A REVISED LOW-LATENCY, GPM-READY PRECIPITATION ALGORITHM: RECENT IMPROVEMENTS AND IMPACTS

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Background and Previous Work

Motivation

- Rain rate estimates from MW data are available only every few hours with a latency of up to 3 h, limiting their direct use in operational forecasting. However, IR data are available every 15 min in many areas with a latency of just minutes.
- Calibrating an IR algorithm with MW rain rates can optimize accuracy, frequency, and timeliness.
- Proposed solution: SCaMPR = Self-Calibrating Multivariate Precipitation Retrieval (Kuligowski 2002; Kuligowski et al. 2013), which has been selected as the operational rainfall rate algorithm for GOES-R and was developed using METEOSAT SEVIRI data (Kuligowski 2010).

Algorithm Description: Calibration Data Set

- Calibration standard : the NWS/CPC combined microwave (MWCOMB) data set (Joyce et al. 2014), which mosaics all available MW rain rates and bias-adjusts them against GMI.
- The calibration dataset is a rolling-value matched MW-IR dataset (Fig. 1) that is updated whenever new MW rain rates become available (Fig. 1).
- Separate calibrations for 3 different cloud types, based on breakpoints between different regimes of the $T_{11.2}$ vs. MW rain rate relationship:
  - "Water cloud": $T_{7.34}<T_{11.2}$ and $T_{8.5}-T_{11.2}<-0.3$ K
  - "Ice cloud": $T_{7.34}<T_{11.2}$ and $T_{8.5}-T_{11.2}\geq-0.3$ K
  - "Cold-top convective cloud": $T_{7.34}\geq T_{11.}$
- Separate calibrations for 30° latitude bands account for variability in rainfall climatology.

Algorithm Description: GOES Predictors

- Eight possible predictors; selected empirically from all possible IR channels and channel differences (Table 1).
- Each predictor regressed against MW rain rates in log-log space to produce a nonlinear transformation of the predictor.

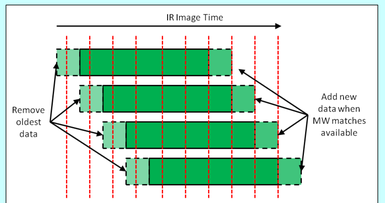

Figure 1. Illustration of the matched MW-IR data files.

Algorithm Description: Calibration Process

- Discriminant analysis is used to select predictors, coefficients, and thresholds for rain / no rain discrimination.
- Stepwise forward linear regression on the raining MW pixels is used to select predictors and coefficients for rain rate retrieval.
- Histogram matching is used to ensure that the distribution of the retrieved rain rates matches MWCOMB.
- See Fig. 2 for the full processing flow diagram.

$T_{6.2}$	$T_{8.5} - T_{7.34}$
$S = 0.568*(T_{min,11.2}-217\ K)$	$T_{11.2} - T_{7.34}$
$T_{avg,11.2} - T_{min,11.2} - S$	$T_{8.5} - T_{11.2}$
$T_{7.34} - T_{6.19}$	$T_{11.2} - T_{12.3}$

Table 1. Available SCaMPR predictors. **Bold** predictors are used in the current-GOES version.

Algorithm Description: Current-GOES Version

- Run in real time since Aug. 2011 for evaluation by developers and NWS forecast offices via collaboration with NASA SPoRT.
- Simplified: uses only GOES-W/E 6.7 and 10.7-µm bands and thus 2 cloud classes.
- Only two cloud types and 4 (untransformed) predictors.
- Forecaster feedback has led to numerous improvements.

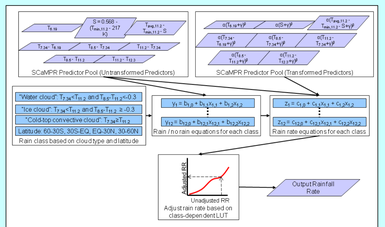

Figure 2. SCaMPR data processing diagram.

Recent Algorithm Modifications and Impact

RH Correction

- **Problem:** Significant overestimation of rainfall, particularly in arid regions with significant sub-cloud evaporation (e.g., western US)
  - More of an issue with the current-GOES version than with the full version, presumably because of better cirrus screening with the latter.
- **Solution:** Developed an RH correction by determining the volume bias of MWCOMB vs. Stage IV as a function of GFS RH for a multi-year data set (Fig. 3).
- **Results:** false alarm /excess rainfall significantly reduced (Fig. 4).

