# Statistics of vertical refractivity gradient over Akure, Nigeria

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# Introduction

- The inhomogeneous nature of the earth’s atmosphere refracts electromagnetic waves leading to anomalous propagation of the waves especially for frequencies 10 GHz in the tropics (Fuwape et al., 2016).

- This gives rise to effect such as fading, interference, radio holes, attenuation of the electromagnetic waves e.t.c.

- The knowledge of the refractive environment is crucial for prediction of the communication range of radio signal propagation (Lowry et al., 2002).

# Introduction

- Vertical refractivity gradient is the difference in the refractivity values at different heights.

- It important for the quantification of anomalous propagation phenomena such as super refraction, sub refraction and ducting (Fuwape et al., 2016), as well as the computation of important parameters such as k-factor, $\beta_o$ e.t.c.

# Introduction

Few researchers have studied the radio refractivity in Akure

- Falodun and Ajewole (2006) studied the radio refractivity over the first 100 km in Akure. The result obtained showed that worst propagation are observed at 1500 - 1800 and 1700 – 1900 local time during the dry and wet seasons.
- Adediji et al., (2011) reported an average of -52.8 N-units per km and high value of refractivity during the wet season over Akure.

# Aim

- In light of the vast growing demand and use telecommunication systems for various purposes(Fuwape and Ogunjo, 2016), there is need for extensive study of the complexities associated with communication for effective future planning, delivery, and improvement of available communication services.

- This work seeks to investigate the diurnal and seasonal variation of radio refractivity and vertical radio refractivity gradient statistics within the first 1 km in Akure.

# Material and Method

- Temperature and relative humidity data at four synoptic hours of the day (0000, 0600, 1200 and 1800) were obtained from the ERA-Interim reanalysis product produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) from 2012 - 2016 at 1000 mb and 900 mb pressure levels.
- Using a resolution of $0.25 \times 0.25$, data for Akure ($7.25^{o}$N,$5:25^{o}$E) were extracted.
- Akure lies in the southwestern part of Nigeria. It is a tropical location with two distinct seasons (wet and dry).

# Material and Method

- The radio refractivity N was computed using equation 1,

$$N = 77.6\frac{P}{T} + 3.75\times10^{5}\frac{e}{T^{2}} \qquad (1)$$

where P = Atm. Pressure(hPa), T = temp. and e = water vapour pressure given by eq.2

$$e = H \times \frac{6.1121\exp\left(\frac{17.502t}{t+240.97}\right)}{100} \qquad (2)$$

# Material and Method

- The vertical refractivity gradient was then computed using equation (3)

$$\frac{dN}{dh} = \frac{N_2 - N_1}{h_2 - h_1} \qquad (3)$$

where $N_2$ and $N_1$ are the refractivity at heights $h_2$ and $h_1$ respectively.

- The k-factor was calculated using

$$k = \frac{1}{1 + R\frac{dN}{dh}10^{-6}} \qquad (4)$$

# Material and Method

$$\frac{dN}{dh} = \begin{cases} > -40, & \text{sub refraction} \\ = -40, & \text{normal refraction} \\ < -40, & \text{super refraction} \\ < -157, & \text{ducting} \end{cases} \tag{5}$$

Equation 5 gives the values of the refractivity gradient for which sub refraction, normal refraction, super refraction and ducting will occur.

