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foF2 Seasonal Asymmetry Time Variation at Korhogo Station from 1992 to 2002

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Abstract

foF2 seasonal asymmetry is investigated at Korhogo station from 1992 to 2002. We show that equinoctial asymmetry is less pronounced and somwhere is absent trough out solar cycle phase. In general, the absence of equinoctial asymmetry may be due to the fact that in equinox and for each solar cycle phase, the asymmetry is due to Russell-McPherron mechanism. The solstice anomaly or annual anomaly is always observed throughout solar cycle phase. The minimum value of $\Delta foF2$ is inferior than −60% seen during all solar cycle phase at 0700 LT. This annual asymmetry may be due to interplanetary corpuscular radiation.

Keywords

Seasonal Asymmetry, Annual Asymmetry, Equinoctial Asymmetry, F2 Layer Critical Frequency, Time Variation

1. Introduction

The asymmetry observed in F2 layer critical frequency (foF2) or in the peak electron density (NmF2) of F2 layer or in the Total Electron Content (TEC) values time variation has been investigated by several authors (e.g. [1]-[7]).

The present paper goal is to investigate an asymmetry observed during equinoctial months and that seen during solstice months at Korhogo station (Long 8.427˚W; Lat: 9.336˚N and dip: −1.88˚) by using foF2 value computed in this ionosonde station. The period of investigation covers ten years from 1992 to 2002 and concerns solar minimum phase, increasing phase, maximum phase and decreasing phase.

It is well known that equinoctial asymmetry is explained by three mechanisms: 1) axial mechanism [8] [9] [10]; 2) equinoctial mechanism [8] [11] and 3)

Russell-McPherron mechanism [12]. By this study, we will point out among them which mechanism can be used in case of the presence of equinoctial asymmetry.

The solstice asymmetry called by [3] annual asymmetry or non-seasonal asymmetry is generally explained by the variation of Sun-Earth distance. This variation can be due to: 1) the variation of O/O2 ratio that modulates the electron loss coefficient in the F2-layer [13]. It is called by [3] "Buonsanto's hypothesis"; 2) the 7% variation in the flux of ionization; 3) interplanetary corpuscular radiation [6]. We will see which process can be invoked for this type of asymmetry.

The paper plan is as follows: after materials and methods, we present our results and end the paper by discussion and conclusion.

2. Materials and Methods

This paper concerns Korhogo station (Long 8.427˚W; Lat: 9.336˚N and dip: −1.88˚) F2 layer critical frequency (foF2) daytime variation for the period 1992-2002. As we focus on asymmetry that can be observed during equinox or solstice, seasons are expressed as follows: equinox months (March-April and September-October) and solstice months (December-January and June-July). foF2 values are carried out basing on solar cycle phases which determination respects the following criteria: 1) minimum phase: Rz < 20, where Rz is the yearly average Zürich Sunspot number; 2) ascending phase: 20 ≤ Rz ≤ 100 and Rz greater than the previous year's value; 3) maximum phase: Rz >100 [for small solar cycles (solar cycles with sunspot number maximum (Rz max) less than 100) the maximum phase is obtained by considering Rz > 0.8 * Rz max]; and 4) descending phase: 100 ≥ Rz ≥ 20 and Rz less than the previous year's value [14].

The morphological or qualitative estimation of equinoctial asymmetry or solstice asymmetry is given by error bars ($\sigma =\ \ \sigma = \sqrt{V}$, V: variance) shown in March-April (noted after by M-A) curve and June-July (indicated after by J-J) graph. Equinox of September-October and solstice of June-July are noted after as S-O and J-J, respectively. The quantitative estimation of the asymmetry is given by $\Delta foF2$ expressed as:

$$\Delta foF2 = \frac{x_i^F - x_i^L}{x_i^L} \times 100$$

where F concerns M-A or J-J and L is devoted to S-O or D-J. x_i^F and x_i^L represent foF2 values for concerning season.

3. Results

Figures 1-4 concern foF2 and $\Delta foF2$ diurnal variation during minimum, ascending, maximum and descending phases. Panel a is for equinoctial months, panel b for equinoctial $\Delta foF2$, panel c for solstice months and panel d for solstice $\Delta foF2$. Full line is devoted to foF2 diurnal variation of M-A or J-J while broken curve exhibits that of S-O or D-J.

