Temporal and longitudinal variability of the equatorial ionization anomaly observed by ground-based GNSS receiver networks over South America.

Lomotey, S. O. [1], Wrasse, C. M.[12], Souza, R. J. [13], Takahashi, H. [14], Barros, D. [15], Figueiredo, C. A. O. B. [16], Essien, P. [17], Ayorinde,T.T. [18] ,Gobbi, D. [19], Bilibio, A. V. [10]

[1] Aeronomy Division - National Institute for Space Research (DIDAE / CGCEA - INPE), Av. Dos Astronautas, 1758, Jd. da Granja, São José dos Campos - SP - CEP: 12227-010.

Abstract

The equatorial ionization anomaly (EIA) structures and evolutions were mapped in 10 min time resolution using total electron content (TEC) from GNSS ground-based network receivers over South America. Temporal and longitudinal variation of the EIA crest location, peak intensity (in TEC) were studied. This present study aimed at studying the day-to-day variation of the crests positions and this was done by picking the TEC along two a magnetic meridians line (i.e., meridians crossing the respective magnetic longitudes of 3.36˚E and 7.58˚E) at an altitude of 300 km during 2014. A clear seasonal variation was observed along the entire year; the peak intensities were enhanced in Equinoxes (i.e., March, April, September, and October) and Summer (I.e., November, December, January, and February), while it was observed a suppression in winter (i.e., May, June, July, and August). Our results revealed that the day-to-day variations of the EIA southern crest positions might be related to planetary scale waves.

Introduction

The equatorial ionization anomaly (EIA) also termed as equatorial ionospheric anomaly by some researchers, is an important feature in the equatorial and low-latitudes in the ionosphere. It was found to exhibit an unexpected large structure characterized by a trough at the magnetic equator with two crests at about ±17º either side of the magnetic equator.

Several theories like the diffusion (Mitra, 1946) and electrodynamic drift (Martyn,1955) were suggestions which helped to explain the anomaly. According to these theories, the plasma is vertically lifted upward during the daytime and then diffuses along the geomagnetic field lines, away from magnetic equator due to the Earth's pressure gradient and the gravitational forces leading to the formation of the EIA. In addition to these theories, Marytn (1955**)** proposed that the upward **E**×**B** drift is an important ingredient for the formation of the anomaly. Although studies have shown that electrodynamic processes are the primarily forces responsible from day-to-day variation. And to better understand the spatial and temporal variation of the EIA and the day-to-day variability of the southern crest of the EIA we used TEC data from GNSS receivers over South American.

Methodology and Data Analysis

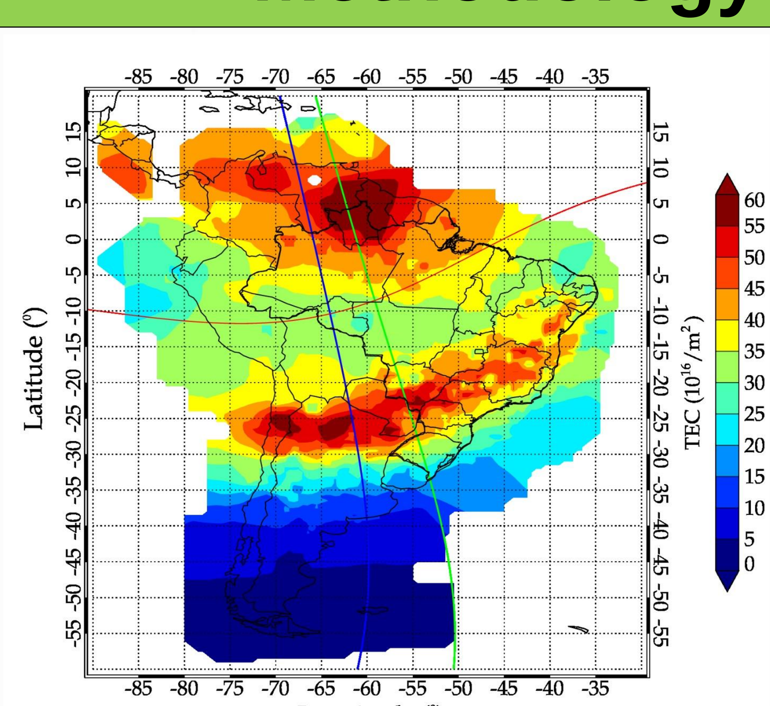


Figure 2.0: GPS based TEC Map over South America continent. The magnetic meridian lines were then plotted over the map. The TEC level is shown in the color bar ranging from 0 (blue) to 60 (red) TECU next to the map.

