IMERG Precipitation Validation with the GPM Validation Network

Daniel Watters

NASA Postdoctoral Program Fellow, NASA Marshall Space Flight Center

P. Gatlin, P. Kirstetter, G. Huffman, J. Tan, E. Nelkin, D. Bolvin, D. Wolff, J. Wang

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Overview

- The Global Precipitation Measurement [GPM] Mission
  - Core Observatory
  - Satellite Constellation
  - Precipitation Product – IMERG

- The GPM Validation Network
  - Current Status
  - Update: Including IMERG

- Conclusions and Future Studies

GLOBAL PRECIPITATION MEASUREMENT

The Global Precipitation Measurement Mission

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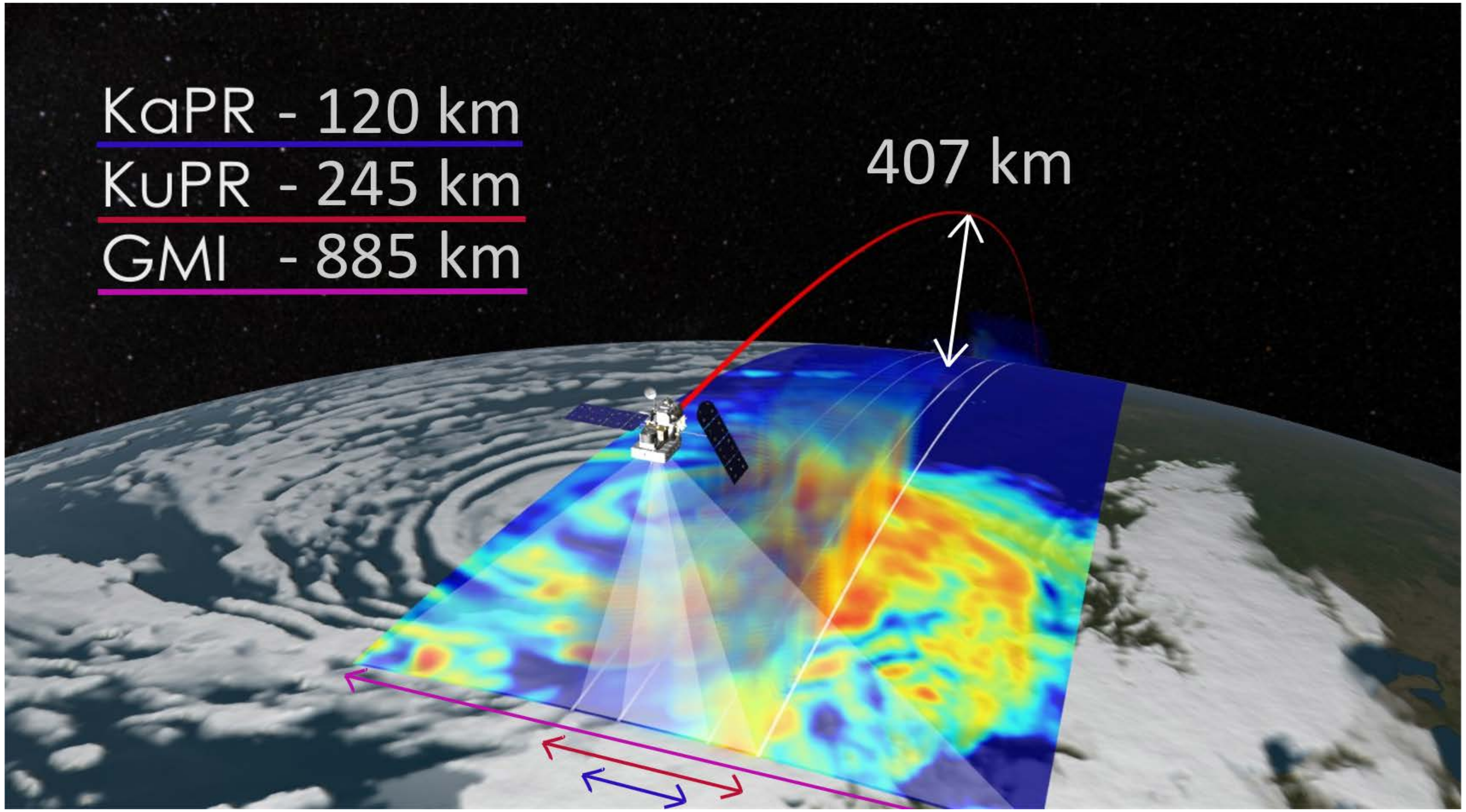
<u>GPM Core Observatory</u>

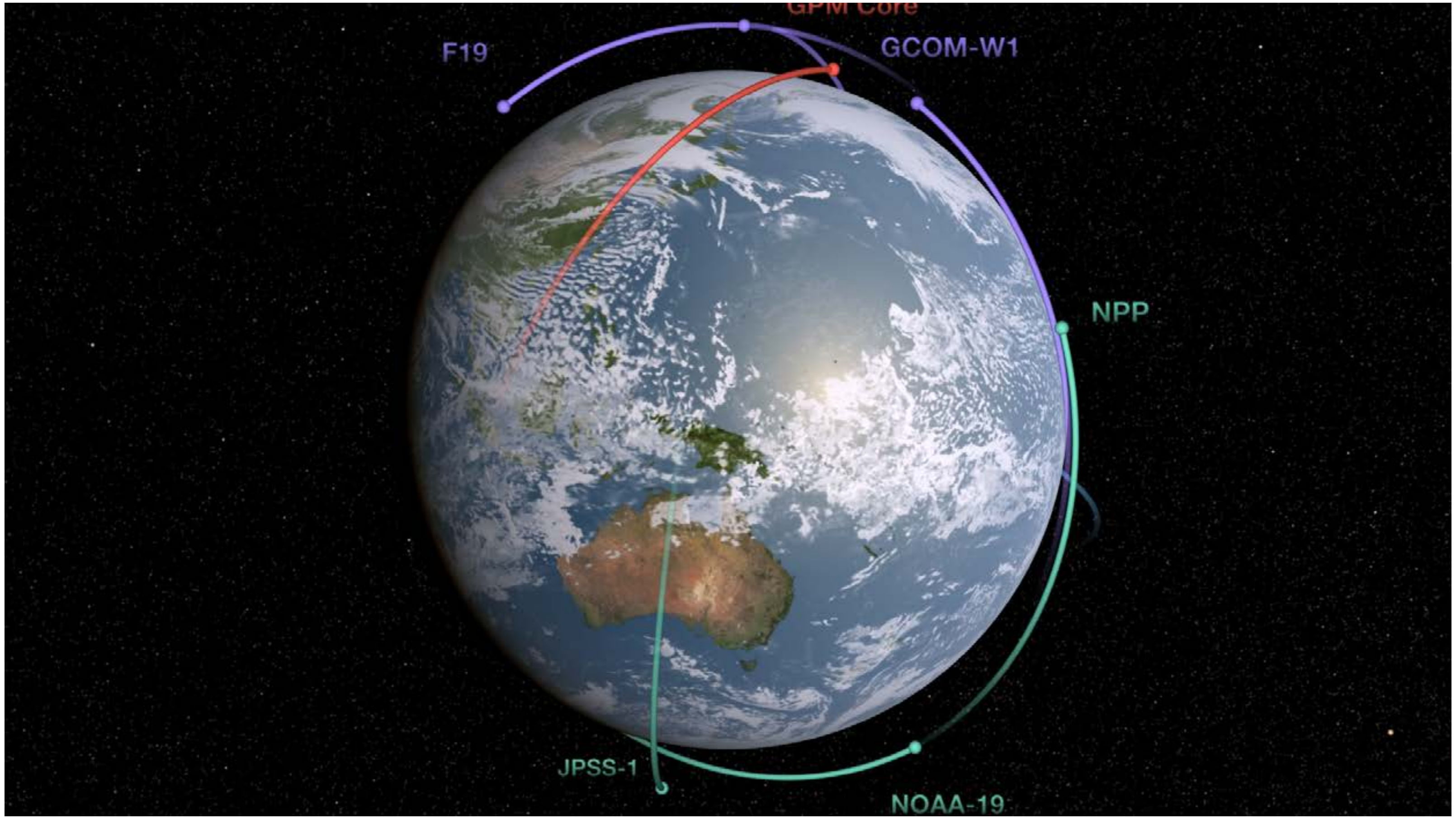
- Radar (DPR)
  - measures precipitation in 3D

