



# Assessing the Global Precipitation Measurement with Multi-Radar/Multi-Sensor for Validation and Improvement: Current Status and Future Directions

Pierre Kirstetter

with contributions of:  
V. Petkovic, W. Petersen, J. Turk,  
S. Tanelli, C. Kummerow, G. Huffman,  
J. Gourley, J. Zhang, and Y. Hong



# Assessing GPM with GV-MRMS: current status and future directions

- 1. Context: GV-MRMS & analysis framework**
- 2. Active sensor: Dual-frequency Precipitation Radar**
- 3. Passive sensor: GPM Microwave Imager**
- 4. Multi-satellite: Integrated Multi-satellitE Retrievals**
- 5. Conclusions & perspectives**

# Overview of the Multi-Radar Multi-Sensor System (MRMS)

**Domain:** 20-55° N, 130-60° W

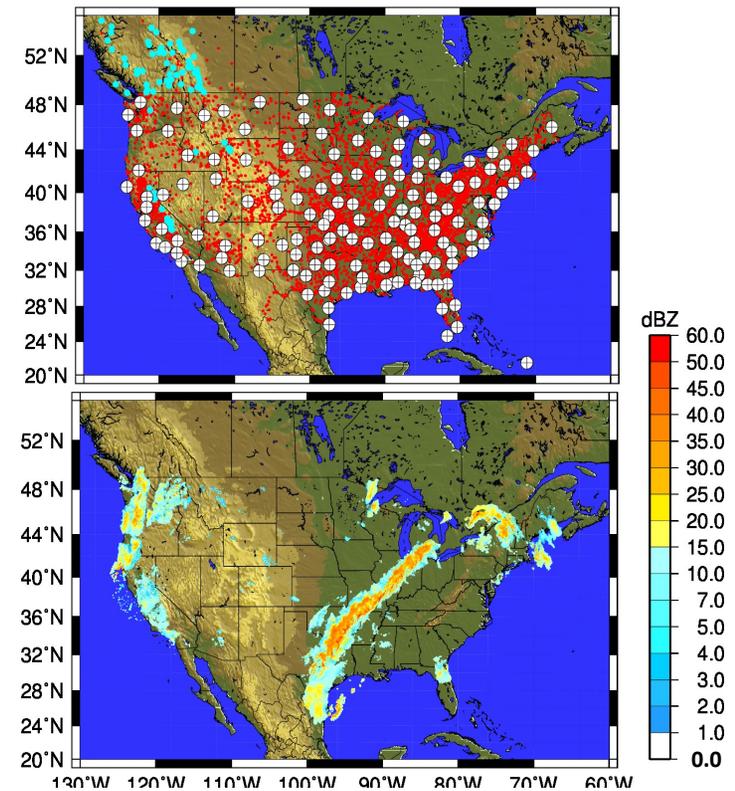
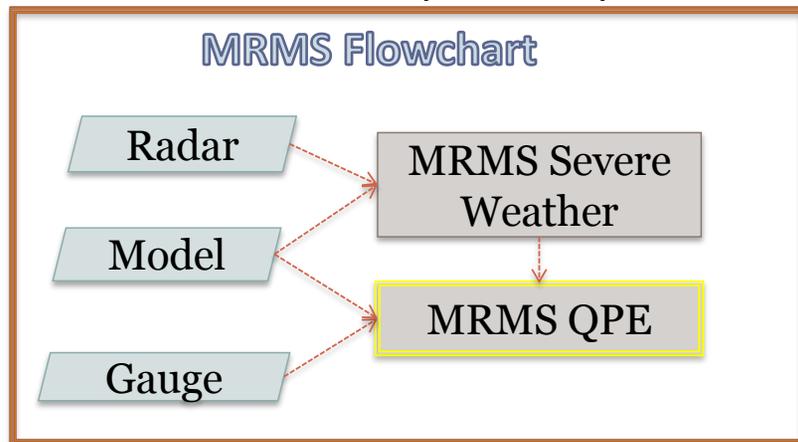
**Resolution:** 0.01° , 2 min update cycle

**Data Sources:**

~180 **polarimetric** radars every 4-5min

~9000 gauges every hour

- RAP model hourly 3D analyses



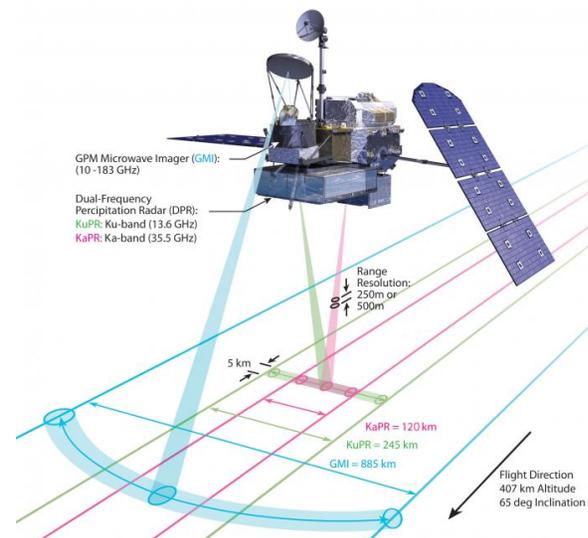
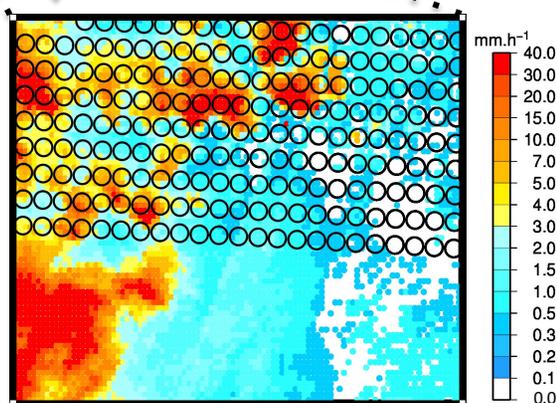
frontal system at 0800 UTC on 11 April 2011

# GPM and GV-MRMS



## Reference precipitation added value:

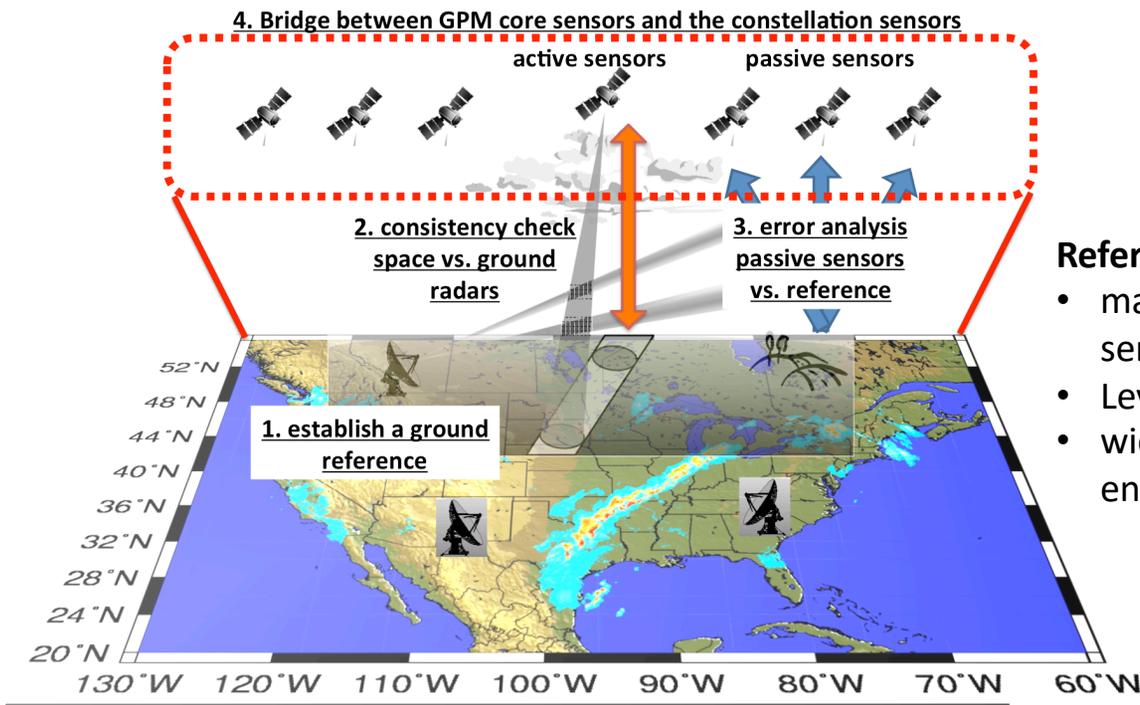
- gauge adjustment
- quality/quantity controls
- finer spatial resolution than any satellite precipitation



