Large-scale Environment to Improve PMW Estimates of Heavy Precipitation Over Land

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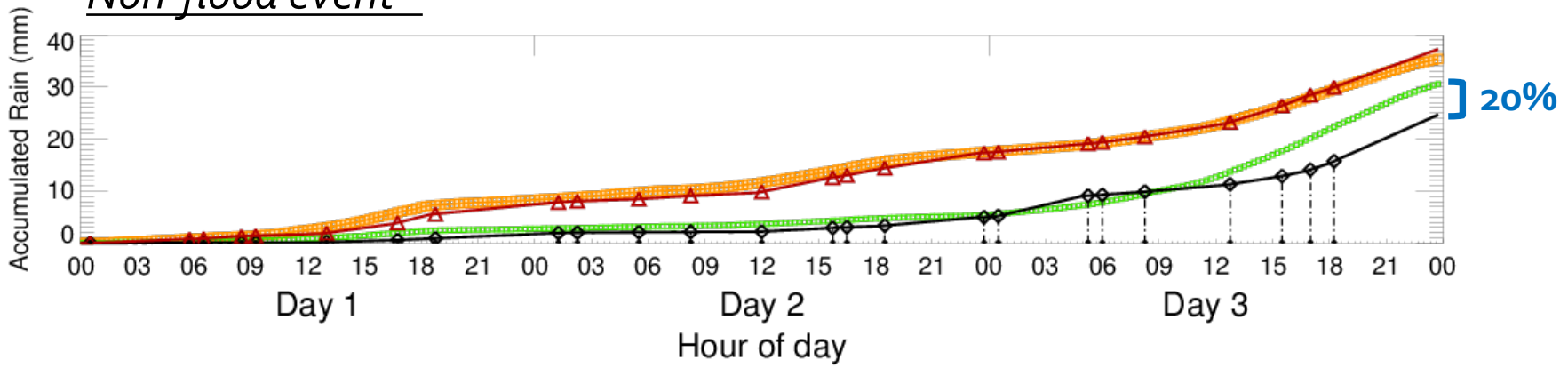
Data and instruments

- **Radiometers**:
  - TMI, GMI, AMSR2, SSMI/Ss (level 1-C): Brightness Temperatures
- **Radars**:
  - PR (TRMM) : precipitation rates and reflectivity
  - DPR (GPM) : precipitation rates and reflectivity

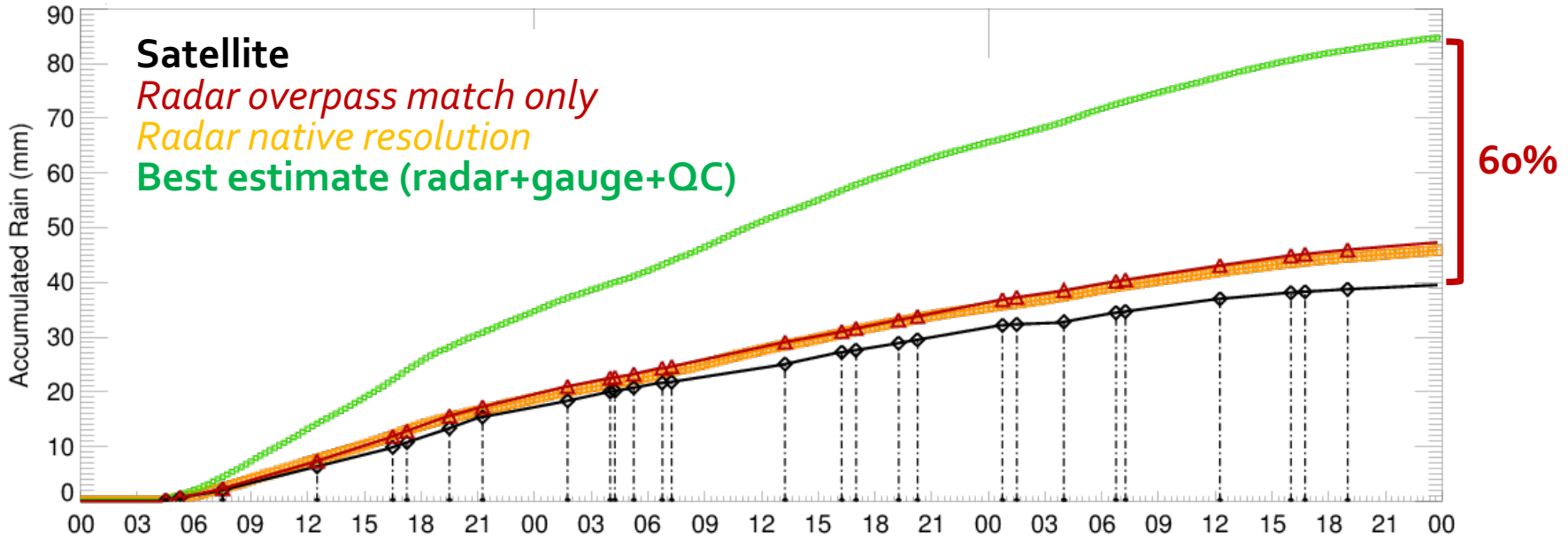
- **Ground networks, Models and algorithms**:
  - MRMS : precipitation rate, reflectivity and quality index
    - 0.01° every 2-min over CONUS (Nexrad + gauges)
  - OPERA : precipitation rate, reflectivity
    - 0.02° every 15-min over Europe (C-, S-band)
  - GEOS-Chem - model with the online aerosol microphysics module TOMAS (N40) - CCN concentration
    - 2 ° x 2.5 ° every 3 hours
  - ECMWF Interim - 2mT, TPW, CAPE, u- and v-wind, Td, Spec. humidity
    - 0.75° -1.5° every 6-h at n pressure levels
  - GPROF – Precipitation rate

Problem: Two events; same 5°x6° region; 28/29 overpasses of GPM (F-16,-17, -18, GMI, AMSR2)

Non-flood event



Flood event



(Petković and Kummerow: *J. Hydrometeorol. 2015, 16, 2501–2518.)*

Non-flood event

Z-R	240 $R^{1.6}$
GPROF bias	- 20 %
Regime	Scattered, Average

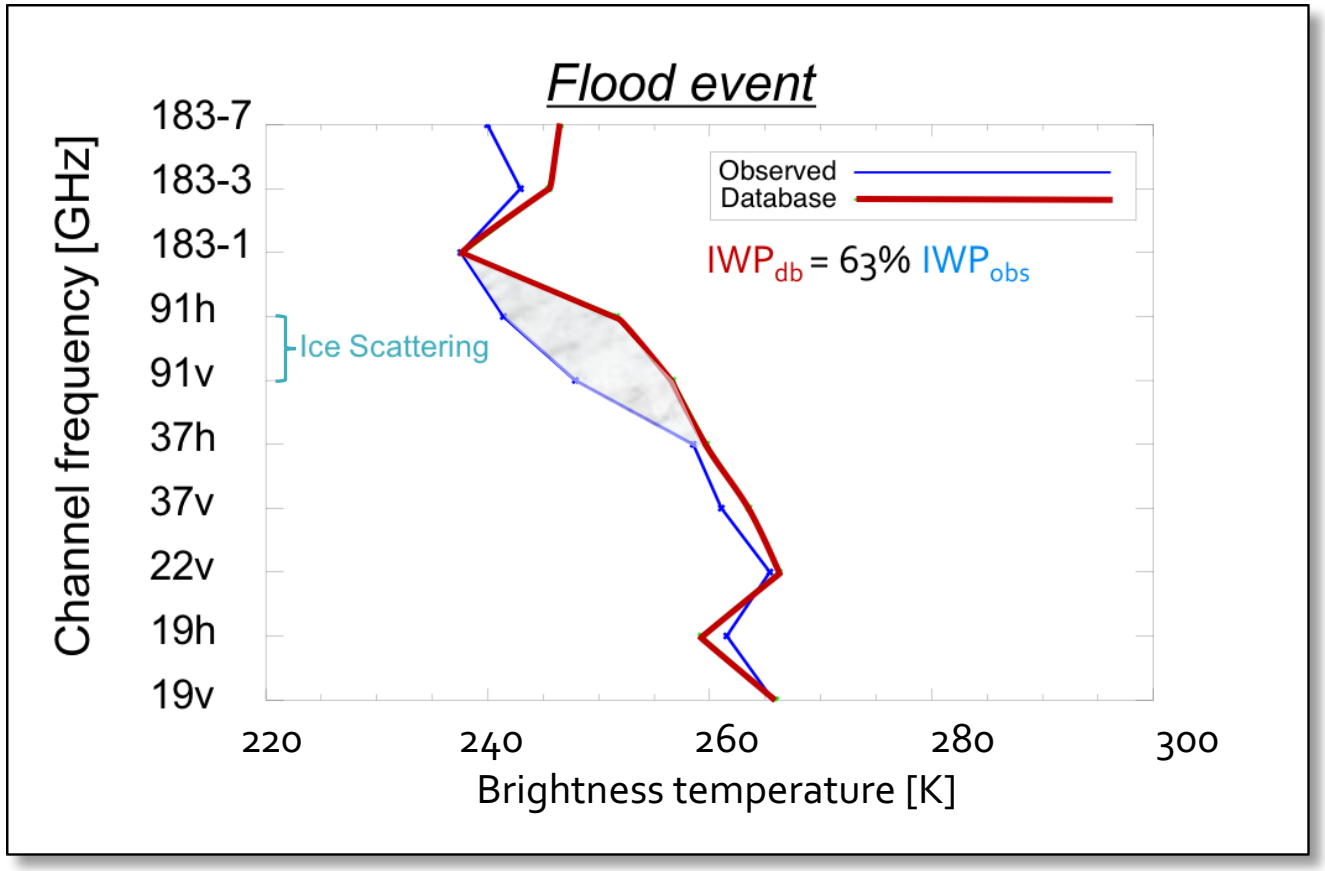
Bayesian Caveats:

