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Research Article

The Impact of Cosmic Rays Flux in South West Region of Nigeria (A Case Study of Akure in Ondo State Nigeria)

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ABSTRACT: *A comparative research on the effects of cosmic ray flux on tropospheric refractivity variations were carried out in south west part of Nigeria. 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 for a 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 0.4676,0.3139 and 0.5854 during dry season and 0.2335,0.2241,0.4350 during raining season at 5% significant level respectively were found between these variations. The results indicated that the impact of cosmic rays on atmosphere in Akure during rainy season are greater than the results in dry season in . 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.*

KEYWORDS: *Cosmic Rays, Flux, meteorological parameters, refractivity, tropospheric*

1. INTRODUCTION

Over the years research on cosmic rays have been ongoing and how its impact is felt on the atmosphere have be taken care of partially by [1] who tried in establishing its effect in South Eastern part of Nigeria. Cosmic rays are high energy charged particles ($\geq 10^{16}$ eV) originating from outer space that travel nearly with the speed of light (3.0x10 m/s) and strike the earth's atmosphere from all directions of the terrestrial and extraterrestrial domain [2] Over the years, research on cosmic rays has been an interesting issue for global discussion especially when linked to atmospheric occurrences. The atmospheric electricity (ionization of air) plays important role on weather and climate. The major contribution of cosmic ray fluxes comes from the "Galactic Disc", but in some wavebands. Variations of the cosmic ray flux depend also on particle energy present in the atmosphere [3] High energy collision in the upper atmosphere produce cascades of lighter particles such as pions and kaons. These particles decay to produce muons and these muons constitute more than 50% of the cosmic radiation at sea level, the remainder being mostly electrons, positrons and photons from cascade events.

Cosmic rays form an ionizing radiation and this form of ionization affect atmospheric temperature and this is the reason why so many authors are considering it as one of the factors that affect atmospheric temperature [1] while some are of the opinion that solar activity variations like solar wind, sun spot, geomagnetic storm and solar flare have a strong positive effect on the atmosphere [4],[5],[6].The scientific communities are interested in the effects of ionization and nuclear-electromagnetic cascade due to space radiation on the Earth's atmosphere. The ionization due to galactic cosmic rays (GCRs) is always present in the atmosphere, and it changes with the 11-year solar cycle due to the solar modulation. The impact of cosmic rays on the ozone layer and formation of clouds in the troposphere is currently an interesting new area of study; hence our interest on this area of research because within the region of the atmosphere(troposphere) there is generally a steady fall in temperature with height. We discover that in frequencies above 30 MHz, it is found that the troposphere has an increasing effect on radio signals and radio communications systems.

In spite of these, the continuous motoring of the Earth's atmospheric ionization remains unlimited for astronomers, astrophysics and space scientist globally [7]The propagation of electromagnetic waves in the atmosphere (mainly the troposphere) is greatly affected by the composition of the atmosphere[8]. This is due to the fluctuations of atmospheric parameters primarily at the troposphere - "the lower" part of the earth. Consideration of the refractive properties of the lower atmosphere is of importance when planning and designing terrestrial communication systems mainly because of multi-path fading and interference due to trans- horizon propagation. Several works carried by many researchers showed that the refractivity fluctuation in the lower atmosphere (troposphere) is a function of atmospheric parameters [9] Bending of radio signal as it propagates through the troposphere can cause a lot of problem in systems such as the accuracy of tracking radio source (such as stars) with radio telescope, tracking of satellites (such as GPS satellite) , missile range etc. As radio wave propagates in the troposphere the vertical gradient of the refractive index induces a bending of its path which remains every point of space constrained within the vertical plane [10]

The study intend to statistically analyzed the variations of cosmic ray flux and the tropospheric refractivity and correlating the variations both diurnally and seasonally with Origin Pro software to check its impact in Akure South West Nigeria.

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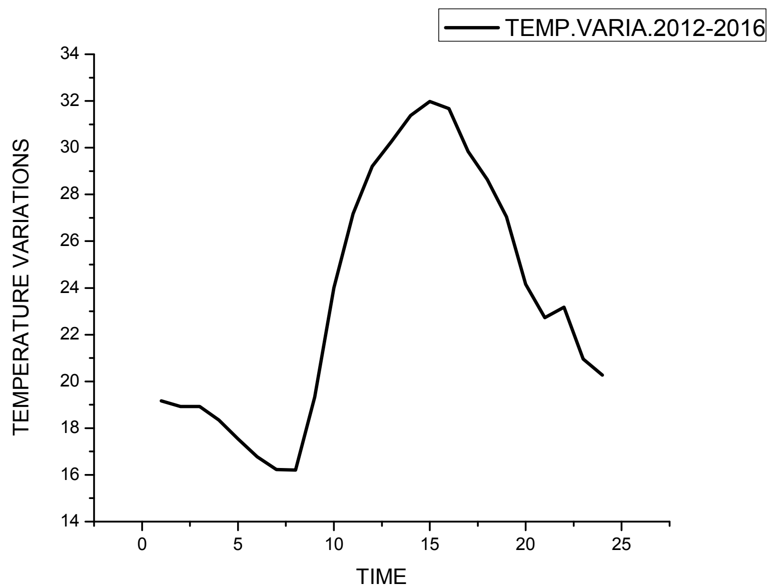

Figure 1: Average Atmospheric Temperature variation at Akure during the Winter from 2012-2016

