A Comprehensive Evaluation of SM2RAIN-GPM Precipitation Product over India

Deen Dayal*, Ashish Pandey and Praveen Gupta

Department of Water Resources Development and Management
Indian Institute of Technology Roorkee,
Roorkee - 247667, Uttarakhand, India

EGU General Assembly 2022

175 YEARS OF IIT ROORKEE Estd. 1847

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

Background

- A wide range of applications, from hydrology to climate studies, require accurate information of precipitation.

Precipitation measurement

- **Rain gauges and weather radars**
  - **Most accurate measurements**
  - Point and regional scales (unable to cover the entire globe)
  - Affected by local terrain, weather regimes, environment, and economy,
  - Challenging to obtain continuous (in space and time) precipitation series in areas with complex terrain and developing countries.
- **Satellite Precipitation Estimates (SPEs)**
  - **Global precipitation at a high spatiotemporal resolution**
  - **Cost-effective,**
  - **Continuous timeseries**
  - Less accurate,
  - heavily affected by biases and uncertainty, especially over mountainous areas

- In recent years, numerous studies have focused on the development of satellite-based precipitation products, and number of satellite-based precipitation products have been launched:

-- CHIRPS, -- PERSIANN -- MSWEP -- CMORPH -- IMERG

-- GSMaP -- SM2RAIN-ASCAT, -- SM2RAIN-CCI, -- SM2RAIN-GPM

Research Objectives

The objectives of this study are:

- **To assess the performance of SM2RAIN-GPM, products across agro-climatic zones of India,**
- **To quantify the error and bias components,**
- **To assess the association of topographic and vegetation characteristics on the performance of SPEs.**

