Assessment of NESDIS GOES-R Quantitative Precipitation Estimate (QPE) and CIRA Layered Precipitable Water (LPW) Products along West Coast to Diagnose Large Precipitation Events in Radar/Data-Void Regions in Spring, 2013

West Coast NWS WFOs, March and April 2013

Introduction

This report summarizes the simultaneous assessment of two experimental products, NESDIS GOES-R QPE and CIRA LPW. The assessment and the transition of the products to National Weather Service Weather Forecast Offices, or NWS WFOs, were conducted by NASA-SPoRT. NESDIS GOES-R QPE is produced by Bob Kuligowski at NOAA-NESDIS-STAR. CIRA LPW is produced by Stan Kidder and John Forsythe at the Cooperative Institute for Research in the Atmosphere, or CIRA.

NESDIS GOES-R QPE is a satellite-based quantitative precipitation estimation product that is being designed for the GOES-R era and is an Algorithm Working Group Baseline product. This version operates on current GOES-East and Goes-West, using IR channels to estimate rainfall rates, and calibrates those rainfall rates with microwave rain rate retrievals from the Tropical Rainfall Measurement Mission Microwave Imager (TRMM TMI), and NOAA satellite 18 and 19's Microwave Humidity Sounder (MHS).

CIRA Layered Precipitable Water is a microwave-based retrieval of water vapor over discrete layers (surface-850 mb, 850-700 mb, and 700-500 mb). LPW uses data from NASA's Atmospheric Infrared Sounder (AIRS) and NOAA's Microwave Integrated Retrieval System (MIRS) to acquire observational data for the product, which is produced every three hours.

These two products are being evaluated for their effectiveness in providing utility to forecasters in high impact precipitation events in data-sparse regions. For this reason, West Coast National Weather Service Weather Forecast Offices (NWS-WFOs) of Medford (MFR), Eureka (EKA), and Monterey (MTR) were chosen to assess these products. The months of March and April were identified in order to capture the predominant precipitation and atmospheric river season for the participating offices.

This is the first formal assessment of these products in operations performed by NASA-SPoRT. This assessment report is intended for program managers, product developers, end users in the forecast community, Proving Ground participants, and the general research-to-operations community.

Product Description

NESDIS GOES-R Quantitative Precipitation Estimate (QPE) is a proxy (QPE) product for the GOES-R baseline QPE product and currently uses GOES infrared and passive microwave data (from MHS on NOAA 18/19 and METOP-A, and TMI on TRMM) to estimate rainfall in a domain covered by GOES (and the GOES-R) domains. It is produced at a temporal resolution of 15 minutes and a spatial resolution of 4

km. This product was developed by Dr. Bob Kuligowski at NOAA-NESDIS-STAR (Kuligowski 2002) and transitioned to selected end users by NASA-SPoRT for evaluation.

The transitioned product suite consisted of a 15-minute instantaneous rain rate estimation, and several accumulation products (1-hr, 3-hr, 6-hr, 12-hr, 24-hr, 3-day, and 7-day) that are consistent with other radar and gauge estimates of QPE available to these end users. The instantaneous product provides a rain rate in inches per hour. The accumulation products composite the previous rainfall amounts and indicate how many inches of rain fell in the given timeframe. The products were available for use in the users' native display system (i.e., AWIPS/D2d).

