Using XPOL Observations from Complex Terrain Field Experiments to Characterize Passive Microwave Retrieval Uncertainty

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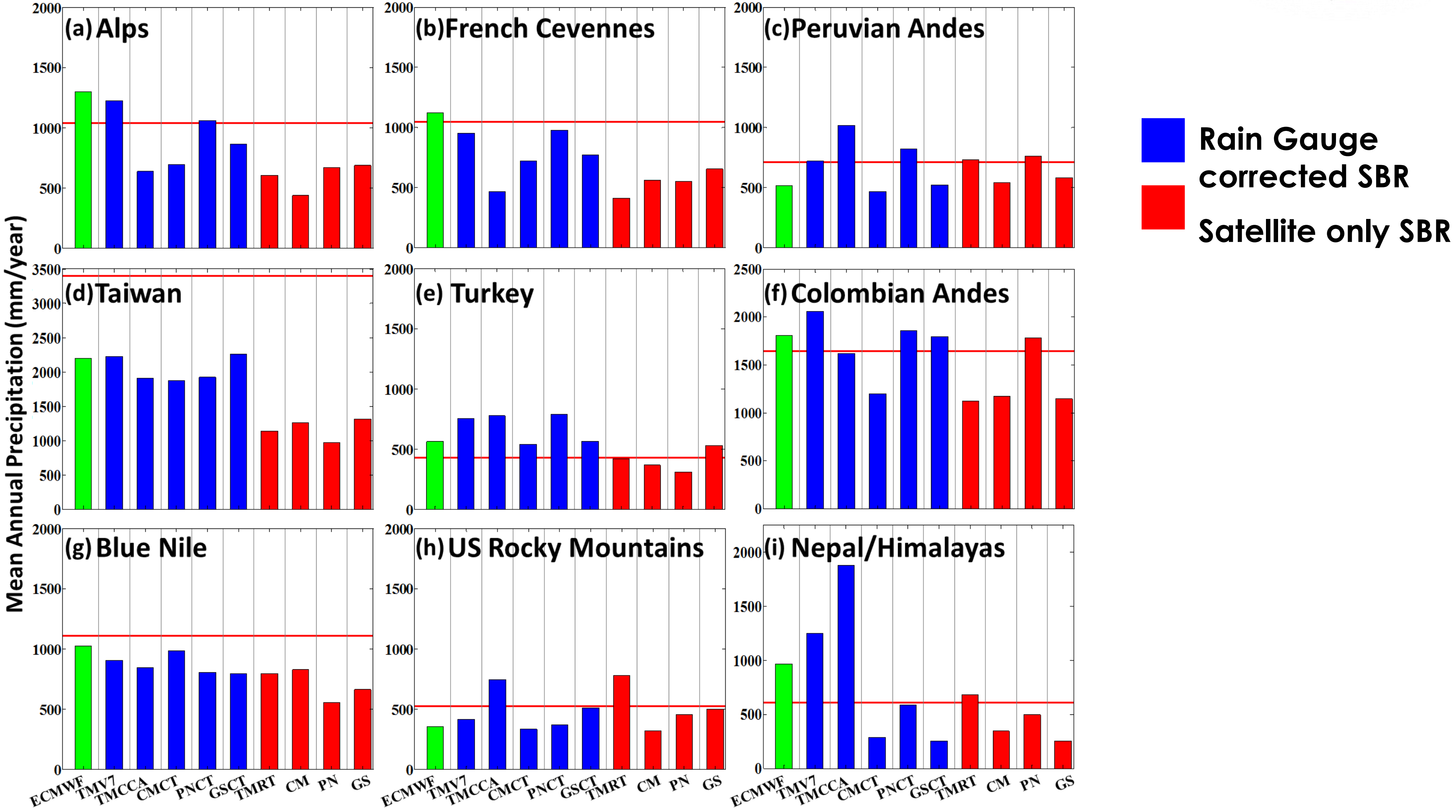
PMM Land Surface Working Group

Multi-regional Satellite Precipitation Products Evaluation over Complex Terrain



Derin, Y., E. N. Anagnostou, A. Berne, M. Borga, B. Boudevillain, W. Buytaert, C-H. Chang, G. Delrieu, Y. Hong, Y. C. Hsu, W. Lavado-Casimiro, B. Manz, S. Moges, E. I. Nikolopoulos, D. Sahlu, F. Salerno, J-P. Rodrigues-Sanchez, H. J. Vergera, and K. K. Yilmaz, 2016: Multi-regional satellite precipitation products evaluation over complex terrain. J. Hydrometeor., 17, 1817-1836.

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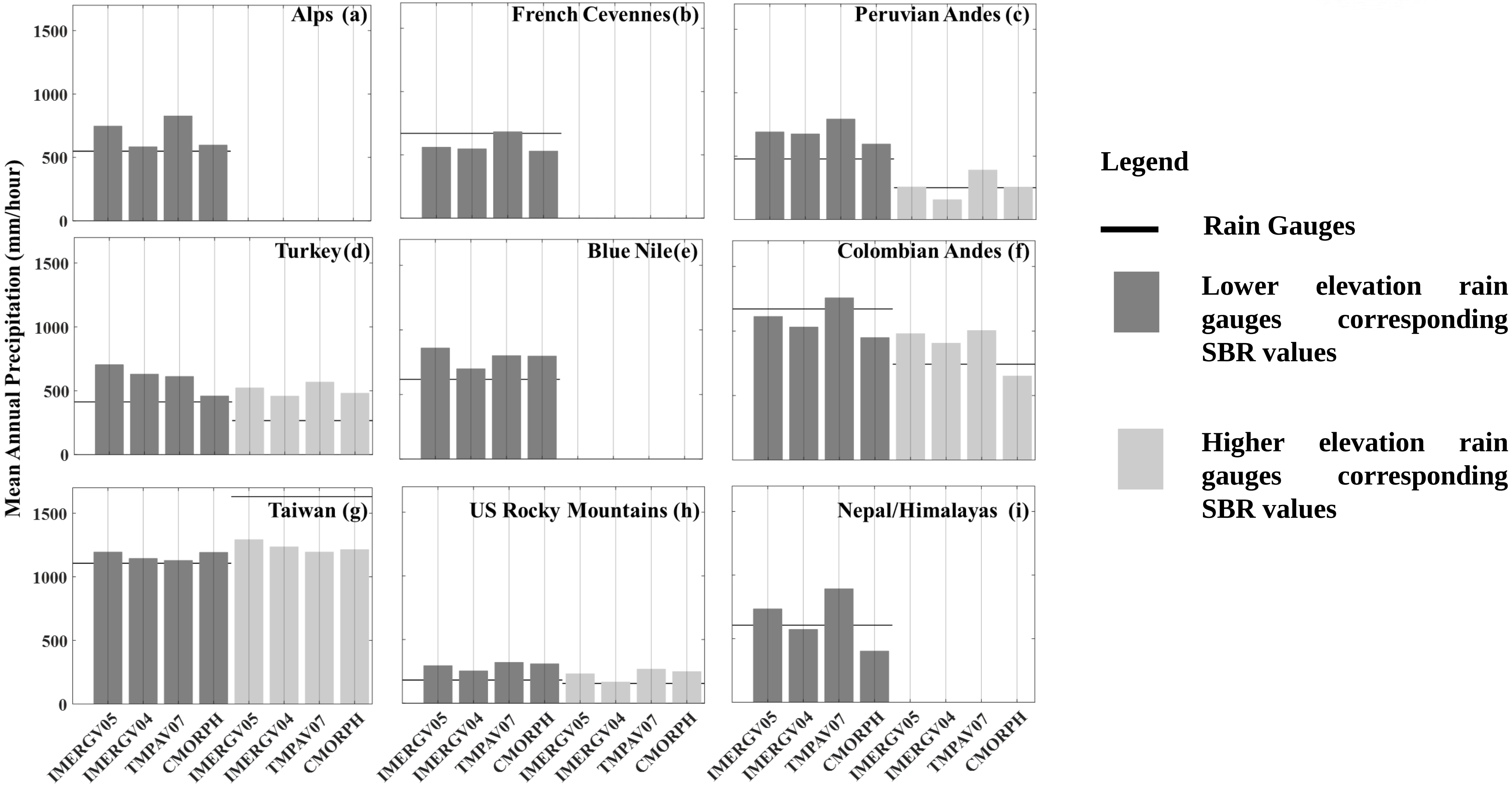

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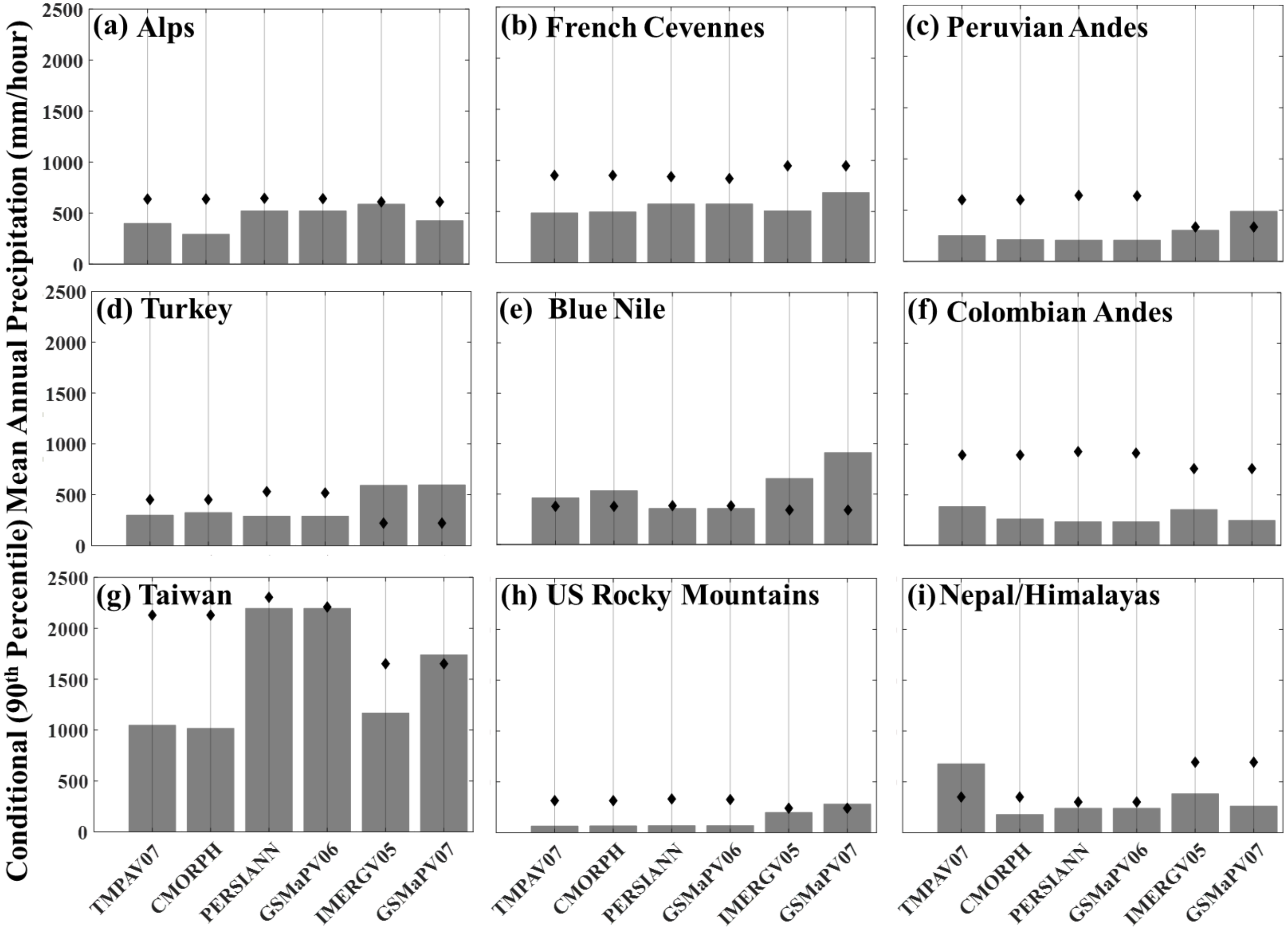