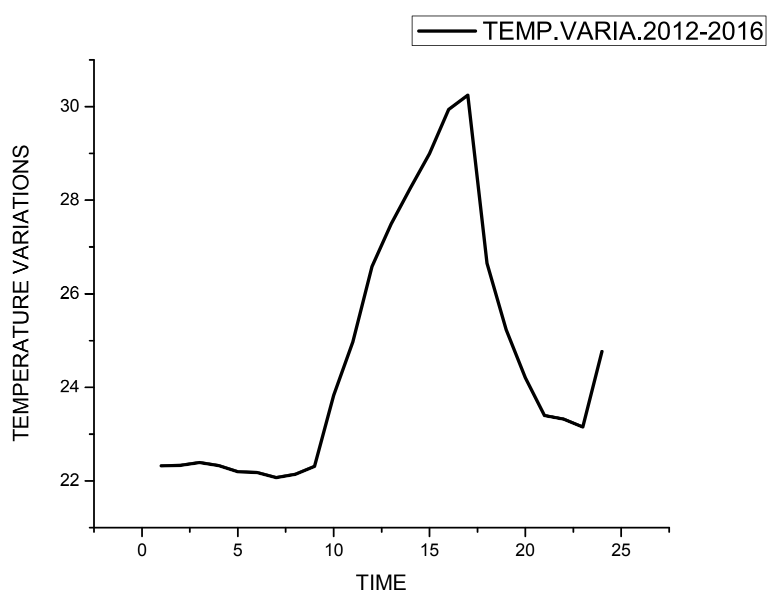

Figure 2: Average Temperature during the Spring using Akure data from 2012-2016

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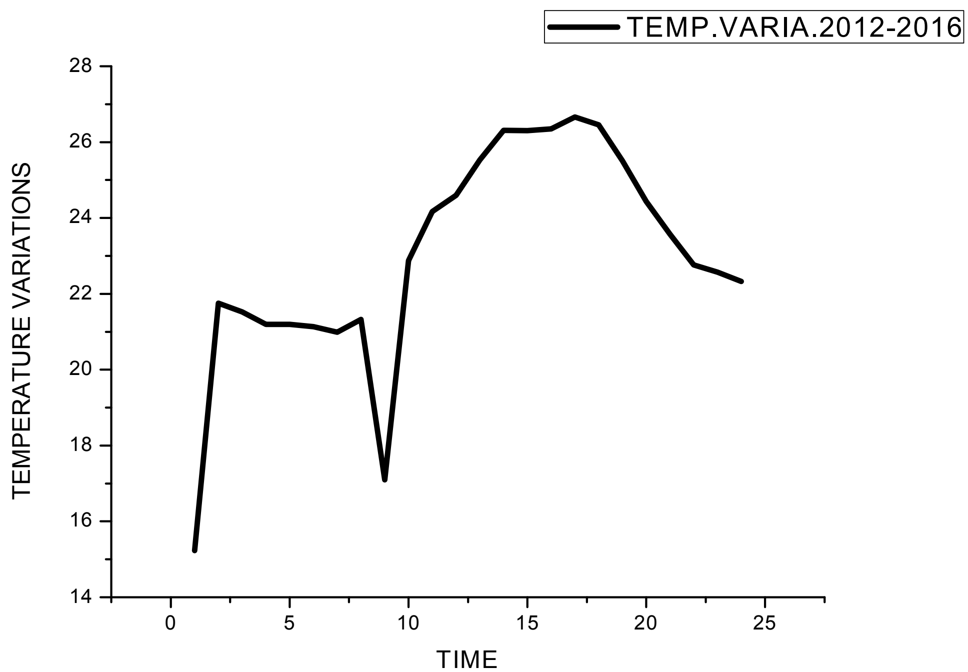

Figure 3:Average Temperature during the summer using Akure data from 2012-2016.

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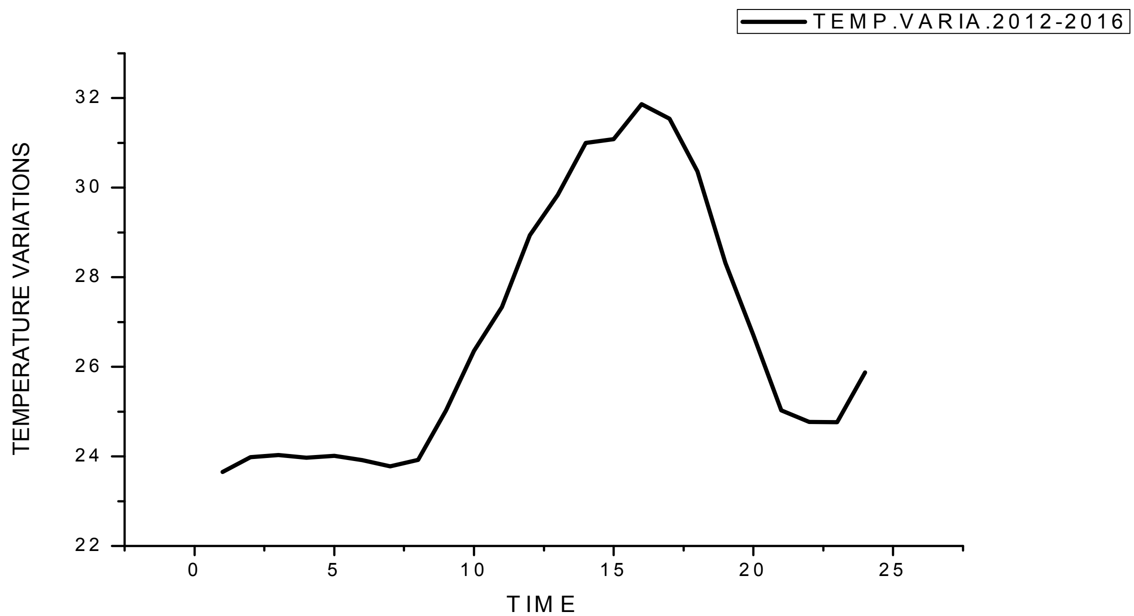

Figure 4: Average Temperature during the Autum using Akure data from 2012-2016

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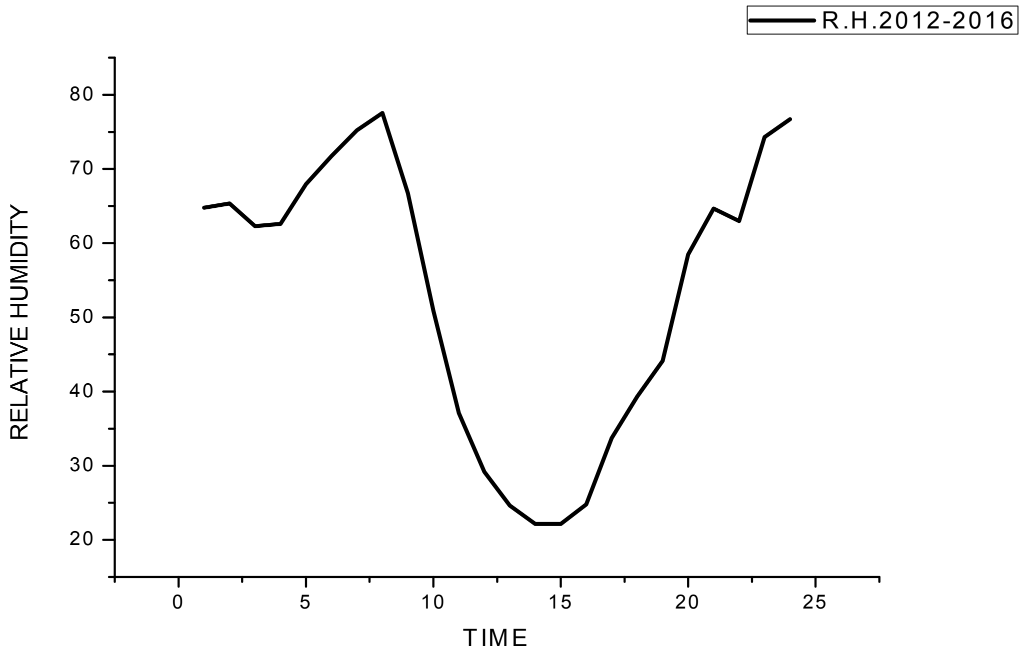

