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Full Length Research Paper

Comparison of results of drift measurement of E and F region irregularities at Ibadan

Somoye E. O.

Lagos State University Ojo, P. M. B. 1087, Apapa, Lagos, Nigeria. E-mail: femi2000somoye@yahoo.com.

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Results of measurements of drift and pattern parameters of E and F region irregularities are found to show that while these parameters for F region increase with sunspot, number those of E region show no such trend. Values of drift and pattern parameters of both regions do not differ much during minimum solar activity. During maximum and moderate solar activity, on the other hand, values of drift and pattern parameter measurements of both regions are observed to be quite different.

Key words: Ionosphere, drift parameter, pattern parameter, irregularities.

INTRODUCTION

The intensity of radio waves reflected from or transmitted through the ionosphere is found to vary over an interval of time. This fading of the radio waves is attributed to iregularities in the ionization density of the ionosphere which, acting as a diffracting screen, modify the amplitude and phase of the radio wave by scattering the incident radiation (Ratcliffe, 1948, 1956; Briggs and Philips, 1950; Hewish, 1951; Booker, 1955). Fading occurs due to the changes taking place in the diffraction pattern formed on the ground as a result of the drift and deformations in the structure of the irregularities. It is usually assumed that the angular spectrum of the down coming waves is randomly phased. Deductions are then based on measurements of the amplitude of reflected signals.

In this study various parameters which can be used to describe the temporal and spatial characteristics of the ground pattern and from which inferences about the irregularities of both regions can be made are compared.

EXPERIMENTAL SET UP, DATA AND METHOD OF ANALYSIS

Figure 1 shows the triangular array of aerials originally due to Mitra (1949). Fading records obtained at three closely spaced aerials by past workers at Ibadan during 1958 and 1964 and whose fading rates fall within the modal range in order to exclude records with extreme fading rates, Somoye (2002), were reduced. The receiver, a conventional superheterodyne type was fed by the receiving aerials. The position of the transmitting aerial a vertical rhombic loop terminated by an impedance of 1000 ohms and of apex angle 135° and leg 39 m is shown as Tx in Figure 1. It was oriented with its plane lying in the magnetic meridian. The receiving aerials located at points 1, 2 and 3 shown in Figure 1 and referring to North, South and West respectively were 2.4 MHz halfwave dipoles. They were oriented to lie along the magnetic meridian and were almost 10 m above the ground. With this arrangement at Ibadan, Skinner (1956) had shown that no appreciable extra-ordinary ray would be received. This is because in the neighbourhood of the magnetic equator, extra-ordinary rays are polarized along East-West direction. This arrangement of aerials in the North-South direction ensured that it is the ordinary rays that were transmitted and received. Fading records obtained at the three closely spaced aerials by past workers at Ibadan during 1958 and 1964 and whose fading rates fall within the modal range in order to exclude records with extreme fading rates (Somoye, 2002) were reduced. Drift and pattern parameters are deduced, using the full correlation method of analysis by Briggs and Phillips (1950) and extended by Philips and Spencer (1955) for anisotropic patterns.

RESULTS

The results obtained for various drifts and pattern parameters of the irregularities in this study for 1958 and 1964 and by Bamgboye et al. (1974) for 1967 at the same station of Ibadan are summarized in Table 1.

The drift velocity, V

The drift mean velocity of E region irregularities is found to be significantly smaller than that of F region irregularities during 1958 (a year of maximum solar activity), (Table 1). Significant difference is also found in the drift velocity of both regions during 1967 (a year of moderate solar activity). During 1964 (a year of minimum solar activity), drift velocity were of the same order of magnitude for the irregularities of both regions. This result is in good agreement with that of Moriss (1967). The implication of these results is that while the drift velocity of F region varies with epochs of solar cycle that of E region is independent of solar activity. Oyinloye and Onolaja (1977) mentioned that there is no evidence of variation of E region drift with Zurich sunsport number, Rz.

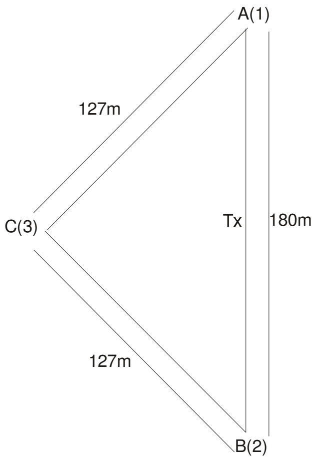

Figure 1. Aerial array at Ibadan.

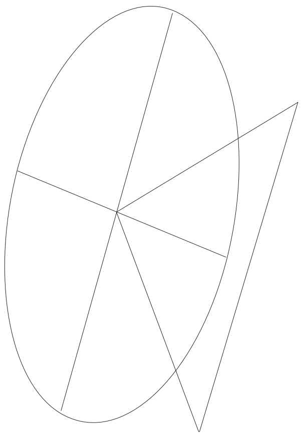

Figure 2. Characteristics ellipse and aerial arrangement.

