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Microphysical Parameters Analysis of Cloud using X & Ka band Dual Polarized Doppler Weather Radar

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Abstract: *The study of microphysical parameter of clouds is studied and analyzed using X &Ka band Dual Polarized Doppler Weather Radar. Field work is done on operational characteristics of both the radars stationed at Mandhardevi and is used to analyze cloud pattern behavior over Mahabaleshwar region during monsoon period. X band radar is used for analysis of precipitation characteristics of cloud for convective and stratiform rainfall pattern. Ka band radar is used for study and analysis of cloud dynamics which include cloud height behavior during a rain event over Mahabaleshwar region. Disdrometer is used to measure the drop size distribution for convective and stratiform rain events over Mahabaleshwar.*

Keywords: Radar, Reflectivity, Disdrometer, Cloud dynamics.

I. INTRODUCTION

India being a tropical country has four seasons throughout the year, out of which monsoon is one of the major season as the India's agrarian economy mostly depends upon monsoon for rains which is important factor for agricultural activities. Monsoon season occurs in Indian during phase of June to September which is further briefly classified into two sub types i.e. South-West monsoon & North-East monsoon. In this project we are concentrating on South-West monsoon season winds which interact first with Western Ghats region.

In present study we are going to study the rainfall pattern over Western Ghats region. Here we are concentrating on cloud behavioral pattern over Mahabaleshwar region. RADAR observations are firstly analyzed from both X & Ka band Dual Polarized Doppler Weather RADAR owned by Indian Institute of Tropical Meteorology (IITM), Pune a premier research institute under Ministry of Earth Sciences, Govt. of India. Study mainly focusses on two types of rainfall pattern i.e. convective rainfall[3] and stratiform rainfall[4] over High Altitude Cloud Physics Lab (HACPL) which is stationed at Mahabaleshwar, X & Ka band RADAR are stationed at a place Mandhardevi which is at same altitude as that of HACPL. Disdrometer analysis is also been taken into consideration for this study of microphysical parameters of cloud.[8]

II. THEORY

A Doppler radar is a specialized radar that makes use of the Doppler Effect to produce velocity data about objects at a distance. It tdoes this by beaming a microwave signal towards a desired target and listening for its reflection, then analyzing how the frequency of the returned signal has been altered by the object's motion. This variation gives direct and highly accurate measurements of the radial

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component of a target's velocity relative to the radar. Doppler radars are used in aviation, sounding satellites, meteorology, etc. Most modern weather radars use the pulse-Doppler technique to examine the motion of precipitation, but it is only a part of the processing of their data.[11] Below is the (1) determining how Doppler shift can be calculated, this Doppler shift can be used to find velocity or direction of microphysical parameters of cloud.

$$fr = ft\left(\frac{1+v/c}{1-v/c}\right) \qquad (1)$$

Here, c is the speed of light, v is the target velocity gives the shifted frequency (f_r) as a function of the original frequency (f_t) . Doppler Weather Radar are usually classified into two main category i.e. Single Polarized & Dual Polarized Doppler Weather Radar. In this study we are using X & Ka band Dual Polarized Doppler Weather Radar.

III. EXPERIMENTAL SETUP

The experimental setup consist of X & Ka band Dual Polarized Doppler Weather Radar which operates with two scanning strategy i.e. Plan Position Indicator (PPI) scan where radar is set up at a fix elevation angle w.r.t horizon and the azimuth angle is varied and a scan of 360° is taken. Another scanning strategy is Range Height Indicator (RHI) scan in which azimuth is kept constant at certain specific angle as in our case pointing towards Mahabaleshwar which lies at 237° from the azimuth angle and elevation angle is varied from 0° to 90°. In this study we have concentrated on RHI scan strategy which helps us to give vertical structure of cloud over Mahabaleshwar region. RHI scan plots can be seen for backscattered signal using EDGE software, by analyzing these plots we can differentiate between a precipitating rain event and a non-precipitating rain event. Based on this analysis we can classify rain events during monsoon and can study how a rain transition occurs. EDGE software gives us a basic data file which consist of all the products or as we call it as radar parameters which include reflectivity (DBZ), velocity (VEL), differential reflectivity (ZDR), range, elevation, time and many more products. This base file is of .vols format for X band and .rpp for Ka band but the problem with these file format is that these cannot be analyzed by any software. So these file formats are converted into common data file format such as comma separated value (.csv) / Net CDF (.NC) file formats so this basic file format data can be used for analysis in simulation software such as MATLAB. This common formats can then be accessed by extracting data from this file about the products using MATLAB coding. MATLAB is then used for plotting various radar product behavior and by analyzing these plots we can derive our conclusions linking the plot results with theoretical atmospheric science phenomena.

