



Multi-Event, Cross-Seasonal Sensitivity Assessment of Microphysics Parameterization Schemes for Simulating Heavy Rainfall over Chennai, India

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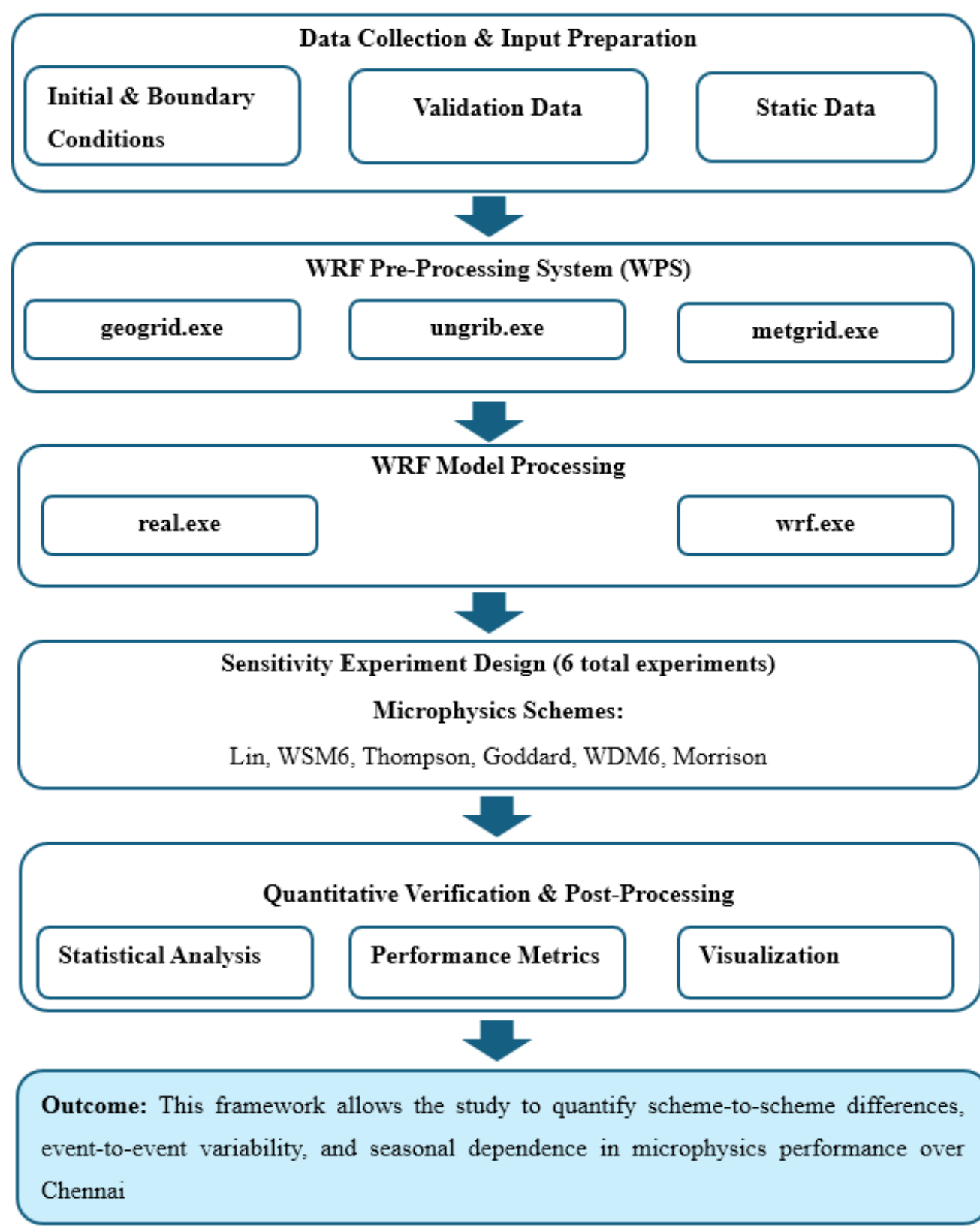
Introduction

- Extreme precipitation events are among the most damaging natural hazards that impact densely populated coastal areas around the world, often leading to widespread urban flooding, infrastructure damage and socioeconomic losses.
- The frequency and intensity of extreme heavy rainfall events over the Indian subcontinent have increased significantly in recent decades, driven by the rapid warming of sea surface temperatures over the Bay of Bengal which enhances moisture availability and convective instability over coastal regions.
- The southeastern coast of India and Chennai is therefore exposed to a compounding risk of extreme rainfall driven simultaneously by Bay of Bengal synoptic distributions, ENSO-enhanced Northeast Monsoon activity, and positive IOD forcing.
- A notable example of this combined large-scale forcing was witnessed on 1st December 2015, when Chennai experienced a recorded rainfall of 490 mm within a single day.