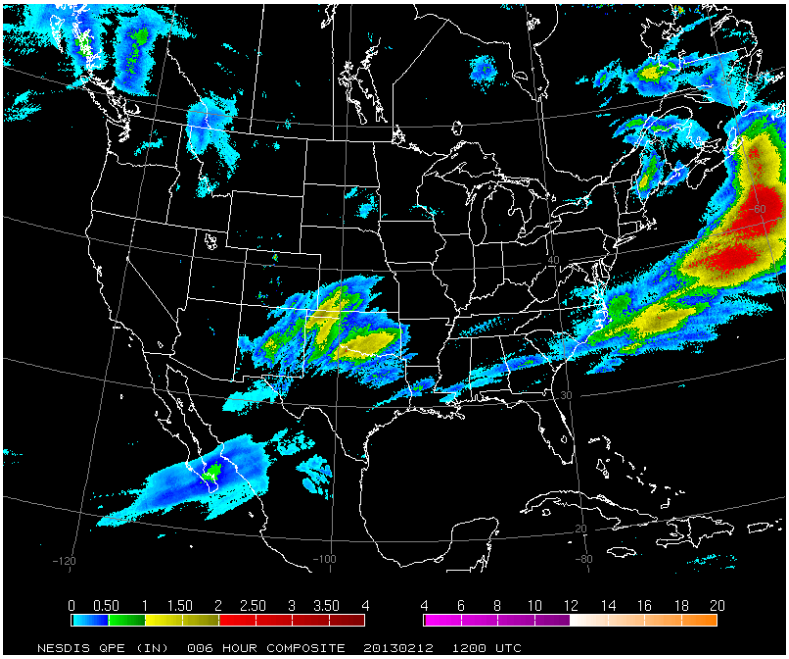

Figure 1 GOES-R QPE 6-hr accumulation product

The CIRA LPW, or Layered Precipitable Water, is a microwaved-based precipitable water product that separates the PW values into discrete layers. The product combines Microwave Integrated Retrieval System (MIRS) retrievals produced operationally at NOAA/NESDIS from NOAA-18, NOAA-19, MetOp-A, and DMSP F-18 and AIRS Version 6 retrievals made available via the NASA Land Atmospheric Near real-time Capability for EOS (LANCE) system (Kidder and Jones, 2007). Coverage for LPW is near-global, and the product is updated with new swath information every three hours. This product was developed by Dr. Stan Kidder and Mr. John Forsythe at CIRA as part of the ROSES 2010 solicitation.

The transitioned product suite was composed of total column-integrated precipitable water and precipitable water values in four individual layers: surface-850 mb, 850-700 mb, 700-500 mb, and 500-300 mb. These products were also made available on end users' AWIPS/D2d systems and web graphics.

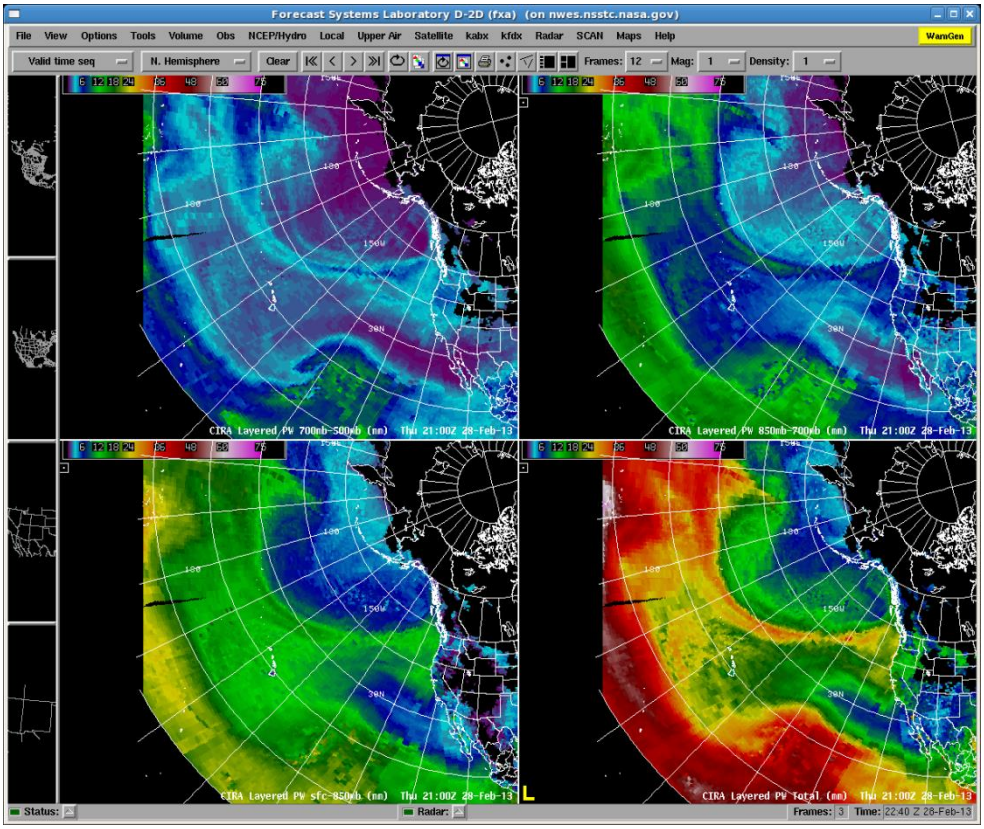

Figure 2 Four-panel display showing CIRA LPW detecting an atmospheric river. (a) 700-500 mb; (b) 850-700 mb; (c) sfc-850 mb; (d) total column PW.

