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Research Article

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Analysis of Seasonal Variation of Densities Electronic: NmE and NmF Boundary of E and F Layers of Ionosphere in Low Latitudes, Ouagadougou Station.

Kadidia Nonlo DRABO[1,2]*, Roger NAKOLEMDA[2], Gédéon SAWADOGO[2,3,] Emmanuel NANÉMA[1,2.]

[1]Centre National de la Recherche Scientifique et Technologique, Institut de Recherche en Sciences Appliquées et Technologies, 03 BP 7047 Ouagadougou 03, Burkina Faso.
[2]Laboratoire de ChimieAnalytique de Physique Spatiale et Energétique (L@CAPSE), Université Norbert Zongo BP 376 Koudougou, Burkina Faso.
[3]Centre Universitaire de Tenkodogo / Université Thomas SANKARA, Ouagadougou Burkina Faso.
*Corresponding Author's Email: drabo.kadidia@yahoo.fr

Abstract: This work was undertaken to contribute to a better understanding of the atmospheric layer by analysing variations in ionospheric parameters, in particular the electron density at Ouagadougou station at low latitude during the cycle solar cycle 23.

This variation is the result of the disturbances that are regularly observed in the ionosphere, which is the upper part of the Earth's atmosphere ionised by solar radiation. To do this, we used the IRI (International Reference Ionosphere) in its 2016 version, which is an empirical model that was used to collect data for the days of the months characteristic of the minimum and maximum phase of the solar cycle.

At the end of our study, we found that the variability of the electron density density of the F (NmF) layer and the variability of the electron density of the E (NmE) layer, follow the evolution of the intensity of the sun due to the geographical situation close to the ionospheric equator of our study station. NmE and NmF present significant values during the day, because the ionization produced by the sun's rays is important.

At the limit of the E and F layers, the ionospheric day corresponds to the period where the NmE and NmF values are important and conversely during the ionospheric night the values of NmE and NmF are very insignificant.

Keywords: Electron density, ionosphere, phase maximum, phase minimum, quiet days.

1. Introduction

Ultraviolet light from the sun is the main source of the ionised environment of atoms and molecules in the Earth's upper atmosphere. This ionization increases as the altitude increases, and we can distinguish three main layers of the ionosphere: layers D, E and F. The electron density Nm varies not only with altitude but also with the solar cycle solar cycle, season, day and time. In this article, it will be a question of devoting ourselves to study of the variation of the electron densities NmF and NmE in the boundary region E and F of the ionosphere in low latitudes of the African sector. The study will be carried out at the Ouagadougou station located in West Africa, latitude 12.4°N and longitude 358.5°E. The quiet periods of maximum and minimum phase of solar cycle 23 are considered. The International Radio Consultative Committee (CCIR) and International Radio-Scientific Union (URSI) of the 2016 version of the International Reference Ionosphere (IRI-2016) model at low latitudes of the African region are considered .At the end of the stimulation study, it appeared that the variation in electron density is a function of solar irradiation, the season, the months of the season, the quiet days of the month, the hours of the day, at a given altitude at the boundary of layers E and F.

2. Materials and Data

The study was carried out at Ouagadougou station, at the boundary of layers E and F as shown in Figure 1.

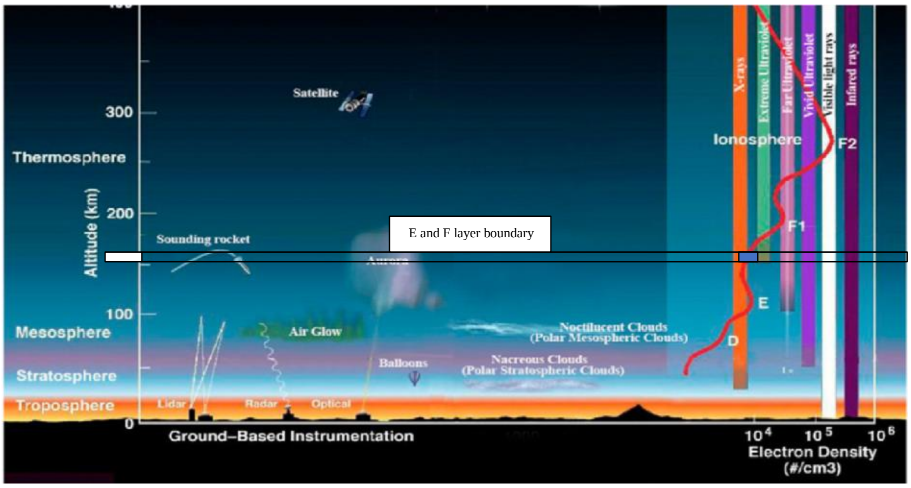

Figure 1: The boundary zone of layers E and F.

