Neural network-based modelling of the topside ionosphere using Vary-Chapman function with a linear scale height decay

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Abstract

The ionosphere is an ionized part of the upper atmosphere, spanning from ~60 to around 1.000 km in altitude. The number of electrons in the ionosphere is large enough to affect the propagation of electromagnetic signals, including those of the GNSS systems. Therefore, knowing electron density values in the ionosphere is crucial for industrial, as well as scientific, applications. Here, we employ the radio occultation profiles collected by the CHAMP, GRACE, and COSMIC missions, to model the electron density in the topside ionosphere using the Vary-Chapman functions. Assuming a linear decay of scale height with altitude, we create a model of 4 parameters, namely the F2-peak density and height (NmF2 and hmF2) and the slope and gradient of scale height in the topside (H0 and grad_H0). The model is based on feedforward neural networks and takes as input the geographic and geomagnetic coordinates, the solar flux and geomagnetic indices. The resulting density reconstructions are validated by over a hundred million in-situ measurements from CHAMP, CNOFS and Swarm satellites. The developed model has also been compared to the International Reference Ionosphere (IRI-2016), and was found to outperform IRI by over 50%, especially at high altitudes and during periods of low solar activity.