**Analysis and Comparison of Tropospheric Scintillation Prediction Models at Covenant University, Ota, Southwest Nigeria**

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**Abstract**. Knowledge of tropospheric scintillation is an important phenomenon in the design of satellite communication systems especially in the case of signal propagation. One year of scintillation data from January 2015 to December 2015 extracted from Astra 2E/2F/2G Satellite link measurement installed at Covenant University, Ota (Lat: 6.7 oN, Long: 3.23 oE) Southwest Nigeria, at an elevation angle of 59.9o and a frequency of 12.245 GHz was used in this study. The analysis and the result were compared with some reputable scintillation prediction models to obtain the best performance model for Ota region. From the result, it was discovered that the Karasawa model gives the lowest percentage error rate for both fade and enhancement of about 0.57% at 0.1 percentage of time and 6.93% at 0.01 percentage of time respectively and therefore was best found fit for the prediction of propagation impairment for the region. However, the model should be tested further using higher frequency bands such as Ka and V bands to confirm the accuracy of the model. The information provided in this study is usefulin fade margin for antenna sizing and performance needed for satellite communication link in the region.

Keywords: Tropospheric scintillation, Attenuation prediction, Satellite communication, Ku band, Performance evaluation

## INTRODUCTION

Tropospheric scintillation occurrences transpire to be one of the key signal impairments that affect earth-satellite path [1-6] in modern earth-space communication systems, most importantly at higher frequency bands (both uplink and downlink). The influence of scintillation on radio wave signal transmission cannot be over highlighted due to its constant variation in phase and amplitude which affect signal power [7-8]. At short microwave or millimeter-wave bands, scintillation intensity increases with decrease in elevation angle, antenna size and with increase in frequencies [9]. Yet, the tropospheric scintillation is an intricate occurrence on earth-space transmission path, which includes the presence of gasses [10], and margin level up to altitudes of about 20 km within the tropical troposphere [11].

These disparities in turn transform the amplitude and phase of the received electric field. In fact scintillation intensity is a variable that can be influenced by atmospheric conditions [8], and the subsequent variability in tropospheric scintillation strength has a significant impact on the statistics of the scintillation process [12]. Also, tropospheric scintillation is acknowledged to show a robust correlation with some climatic parameters such as temperature, pressure and humidity [7].

## METHODS AND DATA ANALYSIS

The tropospheric data site is located at the Covenant University, Ota, Southwest Nigeria from Astra 2E/2F/2G beacon satellite 12.245 GHz (Lat: 6.7 oN, Long: 3.23 oE, Elev. Angle: 59.9o) at a sample rate of 1 second. The data for this study were measured from January 2015 to December 2015. However, the non-rainy days were separated from rainy days for the analysis by using Davis automatic weather station and

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spectrum analyser at rain rate 0 mm/h observed for non-rainy events, meanwhile the rain rate above 0 mm/h were removed from the corresponding days and time data within the period of observation because the rain rate above 0 mm/h indicate the presence of rain [please include a reference]. A monthly average data was used as reference data signal level and was subtracted from daily measured received data signal level to obtain the non-rainy attenuation on every one minutefor each clear-sky day [1]. Subsequent filtering procedure results in data which consists of +ve(positive enhancement) and -ve(negative fade) scintillation amplitude that is above or below the mean level respectively.

Also, the ground tropospheric scintillation measured data were compared with some of the existing scintillation prediction models. In this study, the considered models that predict the variance of signal log-amplitude are: ITU-R model [13], Karasawa model [14], Otung model [15], Van de Kamp model [16]. Finally, performance evaluation of each of the tropospheric scintillation was tested based on the fractional percentage error as presented in Eq. (1).

Error (𝜀) = 𝑝𝑟𝑒𝑑𝑖𝑐𝑡𝑒𝑑 −𝑚𝑒𝑎𝑠𝑢𝑟𝑒𝑑

𝑚𝑒𝑎𝑠𝑢𝑟𝑒𝑑

𝑥 100% (1)

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|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 1: Percentage error of the models check the caption format.. | | | | | | | | | |
|  | **% of time** | **ITU-R** | **Fade** | | | **Enhancement** | | |  |
| **Kasarawa** | **Otung** | **Van de Kamp** | **Kasarawa** | **Otung** | **Van de Kamp** |
|  | 0.01 | 55.77558 | 28.02516 | 190.9347 | -39.1306 | 6.92731 | 71.48973 | -31.7537 |
|  | 0.1 | 22.36777 | 0.570562 | 45.80179 | -54.7107 | -10.2135 | 1.607013 | -50.2639 |
|  | 1 | -2.97606 | -20.2577 | -25.8888 | -66.6068 | -24.1086 | -51.4064 | -64.6062 |
|  | 10 | -33.2918 | -51.3273 | -56.6163 | -78.5266 | -44.9347 | -98.2782 | -77.5358 |

