Analysis of the Effects of Atmospheric Attenuations on C, Ku and Ka Frequency Bands in Satellite Communication Using Fuzzy Logic

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ABSTRACT
The effects of atmospheric attenuations on frequency bands in satellite communication cannot be over emphasized. Atmospheric attenuations such as cloud, rain, oxygen and water vapor attenuations have much significant effect on the transmission and receiving of signals over satellite communication in the country especially in locations prone to rainfall. This paper analyses the effects of atmospheric attenuation over satellite communication in selected locations in the city of Aba, Nigeria. Rain fall, cloud and gas data were measured for a period of three months of which the data were used to determine what frequency bands are suitable for satellite communication within the areas during bad weather conditions. The International telecommunication union-Radio communication sector (ITU-R) attenuation standards were implemented in this study as mathematical descriptions and Matlab/simulink with the aid of fuzzy logic inference system is used to design and improve the signals received during satellite communication by selecting suitable frequency bands for signal transmission and also the affected rain parameter. The results presented in this paper was able to compare the elevation angle at various angles and also the specific gas attenuation for K-above (Ka), Kurtz-under (Ku) and C frequency bands, the results of these frequencies under the developed model also shows that the developed model would go a long way to mitigate attenuation issues in the telecommunication industry. The study also presents application of the improved model on selected locations in Aba city, Nigeria.

Keywords: **Atmospheric attenuation, rain attenuation, fuzzy logic, satellite communication, C, Ku, Ka bands.**

1. Introduction

Satellites are mainly space-based receiving and transmitting radios. They send electromagnetic waves which carry signals/information over long distances without using wires. Since its main work is to send signal from one place on the Earth to another, it therefore works as a radio-frequency repeater. A satellite therefore receives radio-frequency signals, collected from a dish on the ground, called a ground Station or Antenna. It then magnifies the signals, modifies the frequency and resends the signals from the satellite to different Earth Stations (Maval and Bousquet, 2002).

A satellite functions most effectively if the transmissions are directed to a desired area. When the desired area of coverage is focused, the emissions do not move away from the designated area and it minimizes the interference to the other systems. In designing a satellite, one of the major properties is on the ability to communicate with a ground station. Without a functioning communication link, most satellites are rendered useless. To ensure a proper satellite to ground link, one has to make estimations of the signal attenuation because of the distance to the satellite, atmospheric distortions and other system specific losses. An important aspect is noise originating in the system components and from general background radiation (Vangli, 2010).

Satellite based communication networks at high frequencies are rapidly expanding. These high frequency operations have enabled a large number of available applications and services including communications, navigation, telemedicine, remote sensing, network sensors distribution, and access to internet without the use

of wires. However, high frequency applications can generally result to large transmission problems because of atmospheric attenuations (Harb *et al*, 2012).

Satellites send signal using frequency bands. The most profitable bands presently used are C and Ku-bands. The application of a new band called Ka-band is expected to emerge in the nearest future. Generally, C-band uses frequency bands of 4-6 GHz which is usually applied for constant services like mobile feeder links, Internet Trunking and Public Switched Network. Ku-band uses frequencies of 12-18 GHz range which is widely applied in constant services like VSAT, serving small businesses and corporate networks that use a small transceiver which is directly connected to the satellite in star system topology. Ku-band serves video distribution applications and Internet trunking (Kota and Marchese, 2003).

Application of larger bands like the Ku band for satellite services offers so many advantages which include congestion reduction in the lower bands that are been distributed within terrestrial connections; it propagates larger available bandwidths at higher bands and offers lower cost application of spectrum conservation methods and a better utilization of the geostationary arc. (Sarat et al, 2008) posited that the increase in radio wave propagation increases frequency due to severity of atmospheric impairments. It therefore implies that in depth idea of the propagation study influencing availability of the system and quality of signal in different bands are required.

Rainfall causes attenuation of radio waves by absorption and by scattering of signal obtained from the wave and facilitate increase in the frequency that reduces the reliability and efficiency of the communication satellite link. Rain effects are dependent on frequency, rain rate, drop size distribution and drop shape, which are determined by the type of rain being witnessed in a particular region (Nethern *et al*, 2013).

Attenuation caused by rain is a primary source of impairment to information propagation at millimeter and microwave wavebands. These impairments become particularly severe at higher frequencies, especially beyond Ku-band. Because of this, it is very difficult to maximally utilize satellite-based network resources which are affected by weather attenuations. Therefore, there is need to adequately study important attenuation factors which influence quality of service and the application of fuzzy logic can be deployed over the system to enhance received signal over satellite broadcasting.

2. Literature Review

Ramachadran and Kumar (2006) examined modified rain attenuation model for tropical regions for Ku-band signals. In their work, rain attenuation predicted by ITU-R and Crane global models revealed remarkable deviation to the obtained values. The improvement to the ITU-R model for adopting in the tropics are mainly based on the properties that the accumulation period factor at the breakpoints is an invariant and at higher rainfall rates complex rain cells cross the slant path. Result of their work indicated noticeable agreement with the measured Ku-band attenuation in seven tropical sites. However, the work was based on modification of rain attenuation and not in any way suggests how to improve received signal from transmission link.

Kamal *et al* (2008) carried out intelligent weather systems using fuzzy logic controller for satellite communications. An intelligent decision support system was important for service providers by consistently evaluating fog, scintillation, cloud, rain, and gaseous attenuations applying predicted signal weather correlated database in combination with ITU-R propagation models joined with earth terminal and gateway characteristics. A three-dimensional relationship system was proposed among these attenuations with respect to rate of rainfall and angle of propagation. The results show that with fuzzy logic algorithm Quality of Service, QoS was improved by providing accurate estimates for different weather attenuations that leads to adjusting

SNR output in lieu of a wider range of rainfall rate and transmitted power for any specific frequency, propagation angle, transmission rate, gain and location.