The ratio of characteristic random velocity to drift velocity, Vc

The mean characteristic random velocity, a measure of the random changes taking place in the pattern is usually expressed in terms of the ratio Vc/V, that is, the ratio of characteristic random velocity to the drift velocity. The mean values of this ratio are shown in Table 1. These results agree with the observation of Mitra et al. (1971) that Vc/V shows no systematic increase with sunspot activity. The ratio is found to be of the same order for the irregularities for both regions during 1958 since the characterristic random velocity was higher for F region irregularities than for E region irregularities as the drift velocity was higher for F region irregularities than for E region irregularities during this period. The ratio is also found to be in the same neighborhood for the irregularities of both regions during 1964, the characteristic random velocities, Vc being of the same order as the drift velocities, V were also of the same order for the irregularities of both regions.

Table 1. Values of drift and pattern parameters of irregularities during 1958, 1964 and 1967.

Parameters	Region	Solar	Cycle years	
		1958	1964	1967
Drift velocity V(m/s)	E	69±9	63±10	65±10
	F	122±20	62±9	100±12
Ratio of characteristics random v,vc/v	E	0.85±.16	0.81±.12	0.8±.15
	F	0.90±.14	0.89±.15	0.75±.15
Elongation (axial ratio) of irregularity r	E	4.5±0.9	4.5±.8	6.5±1.5
	F	11.0±1.6	5.2±0.9	8.3±1.5
Size of irregularity L(m)	E	225.3±50.8	226.1±25.8	230.6±46.5
	F	350.0±50.0	180.0±30.0	260.6±46.5

Elongation of irregularities

Elongation of F region irregularity is greater than that of E region irregularities during 1958, as evident from Table 1. During 1964, however, enlongation of irregularities of both regions was of the same order of magnitude. These results are in fair agreement with that of Chandra and Rastogi (1972) who working at Thumba, another equatorial station obtained a median axial ratio of 9.6 during 1967 for F region irregularities and 5.9 for E region irregularities. The average elongation of 3.2 obtained by Rastogi et al. (1972) for E region during 1964 is also in fair agreement with the present result.

Irregularity sizes

Sizes of ionospheric irregularities are measured in terms of North-south extent or East-west extent of the characteristics ellipse of pattern irregularity (as illustrated in Figure 2). The product of axial ratio (elongation) and East-west extent would give the North-South extent if the size is given in terms of East-West extent of the irregularity. Results of mean irregularity sizes of (North-South extent) shown in Table 1 indicate statistically significant difference between the irregularity sizes of both regions during 1958. Irregularity size of order 300 m given by Koster and Katsriku (1966) for F region irregularities during 1962 at Tamale (dip 0.6˚S) agrees with the present results. Also in agreement with the present result is the 50 m East-west extent of the irregularity obtained by Chandra and Rastogi (1972) at Thumba (dip 0.3°S) during 1967 a period of moderate sunspot number which corresponds to North-South extent of 350 m. This value is the same with the Ibadan value for 1958 since Thumba is closer to the magnetic equator than Ibadan. Elongation and therefore the North-South extent is greater as we approach the equator (Kelleher, 1966). During 1964 the irregularity sizes of both regions are of the same order of magnitude (Table 1).

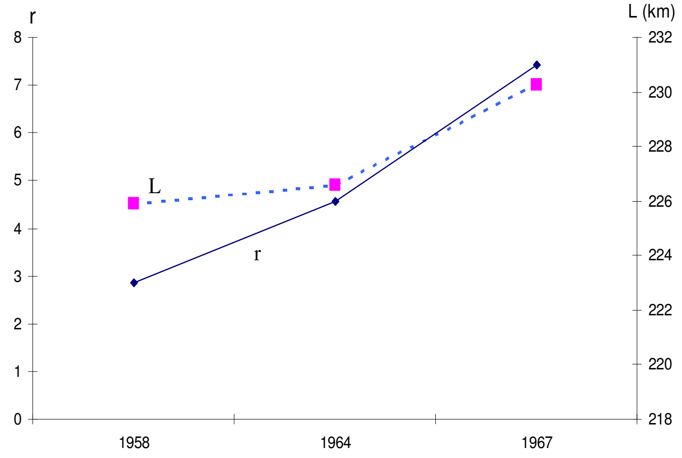

Figure 3a. E-region irregularity, L and elongation, r, at different epochs of solar cycle.