1. Averaging pulls the solution towards database mean
2. Limited information content allows for accurate retrieval of only well represented scenes

Flood event

Z-R	70 $R^{1.6}$
GPROF bias	- 60 %
Regime	Well-organized

GPM radar - DPR	Non-Flood	Flood
Mean freezing level	2700 m	1700 m
Convective fraction	28%	3%
Stratiform fraction	70%	95%
Sfc. max. refl.	27-32 dBZ	30-35 dBZ



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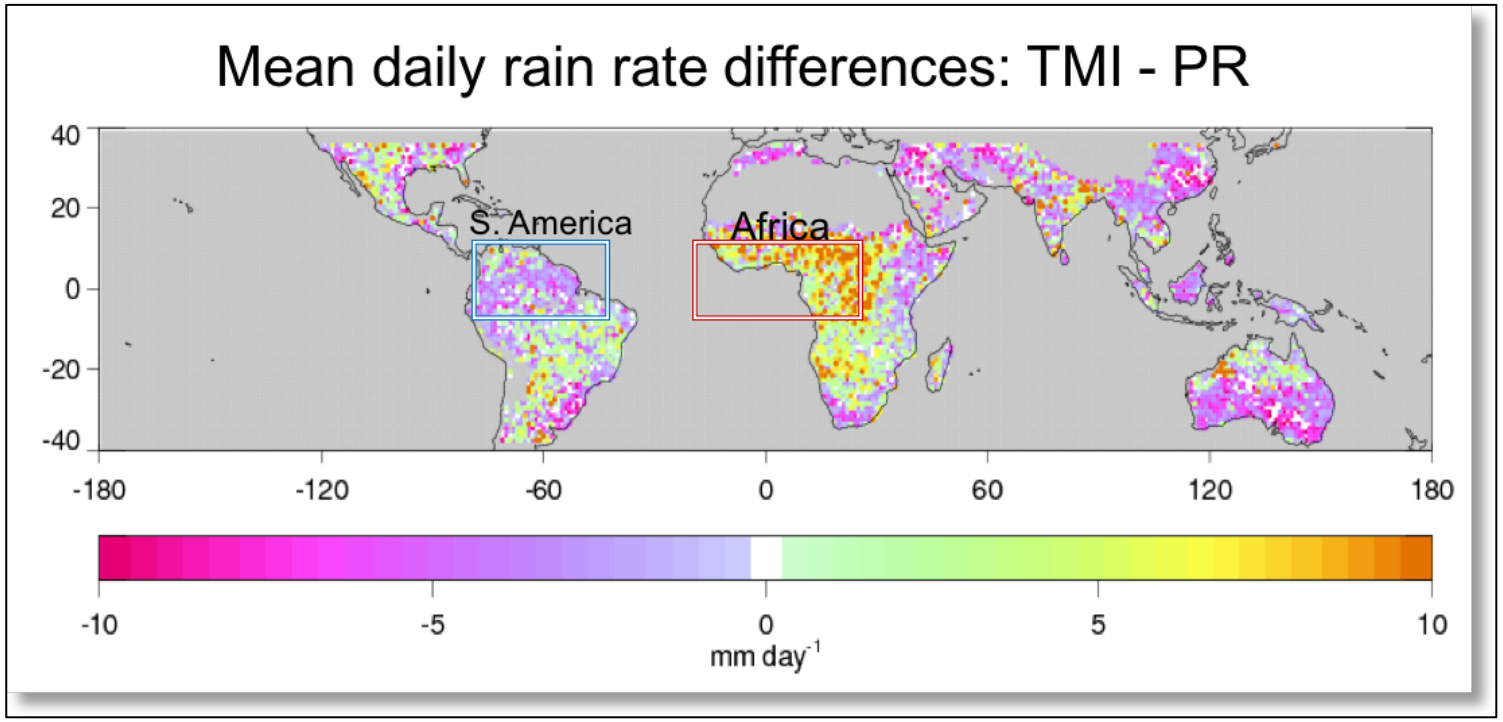
Solution:

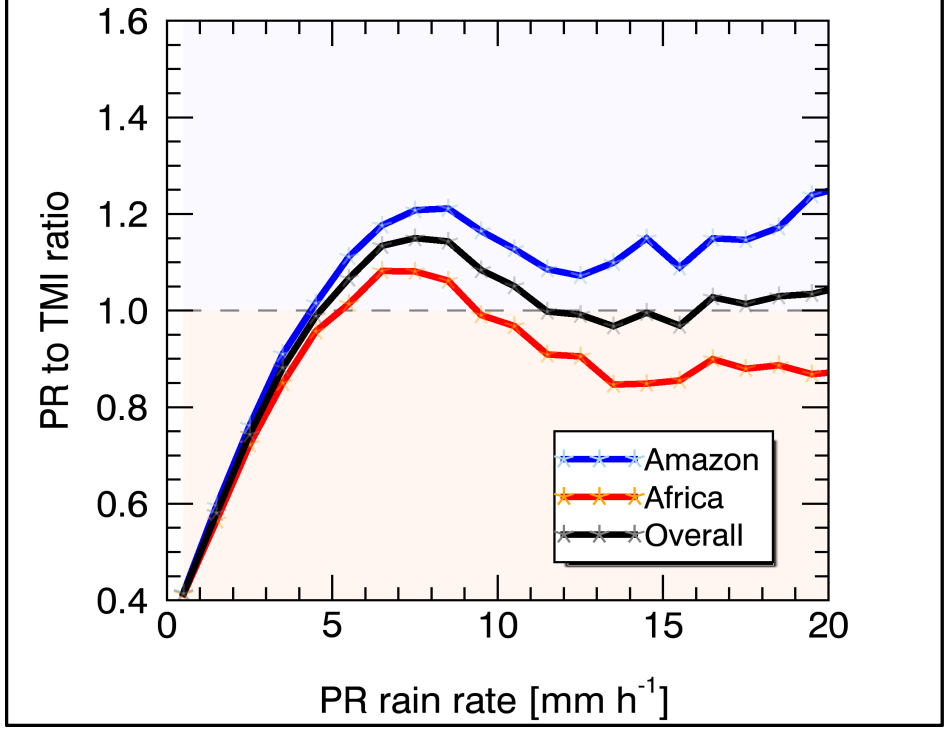
Identifying Systematic Errors

Global Distribution of Regional Biases of GPROF TMI Retrieval



One year of TRMM data at 0.25° grid; High elevation masked out;
Two marked regions: similar surface type and land area

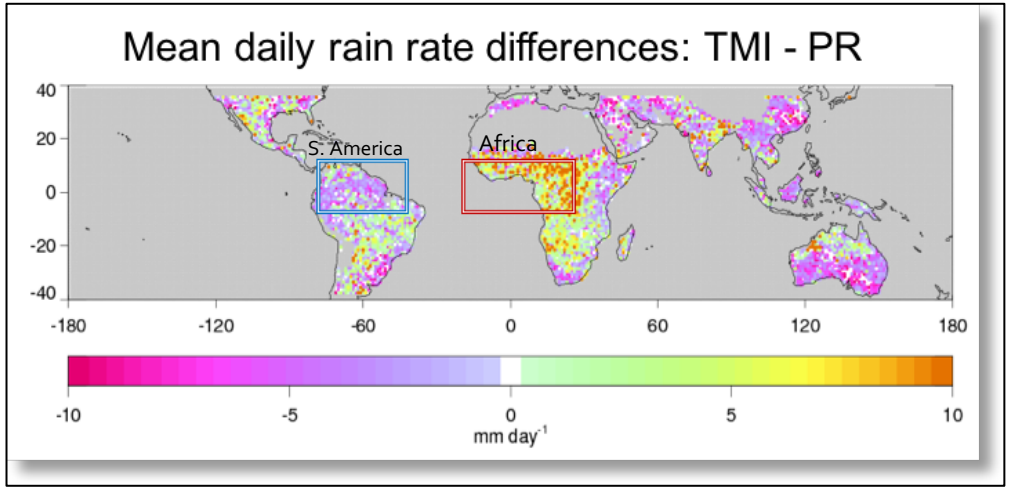
Regional bias as a function of precipitation rate



Linking the Systematic Errors to Precipitation Regimes

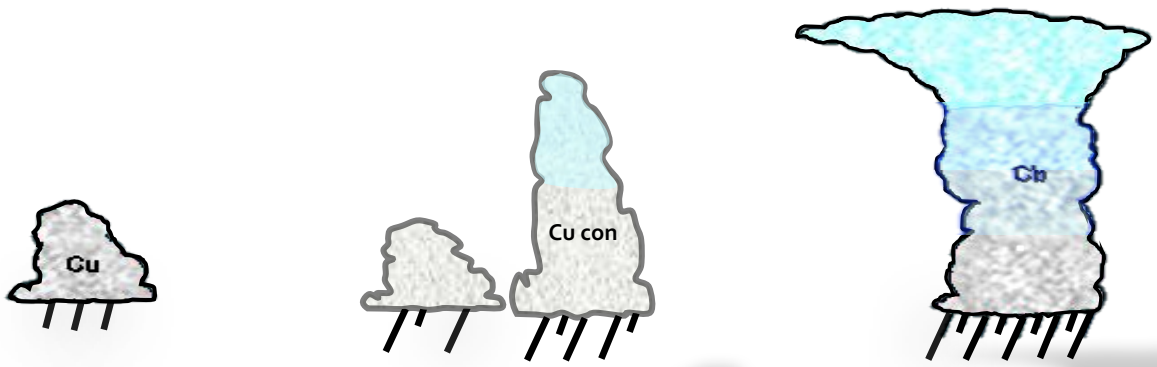
Separate 1° x 1° raining scenes into:
Shallow, ***Deep-Unorganized*** and ***Deep-Organized*** systems using:

- PR's top echo height
- Convective rainfall
- Raining fraction (Elsaesser et al. 2010, *J. Climate*)



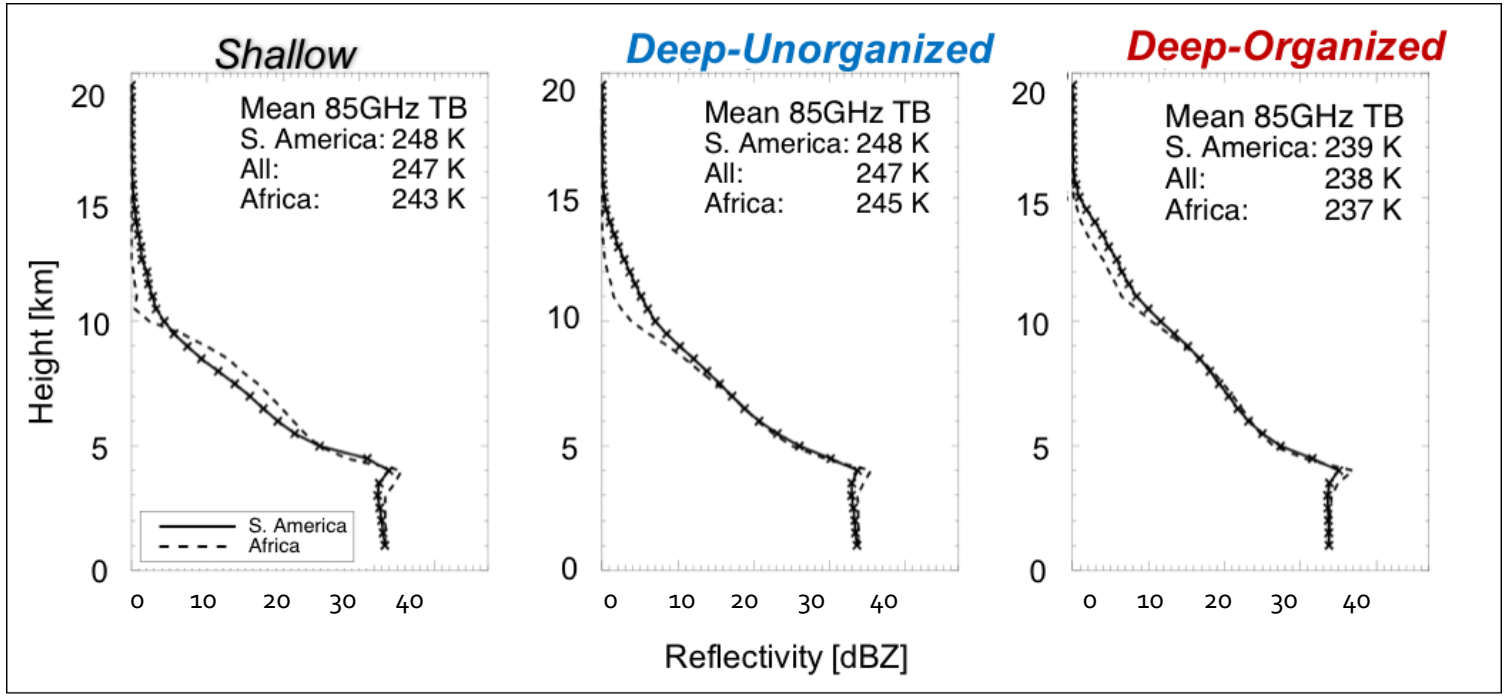
Contribution to the total precipitation

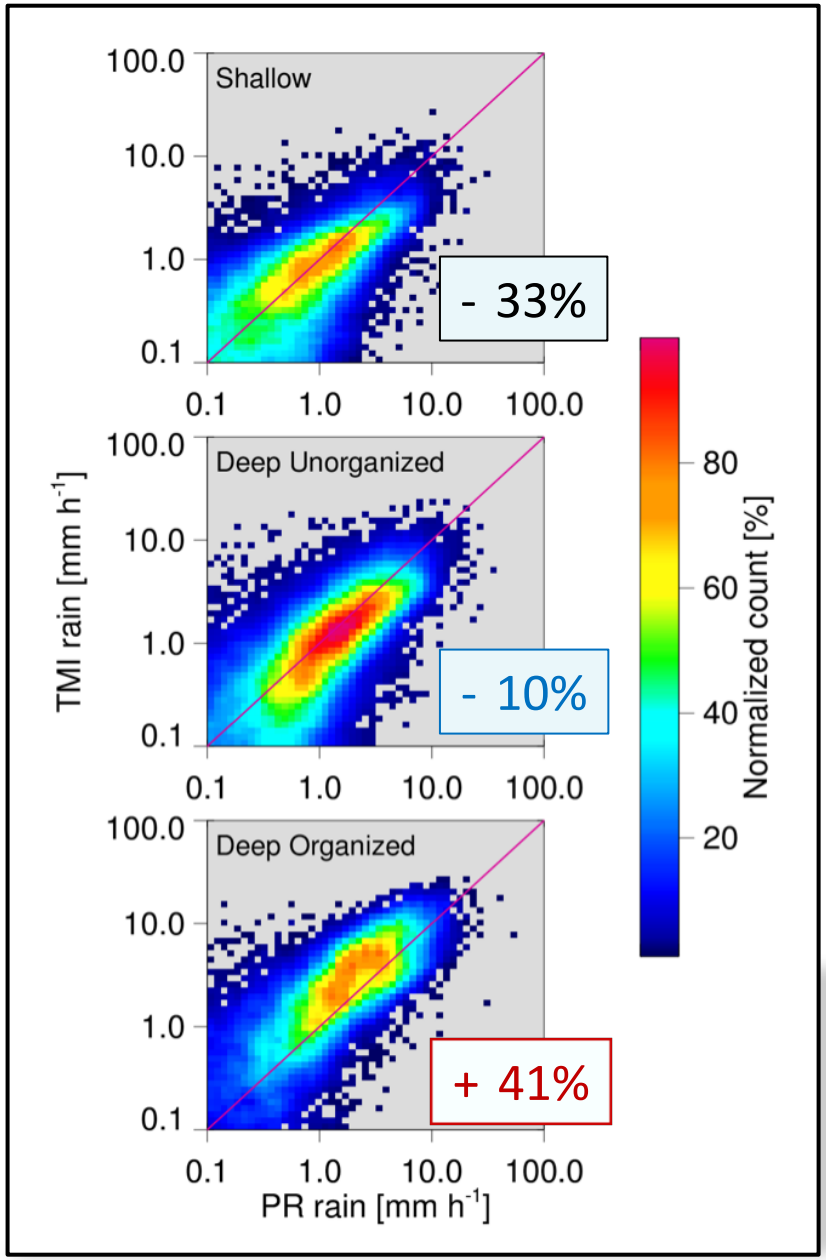
	S. America	Africa
Shallow	50-60%	10%
Deep-Unorganized	30-40%	30-40%
Deep-Organized	10%	50-60%



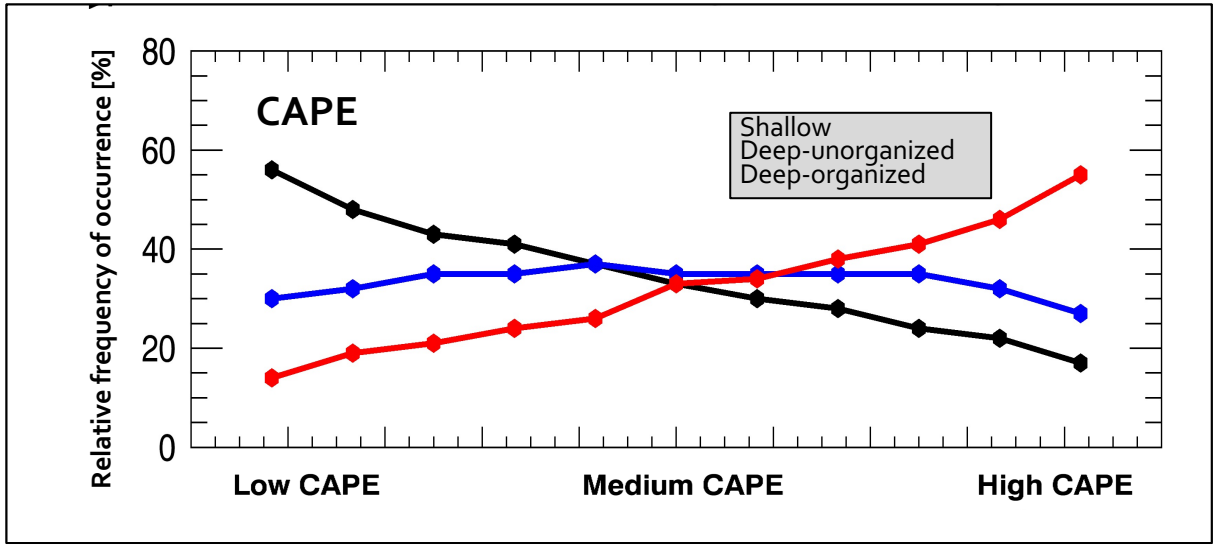
Shallow ***Deep-Unorganized*** ***Deep-Organized***

