UHF RADAR STUDIES OF VERTICAL MOTION AND TURBULENCE CHARACTERISTICS IN PRE-MONSOON THUNDERSTORM OVER AN INDIAN TROPICAL STATION

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I. INTRODUCTION

One of the most elusive of the parameters required in diagnostic and prognostic studies of the atmosphere is the vertical motion. Vertical motions exert a profound influence on the distribution of clouds and on the occurrence of precipitation. They provide the mechanism for vertical transport of any atmospheric property and thus influence the distribution of mass, momentum and energy. Wind profilers are the only instruments that can provide virtually continuous observations of vertical motion through a column within convection at scales that can accurately sample the convection itself. This together with information on horizontal winds, hydrometeor fall velocities with high time and space resolution has been used to explore the relationship between air motions within the convective storm and the microphysics (May and Rajopadhyaya 1996).

II. PRESENTATION OF RESEARCH

The aim here is to present a case study observed with 404 MHz UHF radar/wind profiler data from a tropical land station, Pune (18.31^0 N, 73.58^0 E) during a pre-monsoon season severe convection event. The ability of wind profiler to directly measure vertical air motions and hydrometeor fall velocities through precipitating and non-precipitating systems has been explored through an analysis of the pre-monsoon thunderstorm which occurred in the evening hours on May 16, 2004. Using the observed UHF radar data, the extent of the enhancement in the vertical velocity, horizontal wind shear and the turbulence distribution during the thunderstorm activity is discussed in this paper. Temporal variation of surface meteorological parameters before and during the thunderstorm event is also presented as supporting information.

III. RESULTS AND CONCLUSIONS

Time-height variation of vertical velocities (top panel), reflectivities calculated from the observed spectral signal to noise (SN) ratio (second panel), turbulence parameter (third panel) and horizontal wind shear (bottom panel) observed in the height range 1.05 km to 8 km for May 16 during 0800 to 2100 hrs local time obtained from Pune wind profiler are presented in Figure 1. The measured vertical velocity profiles show upward motions in the morning hours up to an altitude of 3 km. When the thunderstorm starts developing or gets initiated a strong downdraft with velocities between -1 m/sec to even -4 m/sec are seen in the height region of 3 to 10 km. In the growing stage, the downdraft can be seen to be prevalent right from lowest observable heights of 1.05 km. It is observed that, the precipitation signals (Rayleigh scattering) dominate the UHF signal during thunderstorm period. The reflectivity profiles during clear air conditions before thunderstorm activity were predominantly negative. The reflectivity increases by more than 0 dB, as convective cloud starts developing after 1400 hrs. Reflectivities are as high as 20 dB once the heavy precipitation starts falling during the period 1800-2000 hrs. One can see the initiation of thunderstorm (around 1400 hrs), it vertical growth from 1400 to 1800 hrs from the upward sloping reflectivity contours. The vertical velocity fluctuations (given by S_w, spectral width) show a region of strong turbulence (right from 1.05 km to 8 km in the vertical) with high S_w values during the growing and mature stage of the thunderstorm. Vertical shear of horizontal wind showed increased shear in the entire height region from 1.35 to 5 km during the peak activity of thunderstorm. Wind shears ranged between 0.01 and 0.03 m^2/sec^2 at the time of intense convection. Thunderstorm produces convective wind shear for a short period of time which is seen in this case study.

