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Protection Value of Tropospheric Radio Refractivity over Nigerian Atmosphere

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Authors' contributions

The lead author of this paper designed the study, did the literature searches, performed the statistical analysis and wrote the first draft of the manuscript while the co-author prove read the manuscript, reviewed, edited the paper and managed the analyses of the study. Both authors read, agreed and approved the final manuscript for publication.

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ABSTRACT

This study enumerates the protection values derivable from refractivity variation of the tropospheric surface in Nigeria. The investigation was conducted in four cities of Nigeria using meteorological data of 2008 procured from the centre for basic space science (cbss), university of Nigeria, (unn), Nsukka. Data were captured from four different stations: Akure, Nsukka, Minna and Sokoto using vantage pro II automatic weather station. Data measurement at half hourly interval for the whole year took place at the ground level, 0 m and 100 m altitude of the troposphere. The results of the analyzed data revealed that at 100 m altitude, Nzukka and Akure experienced better protection at refractivity value of 350 unit than Sokoto and Minna at 250 unit. At the ground level (0) m, refractivity values becomes more distinct with; Nzukka, 500 unit, Akure, 370 unit while Minna and Sokoto shared the same refractivity value of 270 unit. This trend of refractivity variation showed a decreasing order of protection against exposure to damaging effects of the cosmic and out of space radiation as we move from the south towards the northern part of the country.

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1. INTRODUCTION

The tropospheric layer of the atmosphere spans about 10 km altitude from the earth's surface at the mid-latitudes, 6 km at the poles and up to 18 km at the equator[1,2] and the basic parameters that describe the tropospheric region are pressure, temperature and relative humidity. Variations in these conditions within the troposphere unleash a direct effect on the refractive index of air which can be significant at all frequencies especially at large scale changes of refractive index with height causing refraction of radio waves [3,4]. Studies from different authors across the globe had underscored the significance of the effects of refractivity on radio propagation. [5,6,7,8].

Similarly, radiation of varied energy factor assailed the earth atmosphere from out of the cosmic, galactic and solar sources, some of these can have damaging effects on the cells of the living organisms on earth. As a natural protection mechanism, these energetic radiations suffer attenuation and diversion from both the magnetosphere and atmosphere, as a compliment to this natural protection, the dense atmosphere described by atmospheric parameters especially the relative humidity offer additional protection against these radiations as they penetrate the troposphere on their way to lives on earth.

The atmospheric water molecules are polar as they contain dipole moments while other gases which are basically non-polar get their molecules induced with dipole moment when electromagnetic radiation propagates through them thereby causing changes in the refractive index 'n' of the atmosphere; as a consequence, reflection, polarization and scattering of the incident radiation hitting the atmosphere begin to occur.

In this study we investigated the tropospheric surface refractivity in four selected cities of Nigeria with the primary objective of delineating the variability of the refractivity across country; we presumed that a region of high refractivity will present a front of reflection, polarization and scattering of the incident radiation on the troposphere. Hence the protection offered lives on earth against ionizing radiation bombarding earth from out of the cosmos, solar and galactic objects is fortified. The knowledge of the tropospheric surface refractivity variation in this work can guide the insights into the degree of protection afforded different zones against the damaging effect of electromagnetic radiations.

