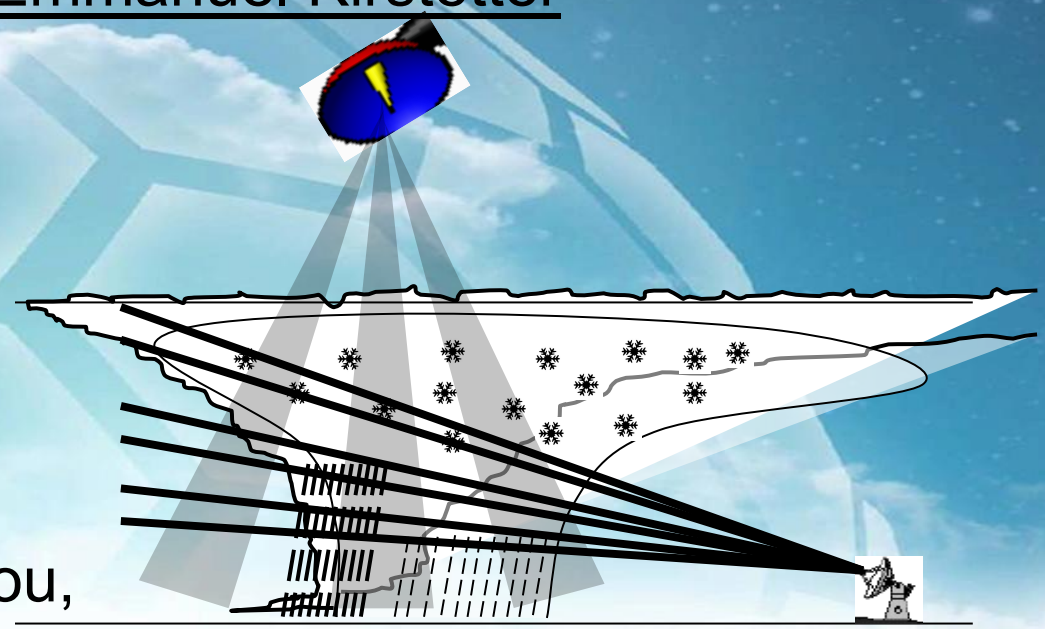
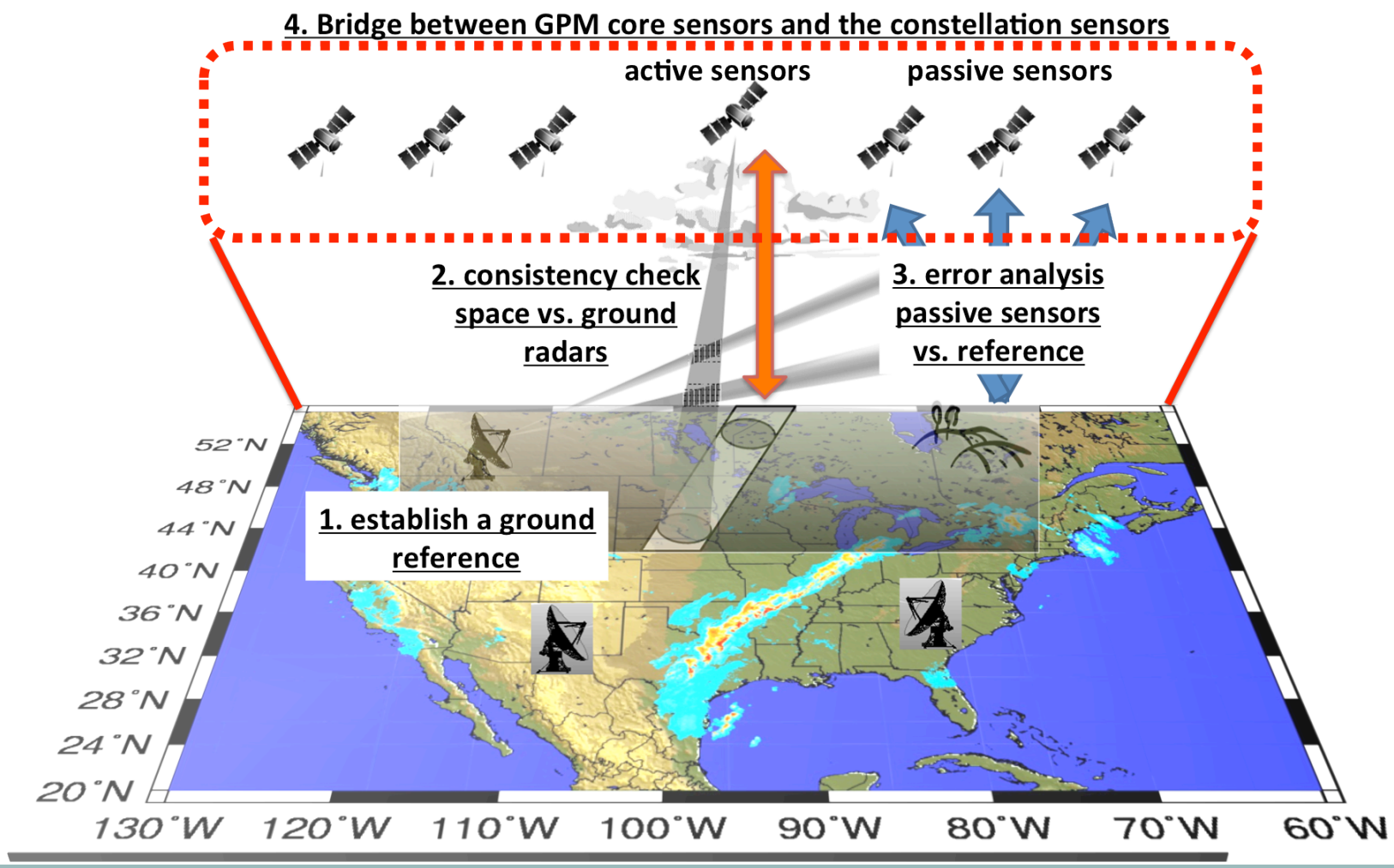
Comparing GPM with Multi-Radar Multi-Sensors toward bridging the Core and Constellation Sensors

Pierre-Emmanuel Kirstetter



with contributions of:
J.J. Gourley, Y. Hong,
N. Carr, W. Petersen,
M. Schwaller, E. Anagnostou,
C. Kummerow, R. Ferraro, N.Y. Wang

Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors



Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors

1. Reference from Multi-Radar Multi-Sensor

2. Diagnostic analysis

3. Prognostic analysis

Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors

1. **Reference from Multi-Radar Multi-Sensor**
   - **Precipitation features**

2. **Diagnostic analysis**

3. **Prognostic analysis**

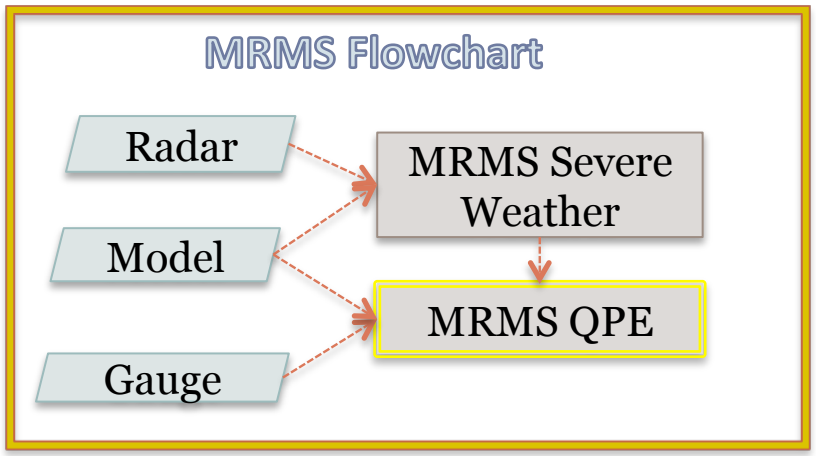
Overview of the Multi-Radar Multi-Sensor (MRMS) System

