Effects of different estimation techniques of GPS-TEC on the validation of TEC models - comparison with values from IRI-2016, NeQuick-2 and IRI-Plas 2015 models

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Introduction

- TEC is an essential element for effective satellite communication and navigation.
- It constitutes one of the critical parameters for observing the variable structure of the ionosphere.
- Characterization of TEC plays a key role in space physics and space weather.
- Several applications rely on these estimated values – space weather studies, navigation, communication and validation with TEC models.
- Different estimation techniques.

Introduction

- Arikan et al. (2003) - three categories: computation of TEC using the pseudoranges, carrier phase delays, or a combination of pseudorange and phase delay measurements.
- The primary source of error - effect of the differential satellite and receiver instrumental delay biases.
- GPS-VTEC - IONOLAB group (Arikan et al., 2003) compared with Seemala (2011).
- Estimated VTECs compared with model predictions.
- https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php, http://ionolab.org, and http://t-ict4d.ictp.it/nequick2/nequick-2-web-model
- The success of validation is a function of the reliability of the experimental values.

Data and Methodology

- Table 1: List of station names, their codes, and geographic coordinates

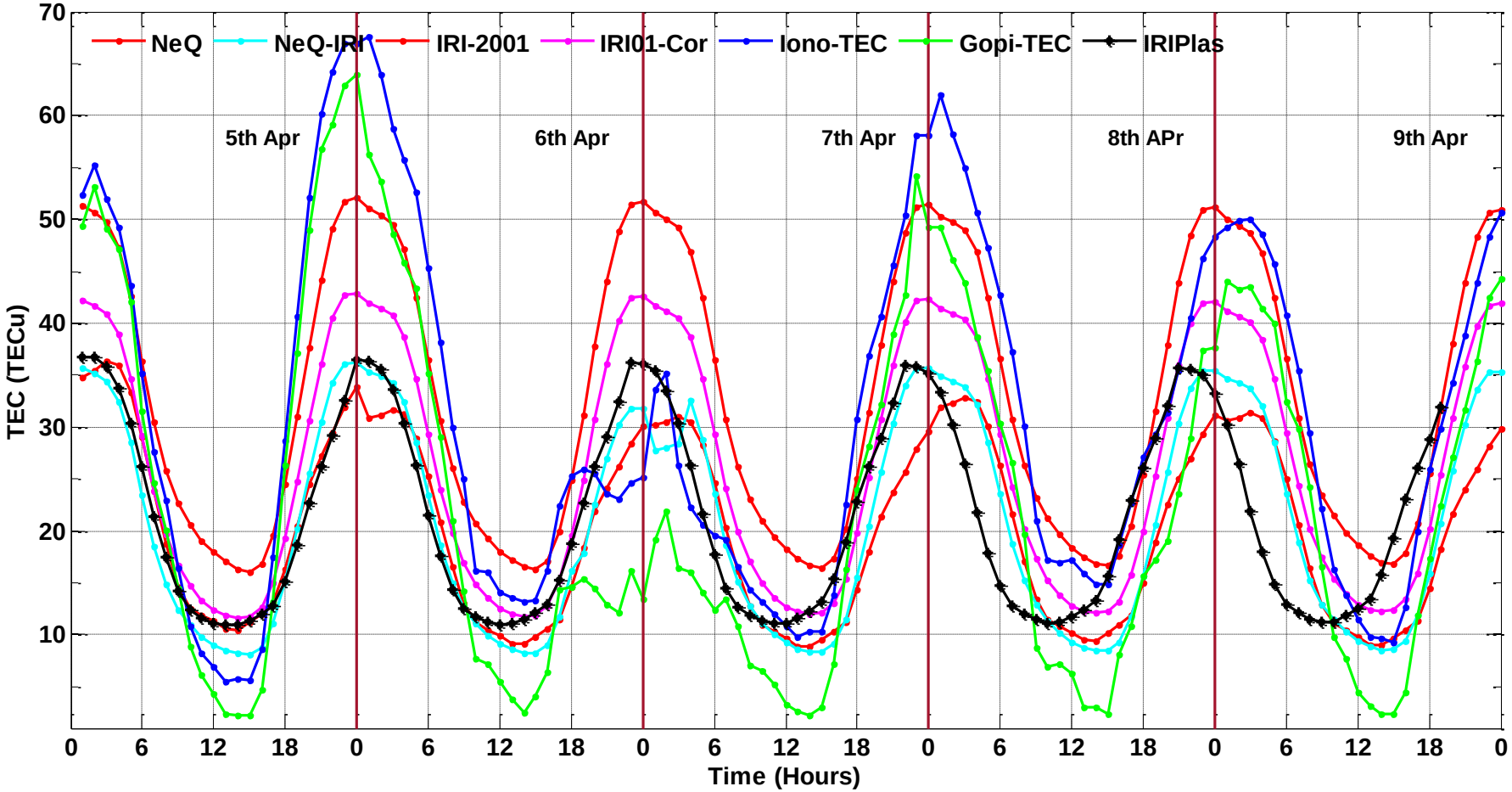
Code	Station Name	Longitude	Latitude
ade1	Salisbury	138.6473	-34.729
Artu	Arti	58.5605	56.4298
azu1	Azusa	242.1	34.13
bay2	Cold Bay 2	197.2	55.1904

