

The Impact of Ionospheric parameters on Space Communication in Ikeja airport and MTN Falomo Ikoyi, Lagos

Adedeji Adegoke Adetoyinbo

Department of Physics, University of Ibadan, Nigeria

Email: dejiade39@yahoo.com

December 4, 2024

Abstract

The effects of ionosphere on the various types of terrestrial communication on large and small scale in the mid-latitude were investigated in this study using appropriate and relevant standard techniques. The communication types are wireless/mobile for MTN and radar in airport. Three main factors that affect communication were identified (weather, frequency and attenuation) for Airport and MTN. Data of daily activities for the three factors per month were collected from January to August and the calculated average weather, frequency and attenuation values revealed that the Ionospheric parameters for the Airport was highest (13.6 MHz) in the month of August and lowest (13.2 MHz) in the months of January, February and July respectively. For NTN, the highest was 7.7 MHz in March while the lowest was 7.2 MHz in January, this shows that the communication company encounters lesser problem than the airport; therefore the communication company is able to manage and control the effect of Ionospheric parameters on space communication.

1. Introduction

The outer space has always fascinated people on the earth and communication through space evolved as an offshoot of ideas for space travel. In the area of space communications, the technology has been responsive to the imaginative dreams (John, 2003). Hence it is also expected that technological innovations will lead the evolution of space communications towards the visions of today. Before the transformation of the concept of communications by satellite to blue print and subsequent development of the hardware took place it was necessary to make the scientific communities convinced about the technical feasibility of such a system. (François, 2014) Antenna coupling, received power levels continually changes as a result of motion of relative motion between spacecraft and the Earth. The relative motion and important changes in communication either small or large have a major impact on level, length and the possibility of interference. (Jie, *et al.*, 2022) Real-time processing, transmission of data are needed in present satellite communications, elimination code interference also play a major role in high speed data transmission in satellite channel. Hence, the interference of code can be reduced by the application of equalizer.

The ionosphere consists of layers of ionized plasma trapped in the magnetic field which extends from 50 to 500 Km above the earth's surface, it is divided into bands such as D layers which extends from 45 to 55 miles (Waldock and Jones, 1987), E layers extends from 65 to 75 miles (Fenwick and Villard 1963), the F1 layers extends from 90 to 120 miles while the F2 layers covers 200 miles above

the F1 layer (Cander and Zolesi, 2004). F1 is the lower portion of F layer while F2 is the upper portion of F layer, (Cummer and Otuska, 2010) reported that for horizontal waves, the single-hop F2 can reach a distance of 3000 miles. The ionosphere is the ionized plasma from that is essential to sky-wave propagation and provides the basis for nearly all High Frequency (HF) communications beyond the horizon (John, 2005). The advantages of the HF band include inexpensive and widely available equipment and reasonably sized antennas. The ionosphere is the most important region of the Earth's atmosphere for long distance, point-to-point communications, also important in the study of satellite communications at higher frequencies (John, 2005). The ionospheric effects can obstruct satellite communication and ionospheric propagation can sometimes create interference between terrestrial communications systems operating at HF and even VHF frequencies, when signals from one geographic area are scattered or refracted by the ionosphere into another area (John, 2005). According to (Couch, 2001 and Newington, 1994) the ionosphere consists of several layers of ionized plasma trapped in the earth's magnetic field. Among the layers of the ionosphere, the electron density is highest in the F layers. The layers exist during the daytime and nighttime. During the day it is ionized by solar radiation, during the night by cosmic rays. The D layers disappear during the night compared to the daytime, and the E layers become weakened. System facilitating one way and/or two-way audio, video or data communication for users within a restricted geographical area with use of frequencies within the microwaves range and a relatively low power output, characterized in, that the system comprises at least two local terrestrial satellites (LTS) having high frequency communication equipment substantially corresponding to a conventional geostationary satellite utilized digital transmission techniques, the antenna system of each LTS being located spaced from remaining LTS serving the geographical area to be covered, said antenna system being preferably omnidirectional and arranged for transmission in a substantially horizontal plane, users of the system having directional antenna installation being able to select desired LTS by a change of the directional antenna in an horizontal, rotary plane or vertical plane of inclination thus facilitating that frequencies used by one LTS of the also are being used by any other LTS inclined in the system for similar or different communication purposes, thereby increasing the number of communication channels available within a given frequency segment to a substantially unlimited number of channels by inclusion of further LTS covering an intended geographical area.

Many of the systems affected by space weather are illustrated in just like terrestrial weather, space weather is pervasive and compensating for its impact is a challenge. Space weather exhibits a climatology which varies over timescales ranging from days to 11-year solar cycle and longer periods such as grand solar maxima and minima (Lockwood *et al.*, 2012). The instrument used to obtain data for weather is called weather counter and the component that constitute the disturbed weather are wind, rainfall, snow, humidity air temperature, e.t.c, (Astafyeva, and Afraimovich, 2006), point to point propagation of travelling ionospheric F2 layer disturbances, 26 December 2004, 58, 1025 – 1031, 2006).

The main objective is to determine the effect of ionosphere parameters in transmission of communication between space, the ground station and how it could be managed.

2. The study areas

The study area covers the confines of Murtala Muhammed International Airport Lagos Main Land, located on latitude 6°27' North and longitude 3°24' East and runs 22 km (14 miles) North West of Lagos State. It has two terminals which are MMIA and MMIA2 (local terminals) but MMIA, which is the International terminal is of interest in this work. Also covered in this work is MTN Nigeria communication which covers the confines of MTN Nigeria Lagos head office, located at Golden plaza Ikoyi Lagos Main Land, located on latitude 4°53' east and 2°25' North. The study

areas are shown in Figures 1 and 2 below.

