Project Details

ROSES ID: NNH05ZDA001N
Selection Year: 2006
Program Element: Focused Science Topic

Topic: Storm effects on the global electrodynamics and the middle and low latitude ionosphere

Project Title:
Modeling the Impact of Storm-time Electrodynamics on the Mid and Low Latitude Ionosphere

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Summary:
Project Summary: The goal of this research is to determine the circumstances leading to the massive restructuring of the mid and low latitude ionosphere and the development of large-scale bite-outs of electron density at low latitudes during geomagnetic storms. Good examples of these features occurred during the Halloween storm in October 2003. Maps of total electron content (TEC) showed a factor of four increase at mid latitudes, and measurements of electron density by the DMSP satellite at 850 km indicated the ionosphere had virtually disappeared over a wide latitude swath at low latitudes. The depleted region, or bite-out, was accompanied by smaller scale ionospheric irregularities, or bubbles, on its flanks. It is expected that the dramatic plasma gradients were created by exceptionally large upward ExB plasma drifts, raising the ionosphere to higher altitudes, transporting plasma poleward, and driving the huge depletions at low latitude. This study will investigate the interaction and feedback between the two main sources of the plasma drift the prompt penetration (PP) and disturbance dynamo (DD) electric fields, and determine the cause of the massive restructuring of plasma at mid and low latitudes during storms.

This project is a linked proposal between research teams at University of Colorado (PI Tim Fuller-Rowell) and Rice University (PI Stan Sazykin). The success of the project relies on the self-consistent coupling between physical processes in the thermosphere, ionosphere, and plasmasphere (as captured in the CTIPe model) and the inner magnetosphere (as captured in the RCM). Combining these two models includes both dynamo and penetration electrodynamics, and consistently handle the feedback between the two regimes. This study is therefore unique in its ability to couple the various domains and address the science questions in a rigorous mathematical approach. This study will: 1) Determine the physical processes leading to the large vertical plasma drifts and the interaction and feedback between the penetration and dynamo electric fields, 2. Determine the impact on the mid and low latitude ionosphere including the cause of the massive restructuring of plasma density, and 3) Investigate the possible causes of the strong longitude dependence in the storm-time response.

The first phase of the study will perform the comprehensive coupling of the CTIPe and RCM models where the polar cap boundary, the neutral wind driven dynamo currents, and the field-aligned magnetospheric currents are consistent between the two codes. The effects of under and over shielding in the inner magnetosphere will be implicitly included in the field-aligned currents and the potential solver. Numerical experiment will be performed with a goal of understanding the complex interaction between the geophysical domains including the electrodynamic feedback between PP and DD. For validation, the coupled model will be used to simulate the recent storms targeted by the recent CDAW workshop. The chosen storms have good global and regional coverage for TEC, have reasonable measurement of the electric fields, and have well developed experimental/observational databases.

The potential benefit of this study for space weather is clear. Large-scale changes in the ionosphere impact GPS navigation signals and alter the propagation of HF radio-wave communication. The large-scale ionospheric changes are also associated with the generation of small-scale ionospheric irregularities responsible for scintillations on satellite communication signals. Understanding the physical processes will lead to the possibility of improvement in predicting and forecasting the storm-time plasma redistribution and the creation of irregularities. This proposal targets the specific research topic of the LWS TR&T Focused Science Topic Storm effects on the electrodynamics and the middle and low latitude ionosphere .

Publication References:

Summary: no summary

Reference: Fuller-Rowell, T.J., A.D. Richmond, and N. Maruyama (2008), Global modeling of storm-time thermospheric dynamics and electrodynamics, AGU Geophysical Monograph, in press.

Summary: no summary

Reference: Tsurutani, B. T.; Guarnieri, F. L.; Fuller-Rowell, T.; Mannucci, A. J.; Iijima, B.; Gonzalez, W. D.; Judge, D. L.; Gango padhyay, P.; Saito, A.; Tsuda, T.; Verkhoglyadova, O. P.; Zambon, G. A.; (2006), Extreme solar EUV flares and ICMEs and resultant extreme ionospheric effects: Comparison of the Halloween 2003 and the Bastille Day events, Radio Science, Volume 41, Issue 5, CiteID RS5S07, doi: 10.1029/2005RS003331