Objectives

- Evaluate the six simulations on post-monsoon heavy rainfall events to check whether the model reproduces the observed rainfall over Chennai.
- Apply the same configurations to pre-monsoon and monsoon events, to test whether skill from post-monsoon events carries over to other seasons.

Methodology & Model Setup



- Model: WRF v4.5.2
- Domain: Three two-way nested domains (27, 9, 3 km)
- Initial/boundary data: NCEP GDAS-FNL, 0.25°, 6-hourly.
- Microphysics schemes: Lin, WSM6, Thompson, Goddard, Morrison, WDM6
- Cumulus scheme: Kain–Fritsch
- PBL scheme: YSU
- Radiation scheme: Longwave- RRTM, Shortwave- Dudhia
- Land surface scheme: Noah
- Surface layer scheme: Revised MM
- Validation: GPM IMERG Final Run (0.1°)
- 9 events $\times$ 6 schemes = 54 simulations

Study Domain & Heavy Rainfall Events

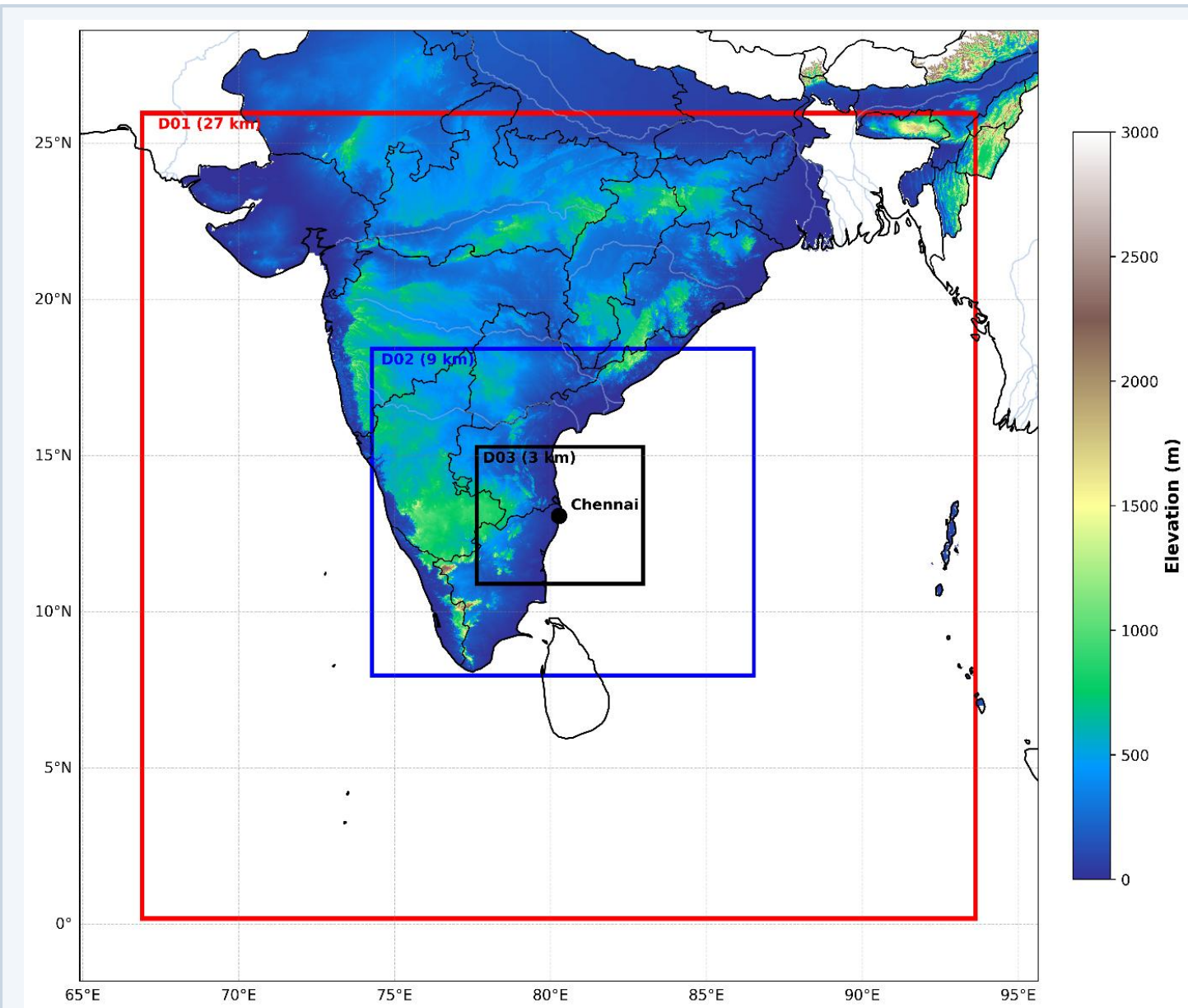


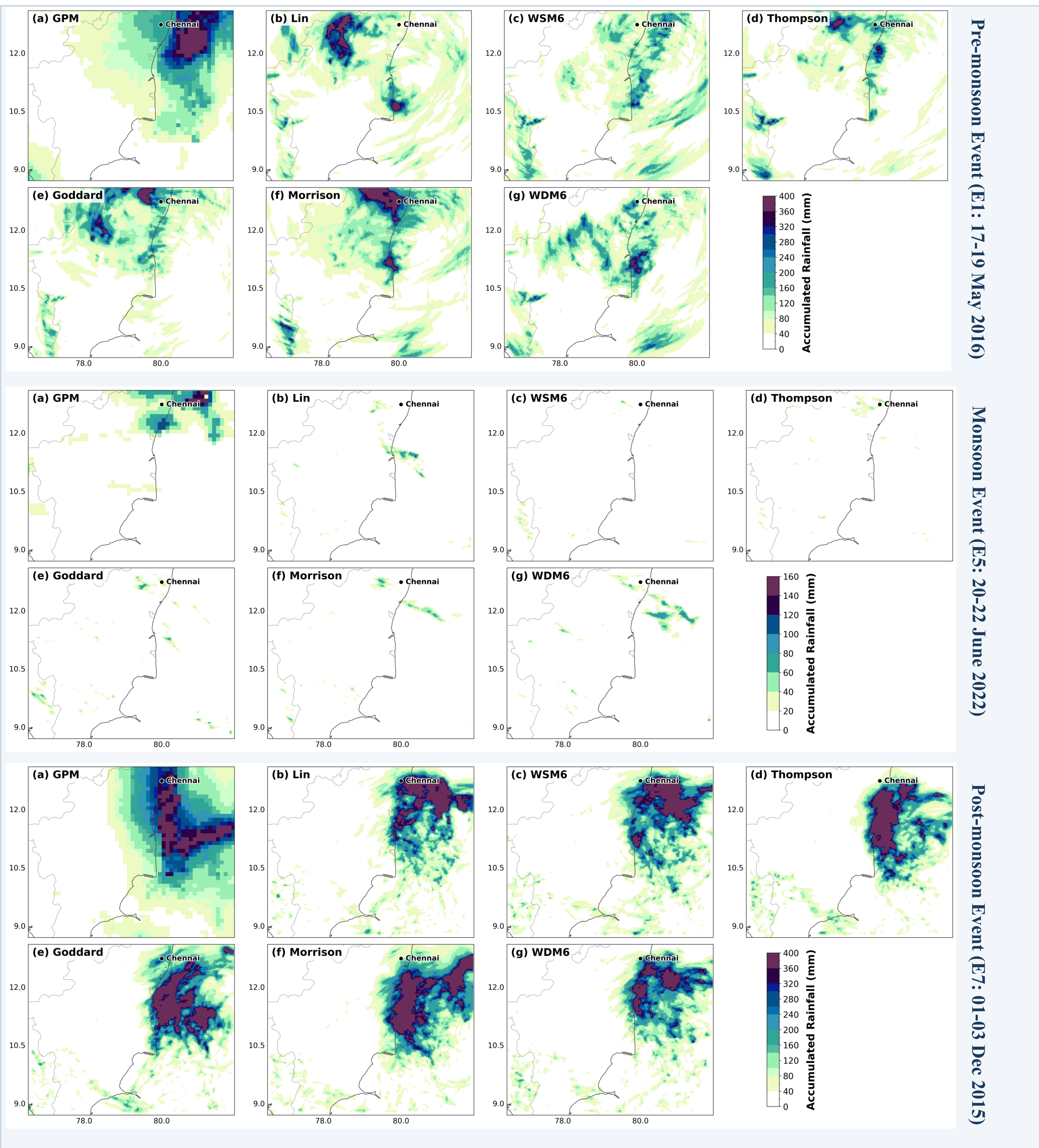
Fig: WRF model domain configuration used in this study