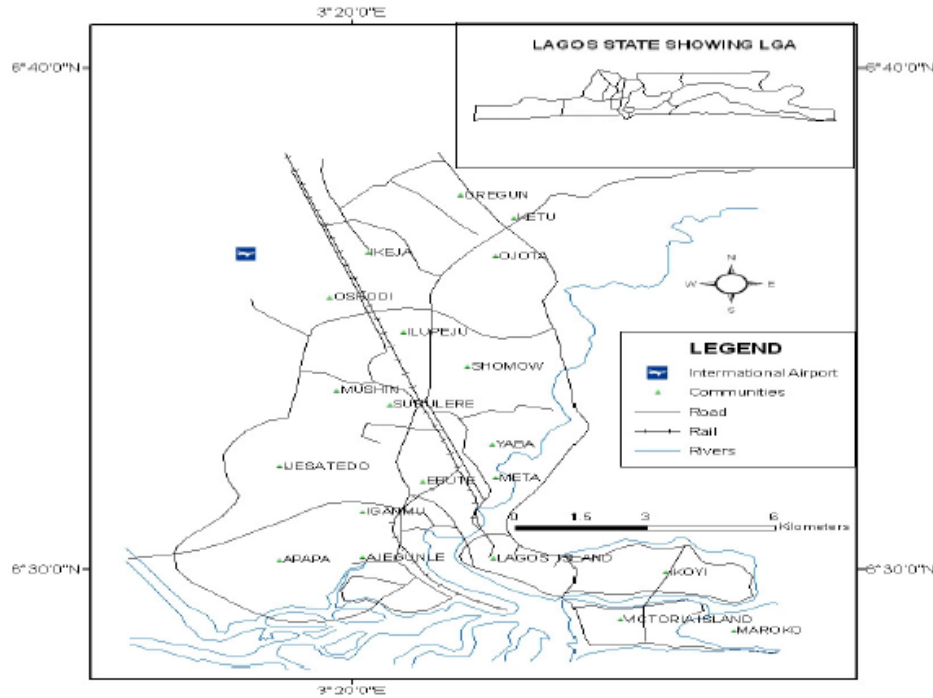


Figure 1: Ikeja Showing the Murtala Mohammed International Airport (MMIA). (Source Ethiopian Journal of Environmental Studies and Management Vol. 7 no. 3, 2014)



Figure 2: MTNN's Corporate Head Office-Lagos, Nigeria

2. Theory

2.1.1 Propagation of radio waves in the ionosphere

The mechanism of radio wave in the ionosphere is complicated than in the troposphere, when frequency is high, only electrons participate in the propagation of radio waves; the natural frequency of their oscillations (Langmuir frequency) is given by:

$$\omega_0 = \sqrt{4\pi Ne/m} \tag{1}$$

Where e is the charge, m , the mass of electron and N is the electron concentration respectively
 The dielectric constant ϵ , which is less than 1 for ionosphere is given in terms of frequencies by the equation below:

$$\epsilon = 1 - \omega_0^2/\omega^2 \quad (2)$$

Where ω_0 is the natural frequency and ω is the medium frequency

3 Results and Discussion

The ionosphere (F layer) which play an important role in the long distance point to point communication, identify three major factors affecting the signals which are (weather, frequency and attenuation).The instrument used in obtaining the data for frequency is called frequency counter and the component that constitute or affect frequency in the ionosphere are; snow wave, radiation, etc. the instrument use to store data for frequency is called storage facility, the component that constitute the effect are; rain, dust, wind, wave, etc. The results obtained from Ikeja airport and MTN Falomo, Ikoyi were discussed below.

3.1 Data obtained from Airport Ikeja

The data obtained from Airport Ikeja between the Months of January to August includes data of daily activities for the three factors per month and ranged between 4.0 – 4.9MHz. It was stated that if any factor falls within 1.0 – 3.8 MHz, it shows that the particular equipment is malfunctioning and need urgent attention and if it falls above 5.5 – 6.0 MHz, which means there will be difficulty in transmission of communication between the ground station and airport transport.

3.2 Data obtained from MTN, Falomo, Ikoyi

The data obtained from MTN between the Months of January to August includes data of includes data of daily activities for the three factors also per month and ranged between 2.0 – 2.9MHz. It was also stated that if any received data falls below 0.8 – 1.8 MHz, the equipment been used to obtain such data need a quick attention and if it falls above 3.5 – 4.0 MHz, which implies that there is difficulty in sending and receiving of calls.

3.3 Data analysis for airport

The data obtained contain three columns, first column is for weather, second column are for frequency and the third column are for attenuation. Between the month of January to August, three columns were located (weather, frequency and attenuation) which illustrate the lowest medium and highest value to a particular date.

Table 1: Weather, Frequency and Attenuation Data for data analysis for Airport

Month/Day	Weather MHz	Frequency MHz	Attenuation MHz	Sum MHz
January				
16 th -Lowest value	4.3	4.2	4.4	12.9
10 th -Medium Value	4.2	4.5	4.6	13.3
25 th -Highest value	4.9	4.3	4.4	13.6

Month/Day	Weather MHz	Frequency MHz	Attenuation MHz	Sum MHz
Average value = total sum/3 $39.8/3 = 13.3$				
February				
14 th -Lowest value	4.0	4.4	4.3	12.7
11 th -Medium Value	4.4	4.2	4.0	12.6
1 th -Highest value	4.9	4.9	4.5	14.3
Average value = total sum/3 $39.6/3 = 13.2$				
March				
24 th -Lowest value	4.0	4.2	4.4	12.6
11 th -Medium Value	4.2	4.2	4.3	12.7
10 th -Highest value	4.9	4.7	4.7	14.3
Average value = total sum/3 $39.6/3 = 13.2$				
April				
17 th -Lowest value	4.2	4.2	4.4	12.8
12 th -Medium Value	4.3	4.5	4.1	12.9
10 th -Highest value	4.9	4.8	4.9	14.6
Average value = total sum/3 $40.3/3 = 13.4$				
May				
22 th -Lowest value	4.1	4.3	4.3	12.7
10 th -Medium Value	4.5	4.3	4.5	13.3
6 th -Highest value	4.9	4.8	4.6	14.3
Average value = total sum/3 $40.3/3 = 13.4$				
June				
3 rd -Lowest value	4.2	4.3	4.3	12.8
26 th -Medium Value	4.5	4.3	4.3	13.1
23 rd -Highest value	4.9	4.7	4.7	14.3
Average value = total sum/3 $40.2/3 = 13.4$				
July				
26 th -Lowest value	4.2	4.0	4.3	12.5
18 th -Medium Value	4.2	4.5	4.2	12.9
10 th -Highest value	4.8	4.9	4.6	14.3
Average value = total sum/3 $39.7/3 = 13.2$				
August				
29 th -Lowest value	4.2	4.4	4.3	12.9
29 th -Medium Value	4.6	4.3	4.5	13.4
10 th -Highest value	4.8	4.9	4.9	14.6
Average value = total sum/3 $40.9/3 = 13.6$				

