Project Details

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Program Element: Focused Science Topic

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

Project Title:
Dynamic and Coupling Processes in the Mid-Latitude and Equatorial Thermosphere and Ionosphere during Geomagnetic Storms

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Summary:
A compelling challenge in the study of global ionospheric electrodynamics during geomagnetic storms is to identify and characterize penetration and disturbance dynamo electric fields and their impacts on the behavior of the ionosphere during geomagnetic storms. The objective of this proposed work is to achieve breakthroughs in understanding and quantifying storm-time penetration and dynamo electric fields in the mid-latitude and equatorial ionosphere through comprehensive data analysis and physics-based model simulations. Ionospheric electric fields play a key role in the Sun-Earth connection as they are the result of direct coupling between the solar wind and the magnetosphere/ionosphere system and between thermospheric neutrals and ionospheric plasma. However, many aspects of the fundamentals of storm-time penetration and dynamo electric fields are still not well understood. Recent studies have revealed that penetration electric fields play a much more important role in ionospheric storms than previously thought and that disturbance dynamo electric fields can dominate equatorial electrodynamics for a long period of time (e.g., 20 hours) after a magnetic storm ceases.

We propose to undertake a comprehensive study of the storm-time behavior of mid-latitude and equatorial ionospheric electrodynamics and its interaction with the thermosphere using analysis of data from global observations and state-of-the-art first principles modeling. The specific goals of this effort are to address the following outstanding science issues:

(1) What are the Characteristics of Penetration Electric Fields in the Equatorial Ionosphere during Geomagnetic Storms?

(2) What are the Characteristics of Disturbance Dynamo Electric Fields in the Equatorial Ionosphere during Geomagnetic Storms?

(3) How Long Does Shielding Electric Field Take to Grow to Its Maximum Level? Can Shielding Electric Field Be Strong Enough to Cancel Penetration Electric Field?

(4) What are the Longitudinal Variations of Ionospheric Electric Fields during Geomagnetic Storms?

We will analyze extensive data sets from multiple satellites and ground-based measurements and run the physics-based LTR model, which couples the Lyon-Fedder-Mobarry (LFM) Magnetospheric MHD Model, Rice Convection Model (RCM) of the inner magnetosphere and ring current and the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) through the Magnetosphere Ionosphere Coupling/Solver (MIX), to address the above science issues. Data from the Defense Meteorological Satellite Program (DMSP), Communication/Navigation Outage Forecasting System (C/NOFS), Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED), and other satellites, as well as ground based measurements, will be used to investigate the characteristics and changes of ionospheric electric fields during geomagnetic storms. The LTR model, driven by the observed solar wind data, will be run for different types of geomagnetic storms to compare with data. The four science issues will be addressed through data analysis, model simulations and comparison between model outputs and observations. The combination of expertise of the team members in modeling, observations, and data analysis assures the success of the proposed work.

The proposed work is directly related to 2018 LWS Focused Science Topic #1 Mid-latitude and Equatorial Dynamics of the Ionosphere-Thermosphere System . The proposed work will contribute to the LWS program objective by providing a quantitative specification of the ionospheric electric fields during geomagnetic storms and a comprehensive understanding of the variations of the electric fields. The expected results of this project will advance our understanding and knowledge of ionospheric dynamics and provide fundamentals for developing the forecasting capability of storm-time ionospheric behavior.

Publication References:

no references