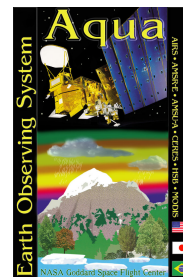


# *MODIS Infrared Atmospheric Profiles and Water Vapor: Updates for Collection 5*

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Cooperative Institute for Meteorological Satellite Studies  
University of Wisconsin-Madison

Presented to MODIS Atmosphere Group on 14 July 2004



## MOD07 Collect 5 Delivery – Changes to the Algorithm

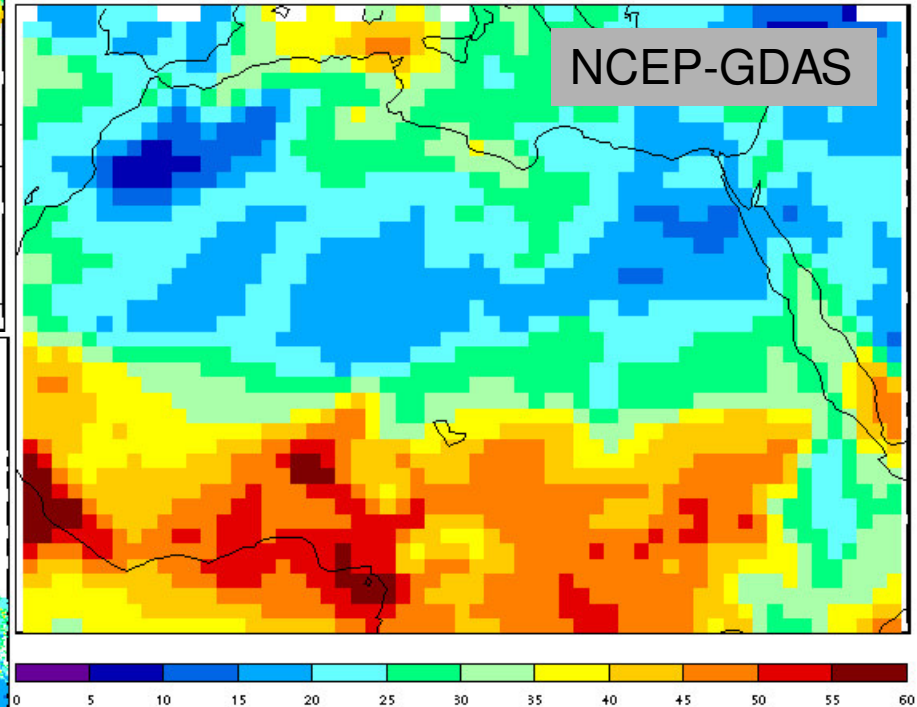
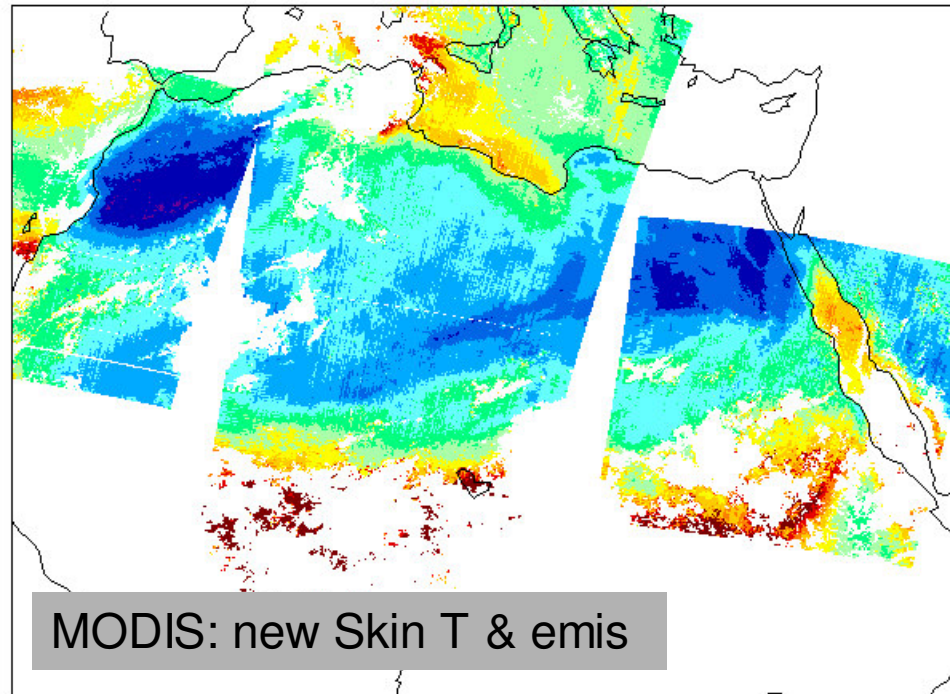
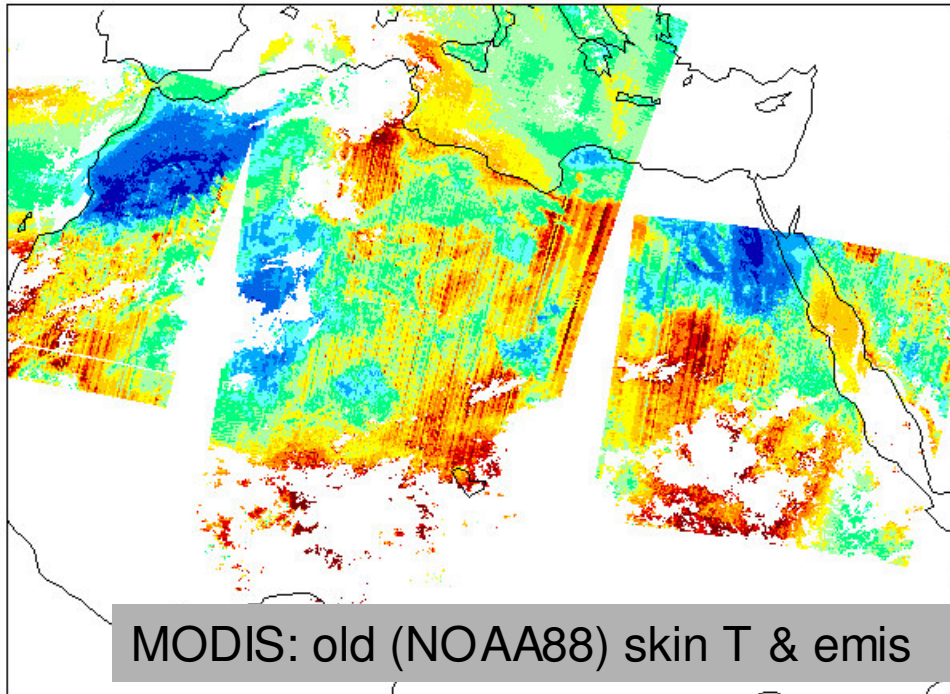
- 1) Updated Training Data used to compute the regression coefficients:
  - Added more profiles (12,208 was 8447), with the additional ones drawn from TIGR-3, ECMWF, CMDL ozonesondes.
  - Performed a saturation check of profiles (required < 95% RH below 250hPa)
  - Improved surface characterization for each profile:
    - New emissivity based on ecosystem, month, and latitude
    - New skin temperature, based on solar zenith and azimuth angles, as a function of surface air temperature
  - Regression-based ozone derived for profiles where ozone was not available
  - New forward model used to compute the coefficients from the profiles, based on LBLRTM 7.04/UMBC profiles
- 2) New land/ocean partitioning of training data and retrievals to take advantage of new, more physical emissivity & skin temperature.
- 3) Modified 11 $\mu$ m BT zones to allow for sufficient profiles after partitioning into land and ocean groups.
- 4) Radiance bias (obs-calc) corrections were updated after improvements were made in the global bias calculation algorithm, and to account for the new forward model version.
- 5) Now applying destriping to L1B data before running the MOD07 algorithm

## MOD07 Collect 5 Delivery – Improvements to the Products

- 1) Reduced the moist bias for dry cases (TPW < 17mm). For Terra, at SGP-CART site, dry cases are now 0.11mm too wet on average. Aqua was 1.5mm too wet for dry cases, and now has a bias of only 0.02mm.
- 2) Reduced the along-track noise with the improved training data, surface characterization, and new zones.
- 3) Improved the polar ozone. Previously, total ozone over Antarctica was unrealistically high.
- 4) Reduced the overall RMS for TPW at the SGP-CART site to 2.6mm for Terra
- 5) Reduced the across-track striping by including destriping of L1B radiances prior to performing the retrievals.

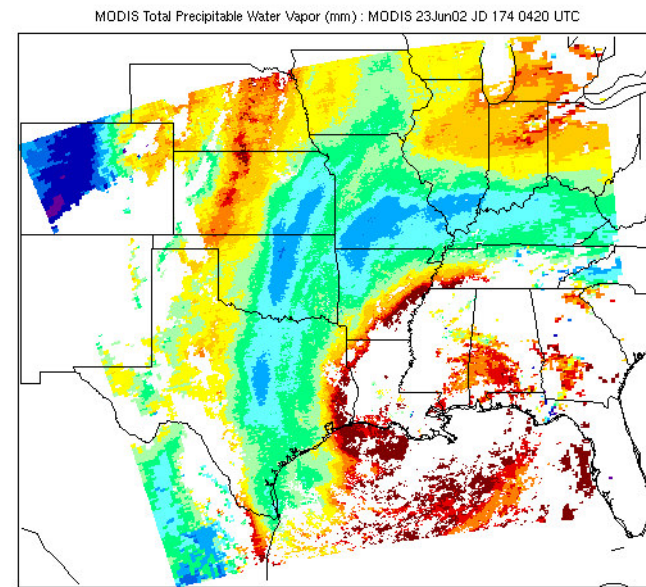
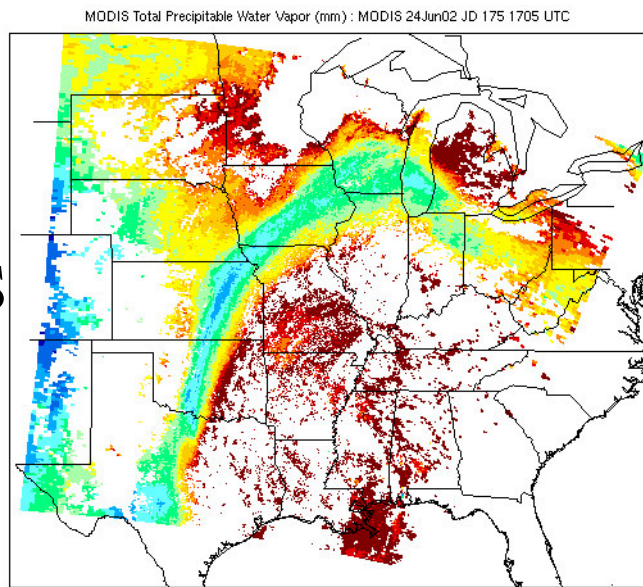
Examples of improvements to the products...