3.3.1 Data analysis for MTN

The data set obtained contains three columns as in Table 1. Between the month of January to August

Table 2: Weather, Frequency and Attenuation Data for data analysis for MTN

Month/Day	Weather MHz	Frequency MHz	Attenuation MHz	Sum MHz
January				
24 th -Lowest value	2.0	2.1	2.0	6.1
10 th -Medium Value	2.5	2.3	2.5	7.3
18 th -Highest value	2.9	2.6	2.6	8.1
Average value = total sum/3 $21.5/3 = 7.2$				
February				
7 th -Lowest value	2.0	2.4	2.2	6.6
27 th -Medium Value	2.5	2.4	2.3	7.2
19 th -Highest value	2.9	2.8	2.7	8.4
Average value = total sum/3 $22.2/3 = 7.4$				
March				
20 th -Lowest value	2.4	2.3	2.5	7.2
14 th -Medium Value	2.5	2.4	2.5	7.4
19 th -Highest value	2.8	2.8	2.9	8.5
Average value = total sum/3 $23.1/3 = 7.7$				
April				
17 th -Lowest value	2.0	2.1	2.4	6.5
15 th -Medium Value	2.4	2.5	2.3	7.2
26 th -Highest value	2.9	2.9	2.7	8.5
Average value = total sum/3 $22.2/3 = 7.4$				
May				
31 th -Lowest value	2.3	2.2	2.1	6.6
11 th -Medium Value	2.6	2.2	2.3	7.1
18 th -Highest value	2.8	2.7	2.9	8.4
Average value = total sum/3 $22.1/3 = 7.4$				
June				
12 th -Lowest value	2.0	2.1	2.3	6.4
2 nd -Medium Value	2.4	2.3	2.3	7.0
7 th -Highest value	2.8	2.5	2.6	7.9
Average value = total sum/3 $21.3/3 = 7.1$				
July				
12 th -Lowest value	2.0	2.3	2.5	6.8
1 st -Medium Value	2.5	2.4	2.2	7.1
29 th -Highest value	2.8	2.9	2.9	8.6
Average value = total sum/3 $22.5/3 = 7.5$				
August				
31 st -Lowest value	2.3	2.4	2.1	6.8
23 rd -Medium Value	2.2	2.5	2.4	7.1
4 th -Highest value	2.9	2.8	2.8	8.5
Average value = total sum/3 $22.4/3 = 7.5$				

3.3.2 Distribution chart for the Months of January to August for Airport

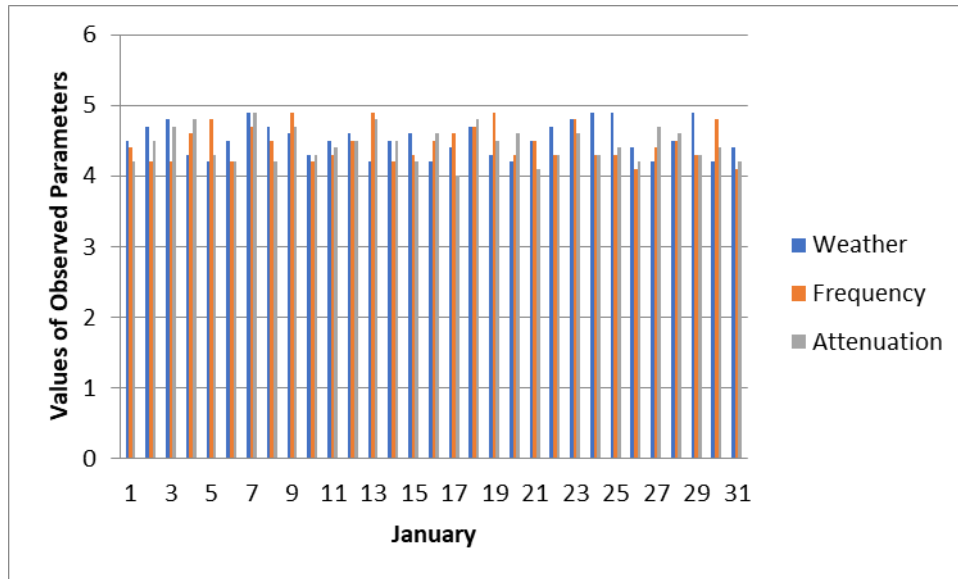


Figure 1: Graph of observed parameters against month of January (Airport)

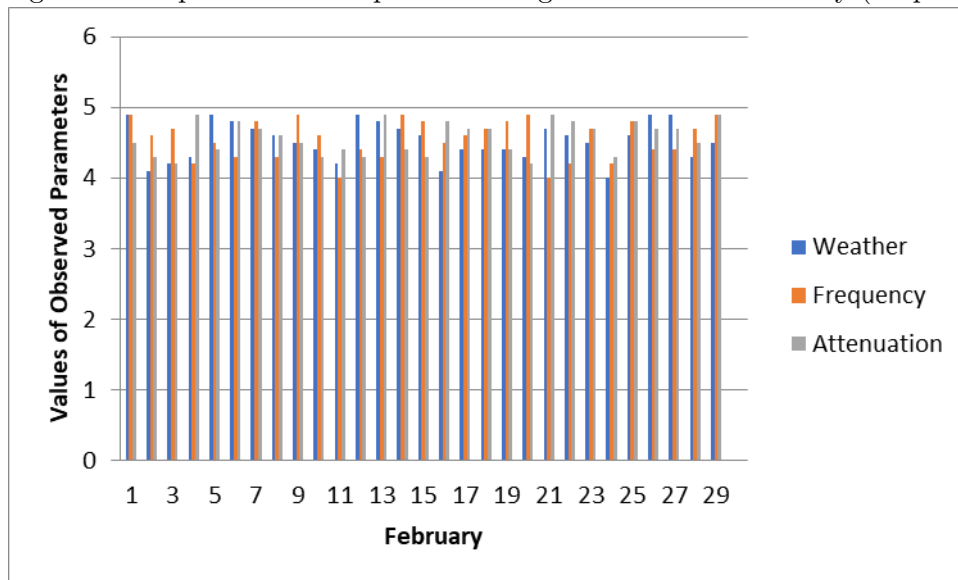


Figure 2: Graph of observed parameters against month of February (Airport)

