ESA Alcantara Initiative

Characterization of equatorial Ionospheric Anomaly in the African region (IONAF)

Executive Summary

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Picture:

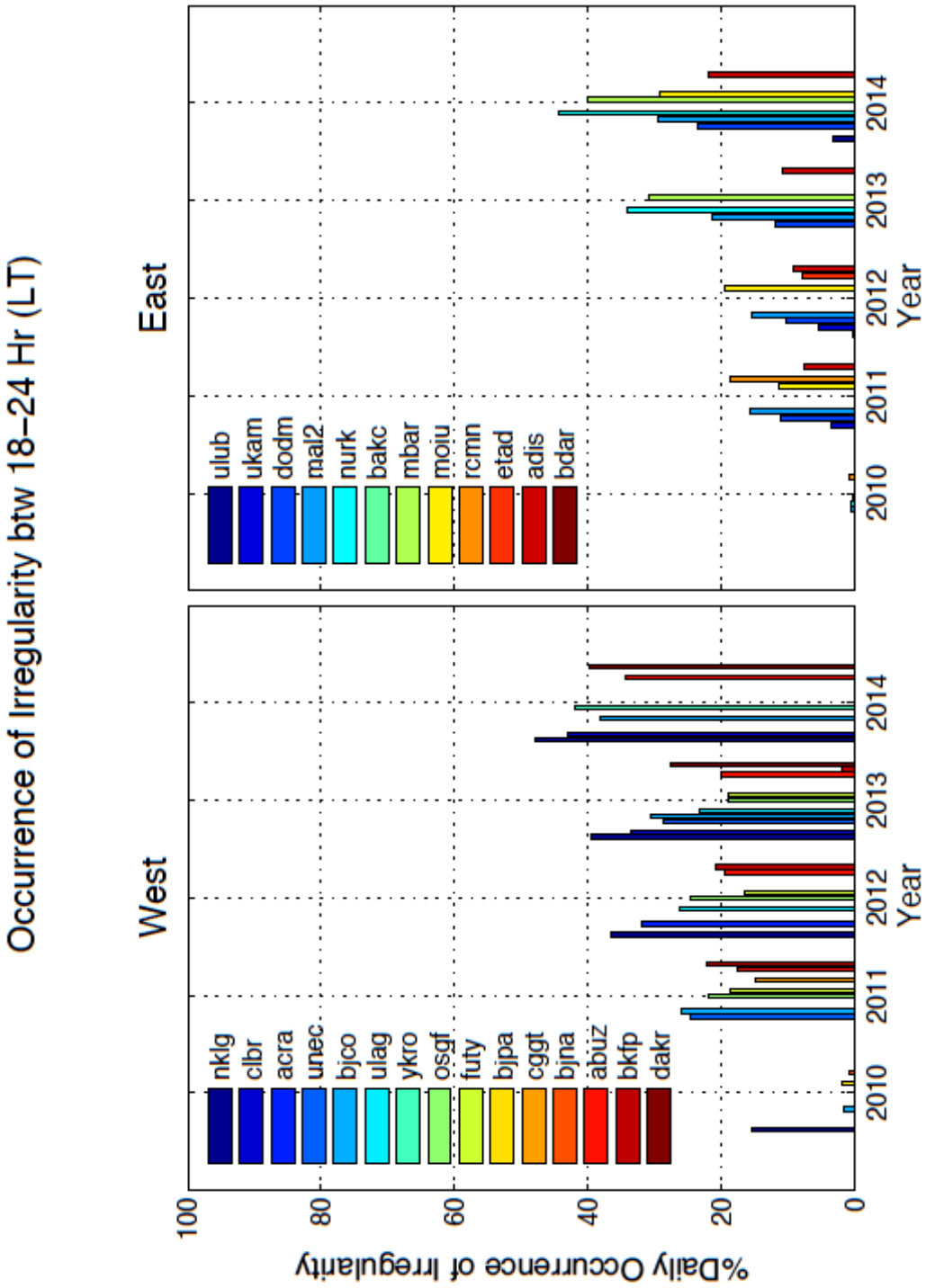

Figure 1 Yearly percentage of days along eastern and western African longitudes for all the *available stations when ROTI average within each hour in the range 18 - 24 LT was ≥ 0.3.*

