Effects of Height of F2-Layer on Critical Frequency by Use of Data at Ouagadougou Station

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Abstract

Ionosphere investigation leads to the knowledge of its composition in particles. The particle density and composition determine the capacity of this region to reflect radio waves in the atmosphere at different heights. Some variables such as season, solar cycle phase also influence the ionosphere behavior. Radio waves frequencies pass through the ionosphere layer without reflection above a critical value determining the critical frequency. This study determines the critical frequency of radio waves in the F2 layer (foF2) of the ionosphere by use of data at Ouagadougou station during the minimum and the maximum of solar cycle 22, at different seasons with the height of F2-layer (hmF2). Daytime and nighttime also influence ionosphere parameters. The study presents the hourly behavior of foF2 according to hmF2 values.

Keywords: Ionosphere, critical frequency, height of F2-layer, solar cycle phases

1. Introduction

This work deals with the critical frequency variability in the F2-layer. In previous studies (Ouattara & Nanéma, 2014), (Ouattara, 2013) we determined the foF2 variability at Ouagadougou (lat = 12.4˚N, long = 358.5˚E, West Africa) station. By use of foF2 and foE data provided by Telecom Bretagne and with the help hmF2 values (Ouattara & Nanéma, 2013), we determine the hourly profiles of critical frequency of F2-layer under quiet time variation at Ouagadougou station during the minimum and the maximum of solar cycle 22 and the effects of hmF2 hourly variability on this parameter. The study also considers the seasonal effects on foF2 and hmF2 hourly variability during equinox and solstice months. Some hourly data of foF2 are missing in Telecom Bretagne database.

2. Materials and Methods

The methodology of the study is based on the five quietest days of each month in the minimum and the maximum of solar cycle phases. Solar cycle phases are determined by the yearly average of Zürich Sunspot number Rz. The minimum phase is obtained for Rz < 20 while the ascending phase and maximum phase are respectively obtained with $20 \leq Rz \leq 100$ and Rz >100 (Zerbo et al, 2011; Ouattara et al 2012; Gnabahou & Ouattara, 2012). Quiet days are determined by considering $Aa \leq 20$ nT.

With these criteria, the retain days are indicated in the Table 1.

Table 1. Retain days for the study

Solar cycle	Phase	Year	Months			
			March (Equinox)	June (Solstice)	September (Equinox)	December (Solstice)
22	Min	1985	9,13,21,22,25	3,14,16,18,19	2,3,4,5,29	8,9,21,23,29
	Max	1990	4,10,16,17,31	16,17,20,21,30	2,3,27,29,30	10, 11, 19, 21, 29

The study uses the data values of foE and foF2 provided by Telecom Bretagne database. The height of F2-layer (Dudeney, 1983; Zhang et al, 2003) is given by (1)

$$hmF2 = \frac{1490MF}{M + \Delta M} - 176 \qquad (1)$$

where

$$MF = M \sqrt{\frac{0.0196\,M^2 + 1}{1.2967\,M^2 - 1}} \qquad (2)$$

And

$$\Delta M = \frac{0.253}{\frac{foF2}{foE} - 1.215} - 0.012 \qquad (3)$$

M indicates the factor of propagation M(3000)F2, and foE the critical frequency in the E-Region. The knowledge of foE and foF2 helps to determine the hourly values of ΔM.

Note that for missing hourly data of foE and foF2, the profiles are not completed.

3. Results and Discussion

hmF2 and foF2 time variation given by data for solar minimum (year 1985) are shown on Figure 1 (Panels (a), (b), (c), (d)). On Figure 2 (panels (a'), (b'), (c'), (d')), we present hmF2 and foF2 time variation given by data for solar maximum (year 1990) of C22.

