Global Precipitation Measurement mission GPROF comparison with MRMS

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with contributions from:
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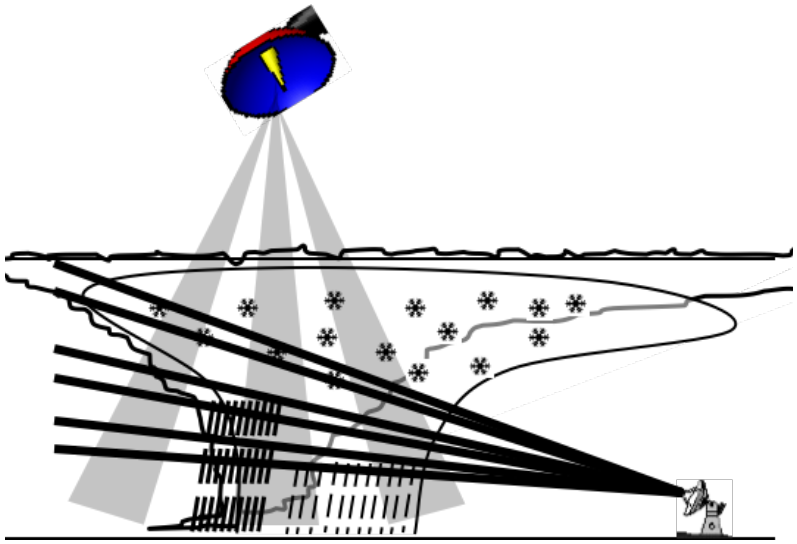
PMM Land Surface Working group
May 25, 2016

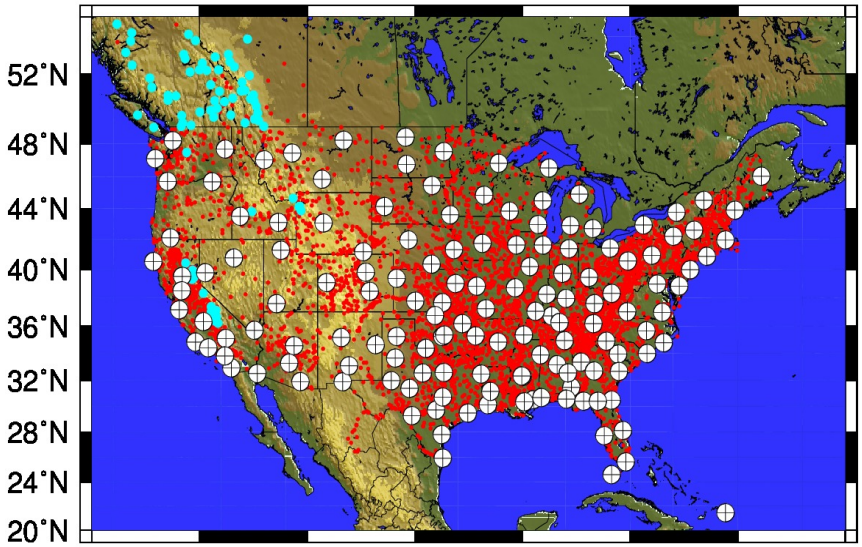


Context

- **GMI V03 to V04**
  - GPROF retrieval database: empirical (MRMS-match ups with Tbs) to populated with profiles from the GPM core observatory.
- **Level 1 requirements**
  - in preparation for the early 2017 End of Prime Mission reviews and to request extended operations, GPM must prove mission success
  - joint effort between the GV and the Algorithm teams
- **Requirements for the GMI Level 2 products**
  - quantify rain rates between 0.2 and 60 mm/hr at effective resolution of 15 km
  - detection of snowfall at effective resolution of 15 km
- **Requirements for the GMI, DPR or CMB Level 2 products**
  - rain rate biases at 50 km resolution <50% at 1 mm/hr; <25% at 10 mm/hr
  - rain rate random error at 50 km resolution <50% at 1 mm/hr; <25% at 10 mm/hr

Reference precipitation

- **provide calibrated ground-based precipitation measurements** and associated error characterizations for comparison with space-based radar and radiometer measurements
- identify the best sampling areas for MRMS



Sensor network
radars and HADS gauges

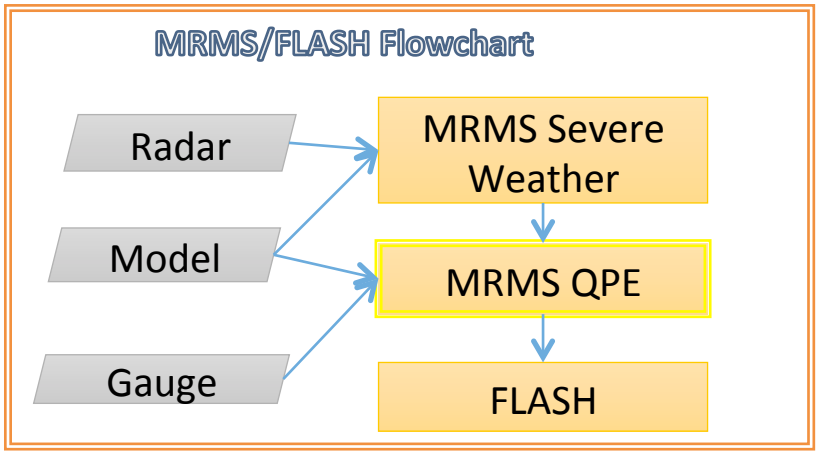
Multi Radar Multi Sensor System (MRMS): overview

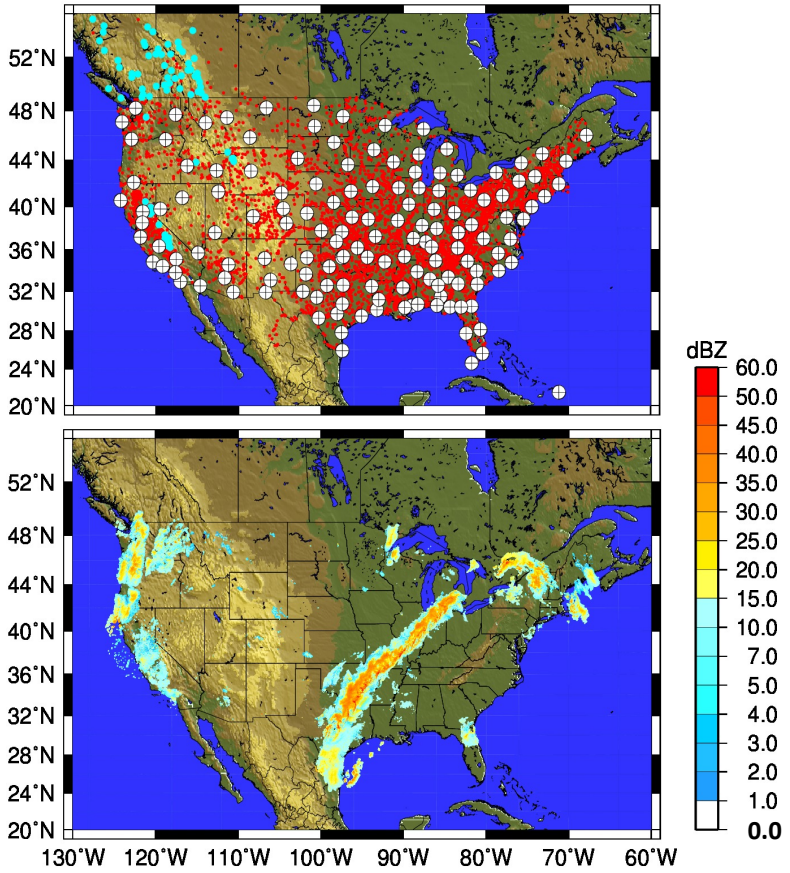
Domain: 20-55°N, 130-60°W

Resolution: 0.01°, 2 min update cycle

Data Sources:

~180 radars every 4-5min
~9000 gauges every hour
RAP model hourly 3D analyses



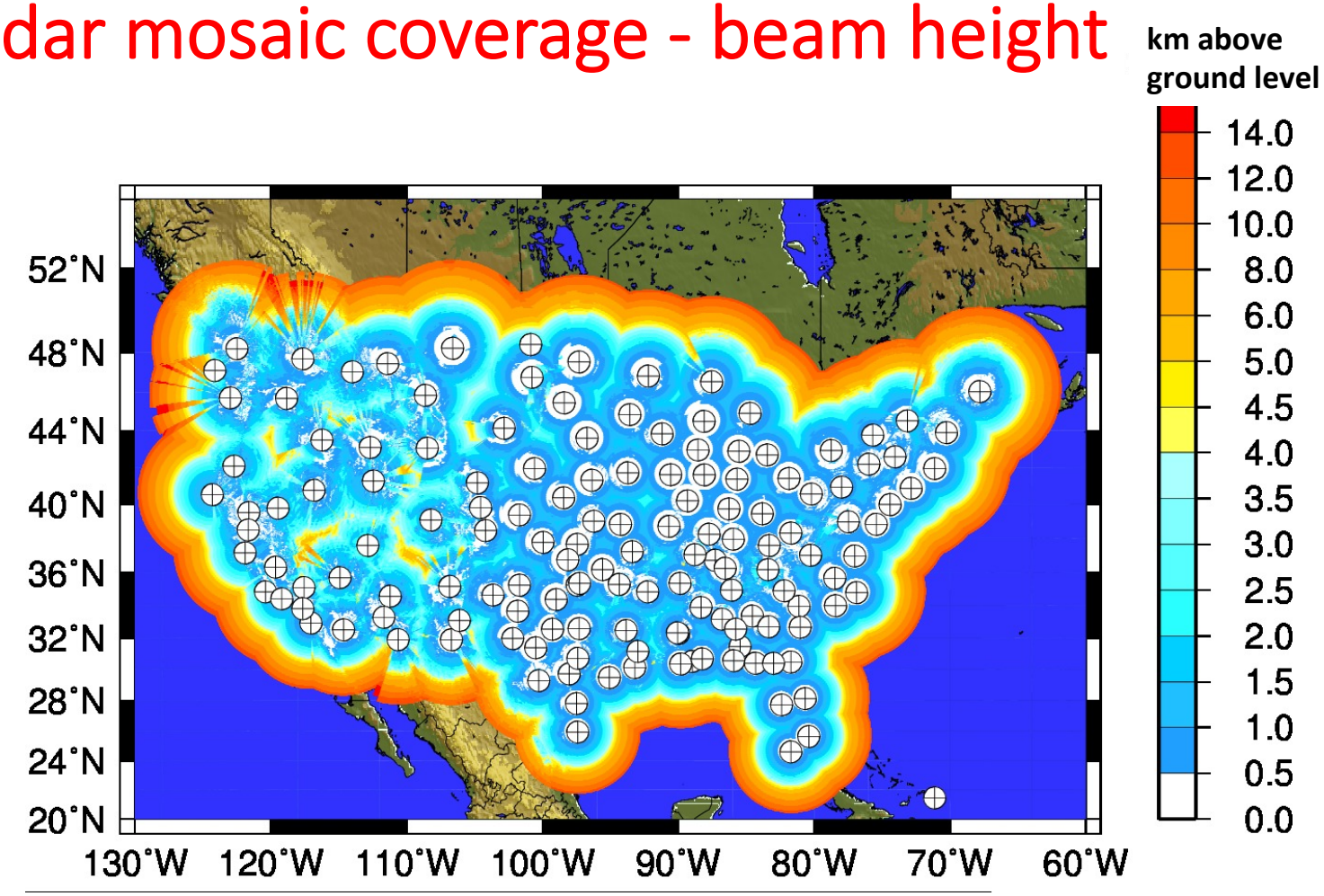


frontal system at 0800 UTC on 11 April 2011 near Michigan

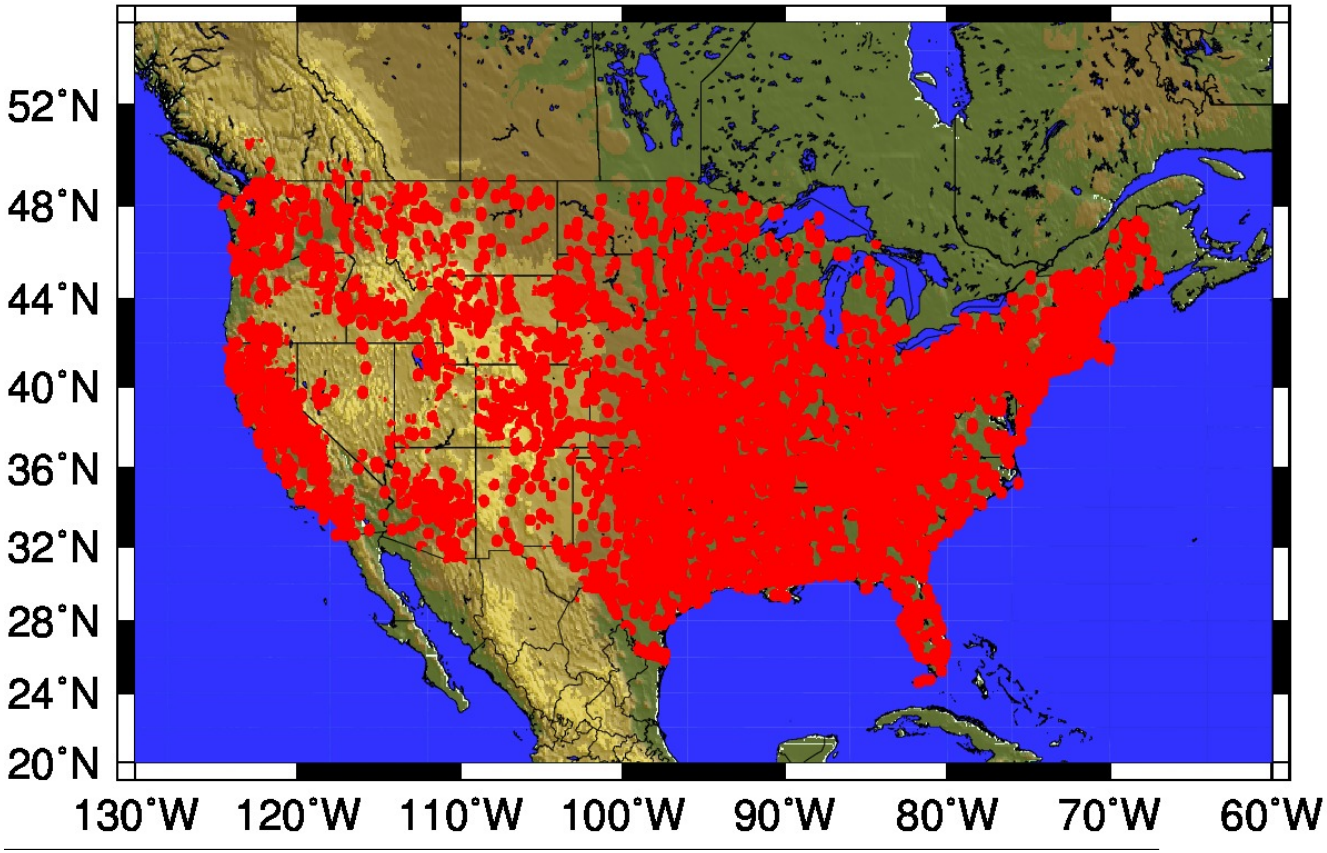
MRMS best observation areas

- **Objective**: identify MRMS best observation areas for GPM Level-1 requirements
- **Definition**: combination of good radar coverage (low radar beam) and high network density
  - **Beam height:** beam close to the surface
  - **Gauges density:** gauges nearby to support the QPE (hourly time scale)
- **Assumption**: rain field has a 25 km decorrelation distance at 1h timescale (Habib et al., 2001; Ciach et al. 2006; Kirstetter et al. 2010, 2013; …)
- **Comment**: static identification based on radar hydrologic visibility and gauge network location. To combine with dynamic radar visibility (RQI) and gauge information (radar-gauge ratios)

