International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS)
Volume VIII, Issue XI, November 2019 | ISSN 2278-2540

Effect of Meteorological Paramrters on Tropospheric Refractivity in Jos, North Central of Nigeria

Afolabi, Lateef Olashile[1], Olaiya Olayinka Oluwaseun[2]
[1]Electrical Electronic Engineering, Federal Polytechnic Offa, Kwara State, Nigeria
[2]Computer Engineering, The Federal Polytechnic ilaro Ogun State, Nigeria

***Abstract:-* The paper analysed the effect of meteorological parameters on tropospheric refractivity in Jos for better planning of wireless communication signal. Jos, capital of Plateau stateis located on latitude $09^0 38^{'} N$ and longitude $08^0 51^{'} E$, north-central of Nigeria. The year was divided into four; early dry season, late dry season, early rainy season and late rainy season.The tropospheric refractivity variation with hours of the day for nine different months was investigated. The data used were collected from NIMET, Nigeria and the analyses were based on ClausianClapeyron's equation. It was discovered that in most of the months, a minimum refractivity around 240N-Units are recorded between 60% to 70% hours of the day and maximum refractivity around 335N-units are recorded at early hour in the morning and late hours in the night. More so, rainy season has higher refractivity than dry season and it increases from the early rainy season to late season with September having highest refractivity in the year. The percentage error of this analysis varies from 0.26% to 0.38%.**

***Key words:* Refractivity, Pressure, Temperature, Relative Humidity, ClausianClapeyron**

I. INTRODUCTION

Atmospheric refractive index of a place can cause extended propagation of electromagnetic signal to curve with attenuation relative to free space along its propagation line. In communication design, there is need to take into consideration effects of refractive index on wireless signal below 2GHz. The effect caused bending of the signal toward or away from earth surface as well as causing change in its speed. This is due to the different in refractive index from place to place and its variation with altitude of a place.

Refractive index of a medium is the ratio of speed of a signal in the medium to that of vacuum. The speed of electromagnetic wave in vacuum is 3 x 10^8 m/s and the refractive index is taking as 1.000000. However, at the earth surface, the refractive index is approximately 1.000320. The refractivity, N is the term used to describe refractive index in its 6 decimal places given as:

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

The refractivity of a place varies from around 220 to 420 N-units and it was discovered that this depends on the meteorological parameters of the place. The variation of pressure, temperature, relative humidity and so on with height and from place to place determine the type of refraction that will takes place in the area. There are five types of radio wave refractivity, which aresub refractivity; vacuum refractivity; Normal or standard refractivity; super refractivity; and ducting. Hence, there is need to study the variation of these meteorological parameters in other to determine the type of refractivity that occur in a place.

This paper aims at determining the effect of meteorological parameters on tropospheric refractivity in Jos, north central of Nigeria. Meteorological parameters were collected from NIMET for the year 2014. From the data, the refractivity of Jos wasdetermined per percentage of time of the day in a month. Mean errors, standard deviations and standard errors were determined. The remaining part of this paper is as follows: section 2 described the methods used, section 3 shows the results and discussion, and section 4 gives the conclusion.

II. METHODS

The metrological parameters used were collected from Nigerian metrological unit NIMET for the year 2014. The data were collected for five minute at thirty minutesinterval of the day in the first week of every month from January to December. Average values of each metrological parameter per thirty minutes were computed to represent the metrological parameters for that month at fixed height of 100meter in Jos (latitude $09^0 38^{'} N$, longitude $08^0 51^{'} E$).

The analysis were done in all the months of the studied year, since nigeria is characterise with two season period, two months of November and December represent early dry season, January and February represent the late dry seasons, April and May represent early reainy season, and August and September represents late rainy season.

Change in the refractive index of air in the tropospheric layer varies from its ground value (about 1.0003) which can be determined by changed in tropospheric using the following equation (ITU-R, 2003):

$$n = 1 + N \times 10^{-6}$$

The partial pressure of water, e was determined from the following equation:

$$e = e_S H$$

Where, H is the humidity, and e_S is the saturated vapour pressure over the land is determined by ClausianClapeyron's equation:

$$e_S = 6.1121(hPa)\exp^{\frac{[17.26\times(T(^0C)-273.16^0C]}{(T(^0C)-35.87^0C)}}$$

In terms of measured meteorological quantities, the refractivity N was determined using equation:

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

III. RESULTS AND DISCUSSION

The data were analyses for all the months of the year 2014. Fig.1-9 shows the variation of refractivity at %hours of the day time in selected months. Each month represents the early and late dry and rainy season.

