GOESR3 Periodic Reporting

Reporting Period: January 2018 – June 2018 (2nd half of FY17 funding cycle)

Team Lead: John Forsythe
Team Members: Andrew Jones, Stanley Kidder, Lewis Grasso, Natalie Tourville, Daniel Bikos (Co-Investigators, CIRA, Colorado State University)
Collaborators / Participants: Andy Edman (NWS Western Region), Limin Zhao (NOAA/NESDIS/OSPO); Mark Klein (NOAA/NWS/WPC), Andrew Orrison (NOAA/NWS/WPC)

Project Title: Using the New Capabilities of GOES-R to Improve Blended, Multisensor Water Vapor Products for Forecasters
Project Number: 444

Executive Summary

The second half of the first year of this project saw progress in routine ingest of the GOES-R Total Precipitable Water (TPW) product at CIRA, and comparisons with satellite microwave and Global Positioning System (GPS) TPW products which are currently used in operational TPW. Near-realtime animations of the data are online at CIRA, using data processed with the same data processing system as used in NESDIS operations. A variety of near-realtime ABI and related product animations are available at http://cat.cira.colostate.edu/abi_tpw/. This includes an advected TPW product, which is likely a future direction of blended TPW products for forecasters.

Inspection of GOES-R TPW data animations and comparison with GPS TPW stations, which are considered a validation standard, shows that the data appears to be of high quality. RMS differences of about 4 mm with a bias of +1 mm have been observed. These are fairly low values and bode well for blending of GOES-R TPW with other sources which are currently used in the NESDIS operational blended TPW. An initial blending algorithm is being run hourly at CIRA. A key transition in progress is to use advected passive microwave data, to allow a precise match to GOES-R TPW. Impact studies of the benefit of advection show that the advected microwave product has reduced error versus the non-advected product when compared to coincident GOES-R TPW retrievals. This implies that the advected microwave product should be used to merge with GOES-R to create a next generation blended TPW for forecasters.

Initial simulations of the ABI water vapor channel (channel 9, 6.9 μm) from Microwave Integrated Retrieval System (MiRS) temperature and moisture profiles were completed. The NOAA Community Radiative Transfer Model (CRTM) was implemented within the Data Processing and Error Analysis System (DPEAS). This effort demonstrates a "cloud free water vapor channel". Comparisons to ABI radiance data show the potential of this product to enhance the utility of ABI for users. In the next reporting period, these prototype products will be distributed to NOAA collaborators for evaluation and comment.

Progress toward FY17 Milestones

There were two project milestones this reporting period:

Quarter 3: Begin integration of CRTM with blended water vapor and MiRS temperature profiles

This task is proceeding well. An initial simulation of ABI Channel 09 versus the observed radiance is shown in Figure 1. As scatter plot of the simulated versus observed is shown in Fig. 2. The simulated data is derived from a NOAA-19 overpass. The hypothesis behind this work is that since passive microwave retrievals perform in cloudy skies, they can be used to augment the measured ABI and provide an additional cloud-free depiction of water vapor. This might be especially useful to forecasters when an extensive cirrus field reduces the mid and upper-tropospheric water vapor information available from ABI.

This is a Version 1 simulation, and several minor refinements will be added in the next project period. These include including improving viewing geometry and adding a better specification of the surface, which is most important in mountainous regions. In the future, it might be possible to derive cloud-free ABI imagery from the constellation of 7 to 8 polar orbiting spacecraft, using advection techniques. These products will be refined, created in near realtime, and distributed to operational partners for evaluation in the future.

Quarter 4: Add GOES-R TPW to BTPW, Version 3.0, at CIRA.

The project initially planned to participate in the spring Hazardous Weather Experiment in 2018, but due to training and distribution issues, as well as changing product configurations, we did not participate. We plan to participate in this experiment in spring 2019. PI Forsythe participated in the Flash Flood and Intense Rainfall (FFaIR) experiment at WPC in June 2018 for other related layer precipitable work. While not in the project plan, FFaIR could be a good venue to receive forecaster feedback on blended TPW with GOES-R, as every briefing shift began with a look at the operational blended TPW product. The next FFaIR experiment will be in June-July 2019 at WPC.

