4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

Evaluating performances of the IRI, NeQuick, and 3D-NN model based on in-situ electron density measurements of SWARM satellites

Daniel Okoh[1,2], Yenca Migoya-Orué* [3], John Bosco Habarulema[4], Claudio Cesaroni[1], Bruno Nava[3], Luca Spogli[1,5], and Babatunde Rabiu[2]
(1) Istituto Nazionale di Geofisica e Vulcanologia (INGV), 00143 Rome, Italy;
email: okohdan2003@gmail.com, claudio.cesaroni@ingv.it
(2) United Nations African Regional Centre for Space Science and Technology Education - English (UN-ARCSSTE-E), Obafemi Awolowo University Campus, Ile Ife, Nigeria; email: tunderabiu@gmail.com
(3) STI, The Abdus Salam International Centre for Theoretical Physics, Strada Costiera, 11 - I-34151 Trieste, Italy; email: yenca@ictp.it, bnava@ictp.it
(4) South African National Space Agency (SANSA), P.O Box 32, Hermanus 7200, South Africa; email: jhabarulema@sansa.org.za
(5) SpacEarth Technology, Via di Vigna Murata 605, 00143, Rome, Italy; email: luca.spogli@ingv.it

The SWARM satellites, flying at altitudes of about 450 and 530 km, make in-situ measurements of the ionospheric electron density using Langmuir Probe sensors onboard the Electrical Field Instrument. The present study is a comprehensive investigation into the climatologic performance of three ionospheric models when compared to the SWARM satellite in-situ measurements. The models are the International Reference Ionosphere (IRI) model, the NeQuick, and the 3D-NN model (a 3-dimensional electron density model based on artificial neural network training of COSMIC radio occultation measurements).

The mean monthly latitudinal profile of SWARM measurements was computed by binning the SWARM electron density measurements in 15-degree longitudes starting from longitude -180° in steps of 15 degrees to 180 degrees. For each longitude bin, the monthly latitudinal profiles were computed as the average of the electron density measurements for satellite passes over the longitude bins on one hourly basis during quiet days. Similar latitudinal electron density profiles were computed for each of the three models during quiet days at a constant altitude (equal to the mean altitude of the given SWARM satellite in each bin). The monthly latitudinal profile for each bin at a given hour is the mean of the hourly latitudinal profiles during geomagnetic quiet days of the month. The periods selected for the study are representative months of years 2014, 2016, 2019 and 2022, covering different phases of the solar cycles 24 and 25.

Preliminary results from the study show that modelled electron densities from all three model climatological versions are fairly good representations of the SWARM satellite measurements. While IRI and NeQuick exhibit in general a similar performance, there are differences at certain times and latitudes. It has been found, for example, that IRI performs better in north middle latitudes while NeQuick show lower errors during evening and postmidnight in high and middle latitudes. All three models struggle in representing low latitudes values, with exception of the 3D-NN model that exhibits the lowest mean RMSD during daytime.

This study looks to reveal the forecasting performance of the models across the globe at different longitudes sectors, latitude sectors, times of the day, seasons, and solar activity phases.