Diurnal variability of convection over a coastal station Thumba using C- band Doppler Weather Radar (DWR)

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Abstract

Diurnal variability of mesoscale convection using C-band Doppler weather radar over a coastal station Thumba is addressed in the present study. The differences in the diurnal variability of convection are addressed during different seasons. The observation shows that during the monsoon and winter the convection observed is of mesoscale in nature. The maximum vertical extent observed during all the seasons extend up to an altitude of 5 to 6 km. This shows the convection is mostly shallow over this region. The diurnal variability showed peak during morning in the monsoon and late afternoon during winter over Thumba.

1. Introduction

Tropical mesoscale convective systems are most intense Tropical mesoscale convective systems are most intense and severe in the mesoscale level. Diurnal cycle of convection is one of the strongest elements in the tropics [*Lin et al.* 2000; *Sorooshian et al*. 2002]. Within a geographic region, convective systems form, propagate and dissipate in preferred places which are closely associated with diurnal cycle.There have been several studies using satellites (like TRMM, MT-SAPHIR) on the diurnal cycle of convection and rainfall. Most of the studies show afternoon peak over the land and early morning peak over the oceans [e.g., *Nitta and Sekine*, 1994; *Mori et al*., 2004; *Sato et al*. 2009; *Birch et al*. 2016; *Yokoi et al*. 2017]. Satellites can provide diurnal cycle, however, it has sparse temporal and spatial sampling and we need to aggregate days to months to attain the diurnal cycle.The usage of Doppler weather radar can overcome poor resolution problem as it has high spatial and temporal resolution and can better characterize the diurnal variation in convection. The focus of the present study is to understand the diurnal variability over a coastal station Thumba using DWR.

2. Data

2.1 C-band DWR

The C-band polarimetric DWR was installed at Thumba in August, 2015. The operating frequency is in the range of 5.6 to 5.65 GHz with peak transmitting power of 250 kW. It is a polarization radar and the products available are reflectivity (Z), spectral width (W), radial velocity (V), radar reflectivity factor (Zh), differential reflectivity factor (Zdr), differential propagation phase (ϕdp), and correlation coefficient (ρhv). The present study utilized diurnal data during June 26, 2017 and December 01, 2017. Data is downloaded from https://mosdac.gov.in.

2.2 CMORPH Rain rate

Global Rain rate was downloaded from NOAA Climate Data Record (CDR) of CPC Morphing Technique (CMORPH) High-Resolution Global Precipitation Estimates. The CMORPH CDR is a reprocessed and bias-corrected global precipitation product created on an 8kmx8km grid over the globe (60S-60N) and in a 30-minute temporal resolution for an 18-year period from January 1998 to the present. TheClimate Prediction Centre morphing method (CMORPH) uses motion vectors derived from half-hourly intervalgeostationary satellite IR imagery to propagate the relatively high quality precipitation estimates derived frompassive microwave data. The present study used the CMORPH data during the passage of convective systems.

3. Resultsand Discussion

Figure 1 show the spatial map of DWR averaged reflectivity at 02, 03, 04 and 05 UTC at 4^{o} Elevation on June 26, 2017.Reflectivity is observed to be > 35 dBZ over an area in the south-west location of the radar. As the time progressed the convective area reduced and dissipated around 5 UTC. The system persisted for about 4 hrs over the location shown with high reflectivity. It extends to more than 100 km in north as well as in the east direction, a typical nature of the mesoscale convective system. The corresponding rain rate is shown in figure 2 which shows maximum rain observed 20 -25 mm/hr over few regions within the MCS. During winter also, we observed MCS over the location and it is observed to be strong in comparison with the monsoon, however the MCS sustained for about 2 hrs and then dissipated.

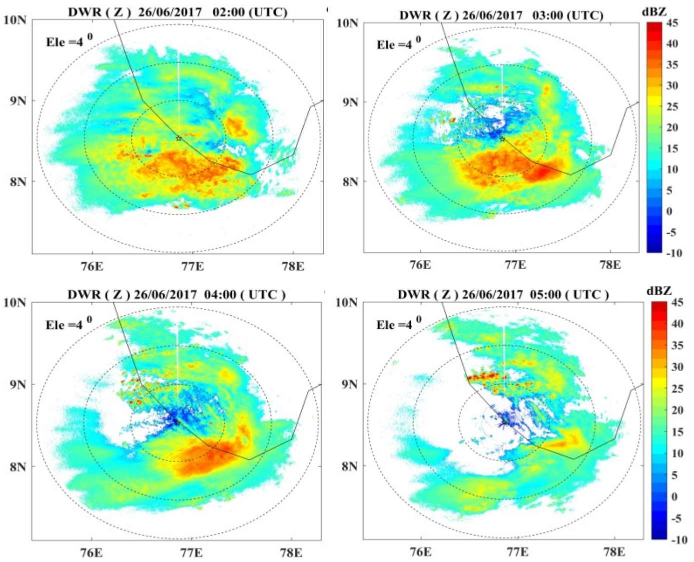

Figure 1. AveragePPI of reflectivity on June 26 2017 at elevation 4° at (a) 02, (b) 03, (c) 04 and (d) 05 UTC.