# Results and Discussion

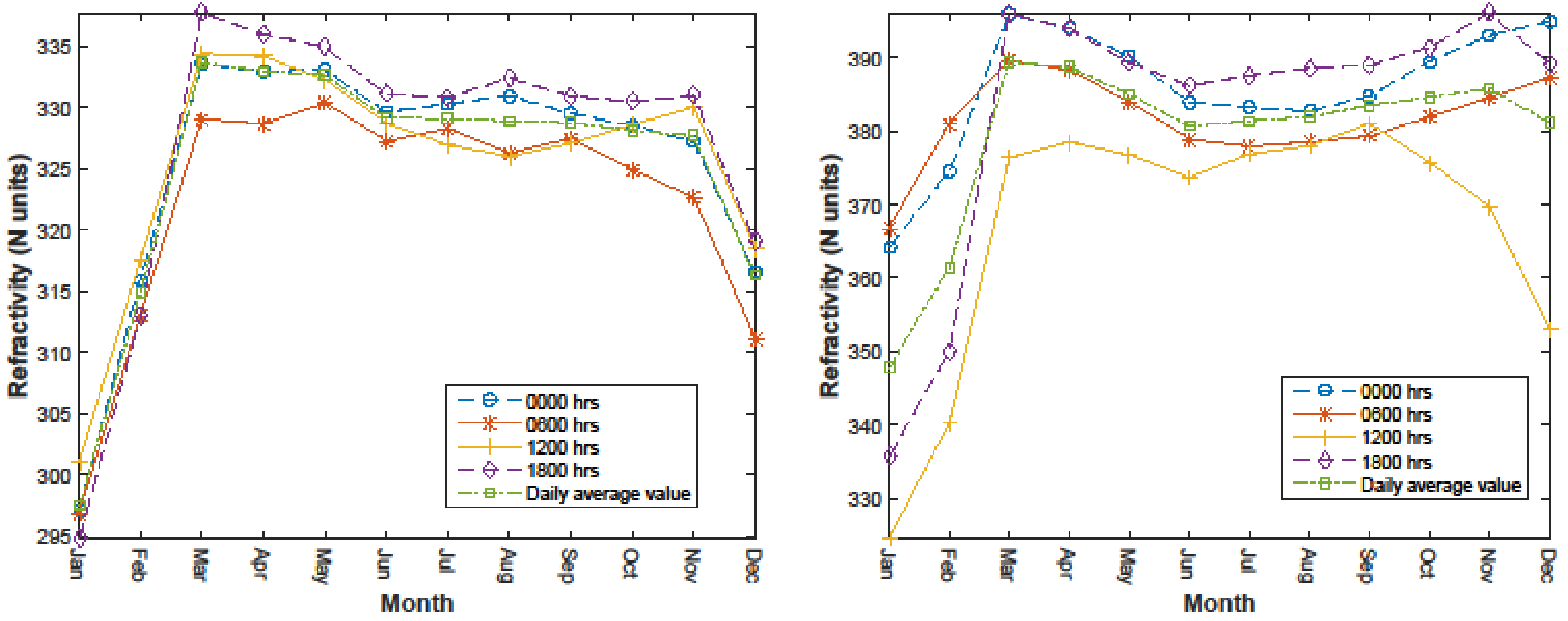


Figure 1: The monthly variation of radio refractivity for (left) 900 mb and (right) 1000 mb

# Results and Discussion

- The mean monthly radio refractivity values at 900 mb were in the range 295 - 335 N-units, and was lowest at 0600 local time and highest at 1800 hrs local time.

- At 1000 mb, the mean monthly radio refractivity ranged from 330 – 395 N-units and were lowest and highest at 1200 and 1800. The refractivities at 1000 mb were higher than that obtained at the 900 mb.

- The refractivity were low during the dry season but increases to maximum values at the onset of the raining season. This result agrees with the works of Adediji et al., 2011.