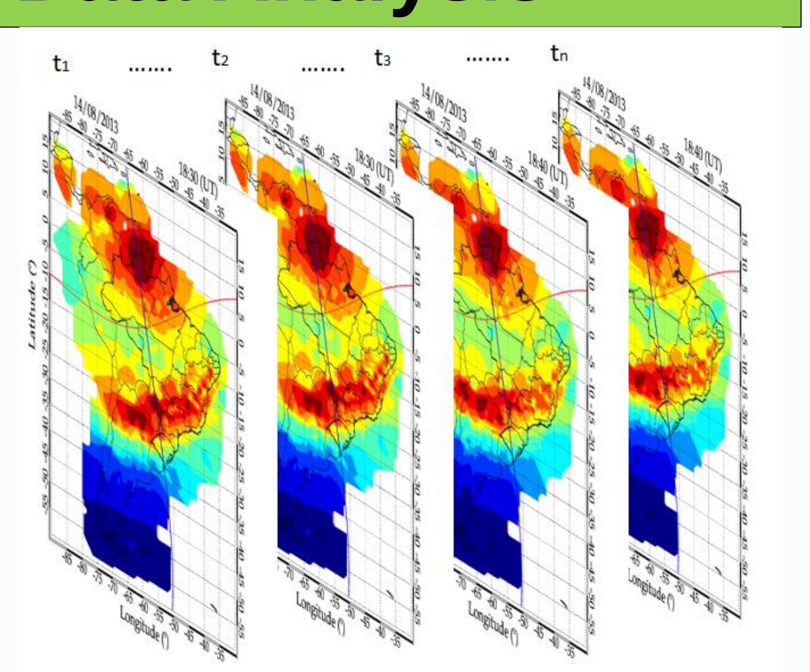


Figure 3.0: Consecutive TEC maps used to construct a keogram are shown. The keogram consists of geographic latitude, universal time (UT) for a chosen geomagnetic meridian. It is constructed by picking the TEC along the such meridian, by sampling of TEC maps in geographic coordinates, for every 10 minutes. These samples are accumulated throughout the day, forming a time series as a function of geographic latitude, as shown in Figure 4.0 below.

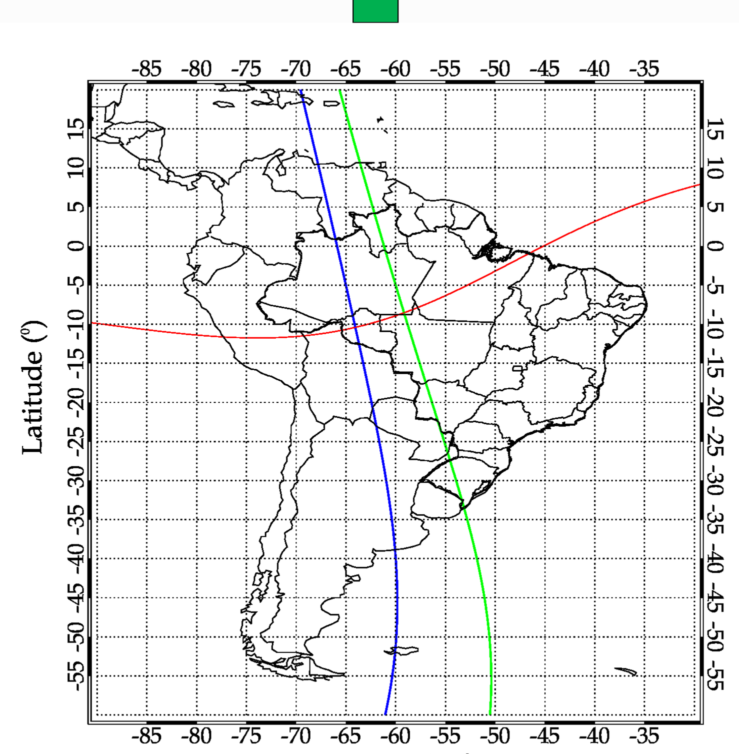


Figure 1.0 : construction of geomagnetic lines (the blue is 3.36˚E and the green is 7.58˚E) using the IGRF model at an altitude of 300 km. In the map, the red continuous line depicts the geomagnetic equator.

