Package (IMAPP) an algorithm has been developed at Cooperative Institute for Meteorological Satellite Studies (CIMSS) to retrieve atmospheric and surface parameters from AIRS-L1B radiance measurements. In this presentation some aspects of the AIRS sounding retrieval, based on principal component regression (PCR), will be discussed. Presentation will mainly focus on retrieval sensitivity to infrared (IR) spectral surface emissivity, training data classification (global versus regional), sunglint/solar-reflection effect, etc. Some interesting features in AIRS observed radiance spectra that might help in detecting boundary-layer temperature inversion, will also be presented.

Global Vs. Regional IMAPP Profile Performance