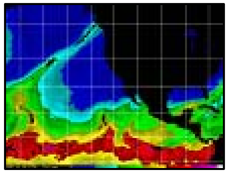

A Blended Satellite Total Precipitable Water Product for Operational Forecasting: History, Method, Future

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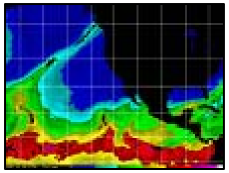
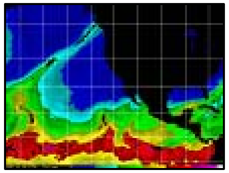
Cooperative Institute for Research in the Atmosphere

Colorado State University



History

- Began with a 1998 grant to CIRA to use AMSU data for "Advanced Applications Products" which included
  - Tropical storm products
    - ✓ Kidder, S. Q., M. D. Goldberg, R. M. Zehr, M. DeMaria, J. F. W. Purdom, C. S. Velden, N. C. Grody, and S. J. Kusselson, 2000: Satellite analysis of tropical cyclones using the Advanced Microwave Sounding Unit (AMSU). *Bulletin of the American Meteorological Society*, **81**, 1241-1259.
    - ✓ Knaff, J. A., R. M. Zehr, M. D. Goldberg, and S. Q. Kidder, 2000: An example of temperature structure differences in two cyclone systems derived from the Advanced Microwave Sounding Unit. *Weather and Forecasting*, **15**, 476-483.

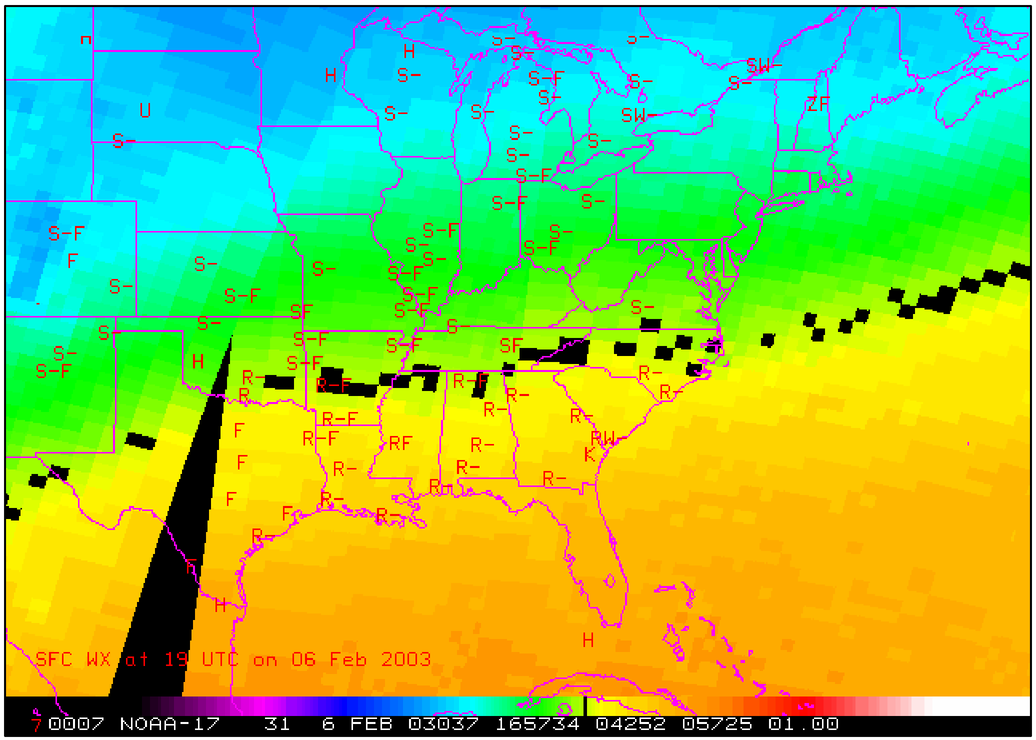


History

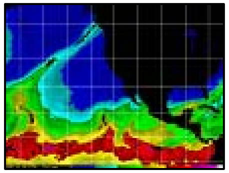
- Precipitation, moisture and flooding products
  - ✓ Kidder, S. Q., S. J. Kusselson, J. A. Knaff, R. R. Ferraro, R. J. Kuligowski, and M. Turk, 2005: The Tropical Rainfall Potential (TRaP) Technique. Part 1: Description and Examples. *Weather and Forecasting*, **20**, 456-464.
  - ✓ Ferraro, R., P. Pellegrino, M. Turk, W. Chen, S. Qiu, R. Kuligowski, S. Kusselson, A. Irving, S. Kidder, and J. Knaff, 2005:. The Tropical Rainfall Potential (TRaP) Technique. Part 2: Validation. *Weather and Forecasting*, **20**, 465-475.

History

- ➢ Synoptic and mesoscale analysis
  - ✓ http://amsu.cira.colostate.edu



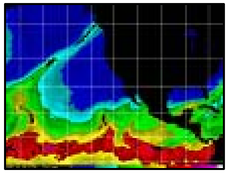
1000-500 mb Thickness



History

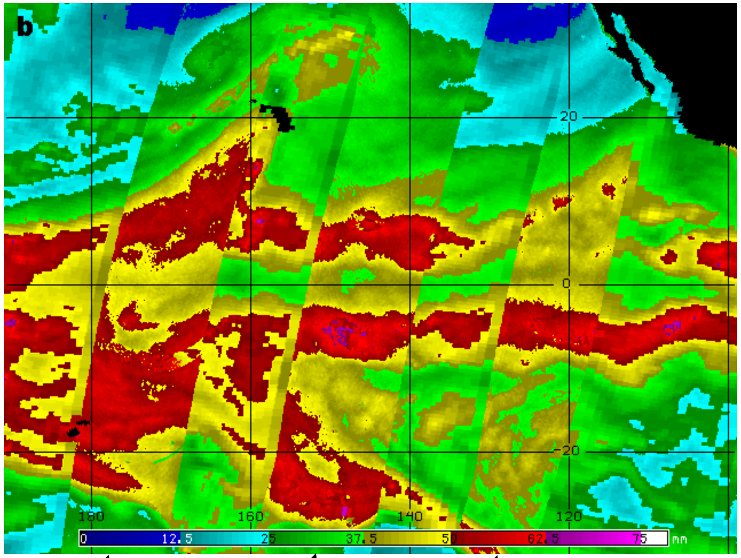
- Data fusion products
  - ✓ Kidder, S. Q., and A. S. Jones, 2007: A Blended Satellite Total Precipitable Water Product for Operational Forecasting. *Journal of Atmospheric and Oceanic Technology*, **24**, 74–81.
  - ✓ Jones, A. S., and T. H. Vonder Haar, 2002: A dynamic parallel data-computing environment for cross-sensor satellite data merger and scientific analysis. *Journal of Atmospheric and Oceanic Technology*, **19**, 1307-1317.