Methodology

SPoRT personnel and product developers provided training via telecons to the forecasting staff of all three NWS WFOs. SPoRT also provided additional training in the form of single sheet "Quick Guides", which were accessible on the NASA-SPoRT webpage and were sent as paper copies (http://weather.msfc.nasa.gov/sport/training/). Furthermore, product producers and SPoRT staff were available throughout the assessment period to answer questions about the products as questions occurred.

Participants were encouraged to fill out "Two-Minute Survey" assessment forms on the NASA-SPoRT webpage throughout the assessment period on weather events to provide feedback on the products. Additional information, like screen captures from AWIPS, was submitted in email attachments and described in the Two-Minute Survey open response section. Survey responses could be viewed by the participants and the product producers by visiting the SPoRT webpage and querying a database. Forecasters and SPoRT personnel also were able to contribute to the Wide World of SPoRT blog to show operational examples of the products to the broader community (http://nasasport.wordpress.com/). Two blogs were written about these products during this assessment.

Results

In total, 11 responses were received from seven different forecasters in two different offices via the formal evaluation page on the web, and several other comments were sent via email to the SPoRT personnel and product developers from all three offices. Six of the seven different forecasters had indicated that they had reviewed the training materials for both products prior to evaluating the products. There were no follow-up questions specifically regarding training, indicating that forecasters likely felt that they were adequately trained to use these products prior to the assessment.

Forecasters identified several different modes of precipitation that occurred during the assessment of these products throughout the evaluation period (Figure 3); no atmospheric river cases were observed, however, and the overall weather conditions were drier than normal for the season. Specific results from each product are discussed in the relevant subsections herein.

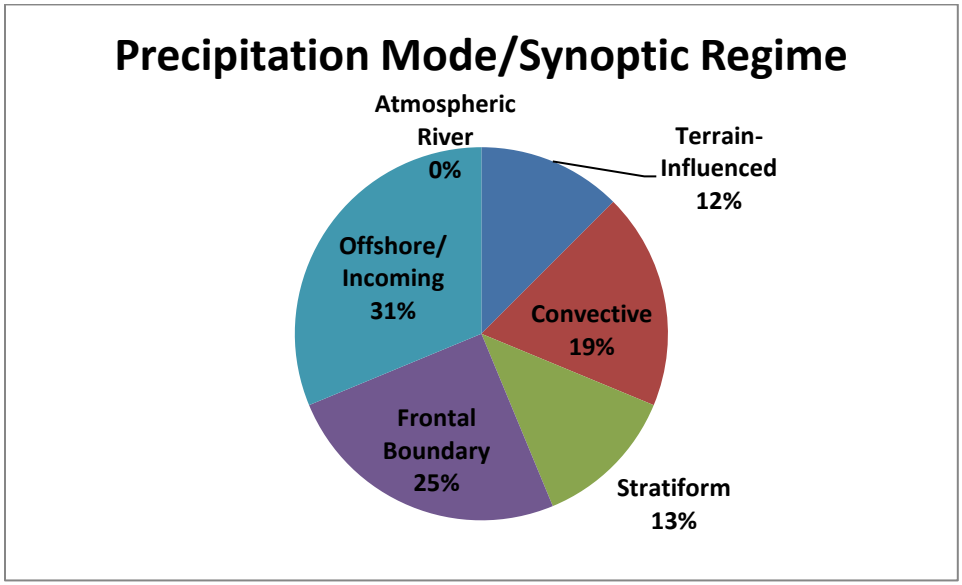

Figure 3 Precipitaion mode or synoptic regime at the time of the assessed event

CIRA LPW

Forecasters indicated that the product dataflow was timely (10 of 11 responses). Forecasters had medium or high confidence that the LPW values were accurate (7 and 2 responses, respectively, see Figure 4), and they often cited some or large value of this layered version of precipitable water measurement over the standard total precipitable water measurement that is also available (4 responded “some value”, and 5 responded “large value”, see Figure 5). However, when asked to rank the impact this product had on the forecast process, most respondents indicated that LPW had a small (5 respondents) or very small impact (3 respondents, Figure 6).