Figure 5:Average Relative Humidity during the Winter using Akure data from 2012-2016

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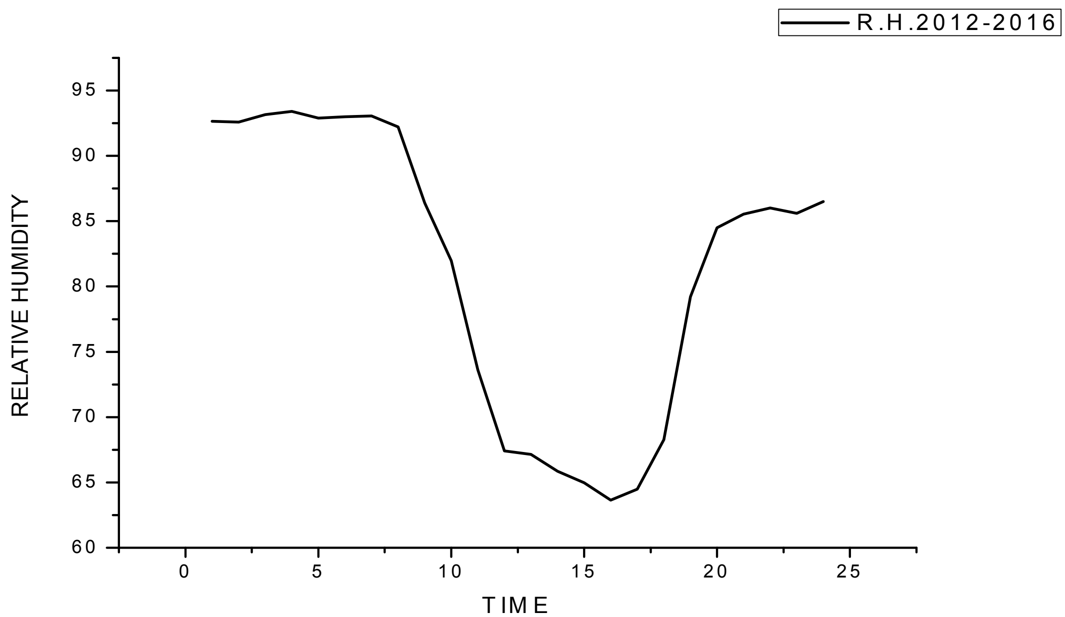

Figure 6: Average Relative Humidity during the Spring using Akure data from 2012-2016

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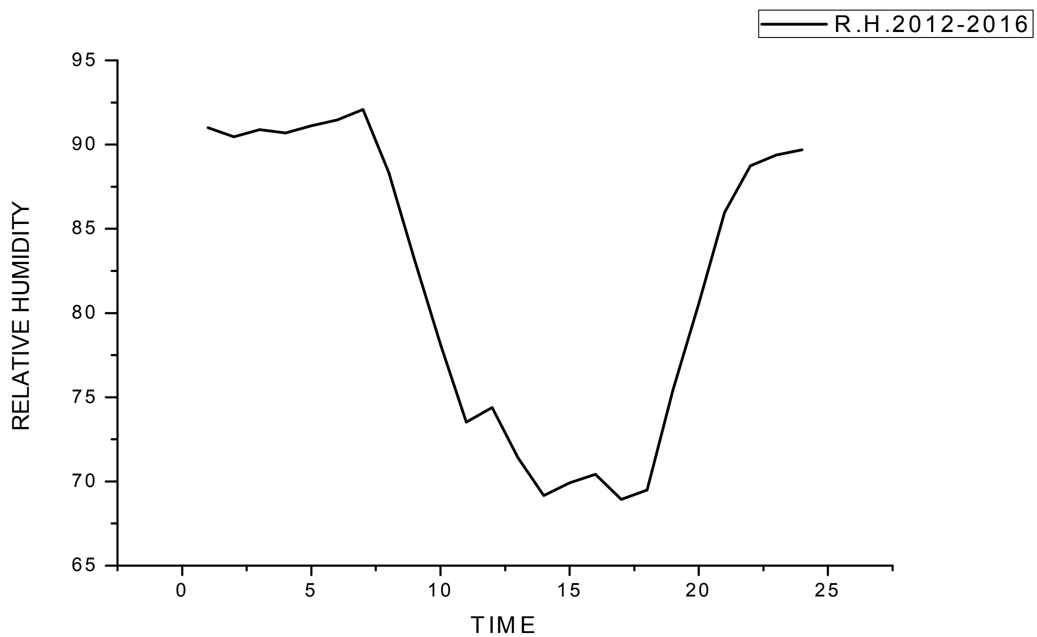

Figure 7: Average Relative Humidity during the Summer using Akure data from 2012-2016

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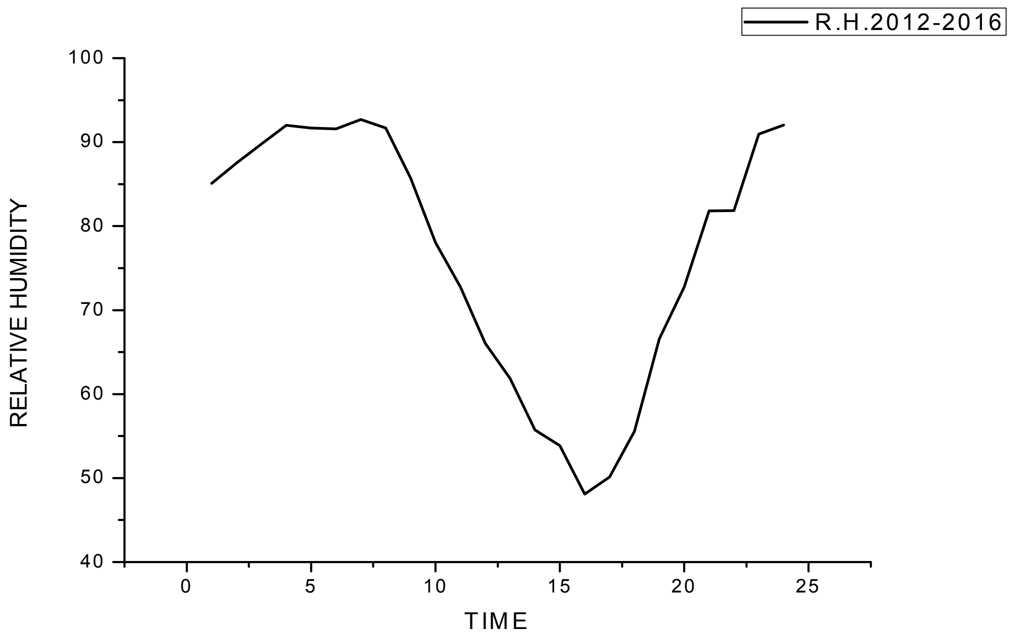

