Bridging of Ground Validation between Gridded and Orbit-Level Rainfall through IMERG

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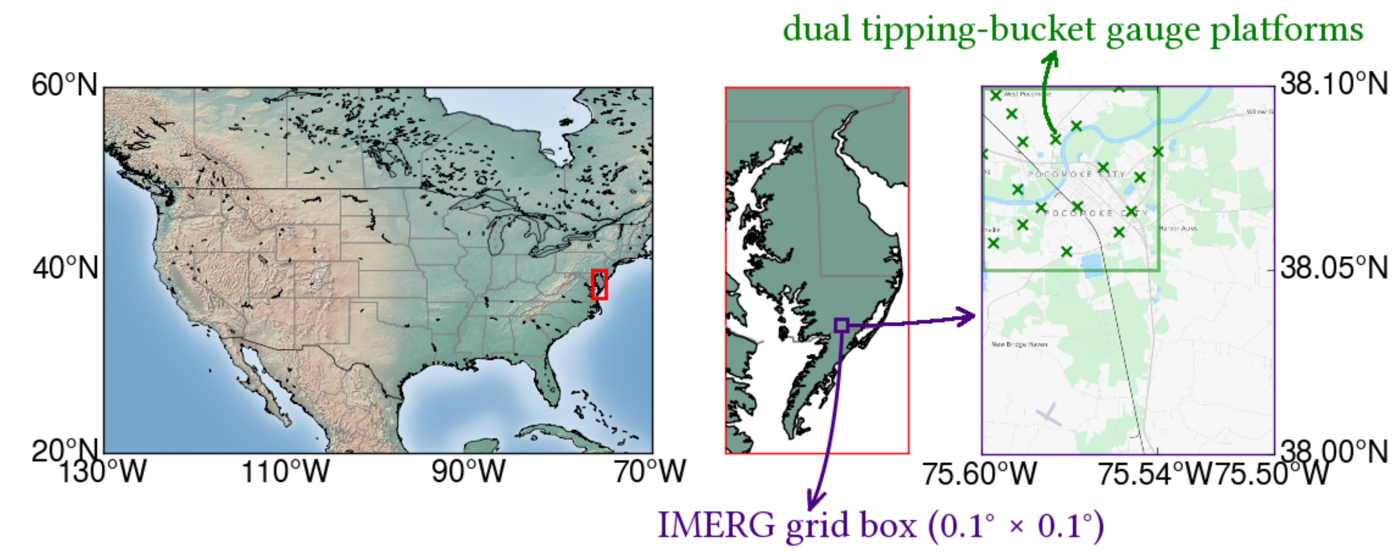
Intro & Methods



AIMS & GOALS

Use dense gauge network in Pocomoke City, MD to validate the Multi-Radar Multi-Sensor (MRMS) rainfall product, then use MRMS to validate Integrated Multi-satellite Retrievals for GPM (IMERG) over larger region; and ultimate advance our understanding rainfall retrieval errors and improve satellite rainfall estimates.

DATA & VARIABLES

IMERG: GPM Level 3 product; 0.1°, 30 min; up to ±60° latitude
MRMS: radar-based estimate of rainfall; 0.01°, 1 h; CONUS (Stage III)
Pocomoke gauges: network of tipping-bucket gauges maintained by WFF

P_G: average rain rate of 18 × 2 gauges
P_I: IMERG rain rate
P_{MG}: average MRMS rain rate over gauges (green box)
P_{MI}: average MRMS rain rate over IMERG grid box (indigo box)

APPROACH

Using 12 months of data (Apr 2014 to Mar 2015) excluding days with snow and the day after, we evaluate IMERG based on two aspects: (i) how well it identifies rain instances (≥ 0.1 mm / h) and (ii) how well it captures rain rates for raining instances.

MRMS is used to determine the effect of area difference (indigo box vs. red box) and to serve as a benchmark for IMERG.

