Enhancement of Re-Calibrated of PERSIANN-CCS Estimation Using Passive Microwave Precipitation Data

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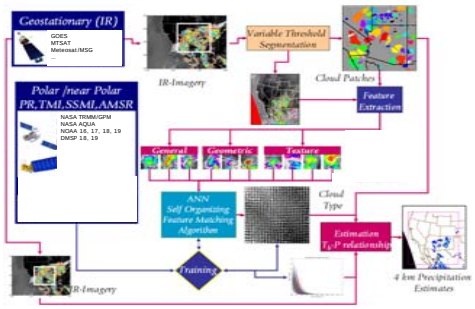
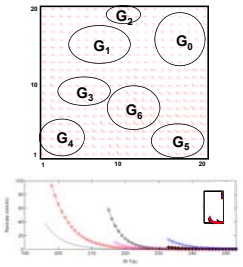
Abstract

- *Effective integration of Low Earth Orbit (LEO) Passive Microwave (PMW) precipitation estimation with more frequent samples from Geostationary Earth Orbit (GEO) images can provide improved sampling of precipitation events in space and time.*
- *The re-calibration of PERSIANN-CCS estimation is implemented in the Integrated Multi-satellitE Retrieval for GPM (IMERG) algorithm.*
- *Re-calibrated PERSIANN-CCS using PMW rainfall estimation provides improvement of PERSIANN-CCS to adapt its estimation to local/regional and seasonal variability of the cloud to rainfall relationship.*
- *This poster presents the development of re-calibrated PERSIANN-CCS precipitation estimation and uncertainty analysis of estimation using a generalized distribution function.*

PERSIANN-CCS Estimation

- *The PERSIANN-CCS algorithm enables the categorization of cloud-patches from features such as coverage area, texture, temperature gradient, and geometry extracted from the long-wave infrared (IR) imagery (~11 μm) of geostationary satellites.*
- *The algorithm uses image segmentation and object classification methods to process cloud images into separated cloud-patch regions; The pixel rain rates under the cloud-patch coverage are calculated using the histogram matching method.*
- *Each image classification group is assigned a unique IR brightness temperature (Tb) and rainfall (R) function.*

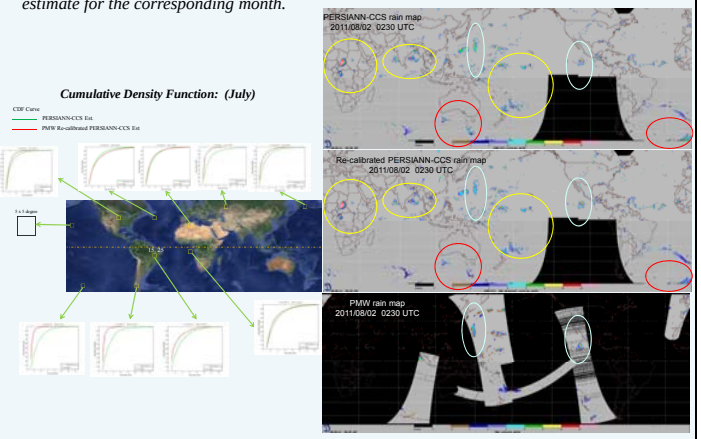




- *The Tb-R relationship of 20x20 cloud patch groups and the Tb-R curves with respect to the SOFM groups G0~G6.*
- *For the group in region G0, the cloud Tb is high (clear weather pattern) and has no rain associated with it. The slopes of Tb-R curves are higher for the G2, G4, and G6 regions, implying that those cloud groups represent high precipitation clouds at low, medium, and high altitudes.*
- *For the regions covered by G1, G3, and G5, the slopes of Tb-R are less steep and are associated with light or no-rain clouds at low, medium, and high altitudes, respectively.*