Figure 8:Average Relative Humidity during the Autum using Akure data from 2012-2016

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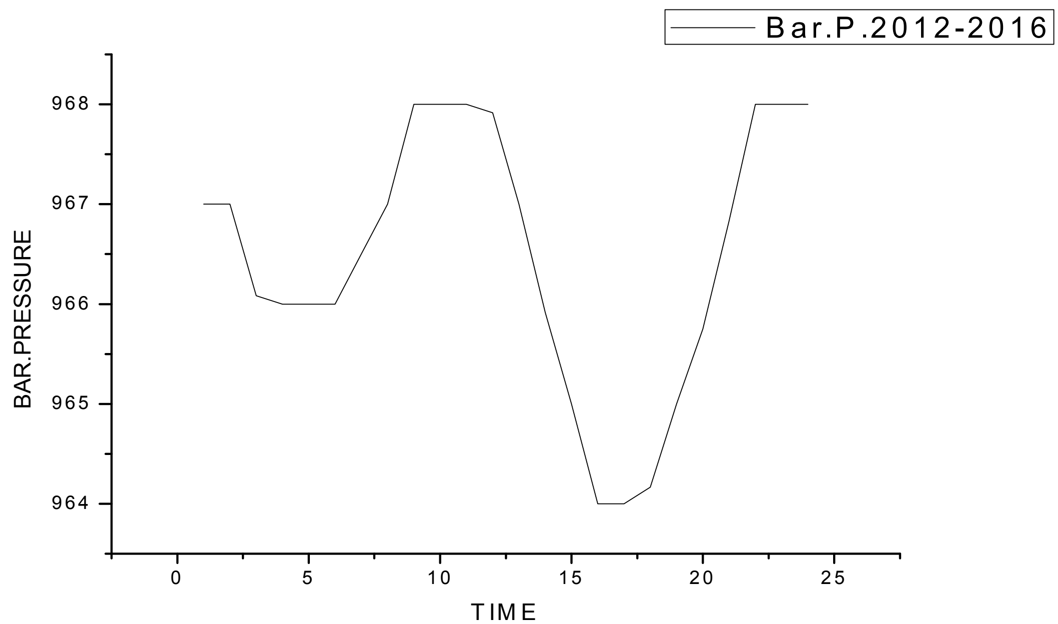

Figure 9:Showing seasonal variation of Average Bar Pressure during the Winter using Akure data from 2012-2016.

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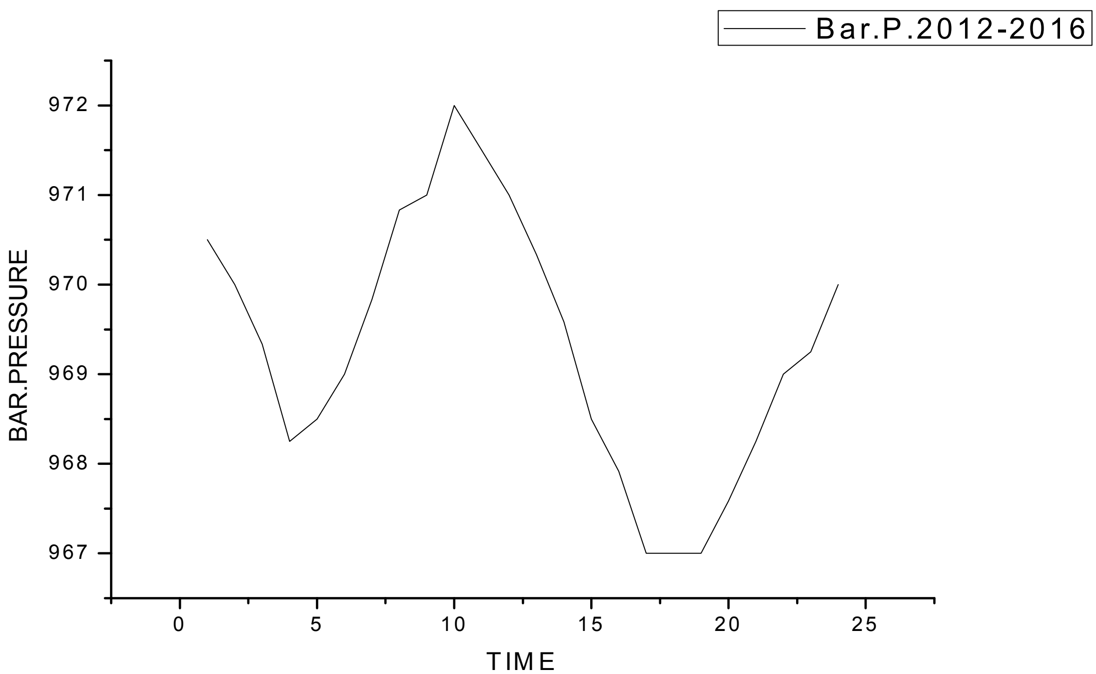

Figure 10:Showing seasonal variation of Average Bar Pressure during the Spring using Akure data from 2012-2016.