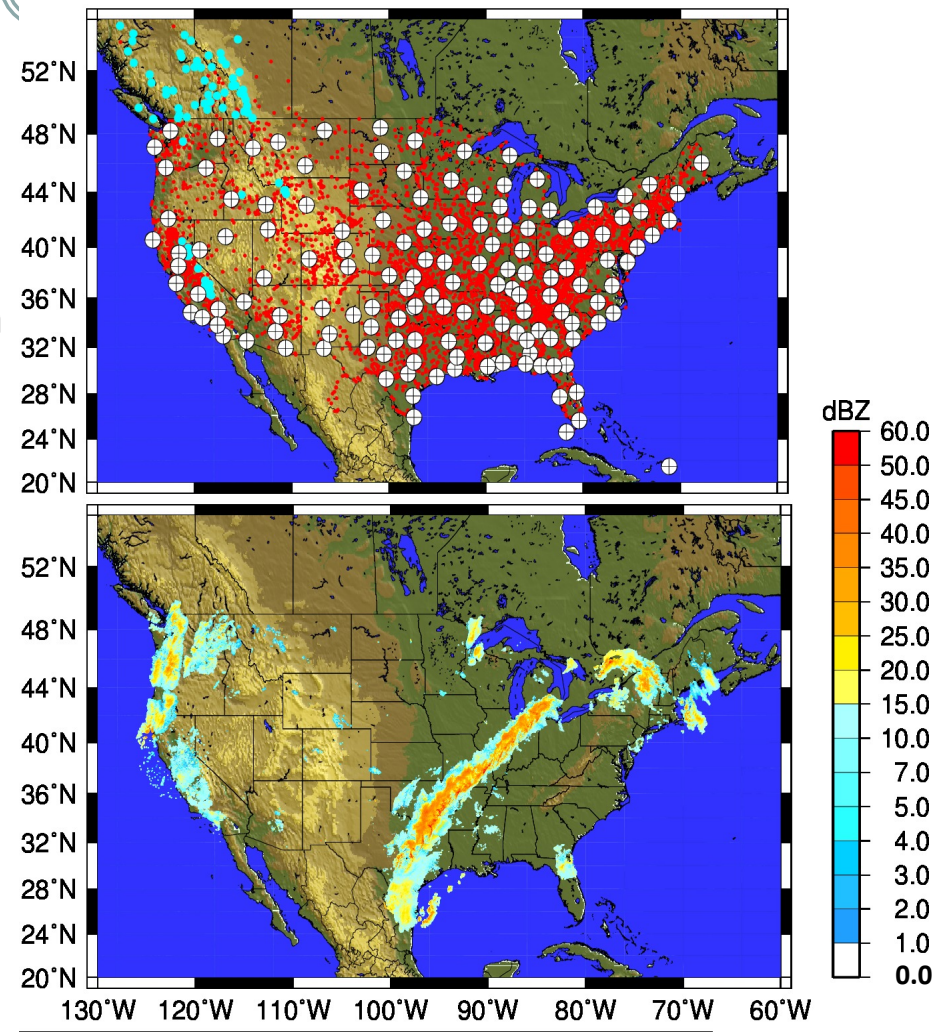
Domain: 20-55°N, 130-60°W

Resolution: 0.01°, 2 min update cycle

Data Sources:

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





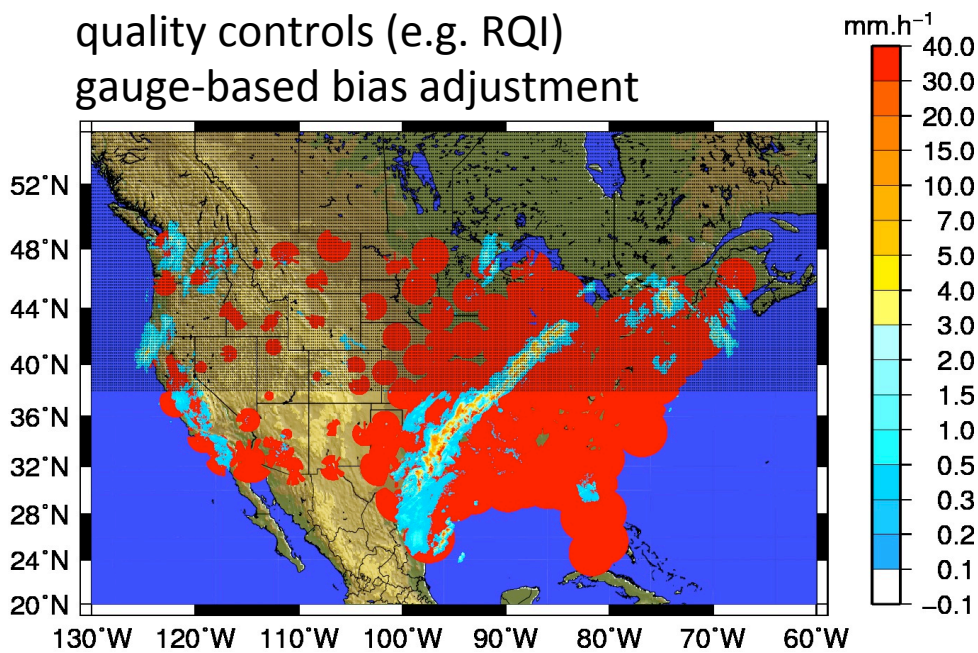
frontal system at 0800 UTC on 11 April 2011

A reference is derived from Multi-Radar Multi-Sensor quality controls

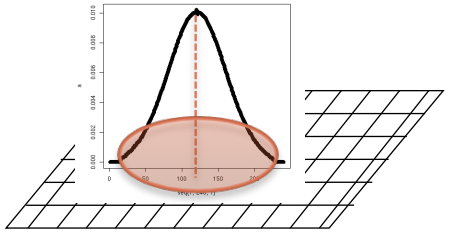
#1: <u>prerequisites</u>:

- **refine reference precipitation as much as possible**
- **adapt (upscale) to the resolution of the satellite**

quality controls (e.g. RQI)
gauge-based bias adjustment



satellite footprint
(DPR: ~5km resolution)

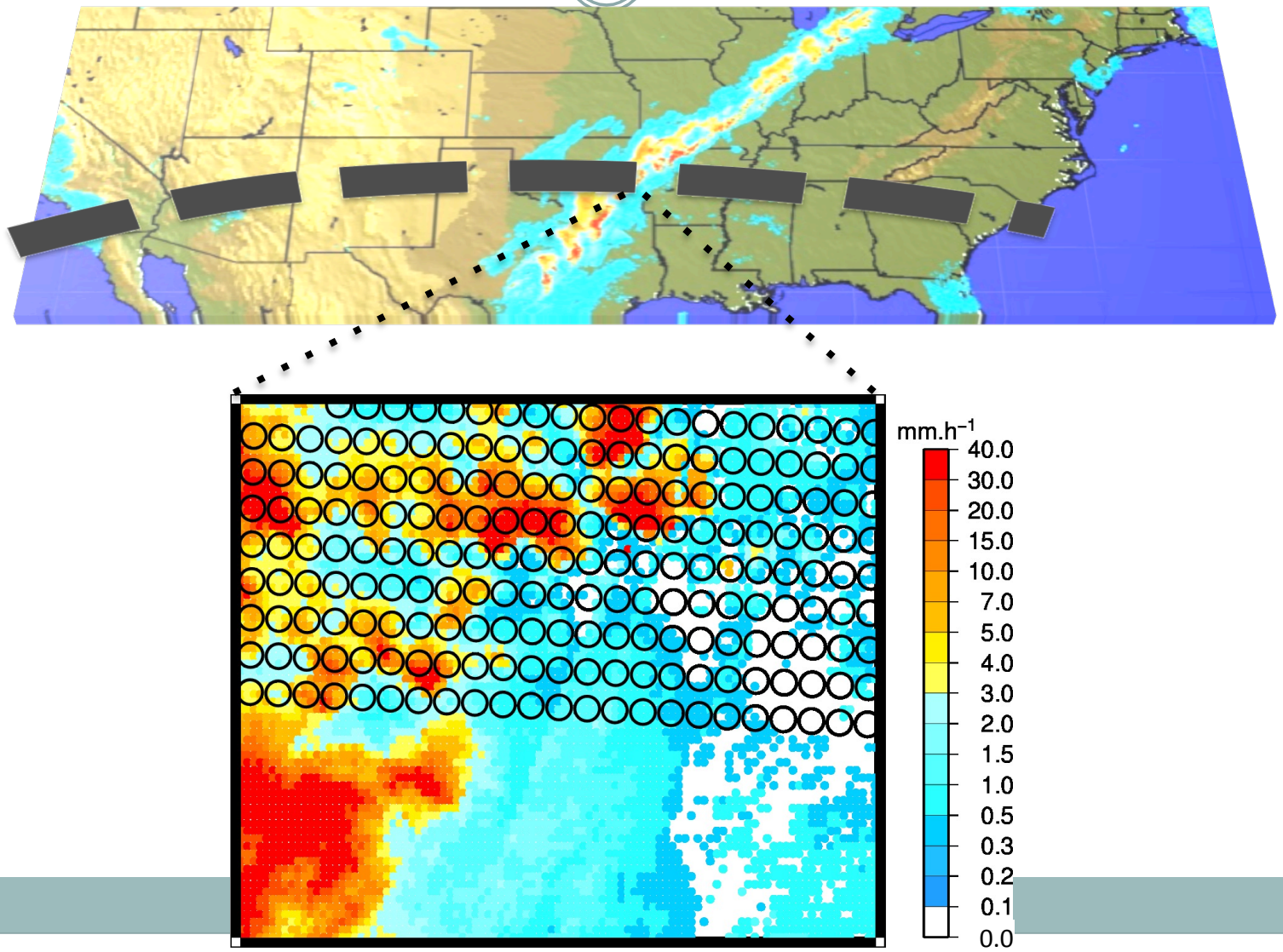


Q3 grid (~1km resolution)

<u>Output</u>: - improved data quality steps ⇔ increased consistency between space and reference