PMW Re-calibration of PERSIANN-CCS

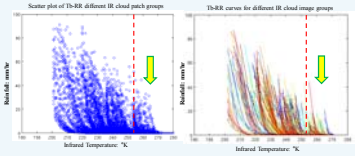
- *Re-calibrated PERSIANN-CCS using PMW rainfall estimation provides improvement of PERSIANN-CCS to adapt its estimation to local/regional and seasonal variability of cloud and rainfall relationship.*
- *Multiple years of concurrent samples of PERSIANN-CCS and PMW rainfall estimation were used to re-calibrate the PERSIANN-CCS estimation.*
- *The implementation of the percentile matching method is considered with regional and seasonal precipitation variability.*
- *The adjustments are calculated for each month within 5° x 5° boxes to accommodate both spatial consistency and regional climatology.*
- *The probability mapping coefficients are estimated/stored (as a lookup table) for each 5°x5° grid by calendar month and are applied to adjust each 30-minute PERSIANN-CCS estimate for the corresponding month.*

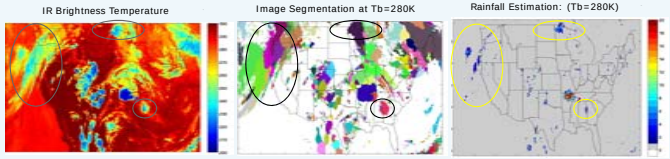


Improving Warm Rain Estimation

- *Re-calibrated PERSIANN-CCS uses IR brightness temperature threshold at 220K, 235K, and 253 K to extract the spatial features of cloud patches.*
- *Extending to higher brightness temperature thresholds (e.g. 280K) for cloud segmentation and feature extraction will improve both precipitation detection and estimation for warm clouds.*

IR brightness temperature and rainfall rate relationships from cloud patches under an IR temperature threshold at 280K.





Uncertainty Analysis

- *Understanding the uncertainty of satellite estimates is important for flood forecasting and water resource management.*
- *A generalized-normal distribution (GND-Type II) is flexible for generating both Gaussian and unimodal distributions.*
- *The precipitation product uncertainty model varies with rainfall rate and product resolution in space and time accumulation.*
- *Suitable GND functions, $p(x|R_{sat})$, can be fitted with product samples and reference data.*

A density function of GND of a satellite precipitation product, p(x), for a given satellite estimation, R_{sat}, is described as:

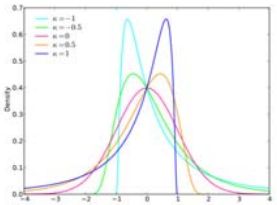
$$p(x|R_{sat}) = \frac{\phi(y)}{\alpha - \kappa(x-\xi)}$$

where

$$y = \begin{cases} -\frac{1}{\kappa} log\,[1 - \frac{\kappa(x-\xi)}{\alpha}] & if\ \kappa \neq 0 \\ \frac{x-\xi}{\kappa} & if\ \kappa = 0 \end{cases}$$

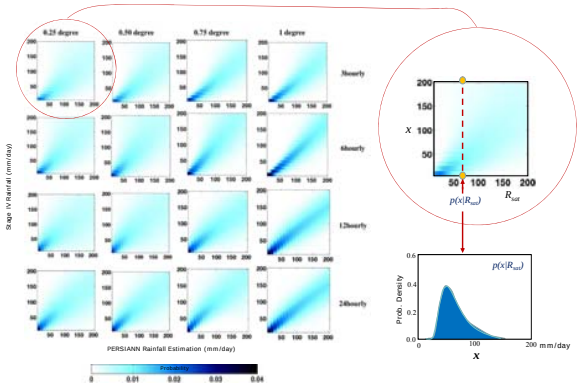
$$x \in \left(\xi + \frac{\alpha}{\kappa}, +\infty\right) \quad if\ \kappa < 0$$
$$x \in (-\infty, +\infty) \quad if\ \kappa = 0$$
$$x \in \left(-\infty, \xi + \frac{\alpha}{\kappa}\right) \quad if\ \kappa > 0$$

GND-Type II density functions



α is positive as scale parameter; κ is a shape parameter; ζ is a location parameter; and Φ(y) as the standard normal probability-distribution function.

- *The joint probability distribution of the PERSIANN product and Stage IV precipitation analysis at various spatial and temporal scales is estimated (see figures below).*



- *The uncertainty analysis of satellite estimation using GND distribution function can be extended to the re-calibrated PERSIANN-CCS estimation and other products (e.g. TMPA, CMORPH, & IMERG).*

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