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Session 7A Paper 4

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Observations of HF radio propagation at high latitudes and predictions using data-driven simulations

Space weather events can influence the ionosphere in a number of ways, and these can be particularly pronounced at high latitudes (i.e. within the auroral zone and polar cap). The most severe space weather events lead to a total loss of communications within the HF band (a radio blackout) via strongly enhanced D-region absorption. More commonly, events of intermediate severity can lead to disruption of communications that may be managed by appropriate frequency selection, relaying of messages, and possibly by spatial diversity if the operational configuration is such as to allow this.

Communications within the high latitude region is of growing importance for civil airlines operating trans-polar routes as these may form the shortest path between significant destinations (e.g. New York to Hong Kong), reducing travel time, cost and carbon emissions. In 2014, polar routes were operated by more than 10 major airlines, with over 12,000 cross-polar flights. However, in the polar cap above 82°N geostationary satellites lie below the horizon, and geographic and geopolitical considerations mean there are limited VHF radio air-traffic control facilities. Thus HF radio propagation via the ionosphere is of critical importance in maintaining communications. Adverse space weather conditions, leading to ionospheric disruption that in turn affects HF radio propagation, is of critical importance when considering whether polar routing is viable in the hours in advance of a flight (forecasting) and to the management of HF communications during a flight (nowcasting). Our research is currently directed towards the nowcasting and forecasting requirements. There are two aspects: (a) absorption, and (b) ray path characteristics.

The HF absorption estimates are determined either from the NOAA D-Region Absorption Prediction (DRAP) model [Sauer and Wilkinson, 2008; Akmaev et al. 2010] that incorporates real-time X-ray and energetic proton flux measurements from the geostationary GOES-15 satellite, or the Polar Cap Absorption Model (PCAM) [Rogers and Honary, 2015; Rogers et al. 2015] which is a modification of DRAP that assimilates direct real-time absorption measurements from high-latitude riometers.

Our ray-tracing model as previously reported [Zaalov et al., 2003; 2005] was based on goniometric measurements of azimuthal direction of arrival obtained in the 1990s. More recently, we have undertaken further measurements of signals received over a number of paths, including direction of arrival, time of flight (TOF) and signal strength with the specific aim of validating and developing our modelling procedures. In this paper we present illustrative measurements for two periods:

a) The effect of an intermediate-level absorption event - a series of M and X class solar flares and a relatively weak CME on HF radio performance from 6 to 13 January 2014. Significant ionospheric absorption was observed during this event, but - aside from a short period - were not sufficient to produce a radio blackout.

b) A period where much off-GC propagation is evident during October 2014.

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