By using the rain estimate source in the IMERG files, we can further trace half-hour comparisons of IMERG and the gauges to each source category. This allows us to bridge the ground validation to orbit-level products.

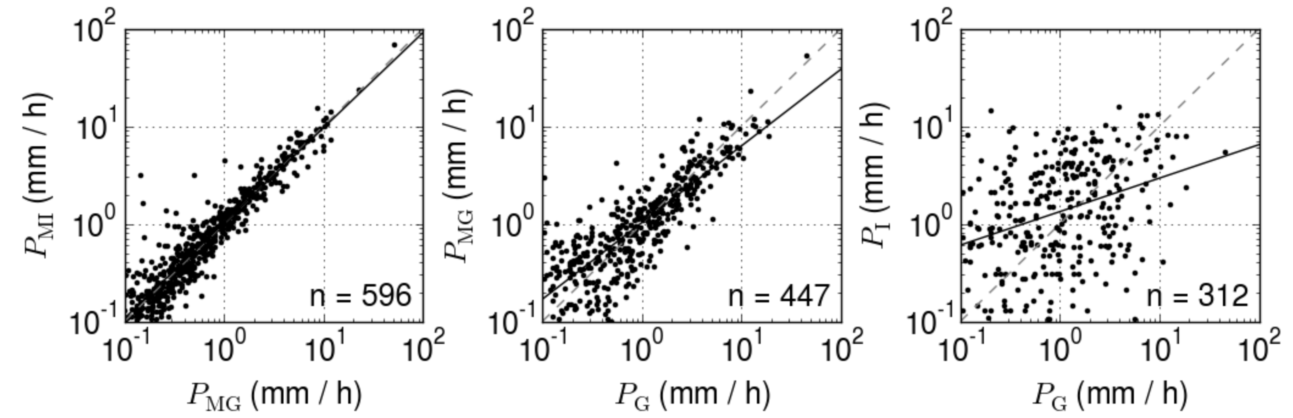
Validation of IMERG

	P_{MI} ≥ 0.1 mm / h	P_{MI} = 0 mm / h
P_{MG} ≥ 0.1 mm / h	596 (9.3%)	0 (0.0%)
P_{MG} = 0 mm / h	14 (0.2%)	5804 (90.5%)

	P_{MG} ≥ 0.1 mm / h	P_{MG} = 0 mm / h
P_G ≥ 0.1 mm / h	447 (7.6%)	49 (0.8%)
P_G = 0 mm / h	93 (1.6%)	5274 (90.0%)

	P_I ≥ 0.1 mm / h	P_I = 0 mm / h
P_G ≥ 0.1 mm / h	312 (4.2%)	277 (3.8%)
P_G = 0 mm / h	121 (1.6%)	6666 (90.4%)

Contingency tables show hits (top-left), misses (top-right), false alarms (bottom-left) and correct rejections (bottom-right) between pairs of data. For the hits, we examine the rain rates below.



For the hits, we calculate the normalized total error (NTE) and normalized absolute error (NAE), which characterizes systematic and random errors respectively. We also apply the multiplicative error model, which is more valid for rainfall error analysis (Tian et al., 2013). In this model, systematic errors are represented by α and β while random errors are represented by ε ~ N(0, σ). The model describes a straight line in logarithmic space.

$$\mathrm{NTE} = \frac{\sum_{i=1}^{n}(y_i - x_i)}{\sum_{i=1}^{n} x_i} \quad \mathrm{NAE} = \frac{\sum_{i=1}^{n}|y_i - x_i|}{\sum_{i=1}^{n} x_i}$$

$$y_i = e^{\alpha} x_i^{\beta} e^{\varepsilon_i}, \ \varepsilon \sim \mathcal{N}(0, \sigma)$$