A reference is derived from Multi-Radar Multi-Sensor

Precipitation features

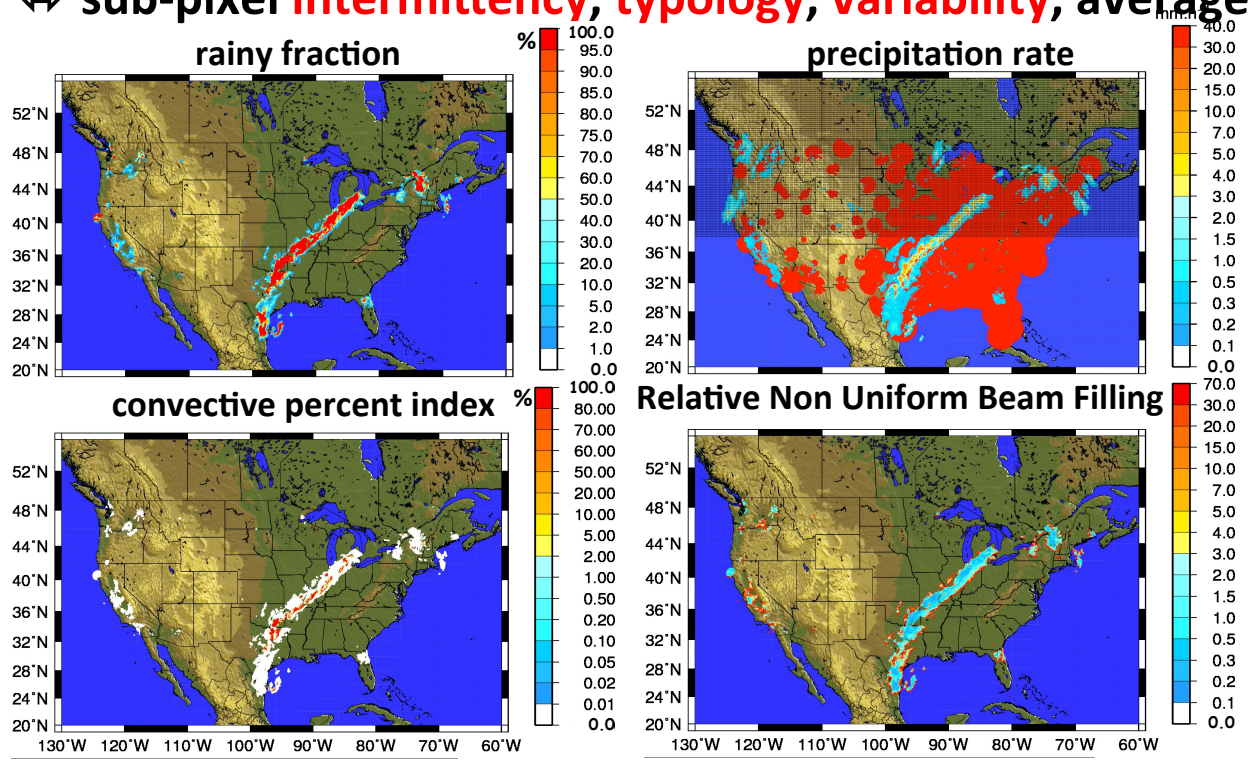


A reference is derived from Multi-Radar Multi-Sensor

Precipitation features

Consistent analyze: detection, classification, quantification

⇔ sub-pixel intermittency, typology, variability, averaged rate



- **Detection abilities of active / passive sensors**
- **Precipitation typing, Z-R relationships, convective rainfall (passive)**
- **First and second order quantitative discrepancies, conditioned on factors**
- **Non Uniform Beam Filling for active and passive sensors**

Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors

1. Reference from Multi-Radar Multi-Sensor

2. **Diagnostic analysis: biases & uncertainty = f (reference)**

   Algorithm ← Estimate ⟷ Reference → Features

3. Prognostic analysis

Precipitation physics driven analysis

Diagnostic: biases & uncertainty = f (reference)

Previous analyses:

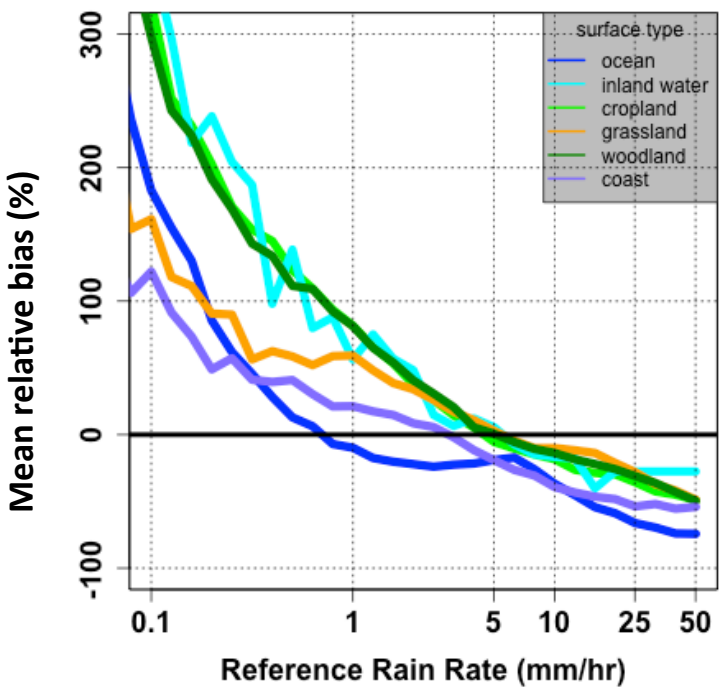
- comparisons of rainfall detectability & distributions
- separation of systematic biases and random errors
- spatial representativeness of error
- regional precipitation biases
- comparison between satellite products
- assessing the influence of surface types & precipitation properties
- bridge in-depth error characterization across constellation sensors

Precipitation physics driven analysis

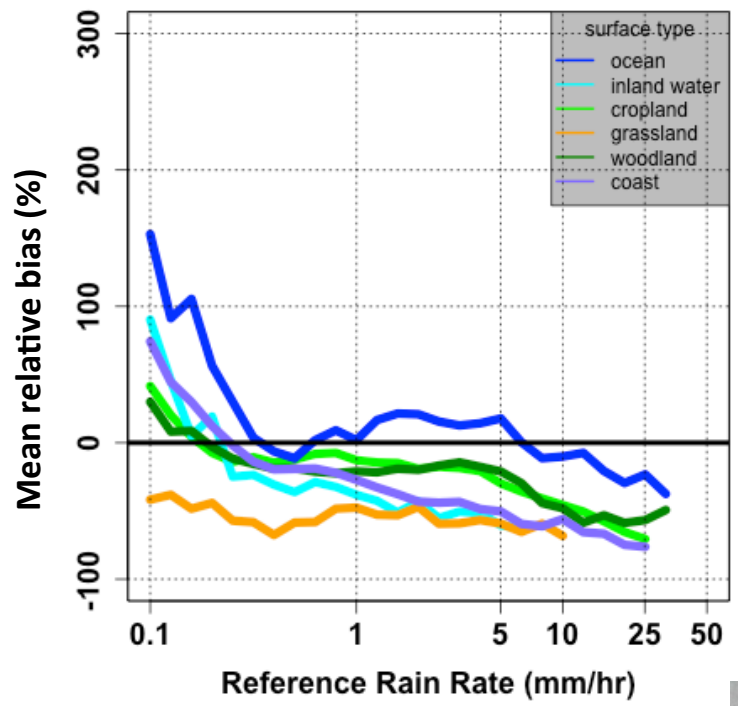
Diagnostic: biases & uncertainty = f (reference)