The Problem



- If one tries to blend (or fuse) data from different satellite sensors (and especially data retrieved by different methods) one needs to take differences into account.

Total Precipitable Water

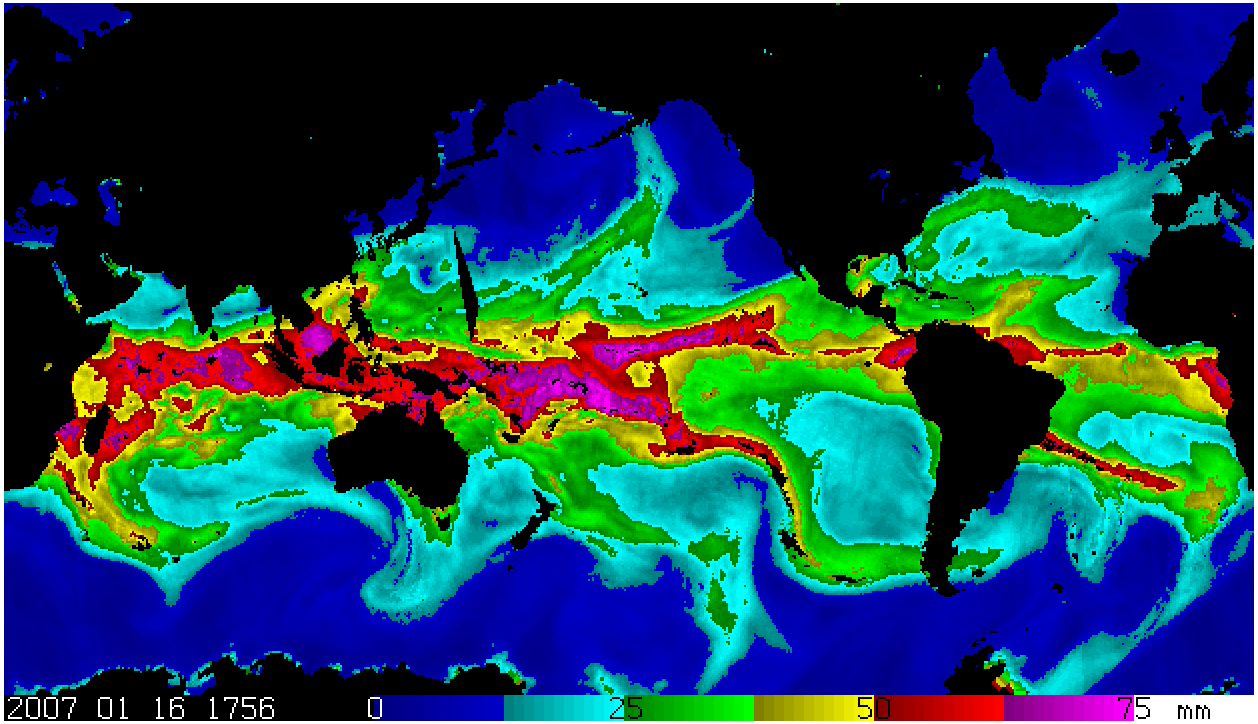


SSM/I swaths on top of AMSU

SSM/I TPW seems to be greater than AMSU TPW, and the "overlaid" product has artifacts which tend to confuse the analyst.

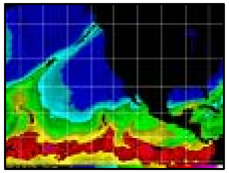
Method

- ❑ First, find something that is constant, i.e., that each sensor views.



Global TPW Distribution

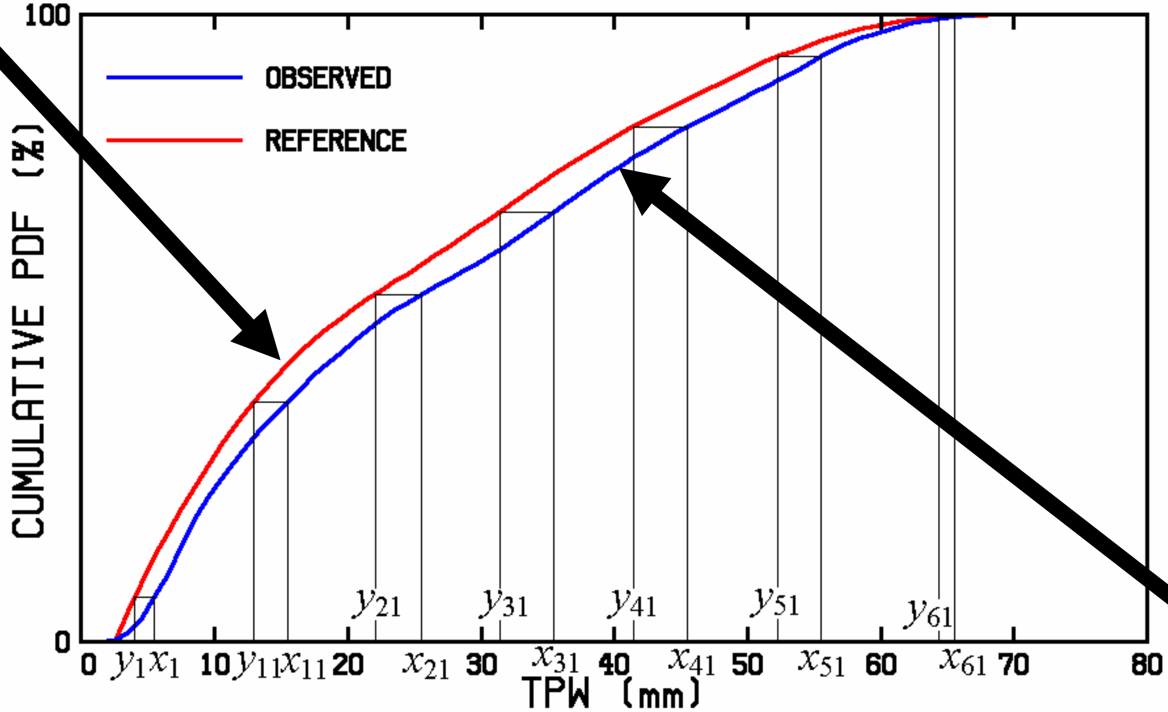
Method



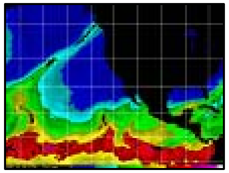
- Histogram Matching
  - Form cumulative probability distribution function of the observations for each sensor. (We chose 5-day PDFs.)
  - Select a reference sensor. (We chose the average of NOAA 17 TPW for scan positions 6−25.)
  - “Match” the PDFs.

