Project Details

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Topic: Studies of the Global Electrodynamics of Ionospheric Disturbances

Project Title:
Storm Enhanced Density, Tongues of Ionization, and Sub Auroral Polarization Streams

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Summary:
Science goals: The Total Electron Content (TEC) is a critical ionosphere state parameter with significant space weather implications, primarily affecting communication and navigation systems. Sub-Auroral Polarization Streams (SAPS), also known as Sub-Auroral Ion Drifts (SAIDs), are fast westward flows in the ionosphere that occur at latitudes lower than auroral precipitation, and well separated from the high-latitude convection pattern. Although SAPS were first observed in the ionosphere, they can also be seen in the magnetosphere, and they are believed to be driven by a combination of region-2 currents and low ionospheric conductance. SAPS are thus governed both by magnetosphere and ionosphere processes and require self-consistently coupled models of the outer magnetosphere, the inner magnetosphere and the ring current, and the ionosphere-thermosphere system. In conjunction with the convection patterns associated by SAPS, plasma with high electron density is convected both sunward and upward through the cusp and forms a region of strongly enhanced TEC that extends over the polar cap, creating Storm Enhanced Density (SED) and the Tongue of Ionization (TOI). Over extended time periods, the TOI can reconnect with the convection pattern in the night side. SED, SAPS and the TOI are primarily storm time phenomena, and they produce depletion as well as enhancements in TEC. Thus, understanding the underlying physics and developing predictive models is important.

Specifically, we will address the following questions:

1. How do SAPS and TOI depend on solar wind drivers?

2. What are the mechanism that control SAPS, such as recombination, transport, and inner magnetosphere plasma populations?

3. How do SED, SAPS and the TOI connect to the magnetosphere?

4. How do SAPS affect the penetration electric field?

5. Does the proposed positive feedback mechanism between flows, recombination, and conductance exist and does it require a threshold of convection to become effective.

Methodology: We will primarily use the OpenGGCM-RCM coupled model, which includes all of the required physical processes and feedbacks. In particular, the ionospheric conductance is computed self-consistently from both magnetosphere electron precipitation, solar ionization, and ionospheric chemistry within the fully dynamical CTIM sub model of OpenGGCM. Furthermore, CTIM includes the recombination feedback of streaming ions. The ability of the coupled model to reproduce SAPS events has recently been demonstrated. During the course of the investigation, CTIM will be replaced by a more sophisticated ionosphere model, the Ionosphere Plasmasphere Electrodynamics (IPE) model developed at NOAA and CU. The latter model provides a unified treatment of the ionosphere over all latitudes, and a plasmasphere model as well. We will also use available data, such as radar, TEC maps, LEO satellite data, and inner magnetosphere data from the VAP, MMS, and THEMIS missions, to validate model results. Physical processes will be investigated by, for example, calculating energy and momentum flows, examining Poynting fluxes, examining the current systems, and by turning on or off various coupling terms.

Contributions to the FST effort: We will particularly address LWS topic SSA-4 Physics-based TEC forecasting capability, and also contribute to SSA-5 because scintillations result from TEC gradients.

Publication References:

no references