# Terra MODIS TPW (mm) for August 24, 2002 in the Sahara Desert region

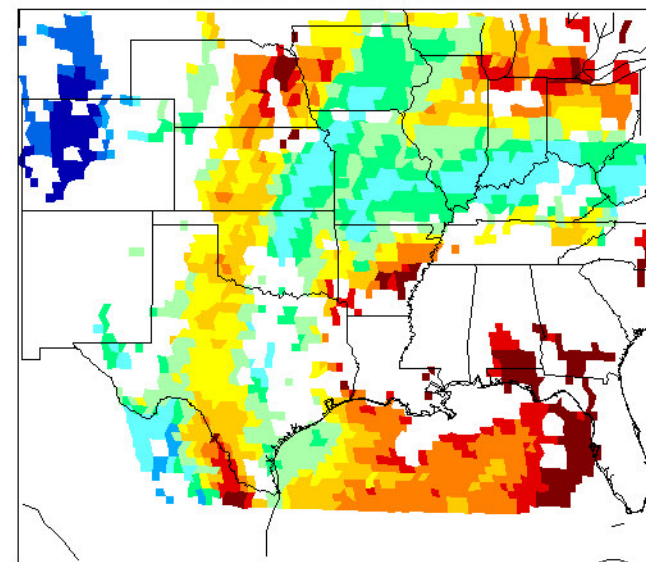
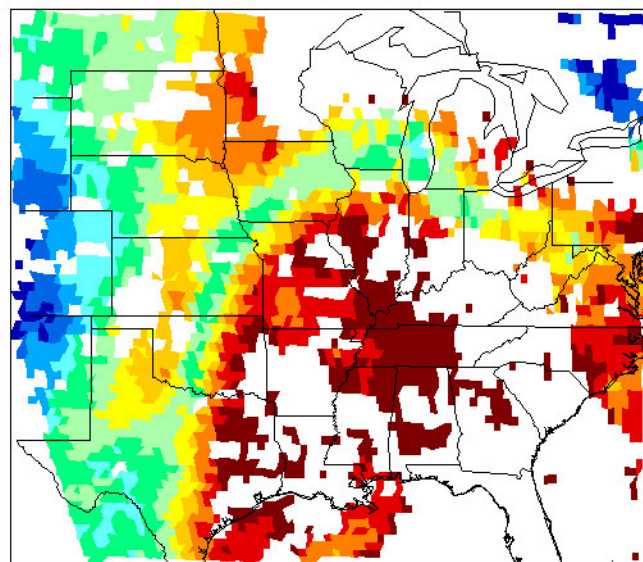




MODIS



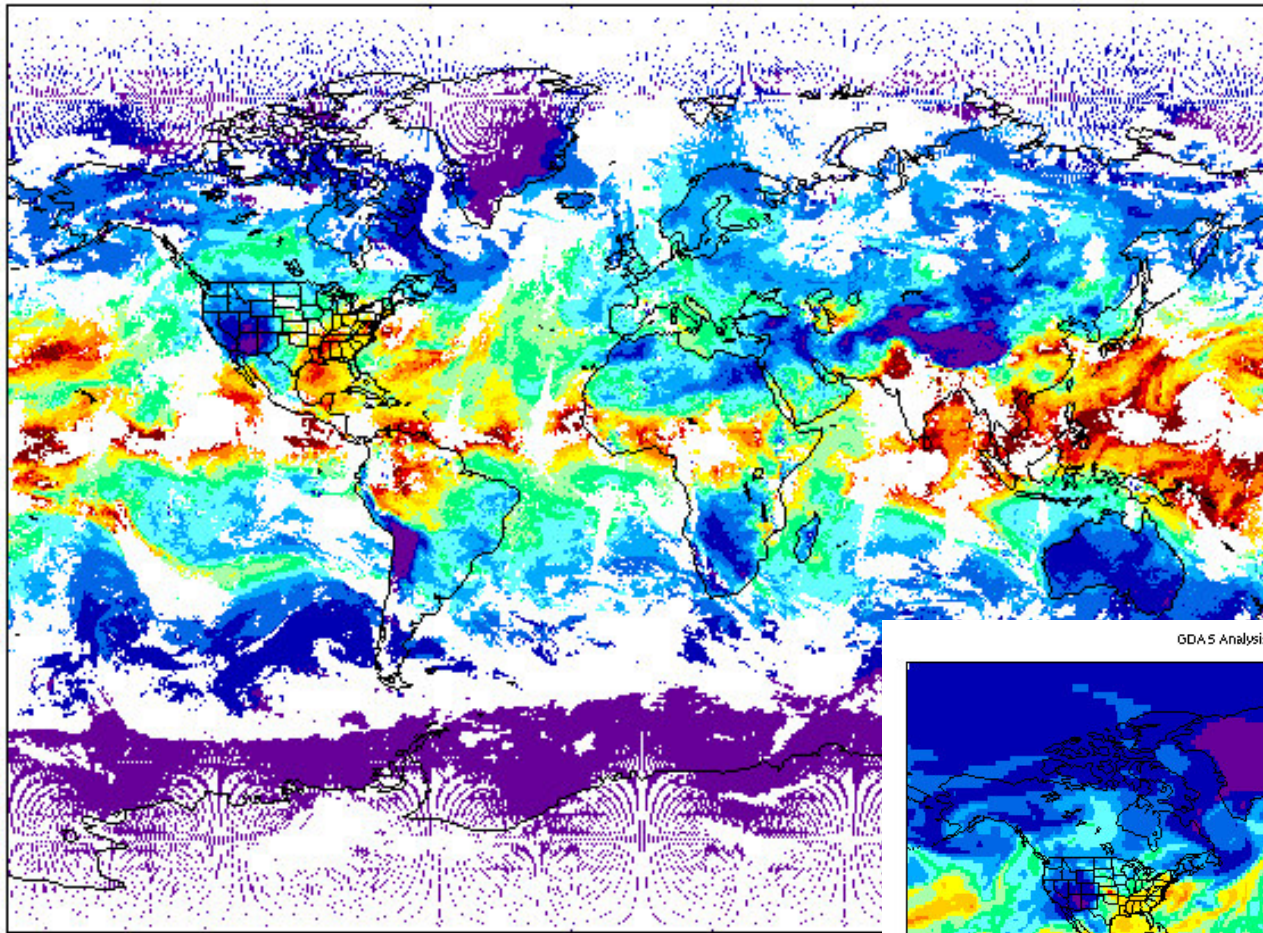
GOES





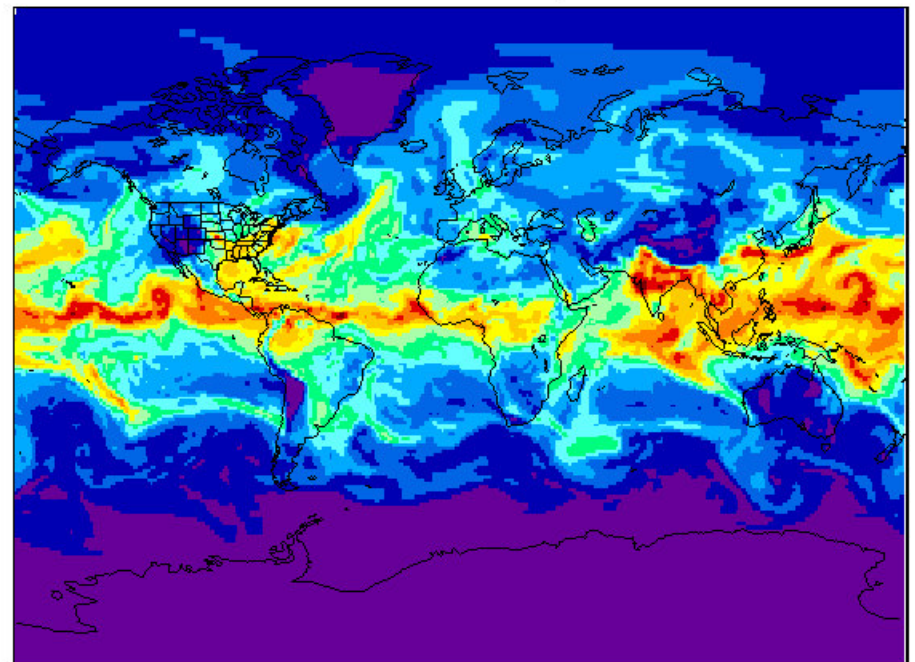
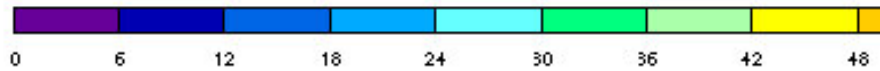
MODIS 25km Total Precipitable Water Vapor (mm): New Training Data - Terra 24 August 2002 (236)

MODIS



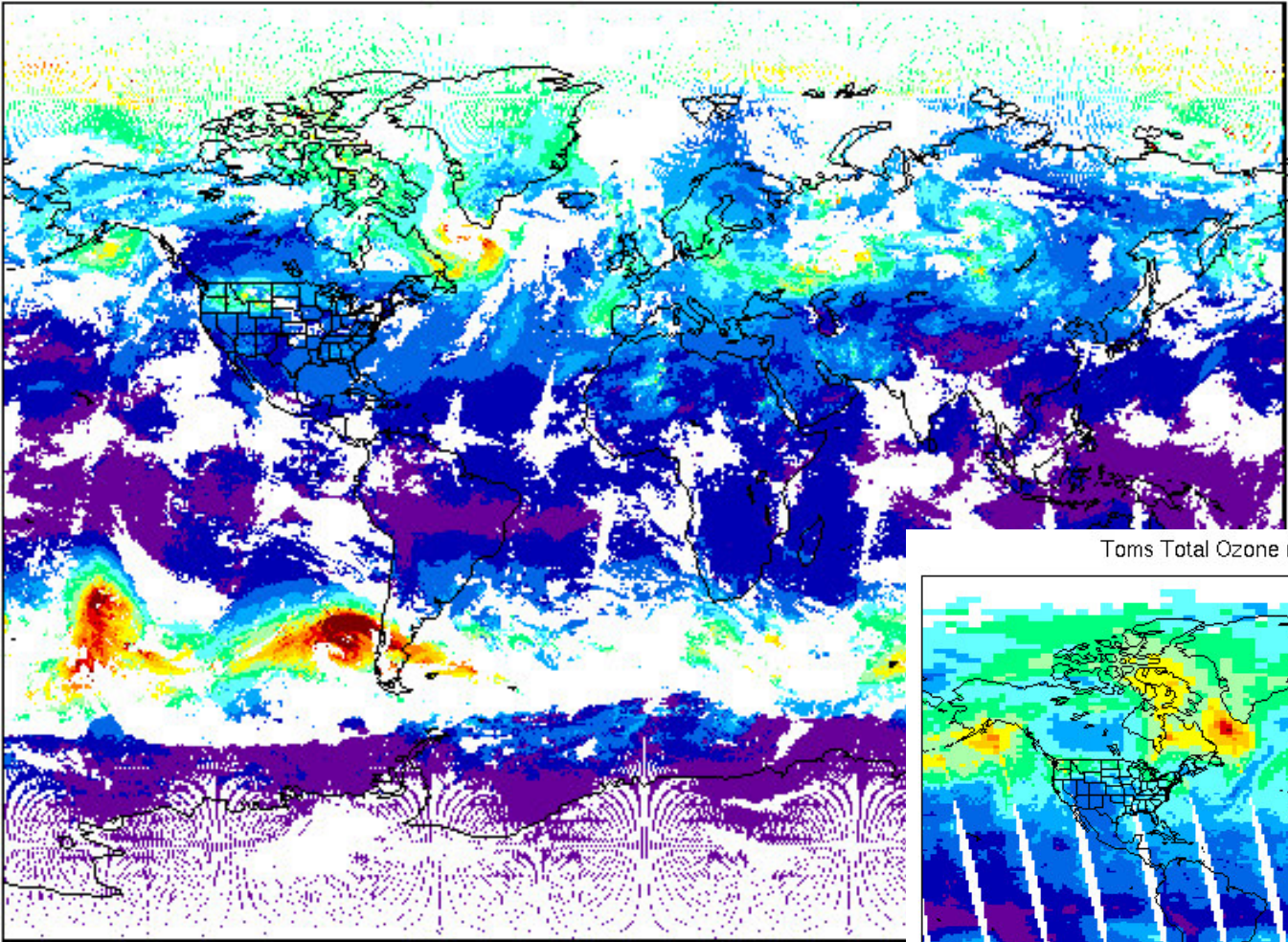
GDAS

GDAS Analysis PWAT (mm): 12UTC August 24, 2002 (236)