Datasets

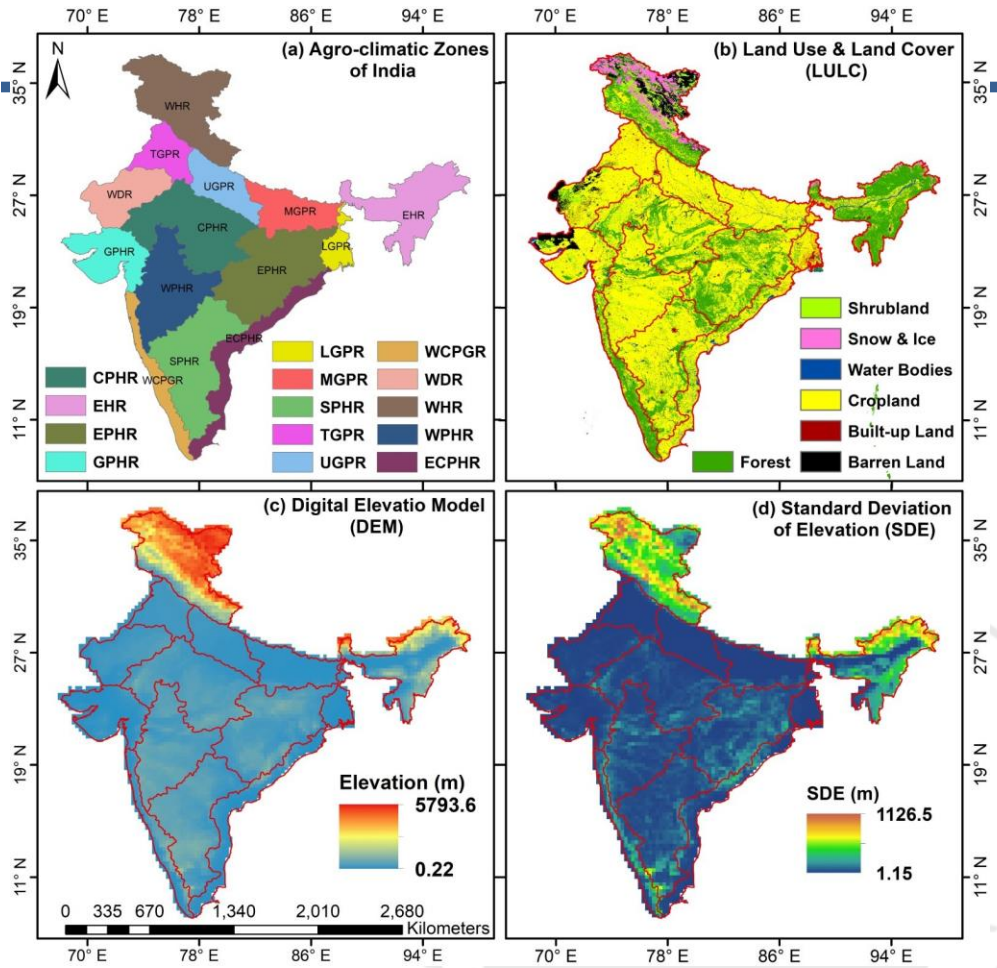
SM2RAIN-GPM

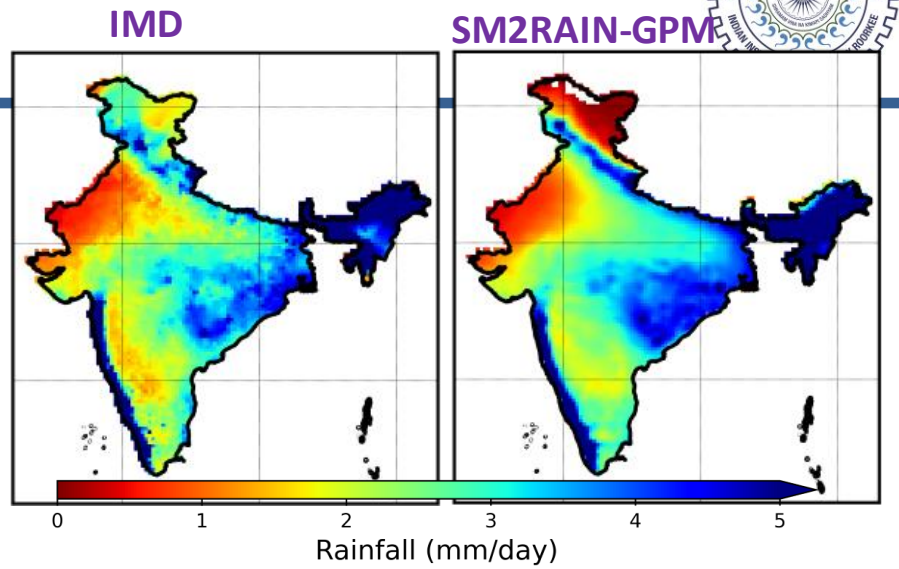
- SM2RAIN-GPM dataset is a quasi-global (over land region between 60°S to 60°N) rainfall product
- Grid size of 0.25° ,
- Daily temporal resolution for the,
- Time span of 2007 to 2018, with latency of 2-3 days
- The dataset was developed by integrating the SM2RAIN-based rainfall datasets (SM2RAIN-ASCAT, SM2RAIN-SMOS and SM2RAIN-SMAP) and GPM-based IMERG-Early Run (IMERG-ER) rainfall roduct.
- Before integration, all the datasets were resampled to same grid size (0.25°) and interpolated to fill the data gaps.
- The ERA5 data was utilized for the correction of rainfall climatology

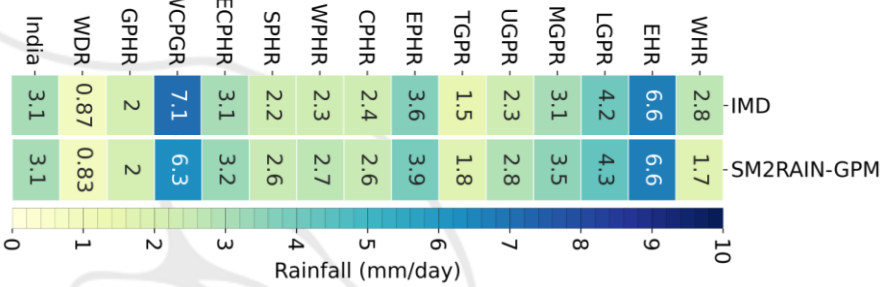
Reference Dataset

- Gridded data prepared by India Meteorological Department's (IMD) for India,
  - By interpolating observed precipitation from 6995 rain gauge stations,
  - Station density varied from year to year, and on an average, about 2600 stations per year were available to prepare the gridded data
- Grid size of 0.25°,
- Daily temporal resolution

Study Area







(i) Western Himalayan Region (WHR), (ii) Eastern Himalayan Region (EHR), (iii) Lower Gangetic Plain Region (LGPR),

(iv) Middle Gangetic Plain Region (MGPR), (v) Upper Gangetic Plain Region (UGPR), (vi) Trans Gangetic Plain Region (TGPR),

(vii) Eastern Plateau & Hills Region (EPHR), (viii) Central Plateau & Hills Region (CPHR), (ix) Western Plateau & Hills Region (WPHR),

