

Assessment of global ionospheric maps performance in the Brazilian region using ionosonde data

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Introduction

Many efforts have been made in the last few decades to provide reliable VTEC values in terms of global ionospheric maps (GIMs). Since 1998, several Ionosphere Associated Analysis Centers (IAACs) from IGS (International GNSS Service) have developed methods to provide GIMs [1].

The quality of ionospheric models is commonly defined based on comparisons with reference values from consolidated ionospheric models such as IRI (International Reference Ionosphere [2]) [3], IGS GIMs [4], ionosonde data [5], and VTEC values from altimeter and GNSS data [6].

Several investigations regarding the comparison of VTEC with foF_2 and its dependency of slab thickness have been performed [7-9]. However, there is still room for the definition of a systematic GIMs quality assessment based on foF_2 measurements.

We present a new GIM assessment method based on how much VTEC from GIM can help in the interpolation of directly measured and manually scaled foF_2 , considering periods and regions with variable slab thickness. We have applied this strategy in one of the most challenging ionospheric scenarios: the most recent solar maximum (2014) at low latitudes [10].

Method

In this method, data from one ionosonde (Iono1) is estimated based on data from the other ionosonde of the considered pair (Iono2). The VTEC (from GIM) variation between both places is used to transport the foF_2 from ionosonde 2 to the location of the ionosonde 1. In this way, estimated foF_2 can be compared with the real foF_2 measured at the first ionosonde (Iono1), and, implicitly, the GIM quality can be assessed in front of a manually scaled foF_2 measurement.

$$foF_2'_{iono1} = foF_{2_{Iono2}} \frac{VTEC_{Iono1}}{VTEC_{Iono2}}$$

$$foF_2'_{iono1} = foF_{2_{Iono2}} \sqrt{\frac{VTEC_{Iono1}}{VTEC_{Iono2}}}$$

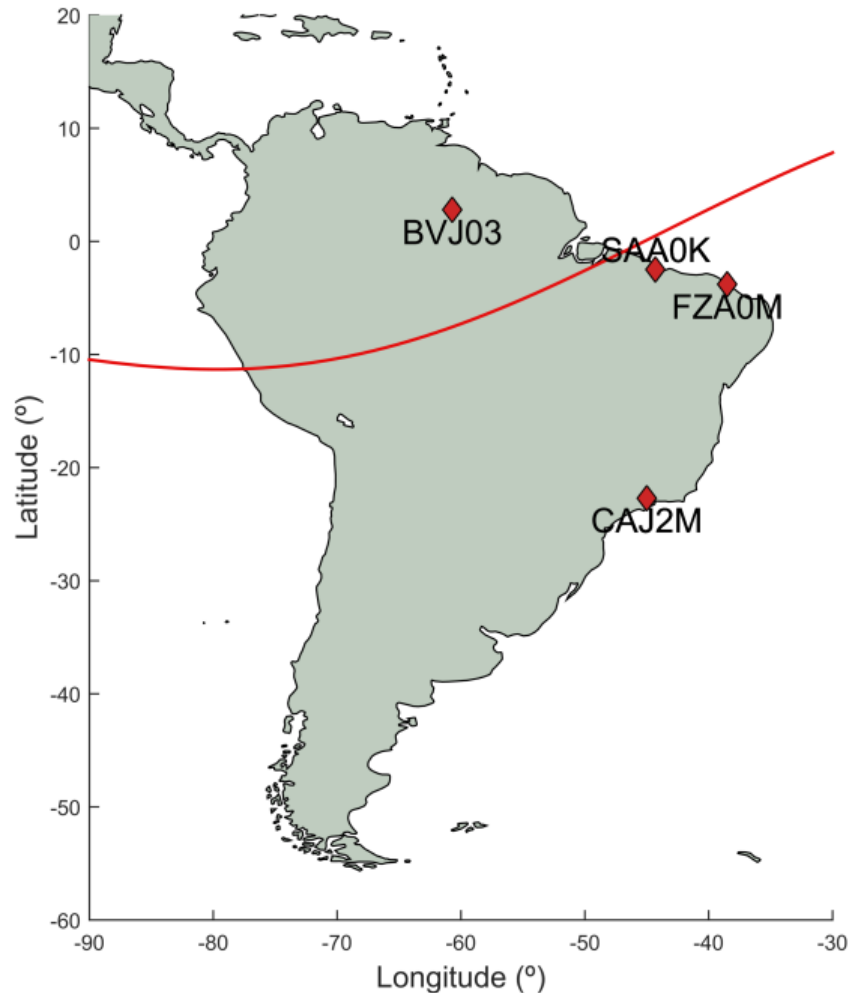
GIM assessment was based on the root mean square (RMS) of the differences between the values of foF_2 measured at the first station ($foF_{2_{Iono1}}$) and the values estimated with GIMs ($foF_2'_{Iono1}$) and the rates of improvement (RoI):

$$RMS = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(foF_{2_{Iono1,i}} - foF_{2_{Iono1,i}}' \right)^2}$$

$$RoI = \frac{(foF_{2_{Iono1}} - foF_{2_{Iono2}}) - (foF_{2_{Iono1}} - foF_2'_{Iono1})}{(foF_{2_{Iono1}} - foF_{2_{Iono2}})}$$

