KU-BAND RAIN ATTENUATION OBSERVATIONS ON AN EARTH-SPACE PATH IN THE INDIAN REGION

Animesh Maitra[(1)] **and Kaustav Chakravarty**[(2)]

[(1)]*Institute of Radio Physics and Electronics, University of Calcutta, Kolkata 700009, India*
Email: animesh_maitra@yahoo.co.in

[(2)]*S.K. Mitra Centre for Research in Space Environment, University of Calcutta, Kolkata 700009, India*
Email: to_kaustav@yahoo.co.in

ABSTRACT

Measurements of rain attenuation over an earth-space path at Kolkata (22°34' N, 88°29' E), India, have been carried out since June 2004 by receiving a Ku-band signal from the satellite NSS-6 (geostationary at 95^0 E). The instantaneous attenuations are estimated from the point rain rates measured with an optical raingauge and using the Simple Attenuation Model (SAM). The estimated values closely follow the measured attenuations for rain rates below 20 mm/h, and at higher rain rates (> 30 mm/h) the measured attenuations are significantly lower than the model estimations. Experimental data over a year reveal that occurrences of both rain rate and attenuation at Kolkata are higher than that given by the ITU-R model.

INTRODUCTION

Measurements of rain attenuation at frequencies above 10 GHz over the earth-space paths have remained sparse in the Indian region, particularly in view of highly varying rain climate of the tropical region. The ITU-R model [1] for predicting rain attenuation in the Indian region is yet to be examined [2]. There are several factors that control the rain attenuation over the earth-space paths, namely, rain dropsize distribution, rain height and rain cell size. There are two aspects of rain attenuation studies over the earth-space links: (i) the instantaneous relationship between the rain attenuation and point rainfall measurements, and (ii) the statistical behaviour of rain attenuation vis a vis rain rate at a location. These studies are important for predicting the fade margin of a satellite link and optimize fade mitigation techniques, such as adaptive coding or modulation, data rate switching and power control.

In the present paper, some results of rain attenuation measurements of Ku-band signal received from a satellite obtained at Kolkata, India, are presented along with the measurements of rain rates and rain drop size distributions at the receiving site. Rain events are studied to examine the efficacy of predicting the slant-path attenuations from point rain rate measurements. Experimental data over a year have been utilized to obtain the cumulative distribution of rain rate and rain attenuation which are compared with the ITU-R models [3].

EXPERIMENTAL SET UP

Fig. 1 shows the experimental set up for the propagation studies at the Institute of Radio Physics and Electronics, University of Calcutta, Kolkata (22°34' N, 88°29' E), India. A Ku-band signal of frequency 11.172 GHz from the satellite NSS-6 (geostationary at longitude 95^0 E) is being received with a parabolic dish antenna of about 60 cm diameter. The elevation of the path is 62.5^0 and the receiving polarization is horizontal. The Ku-band signal is downconverted to a L-band signal by a low-noise block converter (LNBC) having noise figure 0.5 dB. The L-band signal is fed to a spectrum analyzer (model: HP 8590L) which is operated with zero time span at the peak of the received spectrum of the satellite signal and the output of the video filter is recorded with a data logger and stored in a PC. The calibration of the satellite signal is done using a X-band oscillator (model: HP 8620C) and a rotary vane attenuator. Further, the rainfall rate at the satellite receiving site has been measured by an optical raingauge (model: OSI ORG-815-DA) and recorded simultaneously with the satellite signal. The satellite signal and rain rate are recorded with a sampling interval of 10 sec. Also, rain dropsize distributions (DSD) are measured at the same site using a Josstype disdrometer (model: Distromet RD-80) with a minimum integration time of 30 sec. Experimental observations during the period June 2004 to May 2005 have been used in the present study.

