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A New Empirical TEC Model for the MSNA Area in Northern Hemisphere

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The Mid-latitude Summer Nighttime Anomaly (MSNA) in the Northern Hemisphere is characterized by a reversal of the normal diurnal cycle, with electron density maximizing in the evening, and the diurnal minimum occurring near local noon, which is most prominent around 120-140E longitudes. This Northern summer anomaly can be also observed at similar local time by continuous ground-based GPS TEC observations. Using the TEC data provided by the Center for Orbit Determination in Europe (CODE) over more than one and a half solar cycles (1999-2015), this paper proposes a new empirical TEC model (called TECM-MSNA-N) for the typical region (40-60N, 120-140E) of MSNA in the Northern Hemisphere with the help of nonlinear least squares fitting (NLSF) technique. The TECM-MSNA-N model is described as a multiplication of four separable components, including diurnal variability, seasonal variability, geomagnetic variability and solar activity. The diurnal variability is composed by three parts: four sub-harmonics of the solar day with periods 24, 12, 8 and 6h, expressions of the irradiation angle of the sun, and the correction for MSNA which dependencies on geographic location, season and local time. Similarly, the four sub-harmonics of the year with periods annual, semiannual, 4, and 3 month are used to describe the seasonal variability. For the geomagnetic variability, the geomagnetic latitude is based on the latest International Geomagnetic Reference Field (IGRF12) model. Compared with the similar empirical models, the solar proxy index F10.7P=(F10.7+F10.7A)/2, where the F10.7A is the 81-day running mean of daily F10.7, is chosen as a linear relationship with TEC for the model instead of F10.7. There are 23 coefficients for this model, which are determined by NLSF. The TECM-MSNA-N model fits to the TEC/CODE input data with a bias of 0.04TECU and a RMS deviation of 2.9TECU. The northern hemispheric winter nighttime enhancement and summer nighttime enhancement, appearing as a secondary maximum in TEC both in the pre-midnight and post-midnight hours, which are different from MSNA, can be also reproduced by this model.