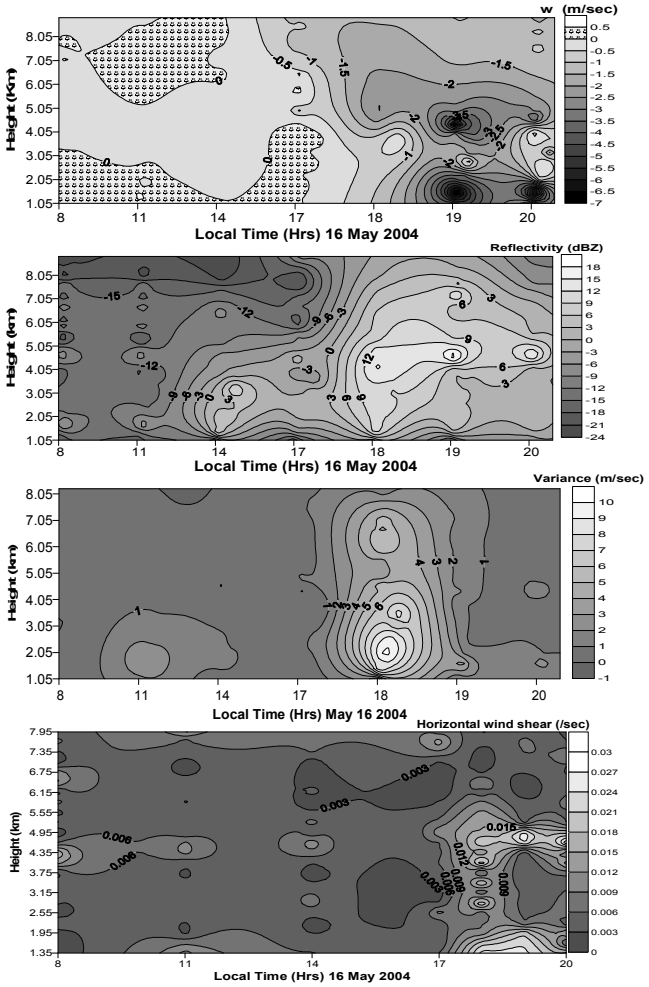

FIG 1: Time-height cross sections of vertical velocity (top panel), reflectivity (second panel), variance (third panel) and horizontal wind shear (bottom panel).

Surface meteorological parameters recorded at the wind profiler site, namely, Wind speed (hourly average and maximum during that one hour), hourly average Temperature, Relative Humidity, Pressure and total Rainfall during the hour are plotted and shown in Figure 2 for 16 May 2004 between 0800 and 2100 hrs LT.

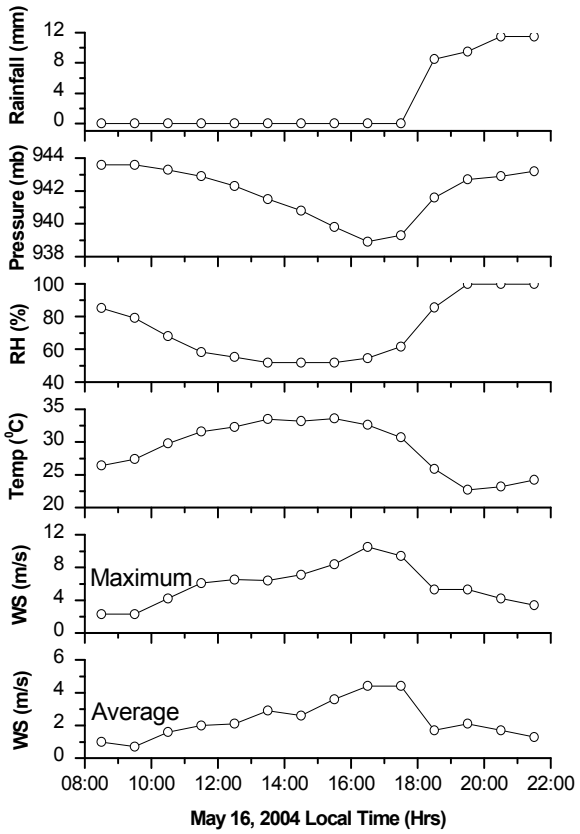

FIG 2: Surface meteorological parameters recorded at UHF radar site on May 16 2004.

Wind speeds were maximum in magnitude at the mature stage of the thunderstorm and the instantaneous values reached as high as 10-12 m/sec when thunderstorm was overhead and fully developed. Maximum surface temperature at this tropical station usually occurs around 1400 hrs LT, but on this particular day the condition of maximum surface temperature extended by nearly two hours. Relative humidity started increasing just before precipitation occurred. Surface level pressure fell by about 7 mb and showed minimum at the mature stage of the thunderstorm. Thus all the surface meteorological parameters showed changes typical of the various stages of a tropical pre-monsoon thunderstorm. Data at shorter interval will be further analyzed to delineate the various stages in more detail.

The above case study during a pre-monsoon thunderstorm event over a tropical station shows number of different interesting features during period of atmospheric strong convection. These include large rapidly varying vertical velocities (updrafts and downdrafts), large values of vertical spectral width, enhanced signal powers in the troposphere and associated low level wind shears, changes in momentum fluxes during the life cycle of thunderstorm activity. As the radar echoes from UHF radars clearly distinguish those from hydrometeors and from clear air, it is possible to ascertain the time when actual precipitation occurs. The UHF radars/wind profilers provide wind and turbulence information at high temporal and spatial resolution which enables one to study such events of intense convection in detail.

IV. AKNOWLEDGMENTS

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V. REFERENCES

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