This particular finding seems to be because forecasters were using the LPW product to confirm or verify model forecasts of precipitation events or observations. They stated that LPW was “useful” quite often in the comments section and that the product was accurate, but implied that they used it in the capacity as a supplement to other information. For example, one forecaster wrote in the comments section that

he used it to determine the depth of the moisture associated with an incoming system and to confirm other observations that suggested the system was weakening as it was approaching the CWA.

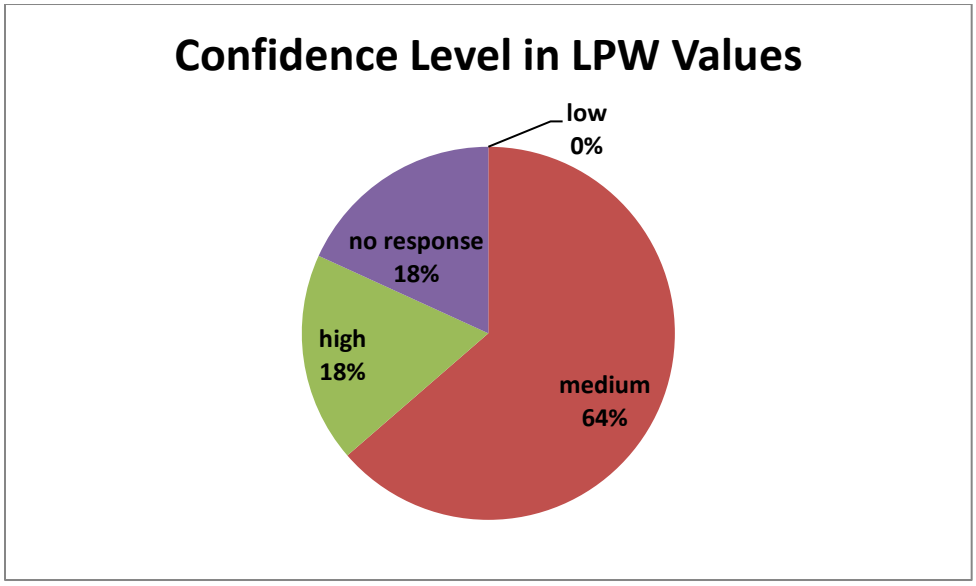

Figure 4 Confidence in LPW values

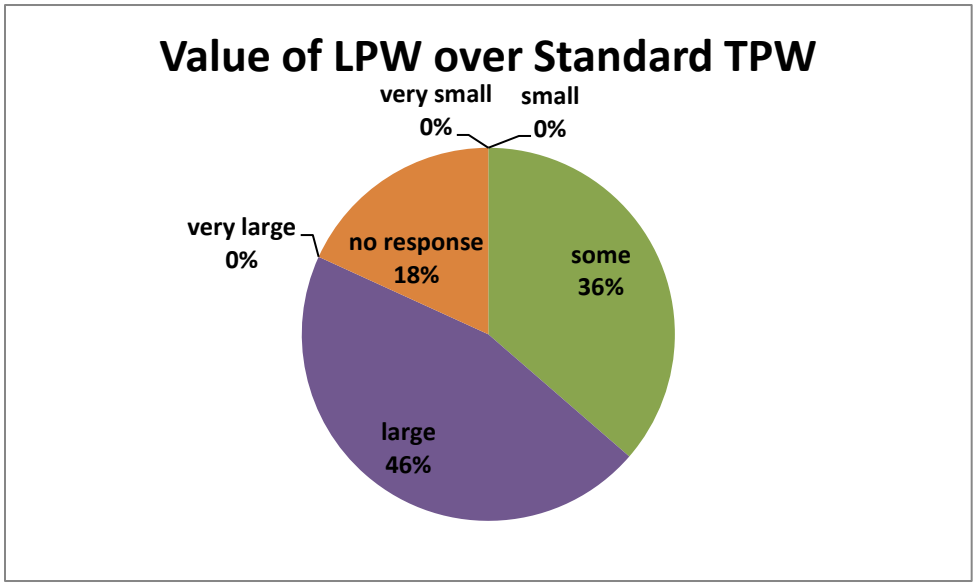

Figure 5 Value of LPW product suite compared to standard TPW product

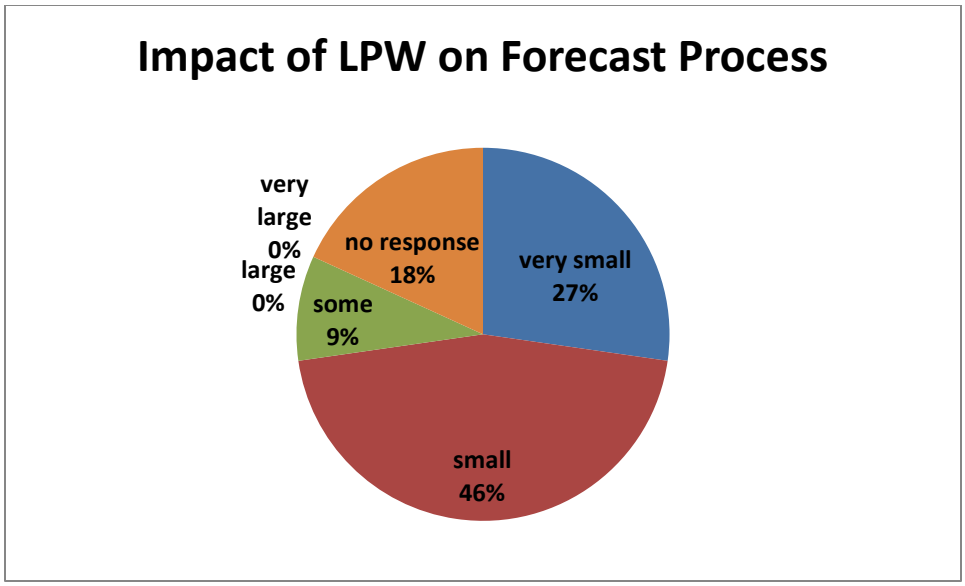

Figure 6 Impact of LPW on forecast process

NESDIS GOES-R QPE

Forecasters indicated that GOES-R QPE was timely for most events (9 of 11). However, after a forecaster suggested that the 1-hr product seemed to arrive a little too late to be relevant, the product producer was able to reduce the processing time for GOES-R QPE, allowing this product to be more applicable to real-time