- for 5th – 9th April 2000

Data and Methodology

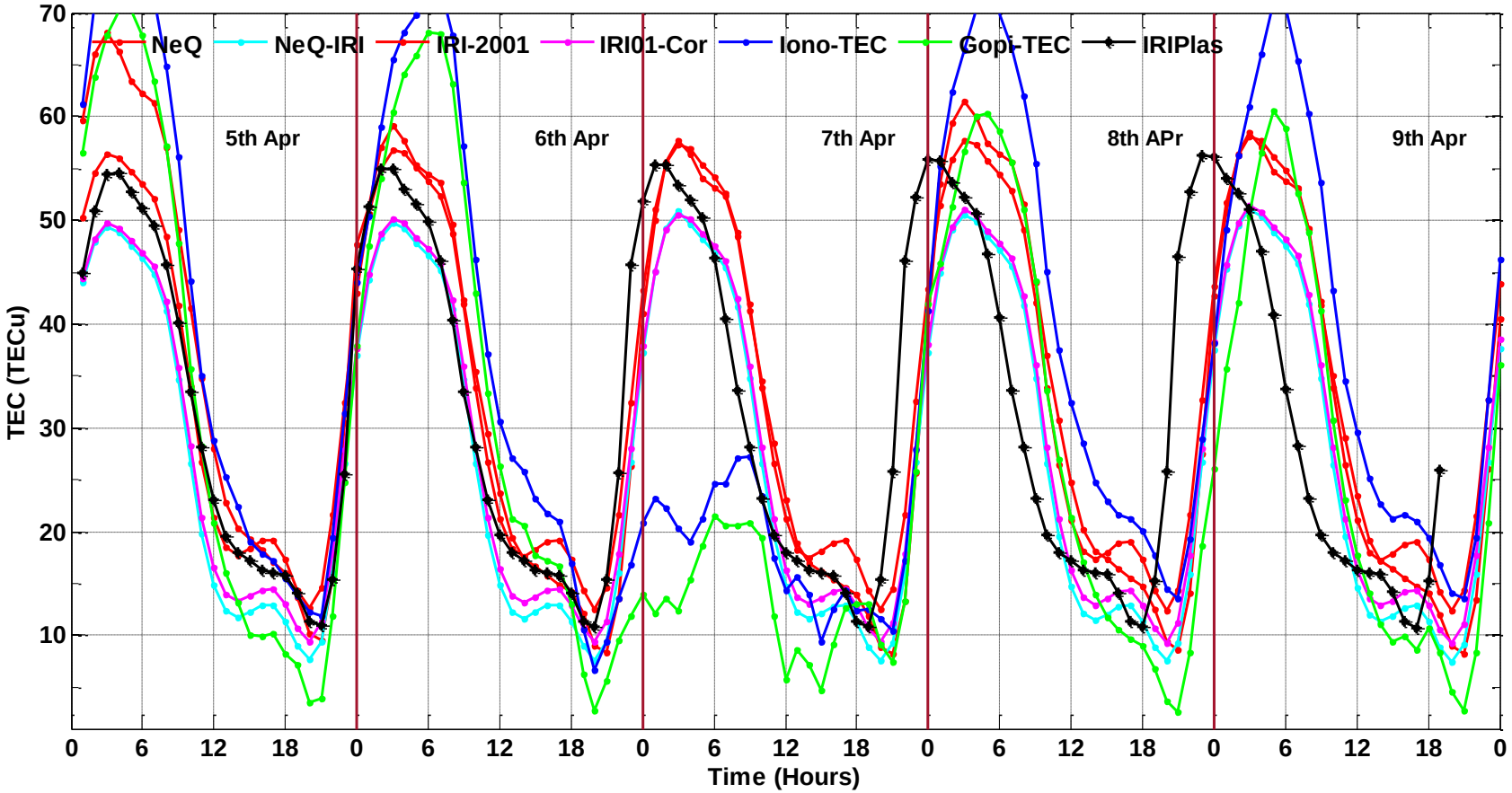
- The root-mean-square error (*RMSE*) has been used here to quantify the performance of the models
- . $RMSE = \sqrt{\sum_{i=1}^{N} \frac{1}{N} \left(VTEC_{OBS} - VTEC_{IRI}\right)^2}$
- $RMSE_{average} = \frac{1}{k} \sum_{j=1}^{k} (\mathrm{RMSE})_{\mathrm{j}}$