Method

NOAA 17, Scan positions 6-25, for the 5-day period ending 2215 UTC 29 March 2006 (~20 x 30,000 = 600,000 observations)

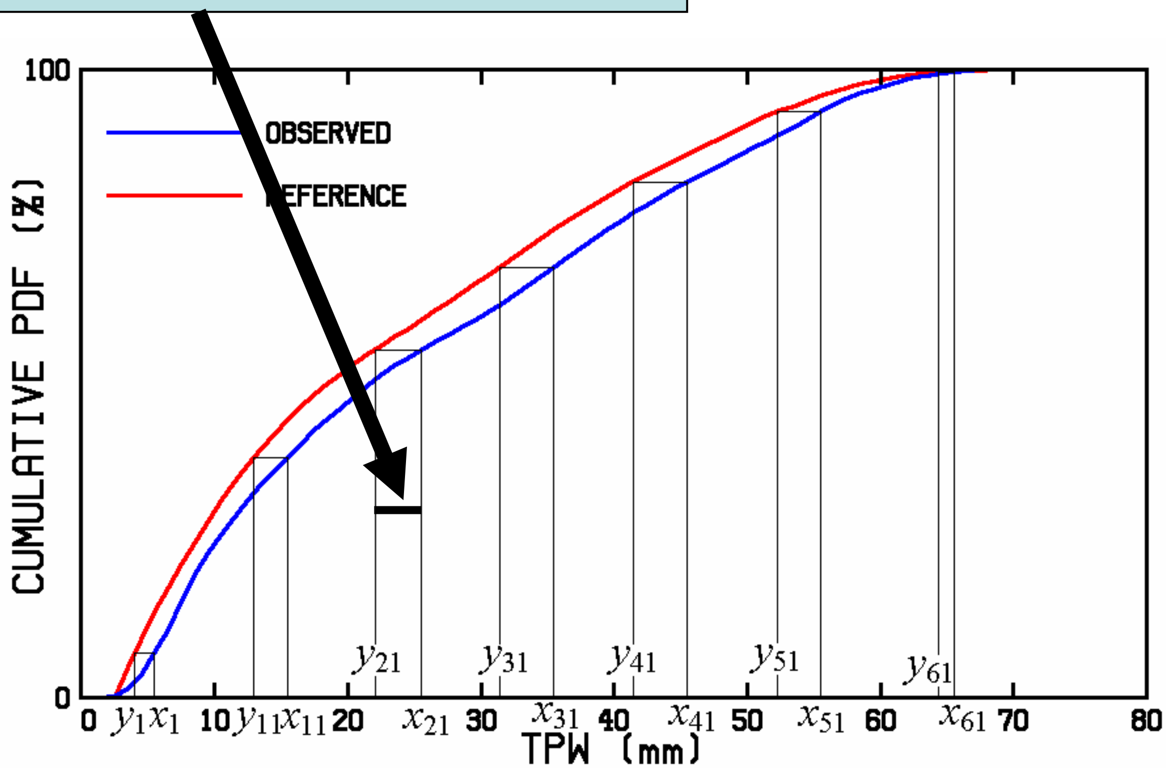


DMSP F14, scan position 32, for same time period (~50,000 observations)

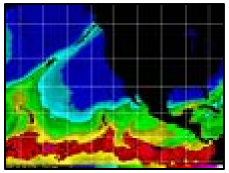


Method

Width of "bars" indicates magnitude of adjustment needed

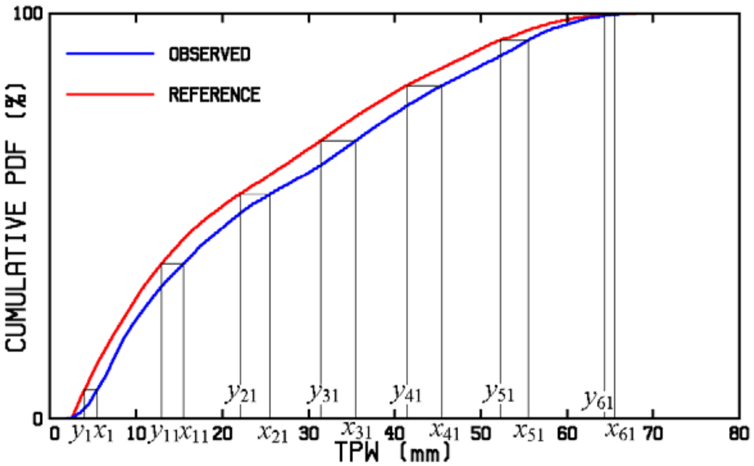


In general, SSM/I is wetter than AMSU, particularly in the middle of the TPW range.



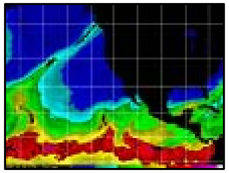
How to Adjust

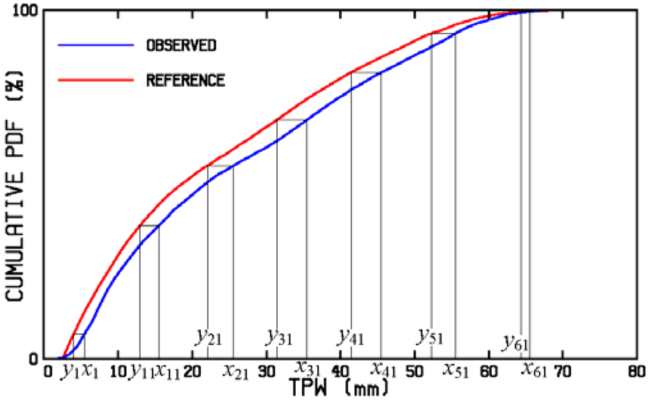
1. Debiasing:
   - ✓ *y = x − bias*
   - ✓ Shifts the PDF line left/right.
   - ✓ Works well when "bars" are of uniform width



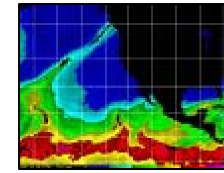
How to Adjust

2. Linear adjustment:
   - ✓ $y = ax + b$
   - ✓ Shifts PDF left/right and changes its slope
   - ✓ For normal distributions, corrects both mean and variance.
   - ✓ Works well when “bars” are monotonically increasing/decreasing in width.





