Using novel incoherent scatter radar methods to resolve the drivers of F-region plasma density variations (Invited Talk)

Lindsay V. Goodwin[(1)], Gareth W. Perry[(1)], and Magnus Ivarsen[(2)(3)]
(1) Center for Solar-Terrestrial Research, New Jersey Institute of Technology, Newark, New Jersey, USA, 07102, https://centers.njit.edu/cstr/cstr-home/
(2) Department of Physics, University of Oslo, Oslo, Norway.
(3) Department of Physics and Engineering Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

Characterizing the formation and evolution of plasma density structures is critically important in understanding how the high-latitude ionosphere impacts over-the-horizon radio communication and global navigation systems. Irregularity spectra are useful for quantifying which plasma density structures are abundant within a region, as well as their drivers [1]. From this information it is then possible to forecast the occurrence of irregularities and predict their impact on radio wave propagation. To provide new insights into the relationship between geomagnetic conditions, plasma irregularity scale-sizes, and radio wave propagation at high-latitudes, irregularity spectra are developed using a novel Incoherent Scatter Radar (ISR) technique. This new technique leverages: 1) the ability of phased array Advanced Modular ISR (AMISR) technology to collect volumetric measurements of plasma density, 2) the slow F-region cross-field plasma diffusion at scales greater than 10 km, and 3) that high-latitude geomagnetic field lines are nearly vertical. The resulting irregularity spectra are of a higher spatial-temporal resolution than has been previously possible with ISRs, capable of resolving approximately 20 km structures in less than two minutes (depending on the radar mode). By comparing irregularity spectra from high-latitude Resolute Bay ISR data to solar and magnetospheric conditions, we have found that although structures 100s of km wide can be prevalent for a variety of geomagnetic conditions, polar cap structures 10s of km will become more prevalent during quiet geomagnetic conditions. Furthermore, structures that are 10s of km wide will also become more dominant near midnight, indicating the role of polar cap convection in breaking down large-scale photoionized structures as they travel from the dayside ionosphere to the nightside. Some of these findings are shown in Figure 1, which utilizes 2016-2018 ISR data taken from the 52 beam *imaginglp* mode. This presentation will expand on these findings, as well as examine the relationship between these structures and overlapping ionospheric backscatter observed using radars from the Super Dual Auroral Radar Network (SuperDARN).

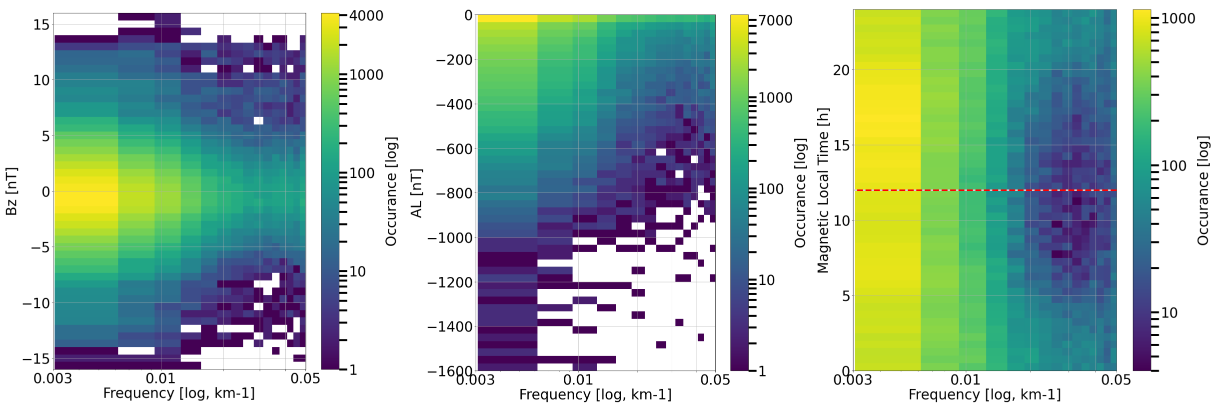

Figure 1. The occurrence of a given plasma density spatial frequency observed in Resolute Bay ISR-North observations between 2016 and 2018 during the imaginglp mode. Each panel organizes the occurrence and spatial frequency according to a different geomagnetic condition or region. **Left Panel)** B_z interplanetary magnetic field direction, **Middle Panel)** AL index, and **Right Panel)** magnetic local time, where the red line indicates local magnetic noon. Note that the spatial frequency and occurrence are given on log scales.

References

[1] M. C. Kelley, J. F. Vickrey, C. W. Carlson, and R. Torbert, "On the origin and spatial extent of high-latitude F region irregularities," *Journal of Geophysical Research: Space Physics*, **87**, A6, June 1982, pp. 4469–4475, doi:10.1029/JA087iA06p04469.