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Comparing the Impact of Cosmic Rays on Tropospheric Radio Refractivity And its Variation with Meteorological Parameters over Yola.

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Abstract: *This paper investigates the effect of cosmic ray variations and meteorological parameters on the tropospheric radio refractivity during dry and rainy seasons in Yola from 2012 to 2016. The hourly averages of refractivity during dry and rainy seasons were calculated from the data obtained from the Centre for Atmospheric Research CAR and cosmic ray data were downloaded from Mexico Observatory. This data used for the computation of tropospheric refractivity is in two minute's interval of the variations of meteorological parameters for each day of the months and was carried out fora period of six years. Careful application of correlation text was carried out between the variation of cosmic ray and the variation of tropospheric refractivity variations, Correlation coefficients of 0.45.0.64, 0.56 during dry season and 0.13,0.33,0.44 during raining season at 5% significant level respectively were found between these variations The results indicated that the hourly averages of radio refractivity during rainy season (May-August) are greater than the results in dry season (October-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*
Keyword: *Cosmic rays, Meteorological parameters, Troposphere and Refractivity*

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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. Since we already know that 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. A lot of authors (Ekpe *et al.,* 2009, Agbo, 2011, Ayantunji *et al.*, 2011 and Chima et al., 2015) who have carried out similar research have given us enough facts to embark on this research.The continuous monitoring of the Earth's atmospheric ionization remains unlimited for astronomers, astrophysics and space scientist globally (Tinsley, 2006).The propagation of electromagnetic waves in the atmosphere (mainly the troposphere) is greatly affected by the composition of the atmosphere (Korak, 2003).During the design of radio communication networks, it is important to know the atmospheric radio refractivity index which is the ratio of the velocity of propagation of a radio wave in free space to the velocity in a specified medium. Radio–wave propagation is determined by changes in the refractive index of air in the troposphere (Adediji and Ajewole, 2008). At standard atmospheric conditions near the Earth's surface, the radio refractive index is approximately 1.0003 (Freeman, 2007). Changes in the value of the troposphere radio refractive index can curve the path of the propagating radio wave .In the troposphere, the refractive index is influenced by temperature, pressure and water vapour. In many instances, terrestrial radio propagation is governed, to a great degree, by the regions of the atmosphere through which the signals pass. Without the action of the atmosphere it would not be possible for radio communication signals to travel around the globe on the short wave bands.Galactic cosmic ray fluxes (GCRF) are energetic particles (mostly Protons and x-particles) which originate from outside the solar system (Calisto *et al*., 2011; Usoskin *et al*., 2004). The energy of GCRF falling on the Earth's atmosphere ($\sim 10^2$erg m^{-2} s^{-1} for particles with energy $E \geq 0.1$GeV) is small in comparison with the solar electromagnetic radiation ($\sim 10^{10}$erg m^{-2} s^{-1}) by $\sim 10^8$ times. Variations of the cosmic ray flux depend also on particle energy present in the atmosphere (Bazilevskaya *et al.,* 2008). High energy collision in the upper atmosphere produce cascades of lighter particles such as pions and kaons. These particles decay to produce muons. These muons constitute more than 50% of the cosmic radiation at sea level, the remainder being mostly electrons, positrons and photons from cascade eventsIn this study the influence of cosmic ray variation on tropospheric radio refractivity will be examined and we intend to statistically analyze the variations of cosmic ray flux and the tropospheric refractivity and correlating the variations both diurnally and seasonally.