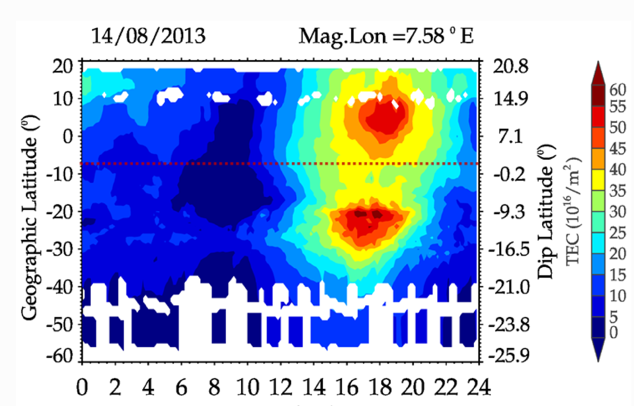


Figure 4.0: contour plot shows the morphology of the EIA crests formations in both the north and south hemispheres.

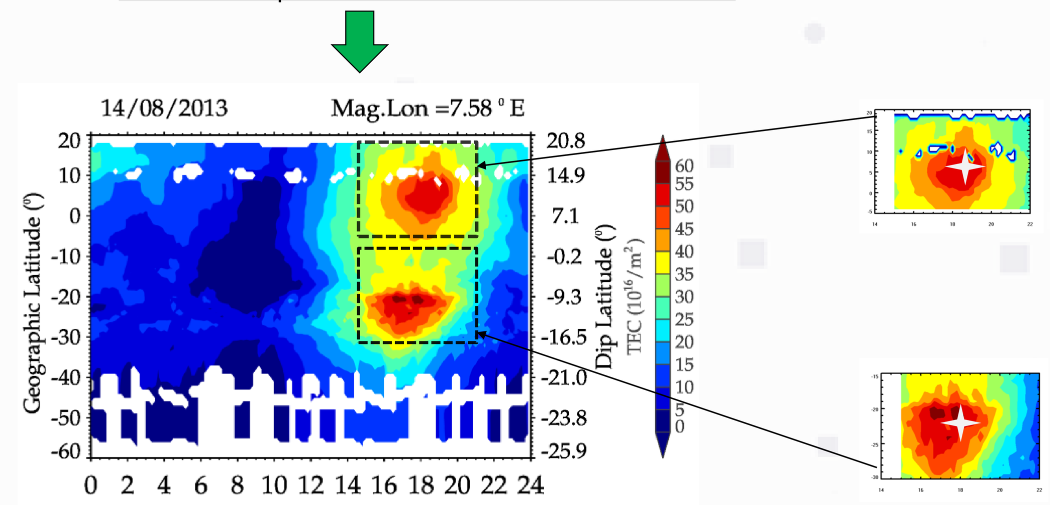


Figure 5.0:The analysis carried out on the keogram from Figure 4.0, to obtain the parameter's of the crest using the centroid function (white). This procedure was used determine the location, intensity and the time of occurrence .