Method

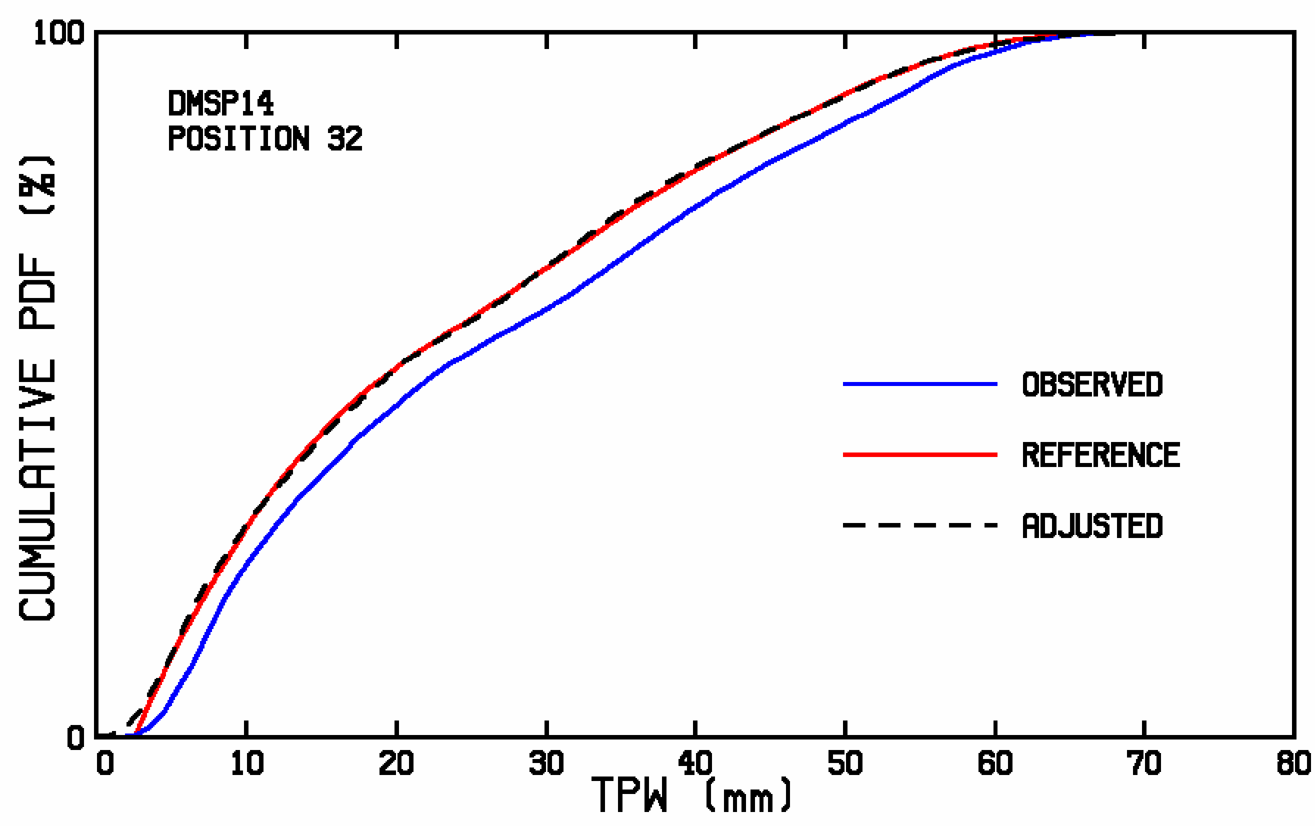


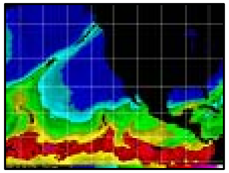
3. Our method:

- ✓ $y = a_0 + a_1x + a_2x^2 + a_3x^3$
- ✓ If distributions were “normal,” could correct for mean, variance, skewness, kurtosis.
- ✓ 1128 coefficients stored for use in the blending algorithm [4 x (3 SSM/I x 64 scan positions + 3 AMSU x 30 scan positions)]
- ✓ Coefficients retrieved for 6 < TPW < 69 mm, but applied everywhere
- ✓ Values clipped for adjusted TPW < 0 or > 75 mm

Result of Adjustment

Good agreement between adjusted and reference PDFs

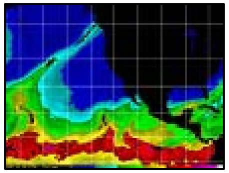




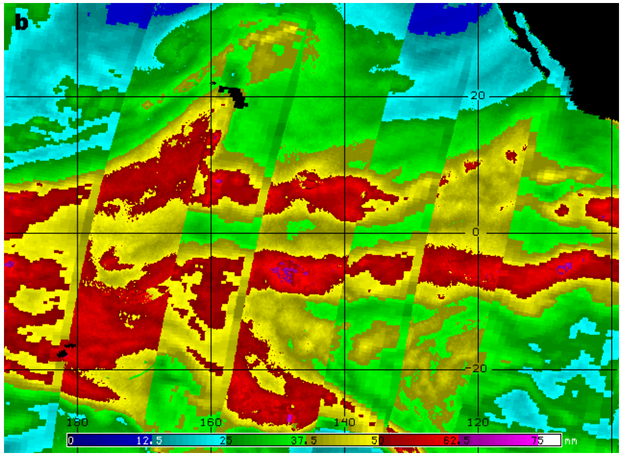
Notes

- The adjusted TPW values are not necessarily more accurate, but the differences with the reference are dramatically reduced for all instruments,
- This is a blending algorithm, not a retrieval algorithm.

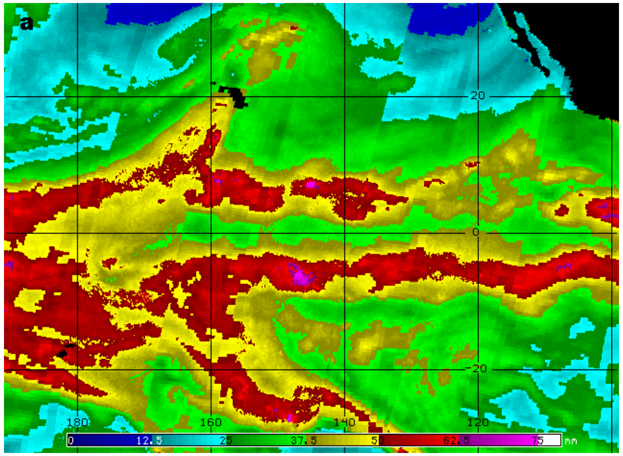
Improved Product



- Composited data from disparate instruments appear to be from the same instrument—artifacts are reduced



