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Study of Ionospheric drift and Anisotropy of E-region irregularities at Udaipur during low and high solar activity periods

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Abstract – Ionospheric irregularities play an important role in ionosphere. Here an attempt has been made to study the different parameter of ionospheric irregularities such as apparent drift speed, true drift speed, apparent drift direction, axial ratio, semi-minor axis and orientation of characteristic ellipse. A comparative study has been presented during different periods of solar activity. Closely space receiver technique have been used for Ionospheric drift measurement at E-region height. Records obtained are analyzed by correlation method.

Key Words – Solar activity Ionospheric irregularities and Anisotropy parameters.SMY solar maximum year

Introduction

Ionospheric drift measured at low latitude station Udaipur (Geomas lat 14.5 N) day time E-region during low and high solar activity periods have been studied. The closely spaced receiver technique[1] has been used for measurements of ionospheric drift at high latitude[2,3] equatorial latitude[4] and low latitude[5] These studies have given rise to a fair understanding of various morphological feature, including seasonal variation of horizontal ionosphenic drifts. It is well known that sun is main driving force of a vast majority of ionospheric phenomena including the sustenance of the ionosphere.

The changes in the upper atmosphere have been found to be closely related with the variation in solar activity and geomagnetic variation[6] It is observed that long term variations in the neutral temperature of the upper atmosphere were correlated to the variation in solar electromagnetic radiation , whereas short terms fluctuation were strongly related with changes in geomagnetic activity. Present paper describes the effect of solar activity on drift and anisotropy parameters of the ionospheric irregularities. such studies are important in few of possible relationship at ionospheric levels among the winds, currents and drifts of ionization in the geomagnetic field.

Experimental setup

The Experimental setup used at Udaipur have been described earlier[7] The probing frequency used is 2.5 MH_Z at E- region heights. The houly drift records were analyzed by correlation method. The sunspot numbers has cyclic variation with period of 11.2 years on an average. The solar minimum years are taken when sunspot $R_Z < 10$ and solar maximum year when R_Z Values for the present purpose have been obtained from solar and geophysical data 'Radio science division vision NPL –New Delhi' High solar activity periods is taken as (1978-1980) and low solar activity periods is taken as (1973-1975).

For the systematic study the results of correlation analysis we grouped into three seasons.

1. Winter – comprising the months November, December, January and Febuary.
2. Equinoxes - comprising the months March, April, September & October of the same year. Here no distinction has made between autumn & spring.
3. Summer – comprising the months May, June, July, August of the same year.

Data Analysis & Results

For the systematic study all the values of apparent and true drift speed have been grouped in the range 0-20, 20-40 m/s etc. The result of the study are shown in the form of histograms

Seasonal Study of Apparent Drift Speed

The histograms of percentage occurrence of the apparent drift speed for different seasons are shown in Figs 1 and 2. Figure 1a shows the results of apparent drift speed for high sunspot periods,, while Figure 1b shows results for low sunspot periods. From Figure 1a . It is observed that 57 percent values of apparent drift speed lie in between 20 and 60 m/s in winter, whereas in summer and equinoxes 80 percent and 53 percent values respectively lie in above range. The respective median values are 56, 50 and 53 m/s for winter, summer and equinox respectively/

