Investigation of The Radio-Refractivity Pattern Variation during Rainy Season in Calabar, Cross River State, Nigeria

Daniel Effiong Oku, Mfon Okokon Charles, Amajama Joseph

***Abstract*— This paper is focused on investigating the Radio-Refractivity pattern variation during the rainy season in Calabar, Cross River State , Nigeria. The daily averages of refractivity for three months of the rainy season in July, August and September, 2014 were evaluated from Metrological parameters(Temperature, Relative Humidity and Atmospheric Pressure), gotten from the Nigeria Meteorological Agency(NIMET). The analysis showed that the refractivity pattern is almost uniform except for July which experiences higher refractivity at the beginning of the months with a standard deviation of 16.7 compared to the month of August and September which have standard deviations of 7.6 and 26.9 respectively in their monthly refractivity.**

***Index Terms*— Metrological Parameters, Pattern Variation, Radio Refractivity, Rainy Season, Troposphere.**

I. INTRODUCTION

It has been observed that the propagation of radio signals in the troposphere which extends from the earth surface to about 10km at the pole and 17km at the equator[5], is often inhibited by certain atmospheric conditions[1]. This signals are often affected by metrological parameters(Temperature, Pressure and Relative Humidity)[8], causing effects like Ducting and Scintillation[1]. A couple of researches have been carried out in Nigeria on radio refractivity variations. [4] carried out a work in the South-West part of Nigeria, on the variation of metrological parameters as they affect Radio Refractivity in Akure, while [3] also did a similar research in Makurdi, North Central part of Nigeria. In both researches there was a significant variation in Rainy Season and Dry Season Refractivity.

Calabar, a Metropolitan City of the Niger Delta in Nigeria located on Latitude $4^{o}57'06''$N and longitude $8^{o}19'19''$E at an elevation of 42m above sea level, and surrounded by a coastal region has a controversial type of tropical climate called the Tropical Moonsoon Climate which is rare in this kind of climatic condition. It is often characterised by lengthy wet season and short dry season which exhibit some precipitations[10]. This Climate experiences less variance in temperature during the course of the year, as compared to Akure and Makurdi which belong to tropical climate and tropical savannah respectively and have been found to experience more variance in temperature[7]. Temperature has been found to be one of the major metrological parameters contributing to refractivity[6] and so studying the pattern variation in the rainy season will help to predict radio signal propagation since refractivity gets high during the rainy season[2], hence increase in the rate of signal path loss and attenuation due to high water vapour in the atmosphere. The pattern variation will contribute to the planning and design of terrestrial communication systems and give an estimate of multipath fading and interference[7]. The refractivity will be estimated by using metrological data gotten from NIMET. [9] have reported that signal propagation quality has a relation to radio refractivity index and this changes in air affects the tropospheric refractivity pattern. In the standard atmospheric condition the value of refractivity index is 1.003 which is related to the refractivity as

$$N = (n-1) \times 10^6 \quad (1)$$

II. METHODOLOGY

The data obtained from the Nigeria Metrological Agency(NIMET) is analysed for three months in the rainy season, July to September 2014. These parameters were Temperature, Relative Humidity and Atmospheric Pressure.

The temperature averages are gotten from taking the average daily temperatures

$$T_{avg} = \frac{Tmin + Tmax}{2} \quad (2)$$

T_{avg} = Average daily temperature in degree celcius
Tmin = Minimum daily temperature in degree celcius.
Tmax = Maximum daily temperature in degree celcius.

The daily variations in the metrological parameters are evaluated, starting from the partial pressure of water(e) in air

$$e = \frac{e_s H}{100} \quad (3)$$

H: Relative Humidity
e_s: saturated vapour pressure

$$e_s = 6.11 \exp\left[\frac{17.26(T-273.16)}{T-35.87}\right] \quad (4)$$

T: Temperature in Kelvin.

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The radio refractivity for each day within the month is then calculated using the relationship

$$N=77.6\frac{P}{T}+3.37\times10^{5}\frac{e}{T^{2}} \qquad (5)$$

where;

P: Atmospheric Pressure(hPa)

e: Water vapour pressure(hPa)

T: Absolute temperature(K)

The range of the daily refractivity for each month is calculated as .

N_R = Highest Radio Refractivity(N_H) - Lowest Radio Refractivity(N_L) (5)

In order to estimate the pattern variations, the mean refractivity for each month July to September is calculated as

$$\overline{N}=\frac{\sum N}{n} \qquad (6)$$

Where

$\sum N$: Sum of daily refractivities

n: number of days in the month

$\overline{N}$ = monthly average refractivity

The standard deviation of refractivity for each rainy season month is calculated as

$$S=\sqrt{\frac{\sum N^{2}}{n}-\overline{N}^{2}} \qquad (7)$$

III. RESULTS AND DISCUSSIONS

Given the data for the metrological parameters, the average of daily metrological parameters were evaluated and the refractivity for the respective three months in the rainy season from July to September were also calculated.

