

GOESR3 Periodic Reporting

Reporting Period: July 2018 – December 2018 (1st half of FY18 funding cycle)

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Project Title: Probabilistic precipitation rate estimates from GOES-R for hydrologic applications
Project Number: 424

Executive Summary

The high-resolution and low-latency of GOES-R observations is essential for the monitoring and prediction of floods and flash floods, specifically in the Western United States where the vantage point of space can complement the degraded weather radar coverage of the NEXRAD network. The GOES-R rainfall rate algorithm will yield deterministic quantitative precipitation estimates (QPE). Accounting for inherent uncertainties will further advance the GOES-R QPEs that will be improved through the new bands, higher resolution, and basic algorithmic improvements. With quantifiable error bars, the rainfall estimates can be more readily fused with ground radar products and incorporated into ensemble hydrologic forecast applications. On the ground, the high-resolution NEXRAD-based precipitation products from the Multi-Radar/Multi-Sensor (MRMS) system, which is now operational in the National Weather Service (NWS), provides QPEs suited for flash flood monitoring and forecasting. However, NWS operations are challenged across the intermountain West due to a lack of suitable coverage of operational weather radars over complex terrain. An opportunity exists to combine the observations from GOES-R and MRMS to provide seamless, high-resolution and low-latency precipitation estimates across the CONUS. The goal of this research project is to derive consistent, accurate and fine-resolution precipitation rates with uncertainties over the CONUS. An already created MRMS-based precipitation database will provide an independent and consistent reference to document, analyse and design GOES-R QPE over a broad sample of precipitation situations. GOES-R precipitation estimates will be matched to the MRMS-based rainfall database in order to derive and analyse distributions of QPE uncertainties associated with the GOES-R deterministic retrievals. The probabilistic model mitigates biases compared to the deterministic GOES-R QPE and quantifies the associated uncertainty. It provides the basis for the generation of GOES-R precipitation ensembles suitable to 1) merge with MRMS-based probabilistic QPEs from ground radar-based algorithms already developed to advance multisensor QPE integration (Kirstetter et al. 2015a) and 2) serve as input to a framework being developed in an already funded project for probabilistic flash flood prediction across the U.S. (Gourley et al., 2013, 2016). The product will be further tested in an operational environment in order to improve its use for weather and water forecasting.

Progress toward FY18 Milestones

The third half-year of the project has been devoted to finalizing the database of matched GOES-16 and MRMS data in preparation of the GOES-16 probabilistic precipitation estimates. Investigations started on probabilistic relations between GOES-R observations and MRMS precipitation estimates. The completed milestones are on-track with the project schedule.

An independent and consistent ground-based reference matching the retrieval scale of GOES-16 precipitation estimates has been derived from ground-based MRMS products (instantaneous rain rate, radar quality index, surface precipitation type) over areas with good radar coverage. Data have been collected through Spring 2018. The matching procedure between MRMS and GOES-16 precipitation estimates is functional. The MWCOMB precipitation product used to train SCaMPR is also matched with

MRMS and evaluated as a benchmark. The SCaMPR algorithm has been analyzed with systematic attention to rainfall detection, classification and quantification. Directions for improvement have been discussed and identified with Dr. Kuligowski. Preliminary probabilistic QPE relations for GOES-R have been established for rainfall detection and quantification (see Fig. 2).

Plans for Next Reporting Period

During the next period, the MRMS-based reference precipitation database will be used to benchmark the MWCOMB precipitation over the CONUS. A refined analysis of performances and the derivation of new probabilistic relations conditioned on precipitation types is underway to improve the GOES-16 precipitation retrievals. Specific challenges will be addressed such as high rain rate retrievals, impact of low-level atmospheric humidity (specifically in dry regions such as the intermountain West), and detection of rain from warm clouds and orographic rainfall. Results will be communicated and close coordination with NOAA GOES-16 scientists and collaborators will proceed so that additional error sources can be investigated if deemed necessary. This work will be presented at the European Geosciences Union in April 2019.

Additional Information

1. Interaction with operational partners –

- Exchanges with collaborator R. Kuligowski (NOAA/NESDIS/STAR)
- Telecons with the Hydrology Initiative working group (Ralph Ferraro)
- Discussion with the MRMS team for possible transition to operation.

2. Conference/workshop participation –

- 9th International Precipitation Working Group workshop (IPWG2018), Seoul, South Korea, November 5-9, 2018.
- AGU Fall Meeting, Washington D.C., U.S., Dec. 10-14, 2018.