Results



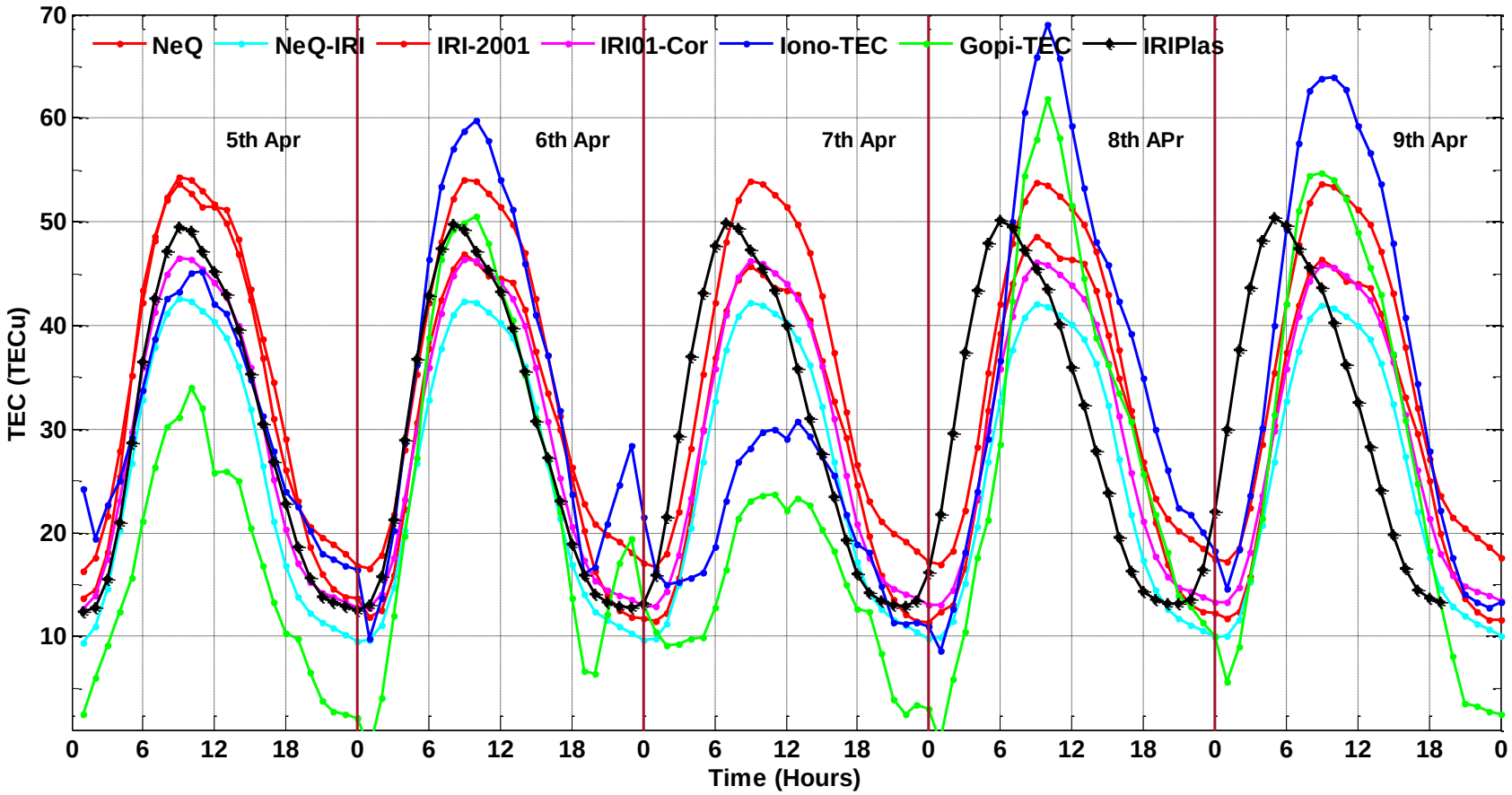
Plots of GOPI-VTEC, IONO-VTEC, IRI-2016 (IRI2001, IRI01cor, and IRI-NeQuick), IRI-Plas 2015 and NeQuick-2 for bay2