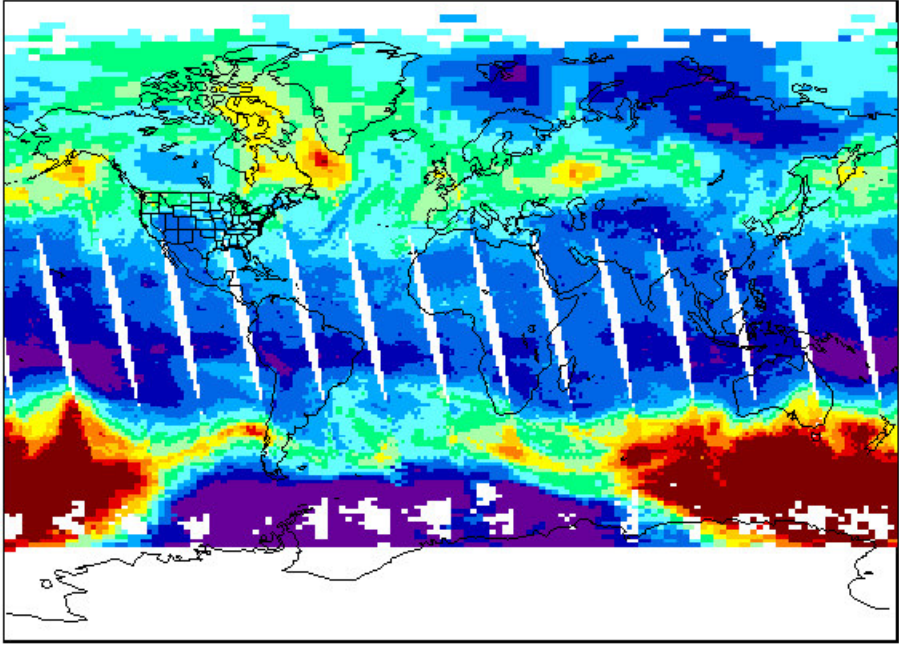
MODIS 25km Total Ozone (dobson): New Training Data - Terra 24 August 2002 (236)



MODIS

TOMS

Toms Total Ozone (dobson): August 24, 2002 (236)

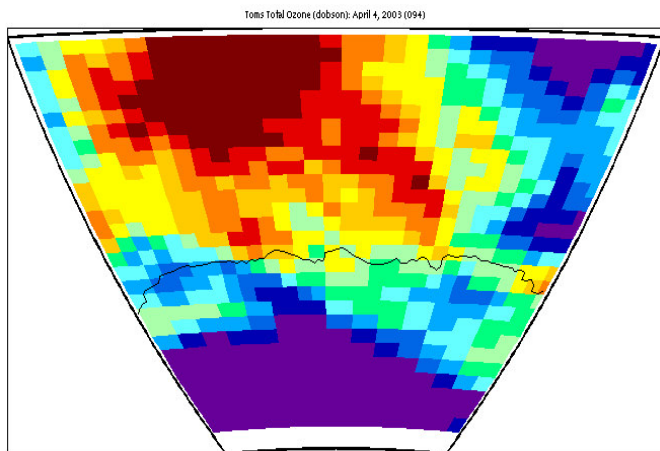


240 255 270 285 300 315 330 345 360

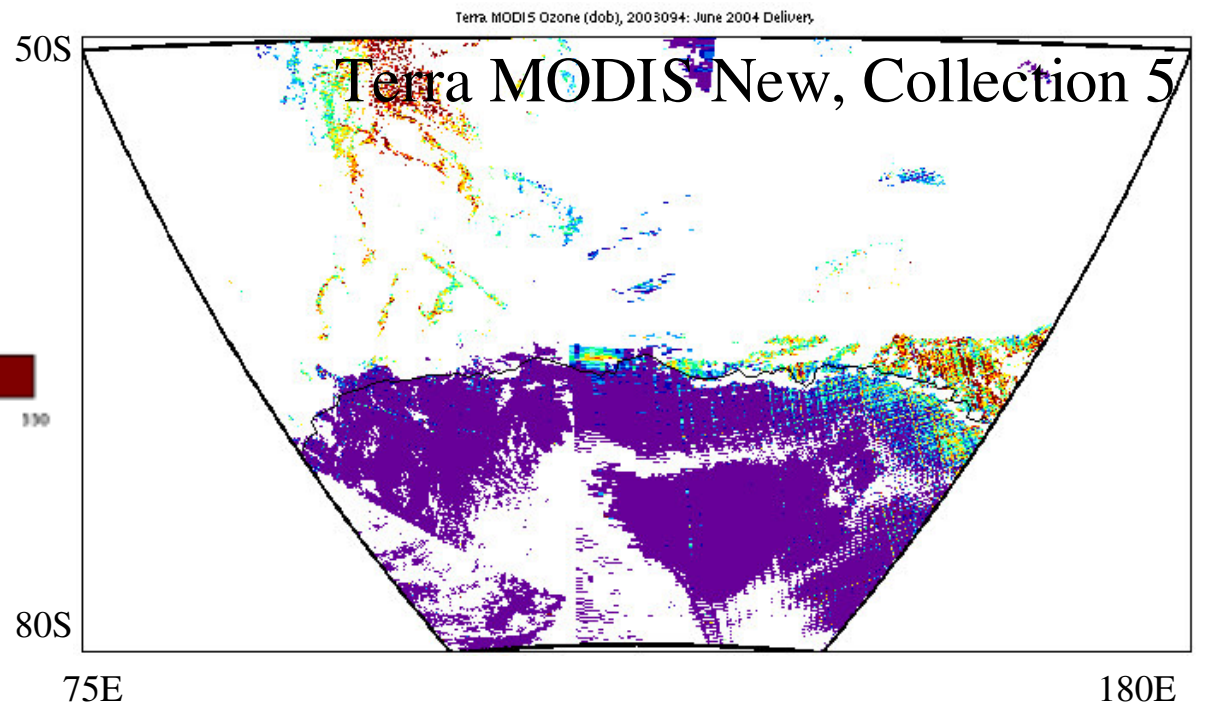
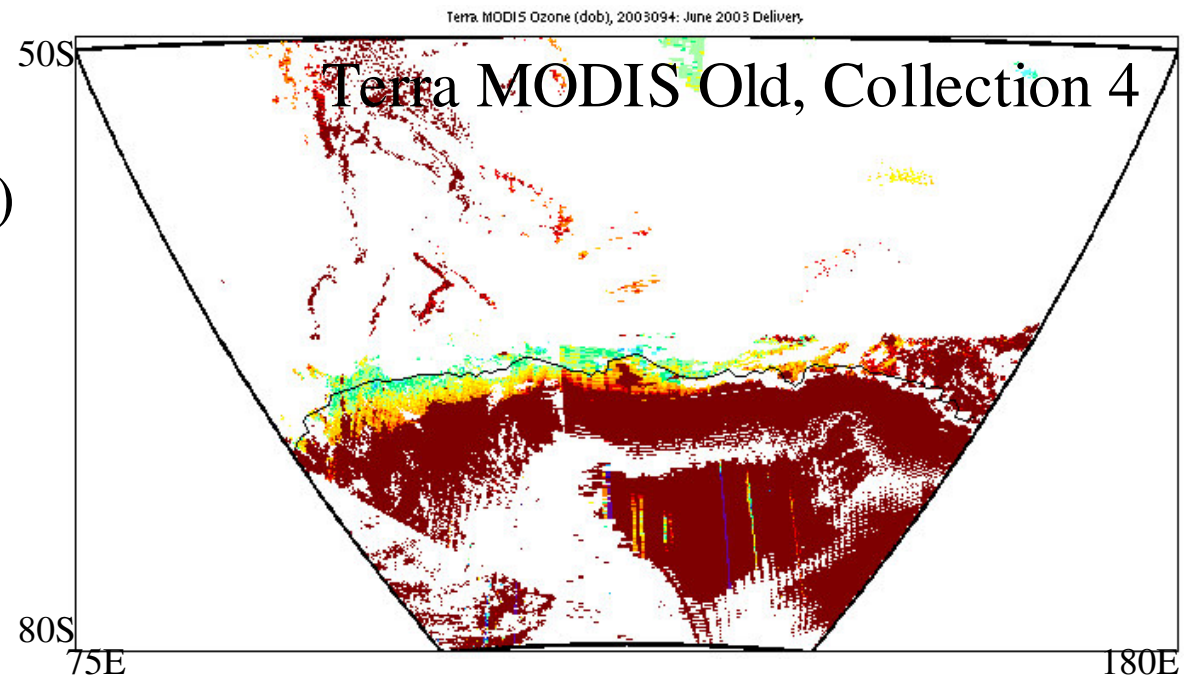
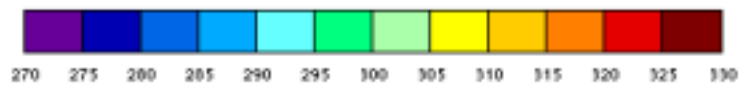
240 255 270 285 300 315 330 345 360 375 390 405 420



