Cloud Morphology Over Three Indian Tropical Stations for Earth Space Communication

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Abstract Microwave and millimeter wave frequency bands are in demand for requirement of larger bandwidth for various applications of radio systems. In future in India too, microwave and millimeter wave frequencies will be in use very extensively for radio communication purposes and remote sensing applications. But, the attenuation due to cloud as well as thermal noise associated with cloud in millimeter wave and microwave frequency bands are of great concern to system engineers and radio researchers. Both cloud attenuation and cloud noise temperature lead to degradation in the performance of microwave communication and radar propagation. The effects of rain on radio wave are more than cloud but the occurrence of cloud is more than rain. In some parts of India cloud occurs for weeks together. The cloud morphology particularly in relation to radio wave propagation over different geographical region of India is therefore very essential and important. In view of this, systematic studies on cloud occurrence morphology over different geographical locations in India have been undertaken. In recent past some results on cloud occurrences over different stations in India have been reported. In this paper, cloud characteristics and cloud attenuation over three more stations are presented. Based on low level cloud coverage observations, cloud occurrences frequency over Mumbai (19.07°N, 72.51°E), Nagpur (21.06°N, 79.03°E) and Ahmedabad (23.04°N, 72.38°E) situated in Indian tropical west coast, central plain and semi arid region of western India in different months during daytime and nighttime has been deduced. The low-level cloud over Mumbai, Nagpur and Ahmedabad has been found to occur for many days and nights and particularly in the months of June, July, August and September. The attenuation of radio wave due to clouds at various frequencies ~10, 18, 32, 44 and 70 GHz over the aforesaid three stations also been deduced.

Keywords Cloud occurrences • Cloud attenuation • Cloud height • Atmospheric noise temperature and radio systems

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Introduction

The requirement of larger bandwidth is necessary for high data transmission rate for communication purposes and for remote sensing application work to get the finer structures of the objects in recent years [1], in India too [2]. Earlier, reliability of radio system has been the only aspect of priority [3, 4]. But, the present scenario of microwave communication has to deal with variety of other aspects. By pumping more power in the transmitter, the reliability of any radio system can be increased. In doing so, we are affecting the working of other radio systems, which are near the vicinity of the receiving site in the form of radio interference, but such transmitted power also affect the performance of other radio systems as well as medical gadgets and testing equipments [2]. The second aspect of the present days microwave and millimeter wave radio communication is the directivity of the transmitted and received power (signal) [2]. Increasing the antenna sizes, we can increase the directivity of the transmitted/received signal. But, the aperture to medium coupling loss becomes a big issue. Increasing the antenna size beyond a point, means, we are not utilizing the contributions of maximum scatterers, which are usually atmospheric irregularities. The scatterers decide the strength of radio signal. Therefore, a compromise between the size of the antenna and maximum radio signal is necessary to get maximum directivity. In recent years there is tremendous advancement in electronics of radio systems. Such advancement has made it possible, the regularization of transmitted power [2]. These days in mobile communication transmitted power is regulated depending on the requirement of the received radio signal. A transmitter located in rainy and cloudy area has to be provided with more power than to a transmitter situated in non-rainy and non-cloudy area. Similarly, it may be argued why people living on non-rainy and non-cloudy region should be exposed to more electromagnetic radiation due to the transmission of high power from transmitter [2]. Over the Indian subcontinent, we have varied precipitation climatic condition [5–9]. Rain and cloud are the most important as far as precipitation is concerned over the tropical India.

In view of the aforesaid aspects such as reliability, directivity and regulation of transmitted power, it is necessary to characterize our radio environment in terms of rain and cloud. The attenuation of radio wave due to rain and cloud can be estimated with good degree of accuracy for proper designing of satellite communication and remote sensing systems [2] with such rain cloud characterization results. It is also important to mention here that such characterization work is upgraded whenever an opportunity arrives.

The effect of rain on radio wave is more than cloud. But, the occurrence of cloud is always more than the rains [7]. Some work has been done on the statistics of rain related work and its effects over different geographical regions in India [5–13] in recent years. Cloud related work in relation to radio wave propagation has not been done much over India. There is still paucity of results on cloud morphology in relation to radio wave propagation work over the tropical Indian subcontinent. Recently, some results on cloud occurrence statistics and attenuation of radio wave due to cloud over some selected stations located in different geographical regions were derived and reported [14–16].

In this paper cloud occurrences over three more stations, viz., Mumbai, Nagpur and Ahmadabad observed during daytime and nighttime of different months are presented. It is seen that low clouds (pertaining to the height from 2 to 6 km)