For modeling we use the semi-empirical IRI model, to determine the electronic densities. IRI is available online at www.irimodel.org in the following conditions:

Firstly, the phases of solar cycle 23: the minimum and maximum phases of cycles. The phase of a solar cycle is characterized by the number of sunspots Rz, if Rz >100, the phase of cycle corresponding is maximum phase, where magnetic activity is at its highest, and if magnetic activity is lowest, for Rz < 20 the phase of cycle corresponding is minimum phase the solar cycle 23.

The average duration of a solar cycle is 11 years, so for solar cycle 23, 1996 is the year corresponding solar minimum phase and 2008 is the year corresponding of solar maximum phase.

Four months are used to characterize the seasons of 1996 and 2008, the four months are: March, June, September December. The characteristic months correspond to the four seasons of the year.

March describes spring, June describes summer, September describes autumn and December describes winter. five quiet days of the month Are also considered. these calm days are characterized by the Aa index < nT. The study take place at the Ouagadougou station. We considered the geographic coordinates of the Ouagadougou station, the study station: the latitude and longitude of the site, and a height of 150 km. Profile time between [0h - 24h] with a difference of 1 hour. Local time in Ouagadougou station corresponds to Universal Time.

Once all these parameters have been taken into account and entered in IRI, we obtain the NmE and NmF data in matrix form the five calm days during the 24 hours of day of each month characteristic of the solar cycle. These output data will then be outputs will be processed on EXEL. Global electron densities are determined by calculating the monthly hourly average of the NmE and NmF values. The critical frequency, also called plasma frequency and the electron density are related by equation (1):

$$f_p = \frac{1}{2\pi}\left(\frac{n_e . q_e^2}{m_e . \epsilon_0}\right)^{1/2} \qquad (1)$$

With:

q_e: electron charge: $1.6022*10^{-19}$ Coulombs.

m_e: electron masse: $9.1095*10^{-31}$ kg.

n_e: electron number by unit volume, électron/m^3

ε_o: dielectric constant of free space: $8.8542*10^{-12}$ farad-mètre $^{-1}$

after simplification and calculation, we obtain:

$$f = 9.\sqrt{n_{ie}} \quad (2)$$

f: Hz

ne: electron number by unit volume, électron/m^3

In conclusion, $f_c = 9.\sqrt{Nm}$; (3)

f_c: critical frequency, Nm: electron density.

Nm of the characteristic month, is the daily hourly average of the five quiet days.

$$Nm = \frac{\sum_{i=1}^{5} Nm^i}{5} \quad (4)$$

$$\text{F layer, } NmF = \frac{\sum_{i=1}^{5} NmF^i}{5} \quad (5)$$

$$\text{E layer, } NmE = \frac{\sum_{i=1}^{5} NmE^i}{5} \quad (6)$$

3. Results

After data processing, calculation of hourly averages of electron density for quiet days for E layer and F layer, we represent the values obtained on a graph for each month characteristic of each phase of solar cycle 23. Figures 1,2,3,4; represent the minimum phase of solar cycle and figures 5,6,7,8; represent the maximum phase of solar cycle.

