Project Details

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Topic: Ion Circulation and Effects on the Magnetosphere and Magnetosphere - Ionosphere Coupling

Project Title:
Tracing the Height-dependence of Upward Acceleration in Ion Outflow

PI Name: Ennio R Sanchez
PI Email: ennio.sanchez@sri.com
Affiliation: SRI International
Project Member(s):
- Kasahara, Yoshiya;Collaborator;KANAZAWA UNIVERSITY
- Tu, Jiannan;Co-I;University Of Massachusetts, Lowell
- Varney, Roger H;Co-I;SRI International
- Chaston, Christopher C;Co-I;University of California, Berkeley

Summary:
Objectives and Significance. The extraction of plasma from the atmosphere is one of the most important effects of space weather, on Earth and any other planet that has an atmosphere. The process of extraction likely results from a sequence of mechanisms that start accelerating upward the ions in the F-region and continue to accelerate them well above it. The contribution that each mechanism has on the ion acceleration is not well determined. Furthermore, the wave modes' identification as well as the height dependence of their amplitude is not well established. This project will take full advantage of ground-based assets (incoherent scatter radars, ISRs), spacecraft assets (Fast Auroral SnapshoT, FAST, and Akebono), and models (Ionosphere/Polar Wind Model, IPWM, and Dynamic Fluid-Kinetic, DyFK) to trace for the first time the ionospheric populations from their source -the F-region of the ionosphere-into high altitude with the objective of quantifying the contribution of the different likely acceleration mechanisms and the ability of outflow models to predict the observed fluxes. The team assembled for this project has the expertise and experience in incoherent scatter radars (ISRs), fluid and hybrid models, FAST and Akebono wave data analysis, to successfully carry out all tasks of the project.

Methodology. We will construct an empirical statistical model of the variation of wave amplitude with altitude using FAST and Akebono wave data. We will use this model to establish mean and variance of waves' amplitudes with altitude that can be used to constrain the allowable changes in the ion extraction models. We will employ two different models of ion outflow: The IPWM and the DyFK model. We will identify all events in the ISR databases (Sondrestrom and EISCAT) that contain signs of up-flow in the F-region while either FAST or Akebono is near to the ISR location. We will use the ISR measurements in the F-region to initialize the out-flow models from below and spacecraft measurements to constrain them from above, and model the ion fluid (or particles) motion along the flux tube while convecting the flux tubes horizontally. We will compare the flux and particle distribution predicted by the outflow models (with the wave properties from the FAST-Akebono empirical model as input) with the flux and particle distribution observed by the spacecraft, and iteratively adjust the wave-particle interaction (WPI) inputs to the models until satisfactory agreement is achieved within the error limits imposed by the FAST-Akebono empirical model. We will compare the final solution for the WPI inputs to the wave observations from the spacecraft and will repeat the comparison methodology for events at different locations of the polar ionosphere and levels of geomagnetic activity.

Impact of the Work. The empirical model of wave power versus altitude will help reduce the large uncertainty in the currently assumed variation of wave power with altitude, region, and geomagnetic activity. This investigation will also provide a direct estimation of the prediction error that can be assigned to each of the models and the quantification of the adequacy of the assumption of ion cyclotron resonance heating by extremely low frequency (ELF) waves. The improvement in the specification of ion acceleration in the IPWM model will benefit all other work using that model, including global modeling efforts using IPWM coupled to the MultiFluid Lyon-Fedder-Mobarry (MFLFM) global magnetospheric model. Past experience with the global coupled model has shown that the coupled system dynamics and global magnetic field fluctuations are highly sensitive to the local details of how ion acceleration is regulated. Therefore, an improved understanding of local ion acceleration is expected to have a significant impact on our ability to predict global dynamics.

Publication References:

no references