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Database of Jason-2 Plasmaspheric Electron Content for Validation and Correction of IRI-Plas Model

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ABSTRACT

One of the key parameters of the International Reference Ionosphere and Plasmasphere model, IRI-Plas, is the total electron content, TEC, integrated through the electron density distribution in the ionosphere, iTEC, and the plasmasphere, pTEC, up to a few Earth's radii [1, 2]. Fundamental parameters of the ionosphere and plasmasphere are the plasma density and composition. We can gain new knowledge about plasma density distribution within the ionosphere-plasmasphere system using advantages provided by the space-borne GPS measurements. Many modern LEO (Low-Earth-Orbit) satellites are equipped with a dual-frequency GPS receiver for POD (precise orbit determination) aims.

There are only few papers on the climatology of the topside ionosphere and plasmasphere using the experimental data of LEO-based GPS measurements. In particular, the global morphology of the plasmaspheric density in relation with the ionospheric density based on the simultaneous altimeter and POD TEC measurements of the Jason-1 satellite (altitude ~1330 km) has been investigated in [3]. As a result of the simultaneous analysis of the global plasmaspheric density derived from POD TEC measurements of Jason-1 satellite and ground-based GPS TEC, the relative contribution of pTEC into GPS TEC was estimated for equatorial, mid- and high-latitude regions [4].

For the model options evaluation and improvements, the data of Jason-2 mission can represent a unique database of the plasmaspheric electron content, pTEC, measured through the plasmasphere over the Jason-2 orbit (1335 km) to the GPS orbit altitude (20,200 km) which become possible from GPS receiver placed onboard Jason-2 with a zenith looking antenna that can be used not only for precise orbit determination (POD), but can also provide new data on the plasma density distribution in the plasmasphere.

The present study is focused on a comparison of the pTEC predictions provided by the IRI-Plas model with a unique data base of the plasmasphere electron content, pTEC, using GPS measurements onboard the Jason-2 satellite for 24 hours of local time during four seasons at the

solar minimum (2009) and solar maximum (2014). The Jason-2 GPS POD measurements were processed to retrieve the topside TEC values above the orbit altitudes of 1335 km. The details of the method for TEC determination from LEO POD GPS measurements are described in [5]. Slant TEC values are scaled to estimate vertical pTEC using a geometric factor derived by assuming the plasma occupies a spherical thin shell at 1400 km. The elevation angle cut-off is selected as 40°. Global distribution of the POD TEC values is presented in the form of global pTEC maps that are made by projecting the pTEC values on the Earth from the ionosphere pierce point at the shell altitude. Along the satellite pass for each epoch we have pTEC values for several linked LEO-GPS simultaneously, that can be binned and averaged into map cells.

Here, we construct the global maps of pTEC values derived from the Jason-2 POD observations. For each specific month we processed 50 days of observations (±25 days from a solstice/equinox) to obtain monthly averaged pTEC map. All values were binned and averaged in cells of 5 x 15 deg resolution in geographical latitude and longitude. The global TEC maps are presented in local time domain.

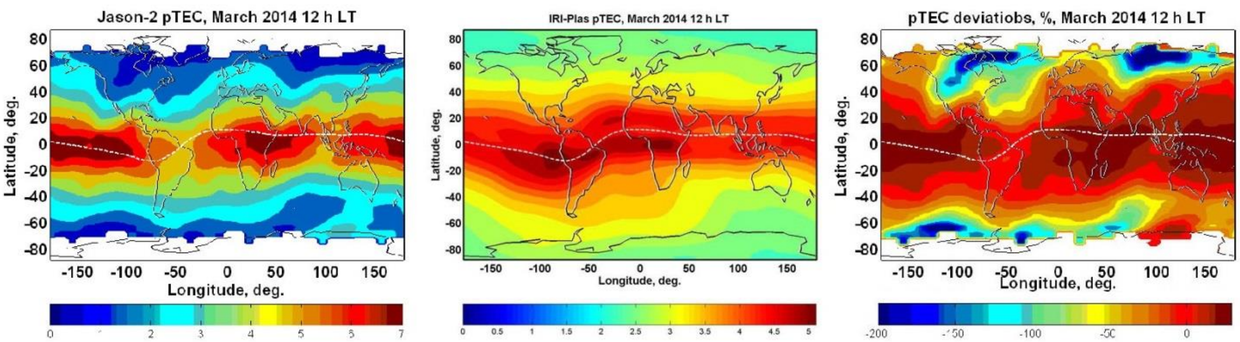

Figure 1. Selected frames of global pTEC map for 12 h LT at March, 2014: (a) Jason-2 data; (b) IRI-Plas model prediction; (c) percentage deviation ΔpTEC = (Xobs – Xmodel)/Xobs*100%. White area – not sampled Jason-2 observations.

As follows from Figure 1, pTEC values derived from the Jason-2 GPS measurements show excess over model by about 10% at the majority of the plasmasphere cells except few sub-polar regions where extremely low pTEC has been deduced from Jason-2 data in the vicinity of not sampled Jason-2 observations. The pTEC can be mainly obtained within 60N-60S latitudinal range due to the Jason-2 orbit inclination of 66 degree, Comparative model-data analysis in terms of local time, season and solar activity is presented in the paper.

The normalized root mean square error (NRMSE) between the 'true' pTEC data (*Xobs*) and those simulated with IRI-Plas model (*Xmodel*) is provided in Table 1. NRMSE presents RMSE normalized to the mean of the observed data for all cells *n* from all Local Time maps of pTEC:

$$NRMSE = \frac{RMSE}{\overline{X}_{obs}} \qquad (1)$$

where

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_{obs,i} - X_{model,i})^2}{n}} \qquad (2)$$

Year	2009				2014			
Month	**03**	**06**	**09**	**12**	**03**	**06**	**09**	**12**
NRMSE	.7106	.7853	.6778	.6244	.4754	.5394	.4614	.3953
n	99,127	98,087	98,597	98,407	98,738	98,732	94,476	98,220

Table 1. Data-model comparisons for four seasons at solar minimum (2009) and solar maximum (2014).

Conclusions

The Jason-2 data base can provide a valuable source of data for the plasmasphere model validation and improvements. Special interest represents possibility of the potential increase of the data volume in two times due to the successful launch of the Jason-3 mission on 17 January 2016. The plasmasphere model of IRI-Plas system built in terms of local time, solar and geomagnetic activity has a potential for the further improvement with a unique database of Jason-2 pTEC observations.

Key words: Ionosphere, Plasmasphere, IRI-Plas model, Jason-2, pTEC.

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