## Precipitation features:

- intermittency
- type
- rate variability

# GPM & GV-MRMS: bridging the Core and Constellation



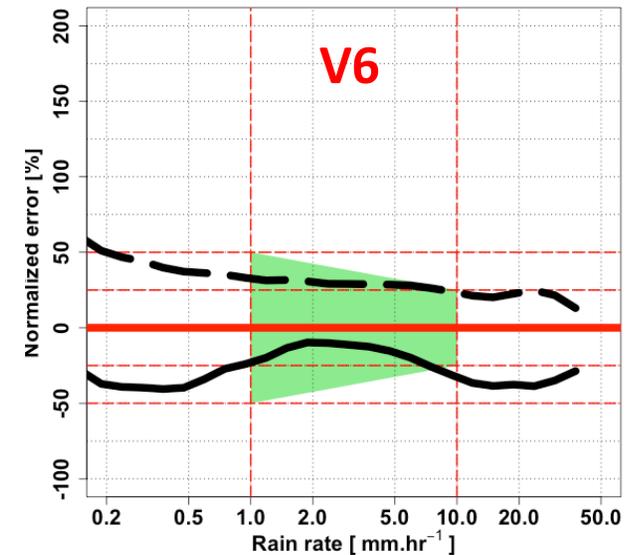
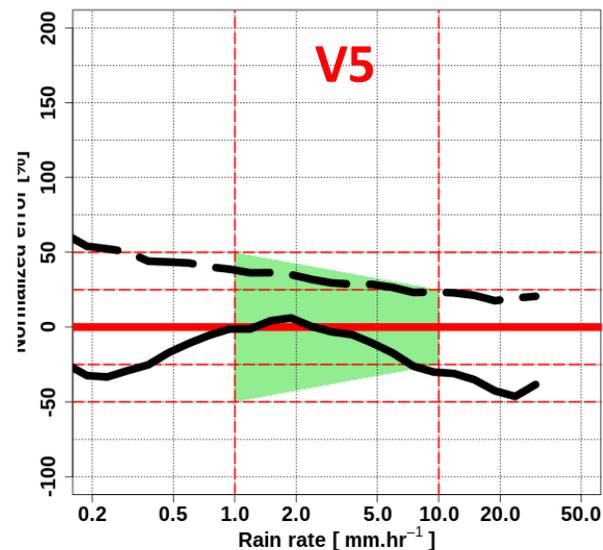
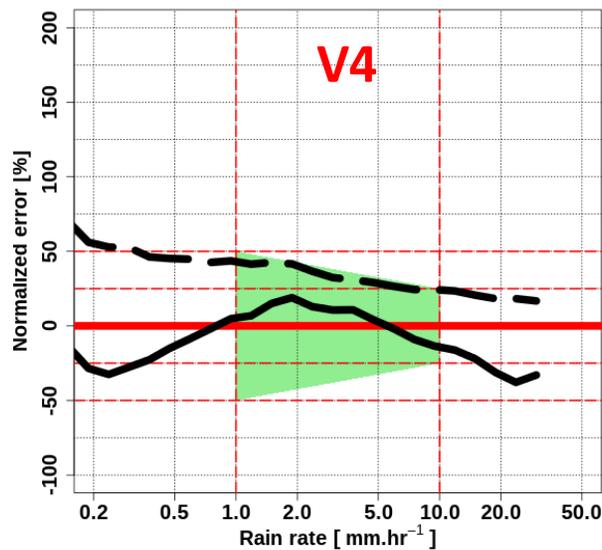
## Reference precipitation added value:

- matching the resolution of each sensor/product
- Level 2 active & passive, Level 3
- wide diversity of precipitation, surface, and environmental conditions

- GPROF at-launch version
- GPM Senior Review and End of Prime review

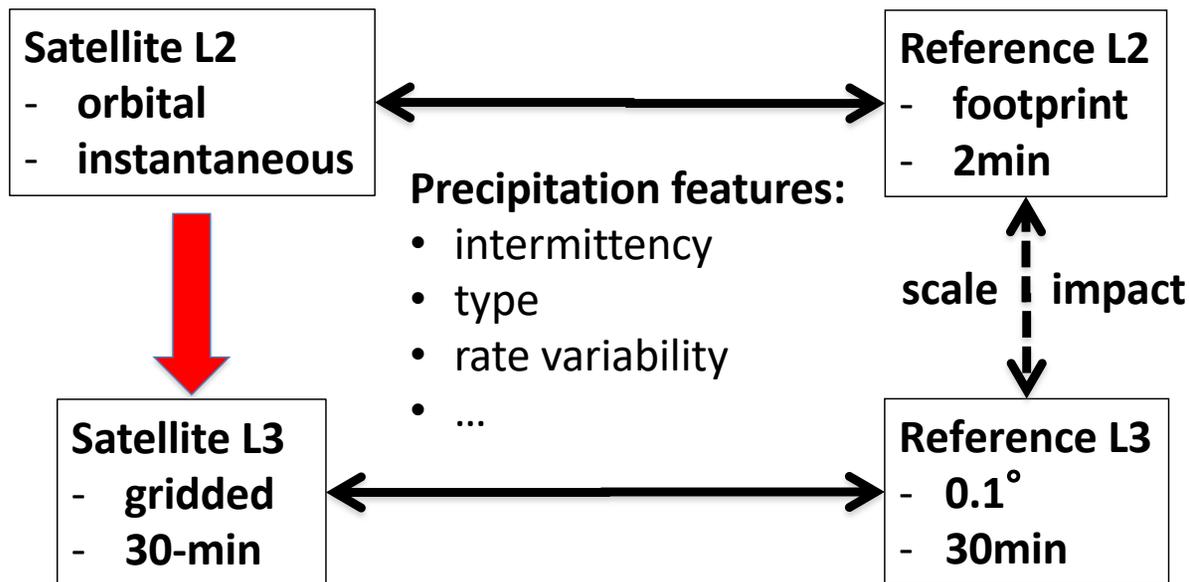
# GPM & GV-MRMS: bridging across product versions

- period: 05/14 – 10/16 ; ~3 millions matched pairs
- L1 (50 x 50 km) **2AKu** rain rates V4-V6

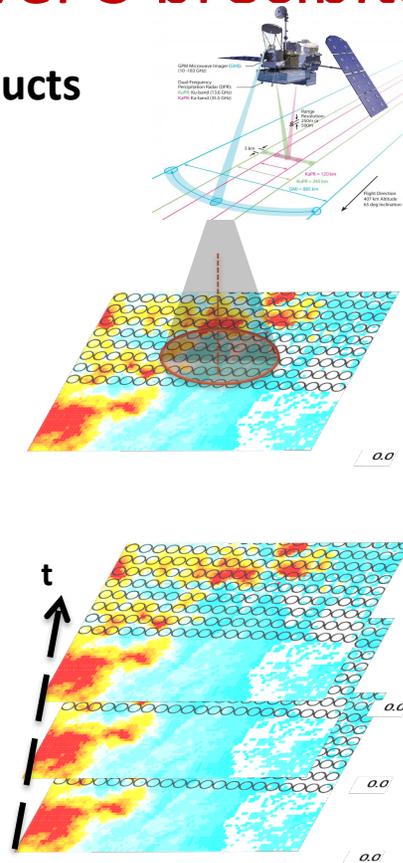


# GPM & GV-MRMS: bridging orbital Level-2 and gridded Level-3 precipitation

Objective: improve precipitation across Level 2 and Level 3 products



- Identify conditions of agreement / disagreement
- Provide guidance to improve the retrievals



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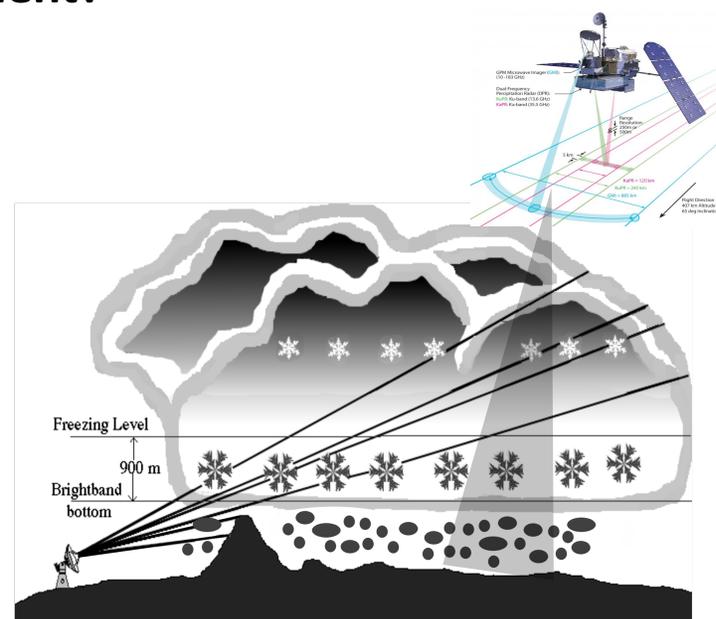
# DPR - GV bias mapping: complementary perspectives

## 1. Mapping DPR - GV bias **w.r.t. GV observations**

- What is sampled by DPR? (e.g. intermittency, NUBF, **precipitation types**)
- How does it condition DPR – GV disagreement?