The Fig. 1 shows refractivity of the month of January that represents late dry season of the year. The refractivity value has maximum value above 260 N-units later of the day (80% time of the day). A record of minimum refractivity less than 246 N-units occurred around 50% to 60% of time of the day (afternoon). The refractivity variation can be describes as one circle with higher value in late and early hours of the day and lower value in the middle of the day.

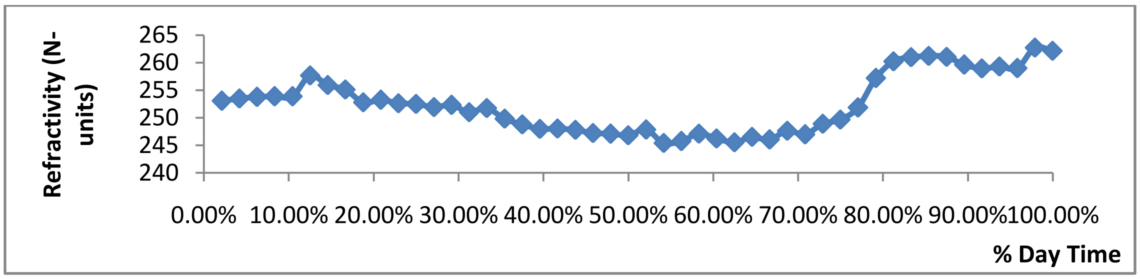

Fig. 1: Variation of refractivity with % time of the day month of January

The Fig. 2 shows refractivity of the month of February that represent second month of late dry season of the year. The refractivity value has maximum value above 260 N-units around 30% to 40% hours of the day and record of minimum refractivity slightly above 246 N-units around 60% to 70% hours of day (afternoon).