Results

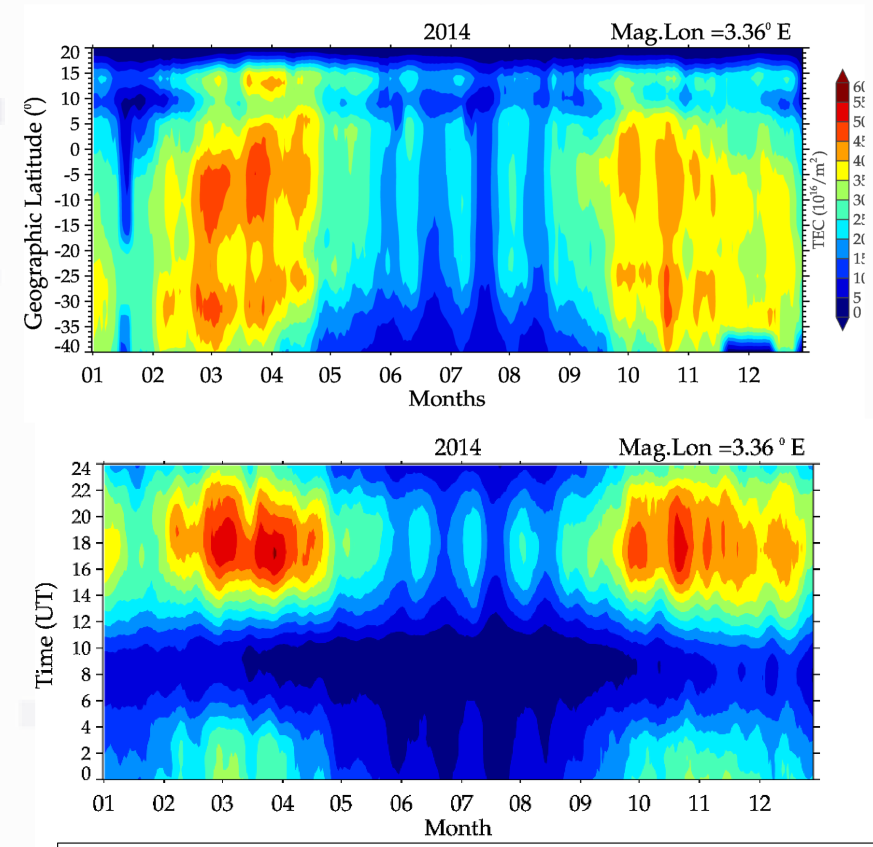


Figure 6.0: Contour plots of (a) the daily mean of EIA and (b) time of evolution as functions of months at 3.36˚E (geomagnetic longitude)