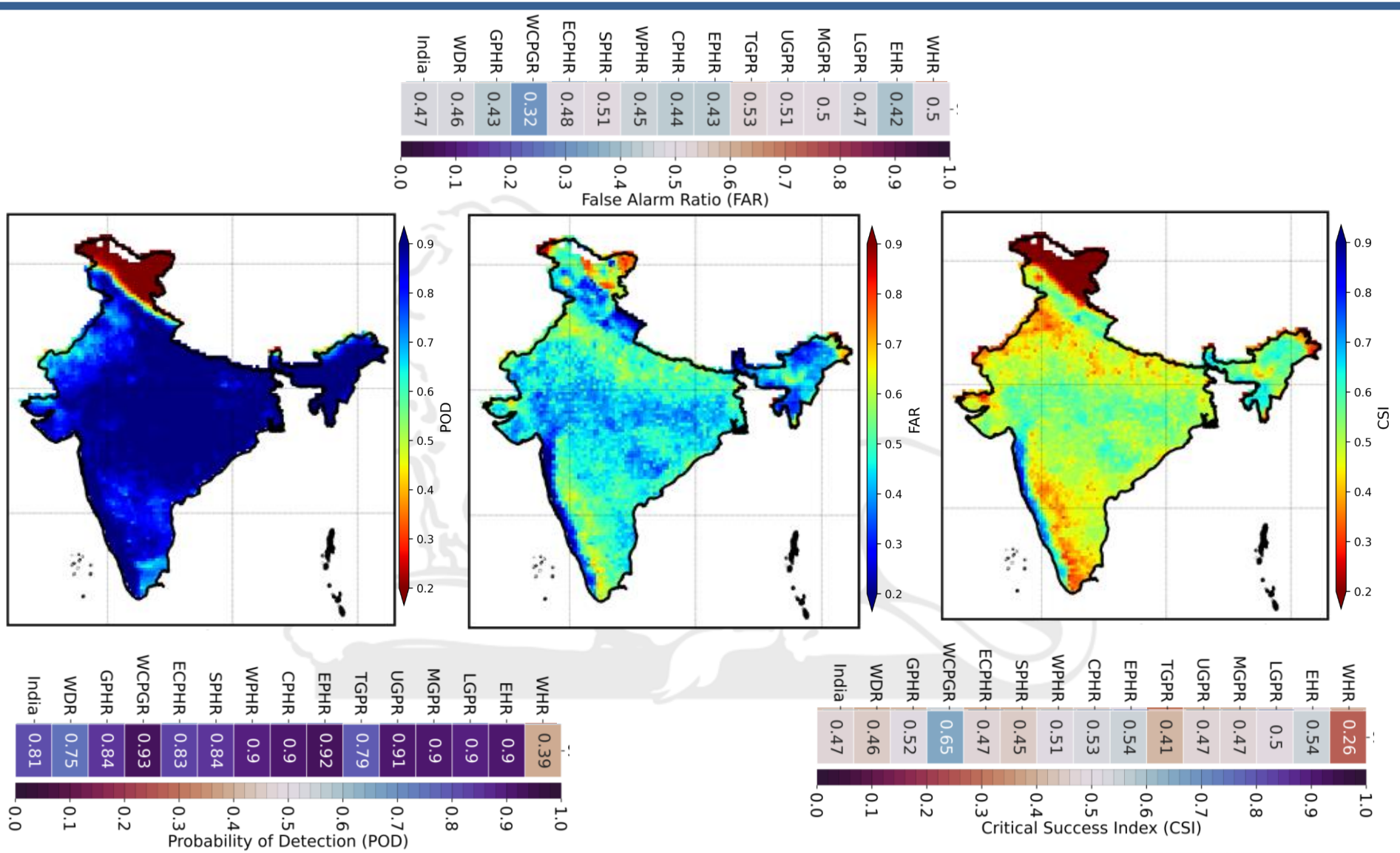
(x) Southern Plateau & Hills Region (SPHR), (xi) East Coast Plains & Hills Region (ECPHR), (xii) West Coast Plains & Ghat Region (WCPGR),

(xiii) Gujarat Plains & Hills Region (GPHR), (xiv) Western Dry Region (WDR)