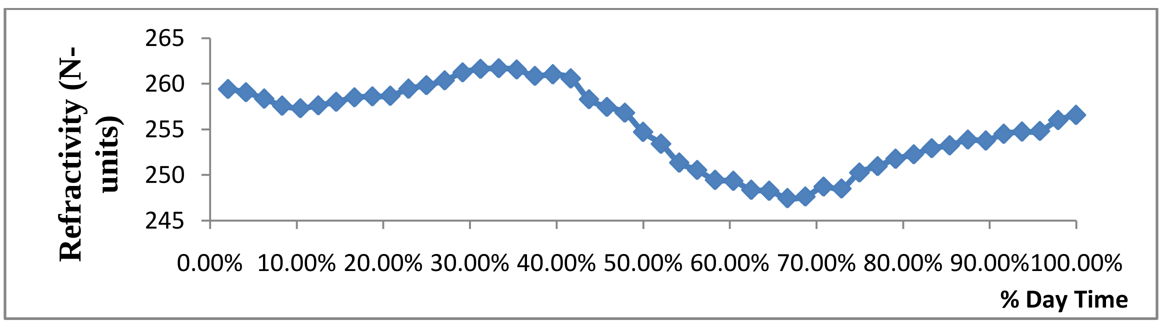

Fig. 2: Variation of refractivity with % time of the day month of February

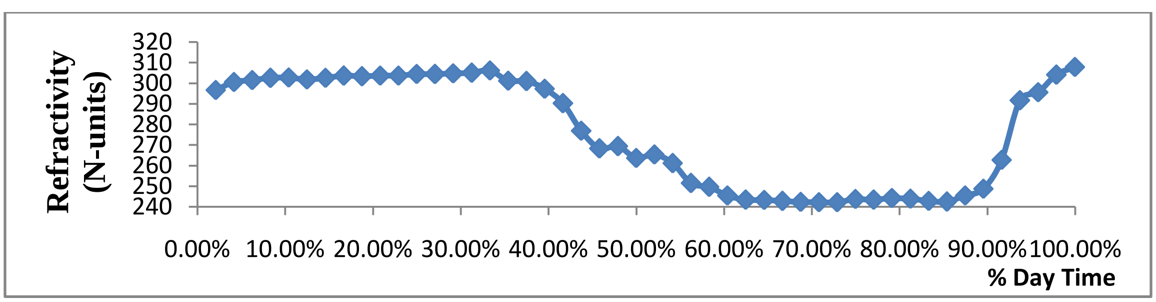

Fig. 3: Variation of refractivity with % time of the day month of March

The Fig. 3 shows refractivity of the month of March that represent first month of early rainy season of the year. The refractivity values seem nearly constant at early hours and fall around 30% to 50% hours of the day and nearly remain constant till about 85% hours where it started increases. The range of refractivity is between slightly above 300 N-units and slightly above 240 N-units. It has maximum value around 30% to 40% and 90% to 100% hours of the day (late night) and record of minimum refractivity around 50% to 90% hours of day (from afternoon to late night).

The Fig. 4 shows refractivity of the month of April that represent second month of early rainy season of the year. The refractivity value varies drastically throughout the day; it falls from early hours to evening hoursof the day. The range of refractivity is between slightly below 330 N-units and slightly below 280 N-units. It has maximum value around 0% to 10% hours of the day (early morning) and record of minimum refractivity around 65% to 70% hours of day (afternoon).

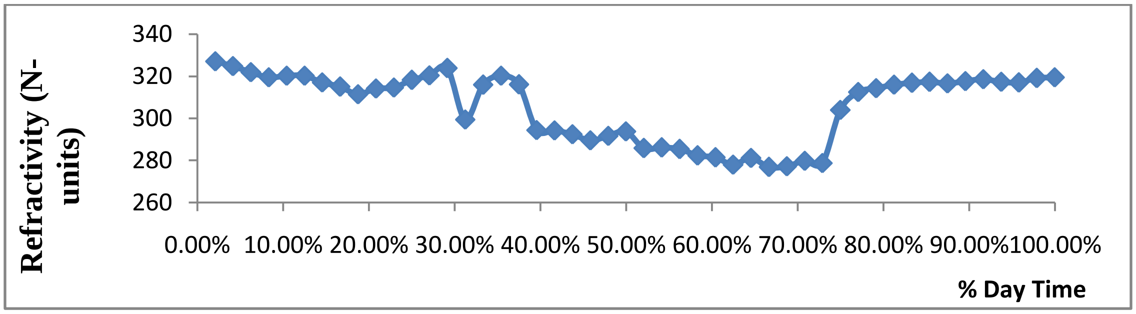

Fig. 4: Variation of refractivity with % time of the day month of April

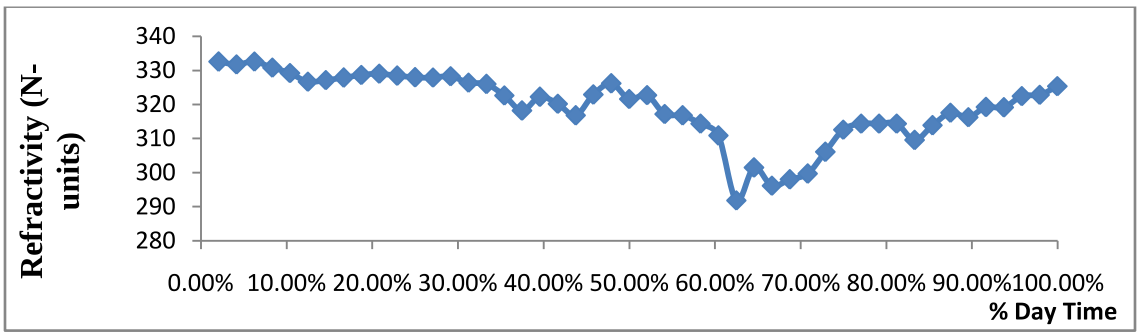

Fig. 5: Variation of refractivity with % time of the day month of May

The Fig. 5 shows refractivity of the month of May that represent third month of rainy season of the year. The refractivity value varies drastically throughout the day; following similar pattern of the month of April. That is, it decreases from early hours to evening hoursof the day. The range of refractivity is between slightly below 335 N-units and slightly above 290 N-units. It has maximum value around 0% to 10% hours of the day (early morning) and record of minimum refractivity around 60% to 65% hours of day (afternoon).

