Statistical comparison of convection permitting model simulations with radar observations over the Western Ghats of India

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The coastally oriented, mesoscale mountain ranges in the western parts of India are known as the Western Ghats (WG) records rainfall maxima along the windward slopes (during southwest monsoon), rapidly decreasing on the eastern lee side. Deployment of X-band Doppler radar by Indian Institute of Tropical Meteorology (IITM) at the strategic location of Mandhardev (18.04°N, 73.85°E, and 1.3 km MSL) aims to fill a noticeable void in ground based continuous details of convection with respect to underlying topography of the Ghats. The radar provides unique and valuable information on the three dimensional convective structures at frequent time intervals (typically 10 minutes) with spatial scales comparable to cloud resolving model (CRM) grid spacing. This ability of radar allows the statistics of a cloud population to be determined, which provides a useful source for model evaluation.
In this study, we have compared the convection-permitting model simulations (horizontal grid spacing of 1 km) to X-band radar observations. The cell tracking algorithm, Thunderstorm Identification Tracking Analysis and Nowcasting (TITAN) is applied to simulations of convection over the WG during 26 to 30 July 2014 by Advanced Research Weather Research and Forecasting model (ARW-WRF) and radar data to identify and track individual convective cells and estimate their properties like depth, size, lifetime and movement. Thus by using object based methodology, information about horizontal structure of individual convective elements is preserved. The WRF model simulation has three one way nested domains and dimensions of the innermost domain were selected such that it covers range of the radar (Figure 1). The initial and boundary conditions are taken from 6 hourly ERA Interim data. Two different simulations are carried out with the WSM6 and Thompson microphysical schemes. The model microphysical quantities are stored every 10 min for the length of each simulation, which matches temporal resolution of X band radar data (10 min). The domains convective cell properties are determined in similar way for model and radar data. This made it possible to compare statistics of convective cells observed by radar and simulated by model. Comparison of model simulated convection statistics on its inner most domains (250 km by 250 km size) are made with radar derived statistics (250 km by 250 km size) wherein the horizontal grid spacing is of 1 km.

After applying the TITAN algorithm to radar observation and simulation periods (4 days after removing 1 day of spin-up time, 10 min interval data), 2174 (3184) convective cells were identified in radar (model) data when a reflectivity threshold of 35 dBZ is used to define the convective cells. Spatial plots of frequency of occurrence for storm track entries in radar and simulation showed a good agreement. Both data showed an increase in frequency of convective storm location along the mountain ranges in the Windward side (owing to orographic influence) when compared with Leeward side of the Western Ghats (Figure 1). Time series of number of convective cells identified per hour during 27 to 30 July 2014 in radar and simulation showed that model approximately reproduces the periods having occurrences of large number of convective cells. On a diurnal scale, peak in convective cell occurrence at around 1430 hrs in radar observation is well captured by the model. However, there are differences in the timing and intensity of individual events. Timing of diurnal cell occurrence maxima is well captured. There is an overestimation of diurnal cell occurrence maxima and underestimation of diurnal cell occurrence minima noticed.

The comparison of frequency distributions of convective cell properties obtained using radar (top height 4.8 km, duration 53 min, direction of propagation 134 degrees, area 39 km^2 and volume 62 km^3) and model (top height 4 km, duration 57 min, direction of propagation 140 degrees, area 32 km^2 and volume 54 km^3) showed a very good agreement. It is observed that the contribution of small sized cells to total cloud population is more compared to large size storms signifies dominance of sub MCS convection during study period. The convective cell area, height and duration follow lognormal distributions. The Shallow convection dominates in Western Ghats and persists for mean duration of 53 min. The simulated convective cells reached lower altitudes than the observations.
Present study tries to bring out important similarities and differences between the model and radar observations. This convective cell-based method provides a tool for utilization of radar data for convection scale model validation. The detailed results will be presented at the conference.

