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VALIDATION OF GOES-8/11 SOUNDER DERIVED PRODUCTS DURING IHOP 2002 FIELD EXPERIMENT

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1. INTRODUCTION

The International H2O Project (IHOP) was conducted in the Southern Great Plains (SGP) region of the United States from 13 May – 25 June 2002. Two of the primary goals for the program were to measure water vapor variability at high temporal/spatial resolution and to study the mechanisms for convective initiation.

In anticipation of the IHOP research program, precipitable water and stability indices were derived from the Geostationary Operational Environmental Satellite (GOES) sounders at Single Field of View (SFOV) (approximately 10 km^2) spatial resolution every hour at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) within the University of Wisconsin - Madison. In addition, GOES-11 was activated by the National Environmental Satellite and Data Information Service (NESDIS) for part of the IHOP campaign, improving the sounder time resolution to 30 minutes and providing a more vertical scanning position over the IHOP domain (Figure 1).

Microwave radiometer and radiosonde data from the IHOP and Department of Energy Atmospheric Radiation Measurement (DOE ARM) (Stokes et al. 1994) programs were used to provide preliminary validation of GOES 8/11 total precipitable water (TPW) sounder derived products (Menzel et al 1998). A preliminary comparison of coarser spatial resolution 3x3 FOV TPW to the SFOV TPW products for both GOES-8 and GOES-11 was conducted to quantitatively demonstrate the accuracy and utility of the relatively higher spatial resolution data.

2. GOES MOISTURE PRODUCT VALIDATION

The DOE ARM SGP site offers TPW measurements that allow for more precise validation of satellite derived retrievals than is possible with radiosondes. An operational microwave radiometer (MWR), located at the SGP central facility near Lamont, OK has demonstrated an accuracy of 0.7 mm under clear sky conditions (Liljegren 1995). All comparisons reported here are for clear sky cases. The MWR is tuned to the microwave emissions of the water vapor molecules in the atmosphere (Liljegren 1994) and measures TPW vapor every five minutes. The MWR measurements are completely independent of those from the GOES Sounder or radiosondes. These high temporal resolution MWR measurements enable validation of the GOES retrievals at times other than the conventional radiosonde launches (00 and 12 UTC). Of course, the MWR and GOES retrievals still differ in that one is a point measurement (although with an improved accuracy compared to radiosondes) and one a volumetric measurement.

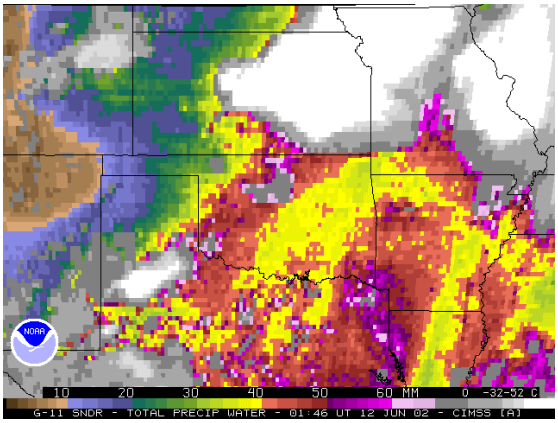

Figure 1: GOES-11 derive total precipitable water (TPW) during the IHOP field campaign at 0146 UTC on 12 June 2002.

TPW values computed from GOES-8 and GOES-11 retrievals (Ma et al. 1999) were compared to the MWR TPW during the IHOP field program from 13 May – 25 June 2002. Until recently, the satellite retrieval algorithm at CIMSS used a 3x3 FOV matrix of radiances (equating to a 36 km x 45 km box). Thus, the 3x3 retrievals represented a volumetric profile over a larger horizontal area than the MWR (which represents the atmosphere directly above the instrument). An example of a previous 3x3 GOES-8 retrieval comparison to MWR data is indicated in Fig. 2 (Schmit et al. 2002). While the first guess (diamonds), which was interpolated from 6-hourly

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forecasts, is relatively flat throughout the period, the GOES retrieval algorithm (plus signs) produces nearly the same water vapor tendency patterns as measured by the MWR (dashed line). During the IHOP field experiment, GOES satellite sounder radiances were used to produce SFOV retrievals to increase the horizontal resolution offered by GOES retrievals.

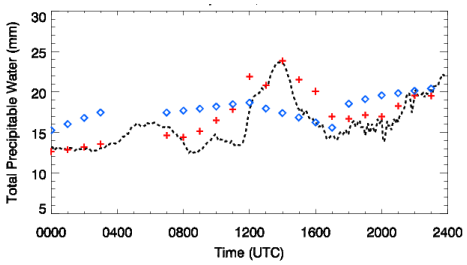

Figure 2: Microwave radiometer (dashed line), Eta model forecast (diamond symbols), and GOES-8 physical retrieval (plus symbols) total precipitable water vapor comparisons near Lamont, Oklahoma on 12 April 1998.