Precipitation magnitude and surface impact on PMW retrieval bias

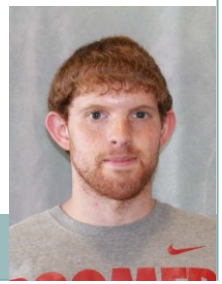
TRMM-TMI



GPM-GMI



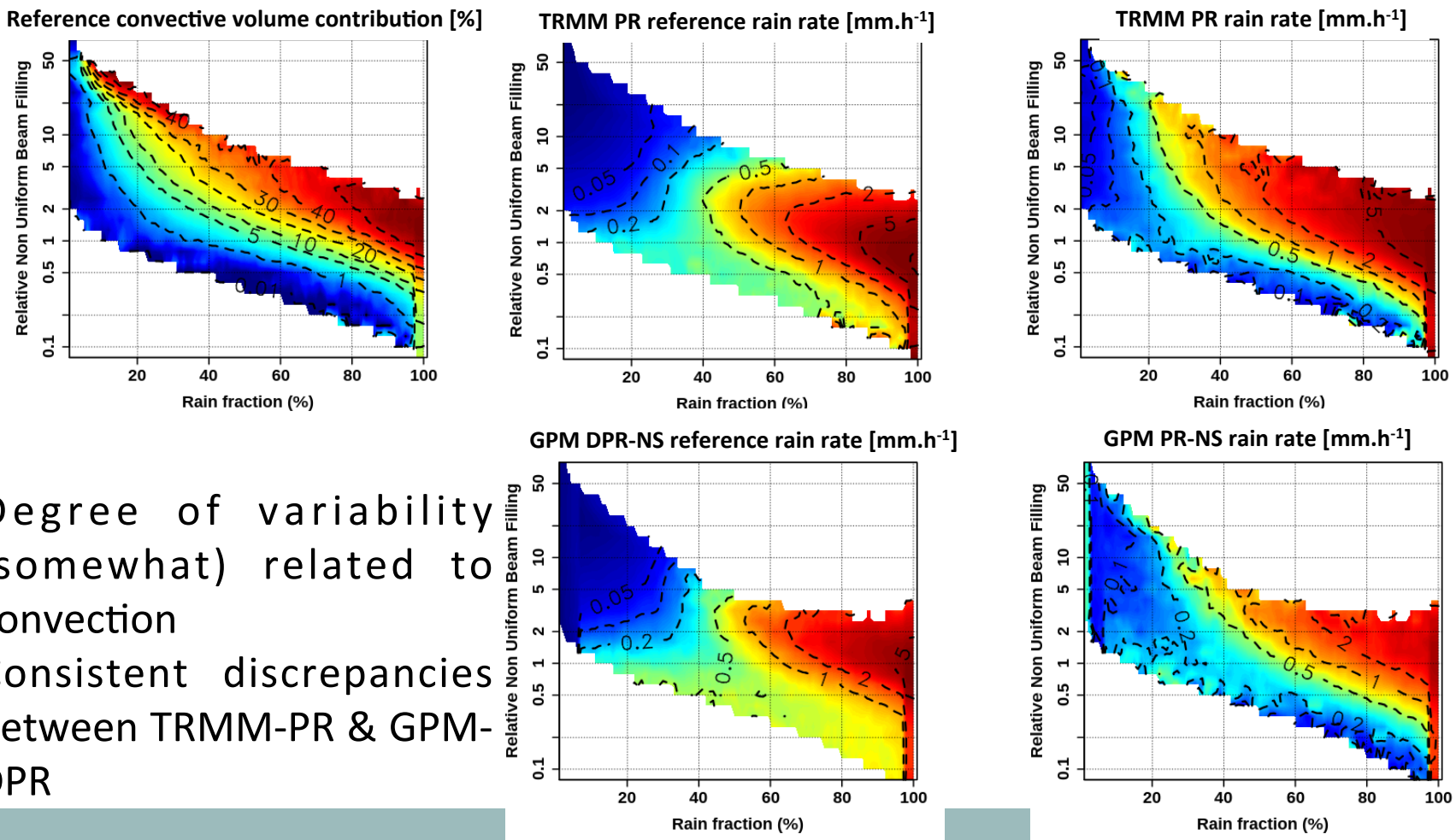
- Surface type has an impact that varies with rain intensity
- GMI improves on TMI



Precipitation physics driven analysis

Diagnostic: biases & uncertainty = f (reference)

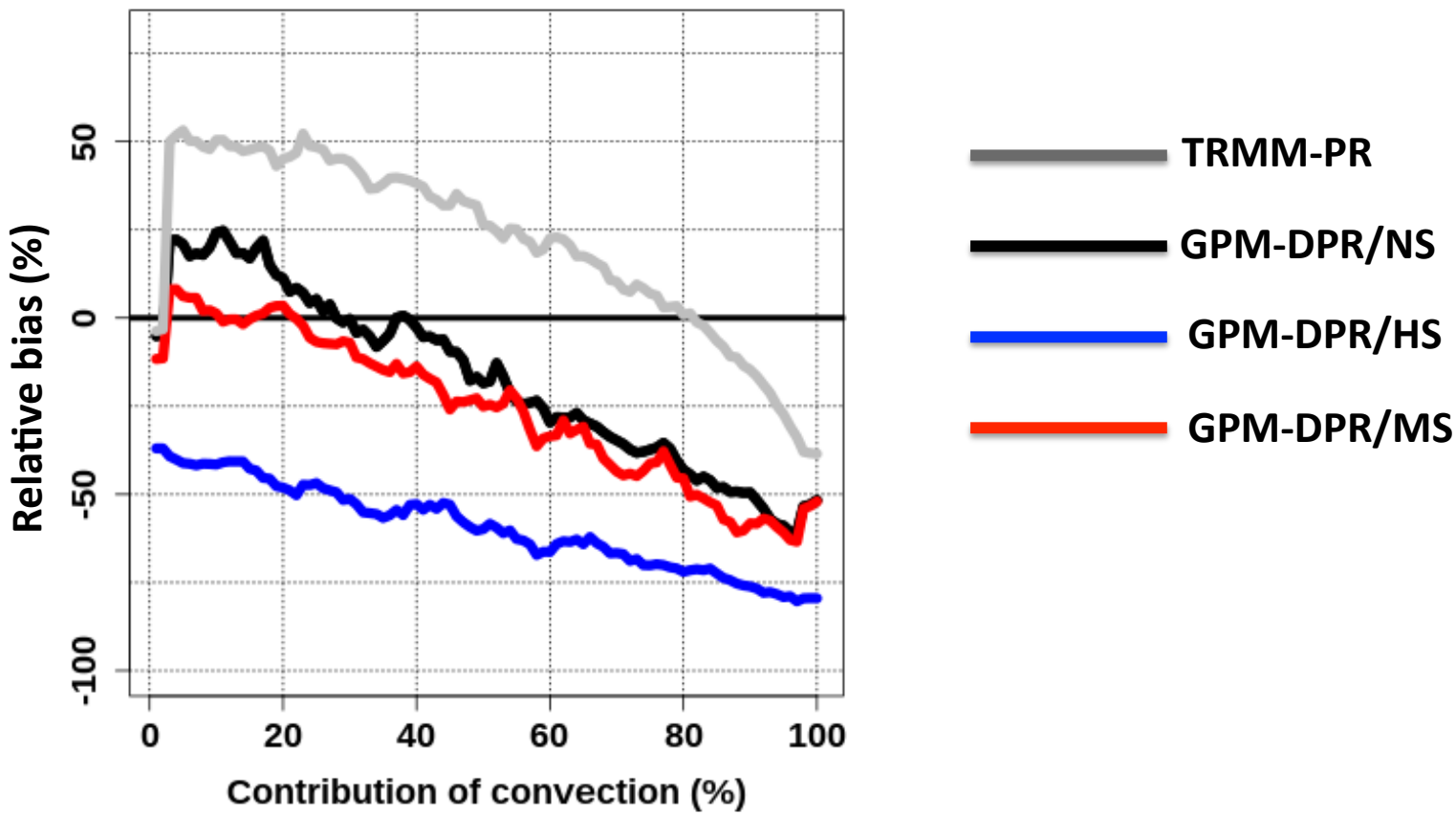
Non-Uniform Beam Filling impacts on radar quantification



- Degree of variability (somewhat) related to convection
- Consistent discrepancies between TRMM-PR & GPM-DPR

Precipitation physics driven analysis

Contribution of convection impacts on radar bias



Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors

1. Reference from Multi-Radar Multi-Sensor

2. Diagnostic analysis

3. **Prognostic analysis: biases & uncertainty = f (satellite)**

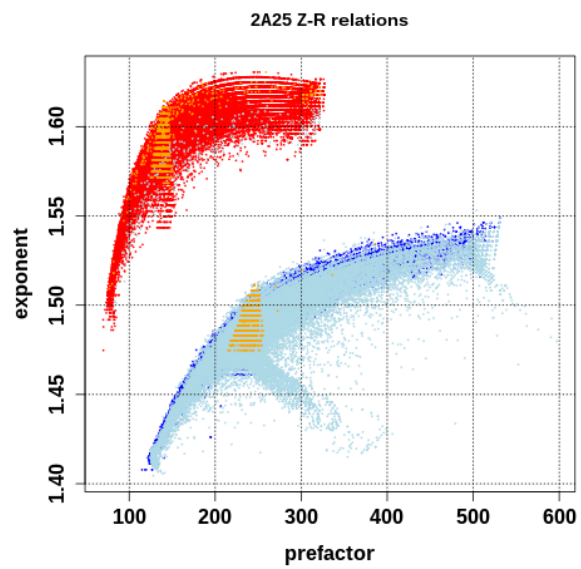
Algorithm ← Estimate ⟷ Reference → Features

Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Radar QPE = f(reflectivity, incidence angle, Z-R, NUBF)

- a multi-dimensional problem



Algorithm driven analysis

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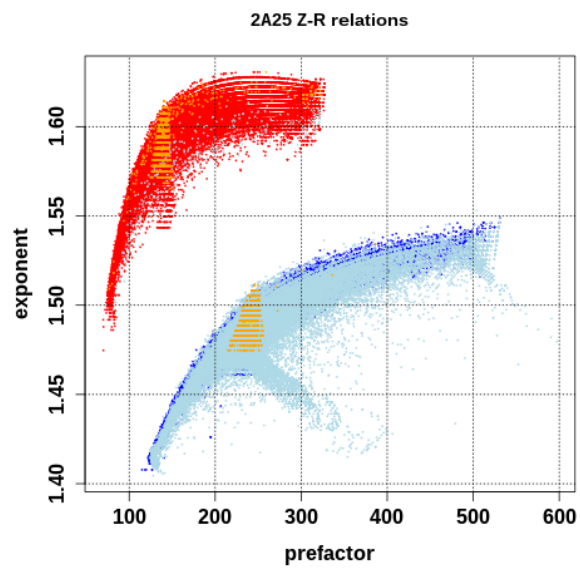


