

DIURNAL VARIATIONS OF MELTING LAYER, FALL VELOCITY, DROP SIZE DISTRIBUTION IN TROPICAL SOUTH INDIAN REGION

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Abstract: Rain Analysis plays a crucial role in maintaining the link between the satellite and ground based station. Performance of satellite communication at high frequencies (above 10 GHz) is affected by rainfall. In this paper, rain characteristics are explained in detailed manner. The parameters are Height of melting layer (which is derived from rain rates at various heights), Drop falling velocity. Readings are taken from Micro Rain Radar (MRR2 which is inclined at 45 degrees from earth) at K L University (16.4418° N, 80.6222° E), Vaddeswaram, Guntur District. The analysis shows the diurnal variation of melting layer, fall velocity, Drop size distribution in the current location. The sudden changes in the height of melting layer, is explained clearly. Explanation includes before, during and after effects of rainfall. Drop size distribution is analysed for few rain events.

Keywords: Drop size distribution, Falling Velocity, Melting layer, Rain rate.

1. Introduction

In the design of Communication systems with higher frequencies the climatic conditions of that location like rain rate, average rain fall should be taken to consideration. Design of time series patterns and attenuation prediction models also depends on rain data of the region.

Water contents like precipitation, fog, hail and melting layer will attenuate the signal at higher rate. Sometimes it is difficult to demodulate the signal and retrieve the original signal. There are various methods to calculate rain rate. Rain attenuation plays a major role in calculation of rain rate [1]. In most of the methods the average value of melting layer height is used in attenuation calculation. But in tropical regions where the height of melting layer and rain rates fluctuate these type of methods will not give accurate results. Propagation Impairment Mitigation Techniques (PIMT) are also implemented effectively only if the rain data of the location is completely available. In this project the average values are given by the Micro Rain Radar which will calculate the attenuations dynamically which means the attenuation can be calculated effectively. MRR has the capability to take readings for every 10 seconds and can ignore errors caused by unforeseen events like flying of birds, any obstacles like leaves etc.

2. Data Analysis

The data is obtained utilizing the vertical looking MRR for 6 months (July-December 2016) at K L University (16.4418° N, 80.6222° E). K L University is located in the Vaddeswaram Guntur District of Andhra Pradesh, India. It gets rainfall from both

southwest monsoon and northeast monsoon. It has a tropical atmosphere with hot summers and a rainy season. The data analysis is done in the rainy season. The MRR is a FM-CW (Frequency Modulated Continuous Wave) Doppler radar which works with a centre frequency of 24.1 GHz. The time resolution is set to be 10 seconds with which the MRR software provides the average data of radar reflectivity, drop size distribution, falling velocity and rain rate. It gives the values of power spectra for various levels F_i , Drops sizes, Spectral drop densities for various levels and various heights. In current analysis the height gap is fixed as 200 meters and it covers distance from 200 meters to 6200 meters [2]. MRR also provides the Rain Rate, Path Integrated attenuation, reflectivity, fall velocity for various heights. In current analysis rain rate, fall velocity and drop size distribution spectrum are taken.

2.1. Detection of melting layer from rain rates

Presence of bright band in the reflectivity Vs height plot indicate the melting layer because there is a change in the dielectric constant in the area of melting layer height which will change the reflectivity. The peak of reflectivity is not sharp when compared to rain rate plot so; the rain rate will be effective in measuring the height of the melting layer [3]. In other words it can be even identified from the rain rate plot [4]. There will be a peak in the rain rate Vs height plot if there is a melting layer. The height corresponding to the peak is considered as height of melting layer. The height corresponding to the starting of the peak is the bottom of melting layer and the height where the peak ends corresponds to the top of melting layer and their difference gives the thickness of melting layer [5].

2.2. Drop Size Distribution

Drop size distribution is defined as the frequency distribution of drop sizes. It is the ratio of spectral volume cross section and single particle cross section. Single particle cross section is measured using pie scattering theory. Micro Rain Radar calculates the Drop size

distribution for various diameter and various heights. The Drop size distribution can be analyzed by plotting the Drop size distribution Vs diameter for various heights [6]. Here the drop size distribution is analyzed in the height of the melting layer. Drop size distribution and Diameters at various levels is calculated from the received power spectrum. MRR gives all the calculated data in the final values of N_i corresponding to various heights (varying from 200 to 6200) and Diameters but diameters will not exists for all the levels. Radar Reflectivity factor (Z) is dependent on the Drop Size Distribution (DSD) and it is extremely sensitive to distribution of large drop components [7].

$$Z = \int N(D) D^6 dD \quad (1)$$

2.3. Fall velocity

Fall velocity is defined as the velocity with which the water drop falls; it will be varying from height to height depending on the drop size distribution and drop diameter [6].

$$W = \frac{\pi}{6} \int N(D) D^3 dD \quad (2)$$

MRR applies the above formula for all diameters and drop size distributions and finally gives the fall velocity for all the 31 levels of height.