II. Materials And Method

The cosmic ray data for this work is obtained from the Mexican cosmic ray observatory center, while the atmospheric data is obtained from Center for Atmospheric Research CAR, National Space Research and Development Agency, NASRDA, Anyigba, Kogi State, Nigeria. The NASRDA Center for Atmospheric Research provides research facilities and services for the atmospheric and Earth Sciences community, as part of their effort to simply the access of research data to different research groups worldwide through the Tropospheric DataAcquisition Network (TRODAN). The Tropospheric Data Acquisition Network TRODAN is a project that was design to monitor the lower earth's atmosphere which covers region from the surface of the earth to the altitude of 11km.A Campbell automatic weather station was employed for data acquisition for this study. The standard station is a fully configured, solar powered, automated weather station. The weather station is equipped with a standard set of sensors which takes records of: air temperature, relative humidity, wind speed and direction etc. The data logger is programmed using CR basic for the sensors supplied. When completely connected the weather station will automatically start to take measurements through each of the parameter sensors outside of the box.. The CR1000 data logger type is used for measurement and data storage in this station at five-minute update cycle. In-situ measurement of meteorological parameters of temperature, humidity and pressure from the station were employed. The data were collected at the station for the period under study. The records cover 24hours each day from 00 hours to 2300 hours local time at five minutes interval. The values of temperature in degree Celsius, humidity in percentage value and pressure in mbar is extracted from the data collected for the determination of trophospheric refractivity, N, using ITU-R P.453-10 model. For the purpose of this study, the year was divided into dry and rainy month. Also both seasonal and diurnal variations of refractivity were obtained, first by averaging the five minutes interval data into hourly values then into daily values and lastly into monthly values for the station. Data obtained for each month was added with all the data for the corresponding months in the years considered to obtain the seasonal variation. The diurnal variation was obtained using the same method for corresponding hours.For the purpose of finding the diurnal variations, the year was divided into rainy and dry seasons.Also software's such as Matlab and Origin Pro 8 was used in plotting the graph's for easy interpretations.

III. Results

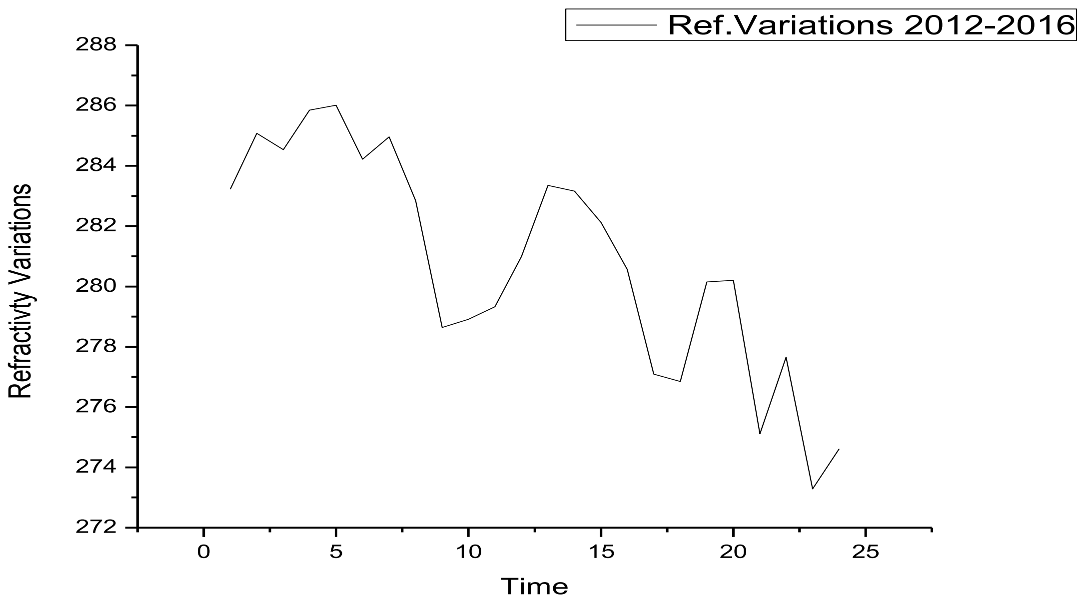

Figure 1: Showing Diurnal Refractivity variations over Yola for Dry season.

