

Merged Modeling & Measurement of the Ionospheric Source of Magnetospheric Plasma— Plasma Sheet, Ring Current, Substorm Dynamics

Topic: Over the past four decades, it has become progressively more obvious that the Earth's ionosphere is a significant source of the energetic plasma of the magnetosphere and a strong influence on the dynamics of the geospace environment. The ionospheric source is contributing to the formation of the plasmasphere, the plasma sheet and the ring current and through wave particle interactions is playing a major role in the formation and dynamics of the radiation belts. Hence, the understanding of the strength and dynamics of the outflow of ionospheric particles up into the magnetosphere and their subsequent energization and movement is of critical importance to understanding how the magnetosphere is populated and influenced by these initially low energy particles. These particles are transformed in energy as they move through the magnetosphere, contributing to the different major particle regions. Our need is to understand the origin, energization and dynamics of these particles through both measurement and merged modeling. We want to compare these two approaches in order to build and test an accurate and successful GGCM that can be used in the future to predict ionosphere-magnetosphere coupled dynamics. This goal is the principal motivation for this proposed GEM focus group.

Timeliness: For the past five years, the GEM focus group on The Ionospheric Source of Magnetospheric Plasma— Measuring, Modeling and Merging into the GEM Geospace General Circulation Model (GGCM) has been actively pursuing this fundamental topic in magnetosphere-ionospheric physics. It has brought together a large international group of experimentalists and modelers to study the role of the ionospheric source in populating the magnetosphere and influencing its dynamics. It has made a significant contribution to improving our understanding of this process, including organizing 20 GEM sessions over this period and carrying out an AGU Chapman Conference on this topic. The focus group has stimulated many coordinated studies including the first ever mergers of generalized ion outflow models with MHD magnetospheric models. This focus group is ending its period of operation at the end of 2015 but the central importance of this topic requires a continued focus within the GEM program.

The timeliness of continuing this thrust of research in GEM comes from both the merged modeling advances and the exciting new satellite missions, the Magnetospheric Multiscale Mission and the E-POP ionospheric outflow mission. During the past 5 years, the merged models have succeeded in combining the detailed generalized polar wind model (GPW) with the BATS-R-US and the LFM models. This investment in merged modeling has brought us to the threshold of a new capability of merged models that will be available to be compared with the new spacecraft and ground-based data. Completion and inter-comparison of these merged models will be an important part of this proposed focus group activity.

Secondly and very importantly, the new availability of the E-POP and MMS data is ideal for comparison with the merged models. The unique and extensive capabilities of the four spacecraft MMS mission will bring a comprehensive set of plasma instrument techniques that will permit the measurement of the low energy outflowing ionospheric plasma and observe its progressive energization in the lobes, the plasma sheet, and the ring current. The MMS orbits are ideal to follow the outflow of the plasma from the ionosphere across the polar cap and the lobes of the tail and into the plasma sheet region where it is energized and transported Earthward becoming the warm plasma cloak and the ring current. Being able to measure this process and to compare it with the evolving merged models will be a focus of GEM activities.

Fit with other Focus Groups: Since the supply process of filling the magnetosphere with plasma is so fundamental to the creation and dynamics of the magnetospheric particle regions, this focus group activity is important to very many of the other focus groups, e.g. Tail-Inner Magnetosphere Interactions, Inner Magnetosphere Cross-Energy/Population Interactions, Storm-Time Magnetosphere-Ionosphere Convection and Tail Environment and Dynamics. We expect a large research cross-fertilization with these and other GEM focus groups.

Goals and Deliverables: Our goal is to understand the role of the ionosphere in populating the magnetosphere with plasma and the magnetospheric dynamics that are influenced by this process. The specific deliverables are further development of the merged GGCM models of the ionosphere and magnetosphere that will explain the observations. These models will become effective predictors of the dynamic response of the ionosphere and magnetosphere to changing solar and solar wind conditions. Examples of these merged models that will be advanced from the earlier focus group are the GPW/BATS-R-US, the PWOM/BATS-R-US and the GPW/LFM models with both multi-fluid and multi-species capabilities. We will also continue the organization of joint model/observation comparison sessions in which the spacecraft and ground-based observations during different solar cycle and solar wind conditions have driven the model development and vice versa.

Co-Chairs: The co-chairs of this proposed focus group will be:

Vince Eccles, Utah State University—Development and production using the Generalized Polar Wind ion outflow code at USU
Shasha Zou, University of Michigan—Ionospheric Dynamics studies with modeling/observations and interaction with MHD modelers at UM
Barbara Giles, NASA Goddard Space Flight Center—MMS Fast Plasma Investigation deputy lead scientist and Associate Laboratory Chief

Research Areas: This focus group would be directly connected to the Magnetosphere-Ionosphere Coupling research area and would also have a significant overlap with the Magnetotail and Plasma Sheet as well as the Inner Magnetosphere research areas. In addition, it would have an overlap with the Global System Modeling research area.

Term: We would recommend a 5 year term for this focus group beginning in 2016.

Expected Activity: We anticipate the same breadth of activity for this focus group that was seen with its predecessor focus group. This results from the contact and coordination of multiple modelers and observers that happens as a part of the focus group process.

First, we have already compiled a large email list of international scientists who represent the ionosphere and magnetosphere communities both with observations and modeling and who are interested in ion outflow and its affects on the magnetosphere. Second, we anticipate three to four sessions at each of the GEM meetings as we have had over the past 5 years. These sessions typically do comparisons between the different merged modeling approaches, comparisons between the merged models and the observations for selected storm periods and the planning of future coordinated events or challenges. This approach has lead to a large number of joint research activities which have produced research papers being published in JGR, Planetary and Space Science, the AGU Yosemite monograph, and an ISSI special book.