

Skill Assessment of Rainfall and Lightning over India Using Dynamical Downscaling with the WRF Model

Arya V.B., Chandrima Mallick, Moumita Bhowmik, Anupam Hazra, Naman Prakash Rai, Prasanth Pillai, Soumyajoti Jana, Medha Deshpande, Sachin M. Deshpande, Subrata Kumar Das and Suryachandra A. Rao

Indian Institute of Tropical Meteorology, Pune – 411008, India

Email: aryavb1990@gmail.com



1 Background & Motivation

- The Indian Summer Monsoon (ISM) frequently produces heavy rainfall, thunderstorms and lightning.
- Large spatial and temporal variability makes accurate prediction challenging.
- High-resolution forecasts are essential for early warning and disaster preparedness.
- Operational rainfall–lightning forecast skill over India remains insufficiently evaluated.
- We evaluate the operational IITM-WRF system for rainfall and lightning prediction.

2 Study objectives

This study aims to evaluate the capability of a high-resolution dynamical forecasting system to predict categorical rainfall and lightning flash density during the ISM (JJAS) season.

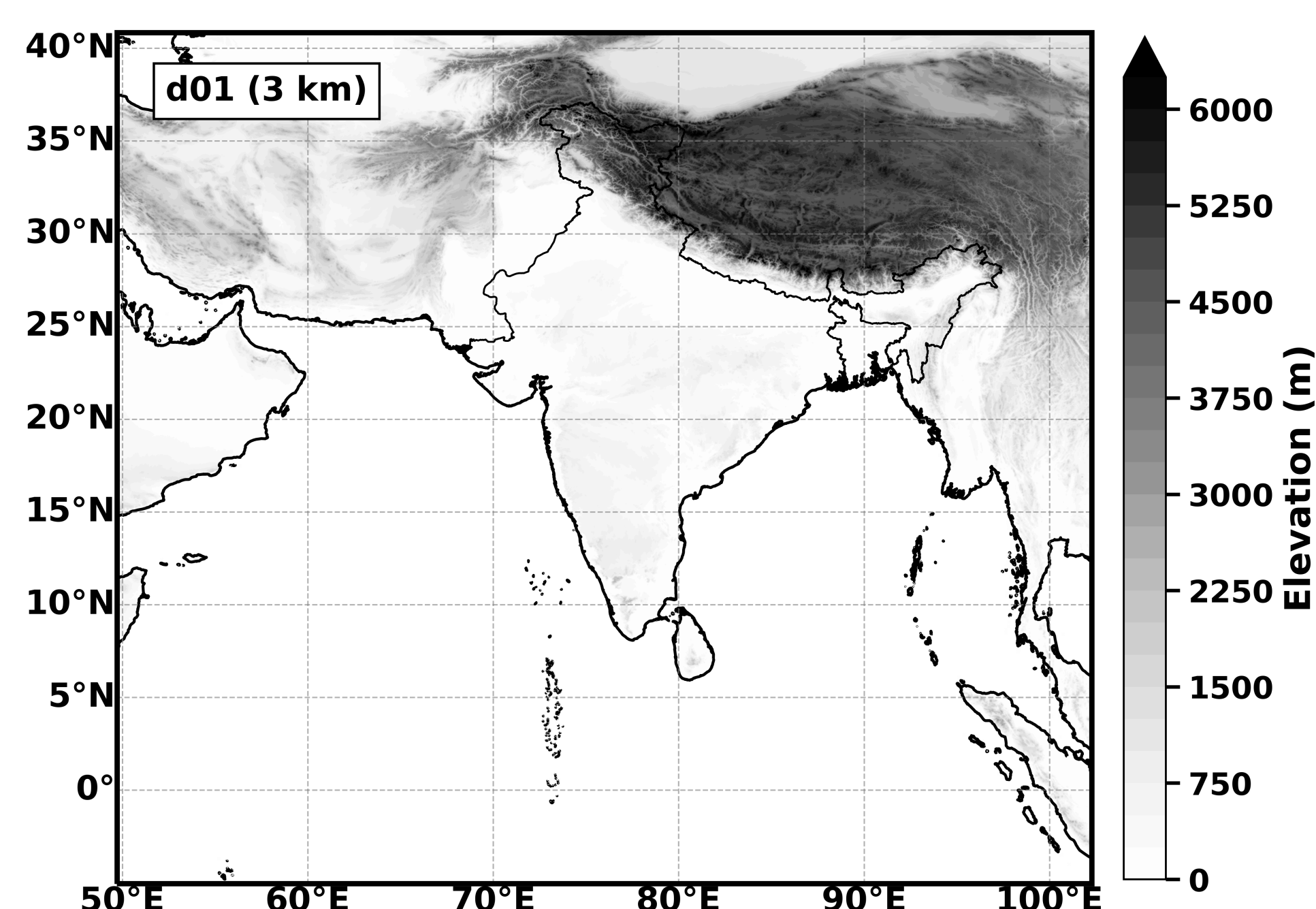


Figure 1: Model domain used for the operational forecasting system. The single WRF domain (d01) has a horizontal grid spacing of 3km. Gray shading denotes the terrain elevation.