## 2. Mapping DPR - GV bias **w.r.t. DPR**

- bias w.r.t. DPR storm vertical structure
- bias w.r.t. DPR **algorithm parameters**



# DPR - GV bias mapping: complementary perspectives

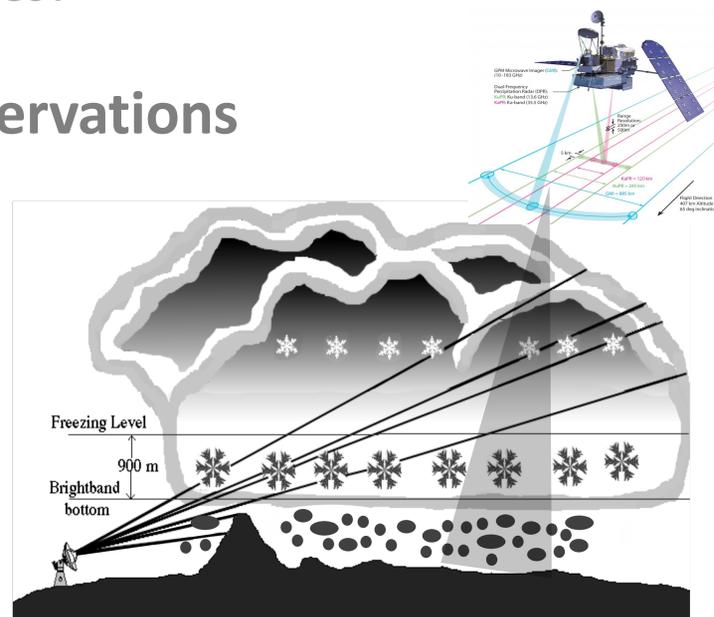
## 1. Mapping DPR - GV bias w.r.t. GV observations

- What is sampled by DPR? (e.g. intermittency, NUBF, precipitation types)
- How these factors condition DPR – GV biases?

## 2. Mapping DPR - GV bias w.r.t. DPR observations

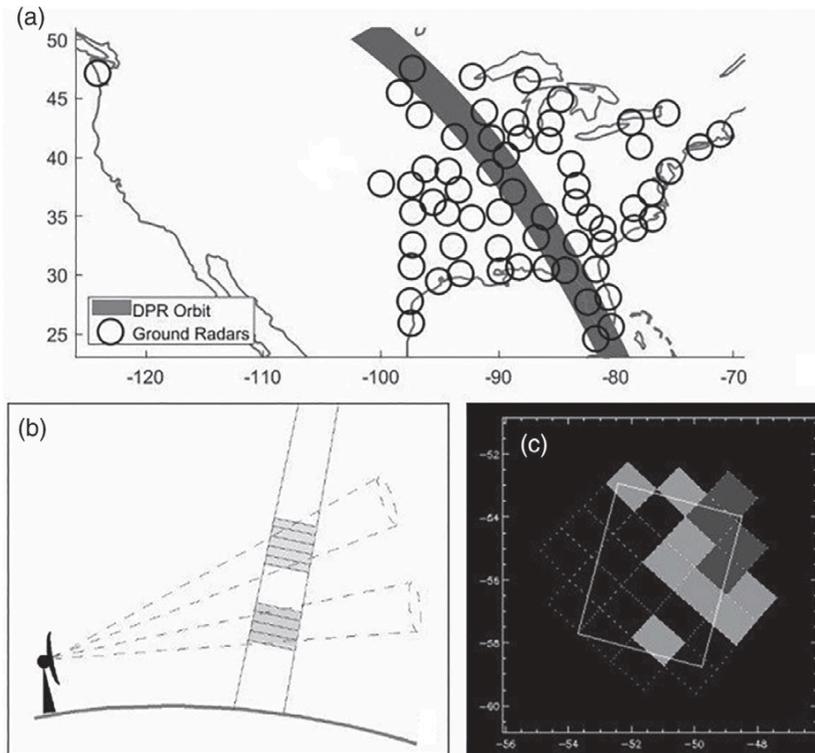
- bias w.r.t. storm vertical structure
- bias w.r.t. DPR algorithm parameters

## 3. Exploring new process signatures in DPR observations



# Exploring new process signatures in DPR observations

Refine DPR microphysical relevance



- distribution of WSR-88D GRs
- 6 February 2015 GPM orbit track

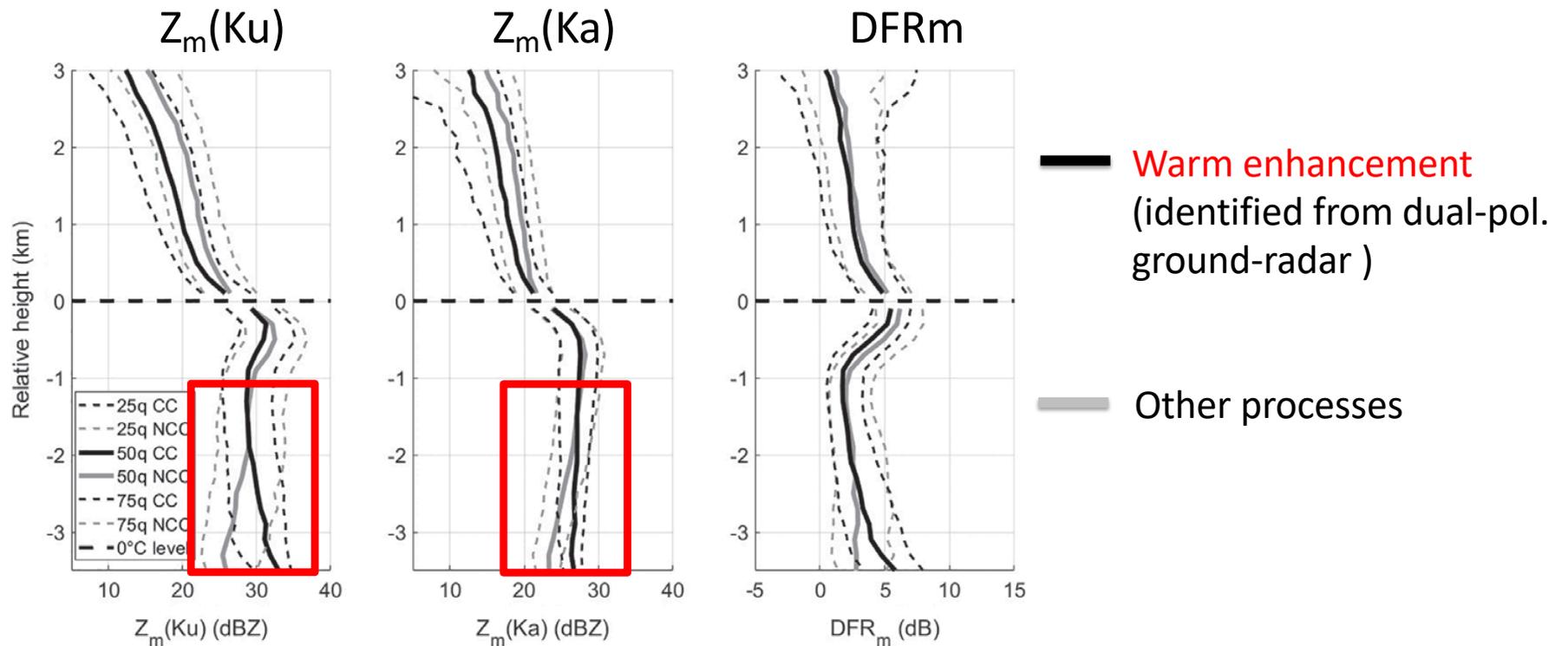
VN framework:

- (b) DPR beam intercepting GR beams
- (c) schematics of a waffle of GR bins

Morris and Schwaller (2011)

# Exploring new process signatures in DPR observations

Specific enhancement signatures of **warm processes** in DPR profiles



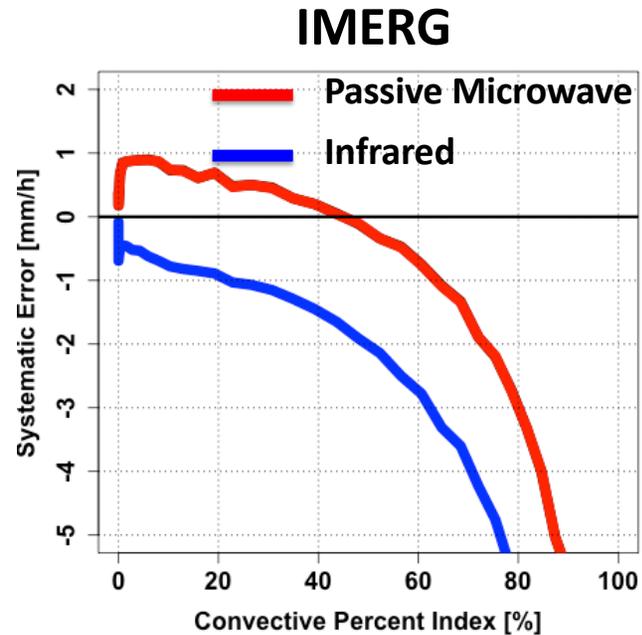
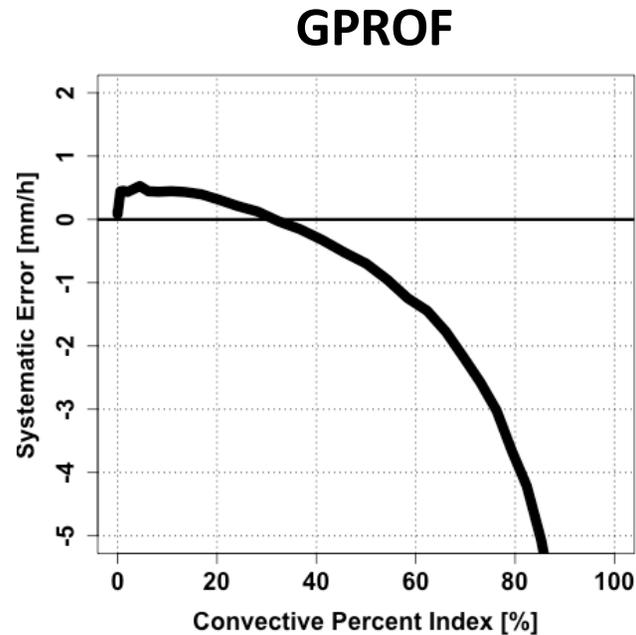
Porcaccia et al. (2019)