Event	Dates
Pre-Monsoon	
E1	17–19 May 2016
E2	21–22 May 2021
E3	18–21 Mar 2023
Monsoon	
E4	19–20 Sep 2019
E5	20–22 Jun 2022
E6	19–21 Jun 2023
Post-Monsoon	
E7	01–03 Dec 2015
E8	01–05 Nov 2017
E9	04–06 Dec 2023

Table: Details of selected heavy rainfall events over Chennai

Results

Simulated rainfall and Observed Rainfall (GPM IMERG)



Statistical Analysis

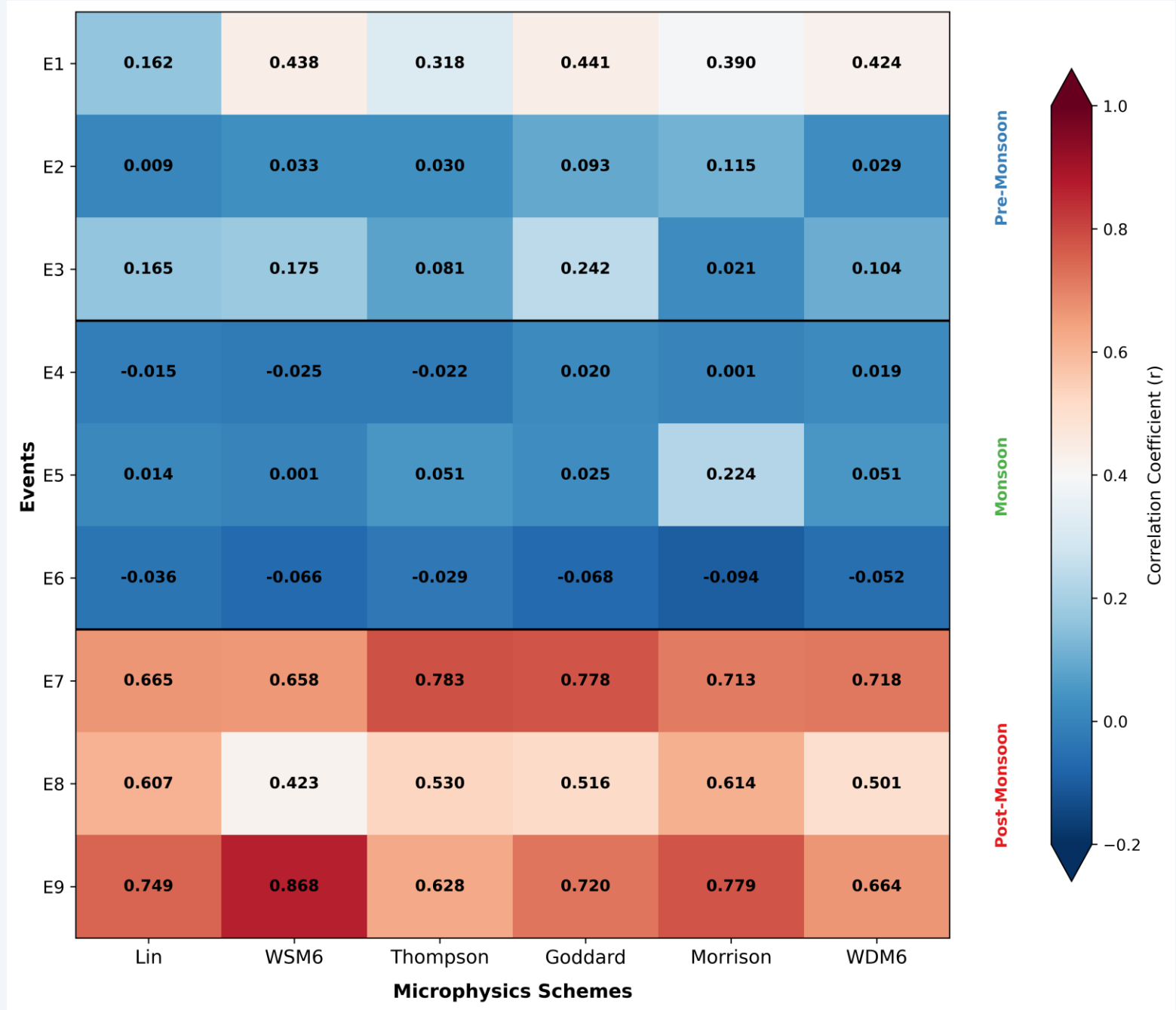


Fig. Event-wise correlation (r) against GPM IMERG for all 54 simulations

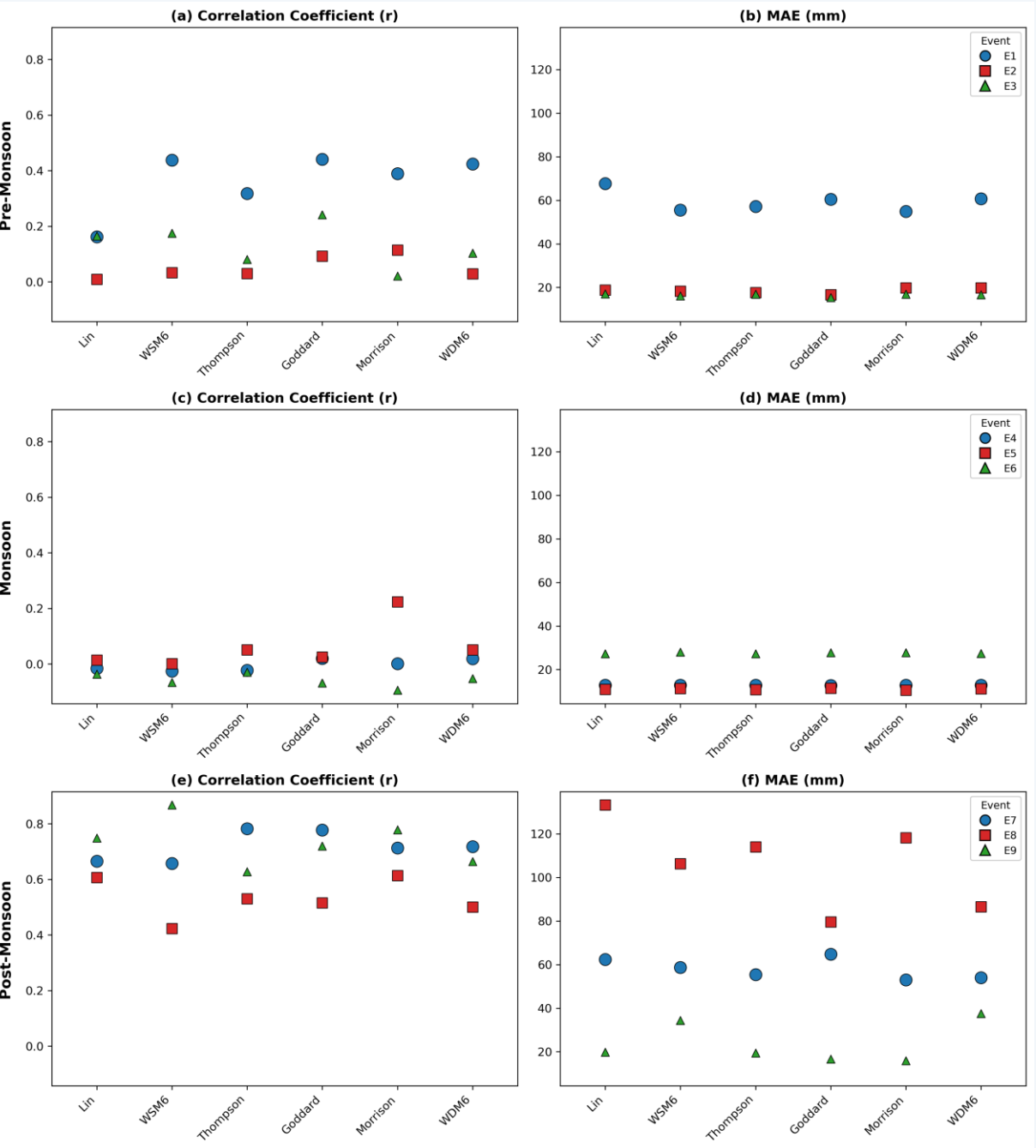


Fig. Event-wise correlation (r) and MAE (mm) for the six microphysics schemes, by season

Conclusions

- Across 54 simulations, the type of rainfall season controlled WRF accuracy over Chennai more than the choice of microphysics scheme.
- For the monsoon season, all six schemes failed similarly, with almost no spatial match to observed rainfall (near-zero or negative correlation) and rainfall underestimated by more than 87%.
- For the post-monsoon season, rainfall patterns were captured well, but the amount of rain varied most from one scheme to another.
- Monsoon forecasts are more likely to improve by fixing cumulus, boundary-layer and boundary-condition settings than by changing the microphysics scheme.

References

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