The performance evaluation of TEC variations over two equatorial stations and the three topside options in IRI-2012 Model

[*1]B.W. Joshua, [2]J.O. Adeniyi, [2]O.A. Oladipo, [3]P. H. Doherty, [4]S.J. Adebiyi, [2]I.A. Adimula, [2]A.O. Olawepo,

[1] Department of Physics, Kebbi State University of Science and Technology Aliero, Kebbi State, Nigeria (benjaminjoshua7@gmail.com)

[2]Department of Physics, University of Ilorin, Ilorin, Nigeria (segun47@yahoo.com, abeladipoo@yahoo.com, iaadimula@hotmail.com, nijiolawepo@yahoo.com)

[3]Institute for Scientific Research, Boston College (dohertpd@bc.edu)

[4]Department of Industrial Physics, Landmark University, Kwara State, Nigeria (johndat2003@yahoo,co.uk)

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Abstract

This study investigates the performance of the three topside option of the IRI-2012 model (i.e. IRI-Ne Quick, IRI-2001 & IRI-2001 corr.) in predicting total electron content (TEC) over two equatorial stations; namely, Ilorin, Nigeria (Geog. Lat. 8.50°N, long. 4.50°E) and Libreville, Gabon (Geog. Lat. 0.35°N, long. 9.67°E). Data for January to December, 2010 were utilized.

1.0. Introduction

Prediction models of total columnar electron content of the ionosphere (TEC) are of great value in the operations of radio communication systems. A number of such models rely on measured data, but because of poor data coverage, some of these models do not perform well in some region of the earth, particularly in a large part of the African region. Model validation helps in identifying areas of poor performance in order to help in the improvement of their predictive capabilities. The aim of this study therefore, is to validate IRI TEC models with measured data from the equatorial region in the African region. The IRI model provides three options for prediction of TEC: IRI-2001, IRI-2001, and NeQuick [1-4].

2.0. Data and Method of Analysis

The slant total electron content (STEC) recorded by the GPS was used to calculate the vertical total electron content (VTEC) referred in this study as TEC, over two stations. This was done using the GPS TEC application software developed by Gopi Krishna Seemala of the Institute of Scientific Research, Boston College, USA. The TEC values were compared with the three topside options of the IRI-2012 model predictions (i.e. IRI-Nequick, IRI-2001 & IRI-2001 corr.). The Root Mean Square Error (RMSE) values were calculated for the three options, using equation (1) below:

$$\sqrt{\frac{1}{N}\sum_{I}^{N}(\beta_{measured} - \beta_{IRI})} \qquad (1)$$

Where $\beta_{mesured}$ are the measured values of TEC, while β_{IRI} are the corresponding IRI derived values of TEC. The data-sets spans January-December, 2010, a year of low solar activity (F10.7 = 81 solar flux unit). The ten magnetically quiet days data for each month were utilized.

3.0. Results

3.1. Diurnal and seasonal variation of TEC

TEC values measured at Libreville were observed to be higher than those measured at Ilorin during all seasons. The peak values of TEC ranges from 23-33 TECU at Ilorin, while at Libreville, it ranges from about 41-46 TECU. The lowest TEC values were recorded during the June solstice and March equinox respectively at Ilorin and Libreville.

3.2. Performance of the 3 topside options

A close look at the two figures and the tables reveals that the IRI-NeQuick and IRI-2001 corr. performed better at the two stations than IRI-2001. Fig. 1 and table 1, shows that IRI-NeQuick and IRI 2001 corr. performed better during the Solstices and worst during the March equinox (i.e. RMSE = 4.97 and 3.81 respectively). The IRI-2001 performed better during the March equinox (i.e. RMSE =10.77) and worst during the September equinox (i.e. RMSE =12.23) at Ilorin. Observations from Libreville (. Fig. 2 and table 2) shows that IRI-NeQuick is the best option during the equinoxes particularly during the March equinox (RMSE = 6.46) it however recorded a worst performance during the December solstice (i.e. RMSE =9.14). IRI-2001 and IRI-2001 corr. performed better during the solstices (i.e. RMSE =4.37 and 6.52 respectively during the June solstice), it had the worst performance during the March equinox (i.e. RMSE =17.94).