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## Toward the next GPROF (and IMERG ?) version: convective contribution

- Currently GPROF does not condition the retrieval by precipitation types → systematic error propagates to IMERG
- Demonstrated the interest of accounting for convective contribution in GPROF



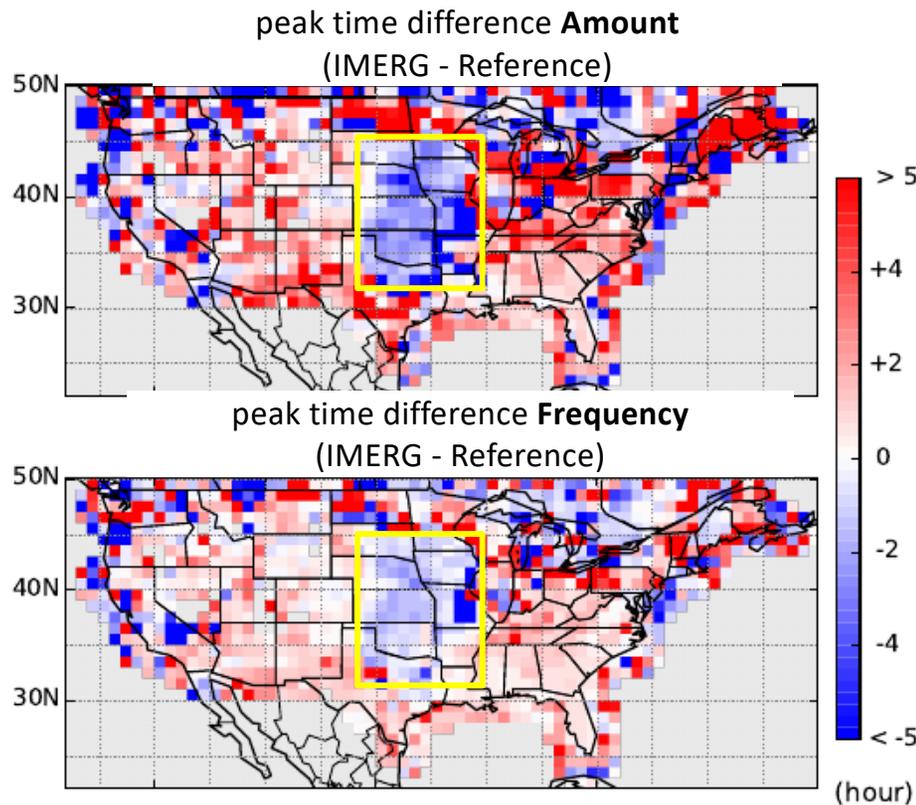
→ Petkovic et al. (2019)

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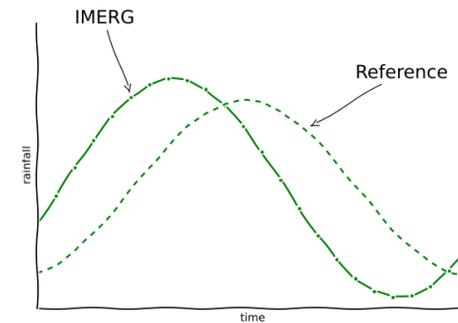
# Diurnal cycle over CONUS: peak time

- **period: summer (June–August) 2014–2015**



- IMERG peaks *later*
- IMERG peaks *earlier*

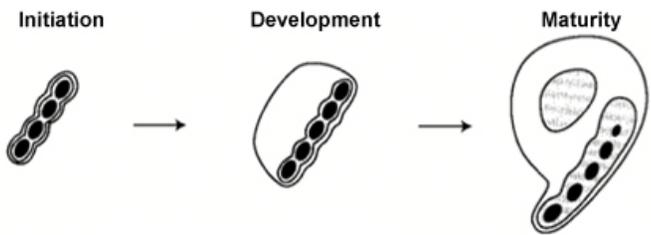
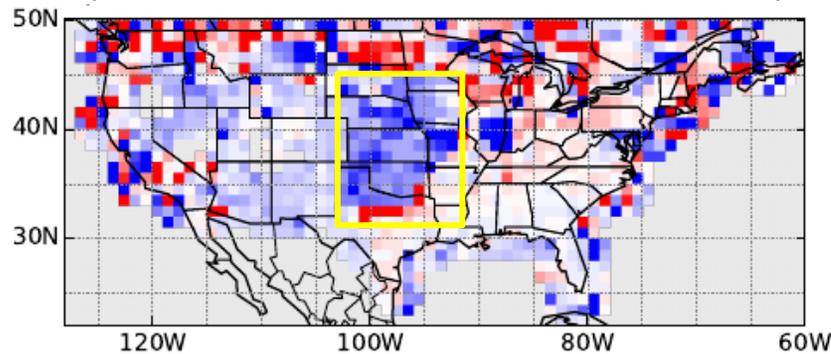
- IMERG shows late bias at most locations, except the central US (i.e. MCS region)



O and Kirstetter (2017)

# Diurnal cycle over CONUS: precipitation types

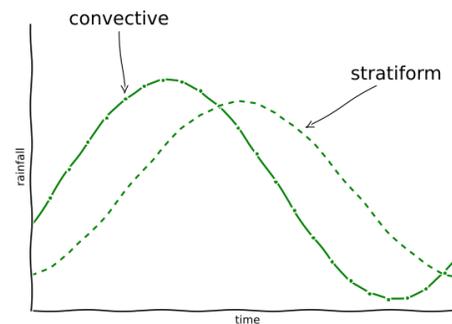
peak time difference GV-MRMS  
(convective – stratiform, occurrence)



Parker and Johnson (2000)

■ Convective peaks *earlier* than stratiform

- Comparison of convective vs stratiform shows a similar pattern
- ➔ Rainfall types can cause the systematic peak time difference?



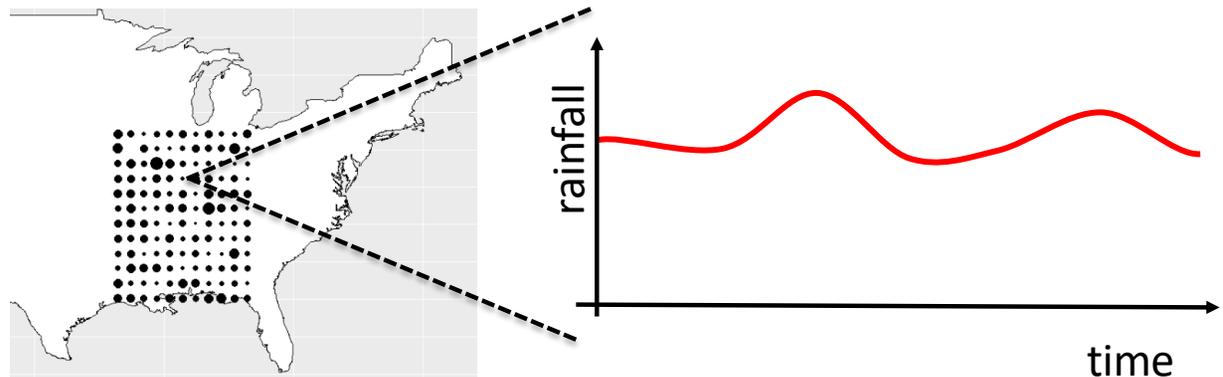
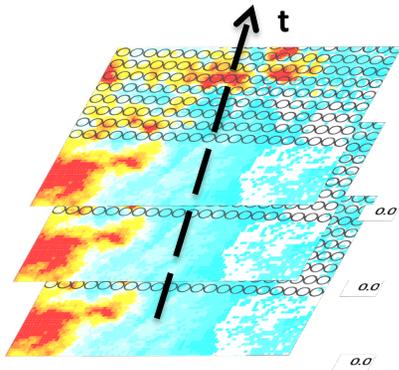
O and Kirstetter (2017)

# Eulerian evaluation: time series analysis

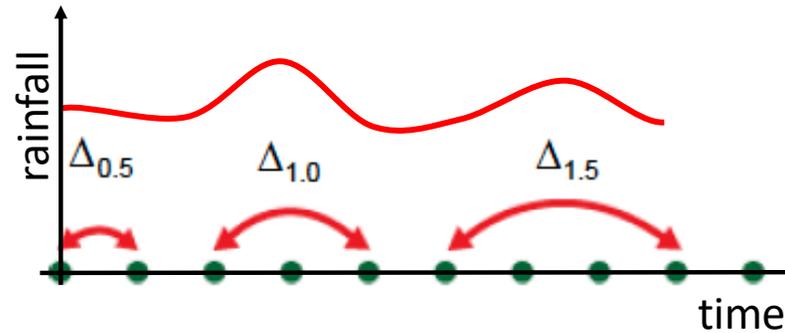
The GPM constellation aims at observing precipitation at every location every 3h on average.