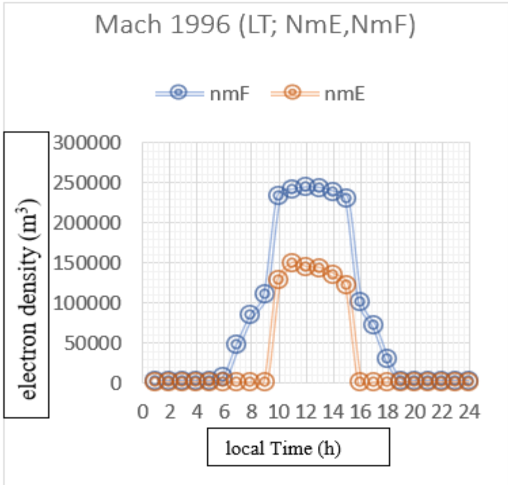

Figure 2: variability of NmE and NmF in Spring 96

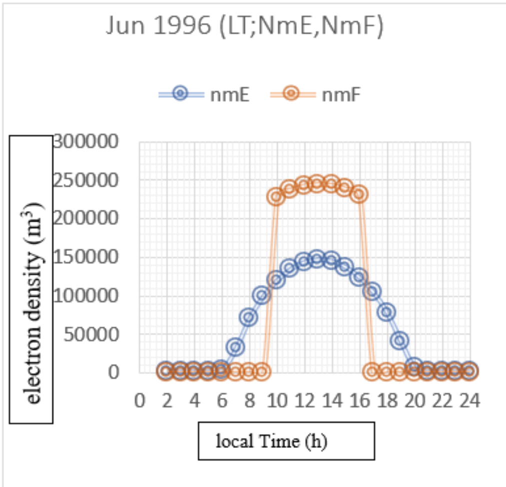

Figure 3: variability of NmE and NmF in summer 96

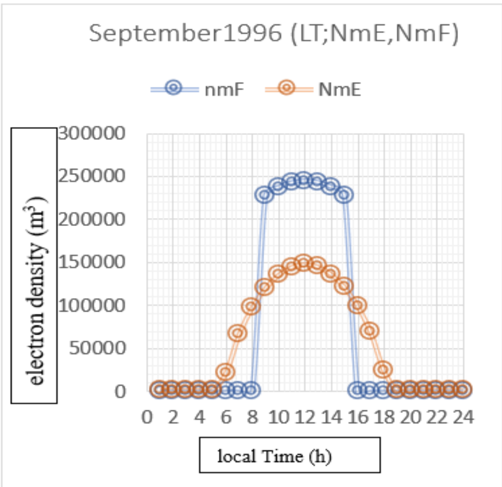

Figure 4: variability of NmE and NmF in autumn 96

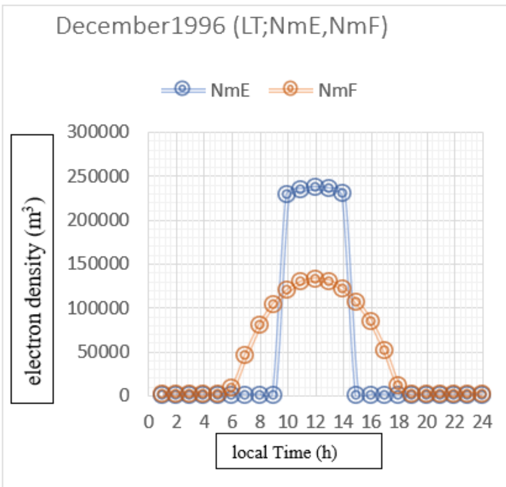

Figure 5: variability of NmE and NmF in winter 96

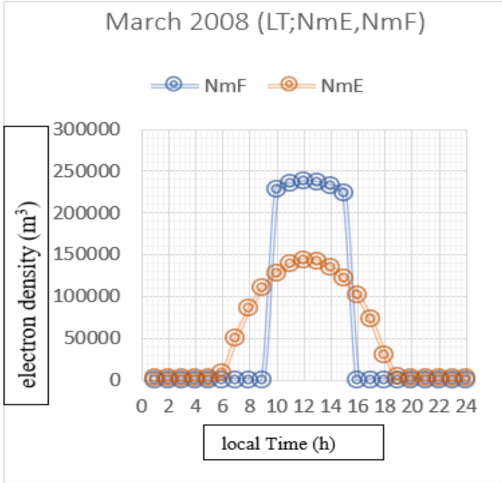

Figure 6: variability of NmE and NmF in Spring 08

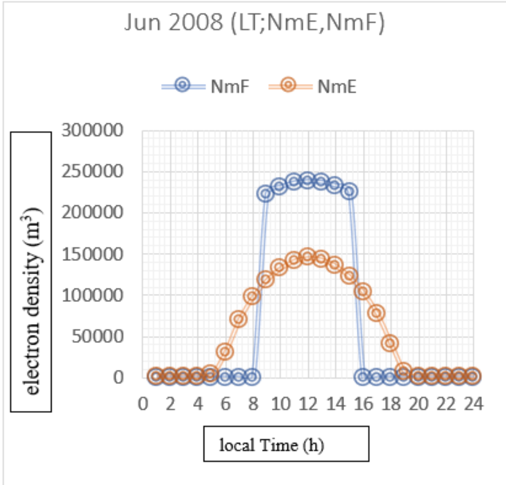

Figure 7: variability of NmE and NmF in summer 08

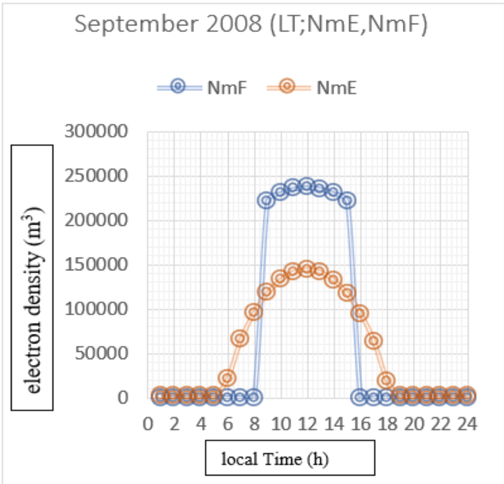

Figure 8: variability of NmE and NmF in autumn 08

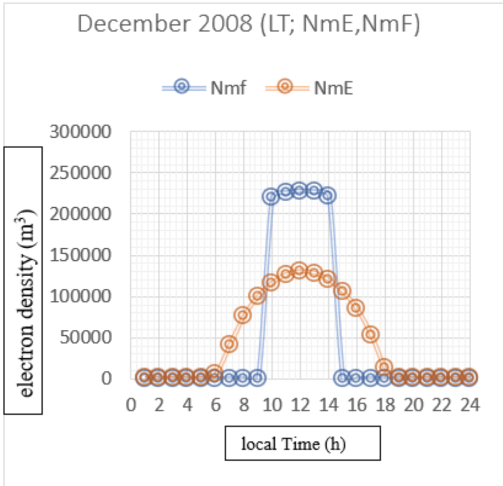

Figure 9: variability of NmE and NmF in winter 08

4. Discussion

after analyzing different graphs, you can see that:

At the boundary of layers E and F, at altitude of 150 km, profiles of electrons densities for year 1996 depends on the season and the Local Time.

At the boundary of layers E and F, at altitude of 150 km, profiles of electrons densities for year 2008 depends on the season and the Local Time.

The values of the electron densities are lower at solar minimum phase than at solar maximum phase of solar cycle 23. This is explained by the fact that solar activity during the minimum phase is low compared to the maximum phase.

During the maximum and minimum phases of the solar cycle 23 , NmE and NmF have lower values in winter than in summer.

Observation of the seasonal variation profiles NmF and Nme, function of time shows us three parts, a horizontal part, an increasing part and a decreasing part.

The seasonal variation profiles NmF and NmE have a parabolic shape. We can also see that the two profiles intersect at two points.