# Antarctic Ozone (Dobsons) 2003094



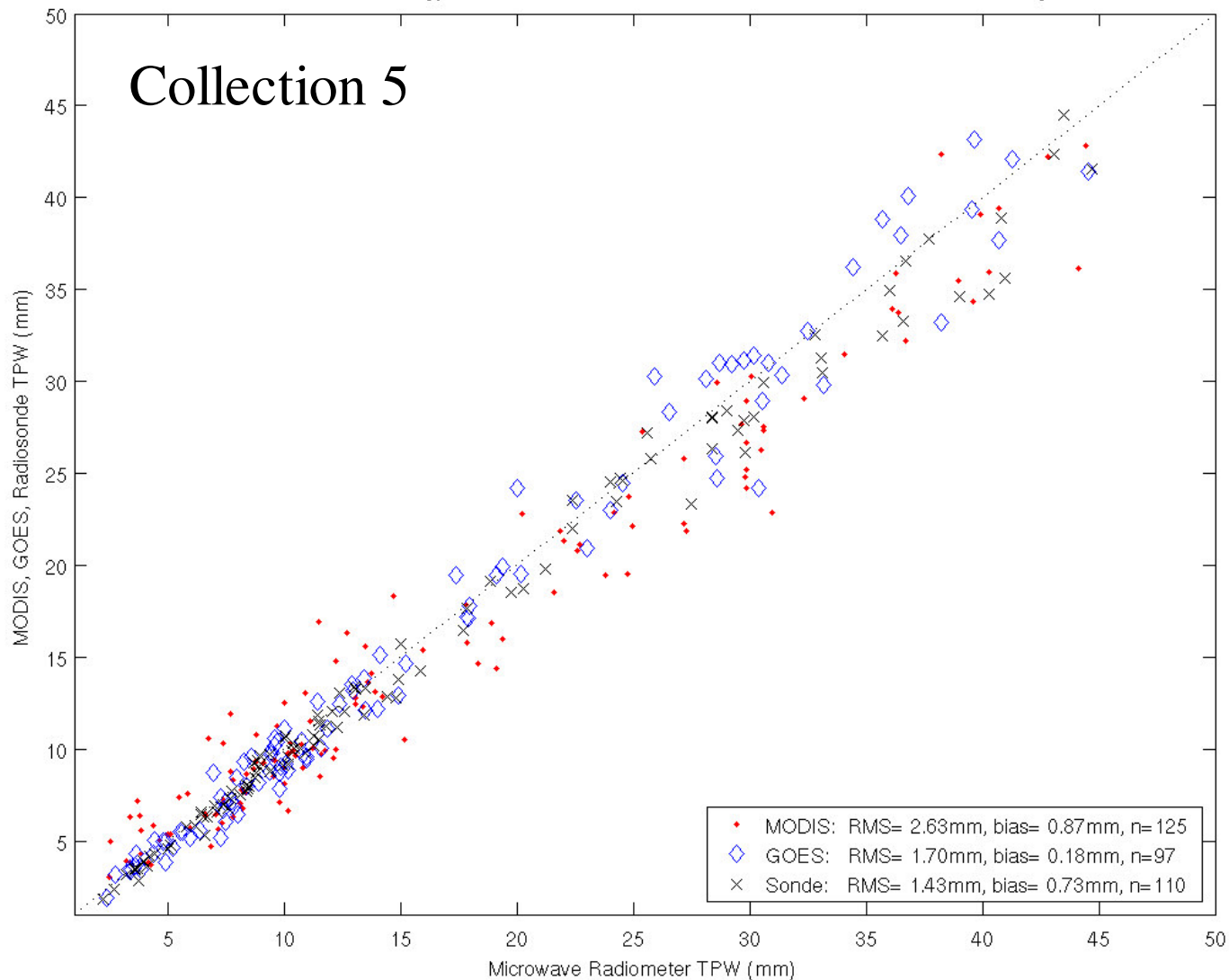
TOMS for comparison





Comparison of TPW from Terra MODIS (**red dots**), GOES-8 (**blue diamonds**), and radiosonde (**black crosses**) with the SGP ARM-CART microwave water radiometer

**Terra:** 125 clear sky cases from April 2001 to September 2003



## Aqua – Summary of impacts

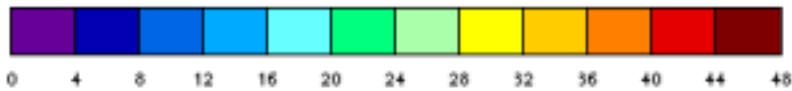
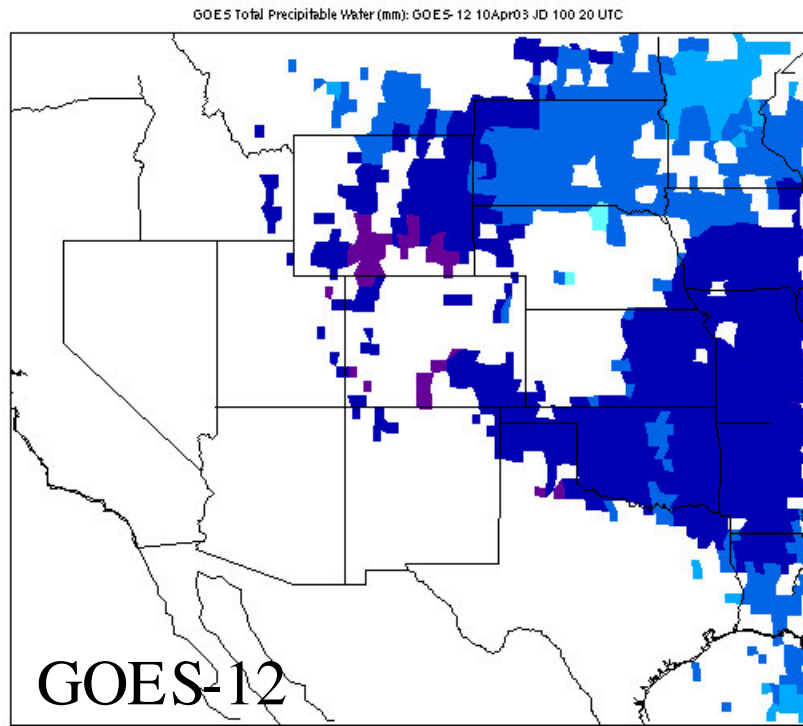
At the SGP CART site, new collection 5 Aqua TPW compares better with the MWR, sondes, and GOES for dry cases (TPW < 17mm), but is slightly worse for moist cases (TPW > 17mm).

The new algorithm makes significant improvements in Aqua image quality, reducing along-track noise and splotchiness due to surface effects.

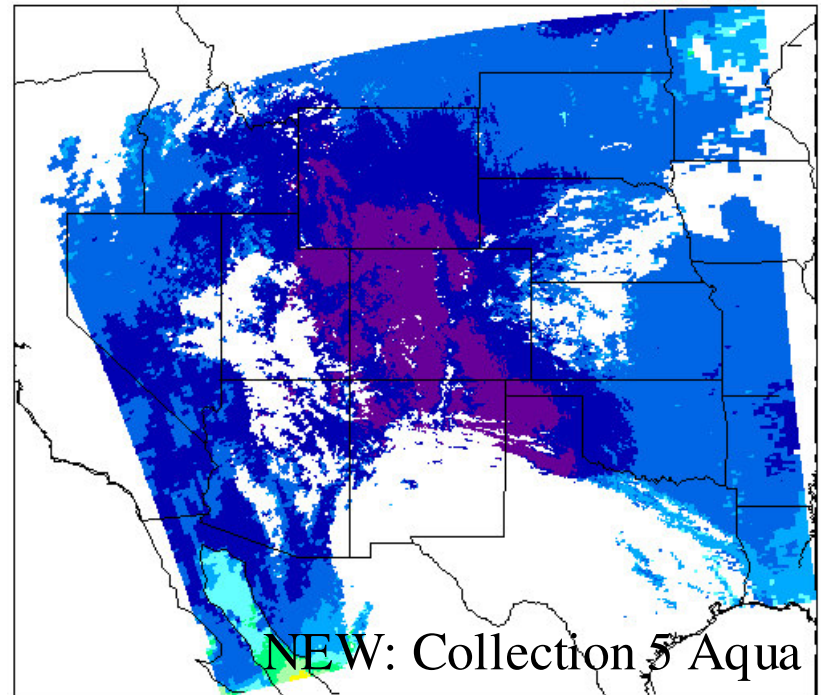
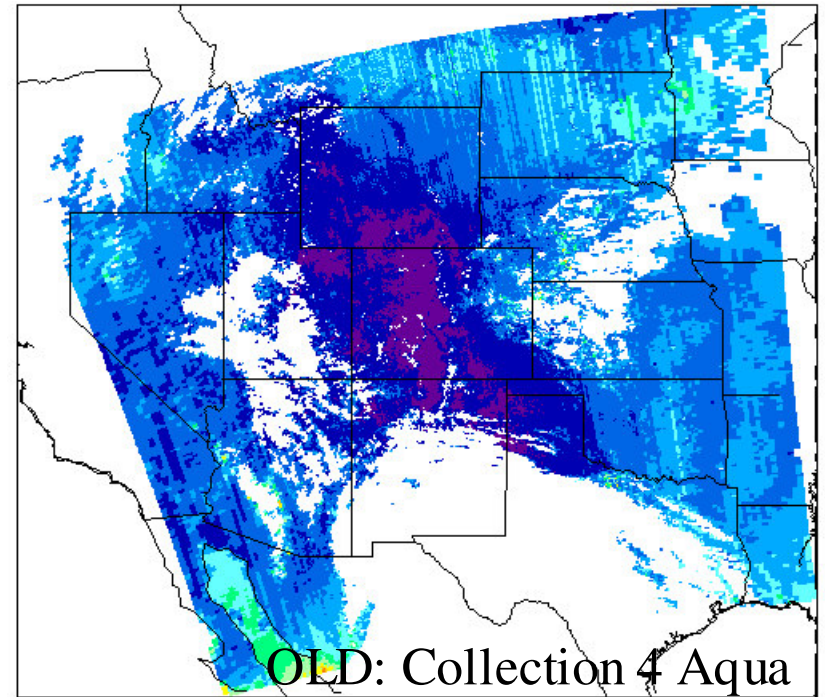
See next few slides for examples.



April 10, 2003: JD 100, 2005 UTC

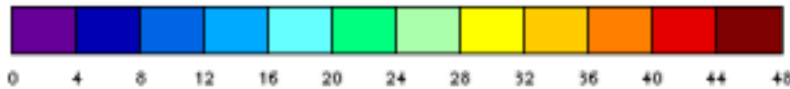
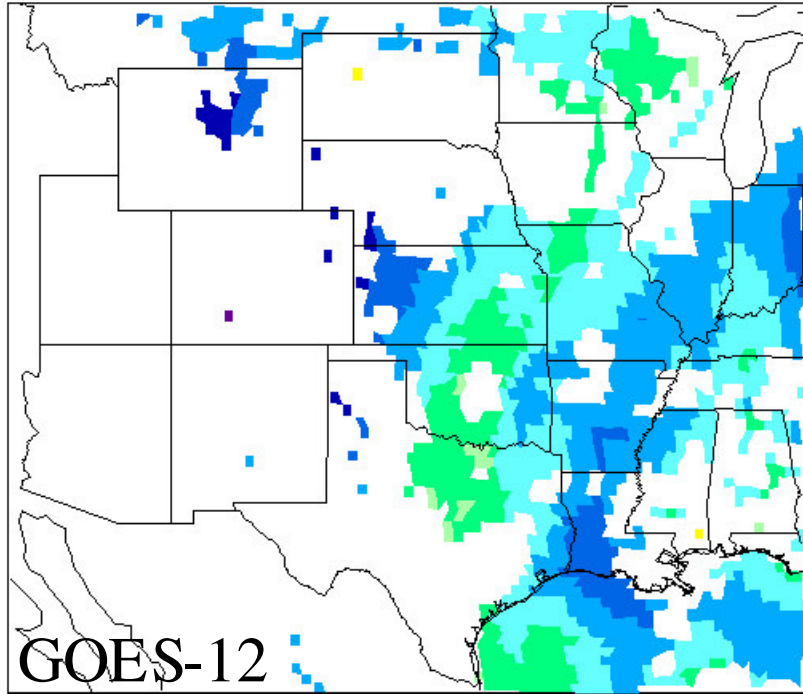


Along-track noise significantly reduced  
due to improved training data, surface  
characterization, and BT zones



