Inferring 2D spatio-temporal properties of irregularities from a closely-spaced sub-auroral scintillation array

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Auroral zone irregularities affect a broad swath of radio frequencies through rapid phase fluctuations in the received signal experienced by the receiver, known as scintillation. Scintillation can lead to loss of HF communications and L-band satellite-based navigation through receiver loss of lock. For this reason, the ability to quantify the severity and predict the occurrence of high-latitude scintillation continues to be a major goal in upper atmospheric science and applied research. Some scintillation models characterize scintillations by phase and/or amplitude variance indices sigma-phi and S4, while others parameterize the power spectral density of the phase scintillations observed, but these apply for single station observations. Often it is useful for applications as well as scientifically to understand how the scintillation parameters measured at one location may be correlated with scintillation occurrence and severity at another nearby location. In other words, we would like to know the spatial and temporal variation of the phase fluctuations themselves. Since the fluctuations at Global Navigation Satellite System (GNSS) L-band corresponds to scale sizes on the order of 100 m, it is useful to know about spatial variations at the 100 m to 1 km scale range. Advances in GNSS scintillation monitoring technologies and reduction in instrumentation cost have enabled the ability to establish arrays of ground-based arrays with km and sub-km baselines in two dimensions.

In this effort, we present our continuing analysis of scintillation observations made with a 2-dimensional array of sub-km spaced receivers in the northern auroral zone. Previous estimates of the phase fluctuation velocity with respect to the ground, as observed by the array, are refined by accounting for relative Global Positioning System (GPS) signal raypath motion, by projecting the observable direction onto the locally horizontal plane, and by appropriate weighting of the observables in the estimation equation. These are compared with auxiliary data from magnetometers, SuperDARN and all-sky image data sets. We conduct spectral analyses of the fluctuations at each of the array receivers. For cases where the "frozen field" approximation is valid, and we have a wavenumber spectrum along the direction of the velocity, the Rino and Fremouw (J. Atmospheric and Terrestrial Physics, vol. 39, p. 859-868, 1977) equation relating observed phase to statistical properties of the irregularities, will be used to infer the spatial spectrum, altitude and thickness of the irregularities. In addition, the ground 2D drift velocity can then be projected to the irregularity altitude providing the drift speeds at ionospheric heights.