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New frontiers in Auroral Plasma Dynamics inferred from dense GNSS receiver array Observations

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Ionospheric electron density irregularities alter Global Navigation Satellite Systems (GNSS) signals, causing either their amplitude or phase fluctuations. At high latitudes the source of the most severe fluctuations are geomagnetic storms, producing localized electron density intensifications and related electrodynamic turbulences. Recently published observations using a network of 9 closely spaced GNSS receivers show periods of long lasting phase scintillation clustered on a specific side of auroral features. A careful examination reveals that the peaks in scintillation lag the peaks in Total Electron Content (TEC) and 557.7-nm auroral emission brightness. Moreover, observations by the co-located Poker Flat Incoherent Scatter Radar (PFISR) indicate strong and turbulent electric fields (>100 mV/m) over the sensors' field of view.

Comprehensive analysis and careful data fusion, taking into account the complex observational geometry, reveal that the affected lines-of-sight probed the auroral structures along their trailing edge with respect to the auroras' dominant direction of motion. Furthermore, the observation is consistent for all 9 receivers probing the same auroral structures at the same elevation angle. The spatial clustering of the phase scintillation is also independent of the auroras' spatial structure. On the other hand, phase scintillation intensity depends on the electrodynamic perturbations, observed by the PFISR and ground based magnetometers. In aggregate, based upon the observations, we argue that the observed phase scintillation is due to secondary plasma processes such as Gradient Drift Instability (GDI).

This paper emphasizes the need for, and the efficacy of, distributed measurements in understanding space weather impacts on GNSS technology.