- Microwave imager (GMI)
  - measures precipitation column



Watters and Battaglia (2021)

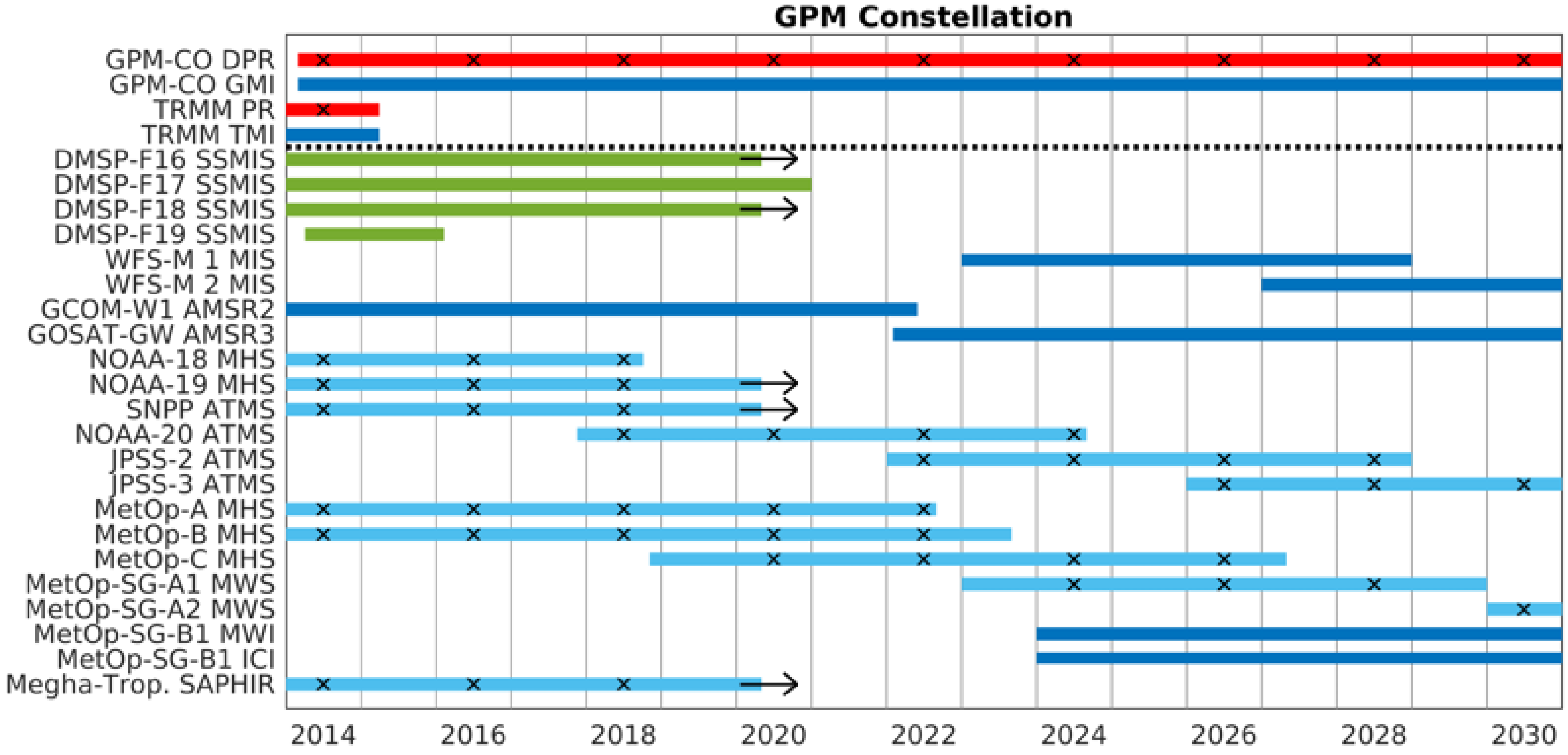
The Global Precipitation Measurement Mission



GPM Constellation

- GPM Core sensors calibrate the constellation of passive microwave [PMW] sensors
- Underpins NASA's global-gridded precipitation product (IMERG)

The Global Precipitation Measurement Mission



Key:
Radar
PMW imager
PMW sounder
PMW imager and sounder

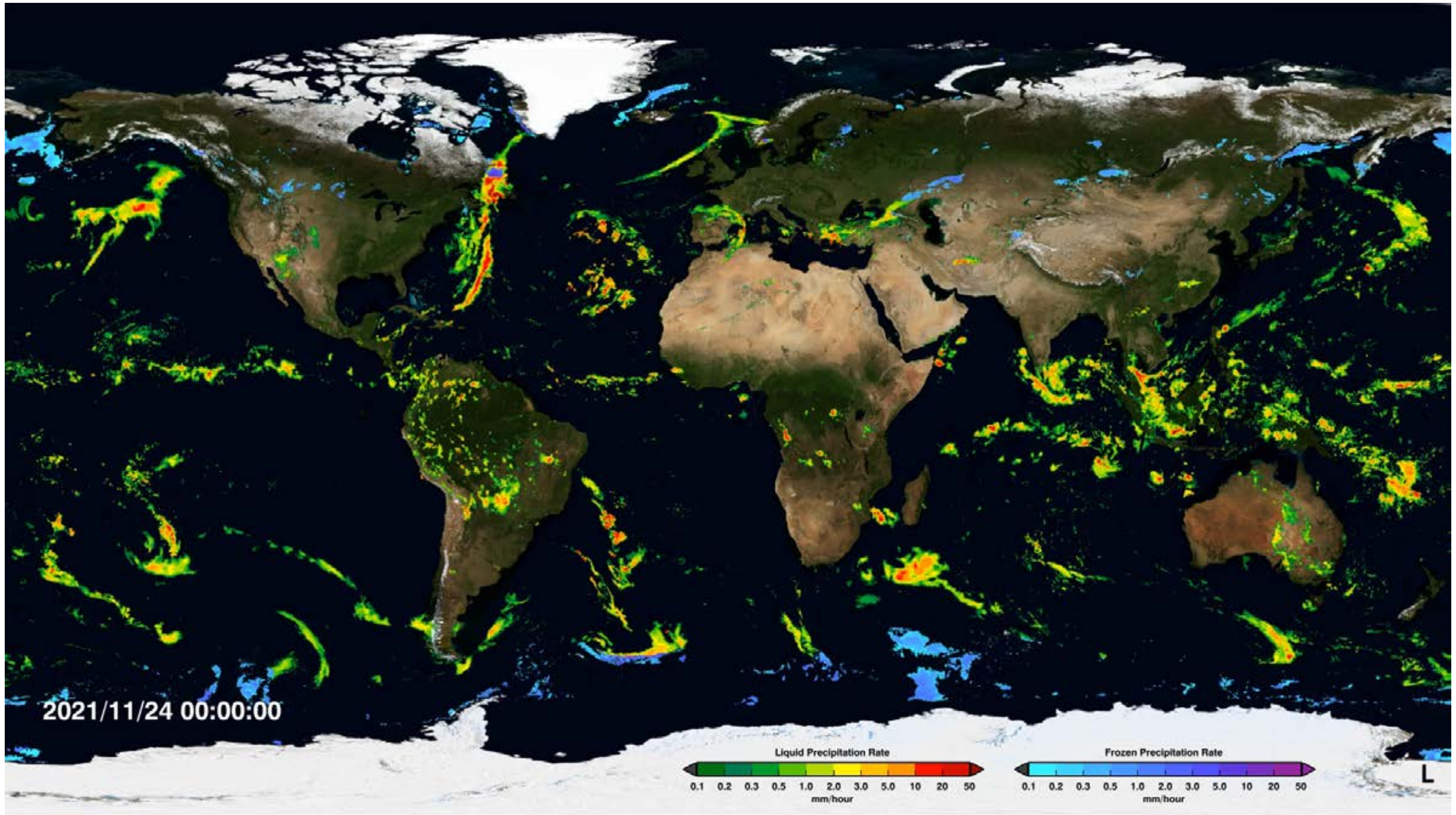
Watters and Battaglia (2021)

12 members at present

7 members in 2030

IMERG: NASA's Flagship Precipitation Product

- High resolution global precipitation estimates:
  - Half-hour
  - 0.1°
- Period:
  - June 2000 - Present
- Outputs:
  - Early [4h]
  - Late [14h]
  - Final [3.5 months]



IMERG = GPM Constellation [PMW] + IR Satellites (+ Gauges)

Why should IMERG be validated?

