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Generalised Linear Modelling of the High-Latitude Ionosphere

Alan Wood, Gareth Dorrian, Lander Bennewith, and Golnaz Shahtahmassebi
Nottingham Trent University, School of Science and Technology, Nottingham, United Kingdom (alan.wood@ntu.ac.uk)

The ionosphere is a highly complex plasma containing electron density structures with a wide range of spatial scale sizes. Large-scale structures with horizontal extents of tens to hundreds of km exhibit variation with time of day, season, solar cycle, geomagnetic activity, solar wind conditions, and location. Whilst the processes driving these large-scale structures are well understood, their relative importance is a fundamental, unanswered question. The large-scale structures can also cause smaller-scale irregularities that arise due to instability processes. These smaller scale structures can disrupt trans-ionospheric radio signals, including those used by Global Navigation Satellite Systems (GNSS).

The technique of Generalised Linear Modelling is used to generate models of various measures of large-scale plasma structuring in the polar ionosphere using 15 years of data gathered by the EISCAT (European Incoherent Scatter) Svalbard Radar. The electron density at the E- and F-layer peaks, the altitude of these peaks, the amount of structuring in each layer and the TEC in each layer is modelled. These models quantify the relative importance of the dominant driving processes and how these vary throughout the day.

The same statistical modelling techniques are then applied to the auroral ionosphere using data from both the EISCAT UHF and VHF radars, allowing a comparison of the driving processes between the polar and auroral ionosphere. Finally, the occurrence of scintillation of GNSS signals in the polar ionosphere is modelled, allowing a comparison of the driving processes in the polar ionosphere at different scale sizes.

These models can make real time predictions for GNSS applications, and a series of trials under a limited range of conditions have been undertaken. These trials have been highly successful and the models give a better representation of the variability in the ionosphere than climatology. The next steps in the development of these predictive models are discussed.