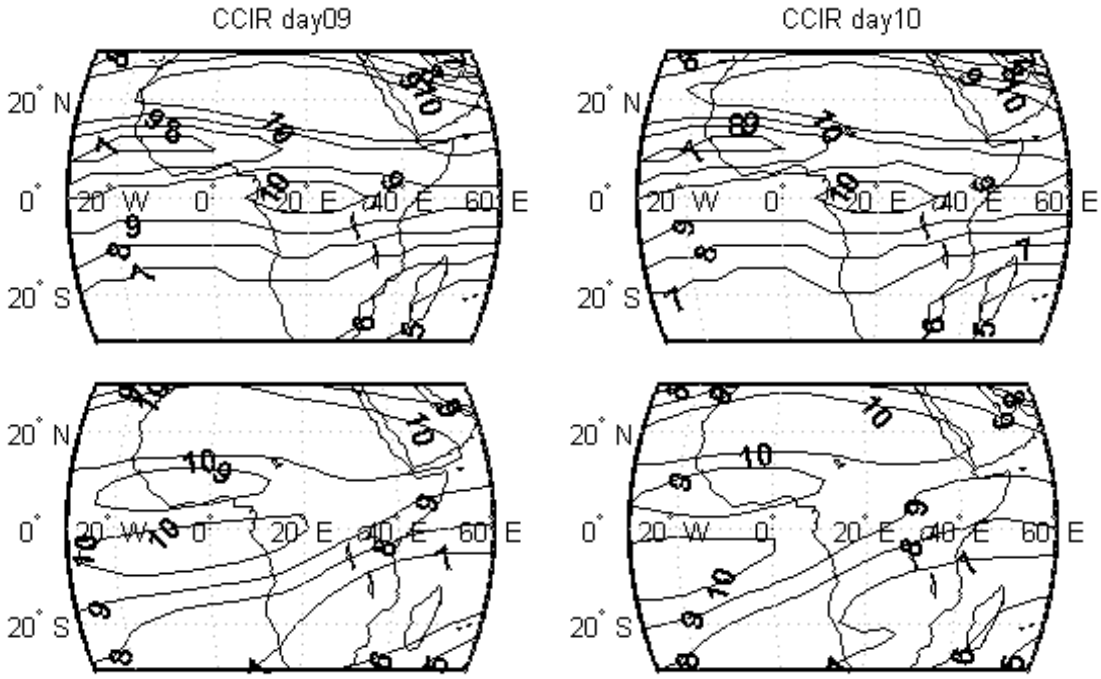

Figure 2 ***Contour maps of retrieved foF2 day-to-day values for the month of SEP 2010. The first row corresponds to ITU-R (CCIR) maps with daily F10.7, second row shows the estimated foF2 by NeQuick after CODE TEC maps ingestion***

Motivation:

The objective of the IONAF project is to characterize the ionospheric electron density distribution and its variability in the area of the Equatorial Ionospheric Anomaly (EIA) over the African region, using GNSS derived Total electron content (TEC) and other available ionospheric data.

Methodology:

TEC is used to study the characteristics of the EIA in terms of diurnal, day-to-day, monthly, seasonal and solar cycle variation of the ionosphere over Africa

As data sources, Global Ionospheric Maps (GIM) of vertical TEC generated by the Center for Orbit Determination in Europe (CODE) for the period 2008 to 2014 have been used. The maps have been used to characterize the behavior of the EIA over the region of interest but also to ingest the TEC

maps into the NeQuick model to reconstruct a 3D representation of the electron density in the region.

In addition, publically available data from ground-based GNSS receiver stations located within ±20˚ geomagnetic latitude of the region for the period from 2008 to 2014 are also used. These were use to validate the results obtained using GIMs and to investigate ionospheric irregularities using the rate of change of TEC (ROT) index ROTI, the standard deviation of ROT over a 5-mins interval.

Results:

The main results of the investigation are:

- The use of global maps of vertical TEC to study day-to-day variability of the ionosphere in terms of vertical TEC is justified. However, the study has shown that the vertical TEC derived from the GIMs presents a systematic but not necessarily constant positive offset with respect to the corresponding data obtained from individual stations.

- From the results of the characterization of the EIA over Africa using GIM, a remarkable asymmetry in terms of magnitude and time of the occurrence of maximum peak values of the northern and southern crests of the EIA, as well as longitudinal differences, have been observed. The results obtained with data from ground based stations confirm basically what was obtained using GIMs.

- The reconstruction of the 3D electron density by ingestion of GIM vertical TEC into the NeQuick model was validated with good results by comparing the reconstructed foF2 values with the experimental values of the same parameters from the only available ionosonde station (Ilorin, Nigeria). Another partial validation effort was done comparing reconstructed slant TEC with slant TEC from a single station. The systematic offsets between GIM and single GNSS stations vertical TEC mentioned above was taken into account in the ingestion process. By considering this offset the results are improved as indicated by the validation. The importance of the thickness parameters in the NeQuick model formulation has been investigated in terms of its effect in the reconstruction process by data ingestion into the model.

- Ionospheric irregularities (as indicated by ROTI) in the IEA region over Africa behave as follows. Their presence is concentrated between 20 and 02 maximizing between 21 and 24 in local time. The highest occurrence is during equinoctial months, during high solar activity and at western longitudes and in the area of the crests of the IEA. A clear influence of geomagnetic activity was not found.

Publications:

- Migoya-Orue, Folarin Olufunmilayo, Radicella, Rabiu. **"Results from the IONAF Alcantara Initiative Pilot Study**", Conference Paper presented at ISEA 14, Bahir Dar, Ethiopia. October, 2015.
- Migoya-Orue, Folarin Olufunmilayo, Radicella, Rabiu, Alazo-Cuartas. "**Characterization of the EIA over Africa based on the ingestion of global ionospheric TEC maps into NeQuick model",** to be submitted for publication.
- Folarin-Olufunmilayo, Migoya-Orue, Radicella, Rabiu. "**Characterization of Ionospheric Irregularities over Sub-Saharan Africa using ROTI**", to be submitted for publication.

Highlights:

A critical point for the characterization of the African low latitudes ionosphere is the still limited number of GNSS receiver stations particularly in central Africa. Our research has shown, however, that vertical TEC GIMs provide a realistic way of ionospheric characterization, particularly when they are used for 3D electron density reconstruction by data ingestion into a model like NeQuick. This line of work should continue increasing also the performance of the model itself introducing improvements in its formulation.