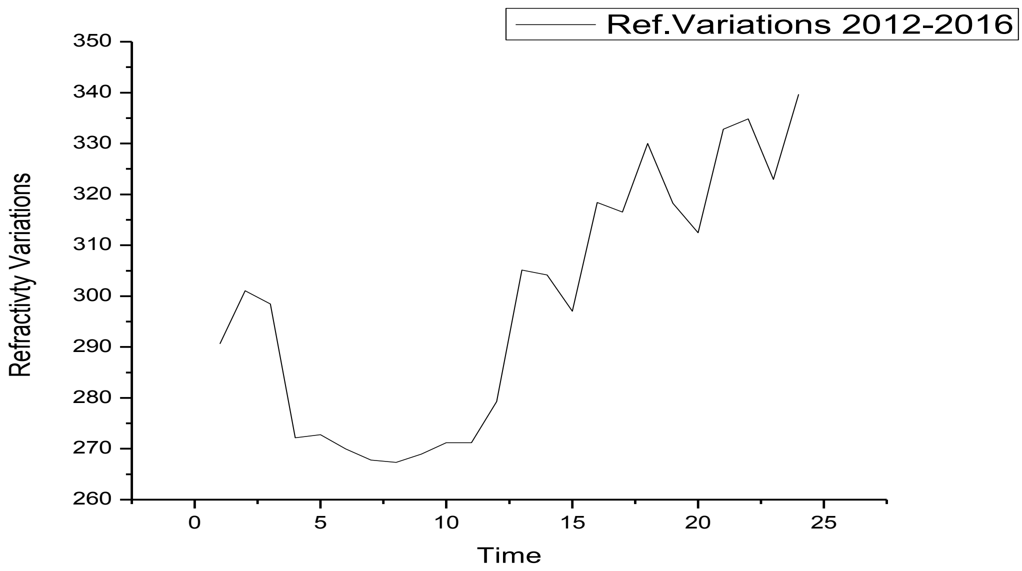

Figure 2: Showing Diurnal Refractivity variations over Yola for Raining season

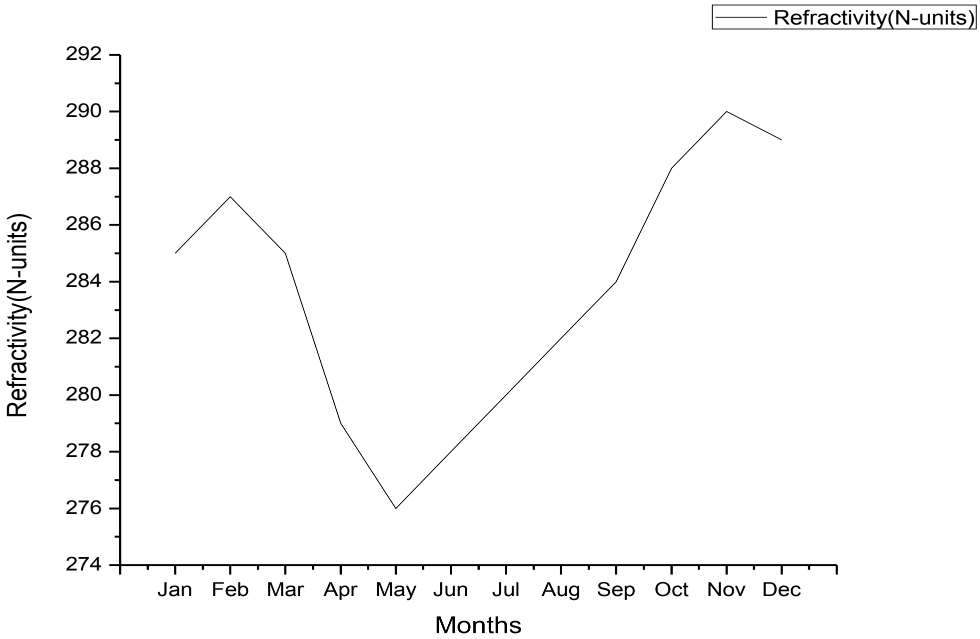

Figure 3: Showing Seasonal Refractivity variations over Yola from 2012-2016

The pattern of variation in Yola showed in Fig 3 and 4 is different, with a very steep rise and fall because of rainfall pattern and shorter period of rainfall in Yola. Yola is located in North-Eastern Nigeria and within Sahel Savannah. The value of refractivity at Yola in the rainy season is however found to be higher than that of other Northern States during the peak period because the rainfall at Yola is usually heavy within the short rainy season.Diurnal refractivity variation showed that the dry term is the major cause of refractivity variation in rainy season and the wet term is the