SOME STUDIES ON RAIN ATTENUATION AT 11.7 GHz FROM INSAT-2C SATELLITE OVER SOUTHERN INDIA.

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INTRODUCTION :

A major hurdle in our efforts to go to higher frequencies in communications [1] is the rain factor. This is especially true in satellite communications and for tropical latitudes where the rain rates are high. At frequencies above 10 GHz rain strongly attenuates and depolarizes radio waves and constitutes a major impediment to satellite link performance [2]. The impairing factors of rain have always been considered when designing links at above 10 GHz [3], Therefore, meteorological variations of humidity and rainfall need to be studied to predict propagation conditions and effective receiving systems aiming at high reliability.

Most of the attenuation studies on earth-satellite paths have been carried out in the temperate regions of the world. The increasing use of satellites for telecommunications and broadcasting services have necessitated more than before the need for earth-space attenuation studies in the tropics. In the tropical countries, rain is the main consideration, as the occurrence of other hydrometeors is very rare [4]. The precipitation characteristics in the tropics differ appreciably from those of the temperate regions in that empirical relationships obtained in the latter may not be very suitable for system design in the former. There are several factors contributing to this dissimilar pattern. For example, in the tropics, the rain drop size distribution is heavily biased towards larger drops for a given rate. There are also significant differences in the height of 0_0 c isotherm with the tropics having a larger altitude. The problem is further compounded by lack of reliable rain measurements and the present ITU-R rain zones have not performed satisfactorily for rain attenuation calculations in the tropics. Due to very few tropical attenuation measurements in existence, the available propagation models have not performed satisfactorily well in predicting the measured attenuation [4]. A reliable prediction of attenuation by rain is necessary for a system designer to realistically determine link availability, establish the link margin and compensate for rain effects. The characteristics of the rainfall in a particular region must be investigated in the design of communication links through the region in order to meet the system's operational reliability. The problem is two fold. Firstly, the geographical rain rate probability distribution is not available for the tropics. Secondly, the validity of the models used to calculate rain attenuation from rain rate are not proven for the tropics, hence direct measurement of attenuation from operational satellite is one way of estimating margins for future satellite systems. The problem is further compounded by lack of reliable rain measurements and the present rain zones have not performed satisfactorily for rain attenuation calculations in the tropics [5]. Significant contributions on rain attenuation [6, 7, 8, 9] are available and the prediction models of rain attenuation in satellite links have depended almost entirely on measurements in temperate climates. However in tropics, particularly in India no experimental results are available in this area of research using satellite beacons. Available data in India is using radiometers over New Delhi [10] and these measurements are not sufficient to understand the propagation mechanisms in this region.

DATA BASE & EXPERIMENTAL DETAILS:

Some preliminary rain attenuation studies were conducted at 11.69 GHz in Southern India. The signals were monitored at INSAT Master Control Facility, Hassan (76.08$_0$ East, 13.07$_0$ North, 900 m above mean sea level), India, from geostationary satellite INSAT-2C (down link). The elevation angle is 64^0 (circular polarization) and the antenna diameter is 7.2 m. The data has been recorded for about 36 hours from 21 rain events during the year 1997-98, the data is averaged at 1 sample/sec. Rain rate is collected using rapid response rain gauge with one minute integration time at the same earth station where the satellite signals were recorded and from the India Meteorological Department observatory. An attempt is made to study the signal attenuation during of opportunity rain using satellite beacons, from this region of world.

