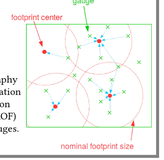
Evaluating the Hierarchy of GPM Products against Dense Gauge Networks

Jackson Tan[1], Walter A. Petersen[2], Gottfried Kirchengast[3], David C. Goodrich[4], David B. Wolff[5]

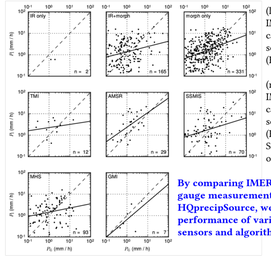
[1] NASA Goddard Space Flight Center / USRA (jackson.tan@nasa.gov) [2] NASA Marshall Space Flight Center [3] Wegener Center for Climate and Global Change, and IGAM/Institute of Physics, University of Graz [4] USDA ARS Southwest Watershed Research Center [5] NASA Wallops Flight Facility

Introduction

- 3 satellite products:
  - → DPR Ku: GPM Level 2 radar-based precipitation product
  - → GPROF: GPM Level 2 radiometer-based precipitation product
  - → IMERG: GPM Level 3 merged precipitation product
- 3 gauge networks:
  - → PCMK (Pocomoke, MD): mid-Atlantic coast with no significant orography
  - → WEGN (WegenerNet, Austria): hilly alpine foreland with dense vegetation
  - → WGEW (Walnut Gulch, AZ): semiarid environment with low vegetation
- Match each satellite pixel to gauges within 2.5 km (Ku) and 7.5 km (GPROF) of the center. Consider match-ups with at least 6 (Ku) or 12 (GPROF) gauges.
- Accumulate for ±2.5 min centered on overpass time.

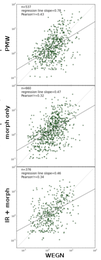


IMERG Validation



(left) Validation of IMERG against PCMK, categorized by the source of the estimates. (From Tan et al., 2016.)

(right) Validation of IMERG against WEGN, categorized by the source of the estimates. (Figure courtesy of Sungmin O, University of Graz.)



By comparing IMERG estimates against gauge measurements as a function of HQprecipSource, we can identify the performance of various intercalibrated sensors and algorithms.

Conclusions

- **Different sensor/algorithm inputs into IMERG have different errors.**
- **Direct GPROF and Ku validation show ranking of performance by sensors (Ku > GMI/AMSR2 > SSMIS/ATMS/MHS) and by surface type (vegetation > coast > semiarid).**
- **False alarms is an issue over WGEW (semiarid environment)**
- **Lag analysis reveals a peak in performance at positive lag, but limited sample sizes prevent a precise quantification.**
- **GPROF tends to overestimate variable rain and underestimate uniform rain.**
- **GPROF appears to have difficulty detecting light rain over coastal and semiarid environments.**
- **Case studies illustrate challenge in retrieving scattered or isolated convective rainfall, as well as false alarms over WGEW.**

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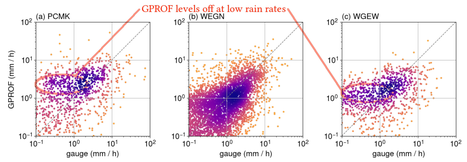
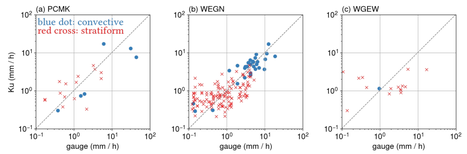
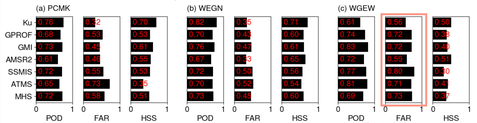
Ku & GPROF Validation

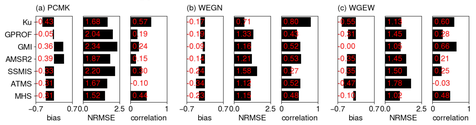




Rain detection at 0.2 mm / h: Probability of Detection, False alarm ratio, and Heidke Skill Score



