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By O. N. Okoro & G. A. Agbo
Ebonyi State University, Abakaliki, Nigeria

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Abstract - This paper investigates the effect of diurnal variations meteorological parameters on the troposheric radio refractivity during dry and rainy seasons for Minna in 2008. The hourly averages of radio refractivity during dry (February) and rainy (August) seasons were calculated from the data obtained from the Center for Basic Space Science (CBSS) through Omini web. This data used for the computation of radio refractivity is a five minutes interval of the variations of meteorological parameters for each day in the troposphere for Minna. The results indicated that the hourly averages of radio refractivity during rainy season (August) are greater than the results in dry season (February). This is as a result of variations in meteorological parameters such as humidity and temperature in the lower troposphere which causes the radio refractivity to vary at different time of the day.

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I. Introduction

The propagation of radio wave signal in the troposphere is affected by many processes which include the variations of meteorological parameters such as temperature, pressure and humidity. These are associated with the change in weather in different seasons of the year. These variations in meteorological parameters have resulted in refractivity changes. According to Grabner and Kvicera (2008), multipath effects also occur as a result of large scale variations in atmospheric radio refractive index, such as different horizontal layers having different refractivity. This effect occurs most often, when the same radio wave signals follow different paths thereby having different time of arrivals to its targeted point. This may result to interference of the radio wave signals with each other during propagation through the troposphere. The consequence of this large scale variation in the atmospheric refractive index is that radio waves propagating through the atmosphere become progressively curved towards the earth. Thus, the range of the radio waves is determined by the height dependence of the refractivity. Thus, the refractivity of the atmosphere will not only vary as the height changes but also affect radio signal.

Author α σ : Department of Industrial Physics, Ebonyi State University, Abakaliki, Nigeria. E-mail : bathonjoku@yahoo.com

The quality of radio wave signal reception and probability of the failure in radio wave propagations are largely governed by radio refractivity index gradient which is a function of meteorological parameters changing in lower atmosphere such as temperature, pressure and humidity (Sarkar 1978; Judd 1985).

Radio waves travel through vacuum with a speed equal to the speed of light. In material medium, the speed of the radio waves is approximately c/n where c is the speed of light in vacuum and n is the radio refractive index of the medium. The value of radio refractive index (n) for dry air is almost the same for radio waves and the light waves. But the value of radio refractive index (n) for water vapor, which is always present in some quantity in the lower troposphere, is different for the light waves and radio waves. This arises from the fact that water vapor molecule has a permanent dipole moment which has different responses to the electric forces of different radio wave frequencies propagated within the atmosphere.

Radio–wave propagation is determined by changes in the refractive index of air in the troposphere (Aediji A. T., Ajewole M. O., 2008). Changes in the value of the troposphere radio refractive index can curve the path of the propagating radio wave. At standard atmosphere conditions near the Earth's surface, the radio refractive index is equal to approximately 1.0003 (Freeman .L., 2007). Since the value of refractive index is very close to unity, then the refractive index of air in the troposphere is often measured by a quantity called the radio-refractivity N, which is related to refractive index, n as:

$$N = (n-1) \times 10^{6} \qquad (1)$$

As the conditions of propagation in the atmosphere vary, the interference of radio-wave propagation is observed. Such interferences are incident with some meteorological parameters (inversion of temperature, high evaporation and humidity, passing of the cold air over the warm surface and conversely), (Valma., *et al*, 2010).

The atmospheric radio refractive index depends on air temperature, humidity, atmospheric pressure and water vapour pressure. Subsequently, meteorological parameters depend on the height at a point above the ground surface. Variation in any of these meteorological parameters can make a significant variation on radio-wave propagation, because radio signals can be refracted over whole signal path (Priestley and Hill, 1985). In the atmosphere, pressure, temperature and humidity decrease exponentially as height *h* increases (Falodun and Ajewole, 2006).

According to Willoughby, (2002), atmosphere has an important feature:- the vertical gradient of the refractive index, *G*. The vertical gradient of the refractive index is responsible for bending of propagation direction of the electromagnetic wave. If the value G is negative, the signal bends downward (Guanjun and Shukai, 2000). The characterization of the seasonal variation in fading and its dependence on meteorological parameters provides the way to improve transmission performance by better tailoring of performance equipment design and usage to the amount of fading expected at a given location and time of the year.

