Project Details

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Program Element: Focused Science Topic

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

Project Title:
Heavy Ions Inside Geostationary Orbit

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Summary:
** Science Goals and Objectives. Singly charged oxygen plays multiple key roles in magnetospheric dynamics. However, our quantitative knowledge of the multispecies ion dynamics inside geostationary orbit is still limited by sparse measurements. We create an empirical model of the inner magnetosphere multispecies ion plasma based on Van Allen Probes data (2012-present), and use this model to address science questions on the distribution and role of O+.

Project Objective: Develop a comprehensive empirical model of the inner magnetosphere near-equatorial multispecies ion environment and use the model to address Focus Science Team (FST) science.

Science Question 1: What is the spatial and temporal relationship between different O+ populations co-located in the inner magnetosphere, and what controls the distribution, amount, and characteristics of O+ during solar cycle changes?

Science Question 2: What is the role of lower energy (

** Methodology. Key data sources for the model are Van Allen Probes data since its launch in late 2012: HOPE (ion data 1 eV through 50 keV), RBSPICE (> 150keV for O+), EFW (spacecraft potential; total plasma density; DC electric field), EMFISIS (total plasma density; magnetic field), OMNI solar wind data (solar wind context), and standard geomagnetic activity indices (e.g., sym-H, AE, etc.). The model is centered around an extensible relational database of binned data with sophisticated query and analysis capabilities.

The model describes species-resolved (O+, He+, H+) ion characteristics (spectra, PADs, moments) and environment parameters (e.g., total density, DC fields) as a function of solar wind and magnetospheric parameters on a configurable 2D L/MLT grid. Time information and data source coordinates are retained. Physical boundaries (e.g., plasmapause) and statistical uncertainties of all model outputs are provided. Outputs are validated with other data-driven models, where available.

Science questions are answered by creating model outputs driven by relevant input parameters and fiducial marks, followed by further analysis.

SQ-1: We perform statistical analyses of the distribution of various ion plasma populations and their drivers. The plasmapause mostly separates warm from cold plasma, therefore we study populations referenced to the plasmapause location. We compare statistical results to HEIDI kinetic model calculations of the ion dynamics inside geostationary orbit.

SQ-2: We perform statistical analyses on ensembles of storms, followed by a detail comparison between model outputs and HEIDI model calculations. HEIDI is seeded by pre-storm model outputs. We investigate the global role of below 40 keV O+ on ring current decay with HEIDI calculations, comparing with Van Allen Probes observations.

** Proposed Contribution to the Focus Team Effort. This proposal contributes significantly to the ion circulation FST. As per the NRA: "Proposals to this FST should aim to determine heavy ion characteristics in the magnetosphere across a wide range of L-shells/geomagnetic latitudes (...)" providing "identification of what controls heavy ion characteristics in the ionosphere and magnetosphere; (...)". Specific investigations, e.g., "data analysis that seeks to characterize the spatial and temporal distribution of O+ in the inner magnetosphere (...)" are suggested.

We characterize the heavy (and light) ion environment for populations inside geostationary orbit in a comprehensive and flexible way using 5+ years of Van Allen Probes data. Our model and science analyses are performed in collaboration with the FST. The model and its outputs are available to the FST during the project. We can expand/modify the model based on FST input. We anticipate collaboration with both simulations efforts and data studies. The model is designed to facilitate easy inclusion of additional data in response to FST needs (e.g., wave data).

Publication References:

no references