Results



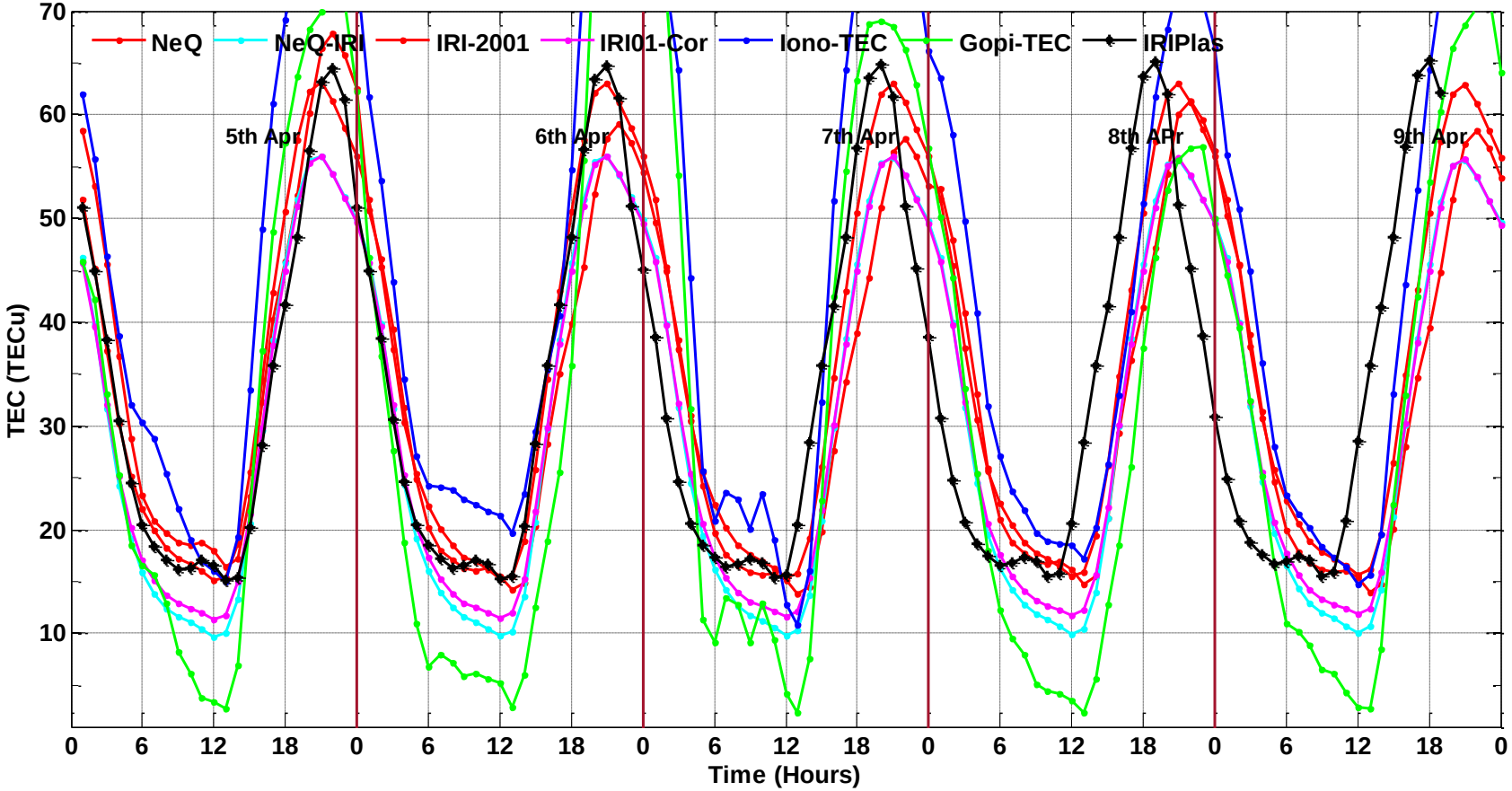
Plots of GOPI-VTEC, IONO-VTEC, IRI-2016 (IRI2001, IRI01cor, and IRI-NeQuick), IRI-Plas 2015 and NeQuick-2 for ade1