Y. Derin, E. Nikolopoulos and Anagnostou., M. N., 2018: Retrieving Extreme Precipitation with Multiple Satellite-based Precipitation Products, Extreme Hydroclimatic Events and Multivariate Hazards in a Changing Climate, Elsevier

Passive Microwave Rainfall Error Analysis Using High-Resolution X-Band Dual-Polarization Radar Observations in Complex Terrain

North Carolina

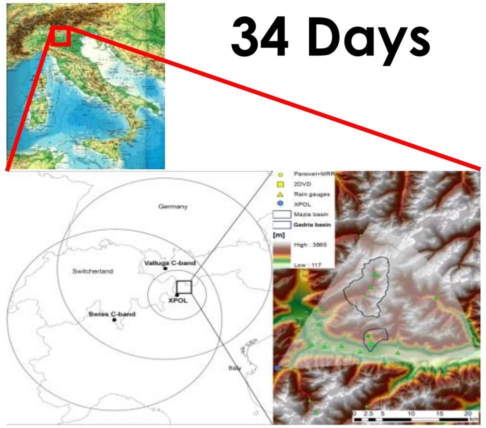
May 1- June 15 2014

21 Days

North Italy

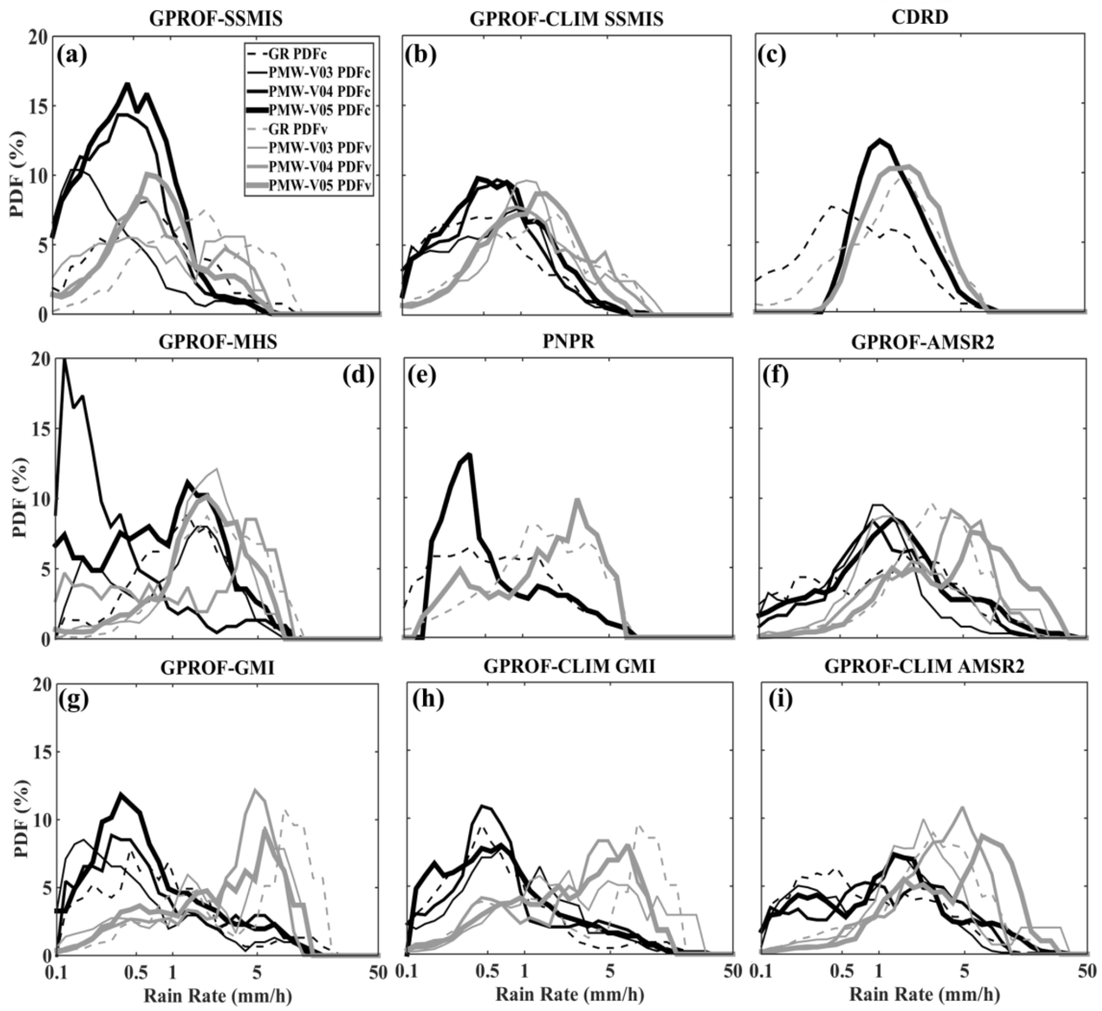
August 1 – Oct 15 2014

34 Days



Main Results;

- The magnitude-dependent systematic error, going from overestimation or weak underestimation of light precipitation to mainly underestimation of heavier precipitation, shows weak covariation with the ground reference.
- GPROF V5 algorithm depicted significant improvement over its previous versions (V3 and V4). In general, the GPROF-CLIM algorithm and GPROF V5 showed the best performance in terms of correlation and systematic error for both regions



Derin, Y., Anagnostou E., Anagnostou M. N., Kalogiros J., Casella D., Marra A. C., Panegrossi G., and Sano P., 2018: Passive Microwave Rainfall Error Analysis Using High-Resolution X-Band Dual-Polarization Radar Observations in Complex Terrain. IEEE Transactions on Geoscience and Remote Sensing, 56:5, 2565-2586; 10.1109/TGRS.2017.2763622

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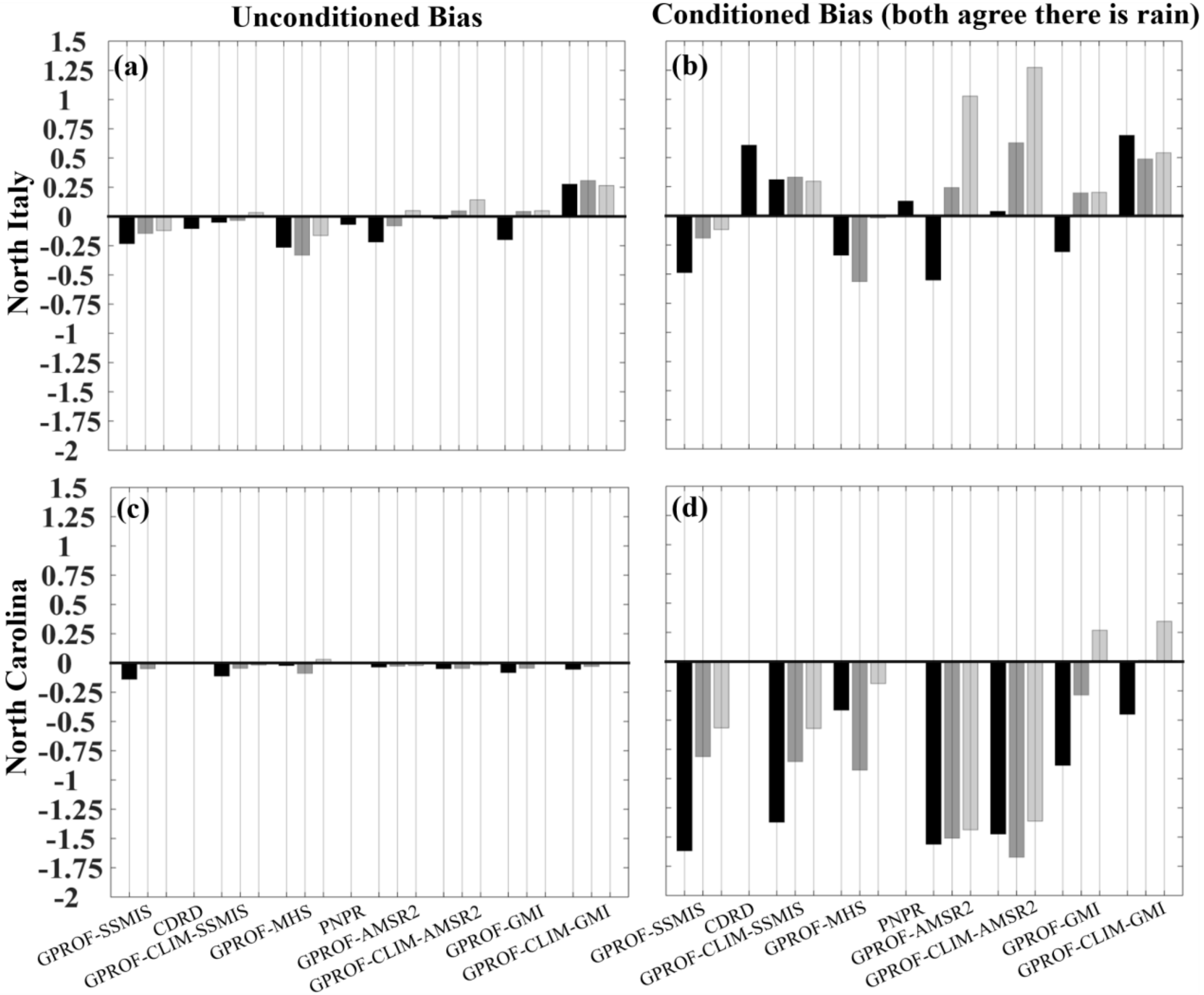