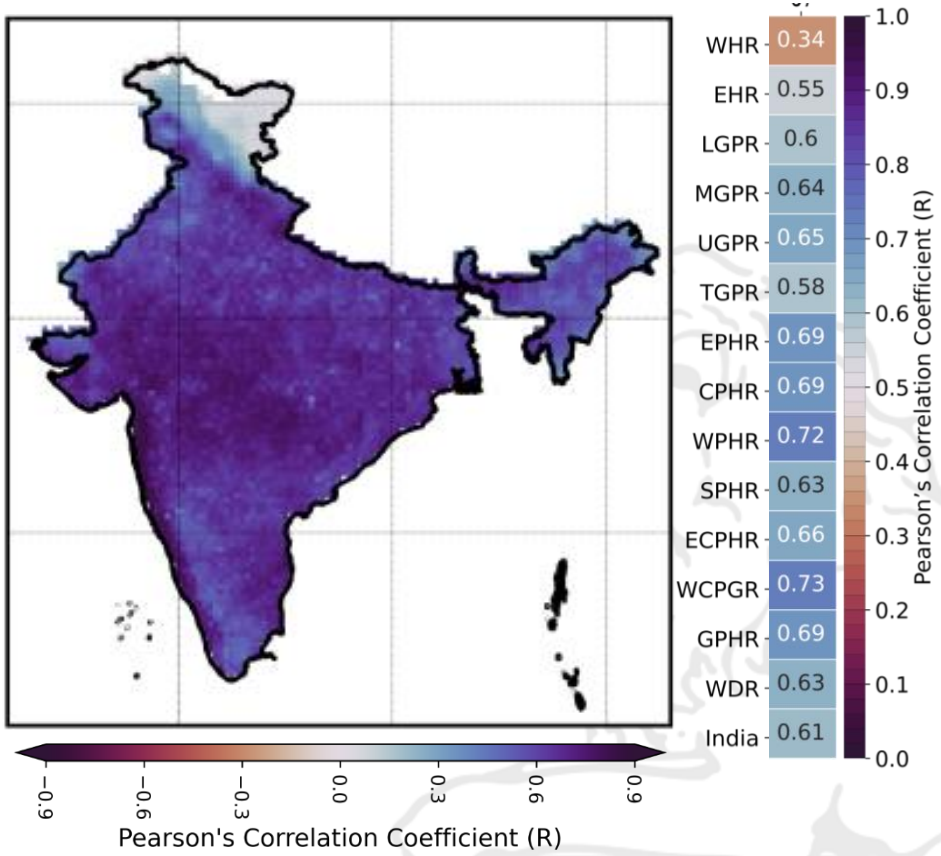
Methodology

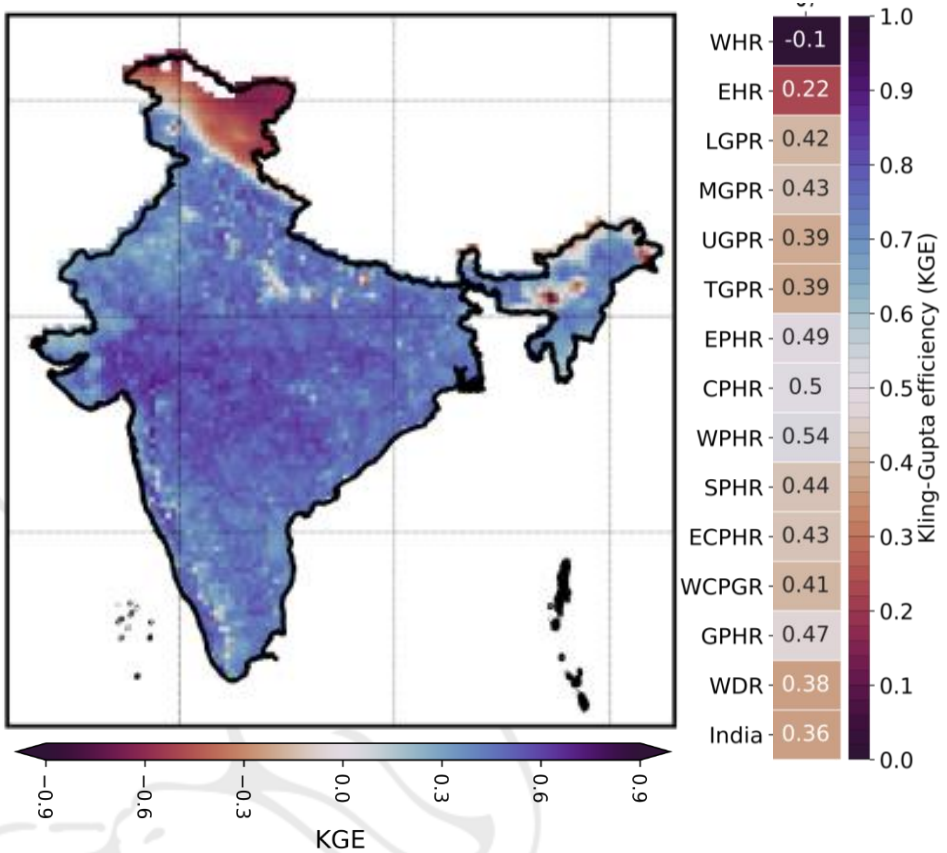
- **Statistical metrics**
  * Probability of Detection (POD), * False Alarm Ratio (FAR), * Critical Success Index (CSI),
  * Pearson's Correlation Coefficient (R), * Kling-Gupta Efficiency (KGE),
  * Mean Absolute Error (MAE), * RMSE to standard deviation ratio (RSR),
  * Percent Bias (PBias)
- **Error/bias decomposition**
  - Systematic and random error components
  - hit bias (HB),
    - over-hit bias (OHB) and under-hit bias (UHB)
    - missed bias (MB), and false bias (FB)
  - Normalized error component
- **Association of Topography and Vegetation with performance of SPEs**
  - **Topography**
    - Altitude
    - Topographic complexity (standard deviation of elevation (SDE) within grid cell)
  - **Vegetation**
    - Vegetation condition (temporal mean of NDVI)
    - Vegetation variability (temporal SD of NDVI)

