Nighttime Winter Anomaly feature reproduced by predictions from a neural network-based TEC model

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Abstract

The ionosphere is a medium containing electrically charged particles and has a delaying effect on the propagation of Global Navigation Satellite Systems (GNSS) signals. Total Electron Content (TEC) describes the ionospheric state and is often described in TEC Units (TECU) where one TECU represents 1016 electrons/m2. The ionospheric delay can be corrected by using multiple GNSS frequencies but in case of single frequency users, external information or ionospheric prediction models are needed. Some examples of ionospheric models are Klobuchar, NeQuickG or the Neustrelitz TEC Model (NTCM). There are also neural network (NN) based TEC models that used Global Ionosphere Maps (GIMs) to train them. The GIMs, containing Vertical TEC (VTEC) data, are more accurate than the broadcast models and are available since the official start in 1998. Most NN TEC models can make VTEC predictions containing large-scale features of the ionosphere but the model presented here is capable of reproducing the small-scale Nighttime Winter Anomaly (NWA) feature, which is newly developed. The NWA is visible at night during low solar activity periods in the Northern Hemisphere at the American sector and in the Southern Hemisphere at the Asian longitude sector. This feature is caused by higher mean ionization levels during the winter nights compared to the summer nights. The NN model's performance has been compared to the NTCM and an improvement of 1 TECU was seen. More importantly, with the predictions of the NN model the NWA can be reproduced which is not possible with the NTCM.