Sarat *et al* (2008) investigated the prediction of Ku-band rain attenuation using experimental data and simulations. In the research, the results of rain attenuation experiment carried out at master Control Facility, at frequency of 11.544GHz in Ku band was given and the results of the measurements were compared with various rain attenuation models. Also, typical frequencies in Ku band which are in operation for various applications were selected for achieving the expected rain attenuation statistics using simulations and results were compared with ITU-R model. The results of the research show that the world wide used ITU-R method underestimating the rain attenuation, showing a difference of about 10dB but the research requires long term experimental data to predict the rain attenuation of the desired location since the data considered is only 4 months which may not provide accurate results.

Harb *et al* (2008) developed an intelligent weather aware scheme for satellite systems. The study aimed at estimating various attenuations using predicted signal-weather correlated database in conjunction with ITU-R propagation models joined with interpolation methods, earth terminal and gateway properties. The proposed method improves QoS by providing accurate estimates for different weather behaviours by improving the signal-to-noise ratio (SNR).

Ojo *et al* (2008) predicted rate of rainfall and attenuation due to rain for communication satellite in Ku and Ka bands. The researchers used contour maps with massive rainfall data of 30 years measured from coast to the arid region. The study was based on predictions and no attempt was made by the research to improving the received signals of satellite communications.

Kamal *et al* (2010), studied the improvement in satellite systems based on Markovian weather prediction for better performance. Prediction of rate of rainfall using weather obtained from environment agencies was carried out and the predictions were used for earth terminal and gateway for efficient control of channel properties. The use of markov theory provides important data to develop improved back propagation-learning algorithm to selectively tune the intelligent system to suit changes in climatic conditions. The efficiency of the algorithm was evaluated on a simulated model to activate the code point control and weighted modulation. The result shows that predicting channel attenuation caused by atmospheric conditions can improve the quality of service, QoS of satellite networks mostly during higher frequencies operations joined with gas and heavy rain attenuations. Also, it did not consider chosen adequate propagation indicators like modulation, coding, power, frequency and transmission rate for the given attenuation level so as to minimize digital transmission errors.

Sanjeev and Madhan (2011) researched on an experimental study of attenuation due to rain at Ku-band frequencies for an earth space path over Chennai. The rainfall data was applied to the proper ITU-R model and the degree of variation between the experimental and observed results for the attenuation encountered by the system have been recorded and tabulated. The results show an effort to provide experimental proof on the limitations of the existing model so as to help in the achievement of more India-specific models in the future but they did not consider the need to improve rain attenuation prediction and slight modifications in the ITU-R model itself to improve its prediction capabilities in the tropical regions such as Chennai.

3. Materials and Method

3.1 Materials
The materials used in the Research are:
- Coaxial Cable

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- Rain Gauge
- Stopwatch
- Compass
- Radiosonde
- Jperf; (Java Perf)
- Parabolic Reflector Antenna
- MATLAB/SIMULINK computing software
- Acer PC

3.2 Method

The method used follows from the procedures as listed in figure 1 which includes collection of data from the study area using the listed components in the material list above and analyzing the data collected using the proposed rain attenuation model in Matlab/Simulink. For performance analysis of the proposed model, comparison will be carried out for the performance of the model of different sections of the selected area for a period of about 3 months.

3.3 Channel Model

The general satellite system model contains three main components: earth station(s), satellite(s) and the link(s) between them (channel(s)). The channel and receiver models were created using MATLAB/SIMULINK.

For case study purposes, the city of Aba in Abia state of Nigeria has been chosen as a study area, however to investigate for satellite attenuation in this area and how atmospheric conditions affects satellite communication with different bands in the area. Atmospheric condition of these areas such as rainfall rate, rain height above sea level, liquid water content of rain drops, Temperature, relative humidity and so on were considered.

The satellite connection may suffer from poor signal quality due to atmospheric disturbances in the study area. Raindrops cause significant effects at higher transmission frequencies, especially above 10 to 250 GHz. Other atmospheric phenomena such as clouds, water vapor and oxygen significantly affect signal attenuation, especially at higher transmission frequencies. The models were implemented in Matlab/simulink based on the International Telecommunication Union (ITU) radio wave sector recommendations, which proved to be suitable for satellite communications.

3.4 Mathematical Modeling of the Rain Attenuation Model

The rain attenuation model shown in Figure 2 was created and implemented based on the modified ITU-R prediction model, however the model includes the Fuzzy logic inference system which acts as a decision scheme to select and adjust the satellite connection to the most band that favours a certain weather impairment within the selected location. In particular, the actually measured rain rate was applied in this paper instead of the predicted values of the ITU-R model to create a more accurate rain estimation model. The model will be implemented with Matlab. The initialization includes values for earth station position parameters (latitude and altitude above sea level), rain parameters (rain rate, rain height, and percentage of exceeding time p), and transmitter parameters (frequency f, elevation angle θ, and polarization angle τ)(Singh et al., 2017).

The developed simulink model performs two procedures simultaneously. The first method starts with obtaining the frequency-dependent rain damping empirical values before calculating the rain-specific coefficients r and ε as shown in equations (1) and (2).

$$r = \frac{r_H + r_v + (r_H - r_v)cos^2\theta \cos(2\tau)}{2} \qquad (1)$$

$$\varepsilon = \frac{r_H\varepsilon_h + r_v\varepsilon_v + (r_H\varepsilon_H - r_v\varepsilon_v)cos^2\theta \cos(2\tau)}{2k} \qquad (2)$$

Where, r_H, r_v, ε_v, ε_h, and k are the horizontal reduction factor, vertical reduction factor, vertical elevation angle, horizontal elevation angle and rain specific coefficient respectively.

