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Correlations of Scintillation Models at Different Frequencies in Ka-Band in Hilly Tropical Region

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***Abstract*-- In this paper, an analysis of the correlation of scintillation prediction models has been studied in Ka-band in a tropical hilly region using the propagation data at Shillong, India. Shillong is a tropical orographic region. The Ka-band beacon signal of the GSAT-14 satellite has been recorded for years at Shillong. Existing prediction models which have been mostly tested in temperate zones give erroneous results in the tropical hilly regions. An appropriate scintillation prediction model needs to be developed. It is established in this paper that the performance of the model also needs a scaling factor to validate the model at a different frequency in the band.**

Keywords—Scintillation, Orographic region, scale;

I. INTRODUCTION

Scintillation, the rapid change in the satellite signal occurs due to the fluctuations of metrological parameters like temperature, humidity, etc. Satellite link design in Ka-band needs a suitable scintillation prediction model. Different scintillation prediction models are available. But these models have been validated mostly validated in the temperate zones. References given below are the available studies of scintillation. Available prediction models give high percent errors when tested in tropical hilly regions. Very few experimental results are available in tropical regions. Here, a study of scintillation in Ka-band at different frequencies in a tropical orographic region has been conducted extensively. The selected place is Shillong, India. It is situated on a plateau at a height of around 5000ft from sea level. It is thus a tropical hilly region. The popular ITUR scintillation model has been modified and validated to give accurate prediction results in this area. A scaling factor has been introduced to suit this model at other frequencies in the same band..

II. EXPERIMENTAL DATA

Two Ka-band beacon signals of 20.2 GHz and 30.5 GHz of GSAT-14 satellite have been recorded for three years (2017-2019). A parabolic dish antenna with a diameter of 11 meters has been installed at an angle of 55 degrees. The sampling frequency was 10 Hz. Figure1 shows the data collection experimental setup. A High-frequency satellite signal is brought down to a lower level using the LNBC converter.

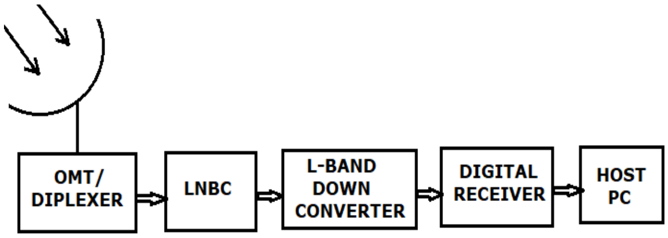

Fig.1. Experimental setup

Meteorological parameters like pressure, humidity, and temperature data of Shillong have been collected from the local Automatic Weather Station.

III. RESULT

The beacon signal of data 20.2 GHz and 30.5 GHz has been recorded from the year 2017 to 2019 at Shillong. The data has been analyzed and compared with the predicted values obtained from the following popular scintillation prediction models.

- ITU-R Model
- Vande Kamp Model
- Otung Model
- Karaswa
- Ortgies Models

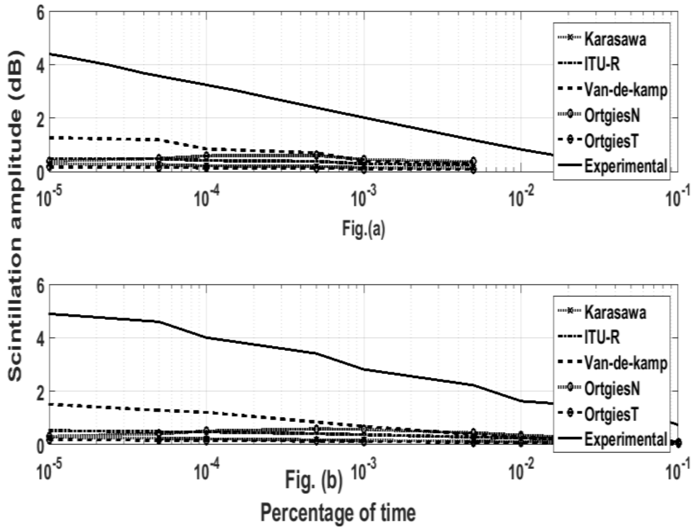

Fig. 1. Scintillation levels as observed and predicted at 20.2 GHz.

