

GEM Focus Group Proposal on “Ionospheric Feedbacks on Magnetospheric Processes”

Topic

The huge volume of the magnetosphere combined with the availability of only sparse *in-situ* observations has long been a major complication in identifying and understanding the physical processes that occur there. However, since the ionosphere/magnetosphere system is coupled via magnetic field lines that permeate most of the region, the ionosphere can be viewed as a “giant TV screen” upon which signatures of magnetospheric processes are projected. The most obvious of these signatures are the northern and southern optical auroral emissions that have been routinely observed from both the ground and from space for decades, but other types of instrumentation/techniques can also be used to detect these signatures including: radars, ground and LEO magnetometers, wave measurements, TEC measurements, ENA imaging, etc. Despite the long history of using auroral observations to understand magnetospheric processes and dynamics, the time-dependent mapping, as well as the limited understanding of the transition region (e.g., auroral acceleration region) between the ionosphere and magnetosphere, the ionospheric signatures of many magnetospheric processes remain often speculative. However, the M-I connection also works in the reverse direction, such that the ionosphere feeds back on magnetospheric dynamic. One such feedback is ionospheric outflow, which is covered by a separate FG and will not be considered here. Electromagnetic feedback is more direct. For example, the electric field of the ionosphere produces shielding and over-shielding of the inner magnetosphere. Conductance – FAC mismatches can produce SAPS/SAIDS, which in turn alter the plasmasphere and convection. During storm recovery, the ionosphere can produce dynamo currents that compete with magnetospheric FACs and also alter convection. More subtle, but possibly of fundamental importance, is the effect of ionosphere conductance on convection during the sub-storm cycle, because a positive feedback loop between precipitation, conductance, and convection, is possible.

The proposed Focus Group will concentrate on developing a detailed understanding of what, if any, ionospheric signatures can be definitely tied to specific magnetospheric processes, and whether or not M-I feedbacks are involved. To accomplish this goal, heavy use of diverse observations and modeling results will be required. Data analysis, using the latest data sets available, such as THEMIS, VAP, MMS, and the vast arrays of ground observations, will help establish and constrain the M-I behavior. However, it is difficult to establish the presence, and/or the efficacy of the M-I coupling processes by data analysis alone. The FG will therefore heavily rely on simulation work. Many of the global models have recently been upgraded to include detailed coupled sub models of the IT system and the kinetic dynamics of the inner magnetosphere and ring current. These models are now well positioned to tackle these problems. In particular, the models allow users to turn off/on various feedbacks to study their effects. This focus group contributes directly to the MI-Coupling and GGCM research areas that have been highlighted by GEM.

Timeliness

This proposed focus group is timely for a number of reasons. Recent observational programs have produced a wealth of data obtained simultaneously from disparate geospace regions. Specifically, these datasets provide exciting new possibilities through numerous conjunctions to examine the interrelationship between convection, currents, plasma structuring, and the ionosphere. Just as importantly, global, coupled models have reached a stage of maturity that promises significant advances in short order. On the flip side, though, the models are also much more complex, so that thorough validation and testing is required. This FG will provide an excellent venue for such activities.

Fit

The proposed FG will relate to several other FGs. Specifically, the “mapping” FG has addressed M-I coupling issues, but from a more passive perspective. Since that FG is wrapping up, its legacy will provide a good foundation for this FG.

There is some overlap with the “Testing proposed links between mesoscale auroral and polar cap dynamics” FG. Although topics addressed there may be relevant to this FG, it is much more focused on substorms specifically. Also, many of the inner magnetosphere FGs (who often ignore the ionosphere) may see some overlap with this FG. More importantly, though, this FG touches many IT issues, so we foresee intense collaboration with the CEDAR community.

Goals & Deliverables

The primary goal of the FG is to gain a detailed physics-based understanding of the nature and the importance of specific ionospheric signatures that can be related to specific magnetospheric processes. We will collect data for specific events, organize campaigns to compare model results with data, establish which models can reproduce which processes, and generally drive the further development, testing, and validation of models.

Co-Chairs

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Research Area: MIC – Magnetosphere/Ionosphere Coupling Research Area

Term: 5 years (2016-2020)

Expected activities

- selection of plenary talks to introduce the topic and summarize progress.
- sample of session topics:
 - How does inner magnetosphere shielding work, and how does it influence RC/RB dynamics?
 - What are the main drivers of SAPS/SAIDs?
 - How much can ionosphere dynamo currents affect the magnetosphere?
 - Does ionosphere conductance affect substorm onset? If so, what are the feedback loops?
- collection of data for community-wide comparative studies.
- organization of challenges and comparison campaigns.
- close collaboration with the CEDAR community, in particular organizing joint sessions.
- organization of joint sessions, in particular with: Tail-Inner Magnetosphere Interactions FG, Inner Magnetosphere Cross-Energy/Population Interactions FG, Storm-time Inner Magnetosphere-Ionosphere Convection FG, Geospace Systems Science FG.
- organize a special JGR issue towards the end of the FG.
- the co-chairs promise to summarize the results in a review paper by the end of the FG. The format is still open. It could be a traditional publication in a journal like SSR, or a “living review.”