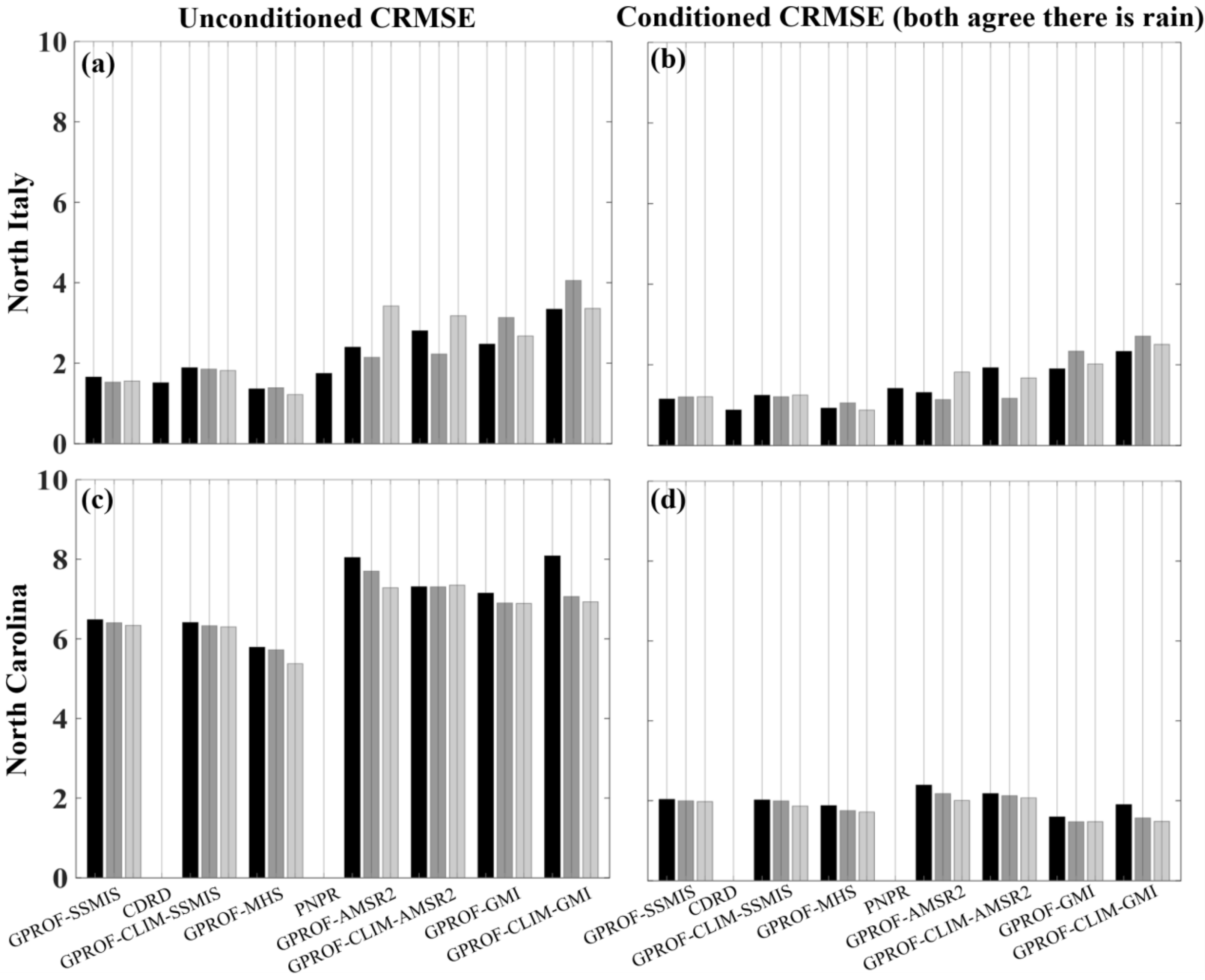

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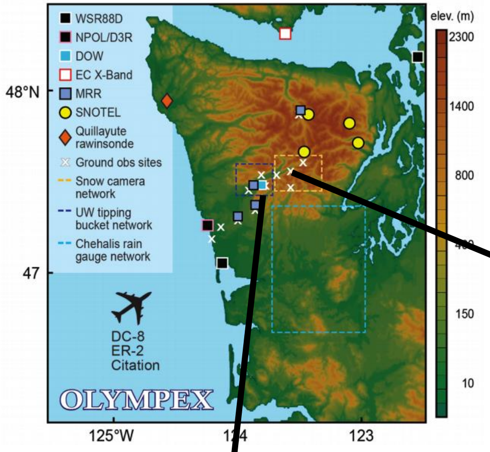
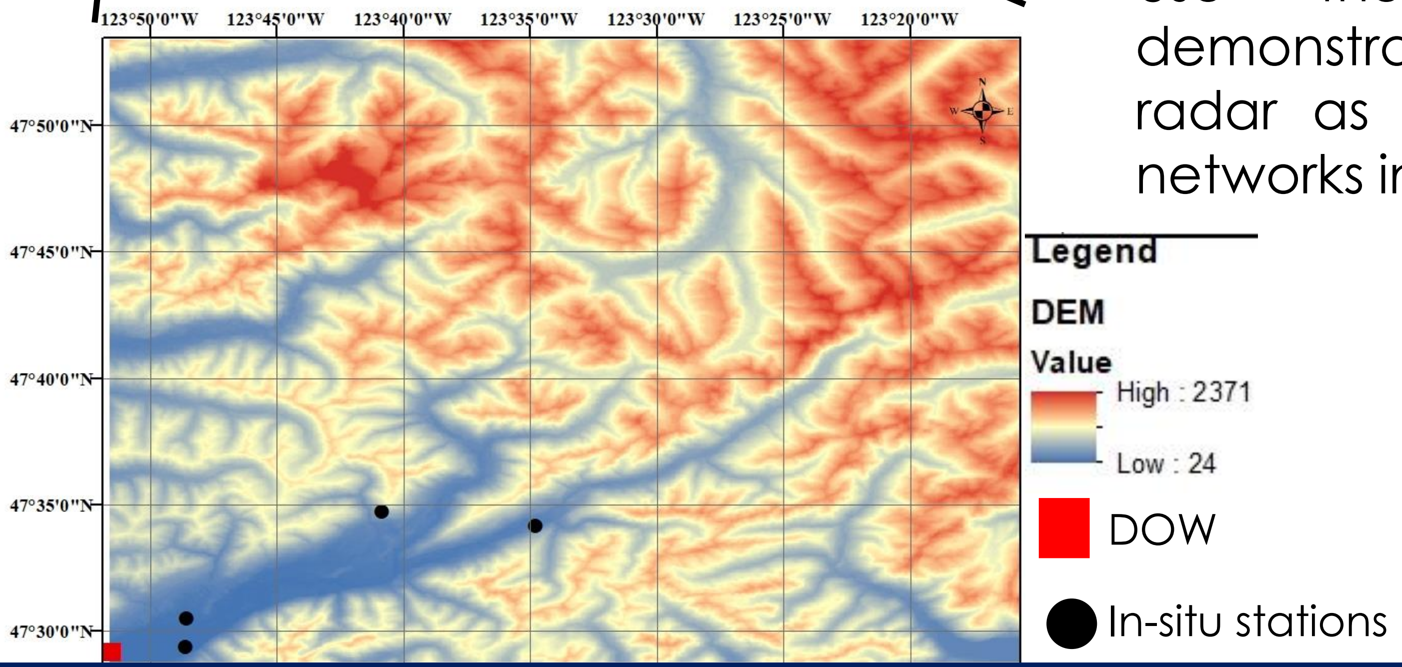
Analysis of X-Band Dual Polarization Radar Observations in OLYMPEX



- Quantify precipitation and microphysical parameters from the OLYMPEX Doppler on Wheels (DOW) dual-polarization X-band radar.
- Evaluate accuracy of these estimates against in-situ measurements from disdrometers, rain gauges and MRR.
- Use the OLYMPEX experiment to demonstrate the value of locally deployed radar as a gap fill to operational radar networks in complex terrain (i.e. NEXRAD).



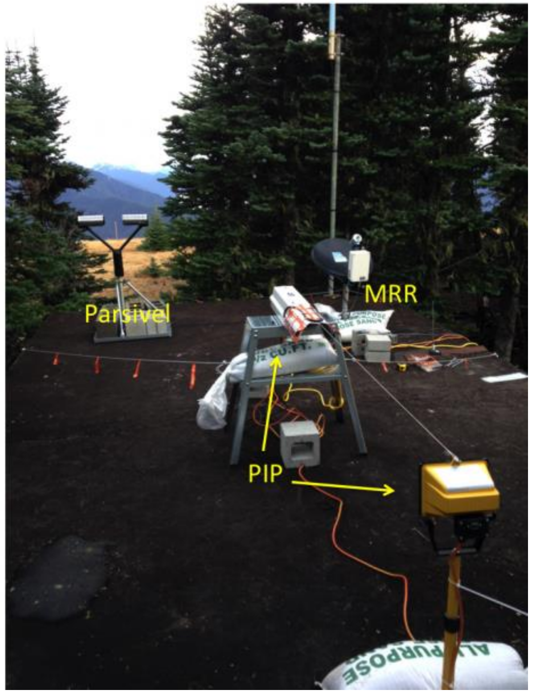
Datasets

- DOW sector volumes contain scans at 6 elevations – app ~ 2.8, 3.0, 5.0, 7.0, 9.0 and 11.0 degrees

$\underbrace{2.8, 3.0}_{\text{Lowest elevation angles}}$, 5.0, 7.0, $\underbrace{9.0 \text{ and } 11.0}_{\text{Highest elevation angles}}$

DOW properties

Range	59.96 km
Gate Length	75 m
Pulse Length	500 ns
Beam Width	0.93 deg
Beam Indexing	0.25 deg