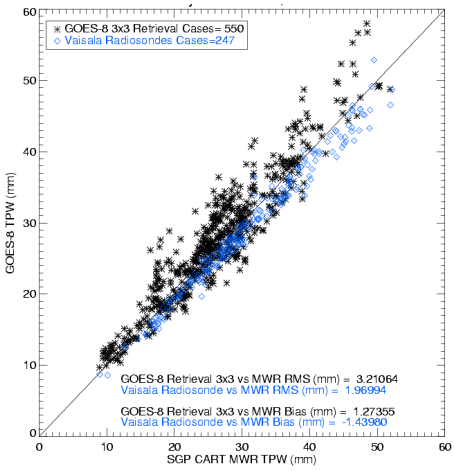

Figure 3: Comparison of TPW derived from GOES-8 3x3 retrievals (black) and Vaisala radiosondes (blue) to microwave radiometer data from 13 May – 25 June 2002 during the IHOP field campaign. Number of MWR matches are indicated in the upper left hand corner of the figure.

Validation of both the 3x3 and 1x1 retrievals during IHOP using MWR and radiosonde measurements provides the first glimpse of GOES Sounder retrieval differences. Figure 3 compares operational GOES-8 3x3 retrievals to MWR TPW. The rms difference for 550 GOES-8 3x3 TPW retrievals is 3.21 mm with a mean bias of 1.27 mm. RS-90 Vaisala radiosondes temporally collocated with MWR data are also plotted for reference. The radiosonde RMS differences indicate batch to batch and radiosonde to radiosonde calibration differences (Revercomb et al. 2002). GOES-8 3x3 retrievals indicate a wet bias relative to the MWR data while the Vaisala radiosondes indicate a relative dry bias of 1.43 mm. This RMS difference of 3.21 mm is higher than the 1.8 mm reported for GOES-8 in Schmit et al. 2002; however, the magnitude of the summertime TPW in this study ranges to 60 mm versus the 30 mm from September – October 1998. The higher RMS differences might therefore be expected due to more absolute water vapor and the difficulty in retrieval of boundary layer water vapor with GOES broadband radiances in high water vapor environments.

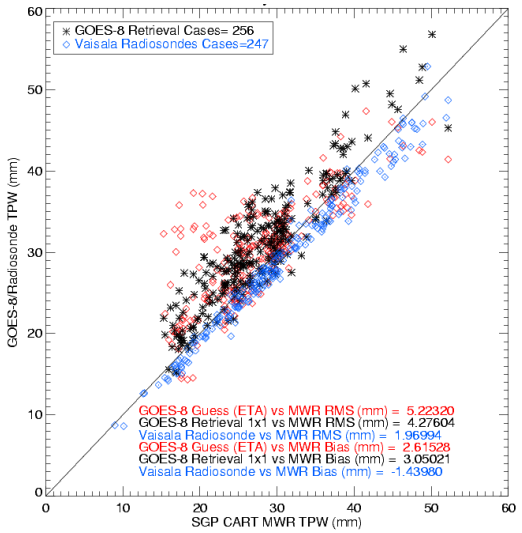

Figure 4: TPW comparison of GOES-8 and Vaisala radiosonde data during the IHOP field campaign from Lamont, Oklahoma. Red diamonds indicate GOES first guess (AVN model), black symbols GOES physical retrievals, and blue symbols radiosonde TPW compared to time correlated MWR TPW data.

Figure 4 shows the improved agreement of the GOES-8 Sounder 1x1 physical retrieval algorithm (black) versus the first guess (red) when compared to MWR measurements during the period 20 May to 25 June 2002. These data were derived by comparing all possible matches between GOES-8 1x1 retrievals and the MWR instrument. For the 256 matched values of MWR and GOES-8 shown in Fig. 4, the physical retrieval improves the first guess of TPW RMS from 5.22 to 4.28 mm. Vaisala radiosonde data was also compared to the MWR (blue symbols), indicating a TPW bias between the two data sets of 1.44 mm. The 1 mm increase in RMS differences between the 3x3 and 1x1 GOES-8 Sounder TPW retrievals (cf. Fig. 3 and Fig. 4) may be a result of 1) greater difficulty comparing the ground-based MWR data with 10 km spatial resolution GOES satellite data, 2) the

differences in TPW retrieval methodology between the 1x1 and 3x3 retrievals, 3) the lack of consistent cloud clearing, and 4) the sample size is half of the 3x3 cases. Improvements to the SFOV retrieval methodology is underway to provide better quality control and to take advantage of the different signal to noise ratios between the sounder channels (the greater the channel noise, the more surrounding channel FOVS must be used to reduce the noise). Figure 5 presents the 94 matches between GOES-11 SFOV Sounder TPW retrievals compared to MWR TPW. A TPW RMS difference of 4.68 mm was indicated by the 1x1 GOES-11 TPW data. Fewer GOES-11 1x1 matches were obtained (94), compared to GOES-8 1x1 (256) because the GOES-11 data set contained 16 fewer days.

