Role of PBL and Microphysical Parameterizations During WRF Simulated Monsoonal Heavy Rainfall Episodes over Mumbai

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Introduction

The desire for comfort and quality of life drives large-scale population migration and urbanization. As a result, the number of anthropogenic activities in the urban environment grows over time. Changes in land use and land cover (LULC) are one indicator that allows for gradual reductions in vegetation cover as a result of urbanization. Model physics can influence city weather conditions in addition to LULC changing the dynamics of Indian cities. As a result, the current research focuses on the sensitivity of WRF model simulations for metropolitan environment to planetary boundary layer (PBL) and microphysics parameterizations.

Objectives

- Evaluation of different PBL and microphysics parameterizations in Weather Research and Forecasting (WRF) model using statistical and ensemble approach.
- Impact of TKE, non-TKE based PBL schemes and microphysics parameterization on heavy rainfall and thunderstorm events.
- Selection of appropriate PBL and microphysics scheme suitable for the study location.

Data & Methodology

The experiments designed using different PBL and microphysical schemes besides surface physics are illustrated in the table below:

PBL	Prognostic Variable	Surface Physics	MP
YSU	Non-TKE	MM5 similarity	Lin et al.
ACM2		MM5 similarity	
Shin-Hong		MM5 similarity	
MYJ	TKE	Eta similarity	
QNSE		QNSE similarity	Lin et al. WSM 6 Goddard WDM 6 Thompson
BouLac		MM5 similarity	Lin et al.
GBM		MM5 similarity	

Results & Discussion

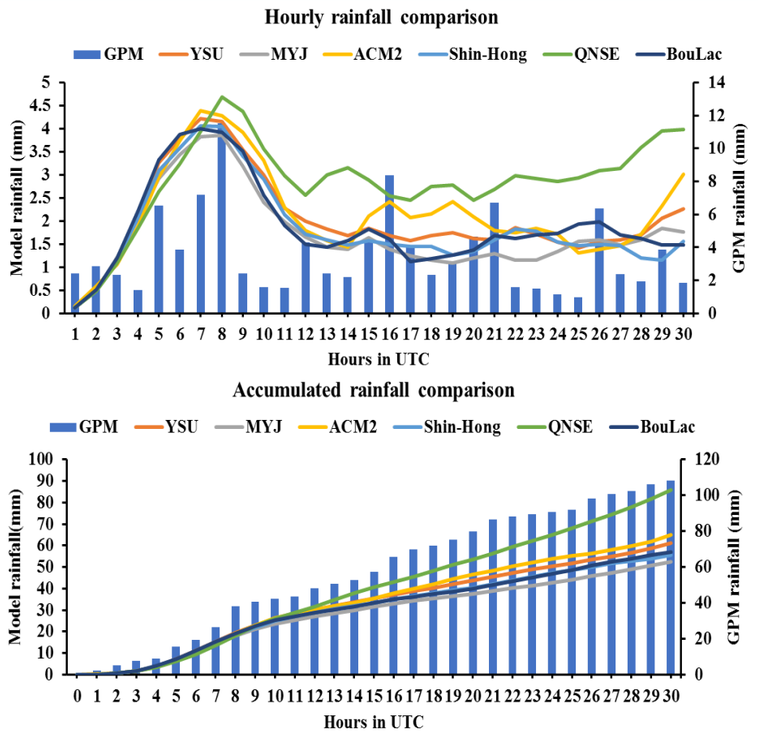

Figure 1. Hourly and accumulated rainfall distribution with different PBL schemes and GPM observations.

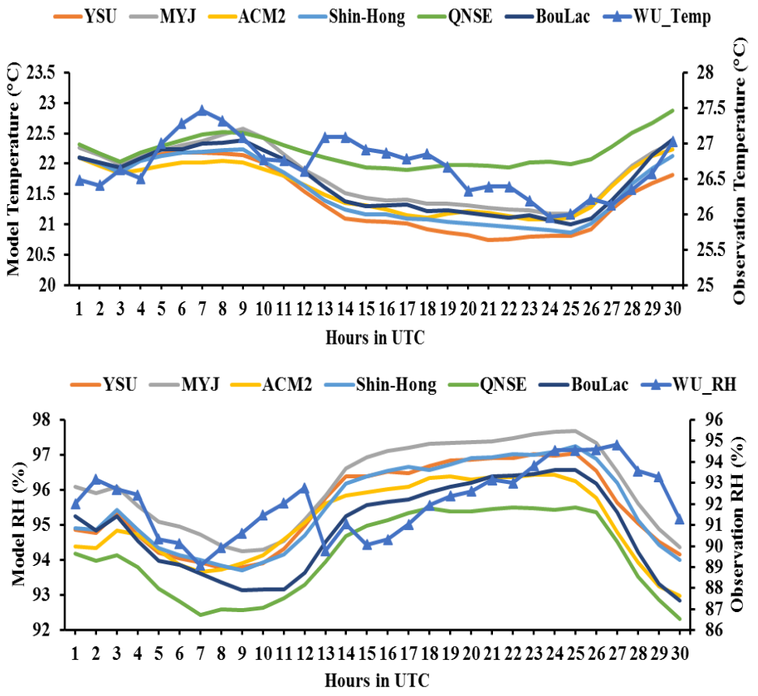

Figure 2. Diurnal variation of 2m-temperature and relative humidity from different PBL schemes and airport station observations.