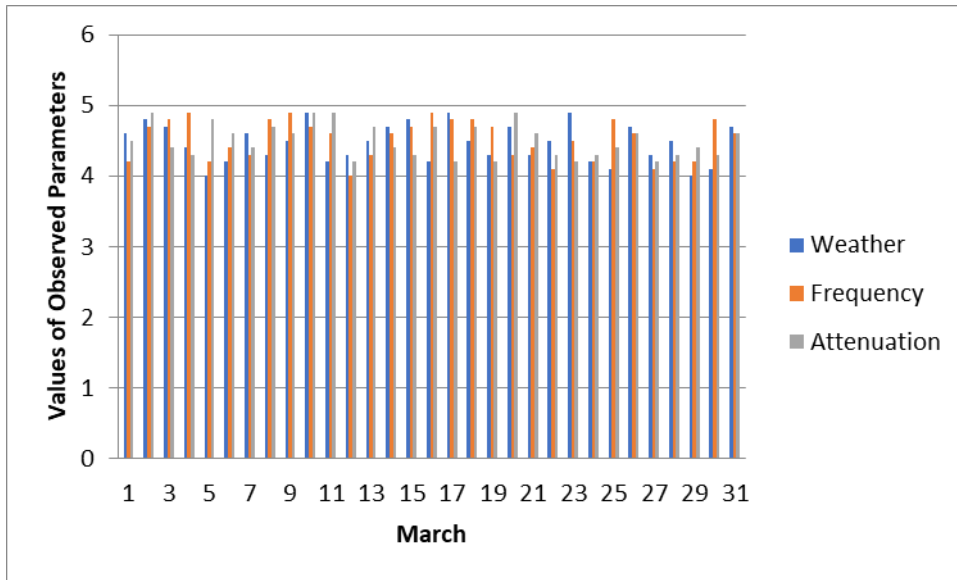


Figure 3: Graph of observed parameters against month of March (Airport)

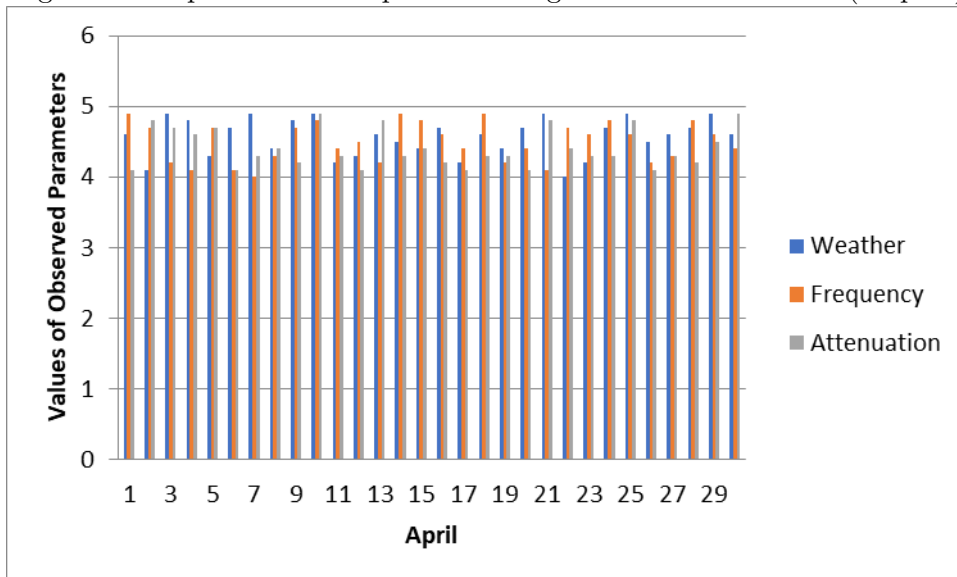


Figure 4: Graph of observed parameters against month of April (Airport)

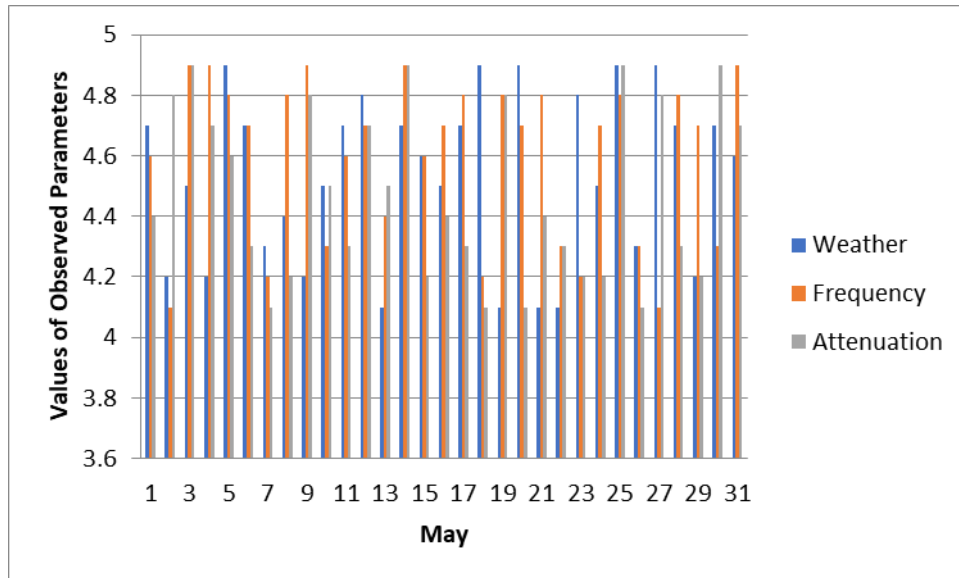


Figure 5: Graph of observed parameters against month of May (Airport)