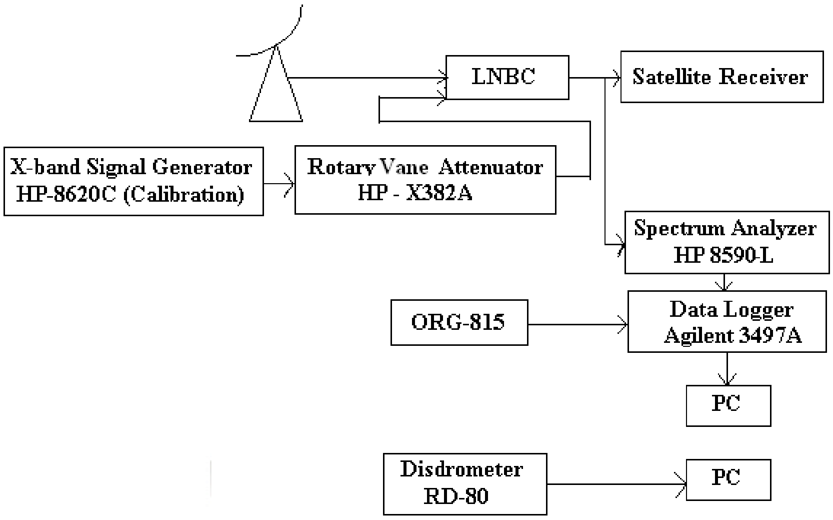

Fig. 1. Experimental setup for the earth-space propagation study at Kolkata

RESULTS

Fig. 2 shows a sample record of simultaneous measurements of attenuation and rain rate. An effort has been made to estimate the instantaneous attenuation over the earth-space path from the measurement of point rain rate using a rain attenuation model. The reliability of attenuation estimate depends on having a dependable model of the horizontal extension of rain cell and the effective rain height. Several models are available for these parameters which need to be tested for the present locations. For the present study, the Simple Attenuation Model (SAM) [4] has been used to

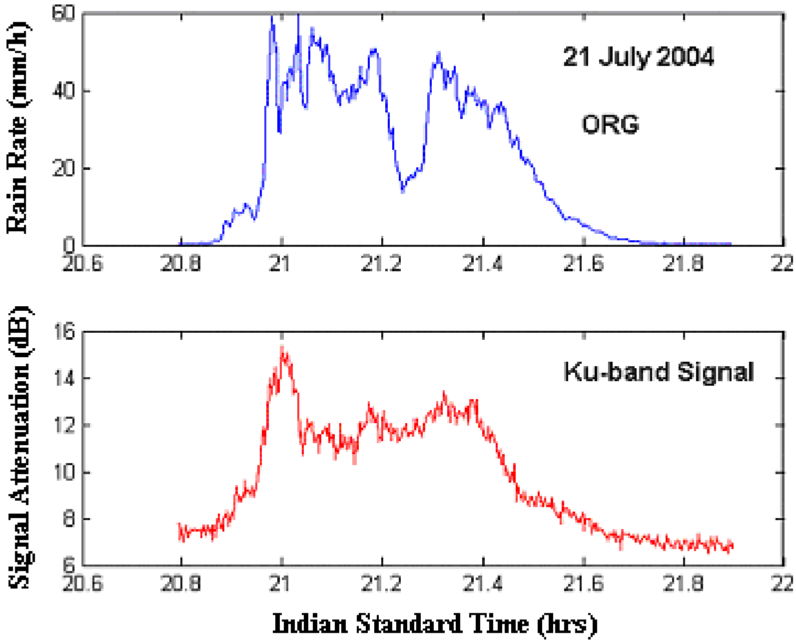

Fig. 2. Variation of Ku-band signal attenuation during a rain event

estimate the rain attenuation over the earth-space path from point rain rate measurements. Fig. 3 gives a typical comparison between the model-generated and the measured attenuations during a rain event. The model-generated attenuation has been found to closely follow the measured attenuation for rain rates below 20 mm/h. At rain rates higher than 30 mm/h, the model values are generally higher than the measured values, indicating that the effective path length through rain considered in the SAM model is greater than that is applicable for the present location at high rain rates. Sharp changes in rain rates are not reflected in the measured attenuations indicating that such changes occur locally and not over the entire satellite path.

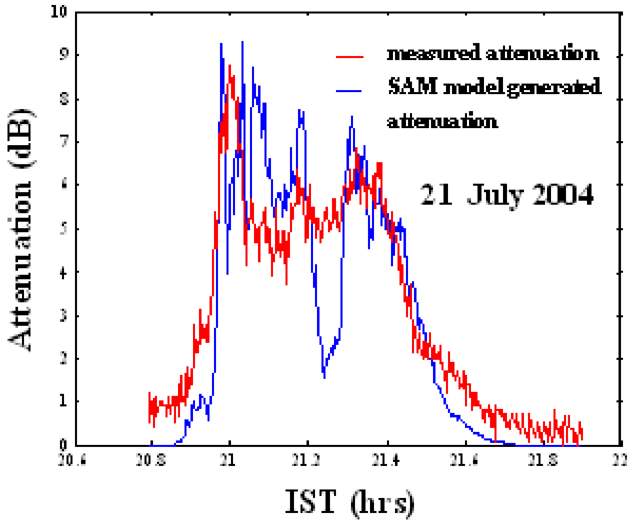

Fig. 3. Measured rain attenuation and SAM model-generated attenuation during a rain event

DSD measurements are used to calculate specific attenuations during rain events and they are compared with the values obtained with the ITU-R model. Fig. 4 gives such a comparison showing that the DSD-generated values are higher than the ITU-R values, indicating that the rain environment at the present location is significantly different from the ITU-R scenario.