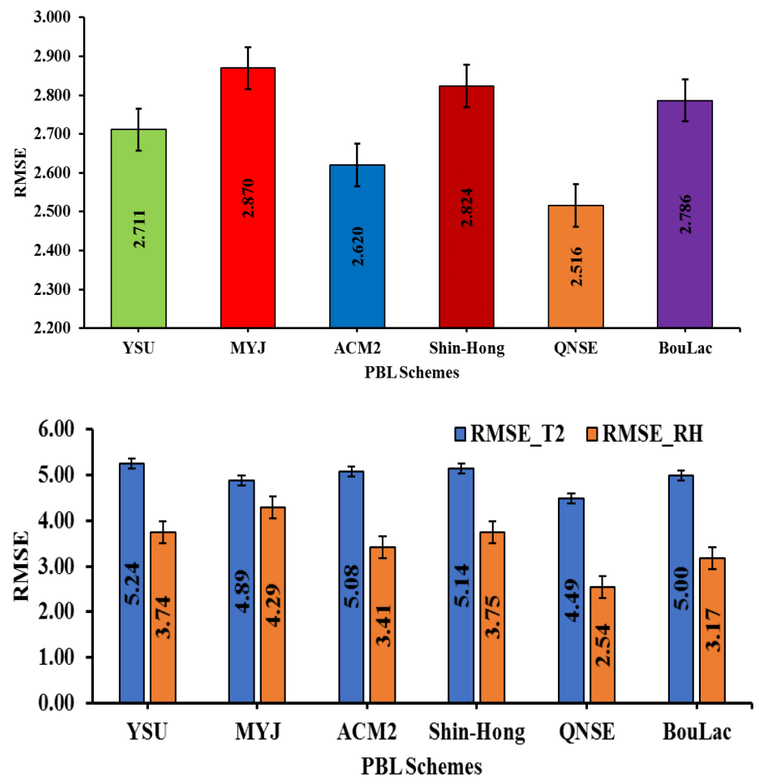

Figure 3. RMSE against station observations for near surface temperature and humidity.

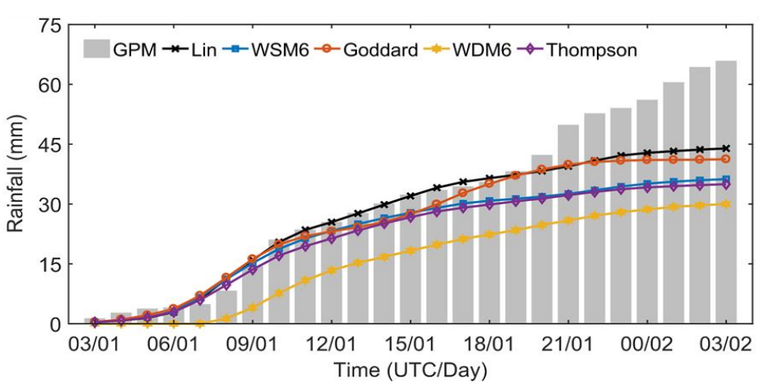

Figure 4. Time series of area-averaged accumulated rainfall for 26 August 2016.

- All the 6 PBL experiments simulated the 8 UTC peak of the heavy rain event.
- The ACM2 and QNSE able to capture other peaks of rainfall reasonably.
- The lowest RMSE (2.516) is found with QNSE for rainfall when compared with GPM-IMERG observations.
- Diurnal variation of model simulated near surface temperature and humidity is compared with station observations.
- Similar to rainfall, lowest RMSE is found in case of QNSE for temperature (4.49) and humidity (2.54).

Summary/Conclusion

- Three TKE and three non-TKE based PBL schemes, and seven microphysics schemes are evaluated for heavy rainfall cases over a coastal urban area (Mumbai) and a near coastal urban area (Bhubaneswar-Cuttack) respectively.
- Within non-TKE PBL schemes, less variation of RMSE for rainfall, near surface temperature and relative humidity is observed compared to TKE based PBL schemes. However, in overall comparison, TKE based PBL scheme performs well.
- In the TKE based PBL schemes QNSE performs well with lowest RMSE as compared to the MYJ and BouLac schemes.
- Seven microphysics schemes are studied and found to be performing well, while mphy-2 and mphy-5 perform better when compared with the GPM-IMERG observations.

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