For layer E;

From 0 LT to 6 LT and from 18 LT to 24 LT, the values of NmE are almost zero, the profile of is horizontal, this period correspond to ionospheric night.

From 6 LT to 12 LT, the values of NmE begin to increase, NmE profile is increasing.

At 12 LT, we reach the highest value of NmE.
From 12 LT to 18 LT, the values of NmE begin to decrease, NmE profile is decreasing.
For layer F;
From 0 LT to 8 LT and from 16 LT to 24 LT, the values of NmF are almost zero, the profile of is horizontal, this period correspond to ionospheric night.
From 8 LT to 12 LT, the values of NmF begin to increase, NmF profile is increasing.
At 12 LT, we reach the highest value of NmF.
From 12 LT to 16 LT, the values of NmF begin to decrease, NmF profile is decreasing.

5. Conclusion

Analysis of the NmF and NmE seasonal variability of E and F layers of the ionosphere at the Ouagadougou station shows that electron density is a parameter which depends on the phase of the solar cycle, the season and the Local Time at altitude of 150km.
During ionospheric nights where solar irradiation is at its lowest, the NmF and NmE profiles are very weak (almost zero values).
During ionospheric days, solar irradiation begins to increase, we observe an increase in the values of NmF and NmE.
NmF and NmE respectively reach their maximum value at around 12 LT, time when the ionization of solar rays is at the highest level.
The electron density of the layers and the critical frequency being linked, this study allowed us to highlight the maximum frequency not to be exceeded by a radio wave at the risk of not being reflected by layers E and F at 150 km.

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