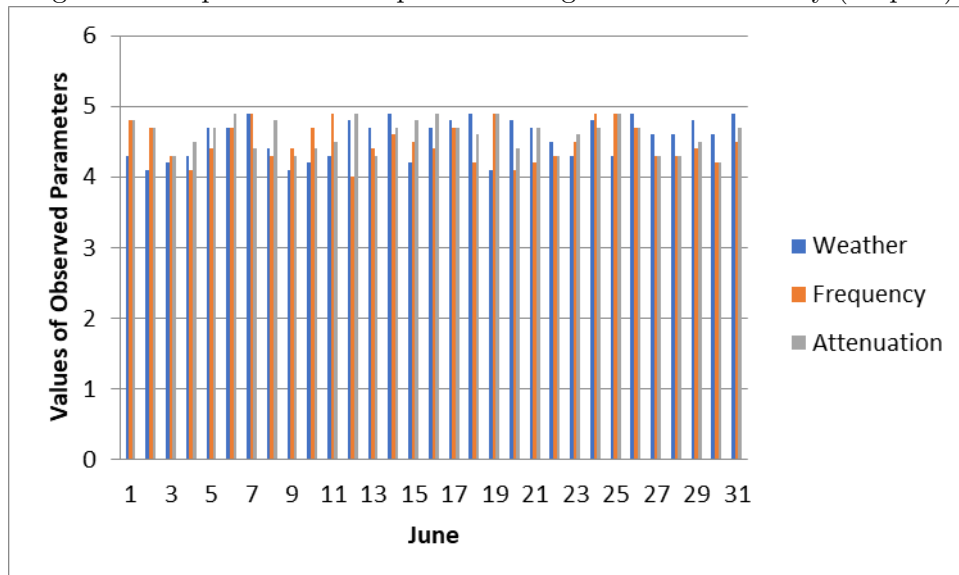


Figure 6: Graph of observed parameters against month of June (Airport)

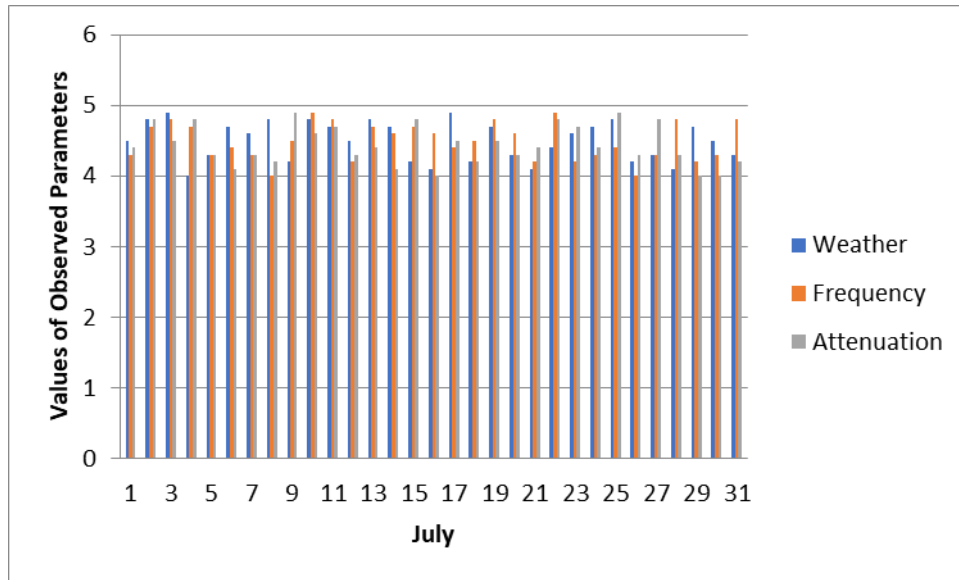


Figure 7: Graph of observed parameters against month of July (Airport)

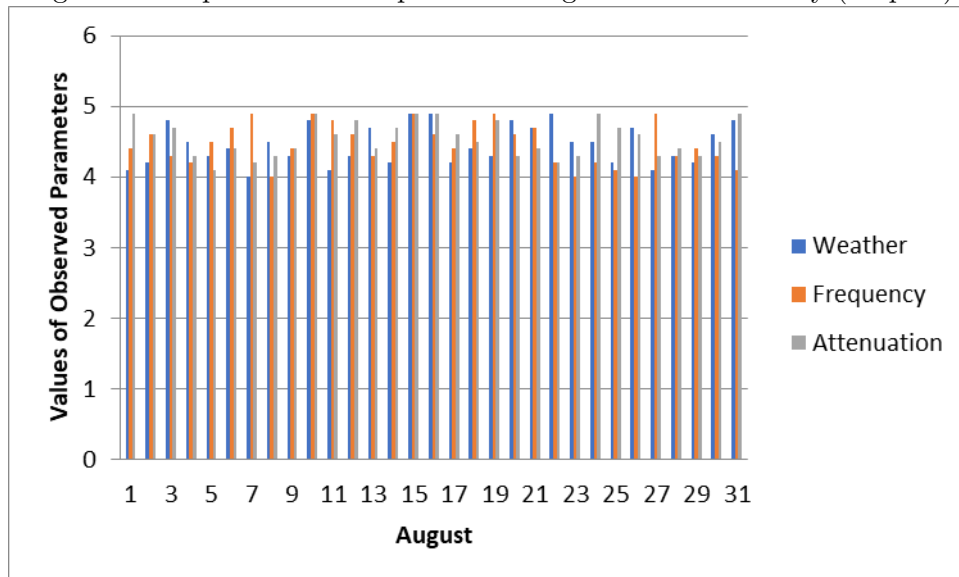


Figure 8: Graph of observed parameters against month of August (Airport)