This work is, therefore, aimed at finding out the diurnal variation of meteorological parameters with the tropospheric radio refractivity in dry and rainy seasons at Minna for the year 2008.

II. Methodology

The meteorological parameters (pressure, temperature relative humidity) used to calculate radio refractivity for Minna were provided by Center for Basic Space center (CBSS).

The analysis were done in all the months of the year 2008, but the months of February and August results were chosen to represent the dry and rainy season in Nigeria.

The hourly variations of meteorological parameters for each day for five minute (5min) interval for each day were recorded for dry and rainy seasons in Minna. The average variation of each hour per day was calculated from the recorded data .The partial pressure of water e was determined from the equation as follow:

$$e = e_s H \tag{2}$$

where H is the relative humidity, and e_s is the saturation vapour pressure determined by Clausius-Clapeyron equation given as:

$$e_s = 6.11 exp[17.26(T - 273.16)/(T - 35.87)] \tag{3}$$

In relation with the measured meteorological parameters such as the temperature, pressure and relative humidity radio refractivity was calculated using;

$$N = 77.6\frac{P}{T} + 3.37\,x\,10^5 e/T^2 \tag{4}$$

where

P = atmospheric pressure (hPa)
e = water vapour pressure (hPa)
t = absolute temperature (K)

Equation (4) may be employed for the propagation of radio frequencies up to 100GHz (Willoughby, *et al*, 2002).

The error associated with the application of the above formula is less than 0.5% (ITU-R, 2003).

III. Results and Discussion

Averages of hourly variations of meteorological parameters for each day were obtained, from the data collected for dry and rainy seasons in 2008, for Minna.

The results were used to calculate radio refractivity.

The plots of diurnal variations of radio refractivity for both dry and rainy seasons are shown in fig 1, 2 and 3 below.

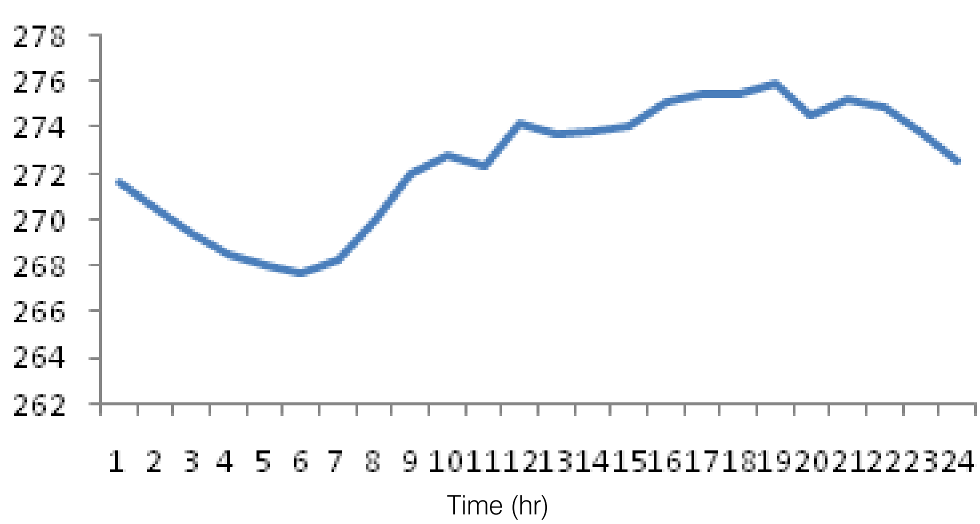

Fig 1 : Diurnal variations of radio refractivity for Day one for dry season (February)