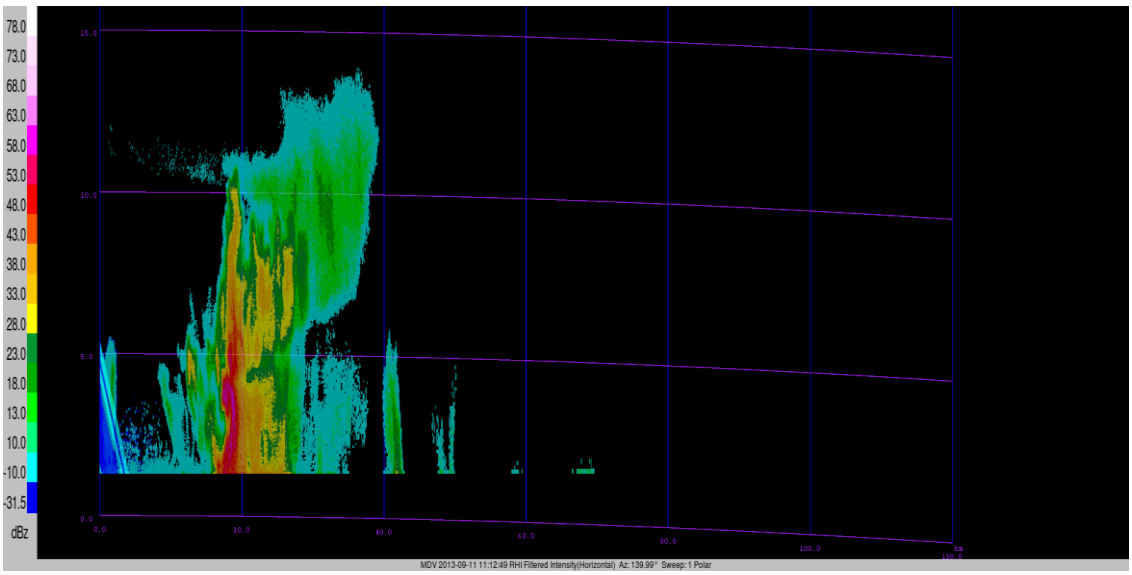

Figure 1: RHI scan plot generated by EDGE software

IV. OBSERVATIONS

The observations taken with help X band radar data analysis using MATLAB give us detail about the precipitation characteristics of cloud and help us to classify whether the rain event is a convective rain event or a stratiform rain event. The below plots are plotted with gate width on X axis and vertical height on Y axis.[1]

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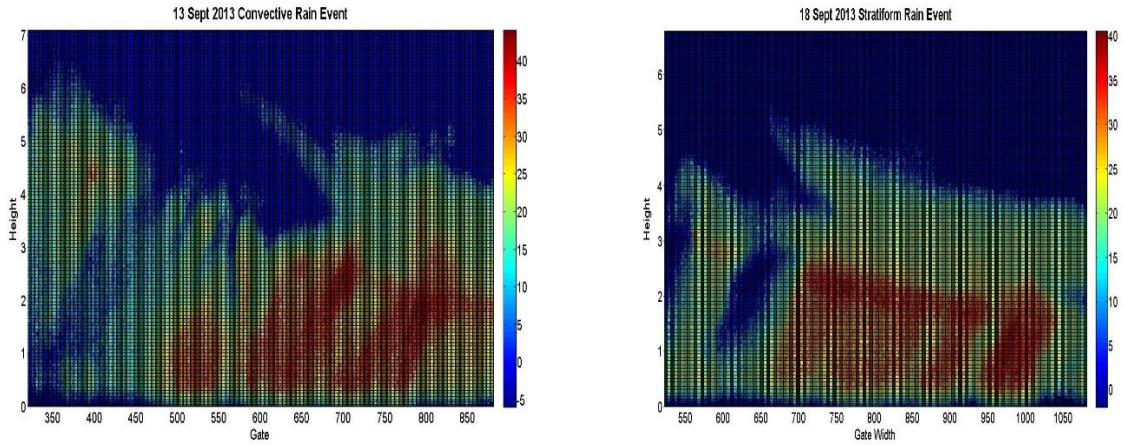