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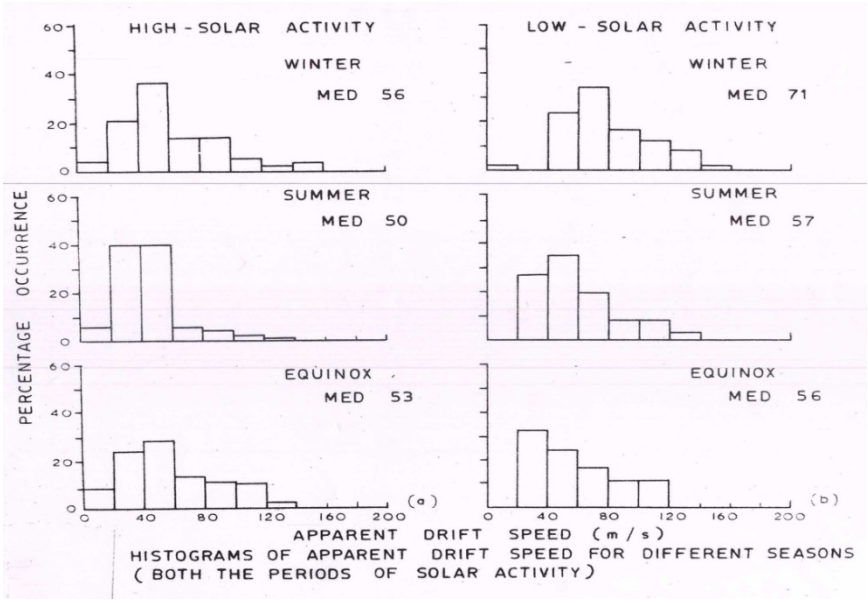

Figure -1

During low sunspot periods, in the winter months 58percent values of apparent drift speed lie in the range 40-80 m/s. In summer and equinoctial months 54 percent and 57 percent values of apparent drift speed occur in the range 20-60 m/s. the median values are 71,57 and 56 m/s for winter, summer and equinoctial months respectively.

Annual study of apparent drift speed

Fig. 2a shows that 65% values of apparent drift speed occur in between the range 20-60 m/s for high sunspot periods while in low sunspot periods 56% values lie in the range 20-60 m/s. The median values are 50 m/s, 58 m/s for high and low sunspot periods.

Figure 2b shows the hourly variation of mean value of apparent drift speed for high and low sunspot periods. It is observed from the Figure that during high sunspot periods the values of apparent drift are slightly lower than that during low sunspot periods. Further, during both the periods of solar activities apparent drift speed in winter season is higher as compared to summer and equinoxes.

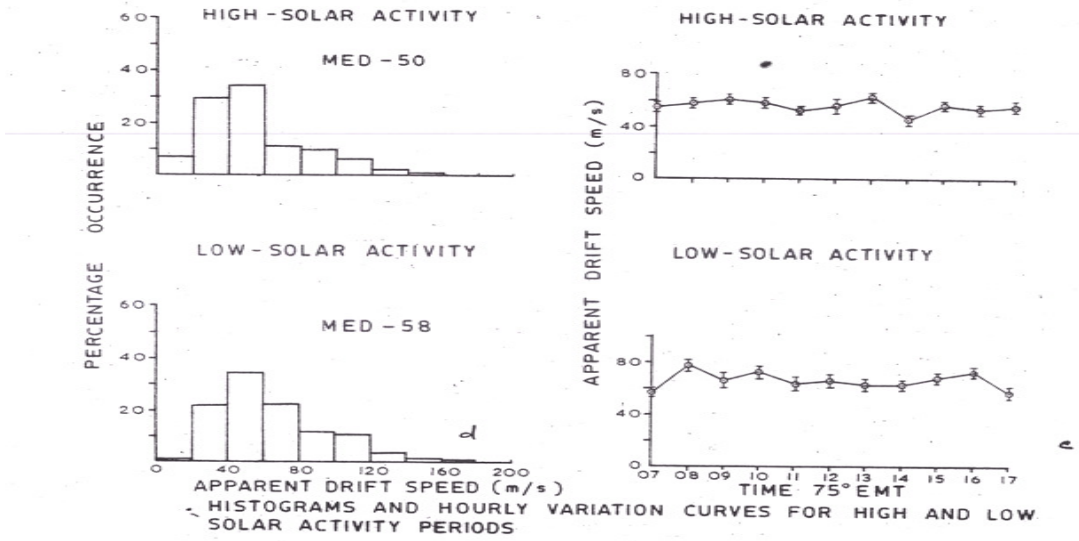

Figure -2

The results suggest that in high sunspot periods apparent drift speed is lower than that obtained during low sunspot periods.

.**Seasonal study of true drift speed:** From figure 3(a,b) it is observed that the value of true drift speed are lower during high solar activity period as compared to values during low solar activity period. Further the values of true drift speed in winter season are found to be higher than summer and equinoxes for both the periods of activity.