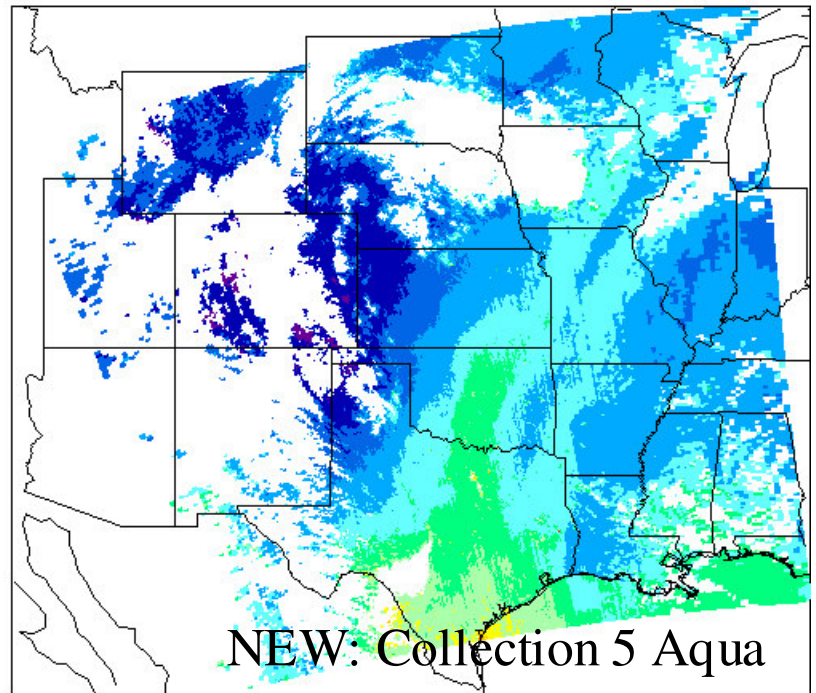
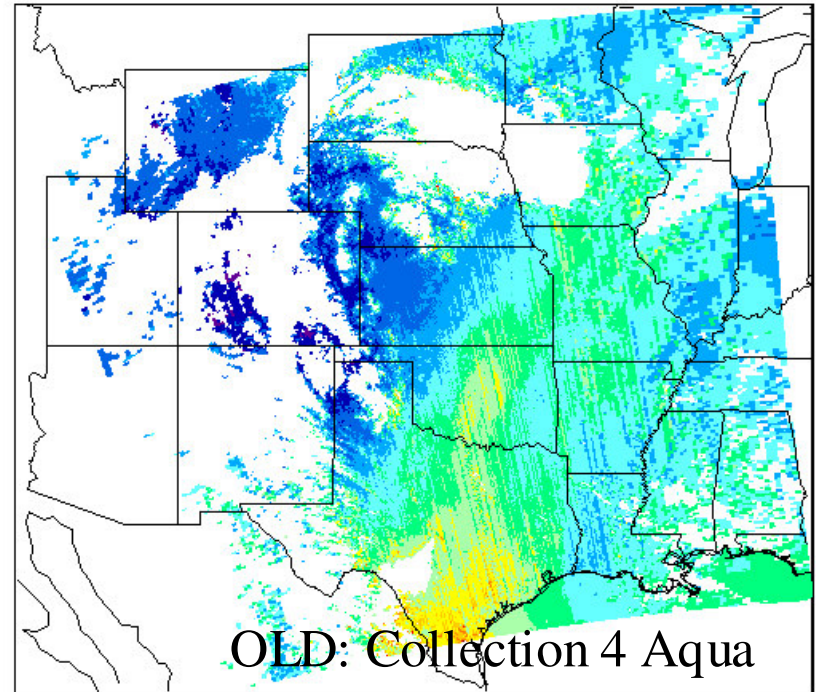
April 14, 2003: JD 104, 1940 UTC

GOES Total Precipitable Water (mm): GOES-12 14Apr03 JD 104 20 UTC



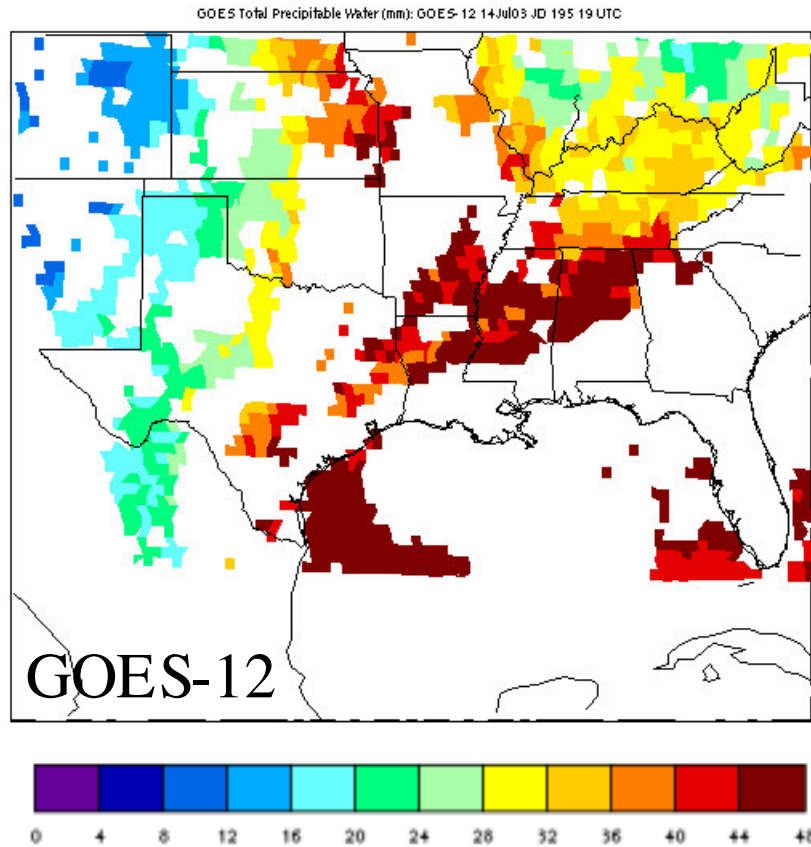
Along-track noise significantly reduced due to improved training data, surface characterization, and BT zones

Magnitude of TPW also improved throughout TX and OK

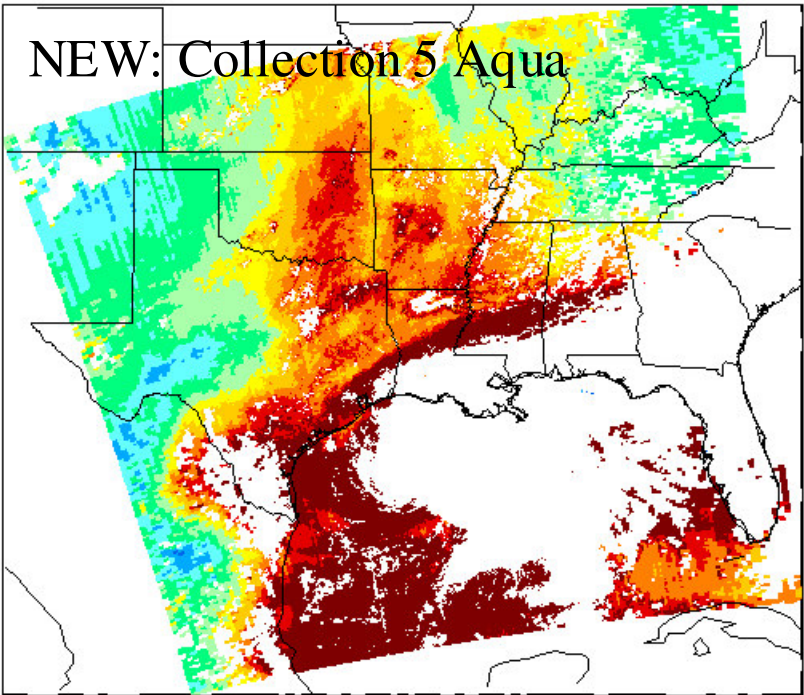
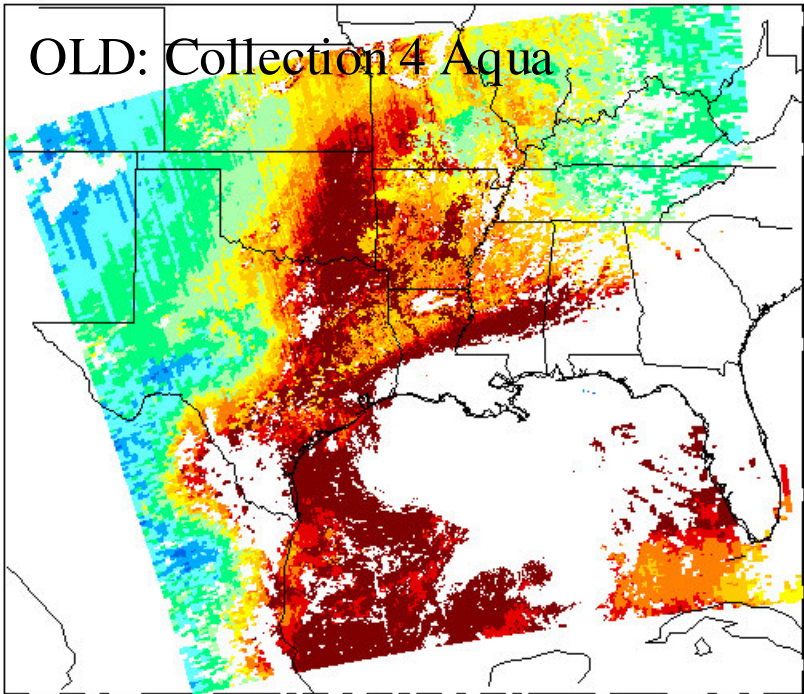




July 14, 2003: JD 195, 1920 UTC



Spotchiness throughout Arkansas and vicinity is removed due to improved regrouped BT zones