Questions:

- What is the characteristic temporal scale of precipitation at a given location?
- How does the GPM constellation sampling frequency (3h) compare with the characteristic temporal scale of precipitation?



# Variogram

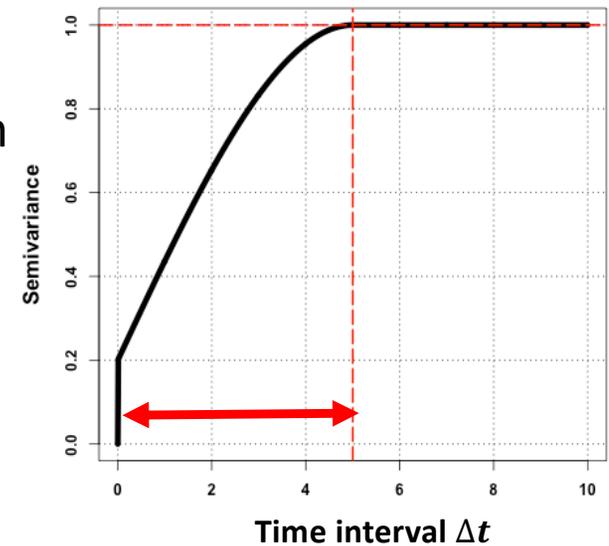
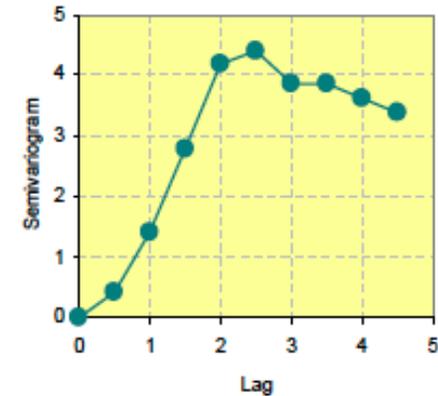


$$\gamma(h) = \frac{1}{2} E \left[ (R(t) - R(t + \Delta t))^2 \right]$$

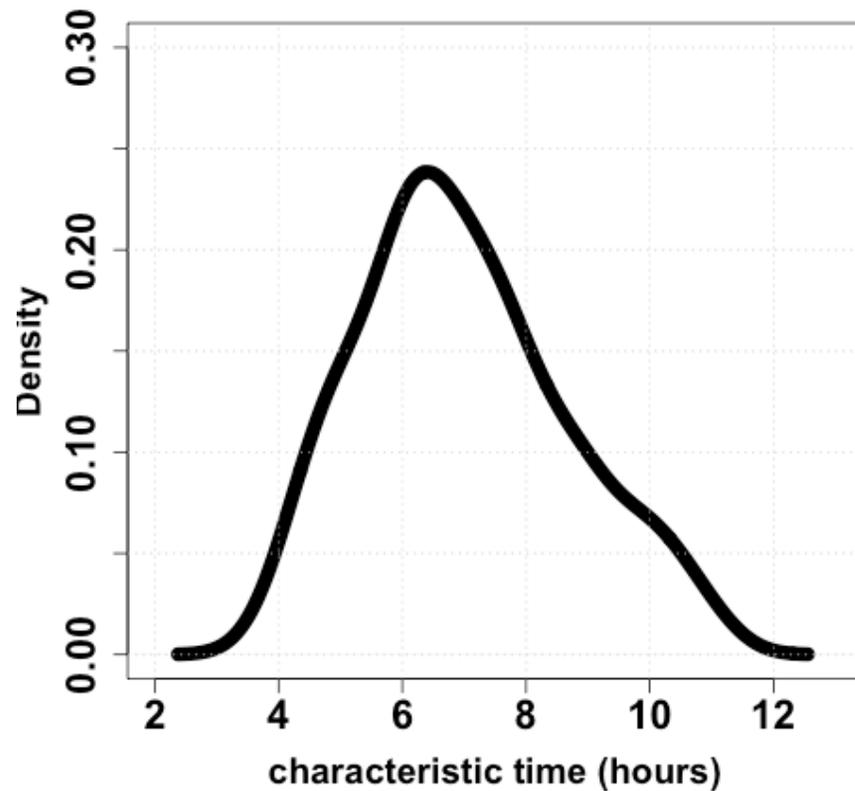
**range:** decorrelation time interval of precipitation estimates

is computed for:

- rainfall occurrence
- rainfall magnitude

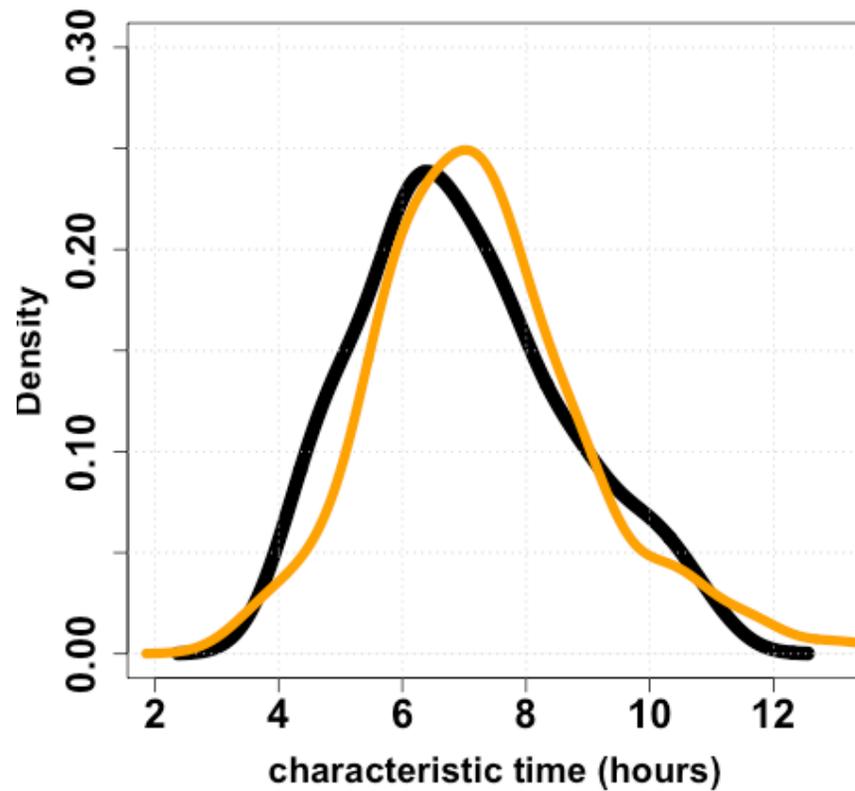


## Distribution of characteristic times for precipitation occurrence



GV-MRMS

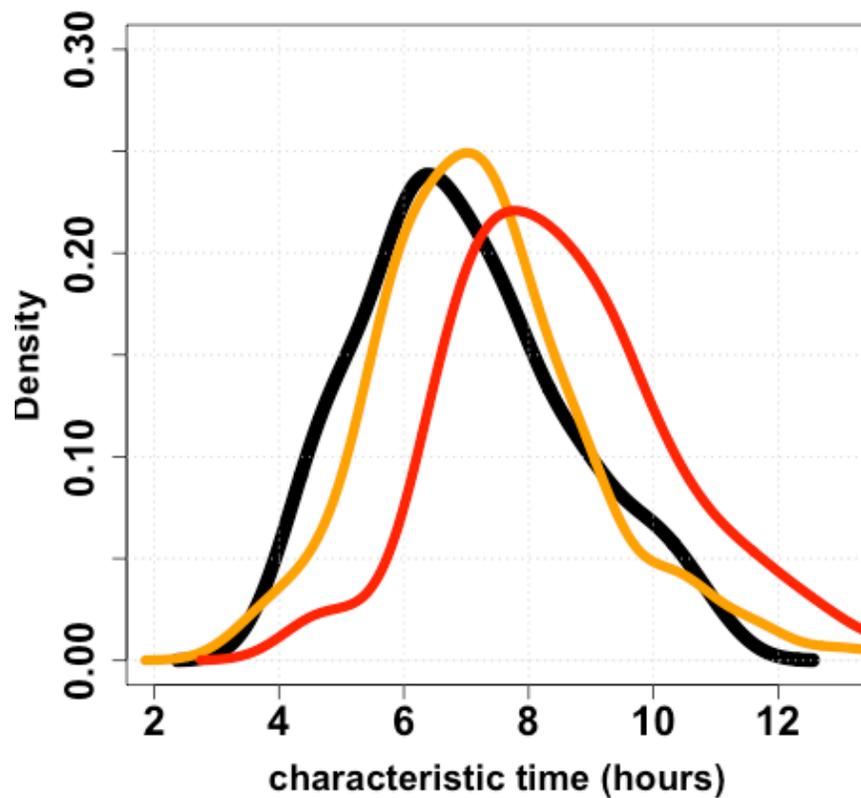
## Distribution of characteristic times for precipitation occurrence