3.3.3 Distribution chart for the Months of January to August for MTN Falomo

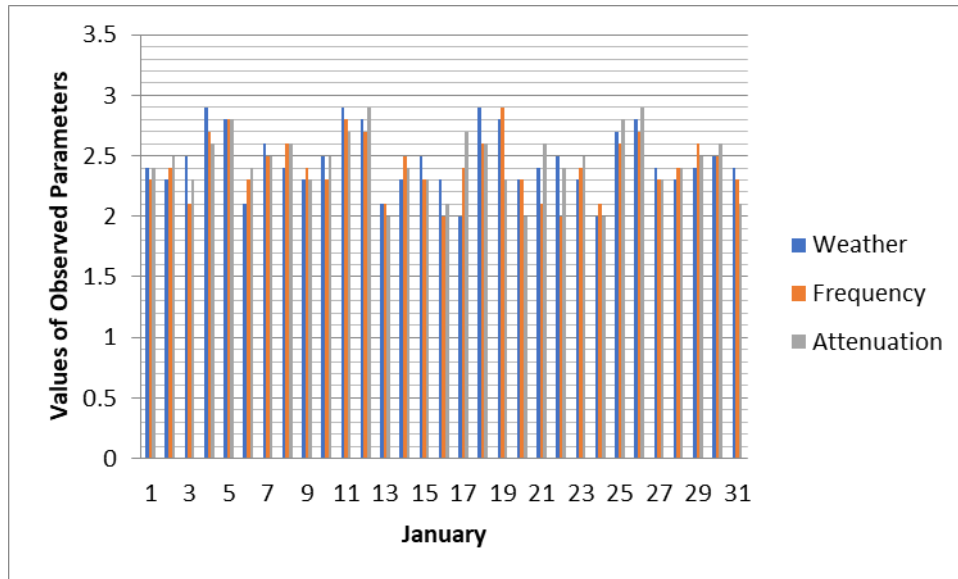


Figure 9: Graph of observed parameters against month of January (MTN Falomo)

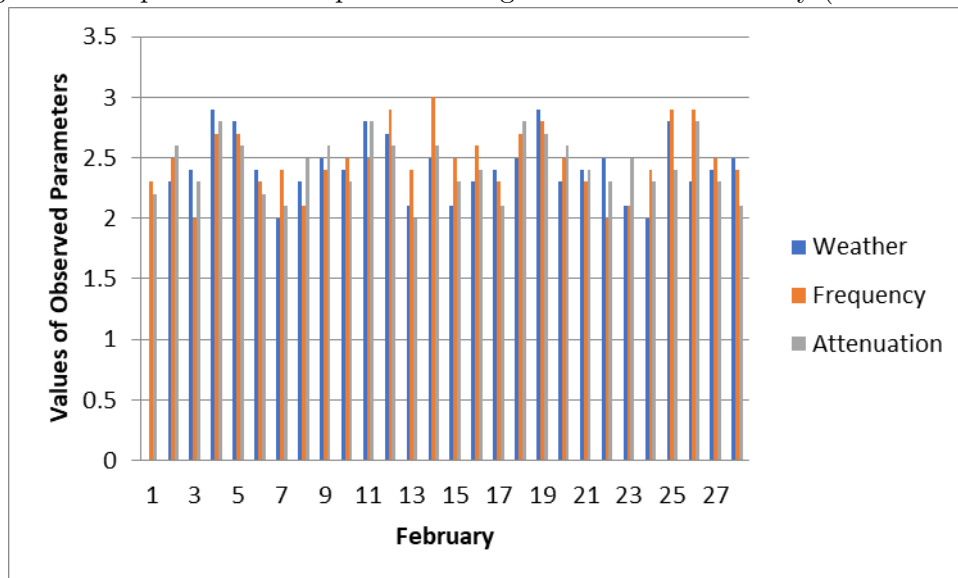


Figure 10: Graph of observed parameters against month of February (MTN Falomo)

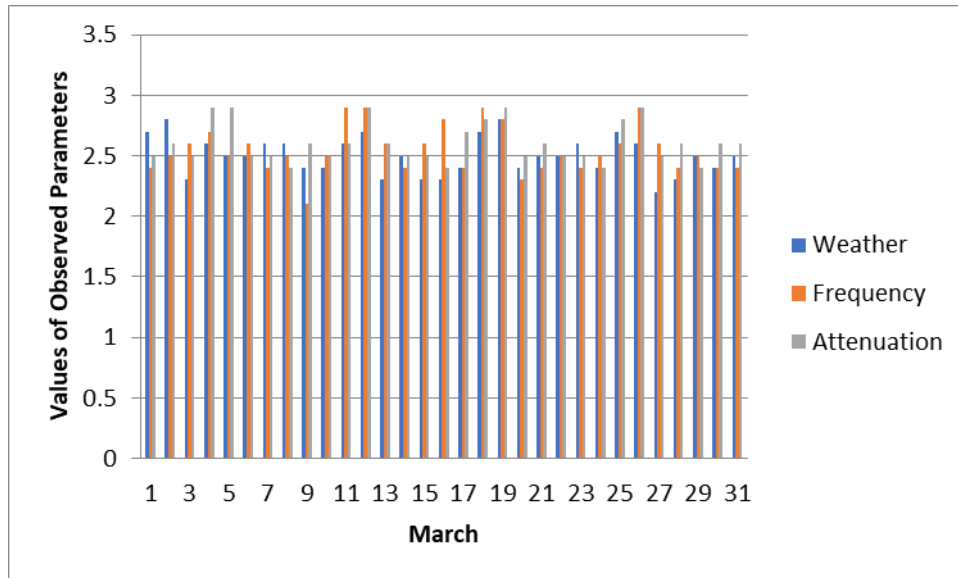


Figure 11: Graph of observed parameters against month of March (MTN Falomo)