The rain-specific attenuation (the rain attenuation per 1 km) is then calculated using Equation (3) dependent on the actual measured precipitation rate (at p = 0.01%) reported in (Al-Saegh et al., 2014) and not on the ITU predicted values in (Al-samawi et al., 2022)

$$\delta_{Rain} = \varepsilon(R_{0.01})^k \tag{3}$$

Where $R_{0.01}$ is the rainfall rate at precipitation rate of 0.01

This value will be applied in the second method to identify the effective path length as well as to predict the overall rain attenuation. The horizontal reduction factor (r_H) for 0.01% of the time can be calculated using Equation (4)

$$r_H = \frac{1}{1+0.78\sqrt{\frac{P_H \delta_R}{f}}-0.38(1-e^{-2P_H})} \tag{4}$$

Where P_H is the horizontal projection which depends on the slant path length and the elevation angle, while δ_R is the rain specific attenuation as imposed by Equation (5)

$$P_H = S_L \cos\theta \tag{5}$$

Where P_H is the horizontal projection, the slant path length S_L depends on the vertical height from the earth station to the rain height as well as on θ, as shown in Equation 6.

$$S_L = \begin{cases} \frac{H_R-H_S}{\sin\theta} & for\ \theta \geq 5° \\ \frac{2(H_R-H_S)}{\sqrt{\sin^2\theta+\frac{2(H_R-H_S)}{E_R}+\sin\theta}} & for\theta \geq 5° \end{cases} \tag{6}$$

Where H_R and H_S are the rain and earth station heights above sea level, respectively; and E_R is the earth radius (8500 km). The vertical change factor (V_F) can be calculated at 0.01% of the time using Equation 7 to 8.

$$\omega = \tan^{-1}\left(\frac{H_R-H_S}{P_H r_H}\right) \tag{7}$$

$$R_L = \begin{cases} \frac{P_H\ rH}{\cos\theta} & for\ \omega > \theta \\ \frac{H_R-H_S}{\sin\theta} & for\omega \geq 5° \end{cases} \tag{8}$$

$$V_F = \frac{1}{1+\sqrt{\sin\theta}\left[31\left(1-e^{\frac{\theta}{1-x}}\right)\frac{\sqrt{R_L\delta_R}}{f^2}-0.45\right]} \tag{9}$$

Where x depends on the latitude (φ) of the earth station(Olimer, 2018). The computation of the horizontal reduction and vertical change factors (V_F) in the ITU-R model is based on 0.01% of the time exceedance because these factors actually indicate the temporal variability of rain drop dimension and rain height, respectively. The effective path length (E$_L$) can be obtained using Equation 10, whereas the total rain attenuation at 0.01% of time ($A_{0.01}$) can be calculated using Equation 11 (Fiebig et al., 2004).

$$E_L = R_L V_F \tag{10}$$

$$A_{0.01} = E_L \delta_R \tag{11}$$

Consequently, the predicted rain attenuation at any percentage of time (p) can be calculated using Equation 12 and 13.

$$\begin{cases} 0 & if\ p \geq 1\%\ or\ |\varphi| \geq 36° \\ -0.005(|\varphi|-36) & if\ p < 1\%\ and\ |\varphi| < 36°\ and\ \theta \geq \quad 25° \\ -0.005(|\varphi|-36)+1.8-4.25\sin\theta & otherwise \end{cases} \tag{12}$$

$$A_{rain} = A_{0.01}\left(\frac{p}{0.01}\right)^{-[0.655+0.033\ln(p)-0.045ln(A_{0.01})-\beta(1-p)sin\theta]} \tag{13}$$

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Where, β is the signal bandwidth. The signal performance during rain events at different transmission parameters is analyzed along with received signal strength and error rates assessments (Fiebig et al., 2004).
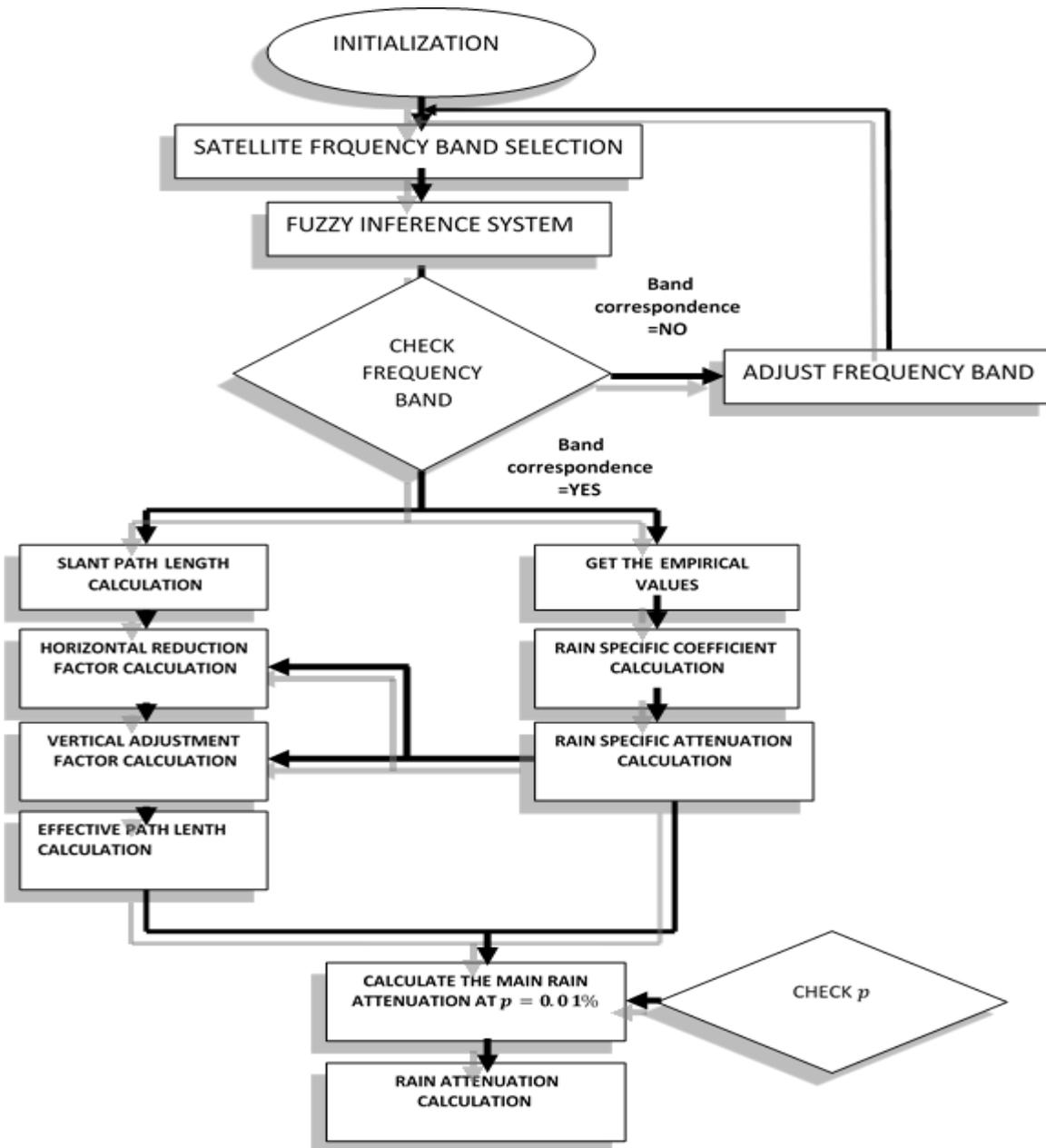