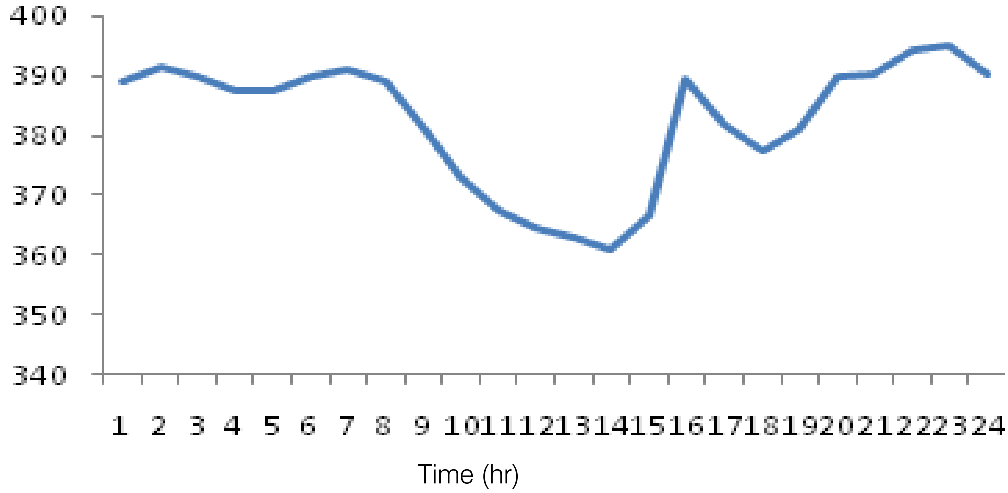

Fig 1 : Diurnal variations of radio refractivity for Day one for rainy season (August)

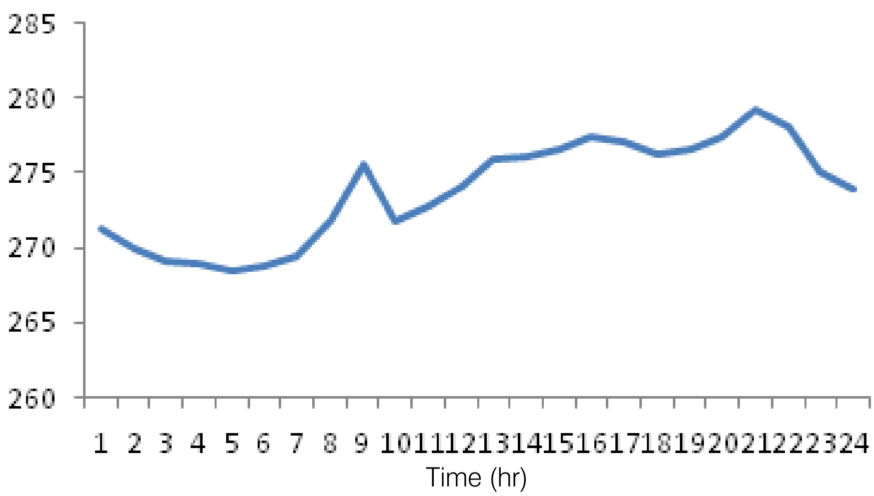

Fig 2 : Diurnal variations of radio refractivity for Day two for dry season (February)

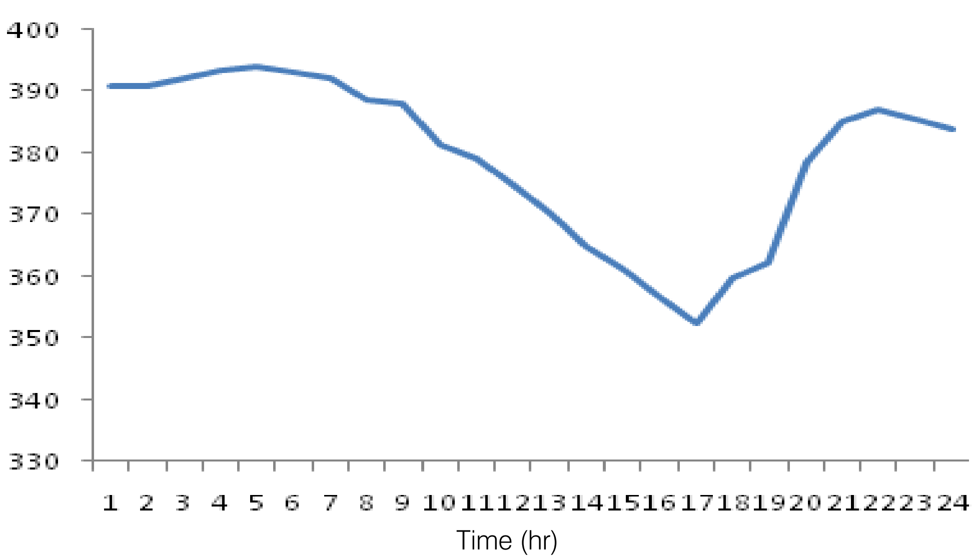

Fig 2 : Diurnal variations of radio refractivity for Day two for rainy season (August)