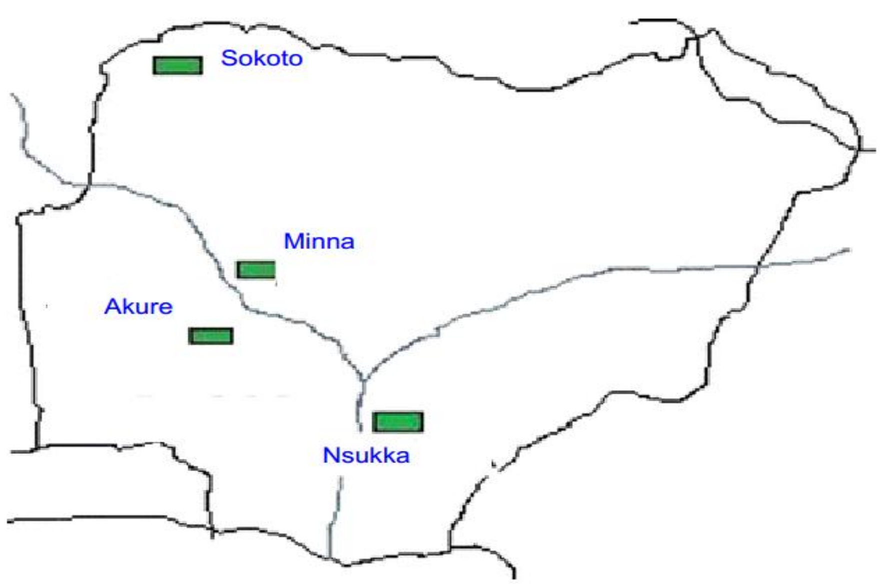

Fig.1. Map of Nigeria showing the study locations

2. STUDY AREA

The study locations include; (Nsuka), a coastal region, (Akure), inland, (Minna), central and Sokoto, northen Nigeria with the geographic coordinates: 6.8429° N, 7.3733° E, 7.2571° N, 5.2058° E, 9.5836° N, 6.5463° E and 13.0059° N, 5.2476° E respectively Fig. 1. Nigeria has two distinct seasons, the wet season spans March to October and the dry season extends from November to February with bi-modal rainfall distribution that peaks in July and September with an August break [9].

The wet season in Nsukka, Akure and Minna is oppressive and overcast but hot, oppressive, and mostly cloudy in Sokoto. Dry season in Nsukka is muggy and partly cloudy with the temperature typically varing from 61°F to 86°F and is rarely below 54°F or above 90°F over the course of the year whereas it is hot, muggy, and partly cloudy in Akure. Over the course of the year, the temperature typically varies from 65°F to 88°F and is rarely below 58°F or above 93°F [10].

Minna is partly cloudy in dry season, and it is hot year round .The temperature typically varies from 60°F to 94°F and is rarely below 54°F or above 101°F over the course of the year. The rainfall of the area on the average per year is 1209.7 mm (47.6 in) or 100.8 mm (4 in) per month [10].

Sokoto is generally hot, oppressive, and mostly cloudy in the wet season and sweltering and partly cloudy during the dry season. Typically the temperature varies from 62°F to 104°F and is rarely below 57°F or above 108°F over the course of the year [10].

3. MATERIALS AND METHODS

The data used for this study were procured from the Centre for Basic Space Science (CBSS), University of Nigeria, Nsukka, (UNN). The atmospheric data measured at half-hourly interval from four different stations; Nsukka, Akure, Minna and Sokoto were utilized.

At 0 m and 100 m altitude of each station, the tropospheric variables; temperature, pressure and relative humidity were captured using Vantage PRO II Automatic Weather Station. The instrument comprised Integrated Sensor Suite (ISS) Fig. 2 designed to collect the weather data while the console records the information and the data were transmitted from ISS through a mirror window in the radio frequency range of 868.0 MHz and 868.8 MHz.

Fig. 2. Integrated sensor suite

3.1 Data Analysis

Descriptive data analysis was carried out using Excel and Statistica applications for generating refractivity values (N unit) per half-hour of each station using the relations [11];

$$N = 77.6\frac{P}{T} + 37300\frac{e}{T^2} \quad (1)$$

Where; P = atmospheric pressure, T = absolute temperature in Kelvin and e = partial pressure or absolute humidity due to water vapour in mill bars given by;

$$e = e_s\frac{e_r}{100} \quad (2)$$

Where; e_s = saturated humidity whose value is $6.112e^{[\frac{17.5t}{t+240.97}]}$ and e_r is relative humidity.

The mean refractivity values of each half-hour data point and corresponding standard deviation were generated using 'descriptive statistics' from 'statistica.

4. RESULTS AND DISCUSSION

The 48 data points generated for half hourly diurnal variation of Refractivity for each station at 100 m and ground level (0) m altitude are presented in Figs. 3 and 4 respectively.

At 100 m altitude, refractivity across the regions assumed two value states i.e., Nzukka and Akure maintained a state value of 350 (N-units) refractivity while Minna and Sokoto assumed a lower refractivity value at approximately 250 (N-units); comparatively this expresses a greater exposure to cosmic and out of space radiations and hence minimal protection against them. At the ground level (i.e., 0 m) refractivity values become more distinct this is owing to the fact that refractivity 'N' varies with altitude since the atmospheric parameters such as pressure, temperature and humidity normally decrease exponentially with height; the substances of every point of the troposphere is able to express itself in a more distinct refractivity values as seen in Fig. 4.

Hence, protection values divided into three categories based on refractivity distribution of the troposphere at the ground level (0) m; Nzukka, 500 (N-units), Akure, 370 (N-units) while Sokoto and Minna shares the same refractivity value 270 (N-units). Therefore the highest value of Refractivity was recorded in Nsukka followed by Akure while Minna and Sokoto coalesced below, this shows a decreasing order as we move from the South to the North, this may be ascribed to the fact that the atmospheric (Troposphere) condition of the southern part (a coastal region) of the country presents a higher humidity.