events. Forecasters could articulate the potential utility of this product suite as it pertained to their forecast problems particularly well. For example, one forecaster stated that he would use the product "to determine a flash flood threat using the 3 or 6 hr QPE". Forecasters indicated that the most useful hourly accumulations were the 1-hr, 3-hr, 6-hr, and 24-hr products (Figure 7).

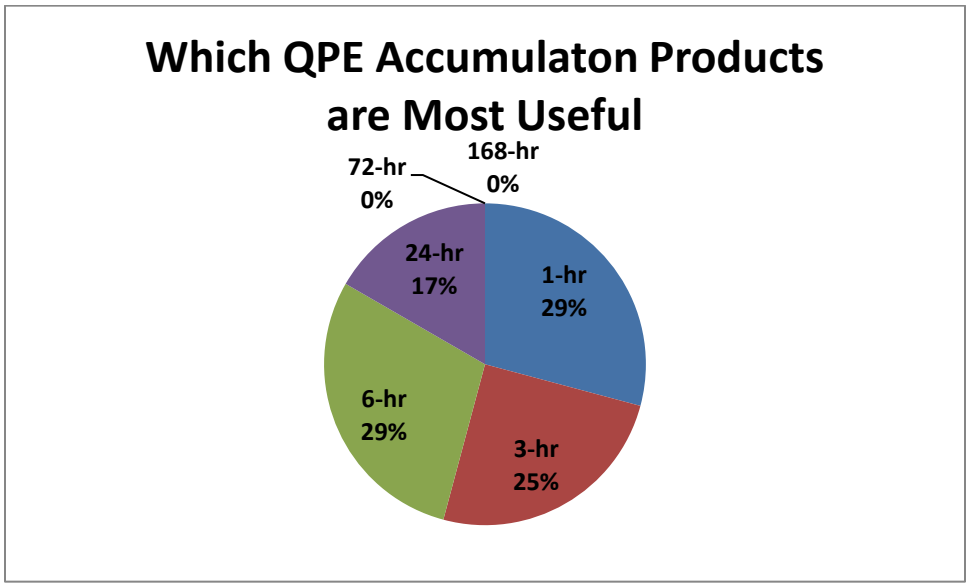

Figure 7 GOES-R QPE accumulation products deemed most useful to forecasters

However, this product suffered inconsistencies in accuracy that seemed at least somewhat dependent upon the terrain in the region. Specifically, forecasters reported that rainfall was underestimated along the coast, where precipitating clouds were confined to low elevations by the terrain and had insignificant IR signatures, and rainfall was overestimated when the precipitating clouds were over or in the mountains. In at least one case, cirrus clouds were forced aloft by the terrain and were falsely given high rain rates in the mountains. For this reason, forecasters did not find QPE very useful in the data-deprived regions, specifically the mountainous terrain, in the events that they assessed (Figure 8).