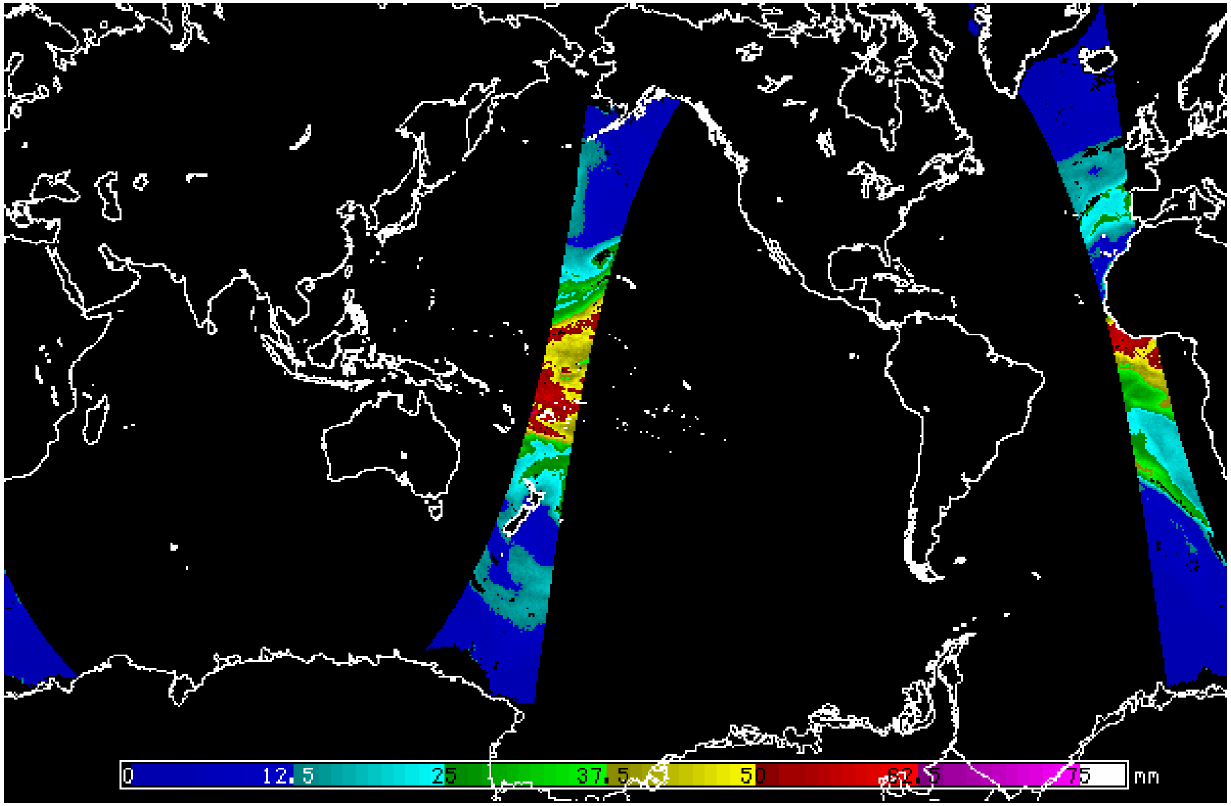
Overlaid without blending



Blended

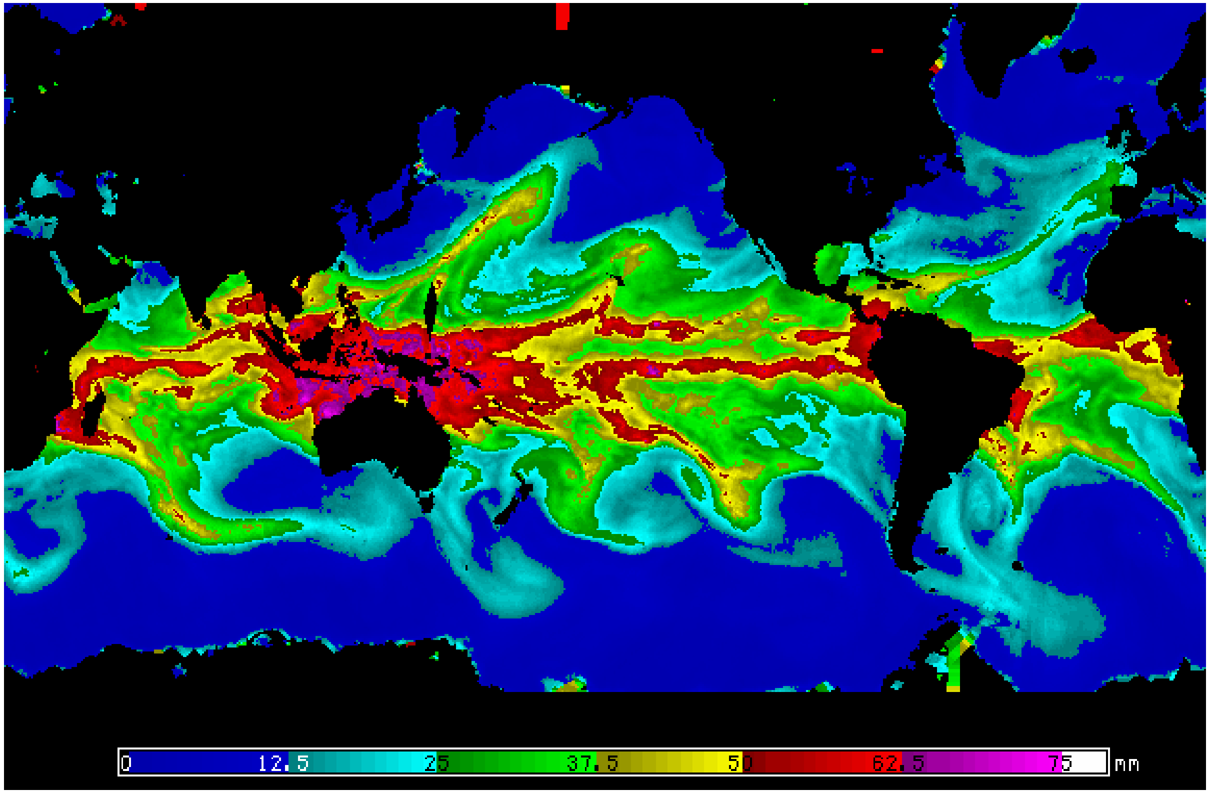
File Processing

- Each orbital file is adjusted and mapped.



