Validation of rainfall distribution by spaceborne radars over the complex topography of southern Meghalaya Plateau, India

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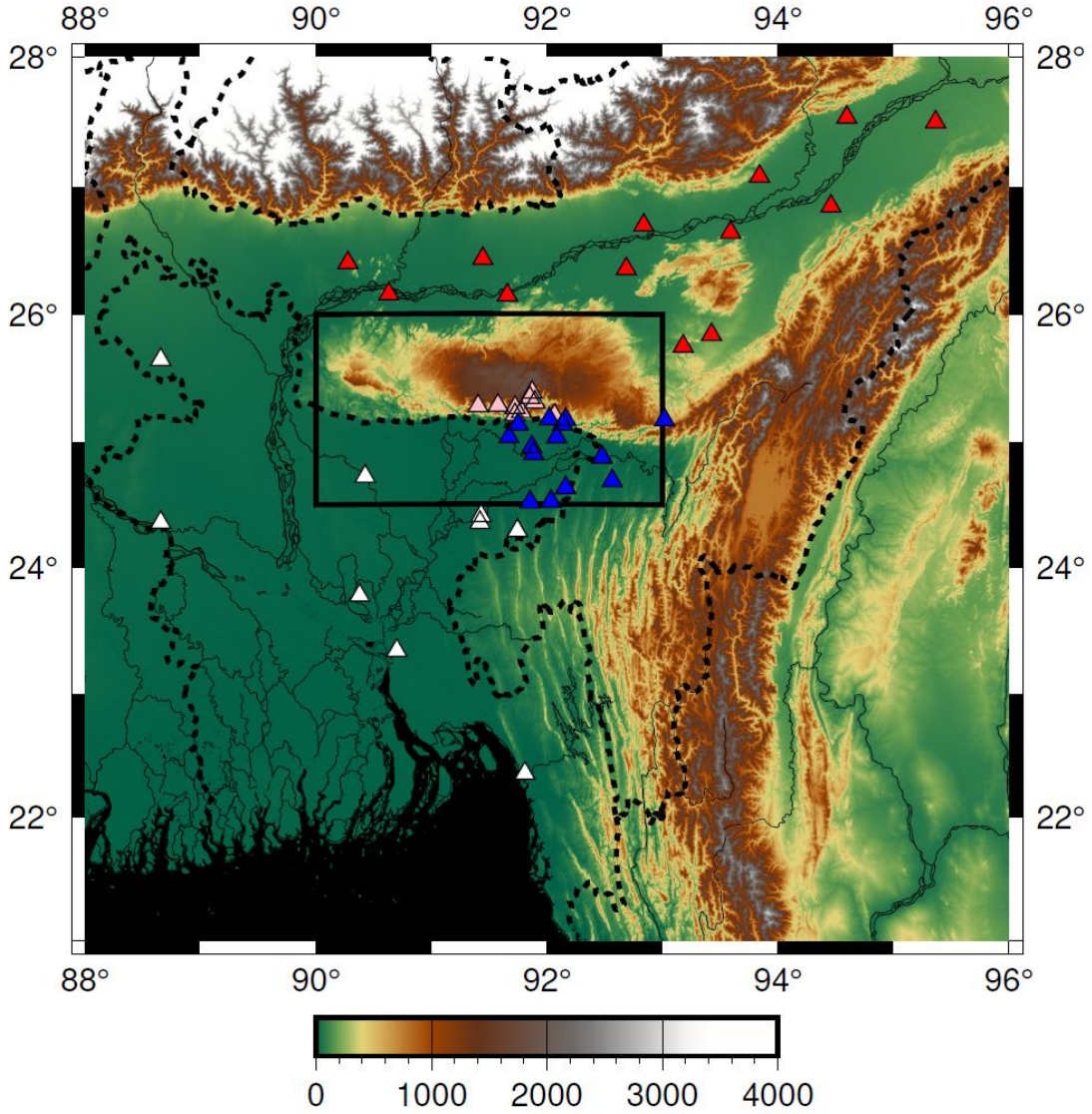
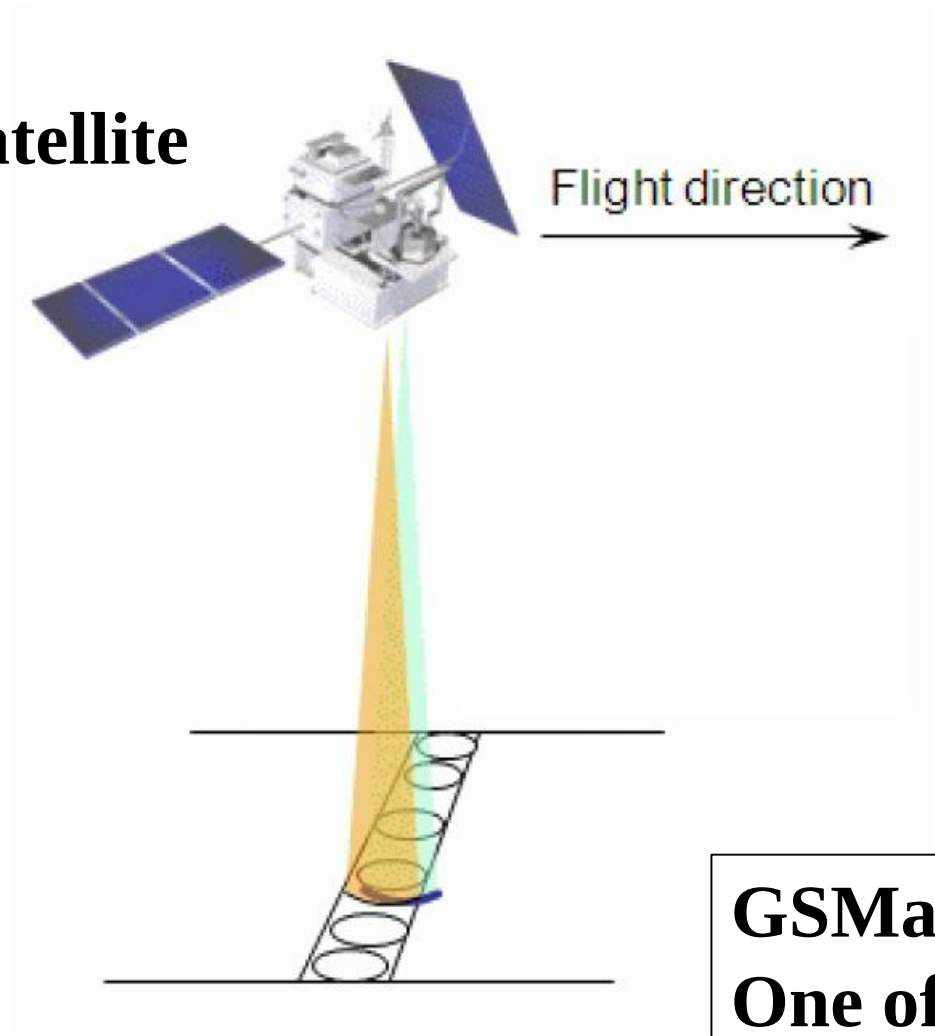
Our rain gauge observation sites