Figure 1 shows graphically the experimental and the predicted scintillation at 20.2GHz. Prediction model data is not matching with the actual data recorded.

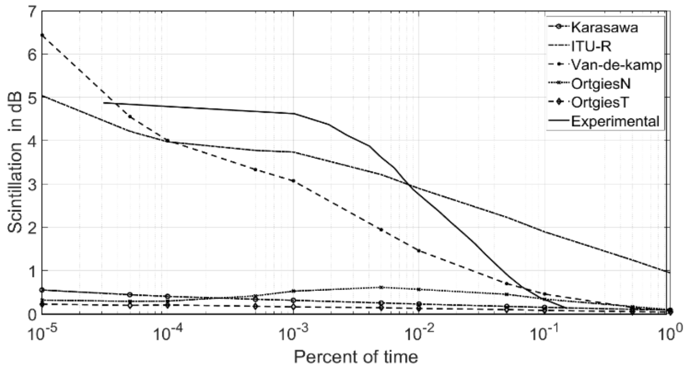

Fig. 2. Scintillation levels as observed and predicted at 30.5 GHz.

Figure 2 shows graphically the experimental and the predicted scintillation at 30.5GHz. In this frequency also the result is showing the distinct level of errors between actual and predicted models.

TABLE I
Performance of existing models

Name of the model	MSE	RMSE	Correlation Coefficient
ITU-R	6.2442	2.4988	0.971385
Karaswa	9.1111	3.01846	0.991277
Van de Kamp	4.288654	2.070907	0.991245
Ortgeis	4.559995	2.135415	0.972628

Table I shows the errors of the prediction models in reference to the actual data received.

The result shows distinct error levels between actual and predicted models. Most of the popular scintillation models have been validated in the temperate zone. These models need modifications to suit as prediction models in hilly tropical regions

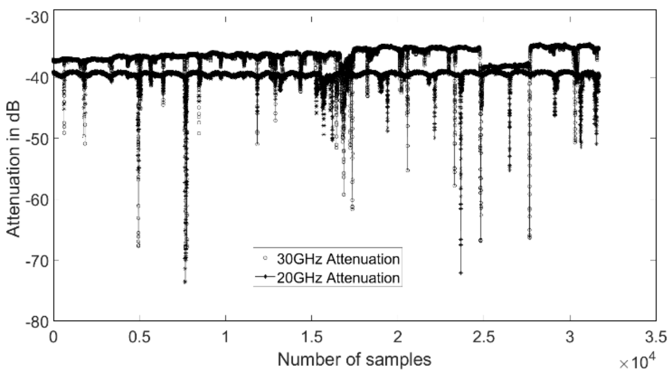

Fig. 3. First sample of attenuation as observed at 20.2 and 30.5 GHz.

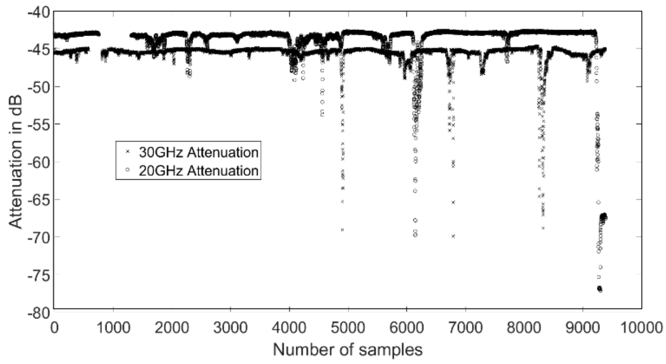

Fig. 4. A second sample of attenuation was observed at 20.2 and 30.5 GHz.