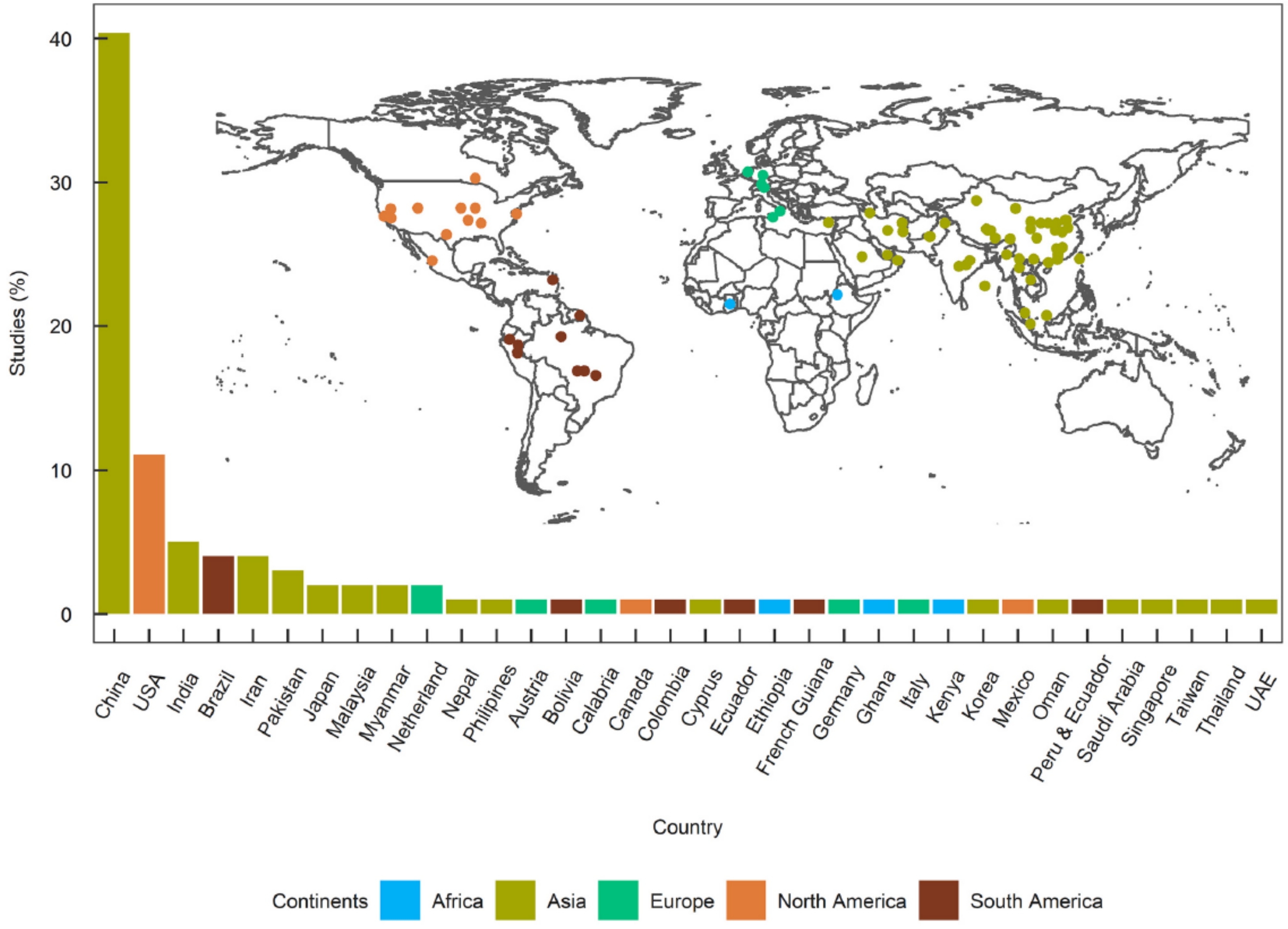


Fig. 1. Geographical distribution of IMERG validation studies across the globe. The points do not represent the extent of the study domain but rather the mean latitude and longitude of the domain.

Pradhan et al. (2022)

- IMERG is NASA's most-widely used precipitation product

- Limited knowledge of IMERG performance by:
  - Sensor input (PMW, IR, gauges)
  - Hydrometeor type (rain, snow, hail, etc.)
  - Time of day
  - Meteorological regime (mid-latitudes, tropics)

How can IMERG be validated?

- By comparing IMERG against ground-based radars
- By tracing IMERG errors back to their source

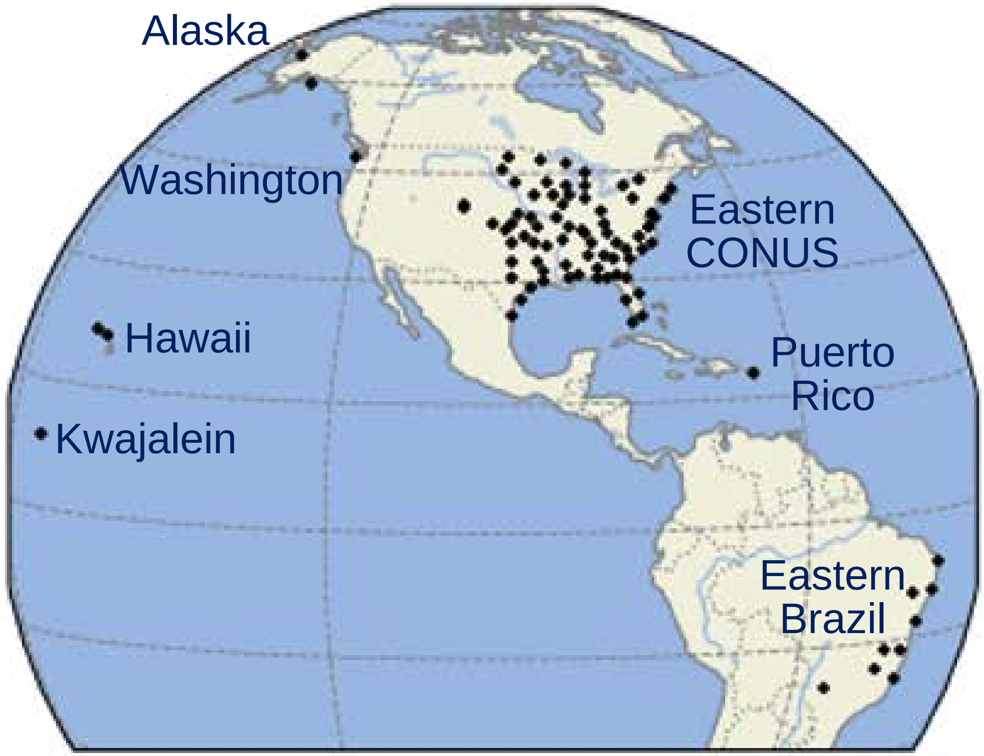
GPROF [PMW] Product
- GMI
- Constellation Satellite

GMI's estimates [GPROF] feed directly into IMERG grid (albeit with some calibration factors applied)