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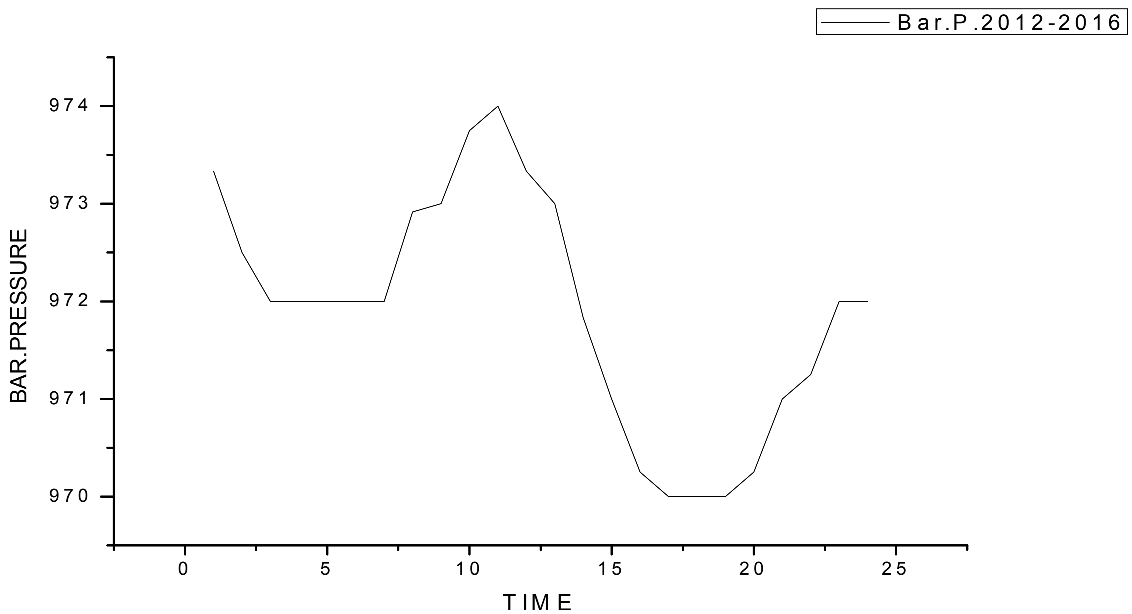

Figure 11:Average Bar Pressure during the Summer using Akure data from 2012-2016.

RESULTS AND DISCUSSION

This section contains results and discussions of various analyses that were done on the variations of average atmospheric parameters. Globally, in the Northern and Southern hemisphere there exist four clear seasons in the year: Spring (March-June),Summer (June-September), Autum (September-December) and Winter (December-March).The four seasons normally are observed within the range of months as indicated with very little variation. In West Africa, however, there are two seasons only: Dry seasons (December-April), Rainy season (May-November) and an intermediate season. Adapting the West African two seasons to the global four seasons we can say as follows:

Rainy season: May - November - Spring, May - September - Summer and September - December - Autumn while Dry season is December-March - Winter. This was done due the inconsistencies experienced for the past decade during rainy and dry seasons which is attributable to manmade activities which is resulting to climate change and also since we are studying cosmic rays which is a global issue, its highly necessary for us to put all these factors into consideration when carrying research of these nature. The first set of graph was plotted using the four seasons that exit in the Northern and Southern hemisphere before bringing it closer to plot for just dry and raining seasons.

The temperature variation at Akure in the winter as shown in Fig.1& 2 shows that the temperature drops to a minimum early in the morning around 8am local time and rose to maximum post noon (2pm-3pm). This result agrees with previous work[11] and[12,[12],[13] that the temperature variation close to the surface is as a result of radiation of absorbed heat rather than direct solar heating of the atmosphere. The earth surface gets heated from

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solar irradiation and in turn emits infrared radiation which heat up the atmosphere, hence, the lag between noon and when the peak temperature. The post noon peak temperature in winter (Jan-March) is attributed low relative humidity as shown in Fig 4. The low humidity reduced temperature retention capability of the atmosphere which leads to faster emission. If the humidity is high, in the atmosphere heat will be retained for longer period and the rise and drop in temperature will not be as sudden as depicted. Figure 2 depicting the variation in Spring follows the same pattern with what was observed in winter, except that the rise was steeper than winter.

The temperature variation in Summer as depicted in Fig 3 shows a different variation pattern with the two seasons earlier considered. The rise in temperature during this season was not as sudden as previous seasons, though the temperature is generally higher. This can be attributed to high humidity as a result of rainfall and the consequent more heat retention capability. There are two peaks in the graph. The actual peak was still post noon and is higher that the peak that was recorded early in the morning. The sudden drop in temperature around 10am local time can be attributed to sudden drop in humidity around same time as depicted in Fig 6. The higher temperature in the summer is due to higher humidity which leads to higher heat retention capability.

Temperature variation in Autum Fig 5 mimics what was observed in winter and spring. This can be attributed to same reason proffered for winter and Spring. The temperature rise in Autum is however gradual unlike Winter and Spring that is sudden. This is due to higher humidity in Autumn compares to winter and summer . The relative humidity variation in Autum is more noisy than in other seasons. The humidity in winter drops as low as 20%,in Autum its 40% but in summer the lowest humidity drop is 70%.

Figs 7-11 depicts pressure variation for the four seasons. The pressure peaks occur in the early hours and post noon minimum. The higher the humidity, the denser the atmosphere and hence higher pressure. In other words, pressure is directly proportional to density, the denser the atmosphere the more pressure in the atmosphere. This explains the pressure variation across the seasons as it relates to temperature and humidity.

Diurnal and Seasonal Refractivity Variations

The diurnal and Seasonal variations of refractivity over the study area is shown in Fig.12-16,having plotted all the graph according to seasons before and also explained earlier why we divided the seasons into four ,it's now necessary for us to bring the explanation closer as it affect the atmosphere of Akure in Nigeria. We now divide the seasons into two (Dry and Raining season) putting into consideration all we have done before now.

The Diurnal variation of refractivity at Akure in the dry season is shown in fig 13. The refractivity shows a high value of about 355N-units to about 365N-units during the early hours of the day and late in the evening (Please note that the refractivity variation are in units), The value of refractivity start dropping about noon and reach a minimum of about 333N-units around 20:00hr local time. This variation was attributed to the response of the earth to solar insulation which is the major forcing behind the weather condition observed. The solar insulation caused the temperature to be high and humidity to be low during the day. The result shows that the refractivity over Akure for dry season is as a result of variation in the wet term of the refractivity. This result is in agreement with previous studies [11] and[12],[13]

The variation of refractivity over Akure for rainy season is shown in fig. 14 The refractivity increase to a first minimum of about 362N-units around 9:00hr local time. It gradually decreases to 356N-units around 12:30hr local time. It increases from 360N-units around 17:00hr local time before increasing for the rest of the day. The pattern of refractivity variation observed here is different from what is described before. To understand the reason for this pattern of variation, we check the pattern of variations of temperature, humidity and pressure which was plotted in fig 15-17. While the variation of temperature and humidity showed the expected pattern, the pressure variation showed a pattern that is synchronous with refractivity variation. It is therefore deduced that the pressure (dry term) is

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the major driver of the refractivity variation over Akure in the rainy season. This shows that while the wet term drive the refractivity variation in dry season, the dry component is the major driver in rainy season.
The seasonal variation of refractivity over Akure as depicted in Fig. 18 also show a seasonal variability with gradual increase from of about 359Nunits in January and of about 348Nunits in October. The refractivity over Akure showed slight drop in June and August. The drop in August can be attributed to August break while that of June can be attributed to slight rain cessation from late May to early July. This signifies that between may and July there will be more signal problems compared to other months in Akure during this period as its effect on radio signals is highly pronounce as a result of more rain within the atmosphere while within Jan-April and October to December will have good signal strength.