Data set

Ionosondes



Ionosonde pairs

Ionosonde Pair	Distance (km)
FZA0M_SAA0K	659.97
SAA0K_BVJ03	1915.83
CAJ2M_FZA0M	2215.02
CAJ2M_SAA0K	2247.41
FZA0M_BVJ03	2573.91
CAJ2M_BVJ03	3307.93

2014 - 2017

GIMs: codg | corg | esag | esrg | igr |
igsg | jplg | upcg | uprg | whrg | whug |
ehrg | uqrg

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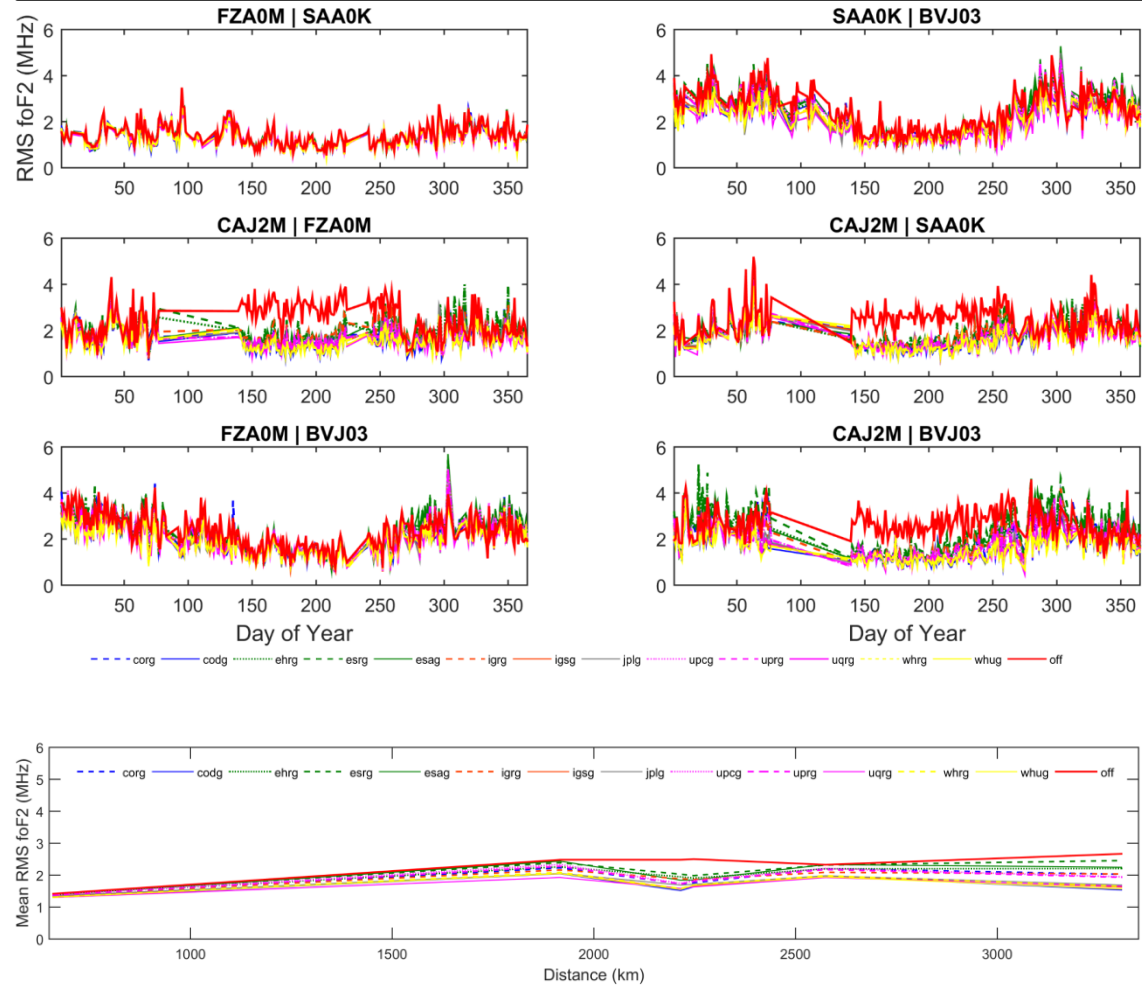
Data set