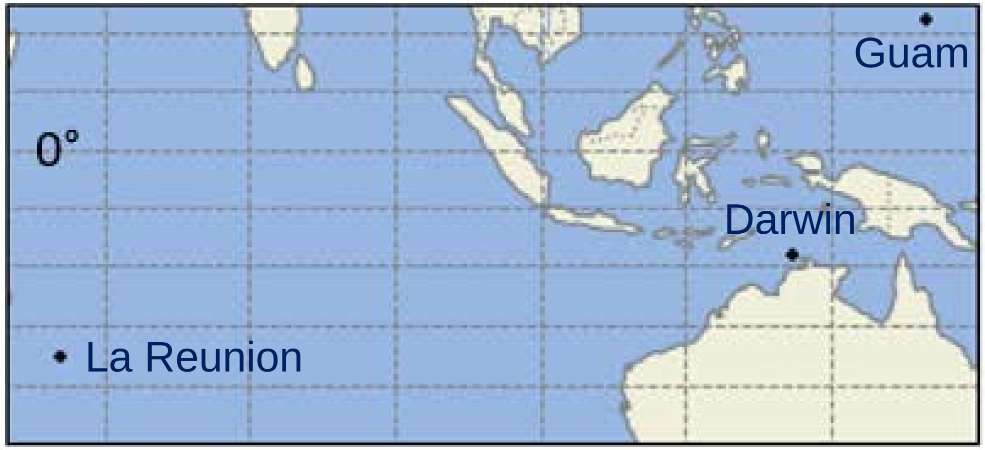
IMERG [Multi-Satellite] Product

Level	Name	Description	Resolution		Coverage	Latency
			Space	Time		
	2A-DPR	DPR Ka and Ku single-orbit rainfall estimates	5km x 5km (at nadir), 125-m vertical resolution	16 orbits per day	Latitudes 67˚N-67˚S, Mar 2014-present	20-120 min (NRT); 24 h (prod.)
GPM Level 2	2A-GPROF-GMI	GMI single-orbit rainfall estimates	11km x 18km	16 orbits per day	Orbital, 70˚N- 70˚S	1 h (NRT); 40 h (prod.)
	2B-CMB	Combined GMI + DPR single orbit rainfall estimates	5km x 5km (at nadir), 250-m vertical resolution	16 orbits per day	Orbital 67˚N-67˚S	3 h (NRT); 40 h (prod.)
GPM Level 3	IMERG	Integrated Multi-satellite Retrievals for GPM	0.1˚ x 0.1˚	30 min	Gridded 60˚N- 60˚S	4-5 h (NRT/Early run) 14-15 h (NRT/Late run) 3 months (prod./Final run)

The GPM Validation Network



Validation Network ground radar sites



Gatlin et al. (2020)

A NASA software system run at Marshall Space Flight Center that geometrically matches 3D precipitation retrievals from GPM Core sensors to ground-based radars.

The GPM Validation Network

Key:
- GPM = Global Precipitation Measurement Mission
- GR = Ground-based radar

Software system steps:

1. Store data for GPM Core overpasses near GRs
   - VN stores all GPM and GR data [rain or no rain] where GPM Core Observatory passes within 200km of GR

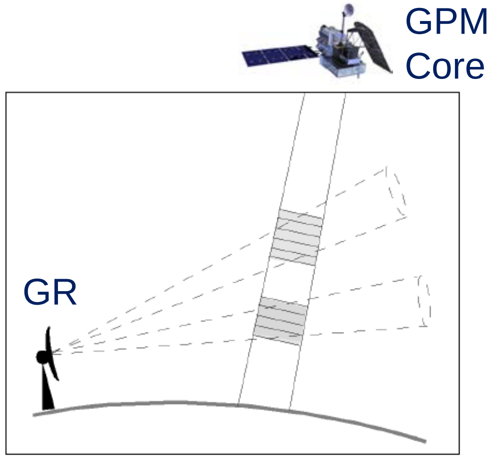
2. Quality control of GR data for GPM matchups

3. Create matchup files
   - Down-select to GPM and GR data within 100km of GR site
   - 20-in-100 criterion: After gridding the DPR Ku-band precipitation estimates, ≥20 pixels must have rainfall for matchup file to be produced

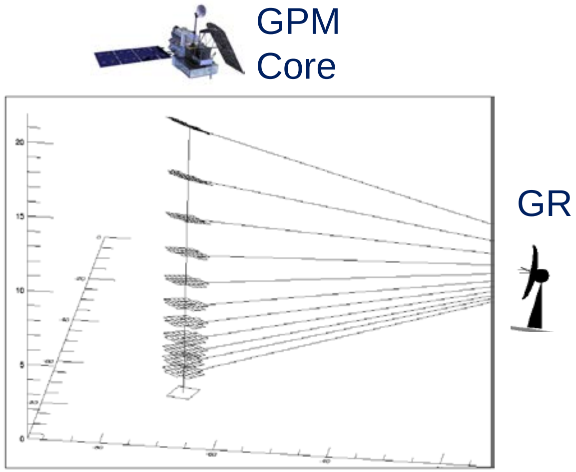
The GPM Validation Network

Producing matchup files: GRtoDPR and GRtoDPRGMI

File: GRto()	Satellite Source	Available from
DPR	Radar	8 March 2014
DPRGMI	Radar + Radiometer	8 March 2014
GPROF	Radiometer	4 March 2014



Vertical matchup – DPR range gates averaged within GR elevation ray



Horizontal matchup – GR rays for each sweep averaged within DPR field of view

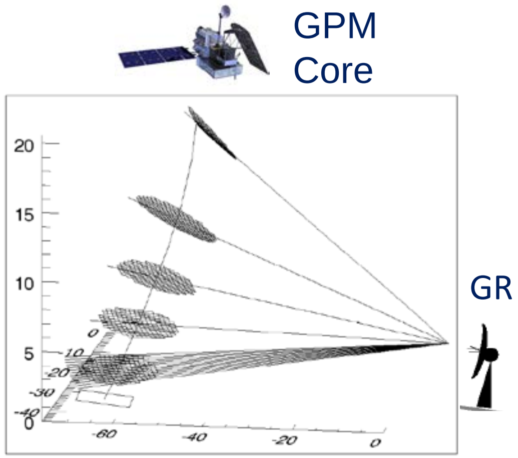
Temporal matchup – Select GR scan set with first sweep closest to GPM overpass time

The GPM Validation Network

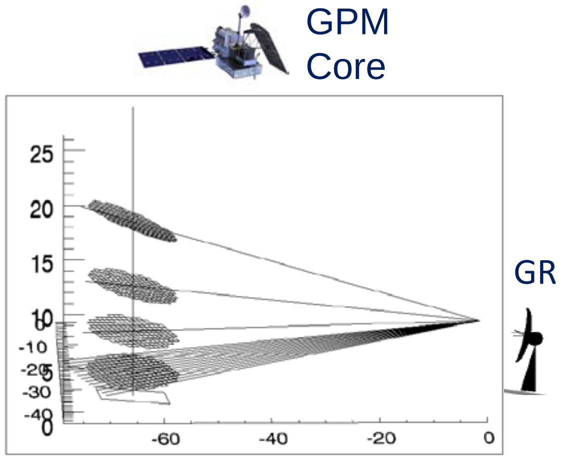
Producing matchup files:

File: GRto()	Satellite Source	Available from
DPR	Radar	8 March 2014
DPRGMI	Radar + Radiometer	8 March 2014
GPROF	Radiometer	4 March 2014

GRtoGPROF



Line-of-sight matchup – GR rays for each sweep averaged within GMI field of view (conical scan)



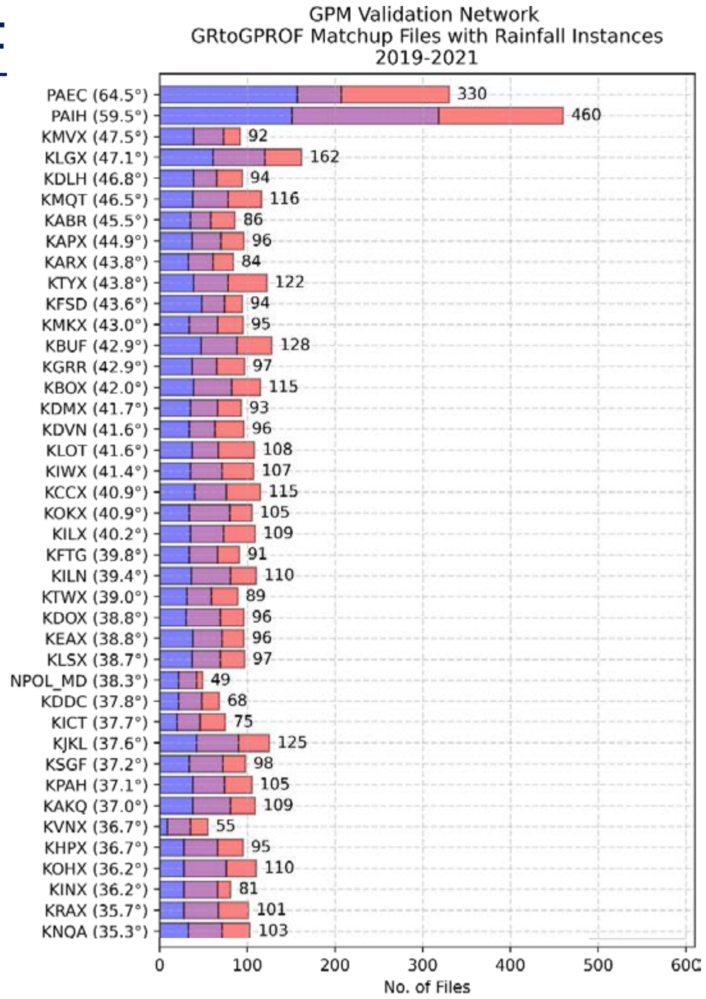
Vertical profile matchup – GR rays for each sweep averaged along vertical directly above GMI surface footprint