Results



Plots of GOPI-VTEC, IONO-VTEC, IRI-2016 (IRI2001, IRI01cor, and IRI-NeQuick), IRI-Plas 2015 and NeQuick-2 for artu

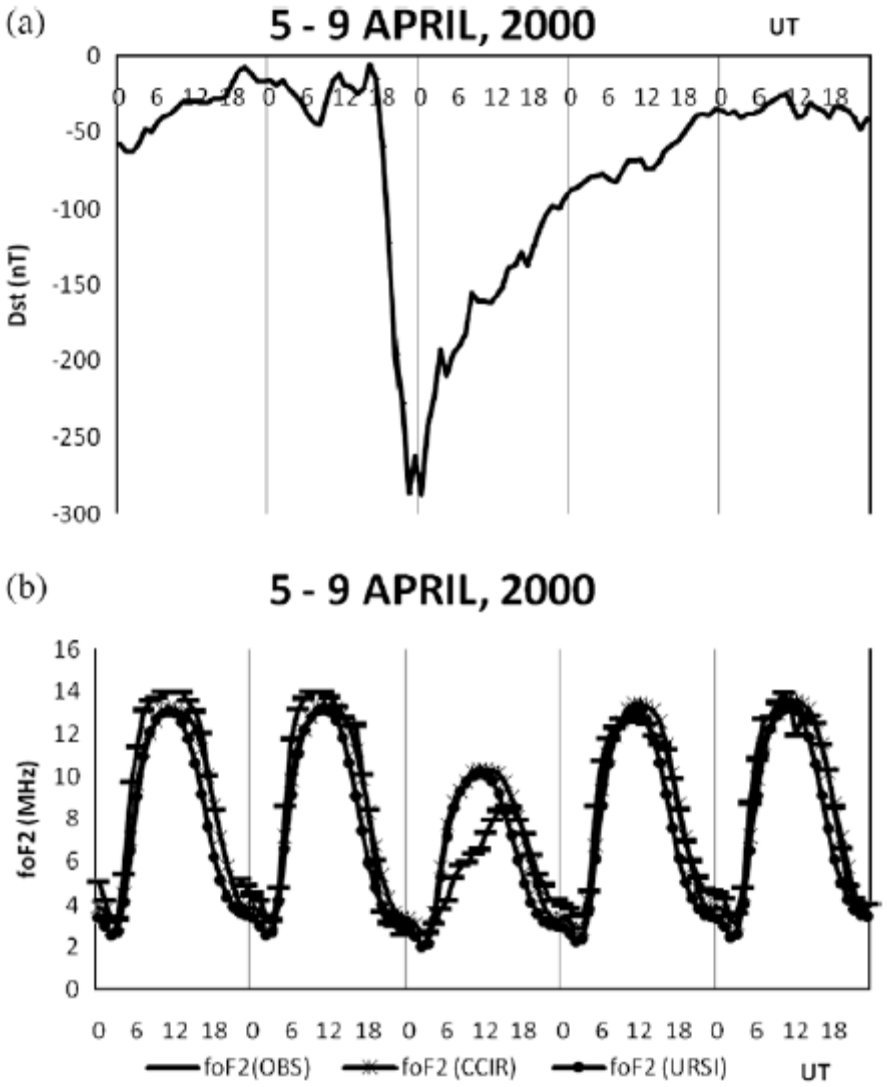
Results

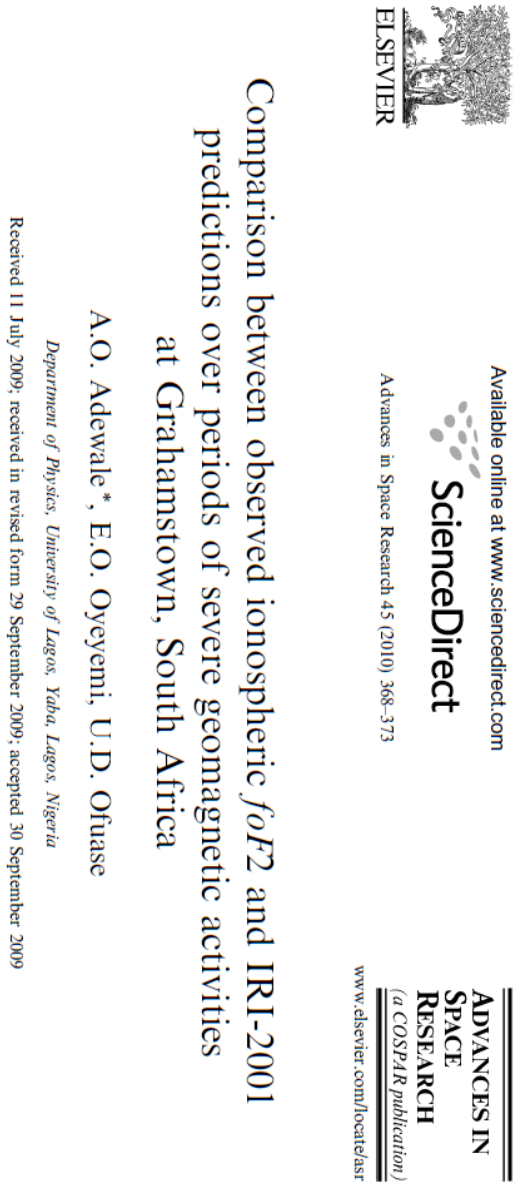


Plots of GOPI-VTEC, IONO-VTEC, IRI-2016 (IRI2001, IRI01cor, and IRI-NeQuick), IRI-Plas 2015 and NeQuick-2 for azu1

Results

Comparison between observed ionospheric foF2 and IRI-2001
predictions over periods of severe geomagnetic activities
at Grahamstown, South Africa

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Comparison between observed ionospheric *foF*2 and IRI-2001 predictions over periods of severe geomagnetic activities at Grahamstown, South Africa