Quantifying Systematic Errors of the Precipitation Regimes





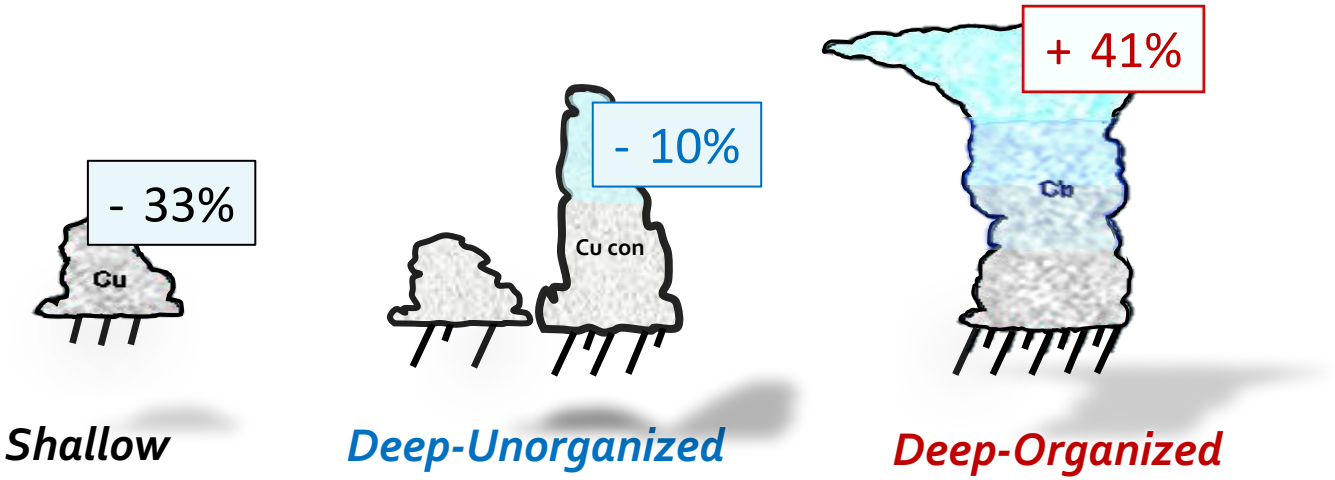
Linking Specific Precipitation Regimes to a Large-scale Environment



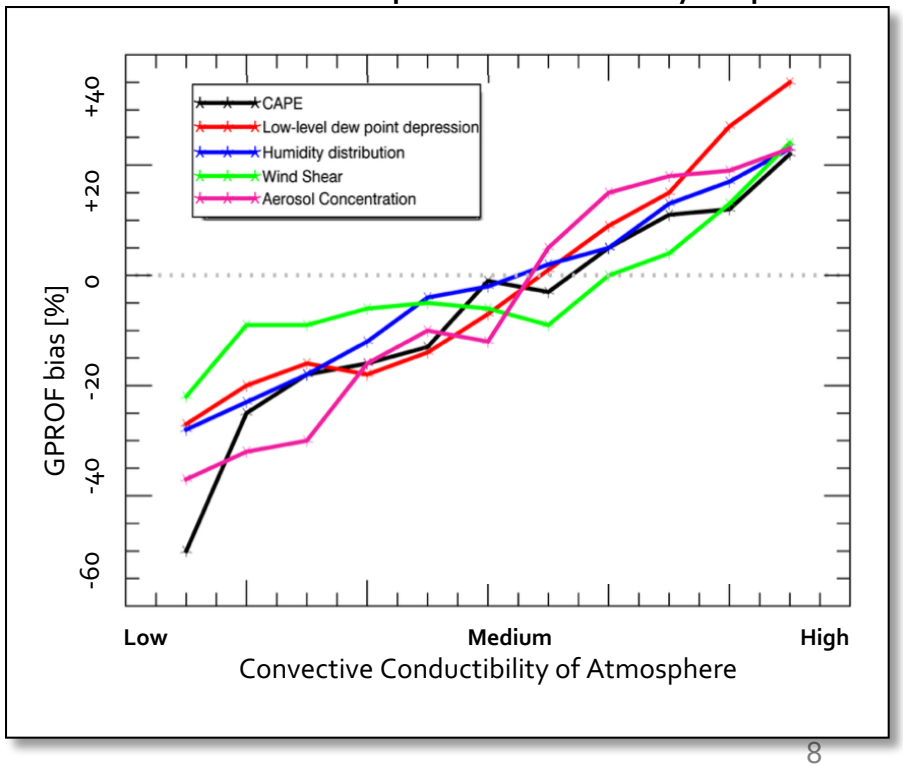
Regime-related environment:

- ***CAPE***
- Shear
- Low-level humidity
- Vertical distribution of humidity
- Aerosol concentrations

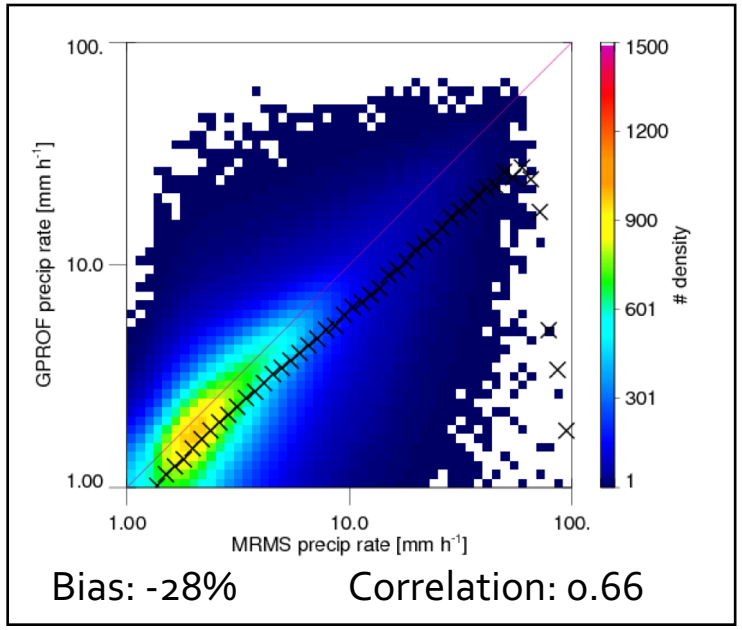
Source: Era-Interim + GEOS-Chem



Retrieval bias dependence on synoptic



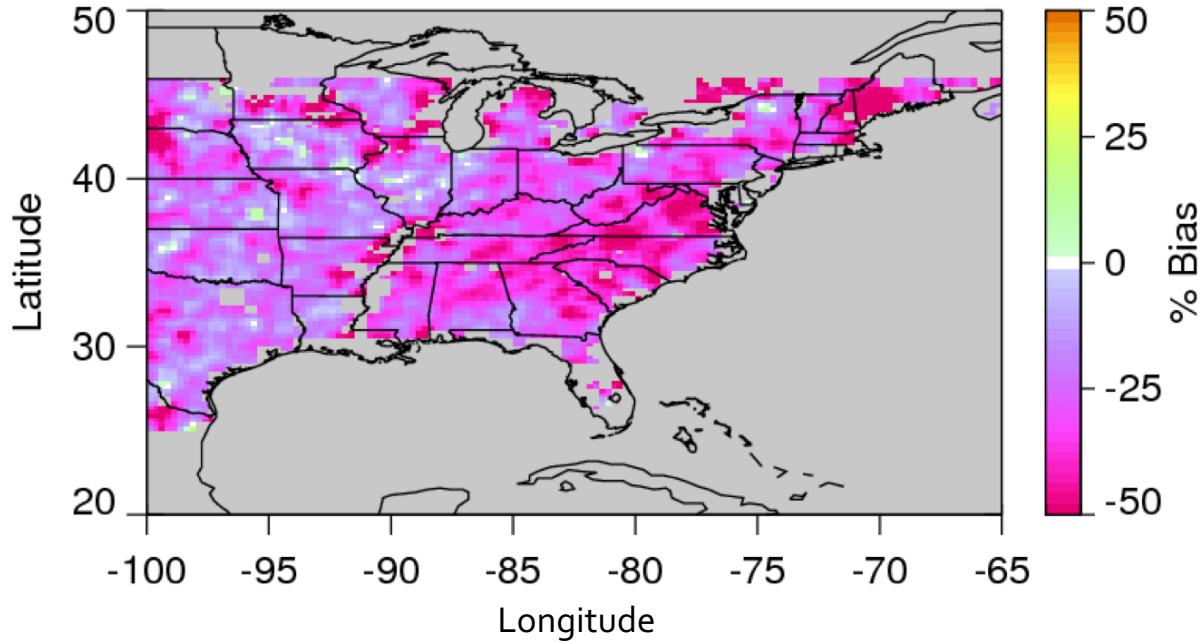
Retrieving Heavy Precipitation Events Over the US