## RESULT AND DISCUSSION

Table 1shows the tropospheric scintillation prediction models with statistical comparison between fade (negative signal) and enhancement (positive signal). It can be observed that Karasawa model gave the lowest percentage error for fade of about 0.57% at 0.1% of time and 28.03% at 0.01% of time respectively. The next model is ITU-R, which is of about 22.37% at 0.1%. Same was observed for enhancement at 0.01% of time for ITU-R. However, at 1% and 10% of time, ITU-R is observed to have the least percentage error. Figure 1 demonstrates the assessment of the ground data in Ota and several models’ prediction for both fade and enhancement, to understand the limits of each predicted model and the degree of validity in Ota region.

For fade signal scintillation amplitude, Karasawa model (0.1%) and ITU-R model (1%) showed a very close agreement with the ground data values in Ota almost for all percentage of time predicted. This was followed by Otung model, which slightly deviated from other models at 0.01%. The Van de Kamp model variance from other models may be attributed to the scintillation measurement during the presence of heavy clouds and rainfall. However, enhancement signal scintillation amplitude also shows a close relationship between measure data and Karasawa predicted model at all levels of percentage of time (most especially at 0.1%). This closeness may be because the model was developed during the non-rainy period with strong contribution from water vapour obtained from surface temperature and relative humidity [6]. No result for ITU-R model in enhancement was found because the model was only designed to yield result for signal fade.

scintillation amplitude (dB)

scintillation amplitude (dB)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| FADE  1.2 ITU-R  KASARAWA  1 OTUNG  VAN DE KAMP  0.8  OTA  0.6  0.4  0.2  0  0.01 0.1 1  Percentage of time (%) | 10 | ENHANCEMENT | | |  |
| 0.7 | | |  |
| KASARAWA |  | OTUNG |  |
| 0.6 VAN DE KAMP |  | OTA |  |
| 0.5 | | |  |
| 0.4 | | |  |
| 0.3 | | |  |
| 0.2 | | |  |
| 0.1 | | |  |
| 0 | | |  |
| 0.01 0.1 | 1 |  | 10 |
| Percentage of time (%) | | |  |

Fig. 1: Comparison of Ota data with Four existing models for fade and enhancement

## CONCLUSION

Evaluation of four existing clear-sky scintillation models namely: ITU-R, Karasawa, Otung and Van de Kamp models have been presented in this study. These existing models were compared with the ground data in Ota obtained from Astra 2E/2F/2G satellite beacon at 12.245 GHz located at Covenant University. The ground measurements from Ota have confirmed that Karasawa model gave the best prediction for tropospheric scintillation intensity for Ota and its environment. Explain and elaborate more which prediction model gives the best result in your analysis. Also suggest what can be done in future work.

## ACKNOWLEDGMENT

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The references are quite obsolete. If you can include more references after the year 2019 that would be good. Yes, I understand you must include the pioneer models, no problem, but you should also include the latest references as well. Please include these references if possible.

1) **Study of tropospheric scintillation effects in Ku-band frequency for satellite communication system(2020)**

2) Analysis of tropospheric scintillation in Ku-band in Malaysian

tropical climate(2022)

3) **[Tropospheric scintillation prediction models for a high elevation angle based on measured data from a tropical region](https://www.researchgate.net/publication/256423289_Tropospheric_scintillation_prediction_models_for_a_high_elevation_angle_based_on_measured_data_from_a_tropical_region?_sg%5B0%5D=SjWtB5c-I1R2isPYDxj-uvk-GiLtBgmbdvuSwk0WG2XxhoDUBF76tsTfy1kILz2ZougFhzQSxgX3-34Qv3gZG1GQhc4pq_7RwAYjrp-A.zhWYPP3ve60cIhSAx0lBDtIxLoBZNBQjUd-4qEAWBN0BTFPAxjQjAC0WIc0Ip21gbgPp7nnZjusHg5uW5ZTJWQ&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6ImhvbWUiLCJwYWdlIjoicHJvZmlsZSIsInByZXZpb3VzUGFnZSI6InByb2ZpbGUiLCJwb3NpdGlvbiI6InBhZ2VDb250ZW50In19)** (2013)

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