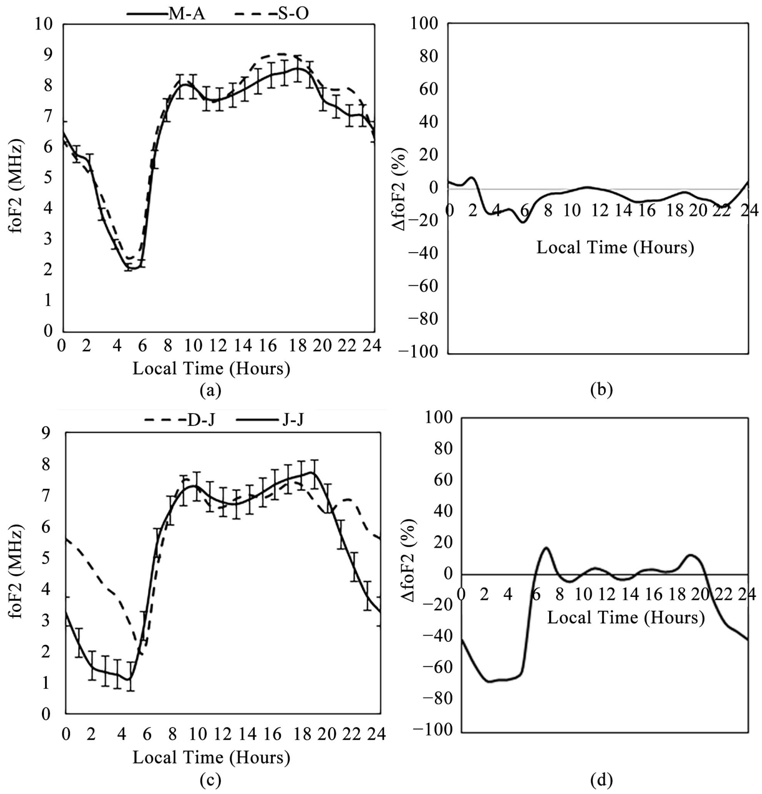

Figure 1. foF2 and Δ*foF*2 diurnal variation for minimum phase. Panel a concerns equinoctial months, panel b is for solstice months, panel c for equinoctial Δ*foF*2 and panel d for solstice Δ*foF*2.

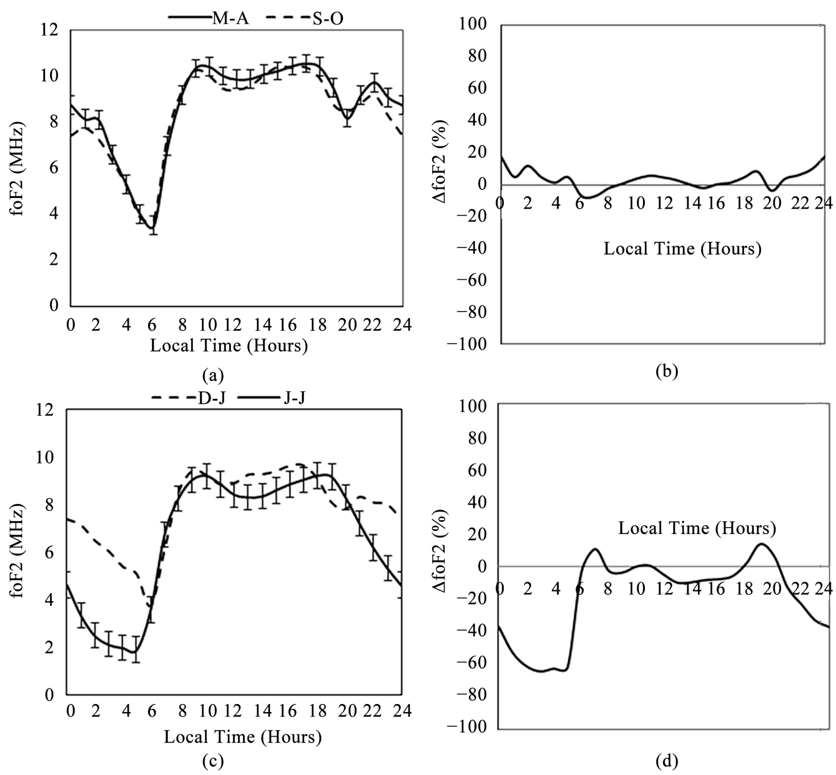

Figure 2. The same as **Figure 1** but for ascending phase.