Figure 1: Rain attenuation model with fuzzy logic decision making

3.5 Mathematical Modeling of the Cloud Attenuation

The amount of liquid water content (LWC) contained in the cloud is also responsible for absorption and scattering of electromagnetic energy especially for frequencies above 10 GHz, but with less intensity than that of rain. Cloud attenuation, in addition to the transmission parameters such as the signal frequency and the elevation angle, rests on the cloud parameters such as average height and thickness, as well as the total columnar content of liquid water in Kg/m2 (liquid water contents LWC) and temperature(Singh et al., 2017). Figure 2 describes the block diagram of the cloud attenuation process to calculate liquid water content and temperature.

The cloud attenuation estimation model has been implemented based on the ITU-R models. The implemented model started with the initialization of the above-mentioned parameters.

However, the cloud specific attenuation coefficient δ_{cloud} can be calculated using Equation 14.

$$\delta_{cloud} = \frac{0.819f}{e''\left[1-\left(\frac{2+e'}{e''}\right)^2\right]} \tag{14}$$

The cloud attenuation at any probability depends on the LWC that can be obtained from radiosonde or radiometric measurements for the selected regions in ABA.

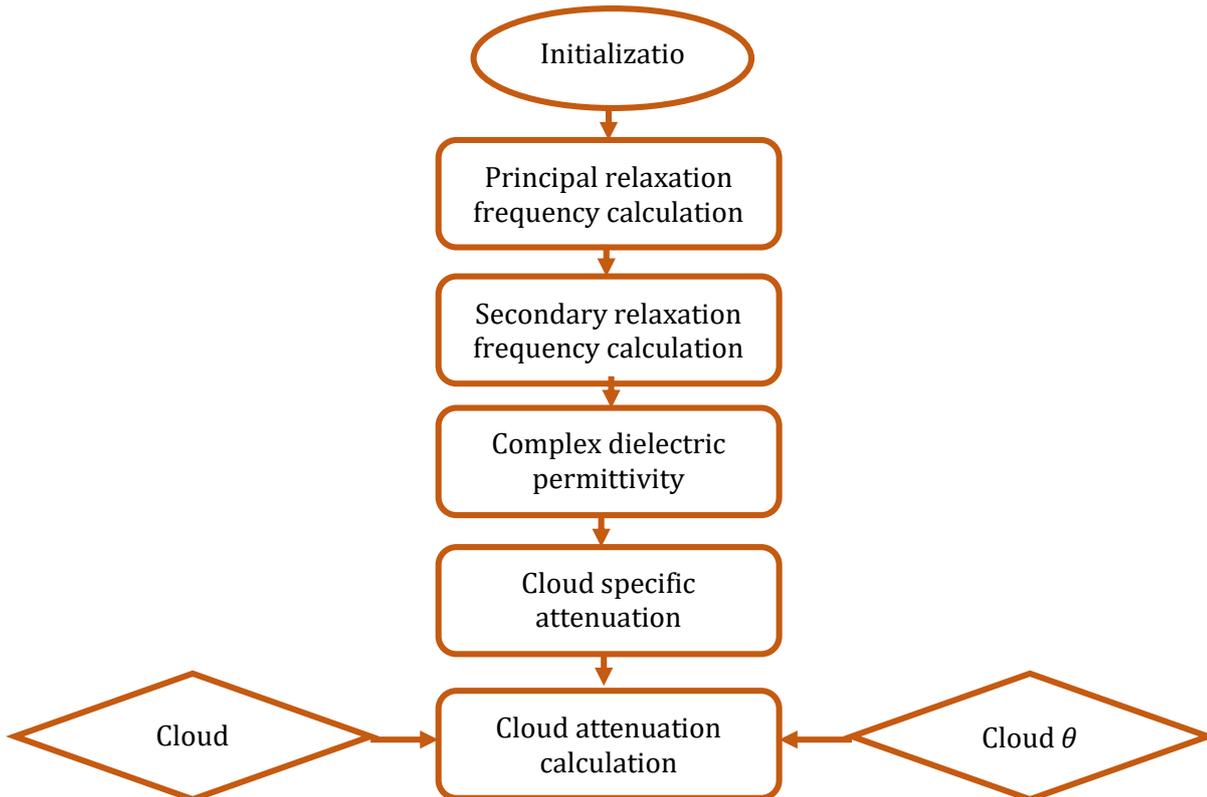$$A_{cloud} = \delta_{cloud}\left(\frac{LWC}{sin\theta}\right) \tag{15}$$

Figure 2: Cloud attenuation model

3.6 Water Vapor and Oxygen Attenuations Model

Equation 16 can be applied to calculate the water vapor specific attenuation (δ_w) in (dB/km).

$$\delta_w = f^2 r_T^{2.5}\rho[s_1 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9] \times 10^{-4} \tag{16}$$

Where s_1 to s_9 are the oxygen pressures in Par, r_T is the total rain rate.