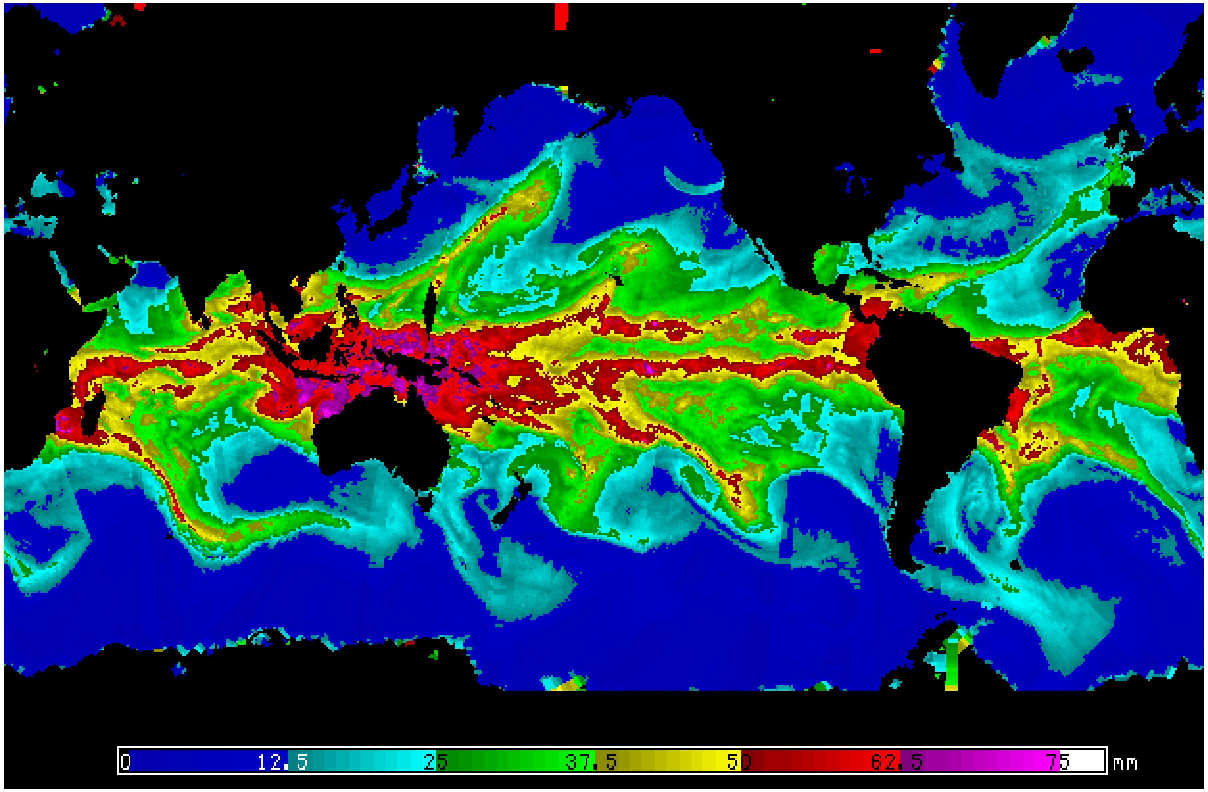
Compositing

- Mapped files are composited in one of two ways.
  - Averaged product



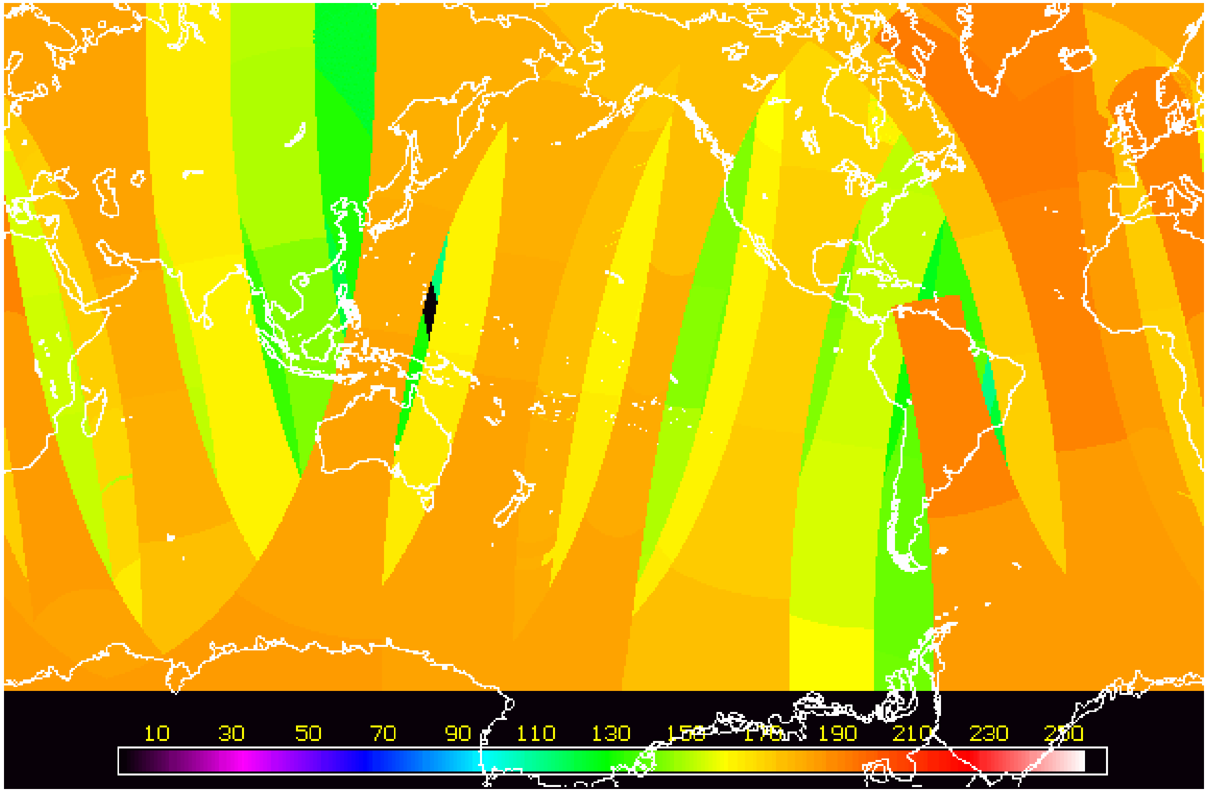
Method

- Overlaid product (newer data replace older data)—less smooth but “faster” than averaged product