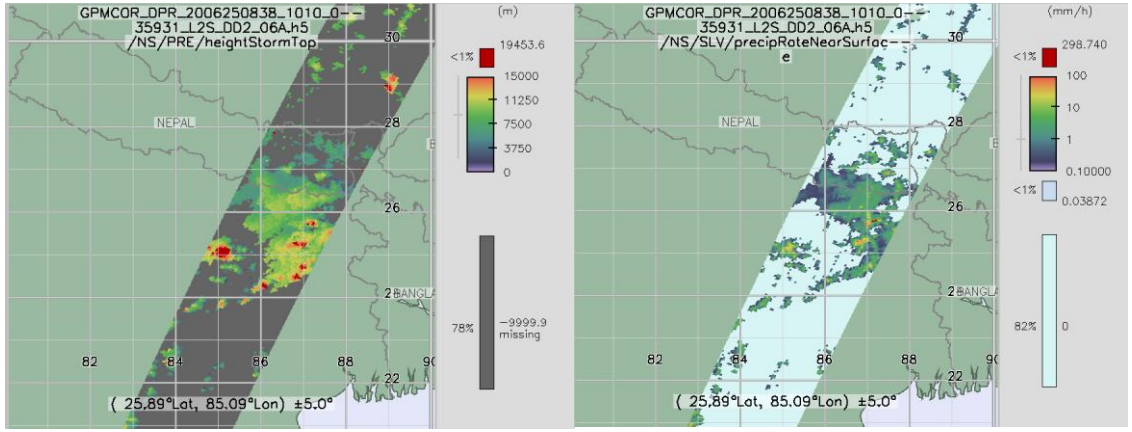


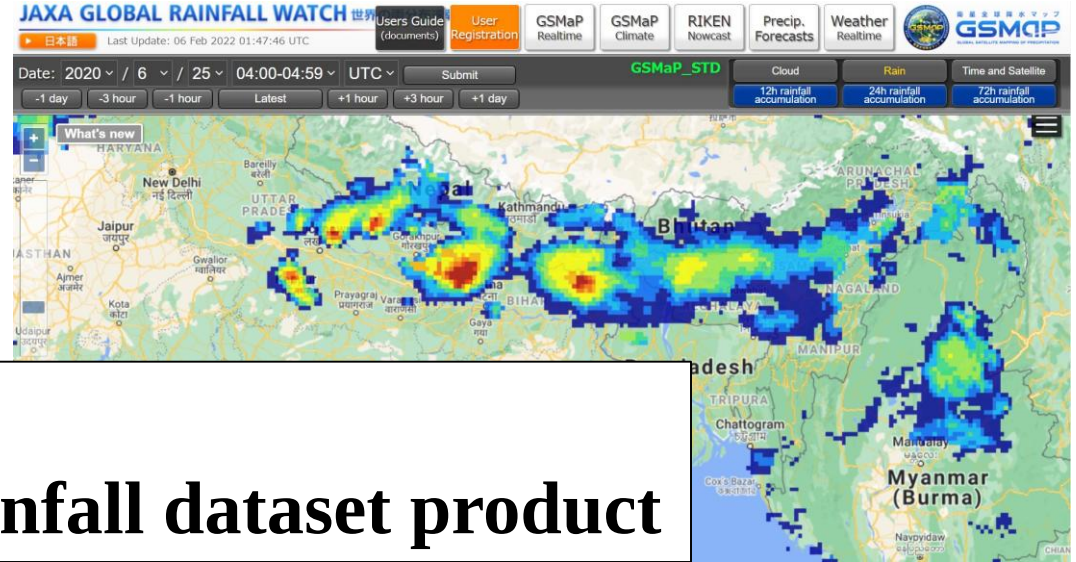
This project is the collaborative work with JAXA for the validation of the spaceborne weather radar

GPM satellite



GPM satellite orbit





GSMaP:
One of rainfall dataset product

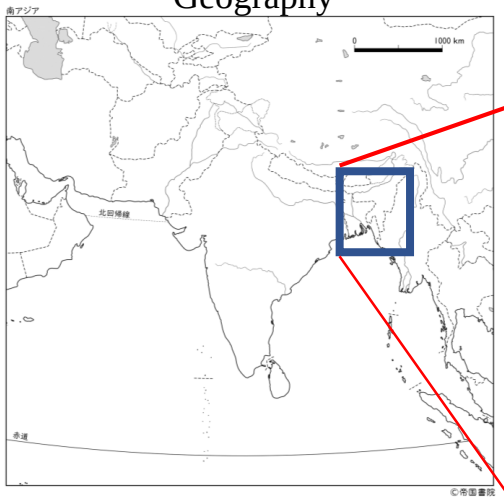
Validation of (a) TRMM PR V7, (b) TRMM PR V8, and (c) GPM DPR V6A

(a) Area	$\overline{RG}$ (mm h^{-1})	$\overline{SAT}$ (mm h^{-1})	$\overline{SAT} - \overline{RG}$ (mm h^{-1})	*Bias* (%)	N_{obs}	N_{rain}
Meghalaya	2.24	1.18	−1.06	−47**	3849	725
Assam	0.43	0.36	−0.07	−16**	8422	878
Sylhet + Barak	1.03	0.70	−0.33	−32**	7445	1210
Bengal Plain	0.44	0.33	−0.11	−25**	6186	571
(b) Area	$\overline{RG}$ (mm h^{-1})	$\overline{SAT}$ (mm h^{-1})	$\overline{SAT} - \overline{RG}$ (mm h^{-1})	*Bias* (%)	N_{obs}	N_{rain}
Meghalaya	2.25	1.48	−0.77	−34**	3829	725
Assam	0.42	0.34	−0.08	−20**	8415	930
Sylhet + Barak	1.04	0.73	−0.32	−30**	7444	1262
Bengal Plain	0.45	0.30	−0.15	−34**	6149	595
(c) Area	$\overline{RG}$ (mm h^{-1})	$\overline{SAT}$ (mm h^{-1})	$\overline{SAT} - \overline{RG}$ (mm h^{-1})	*Bias* (%)	N_{obs}	N_{rain}
Meghalaya	2.17	1.23	−0.93	−43**	1177	275
Meghalaya/new	0.93	1.13	0.20	+21	507	84
Assam	0.46	0.35	−0.11	−24	2893	333
Sylhet + Barak	0.92	0.75	−0.17	−19	1715	296
Bengal Plain	0.43	0.58	0.15	+36	1134	126