The effective water vapor path length is based on the assumption of an exponential atmosphere to describe the relation between water vapor density and altitude. At this point, the total gases attenuation A_{Gases} (oxygen and water vapor attenuations) can be predicted using Equation 17.

$$A_{Gases} = \frac{A_o+A_W}{sin\theta} = \frac{\gamma_O L_O + \gamma_W L_W}{sin\theta} \tag{17}$$

Where $A_o, A_W, \gamma_O, L_O, \gamma_W, L_W$ are the oxygen attenuation, water attenuation, specific oxygen attenuation, length of oxygen, specific attenuation of water and length of water.

3.7 Simulink Implementation of the Rain Attenuation Model

The rain attenuation model used in this paper follows from the ITU-R standard rain attenuation calculation(Singh et al., 2017). The simulink implementation of the rain attenuation model is attached directly to the fuzzy logic decision maker for selection of parameter, the simulink implementation follows from equation (13) which has Matlab program from the slant length, rain height, percentage of exceedance time and elevation angle. The simulink implementation of the rain attenuation model is as shown in figure 3.
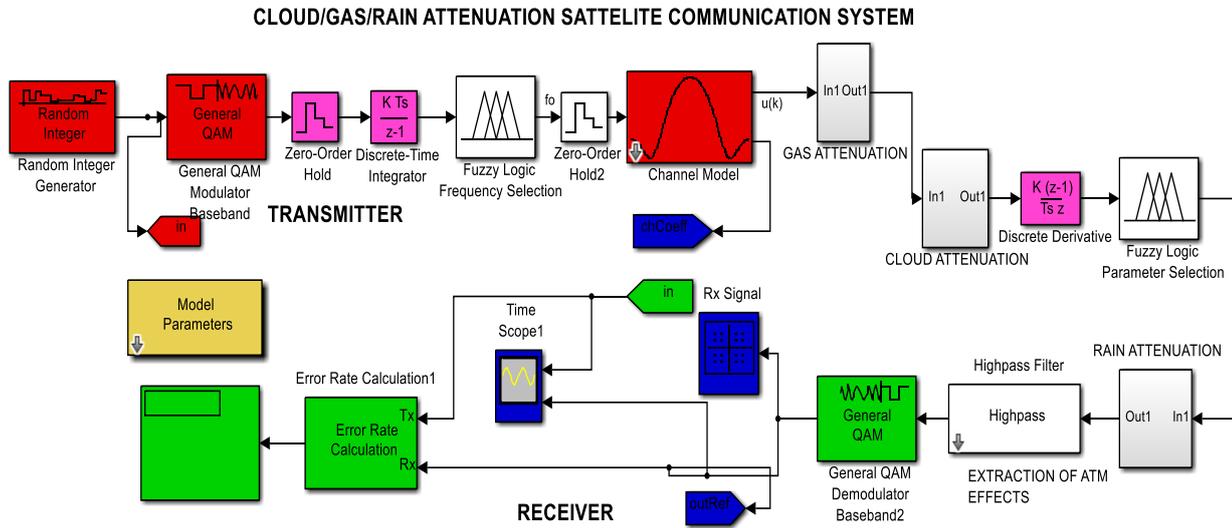

Figure 3: overall simulink implementation of the satellite communication system with attenuation models.

4. Results
4.1 Rain Attenuation Results

Table 1 tabulates the rain attenuation values at the frequency bands for different elevation angle, it can be seen from the table that the higher of the elevation angle, the lower the attenuation.

Table 1: rain attenuation values at C, Ku and Ka bands at different elevation angles

Percentage of exceedance time	@ Elevation angle =10 degree			@ Elevation angle =20 degree			@ Elevation angle =30 degree			@ Elevation angle =40 degree			@ Elevation angle =50 degree		
	C	Ku	Ka	C	Ku	Ka	C	Ku	Ka	C	Ku	Ka	C	Ku	Ka
0.010	14.0440	17.84080	25.32430	13.45070	17.67230	24.05440	14.37360	18.35890	26.18720	13.12440	16.62090	23.31440	12.70280	16.03920	22.36270
0.020	12.45470	16.050	22.9940	11.94060	15.29210	21.80480	12.8050	16.48620	23.80840	11.64880	14.87390	21.1110	11.26180	14.33560	20.22430
0.030	11.46380	14.8060	21.41860	10.98610	14.12870	20.28690	11.78530	15.25440	22.18190	10.70510	13.73480	19.6290	10.34250	13.22810	18.78860
0.040	10.73580	13.90920	20.23080	10.28250	13.26930	19.14760	11.04110	14.34170	20.9690	10.01590	12.89440	18.51830	9.67210	12.41240	17.71490