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Results

Average RMSE for GOPI-VTEC

Date	StationID	Gopi_NeQ	Gopi_IRI_Plas	Gopi_NeQ_IRI	Gopi_IRI_2001	Gopi_IRI01_Cor
05-04-00	bay2	15.6	11.2	11.6	6.7	8.6
06-04-00	bay2	15.1	10.3	11.9	6.2	6.9
07-04-00	bay2	14.7	11.2	9.1	6.3	6.7
08-04-00	bay2	9.5	17.4	17.6	12.2	9.7
09-04-00	bay2	11.2	13.3	12.5	7.1	5.4
05-04-00	ade1	6.0	9.2	22.9	5.9	6.4
06-04-00	ade1	9.5	9.1	22.2	5.2	6.3
07-04-00	ade1	11.7	13.2	18.4	7.1	5.8
08-04-00	ade1	9.0	10.9	23.3	7.5	8.1
09-04-00	ade1	11.4	12.8	18.8	7.0	6.0
05-04-00	artu	18.3	6.5	16.0	6.6	6.5
06-04-00	artu	13.4	5.8	17.3	6.1	5.8
07-04-00	artu	9.3	5.6	12.8	8.7	7.8
08-04-00	artu	18.7	9.4	21.9	8.2	9.0
09-04-00	artu	12.7	5.7	16.0	7.3	7.1
05-04-00	azu1	9.7	22.1	16.4	8.4	10.0
06-04-00	azu1	9.2	18.6	15.7	8.6	9.0
07-04-00	azu1	8.7	22.6	16.1	6.1	8.3
08-04-00	azu1	7.9	21.6	14.1	10.5	8.8
09-04-00	azu1	9.2	22.8	16.4	6.7	8.8
Average rmse		11.5	13.0	16.6	7.4	7.5

Results

Average RMSE for IONO-VTEC

Date	StationID	Iono_NeQ	Iono_IRI_Plas	Iono_NeQ_IRI	Iono_IRI_2001	Iono_IRI01_Cor
05-04-00	bay2	17.5	15.6	13.2	14.5	13.4
06-04-00	bay2	17.0	14.1	11.1	12.9	10.9
07-04-00	bay2	16.9	15.1	10.6	13.7	11.4
08-04-00	bay2	9.4	12.3	11.6	5.1	4.3
09-04-00	bay2	12.8	12.8	9.2	9.1	6.7
05-04-00	ade1	5.8	10.4	18.7	7.7	8.1
06-04-00	ade1	13.4	11.4	17.9	10.3	8.6
07-04-00	ade1	17.0	15.6	14.6	14.7	13.1
08-04-00	ade1	11.7	11.5	19.0	9.0	7.4
09-04-00	ade1	16.3	15.0	14.7	13.8	12.1
05-04-00	artu	7.1	8.4	10.6	9.7	10.7
06-04-00	artu	4.5	7.9	11.9	10.2	9.8
07-04-00	artu	6.0	11.7	8.1	14.5	14.1
08-04-00	artu	6.4	4.4	16.0	6.9	6.4
09-04-00	artu	3.9	8.6	10.5	11.5	11.1
05-04-00	azu1	12.3	28.5	20.9	8.2	15.2
06-04-00	azu1	15.4	24.1	19.4	7.9	12.4
07-04-00	azu1	18.4	30.3	21.5	12.3	16.0
08-04-00	azu1	13.2	26.2	17.0	7.1	11.2
09-04-00	azu1	18.2	30.2	21.4	11.9	15.8
Average rmse		12.2	15.7	14.9	10.5	10.9

Conclusions

- Our results show the disparity in the estimated values of VTEC for the same days.
- The implication of this is that different VTEC model exhibit different performance levels when compared with the estimation techniques.
- The result shows that IRI-2001 has the best prediction for both estimation methods.
- This is in contrast with the work of Akala *et al*. (2015). They reported that, of the three options of IRI-2012 model, NeQuick appears to be the most accurate for TEC estimation over Addis Ababa, although at a very close performance capability with the IRI01 CORR option, while IRI2001 is the least reliable.
- The estimation technique for the observed VTEC likely played a significant role in this disparity.

THANK YOU

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