The Fig. 6 shows refractivity of the month of August that represent first month of late rainy season of the year. The refractivity value varies drastically throughout the day; the pattern of its variation is decreasing from early hours (early morning) to late hours (late night) of the day. The range of refractivity is between around 338 N-units and above 314 N-units. It has maximum value around 0% to 10% hours of the day (early morning) and record of minimum refractivity around 90% to 100% hours of day (late night).

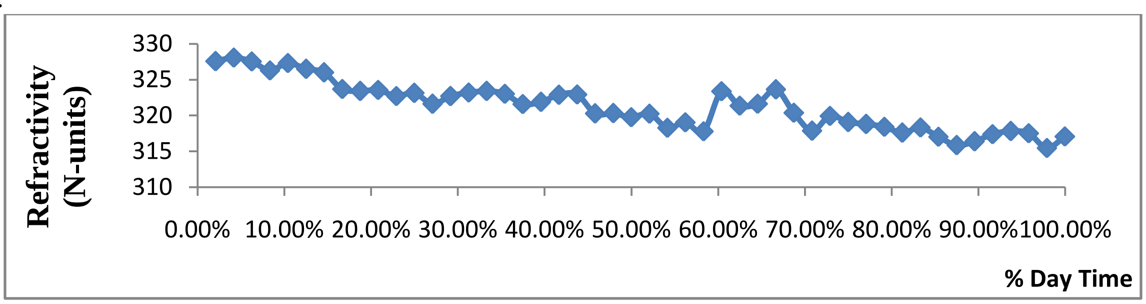

Fig. 6: Variation of refractivity with % time of the day month of August

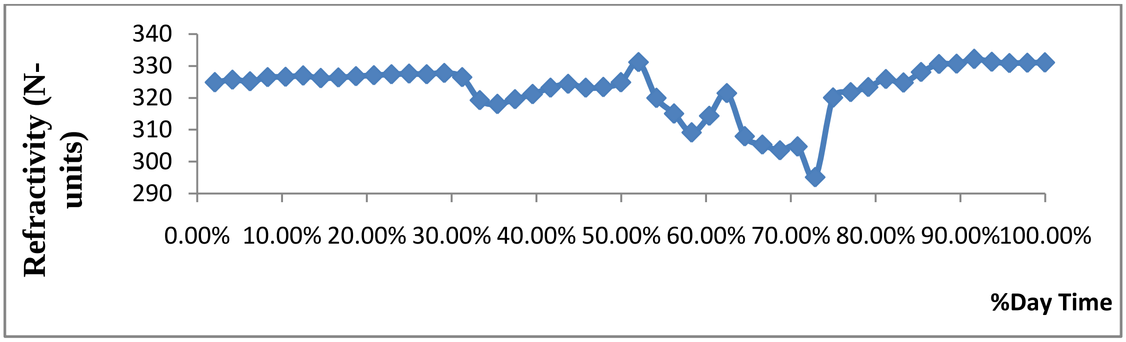

Fig. 7: Variation of refractivity with % time of the day month of September

The Fig. 7 shows refractivity of the month of September that represent second month of late rainy season of the year. The refractivity value nearly constant at early hour and late hour of the day; but fall to minimum values at middle of the day and later rises towards the hours of the night. The range of refractivity is between above 330 N-units and around 295 N-units. It has maximum value around 90% to 100% hours of the day (early morning) and record of minimum refractivity around 70% to 75% hours of day (late night).

The Fig. 8 shows refractivity of the month of November that represent first month of early dry season of the year. The refractivity value nearly looks like a bathtub. Its value is high at early one of the day and decreasing from 20% to 40% hours of the day, remaining nearly constant at 40% to 70% hours and later increases at late hour of the day. The range of refractivity is between slightly above 285 N-units and below 260 N-units. It has maximum value around 10% to 20% hours of the day (early morning) and record of minimum refractivity around 60% to 70% hours of day.