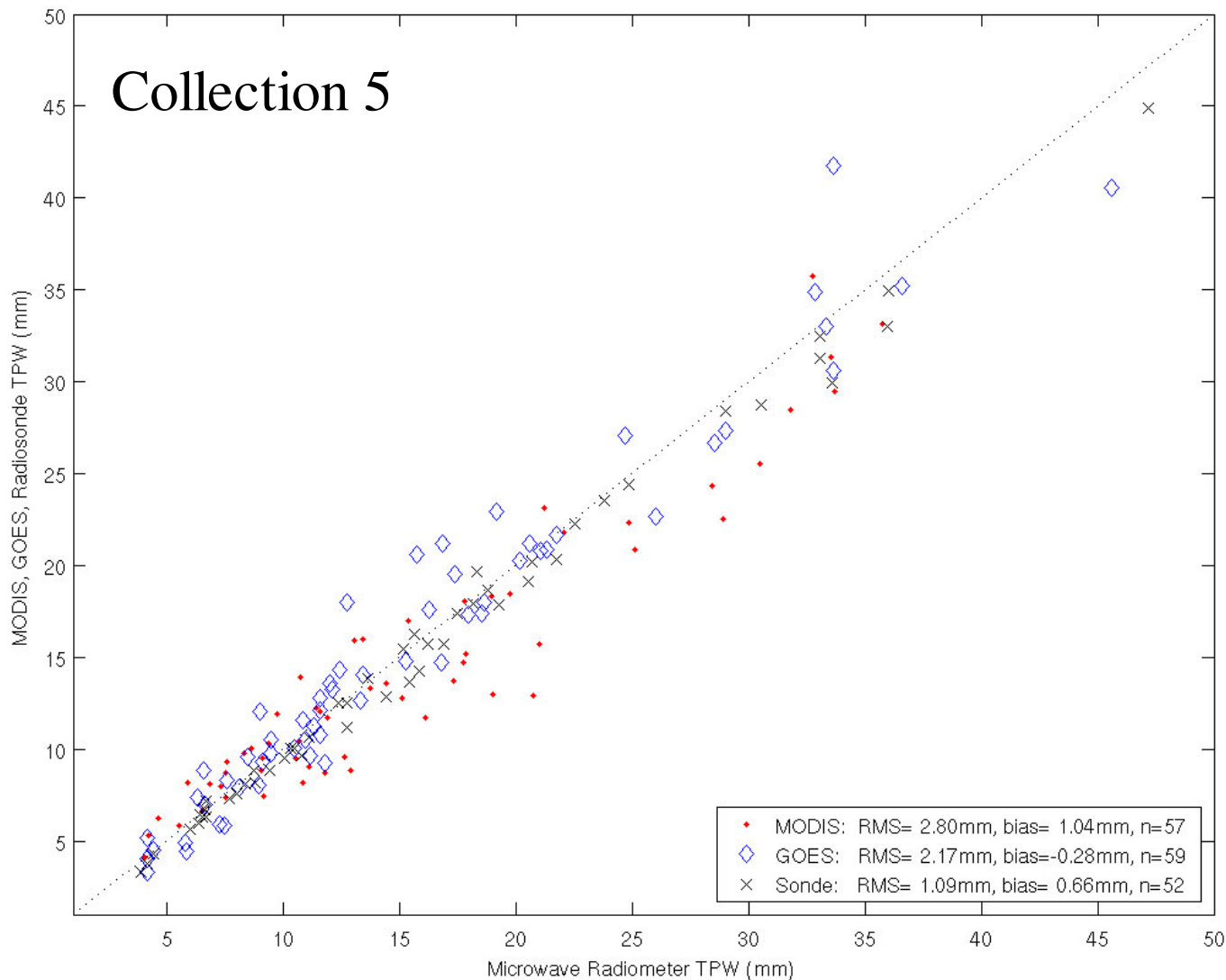






Comparison of TPW from MODIS (**red dots**), GOES-8 (**blue diamonds**), and radiosonde (**black crosses**) with the SGP ARM-CART microwave water radiometer

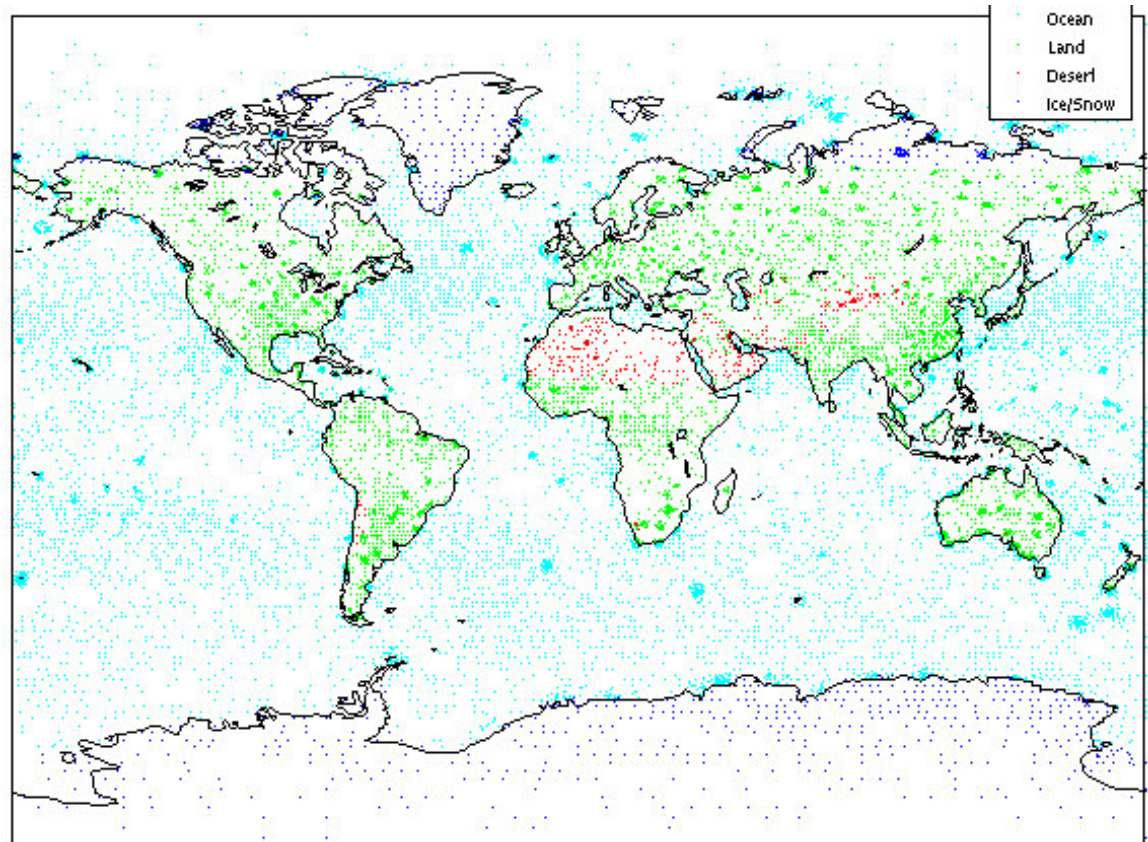
**Aqua:** 57 clear sky cases from December 2003 to October 2003



Explanation of some of the updates ...

**New Training Database of Global profiles:** 12,208 global profiles of temperature, moisture, and ozone for training data set. Profiles are from NOAA-88, ECMWF training set, TIGR-3, ozonesondes, desert radiosondes: all with saturation checks and other QC.

Profiles:	95% RH
NOAA-88b	5356
TIGR-3	1125
Desert sondes	553
Ozonesondes	992
ECMWF profiles	4182
Total	12208





## Partitioned training and retrievals into separate Land/Ocean groups

- New BT zones for land/ocean:

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 11 $\mu$ m 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