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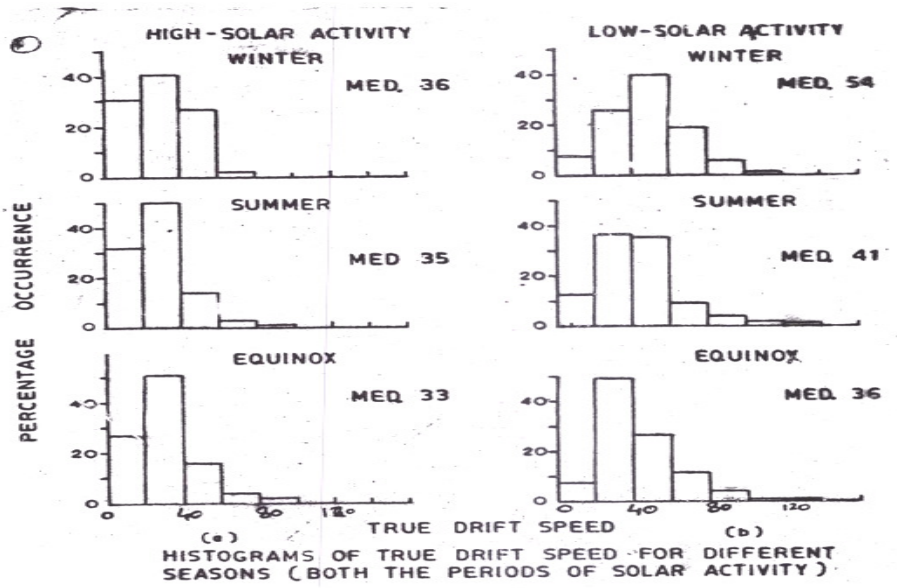
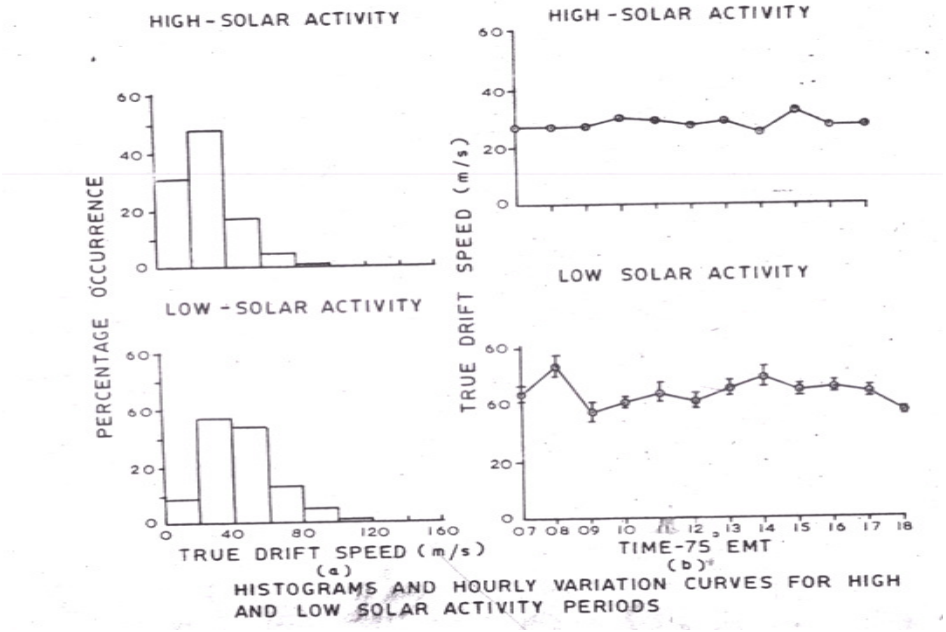


HISTOGRAMS OF TRUE DRIFT SPEED FOR DIFFERENT SEASONS (BOTH THE PERIODS OF SOLAR ACTIVITY)

Figure -3

Annual study of true drift speed: Annual histogram of percentage occurrence of true drift speed for high and low solar activity period are shown in figure 4a. The histogram shows that the primary maxima of true drift speed lie in the range 20-40 m/s for both high and low solar activity periods (48% & 37%).

