SF2A 2021
A. Siebert, K. Baillié, E. Lagadec, N. Lagarde, J. Malzac, J.-B. Marquette, M. N'Diaye, J. Richard, O. Venot (eds)

INTERHEMISPHERIC ASYMMETRY OF THE EQUATORIAL IONIZATION ANOMALY IN THE AFRICAN SECTOR OVER 3 YEARS

A. Loutfi[1,2], F. Pitout[1] and A. Bounhir[2]

Abstract. The electron density in the topside ionosphere recorded by the Langmuir probes on board the Swarm satellites has been systematically analyzed to determine the climatology of the Equatorial Ionization Anomaly (EIA) in the African sector over 3 years. Observations show strong seasonal variations, with the electron density being lower around the June solstice compared to the rest of the year. We have noticed the so-called semi-annual anomaly: the electron density is higher around equinox than around solstice. For solstice seasons, the asymmetries in the electron density with respect to the magnetic equator are stronger at the December solstice than at the June solstice. For equinox seasons, we can notice equinoctial symmetry in all local time sectors, meaning that the same trend is observed for both equinoxes with or without symmetrical crests.

Keywords: Ionosphere, electron density, Swarm, EIA.

1 Introduction

Several studies have investigated the interhemispheric asymmetries of the mid-latitude ionosphere, including the asymmetries of the latitudinal positions and densities of EIA crests. Moreover, the significant longitudinal variations of the EIA interhemispheric asymmetry have been studied in previous works (Lin et al. 2007; Luan et al. 2015). Despite all these studies, the interhemispheric asymmetry of the topside ionosphere needs to be further investigated. We present the first comprehensive study carried out in the Africa sector. Data used in this study were collected during the declining solar cycle (2014-2016) from Swarm satellite A. Langmuir Probes (LP) on aboard Swarm satellites allow to estimate the ambient electron density (Ne) of the ionospheric plasma (Friis-Christensen et al. 2008) at 460 km altitude. To study the seasonal variability of the ionospheric electron density, we have selected all Swarm A satellite passes that cross a rectangle of -60°S, 60°N in magnetic latitude and -7.88°-4°W and -7.88°+4°W in geographic longitude.

2 Seasonal variability of ionospheric electron density.

Figure 1 shows seasonal variability of the latitudinal distribution of the ionospheric plasma density at the mid- and low-latitude regions at around 7.866° W meridian sector (±4° longitude intervals) of all data available for different local time sector over 3 years (2014-2016). At first glance, we can see that the ionospheric electron density is very low at night and the lowest values are mainly found at the June solstice in most local times. We can also often see a hemispheric asymmetry in the electron density distribution. This asymmetry could find its origin in the asymmetry of the magnetic field itself (Barlier et al. 1974). For solstice seasons, the average Ne values indicate the existence of two different EIA asymmetries: Ne is higher in the northern (southern) hemisphere than in the southern (northern) one in the December solstice (June solstice). The overall electron density at low latitude is smaller around June solstice than December solstice. This is explained by the smaller Sun-Earth distance around June (Su et al. 1998). We also note that differences are larger during day time than night time.For equinox seasons, we can notice the so-called equinoctial symmetry in all local time sectors,

[1] IRAP, Universite Toulouse III, CNRS, CNES, Toulouse, France.
[2] Oukaimeden Observatory, Laboratoire de Physique des Hautes Energies et Astrophysique, FSSM, Cadi Ayyad University, Marrakech, Morocco.