major cause of refractivity variation in dry season. In Yola the result was found to be opposite and it is attributed to the fact that in dry season the humidity is almost close to zero while in rainy season the pressure seems to be almost constant but the temperature fluctuates rapidly and consequently the humidity.

Dependence/Impact of Cosmic Rays on Atmospheric Parameters in Yola.

Here statistical analysis was carried out using a Histograme and scatter plot to determine to ascertain the dependence of atmospheric parameters on cosmic rays. We also determine the correlation coefficient of cosmic rays on troposphere to check how its effect is felt aroundYola.

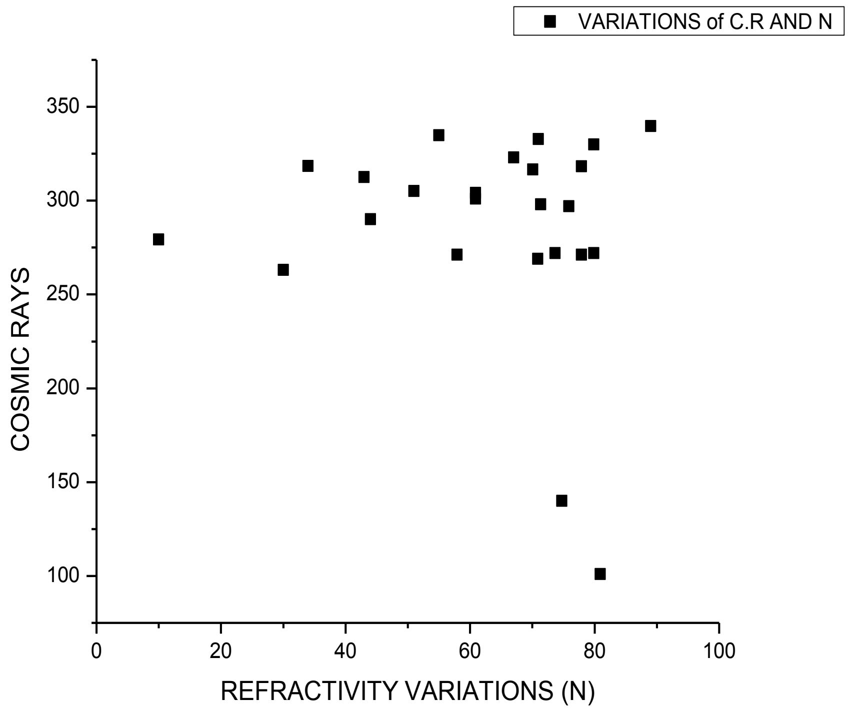

Figure 4: Showing the variations of cosmic rays and refractivity variations during Dry Season in Yola Station from 2012-2016