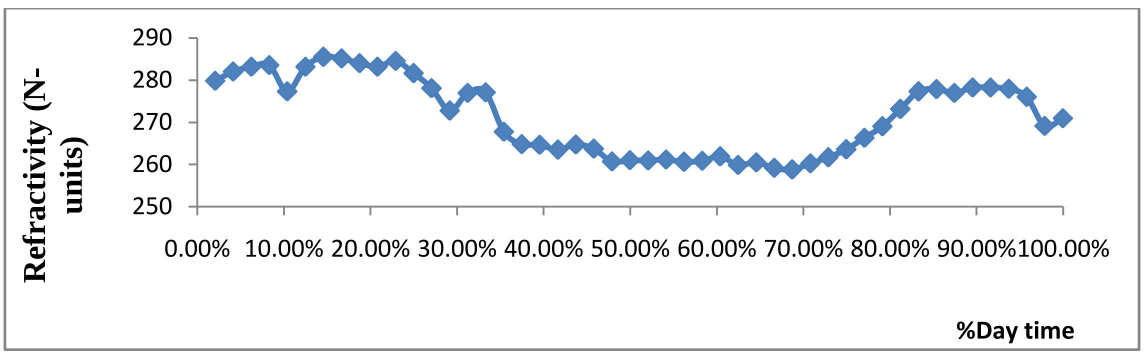

Fig. 8: Variation of refractivity with % time of the day month of November

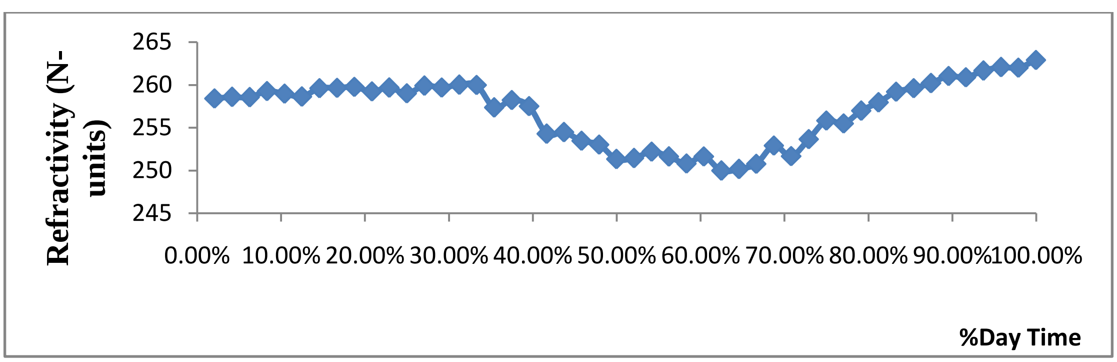

Fig. 9: Variation of refractivity with % time of the day month of December

The Fig. 9 shows refractivity of the month of December that represent second month of early dry season of the year. The refractivity value is similar to month of November. Its value is varies quadratic from high to minimum to high. At early hour of the day it is high and decreasing from 30% to 50% hours of the day, remaining nearly constant at 50% to 70% hours and later increases at late hour of the day. The range of refractivity is between around 262 N-units and slightly below 250 N-units. It has maximum value around 90% to 100% hours of the day (early morning) and record of minimum refractivity around 60% to 70% hours of day.

The Fig. 10 shows average refractivity of 9 months of the year 2014; characterise by early dry season (November and December), late dry season (January, February and March), early rainy season (April and May) and late rainy season (August and September). The mean refractivity is high in both early and late rainy season than dry season. However, there is gradual increment in mean refractivity value from early rainy season to late rainy season. Similarly, there is gradual decrement in mean refractivity in early dry season to late dry season. The mean refractivity for both early and late rainy season is greater than 310 N-units and that of early and dry season is less than 280 N-units. It has maximum value around august and September and minimum value around December and January.