Figure 4(b) shows the annual variation of hourly mean values of true drift speed for high and low solar activity periods. Figure suggests that the values of true drift speed are lower for high sun spot periods.



HISTOGRAMS AND HOURLY VARIATION CURVES FOR HIGH AND LOW SOLAR ACTIVITY PERIODS

Figure -4

Study of ratio V_c/ V: The ratio V_c/ V gives the relative contribution of random movements to the stady drift in the direction of true drift. Another way one can define that the ratio gives the relative stability of the pattern.

Seasonal study of ratio V_c/ V: Histograms of percentage occurrence of variation of ratio V_c/ V for different season have been drawn. Figure 5 (a, b) shows the histogram for high sun spot periods and low sun spot periods. From figure 5(a) it appears that primary maxima of ratio V_c/ V lies in the range 0.6 – 0.8, 0.2 – 0.4 and o.4 – 0.6 for winter, summer and equinoctial months respectively in SMY, whereas it lies in the range 0.4 - 0.6, 0.2 – 0.4 and 0.2 – 0.8 for winter

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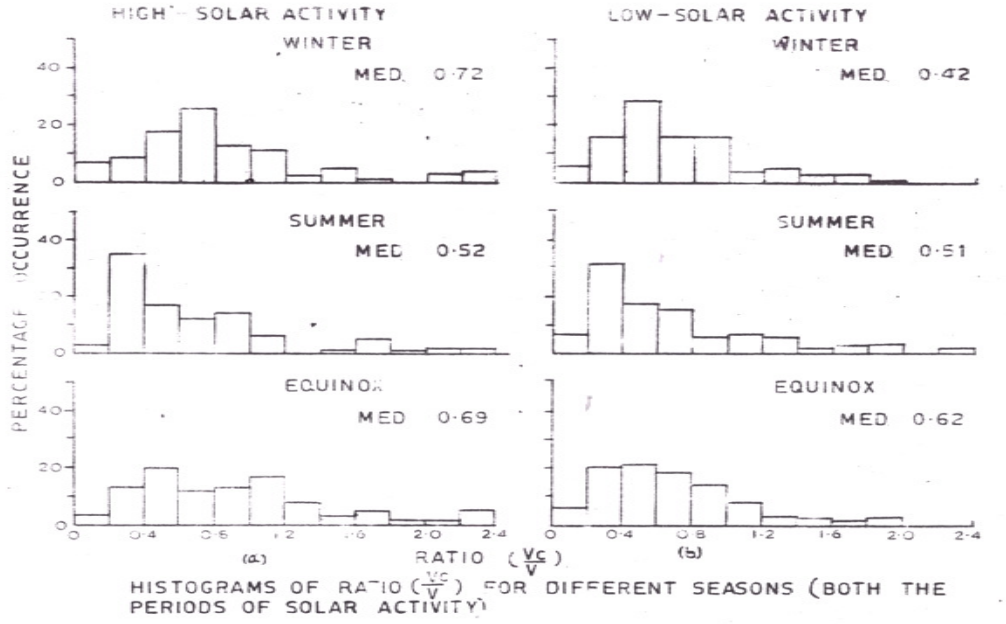
summer and equinoctial months for low sunspot periods. The median values are given in their respective histogram.