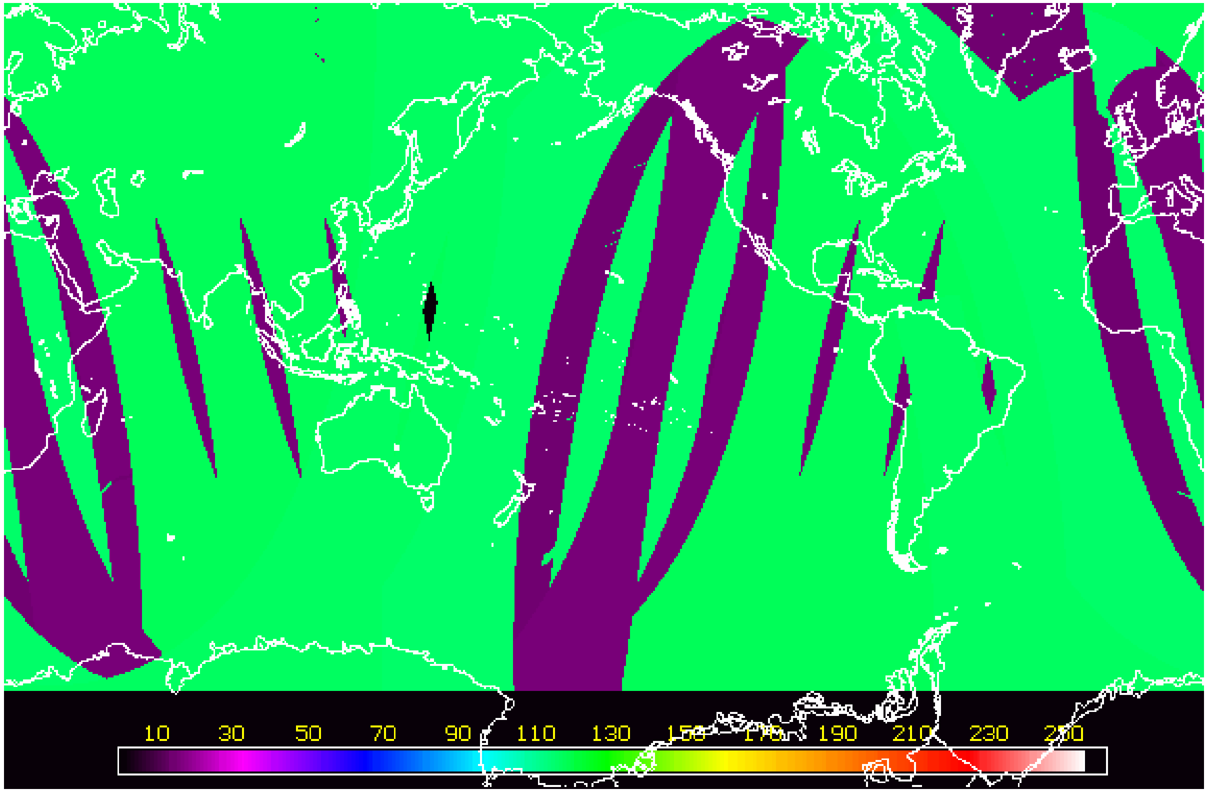
Method

- Can also composite time of satellite observation

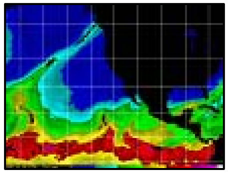


Method

- Also can note which satellite made the observation



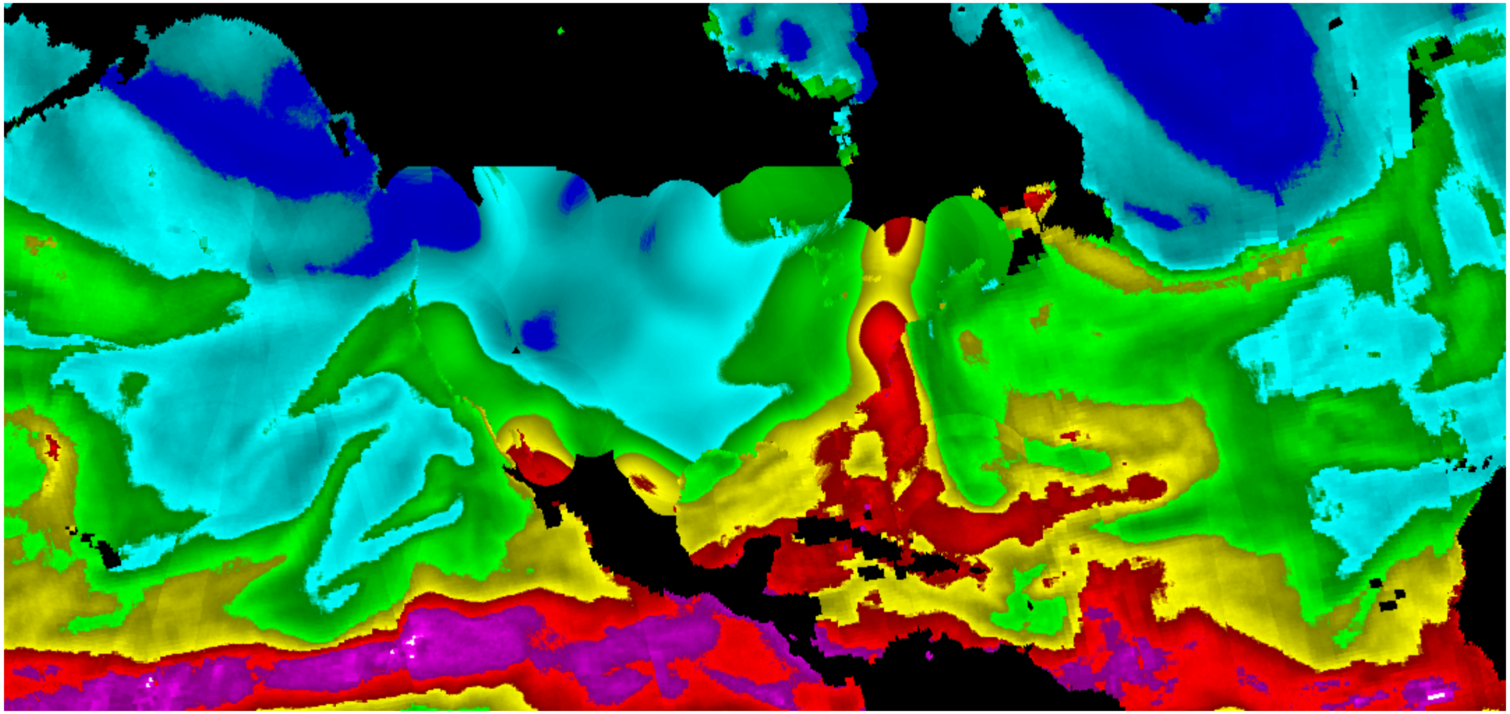
Current Status



- Runs in real time at CIRA and at the new FB4.
  - http://amsu.cira.colostate.edu/TPW
- OSDPD has plans to port DPEAS code to OSDPD IBM.

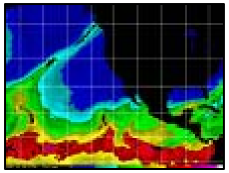
Current/Future

- John Forsythe filled the hole over the U.S. with GPS TPW:



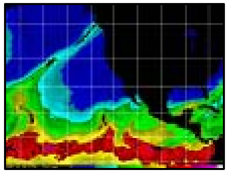
- Hopefully the GPS data will reappear at GSD.

Current/Future



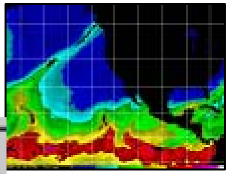
- John’s Web site
  - http://amsu.cira.colostate.edu/GPSTPW
  - Replaced GPS TPW data with GOES Sounder TPW
  - Used NVAP “normal's” to form a “Percent of Normal” product, which is in demand by forecasters

Current/Future



- CIRA One-Dimensional variational Optimal Estimator (C1DOE)
  - Retrieves moisture profiles from AMSU-B data
  - Initial validation over ocean complete
  - Experiments over land continuing
  - Can be run in real-time

November 6, 2006
“Atmospheric River” (Pacific NW Floods)

