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Near Real-Time Background Ionospheric model update by using GPS-TEC and NmF2 for HF Communication Links

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Ionosphere is the main propagation channel for HF (3-30 MHz) communication and direction finding systems. Ionosphere, extending between 60 and 1000 km in altitude, consists of plasma which has very complex structural characteristics. Due to its temporally and spatially varying, dispersive, anisotropic and inhomogeneous nature, ionosphere causes problems for not only HF radio signals but also space based navigation and positioning systems. Therefore, characterization of variability of the ionosphere is of utmost importance for HF communication and satellite positioning systems.

One of the most important parameter for understanding ionosphere is Total Electron Content (TEC) which can be obtained from Global Positioning System (GPS) measurements. Another way to obtain critical ionospheric parameters is ionosonde measurement. Yet, neither ionosondes nor GPS receivers can answer the demands of point-to-point link characterization due to sparsity of their data in time and space.

International Reference Ionosphere (IRI), and one of its possible extensions to plasmasphere, IRI-Plas models, are the foremost empirical climatic models of ionosphere. Both IRI and IRI-Plas models can provide hourly, monthly median values of critical layer parameters of the ionosphere for a desired location, date and time between 60 and 2,000 km and 20,000 km in altitude, respectively. Because of being empirical climatic models, they cannot represent the current state of the ionosphere. Both IRI and IRI-Plas can input critical frequency and maximum ionization height to generate Electron Density Profile (EDP) of current state. One important advantage of IRI-Plas is that it can input GPS-TEC and extend EDP outputs to GPS satellite orbital height. The current model computes instant foF2 using instant TEC input, using slab thickness parameter.

The ionospheric slab thickness is defined as the ratio of TEC to the maximum electron density of the F-region, NmF2. Since IRI-Plas model is a background model, hourly median values of slab thickness and instant slab thickness values are assumed to equal in the algorithm. Therefore, in present IRI-Plas model, the update of ionospheric state using instant GPS-TEC can not be possible and it may not match to instant ionosonde foF2. Therefore, in this study, a new statistical update parameter K is proposed to modify the instant model foF2 using instant GPS-TEC and median slab thickness.

Hourly median of slab thickness and retrospective instant slab thickness values are obtained from Pruhonice (PQ052) ionosonde and gope IGS station data, both in Czech Republic for 2012. At every ionosonde measurement instant, GPS-TEC and median slab thickness are used to compute model K value and instant NmF2. Alternate algorithms are implemented to optimize the model fit to ionosonde NmF2 values. When estimated K values and computed foF2 values are used as input to the IRI-Plas model, the new model foF2 values improved the fit to ionosonde foF2 and reduced the fit error from 40% to 16% for 2012. This study is supported by TUBITAK 114E541, 115E915 and joint TUBITAK 114E092 and AS CR 14/001.