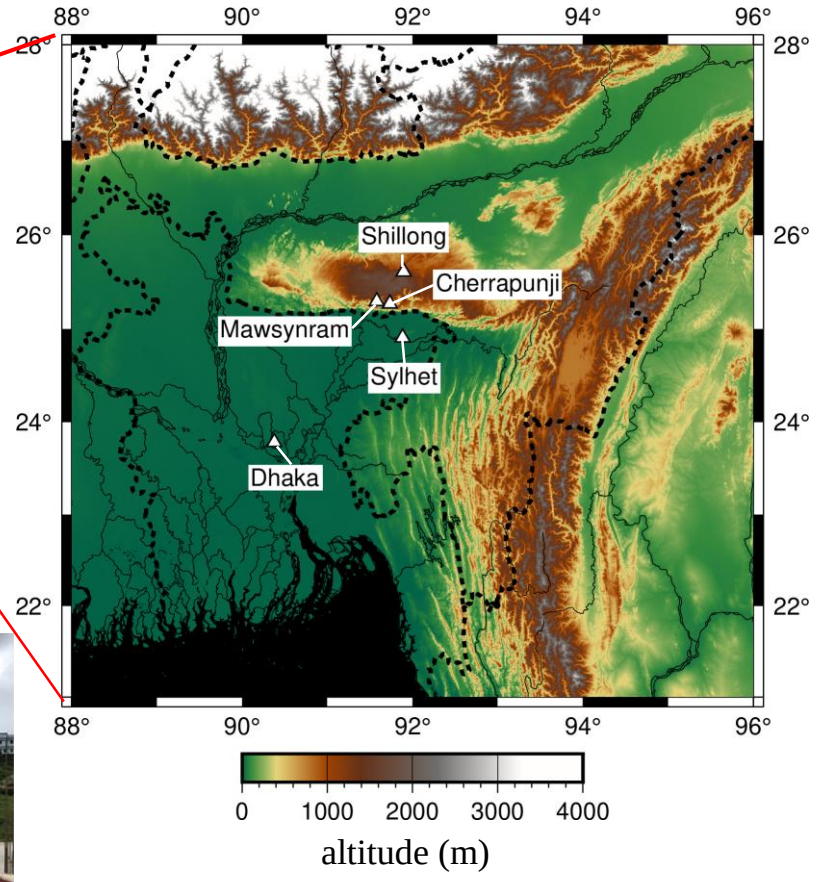
* and ** show significance at the 95 % and 99 % confidence levels.

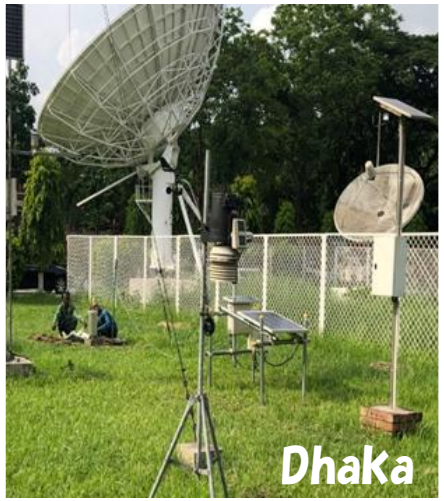
Our disdrometer observation sites

Geography



Topography & Disdrometer stations

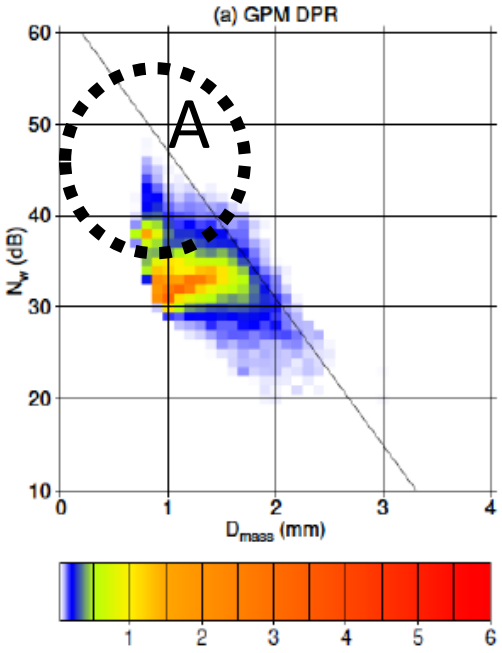


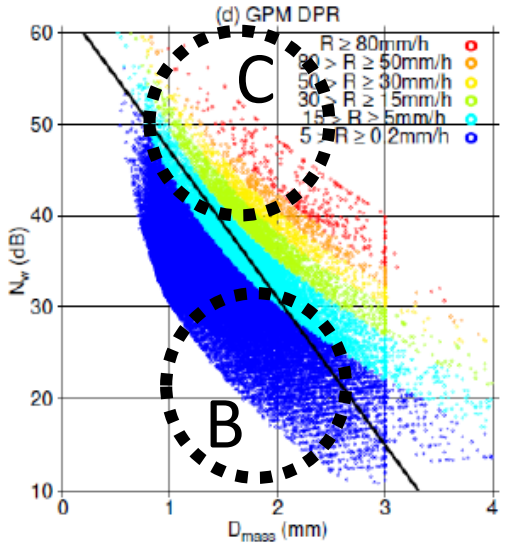


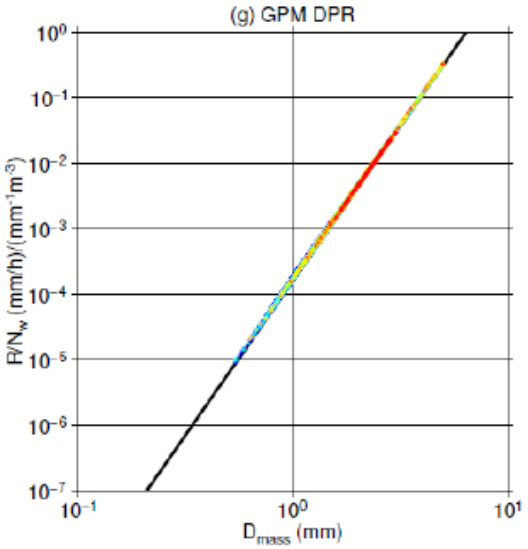
GPM DPR retrievals around the area Including Cherrapunji