3 Result and Discussion

3.1 Rainfall forecast skill

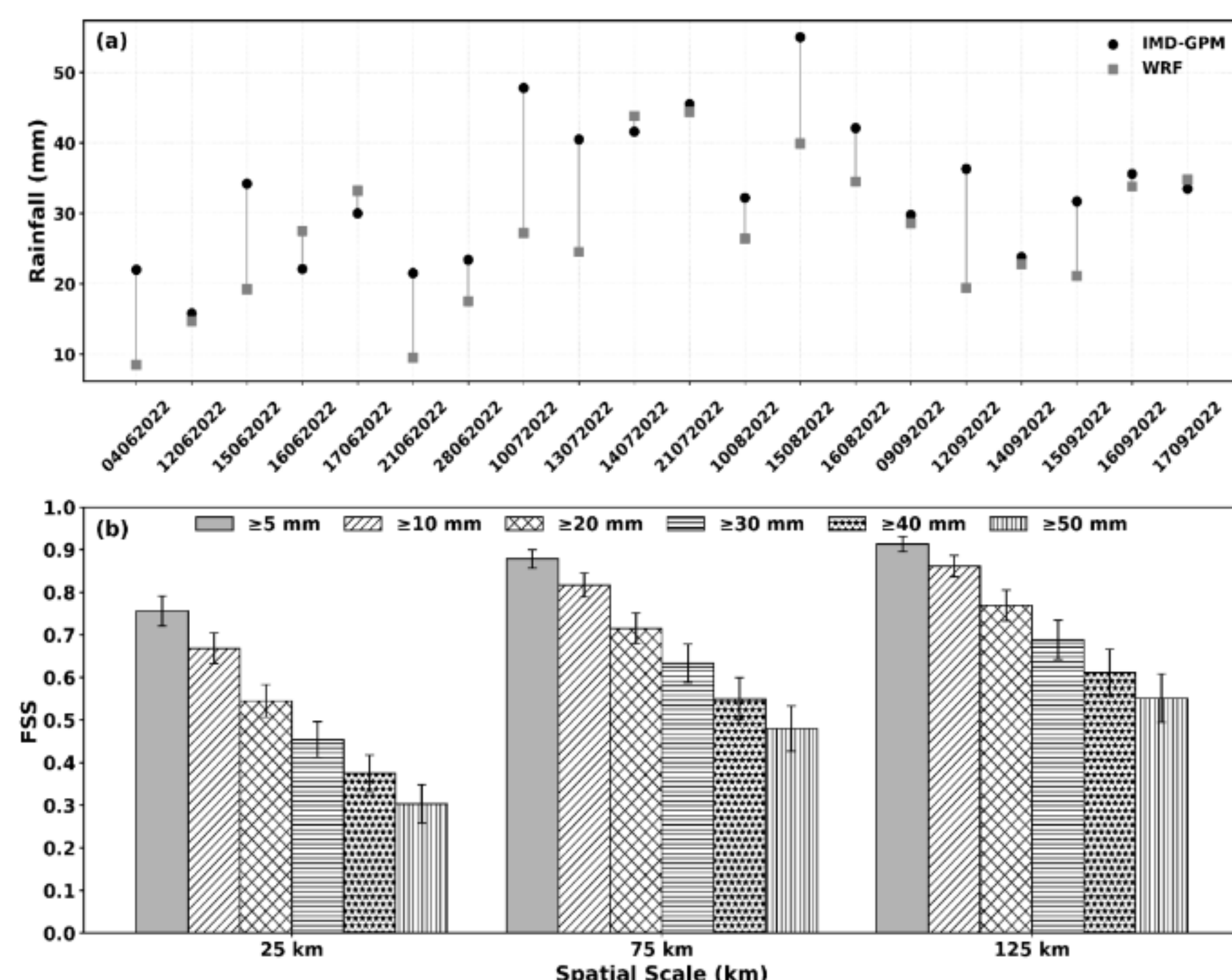


Figure 2: (a) Case-wise comparison of mean 24-h accumulated rainfall (mm) from IMD-GPM observations and WRF model simulations during JJAS 2022. (b) Mean Fractional Skill Score (FSS) values derived from 20 rainfall events at three spatial scales (25, 