Project Details

ROSES ID: NNH18ZDA001N
Selection Year: 2018
Program Element: Focused Science Topic

Topic: Mid-latitude and Equatorial Dynamics of the Ionosphere-Thermosphere System

Project Title:
Exploring the high-latitude origin, evolution, and low-latitude impacts of large scale traveling ionosphere/thermosphere disturbances-NRL1

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Summary:
Science Objectives:
Understanding the formation, progression, and global impact of Large Scale Traveling Atmospheric/Ionospheric Disturbances (LSTADs/LSTIDs) is a long-standing challenge in global space weather research. This has been a particularly perplexing problem due to the strongly coupled nature of the high-latitude ionosphere-thermosphere (I-T) system, where they are believed to originate. At high latitudes, the magnetosphere dumps a large amount of energy (both directly and indirectly) into the I-T system through Joule heating, auroral particle heating, and ion drag. LSTADs are a commonly observed thermospheric response to magnetospheric energy entering the I-T system. It is believed that LSTADs drive a similar wave response in the ionosphere, known as LSTIDs. Recent studies suggest that LSTADs/LSTIDs may also play an important role in transporting high-latitude variability to lower latitudes.

Our knowledge of the origin, evolution and impact of LSTADs and LSTIDs is still very limited. This is due to the scarcity of the data and the inability of the models to accurately capture LSTIDs and LSTADs. New models have shown significant improvement in capturing the complexity of the full I-T system and increasing networks of observational instrumentation now provide sufficient geographic coverage to trace the propagation of LSTIDs and LSTADs. With these updated tools, it is finally possible to address the following focused science questions:

1. How do auroral disturbances generated by magnetospheric forcing drive LSTADs/LSTIDs?
2. Do the background conditions control LSTAD/LSTID generation and propagation to lower latitudes?
3. What is the effect of LSTADs/LSTIDs on the low-latitude longitudinal variations of the I-T system, and how does this affect the longitudinal distribution of the total electron content (TEC)?

Theoretical calculations and observations have indicated that LSTADs are launched from the auroral regions due to: (1) perturbations in the auroral electrojet current, (2) thermospheric heating caused by highly energetic particles from the magnetosphere, and (3) rapid motions of the aurora. Since both LSTIDs and LSTADs can propagate longitudinally and latitudinally on a global scale, they can transport energy and dynamics from high to middle and equatorial latitudes, impacting their thermosphere and ionosphere weather. It is not known under what conditions they are able to effectively transport energy to low latitudes or how that energy transport affects the longitudinal distribution of the ionospheric density. Answers to these questions are essential if we are to bridge the gaps in our current understanding of LSTADs, LSTIDs, and their impacts on the structure of the lower and equatorial latitude regions.

Proposed Contribution to FST:
The proposed effort directly addresses the first Focused Science Topic: Mid-latitude and Equatorial Dynamics of the Ionosphere-Thermosphere System. The goal of the FST is to understand the mid to low latitude plasma density distribution, which is believed to be affected by the propagation of LSTADs/LSTIDs from high latitudes. The proposed work is to specify and quantify how LSTADs/LSTIDs are generated and how they transport energy from high to low latitudes, affecting the longitudinal structure of TEC.

Methodology:
We will utilize two-way coupled WACCM-X (Whole Atmosphere Community Climate Model, Extended) with the three-dimensional first-principles model SAMI3 to simulate LSTADs and LSTIDs and then validate the results against available observations (TEC, NASA C/NOFS, ISRs, GOCE, and CHAMP). The coupled model will use the Weimer model for high-latitude potential and the Hardy model for auroral particle precipitation to provide high-latitude drivers. The system will be run with varying model components to isolate physical processes responsible for particular phenomenology and compared with

observational data to achieve closure on the science questions.

Publication References:

no references