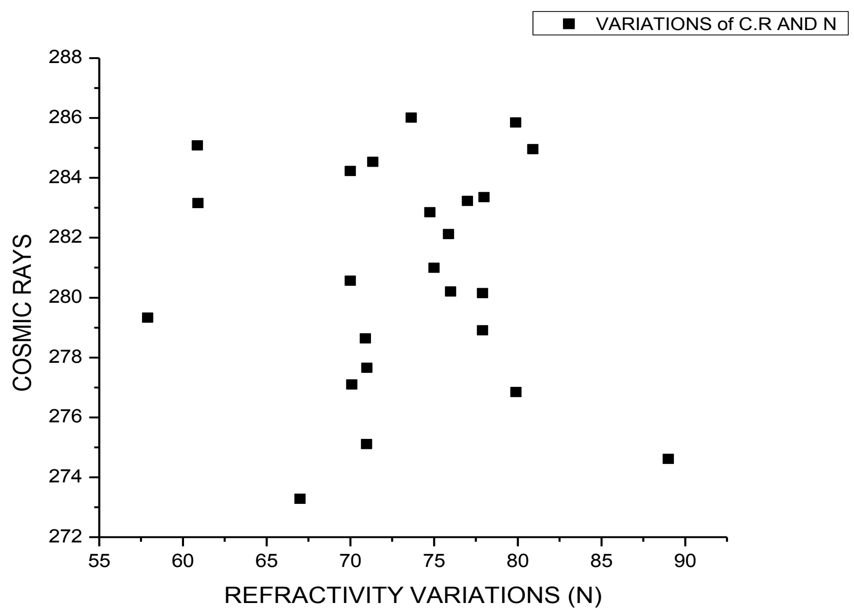

Figure 5: Showing the variations of cosmic rays and refractivity variations during Raining Season in Yola Station from 2012-2016

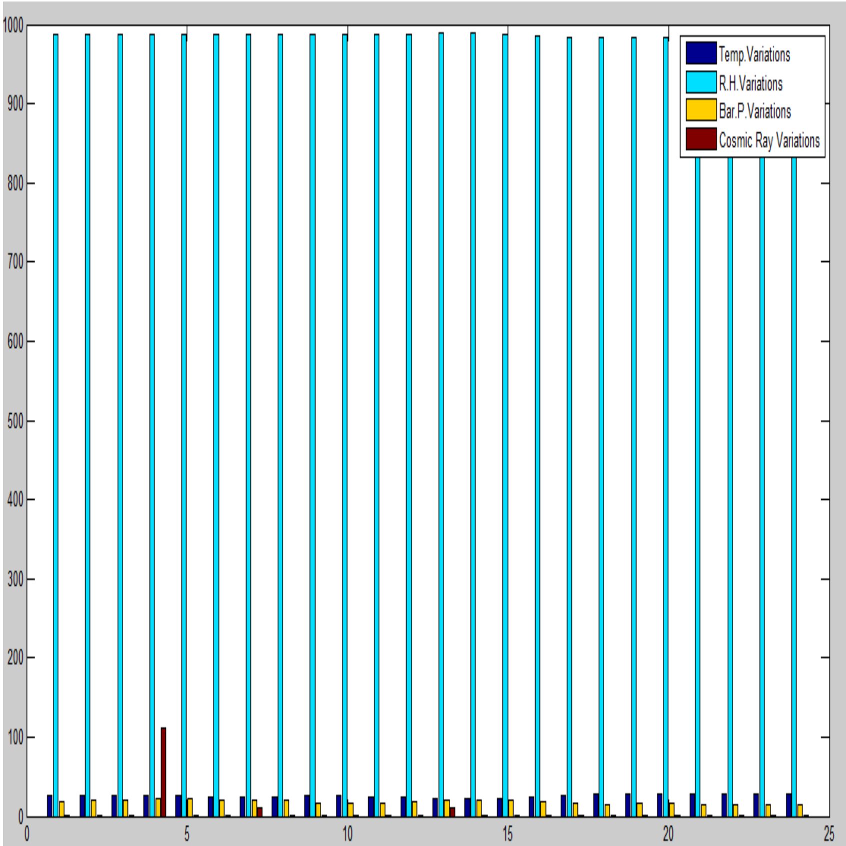

Figure 6: Dependence of Cosmic Rays on Average Atmospheric Parameters during Dry Season in Yola Station from 2012-2016

