Project Details

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Program Element: Focused Science Topic

Topic: Understanding and Predicting Radiation Belt Loss in the Coupled Magnetosphere

Project Title:
Quantitative Assessment of Loss Processes in the Radiation Belts

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Summary:
OBJECTIVES: Understanding the physical processes and timescales for energetic particle loss are crucial to understanding the overall dynamics of the radiation belts. Here we address the overarching science question: "What are the relative effects of particle loss due to wave-particle interactions and magnetopause loss?" In particular,

1) How do different loss mechanisms vary with solar wind drivers and geomagnetic activity? We will examine loss processes as a function of location in the inner magnetosphere, and will use event-specific solar wind conditions and diffusion models to contrast particle loss during CME- and CIR-driven storms.

2) What are the effects of differing ULF and VLF wave distributions on the resulting radiation belt phase-space density profiles? Our method of developing event-specific diffusion models will provide insight into the relative effects of these waves on radiation belt losses.

3) What are the relative effects of atmospheric precipitation as compared to nonadiabatic loss to the magnetopause? Our method allows us to selectively remove or accentuate certain effects and wave modes, allowing us to examine the impact of each separately.

METHODOLOGY: This study will combine state-of-art global simulations of the coupled solar wind/magnetosphere system with comprehensive observations of the inner magnetosphere via the Van Allen Probes, THEMIS, BARREL, geosynchronous, and other available observational platforms.

Simulations will be undertaken using the K2 modeling framework. This model combines global, 3d MHD simulations of Earth's inner magnetosphere with energetic test particle simulations, augmented by Stochastic Differential Equation (SDE) methods, to allow simulation of wave-particle interactions with high-frequency waves not described within the MHD appproximation. This framework can self-consistently model radial transport due to interactions with global ULF waves, impulses in the solar wind, and substorm activity; accurately describes the location and evolution of the magnetopause under varying solar wind condtitions; and captures the effect of precipitation losses due to high-frequency wave-particle scattering.

CONTRIBUTIONS: This proposal addresses Focus Science Topic #2, "Understanding and predicting radiation belt loss in the coupled magnetosphere". This work will directly address all three of the major goals and objectives under this Science Topic, as described in Section 3.2 of the AO. Specifically, our work will (1) provide better understanding and ability to predict how overlapping plasma populations can impact the radiation belt loss processes of electrons, by using comprehensive, coupled simulations of the inner magnetosphere, including the plasmasphere, ring current, plasma trough, and magnetopause, to examine in detail the losses due to wave-particle-induced precipitation. (2) Provide improved understanding and prediction of radiation losses by non-adiabatic dropout events. Our simulation framework will self-consistently model both outward radial transport and the time-evolving location and shape of the magnetopause and associated losses, as well as precipitation due to wave-particle interactions, to elucidate factors controlling the non-adiabatic loss of particles from the radiation belts and identify physical parameters predicting such losses. And (3) examine other potential loss processes, such as non-linear wave-particle interactions and effects of Shabanksy orbits on precipitation and magnetopause loss of electrons.

Publication References:

no references