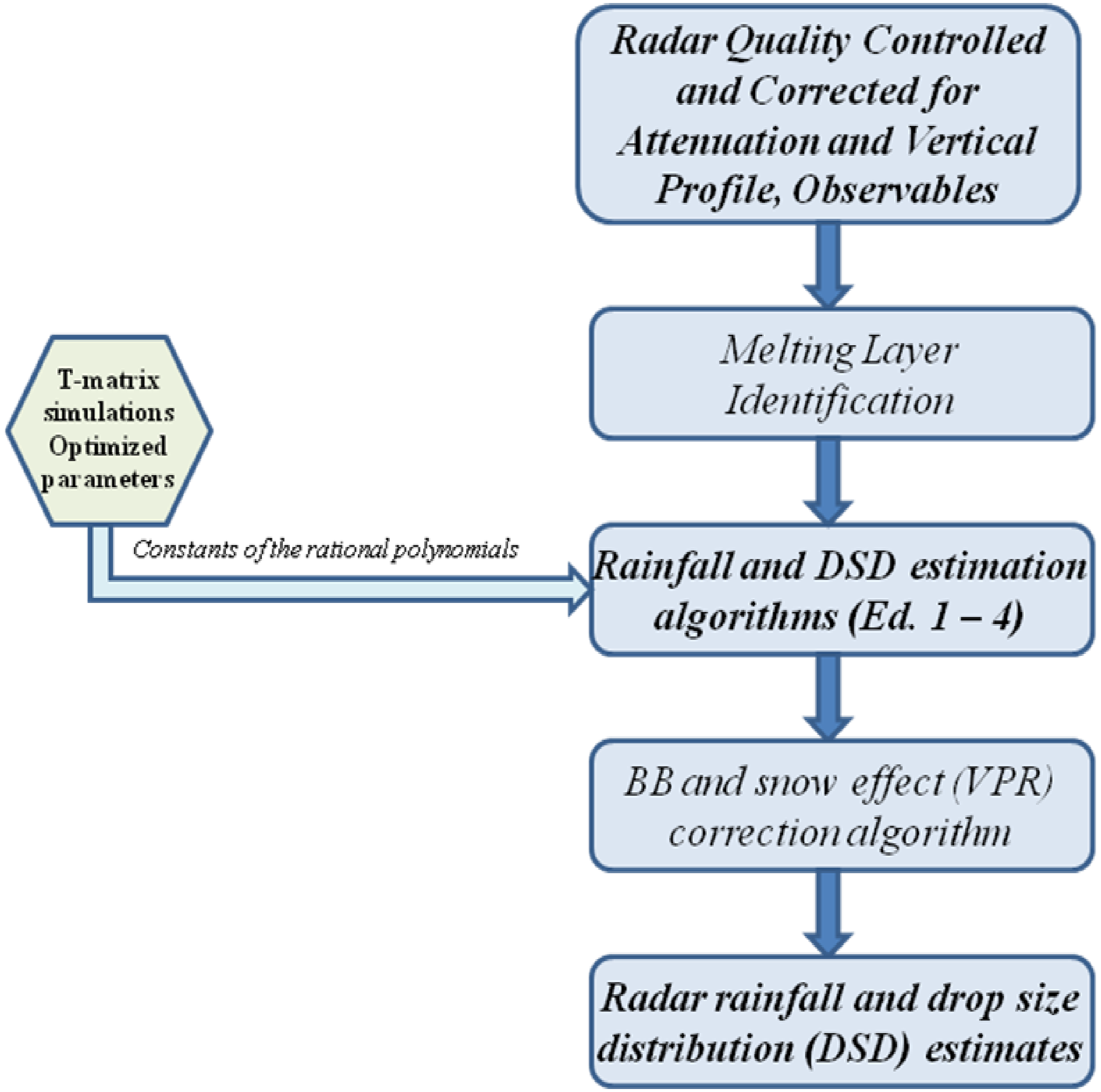


	Site IDs	Instruments	Range from DOW (km)	Elev (m)
	DOW	DOW	-	72
Close in-situ stations	**APU07, NASA0036**	Parsivel, Gauges	4.65	65
	APU08, NASA0029	Parsivel, Gauges, MRR	5.34	87
Far in-situ stations	**APU09, STDALN01**	Parsivel, Gauges	15	116
	APU11, STDALN02	Parsivel, Gauges	23	181

SCOPE-ME ALGORITHM

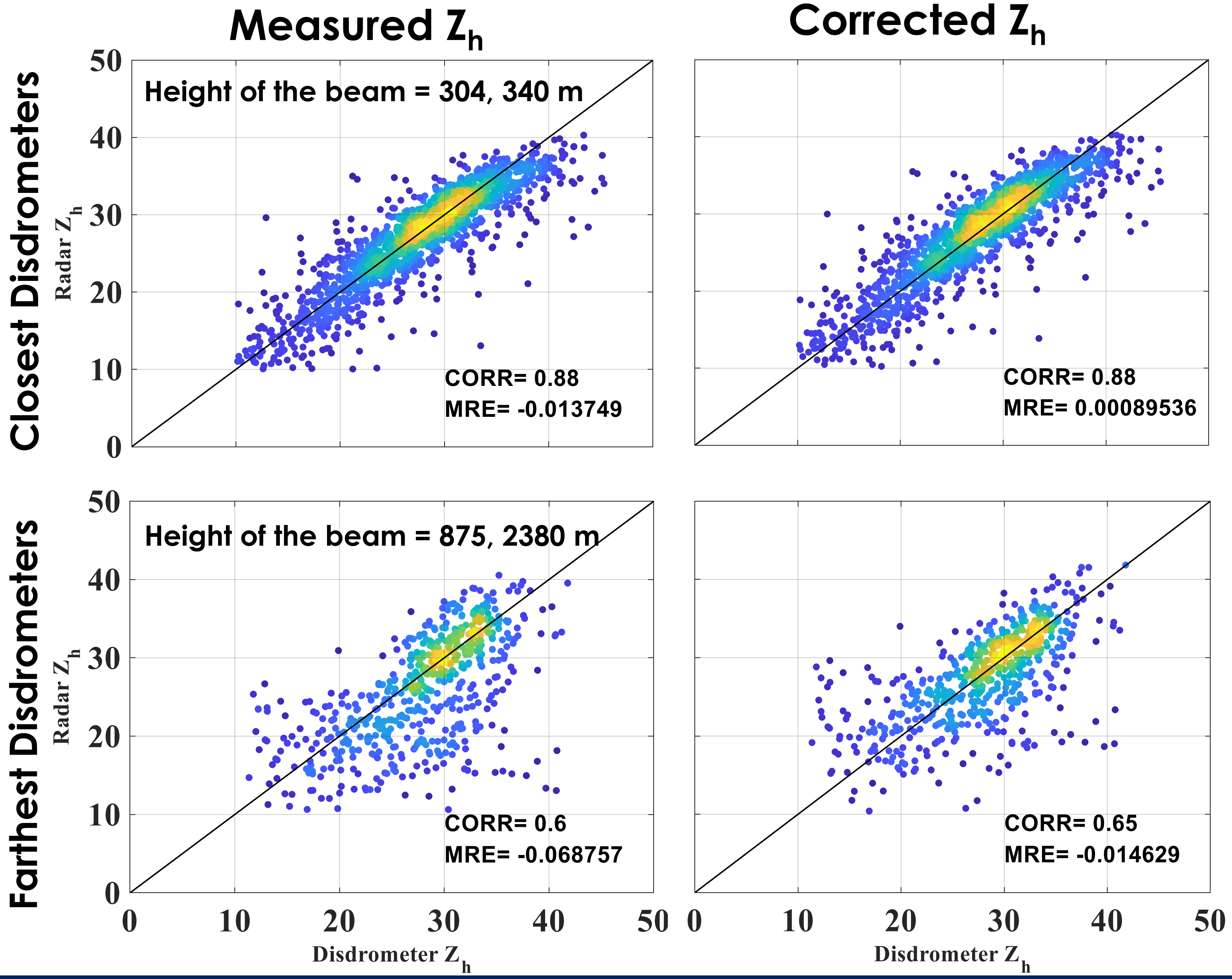
Precipitation Algorithm

- **Quality control** (ρ_{HV}, V_r, σ_{Vr}, signal above noise level):
  - real-time ground clutter detection and suppression
  - beam blockage correction
  - rain signal areas detection (ρ_{HV}>0.8)
  - differential phase filtering (phase continuity, 1- 3 km linear filter for K_{DP})
- **Attenuation correction:** KDP-based iterative differential phase algorithm along each ray
- **Bright-band detection and correction for VPR:** ρ_{HV} based PPI areal method or RHI profile method
- **Rain rate and microphysical parameters estimation** (SCOPE-ME)

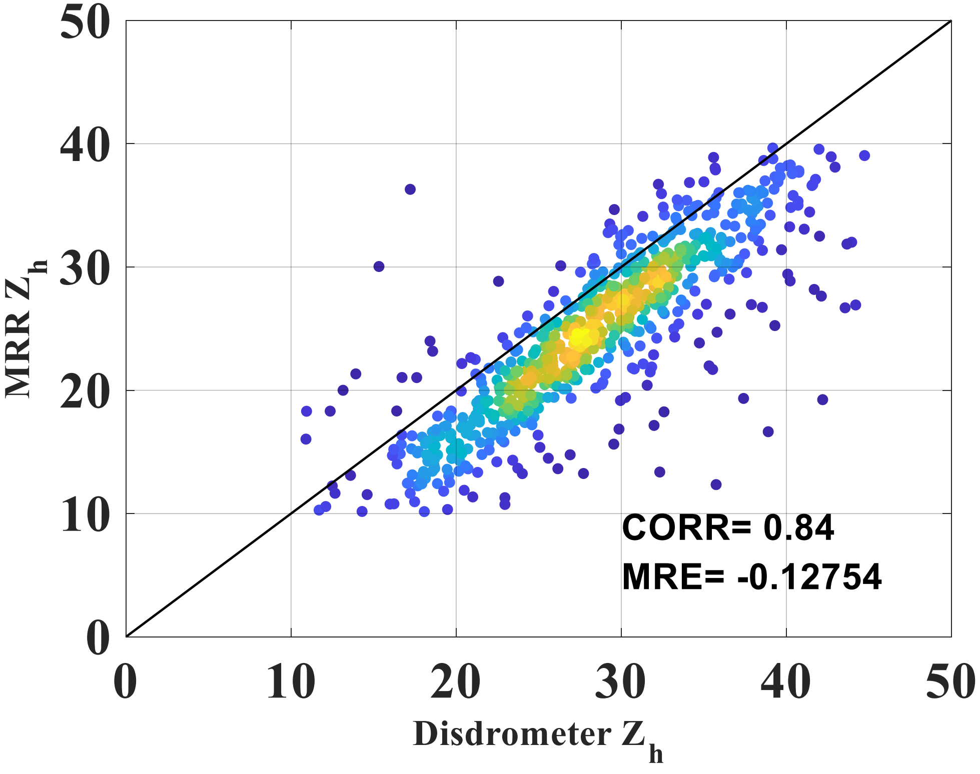


Anagnostou, M. N., John Kalogiros, Frank S. Marzano, Emmanouil N. Anagnostou, Mario Montopoli, and Errico Picciotti, 2013: Performance evaluation of a new dual-polarization microphysical algorithm based on long-term X-band radar and disdrometer observations, *J. Hydrometeor.* **14**, 560 – 576.
Kalogiros, J., M. N. Anagnostou, E. N. Anagnostou, M. Montopoli, E. Picciotti, and F. S. Marzano, 2014: Evaluation of a new Polarimetric Algorithm for Rain-Path Attenuation Correction of X-Band Radar Observations Against Disdrometer Data, *IEEE Geoscience and Remote Sensing Letters*, **52**, 1369 – 1380.