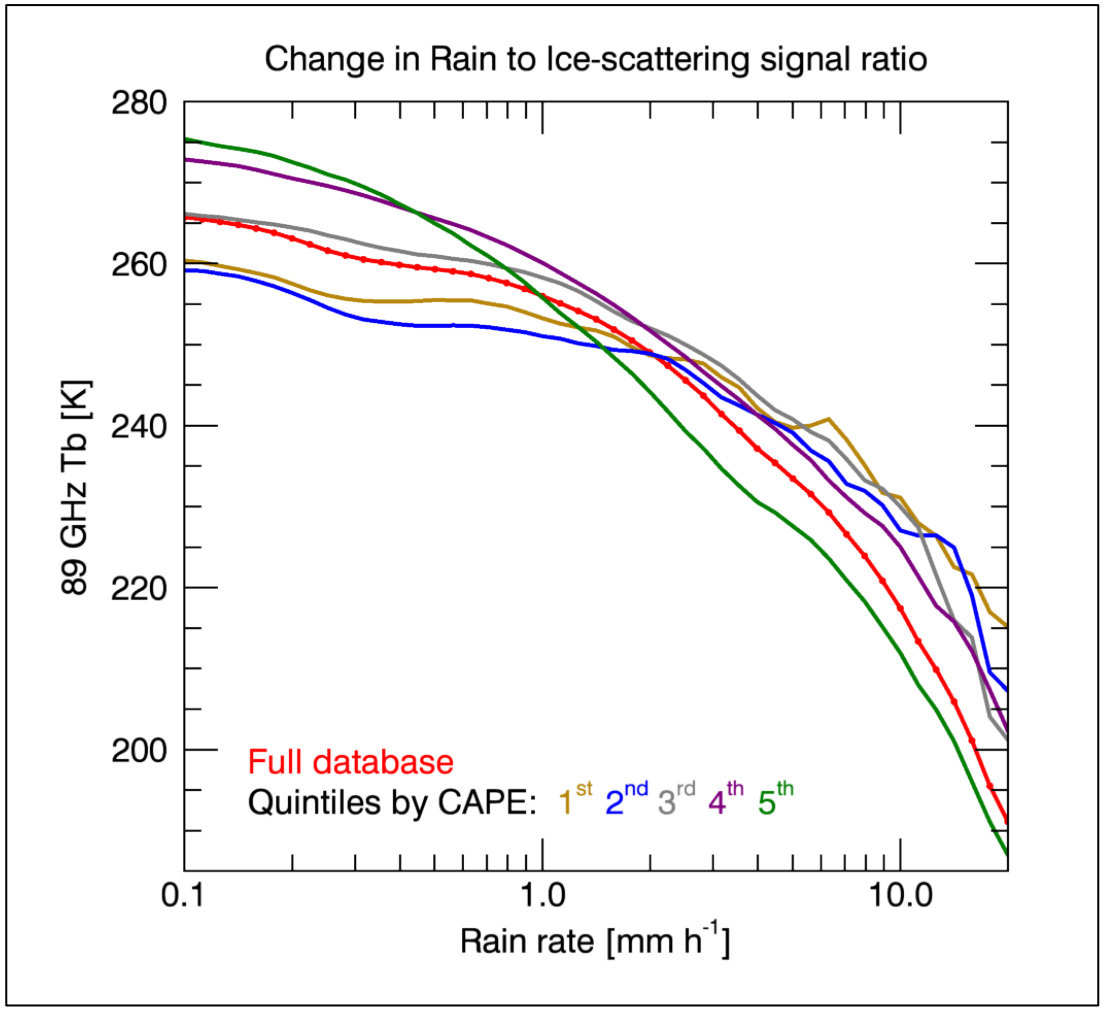
Bias: -28% Correlation: 0.66

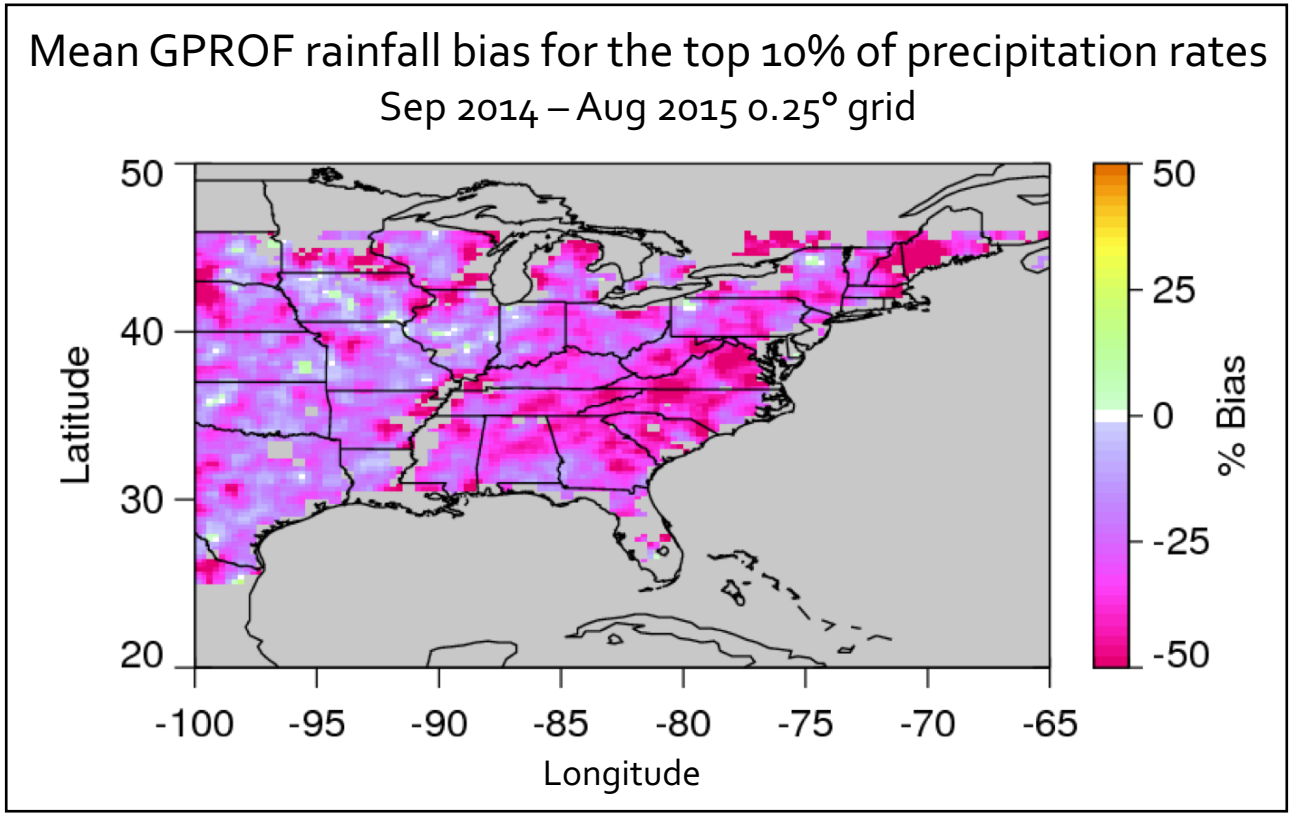
Reference MRMS Precipitation Rates
Spatial res.: 0.01 degree
Temporal res.: 2 min
Domain: CONUS
Compared at satellite FOV level

Mean GPROF rainfall bias for the top 10% of precipitation rates
Sep 2014 – Aug 2015 0.25° grid

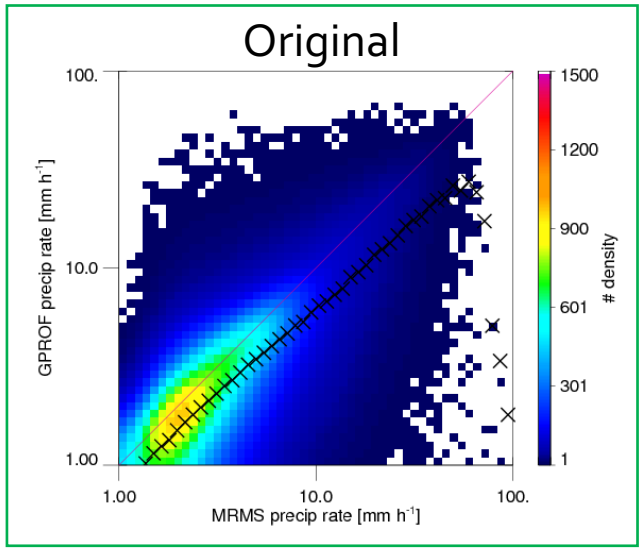


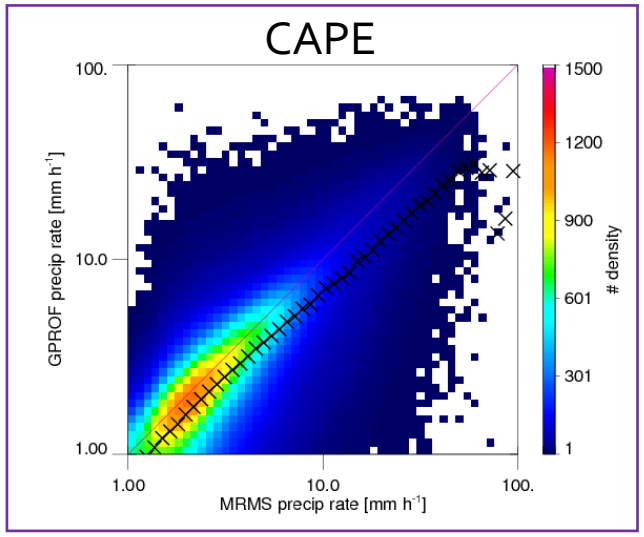
Large-scale environment information content
- CAPE -