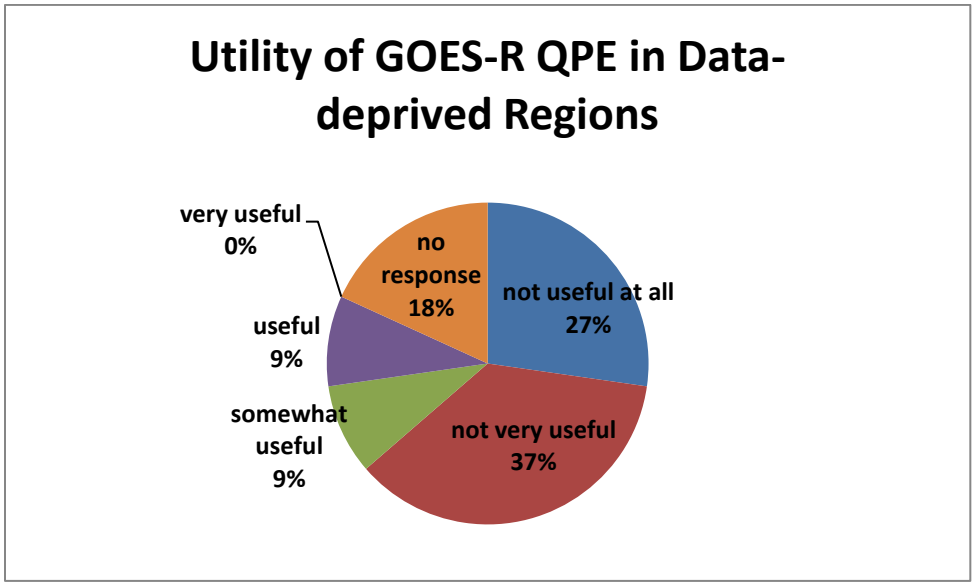

Figure 8 Utility of GOES-R QPE in data-deprived regions

Forecasters seemed generally reluctant to use the survey questions to explain how they believed the QPE rainfall estimates compared to other estimates of rainfall they might have examined during the events they assessed, instead preferring to describe verbally in the discussion boxes how QPE performed in various regions for each event, and followed up with emailed screen captures of other data sources, like ASOS station reports, satellite IR, and other observations. This perhaps indicates the GOES-R QPE did not have inconsistencies in rainfall estimates in a particular accumulation product or for a specific type of precipitation event. Figures 9 and 10 show users' responses to whether QPE was biased when compared to other sources, or biased in any specific accumulation product. Some forecasters could not identify a specific pattern or bias in the product's inaccurate estimations, particularly early in the evaluation, perhaps undermining their enthusiasm to participate later on. Furthermore, although most precipitation events were identified as offshore/incoming or frontal boundary, and only two were specifically identified as terrain-influenced, it is likely that the terrain was a factor for almost all the land-based events assessed. When asked specifically to describe the geography in his CWA, one forecaster answered that the terrain was "as complex as it gets".