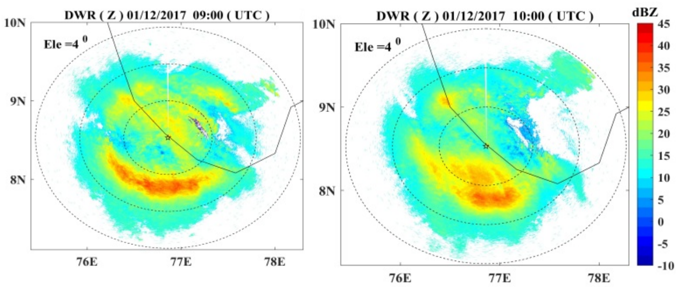

Figure 2. AveragePPI of reflectivity on December 01 2017 at elevation 4° at (a) 09, and (b) 10 UTC.

3.1 CMORPH Rain rate

Hourly Rain rate from CMORPH data has been provided for in Fig.3. Rainfall is observed corresponding to the passage of MCS during both the seasons.

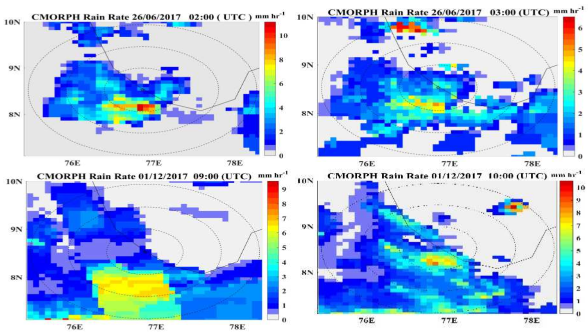

Figure 3. Hourly rain rate (a) 02 UTC and (b) 03 UTC on June 26, 2017. (c) and (d) are same but for December 01, 2017 at 09 UTC and (d) 10 UTC

3.2 Vertical extent

Figure 4a and 4b shows the longitude height cross section of convective cell observed in figure 1 during monsoon and winter respectively. During both the seasons, the vertical extent is observed to be less than 6 km, exhibiting the nature of shallow convection over the location. During winter, bright band signature is observed at 5.5 km.

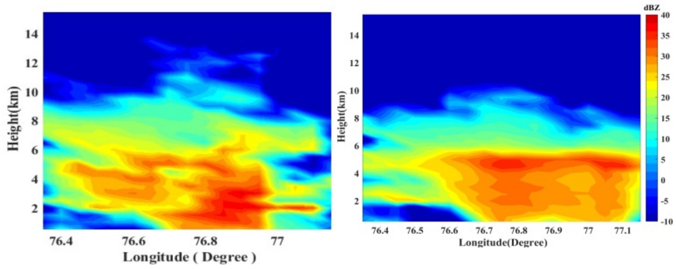

Figure 4. Range height intensity of reflectivity at (a) 02 UTC during monsoon, and (b) at 10 UTC during winter.

3.3 Diurnal variability of convection

Figure 5a and 5b shows the diurnal variation of convection during monsoon and winter respectively. The present study shows the dominance of shallow convection over this location. In order to extract the diurnal variation of convective storm, we adopted a methodology in which we track storms having reflectivity greater than 25 dBZ. The reflectivity threshold should persist for a minimum of ten minutes and its vertical extent should be minimum 2 km. The criteria give a robust method by which convective storms can be identified.

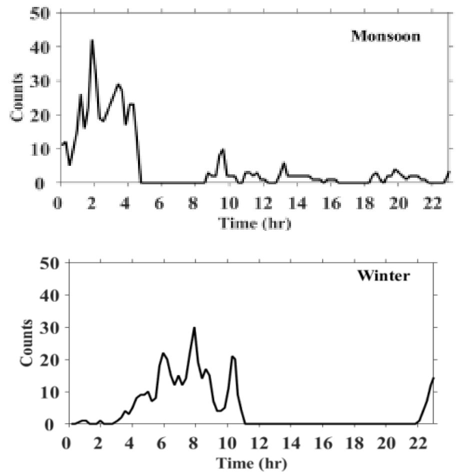

Figure 5. Diurnal variation of convective storm during (a) 26 June 2017 and (b) 01 December 2017

Figures 5a shows that during monsoon the peak in the convection is observed between 00 and 04 UTC. During winter the peak is observed between 4 and 8 UTC. Monsoon convection is observed to dominate in the morning hours and during winter it is early afternoon hours.

4. Conclusion

The present study utilized C-band DWR over a coastal station Thumba to understand the diurnal variability of convective storms. We analyzed two convective events to represent monsoon and winter. The convective storms observed were of mesoscale size. The system persisted for four hours during monsoon and two hours during winter. The vertical extent during both the events was less than 6 km, exhibiting the nature of shallow convection over this location. The peak in the convective storms is in the morning hours during monsoon and in the early afternoon during winter.

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