Reference QPE <= ? => f(reflectivity, incidence angle, Z-R, NUBF)

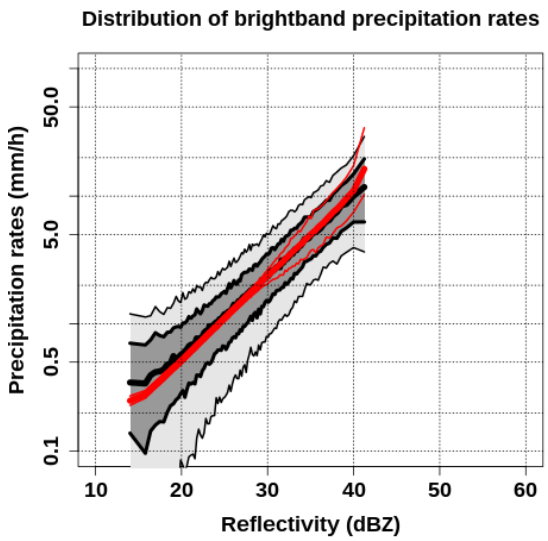
- what is the information content to converge to the reference?
- build on the algorithm assumptions and method
- adjust the algorithm parameters to reflect the precipitation rate

Algorithm driven analysis

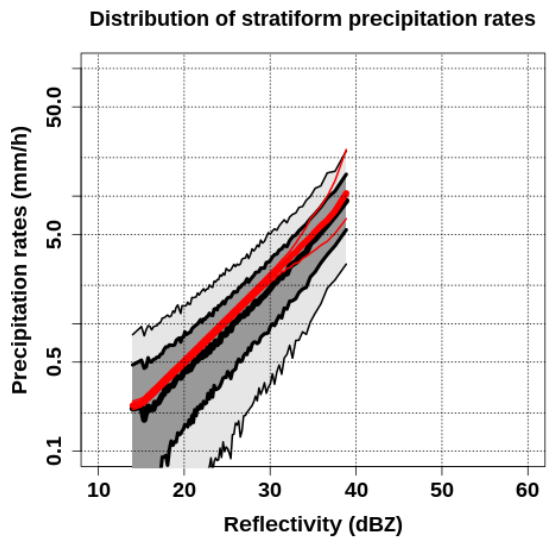
Prognostic: biases & uncertainty = f (satellite)

Reference QPE <= ? => f(reflectivity)

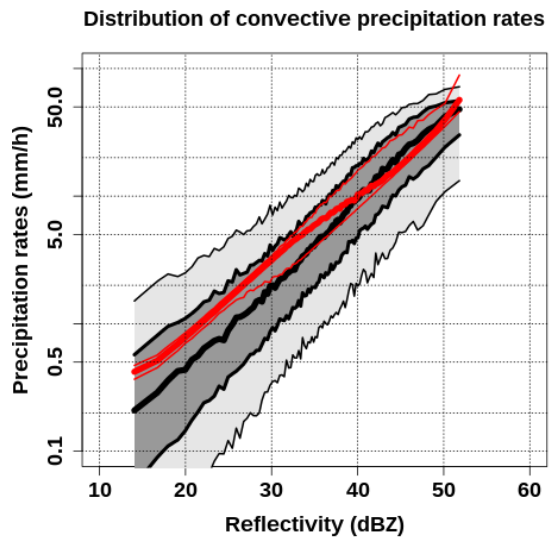
brightband



stratiform



convective



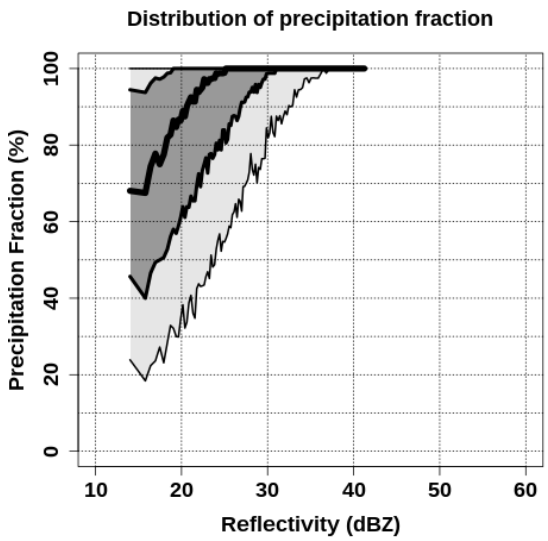
Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Reference QPE <= ? => f(reflectivity)

- reference features: intermittency

brightband



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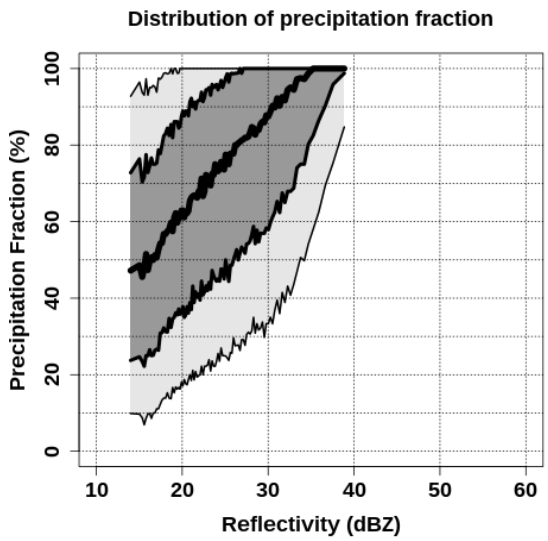

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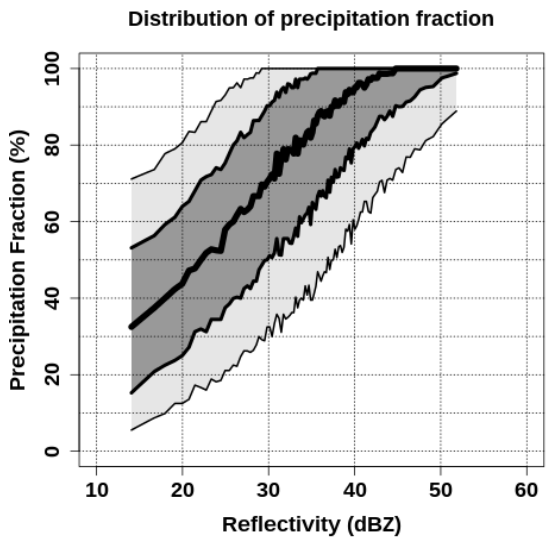


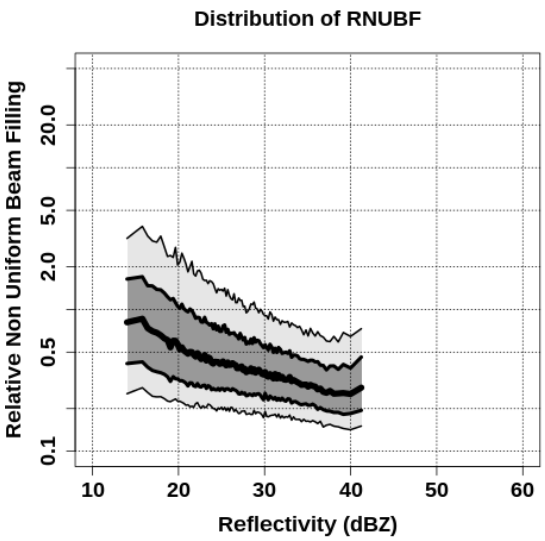
Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Reference QPE <= ? => f(reflectivity)

- reference features: RNUBF

brightband



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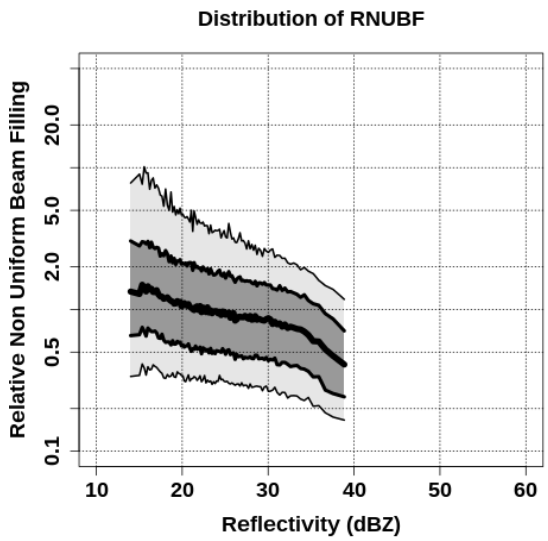

