EGU24-19119
EGU General Assembly 2024

A Long Short-Term Memory Neural Network for predicting Global Ionospheric Total Electron Content 24 hours ahead

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In this study a long short-term memory (LSTM) network architecture is utilized to make 24-hour ahead global ionospheric total electron content (TEC) predictions. The preceding 3-day historical TEC data, geographic longitude and latitude, universal time and day of year are used as model input parameters. We investigated the LSTM performance using proton density, solar wind forcing parameters and interplanetary magnetic field components as external model drivers. Other drivers such as ionospheric disturbance index SYM-H, solar radio flux index F10.7 and geomagnetic activity index Hp30 were included in the investigations as well. The above-mentioned investigated parameters were excluded in the final model development since they did not improve the model's accuracy significantly. The model was trained using the rapid UQRG global ionosphere maps (GIMs) from the Universitat Politècnica de Catalunya (UPC) comprising a period of two solar cycles (1998-2020). The model's performance was analyzed for a test dataset which was excluded from the training data and contained quiet and geomagnetic storm days together with a low and high solar activity period. In order to see the model's performance for near real-time (RT) applications, the model was tested using the combined RT products of the international GNSS service (IGS), e.g. IRTG GIMs. The performance of the LSTM-based model was compared to another neural network (NN)-based method (feed forward NN) and the Neustrelitz TEC model (NTCM). The LSTM-based model was outperforming the two models for both cases, e.g. using the IRTG or UQRG maps as an input for the historical TEC data.