75, and 125 km) for multiple rainfall thresholds. The error bars denote the standard error of the mean, illustrating the variability among the cases.

3.2 Lightning forecast skill

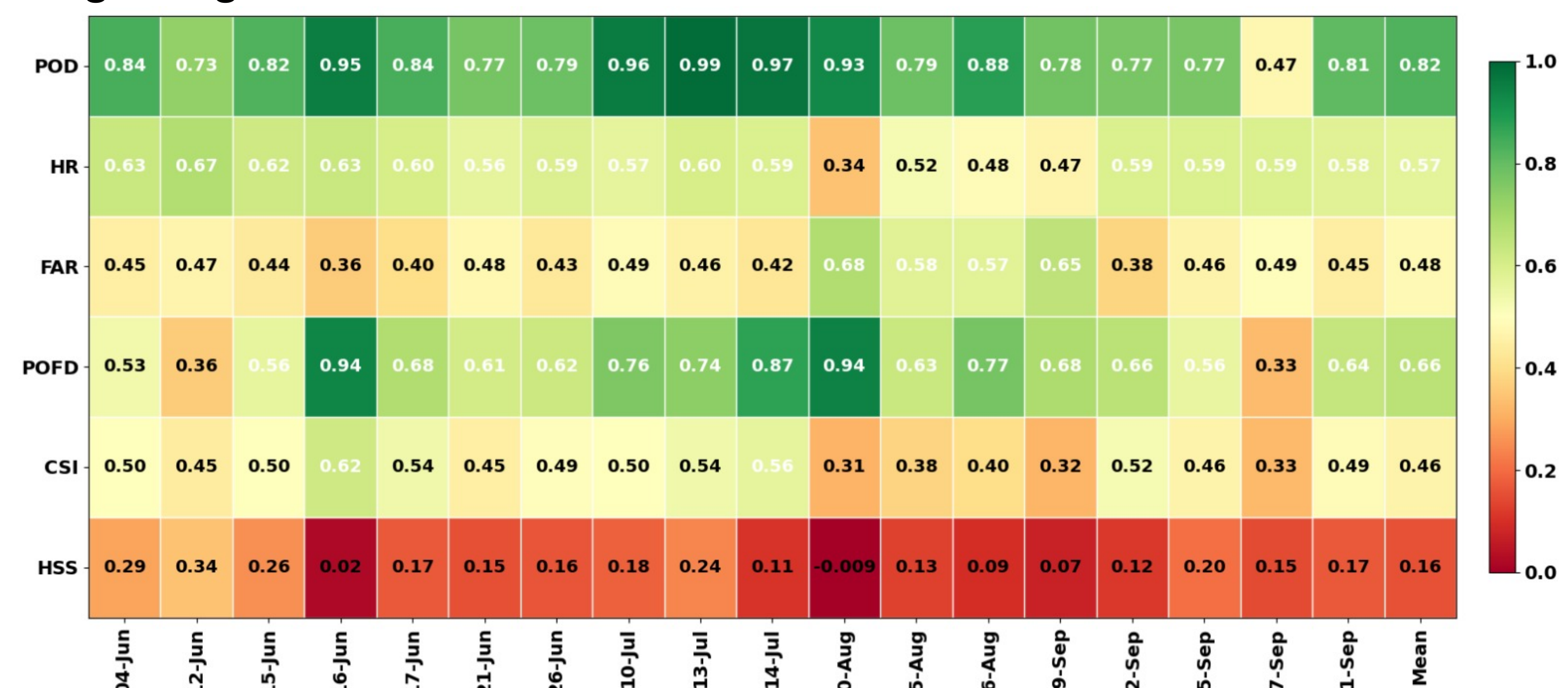


Figure 3: Heatmap of the case-wise lightning skill scores calculated for the 18 selected lightning events during JJAS 2022.