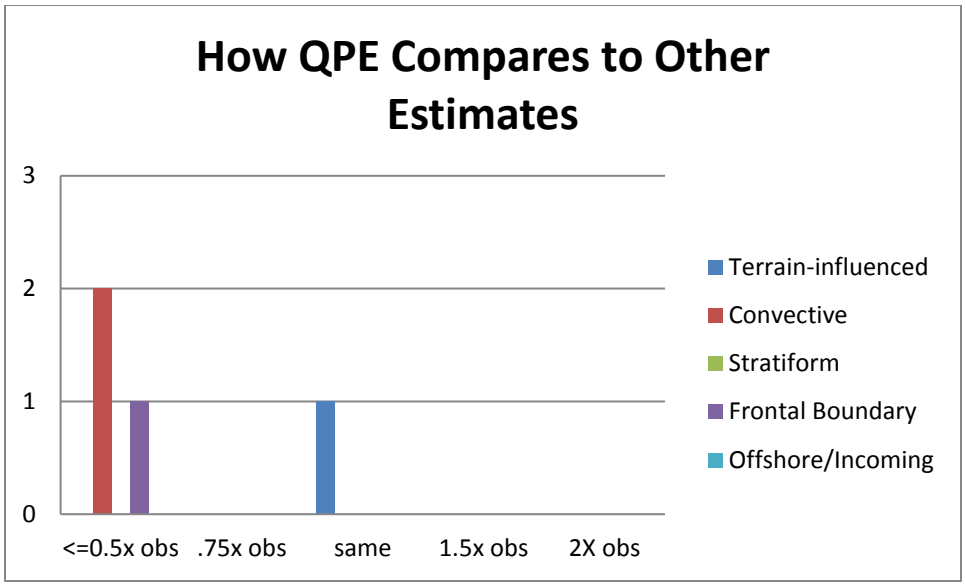

Figure 9 GOES-R QPE bias by precipitation type as estimated by forecasters

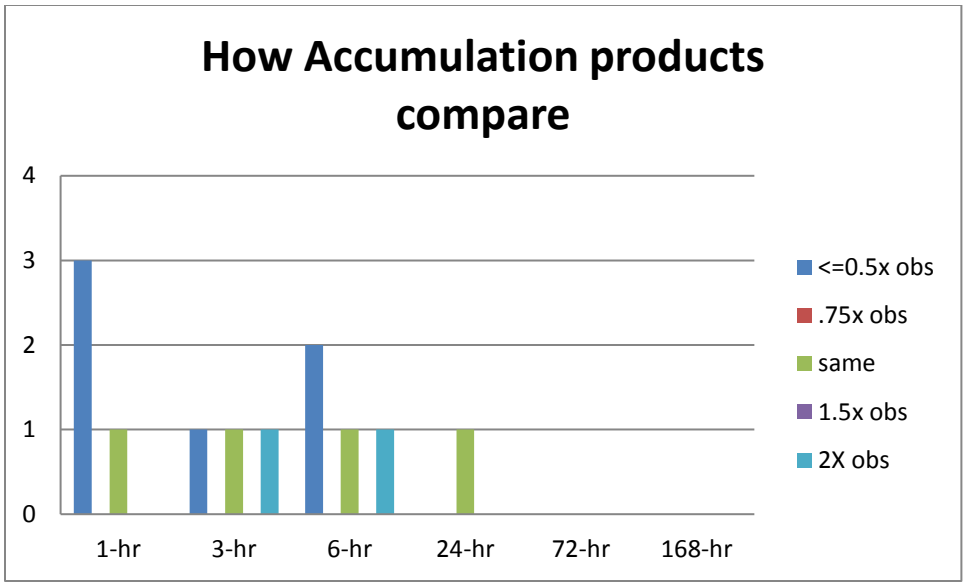

Figure 10 GOES-R QPE bias by accumulation product as estimated by forecasters

Conclusions and Recommendations

In summary, CIRA LWP was well-received in that forecasters in the West Coast offices had medium to high confidence in the accuracy of the product, but used CIRA LPW in concert with other tools to assess water vapor and moisture associated with incoming weather systems. This likely contributed to forecasters' assessment that the product had some, small or very small impact on their forecasting process, despite their comments about how well it worked or how they used it.

The NESDIS GOES-R QPE product suite, on the other hand, contained a number of accumulation products that forecasters expressed interest in using for flood or flash flood awareness; however, the algorithm as a whole seemed inconsistent in locations across the region. These inconsistencies were possibly related to the orography of the CWAs, resulting in somewhat predictable biases (underestimating along the coast west of the mountains and overestimating further inland within the mountains), but forecasters were uncomfortable quantifying the bias or were unable to identify a specific pattern within it.

Recommendations for the products going forward are as follows:

- To adapt GOES-R QPE to complex terrain,
- To supplement the CIRA LPW suite with derivative or anomaly products that may have additional operational utility to forecasters, and
- To evaluate both products over a larger number of cases.

References

Kuligowski, Robert J., 2002: A Self-Calibrating Real-Time GOES Rainfall Algorithm for Short-Term Rainfall Estimates. *J. Hydrometeor*, **3**, 112–130.

Kidder, Stanley Q., Andrew S. Jones, 2007: A Blended Satellite Total Precipitable Water Product for Operational Forecasting. *J. Atmos. Oceanic Technol.*, **24**, 74–81.