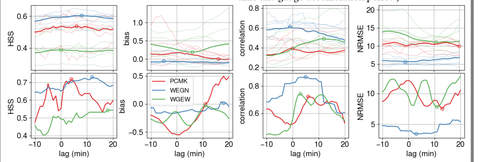
Rain intensity metrics of raining pairs



- **Sensor ranking: Ku > GMI/AMSR2 > SSMIS/ATMS/MHS.**
- **Surface ranking: vegetation (WEGN) > coast (PCMK) > semiarid (WGEW).**
- **Particular problems: false alarms in Ku and GPROF over WGEW; low rain rates in GPROF over PCMK and WGEW.**
- **Limited sample sizes hinder robust conclusions with gauges.**

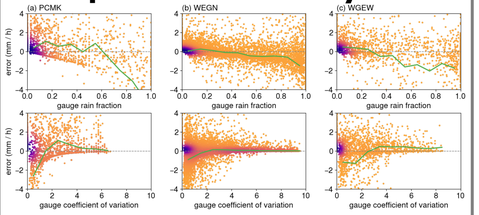
Lag Analysis

(Adding time lag to GPROF overpass time and gauge accumulation period.)



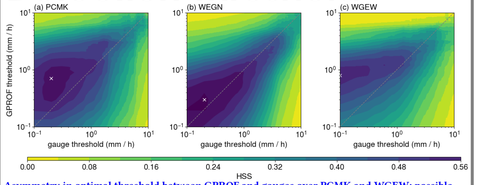
GPROF and Ku show positive lag at 0 to +20 min, but difficult to constrain due to limited sample size.

Sub-pixel Variability



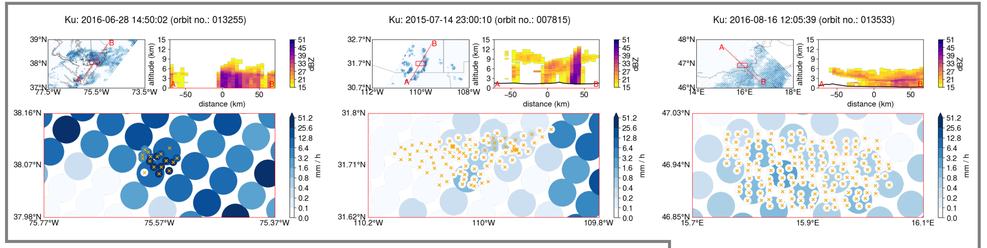
GPROF error is positive at low rain fraction and high CV, and negative at high rain fraction and low CV.

Detection Threshold

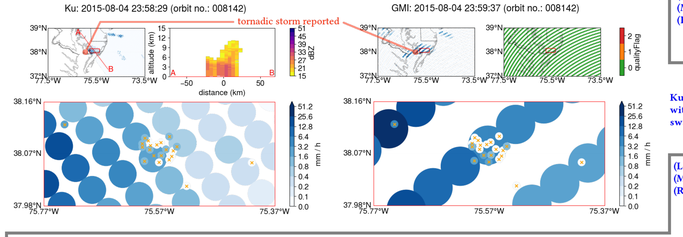


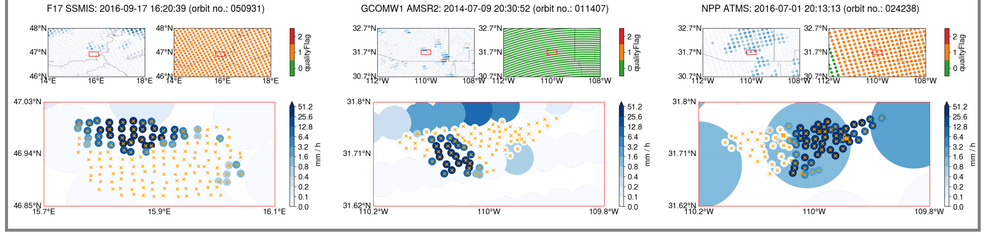
Asymmetry in optimal threshold between GPROF and gauges over PCMK and WGEW; possible limitation in retrieving light rain (≲ 0.7 mm / h) over coastal and semiarid environments.

Case Studies



(Left) underestimation of intense convective storm over PCMK
(Middle) overestimation of isolated convection over WGEW
(Right) false alarm of stratiform precipitation over WEGN



Ku and GMI overestimating isolated deep convection associated with tornadic thunderstorm. Reported tornado is beyond Ku swath.

(Left) severe underestimation by SSMIS over WEGN
(Middle) underestimation of scattered rain by AMSR2 over WGEW
(Right) severe underestimation by ATMS over WGEW