RESULTS & DISCUSSIONS:

For the attenuation of rain, existing prediction models like ITU-R [11], Garcia-Lopez [12] and Moupfouma [13] are used to estimate the effect of rain on Ku band signals. Cumulative distribution of rain rate and rain attenuation are estimated and compared with the above predicted models. Figure.1 shows example of time series of attenuation of INSAT – 2C 11.67GHz signals recorded during rain. Figure.2 shows corresponding power spectral density; in the figure the –20 dB decade slope theoretically predicted for rain effects [14] is seen up to about 0.02 – 0.03 Hz, while the spectral power density due to rain extends up to 0.1 Hz. The cumulative distribution of observed attenuation along with predicted attenuations from models ITU-R, Garcia-Lopez and Moupfouma are shown in Figure.3. From the figure, it can be seen that the values obtained from ITU-R method deviate appreciably for 0.1% of time; Garcia-Lopez and Moupfouma methods fare better. Garcia-Lopez showed the same trend with observed values. Though the number of cdf's compared is not statistically very high, Garcia-Lopez and Moupfouma methods can be used to predict rain attenuation in this region, the advantage of these methods being simplicity and ease of computation. Rain rate for the period of observation is presented along with ITU-R rain rate climate region 'N' [15] in Figure 3. Figure shows that, ITU-R predicted high rain rates in this region, this may be the reason for ITU-R method deviates largely with observed attenuation values.

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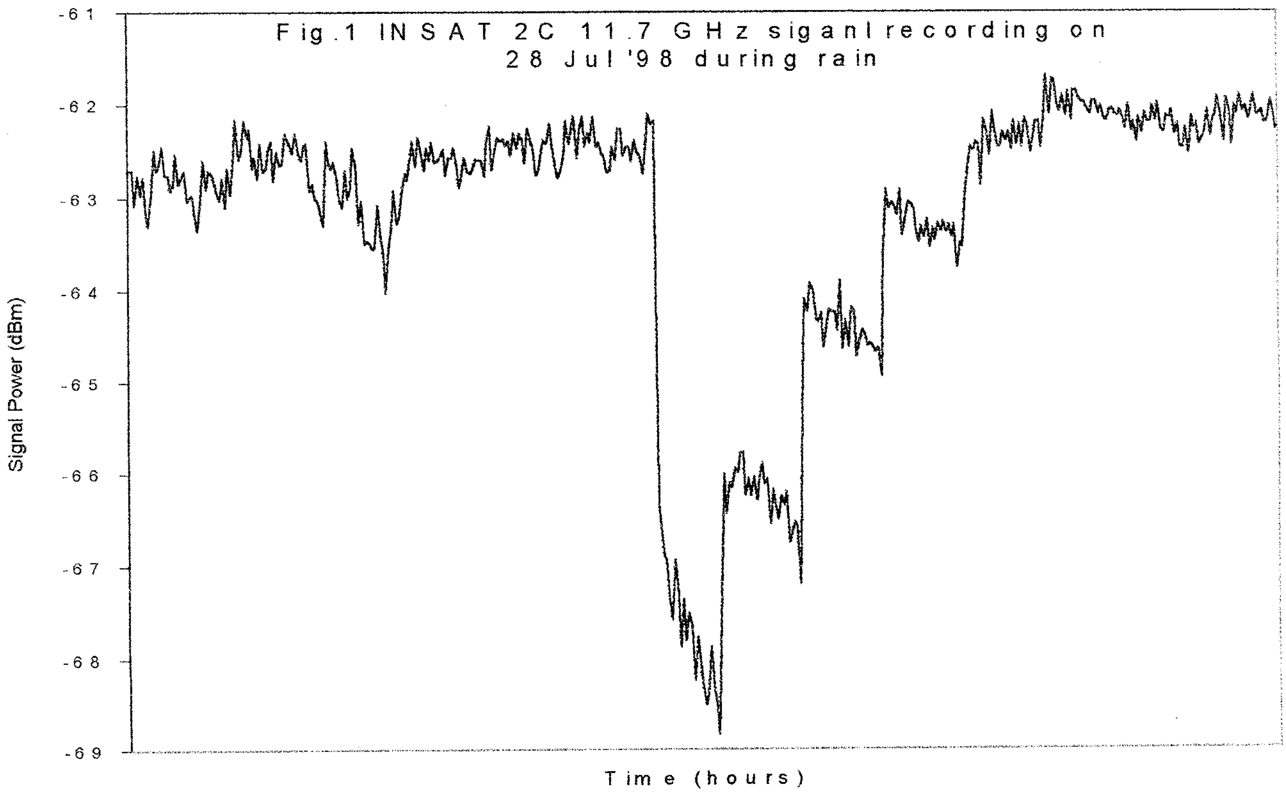