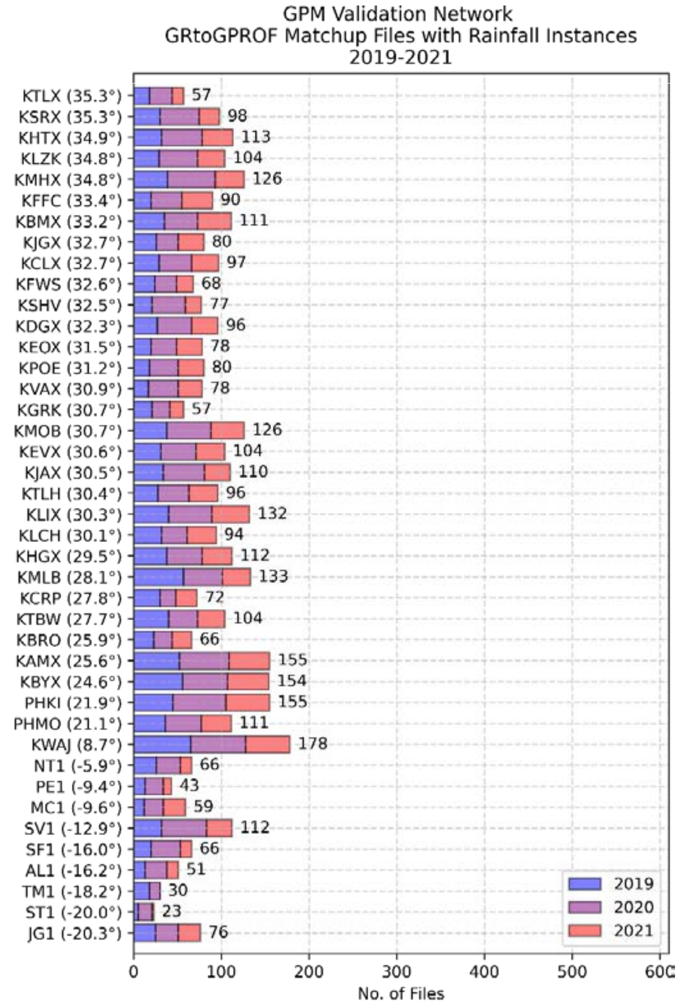
Temporal matchup – Select GR scan set with first sweep closest to GPM overpass time – note that GMI measures around 60-90s ahead/behind GPM Core Observatory

The GPM Validation Network

GRtoGPROF

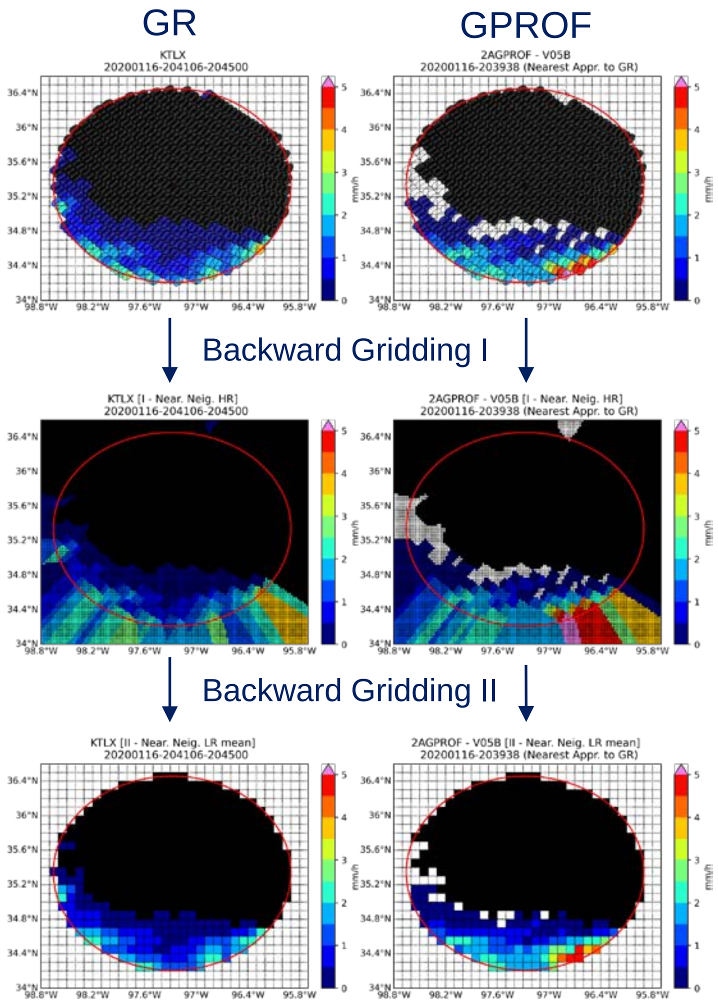
Matchup files
for latest
GPROF version
[V05B]





The GPM Validation Network

GRtoGPROFtoIMERG

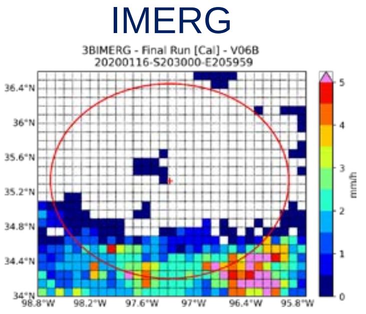


Principle:

- Grid the GPROF and GPROF-scale GR variables to the IMERG grid

Process:

- Backward gridding:
  1. Nearest neighbor interpolation at high resolution
  2. Averaging to IMERG grid scale



Producing matchup files:

File: GRto()	Satellite Source	Available from
DPR	Radar	8 March 2014
DPRGMI	Radar + Radiometer	8 March 2014
GPROF	Radiometer	4 March 2014
GPROFtoIMERG	Radiometer	4 March 2014

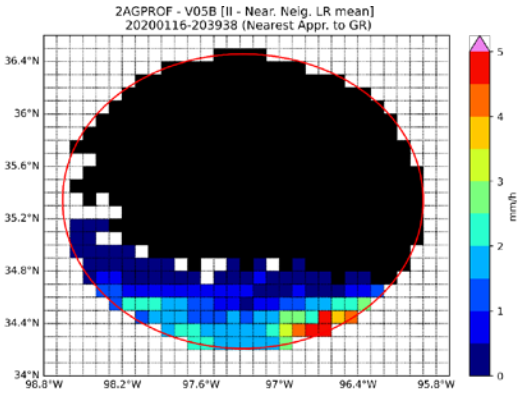
Coming in 2022

The GPM Validation Network

GRtoGPROFtoIMERG

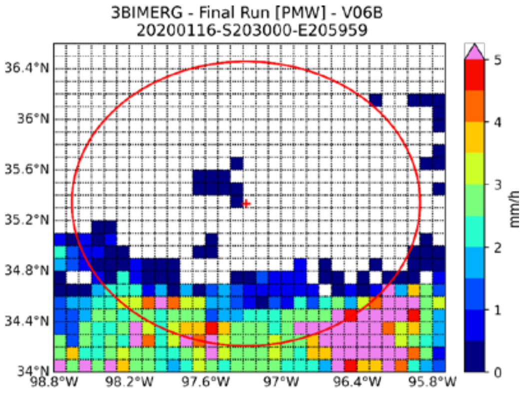
The backward gridding process, used in the IMERG algorithm to incorporate GPROF estimates at GPM Core overpasses, allows for errors to be traced back from the IMERG estimates to their source.