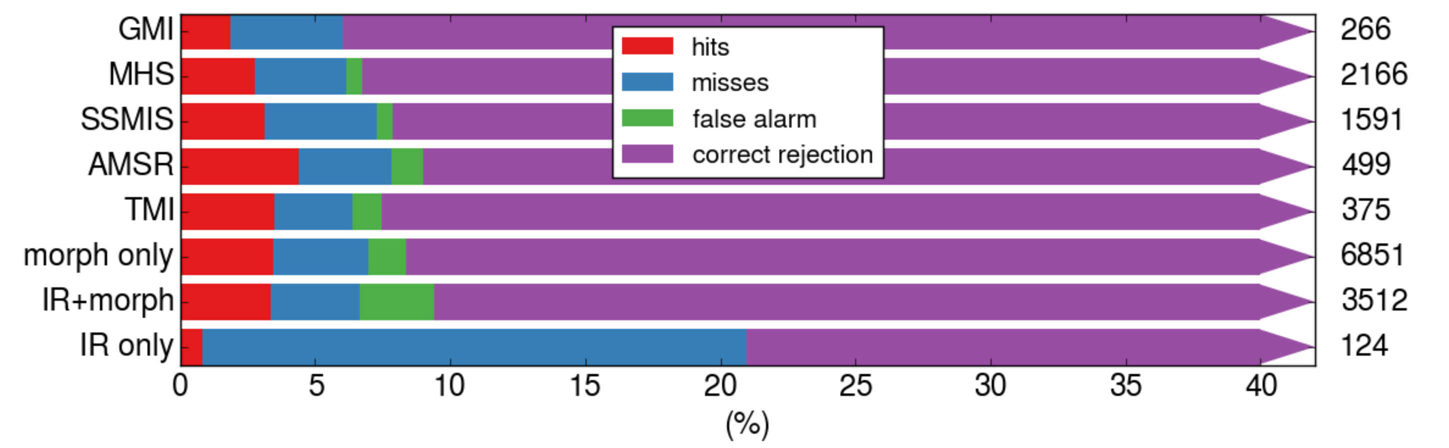
	NTE	NAE	α	β	σ
P_{MI}, P_{MG}	0.062	0.218	0.016	0.976	0.390
P_{MG}, P_G	-0.023	0.344	0.030	0.785	0.597
P_I, P_G	0.158	1.030	0.289	0.343	1.123