The linear trend lines show that foF2 grows rapidly while hmF2 is quiet constant (Figure 1: panels (a), (b), (c) and (d)) on solar minimum. This is shown by a steep slope of the linear trend line for foF2 while hmF2 presents a flat slope. On solar maximum, hmf2 and foF2 linear trend lines present a steep slope (Figure 2: panels (a'), (b'), (c') and (d')). hmF2 and foF2 present higher values at solar maximum than those at solar minimum. So, during solar maximum, the critical frequency gets high value, compared to minimum solar cycle phase. While hmf2 grows from solar minimum to solar maximum, foF2 also grows. This means that from solar minimum to maximum, the critical frequency gets high values. This can be explained by the growth of particles density in the ionosphere region from solar minimum to maximum.
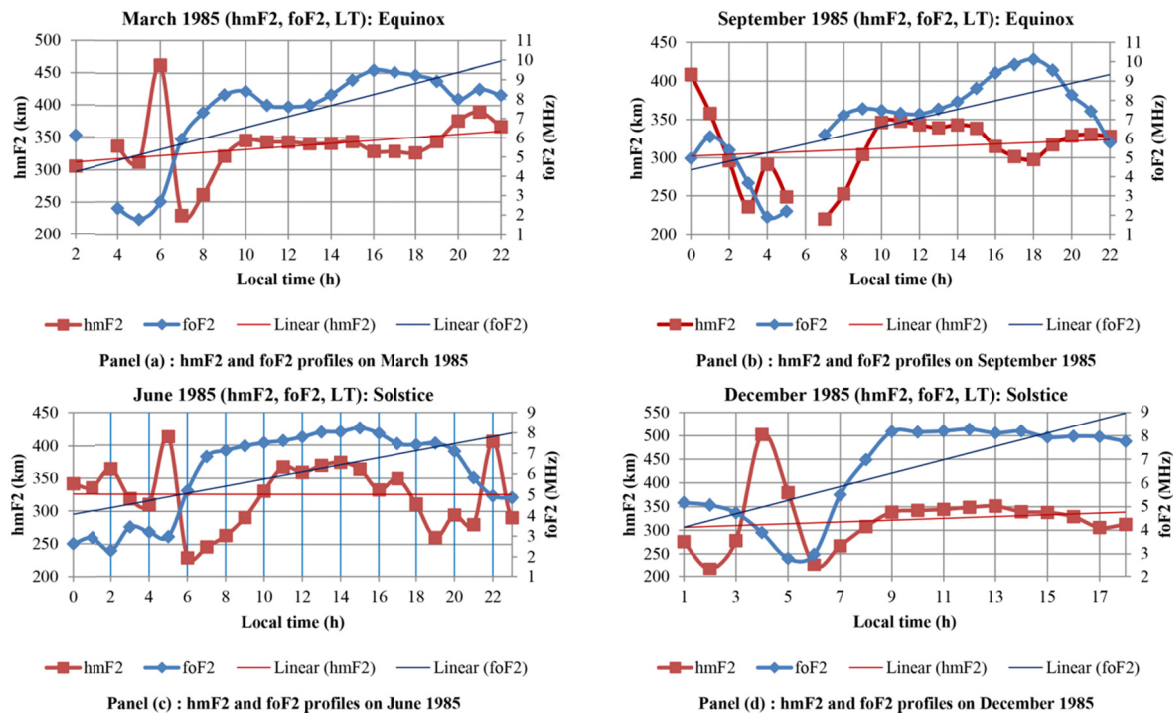

Figure 1. Time variation of hmF2 and foF2 on minimum solar cycle phase of C22
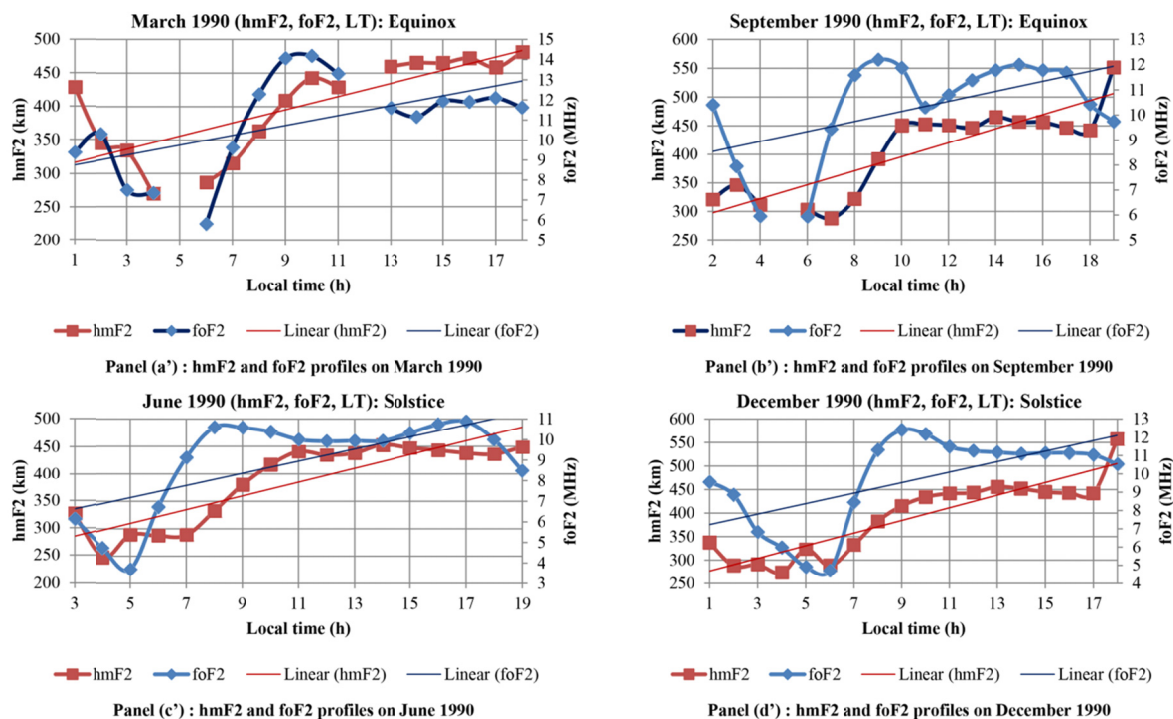
Figure 2. Time variation of hmF2 and foF2 on maximum solar cycle phase of C22

4. Conclusion

During solar maximum, foF2 values are higher than those of foF2 on solar minimum. So, rather hmF2 is high, than foF2 is great. hmF2 influences the behavior of foF2 by the growth of particles density in the ionosphere region from the minimum to the maximum of solar cycle phase.   These results have good correlation with those found during the studies of foF2 and hmF2 by Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) and International Reference Ionosphere (IRI) models.

Aknowledgment

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