Real-time Simulation of HF Signal Coverage in the Polar Regions

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1. Extended Abstract

This paper describes the development of a real-time service for High-latitude Aeronautical HF Radio Prediction (HARP). It is designed specifically to improve the planning of aeronautical communications and reduce the need to cancel or divert flights operating on polar routes during space weather events. Such events include: polar cap absorption (PCA), which can prevent HF communications for several days in the polar cap region; M- and X-class solar flares (X-ray flux enhancements) which temporarily attenuate HF signals on the dayside; and enhanced HF absorption near the auroral zones during geomagnetic storms.

The HARP service combines nowcast and forecast maps of ionospheric D-region attenuation with ray-trace predictions of HF radiowave propagation and with future development it will help in assigning frequency channels and planning the re-routing of either the aircraft or their communications relay paths. Maps of D-region absorption are produced using real-time flux measurements of X-rays and energetic (1-100 MeV) protons from one of the NASA / NOAA Geostationary Operational Environmental Satellites (GOES). This is updated in real-time by assimilating measurements of 30 MHz ionospheric cosmic noise absorption (CNA) from a network of 25 ground-based riometers in Canada and Scandinavia using optimization techniques developed by Rogers *et al.* [1, 2]. Real-time and forecast values of geomagnetic indices K_p and D_{st} published online (e.g. the ENLIL-Rice predictions [3]) are used to provide an initial estimate of the solar proton rigidity cutoff boundary latitude [4] which delimits the region of PCA absorption. These predictions are based on 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. Predictions of auroral absorption (due to magnetospheric electron precipitation) are provided at a specified percentile using a look-up table of CNA from archived riometer measurements parameterized by K_p, magnetic local time and geomagnetic latitude.

The performance of the real-time absorption model is demonstrated using several days of data recorded during a PCA event and subsequent geomagnetic storm in March 2012. The real-time model reduces the root-mean-square error of riometer absorption measurements by up to 30% in comparison with NOAA's D-region absorption prediction (DRAP) model [5].

2. References

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