# Results and Discussion

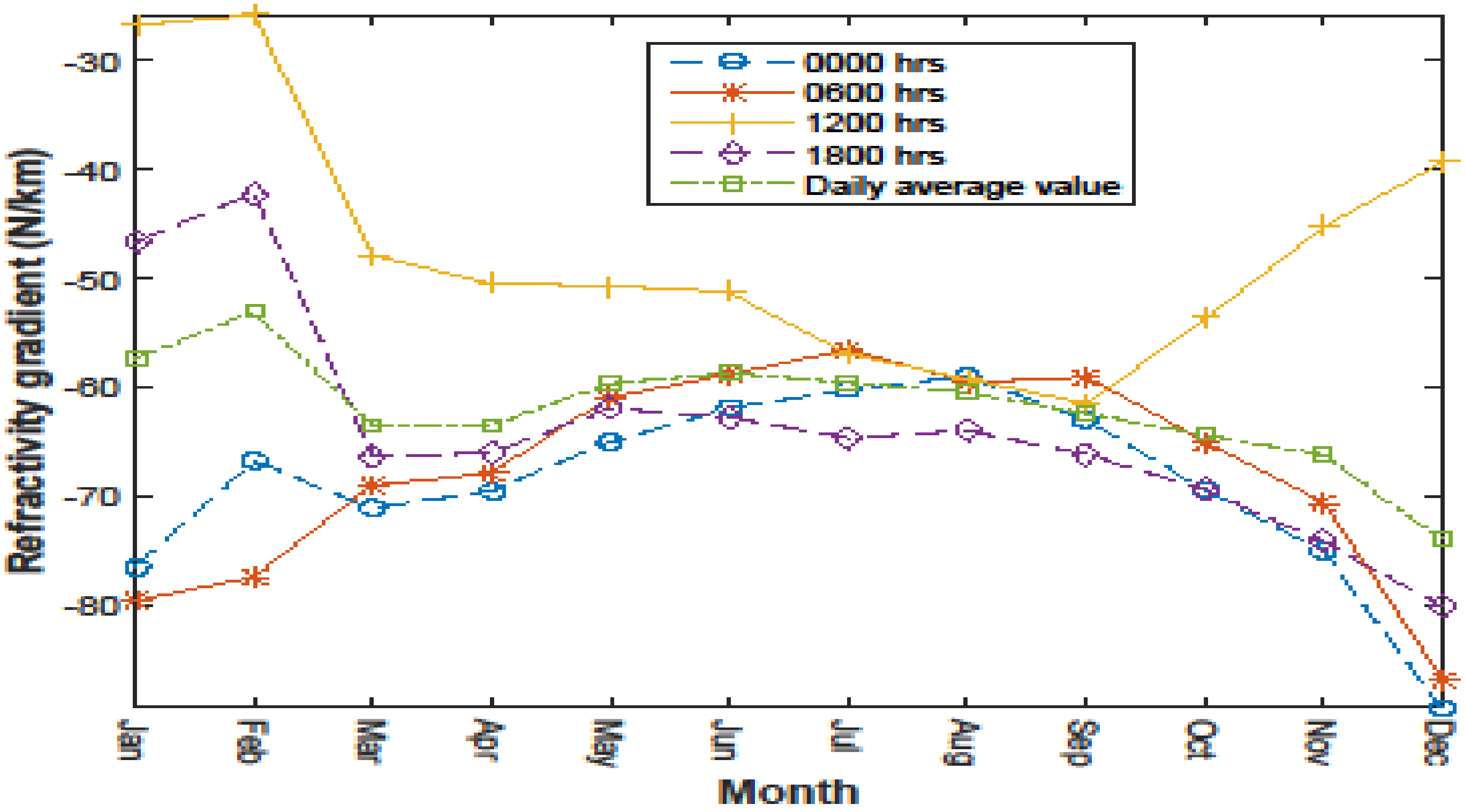


Figure 2: Monthly variation of the refractivity gradient at different time of the day

# Results and Discussion

- The monthly variation of refractivity gradient at different times of the day showed the occurrence of sub-refraction at 1200 hrs local time during the month of January and February.

- The remaining months of the year showed the occurrence of super-refraction in the region.

- The cumulative distribution of the vertical gradient of atmospheric refractivity in the region at different times of the day range from - 20 to - 70N/km.

# Results and Discussion

- Similar trends were observed in the yearly cumulative distribution from 2012- 2016 with the 1200 showing a distinct smooth curves for the years.