Validation of DSD parameters

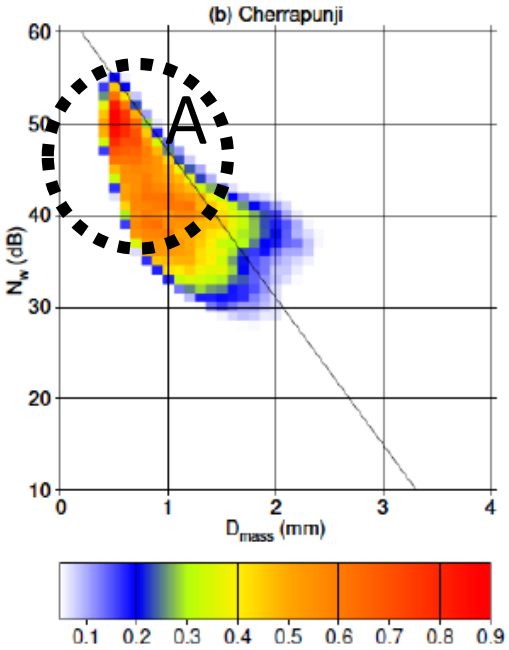
Parsivel[2] disdrometer at Cherrapunji

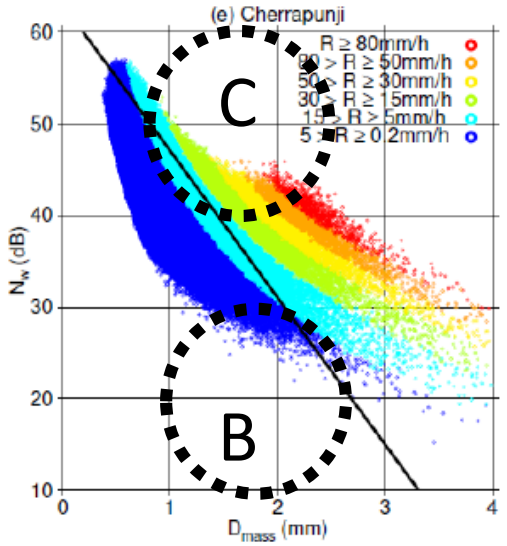


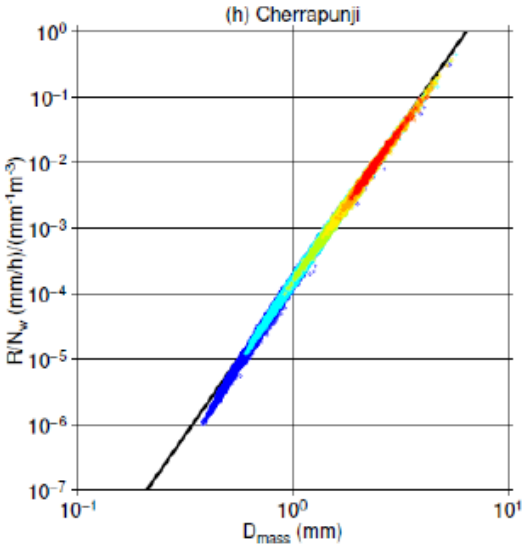




The empirical equation derived from Liao et al. (2020)

