# Project Details

**ROSES ID:** NNH20ZDA001N
**Selection Year:** 2020
**Program Element:** Focused Science Topic

**Topic:** Modeling and Validation of Ionospheric Irregularities and Scintillations

**Project Title:**
Identifying driving mechanisms of GPS scintillation in the high-latitude ionosphere

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**Summary:**
Science goal and objectives:
Our goal is to determine the relation between GPS radio signal scintillation and plasma conditions in three key regions in the high-latitude ionosphere (cusp, nightside auroral oval, and polar cap). The goal will be achieved by addressing three science questions:
(1) How are scintillation occurrence and strength related to ionosphere conditions?
(2) What types of auroral and airglow forms are related to scintillation?
(3) What are the wavenumber spectra of F-region ionosphere density irregularities during scintillation?

Methodology:
The scintillation will be identified using the Canadian high arctic ionospheric network (CHAIN) GPS receiver data. The ionosphere density will be obtained from TEC given by individual receiver-satellite combinations. The flow velocity will be obtained from the SuperDARN radars and Swarm satellites. THEMIS and REGO all-sky imagers will be used to determine auroral intensity and structure. The density irregularity spectra will be provided from the Swarm satellites.
Case studies and linear correlation analyses will be performed for determining the relation among scintillation, TEC, flow velocity, auroral intensity, and their gradients. Nonlinear correlations and causality will be identified through the application of information theory. For nightside and polar cap scintillation, the imager data will be used to find the types of auroral and airglow forms for identifying what auroral forms and airglow structures are related to scintillation occurrence. When the Swarm satellites are in conjunction with the CHAIN network, the slope of the density wavenumber spectra will be calculated to find what cascading processes contribute to formation of density irregularities. The findings from these works will be used to identify what type of instability (e.g, gradient drift instability and Kelvin-Helmholtz instability) is consistent with the observation.

Proposed contributions to the FST effort and relevance to the FST:
The proposed study will provide observational specification of the occurrence conditions of the scintillation in the high-latitude ionosphere. The relation between scintillation and ionospheric structures (TEC, flow, precipitation and in-situ density structure) will observationally show what types of forcing to the ionosphere are important for creating scintillation, and what instability mechanisms explain the scintillation occurrence. These expected findings will directly address the goal of the FST "understand and model the conditions that lead to the onset and evolution of ionospheric irregularities and resulting scintillation events at low, mid and high latitudes.", and two of the FST objectives "Identify the mechanisms and structures that are responsible for ionospheric irregularities and scintillations&" and "Identify the instability mechanisms responsible for polar F-region irregularities".
The observational work is complementary to proposals that will conduct numerical simulations of scintillation. Our work will provide observational constraints of the simulation setup of ionosphere conditions, and will assist interpretation of the physical mechanisms of simulated density irregularities and scintillation. Information theory can also provide a novel approach to model verifications and validations. The traditional model-data comparison methodology of comparing simulation with data at a particular point in space and time can be supplemented with comparing information flow from input to intermediate and to output variables in the simulation and observational data. Our work on high-latitude scintillation in North America is complementary to studies of scintillation at low/mid-latitudes and other longitudes/hemispheres, and will contribute for comparing similarities and differences in scintillation at various regions.

## Publication References:

**Summary:** Blah

**Reference:** Nishimura, Y., Kelly, T., Jayachandran, P. T., Mrak, S., Semeter, J. L., Donovan, E. F., et al. (2023). Nightside High-Latitude Phase and Amplitude Scintillation during a Substorm using 1-second Scintillation Indices. Journal of Geophysical Research: Space Physics, 128, e2023JA031402, doi: 10.1029/2023JA031402

- **Investigation Type:** Other Investigations
- Blah

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