Project Details

ROSES ID: NNH16ZDA001N
Selection Year: 2016
Program Element: Focused Science Topic

Topic: Studies of the Global Electrodynamics of Ionospheric Disturbances

Project Title:
Ionospheric Storm-Time Electrodynamics: Coupling Across Latitudes and Magnetospheric Imprint

PI Name: Stanislav Sazykin
PI Email: sazykin@rice.edu
Affiliation: Rice University
Project Member(s):
- Coffey, Victoria Newman; Co-I; NASA Marshall Space Flight Center
- Hairston, Marc ; Co-I; University of Texas at Dallas
- Fejer, Bela Gyula; Co-I; Utah Sate University

Summary:
Science goals and objectives: We propose a systematic investigation of the role of disturbance electric fields of magnetospheric origin on the ionospheric electron density dynamics, redistribution, and occurrence of spread-F type instabilities. These transient latitude, MLT, and longitude-dependent electric fields are known to produce large changes in ionospheric electron densities, and affect conditions favorable for occurrence of spread F instabilities. Both recent observations and theory indicate that transport in the plasma sheet, which controls formation of region-2 currents, is a bi-modal process of fast and narrow channels of depleted entropy regions (bubbles) sporadically superimposed on the background large-scale convection. Specific science questions:

1.What are the signatures of changes in IMF Bz on ionospheric penetration electric fields when the bi-modal physics of plasma sheet transport is included in models of M-I coupling? How do penetration electric fields vary with plasma sheet temperature, solar wind density, and frequency of dipolarizations in the tail?

2.What are the consequences of penetration electric fields on the ionospheric electron densities? Under what conditions do penetration electric fields lead to enhanced linear growth rates of spread F instabilities at low latitudes?

3.What are the longitudinal variations of penetration electric fields and storm-time electron density redistributions?

4.What is the role of the IMF y-component and/or rotations of IMF vector on penetration electric fields?

Methodology: Our methodology will be systematic data analysis guided by first-principled simulations, aided by model development as needed. Each of the science questions can be answered with data analysis and simulations. We will use a version of the Rice Convection Model (RCM) that uses Euler potentials, includes a realistic IGRF intrinsic magnetic field, and allows for inter-hemispheric asymmetry. With idealized parametric simulations, we will study the morphology and time dependence of penetration electric fields for different plasma sheet, solar wind, and IMF By conditions. The expected outcome is improved physical understanding of how various parameters affect magnitudes, MLT and longitudinal dependence, and duration of penetration fields. We will use available data from CINDI (C/NOFS) mission (IVM ion drift velocities and F-region densities, and VEFI zonal drifts), F-region ion densities from the FPMU instrument suite on board the International Space Station (ISS), supplemented by Swarm mission data, DMSP ion drift and topside density data, and equatorial measurements by the Jicamarca radar (incoherent-scatter and coherent-scatter experiments) to construct empirical models of penetration electric fields and to study their role in occurrence of equatorial spread F. We will also use RCM coupled to the SAMI3 first-principles ionosphere, to predict density response and areas of likely spread F occurrence. With further parametric studies, we plan to identify the areas of best and least agreement between model results and data. The outcome is expected to be an improved model (RCM) of M-I coupling that is predictive, includes longitudinal variations, and is available to the research community.

The project is directly relevant to the LWS science solicitation as it will result in an improved predictive model of ionospheric disturbances at low latitudes induced by geoeffective solar transients.

Proposed contributions to the Focused Team Efforts: Largely improved understanding and forecast of global prompt penetration electric fields and their low latitude ionospheric effects. Improved empirical models of low-latitude storm-time penetration electric fields with solar wind and magnetospheric input parameters and with longitudinal variation. Detailed validation and improved RCM M-I coupling model, event simulations of several storm-intervals with the RCM model, and availability of RCM runs.

Publication References:

no references