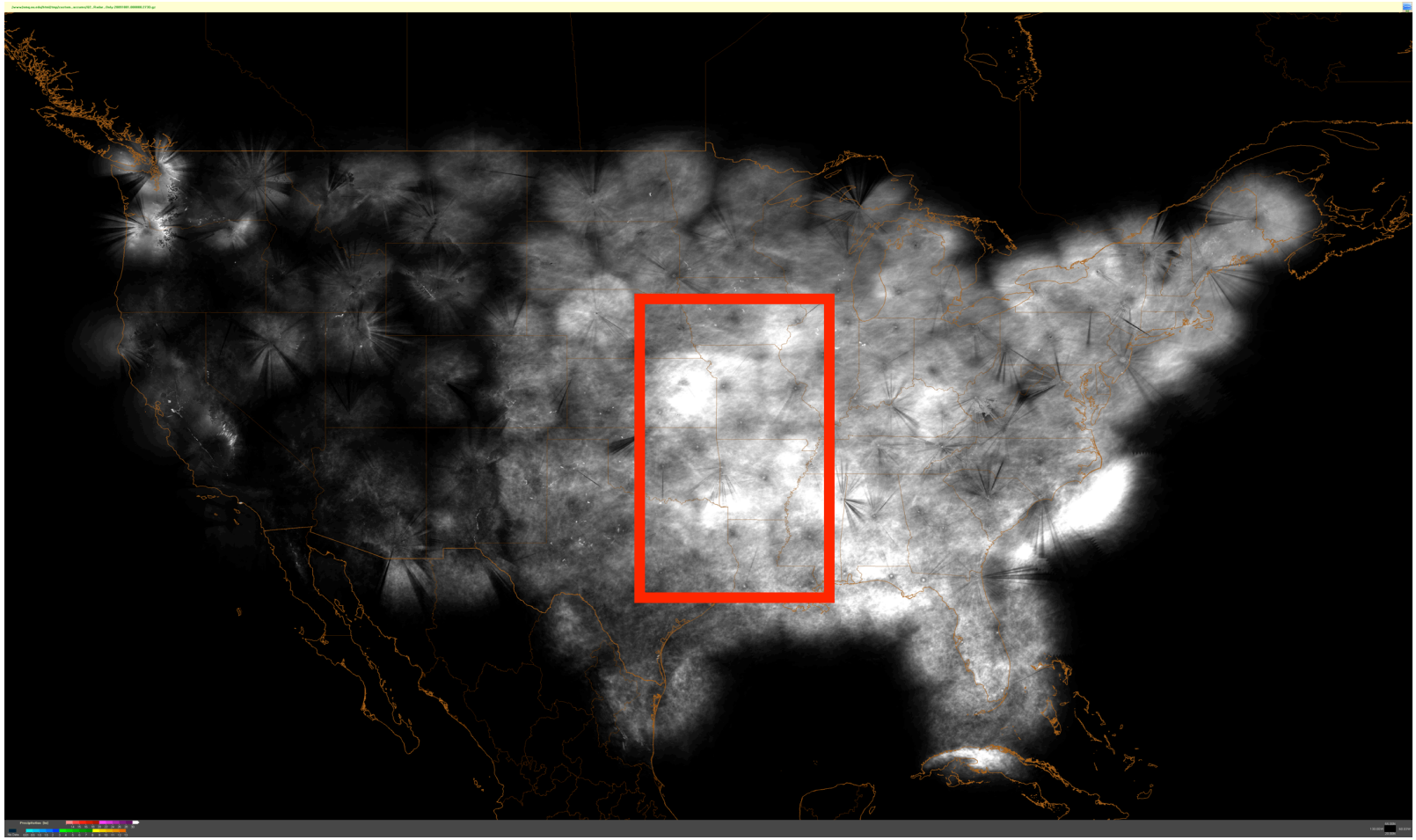
Radar mosaic coverage - beam height



MRMS best observation areas
radar beam height < 2 km & gauge < 25 km

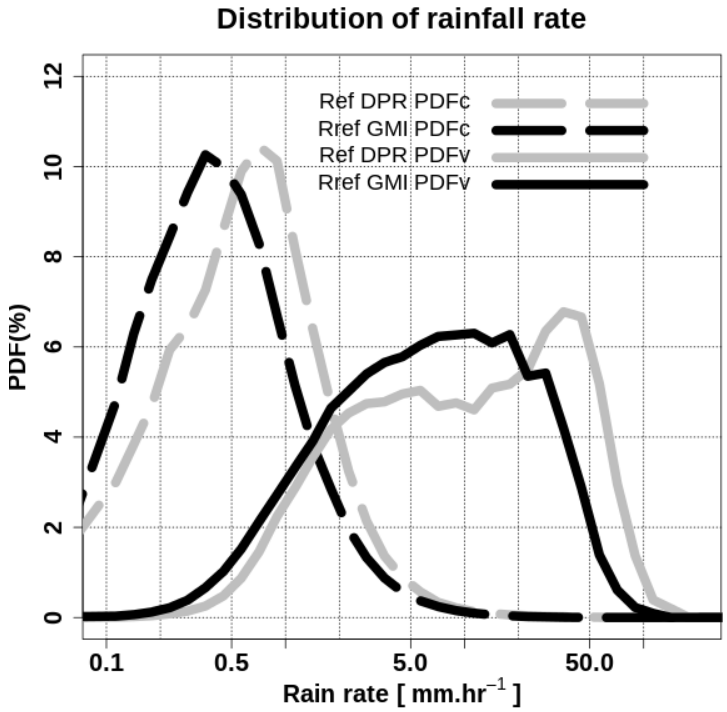


MRMS best observation areas



Reference: scaling analysis

- Reference for DPR & Ku computed at ~5km resolution
- Reference for GMI computed at ~15km resolution



PDFc: PDF by occurrence
PDFv: PDF by volume

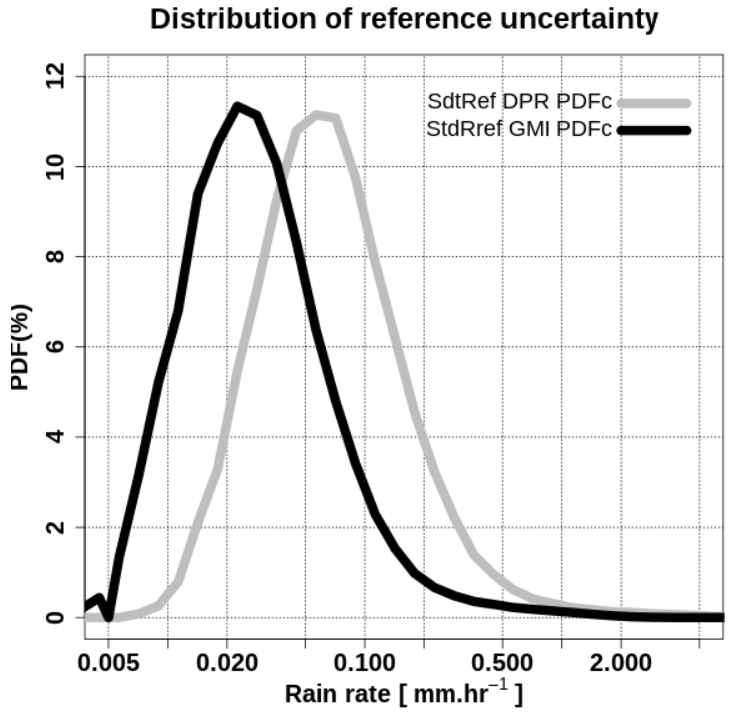
$$R_{\text{ref}}(A) = \frac{1}{\sum_{i=1}^{n} \omega_i} \sum_{i=1}^{n} \omega_i Q2(a_i), \quad \text{with}$$

$$\omega_i = \int_{\theta_{\text{mesh}}(a_i)} f^2(\theta, \theta_0)\, d\theta,$$

Kirstetter et al. 2012

Reference: scaling analysis

- DPR reference relative uncertainty typical range: [7-30] %
- GMI reference relative uncertainty typical range: [4-13] %



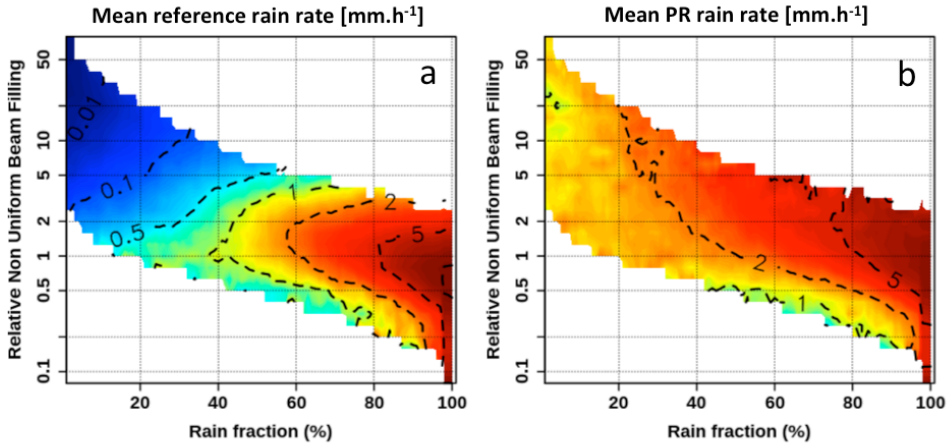
GPM Science Implementation Plan

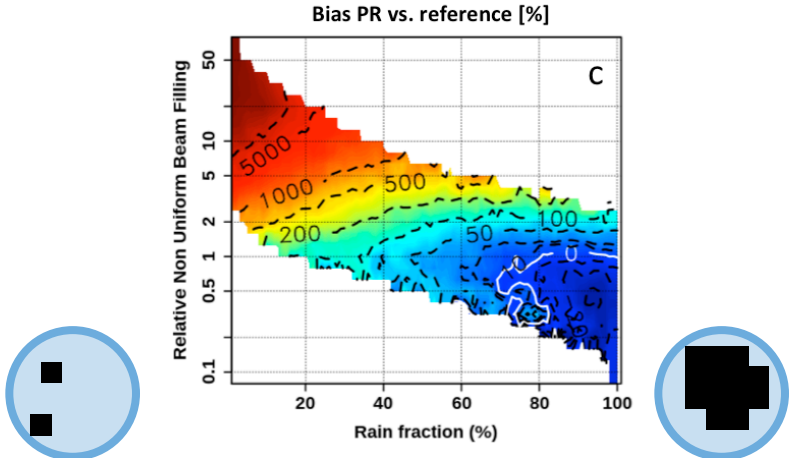
$$\frac{\sigma_{E1}}{\sigma_{E2}} = \left(\frac{L_2}{L_1}\right)^{0.70}$$ = 2.16