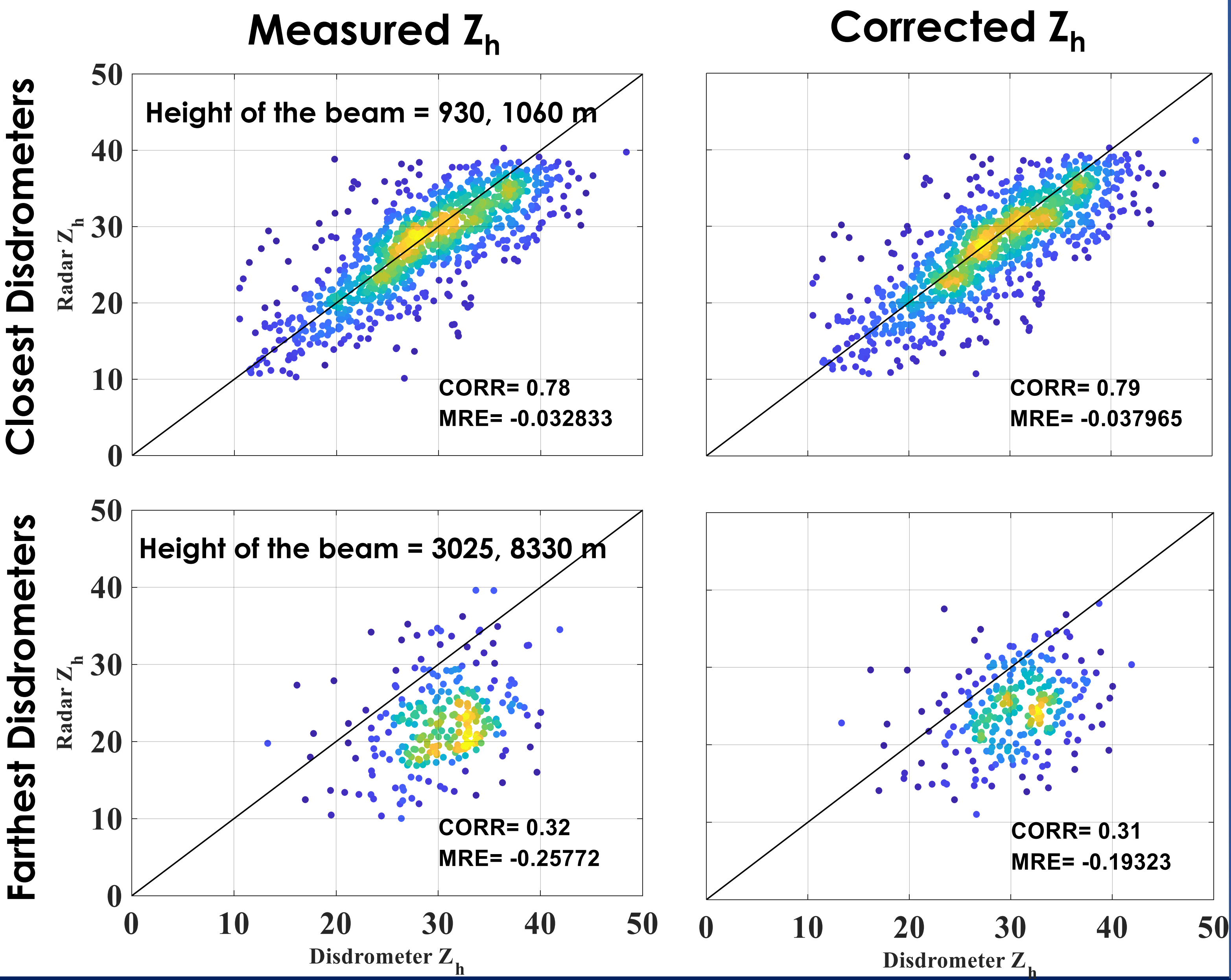
Reflectivity Comparison at Lowest Elevation Angle



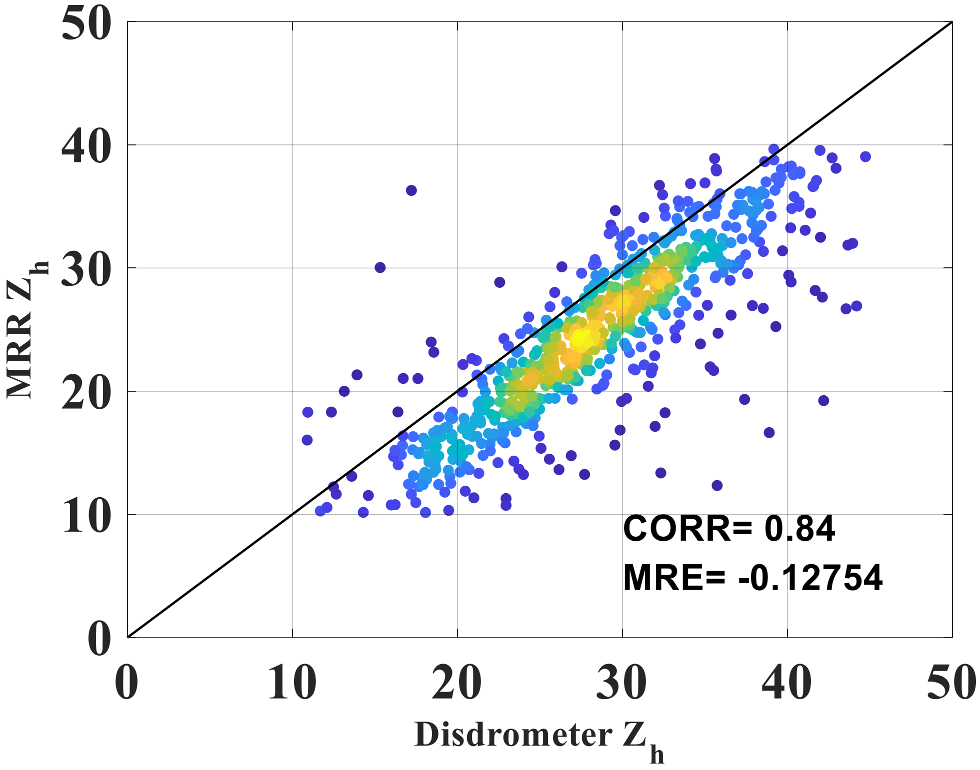
$$MRE = \frac{\sum(Radar\ Z_h - Disdro\ Z_h)}{\sum Disdro\ Z_h}$$



Reflectivity Comparison at Highest Elevation Angle

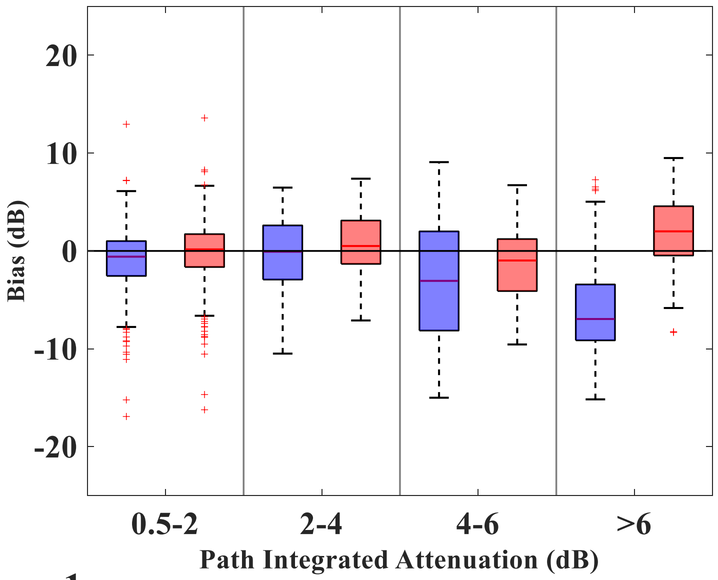


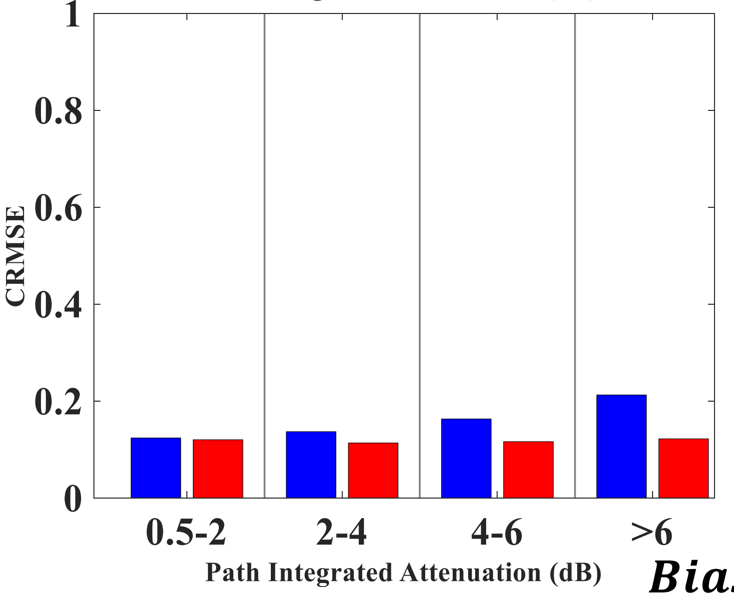
$$MRE = \frac{\sum(Radar\ Z_h - Reference\ Z_h)}{\sum Reference\ Z_h}$$