DISCUSSION

That the drift and pattern parameters of E and F- region irregularities, whose values are given above, show significant difference during 1958, a year maximum solar activity and do not differ significantly during 1964, a year minimum activity, indicate that the similarity or otherwise in the behaviour and characteristics of the irregularities of both regions is dependent on the epoch of solar cycle.

The reason for the similarity in the behaviour and characteristics of the irregularities of both regions during minimum solar activity and the difference in the behaviour and characteristics of the irregularities of both regions during maximum activity may be in the mechanisms of production of irregularities in ionization of both regions. E region irregularities are very likely due to turbulence in the tidal motion of air (Dagg, 1957; Martyn, 1959; Kent and Wright, 1968) across the geomagnetic field which induces electromotive force. The lack of solar cycle variation of drift and pattern parameters of E region irregularities (which make them similar during minimum solar activity and dissimilar during maximum solar activity to F irregularities) is observed in the solar cycle independence of the electromotive force (Appleton, 1959) induced by the wind whose turbulence accounts for the irregularities. Oyinloye and Onolaja (1977) and Somoye (2005) have also attributed lack of solar cycle independence of the E region to the induced electric field.

This solar cycle independence of E region drift and pattern parameters did not necessitate the variation of the film speed used for recording fluctuations of the amplitude of E region echoes at the Ibadan observatory during both years where as the film speed used during 1958 was double of that used during 1964 for F region echoes (Somoye, 2002).

F region irregularities, on the other hand are enhanced when the layer moves up (Martyn, 1959). This has been observed to occur during years of high sunspot numbers (Olatunji, 1966). Thus drift and pattern parameters of F region irregularities are expected to be enhanced during maximum solar activity making their values significantly different from those of E region irregularities during maximum solar activity. The drift and pattern parameters of F region irregularities are not enhanced during minimum activity and as such are of the same order of magnitude as those of E region (Figures 3a and 3b).The elongation of irregularities is largely attributed to the ratio of diffusion of ionization along and across the earth's magnetic field lines (Spencer, 1955; Clemesha, 1963; Dixon and Forsyth, 1970; MacDougal, 1990). Ionization is found to diffuse much more readily along the earth's magnetic field lines than across the lines in the F region (Dixon and Forsyth, 1970). This is not the case with the E region. The diffusion of ionization along field lines in the F region is more prominent during sunspot maximum than during sunspot minimum. According to Spencer (1955), the effective diffusion coefficients along and across the earth's field lines are in the ratio of the corresponding mobility. Rishbeth and Garriot (1969) gave the longitudinal mobility as W/BV and the transverse or Pedersen mobility as VW-/B ($V^2 + W^2$) where B is the magnetic field, V is the collissional frequency and W is the angular gyro-frequency. Using the ratio, R, of the longitudinal of transverse mobility to represent that of the corresponding diffusion coefficients (Spencer, 1955);

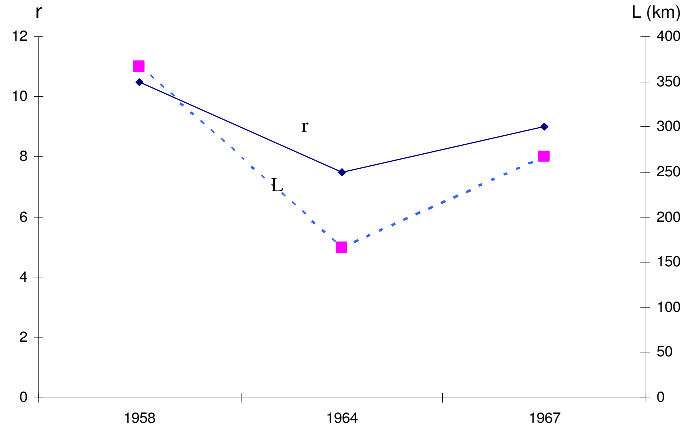

Figure 3b. F-region irregularity, L and elongation, r, at different epochs of solar cycle.

$$R = \frac{V^2 + W^2}{V^2}$$

At F region heights the collision frequency V, of the electrons is negligible, making the ratio R in the equation above large. From the foregoing, R is directly proportional to the elongation of irregularities. Elongation of irregularrities of F region is thus found to be much larger during sunspot maximum than during sunspot minimum.

Conclusion

Irregularity drift and pattern parameters, namely drift velocity, ratio of characteristic random velocity (a measure of the random changes taking place in the irregularity pattern) to drift velocity, elongation and North-South size of irregularities of E and F region at Ibadan during 1958 and 1964. The two years are those of maximum and minimum solar activity respectively. Results of these parameters at Ibadan by Bamgboye et al. (1974) during 1967 for both E and F region are included to take care of period of moderate solar activity. Values of these parameters for F region show variation with epochs of solar cycle being larger for maximum solar activity and smaller for minimum solar activity. For E region, however, values of these parameters do not show such trend.

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