between 5km and 15 km

Empirical result ~ 2.38

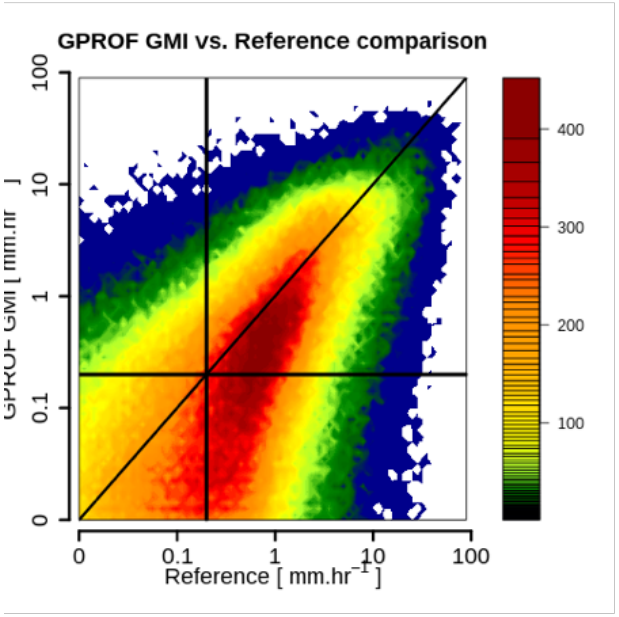
Scaling analysis: pixel conditions



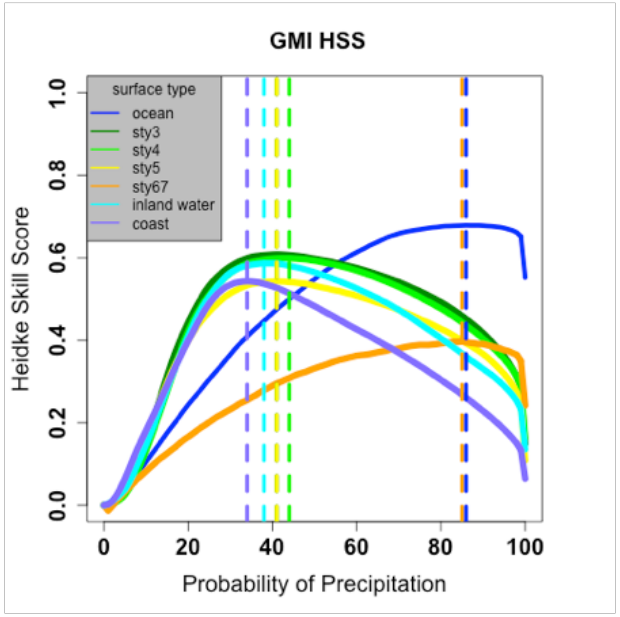


Kirstetter et al. 2015

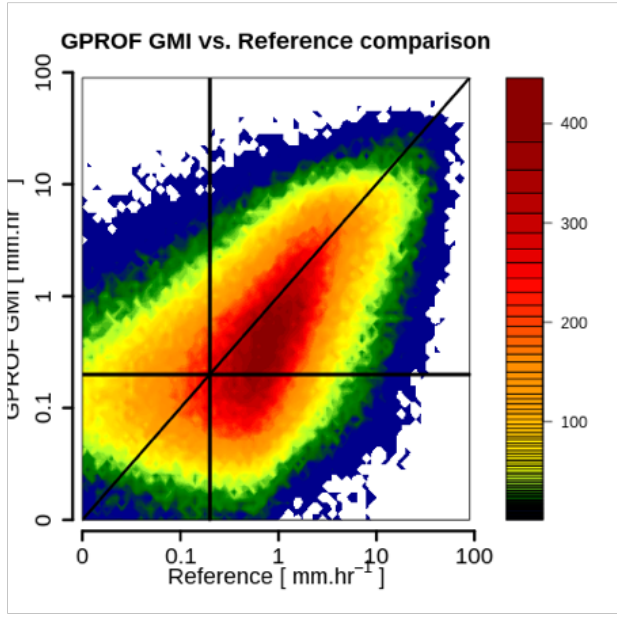
GMI GPROF: probability of precipitation



PoP > 0



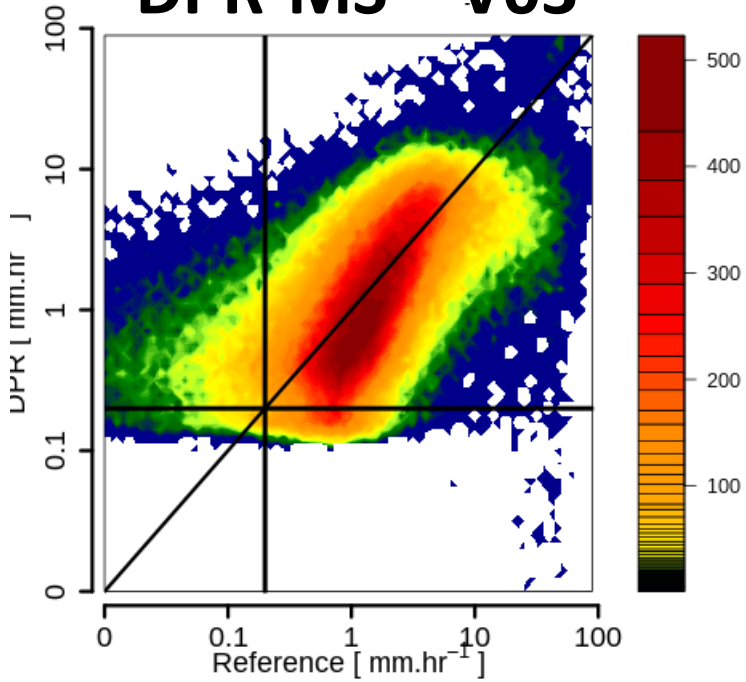
$$HSS = \frac{2(HC - FM)}{F^2 + M^2 + 2HC + (F + M)(H + C)}$$