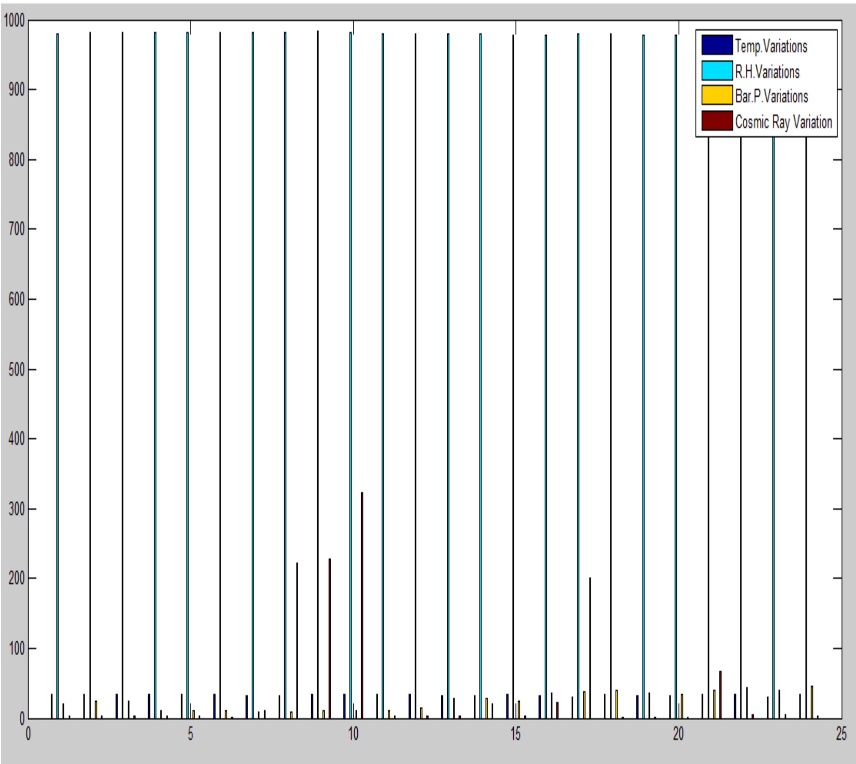

Figure 7: Dependence of Cosmic Rays on Average Atmospheric Parameters during Raining Season in Yola Station from 2012-2016

Table1: Determining The Correlation Coefficient on Dependence of The Variation of Cosmic Rays on Average Atmospheric Parameters in Yola

Atmospheric parameters	Dry season	Raining Season
Temperature	0.454661	0.13027
Relative Humidity	0.63591	0.339086
Bar Pressure	0.08574	0.44308

IV. Summary Of The Results

The data obtained from CAR were employed to determine the impact of the variations of the cosmic ray fluxes with the refractivity of the tropospheric variations in Yola. The work has shown that the effect of meteorological parameters on the tropospheric radio refractivity in Yola has being attributed to seasonal variations in weather in the troposphere most especially at the lower part. This variation in weather was observed to be more significant during the rainy season than the dry season in Yola owing to the increase in the tropospheric temperature and humidity and it therefore resulted to very high radio refractivity which is in line with results obtained from authors who have carried out similar research (Okoro and Agbo 2012,Adedoja et al.,2015). The results also indicate that an average value of 285 N-units and an average value of 300 N-units were observed during the rainy and dry seasons respectively. This shows obviously that radio refractivity during the rainy season is greater than the dry season for the study area. However, the impact of cosmic ray was highly pronounced as shown in the scatter plot in Fig. 4 and 5 which shows the effect of cosmic rays on the variation of radio refractivity with meteorological parameters indicates that high values of radio refractivity and temperature were observed during the rainy and dry seasons respectively and low values of radio refractivity and temperature were observed during the dry and rainy seasons respectively. The dry term contributes 70% to the total value of the radio refractivity while the wet term contributes to the major variation.Also the scatter plot and Histogram was used in checking the dependence/impact of cosmic rays on atmospheric parameters which helped usto check its impact on Yola knowing fully that GCRs are modulated by the sun's and earth's magnetic fields because GCRs are a major determinant of levels of ionization in the troposphere. Correlation coefficient of 0.45.0.64, 0.56 during the dry season and 0.13,0.33,0.44 during the raining season was found to correspond with the nature of the zone because these zone experience inconsistencies in their weather conditions.

Acknowledgement

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