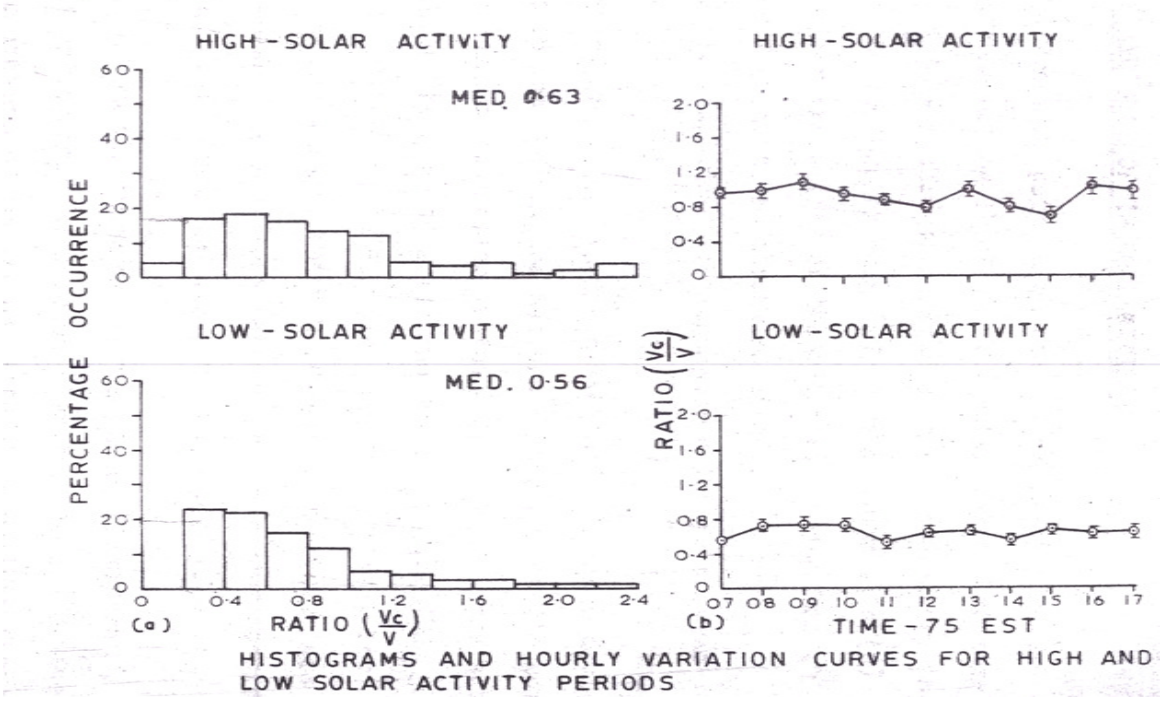


HISTOGRAMS OF RATIO ($\frac{V_c}{V}$) FOR DIFFERENT SEASONS (BOTH THE PERIODS OF SOLAR ACTIVITY)

Figure -5

Annual study of ratio V_c/ V: The annual histogram of percentage occurrence of the ratio V_c/ V for high and low sunspot periods are shown in figure 6 (a,b). The most probable value lies in the range 0.2 – 0.6 for both the periods. The median values are 0.63 and 0.56. Figure 6(b) shows hourly mean variation curve for high and low solar activity periods.

From the above discussion it may be concluded that during summer season in both the periods of activity the values of the ration V_c/V are lower than in winter and equinox.Further the range of most probable value for winter and equinox are higher during high sunspot periods seasonal medium value are higher for high sunspot periods.