PoP > 40

Scatterplots: DPR-MS V03 vs V04

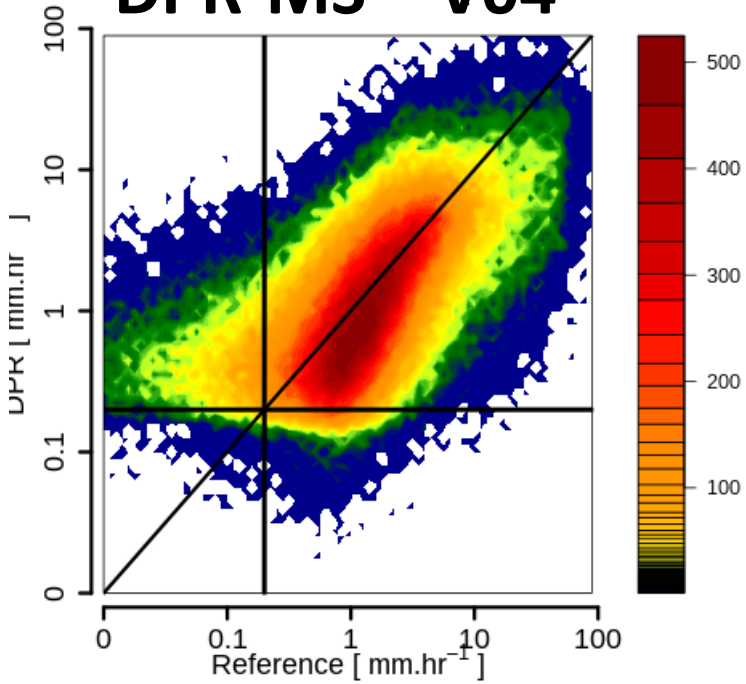
DPR-MS – V03



Bias **-18.7 %**

Correlation **0.40**

DPR-MS – V04

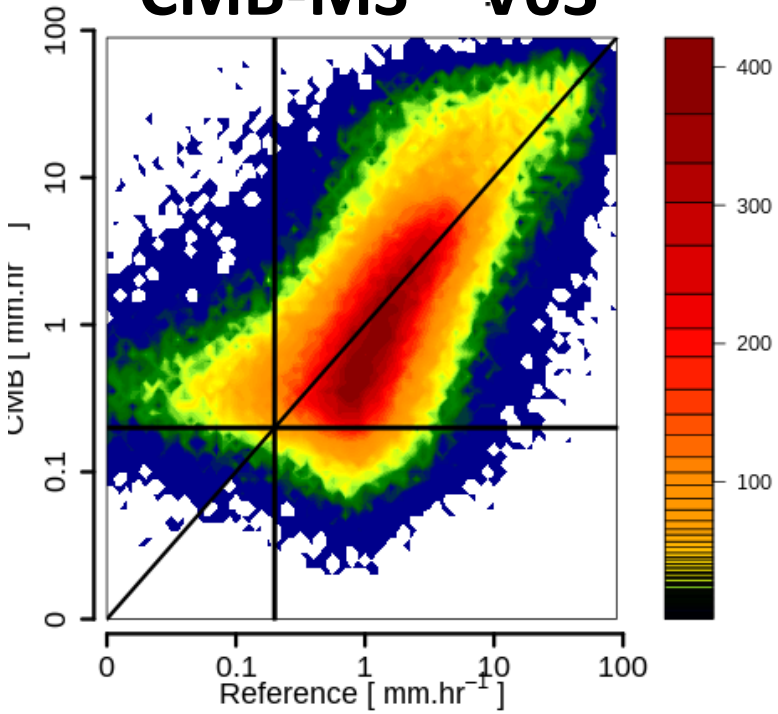


Bias **-18.1 %**

Correlation **0.44**

Scatterplots: CMB-MS V03 vs V04

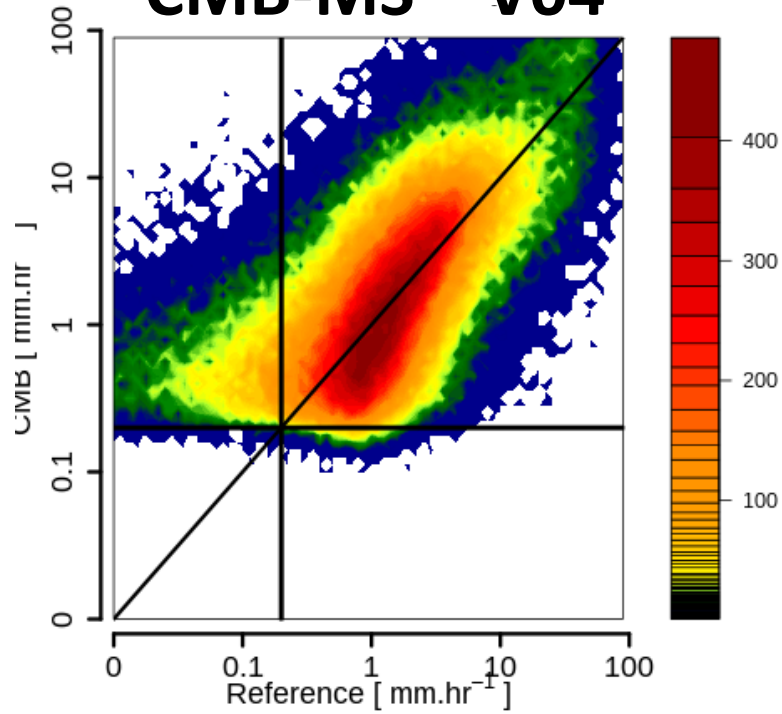
CMB-MS – V03



Bias **+25.5 %**

Correlation **0.55**

CMB-MS – V04

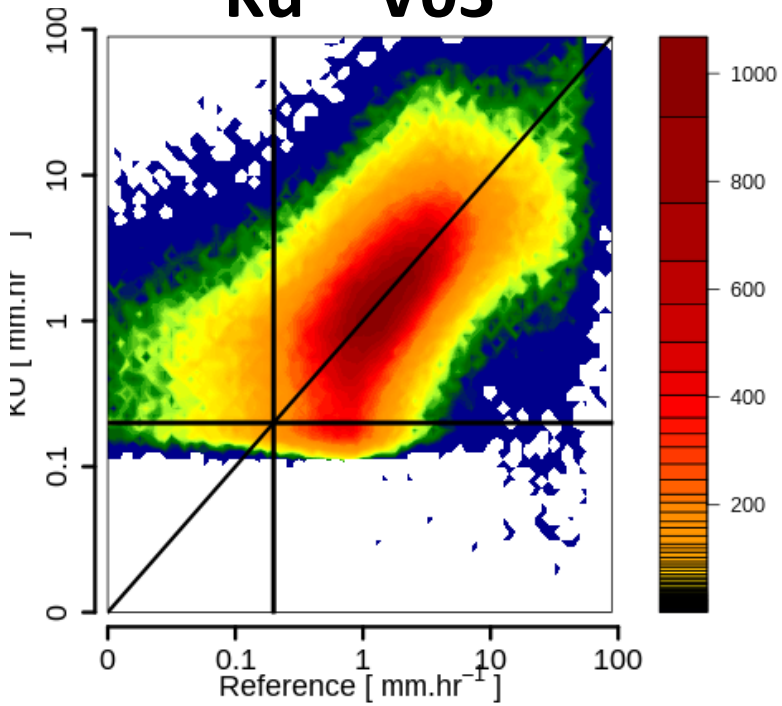


Bias **+37.6 %**

Correlation **0.57**

Scatterplots: Ku V03 vs V04

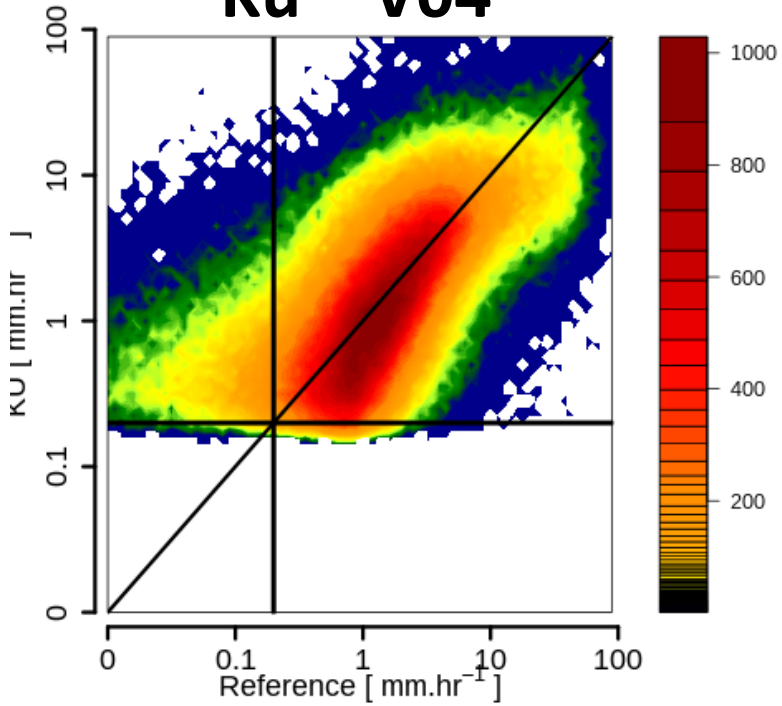
Ku – V03



Bias **1.3 %**

Correlation **0.40**