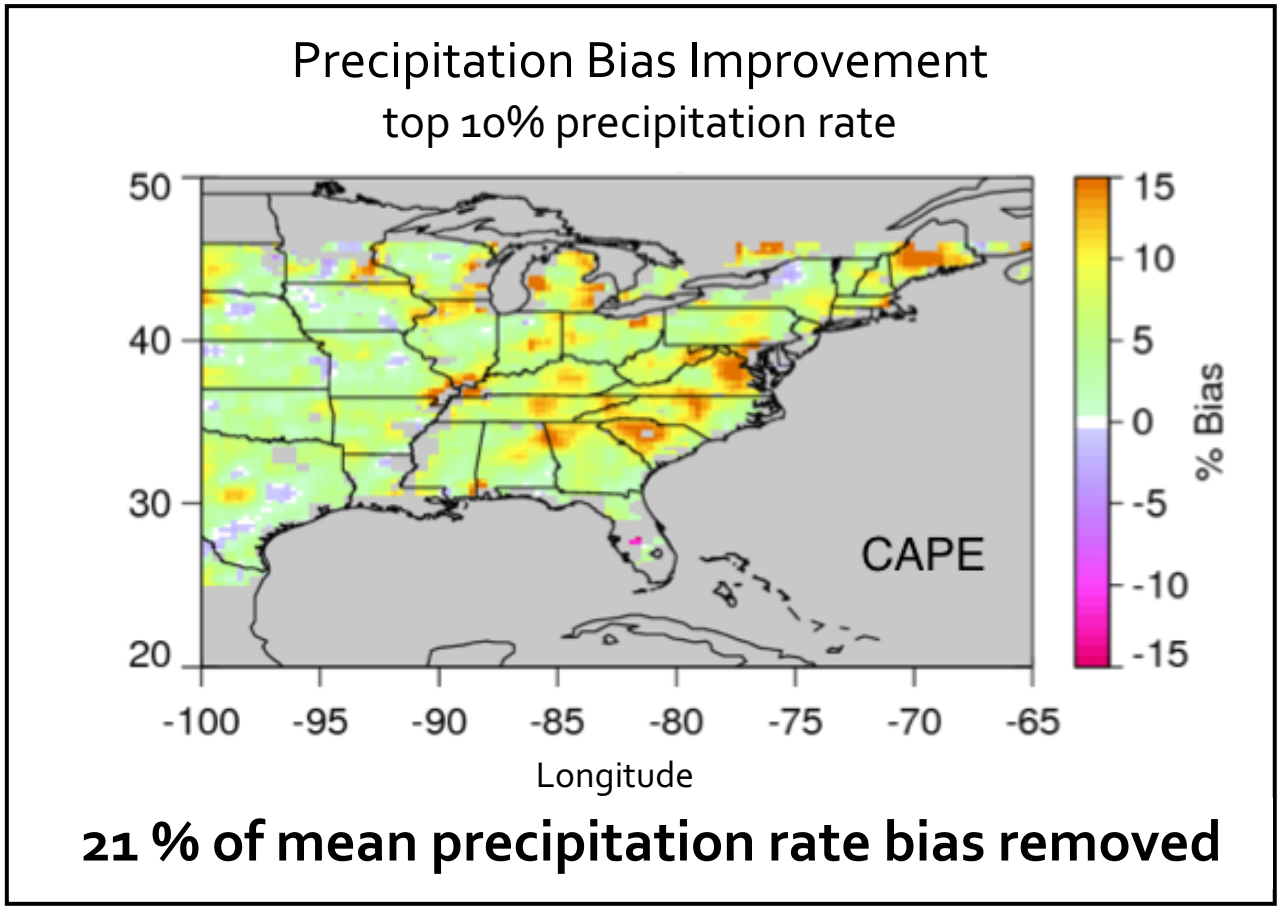




Improving the Quality of Heavy Precipitation Estimates



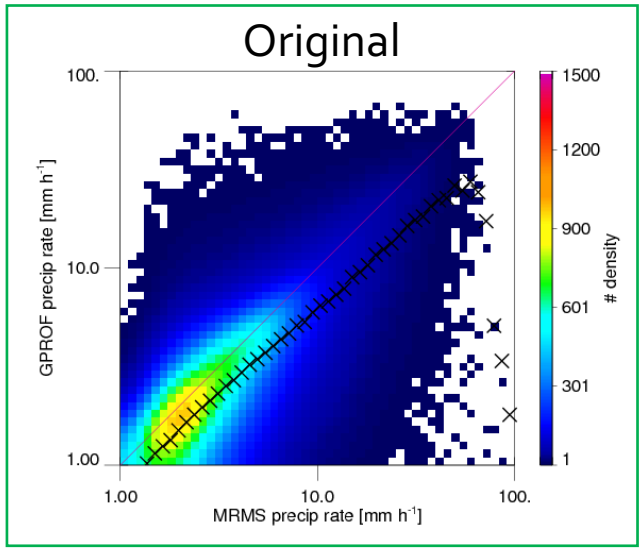


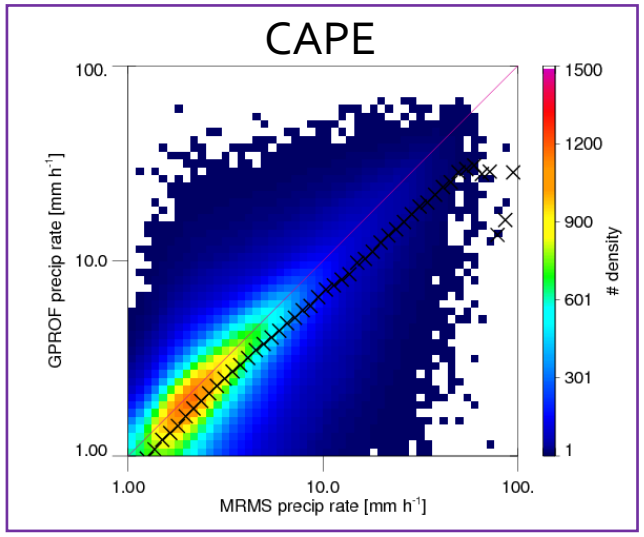


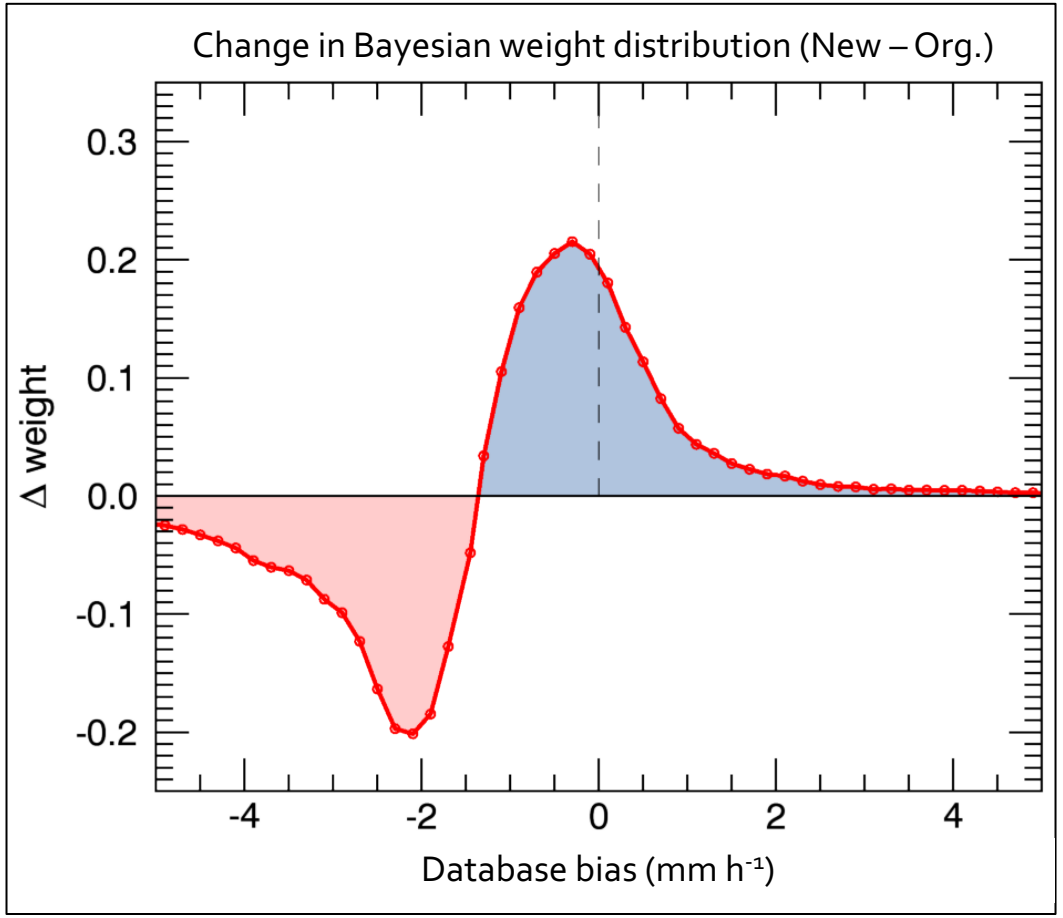
21 % of mean precipitation rate bias removed

	Original	New	Reference
Mean precip rate [mm h^{-1}]	2.87	3.11	3.89
Correlation	0.66	0.69	