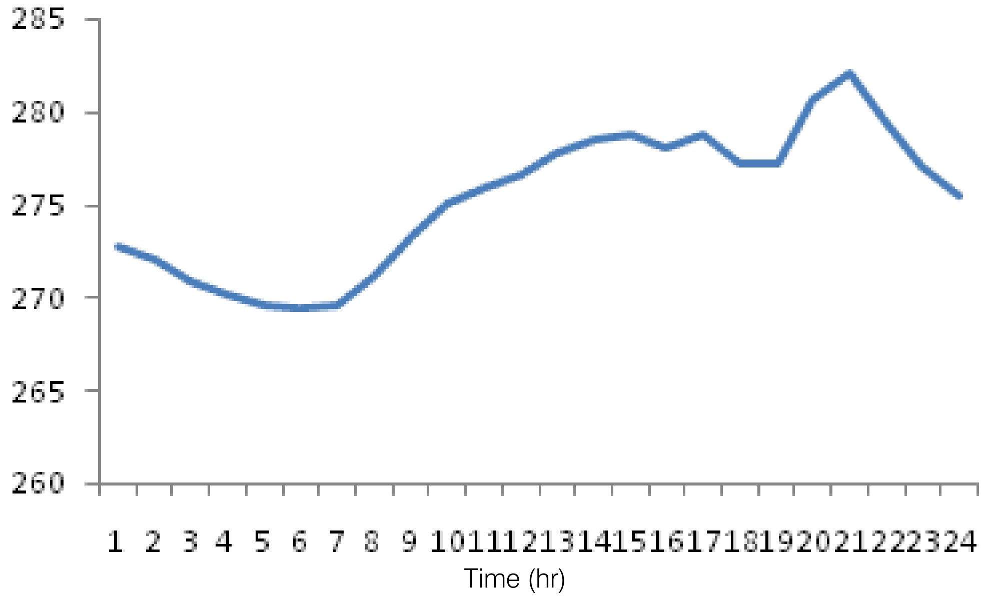

Fig 3 : Diurnal variations of radio refractivity for Day three for dry season (August)

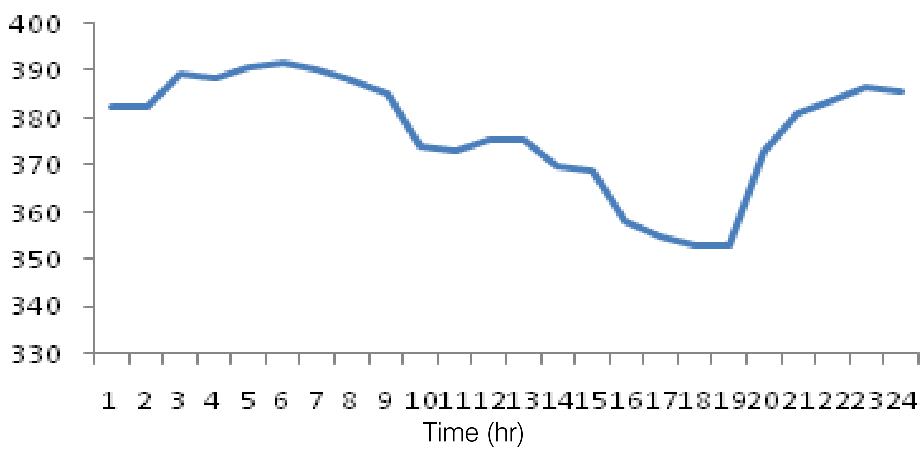

Fig 3 : Diurnal variations of radio refractivity for Day three for rainy season (August)

Minna, Niger State is located on Latitude 9° 36' 50" N and Longitude 6° 33' 24" E and is dominated by dry season within the year. The measured relative humidity was converted to water vapour pressure by applying equation (2) for both dry and rainy seasons.

The result contains both dry air and water vapor. Dry air has no significant variations in composition with altitude, (Smith and Weintrant, 1953). The amount of water vapor, on the other hand, varies widely, both spatially and temporally. Water can also exist in the troposphere in liquid phase (fog, clouds, rain) and solid form (snow, hail, ice) and the most important effect in relation to weather activities, not only presence of rain- and snowfall but also because large amount of energy are released in condensation process.

