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Reconstruction of the ionospheric 3D electron density distribution by assimilation of ionosonde measurements and operational TEC estimations

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New methods to generate maps of the F2 layer peak electron density of the ionosphere (NmF2) and to reconstruct the ionospheric 3D electron density distribution will be presented. For validation, reconstructed NmF2 maps will be compared with peak electron density measurements from independent ionosonde stations.

The ionosphere is the ionized part of the upper Earth's atmosphere lying between about 50 km and 1000 km above the Earth's surface. From the applications perspective the electron density, Ne, is certainly one of the most important parameters of the ionosphere because of its strong impact on radio signal propagation. Especially the critical frequency, foF2, which is related to the F2 layer peak electron density, NmF2, according to the equation $NmF2/m^3 = 1.24 \cdot 10^{10}(foF2/MHz)^2$ and builds the lower limit for the maximum usable frequency MUF, is of particular interest with regard to the HF radio communication applications.

In a first order approximation the ionospheric delay of transionospheric radio waves of frequency f is proportional to $1/f^2$ and to the integral of the electron density (total electron content - TEC) along the ray path. Thus, the information about the total electron content along the receiver-to-satellite ray path can be obtained from the dual frequency measurements permanently transmitted by GNSS satellites.

As data base for our reconstruction approaches we use the vertical sounding measurements of the ionosonde stations providing foF2 and routinely generated TEC maps in SWACI (http://swaciweb.dlr.de) at DLR Neustrelitz. The basic concept of our approach is the following one: To reconstruct NmF2 maps we assimilate the ionosonde data into the global Neustrelitz F2 layer Peak electron Density Model (NPDM) by means of a successive corrections method. The TEC maps are produced by assimilating actual ground based GPS measurements providing TEC into an operational version of Neustrelitz TEC Model (NTCM). Finally, the derived NmF2 and TEC maps in tandem with a new approach of a DLR internal empirical 3D electron density model is used to reconstruct the actual spatial electron density distribution of the ionosphere.