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Improved GOES Water Vapor Products over CONUS – Planning for GOES-R

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Introduction: **The investigation of the Geostationary Operational Environmental Satellite (GOES)-12 total precipitable water (TPW) product data and the coinciding Global Positioning System (GPS) TPW record for the past year and a half has revealed that the moist bias in GOES-12, sounder-derived products remains similar to that from other GOES satellites and is consistent over time. The compelling question for us at Earth System Research Laboratory (ESRL) is just how can we best use the GPS asynoptic data to improve the satellite operational products? If we improve the current GOES product data, will we be better able to produce a GOES-R product? The result is work summarized by this paper, in which we establish a means to characterize the current GOES error based on past data and apply the correction in real time to new product data; furthermore, we examine the characteristics of proxy GOES-R advanced baseline imager (ABI) data derived from current moderate resolution imaging spectroradiometer (MODIS) polar orbiter data and assess its performance.**

Examine Data

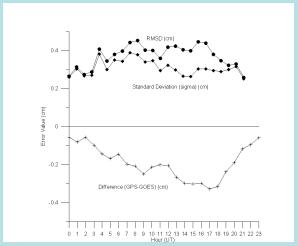


Figure 1. Shows the asynoptic variability of GOES moisture product data when differenced against GPS TPW data at collocated sites during IHOP 2002. The result showed a high periodicity with the best agreement at synoptic times. GOES-12 and GOES-10 data archived up until January 2007 demonstrate the same structure when compared to GPS data.

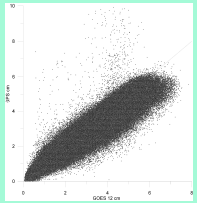


Figure 2. shows the scatterplot of roughly 1.8 million GPS GOES-12-derived, total moisture comparisons for approximately 1.5 years, ending January 2007. A 1:1 line is plotted from 0.0 to 8.0 cm. This exhibits a GOES moist bias similar to what we observed during IHOP 2002; as moisture amount increases, the GOES bias increases. We refer to this as the rooster tail effect since the moist bias appears to curve toward a greater bias at higher moisture levels. The above plot is for all times of day and is a sum total of all observations. Even with these remaining in the data set; they are still dwarfed in number by the huge volume of points plotted near the 1:1 diagonal.

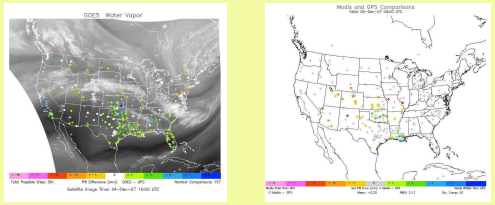


Figure 3. Contrasts CONUS images of current GOES (both 12 [east] and 11 [west] 16UTC 7 December 2007 in 3(a) left, and synthetic ABI data at 09UTC 7 December 2007 in 3(b), right. In 3a the GOES imagery channel 3 (6.7 micron) data is displayed beneath the plotted information. In both images, white 3(a) or gray 3(b), diamonds are most favorable as they show minimal differences between GPS data and the satellite-computed TPW.

Characterize GOES Error

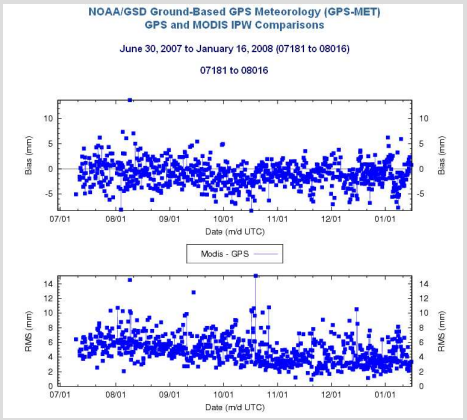


Figure 4. 3 Plots bias (ABI-GPS) mm above and root mean square (RMS) of the difference data below. What is labeled as MODIS is in fact proxy ABI data. The trend seen in the ABI data was **initially near zero bias,** but when moving into a drier season, the ABI product appears to become **dry biased**. Overall **RMS statistics decrease** as the season moves to the dry time of year. No removal of outliers was performed on these plots. The handful of high RMS values (greater than 10 mm) can likely be ignored.

The following simple correction algorithm was devised to match the conventional GOES product TPW to GPS TPW.

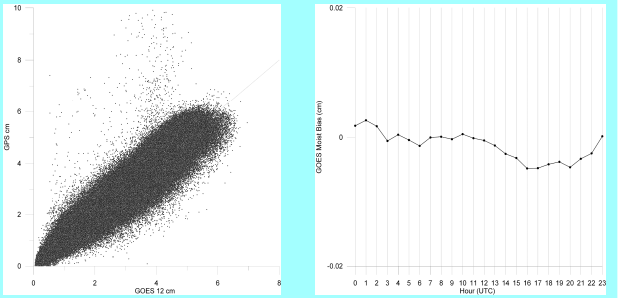
$$G_c = aG^b$$

The coefficients (*a* and *b*) in the above equation were derived my minimizing the functional below that differences all GPS and GOES data.

$$J = \sum_{i=1}^{N} (G_{ci} - GPS_i)^2$$

Assess Correction

Figure 5. Plots of corrected GOES-12 data using the correction algorithm devised in the prior frame. Left is the scatterplot of the same data in Figure 1. Right is a plot of the data differences (bias) for all time periods. Note that the bias has been reduced to values very near 0.0 cm.



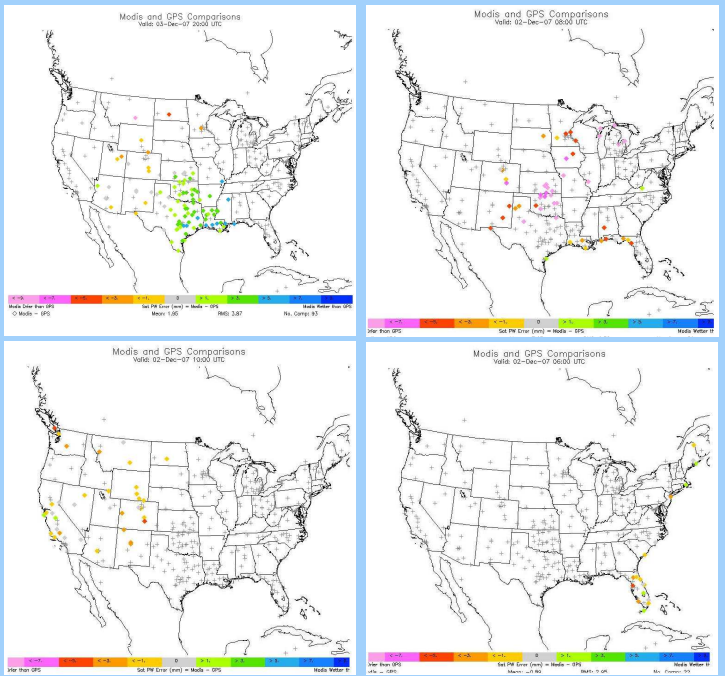


Figure 6. Several images of successive ABI-simulated data compared with GPS. The current ABI-simulated product data currently look very good overall in contrast to current GOES. If things continue on track, GOES-R data products may require little or no correction. However, if corrections are needed, the algorithm devised for the current GOES will likely work well.