Nowcasting Space Weather Impacts on Polar HF Communications

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Aircraft operating on trans-polar routes require reliable HF (3-30 MHz) radio communications links to be maintained throughout each flight. However, solar flares and interplanetary coronal mass ejections (ICME) can often result in enhancements of the electron density in the Earth's ionosphere, which can strongly attenuate HF radio waves in the Polar Regions. In some cases this can result in the cancellation or diversion of flights for periods of several days. This paper describes the scientific basis for an online service for airlines that predicts HF radio coverage for polar flight routes by combining nowcast maps of HF absorption in the lower (D-region) ionosphere with ray-tracing radio propagation algorithms. The absorption maps are generated by assimilating real-time measurements of cosmic radio noise absorption from 25 'relative ionospheric opacity meters' (riometers) deployed across Canada and Scandinavia. These data are combined with real-time X-ray flux and energetic (1-100 MeV) proton flux measurements from the NASA / NOAA Geostationary Operational Environmental Satellites. The effect of geomagnetic shielding of solar protons (which limits HF absorption at lower latitudes) and the location of the auroral absorption zones (which result from magnetospheric electron precipitation) are also parameterised and optimised using indices of geomagnetic activity. The latter are determined either from ground-based magnetometers or predicted from real-time Solar Wind / Interplanetary Magnetic Field measurements from the NASA / NOAA Deep Space Climate Observatory (DSCOVR) stationed at the L1 Earth-Sun Lagrange point. The performance of the real-time HF absorption model is demonstrated using several days of data recorded during a recent solar proton event and subsequent geomagnetic storm. The new data assimilation model reduces the root-mean-square error in riometer absorption by up to 30% in comparison with NOAA's standard D-region Absorption Prediction (DRAP) model.