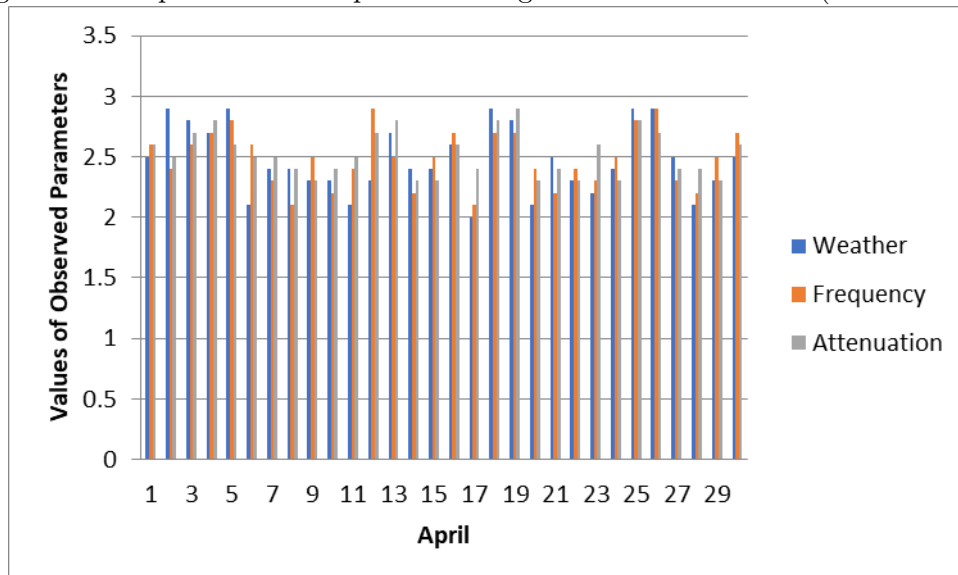


Figure 12: Graph of observed parameters against month of April (MTN Falomo)

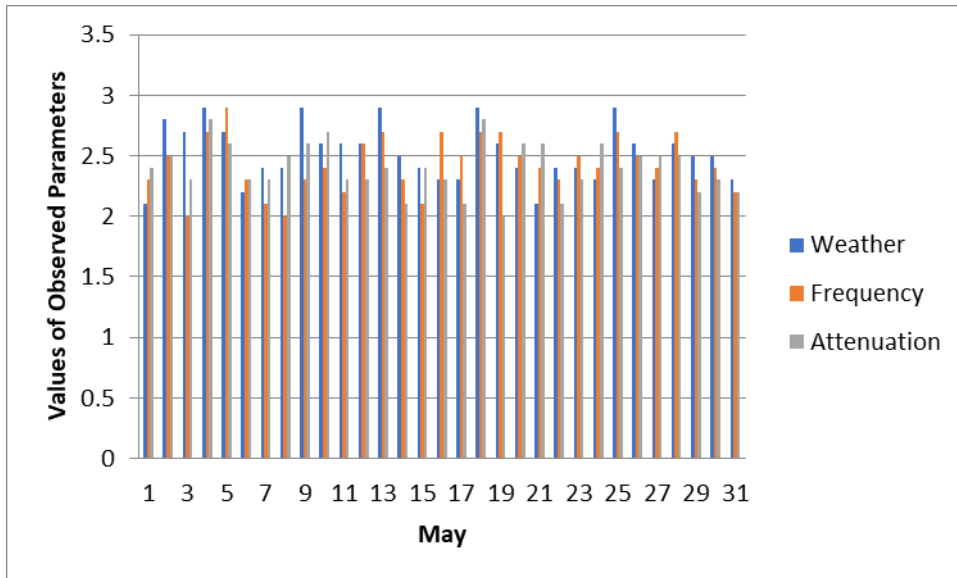


Figure 13: Graph of observed parameters against month of May (MTN Falomo)

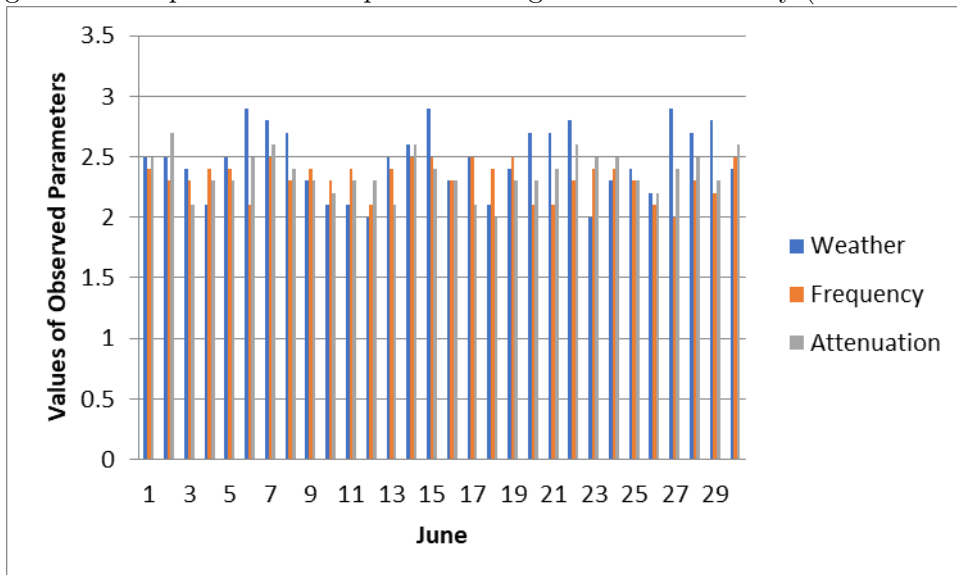


Figure 14: Graph of observed parameters against month of June (MTN Falomo)