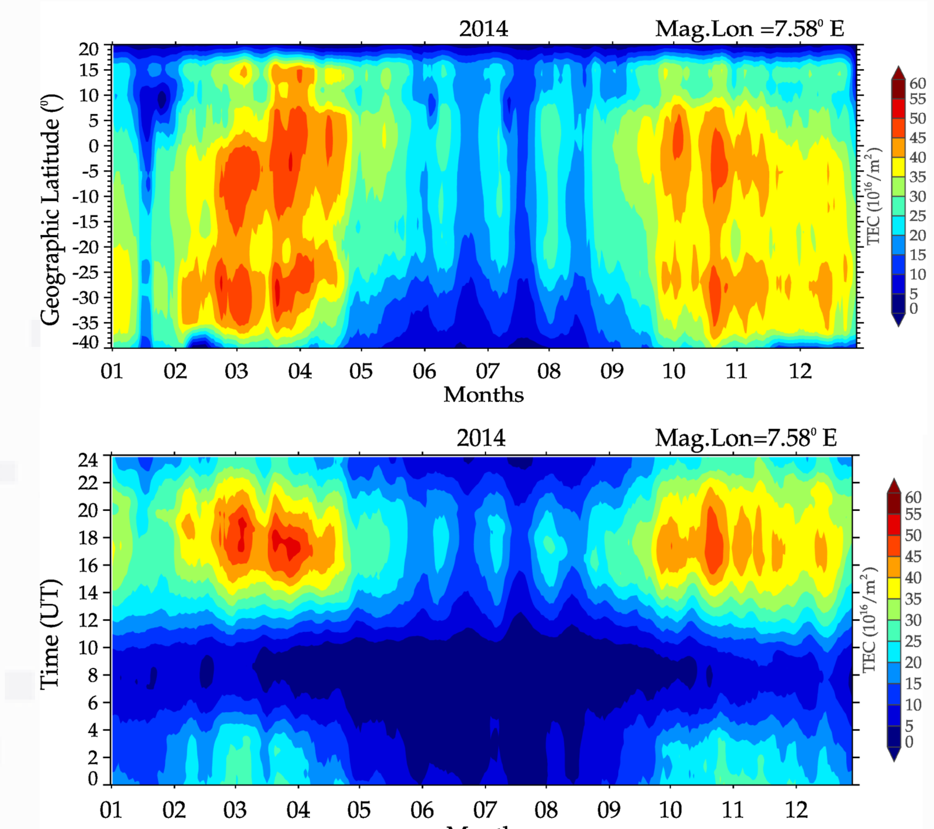
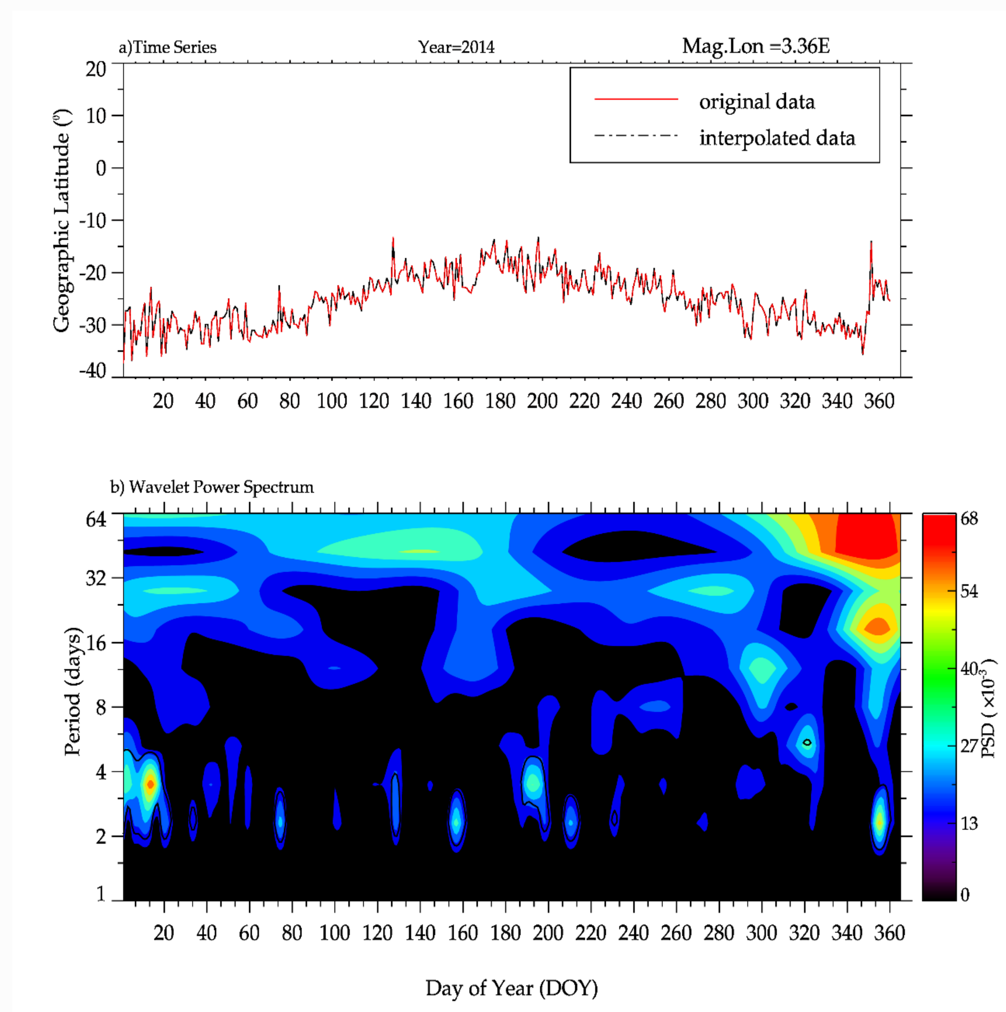
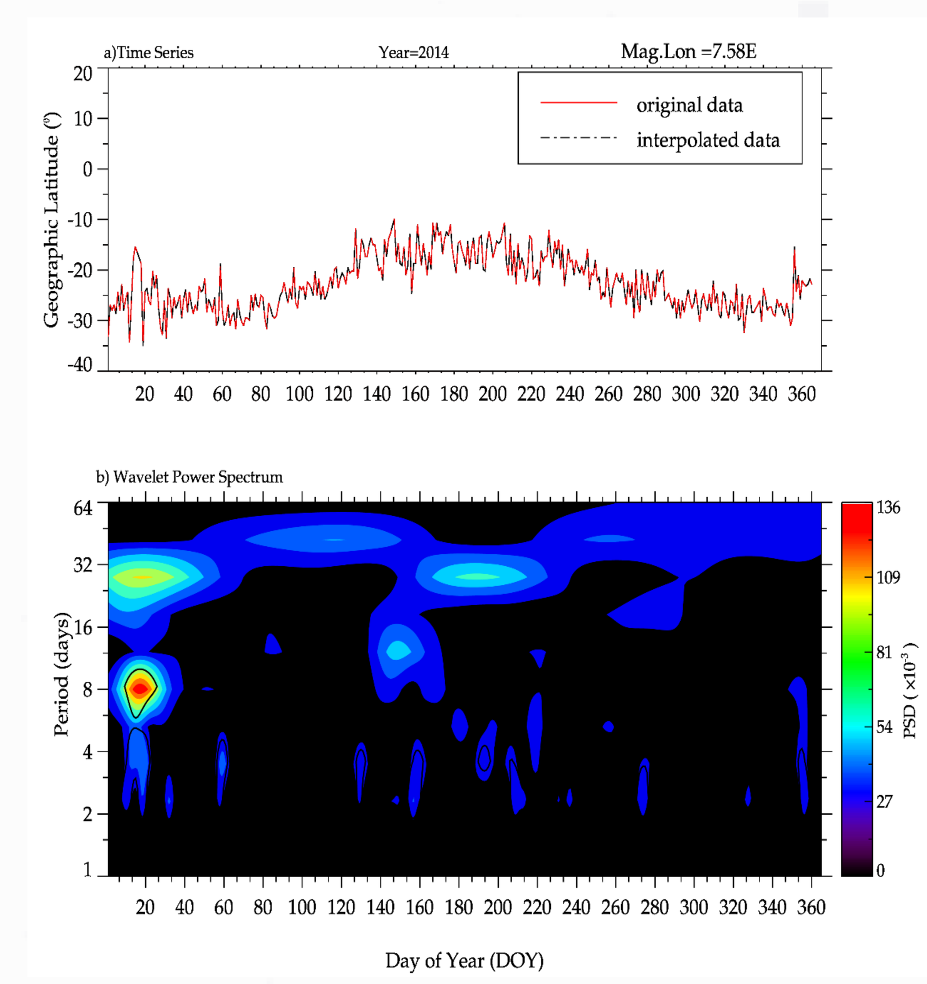