As shown in figure 3 and figure 4, attenuation and scintillation levels are different at 20.2 and 30 GHz.

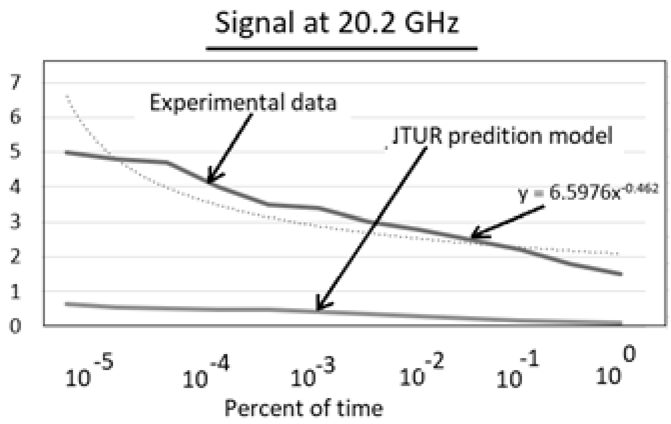

Fig. 5. Observed Scintillation level and ITUR prediction at 20.2 GHz.

Figure 5 shows the graph of the actual received data. Since the ITUR scintillation prediction model is mostly used. The result of ITUR is also drawn. We have drawn a graph that closely follows the actual data and derived an equation following the actual data. It is y= $6.976.x^{-0.462}$. This equation will closely follow the actual data received and we can consider this as a prediction model that will suit a tropical hilly region.

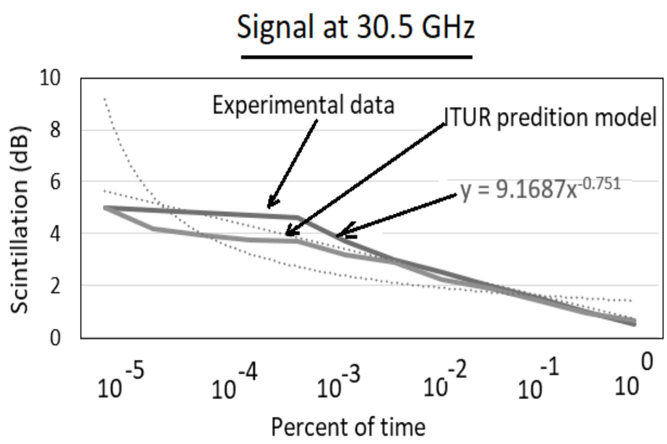

Fig.6. Observed Scintillation level and ITUR prediction at 30.5 GHz.

Figure 6 is the graphical representation of actual, predicted and formulated graphs at 30.5 GHz data.

TABLE II
Desired model performance at 20.2 GHz

Model 20.2 GHz	MSE	RMSE	Correlation Coefficient
Proposed Model 0f 20.2 GHz	0.2025	0.45	0.941

The power law-based model for 20.2 GHz derived from the graph 7 follows the equation

$y = 6.5976.x^{-0.452}$; where y = scintillation in dB and x relates to samples.

The results are tabulated in Table II.

TABLE III
Desired model performance at 30.5GHz

Model 30.5 GHz	MSE	RMSE	Correlation Coefficient
Proposed Model of 30.5 GHz	0.144	0.378	0.974

Power law-based model for 30.5 GHz derived from the graph 7 follows the equation

$y = 9.1687.x^{-0.751}$; where y = scintillation in dB and x relates to samples.

The results are tabulated in Table III.

The prediction model equation of 20.2 GHz needs a scaling factor to suit the 30.5GHz model. Frequency scaling on scintillation is on 30.5GHz based on 20.2 GHz is $1.3897.x^{-0.299}$.

CONCLUSION

The scintillation prediction model based on ITUR has been modified to suit tropical hilly regions. The scaling factor has been indicated to meet the prediction at a different frequency in the band. These have been validated with the data available with the data of different years.

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