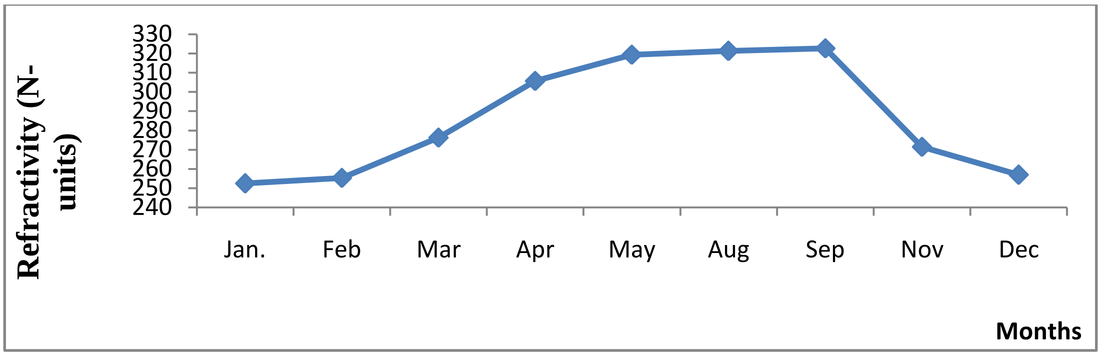

Fig. 10: variation of mean refractivity from January to December of year 2014

Base on the average refractivity, it can be seen from Fig. 11, that March has maximum mean error of $\pm$0.95, standard deviation and standard error, and January, February, August and December has least mean error of $\pm$0.84 , $\pm$0.88, $\pm$0.85 and $\pm$0.89 N-units, Standard deviation and Standard error. This shows that it is very easy to predict and characterise the refractivity in the month of January, February, August and December than any other month and March is most difficult to characterise its refractivity or set it at mean, minimum or maximum refractivity values due to its higher standard deviation and errors.

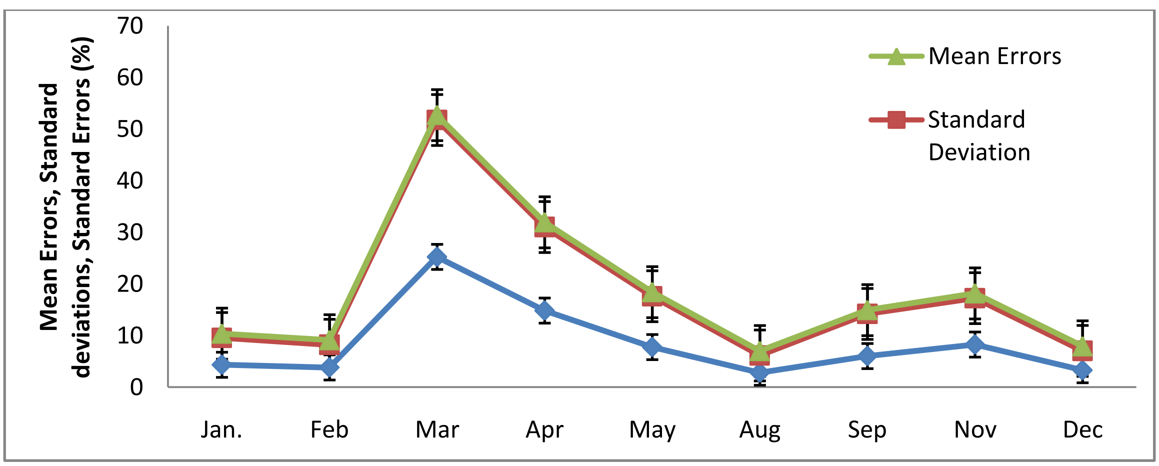

Fig. 11: Mean Errors, Standard Deviations and Standard errors of refractivity from January to December

IV. CONCLUSION

The refractivity variation of Jos, north-central of Nigeria was investigate for different nine months which are grouped into early dry season, late dry season, early rainy season and late rainy season. Its variation over the % hours of the day were analysed for all the considered months and it was found that, in most of the month, a minimum refractivity is recorded between 60% to 70% hours of the day and maximum refractivity are recorded at early hour in the morning and late hours in the night. The lest refractivity recorded in Jos is around 240 N-units which occurred at early night hours of the day in the month of March and maximum refractivity is slightly less than335N-units recorded in early hour of May and middle hour of September. More so, in the whole year, rainy season has higher refractivity than dry season and it increases from the early rainy season to late season with September having highest refractivity in the year. Similarly, it is very easy to predict and characterise the refractivity in the month of January, February, August and December based on the average refractivity with minimum, mean or maximum refractivity. The mean and standard errors and standard deviation is least in these month than any other month but difficult to characterise its refractivity for the month March with its mean, minimum or maximum refractivity values due to its highest standard deviation, and mean and standard errors. The percentage mean error of this analysis varies from 0.26% to 0.38%.