GPROF

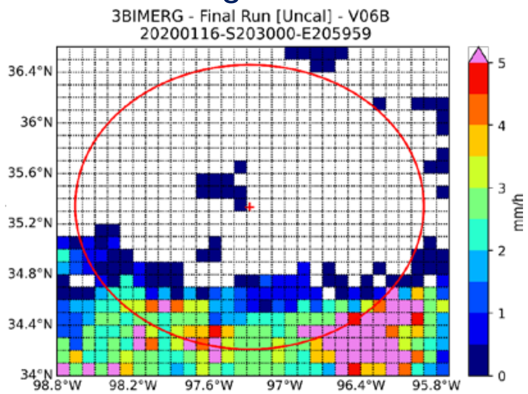


IMERG

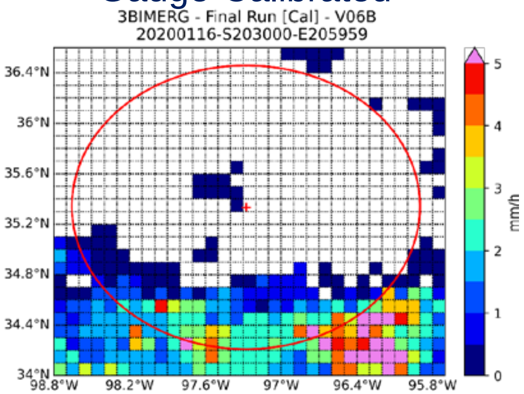
PMW



Pre-Gauge-Calibration



Gauge-Calibrated



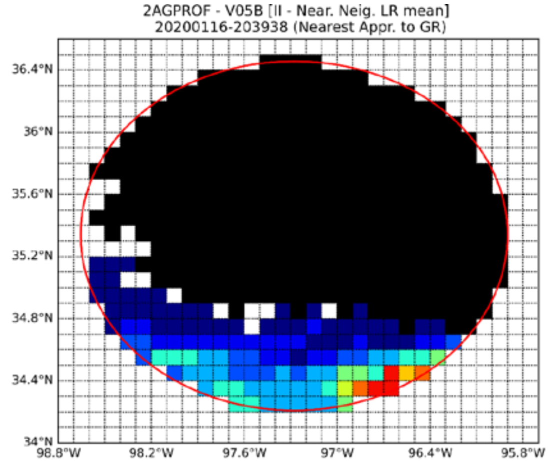
GPROF-GMI estimates adjusted with calibration factors

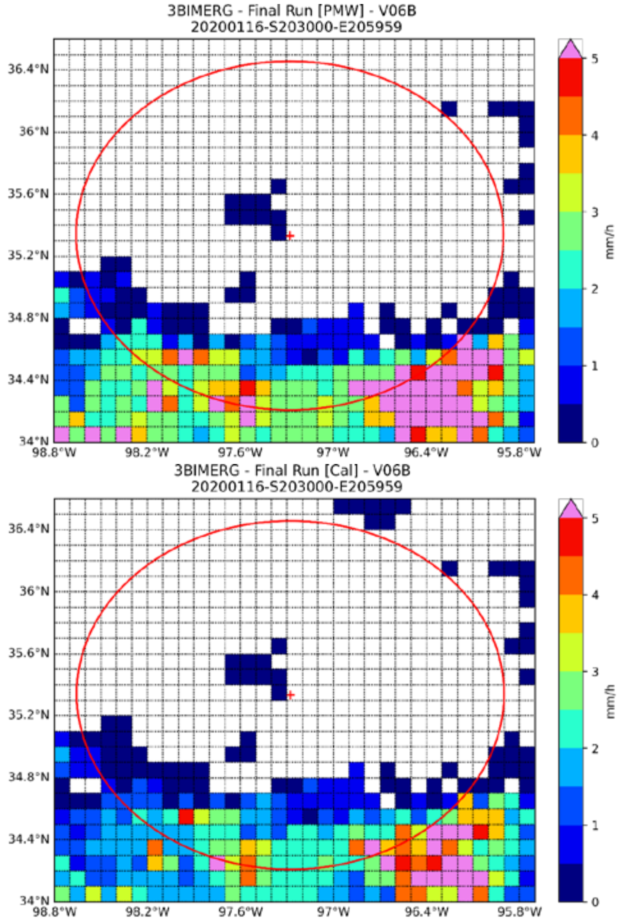
No change in V06B as estimates are not input to Kalman filter

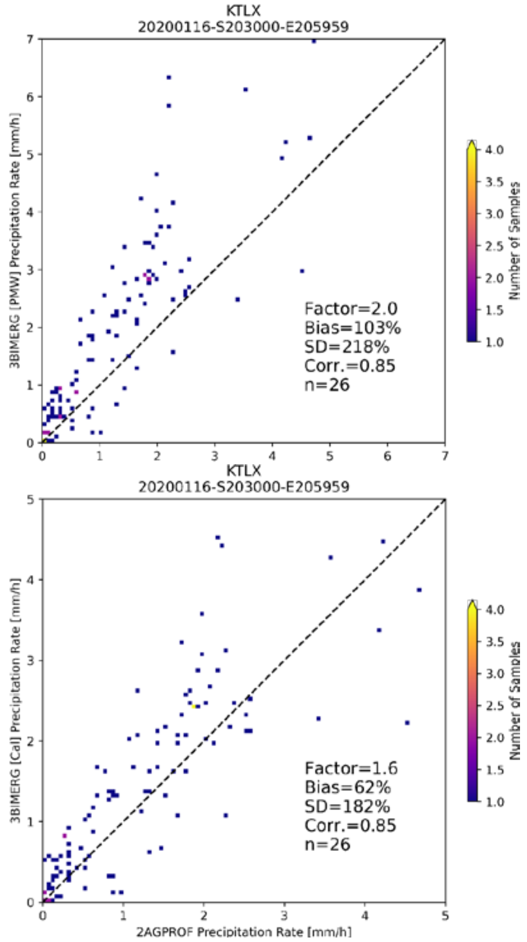
Gauge calibration

The GPM Validation Network

GRtoGPROFtoIMERG – Case Study: Norman, OK [KTLX] - 20200116







How do the IMERG algorithm adjustments compare to the original GPROF inputs?

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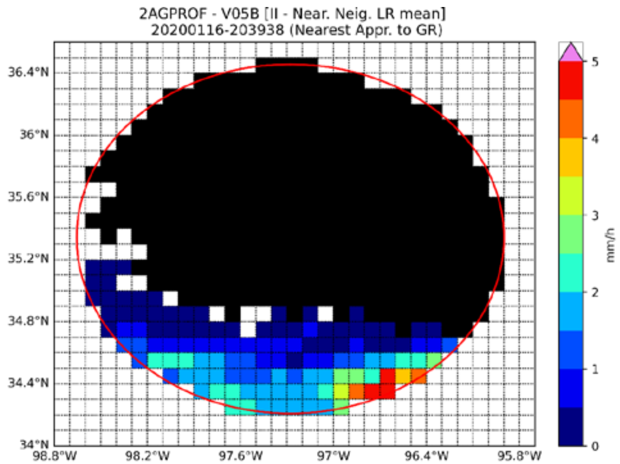
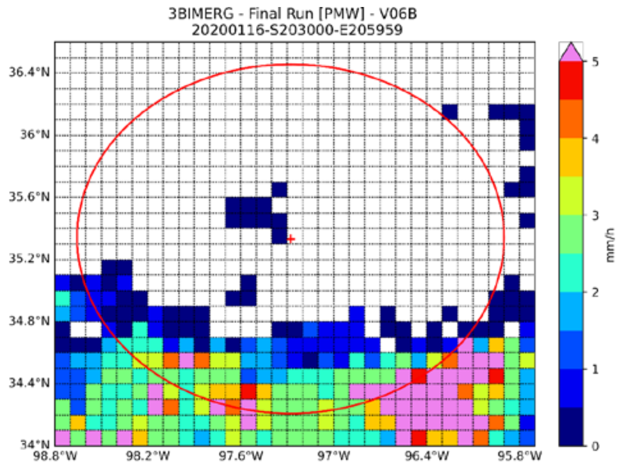
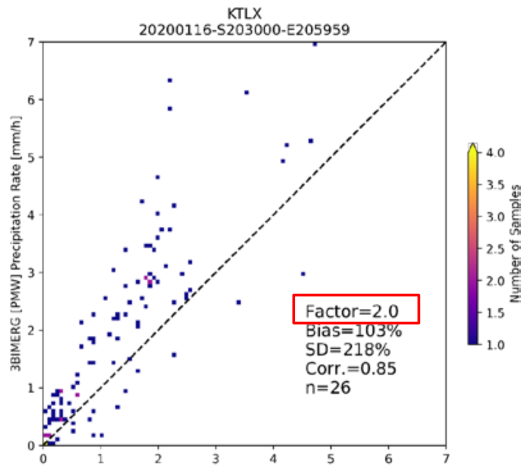
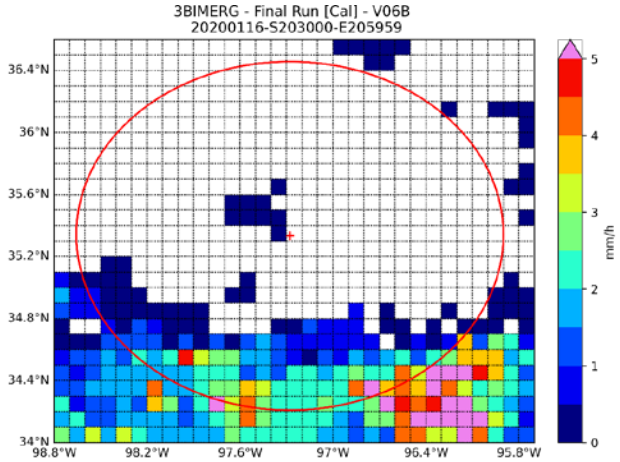
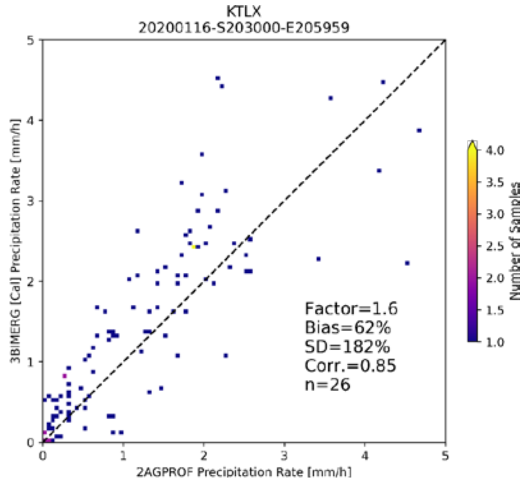