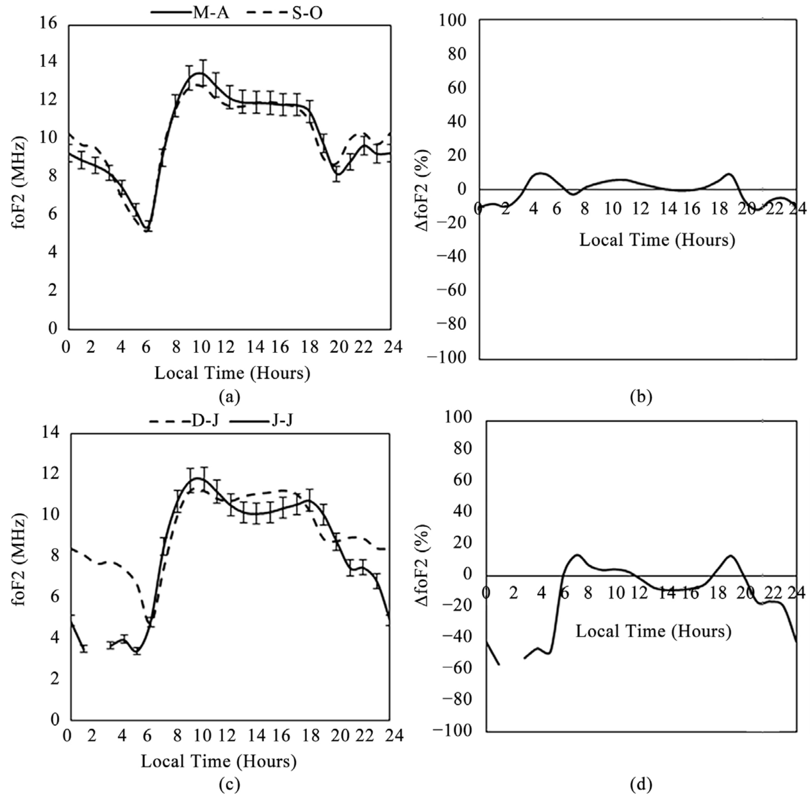

Figure 3. The same as **Figure 1** but for maximum phase.

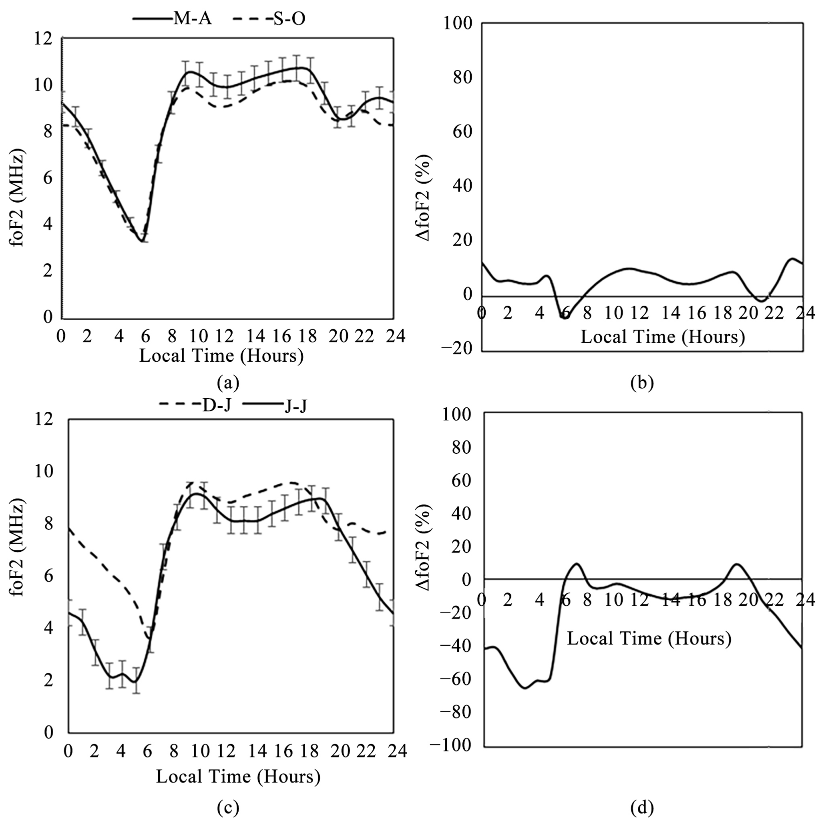

Figure 4. The same as **Figure 1** but for descending phase.

Figure 1(a) shows double pics with trough located at 1200 LT. The afternoon pic amplitude is higher than that of the morning one. In S-O curve it can be observed night time peak at 2200 LT. This figure highlights equinoctial asymmetry due to the fact that S-O foF2 values superior than those of M-A between 1400 LT and 1900 LT and also between 2100 LT and 2300 LT with respect to error bars shown in M-A graph. In Figure 1(b) devoted to equinoctial $\Delta foF2$, it is observed that S-O foF2 values are always greater than those of M-A except from 2300 LT to 02400 LT and from 0000 LT to 0200 LT. The difference minimum value is seen at 0600 LT with fairly −20% as $\Delta foF2$ value. In Figure 1(c), one can see solstice asymmetry shown by the difference of profile morphology; in fact, during daytime J-J graph presents double pics and no peak during night time while D-J during daytime curve shows three pics and presents night time peak at 2200 LT. In both graphs first peaks are matched. Figure 1(d) shows that asymmetry is more pronounced from 2000 LT to 0000 LT and from 0000 LT to 0600 LT. The minimum value of $\Delta foF2$ is inferior than −60% and that at 0200 LT. Figure 1 exhibits that solstice asymmetry is more observed than equinoctial one during solar cycle minimum phase.