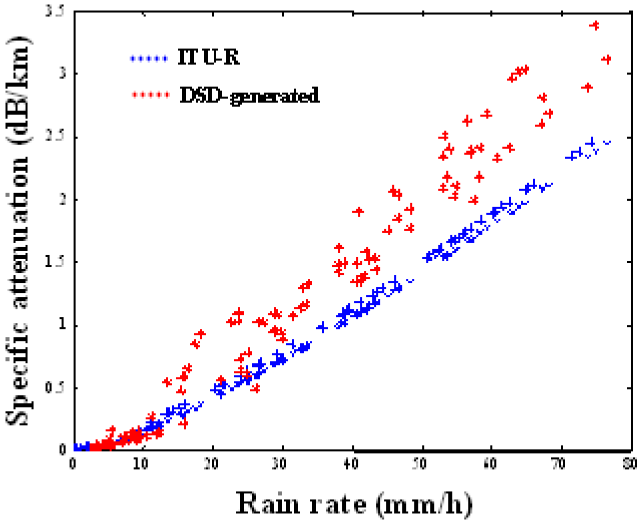

Fig. 4. DSD-generated and ITU-R model-generated specific attenuation during a rain event

Fig. 5 gives the cumulative distributions of the occurrence of rain rate and Ku-band attenuation over the present earth-space path obtained with the experimental data and with the ITU-R models [1,3]. It is found that the ITU-R models underestimate the occurrences of rain rate and attenuation at Kolkata.

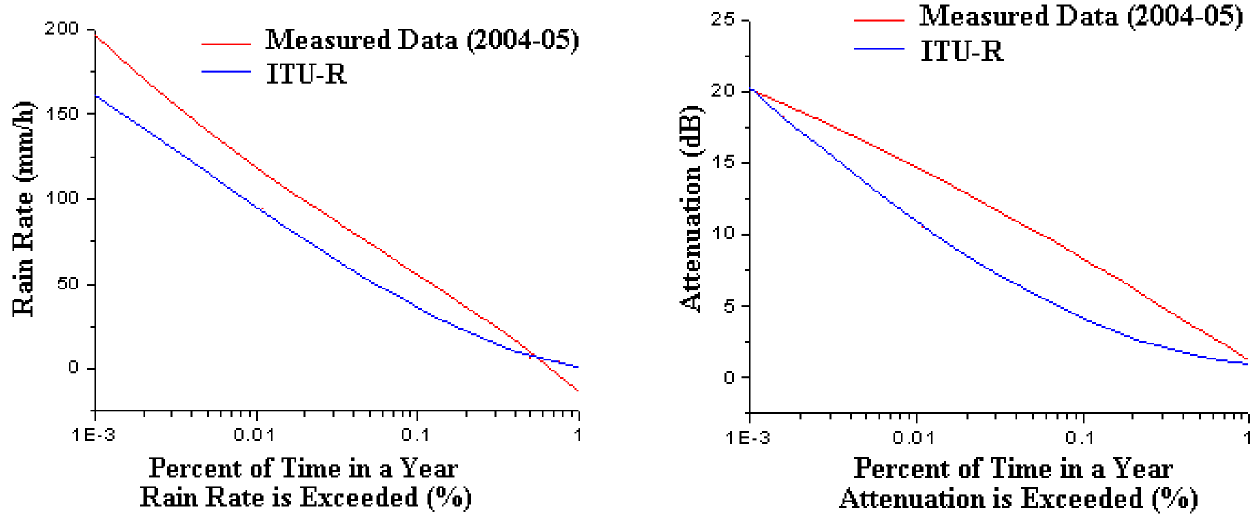

Fig. 5. Cumulative distributions of rain rate and Ku-band attenuation over an earth-space path for Kolkata obtained experimentally during June 2004 – June 2005 and from ITU-R models

CONCLUSION

Based on the experimental measurements, some features of rain attenuation at Ku-band over an earth-space path in the Indian region are presented. The attenuations calculated from point rain rate measurements using the SAM model compare well with the measured attenuations at rain rates lower than 20 mm/h, and at higher rain rates the modelled values are greater than the measured attenuations indicating that the effective path length considered for the model is higher than that is appropriate for the present location. The cumulative distributions show that the occurrences of both rain rate and attenuation are higher than that given by the ITU-R models at the present location.

ACKNOWLEDGEMENT

This work has been supported by a grant from the Indian Space Research Organisation (ISRO) for the project "Radio remote sensing of the tropical atmosphere" implemented through S K Mitra Centre for Research in Space Environment, University of Calcutta.

REFERENCES

[1] Recommendation ITU-R P.837-3, "Characteristics of precipitation for propagation modelling", *ITU-R Recommendations*, ITU, Geneva, 2001.

[2] A. Maitra, "Rain attenuation modeling from measurements of rain drop size distribution in the Indian region", *IEEE Antennas and Propagation Letters*, Vol. 3, pp. 180-181, 2004.

[3] Recommendation ITU-R P.618-8, "Propagation data and prediction methods required for the design of Earth-space telecommunication systems", *ITU-R Recommendations*, ITU, Geneva, 2003.

[4] W.L. Stutzman and W.K. Dishman, "A simple model for the estimation of rain-induced attenuation along earth-space paths at millimeter wavelengths", Radio Science, Vol. 19, pp. 946, 1984.