Propagation prediction for HF communications with aircrafts on trans-polar routes

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During the last fifteen years, the number of flights over the northern polar routes has increased for commercial reasons, since for some routes the airline trans-polar routes represent the shortest distance. Since VHF communications with air traffic center are not available over the pole, and most of aircraft are not equipped for satellite communications (which is not available above 82°), the aircraft rely on HF frequencies. Frequencies within the HF band support "over the horizon'' communication, however, the polar regions are particularly difficult for HF communications since they are strongly affected by space weather (e.g. solar flares, the solar wind etc.). In this research, experimental measurements of HF radio signals over a range of polar cap paths will be compared with the results of simulations and predictions as a part of a project that aims to improve forecasting and now-casting techniques for airline communications.

The HF prediction system is based on a ray-tracing model reported by *Zaalov et al.* [2005]. Firstly, a background ionospheric model is generated making use real-time measurements e.g. ionosonde data from the GIRO database and TEC measurements from the IGS network. Representations of different high latitude ionospheric features, such as polar cap patches and mid-latitude trough, are then used to perturb the background ionosphere. Furthermore, the system incorporates real-time modelling of HF absorption that occurs in the D-region. The HF predicted coverage area is calculated by ray tracing through the ionospheric model from a transmitter, with specified time and frequency. The signal strength is then calculated by adding the power conveyed by the rays taking into account the transmitter power, the HF absorption, and the gains at both the transmitter and receiver antennas.

An example of modelling outcome is presented in Figure 1. The figure displays the predicted signal coverage maps for a transmitter located at Qaanaaq (Greenland) at 7.0 MHz using the ray-tracing model for 1kW transmitter power. The signal strength is presented in S units, where S1 = -121 dBm, steeping upwards in 6dB increments. The effect of strong D-region absorption is evident in the coverage map at 9 January 2014 shown on Figure 1(b) as compared with coverage map during 4 November 2013 presented on Figure 1(a)). This is important to know in order to use higher frequencies where possible in favour of avoiding D-region absorption.

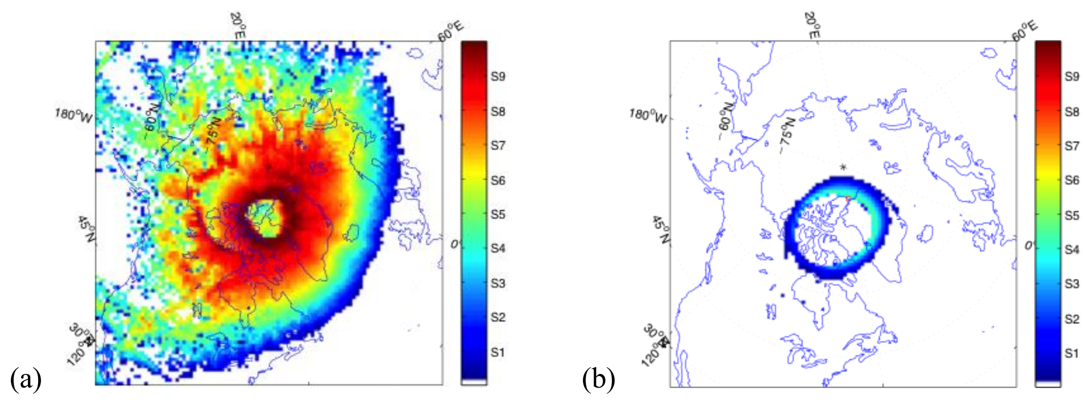

Figure 1: Coverage predicted for the Qaanaaq transmitter at 8.0 MHz. 13:00 UT, (a) 4 November 2013, (b) 9 January 2014.

References

Zaalov, N.Y., E.M. Warrington and A.J. Stocker (2005), A ray-tracing model to account for off-great circle HF propagation over northerly paths, *Radio Science, 40*, RS4006, doi: 10.1029/2004RS003183.