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NTCM based modelling approaches for the estimation of ionospheric key parameters

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A family of Neustrelitz total electron content (TEC) models called NTCM has been developed for last two decades at the Institute of Communications and Navigation, German Aerospace Center (DLR) in Neustrelitz. The basis version of NTCM approach was first used for regional TEC monitoring over the European sector and later in southern and northern polar regions. In 2011 we developed a global TEC model [1, 2] driven by daily solar radio flux index F10.7 for estimating trans-ionospheric radio wave propagation errors. The empirical approach was based on a polynomial consisting of a number of nonlinear terms describing TEC dependencies on local time, geographic/geomagnetic location and solar irradiance and activity. The nonlinear least squares fitting of observations limits the number of model coefficients below 15 for describing the broad spectrum of TEC variation at all levels of solar activity. Recently we proposed an alternative ionospheric correction algorithm called NTCM broadcast model NTCM-BC for next generation global satellite navigation systems [3]. More recently we modified the coefficients of the global NTCM model so that it can be driven by the GPS Klobuchar coefficients instead of F10.7 [4]. The model can be used as complementary to the GPS Klobuchar model for improving ionospheric correction up to 40% especially during high solar activity time. Thus the NTCM model can improve navigation and positioning services for millions of people using small car navigation receivers and smart phones. Following the same modelling approach we developed global empirical models for the peak electron density of the F2 layer NmF2 and corresponding height hmF2 [5, 6]. The models are named as Neustrelitz Peak Density Model NPDM and Peak Height Model NPHM.
In the present work we compared our TEC and peak parameters models with the GPS Klobuchar model and NeQuick model results. We found that when compared with post processed TEC maps, NTCM model gives root mean squared (RMS) TEC deviations as 11.2 and 4.4 TECU during high and low solar activity years 2002 and 2008, respectively, whereas the values are 18.1 and 5.4 TECU for the Klobuchar model. Comparing NPDM and NeQuick models with selected radio occultation and ionosonde data we found similar results with RMS deviations in the order of 5×10^{11} m^{-3} and 2×10^{11} m^{-3} for high and low solar activity conditions. When comparing NPHM with the NeQuick model we found percentage RMS deviations of about 13% and 12% from the observational data during high and low solar activity conditions, whereas the corresponding deviations for the NeQuick model are found to be 18% and 16%, respectively. The performance of the models may be further improved by extending the database used. The discussed ionospheric TEC and peak parameter models can effectively be used as background models for near real time ionosphere reconstruction and prediction in operational services and radio systems.

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