0.050	10.16450	13.20490	19.28180	9.73090	12.59120	18.2390	10.45670	13.61980	19.99290	9.4760	12.23180	17.63330	9.14740	11.79510	16.86040
0.060	9.69650	12.62480	18.49390	9.27940	12.03320	17.48550	9.97750	13.02480	19.18190	9.03430	11.68680	16.90	8.71840	11.24170	16.15310
0.070	9.30140	12.13310	17.8820	8.89860	11.56060	16.84340	9.5730	12.52040	18.48970	8.66190	11.22560	16.27550	8.35690	10.79510	15.55130
0.080	8.96080	11.70760	17.23740	8.57830	11.15190	16.28530	9.22390	12.08360	17.88720	8.3410	10.82670	15.70330	8.04550	10.40910	15.02870
0.090	8.66180	11.33340	16.72090	8.28240	10.79260	15.79260	8.91770	11.69930	17.35480	8.05970	10.47630	15.25410	7.77270	9.76820	14.56770
0.010	8.39630	11	16.25910	8.02680	10.47270	15.35230	8.65540	11.35690	16.87850	7.80990	10.16430	14.82640	7.53030	7.84510	14.15610
0.020	6.71150	8.86710	13.26730	6.40720	8.42490	12.50490	6.9170	9.1640	13.78870	6.22870	8.17330	12.06340	5.9990	6.79200	11.50140
0.030	5.79450	7.69340	11.59350	5.52720	7.30690	10.91590	5.97510	7.95560	12.05740	5.37060	7.08120	10.52380	5.16910	6.08550	10.02510
0.040	5.18160	6.90380	10.45640	4.93970	6.55280	9.83790	5.34510	7.1420	10.8880	4.7980	6.34790	9.48030	4.61590	5.56290	9.02560
0.050	4.72950	6.31850	9.60760	4.50670	5.99430	9.03410	4.88020	6.53860	10.0050	4.37620	5.80520	8.70260	4.20850	5.15320	8.28140
0.060	4.37570	5.85880	8.93710	4.1680	5.55590	8.39970	4.51620	6.06450	9.30550	4.04640	5.37930	8.08920	3.89020	4.81900	7.69470
0.070	4.08760	5.48340	8.38720	3.89240	5.19180	7.87970	4.21970	5.67720	8.73520	3.77810	5.03190	7.58650	3.63140	4.53870	7.21430
0.080	3.84640	5.16820	7.92560	3.66170	4.89790	7.44160	3.97140	5.35180	8.25420	3.55360	4.74030	7.16320	3.41480	4.29860	6.80990
0.090	3.640	4.89780	7.52470	3.46440	4.64040	7.06480	3.75890	5.07270	7.84020	3.36160	4.49050	6.79930	3.22970	4.08940	6.46230
0.10	3.46040	4.66210	7.17590	3.29270	4.41460	6.73550	3.57390	4.82930	7.47810	3.19470	4.27280	6.48130	3.06880	3.83300	6.15870
0.20	2.39480	3.25380	5.06960	2.27560	3.06740	4.74990	2.47560	3.37380	5.28930	2.20590	2.97470	4.56570	2.11660	2.84350	4.33220
0.30	1.86050	2.54030	3.98630	1.76640	2.4040	3.73110	1.92530	2.63560	4.16190	1.71150	2.31910	3.58410	1.64110	2.21520	3.39790
0.40	1.5190	2.08140	3.28260	1.44140	1.96550	3.07020	1.57170	2.16030	3.42890	1.39610	1.89820	2.94790	1.3380	1.81220	2.79310
0.50	1.27570	1.7520	2.77410	1.20950	1.65370	2.5930	1.31980	1.81910	2.89880	1.17110	1.59660	2.48890	1.1220	1.52370	2.35710
0.60	1.08970	1.5050	2.38350	1.03320	1.41570	2.22690	1.12180	1.55830	2.49140	1.020	1.36650	1.85590	0.957960	1.30360	2.02290
0.70	0.947740	1.3050	2.07150	0.893530	1.22660	1.93460	0.976160	1.3510	2.16580	0.864850	1.18370	1.85560	0.828120	1.12900	1.75640
0.80	0.822940	1.13170	1.81540	0.779780	1.07220	1.69490	0.852270	1.040	1.89850	0.754620	1.03450	1.62560	0.722420	0.986420	1.53800
0.90	0.72330	1.090	1.60120	0.68520	0.943460	1.49440	0.749190	0.920330	1.67480	0.662990	0.910150	1.43310	0.634570	0.867670	1.35550
1	0.639130	0.88553	1.41930	0.605330	0.834540	1.32490	0.62090	0.91320	1.48480	0.585040	0.804960	1.26970	0.560440	0.767250	1.2080

The higher the elevation angle, the lower the attenuation and therefore the higher the value of throughput Eb/No.(rate of attenuation in dB). It was observed that at the study area, bad weather attenuates satellite transmission to a large extent. Because during heavy rainfall (around 0.001% of annual time), bad channel quality imposes serious problems to the users of the satellite networks. This leads to communication link outage at lower elevation angles, θ. The elevation angle depends on the Eb/No along with the transmission bit rate and bandwidth. Figures 4 to 5 show that the higher the percentage of exceedance time, the lower the attenuation, also the higher the percentage of exceedance time, the lower the elevation angle. For rainy weather events, the higher the lower the elevation angle, the lower, the higher the rain throughput of Eb/No.
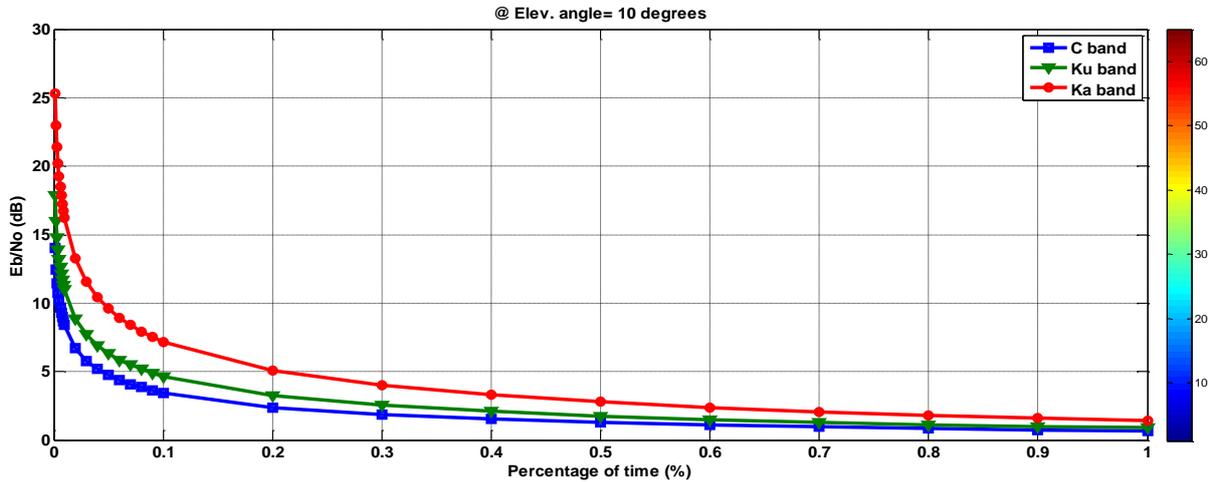
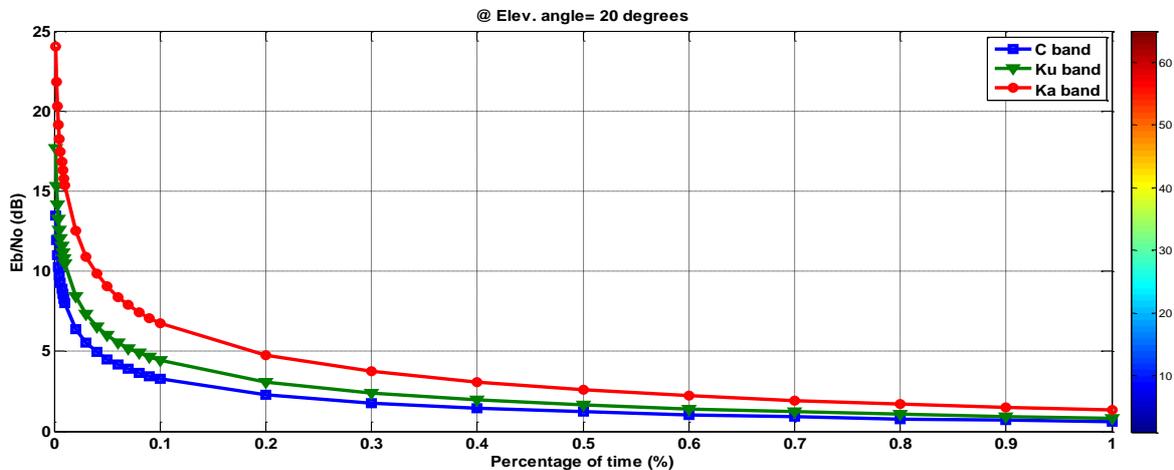Figure 4: plot of Eb/N with rainfall events for C, Ku and Ka frequency bands at 10º Elev. Angle