Redistribution of the *a priori* Elements Weights







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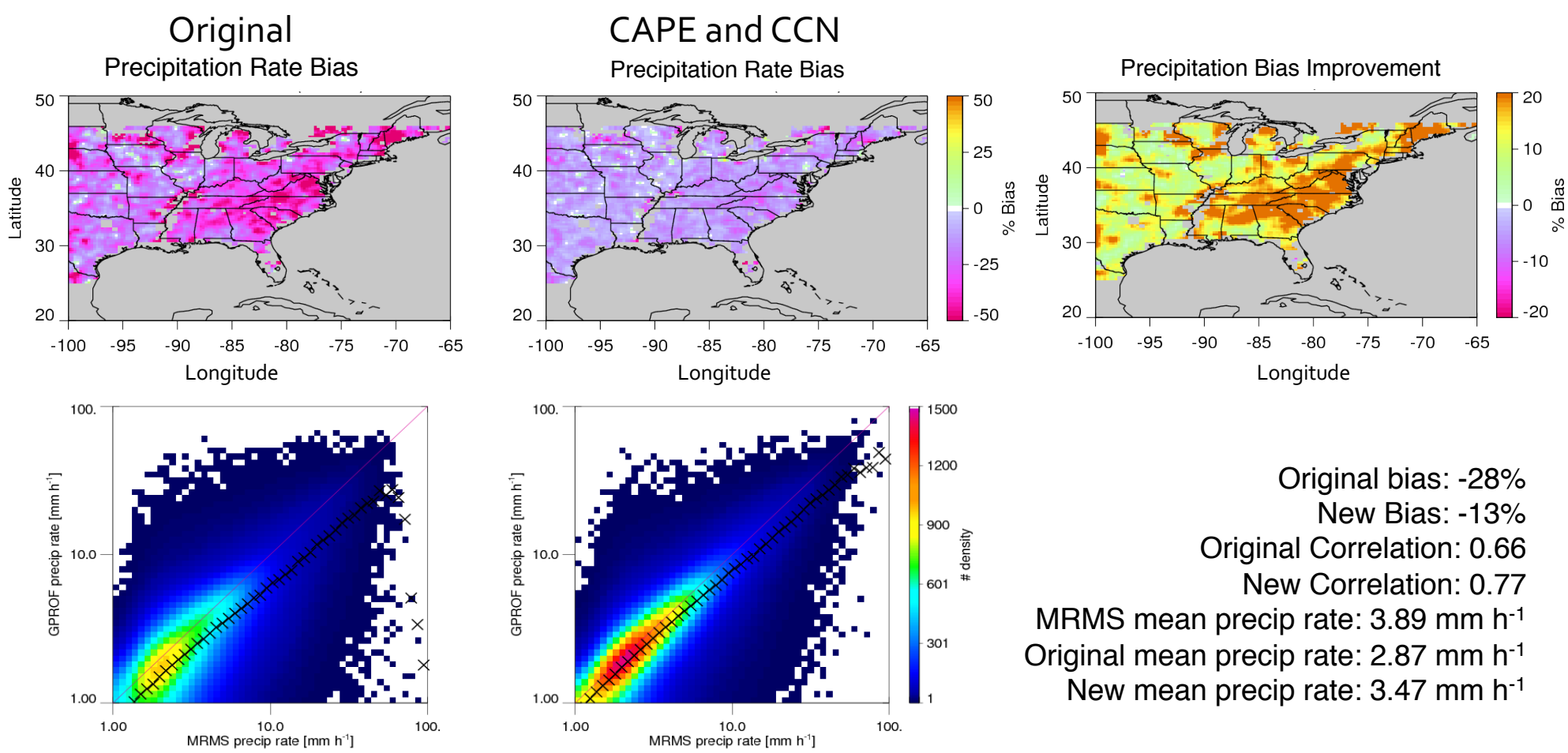
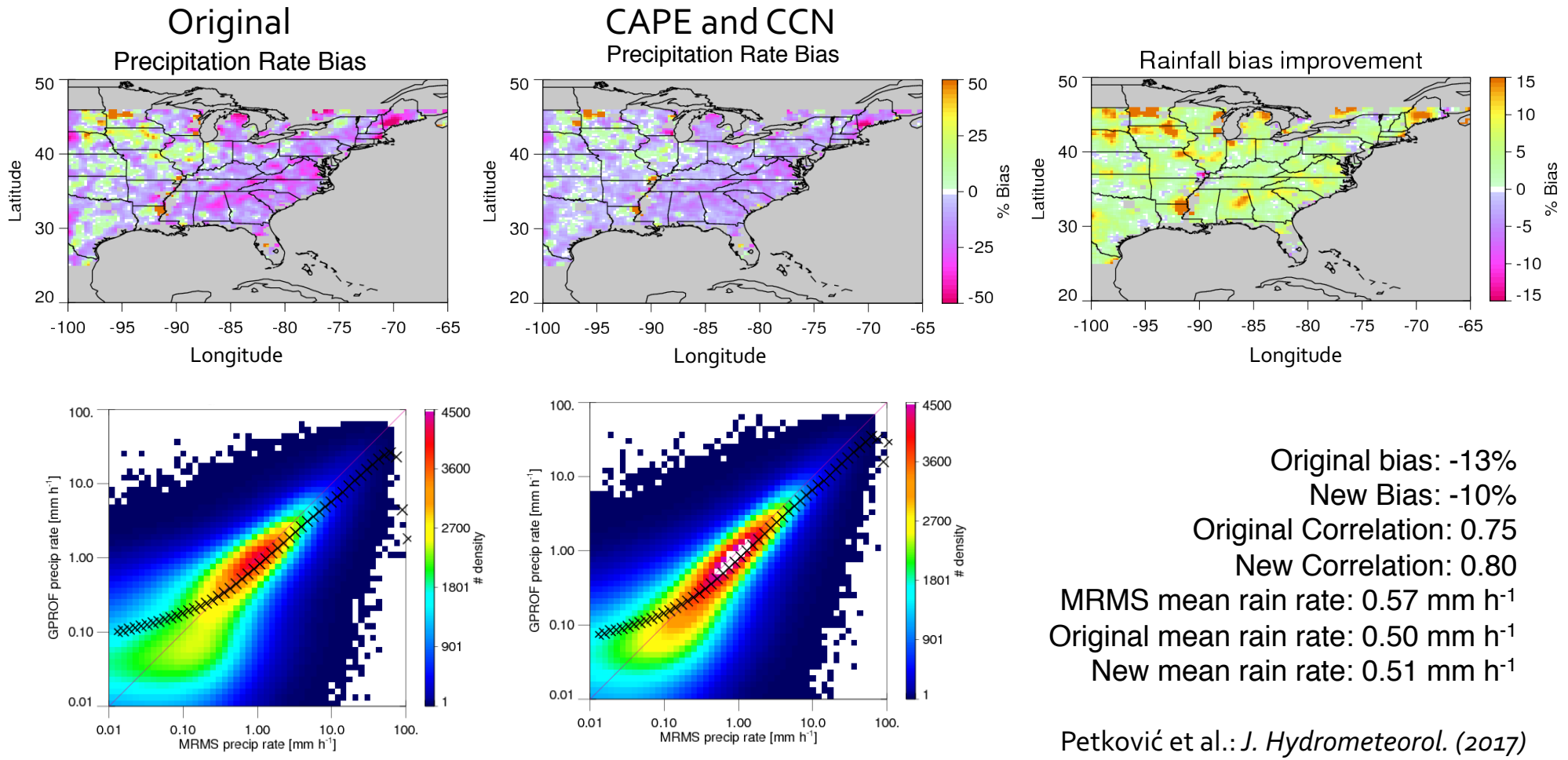


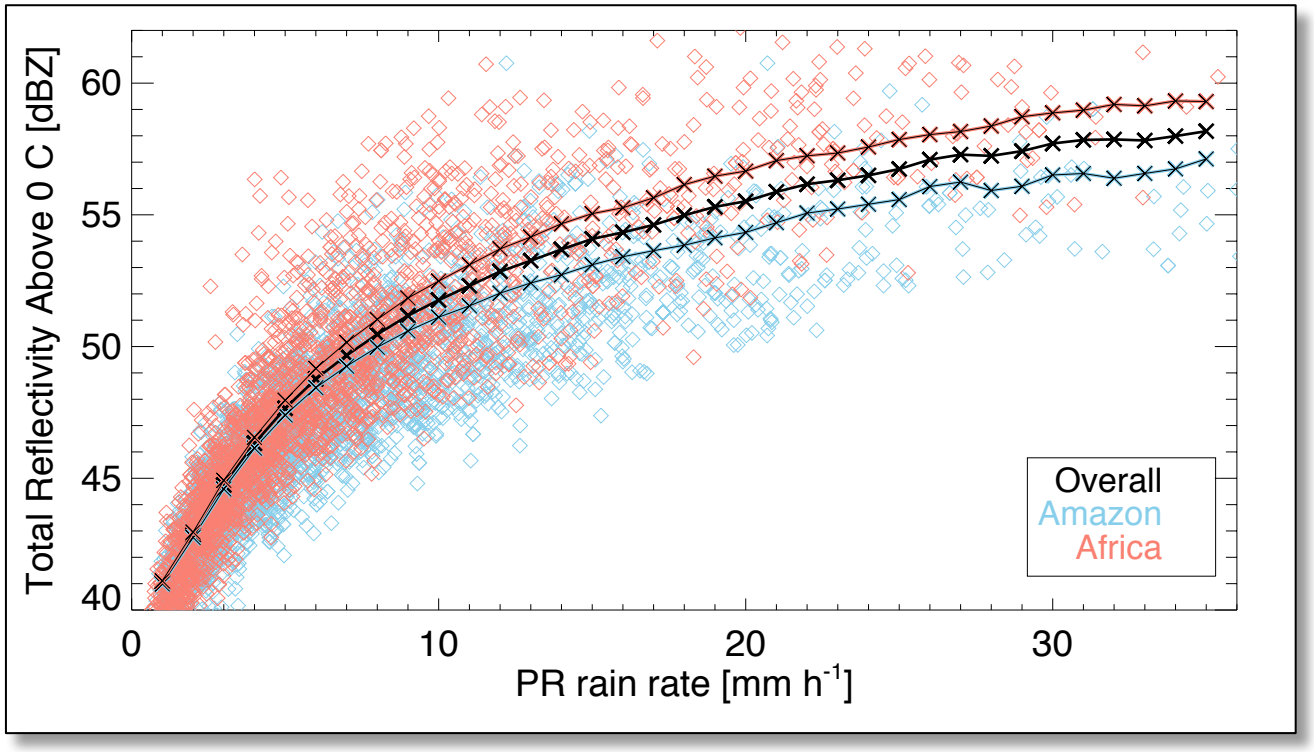
Impact to the Overall Performance of the Retrieval



