ATMOSPHERIC GASES ATTENUATION IN WEST AFRICA

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Abstract— **Atmospheric gases variations were evaluated to have major effect on Ku-band and above at 0.01 % unavailability of an average year on both uplink and down link. The International Telecommunication Union Radio Propagation Recommendation (ITU-RP 676, 2012) data bank was used for the computation of gaseous attenuation for West Africa. Monthly and yearly mean of temperature, pressure and relative humidity were used as input parameters obtained from ITU-R study group 3 data base. The results presented on contour map show that total atmospheric absorption signal fade attenuation values at C, Ku, Ka and V bands is between 0.015 to 0.09 dB, 0.04 to 0.9 dB, 0.04 to 1.4 dB and 0.2 to 3.2 dB respectively for both uplink and downlink frequencies. Generally, consistent signal absorption due to Oxygen and water vapour are higher in the western region than southern part of West Africa.**

I. INTRODUCTION

Atmospheric gases is one of major factors that affects signal impairment of satellite-to-ground and ground-to-satellite links at frequencies C-band (6/4 GHz), Ku-band (14/12 GHz), Ka-band (30/20 GHz), and V-band (50/40GHz) band. The two principal strong absorption lines at centimeters and millimeter wavelengths are water vapour and Oxygen. Although atmospheric gases due to oxygen and water vapour are negligible at frequency below 10 GHz, it become important at higher frequency bands. The absorption of both oxygen and water vapour is significant in the determination of transmitted power and antenna gain on global broadband communication services [1]. In the troposphere, radiowave propagation experience a reduction in signal level (attenuation) due to interaction with the gaseous components in the transmission path. Therefore it is imperative to note that when designing satellite communication system; signal degradation can be severe or sometimes minor depending on, temperature, pressure, relative humidity, frequency and water vapor concentration [2].

The investigations into this area of study are few in West Africa and previous predictions on atmospheric gases are based on temperate region data [3]-[5]. The study carried out in [5] at four different locations using Liebe's model revealed that a coastal region has higher specific attenuation than the inland region in Nigeria. Also [6] used contour map to show that atmospheric gases impairment is low; it ranges from 0.15 to 0.24 dB, 0.65 to 0.98 dB and 2.0 to 3.1 dB for ku-band, Ka-band V-band respectively and also confirmed that southwest has high gas fade than the northern Nigeria.

Many oxygen and water vapour attenuation studies have been carried out in other tropical regions using theoretical and experimental observation [8]-[11]. However, only few studies have been performed in tropical region of West Africa. Hence, to produce a West African based model, ITU-R 676 propagation model [12] was used for the computation of this studies.

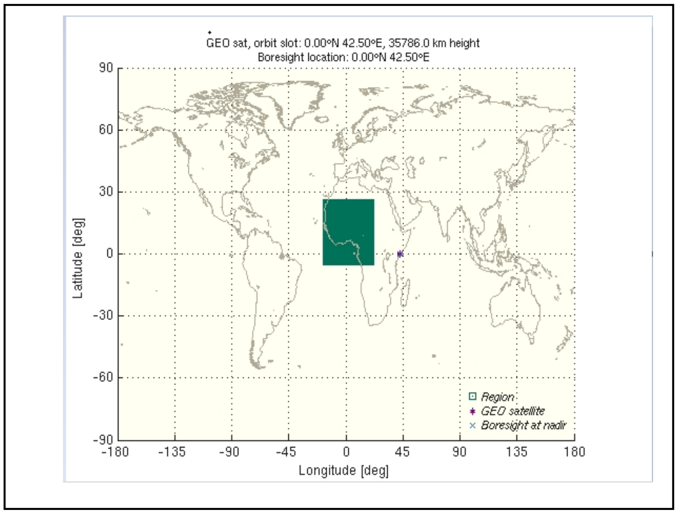

Fig. 1. World Map showing study area.

II. GASEOUS ATTENUATION DATA SOURCE

Figure 1 illustrates the meteorological Geo-satellite signal set up transmitted at longitude 42.5º E and latitude 0.00º N. A look angle to Nigeria was located in Ethiopia at a height of 35,786 km (position of the satellite). The data obtained using the International Telecommunication Union (ITU) data bank were based on indirect measurements. Daily measured data of surface temperatures, pressure, and relative humidity, have been used as input parameters for the study of oxygen and water vapour attenuation loss in West Africa. The gaseous attenuation is calculated along earth-space paths at C-band (6/4), Ku-band 14/12, Ka-band (30/20) and V-band (50/40) GHz frequencies. Matlab 7.0 was used to implement the equations in the procedure of ITU-RP 676 (2012) valid for frequencies between 1GHz and 350GHz.

TABLE I. SUMMARY OF THE RESULT

BAND (GHz)	OXYGEN ATTENUATION		WATER VAPOUR ATTENUATION	
	UPLINK (dB)	***DOWNLINK (dB)***	***UPLINK (dB)***	***DOWNLINK (dB)***
C	**0.04 - 0.09**	**0.04 - 0.09**	**0.012 - 0.09**	**0.005 - 0.016**
Ku	**0.04 - 0.11**	**0.04 - 0.11**	**0.1 - 0.3**	**0.05 - 0.19**
Ka	**0.1 - 0.26**	**0.04 - 0.15**	**0.5 - 1.45**	**0.4 - 1.8**
V	**1.4 - 3.4**	**0.25 - 0.6**	**0.7 - 2.2**	**0.6 - 1.5**

III. RESULT AND DISCUSSION

Table 1 depicted summary of results of Oxygen and water vapour attenuation for 0.01 % unavailability in an average year (53 minutes outage) at C, Ku, Ka, and V frequency bands respectively for both uplink and downlink. It also summarizes the minimum and maximum values of attenuation occurring simultaneously at all frequencies. At 99.99 % of the year, there is likelihood possible for West Africa to experience low atmospheric gases attenuation values between 0.006 dB to 0.09 dB for C-band; 0.04 to 0.3 dB for Ku-band; 0.04 to 1.4 dB for Ka-band and 0.2 to 3.2 dB for V-band. The consistency gas attenuation results shown in the Table 1 is a serious concern for earth-space satellite link, most especially at V band which is generally higher in western part (Senegal and Mauritania) than in the southern part (Nigeria, Ghana, Cameroon e.t.c) of West Africa. The result also suggest that under clear sky conditions (i.e without rain or cloud), 100% fadeout link could be experience if a satellite communication link is designed with a low margin of about 1dB for gas attenuation at V band in tropical areas.

IV. CONCLUSION

Studies on total atmospheric absorption due to Oxygen and water vapour on the earth-space path using ITU-R 676 propagation model at C, Ku, Ka, and V bands for uplink and downlink frequencies for West Africa are discussed and presented in this paper. The gaseous attenuation data used is based on meteorological data from AIRS satellites between the year 2002 and 2009. At C and Ku bands results suggest that 99.99 % availability is possible in West Africa because of their low signal fade between 0.04 to 0.09 dB and 0.04 to 0.1 dB respectively for oxygen and between 0.006 to 0.035 dB and 0.04 to 0.9 dB respectively for water vapour of the combination of uplink and downlink. But at Ka and V bands 0.01% unavailability is possible because of higher signal fade between 0.04 to 0.24 dB and 0.2 to 3.2 dB respectively for oxygen and 0.5 to 1.4 dB and 0.6 to 2.2 dB respectively for water vapour. Generally, gaseous attenuation has little effects at lower frequencies than other impairments like rain; however, it is major effect at higher frequencies in determining the link availability for satellite communication systems. The results in this work will help in planning and predicting transmission and reception of radio wave signals.

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