Figure 5: plot of Eb/N with rainfall events for C, Ku and Ka frequency bands at 20º Elev. angle
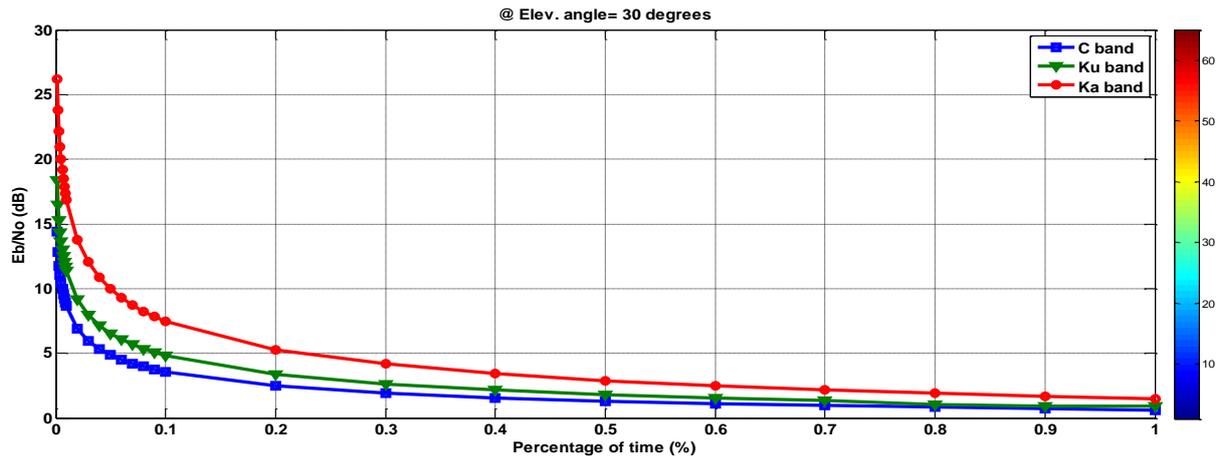
Figure 6: plot of Eb/N with rainfall events for C, Ku and Ka frequency bands at 30° Elev. angle
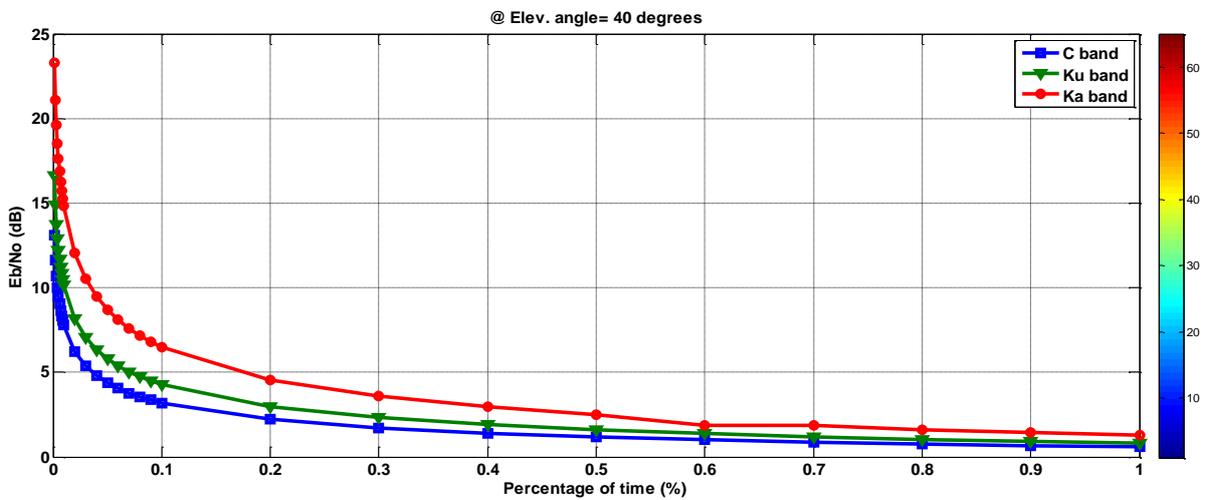