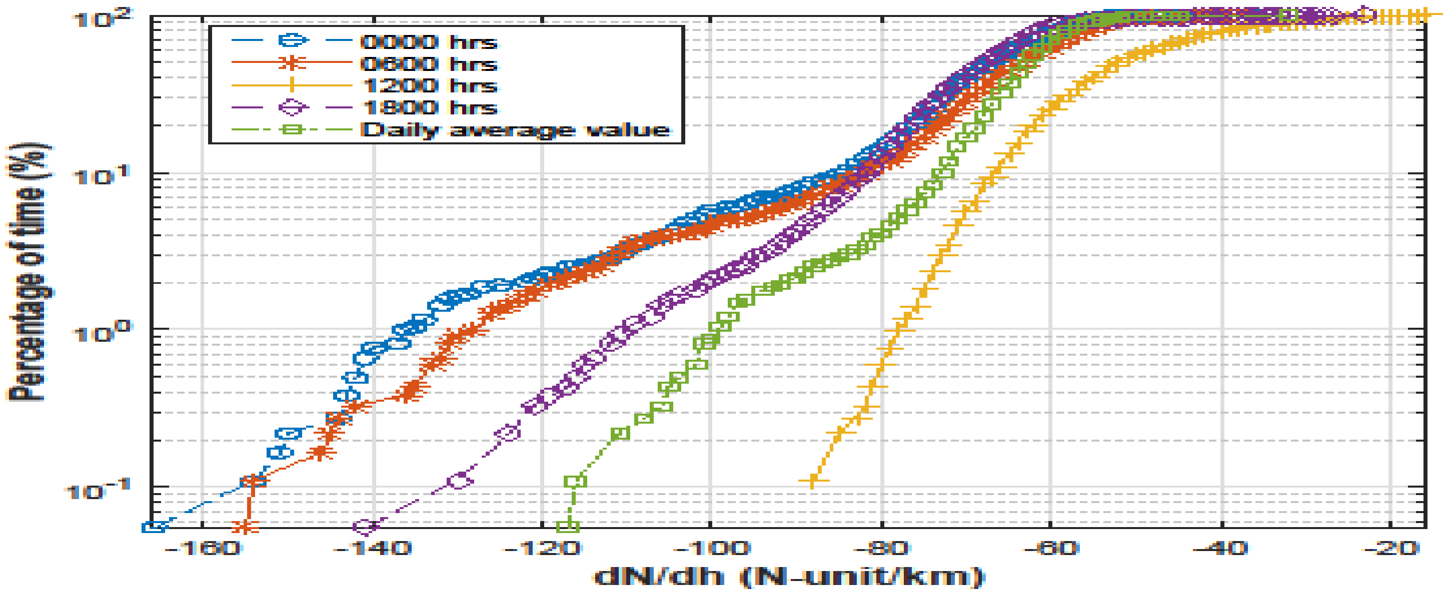


Figure 3: The cumulative distribution of the vertical gradient of atmospheric refractivity in the region for different times of the day for the period 2012 to 2016.

# Results and Discussion

Table 1: Summary of vertical gradient statistics for different hours of the day and average values

| % of time | 0000 hrs | 0600 hrs | 1200 hrs | 1800 hrs | Mean | ITU values |
|---|---|---|---|---|---|---|
| 1 | -135 | -126 | -77 | -109 | -99 | -86.4 |
| 10 | -84 | -82 | -66 | -81 | -72 | -67.4 |
| 50 | -67 | -63 | -52 | -67 | -62 | -50.2 |
| 90 | -57 | -53 | -31 | -57 | -56 | -32.5 |
| 95 | -55 | -50 | -26 | -53 | -54 | -38.5 |
| 99 | -52 | -46 | -21 | -36 | -49 | -22.98 |
| $\beta_0$ | 5.75 | 4.65 | | 2.08 | 0.88 | |
| $k_{50\%}$ | 1.744 | 1.67 | 1.50 | 1.744 | 1.65 | |

# Conclusion

- The values of the radio refractivity were highest at 1800 hrs local time while the lowest values were observed at 0600 and 1200 hrs local time at 900 mb and 1000 mb respectively.
- The values of the radio refractivity were lowest in the dry season months.
- The vertical radio refractivity were high at 1200 hrs local time.
- The cumulative distribution of the vertical radio refractivity shows that ducting occurs about 0.001% of the time in the region at 0000 and 0600 hrs local time.
- Due to temporal and spatial resolutions, the values obtained are slightly different from the ITU values.

# Reference


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# THANK YOU