3. Outside project publicity –

- Hydrology Initiative working group (Ralph Ferraro)
- Visit to NCAR to discuss the broader perspectives of the project on research in hydrometeorology.
- Seminars and presentations:
 - Invited presentation: Probabilistic Quantitative Precipitation Estimates with Ground- and Space-based Remote Sensing. National Center for Atmospheric Research, Boulder, CO, US, August 31, 2018.
 - Invited presentation: Uncertainty – Assessment of global precipitation products. International Precipitation Working Group workshop (IPWG2018), Seoul, South Korea, November 6, 2018.

4. Journal articles –

- Kirstetter, P.E., N. Karbalaee, K. Hsu, Y. Hong, 2018: Probabilistic Precipitation Rate Estimates with Space-based Infrared Sensors. *Quarterly Journal of the Royal Meteorological Society*, 1–15. doi: 10.1002/qj.3243

This paper demonstrates the concept of probabilistic precipitation rate estimates with space-based geostationary infrared sensors similar to GOES-16.

Key Graphics

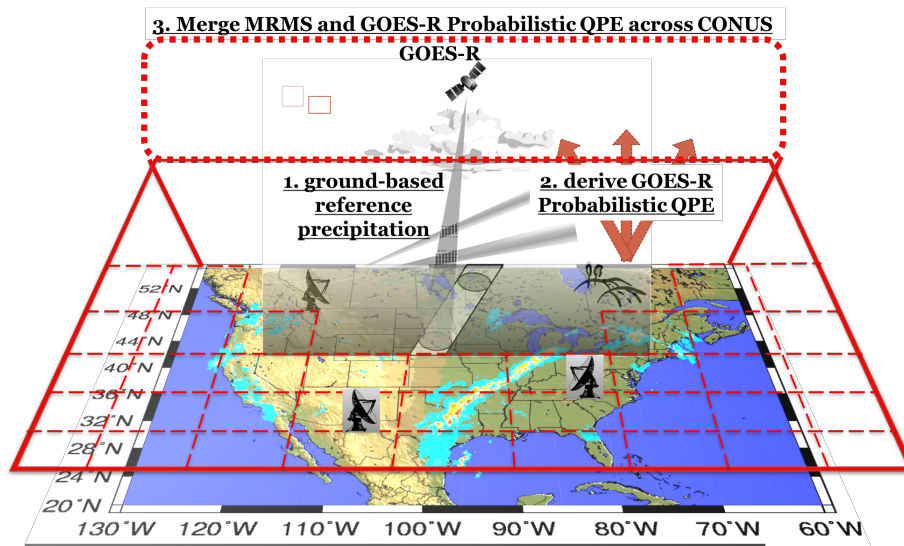


Figure 1: Research framework and overview flowchart of the project.

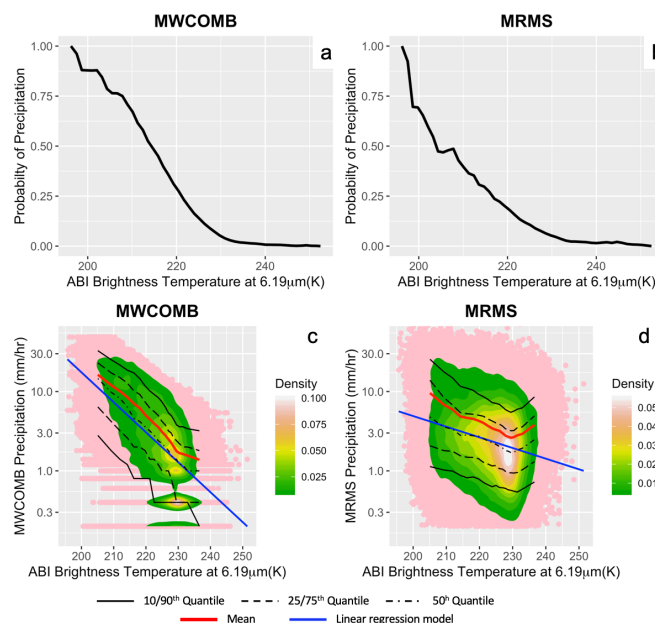


Figure 2: Preliminary probabilistic relations for rainfall detection (a, b) and quantification (c, d). Precipitation rate distributions are displayed as functions of ABI 6.2 μ m infrared brightness temperature with proportion of positive rates for MWCOMB (a) and MRMS-based reference (b) and distribution of positive precipitation rates as density scatterplots for MWCOMB (c) and MRMS-based reference (d). On panels (c) and (d) the dash-dotted black line represents the median (50% quantile), the dotted black lines encompass the area between the 25 and 75% quantiles, the plain black lines encompass the area between the 10 and 90% quantiles; the red line represents the conditional mean rain rate; the blue line represents the linear brightness temperature - rain rate relationship used in the SCAmpr algorithm.