From the figures (1, 2, and 3), the hourly average values of radio refractivity plotted at 1-hour interval were observed to posses similar characteristics in dry season and also a different similar characteristics for rainy season. In fig 1, 2 and 3 of day one, day two and day of dry season, radio refractivity were observe to fall from the midnight hours (between 1:00-7:00hrs) owing to the decrease in humidity within that period of the day. Between 8:00- 21:00hrs, radio refractivity were observed to almost increase at a constant rate because of the presence of fog noticed in the early hours of the day during the period which causes humidity to vary resulting also to change in radio refractivity . At about 20:00hr, radio refractivity was found to increase to a peak value and between 22:00-24:00hrs it decreased again to a lower value resulting fall in refractivity.

In fig 1, 2 and 3, representing rainy season, radio refractivity is found to have the peak values during early hours of the day and rate hours of the night corresponding to the time that the atmosphere is mostly dominated by moisture content of water vapour which eventually increases humidity in the atmosphere. At the rate hours of the day, a decrease in radio refractivity was observed corresponding to the period when there is sun shine.

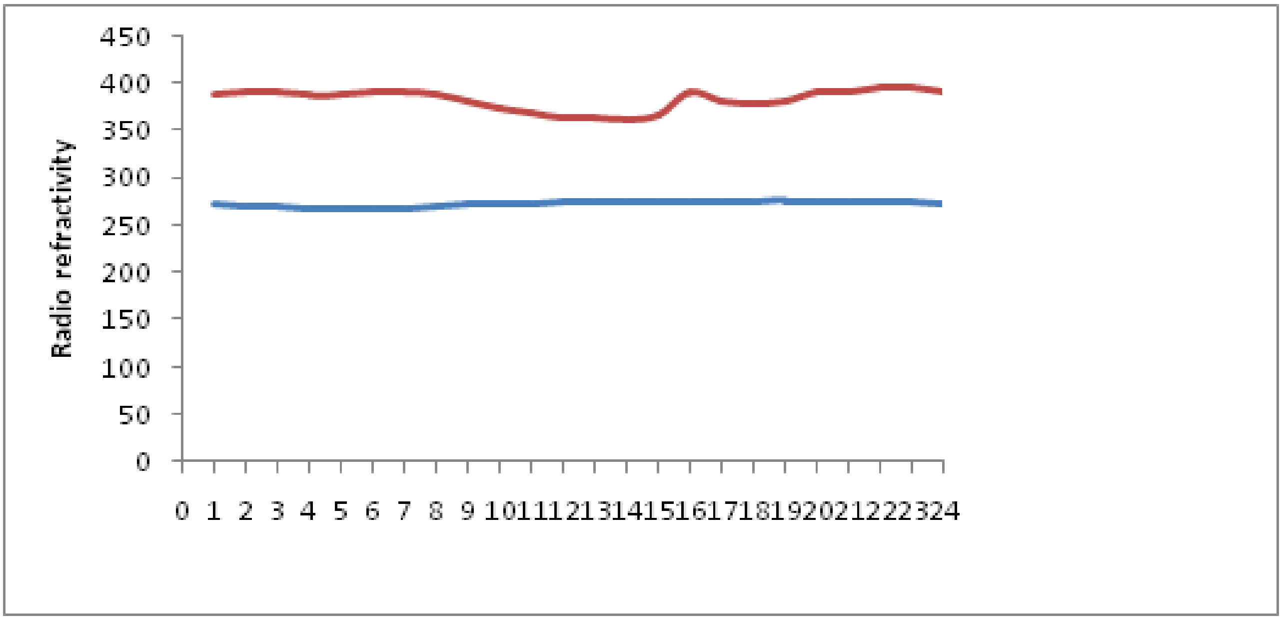

Fig 4 : Comparison of Diurnal variation of radio refractivity with time in February and August

Fig 4 shows the comparison of diurnal variation of radio refractivity with time in February and October. In figure 4, there are high variations of radio refractivity due to the changes in weather in the lower troposphere during rainy season than in the dry season which almost varies linearly with time. This may have resulted in the changes in atmospheric weather condition corresponding to this period which is accompanied by high moisture contents in the troposphere. This high moisture content resulted in the changes of radio refractivity.

IV. Conclusion

The work has shown that the effect of meteorological parameters on the tropospheric radio refractivity in Minna has being attributed to seasonal variations in weather in the troposphere most especially at the lower part (below sea level). This variation in weather was observed to be more significant during the rainy season than the dry season in Minna owing to the increase in the tropospheric temperature and humidity, and it therefore resulted to very high radio refractivity within that period.

V. Acknowledgement

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