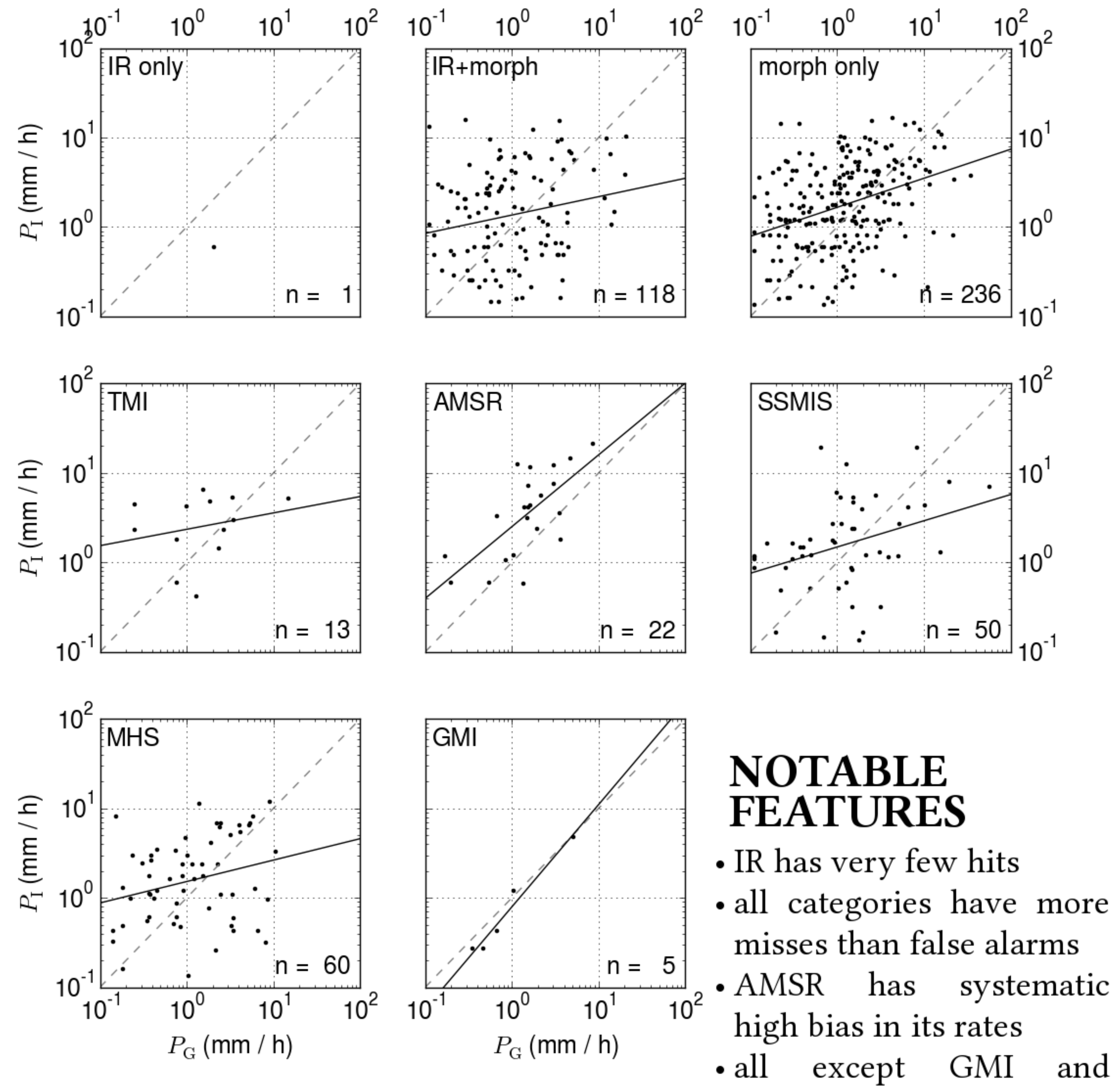
NOTABLE FEATURES

- area difference does not play a significant role in rain instances or rain rates
- MRMS performs admirably against the gauges, though with more false alarms than misses and a slight underestimation of heavy rain
- IMERG has significantly more misses, a greater underestimation of heavy rain and overestimation of light rain, and considerable scatter

Tian, Y., G. J. Huffman, R. F. Adler, L. Tang, M. Sapiano, V. Maggioni, and H. Wu, 2013: Modeling errors in daily precipitation measurements: Additive or multiplicative? Geophys. Res. Lett., 40, 2060–2065, doi:10.1002/grl.50320.

