Project Details

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Program Element: Focused Science Topic

Topic: Characterization of the Earth's Radiation Environment

Project Title:
Predicting Radiation Variability in Earth s Magnetosphere

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Summary:
Science Goals and Objectives

The intensification of the radiation belts and ring current has significant impacts on the space environment. Moderate energy (~10 to 100 keV) electrons can cause surface charging effects, and relativistic (~0.1 to 5 MeV) electrons can cause deep-dielectric charging on space systems. While energetic ions do not cause substantial charging, they are indirect drivers of the radiation belts via wave generation, magnetic and electric field perturbations, etc. Therefore, understanding the physical processes that are controlling the dynamics of the radiation belts and ring current during active periods and being able to predict their variability have important space weather significance.

A number of models have been established to simulate the radiation belt and ring current dynamics during magnetic storms. However, it is still a challenge to accurately predict the absolute intensities of energetic electron and ion fluxes. The user community therefore is often forced to rely on empirical models, which are limited to an averaged picture of the radiation environment but are of limited utility in understanding a particular event.

The primary goal of this project is to build an accurate and reliable radiation environment model of the inner magnetosphere and ionosphere and use it to assess impact on spacecraft charging. Specific science objectives to be addressed are:

1. To characterize how different solar wind inputs affect the radiation environment in the inner magnetosphere and ionosphere.

2. To quantitatively assess the influences of the radiation belts on the charging of spacecraft materials and space systems in various orbits and under different conditions.

The project will include extensive model-data comparisons for model validation and further improvement of the model predictability. A systematic modeling of storm events will help characterize the uncertainty in the radiation environment.

Methodology

To address our first question we will use first principles models of the space environment system. Specifically we use the Comprehensive Inner Magnetosphere-Ionosphere (CIMI) Model. This model combines Radiation Belt Environment (RBE) model and the Comprehensive Ring Current Model (CRCM) to produce a complete, and extensively tested and validated, model of the ring current and radiation belt populations. Recently, CIMI has been coupled with the BATSRUS global MHD model. This combined modeling capability is thus able to simulate the effects of HSS, CME and other solar wind input on the radiation environment in the inner magnetosphere and ionosphere.

We will also assess the implications of the radiation belt variation for spacecraft charging. Surface charging is caused by enhanced fluxes of moderately energetic electrons, such as those encountered during substorms and storms. Models like NASCAP and SPIS are used to model spacecraft charging, but these require as inputs a description of the space plasma and radiation environment. Internal or deep dielectric charging occurs due to penetrating electrons from the radiation environment that become embedded deep inside insulating materials, and are not easily dissipated via sunlight or the cold plasma environment. The relative rates of deposition and dissipation of charge depend on the time variability of the radiation environment due to space weather and spatial variations over a spacecraft orbit.

Proposed Contributions to the Focus Team Effort

The project directly addresses the objectives of the focus science topic Characterization of the Earth s radiation environment . It contributes to the LWS Strategic Science Areas SSA-1 and SSA-6. This project also contributes significantly to the mission and spacecraft design community. The simulation and observational data available to this proposal team will be shared with the entire focus science team and the boarder science

Publication References:

no references