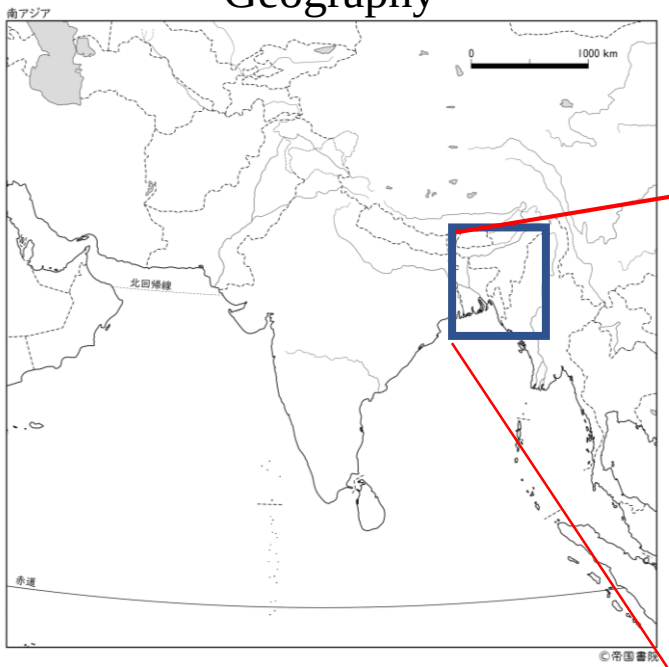




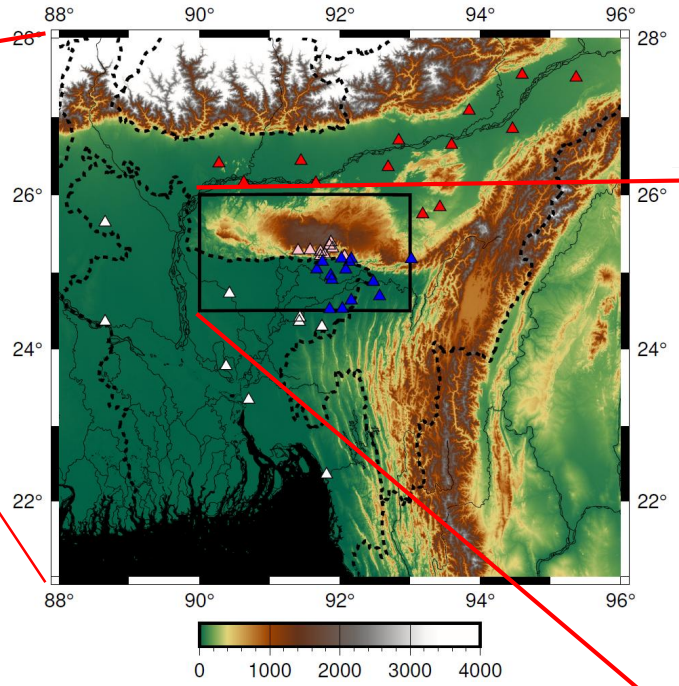


Heavy rainfall area in southern Meghalaya

Geography

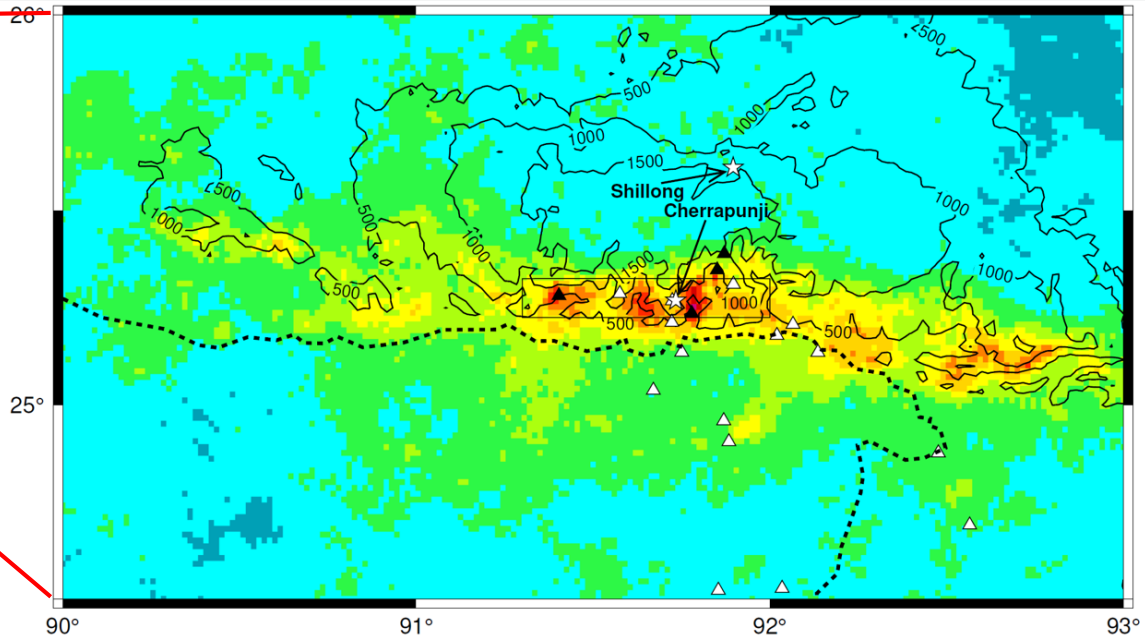


Topography



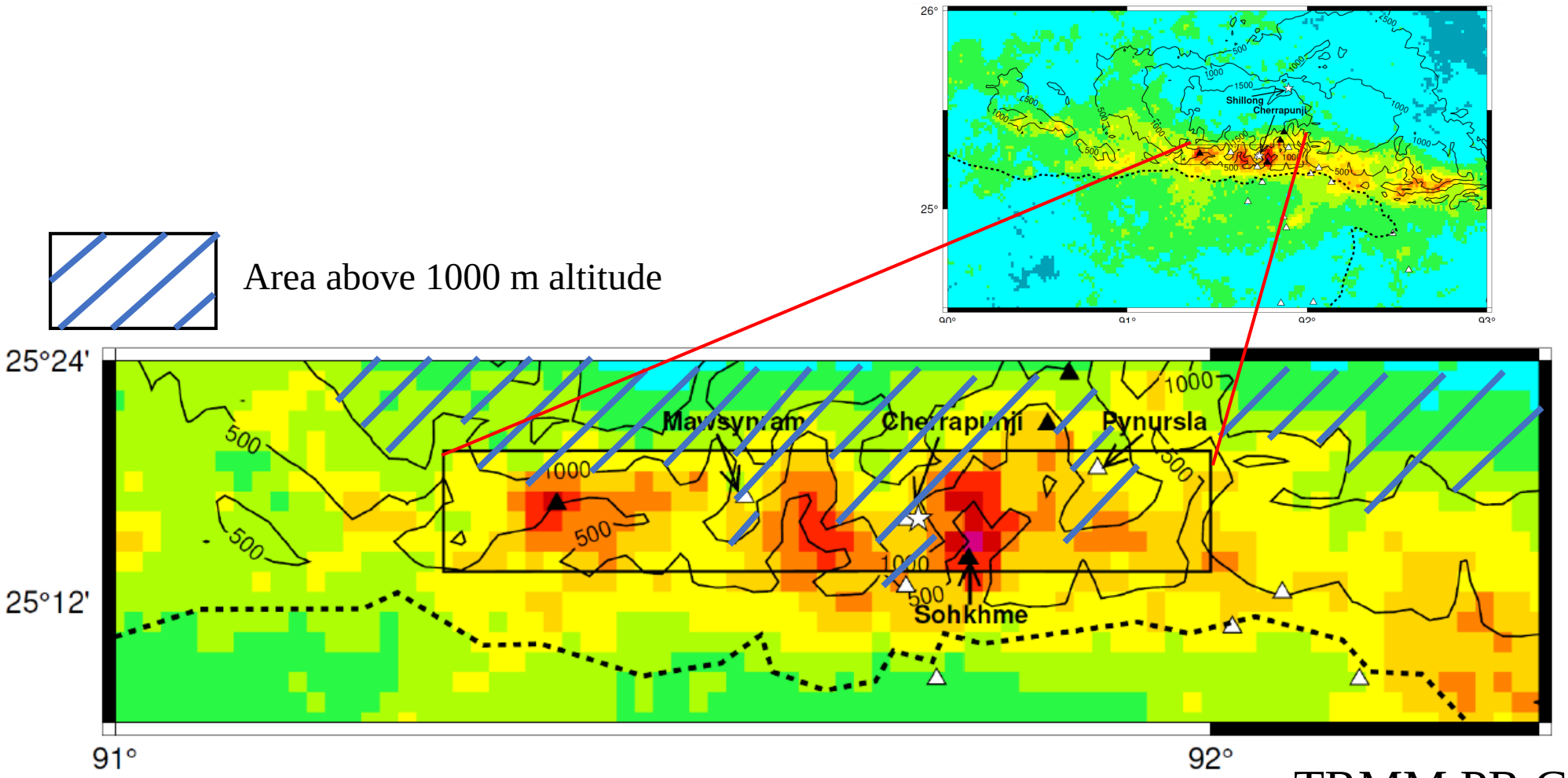
altitude (m)

Rainfall distribution based on TRMM PR data of during year-1998-2013 (Hirose and Okada 2018)