What is lacking from the current operational blended TPW, besides GOES-R inputs, is advection of the multiple polar orbiter swaths in the product to a fixed synoptic time. This approach has been demonstrated by the CIMSS MIMIC TPW product (Wimmers and Velden, 2011). The MIMIC approach does not use GOES data. CIRA has implemented this advection technique, near-realtime examples are available at http://cat.cira.colostate.edu/ABI_TPW/aTPW5.htm. An example of data fusion of GOES-R TPW and the advected product is shown in Figure 3. GOES-R adds fine spatial structure in the clear areas, while the polar orbiter data derived from microwave retrievals onboard eight spacecraft detail the TPW in cloudy regions. The weighting between these two inputs and GPS data are being adjusted before data begins flowing to operational collaborators for evaluation.

The performance gain achieved by using an advected microwave TPW product versus a non-advected product (the current NOAA operational algorithm) can be quantified by comparing these products with GOES-R data. Results from a comparison of advected and non-advected TPW are shown in Table 1. This is from a six day period in August 2018. Comparisons are only performed where all 3 data sets have data. Linear regression of advected TPW vs. ABI TPW explains about 93% of the variance (on average), and the standard error averages 3.4 mm ± 0.3 mm. Linear regression of non-advected TPW vs. ABI TPW explains about 91% of the variance (on average), and the standard error averages 4.0 mm ± 0.6 mm. This indicates the expected performance improvement by using an advected passive microwave product.

Plans for Next Reporting Period

A subscription request for the GOES-16 TPW Full Disk sector will be added to the PDA subscription, to provide TPW every 15 minutes. The project was requested by Prof. Russ Schumacher of CSU Atmos to support the RELAMPAGO (Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations) field experiment in the late fall of 2018 over South America. This will allow for a first-time evaluation of GOES TPW in the preconvective environment in conjunction with traditional blended TPW, as GOES-derived TPW has not previously been available in the southern hemisphere.

Milestones in the next reporting period are:

Quarter 1: Test histogram matching adjustment with GOES-R. Initial creation of advectively blended TPW via advection of LPW. Initial training of forecasters.
Quarter 2: Initial GOES-R radiance simulations in cloudy skies created. <u>Deliver</u> advected TPW to users in AWIPS-II / N-AWIPS format.

The project will participate in the spring Hazardous Weather Experiment in spring of 2019. CIRA will deliver an experimental version of blended TPW using weighted GOES-16 data and a previously developed blending algorithm. A key feature is that the passive microwave TPW field will be an advected field, versus the swath overlay which is currently in the operational blended TPW. This will give forecasters a look at a new approach to a familiar and widely used product, with GOES-R inputs.

Additional Information

1. <u>Interaction with operational partners</u> –

GOES-R plots and updates on the work as needed are provided to Limin Zhao, who is the Precipitation Products Area Lead at NESDIS OSPO. These occur through biweekly telecons related to operational blended product support.

2. <u>Conference/workshop participation</u> –

An abstract "Using the New Capabilities of GOES-R to Improve Blended, Multisensor Total Precipitable Water Products for Forecasters" was submitted to the 15th Annual Symposium on New Generation Operational Environmental Satellite Systems at the 2019 AMS annual meeting.

An abstract "Advected Layered and Total Precipitable Water Products and Applications to Forecasting Hazardous Precipitation Events" was submitted to the AGU Fall meeting in session IN046 JPSS: Providing Advanced Global Observations to Improve Knowledge and Decisions by a Global Interconnected Community. This work is supported by a JPSS Proving Ground and Risk Reduction project, but this GOES-R component will be discussed as an input to blended products.