Calibration factors to GPROF increase the precipitation rates by a factor of 2 on average





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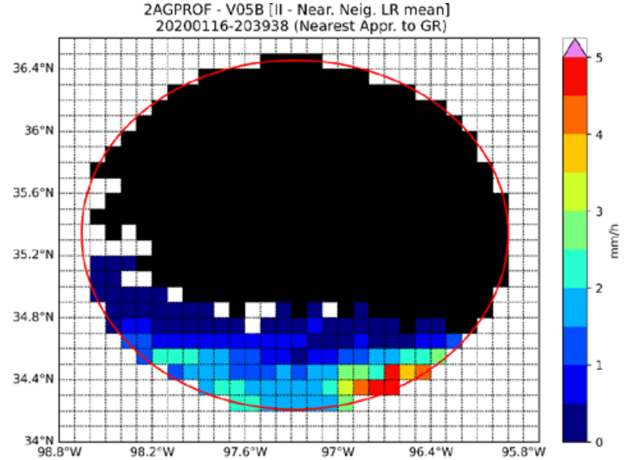
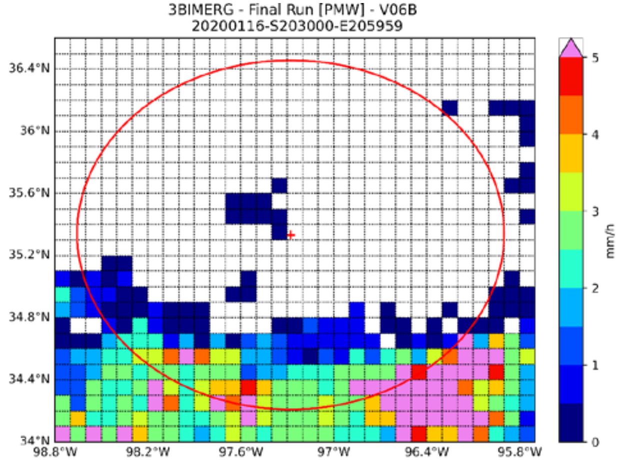
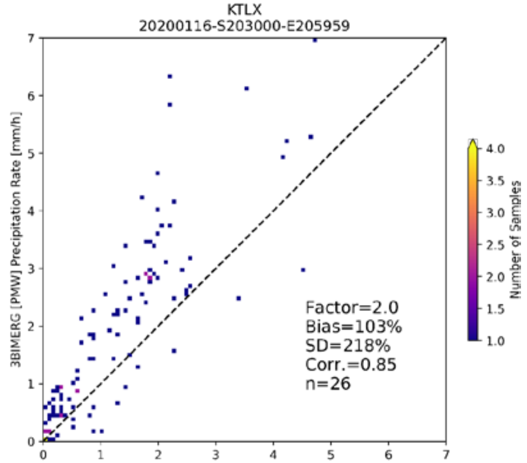
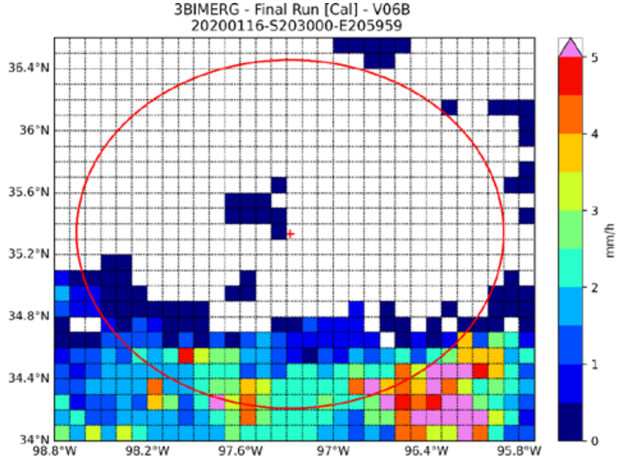
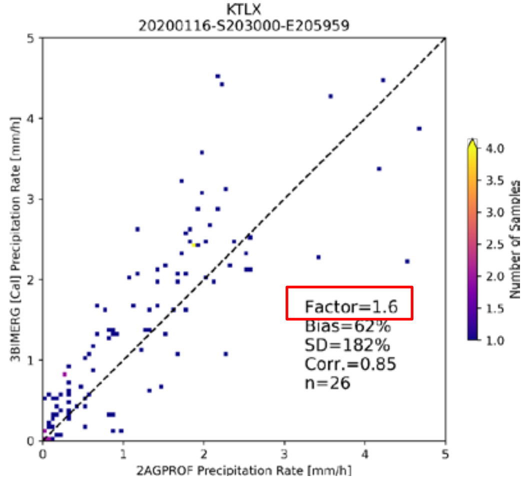






Further calibration to gauges reduces the IMERG/GPROF precipitation rate factor to 1.6 - does this factor increase improve the comparison to the GR?





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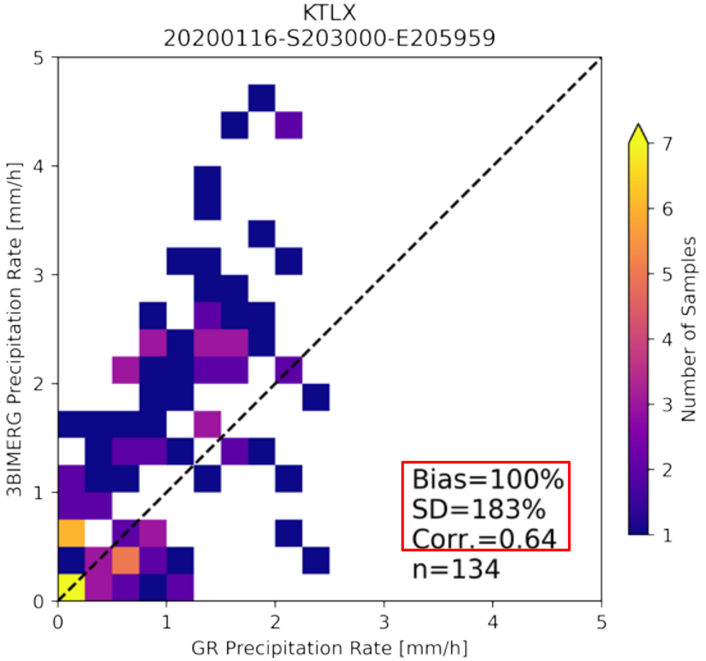
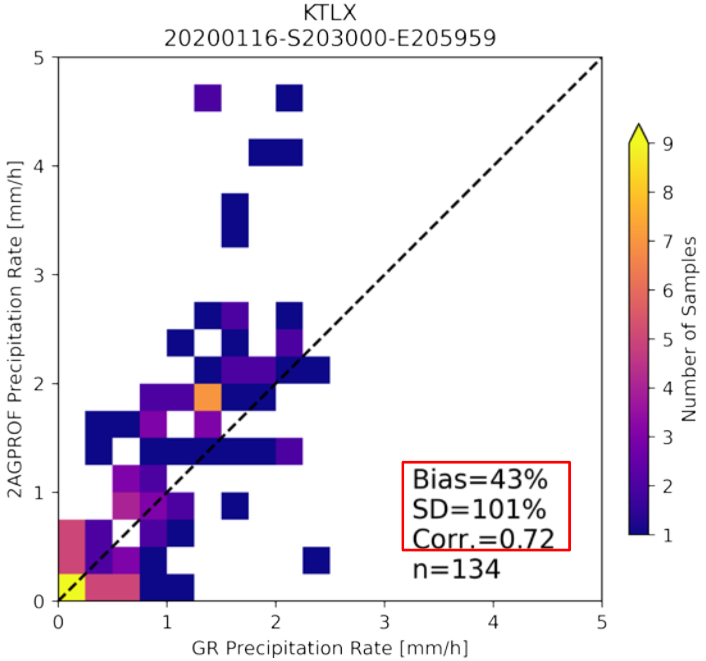
Does the factor increase from source GPROF to final IMERG precipitation rate estimates improve the comparison to the GR? – In this case, no!