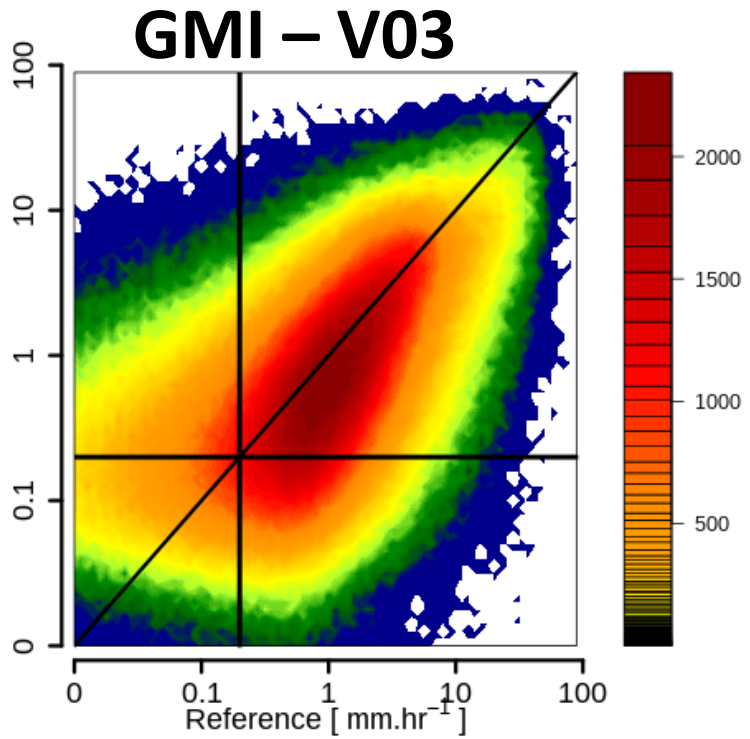
Ku – V04



Bias **-1.8 %**

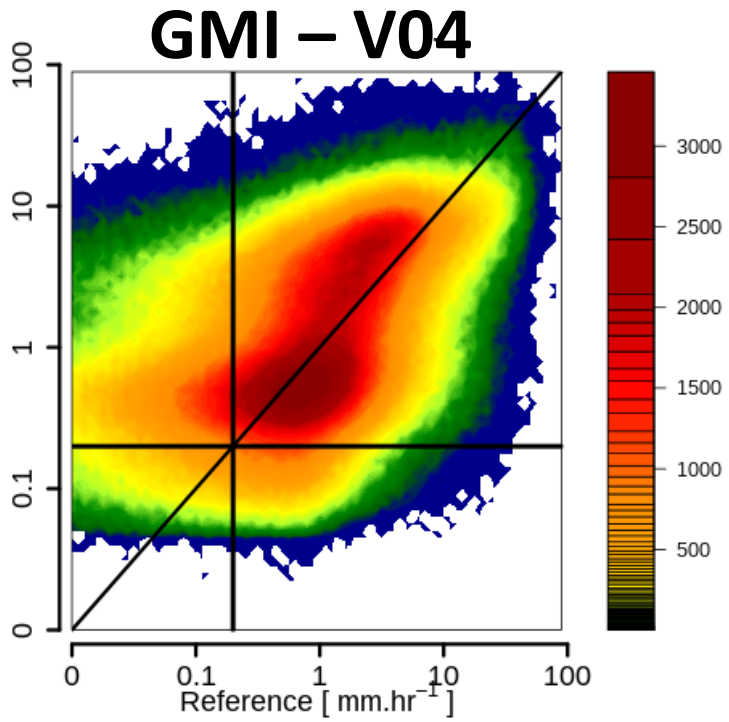
Correlation **0.44**

Scatterplots: GMI V03 vs V04



Bias **-21.4 %**

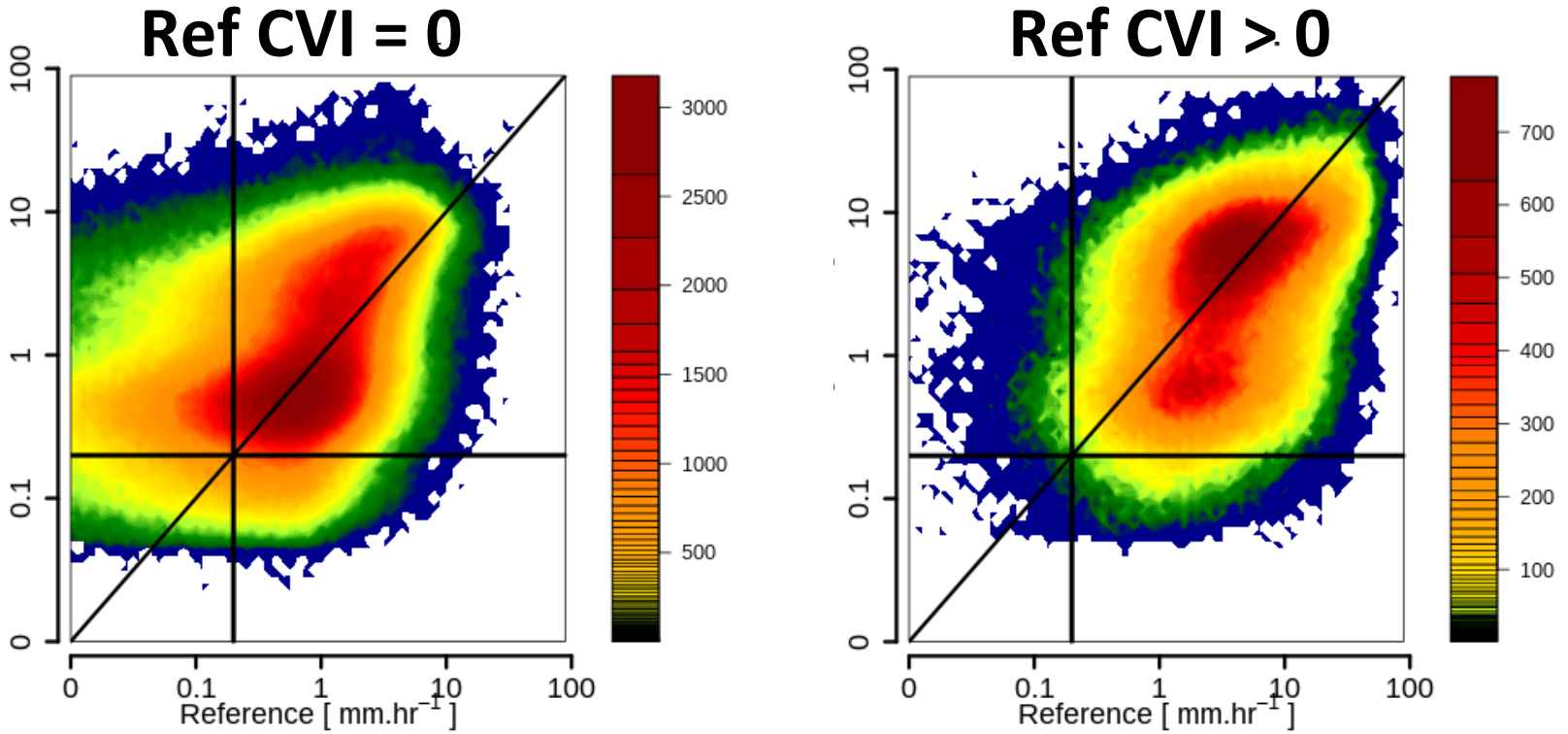
Correlation **0.51**



Bias **+14.7 %**

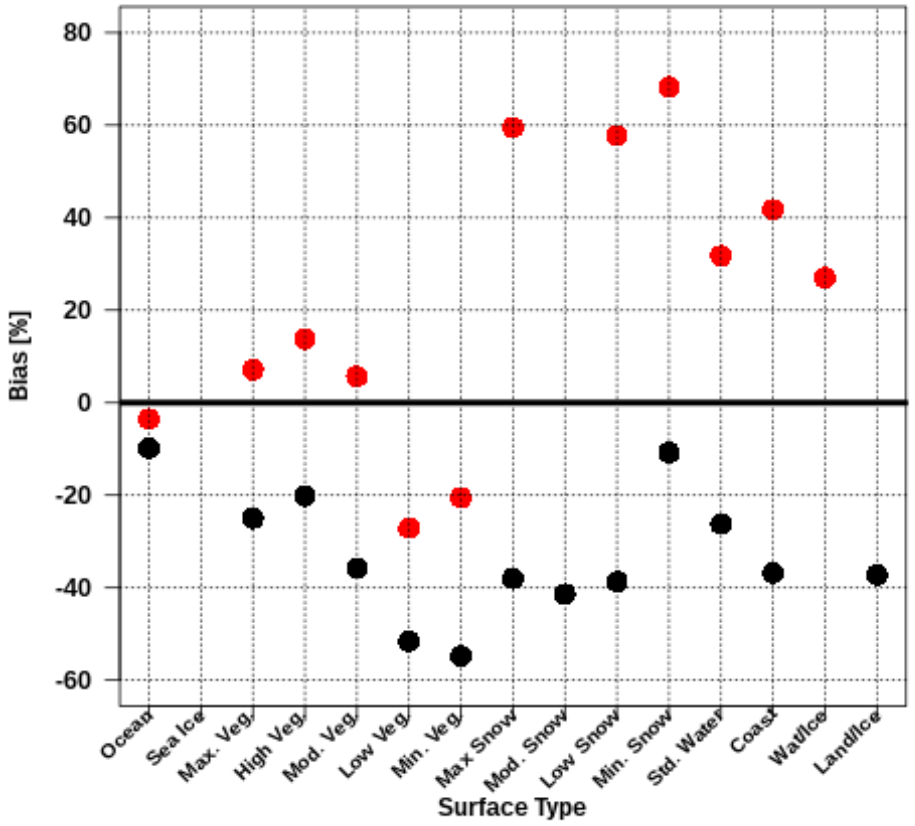
Correlation **0.45**

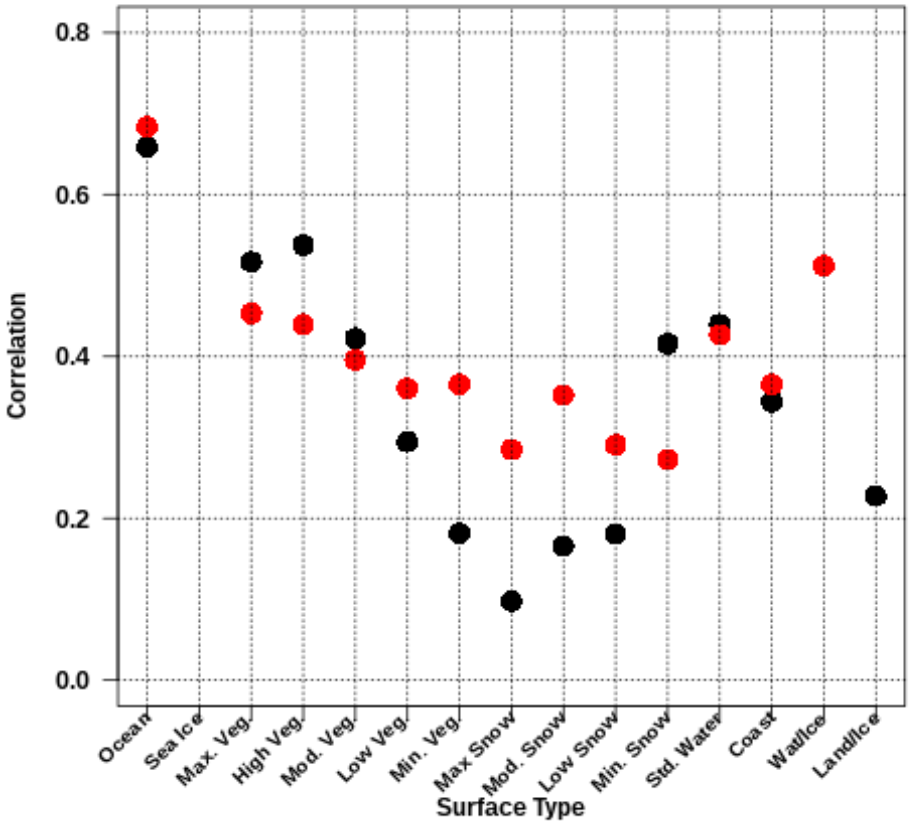
GMI V04 - Precipitation typology analysis



CVI: MRMS convective precipitation volume contribution to the precipitation rate in the GMI footprint

GMI surface type – V03 vs V04





GMI L1 requirements: V03 vs V04