Figure 7.0: Contour plots of (a) the daily mean of EIA and (b) time of evolution as functions of months at 7.58˚E (geomagnetic longitude)

- The enhancement of the intensity of the crest of the EIA occurred in Equinoxes and Summer whiles there is a suppression of the intensity in Winter.
-The EIA crest in winter were found at the geographic equator whereas in Equinoxes and summer there was a drift of the EIA crest to the lower latitude.
- The evolution of the EIA are mostly found between 14UT to 23UT along the entire season. A few observations could be seen after midnight which be could associated to Pre-reversal enhancement.





Periodic oscillation of the day-to-day southern crest position of the EIA are shown in Fig. 8 &9. oscillations are shown in a color contour form according to the spectral density from blue (violet) to red (high).

- The spectrum of the south crest position (top panel) depicts periodic oscillations of 1–64 days.
- Day to day variations of the south crest (top) shown for each magnetic meridian lines during 2014.

Summary and Recommendations

From our analysis, we found the following:

- Keograms from TEC maps is useful to visualize the temporal development and morphology of the EIA .

- A clear seasonal variation of the EIA could be seen over entire year. The peak intensities are enhanced in equinoctial and summer months, with suppressions of the peak during winter.

- There several factors that could lead to the yearly variation such as Trans equatorial winds, Equatorial electrodynamics, geomagnetic storms, solar activity phases, etc.

-The Earth's ionosphere is also subject to forcing by the atmospheric waves that propagate from lower to upper layers of the atmosphere.
- The importance such forcing to upper atmosphere layers for the spatial and temporal changes of the ionosphere has been increasingly noticed by the many scientist (OBERHEIDE et al., 2015; LIU, 2016,).

References

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Contact Me: Solomon otoo Lomotey (PhD Student), Email: Lomoteys@gmail.com, Solomon.lomotey@inpe.br