3.3 Extreme rainfall events – 2025

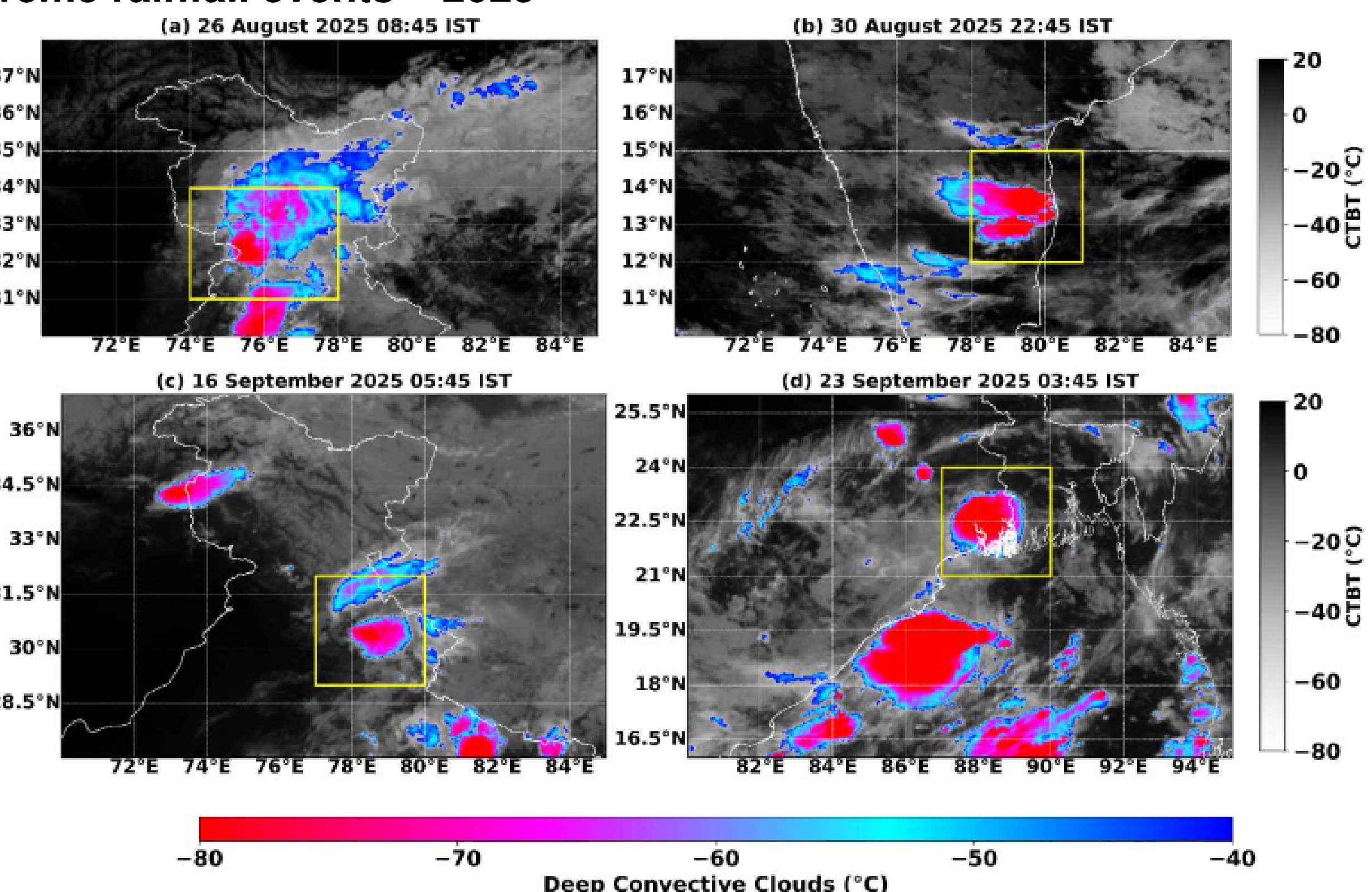


Figure 4: INSAT-3D/3DR CTBT observations during four extreme rainfall events over India in 2025