Reflectivity Comparison at Lowest & Highest Elevation Angle

Lowest Elevation Angle

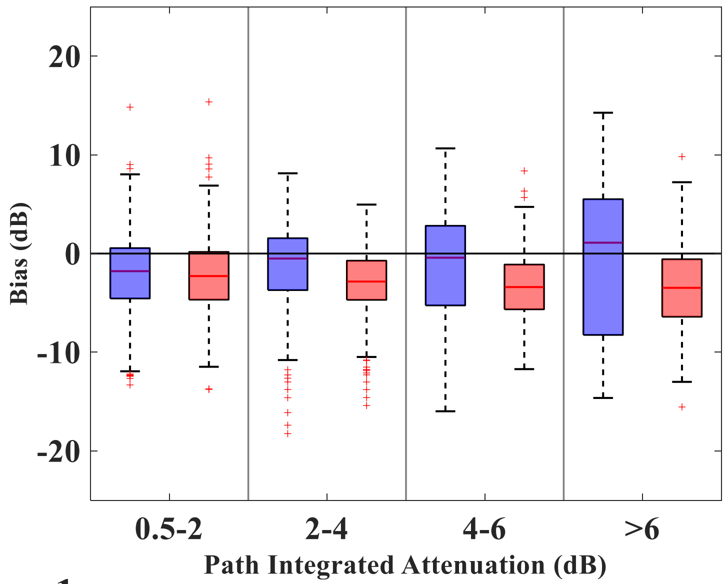


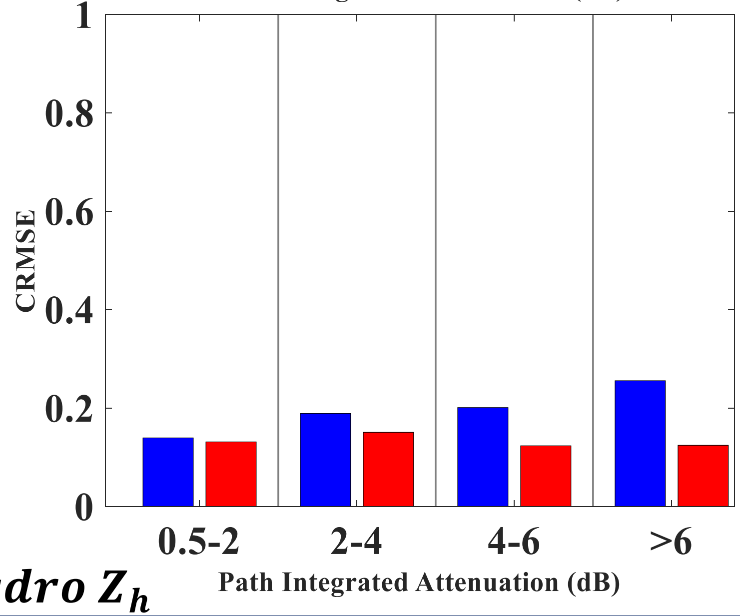


Radar Z_{hm}

Radar Z_h

Highest Elevation Angle





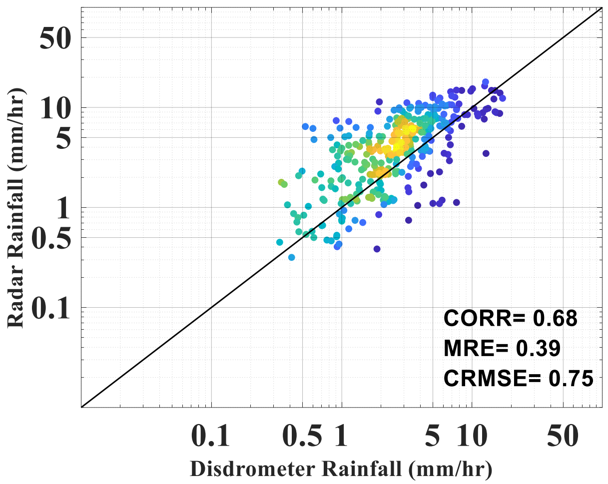
$$Bias = Radar\ Z_h - Disdro\ Z_h$$

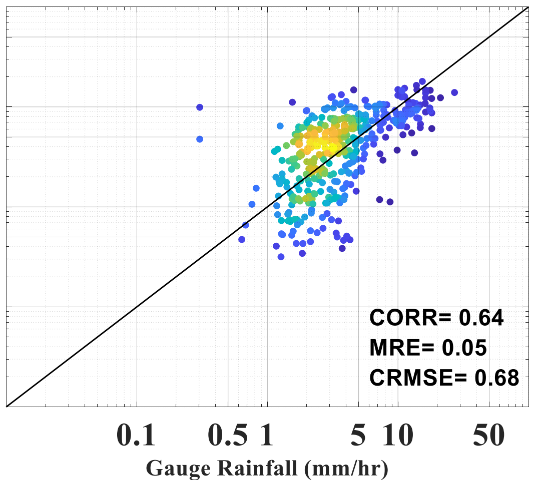
Rainfall Comparison for Lowest Elevation Angle

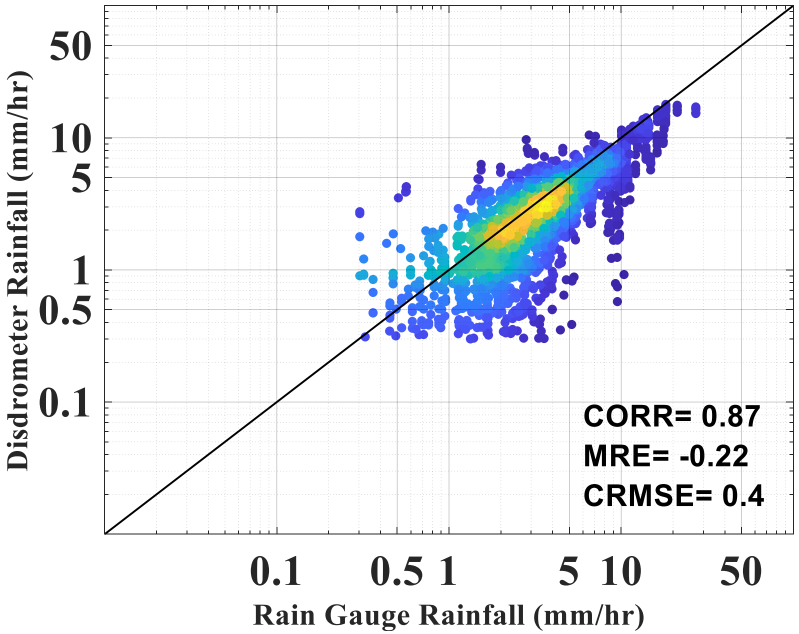
$$MRE = \frac{\sum(DOW\ R\ - Reference\ R)}{\sum Reference\ R}$$

Closest in-situ stations

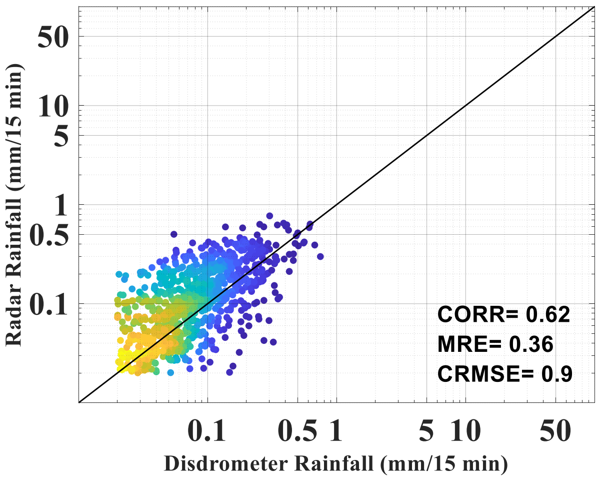
Hourly Rainfall

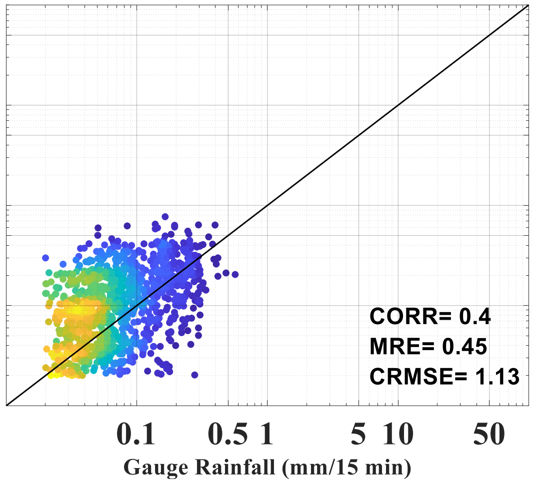


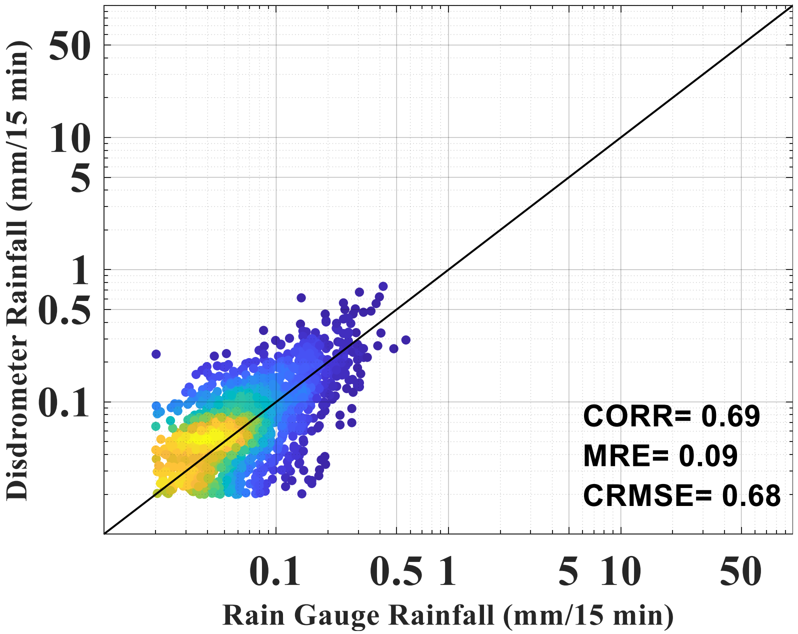




15 min Rainfall





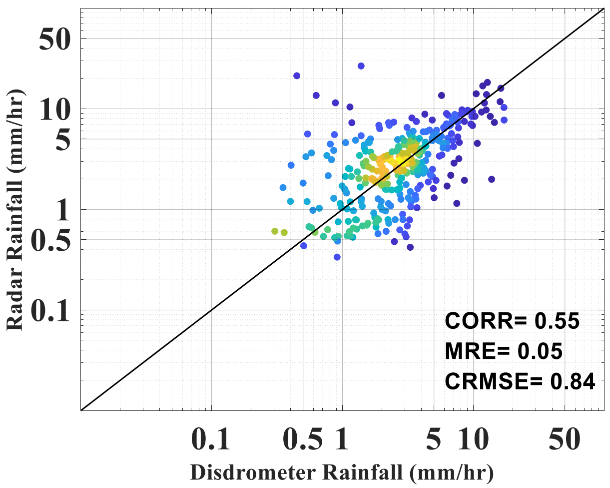


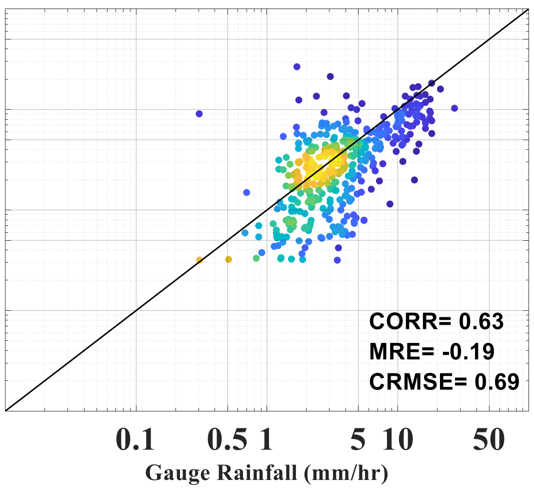
Rainfall Comparison for Highest Elevation Angle

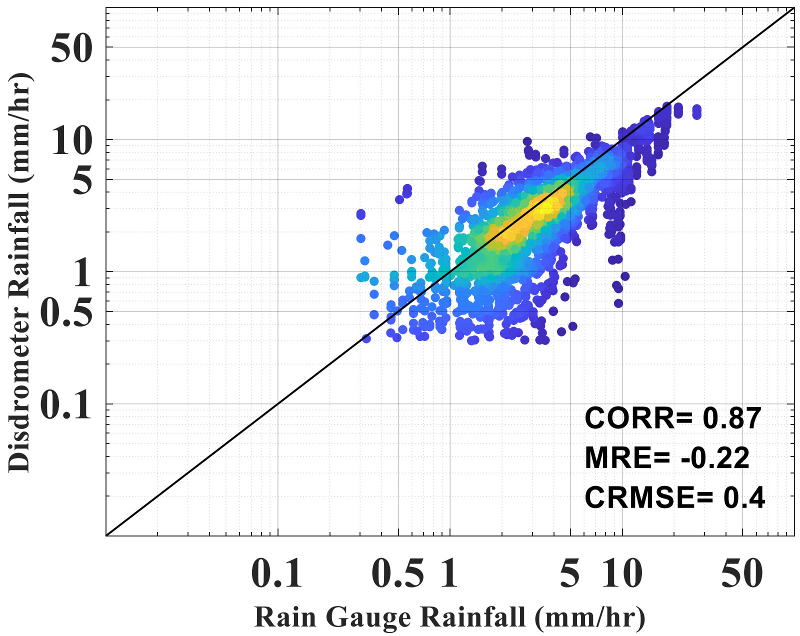
$$MRE = \frac{\sum(DOW\ R - Reference\ R)}{\sum Reference\ R}$$