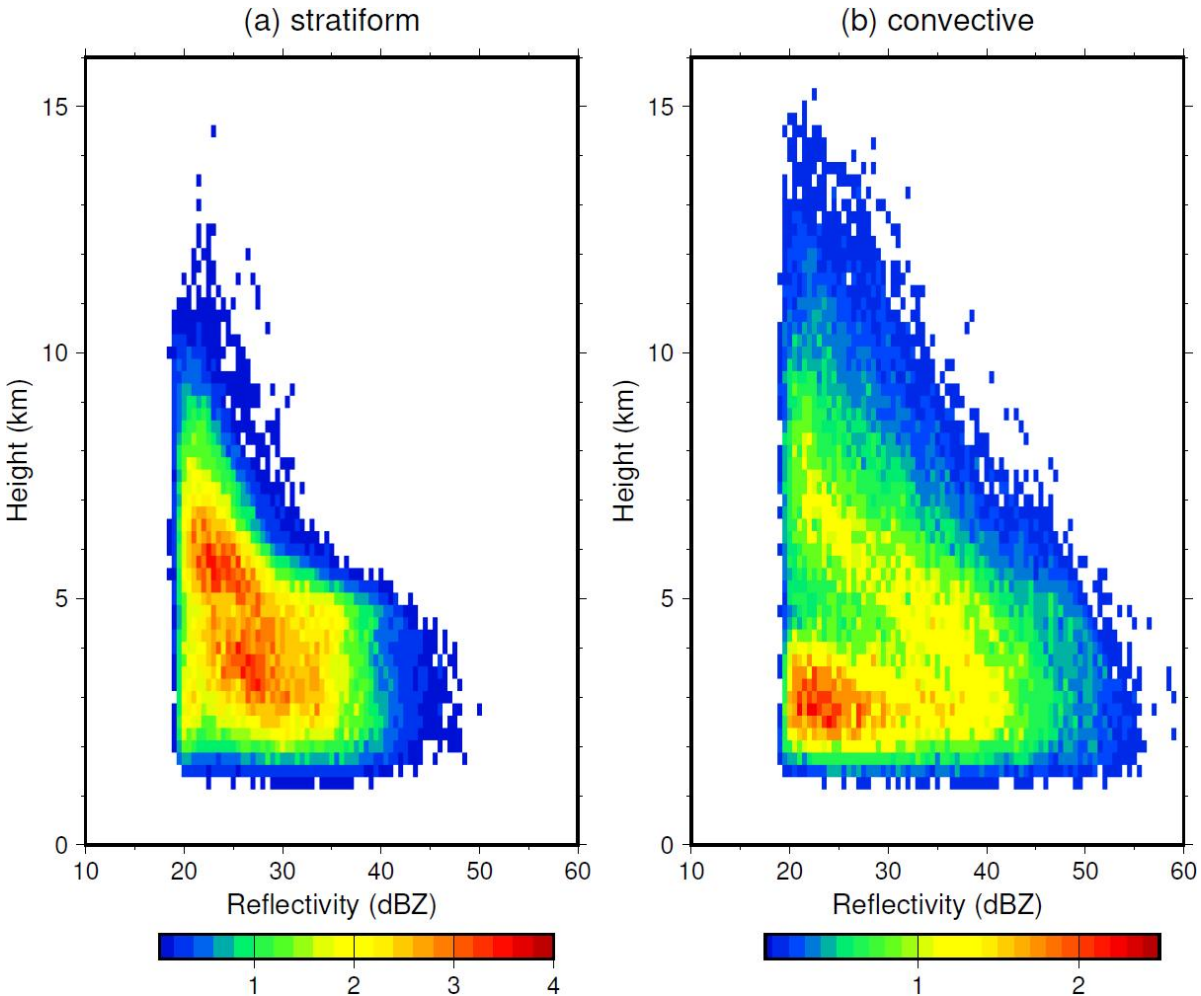
rainfall (mm/day)

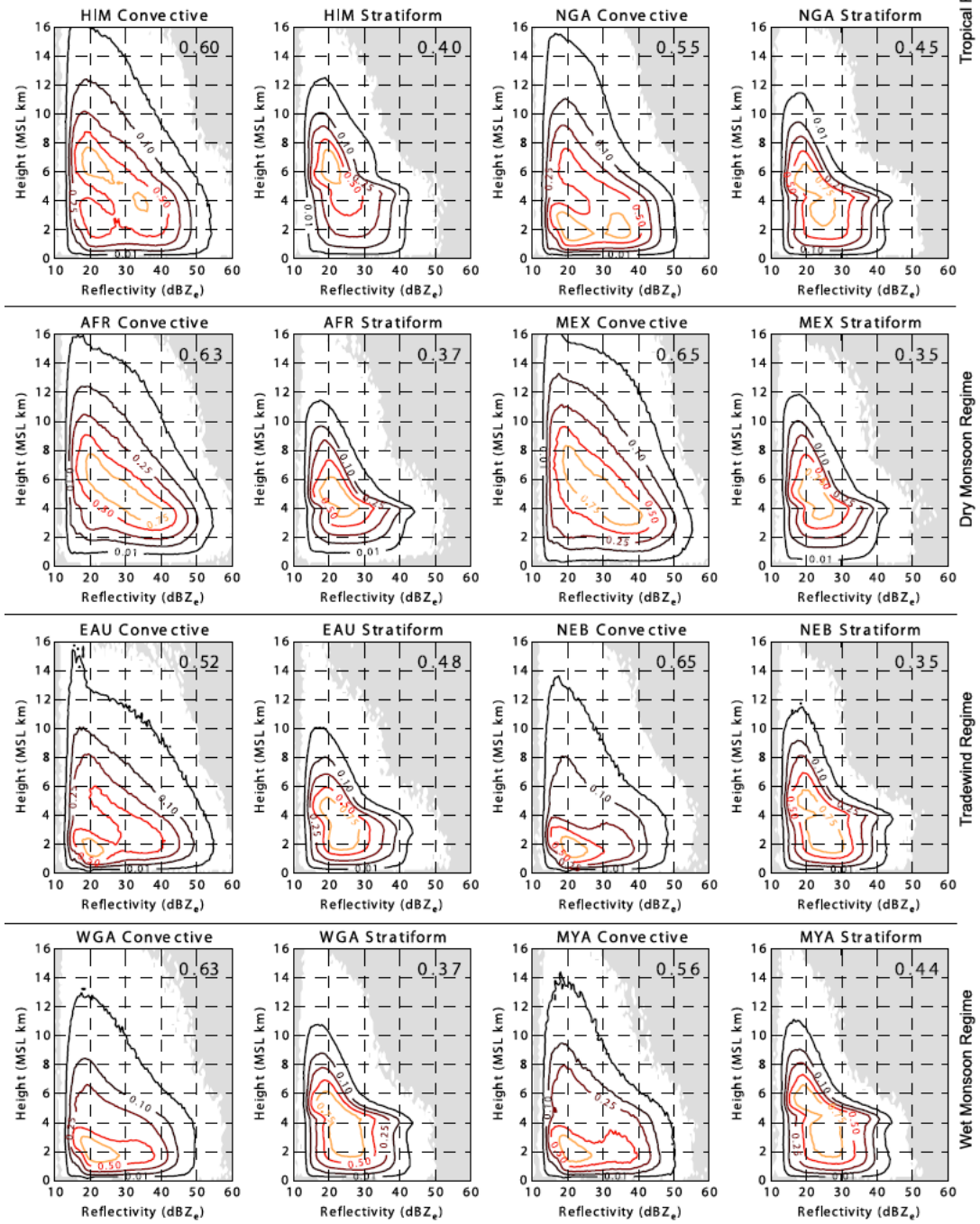
Rainfall around Cherrapunji is more intense in the valley, really?