In general

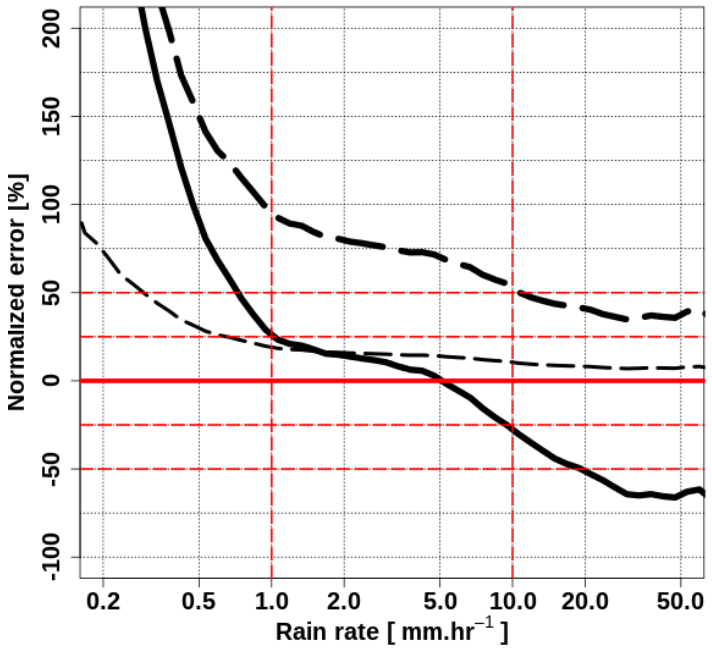
- Reference > 0; Satellite > 0;
- Additional condition specific to GPROF: PoP > 40

L1 conditional plots, for each bin of reference rain rate:

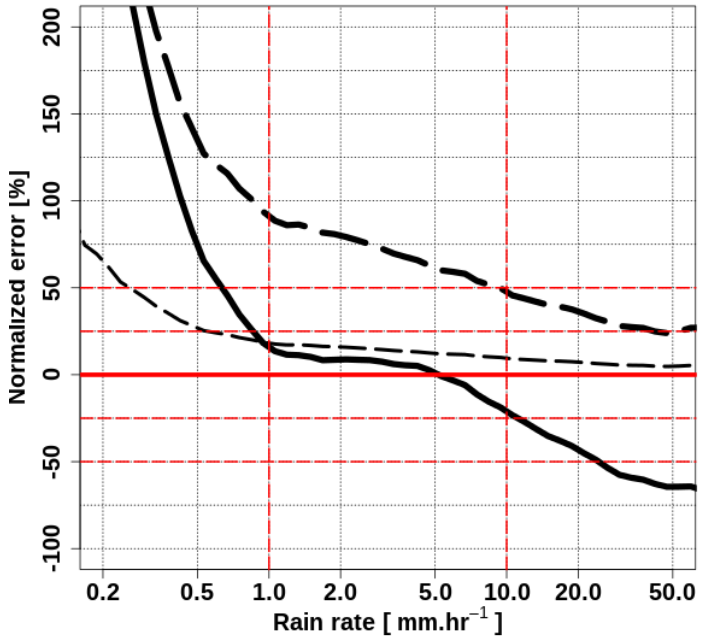
1. Filter out extreme residual (satellite - reference) values: 5% highest and 5% lowest
2. Compute relative bias in percent (systematic error)
3. Compute the standard deviation of residuals (random error). The systematic error is filtered out and the EVS is applied. The standard deviation is normalized by the reference rate and expressed in %.

