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Sunspot activity dependence of ionospheric variability in the low latitude

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ABSTRACT

Variability of foF2 was investigated for Ouagadougou, complementing works that have been done at this station. Four-year data that falls in four different solar activity phases were employed. As expected, nighttime variability is higher than daytime and varies with season. However, against wide believe, foF2 nighttime variability may not always increase with decreasing solar flux levels, especially while considering the "rising" part of the cycle.

Key words: Beacon satellite, Ionosphere, Low-latitude, Solar activity, foF2, African sector

Introduction

The subject of the variability of the ionosphere, especially from its deviation from its average behavior, was the theme of several researches because of the challenges it poses to high frequency (HF) propagation, navigation, and other satellite applications. Many authors studied ionospheric variability, however, with different ionospheric parameters, especially at mid and high latitudes. Bilitza *et al.* (2004), Adeniyi *et al.* (2007), and Akala *et al.* (2011) investigated ionospheric variability for some low latitude stations cutting across the African, American, and Asian sectors.

Variability of the bottomside peak electron density has been reported to be higher during nighttime than daytime and at sunrise than at sunset in the low latitude at all sectors (Bilitza *et al.*, 2004; Akala *et al.*, 2011), with two nighttime peaks. Although, it showed longitudinal dependence; being highest in the American sector and lowest in the Asain sector (Akala *et al.*, 2011). Likewise, according to the published work cited in this paragraph, nighttime variability of the F2-layer peak electron density increases obviously with decreasing sunspot number. However, this may not always be true due to the asymmetric of the "rising" and "falling" phases of the sunspot cycle caused. For example, Quattara and Amory-Mazaudier (2012) ascribed diurnal variation of F2-layer critical frequency in the ascending and descending phases of the sunspot cycle to slow solar wind and fluctuating solar wind respectively. Therefore, this work is set to reconsider some of these observations to aid our better understanding of the role of solar activity on ionospheric variability especially in the bottomside.

Data and Method

This study was carried out with data from Ouagadougou (geogr. 12^{o}N, 1.8^{o}W, dip ~3^{o}). The years used and the corresponding sunspot number is shown in the table below:
Lloyd's classification was adopted for the seasons: J-season/June solstice (May, June, July, August), D-season/December solstice (November, December, January, February), and Equinox (March, April, September, October). Coefficient of Variability (CV), computed as

the percentage ratio of the standard deviation to the mean was adopted for this work.

Table 1: Employed years in the different solar activity phases epochs and their respective sunspot numbers (Rz).

YEAR	Rz	PHASE
1985	18	Minimum
1987	29	Ascending Phase
1993	55	Descending Phase
1989	158	Maximum

Results

The variability is higher at nighttime than daytime at all seasons and solar flux levels (Figure 1). Nighttime variability during J-season, D-season, and Equinox ranges between (11 – 39%), (12 – 36%) and (8 – 36%) in 1985, (11 – 37%), (13 – 46%) and (12 – 38%) in 1987, (6 – 25%), (9 – 23%) and (12 – 25%) in 1989, (15 – 33%), (13 – 28%) and (18 – 35%) in 1993. The prominent post-midnight peak occurred earlier in J-season (0100 LT) than other seasons (0500 LT).

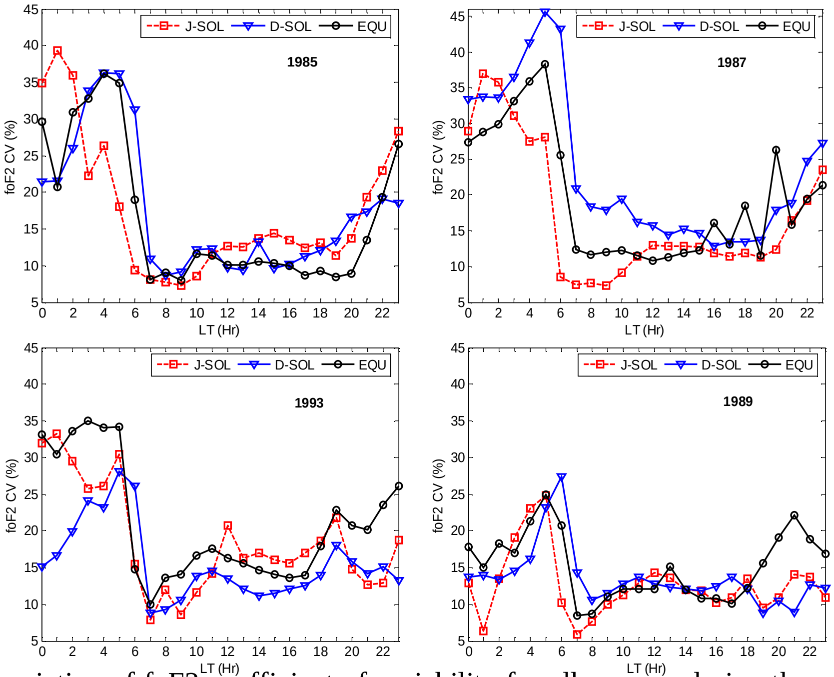

Fig. 1: The diurnal variation of foF2 coefficient of variability for all seasons during the year of solar minimum – 1985 (top left), ascending phase – 1987 (top right), descending phase – 1993 (bottom left), and solar maximum – 1989 (bottom right).

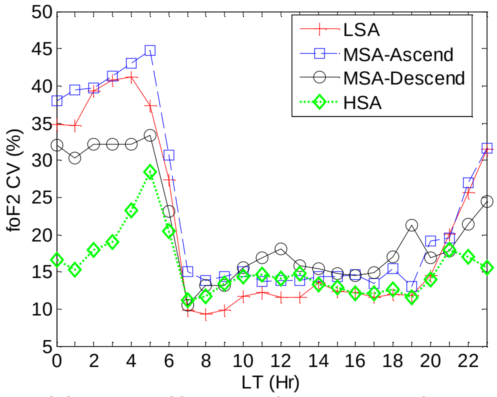

Fig. 2: Diurnal variation of foF2 coefficient of variability for the four sunspot activity phases

The dependence of nighttime variability on solar activity is clearly distinct with yearly data as depicted in figure 2. There is no clear dependence of daytime variability on solar activity. The nighttime peak occurred between 0400 and 0500 LT irrespective of the flux levels. Considering the descending phase of the sunspot cycle, nighttime variability is highest during low sunspot activity (LSA), and least during higher sunspot activity (HSA). In the ascending phase, variability is highest during moderate sunspot activity (MSA) than LSA.

Discussion and Conclusion

High nighttime and low daytime variability have been attributed to the lower and higher foF2 average values respectively with respect to similar absolute deviation (Bilitza *et al.*, 2004) and gravity waves (Akala *et al.*, 2011). Likewise, the reverse relationship between variability and solar activity, which was observed in the falling part of the sunspot cycle, could be related to increased ionization of the neutral species. The increased number of ions decreases the number of neutral species, thereby decreasing variability as solar activity increases. However, the inverse relationship could not be observed in the rising part of the cycle.

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