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Long-term occurrence rates of high-latitude field-aligned irregularities observed using the Super Dual Auroral Radar Network

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High frequency (HF) radiowaves propagating in the ionosphere regularly encounter structured electron density features known as field-aligned irregularities (FAIs). At low latitudes, FAIs commonly cause spreading of the Doppler spectrum as the radiowave propagates through the electron density structures. At high latitudes, the geometry of the wavevector relative to the geomagnetic field allows direct coherent backscatter from the FAI structure to occur, introducing Doppler shifts and Doppler spreading that match the high-latitude plasma convection speeds of 200-2000m/s. These Doppler effects, known as *spread Doppler clutter*, degrade the quality of HF ionospheric sounder data and may impact target detection in over-the-horizon radar applications.

This study examines the occurrence of field-aligned irregularities in the high-latitude ionosphere on diurnal, seasonal and solar cycle timescales. We use observations from the Super Dual Auroral Radar Network (SuperDARN), a global network of HF radars designed to detect field-aligned irregularities from middle to polar latitudes in both hemispheres. The SuperDARN technique for detecting FAIs relies on ionospheric refraction for the wavevector to become perpendicular to the geomagnetic field. This means that backscatter from FAIs occurs only when sufficient ionospheric refraction has occurred. A key aspect of this study is therefore to separate the effects of HF refraction from the presence or absence of FAIs. Our results show two competing effects of solar radiation at high latitudes – increasing ionospheric refraction but suppressing FAI formation. This leads to strong diurnal and seasonal trends in FAI detection probability. We also show that FAI detection probability has a clear solar cycle dependence, which is also likely to be an HF propagation effect.

Using data from multiple SuperDARN radars spanning two solar cycles, we develop a simple model of FAI occurrence probability as a function of location, time of day, season and solar cycle phase. This model can be used to assess the potential impacts of spread Doppler clutter on HF radio instruments operating at high latitudes.