LATITUDINAL DEPENDENCE OF *foF2* DAY-TO-DAY VARIABILITY

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Abstract

We present the diurnal and solar cycle effect on the variability (VR) of the critical frequency of the ionospheric F2 layer (*foF2*) at an equatorial and mid-latitude station. Two ionosonde stations in the African sector namely, the equatorial station of Dakar (14.8°N, 17.4°W, dip 11.4°N) in West Africa and the mid-latitude station of Grahamstown (33.3°S, 26.5°E, 50.6°S dip) located in South Africa during 1982, a year of high solar activity (*HSA*) and 1986, a year of low solar activity (*LSA*). Diurnal variation shows that *foF2* is more subjected to variations during nighttime than daytime with pre sunrise and post midnight peaks at Dakar station. A similar trend is observed at Grahamstown during *HSA* except for December Solstice where higher daytime than nighttime values are obtained and peak values of 26% and 21% at the 17 hour of June Solstice are recorded during *HSA* and *LSA* respectively. Seasonally, March equinox of *foF2* variability (*VR*) has the highest pre sunset and daytime values during 1986, a year of low solar activity (*LSA*) while the differences at other seasons are not easily noticed during both epochs.

Keywords: *foF2*, *VR*; solar activity; midlatitude; diurnal; latitudinal dependence.

Introduction

The dynamics of the equatorial ionosphere must be well understood by satellite users, as both navigation and communication systems rely on this region for proper prediction, functionality and characterization (Basu et al., 2002; Akala et al., 2011). In addition to the regular (daily, seasonal and solar cycle) variation in the ionosphere which occur as a result of temporal and spatial (latitudinal) variations, large day to day variation of both quiet and disturbed geomagnetic days are fairly well understood (Chandra et al., 2009). According to Somoye, (2009), Somoye and Akala, (2010) and Somoye et al. (2011) the day to day variability of all ionospheric parameters that exist in the near earth environment is the most widely used and it is greater than those of hour to hour.

In this paper, we analyze the diurnal, seasonal, solar cycle effect and the effect of latitude on ionospheric *foF2* over the equatorial and mid latitude region. Results obtained agree with those of many workers who have explored the equatorial ionosphere before this time. The mid latitude region of the two stations presented in this study, is the least explored by ionospheric workers. In this regards, it is noteworthy that Somoye et al. (2011) had noted that complementary studies on the application on variability of ionospheric models will enhance space weather exploration.

Data and Method

The data used for this study are the hourly ionospheric *foF2* values derived from two ionosonde stations namely the equatorial station of Dakar (14.8°N, 17.4°W, dip 11.4°N) located in the West African sub region and the mid latitude station of Grahamstown (33.3°S, 26.5°E, 50.6°S dip) located in South Africa. The data were obtained from the website of Space Physics Interactive Data Resource (SPIDR) (http://spidr.ngdc.noaa.gov/) and cover the whole years of High (1982, Rz = 116) and low (1986, Rz = 14) solar activities for both stations except that at Grahamstown, during *LSA* November and December Data are unavailable.

The data were grouped into four seasons namely December Solstice (November, December and January), March Equinox (February, March and April), June Solstice (May, June and July) and September Equinox (August, September and October) in order to show seasonal influence. The variability as described by Forbes et al. (2000) is obtained by using

$$VR\,(\%) = \sigma/\mu \times 100 \qquad (1)$$

Where μ, is the mean and σ, is the standard deviation of *foF2* monthly values. This tool (*VR*) describes the relative magnitude of the standard deviation as compared with the monthly mean of the distribution measurements. Bilitza et al. (2004), Somoye and Akala (2010) and Somoye et al. (2011) have mentioned the merits and demerits of other methods of estimating *VR*, i.e. by either interquartile range and median and/or interdecile range and median.