Results

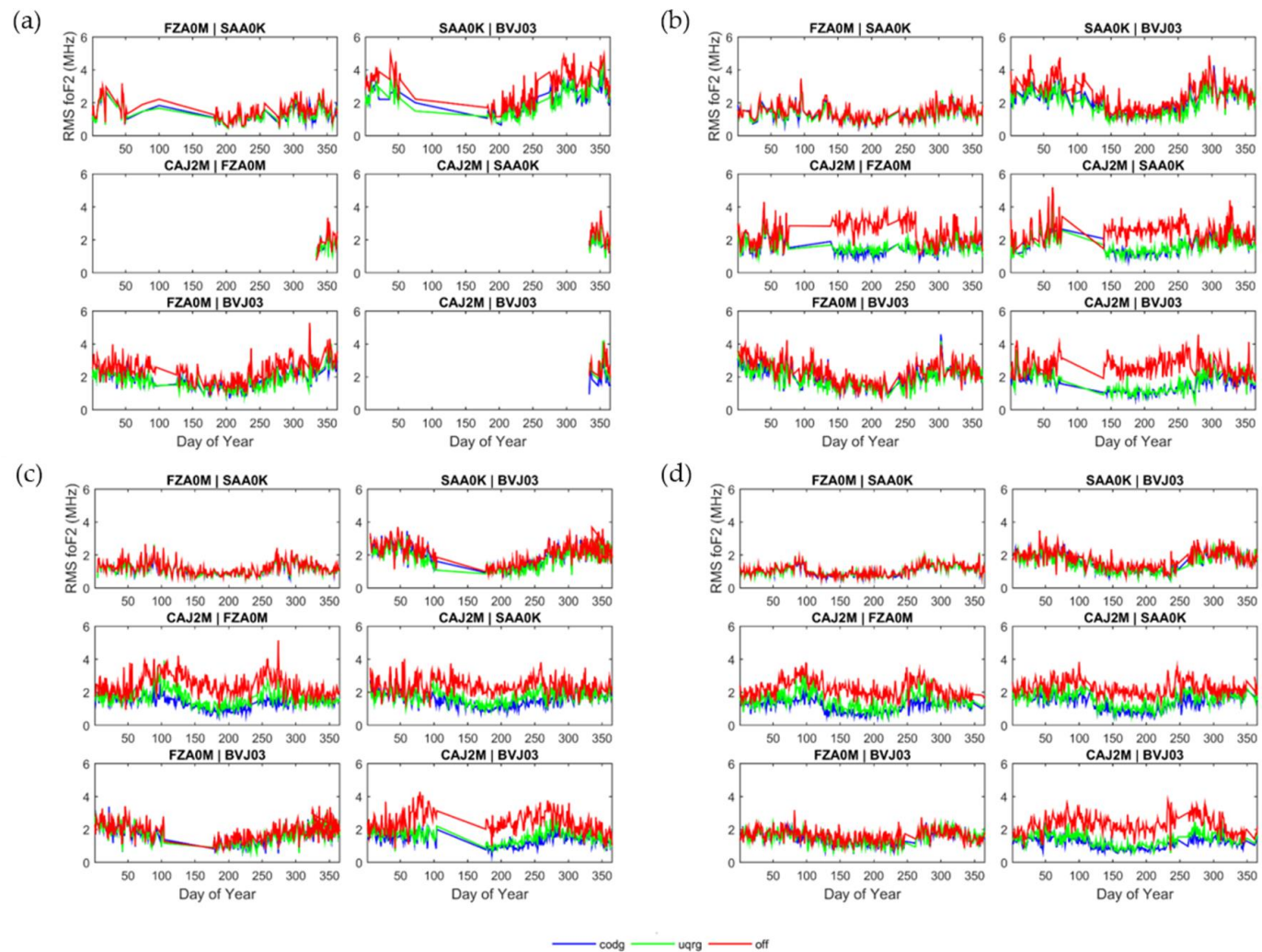
Conclusions

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2015 | All GIMs



2014 (a) – 2017(d) | CODG and UQRG



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Conclusions

- New way of assessing GIMs, by looking at how much they can help in the interpolation of directly measured and manually scaled foF_2 , applied up to four years of data in one of the most challenging ionospheric scenarios: low latitude and around the most recent solar maximum;
- The performance of the different GIMs presented consistency, especially considering the final products. The highest errors and smaller rates of improvement were obtained with rapid products;
- Considering the performance over the Brazilian region, the main improvements were observed in the period of lower ionospheric electron content, considering pairs with ionosondes in different latitudes;
- This behavior could indicate some limitations of the ionospheric modeling in the Brazilian region in periods with larger electron content. That performance can also be related to the limitation of the method when periods and regions with different slab thickness values are considered;
- That was the main limitation observed in the method, regarding periods with significant differences in the ionospheric behavior of the considered regions.

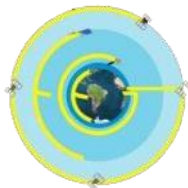


References

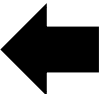
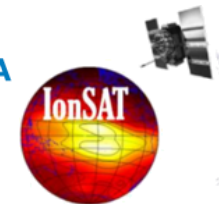
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Thank you!

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