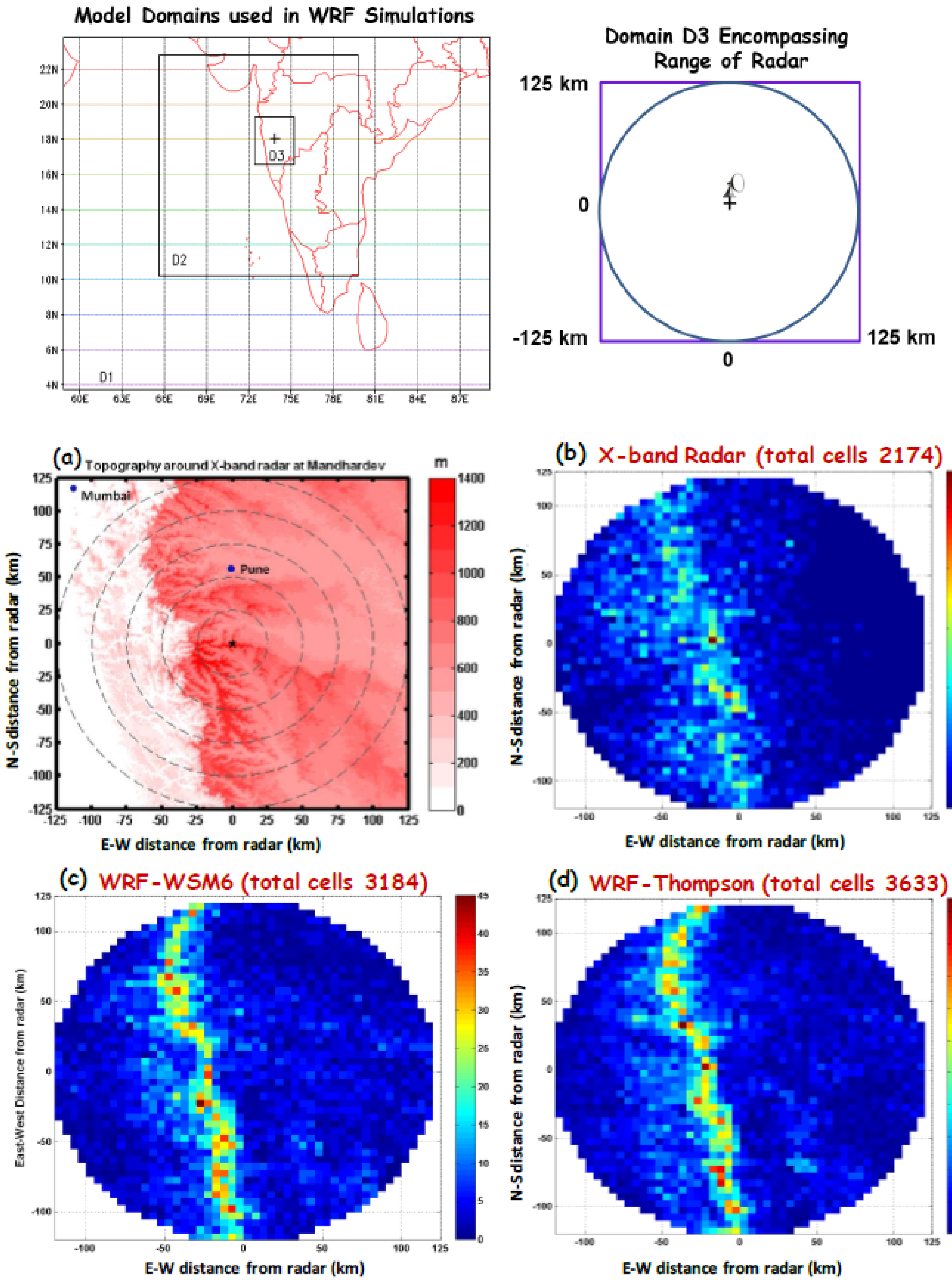

Figure 1: WRF model setup and Spatial plot of convective cells occurrence during 27-30 July 2014 illustrating comparison between Radar observations and high resolution WRF simulations.