Estimation of Ionospheric Irregularities with a Scintillation Auroral GPS Array

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We present analysis methods for studying the structuring and motion of ionospheric irregularities at the sub-kilometer scale sizes that produce L-band scintillations. The quantities estimated by these techniques are: plasma drift velocity, anisotropy magnitude and orientation of the phase correlation, and characteristic or turbulent velocity.

These methods rely on data from an array of at least 3 single-frequency or multi-frequency Global Navigation Satellite System (GNSS) receivers over approximately sub-kilometer baselines. The receivers provide high-rate (100 Hz) power and phase data for each channel. Receivers that output scintillation indices enable automated detection of scintillating periods for an array operating long-term. Because the estimation techniques rely on inter-receiver comparisons of the high-rate data, the array itself forms the sensing instrument.

We demonstrate the use of these techniques at L1 frequency with an array of GPS receivers located in the auroral zone at Poker Flat Research Range, Alaska. As an example, a previously identified scintillation event associated with a severe geomagnetic storm has been revisited. For the first time, the ionospheric drift and anisotropy quantities are estimated for this event. Measurements over an extended period are made and compared to incoherent scatter radar, which shows good agreement in horizontal drift speed and direction during periods of scintillation. Furthermore, the horizontal drifts and anisotropy are estimated for periods during the top 10 days of scintillation detected over a year spanning December 2013 through November 2014. The methods demonstrated here are extensible to other zones and other GNSS arrays of varying size, number, ground distribution, and transmitter frequency.