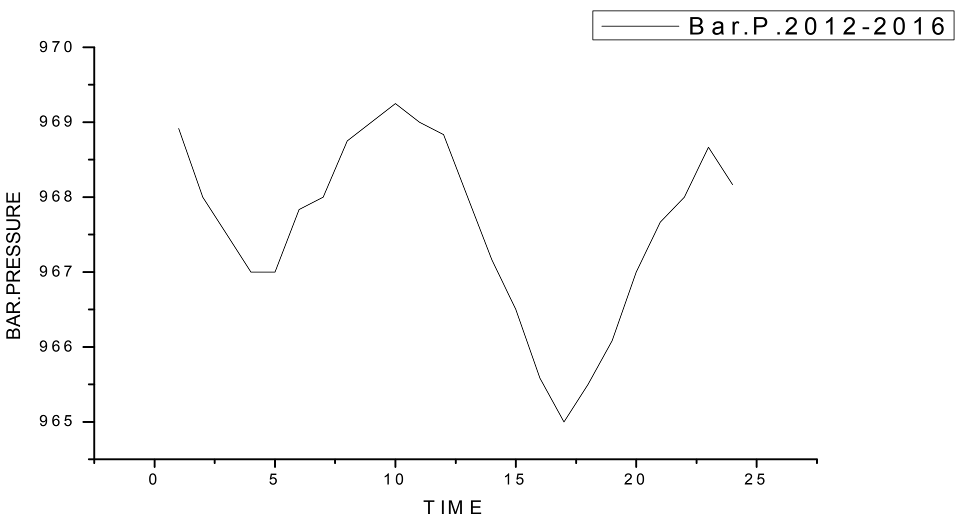

Figure 12:Average Bar Pressure during the Autum using Akure data from 2012-2016.

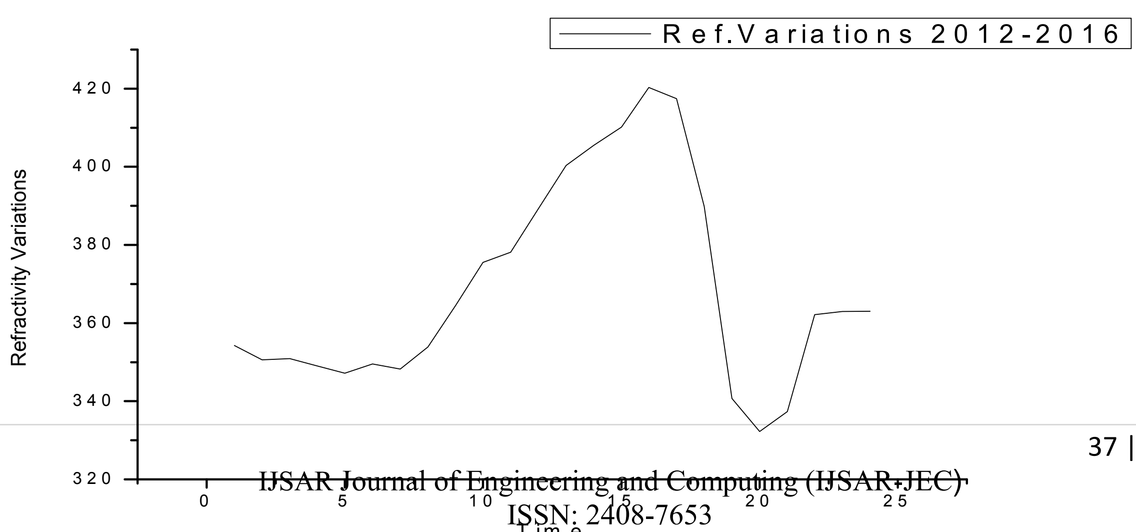

Figure 13: Showing Diurnal Refractivity variations over Akure during the Dry

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Season

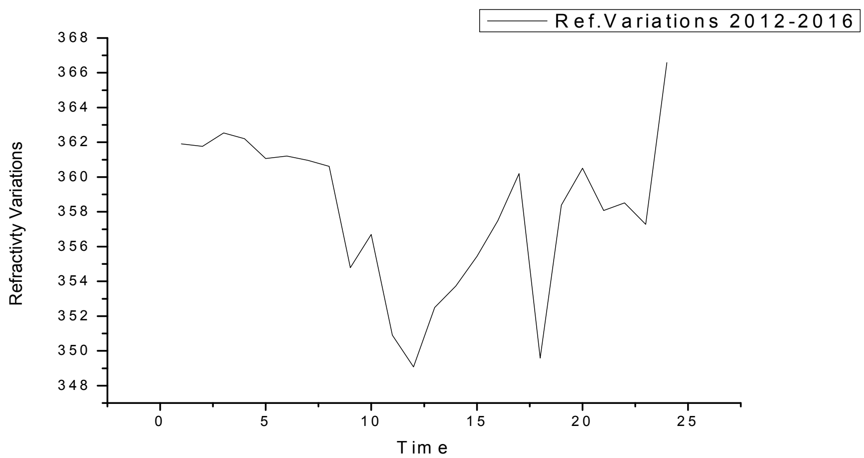

Figure 14: Showing Diurnal Refractivity variations over Akure during the Raining Season

