Project Details

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Topic: Studies of the Global Electrodynamics of Ionospheric Disturbances

Project Title:
Ionospheric Electrodynamics   A Quantitative Characterization

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Summary:
This proposal addresses FST 3.1.3 Studies of the Global Electrodynamics of Ionospheric Disturbances. Deriving storm time iono-spheric electrodynamics is of particular importance to: LWS SSA-2 Physics-based Satellite Drag Forecasting Capability; SSA-4 Physics-based TEC Forecasting Capability; and SSA-5 Physics-based Scintillation Forecasting Capability. We propose to determine storm-time ionospheric electrodynamics from observations as fully as possible using various satellite and ground-based datasets, and quantitatively test existing empirical and physics-based models, thus deriving advances in modeling capabilities to improve quantitative predictive capability of storm-time ionospheric electrodynamics. We will (1) assess storm-time ionospheric electrodynamics from observations including the ionospheric conductivity, currents, and electric fields; (2) quantify the validity of existing empirical and physics-based models of ionospheric electrodynamics; (3) identify key areas of discrepancy and assess techniques, including data-assimilation, to incorporate available data into ionosphere/thermosphere models and to infer external forcing where not well measured; (4) translate modeled/assimilated global electrodynamics to both magnetometer and GIC measurements that can be validated on the ground. The study will consider uncertainties and how the sources of error impact the results. NASA will facilitate interaction with user communities.

We will address the following Science Questions:

1) What are the impacts of ionospheric conductance on Region 2 currents and global ionospheric electrodynamics

2) What are the effects of the inner magnetosphere physics (Region 2 currents, penetration E-fields, energy deposition from the ring current and precipitation) to the global ionospheric electrodynamics?

3) Over what spatial and temporal scales do systematic departures from observations and our next-generation models occur?

4) How does an improved specification of the ionospheric conductance affect the specification of ground induced currents?

We will:

1) Derive stormtime Ionospheric Electrodynamics from a broad set of ionospheric observations, by using multiple existing data sources at ASTRA (DMSP, SuperDARN, AMPERE, magnetometers) and models to improve the E-field specification from AMIE

2) Validate the electrodynamics encapsulated in existing models, and a new coupled model described in the text.

3) Examine the effect of conductivity on AMIE, and explore ways to improve the specification of conductivity by combining AMIE, TIEGCM, and IDA4D. We will also couple the Goddard CIMI model with the TIEGCM and AMIE. We will also compare CIMI electrodynamics (ring current, SAPS E-fields, region-2 currents, etc) with AMIE, AMPERE, etc.

4) Use AMIE and the physics-based models to predict GICs and ground-based magnetic perturbations from which GICs will be com-puted, and then compare with existing magnetometer and GIC data

5) Bring theoretical understanding to interpret the validation results, especially differences between models and data, to infer scientific gaps in our understanding, and to suggest future research areas

6) We will compare ionosphere/ thermosphere data with TIEGCM simulations driven by AMIE electrodynamics to specify the high latitude forcing. The TIEGCM predicts the response of the winds, temperatures, composition, density, and the ionospheric response. TIEGCM output will be compared with various I-T data (Ne, composition, winds, etc.) to infer shortcomings of the I-T forcing terms. Model outputs will be analyzed using already-developed postprocessors and spectral analysis tools to reveal and understand the mechanisms operating in the I-T response. The CIMI model has been coupled with global MHD models, and the coupled model can provide potentials and currents at high latitudes that are alternate inputs to TIEGCM.

Dr. Crowley proposes to act as the FST Team Leader.

Publication References:

no references