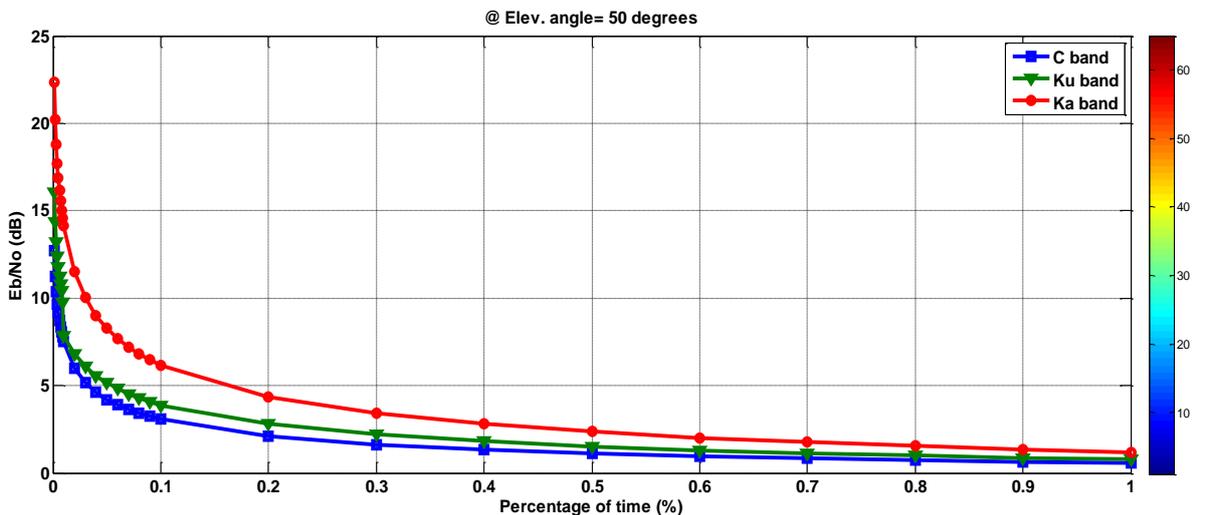Figure 7: plot of Eb/N with rainfall events for C, Ku and Ka frequency bands at 40° Elev. angle

Figure 8: plot of Eb/N with rainfall events for C, Ku and Ka frequency bands at 50° Elev. Angle

4.2 Total Gas Specific Attenuation Results

The significant amount of dry air and water vapor specific attenuation appears at specific regions across the frequency spectrum across the atmosphere of the selected locations in Aba, and hence the total correlated

gases attenuation at various relative humidity's are shown in figure 9, the gas attenuation is seen to increase as frequency increases from 250 GHz. For a significant increases in relative humidity of the gases(Al-Saegh et al., 2014).

The significant specific gas attenuation started at frequencies above 100 GHz mainly due to the effect of oxygen, and then the attenuation level went down. The effect appeared again at frequencies above 210, 310 and 410 GHz during selection by the fuzzy logic inference system, but this time mainly due to water vapor attenuation and the logic implementation to select the best frequency band at the expense of weather with varying relative humidity. The gases attenuation at fixed 50% RH reached higher level at approximately 415 GHz. The relative humidity (RH) is directly proportional to the amount of signal power attenuation due to the water vapor particles in space, and hence the total gases attenuation. However, the location such as Ogbor hill and Umungansi usually suffer from higher RH which indicates increased gases attenuation in the location.
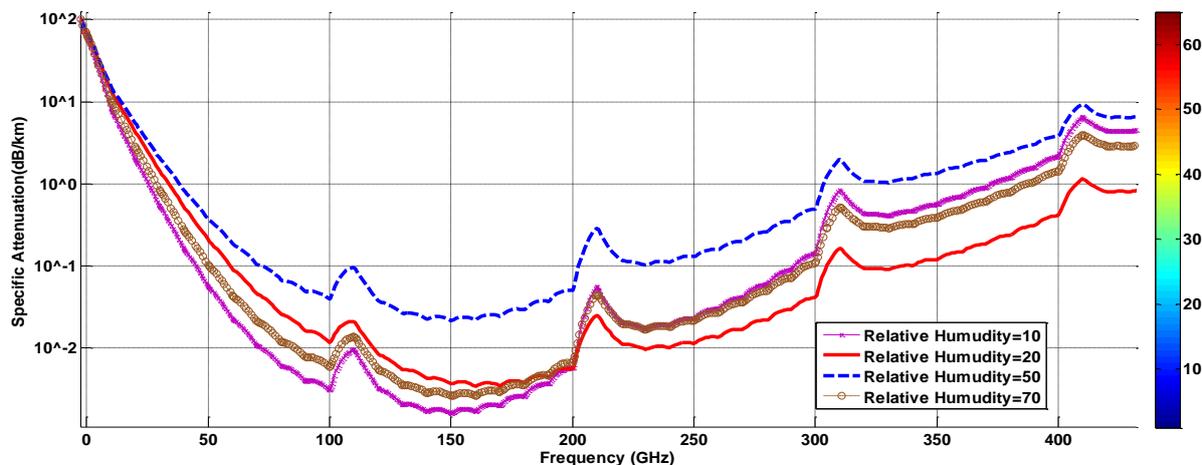

Figure 9: Total specific gas attenuation at various relative humidity

In conclusion, proper implementation of the attenuation model in the satellite communication will help initiate the effective selection of the frequency band that best suits the frequency band.

5. Conclusion

This paper presents effects of atmospheric impairments and its attenuation effects to the satellite signal quality in terms of performance evaluation and assessments/analysis concerning various effective atmospheric and transmission parameters during dynamic weather conditions

Models for cloud, gas and rain attenuation were developed based on ITU-R standard and these models were implemented using Matlab/simulink communication system tool box for satellite communication configuration. The results presented are able to compare the specific gas attenuation relative humidity and throughput at different elevation angle. Observations from the results show that the higher the percentage of exceedance time, the lower the attenuate, also the higher the percentage of exceedance time, the lower the elevation angle.

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