HISTOGRAMS AND HOURLY VARIATION CURVES FOR HIGH AND LOW SOLAR ACTIVITY PERIODS

Figure -6

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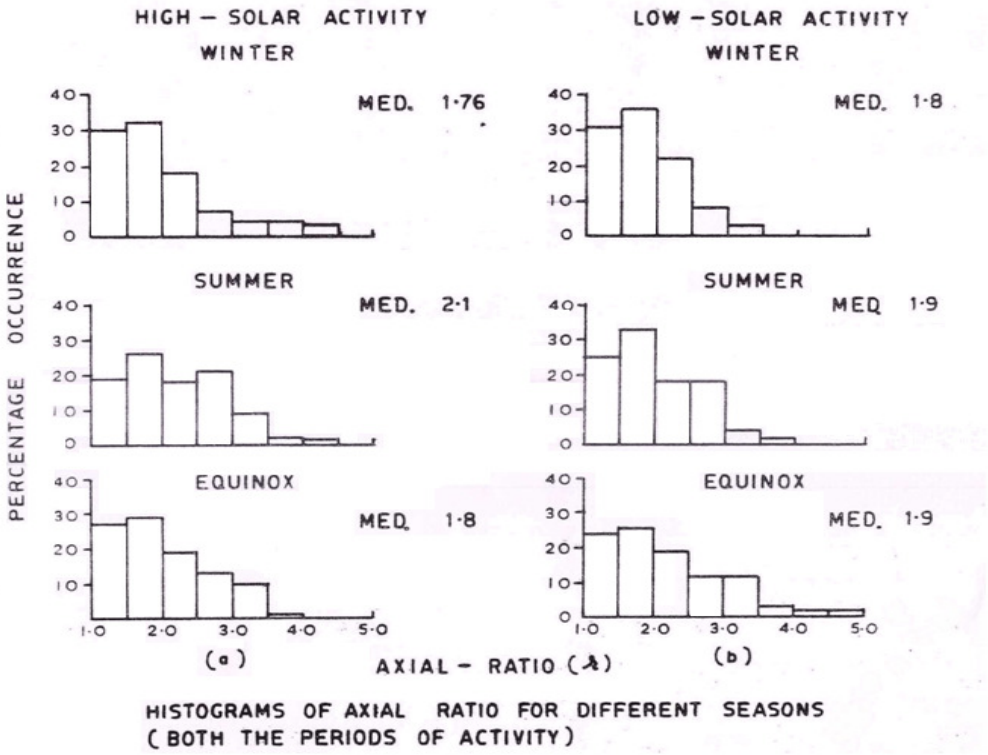
Study of Axial ratio: The diffraction pattern on the ground is generally study by the considering it of an elliptical shape. The size and shape of this diffraction pattern are described by parameters semi- major axis (a) or semi-minor axis (b) and orientation angle ψ size of the ellipse. Orientation is measured from north in clock wise direction. These parameters are related to the Ionospheric irregularities through the diffraction process. In general; whatever be the phase relationship, if there is any changes in the irregularities the respective change also appears in the ground diffraction pattern through the diffraction process.

The axial ration (r = a/b) are generally studies instead of 'a' & 'b'. The semi minor axis 'b' is taken as a measure of the size of the pattern on the ground whereas axial ratio describes the degree of elongation of the ellipse.

Seasonal Study of Axial Ratio

Histograms of percentage occurrence during different seasons aer shown in Figure 7(a,b) it is observed from the Figure 7a that 79 Percent ,61 percent and 75 percent values occur in the range 1-2.5 for winter, summer and equinox respectively (SMY period)figure 7b shows that 89 percent, 75 percent and 77 percent values occur in the same range in winter, summer and equinox respectively during low sunspot periods.



HISTOGRAMS OF AXIAL RATIO FOR DIFFERENT SEASONS (BOTH THE PERIODS OF ACTIVITY)

Figure -7

Annual study of Axial Ratio

The annual histogram of percentage occurrence shown in Figure 8 Figure shows that 72 and 77 percent values of axial ratio occur in between 1 & 2.5 for high and low solar activity periods. The respective median values are 1.9 and 1.8. The hourly mean 4.73 variation curve shown in figure

Study of true drift direction

For different solar Activity Periods polar Histograms of percents occurrence of drift direction have been plotted in the range of 30 ^{o} throughout the day ie. 345 ^{o} -14 ^{o} -15 ^{o} -44 ^{o} etc. The direction is measured clock wise in north.

True drift direction for high and low sunspot periods are illustrated in figure 9 (a,b) respectively. From figure 9 (a) it is observed that during high solar activity periods 30 percent values are true drift direction lie within 285^{o} to 344 ^{o} east of north in winter months, whereas in summer months, the most probable occurs (about 55 percent) between 45^{o} to 134^{o} east of north. In equinoxes direction is scattered in a wide range within 45^{o} to 344^{o} . Figure 9 (b) shows that during low solar activity periods most probable drift direction in winter lies within 195^{o} to 254^{o} east of north while in summer months it occurs within 75 ^{o} to 135 ^{o} east of north. In equinoxes the direction is scattered.