Results and Discussions

Figures 1 (a) and (b) show that the diurnal plots of *foF2* VR which appear to indicate that *foF2 VR* is generally higher at night than during the daytime with two characteristic peaks, i.e. pre sunrise and post midnight peaks. This is in agreement with results obtained by Bilitza et al. (2004), Akala et al. (2011) and Somoye et al. (2011) and several others. In Figure 1 (c), plot of monthly average sunspot number (Rz12) for the solar cycle being considered (i.e. 1981 – 1991) is illustrated. This *foF2* daily fluctuation (*VR*) are affected by the daily variations of F region $E \times B$ vertical drift in the neighbourhood of the equator as pointed out by Duncan (1960) and Somoye et al. (2011). Oyekola and Oluwafemi (2007) also mentioned that the F region vertical drift exhibit strong variations with the phase of the solar cycle. Generally, *foF2 VR* is in the range 9 – 18% during the day and 8 – 48% at night. *foF2 VR* is observed to be higher during *LSA* (9 – 50%) than during *HSA* (8 – 32%). This is because the ionospheric density being largely dependent on recombination rate could be affected by gas composition and magnetic meridional winds (Rishbeth, 1993; Mill[illegible] et al 1997; Chou and Lee, 2008).

In Figure 2 (a) & (b), *foF2 VR* is in the range 7 – 21% during *LSA* and 5 – 26% during HSA. March equinox has highest pre sunrise values (15 – 22%) and lowest daytime values (5 – 16%) with minimum around noon. The peak values of 26% and 21% at the 17 hour of December Solstice during *HSA* and *LSA* respectively could be due to the steep electron density gradient caused by the turn off and onset of solar ionization (Bilitza et al., 2004; Chou and lee, 2008). The mid latitude in the southern hemisphere is about the least explored of the ionospheric regions by workers. Its *VR* decreases with increasing solar activity except for December solstice during *HSA* where the reverse is the case. During *LSA*, *VR* decreases and increases alternately with solar activity with December Solstice peak at 17hour. Results on the behavioral trend in this region could not be obtained unlike equatorial region. The effect of latitude is evident by comparison of Figure 1a and Figure 2a.

Conclusion

Latitudinal dependence, diurnal influence, seasonal and solar cycle effect on *foF2 VR* over equatorial and mid latitude station have been presented. The equatorial station of Dakar (14.8°N, 17.4°W, dip 11.4°N) and mid latitude station of Grahanstown (33.3°S, 26.5°E, 50.6°S dip) were used for the investigation. Results obtained appear to reveal that *foF2 VR* is characterized by two peaks (pre sunrise and post midnight peaks) at Dakar during both epochs. Also, March equinox during *LSA* has maximum pre sunrise and daytime values. A similar trend is observed at Grahamstown during HSA and the maximum values at the 17 hour of December Solstice during both epochs. Seasonally, variability at equatorial and mid latitude region are about the same range during the daytime.

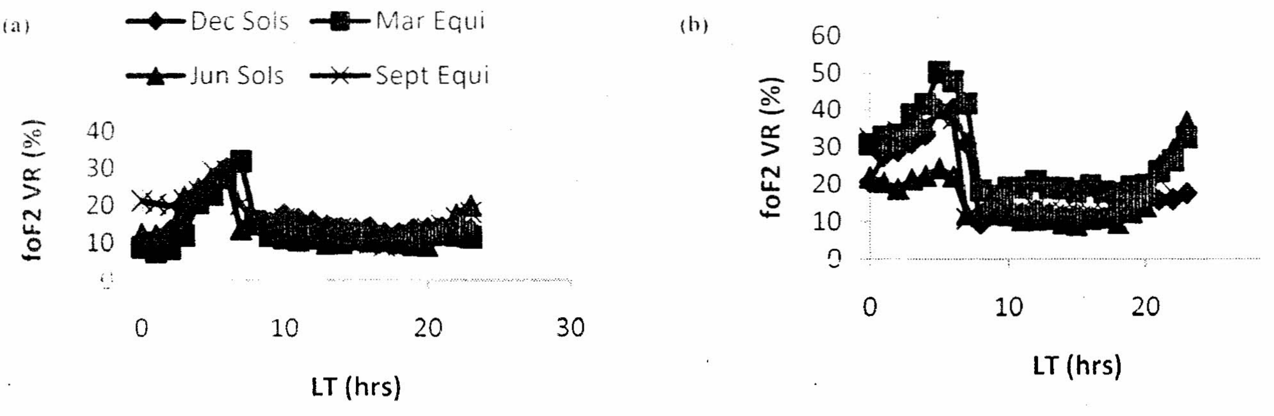

Figure 1 (a) & (b): Diurnal plots of foF2 VR during years of (a) HSA (1982) and (b) LSA (1986) at Dakar