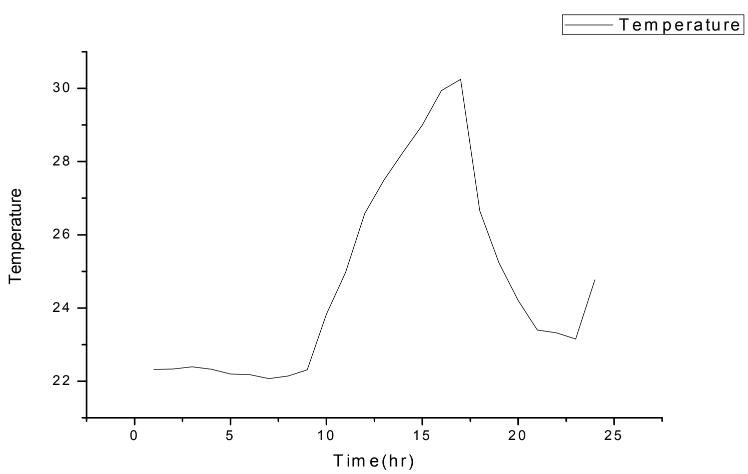

Figure 15: Diurnal variations of Temperature over Akure for Raining Season

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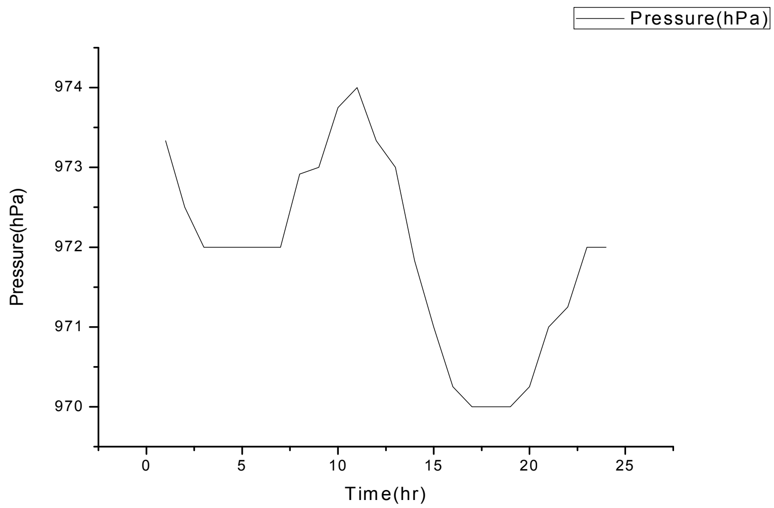

Figure 16: Diurnal variations of Pressure over Akure for Raining Season

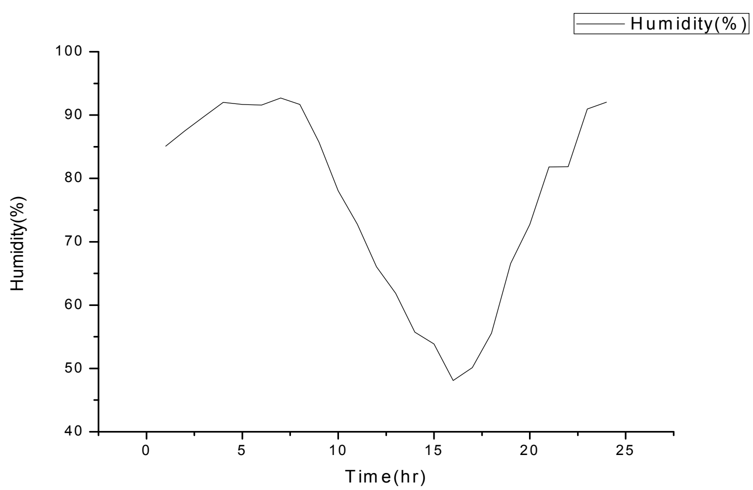

Figure 17: Diurnal variations of Humidity over Akure for Raining Season

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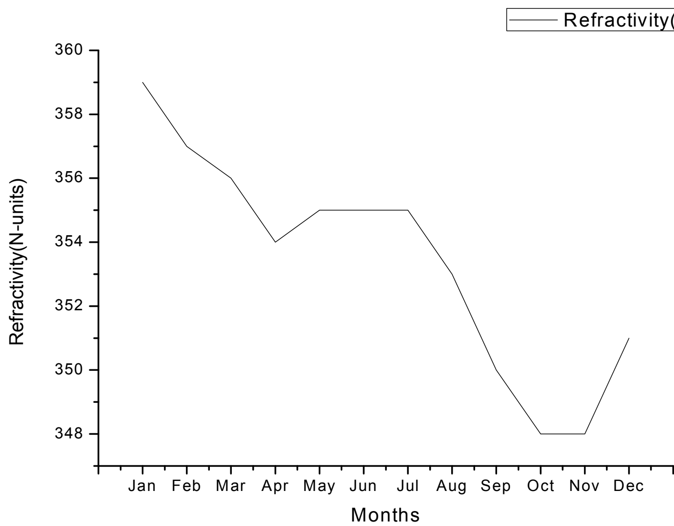

Figure 18: Showing Seasonal Refractivity variations over Akure from 2012-2016

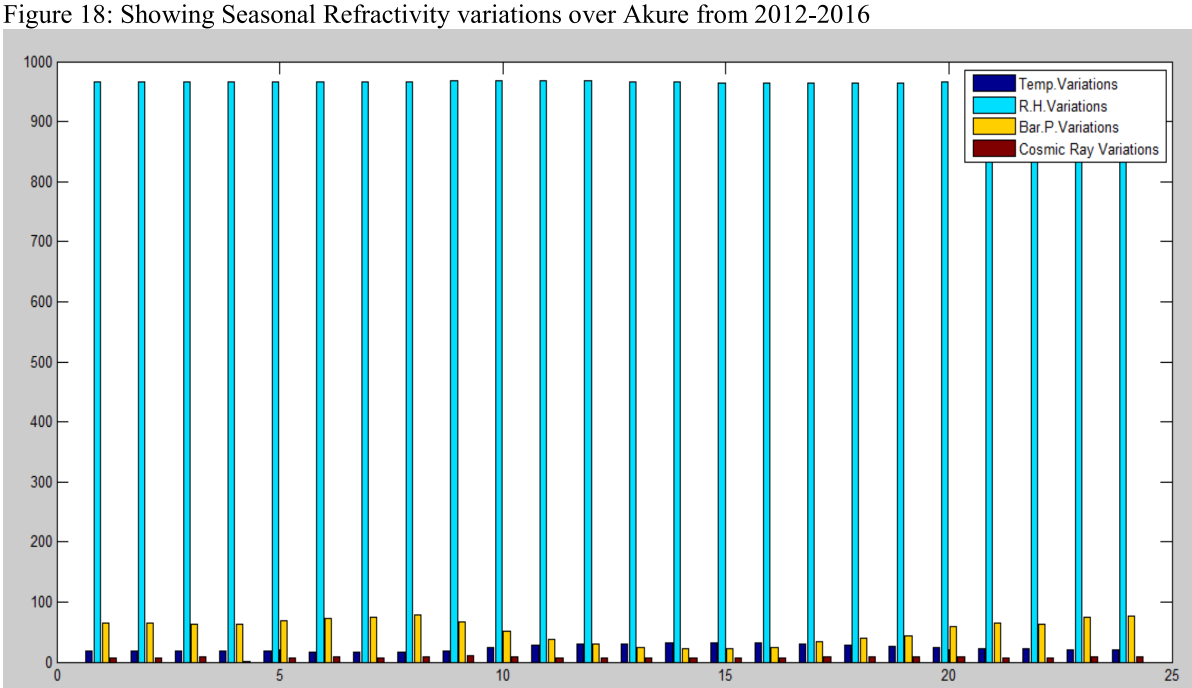

Figure 19: Dependence of Cosmic rays on Average Atmospheric Parameters during dry season in Akure Station from 2012-2016