3. <u>Outside project publicity</u> –

N/A

4. <u>Journal articles</u> –

N/A

Key Graphics

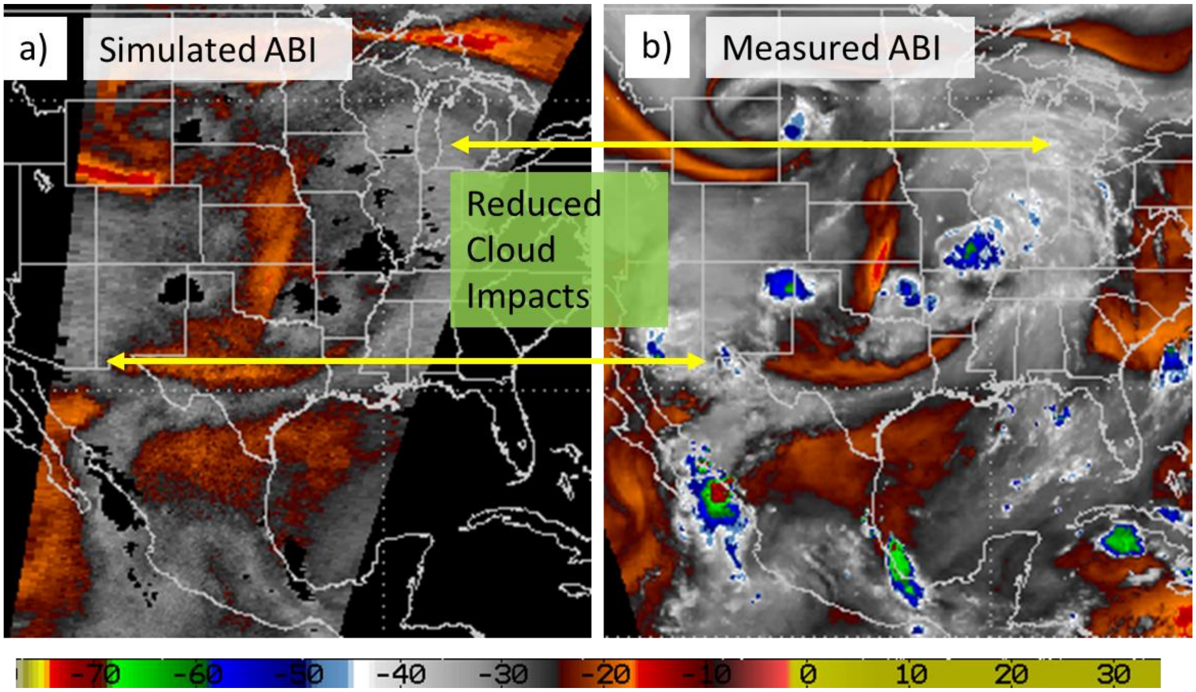

Figure 1: ABI Channel 9 (6.95 µm) radiances on 11 UTC 15 August 2018. A) Simulated from MiRS microwave retrievals and CRTM from NOAA-19 overpass. B) Measured from ABI. Note the elimination of clouds in the simulated data. Black regions in (b) are missing retrievals due to precipitation.

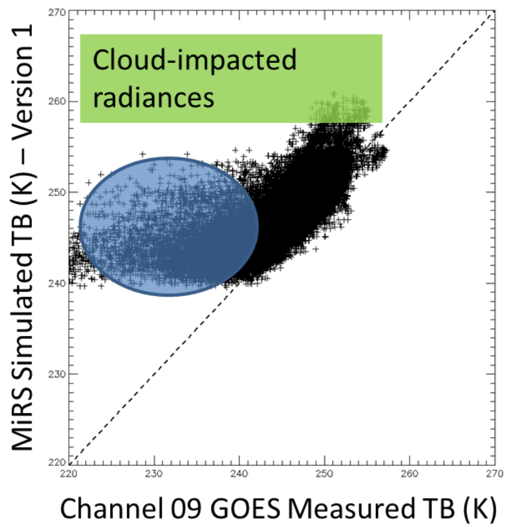

Figure 2: Scatter plot of brightness temperatures from Fig. 1. Notice the cold tail in the observed radiance, indicative of cloud-impacted radiances.

