4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

Derivation of Fresnel scales and adaptive filtering cutoffs for high-latitude scintillation data based on incoherent scatter radar observations

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Interpreting and predicting disturbances in radio propagation through high-latitude ionospheric regions still proves to be a challenge due to the dynamic nature of the high- latitude ionosphere and the multitude of irregularity mechanisms that lead to scintillation in signals like Global Navigation Satellite Systems (GNSS). As the ionosphere in high latitudes is very dynamic and different physical mechanisms occur at the same time, GNSS data analysis requires flexible and reliable tools for data processing and interpretation that cover most ionospheric conditions, be it quiet or geomagnetically active segments. Since the plasma drift velocities in high latitudes are typically much higher than in low latitudes, the standard filtering cutoff frequency used in low latitudes does not achieve the same effect in that it mostly removes the lower than Fresnel- frequency part of the signal, which is due to refraction. In this study, we introduce a new method to adaptively determine filtering cutoff frequencies by incorporating plasma drift velocity measurements from the incoherent scatter radars PFISR at Poker Flat Research Range, Alaska, and RISR at Resolute Bay. We first derive the Fresnel scale and the associated cutoff frequency based on the velocity and height of the irregularity layer as observed by the radar. Next, we compare different filtering techniques and their limitations in processing high-rate GNSS data focusing on scintillation signatures. The result of this study can be used to provide recommendations for specific GNSS data processing approaches under different ionospheric conditions.