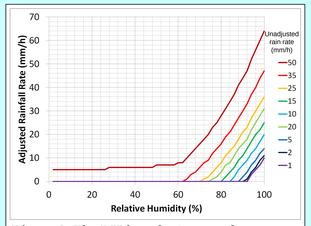

Figure 3. The RH-based rain rate adjustment.

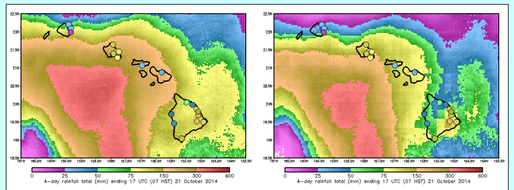

Figure 4. 4-day rain totals ending 17 UTC 21 October 2014 for TS Ana before (left) and after (right) RH correction compared to CoCoRAHS gauges.

Smaller Calibration Regions

- **Problem:** Non-physical changes in rain rate would occur on occasion, and on some other occasions the rain rates of the "deep convective" and non-"deep convective" classes would be incongruous, creating holes in the rain rate fields (Fig. 5; top).
- **Solution:** Reduce the size of the calibration regions to ensure greater homogeneity in the calibration data sets.
- **Results:** Smoother time changes and more consistent rain rates between classes (Fig. 5; bottom), though with a significant increase in computational requirements.

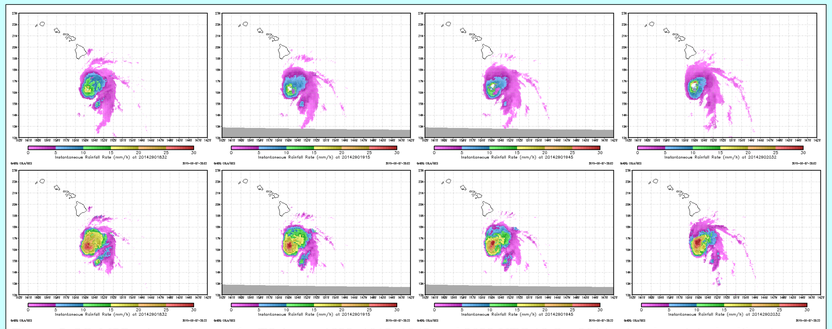

Figure 5. SCaMPR rain rate images for TS Ana at 1832, 1915, 1945, and 2032 UTC 18 Oct 2014 using the original calibration regions (top row) and the 15x15° calibration regions (bottom row).

Calibration using Radar

- Testing gauge-adjusted Q3 radar data in the calibration data set over the CONUS.
- Impact has been neutral over the CONUS during the warm season; currently investigating the CONUS during the cold season as well as using dual-pol radar in Alaska.

Next Steps

Ongoing Work

- Created a version of the algorithm code designed to work on any geostationary satellite—about to begin running in real time for:
  - GOES-W/E (simplified algorithm)
  - Himawari-8 (full algorithm)
  - METEOSAT 7/10 (if resources permit)
- Once the 2000-15 reprocessing is completed, will work to optimally incorporate the SCaMPR rainfall rates into a satellite-radar-gauge framework.
- Continuing to develop an orographic correction for the algorithm; will also evaluate several existing orographic correction schemes to see if results are suitable.

Future Work

- Determine if the gauge-corrected Q3 can be used to develop a robust convective equilibrium level correction.
  - Initial work using Stage IV showed neutral impact, but this may be due to sampling errors when comparing 1-h Stage IV accumulations to instantaneous satellite data.
- Determine the best use of visible data (correction for solar zenith angle assumes a flat cloud surface which is violated for deep convective clouds at low sun angles) and retrieved cloud properties in the algorithm (e.g., Chen et al. 2011).
- Incorporate the gauge-radar-satellite fields into an existing experimental framework for producing 0-6 h rainfall forecasts using an optimal blend of extrapolation-based nowcasts and numerical weather prediction model forecasts.
- Evaluate the impact of these advances on hydrologic forecasts.

References

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