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Identifying E and F Region Irregularities with a Scintillation Auroral GPS Array

Vaishnavi Sreenivash[(1)], Yang Su[(1)], Donald Hampton[(2)], Kshitija B. Deshpande[(3)], Gary S. Bust [(4)], and Seebany Datta-Barua*[(1)]

(1) Illinois Institute of Technology, Chicago, IL, 60616, e-mail: sdattaba@iit.edu; vsreeni1@hawk.iit.edu; ysu27@hawk.iit.edu

(2) University of Alaska Fairbanks, Fairbanks, AK, USA; e-mail: dhampton@alaska.edu

(3) Embry-Riddle Aeronautical University, Daytona, FL, USA; e-mail: deshpank@erau.edu

(4) Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA; e-mail: gary.bust@jhuapl.edu

While Global Navigation Satellite System (GNSS) receivers have been used in arrays spanning the auroral zone for more than a decade, more recently kilometer and sub-kilometer spaced arrays have been used at high latitudes. GNSS scintillation arrays have been shown by a number of methods to be usable as a means of estimating the drift velocity of the irregularities in the scattering layer [1, 2]. Other relevant parameters of ionospheric irregularity models, including anisotropy, height, and thickness of the scattering layer have been estimated as well [3].

In this work we compare observations of Global Positioning System (GPS) L1 and L2C frequency scintillations arraywide for both E and F region auroral irregularities. We seek to determine whether GNSS scintillation arrays can be sensitive to irregularities in either layer, and if so, whether and how the amplitude and phase fluctuation characteristics differ between the regions. The Scintillation Auroral GPS Array (SAGA) is a cluster of six scintillation monitors located at Poker Flat Research Range, Alaska, U.S. over baselines spanning 200 m to 3 km. We classify scintillation events according to amplitude/phase/both on L1/L2C, by applying an automated scintillation detection method using scintillation indices S4 and sigma_phi to historical data from SAGA from 2014-2016. Then an initial estimate of whether a scintillation event is likely associated with irregularities in the E layer or F layer is made by reference to collocated Poker Flat incoherent scatter radar (PFISR) data. This method is also automated to examine peak density altitude during the scintillating time interval.

An initial database of scintillation events is built, and as anticipated at high latitudes, phase scintillation is much more commonly observed than amplitude. There are a few cases of mild to moderate amplitude scintillation, even after using a mask angle of 30 degrees elevation. After providing an overview of the event database, we present a number of case studies in this work. The case studies show that the array is likely sensitive to irregularities in each of the E layer and the F layer. We examine possible differences in high-rate amplitude and phase fluctuations resulting from activity in the two layers. Future efforts will establish whether parameter estimation methods can independently determine the height and thickness of the scattering layer, and how these compare to PFISR measurements.

1. Y. Su, S. Datta-Barua, G. S. Bust, and K. B. Deshpande, "Distributed sensing of ionospheric irregularities with a GNSS receiver array," *Radio Science*, **52**, 8, August 2017, pp. 988-1003, doi:10.1002/2017RS006331.

2. J. Wang and Y. T. Morton, "A comparative study of ionospheric irregularity drift velocity derived from a GNSS receiver array and Poker Flat Incoherent Scatter Radar measurements during high-latitude ionospheric scintillation," *J. Geophys. Res.*, **122**, 6, June 2017, pp. 6858-6881, doi: 10.1002/2017JA024015.

3. Y. Su, G. S. Bust, K. B. Deshpande, and S. Datta-Barua, "Estimating height and thickness of an ionospheric irregularity layer with a closely-spaced GNSS receiver array," *Proceedings of the 30th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2017),* Portland, Oregon, September 2017, pp. 3375-3388.