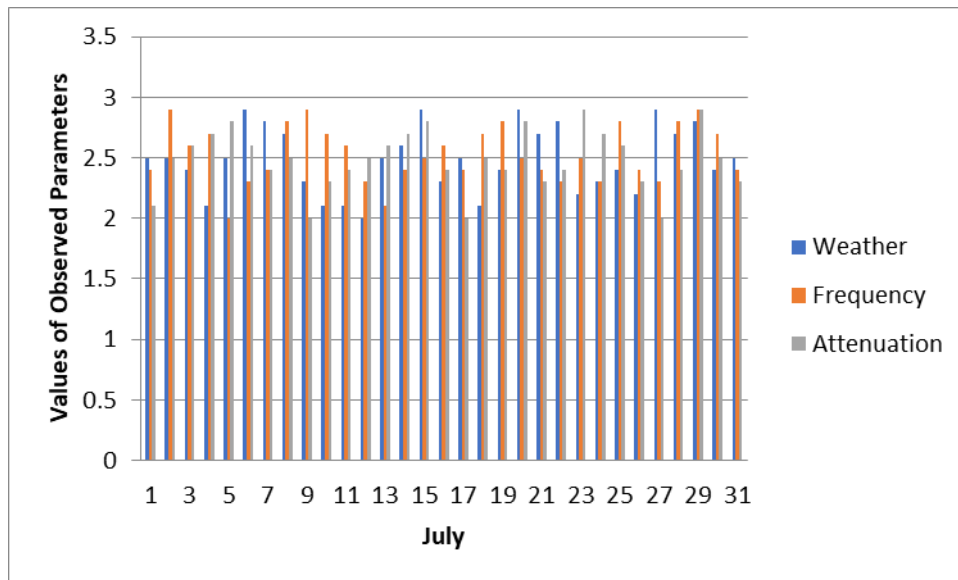


Figure 15: Graph of observed parameters against month of July (MTN Falomo)

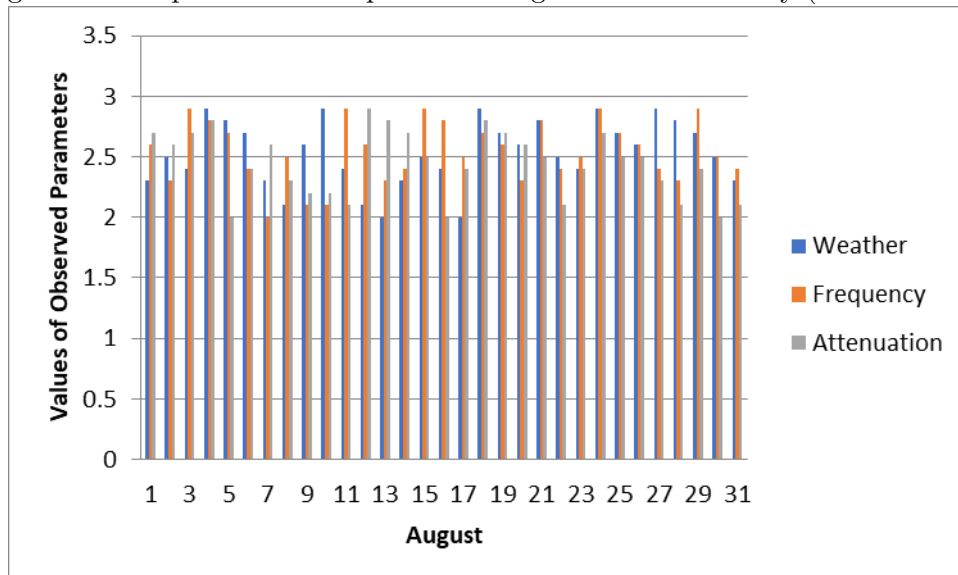


Figure 16: Graph of observed parameters against month of August (MTN Falomo)

4. Results Presentation

4.1 Results Presentation for Airport

The results of the data obtained from the Airport was presented as weather, frequency and attenuation distribution charts as shown in figures 1 to 8, the results showed that after obtaining data which were picked as a result of identifying the lowest, medium and average values for a particular month e.g. January. Day 10 which indicates the lowest value for the three factors, day 16 indicates the medium why day 25 indicates the highest value. After summing the values of the three factors together, the average value was observed for the month which falls within the range of the standard value which was given (must not be less than 10.0 MHz and must be above 15.0 MHz) for a month, if the average value falls below 10.0 MHz, the implication is that the equipment might be malfunctioning, and if the average value falls above 15.0 MHz there will be difficulty in sending

or receiving of signals for that particular period, therefore the average value for a particular day also have a standard value which is between (1.0 - 4.0). The data obtained from Airport ranges from 4.0 – 4.9 and it was stated that the value per day must not fall within 1.0 – 3.8 and for the whole month after making the calculations. It was noted that the average value for a month must not fall below 10.0 and must not be above 15.0, between January and August.

4.2 Results presentation for MTN

The results of the data obtained from MTN was also presented as weather, frequency and attenuation distribution chart as shown in figures 9 to 16 using the same procedure, the result show that after obtaining the data which were picked as a result of identifying the lowest, medium and average values for a particular month e.g. January day 24 which indicates the lowest value for the three factors, day 10 indicates the medium why day 18 indicates the highest value. After summing the values of the three factors together, the average value was observed for the month which falls within the range of the standard value which was given (must not be less than 10.0 MHz and must be above 15.0 MHz) for a month, if the average value falls below 10.0 MHz, the implication is that the equipment might be malfunctioning, and if the average value falls above 15.0 MHz there will be difficulty in sending or receiving of signals for that particular period, therefore the average value for a particular day also have a standard value which is between (1.0 - 3.0).

A range was also given for MTN which must not fall within 2.0 – 2.9 per day and must not be within 3.5 – 4.0, it was also observed that between the month of January – August the values obtained per day falls within 2.0 – 2.9 which means the situation can be managed for the day. Also, the average value was given for the month which falls within 10.0 – 15.0 therefore, between the month of January and August none of the value falls below or above range, the highest value was 7.7 which was for the month of March and the lowest value was 7.2 for the month of January, this value indicates that there is situation in the ionosphere but it has been under control and manageable.

5. Conclusion

In conclusion the values obtained (highest and lowest value) reflect on the terrestrial communication are poor signals, call diversion and echo. Hence, more data should be obtained from time to time to enable the companies put more effort in minimizing the problems and there should be further training for scientists and Engineers obtaining data and analysing it.

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