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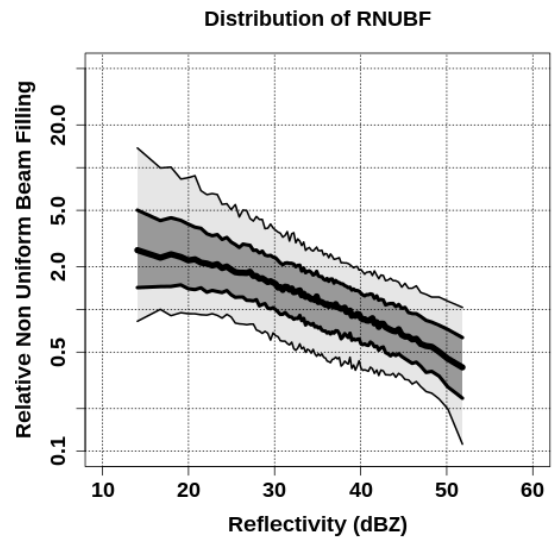


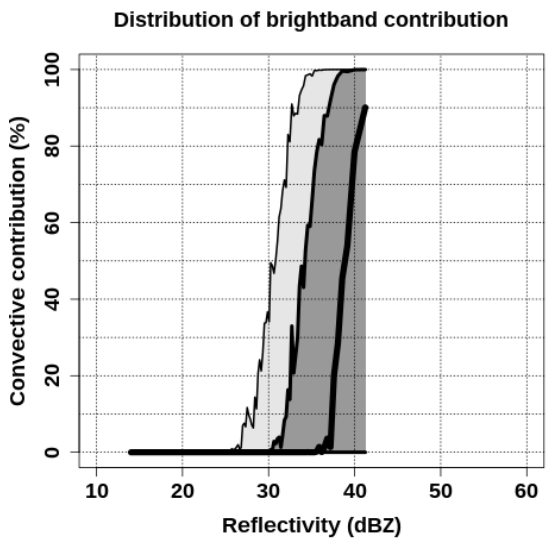
Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Reference QPE <= ? => f(reflectivity)

- reference features: convective volume contribution

brightband



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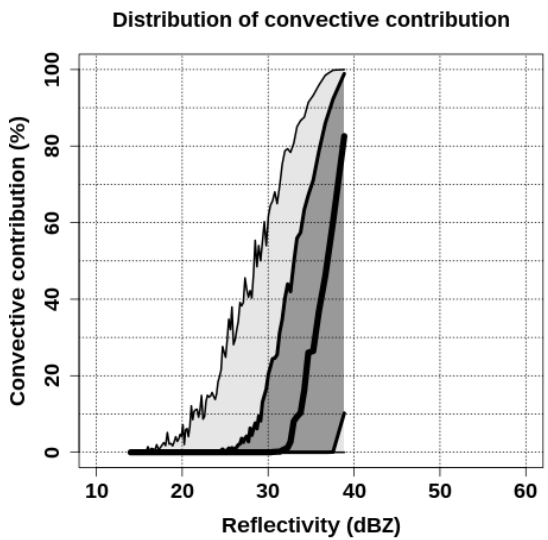

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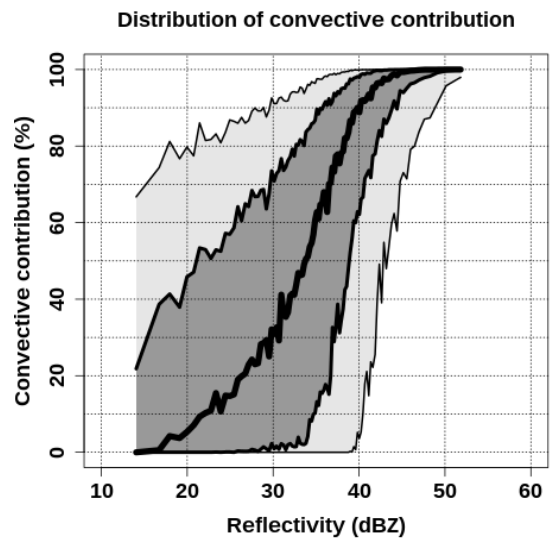
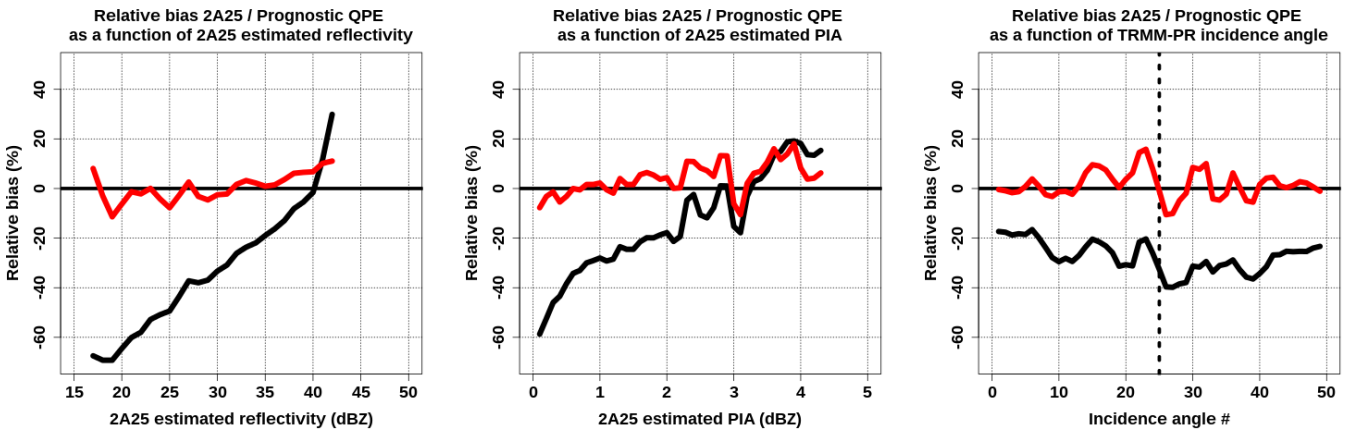


Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Conditional biases relative to 2A25 factors



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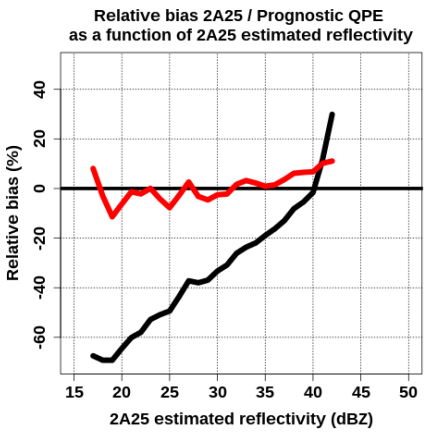
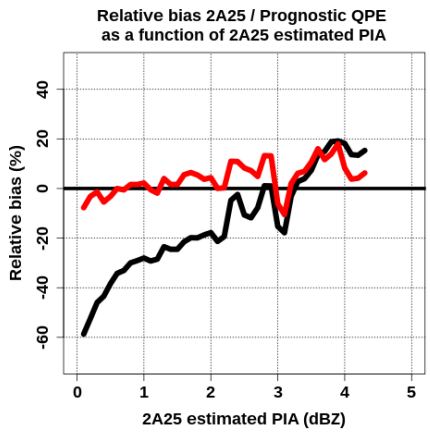
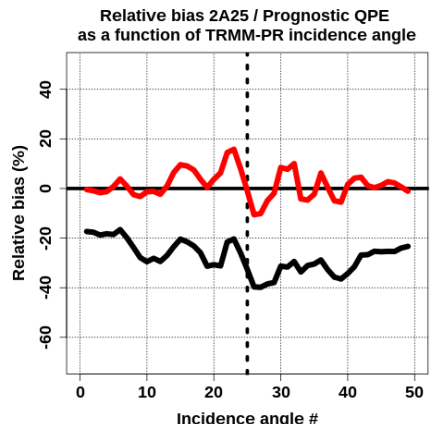