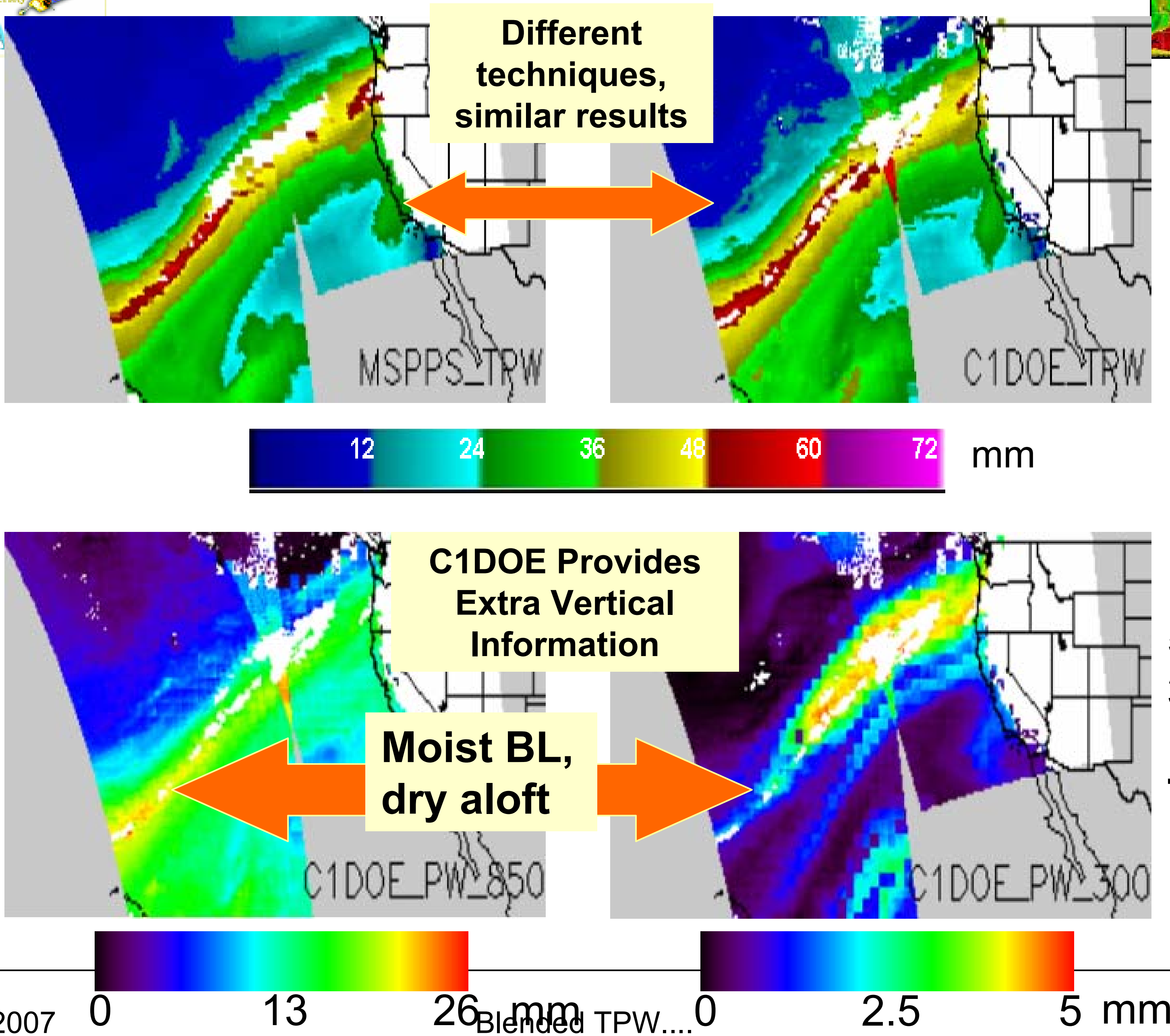


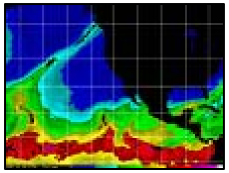
MSPPS TPW

C1DOE TPW

1000 – 850 hPa Layer TPW

500 – 300 hPa Layer TPW

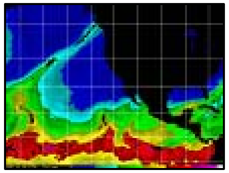




Future

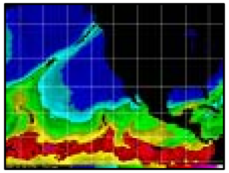
- Produce more/better blended products
  - Rain rate
  - Ocean surface winds
  - Layer precipitable water
- Improve TPW normals to produce better anomaly products

Future



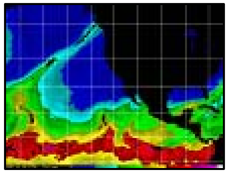
- Improve C1DOE retrievals
  - Employ Andy Jones' surface emissivities over land
  - Refine covariance matrices
  - Utilize cross-sensor data, e.g. GOES IR or WV
  - Validate with GPS TPW and/or COSMIC
  - Collaborate with MIRS group
    - ✓ CRTM validation
    - ✓ Common case studies / Science Data Stewardship

Future

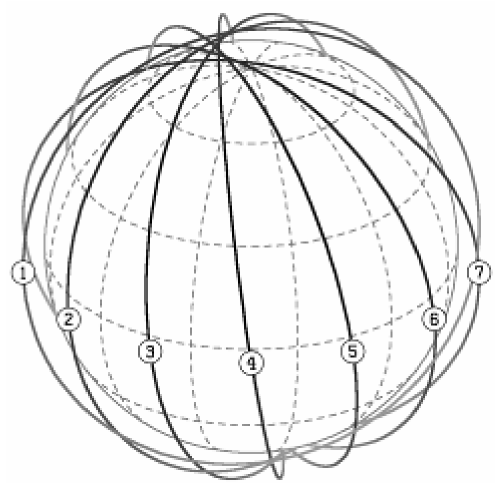


- Prepare for NPOESS and GOES-R
  - Develop blended products using Meteosat Second Generation data
  - Use SSM/IS and NPP data when available
  - Develop cross-sensor, cross-platform blended products
  - Utilize blending techniques for vicarious calibration of NPOESS/GOES-R products

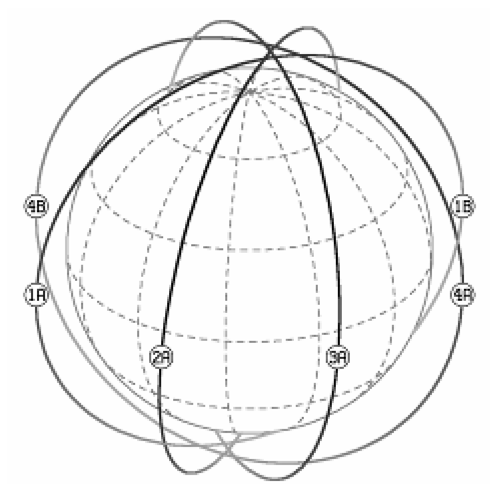
Time for a Constellation?



- So, let's think really big
- 8 to 14 satellites in a constellation could give hourly coverage of the entire earth.
- Blended products from a constellation would significantly advance our ability to forecast the weather.
- And they would solve a lot of the development problems associated with NPOESS.



Sun Synchronous



Not Sun Synchronous