Model Options	March Equinox	June Solstice	Septemeber Equinox	December Solstice
NeQuick	4.97	1.73	2.87	2.5
IRI-01 Corr.	3.81	2.26	3.01	2.83
IRI-01	10.77	11.22	12.23	12.08

Table 1. Seasonal RMSE values for the three topside options of IRI at Ilorin

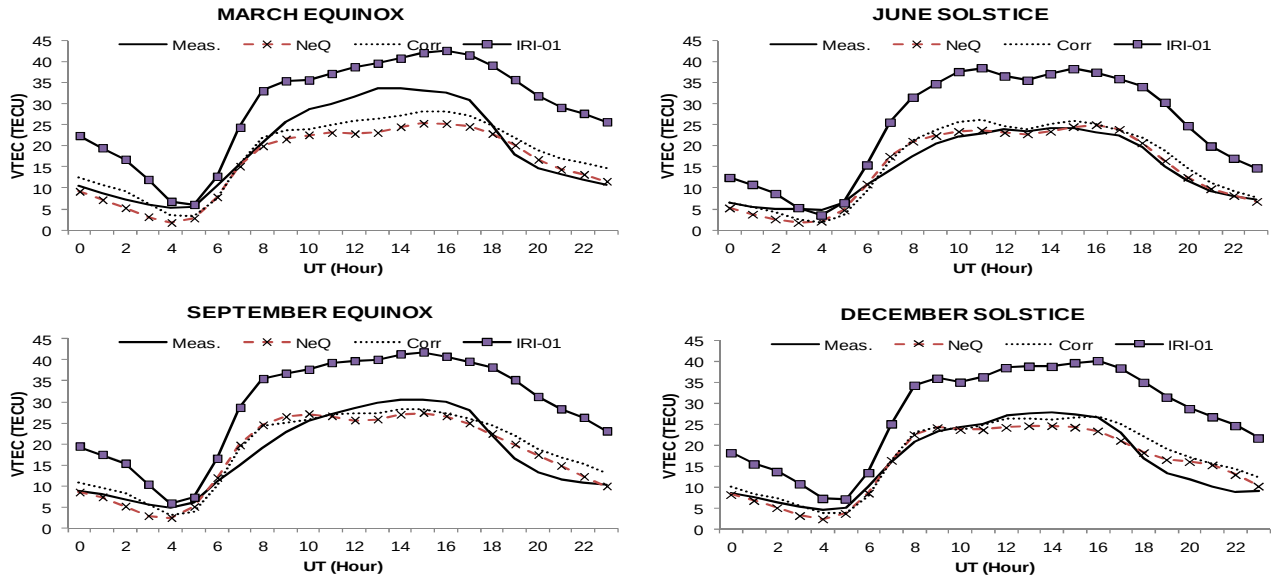

Fig. 1. Measure TEC and the three topside options of IRI model at Ilorin.

Model Options	March Equinox	June Solstice	Septemeber Equinox	December Solstice
NeQuick	6.46	8.97	8.86	9.14
IRI-01 Corr.	6.74	4.37	4.42	5.69
IRI-01	17.94	6.52	11.27	13.69

Table 2. Seasonal RMSE values for the three topside options of the IRI Libreville

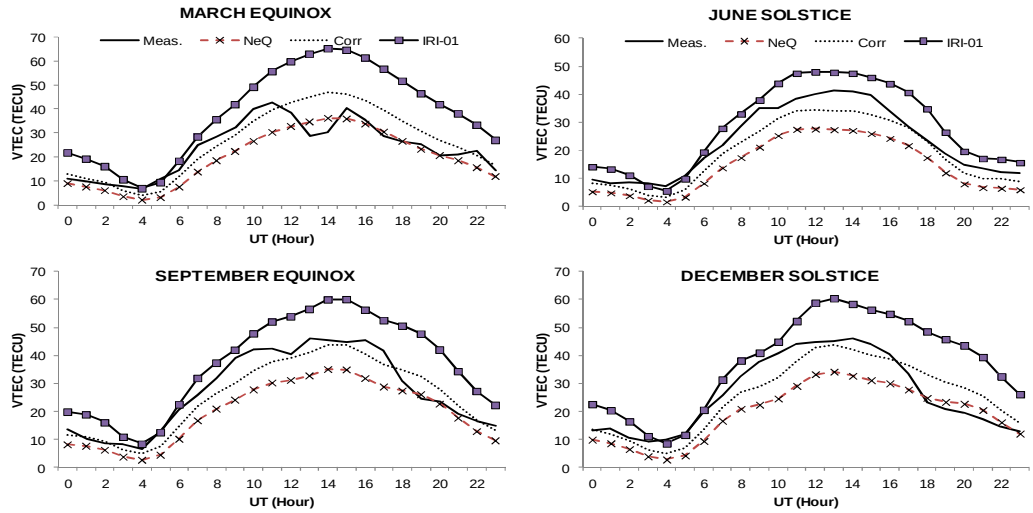

Fig. 2. Measured TEC and the three topside options of the IRI model Libreville.

4.0. Conclusion

The measured TEC and RMSE values were higher at Libreville. IRI-2001 shows significant discrepancies in TEC predictions, while the other two options give TEC values close to the experimental values at both stations, particularly during the night time. The discrepancies in the TEC predictions are generally higher at Libreville. This is partly attributed to its closeness to the Equator and the electrodynamics effect caused by electric and magnetic fields.

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