Project Details

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

Topic: Modeling and Validation of Ionospheric Irregularities and Scintillations

Project Title:
The Influence of Traveling Ionospheric Disturbances on Ionospheric Irregularities

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Summary:
This project will study traveling ionospheric disturbances (TIDs) and their connection to ionospheric irregularities. Ionospheric irregularities are small-scale plasma density structures that exist nearly universally in the Earth's upper atmosphere and which exhibit diverse characteristics. They are believed to be initiated through plasma nonlinear instability processes. Frontier community topics of relevance include how, where, when, and exactly which instabilities are in action for a given condition. Furthermore, TIDs are, very much like irregularities, a ubiquitous and permanent feature of ionospheric variability. Depending on spatial scale and propagation properties, TIDs are excited by forcing from high latitudes and from below. A joint TID and irregularity relationship has been reported in the literature, but there still exists a lack of comprehensive knowledge to establish a connection between conditions for TID excitation, TID propagation, and irregularity onset. We will address some of these fundamental irregularity questions from a TID perspective:,

Q1.1. What is the global climatology and variability of the medium-scale TID (MSTID) activity during quiet times?

Q1.2. What climatological features are common to global MSTIDs and specific irregularities? Can this information be used to gauge irregularity behavior through global TID monitoring?

Q2. What physical mechanisms drive storm-time MSTID excitation at subauroral and mid- latitudes? Do these MSTIDs and associated instabilities trigger plasma irregularities at lower latitudes?

Q3. What are the characteristics of bubble-like ionospheric super-depletion structures observed at mid- and low latitudes during storms? Are they locally generated irregularities under MSTID influences, part of the poleward extension of an equatorial bubble, or an inherent plasmasphere structure?

This project will analyze satellite in situ and ground-based ionospheric remote sensing data. It involves significant statistical work for MSTID global climatology and irregularity characteristics (Q1) as well as case studies (Q2-Q3) utilizing multi-datasets. These include (1) extensive GNSS TEC with global coverage, allowing TID calculation on a daily basis and statistics on a monthly basis for a solar cycle; (2) GOLD observations of nighttime ionospheric bubbles/irregularities with direct comparison to GNSS data; (3) ionosonde data at midlatitude stations (e.g., Austin, TX and Eglin AFB, FL), used to examine Spread-F occurrence at mid-latitudes during storm and quiet times; and (4) in-situ LEO Swarm and DMSP plasma irregularity observations.

Our project addresses the irregularity onset mechanisms associated with MSTIDs during both quiet and storm times, which are directly relevant to the FST goals in the understanding of "the conditions that lead to the onset and evolution of ionospheric irregularities", in particular, to "identify the mechanisms and structures that are responsible for ionospheric irregularities". We will

1- Produce an improved understanding of irregularity onset and global distribution from a MSTID perspective for both quiet and storm conditions. By elaborating MSTID roles, we will contribute to the overall FST science goal on the irregularity phenomenology and mechanisms.

2- Provide unique and comprehensive global MSTID information to the team from GNSS TEC observations. The baseline data used to calculate MSTIDs are available through the MIT Madrigal database. In addition to daily MSTID maps, we will also provide monthly statistics of MSTID global distribution.

3- Provide MSTID-irregularity analysis results and subsequent questions to modeling members of the team and will assist with theoretical understanding and model-data comparison activities.

This project is within Decadal Survey Key Science Goal 2 and LWS Strategic Science Areas SSA-IV (Variability of the

Geomagnetic Environment) and SSA-VI (Localized Ionospheric Irregularities).

Publication References:

Summary: Blah

Reference: Aa, E., Forsythe, V. V., Zhang, S.-R., Wang, W. & Coster, A. J. (2023). Next- decade needs for 3-D ionosphere imaging. Frontiers in Astronomy and Space Sciences, 10, 1186513. https://Aa, E., Forsythe, V. V., Zhang, S.-R., Wang, W. & Coster, A. J. (2023). Next- decade needs for 3-D ionosphere imaging. Frontiers in Astronomy and Space Sciences, 10, 1186513. https://doi.org/10.3389/fspas.2023.1186513

- **Investigation Type:** Other Investigations
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Reference: Zhang, S.-R., Cnossen, I., Lastovicka, J., Elias, A. G., Yue, X., Jacobi, C., Yue, J., Wang, W., Qian, L. & Goncharenko, L. (2023). Long-term geospace climate monitoring. Frontiers in Astronomy and Space Sciences, 10, 1139230. https://doi.org/10.3389/fspas.2023.1139230

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