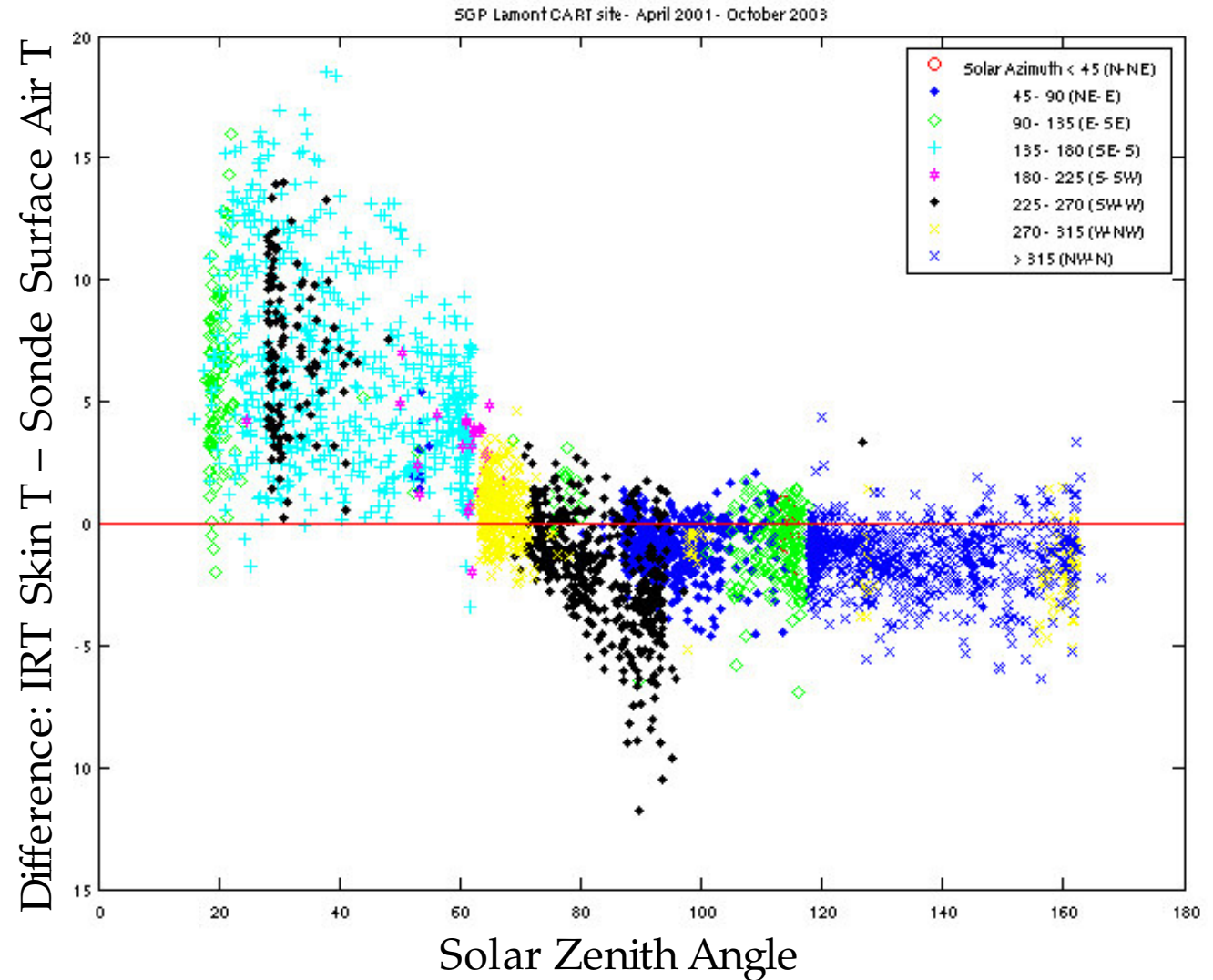
Zone 7: > 310 K

# New Skin Temperature assigned to profiles

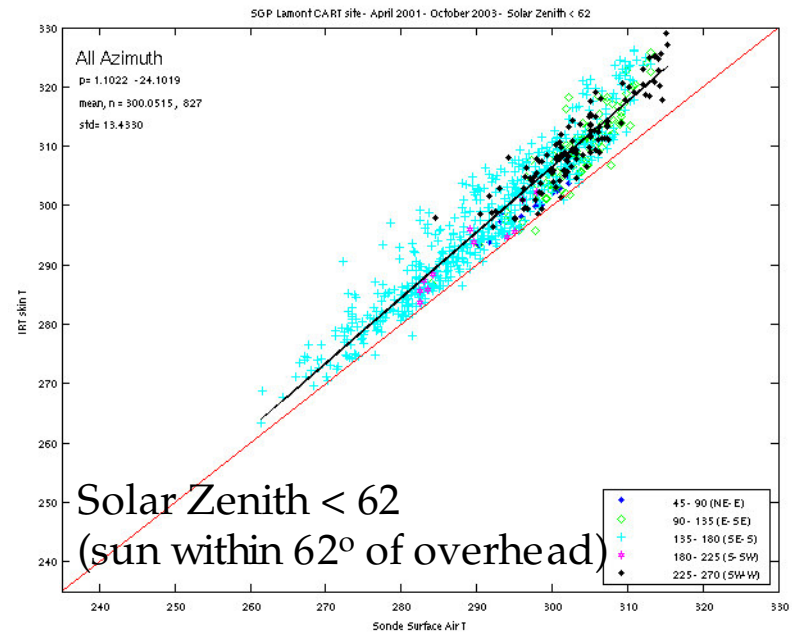
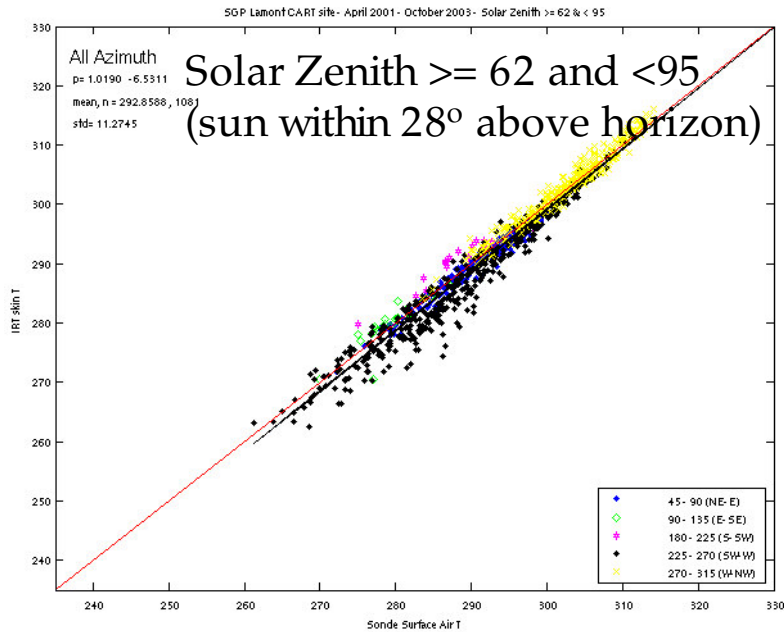
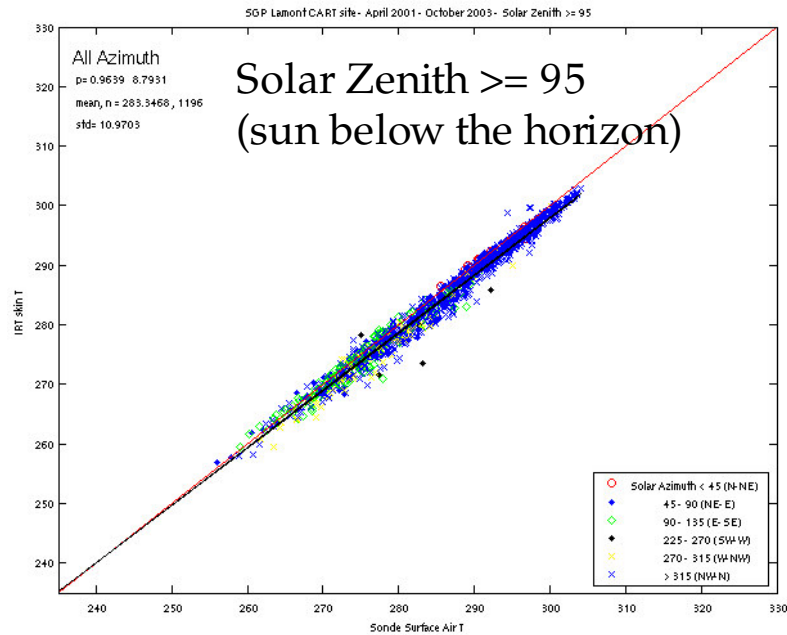


Skin T / Surface Air T relationship for the SGP CART site based on clear sky observations between April 2001 and October 2003.

Points are colored by solar azimuth category.



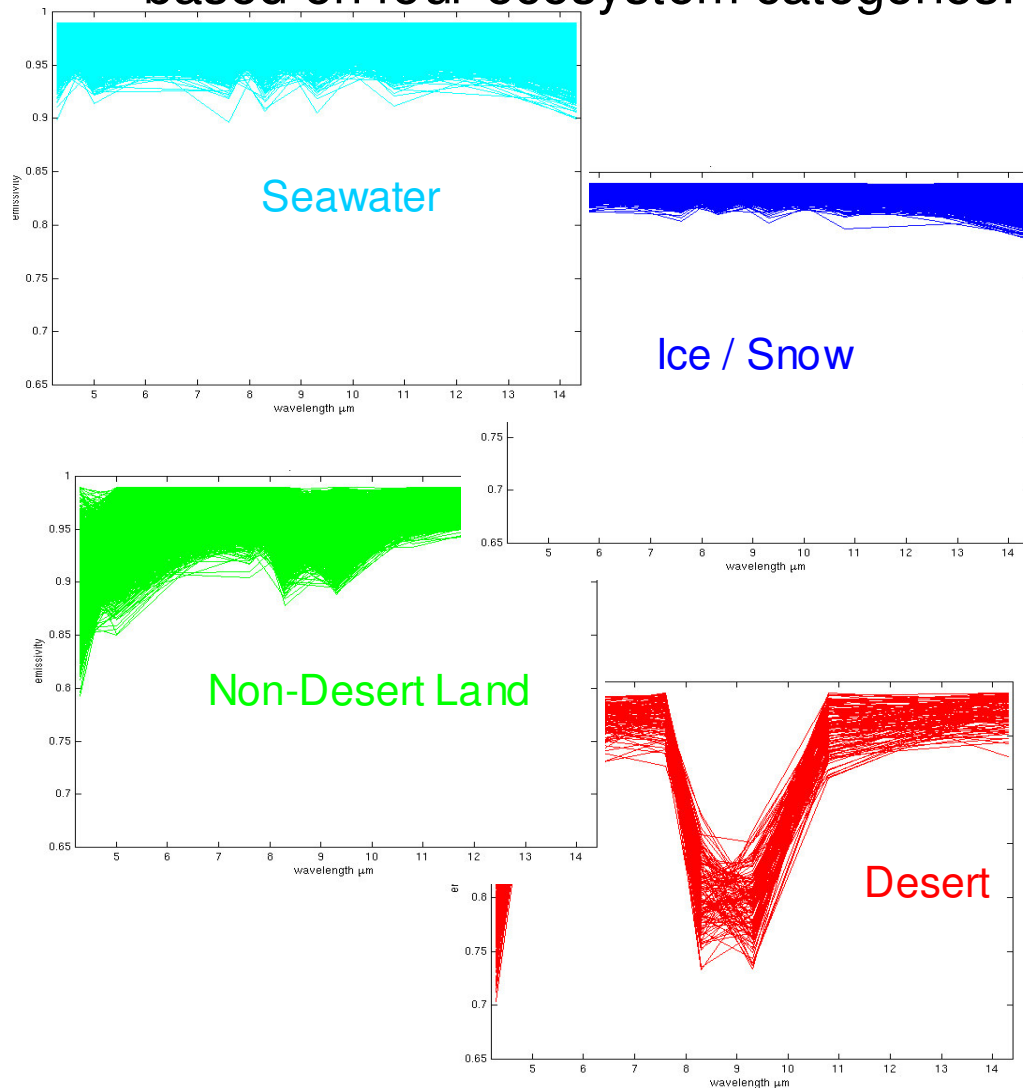
Another look at these relationships, as a function of solar zenith (3 categories) & azimuth (8 categories)





## New Surface Emissivity assigned to profiles

Old Emissivity in collection 4 was based on four ecosystem categories:

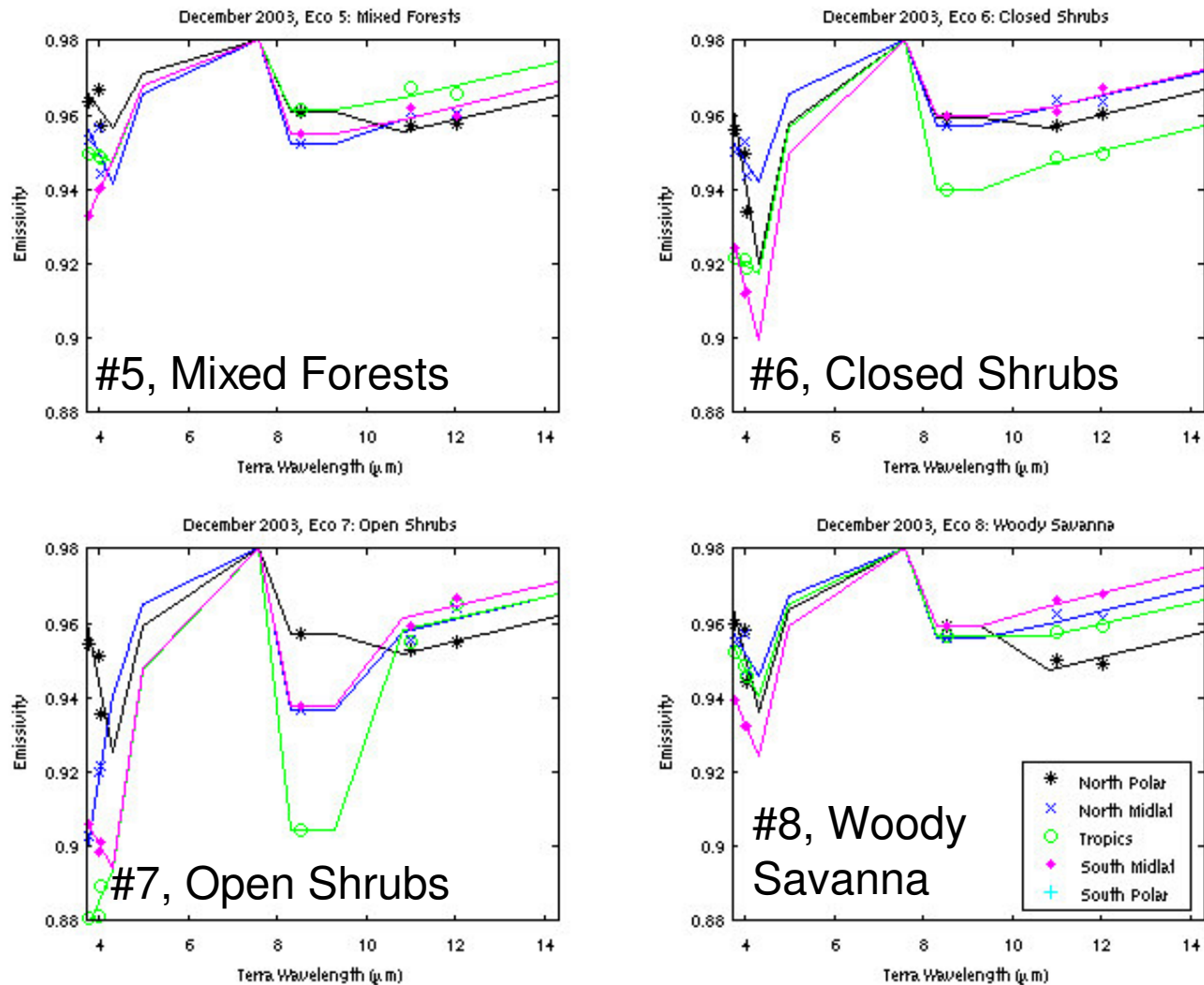


New Emissivity in collection 5 further divides the “non-desert land” category into 14 IGBP ecosystem groups, as a function of month and latitude band. New seawater, desert, and ice/snow emissivities also used.

