Tomographic imaging and modelling of a LSTID during geomagnetic storm conditions

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Travelling ionospheric disturbances (TIDs), wavelike perturbations in ionospheric parameters, are one of the most common ionospheric disturbances that affect Global Navigation Satellite System (GNSS) precise positioning algorithms, such as Real-Time Kinematic (RTK) approaches relying on accurate ionospheric models. For this reason, it is important to develop algorithms for accurate observation and detection of TIDs.

Dense networks of receivers are available for GNSS, such as the Global Positioning System (GPS) and Galileo, and they provide powerful ionospheric sensors. The extensive coverage of such networks makes GNSS an especially valuable tool for studying large-scale TIDs (LSTIDs), which can travel over very large distances and whose structure can extend thousands of kilometres. However, the use of GNSS satellites for moving ionospheric structures is not entirely without drawbacks, as the movement of the satellites in conjunction with the movement of the TID itself complicates the evaluation of the wave parameters.

LSTIDs are the ionospheric manifestations of atmospheric gravity waves generated in the auroral regions during geomagnetic storms. Here, a case study is presented of a LSTID passing over North America during the third day of a series of geomagnetic storms between 29-31 October 2003. The LSTID is imaged in time-varying three-dimensional free electron density using the MIDAS (Multi-Instrument Data Analysis System) ionospheric tomography algorithm and GPS Total Electron Content (TEC) measurements from a large number of receivers. In addition the raw slant TEC measurements between individual receivers and satellites themselves are also examined as time series. The observed TID has a southwesterly direction, an estimated wavelength of around 800 km, an estimated period of ca 30 min and a perturbation of around 4%.

In order to validate the imaging results, the estimated TID characteristics are fed into a physics-based TID model and synthetic TEC measurements are generated by integration through this model. The MIDAS results generated from these measurements are in turn compared to the real data MIDAS images to validate the process end-to-end. One inversion for the real data, as well as one for the model at the same time is shown in figure 1.

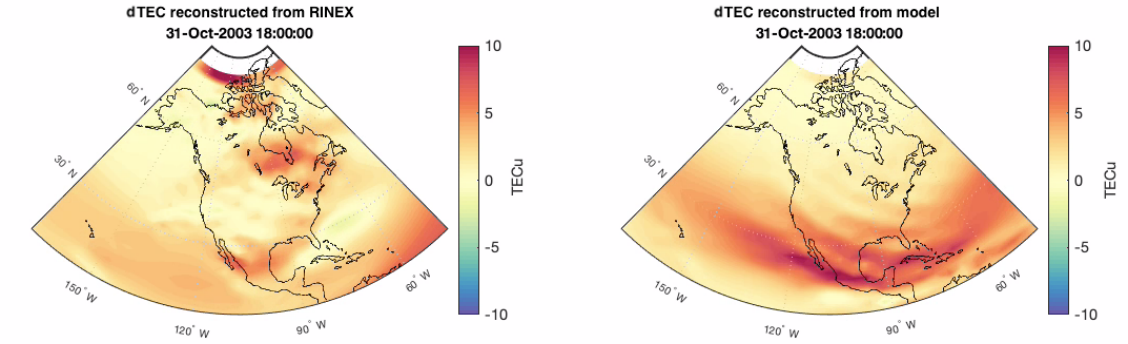

Figure 1: TEC maps with a running average of 2 h subtracted generated from real GPS data (left) and modelled data (right).