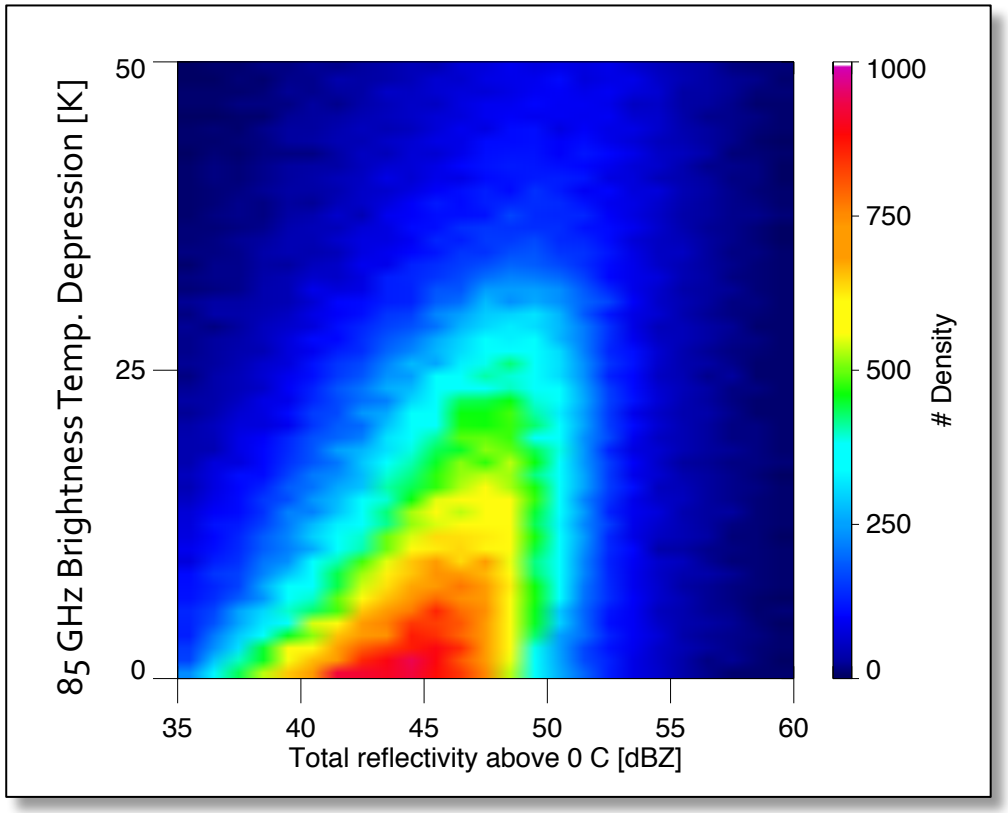
EXTRA SLIDES

Identifying Causes of Systematic Errors

Regional ice content variability as a function of precipitation rate

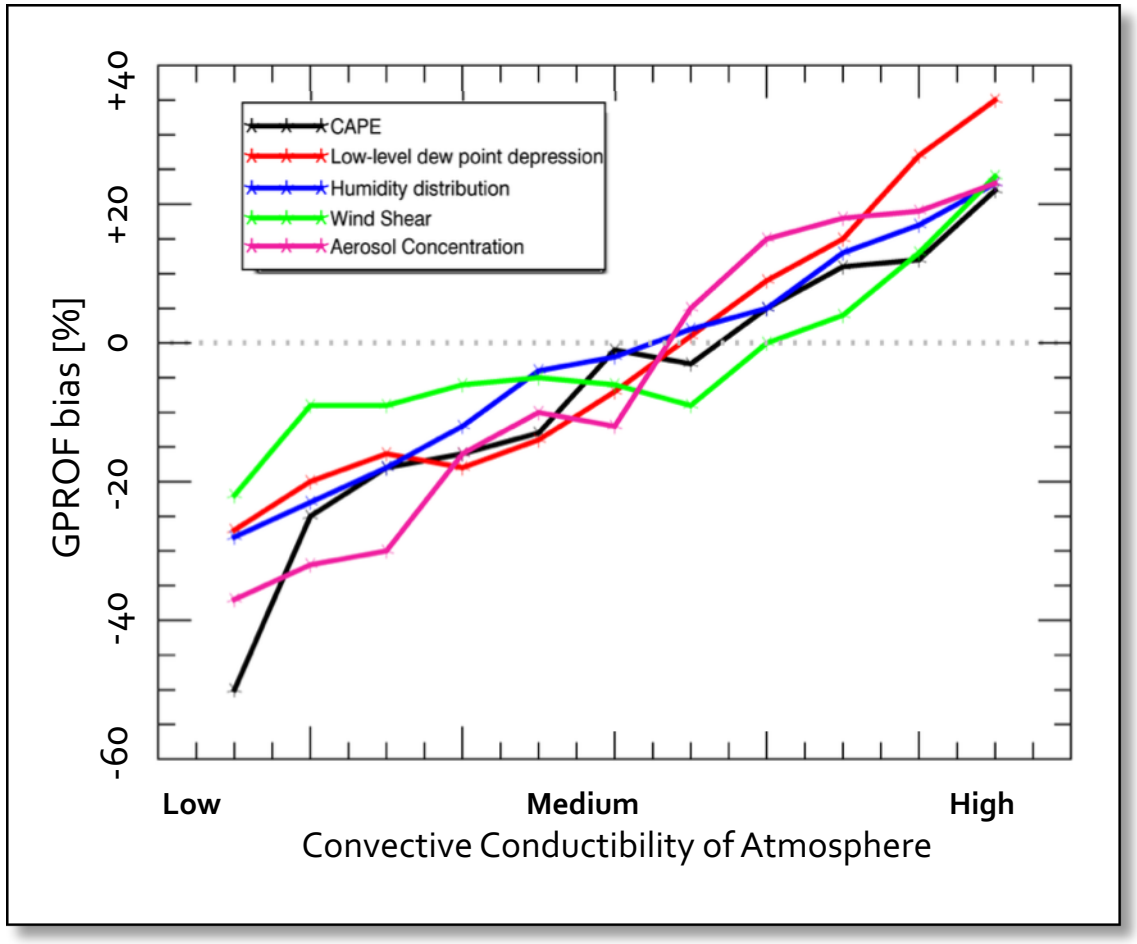


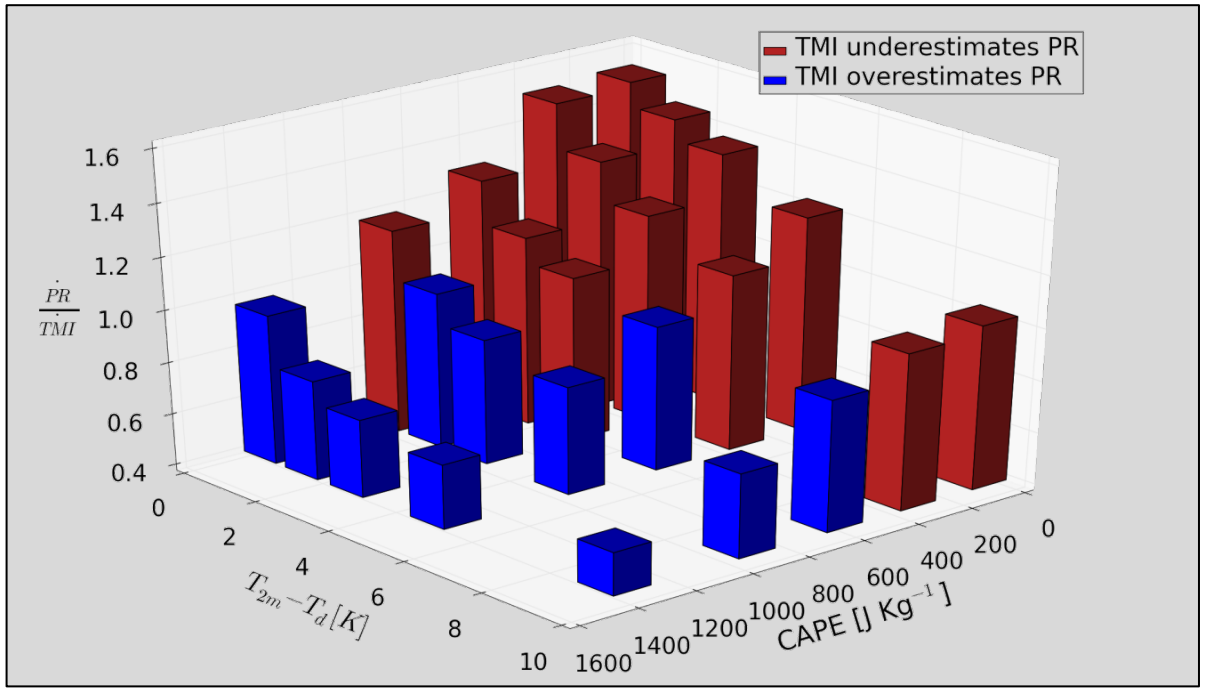
Ice content to brightness temperature relationship



Large-scale environment to GPROF bias relationship

Retrieval bias dependence on synoptic state





References

Problem:

Performance of the Retrieval in an Extreme Precipitation Event

i. Petković, V. and C. D. Kummerow, 2015:
Performance of the GPM Passive Microwave Retrieval in the Balkan Flood Event of 2014. *J. Hydrometeor.*, **16**, 2501–2518

Solution:

Understanding the Sources of Retrieval Systematic Errors

ii. Petković, V. and C. D. Kummerow, 2017:
Understanding the Sources of Satellite Passive Microwave Rainfall Retrieval Systematic Errors Over Land. *J. Appl. Meteor. Climatol.*, **56**, 597–614

Application:

Improving the Quality of Heavy Precipitation Estimates

iii. Petković, V., C. D. Kummerow, D.L. Randel, J. Pierce and J. Kodros 2017:
Improving the Quality of Heavy Precipitation Estimates from Satellite Passive Microwave Rainfall Retrievals. *Under review, J. Hydrometeor.*