Figure 2(a) shows double pics with trough located at 1100 LT and night time peak at 2200 LT. According to error bars there is no equinoctial asymmetry except between 2200 LT and 2400 LT and also between 0000 LT and 0100 LT. In Figure 2(b), $\Delta foF2$ curve shows some additional difference principally between 0900 LT and 1400 LT. It can be noted that these differences are less than 20% and $\Delta foF2$ values generally are positive. These $\Delta foF2$ positive values highlight that M-A foF2 values are superior than those of S-O.

In panel c, both graphs present double peak where the firsts are matched. Only D-J graph presents night time peak. This situation shows equinoctial asymmetry. This is more expressed by the difference in term of values from 0000 LT to 0600 LT, from 1200 LT to 1800 LT and from 2100 LT to 2400 LT. $\Delta foF2$ graph (panel d) pointed out that before sunrise $\Delta foF2$ minimum value is inferior than −60% and after sunset $\Delta foF2$ maximum value is inferior than +20%. In general, $\Delta foF2$ values are negative. Consequently, J-J foF2 values are in general inferior than those of D-J. Figure 2 highlights that during solar cycle ascending phase there is more solstice asymmetry than that of equinox.

Figure 3(a) shows that there is no equinoctial asymmetry but the panel b let us see a fairly asymmetry with negative and positives values of $\Delta foF2$. Negative values are observed after 2000 LT and between 0000 LT and before 0400 LT. $\Delta foF2$ minimum value fairly is equal to −10% and its maximum value fairly is equal to +10%.

In Figure 3(c), it is observed that D-J foF2 values are always greater than those of J-J after 2000 LT and from 0000 LT to sunrise. This same situation is seen between 1200 LT and 1800 LT. the previous observation points out solstice asymmetry in foF2 time variation. This asymmetry is also expressed in term of graphs morphologies. In Figure 3(d), this asymmetry is exhibited by $\Delta foF2$ graph where between 1200 LT and 1800 LT and from 2000 LT to 2400 LT and from 0000 LT to 0600 LT negative percentages are observed. The minimum value fairly is equal to than −60% at 0100 LT and the maximum values fairly are equal to +10% at 0700 LT and 1900 LT. During this solar cycle phase foF2 time variation expresses more solstice asymmetry than equinoctial one.

In **Figure 4(a)**, there is equinoctial asymmetry between 0900 LT and 1400 LT, after 22,000 LT and also from 0000 LT to 0100 LT. The values of M-A foF2 in general are superior than those of S-O especially from 0600 LT to 1800 LT and after 200 LT. This situation is exhibited in panel b graph where except 0600 LT and 1900 LT $\Delta foF2$ values are positive and the percentage maximum value fairly is equal to +10% at 2300 LT and the minimum value is superior than −10%. In panel c, except between 0600 LT and 1100 LT and from 1800 LT to 200 LT there is a solstice asymmetry where D-J foF2 values are superior than those of J-J. This is seen in panel d graph where negative percentages are generally observed. The minimum value of $\Delta foF2$ is inferior than −60% at 0200 LT. The maximum value of $\Delta foF2$ is inferior than +10%. During this solar cycle phase there more solstice asymmetry than equinoctial asymmetry.

4. Discussion and Conclusion

It emerges from this study that in general, the equinoctial asymmetry is less pronounced and somewhere is absent during all solar cycle phases. This is an agreement with the conclusion of [1] results. These authors found that an equinoctial asymmetry is principal due to Russell-McPherron mechanism for all seasons (spring and fall). In consequence, one can expect to have "no equinoctial asymmetry".

The solstice asymmetry is observed for all seasons and the minimum value of $\Delta foF2$ is inferior than −60%. In general, the night time peak observed in D-J curve is not observed in J-J graph.

The similar variation of $\Delta foF2$ lets us assert that the annual asymmetry not only depends on solar cycle phase. Consequently, the flux of solar ionization radiation cannot be the only factor as concluded by [3]. The results of [15] show that the difference between winter and summer is principal due to the amplitude of solar high speed wind. As this type of wind can be a source of interplanetary corpuscular radiation, the annual asymmetry observed here may be due to [6] process.

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