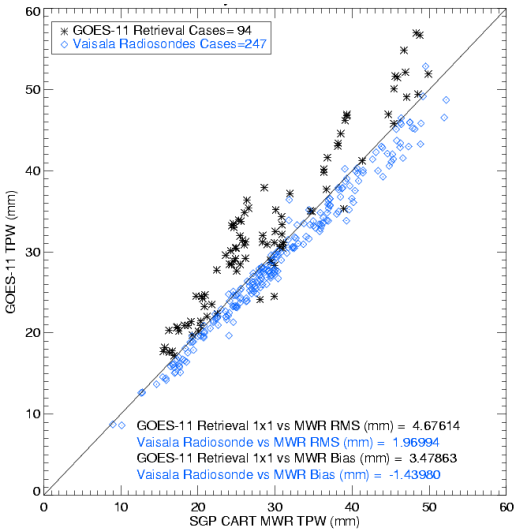

Figure 5: A comparison of GOES-11 1x1 (black) derived TPW to microwave radiometer TPW for 31 May – 20 June 2002.

3. CONCLUSIONS

DOE ARM data have become an important validation source for geostationary and polar orbiting satellite platform sounder data and products. GOES TPW are being extensively evaluated using DOE ARM data. Evaluation of the IHOP GOES-8/11 sounder SFOV retrieval technique used at CIMSS is ongoing. The DOE ARM MWR data will be used to improve new SFOV retrieval techniques, and provides stable validation for space-borne total precipitable water measurements at high temporal resolution. The DOE ARM data are also used within post-launch tests for GOES instrumentation (Daniels and Schmit 2001). Near real-time TPW validation has been implemented at CIMSS to provide timely meteorological satellite product evaluation. More information about the evaluation of GOES TPW can be seen in Schmit et al 2002.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

Daniels, J. M. and T. J. Schmit, 2001: GOES-11 Science Test: GOES-11 Imager and Sounder Radiance and Product Validations. NOAA Technical Report, NESDIS 103.

Liljegren, J. C., 1994: Two-channel microwave radiometer for observations of total column precipitable water vapor and cloud liquid water path. Preprints, *5th Symp. of Global Change Studies,* Amer. Meteor. Soc., Nashville, TN.

------, 1995: Observations of total column precipitable water vapor and cloud liquid water using a dual-frequency microwave radiometer. *Microwave Radiometry and Remote Sensing of the Environment*, D. Solimini, Ed., Utrecht, VSP (Vista Science Press), 107-118.

Ma, Xia L., T. J. Schmit, and W. L. Smith, 1999: A nonlinear physical retrieval algorithm—its application to the GOES-8/9 sounder. *J. Appl. Meteor.*, **38**, 501-513.

Menzel, W. P., F. C. Holt, T. J. Schmit, R. M. Aune, G. S. Wade, D. G. Gray, and A. J. Schreiner, 1998: Application of GOES-8/9 Soundings to weather forecasting and nowcasting. *Bull. Amer. Meteor. Soc.,* **79**, 2059–2078.

Revercomb, H. E., D. C. Turner, D. D. Tobin, R. O. Knuteson, W. F. Feltz, J. Barnard, J. Bösenburg, D. Cook, R. Ferrare, J. Goldsmith, S. Gutman, R. Halthore, B. Lesht, J. Liljegren, H. Linné, S. Melfi, J. Michalsky, V. Morris, W. Porch, S. Richardson, B. Schmid, M. Splitt, T. Van Hove, E. Westwater, and D. Whiteman, 2002: The Atmospheric Radiation Measurement (ARM) Program's Water Vapor Intensive Operational Periods: Overview, Accomplishments, and Future Challenges. *Bull. Amer. Meteor. Soc*., Accepted for Publication.

Schmit, T. J., W. F. Feltz, W. P. Menzel, J. Jung, A. P. Noel, J. N. Heil, J. P. Nelson III, and G. S. Wade, 2002: Validation and Use of GOES Sounder Moisture Information. *Wea. Forecasting*, **17**, 139 - 154.

Stokes, G. M., and S. E. Schwartz, 1994: The Atmospheric Radiation Measurement (ARM)

program: Programmatic background and design of the cloud and radiation testbed. *Bull. Amer. Meteor. Soc*., **75**, 1201-1221.