Ku L1 requirements: V04

Ku – V03



Ku – V04

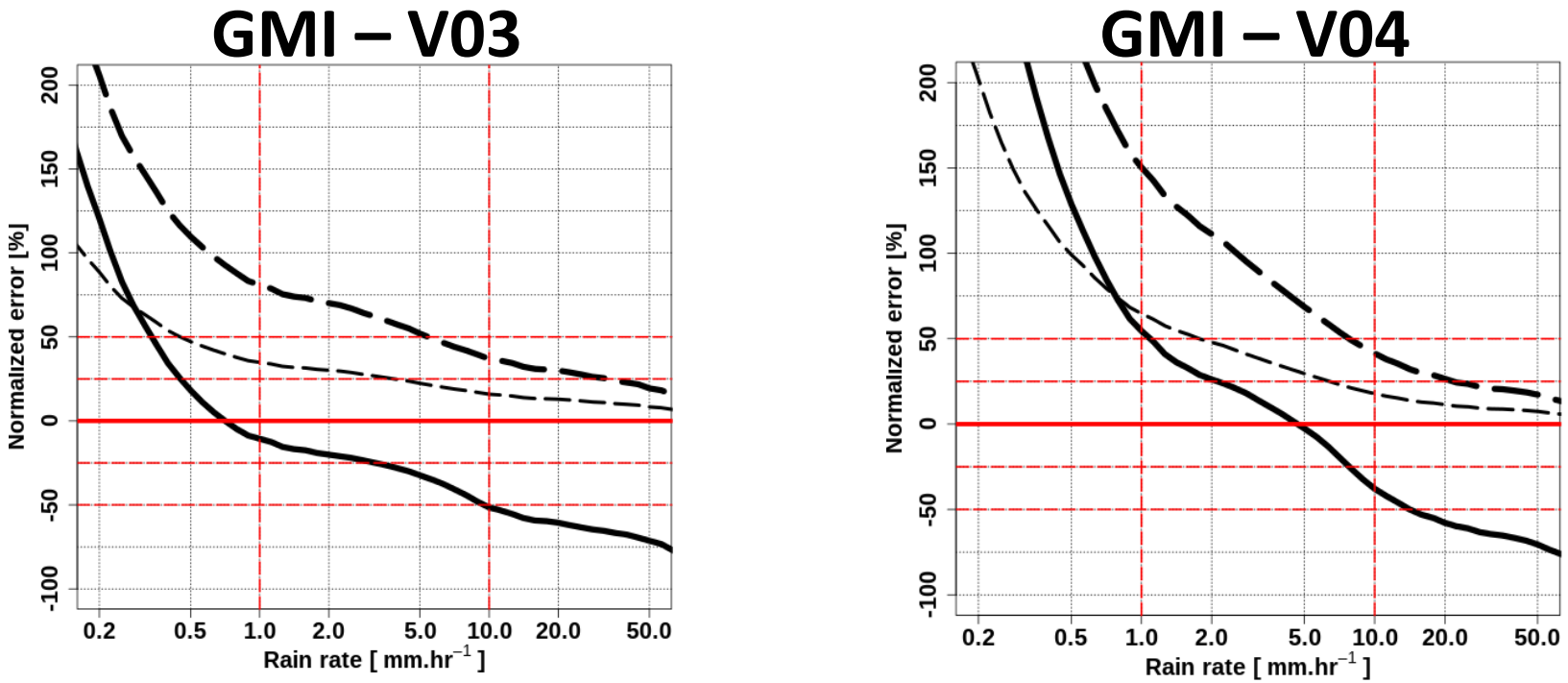


bias observed at Ku resolution

RMSE observed at Ku resolution

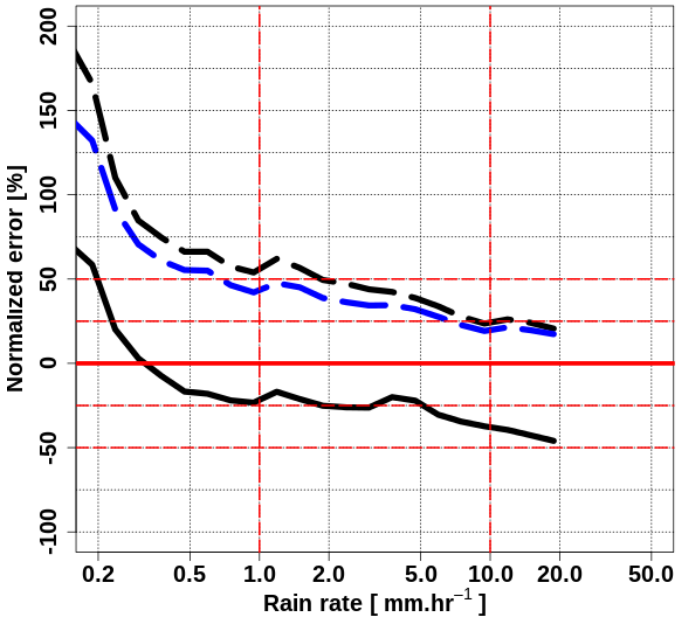
RMSE predicted at 50 km resolution

GMI L1 requirements: V04

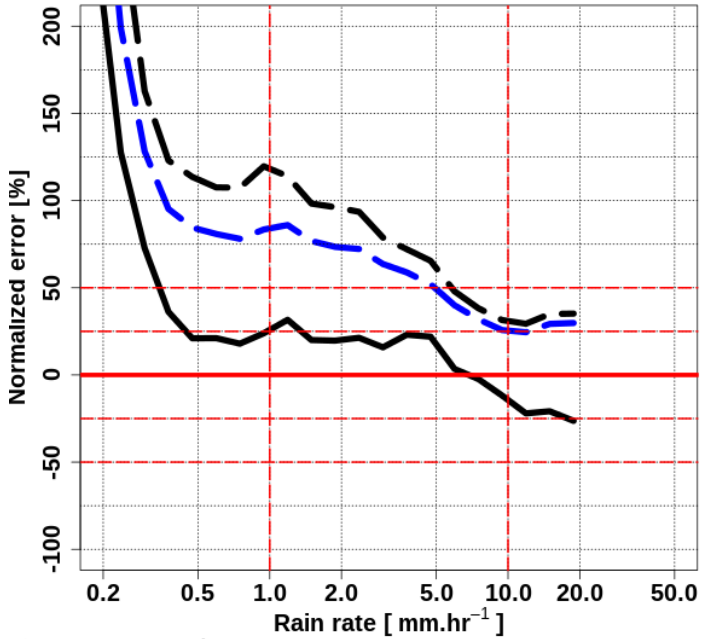


GMI L1 requirements: V03 vs V04 at 50 km

GMI – V03



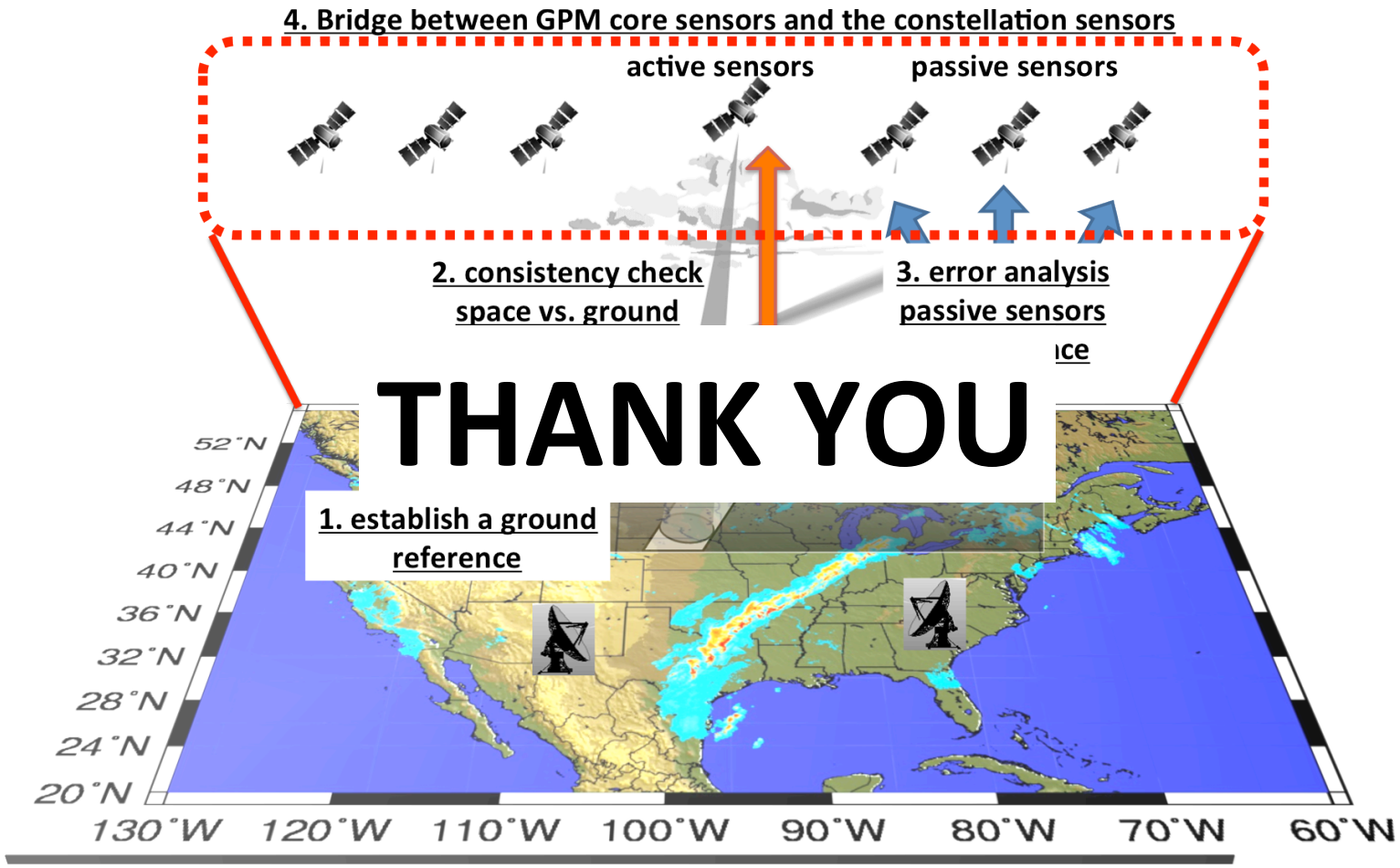
GMI – V04



bias observed at 50 km

RMSE observed at 50 km

MAE observed at 50 km


4. Bridge between GPM core sensors and the constellation sensors
active sensors
passive sensors
2. consistency check
space vs. ground
3. error analysis
passive sensors
THANK YOU
1. establish a ground
reference
52°N
48°N
44°N
40°N
36°N
32°N
28°N
24°N
20°N
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W