Categorization by Source



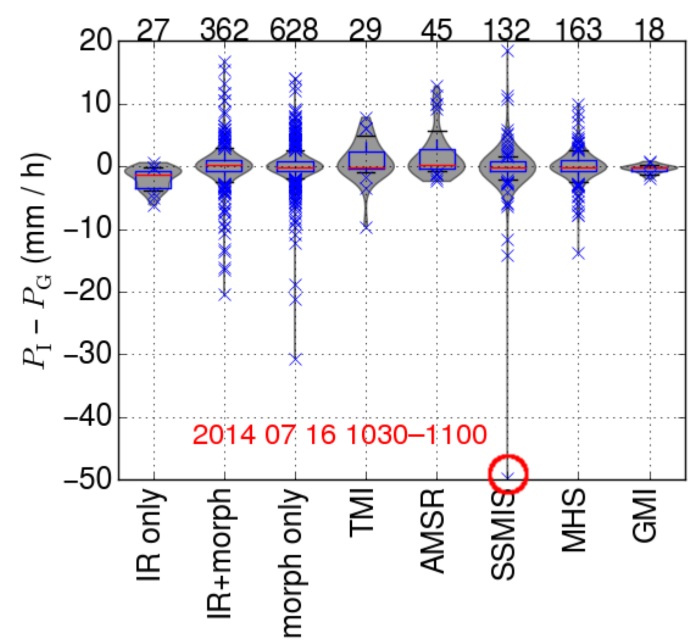


	n	NTE	NAE	α	β	σ
IR+morph	118	0.186	1.186	0.309	0.206	1.188
morph only	236	0.200	1.032	0.508	0.324	1.034
TMI	13	0.228	0.947	0.854	0.183	0.794
AMSR	22	1.706	1.820	0.921	0.803	0.784
SSMIS	50	-0.144	1.078	0.398	0.293	1.090
MHS	60	0.227	1.006	0.420	0.240	1.052
GMI	5	-0.099	0.136	-0.232	1.143	0.208

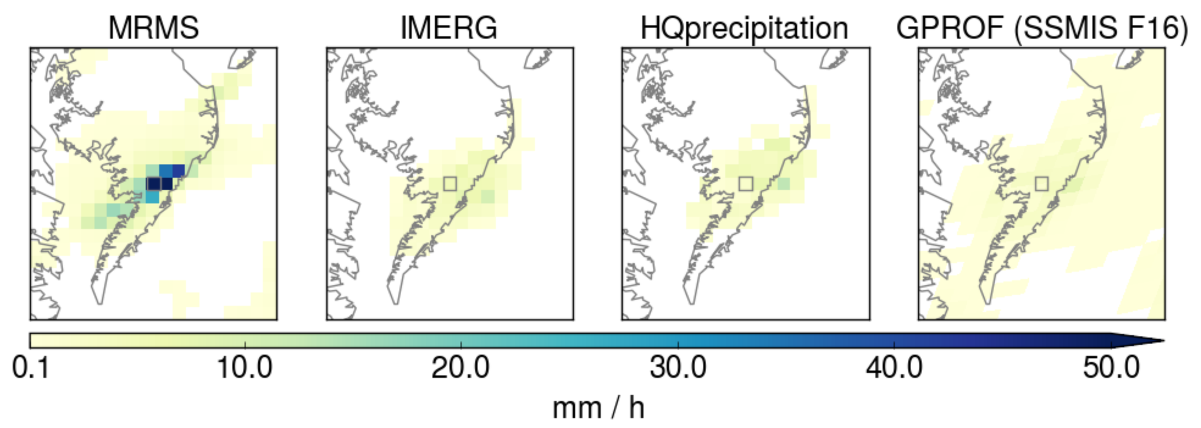
NOTABLE FEATURES

- IR has very few hits
- all categories have more misses than false alarms
- AMSR has systematic high bias in its rates
- all except GMI and AMSR has "too much drizzle, too little heavy rain"
- TMI, AMSR and GMI have lower random error
- ranking in performance: microwave, morphing, IR

Case Study



An event in which IMERG severely underestimates the rain rate was associated with SSMIS (left). Looking at the large-scale picture (below), this is because the orbit-level estimates (GPROF) failed to pick up this cell. This comparison illustrates the bridging of ground validation to orbit-level products via IMERG.



Summary & Future Work

At pixel level, IMERG has more misses than false alarms, overestimates drizzle and underestimates heavy rain, and has considerable scatter. Breaking it down into sources, these issues are common with most categories. Moreover, AMSR has a systematically high bias while IR is deficient at identifying raining events. A case study involving SSMIS illustrates the bridging of ground validation between gridded and orbit-level products.

Future work will extend this analysis to larger regions using half-hour MRMS currently in development. This will enable us to obtain results that are statistically more robust, as well as examine the performance of various sources in different climates.

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