IMERG v GR



GPROF v GR



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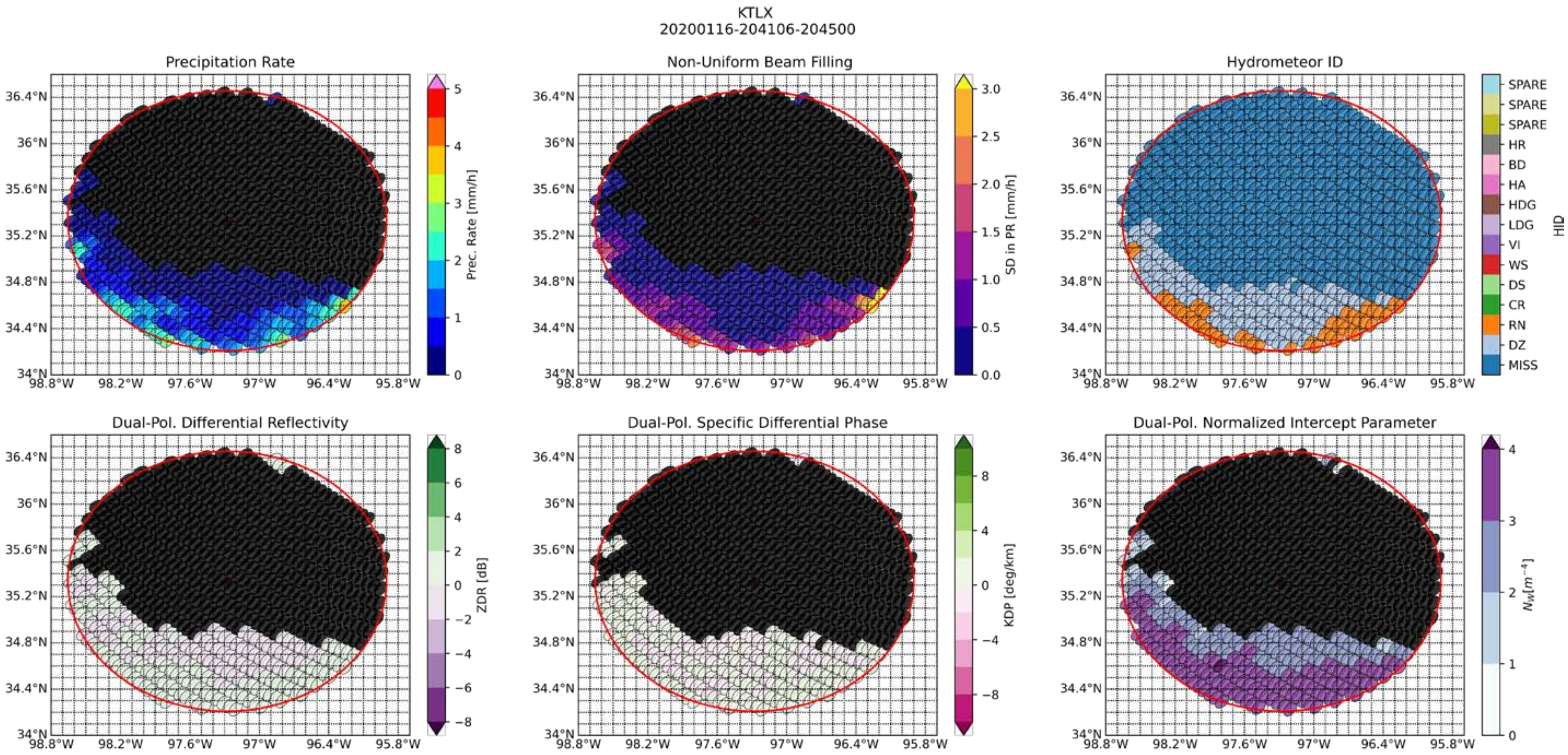


Hydrometeor ID and precipitation characteristics deduced from GR measurements can be used to stratify validation results in future

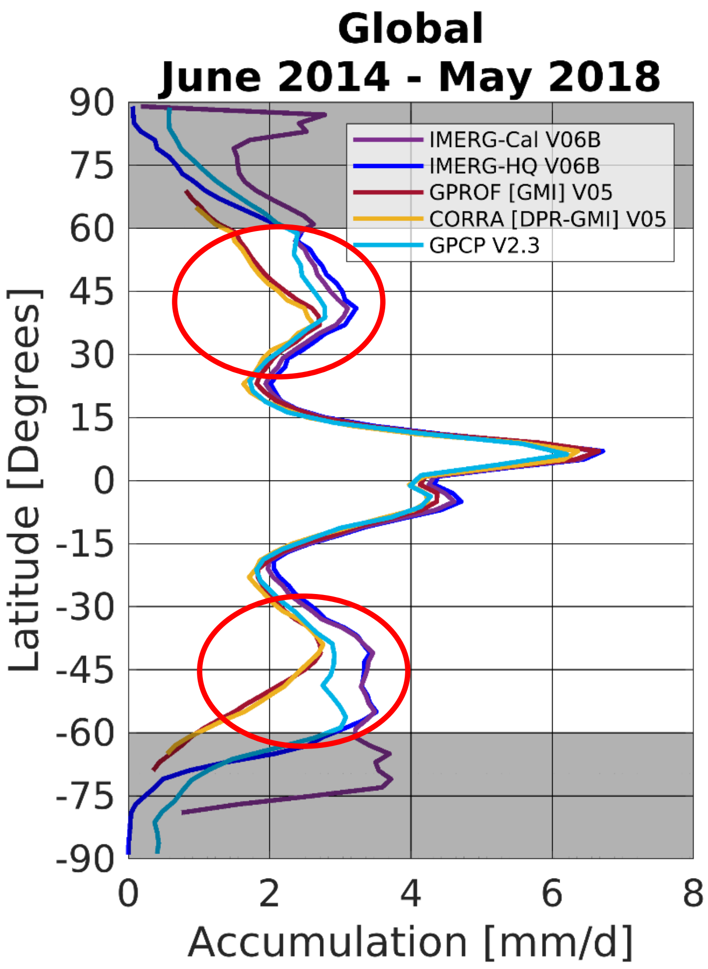
Conclusions and Future Studies

- The GPM Validation Network offers a novel opportunity to validate IMERG against ground-based radars scattered across the Americas and Pacific Islands

- Upcoming update to the Validation Network: Inclusion of IMERG

- Tracing errors – the Validation Network will enable errors to be traced back through IMERG to the original GPROF estimates retrieved from the GMI on the GPM Core Observatory

- Future research:
  - Updated Validation Network to be used to assess the oceanic performance of IMERG across island sites
  - Assessment of best method for gridding other GR variables such as hydrometeor classification, vertical profile of reflectivity, etc.
  - Better understand IMERG's diurnal performance



Watters - Thesis (2021)

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