TRMM PR Climatology rainfall (mm/day) (Hirose and Okada 2018)

CFAD of Heavy rainfall area in Meghalaya





Anders and Nesbitt (2015)

Better performance of near-nadir data around Cherrapunji area

(a) near-nadir

sum 1305		rain gauges	
		rain	no rain
radars	rain	96	62
	no rain	16	1131

$$\mathrm{POD}=\frac{96}{96+16}=86\%$$

$$\mathrm{FAR}=\frac{62}{96+62}=39\%$$

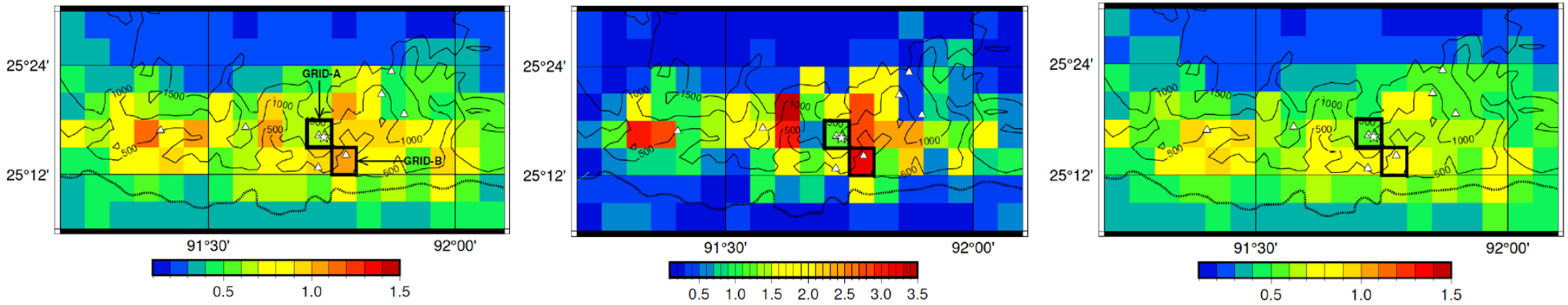
(b) off-nadir

sum 7603		rain gauges	
		rain	no rain
radars	rain	333	381
	no rain	175	6714

$$\mathrm{POD}=\frac{333}{333+175}=66\%$$

$$\mathrm{FAR}=\frac{381}{333+381}=53\%$$

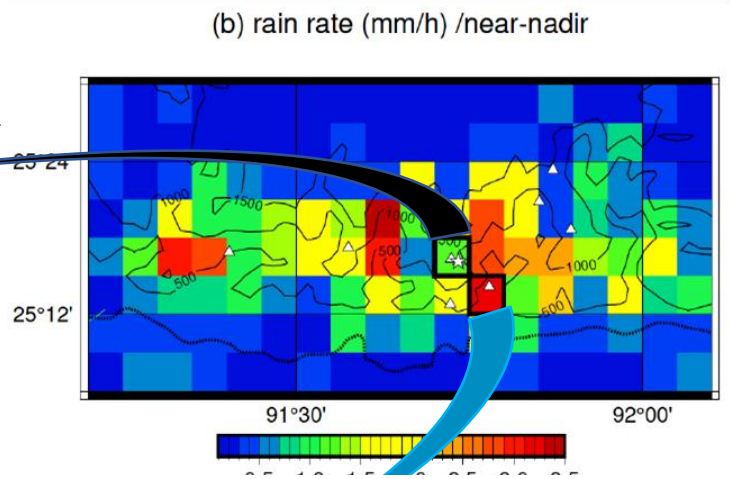
all-angle **near-nadir only** **off-nadir only**



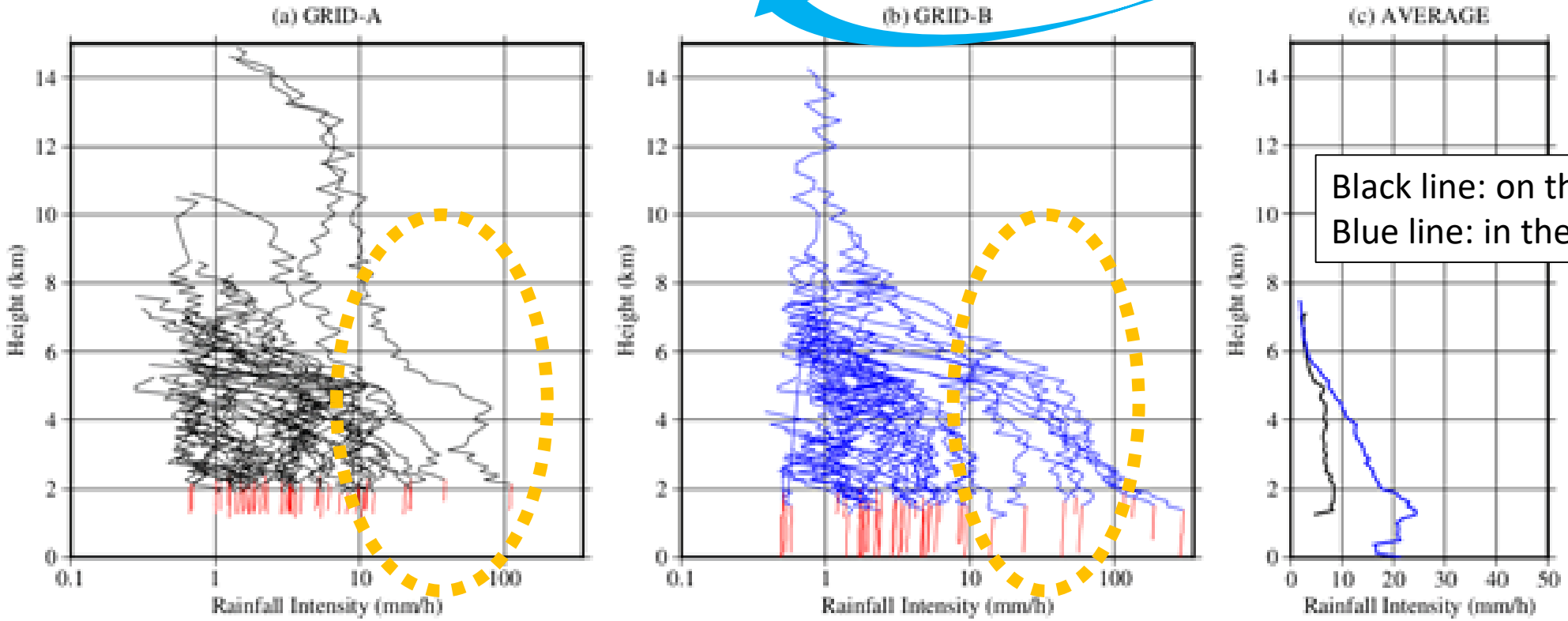
Average rain rate of GPM DPR over the heavy rainfall area of the Meghalaya Plateau