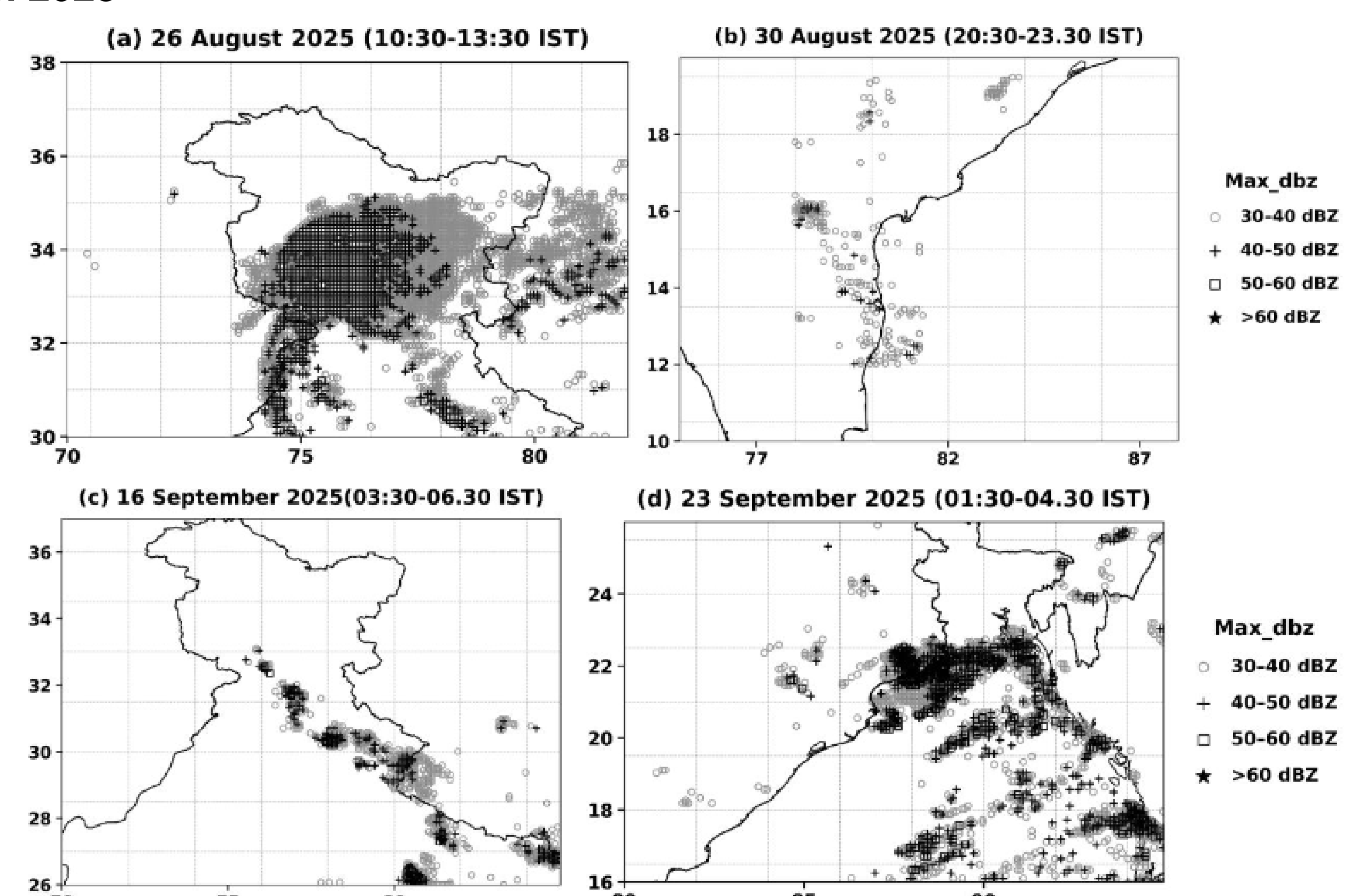


Figure 5: Spatial distribution of model-simulated maximum reflectivity during four extreme rainfall events over India in 2025

4 Conclusion

- IITM-WRF demonstrates good skill in predicting monsoon rainfall and lightning, particularly for moderate-to-heavy rainfall
- Its ability to capture lightning-associated rainfall and extreme events highlights strong potential for real-time forecasting, early warning and impact-based disaster preparedness.

5 Acknowledgment

We thank the Director, IITM, the HPC (Pratyush/Arka) team, and the IITM-LLN group for their support and data.