GV-MRMS

IMERG early

## Distribution of characteristic times for precipitation occurrence

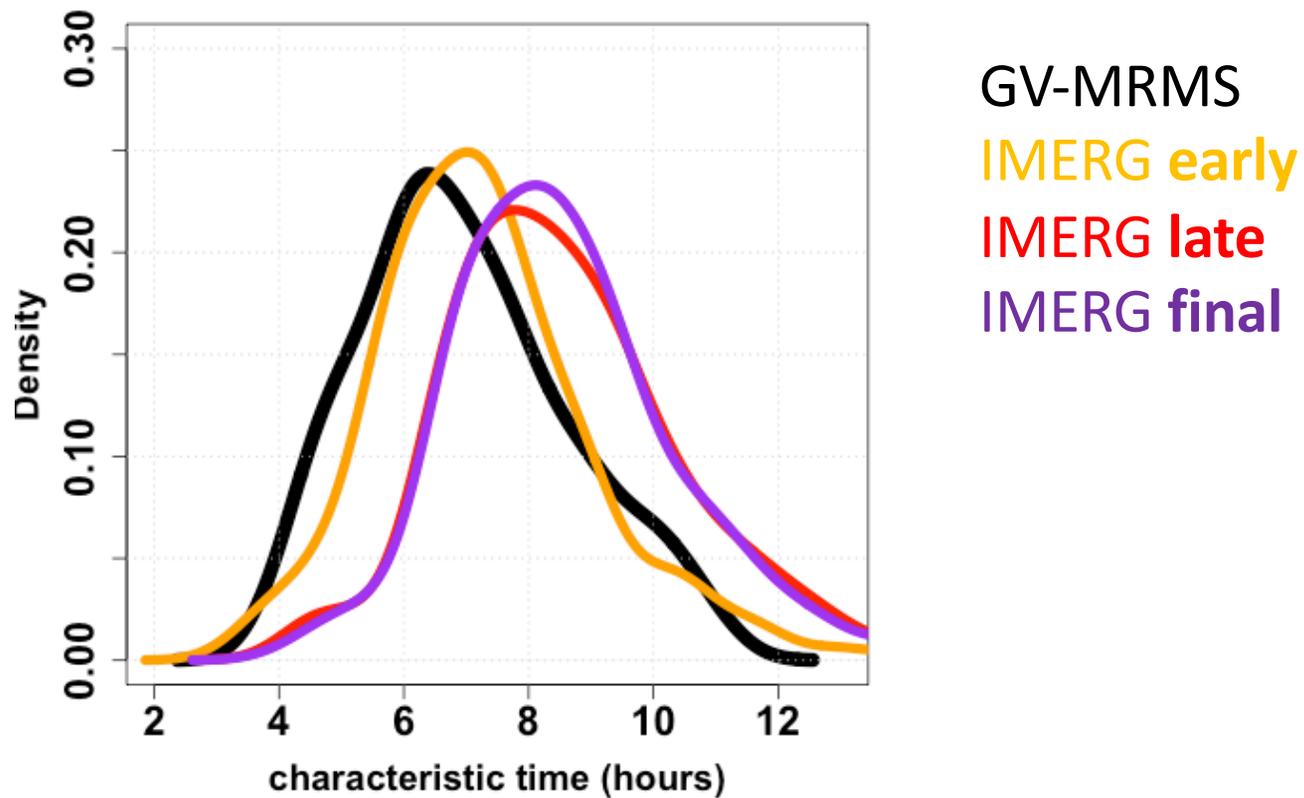


GV-MRMS

IMERG early

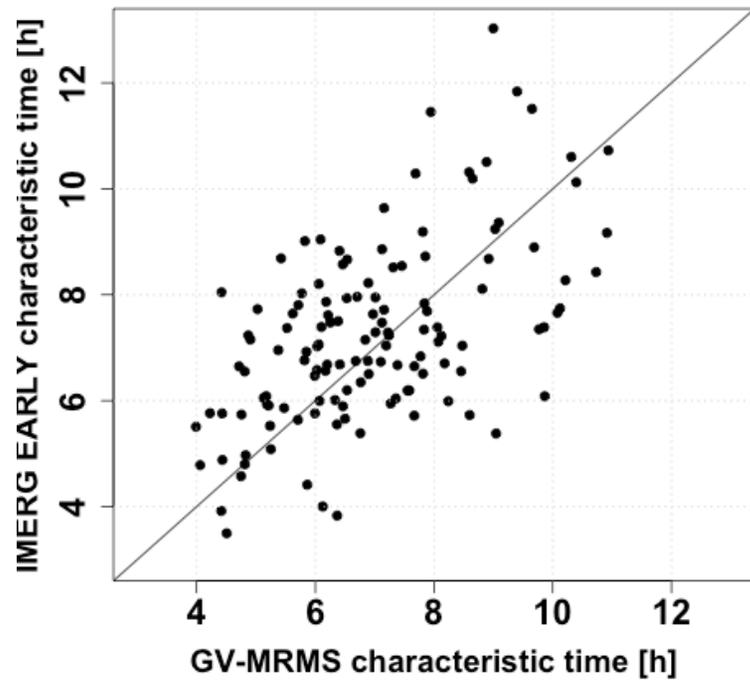
IMERG late

## Distribution of characteristic times for precipitation occurrence

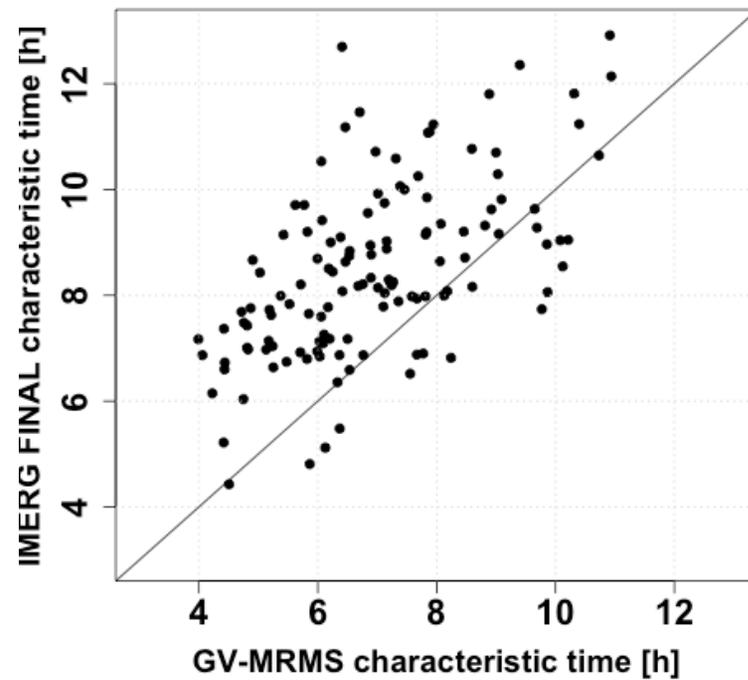


# Characteristic times for precipitation occurrence

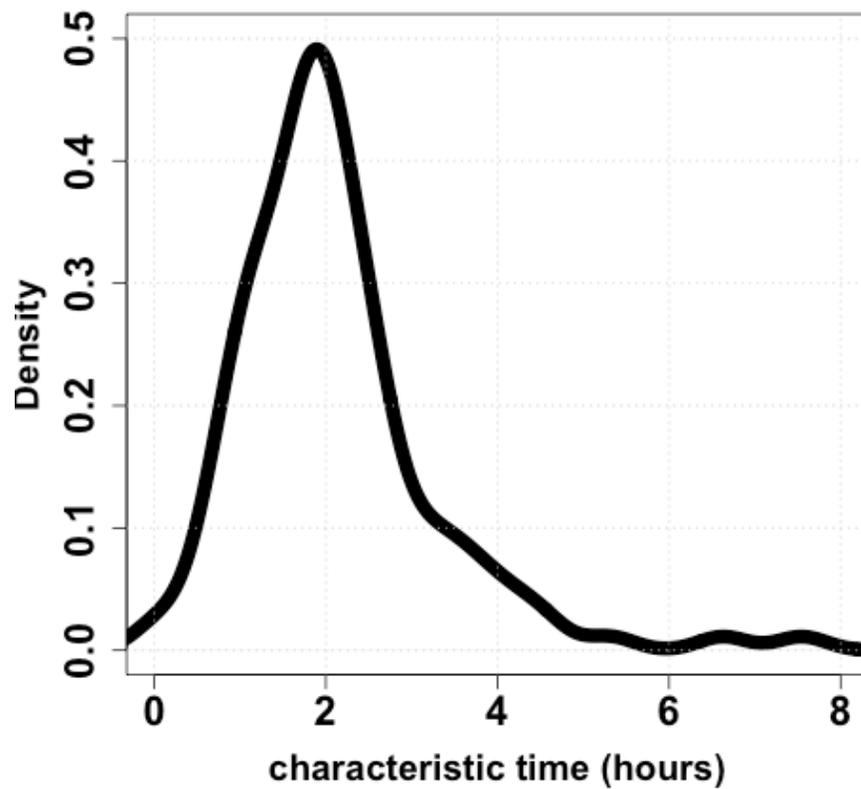
IMERG EARLY



IMERG FINAL

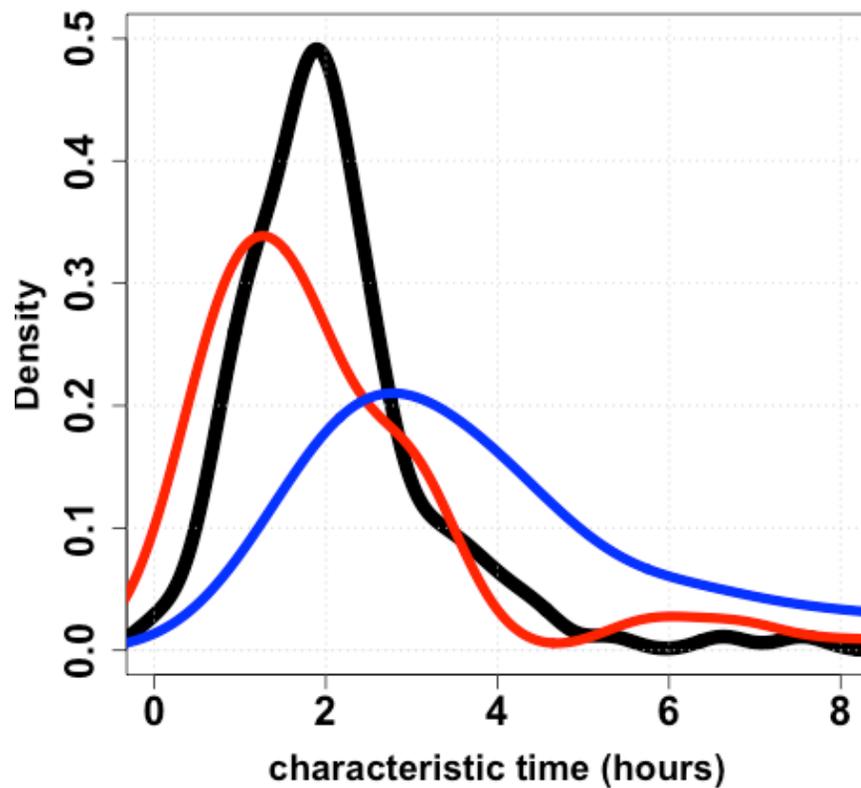


## Distribution of characteristic times for precipitation rate



GV-MRMS all