Closest in-situ stations

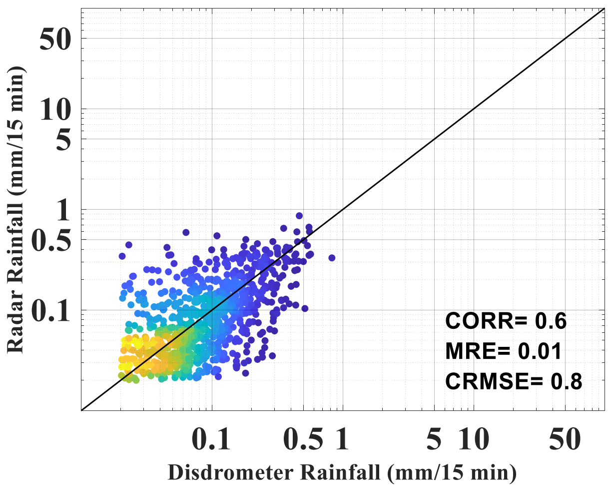
Hourly Rainfall

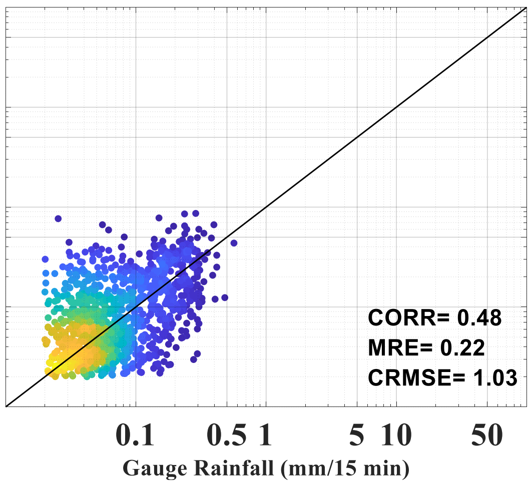


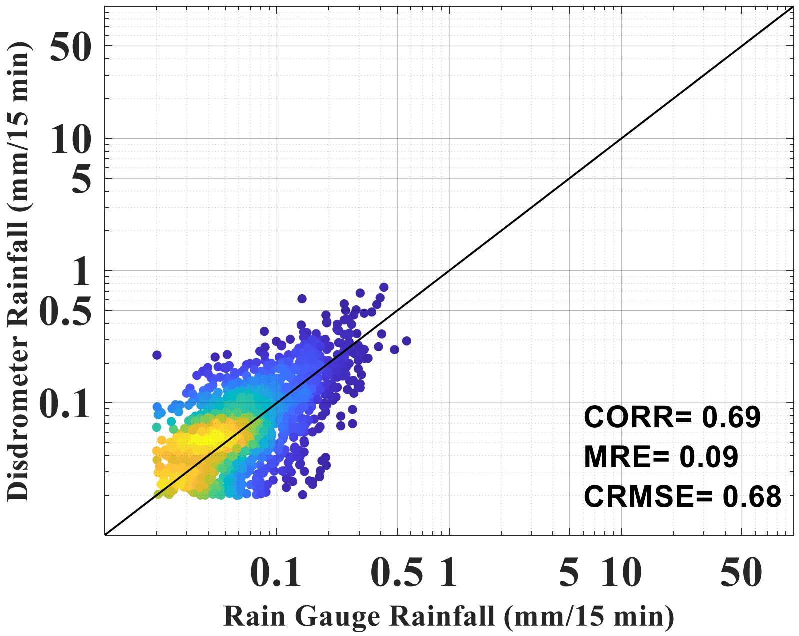




15 min Rainfall







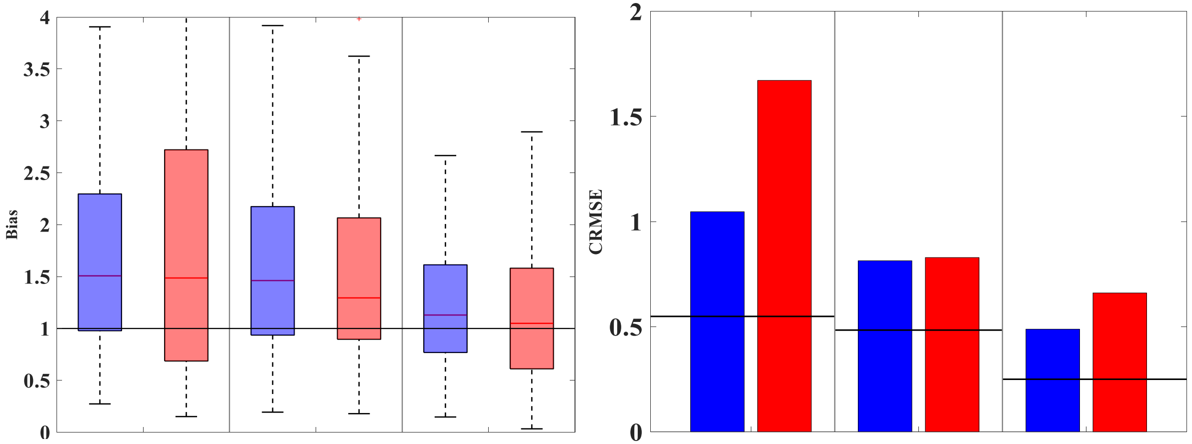
Rainfall Comparison for Lowest & Highest Elevation Angle

