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Evaluation of Performance of PBL schemes in mesoscale simulation of squall-lines over Gangetic West Bengal using WRF model

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The planetary boundary layer (PBL) processes play significant role in the formation and evolution of the thunderstorms. The PBL is particularly important in turbulent transfer of energy and moisture from the surface. PBL parameterization schemes represent the boundary layer processes in the numerical weather prediction models. In this paper, numerical experiments are conducted to evaluate the performance of eight PBL schemes towards meso-scale simulated features associated with the squall line that affected Kharagpur and the adjoining area in the Gangetic West Bengal (GWB) on 7th May 2010 using Weather Research and Forecasting (WRF) model. The schemes include the first order closure schemes and turbulent kinetic energy (TKE) closure schemes. The triple nested model with the innermost domain of 2 km horizontal resolution with explicit convection is used for 24 h simulation of the squall. The initial and boundary condition of the model is derived from 1° X 1° FNL analysis. The simulated results of the squall line are validated with high frequency Automatic Weather Station (AWS) data, 50 m micro-meteorological tower data, rainfall products from TRMM and the products of Doppler Weather Radar (DWR) located at Kolkata (22.570N, 88.350E).

The results indicate that the model simulated result is sensitive to the PBL schemes used. In model simulations (with all PBL schemes), the squall passes over Kharagpur region almost one and half hour after the actual passage of the storm. The results reveal that the local turbulent kinetic energy (TKE) based PBL schemes show better performance than the non local PBL schemes. It is also observed that the model with local PBL schemes simulated moister boundary layer leading to instability supporting deeper convective development. On the other hand it is seen that the non local PBL schemes are producing deeper mixed boundary layer. The local PBL schemes (MYJ, QNSE) simulated surface rainfall distribution closer to observations. All the PBL schemes except TEMF scheme simulated the surface temperature, relative humidity and wind associated with the squall line reasonably well. The model simulated reflectivity profiles from local TKE based PBL scheme were more consistent with the observed reflectivity profiles than the non local PBL schemes. The sensitivity of surface layer parameterizations schemes is also investigated to assess the influence of the surface layer parameterization on the performance of PBL schemes in simulating boundary layer characteristics. It is found that the surface layer parameterizations only contribute to near-surface variability of meteorological parameter whereas their vertical profile mainly depends on the mixing algorithms.