Performance of COSMIC electron density profiles over the Brazilian region by means of ionosonde data: ionPrf versus igaPrf

Gabriel Oliveira Jerez[1,2], Manuel Hernandez-Pajares[2], Fabricio dos Santos Prol[3], Daniele Barroca Marra Alves[1] & João Francisco Galera Monico[1]

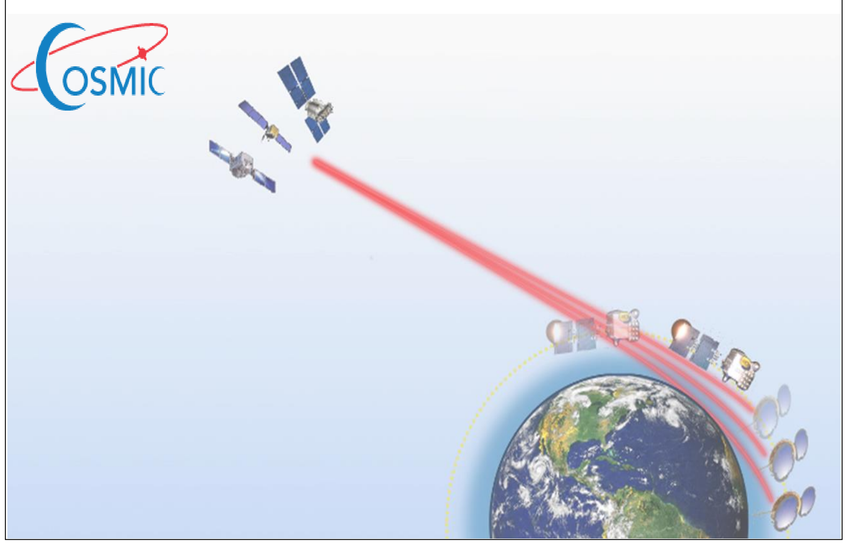
[1]Sao Paulo State University (UNESP), Cartography, Presidente Prudente, Brazil;
[2]Universitat Politècnica de Catalunya (UPC-IonSAT), Barcelona, Spain;
[3]German Aerospace Center (DLR), Neustrelitz, Germany.

Introduction

COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) (2006-present) is one of the main RO missions, with significant amount of atmospheric data available, especially related to the ionosphere.

Several atmospheric products are provided, including neutral atmosphere and ionosphere.

We investigate the performance of COSMIC electron density profiles (ionPrf and igaPrf) over one of the most challenging regions, the Brazilian territory for one year-data.



Method

Products:
ionPrf: ionospheric profile obtained by the standard Abel inversion;
igaPrf: ionospheric profile obtained by the application of Abel inversion aided by monthly mean NmF2, to take into account information on horizontal gradients in the ionosphere[1].

For the assessment method we compare the critical frequency (foF2) and the altitude peak (hmF2) with manually scaled data from four ionosondes in Brazil.

We also analyze the profiles assuming as reference the foF_2 measured at the ionosondes and transported to the position of the occurrence of the radio occultation ($foF_{2IonotoRO}$). For this approach, it is considered that the spatial variability of the foF_2 is proportional to the variability of VTEC from GIMs in the position of the ionosonde ($VTEC_{Iono}$) and at position of the occurrence of the F2 peak ($VTEC_{RO}$)[2]:

$$foF_{2IonotoRO} = foF_{2Iono}\sqrt{\frac{VTEC_{RO}}{VTEC_{Iono}}}$$

Data set

Ionosondes

Year: 2015;

Reference data: ionosonde data+GIM;

GIM: UQRG;

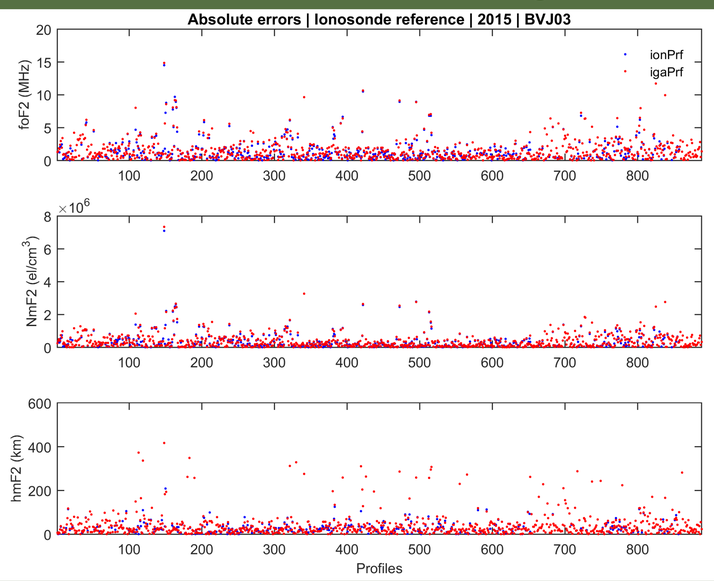
Window: 20° x 20° (lat x lon);

Total profiles: ~241000;