## Distribution of characteristic times for precipitation rate



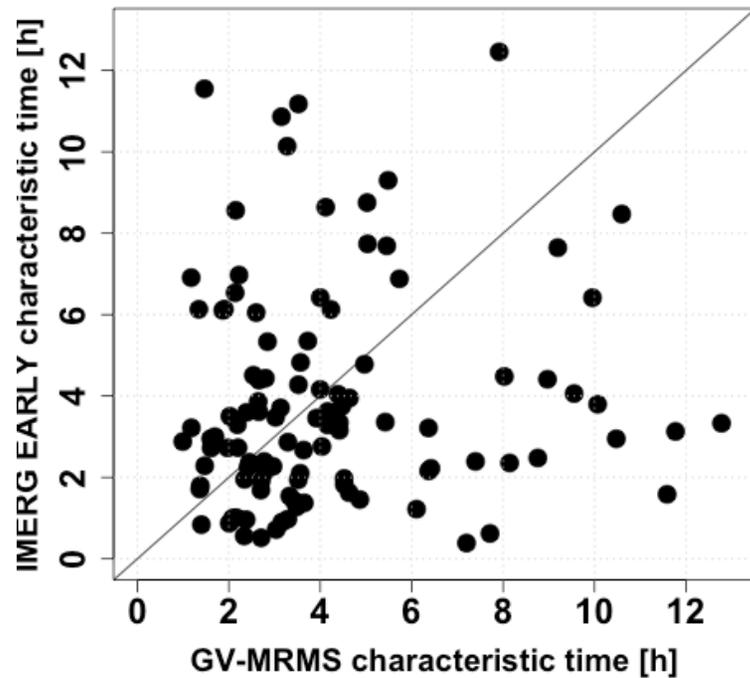
GV-MRMS all

GV-MRMS convective

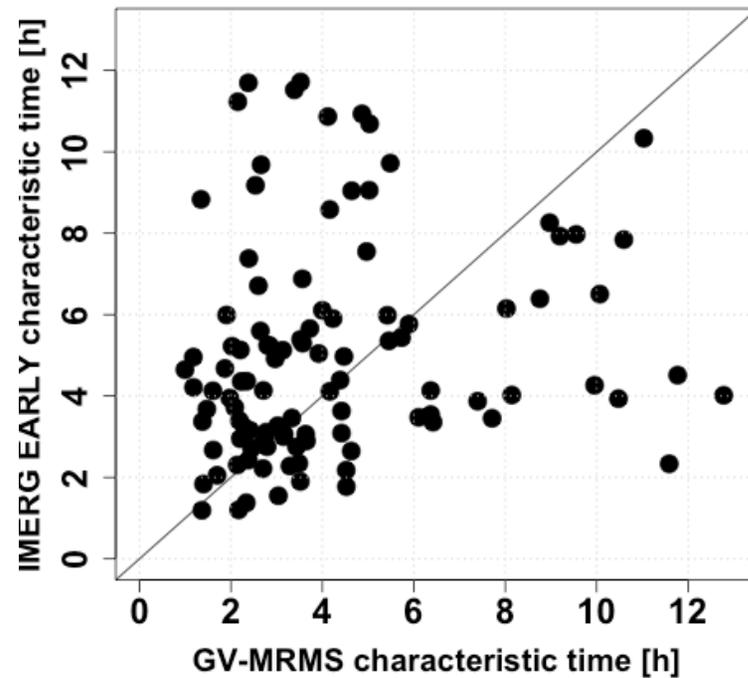
GV-MRMS stratiform

# Characteristic times for stratiform precipitation rate

IMERG EARLY

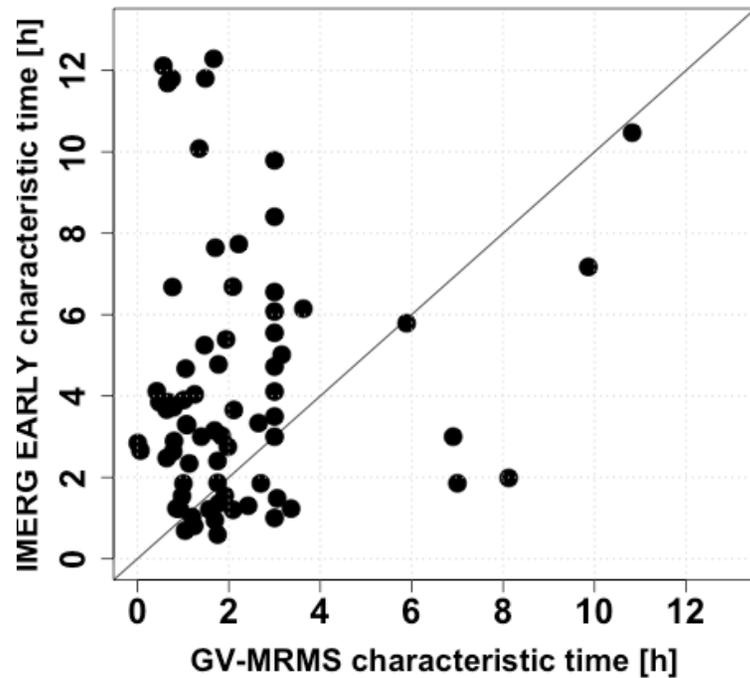


IMERG FINAL

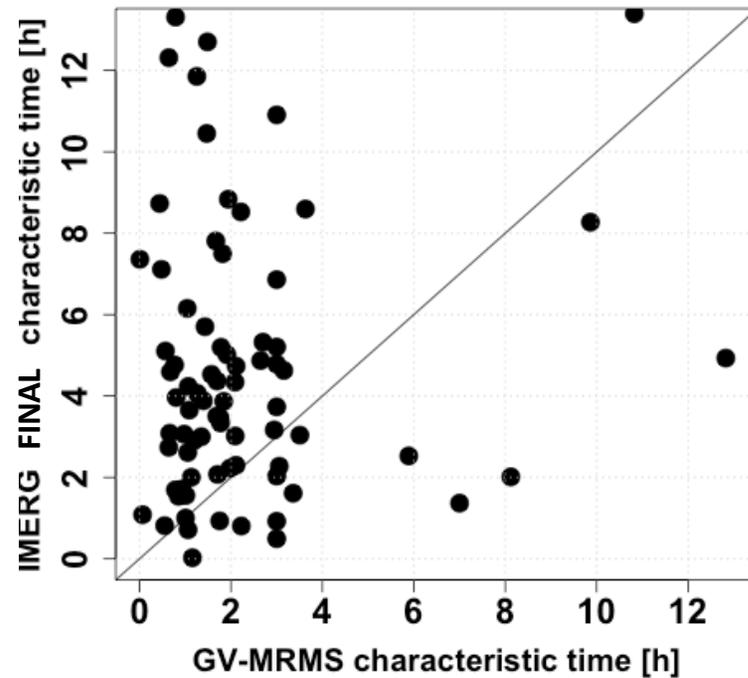


# Characteristic times for **convective** precipitation rate

IMERG EARLY



IMERG FINAL



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## 1. Dual-frequency Precipitation Radar