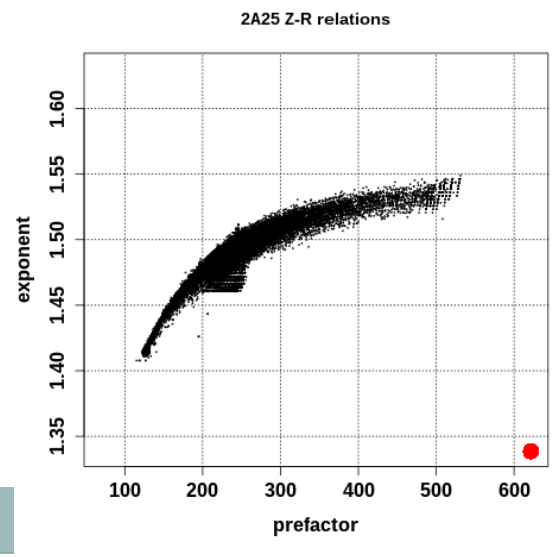


- **2A25 Z-R relationship analysis**

  2A25

  Prognostic model

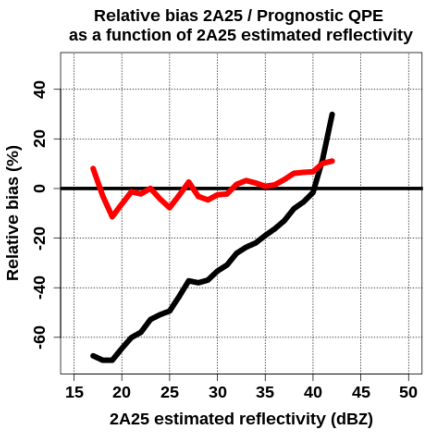
- **NUBF factor is multiplied by 4**

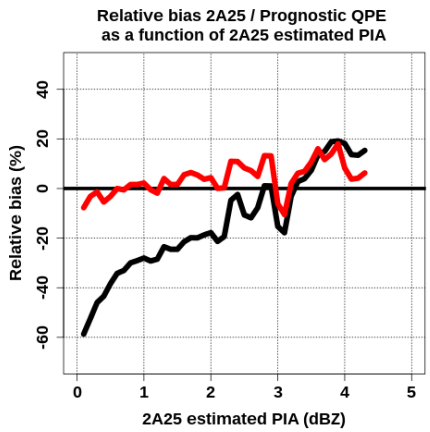


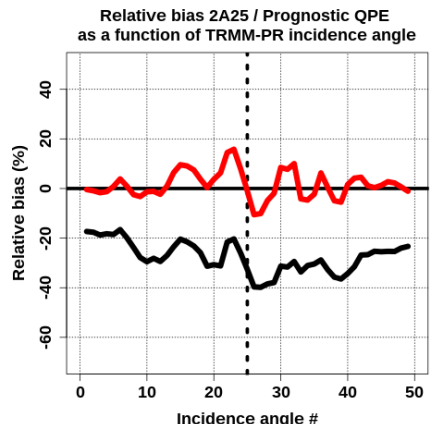
Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Conditional biases relative to 2A25 factors







- **2A25 Z-R relationship analysis**

  2A25

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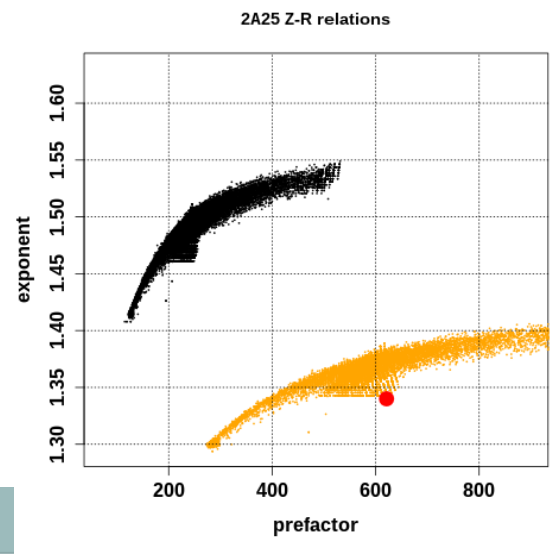


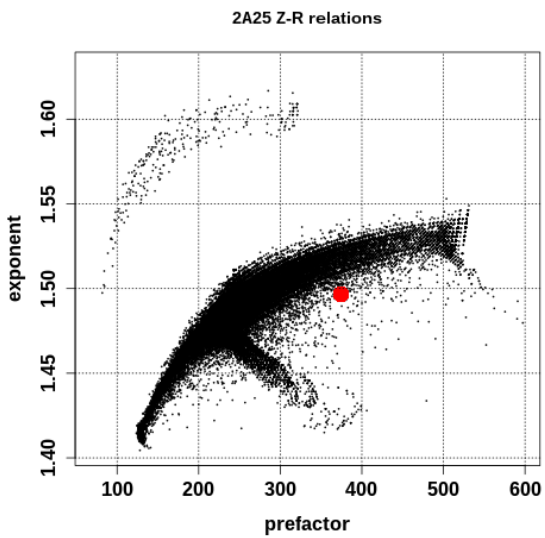
Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Reference QPE <= ? == f(reflectivity, incidence angle, Z-R, NUBF)

- Z-R relationships

brightband



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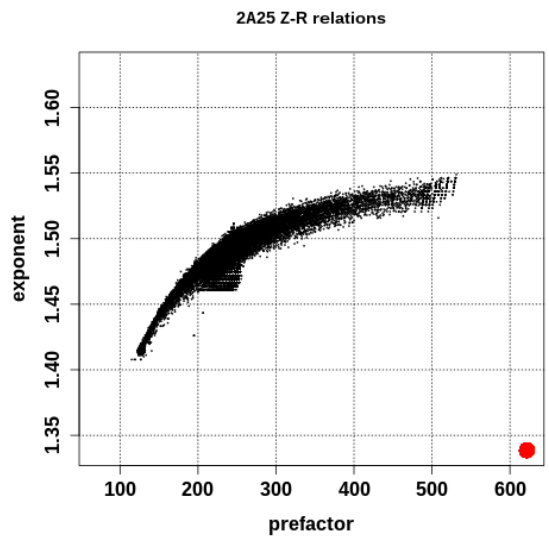
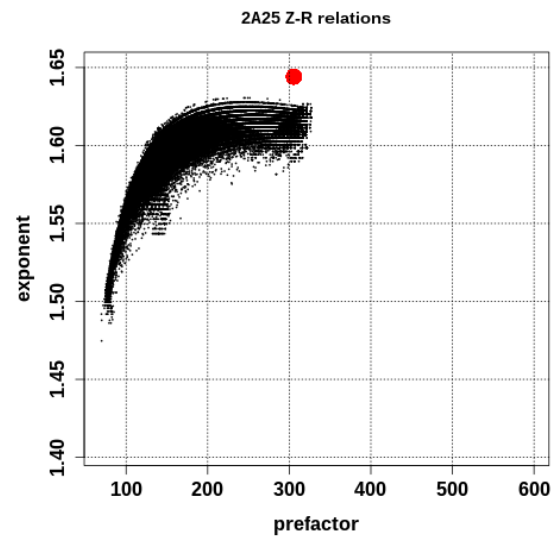


convective



- NUBF correction factor

X 8 **X 4** **X 400**

Algorithm driven analysis

Prognostic: biases & uncertainty = f (satellite)

Reference QPE <= ? => f(reflectivity, incidence angle, Z-R, NUBF)

Conditions: stratiform

Identification of significant 2A25 factors:

- ✓reflectivity
- ✓ incidence angle
- ✓ NUBF factor

	Bias (%)	Correlation
2A25	-26 %	0.56
Prognostic model	-0.4 %	0.66

Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors

1. **Reference from Multi-Radar Multi-Sensor**
   - Precipitation features

2. **Diagnostic analysis**
   - biases and uncertainty = f (reference precipitation)
   - ability to reflect the reference features
   - questions the algorithm assumptions and method

3. **Prognostic analysis**
   - biases and uncertainty = f (satellite precipitation)
   - build on the algorithm assumptions and method
   - adjust the algorithm parameters to reflect the precipitation rate

Summary

1. Direct statistical validation at the surface

- **provides overall picture**

2. Reference precipitation physics driven analysis

- **ancillary information on the precipitation column ⇔ satellite retrieval algorithm performances under a variety of environmental conditions**

  → active: GPM-DPR improves relative to TRMM-PR

  → passive: GPM-GMI better than TRMM-TMI

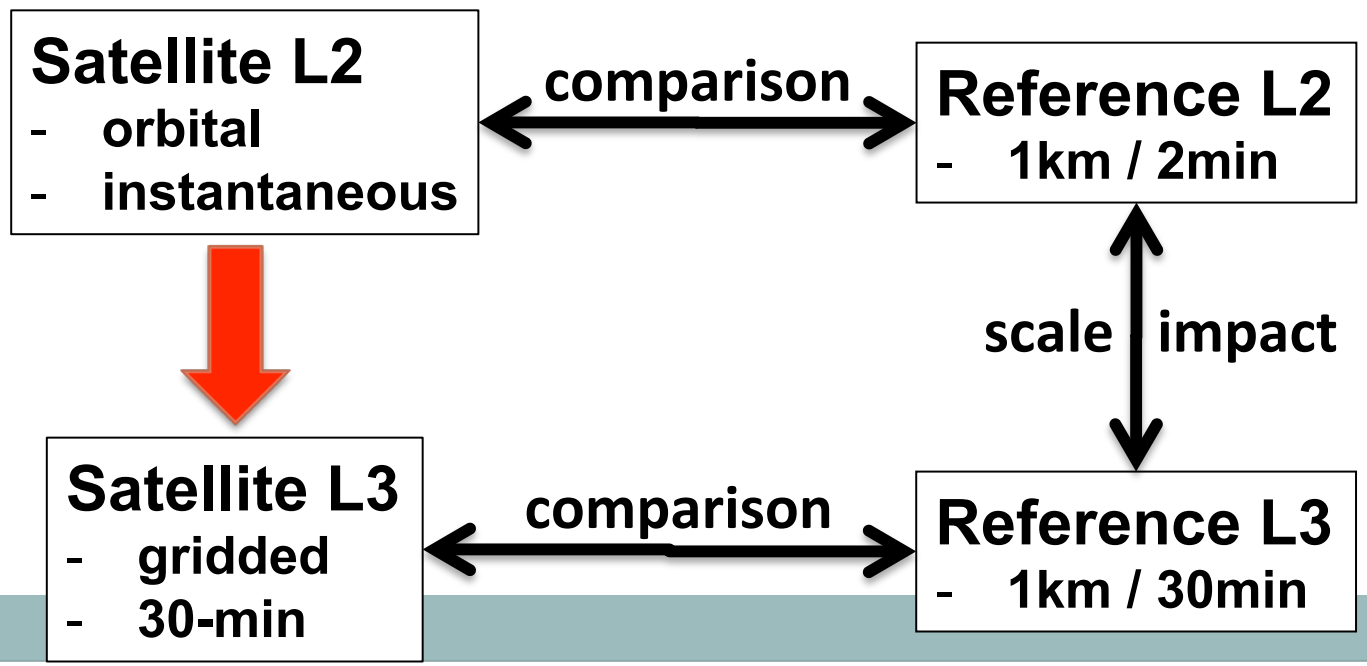
3. Algorithm driven analysis

- **satellite retrieval algorithm performances under a variety of algorithm conditions**
- **prognostic model for TRMM-PR**