MODIS MOD11 emissivity and laboratory measurements were used to derive these new emissivities.

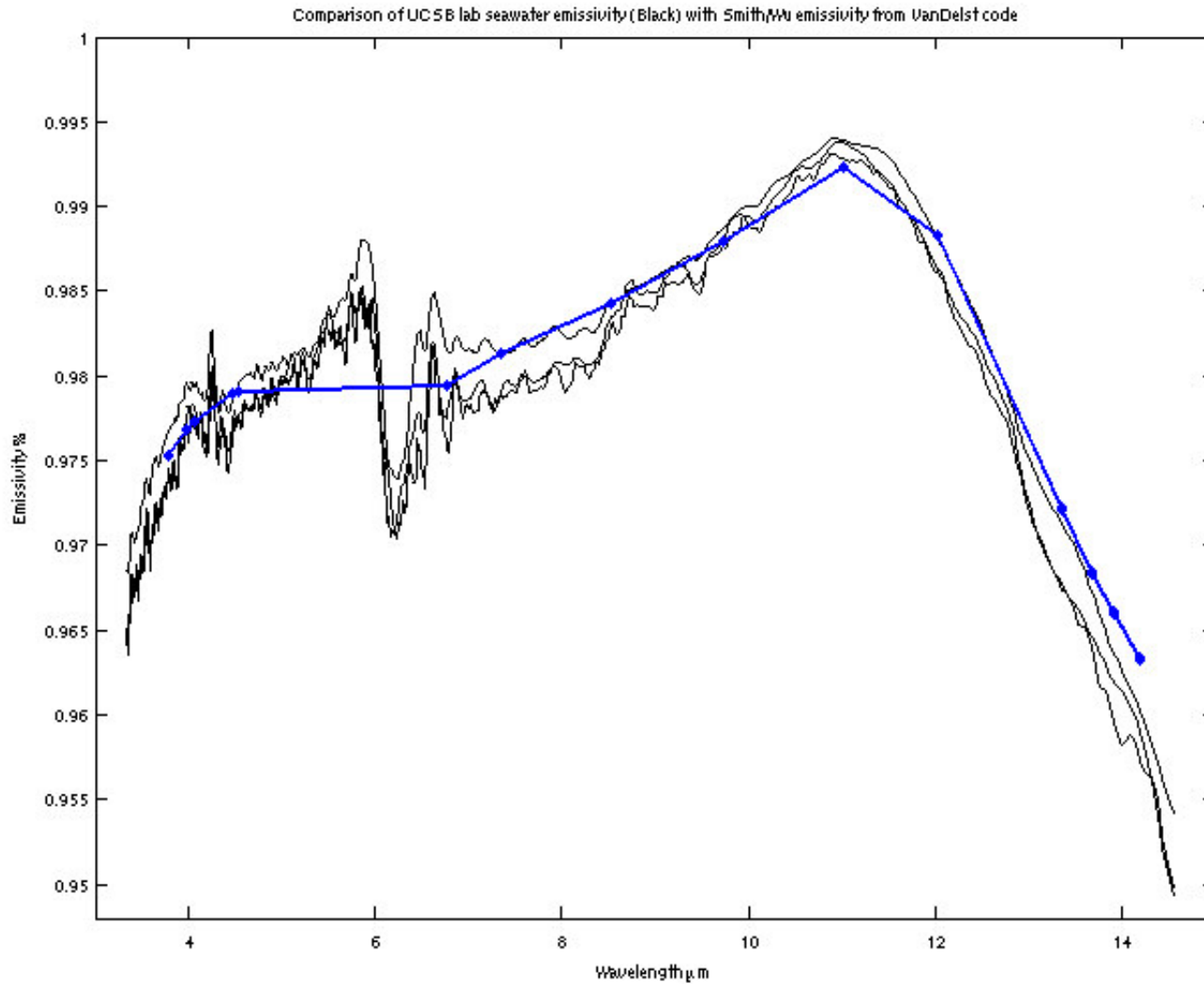
See next slides for more on new emissivity.

A few examples of the results for December 2003:  
Colored by latitude band for 4 selected ecosystems



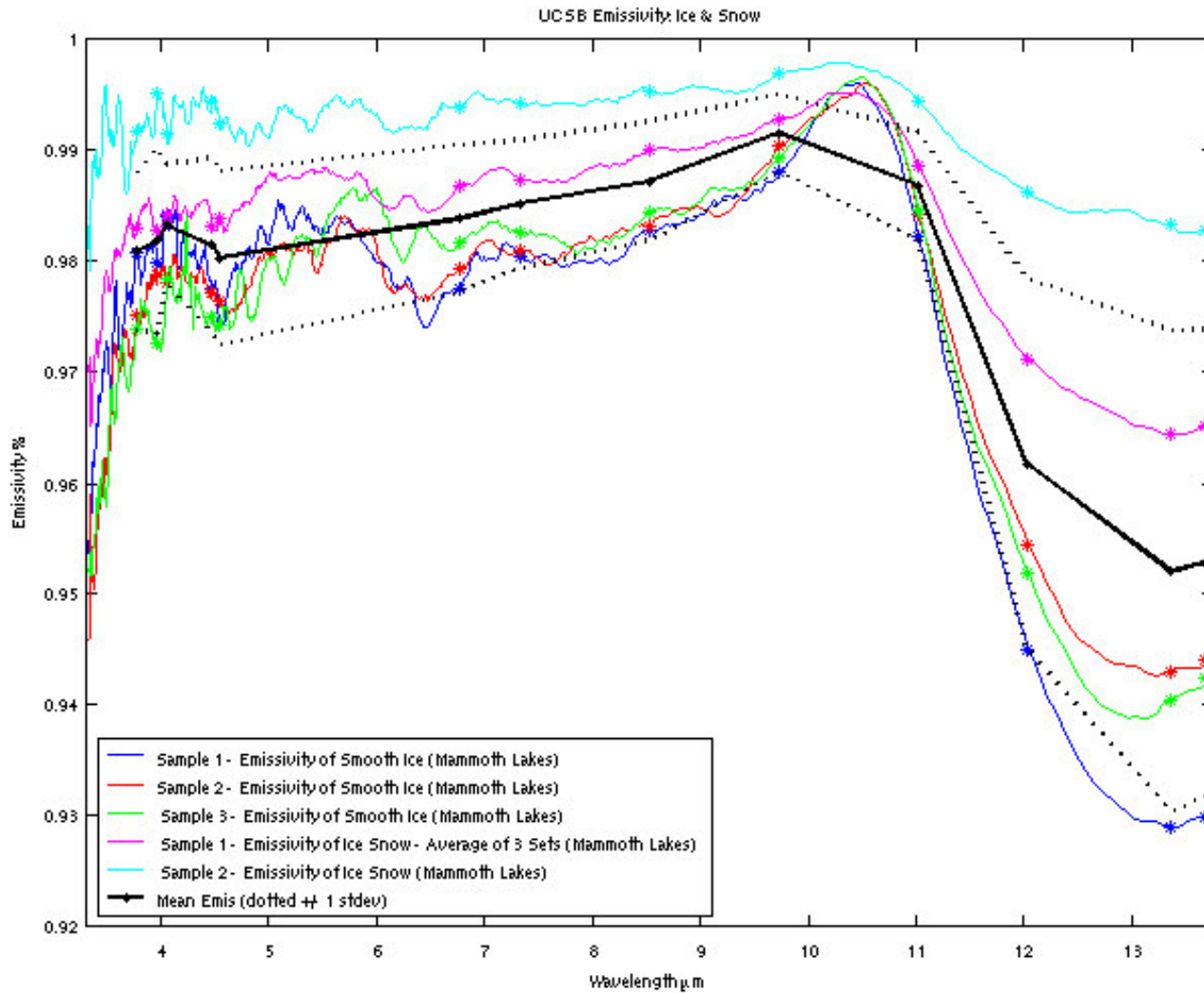
Symbols indicate MOD11 points; Lines are based on laboratory baseline fit to MOD11 points

# Ice/snow and Seawater handled somewhat differently...



Seawater emissivity is based on the Smith/Wu emissivity model, as a function of windspeed and viewing zenith angle





Ice & Snow emissivity is based on the the average of a number of ice and snow laboratory measurements from UCSB's emissivity library (Dr. Wan).

**Delivery of MOD07 Code**  
**May 13, 2004 –finalized June 2, 2004**  
**Suzanne Wetzel Seemann**

Primary changes with this delivery are updates to the training data used to create the regression coefficients, including new profiles and better characterization of the surface. Training data and retrievals are also partitioned into separate land and ocean classes now, and new BT zones are used. In addition a new L1B reader is used in order to be consistent with other UW/SSEC products and to prepare for destriping.

**I. CHANGES TO RETRIEVAL CODE**

- 1) L1B\_Reader\_V2.1\_mod07.inc, L1B\_Reader\_V2.1\_mod07.f replaced with L1B\_Reader\_V2.2.inc, L1B\_Reader\_V2.2.f to be consistent with other UW products

Some changes were made to accommodate this change:

- mod07\_data.inc: included a new variable LAST\_MODIS\_BAND that is needed for the call to the new L1B reader
- mod07\_get\_data.f: new variable v\_code and other changes for new reader

- 2) Input regression coefficients now include surface emissivity at 15 MODIS bands, instead of 7 wavelengths. This affects the filesize and record length of coefficients.

To accommodate this, changes were made in

- mod07\_open\_files.f
- modis\_ges101.f

- 3) Small change made to the routine that integrates water vapor to TPW

- tprecw\_new2.f

- 4) Training coefficients and retrievals were split into separate land and ocean groups. Then new Band 31 BT zones were used to insure enough training data in each zone after partitioning into land/ocean. New zones for land and ocean are:

land: < 272, 272-287, 287-296, > 296

ocean: < 283.5, 283.5-293, > 293

All changes for this were made in

- modis\_ges101.f

**II. CHANGES TO REGRESSION COEFFICIENTS**

New regression coefficients (reclen 1340 bytes, creation date 2004122)

- Added additional training profiles (total profiles: 12,208). New profiles were drawn from ECMWF & TIGR-3 profile databases, and CMDL ozonesondes
- Updated emissivities assigned to training profiles:
  - New global IGBP ecosystem-based emissivity assigned to land profiles
  - New emissivity assigned to seawater profiles based on Smith/Wu model
  - New snow/ice emissivity based on laboratory measurements from UCSB
- Skin temperature assigned to each profile was updated based on measured skinT/surface air T relationships, as a function of solar zenith angle and azimuth.
- Included regression-based ozone in radiosondes where ozone is not available.
- Performed a check for saturation of all profiles, and excluded those that exceed 95% RH below 250hPa.
- New forward model coefficients created with LBLRTM 7.04/UMBC profiles

**III. CHANGES TO RADIANCE BIAS CORRECTIONS**

Terra and Aqua radiance bias (obs-calc) corrections were updated based on a revised global bias calculation algorithm.