Figure 2: Convective & Stratiform rain event contour plots

Reflectivity is varying factor in both of above graphs which is varying according to color bar scale from -5 to 40 dBz. Red color signifies maximum reflectivity at that particular height and a series of band of such red gates make up a bright band, by observing bright band we can classify whether a rain event is convective[2] one or stratiform one. A convective rain event has vertical bright band structure in any rain event and a stratiform rain event has a horizontal bright band structure.[4]

The observation taken with help of Disdrometer help us to study the variation of raindrop size distribution in convective and stratiform rain event which is one of the important microphysical parameter in clouds.[6]

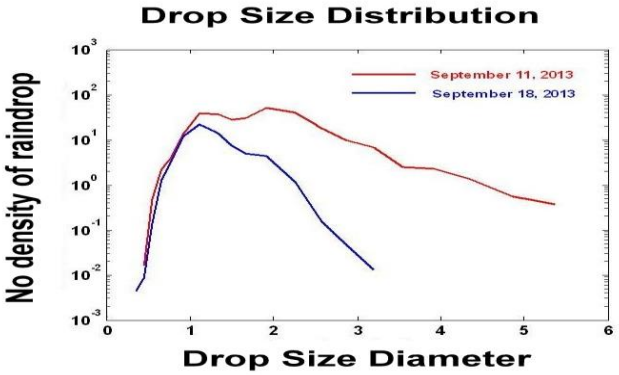

Figure 3: Rain drop size distribution using Disdrometer data

Here we can see graph is plotted between drop size diameter in mm v/s no density of raindrop. The red line in graph depicts about convective rain event we can see that drop size density and diameter of drop is quite higher than that of blue line depicting a stratiform rain event. This shows that raindrops present in a convective rain event are usually larger and denser than its counterpart stratiform rain event.[5][7]

The observation done with Ka band radar help us to find detail about cloud dynamics. In this study we have done analysis on clouds height transition over Mahabaleshwar region during a rain event.

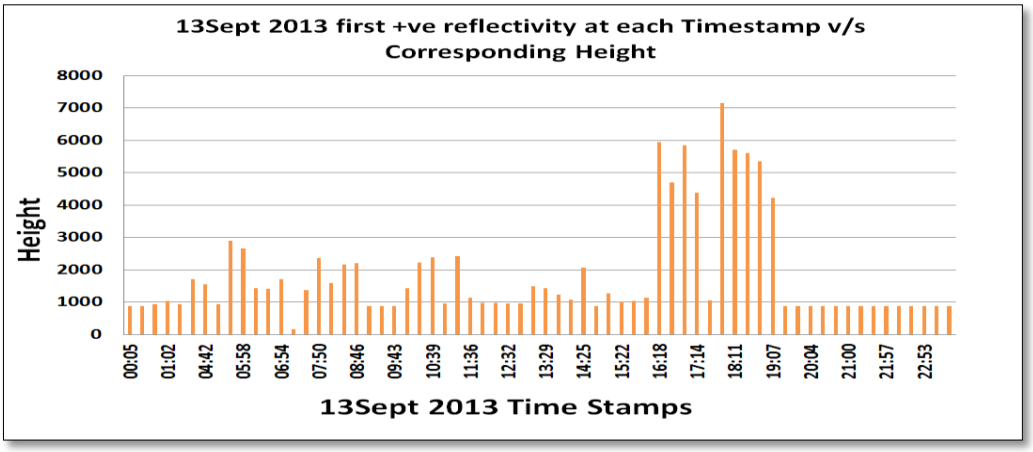

Figure 4: Clouds height transition over Mahabaleshwar

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The cloud height is taken at each time stamp (RHI scan time) measuring first positive reflectivity value using Ka band radar data. The graph is plotted between time stamps on X axis and vertical height in kms. The time stamps considered here are for a whole day in a rain event. As we can see that cloud height is varying from 1-3 km before the actual transition of rain event.[10] When the transition begins we can see that cloud height suddenly increase to 5-8 km this phenomena occurs when clouds after accumulation of raindrop usually move upwards which clearly tells us that this transition is of updraft of clouds before rain. As the cloud transit at greater height due to temperature variation the accumulated rain drop start to percolate in form of rain and suddenly cloud height is decreases and rainfall occurs this describes that cloud lower their height during a rainfall transition in rain event.[9]

V. ACKNOWLEDGEMENT

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