Rainfall detection capability

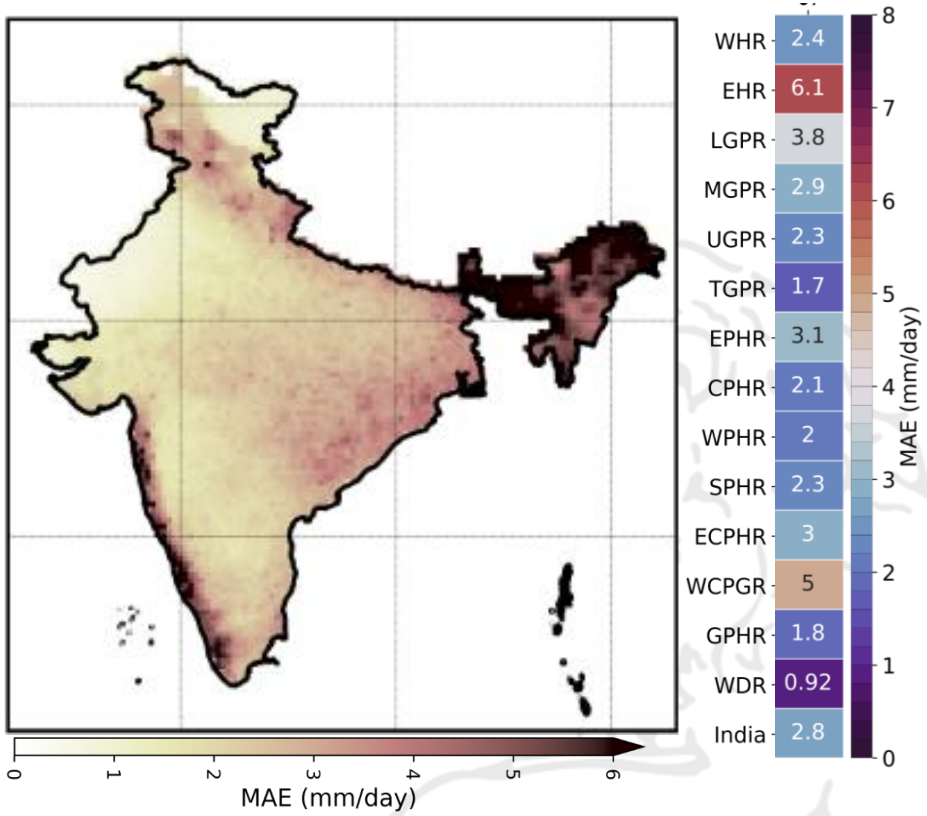


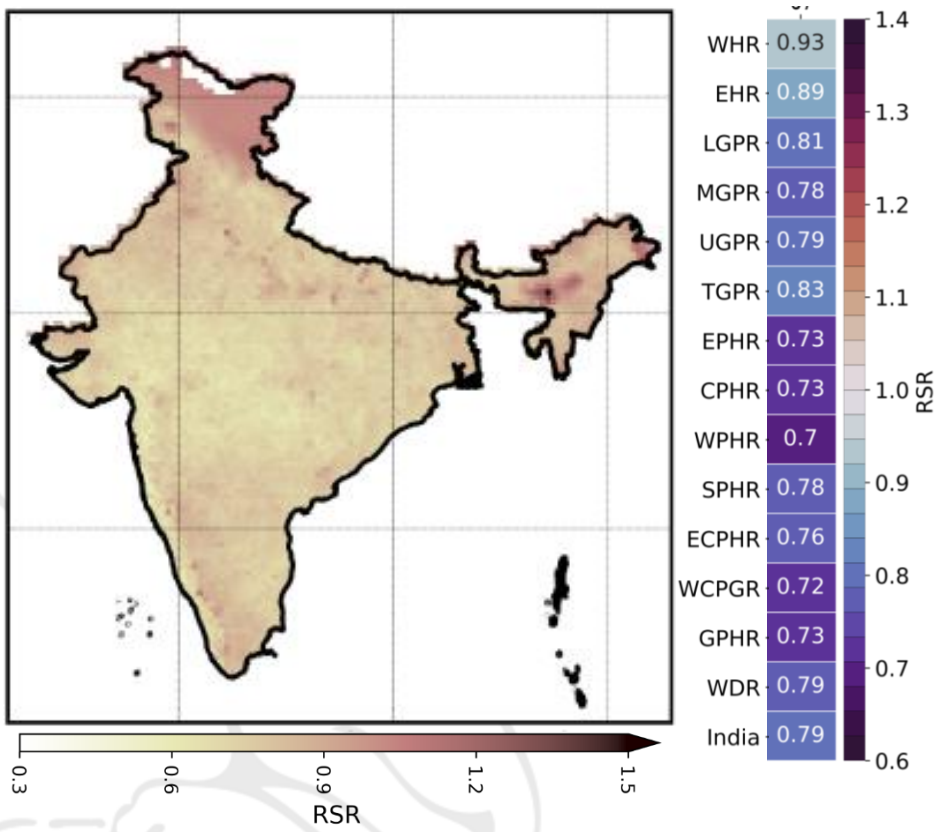
Correlation and efficiency



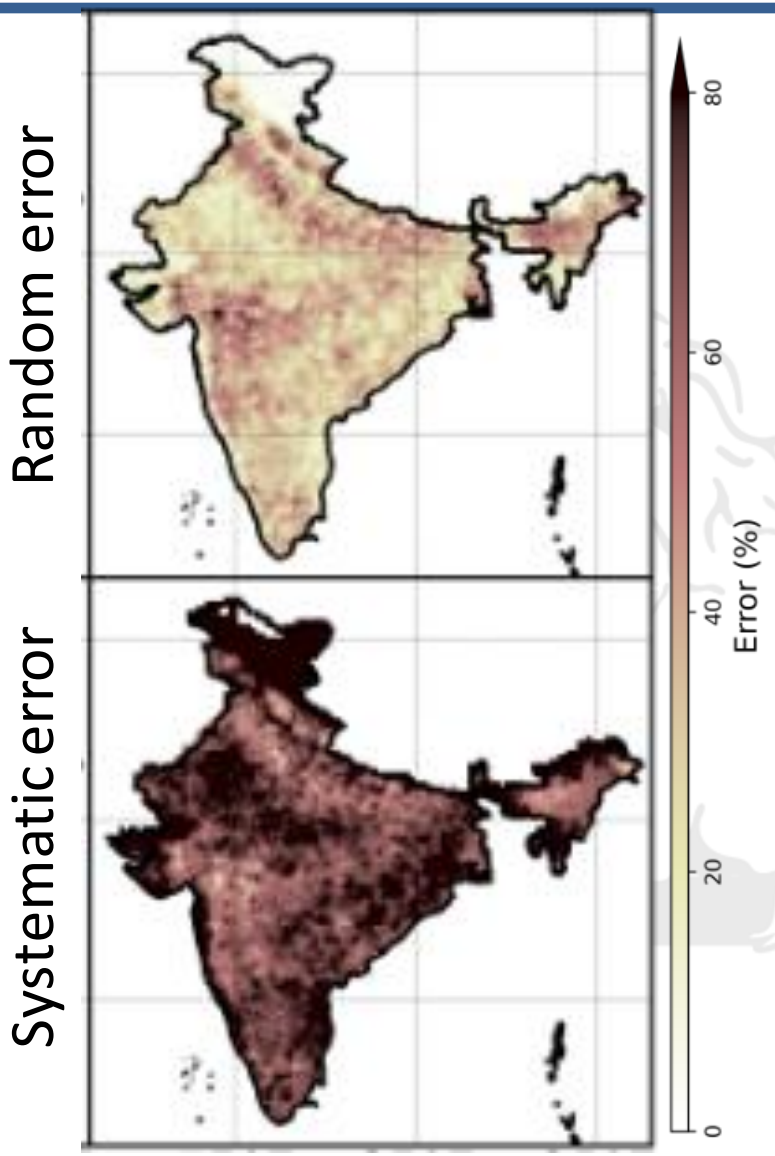


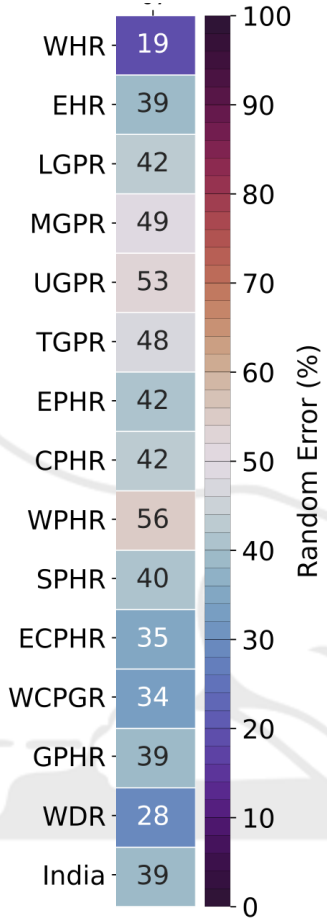
Error

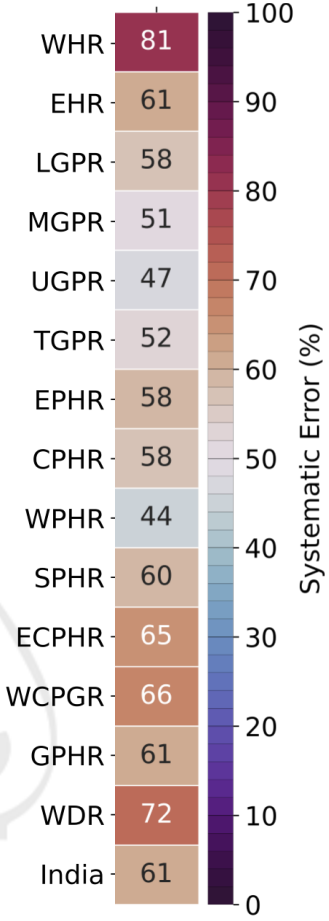

WHR 2.4
EHR 6.1
LGPR 3.8
MGPR 2.9
UGPR 2.3
TGPR 1.7
EPHR 3.1
CPHR 2.1
WPHR 2
SPHR 2.3
ECPHR 3
WCPGR 5
GPHR 1.8
WDR 0.92
India 2.8
MAE (mm/day)
0 1 2 3 4 5 6 7 8
MAE (mm/day)


WHR 0.93
EHR 0.89
LGPR 0.81
MGPR 0.78
UGPR 0.79
TGPR 0.83
EPHR 0.73
CPHR 0.73
WPHR 0.7
SPHR 0.78
ECPHR 0.76
WCPGR 0.72
GPHR 0.73
WDR 0.79
India 0.79
RSR
0.3 0.6 0.9 1.2 1.5
RSR
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4