Closest RGs

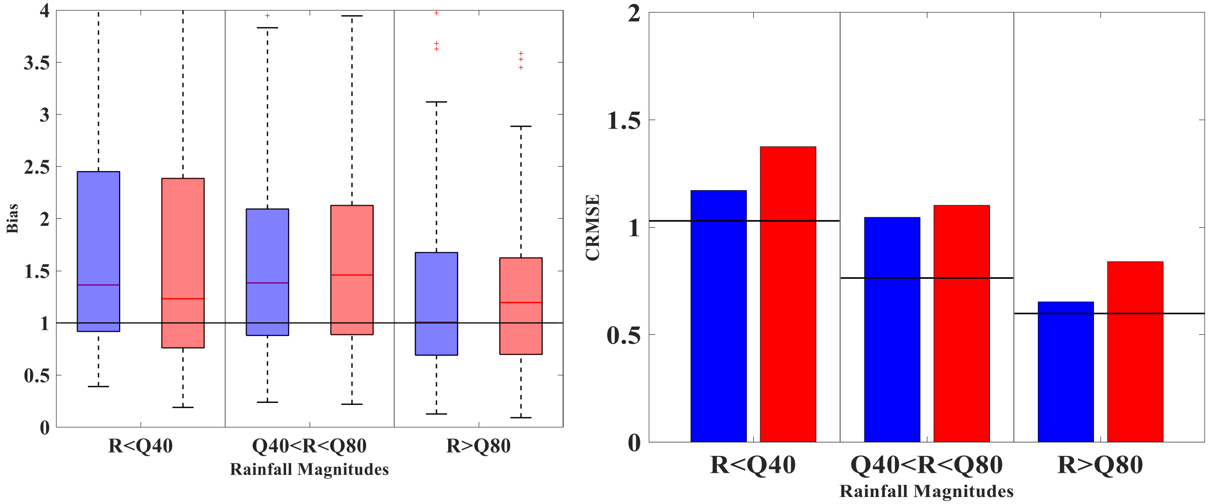
Farthest RGs

Lowest Elevation Angle

Hourly Rainfall

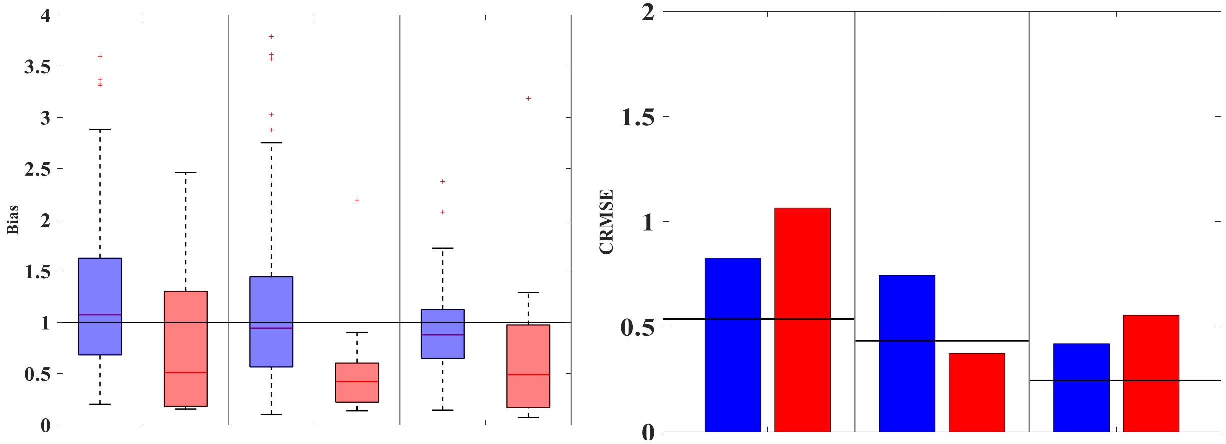


15 min Rainfall

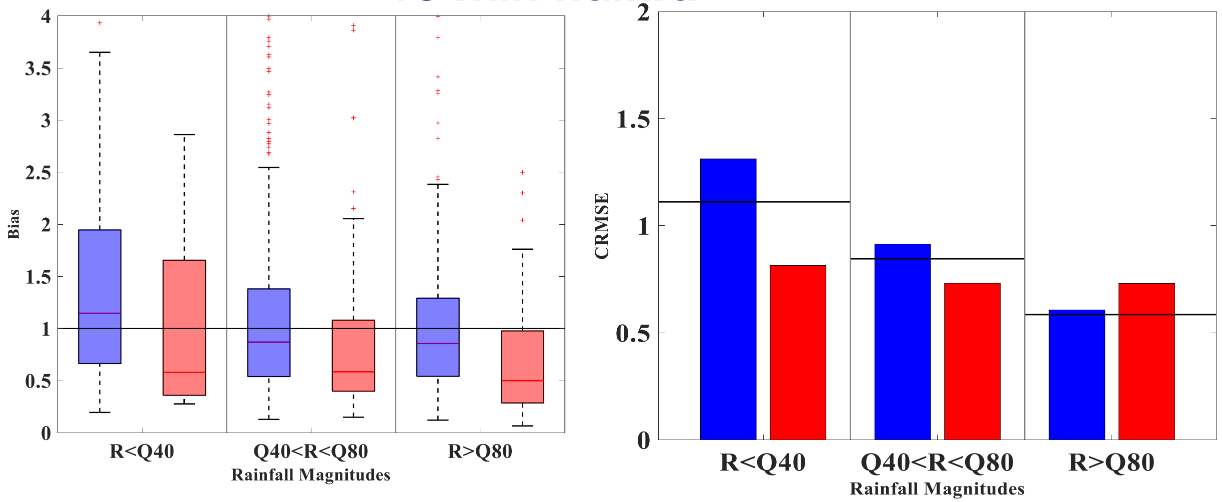


Highest Elevation Angle

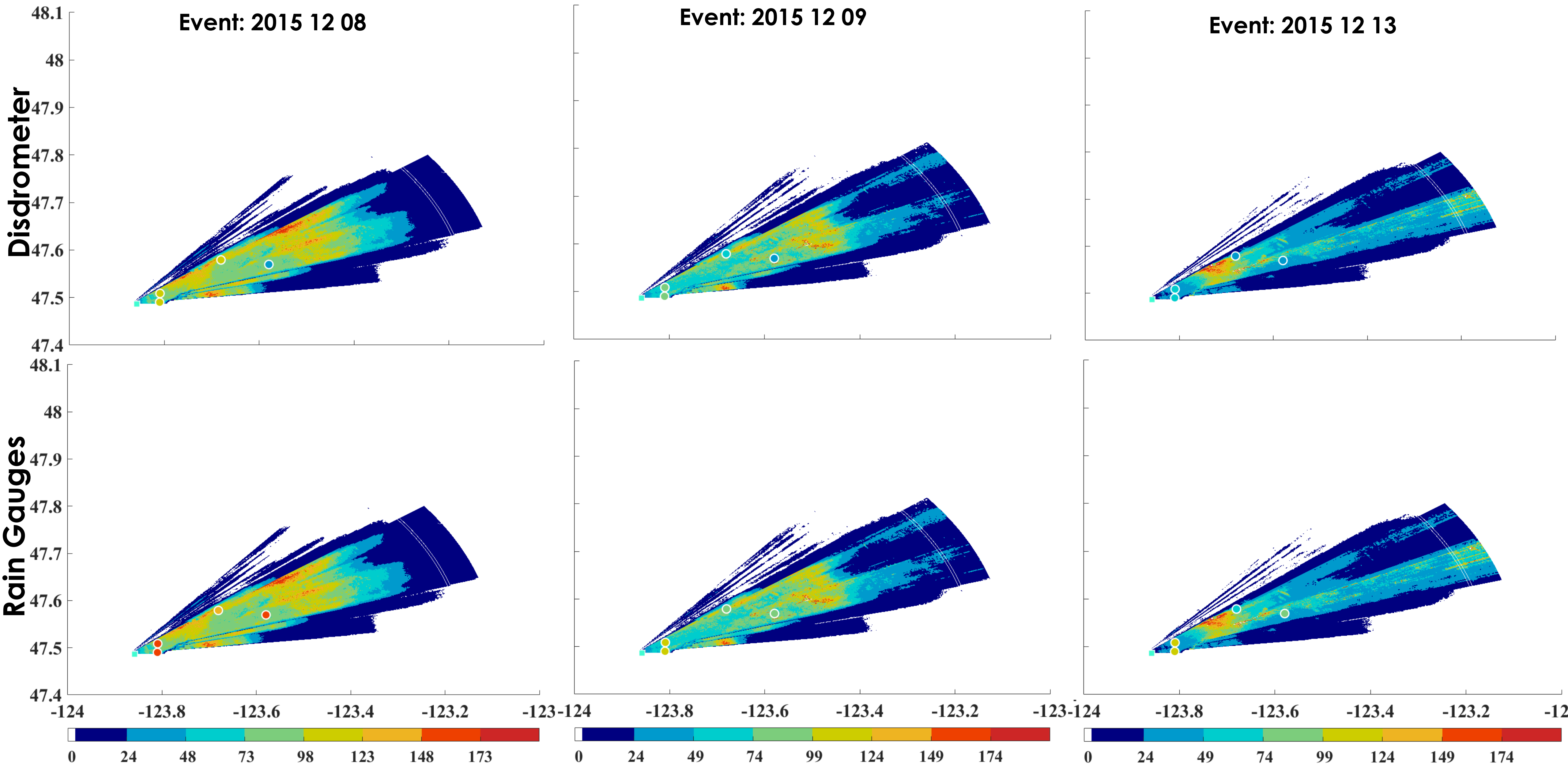
Hourly Rainfall



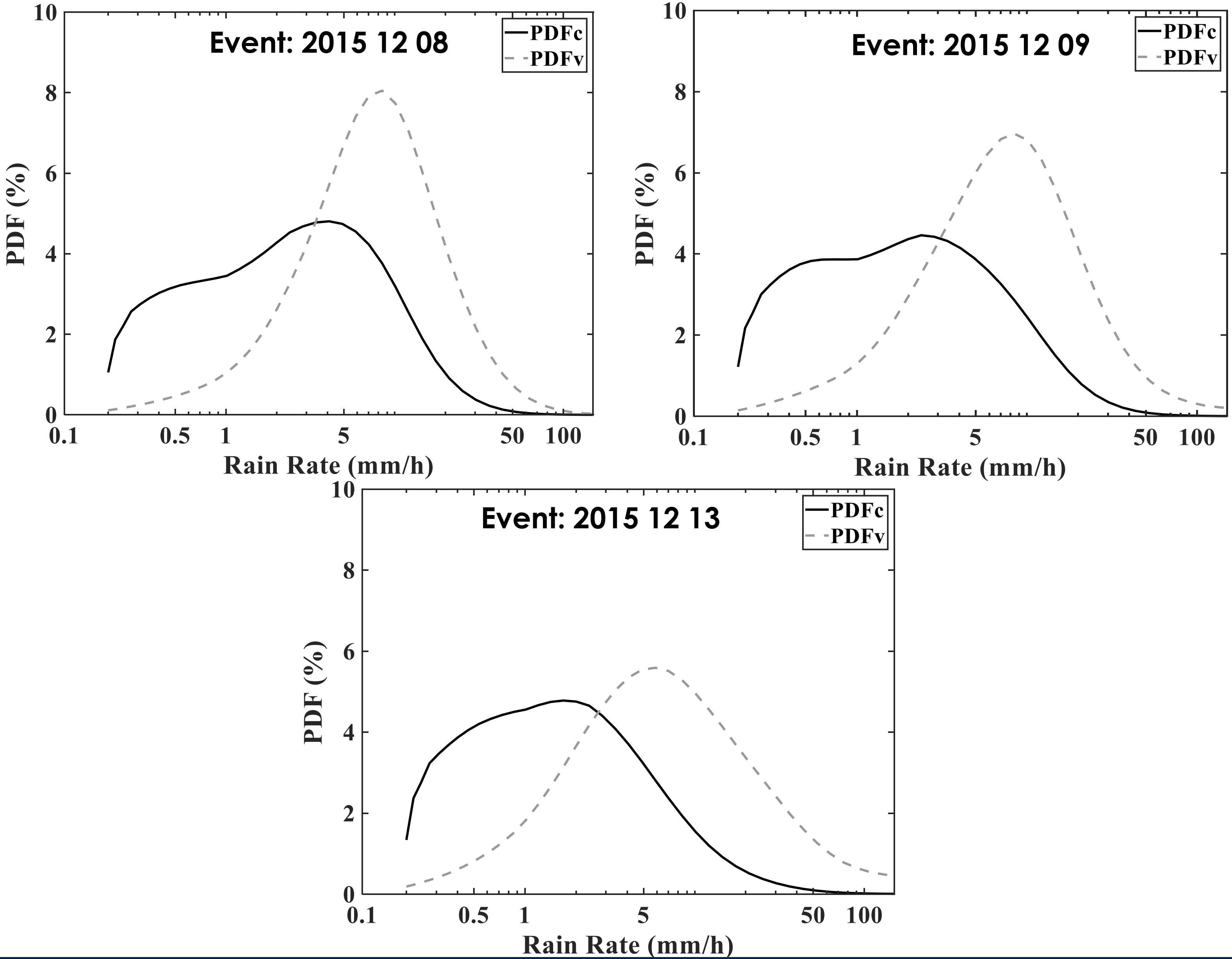
15 min Rainfall



Event-based Accumulated Rainfall



Event-based PDFc (PDF by occurrence of rain rates) and PDFv (PDF by volume of rain rates)



Closing Remarks

- Our error analysis over North Carolina and Northeast Italy showed that PMW-based estimates have systematic underestimation particularly of high rain rates. In addition we showed that GPROF algorithm (both versions) applied on GMI has the least conditional bias. Almost all sensors have problem detecting light precipitation rates, however, performance varies across different algorithms.

- The XPOL algorithm presented in this study would facilitate more comprehensive investigation of those PMW retrieval error characteristics, because the XPOL estimates were shown to have consistently low bias and random errors across different radar ranges and rainfall magnitudes. In addition, we showed that rainfall estimation error statistics is comparable to random error evaluated by comparing collocated in-situ stations.

Future Work

- Apply XPOL estimates to study PMW retrieval uncertainty
- Extend the work to additional complex terrain study areas capitalizing on their local XPOL observations.

	Ground Radar	Location	Period	Collaborator
Processed	X-POL	Northeast Italian Alps	07/2014-09/2014 (21 events)	John Kalogiros, NOA
Processed	NOXP	Appalachian, North Carolina	05/2014-06/2014 (25 events)	NASA, IPHEX
Processed	DOW	Olympic Mountain, Washington	10/2015-02/2016 (39 events)	NASA, OLYMPEX
Processed	NOXP	Rocky Mountains, Colorado	09/04/2014-10/13/2014 (35 events) 07/31/2015-09/30/2015 (53 events) 03/01/2017-04/21/2017 (32 events)	Pierre Kirstetter, OU
To be processed	X-POL	Swiss Alps	02/2014 03/2014-06/2014 06/2014-05/2015 11/2016-current	Alexis Berne, EPFL
To be processed	NOXP	Andes, Peru	01/18/2018-04/02/2018 (45 events)	Boonleng Cheong, OU
To be processed	X-POL	French Cevennes & Alps	09/2012-10/2012 09/2013-current	Guy Delrieu Univ. of Grenoble
To be processed	X-POL	Korea	01/14/2018-03/12/2018	Alexis Berne, EPFL ICE-POP
To be processed	X-POL	Arizona	2018 summer (to be deployed)	Jonathan Gourley, OU
To be processed	X-POL	Sierras de Córdoba Mountain range, Argentina	2018 (to be deployed)	Joseph C. Hardin, Pacific Northwest National Laboratory