Solar cycle and seasonal variation of F2 layer nighttime/daytime ionization ratio at the equatorial station of Ibadan

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ABSTRACT

An investigation into the maintenance of nighttime ionization in the F2 layer at the equatorial station of Ibadan (7.4°N, 3.9°E, 6°S dip) is hereby reported. Presently, nighttime ionization in the F2 layer is shown to depend on seasons over three epochs of solar activity namely high solar activity (HSA), moderate solar activity (MSA) and low solar activity (LSA). Furthermore, F2 layer nighttime ionization appear comparable to daytime ionization being greater than or equal to 60% of the latter during the equinox and December Solstice at the three epochs. Nighttime ionization is also lowest during June Solstice being less than 60% of daytime ionization during the HSA and LSA and less than 70% during MSA. In addition, the ratio of nighttime ionization to that of daytime is found to be greater at all seasons during MSA than during HSA and LSA.

Keyword: F2 layer; seasonal variation; ionization; solar activity; night time/day time ratio.

Introduction

The F region of the equatorial ionosphere behaves differently from other layers. It is known to be a non-chapman layer since it is not strictly solar controlled though the critical frequency of the layer, foF2, rises rapidly immediately after sunrise (Vanzandt, 1967). For instance, the diurnal variation of *foF2* is characterised by two peaks, pre- and post-noon peaks, instead of a single peak at noon when the sun's ray is overhead at the equator. There is substantial ionization in the equatorial F region at night as exemplified in the ratio of the mean value at midnight to that at noon. Awe (1975) at Ibadan reported that the value of this ratio is sometimes greater than unity. Nighttime electron concentration (or ionization) derived from *foF2* has also been reported to be greater than its value at noon by other workers such as Rajaram (1977), Rishbeth and Garriot, (1969). Tsagouri and Belehaki (2002) mentioned the enhancement of F2 layer nighttime ionization while Mikhailov et al. (2000) observed increase in nocturnal electron concentration of F2 layer.

According to Stubb (1968), the rise and maintenance of nighttime ionization is caused by electron loses, ambipolar diffusion and plasma drift. Duncan (1960) and Rajaram and Rastogi (1977) pointed out that electrons are lifted and stored in a high region of low decay (i.e. at great heights) as a result of ***E×B*** (E being the electric field due to the equatorial electrojet current (EEJ) which is coupled to the F region and **B**, the horizontal magnetic field in the neighbourhood of the equator) uplift of ionization. This should give it a long life and a relatively high electron density should therefore persist after sunset.

The post-sunset rise in peak height of ionization, *hmF2*, due to ***E×B*** uplift of ionization which is the most likely cause of the maintenance of nighttime ionization is said to be most pronounced during the equinox months of high sunspot years (Rajaram, 1977) while Rajaram and Rastogi (1977) mentioned that irrespective of the sunspot, the post-sunset rise is largest in the equinox month of April and weakest in July. In regards to these results, it is desirable to investigate the seasonal variation of the ratio of nighttime ionization to that of daytime in the equatorial region hence the present investigation at Ibadan during High, moderate and low sunspot years of 1958, 1973 and 1965 respectively.

Method

Critical frequencies of F2 layer, *foF2*, were obtained at Ibadan using the Union Radio Mark II Recorder type ionosonde which was developed at the Radio Research Station in Slough. The details of the ionosonde had been given by Somoye (2009). The ratio of nighttime ionization to daytime ionization is obtained by averaging the mean values of t-1, t and t+1, where t represents 0000LT (2300UT) for nighttime ionization and 1200LT (1100UT) for daytime ionization, during HSA, MSA and LSA. The quotient of nighttime ionization and daytime ionization is then determined for the three epochs. The plots of these quotients for the different months of the three epochs are shown in Figure 1 (a), (b) and (c).

Results and Discussions

Figure 1(a) – (c) show the monthly plot of the ratio of midnight *foF2* mean to that of noon during high solar activity (HSA), moderate solar activity (MSA) and low solar activity (LSA) respectively. The ratio indicates that nighttime ionization compares fairly with daytime ionization generally. This result agrees with that of Awe (1975) who got the ratio of an average of 0.75 during IGY i.e. HSA and an average ratio of 0.48 during IQSY i.e. LSA. In the present result, an average ratio of 0.65, 0.73 and 0.71are obtained for HSA, MSA and LSA respectively. Curiously the ratio is greatest during MSA and LSA and least during HSA. That the ratio is least for HSA than MSA and LSA is due to the greater difference between the midnight average values and the noon average values during HSA than during MSA and LSA.