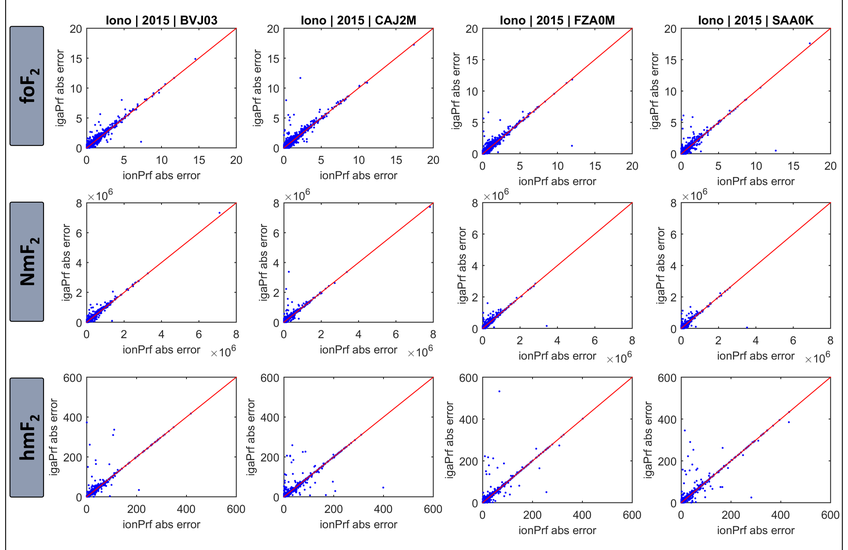
Analyzed profiles: ~4400;

Results

Absolute error: ionPrf versus igaPrf



Absolute error: ionPrf versus igaPrf



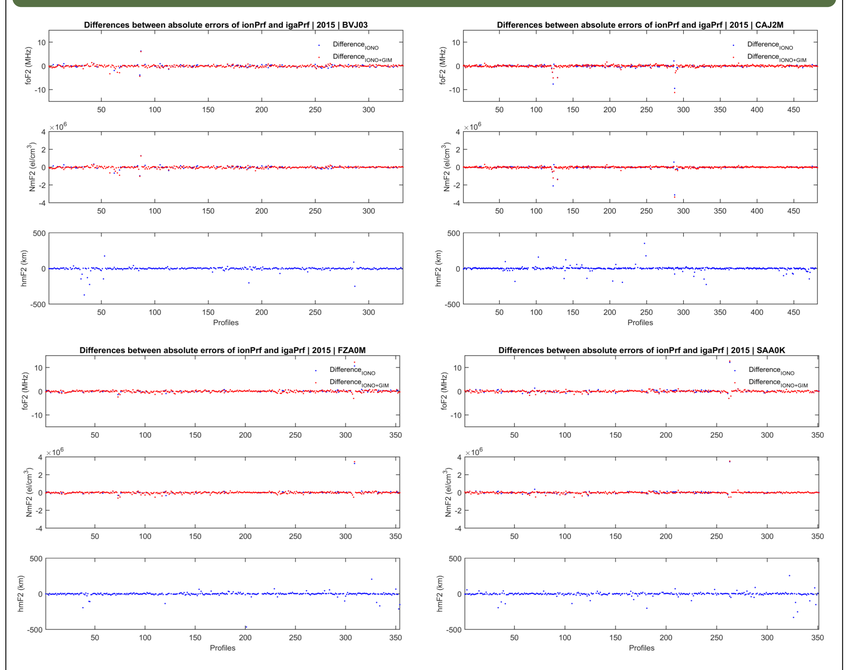
Number of profiles with largest errors*

Iono	Largest error (profiles)		Total	Mean distance (km)
	ionPrf	igaPrf		
BVJ03	217	368	585	772.43
CAJ2M	521	679	1200	860.88
FZA0M	260	401	661	862.53
SAA0K	262	354	616	857.01

*Total not considering cases when ionPrf and igaPrf presented the exactly same results

Results

Differences of errors using ionosonde and ionosonde+GIM



Mean errors

Ionosonde

foF2 (MHz)		
Iono	ionPrf	igaPrf
BVJ03	***1.5***	1.5
CAJ2M	***1.0***	1.1
FZA0M	***1.2***	1.2
SAA0K	***1.0***	1.1

NmF2 (10^5 elec/cm^3)		
Iono	ionPrf	igaPrf
BVJ03	***3.6***	3.7
CAJ2M	***2.0***	2.2
FZA0M	***2.5***	2.7
SAA0K	***2.3***	2.3

hmF2 (km)		
Iono	ionPrf	igaPrf
BVJ03	***37.6***	39.6
CAJ2M	***33.3***	33.8
FZA0M	***40.6***	42.1
SAA0K	***45.0***	46.8

Ionosonde + GIM

foF2 (MHz)		
Iono	ionPrf	igaPrf
BVJ03	***1.0***	1.1
CAJ2M	***0.9***	0.9
FZA0M	***1.0***	1.1
SAA0K	***0.9***	0.9

NmF2 (10^5 elec/cm^3)		
Iono	ionPrf	igaPrf
BVJ03	***2.5***	2.7
CAJ2M	***1.7***	1.9
FZA0M	***2.3***	2.4
SAA0K	***2.0***	2.0

Conclusions

Brazil is a region with a challenging ionosphere;

For the Brazilian region most part of the ionPrf analyzed presented smaller errors than igaPrf;

There is a small number of ionosondes in Brazil, a limitation for the assessments;

One alternative for assessing ionospheric information is the use of ionosonde+GIM to minimize the impact of the distance between the occultation occurrence and the ionosonde;

The approach considering ionosonde+GIM have led to smaller errors for both products.

References

[1]Pedatella, N. M., Yue, X., Schreiner, W. S. (2015). An improved inversion for FORMOSAT-3/COSMIC ionosphere electron density profiles. Journal of Geophysical Research: Space Physics, 120(10), 8942-8953.
[2]Jerez, G. O., Hernández-Pajares, M., Prol, F. S., Alves, D., & Monico, J. F. (2020). Assessment of Global Ionospheric Maps Performance by Means of Ionosonde Data. Remote Sens. , 12(20), 3452.