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Radar characteristics of convection over Western Ghats during Monsoon: Mean properties and trends

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Time continuity and high coverage of ground based radars makes it suitable for convection study compared to space based platforms. The Indian Institute of Tropical Meteorology (IITM) has deployed an X-band Doppler radar at Mandhardev (18.51°N, 73.85°E, MSL 1297 m), located in the Western Ghats (WGs) of India. WG receive copious amounts of rainfall on the windward sides of about 6000 mm yr^{-1} and there is a sharp gradient of rainfall in the east-west direction. This makes the region an interesting test-bed for convection studies. In this work, high resolution X-Band radar data collected during the south-west (SW) monsoon season (June-September 2014) have been utilized to examine the ensemble properties of convective population and diurnal cycle over the WGs region around Mandhardev. Dynamical SW monsoon systems are associated with large scale organization and evolution of cloud systems which exhibit pseudo-periodicities in as far as rainfall over a region is concerned marked by distinct dry and wet spells.

Using a cell-tracking algorithm, Thunderstorm Identification Tracking Analysis and Nowcasting (TITAN), a convective cell (or storm) is identified as three-dimensional region in space satisfying the various thresholds such as minimum reflectivity (35 dBZ), volume (15 km^3) and duration of two radar scans (24 min) etc. The total number of ~ 4500 such storms have been identified and tracked during their life cycle. The spatial distribution of storm track location showed a distinct pattern wherein a cluster (disperse) of cells in the windward (leeward) sides of the WG is seen. Three hourly composites of Convection Initiation for the whole season depict a pronounced influence of underlying topography in generation of convection in the domain. Also the storms are oriented along the East-West direction with an angle of ~ 90^o from true North along the ridges of the WG.

Based on echo top heights, cells are classified into cumulus, congestus and deep convection types. In the diurnal cycle, a maximum in the congestus occurrence at 1430 hrs is followed by a peak in the deep convection at 1530 hrs. A lead-lag relation is observed in diurnal scales amongst several cloud types, however on an average their mean lifetime is comparable. On diurnal scales the radar estimated precipitation flux correlates well with the mean reflectivity (r = 0.7). Higher reflectivity clouds signifying intense convective activity generally attains higher cloud tops up to ~ 10 km. Generally, frequency distribution of convective cell properties such as the areas, heights, and durations exhibited truncated lognormal distributions. The mean durations of convective storm (~ 46 min) in WGs region are smaller when compared with other tropical land and oceanic regions (~ 90 min GATE Experiment).

Variability of convection during Monsoon plays an important role in the amount of precipitation the cloud systems generates over a region. The dry and wet spells of monsoon 2014 is envisaged. From Indian Meteorological Department (IMD) datasets long term (50 years) daily mean) rainfall time series with high spatial resolution of 0.25^o by 0.25^o have been obtained and overlain with 2014 rainfall to obtain the anomalies which have been standardized with the standard deviations. A criterion for dry (wet) periods has been defined if the standardized anomaly exceeds 0.5 (-0.5) for three consecutive days. Radar observed cloud properties pertaining to dry and wet spells in respect of their diurnal and spatial variations have been analyzed.

Echo top heights show a pronounced diurnal feature for the dry composites. It exhibits two distinct peaks one during afternoon (1400 hrs LT) and another post midnight to early morning (~0330 hrs LT). This is not true for the wet composite that shows a consistent high value throughout the day. Irrespective of wet or dry phase, the height of 30-dBZ echo top (signifying precipitating convection) remains below the freezing level. Spatial distribution of 0 dBZ tops (signifying cloud tops) shows a lower (higher) heights for dry (wet) composite over the North-South WG mountains, however the cloud top heights increase (decrease) over the Leeward side on an average. A similar feature is observed for the 15dBZ echo tops (signifying drizzle heights). The frequency distributions of height reached by 0 dBZ and 30 dBZ echoes are compared for dry and wet spells. In dry (wet) phase the distribution of heights reached by 0 dBZ echoes show a bimodal (unimodal) feature peaking at 3 km and 6.5 km (6 km). In dry (wet) phase, the scarce (abundant) 30 dBZ echoes signify fewer (frequent ~ 5 times) intense precipitating cells.

Vertical Integrated Liquid (VIL) is an estimate of the total mass of precipitation in the clouds. Their typical values have strong regional and temporal dependence. Variations in VIL obtained from radar estimates were positively correlated with those in cloud top heights on diurnal scales for both dry and wet phases. Also high VIL values (0.04-0.08 kg/m^2) were observed to be spatially preferential over the North-South Mountain ranges of the WG mountains during wet phases signifying higher potential of precipitation than during dry phases (0.03-0.06 kg/m^2).

Other cloud properties shall be compared in terms of reflectivity exceeding certain threshold as attained by clouds over these wet and dry regimes. This analysis shall provide a framework to unravel the behavior of cloud population in terms of their temporal evolution, spatial distribution, microphysical behavior and vertical structure. The detailed results will be presented at the conference.