The coalescing of the Minna and Sokoto station refractivity profile showed that the two stations shared the same atmospheric condition.

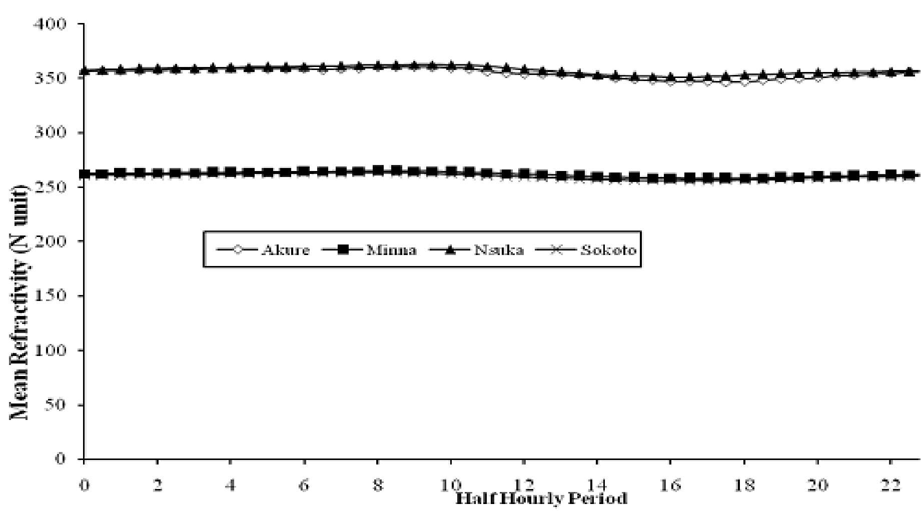

Fig. 3. Mean refractivity at 100 m altitude across the half hourly period under different locations

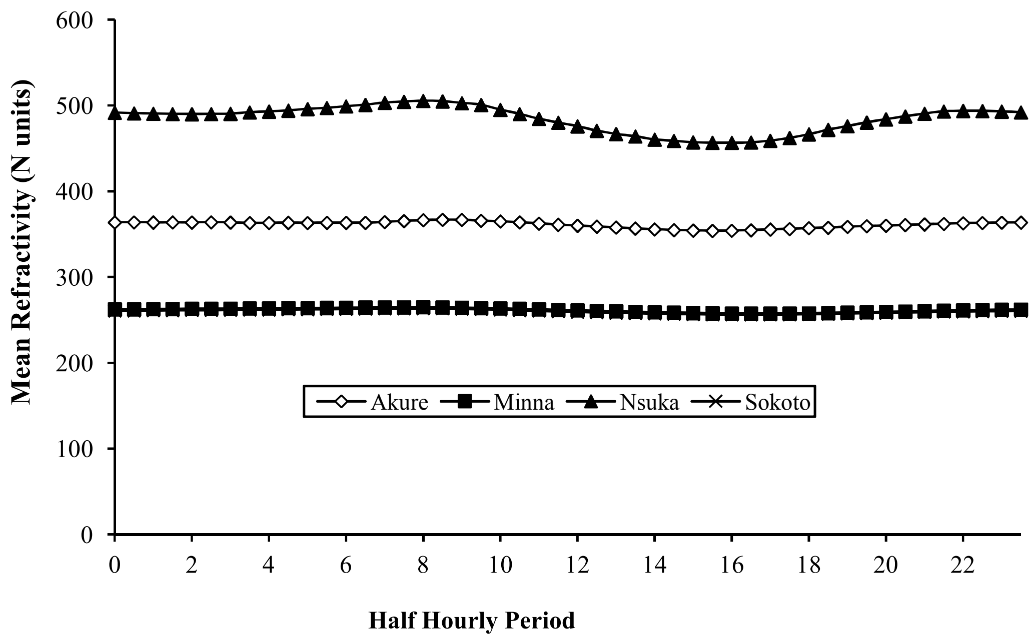

Fig. 4. Refractivity at 0 m altitude across the half hourly period under different locations

5. CONCLUSION

In this work refractivity from four different locations in Nigerian has been assessed and from the results of the analysis it is inferred that the tropospheric radio refractivity can be used as a measure of protection against damaging effects of ionizing radiation from the cosmos, thus the region of higher refractivity portends a greater protection than the lower region at a given period of the season.

Therefore since the variation in the refractivity profile across the country diminishes from the coastal region via inland Northwards, the protection afforded to lives diminishes as we move from the southern to northern region of the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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