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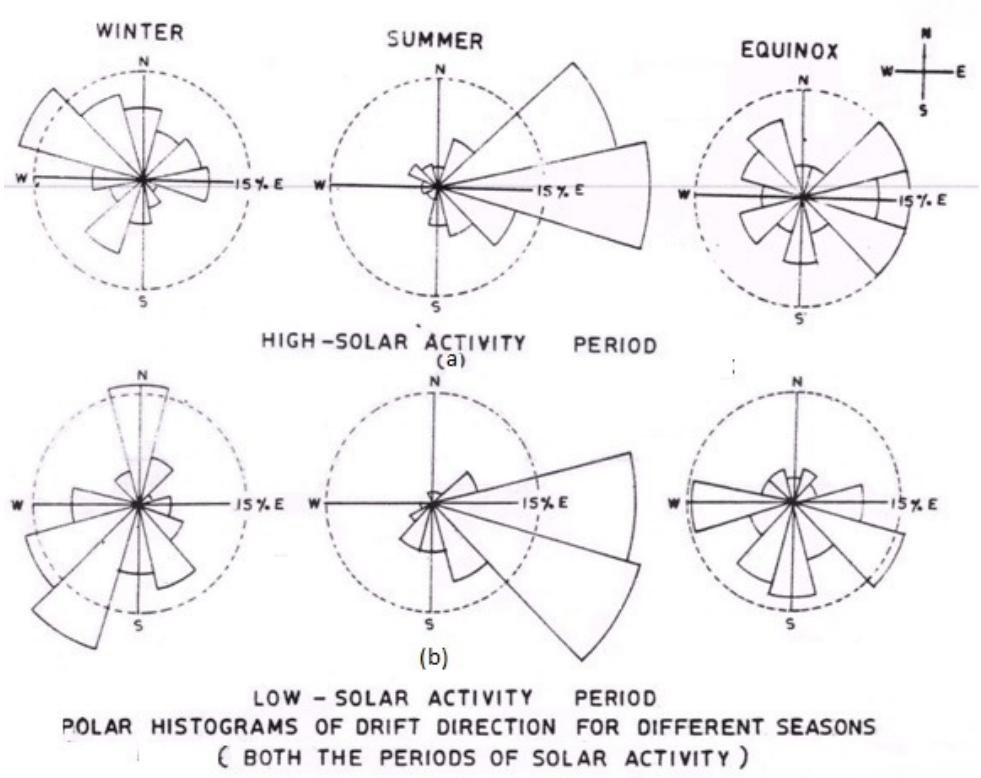

Figure -8

Discussion and Conclusion

From the above study it is found that true drift speed and anisotropy parameter have solar cycle as well as seasonal dependence. The percentage occurrence towards lower range is more during high sunspot periods. The ratio $\mathbf{V_c/V}$ has higher value in high sunspot periods. In winter true drift speed shows higher values as compare to summer and equinoxes in both the periods of solar activity. The ratio $\mathbf{V_c/V}$ has lower value in summer month as compare to winter and equinoxes in both the periods of solar activity. The result obtained by correlation analysis of ionospheric drift measurements, reported by other workers are discussed below. Misra etal(1971) have reported that true drift speed has lower values during high sunspot periods as compare to low sunspot periods whereas ratio $\mathbf{V_c/V}$ shows higher value and high sunspot periods than that of low sunspot periods. Sastry[8] (working at Waltair has found that true drift speed and $\mathbf{V_c}$ are independent of solar activity. Patel[9] and Kaushika[10] have reported the results for different periods of solar activity at Ahmedabad. It has been observed that the ratio $\mathbf{V_c/V}$ shows higher values during moderate sunspot periods as compare to low sunspot periods. It may be concluded that the increase of the ratio $\mathbf{V_c/V}$ suggest that the ionosphere is more turbulent during high sunspot periods.

As far as anisotropy parameters are concerned, it has been found that axial ratio does not show any remarkable difference in values in both the periods, whereas pattern size is reduced during high sunspot periods. Further in winter months the pattern size is larger than that of summer and equinoctial months. The axial ratio does not show any remarkable difference during different season. The orientation of characteristic ellipse during high sunspot periods shows that the irregularities are aliened along the NE direction in winter, along N-S direction in summer and are spread in equinoxes.

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