Project Details

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

Project Title:
Modeling oxygen outflow: its origins and energization

PI Name: John Lyon
PI Email: lyon@tinman.dartmouth.edu
Affiliation: Dartmouth College
Project Member(s):
- Varney, Roger H;Co-I;SRI International
- Read, Sherrie J;Collaborator;Self
- Lotko, William;Co-I;Dartmouth College
- Blandin, Jean;Collaborator;Self
- Merkin, Viacheslav G.;Co-I;Johns Hopkins University

Summary:
Science Goals and Objectives:

Heavy ion outflow - mainly oxygen - is an important element of the magnetosphere-ionosphere system. For example, heavy ions may become a major or even the dominant plasma constituent both in terms of their number and energy density in the plasma sheet and ring current during disturbed times. However, the mechanisms by which oxygen is raised, accelerated and heated remain uncertain. This proposal will use modeling in conjunction with data inputs to characterize the key mechanisms of O+ upwelling, acceleration and heating. In particular, we will investigate how self-consistent drivers of plasma and neutral motions, including the solar wind-magnetosphere interaction, regulate outflow. This is motivated by the fact that both wave and particle energy flows within the magnetosphere are driven by the interaction with the solar wind. In addition, the state of the neutral atmosphere affects amount of oxygen available and its possibility of outflow. We will further investigate how O+ is energized to escape velocity and beyond, and what determines the O+ outflow flux. Generally, the ionospheric ambipolar field is sufficient to cause oxygen to upwell but insufficient to have it escape let alone achieve energies seen within the magnetosphere. Does outflow itself create feedback loops with the rest of the magnetosphere and ionosphere that affect outflow? Studies have shown that oxygen outflow may cause the magnetospheric sawtooth events. Are there other ways in which outflow either self-regulates or causes magnetospheric phenomena which indirectly control outflow? The use of a fully self-consistent model for magnetosphere including ionospheric outflow allows us to test various mechanisms for oxygen outflow through comparison with data and to use that data as well to produce causal relations for the outflow.

Methodology:

This proposal attacks these questions though an advanced model for polar wind outflow coupled to simulation of the solar wind-magnetosphere-ionosphere system. The key elements of the model chain are the Ionosphere/Polar Wind Model (IPWM), including treatment of an energetic O+ fluid population accelerated by wave-particle interactions, the multifluid LFM model, and the ionospheric electrodynamic coupler MIX including embedded models of diffuse, monoenergetic and broadband electron precipitation which influences the ionospheric electrodynamics and the source populations for ionospheric outflows. IPWM can use various models for the neutral thermosphere in order to investigate the interaction of neutral dynamics with oxygen outflow. An additional capability is ion tracking through the model fields. These traced particles can be subjected to parameterized wave-particle interactions to test models. The planned research will attempt to isolate elements leading to outflow by changing parameters, such as sub-grid scale heating, and assessing the effects on the outflow and the magnetospheric system. A major part of that assessment will be data-model comparison. In addition, we will examine sources, such as the FAST data, to probe for direct contributors to or proxies for oxygen acceleration.

Proposed Contributions to the Focus Team Effort:

A wide range of data relevant to the focus topic is available from NASA missions. These include FAST measurements at low altitude, MMS dayside and tail measurements, data composition data from Cluster and Geotail, and inner magnetosphere data from Van AllenProbes. Ionospheric and related ground data is also available from SuperDARN, SuperMAG, and AMPERE. Our fit within the team is to provide a first-principles modeling context for the effort. Having a comprehensive model of outflow will allow observations taken at one point to be related to data from another region. With aid of other team members observational data will be used to constrain the outflow models. One specific milestone will be an improved causal model for oxygen outflow for system-wide studies

Publication References:

no references