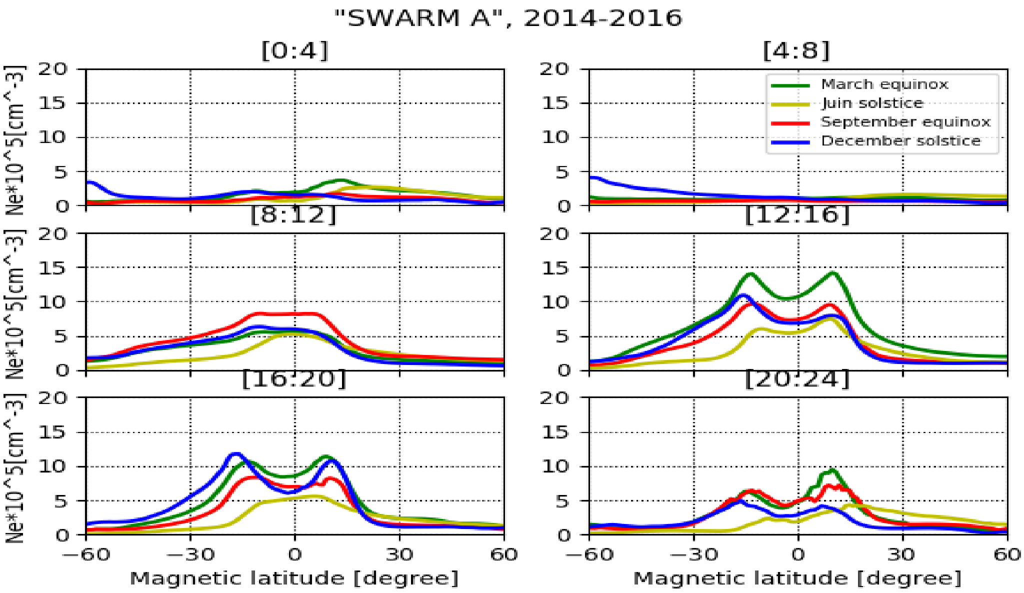

Fig. 1. The seasonal variation of the ionospheric plasma density structure at the mid- and low-latitude regions at around 7.866° W meridian sector (±4° longitude intervals) in different local time sectors.

meaning that the same trend is observed for both equinoxes with or without symmetrical crests. This features of the equinoctial symmetry is in good accordance with the result reported by Bailey et al. (2000). Still around equinoxes, EIA crests asymmetry is observed from 20 LT to 04 LT where the northern hemisphere crest density is higher than the southern one. The average of the electron density in March equinox is greater than the September one except from 8 LT to 12 LT where the opposite is observed for the single crest ionospheric density. A mechanism for this latter equinoctial asymmetry has been studied using CTIP (Coupled Thermosphere Ionosphere Plasmasphere model). The model results reproduce the observed equinoctial asymmetry and suggest that the asymmetries are caused by the north-south imbalance in energy imput into the thermosphere and ionosphere. This imbalance is due to the slow response of the thermosphere arising from the effects of the global thermospheric circulation (Bailey et al. 2000). From comparing the average electron density at equinox and solstice seasons, we have noticed the semi-annual anomaly: the electron density is higher at the equinoxes than at the solstices. This is in accordance with the observations made by the Hinotori satellite (Bailey et al. 2000).

3 Conclusions

The seasonal variability of the ionospheric electron density around 460 km altitude has been studied using 3 years (2014-2016) of Swarm satellite data in the African sector. Observations show strong seasonal variations, with the electron density being lower around the June solstice compared to the rest of the year. We have noticed the semi-annual anomaly: the electron density is higher around equinoxes than around solstices.

This project is financially supported by Campus France through the French-Moroccan bilateral program "PHC Toubkal 2019" (grant number: 41409WJ). The European Space Agency is acknowledged for providing the Swarm data. The official Swarm website is http://earth.esa.int/swarm, and the server for Swarm data distribution is ftp://swarm-diss.eo.esa.int.

References

Bailey, G., Su, Y. Z., & Oyama, K.-I. 2000, Annales Geophysicae, 18, 789

Barlier, F., Bauer, P., Jaeck, C., Thuillier, G., & Kockarts., G. 1974, Journal of Geophysical Research, 79(34), 5273–5285.

Friis-Christensen, E., Lühr, H., Knudsen, D., & Haagmans, R. 2008, Advances in Space Research, 41(1), 210–216.

Lin, C. H., Liu, J. Y., Fang, T. W., et al. 2007, Geophys. Res. Lett.,34, L19101,

Luan, X., Wang, P., Dou, X., & Liu, Y. C.-M. 2015, J. Geophys. Res. Space Physics, 120 , 3059–3073,

Su, Y., Bailey, G., & Oyama, K. 1998, Annales Geophysicae 16, 974–985