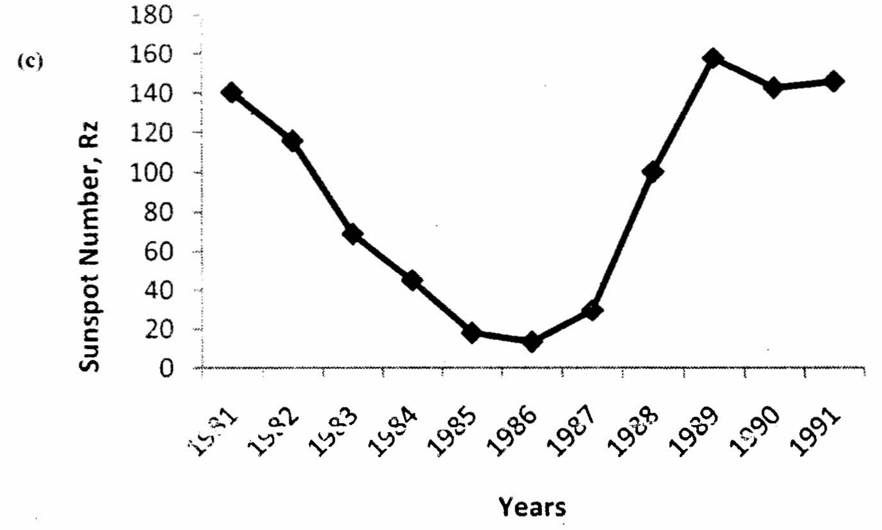

Figure 1 (c): Plots of monthly average sunspot number for a solar cycle (1981 – 1991).

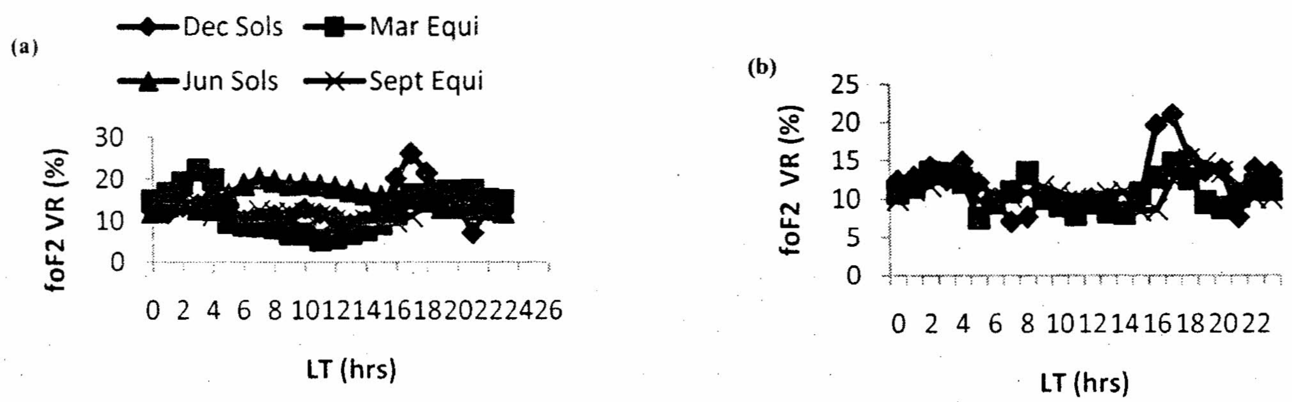

Figure 2: Diurnal plots of foF2 VR during years of (a) HSA (1982) and (b) LSA (1986) at Grahamstown

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