REFERENCES

[1]. Adediji A T and Ajewole M. O., (2008), Vertical Profile of Radio Refractivity Gradient in Akure South-East Nigeria, *Progress in Electromagnetics Research C*, vol. 4, 157-168.

[2]. Agbo G. A., Tropospheric Refractivity Dependence On Atmospheric Weather Conditions In Jos-Nigeria, *Journal of Basic Physical Research, Vol. 2, No.2, pp 1 - 6, November, 2011, ISSN;* 2141-8403 PRINTS, 2141-8411 ONLINE

[3]. Agunlejika O., Raji T. I., (2010b), Validation of ITU-R Model for Atmospheric Refractivity Profile, *International Journal of Engineering and Applied Sciences* (IJEAS), Vol.2, No.4, 72 -82.

[4]. Agunlejika, O. and Raji T. O., (2010a), Empirical Evaluation of Wet-Term of Refractivity in Nigeria, *International Journal of Engineering and Applied Sciences*, vol. 2, No. 2, 63-68.

[5]. Ayantunji B. G., Okeke P. N. and Urama J. O. (2011), Diurnal and Seasonal Variation of Surface Refractivity over Nigeria, *Progress in Electromagnetics Research B*, vol. 30, 201 – 222.

[6]. Chigbu, N.N.; Onogu, M.I., Ajayi, G.O.,(2004), "Characteristics of Microwave Propagation in Vapourised Atmosphere" *Global Journal of Mathematics Sciences*, vol. 3(2), 123-136.

[7]. Ekpe O. E., Agbo G. A., Ayantunji B. G., Yusuf N and Onugwu A. C., (2010), Variation of Tropospheric Surface Refractivity at Nsukka in South Eastern Nigeria, *Nigerian Journal ofSpace Research* vol. 7, 42-48.

[8]. Falodun, S. E. and M. O. Ajewole, (2006), Radio Refractive Index in the Lowest 100m Layer of the Troposphere in Akure, South-Western *Journal of Atmospheric and Solar-terrestrial Physics*, vol. 68, 236-243.

[9]. Freeman R. L., Radio System Design for Telecommunications. – Hoboken, New Jersey, John Wiley & Sons IncPb, 2007. – 880 p.

[10]. Gao J., Brewster, K., Xue, M. Variation of radio refractivity with respect to moisture and temperature and influence on radar ray path // Advances in Atmospheric Sciences, 2008. – Vol. 25. – No. 6. – P. 1098–1106.

[11]. GuanjunGuo, Shukai Li. Study on the vertical profile of refractive index in the troposphere // International Journal of Infrared and Millimeter Waves, 2000. – Vol. 21. – No.7. – P. 1103–1112.

[12]. O. N. Okoro& G. A. Agbo, The Effect of Variation of Meteorological Parameters on the Tropospheric Radio Refractivity for Minna, *Global Journal of Science Frontier Research Physics & Space Science*, Volume 12 Issue 2 Version 1.0 February 2012, Online ISSN: 2249-4626 & Print ISSN: 0975-5896, pp 36-42

[13]. Priestley J. T., Hill R. J. Measuring High–Frequency Refractive Index in the Surface Layer, *Journal of Atmospheric and Oceanic Technology*, 1985. – Vol. 2. – No. 2. – P. 233–251.

[14]. Valma E., Tamosiunaite M., Tamosiunas S., Tamosiuniene M. &Zilinskas M., Variation of Radio Refractivity with Height above Ground, *Electronics and electrical engineering, telecommunications engineering*, 2011. No. 5(111), pp 23-26, ISSN 1392 – 1215

[15]. Willoughby A. A., Aro T. O., Owolabi I. E. Seasonal variations of radio refractivity gradients in Nigeria, *Journal of Atmospheric and Solar–Terrestrial Physics*, 2002. – Vol. 64. – P. 417–425.