Vertical profiles of rain rate

only near-nadir data

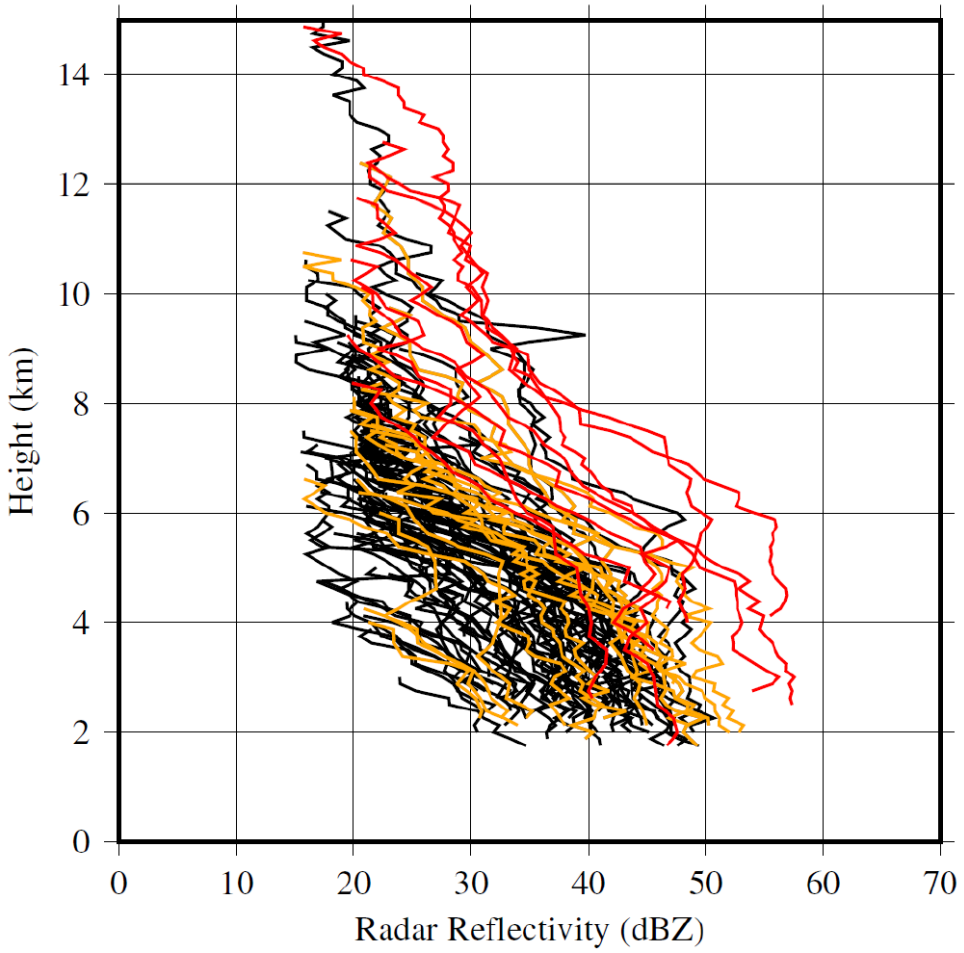


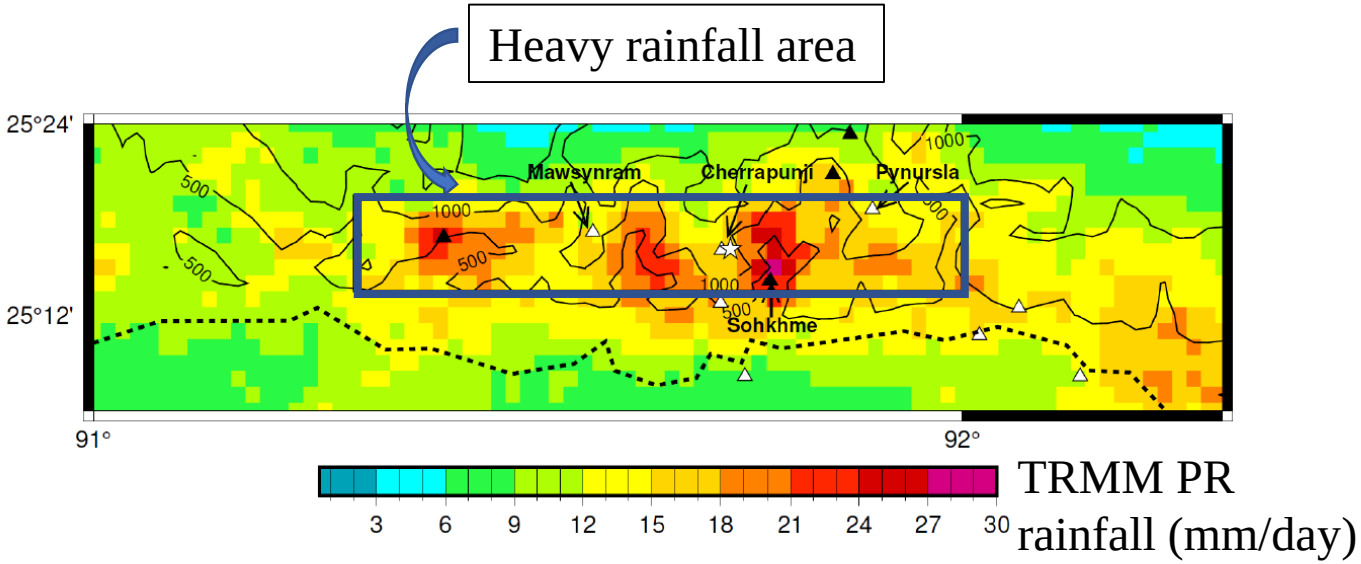
Grid on the plateau Grid in the valley Average profiles



Black line: on the plateau
Blue line: in the valley

Vertical profiles of GPM DPR radar reflectivity in rain gauge matchups for heavy rain rate case





Red lines: rain rate > 80 mm/h

Orange lines: rain rate > 50 mm/h

Black lines: rain rate > 30 mm/h

Summary

- We have been observed rainfall by tipping-bucket rain gauges over Assam, Meghalaya, and Bangladesh since 2006, and studied rainfall over the complex topography in northeast Indian subcontinent. These data was utilized to validate the spaceborne radars: TRMM PR and GPM DPR. These spaceborne radars tended to underestimate the rainfall over the complex topography.
- We also have deployed Parsivel optical disdrometers in northeast Indian subcontinent since 2017. The validation of raindrop size distribution parameters from GPM DPR showed that GPM DPR retrievals had too little number of small drops from orographic shallow rainfall, and too much number of bigger drops for drizzles, and (C) too much N_w values for intense rain rate, in comparison with disdrometers in the Meghalaya.
- Over the heavy rainfall area in the southern Meghalaya, Cherrapunji and Mawsynram is located on the plateau, while heavier rainfall of spaceborne radars tends to observe in the valleys. Near-nadir data shows heavier rainfalls tends to occur in the valley than on the plateau, and the deeper convections tends to produce intense rain rate near the ground. Therefore, it is assumed that the contrasting rainfall distribution between plateaus and valleys may be not an artifact from rainfall estimation errors.