3. Results

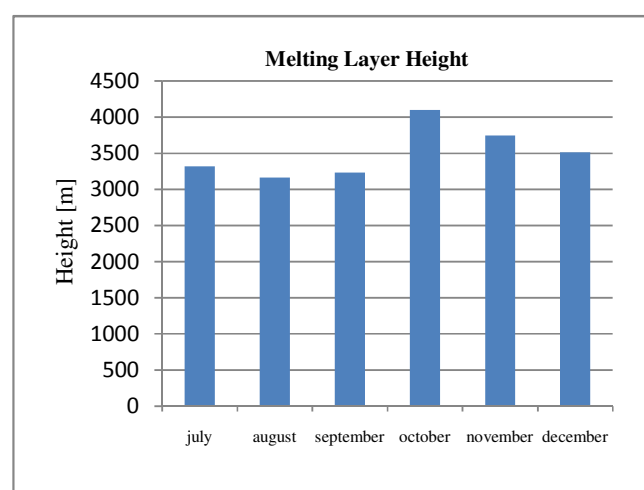


Figure 1. Variation of Melting layer with respect to various months.

The Fig. 1 shows the variation in the height of melting layer in K L University for the time period of June 2016- December 2016. The height of melting layer varies monthly with a drastic change. The height of melting layer is high in October when compared to the monsoon season because most of the rain events occurred with lower heights of melting layer. There is presence of melting layer in non-monsoon season (November, December) because of fog that is predominant in this season. The height of melting layer is directly proportional to the temperatures of the region. Local climate and latitude dependency affect the height of the melting layer.

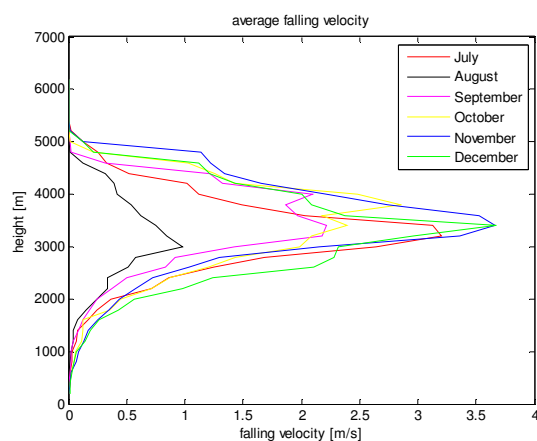


Figure 2. Variation of Falling Velocity with respect to Height.

The Fig. 2 shows the averages of fall velocity for various months (July to December) in 2016. There will be a decrease in fall velocity from top (6200mts) to bottom (200 meters) because various opposite forces will be acting on water drop. It is observed that there is a slight increase in fall velocity in the area around melting layer. If we analyze the fall velocity around melting layer there will be a huge increase in non-monsoon seasons (almost looks like a sharp peak) but in the monsoon seasons the peak is not very sharp i.e., there is only a slight increase in the fall velocity. The fall velocity is also very high around melting layer during non-monsoon season and cyclonic season.

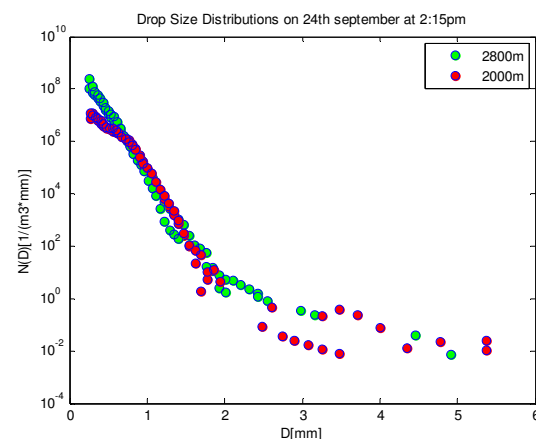


Figure 3. Spectral volume cross section Vs Single drop cross section.

The Fig. 3 shows the Drop size distributions corresponding to various diameters for an event occurred on 24th September 2016 around 2:15 pm. From the graph it is clear that the rain rate is heavy because there is a steep slope in the graph at 2800m and the number of rain drops decreases as the diameter of the drops increase. At 2000m there is change in the number of droplets with normal slope then it can be taken as light rainfall.

4. Conclusion

From the results of the height of melting layer it can be understood that the height of the melting layer is varying monthly that means while measuring the attenuation of any system considering monthly height of melting layer may lead to errors because there are huge changes in the height of the melting layer. The rainfall is heavy in the period between September and December. So, it is clear that the regions receives have amount of rainfall from the retreating monsoons and the cyclones. The height of the melting layer also changes because of the environmental conditions like cyclones or depressions. From the results of drop size distributions it can be understood that the liquid water drops distribution varies with amount of rainfall (heavy/low) and the attenuations of signal is caused by the scattering and absorption of electromagnetic signal by the rain drops.

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