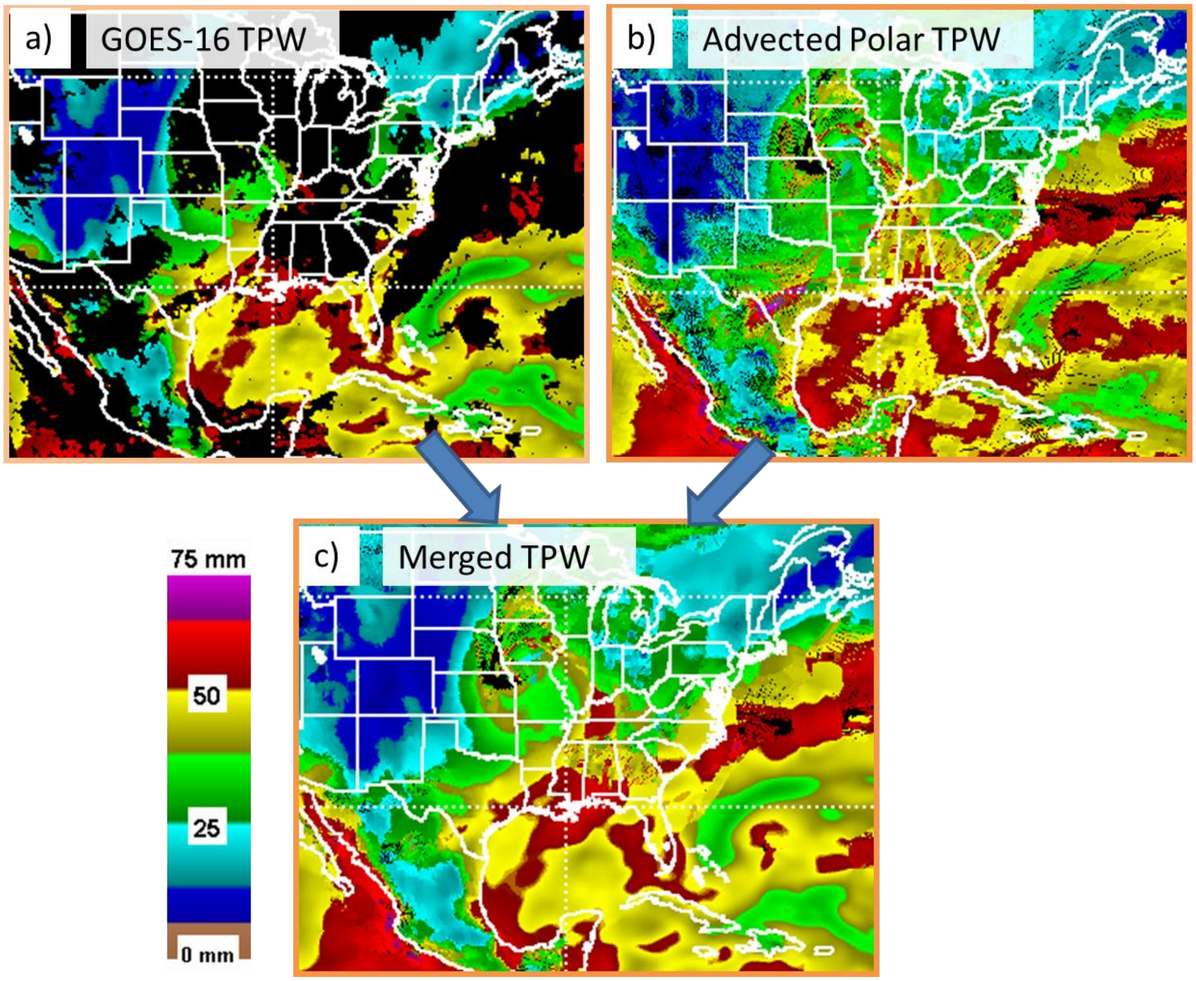

Figure 3: For 15 UTC 20 August 2018, a) GOES-16 TPW, b) CIRA advected TPW from polar orbiting data and c) Merged TPW.

	Slope	Intercept (mm)	r^2	Standard Error (mm)	N
Advected TPW vs ABI	1.00	0.28	0.93	3.42	152782
Non-advected TPW vs ABI	1.02	-0.18	0.91	3.96	152782

Table 1: Comparison of ABI TPW versus and advected and non-advected TPW from passive microwave data. Comparison period is August 10 – 16, 2018 (137 hours).