Seasonal variation in the ratio of nighttime/daytime of foF2 means is evident in the Figure 1 (a) – (c). The ratio is least during May, June, July and August, months comprising the June Solstice, according to the grouping by Bandyopadhay and Montes (1963) during the three epochs. Rastogi and Rajaram (1977) mentioned that the post-sunset rise of *hmF2*, observed at Koidaikanal (dip 3.5) is largest during equinox and weakest during June Solstice. Their observation is in good agreement with the present result, if we remember that the maintenance of nighttime ionization is largely dependent on the post-sunset rise of *hmF2* (Duncan, 1960). Seasonal variation in F2 layer nighttime ionization is evident in Figure 1(a) – (c). The ratios of mean values of *foF2* in the nighttime to those of daytime are least in the months comprising June Solstice and part of the equinox. Oyekola (2006) in his comparison of F region vertical electrodynamic plasma drifts obtained by different techniques, reported that the pattern and trends of the $E \times B$ vertical drifts for June Solstice are quite different from those for the equinoctial and December Solstice. In other words $E \times B$ vertical drifts suffer seasonal variation. This possibly results in the seasonal variation of the ratio of nighttime to daytime ionization ratio. Umoh and Adeniyi (1995) reported that nighttime anomaly (NTA) – discontinuity in the fall of ionization at night – is highest during the equinoxes and least during the June Solstice. The maintenance of nighttime ionization is due to NTA.

CONCLUSION

Nighttime ionization of the F2 layer represented by *foF2* hourly mean at the equatorial station of Ibadan is investigated. The results of the present study appear to indicate that Nighttime ionization is comparable to daytime ionization (≥60%) at the three epochs of high solar activity (HSA), moderate solar activity (MSA) and low solar activity (LSA) during the equinox and December Solstice. Furthermore, Nighttime ionization appear not to be comparable to daytime ionization during June Solstice being less than 60% of daytime ionization.

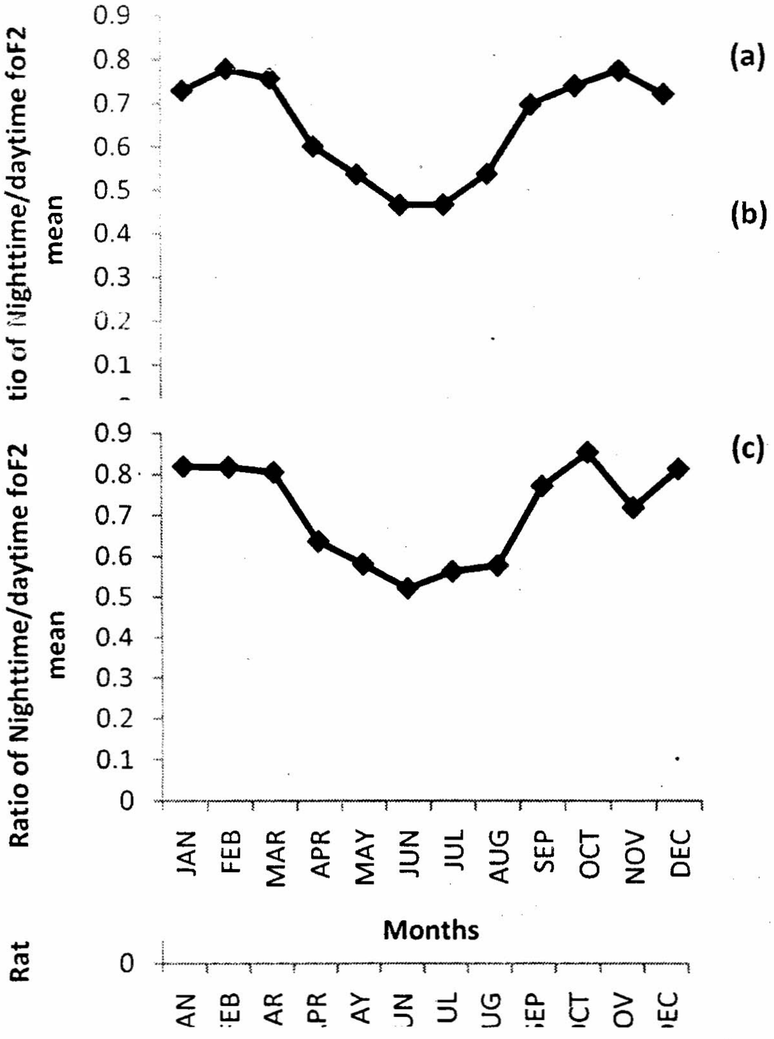

Figure 1(a) – (c): Monthly plot of the ratio of nighttime/daytime foF2 mean during (a) 1958 (HSA) (b) 1973 (MSA) and (c) 1965 (LSA) respectively.

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