- Adjusting R- $D_m$  relations
- Exploring processes signatures in measurements
- Probabilistic QPE

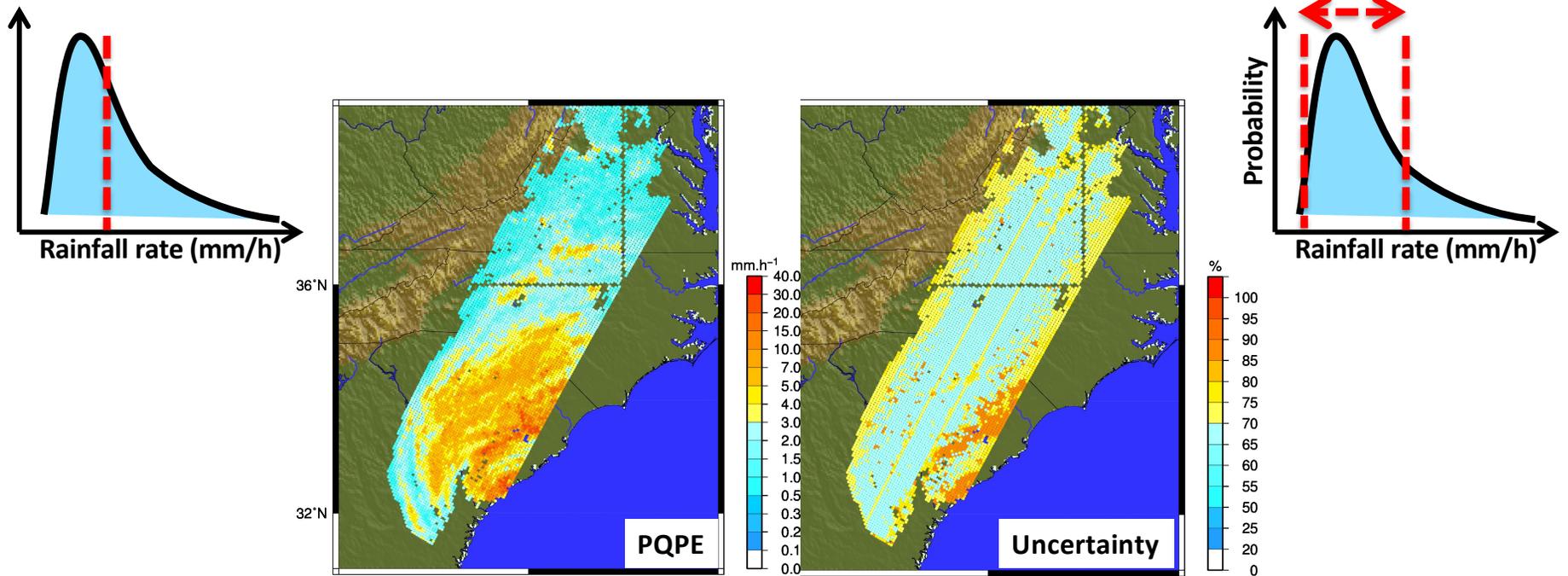
## 2. GPM Microwave Imager

- Including convective index

## 3. IMERG

- Impact of convection on QPE, diurnal cycle, characteristic time
- Probabilistic QPE

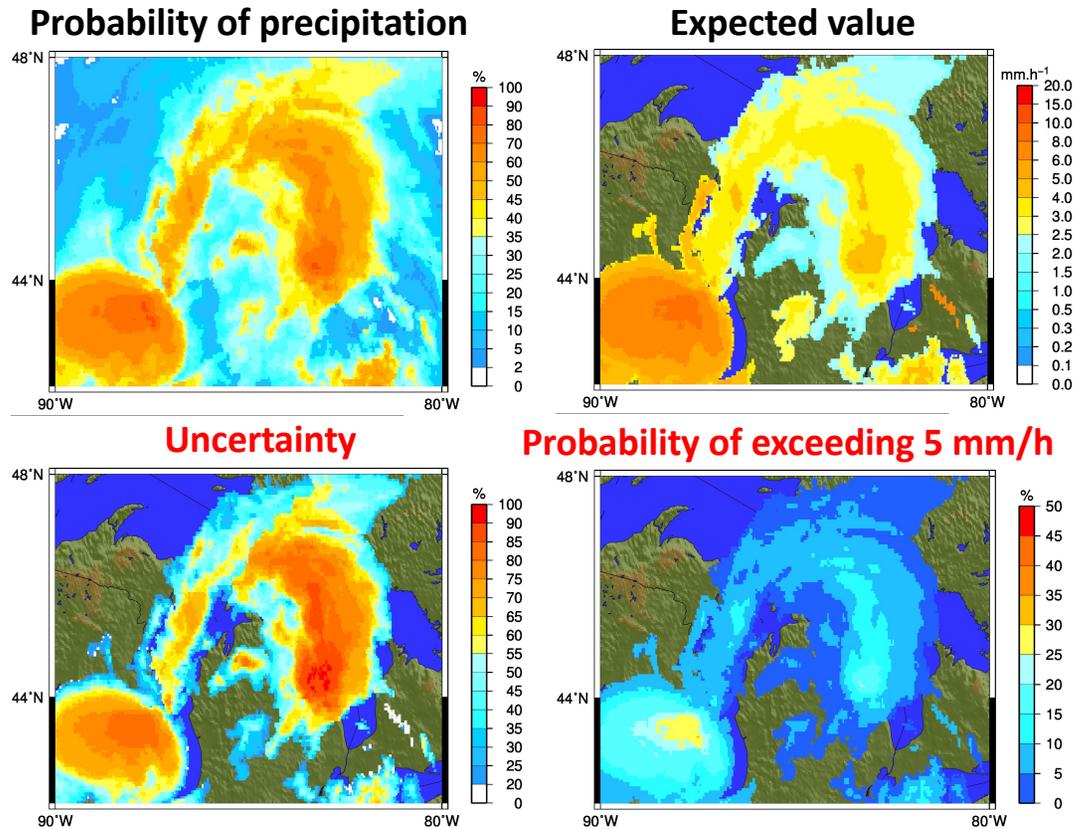
# Probabilistic QPE: GPM-DPR



Hurricane Matthew at 09:15 UTC on 08 October 2016 in North Carolina

# Probabilistic QPE: Infrared Satellite

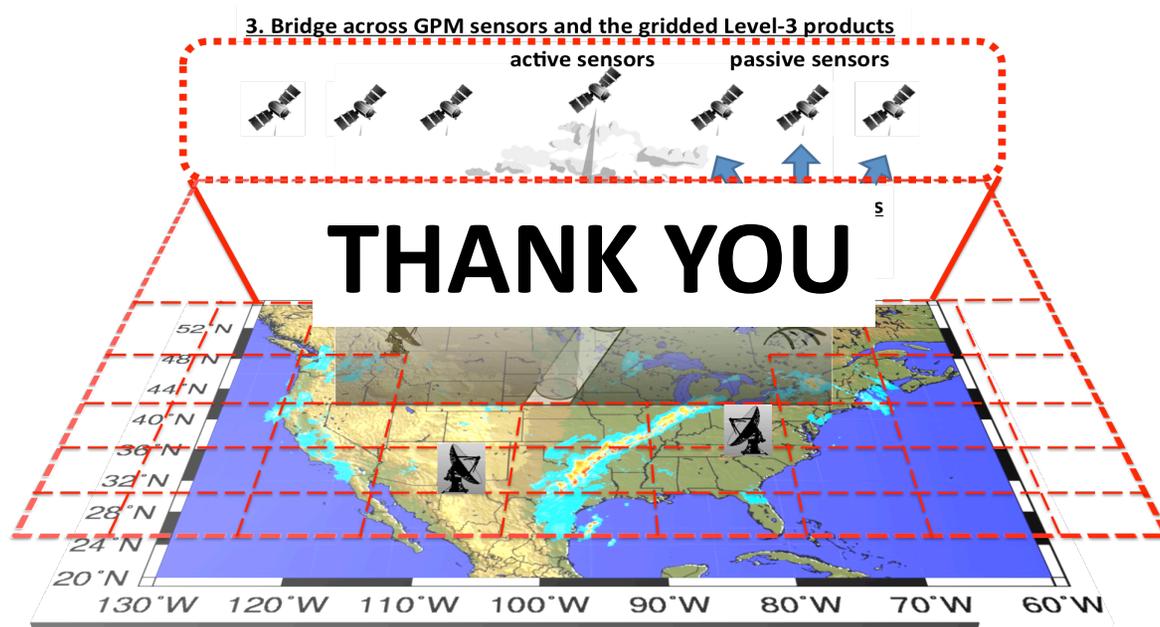
- Uncertainty as an integral part of precipitation retrieval
- Frames precipitation estimates into the user context



precipitation system at 1200 UTC on June 17, 2014

Kirstetter et al. 2018

# Ground Validation leads the way toward improved GPM precipitation estimation



This work is made possible through support by NASA Ground Validation program and Precipitation Measurement Mission program.