Fig.1 INSAT 2C 11.7 GHz siganl recording on 28 Jul '98 during rain

Fig.2 Power spectral density plot of the 11.7 GHz signal recorded on 25 Jul 1998

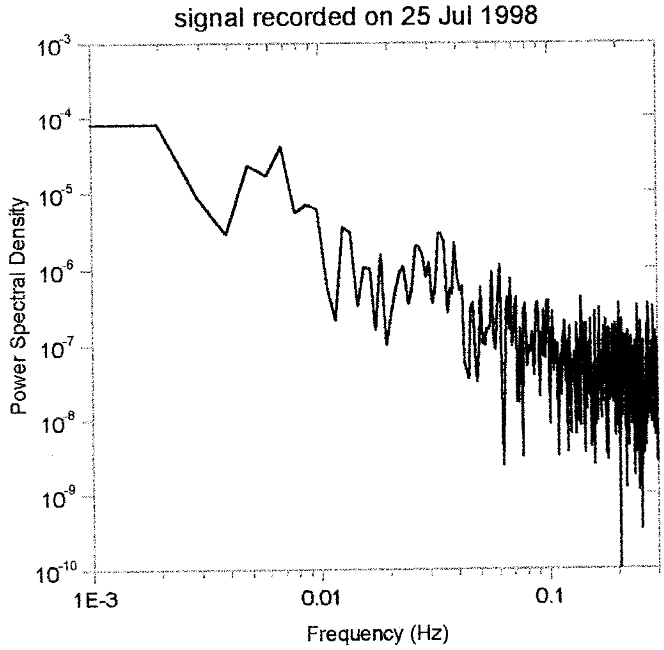

Figure.3 Comparison of attenuation predictions

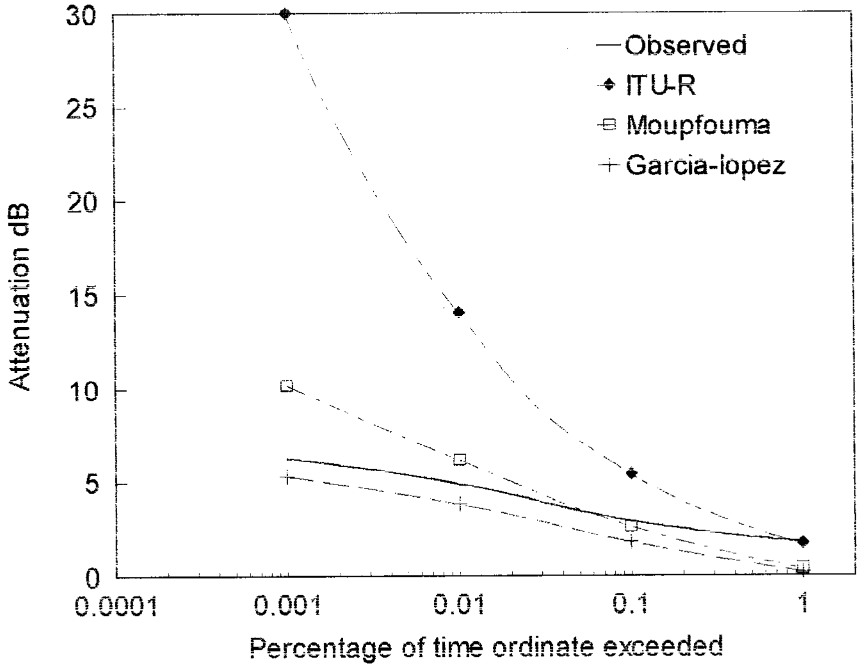

Figure. 4 Comparison of observed rain rate with ITU-R 'N' region rain rate