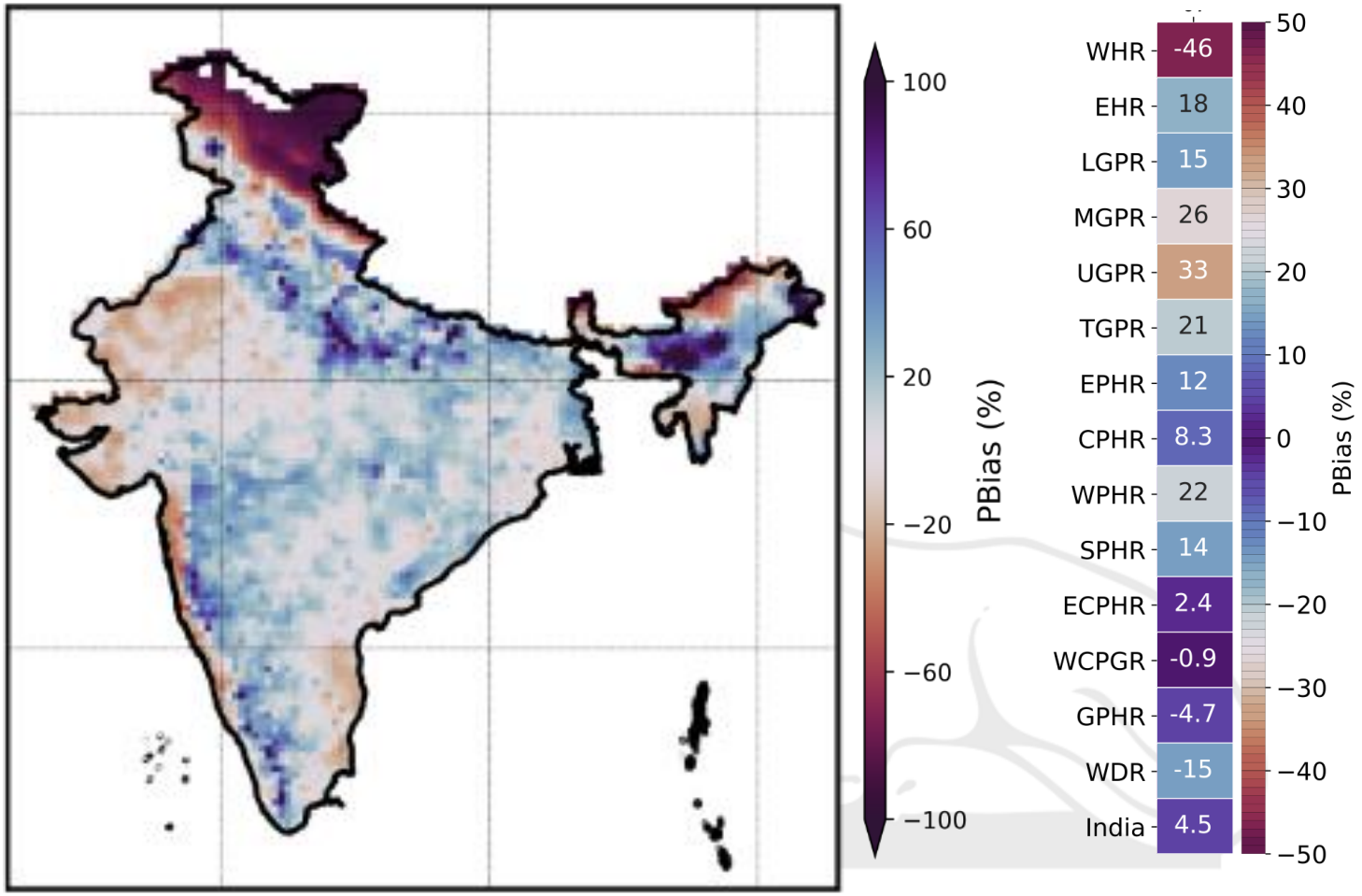
Error components



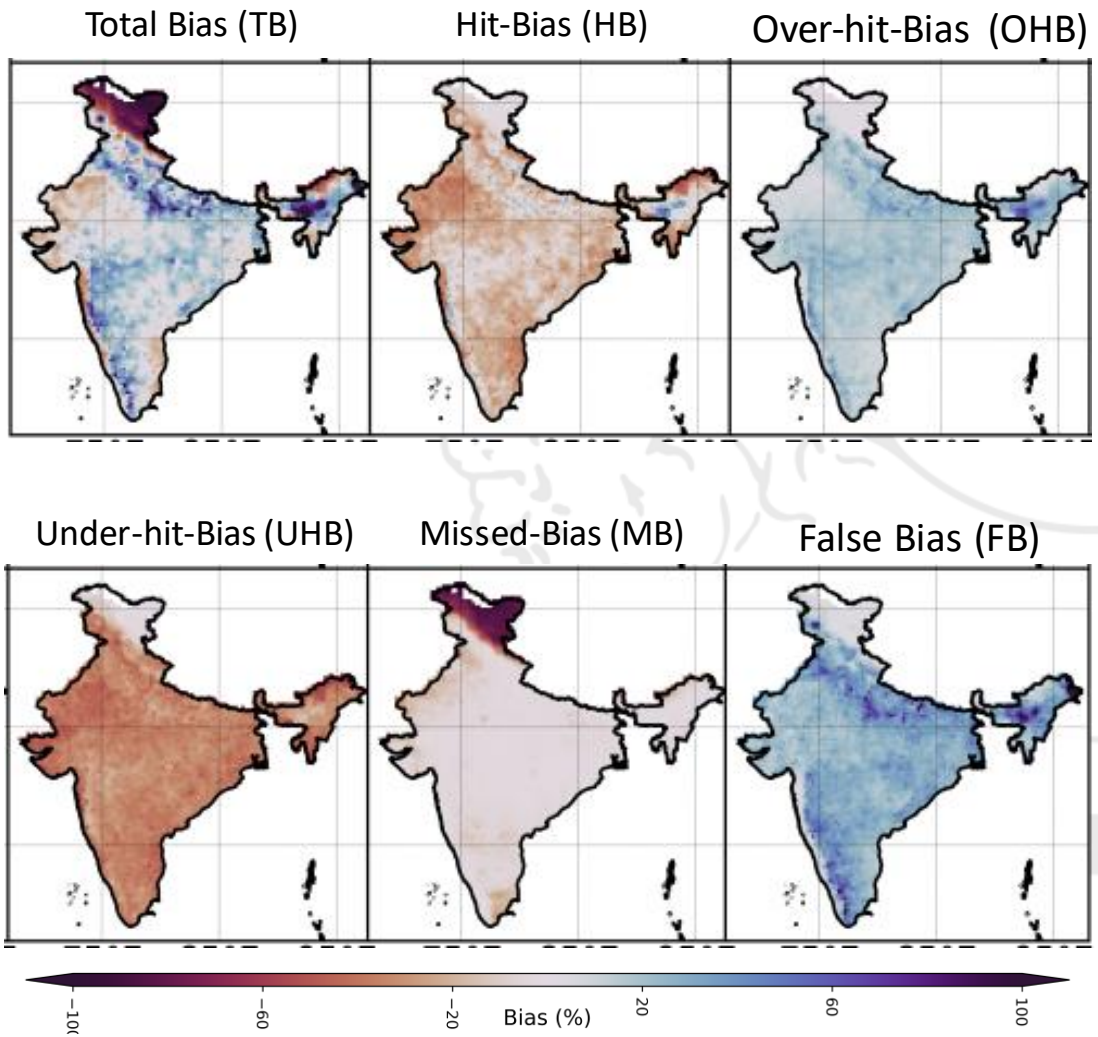




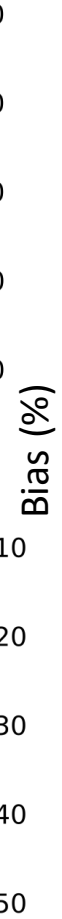
Percent Bias



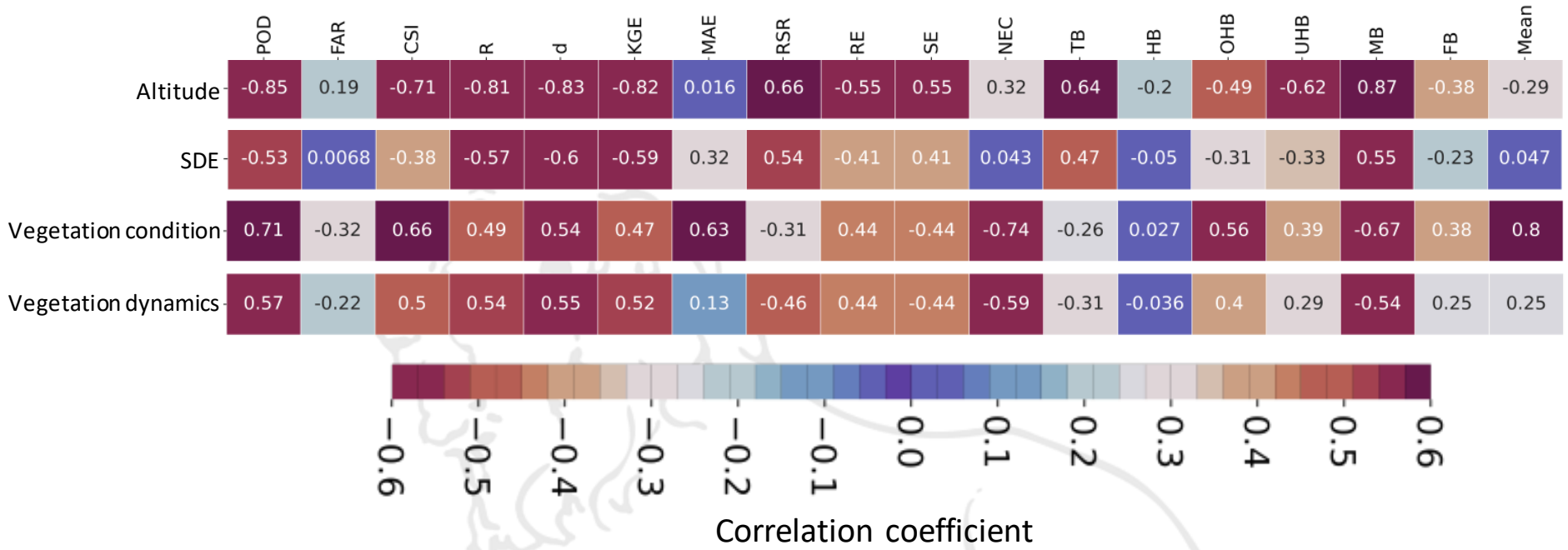
Decomposition of Bias



	TB	OHB	UHB	MB	FB
WHR	-11	7.3	-18	-50	13
EHR	-16	22	-38	-5.1	37
LGPR	-19	19	-38	-4.4	35
MGPR	-13	21	-35	-4.3	39
UGPR	-11	23	-34	-3.2	42
TGPR	-17	17	-35	-11	37
EPHR	-16	19	-35	-3	28
CPHR	-19	17	-37	-3.5	27
WPHR	-9.3	21	-31	-3.8	29
SPHR	-21	15	-36	-7.4	34
ECPHR	-23	15	-38	-7.8	28
WCPGR	-20	17	-36	-2.5	19
GPHR	-23	16	-39	-6.2	20
WDR	-33	8.3	-41	-12	22
India	-18	16	-34	-11	28



Association of topography and vegetation on the performance of SPEs



Summary & Conclusions

- SM2RAIN-GPM is good in detecting rainfall events, However, there is also chances of detecting false rainfall event,
- Product is very poor in detecting the rainfall events over Western Himalayan region (WHR zone),
- The agreement of SM2RAIN-GPM with observed data has found to be good,
- The efficiency of SM2RAIN-GPM product is found to be very poor for WHR and Eastern Himalayan Region (EHR) zones,
- Contribution of systematic error is higher than the random error for SM2RAIN-GPM product,
- Negative bias has been observed over all the agro-climatic zones of India,
- Decomposition of bias shows significant under-estimation in the total bias,
- Hit bias is the major component followed by false bias and missed bias,
- Under-hit bias is more dominating than over-hit bias,
- Missed bias component is the dominant one over WHR zone,
- Performance of SM2RAIN-GPM product significantly decreases with increase in altitude and topographic complexity,
- Vegetation condition and has a strong positive correlation with mean daily rainfall and rainfall detection capability, association, efficiency, error, random error and over-hit bias component.

Thank you...