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GNSS-based Observations and Simulations of Spectral Scintillation Indices in the Arctic Ionosphere

During disturbed times, ionospheric scintillations can be severe and adversely impact satellite-based positioning and radio transmissions. The scintillation occurs in the amplitude, phase, polarization, and angle of arrival of the signal. Precise observation, classification, modeling, forecasting, and development of data-driven methodologies to accurately localize ionospheric irregularities and simulate GNSS scintillation signals are highly desired.

Ionospheric scintillations have traditionally been quantified by amplitude (S_4) and phase scintillations (σ_ϕ). Our study focuses on the Arctic, where scintillations, especially phase scintillations, are prominent. We will present observations acquired from a network of Greenlandic GNSS stations, including 2D amplitude and phase scintillation index maps for representative calm and storm periods. In addition to the traditional indices described above, we are exploring a set of indices derived from the power spectra of the signals. The observed corner frequency of the power spectrum is a function of the Fresnel radius and the drift speed of the irregularities, while the slope of the power spectrum is related to the Fresnel oscillations. We will demonstrate how spectral characteristics of the scintillations act under large total electron content (TEC) gradients and how physical parameters can be extracted from the power spectra, and will present how these parameters of the corner frequencies and power spectra slopes vary during ionospheric storms.

The observations will then be compared to properties of simulated GNSS signals computed by the Fast Scintillation Mode (FSM). The FSM was developed to simulate ionospheric scintillations under different geophysical conditions, and is used to simulate GNSS signals with known scintillation characteristics. This comparison could lead to a better understanding of the observed ionospheric state.