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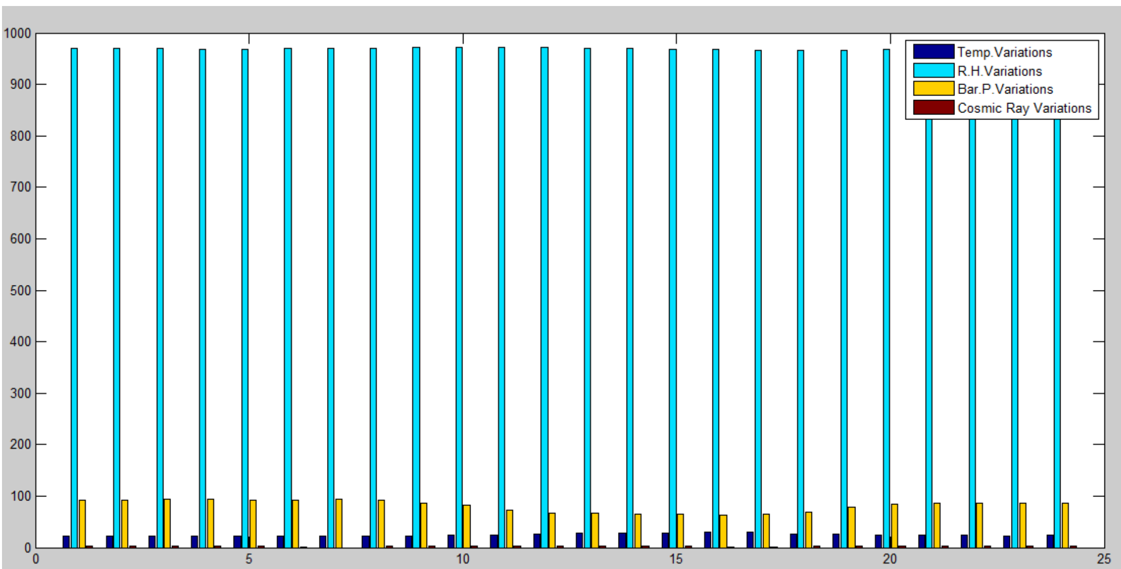

Figure 20: Dependence of Cosmic rays on Average Atmospheric Parameters during raining season Akure Station from 2012-2016

Dependence/Impact of Cosmic rays on Atmospheric Parameters in Akure

Here statistical analysis such as histogram were carried out to ascertain the dependence of atmospheric parameters on cosmic rays in Akure .We also determine the correlation coefficient of cosmic rays on the station used to know how its effect is felt in the environment which will enable us determine its impact on the atmosphere.

Table 1: Determining The Correlation Coefficient on Dependence of The Variation of Cosmic rays on Average Atmospheric Parameters in Akure

Atmospheric parameters	Dry season	Raining Season
Temperature	0.46766	0.23358
Relative Humidity	0.313929	0.224059
Bar Pressure	0.585412	0.435082

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CONCLUSION

From TABLE 1 Careful application of correlation text was carried out between the variation of cosmic ray and the variation of tropospheric refractivity variations and we obtain correlation coefficients of 0.4676,0.3139 and 0.5854 during dry season and 0.2335,0.2241,0.4350 during raining season at 5% significant level respectively were found between these variations. The results indicated that the impact of cosmic rays during rainy seasons are greater as a result of the weather condition during June to early August due to the high moisture concentration in the atmosphere than the results in dry season which is due to lack of water concentration in the atmosphere and harmattan dust .The changes in the two seasons 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.

REFERENCES

[1]Chima A.I, Umahi A.E, Ugwoke A.C and Nwobodo.A.N The Effect of Cosmic Ray Flux on Earth's Atmospheric Temperature *.American-Eurasian Journal of Scientific Research 10 (6) 2015 345 351 IDOSI Publications,ISSN:1818-6785*

[2] Sharma. Atomic and Nuclear Physics. Pearson Education *India. .478. 2008 ISBN 978-81-317-1924-4*

[3]Bazilevskaya, G.A., Usoskin, I.G., Fluckiger, E.O., Harrison, R.G., Desorgher, L., Butikofer, R., Krainev, M.B., Makhmutov, V.S., Stozhkov, Y.I., Svirzhevskaya, A.K., Svirzhevsky, N.S., and Kovaltsov, G.S. Cosmic ray induced production in the atmosphere.,space *Sci. Rev., 2008,137 - 149.*

[4] Drijfhout, S. S., R. J. Haarsma, J. D. Opsteegh, and F. M. Selten , Solar induced versus internal variability in a coupled climate model, *Geophys. Res. Lett., 26, 1999. 205-208.*

[5] Waple,A.M.,M.E. Mann,and R.S.Bradley Long-term patterns of solar irradiance forcing in model experiments and proxy based surface temperature reconstruction,*Clim.Dyn.,18, 2002, 563-578.*

[6]White,W.B.,J.Lean,D.R.Cayan, and M.Dettinger (1997),A response of global upper ocean temperature to changing solar irradiance *,J.Geophy.Res., 102,3255-3266*

[7]Tinsley, B.A., and Zhou, L., (2006) Initial results of a global circuit model with stratospheric and tropospheric aerosols,*J. Geophys.Res.,111, D16205*

[8] Korak shaha, P.N. The physics of the earth and its atmosphere, *John and sons Inc., New York, USA. 2003.*

[9]Ekpe. O. E, G. A. Agbo., B.G. Ayantunji, N. Yusuf and A. C. Onugwu. Variation of Tropospheric Surface Refractivity at Nsukka in South Eastern Nigeria, *Nigerian Journal of Space Research, 7, 2009 5-10.*

[10].Ayantunji, B.G.Okeke P.N and.Urama J.O.Diurnal and Seasonal variation of surface refractivity over Nigeria. *Progress in Electromagnetic research 30, 2011 201-222*

[11]Ayantunji B.G, Mai-unguwa H., Adamu A., and Orisekeh K Tropospheric Influences on Satellite Communications in Tropical Environment: A Case Study of Nigeria *International Journal of Engineering and Innovative Technology IJEIT 2 (12). 2013*

[12]Falodun,S.E Experimetal studies of super-refraction of microwave signal. Unpublished PhD thesis, Department of Physics, F.U.T. Akure, Nigeria 2004.

[13]Falodun, S.E and Ajewole, M.O Radio refractive index in the lowest 100m layer of the troposphere in Akure. South-western *Journal of atmospheric and solar-Terrestrial Physics,68, 2006, 236 - 243*