The refractivity for each of the days of the month are plotted against the days of the month. The results are as shown in the graphs below in Fig1, Fig2 and Fig3, while the last graph in Fig 4. shows the pattern variation for the three months in the rainy season

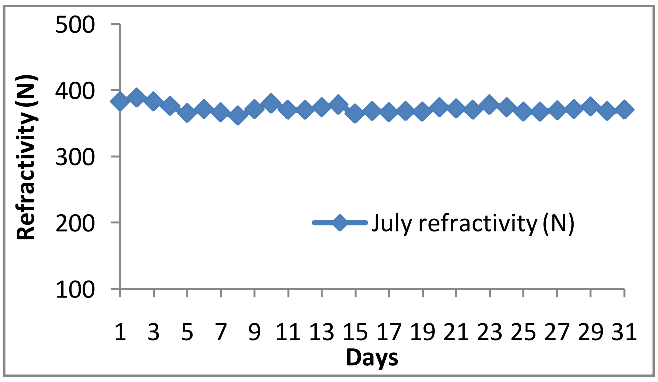

Fig1: Daily Variation of Radio Refractivity for July

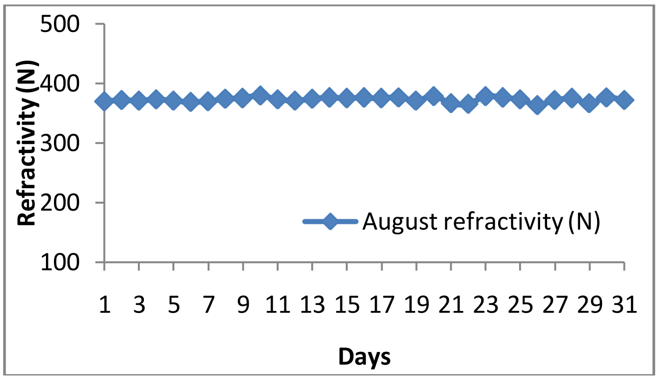

Fig 2: Daily Variation of Radio Refractivity for August

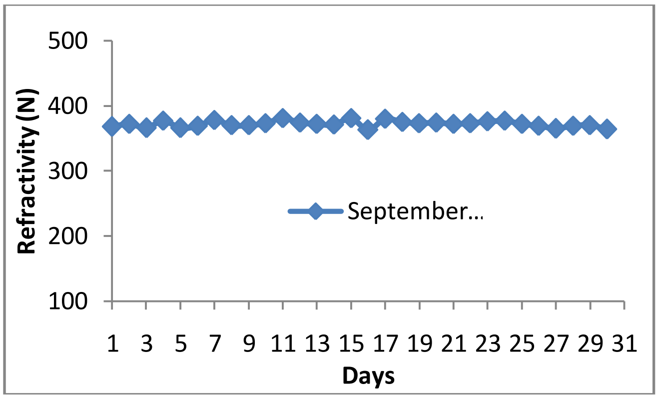

Fig 3 : Daily Variation of Radio Refractivity for September

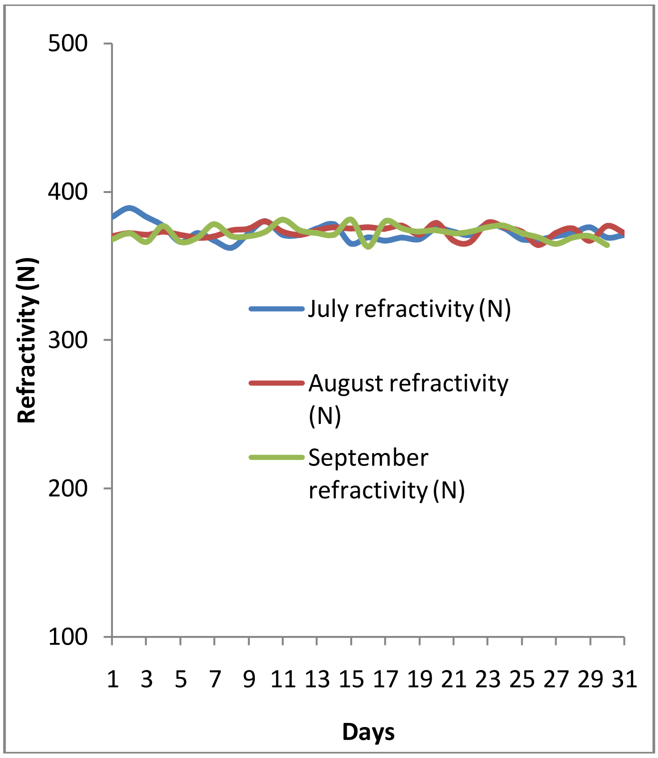

Fig 4: Rainy Season Radio Refractivity Variation

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The standard deviations for the daily refractivity for each month are evaluated using equation (7) and it is observed that August has the lowest standard deviation of 7.6, followed by July, while the highest standard deviation is obtained in the month of September. Other results revealed from the graphs are as follows.

The month of July has the highest and lowest refactivity(N) which ranges from 365 to 389 with an average refractivity value of 373 and range of 24.

The month of September has refractivity ranging from 366 to 381 with average of 372 and range of 15.

The month of August has refractivity(N) ranging from 366 to 380 with an average value of 372 and range of 14.

The results revealed from the graphs in Fig1,Fig2,Fig3 and Fig4 shows there is a very little significant variation in the rainy season monthly refractivity, although in the quantitative calculations we experience an initial minor significant variation in the month of July compared with August and September. This can be explained from the fact that the month of July experiences higher average temperatures and high relative humidity compared to other rainy season months in Calabar.

In the calculations, August has the lowest range in refractivity and standard deviation, which is indicative of the fact that atmospheric metrological parameters are almost stable in the month of August compared to other months in the rainy season.

IV. Conclusion

This research work has indicate the fact that metrological parameters affect the radio refractivity and has also shown that there is no significant variation in monthly radio refractivity during the rainy seasons in calabar, however it has shown that July compared to other rainy season months experiences some higher refractivity initially as a result of higher temperatures and humidity but conditions are stabilised as we move further into other rainy season months.

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PROFILE

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