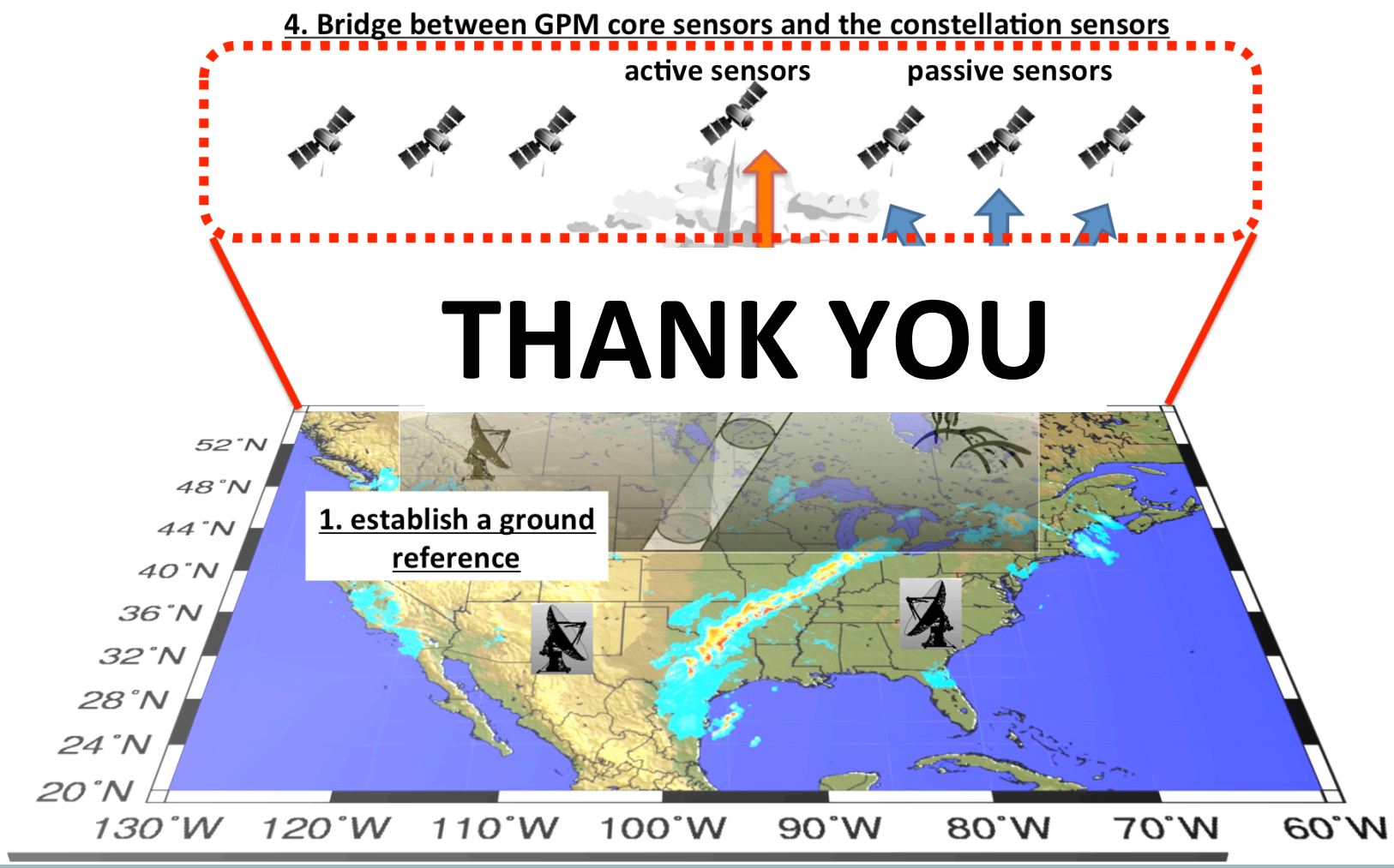
Comparing GPM with MRMS: toward bridging the Core and Constellation Sensors

Perspectives

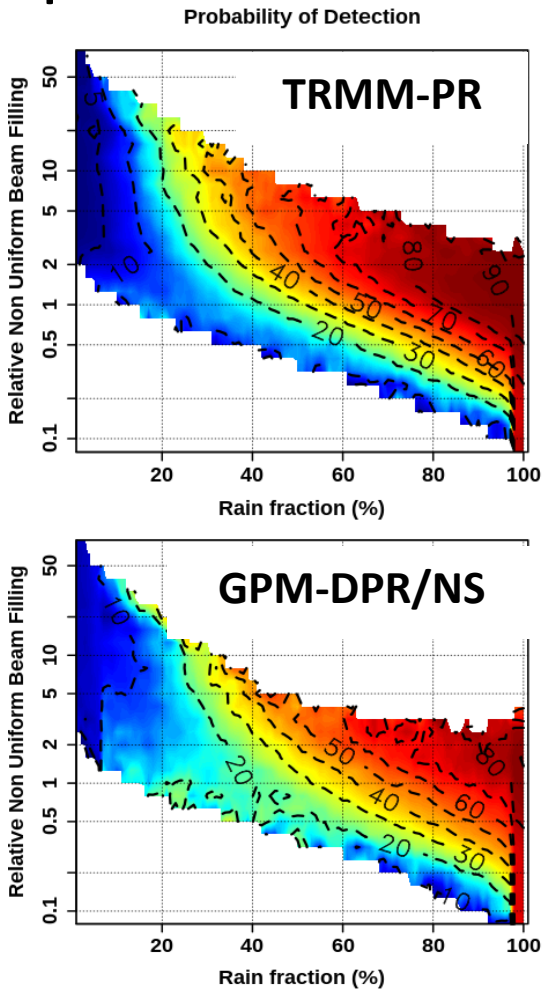
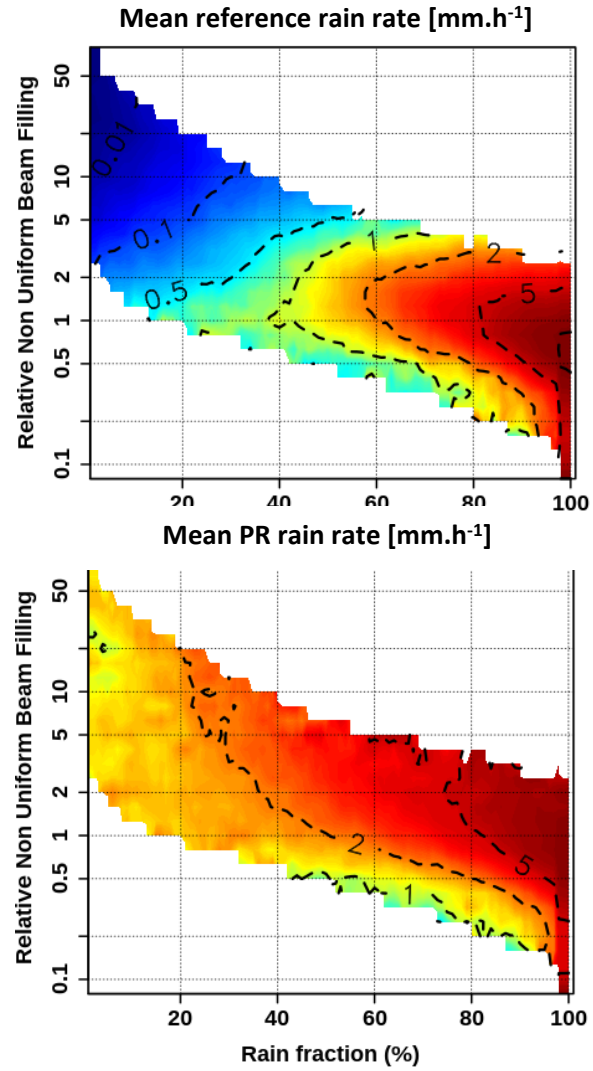
1. Diagnostic/Prognostic approach to other algorithms
   - Passive retrievals (GPROF)
   - Combined algorithm
2. Propagation to the Level-3 products



Comparing GPM with MRMS:
toward bridging Level-2 and Level-3 precipitation products



Non-Uniform Beam Filling impacts on radar detection



Non-Uniform Beam Filling impacts on radar quantification