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Title: A New Drift Shell Integration Technique for Inner Magnetospheric Space Weather Models

Summary: The overarching goal of the proposed work is to deliver a new tool that will significantly advance our understanding of the physical processes responsible for the storm-time variations in the radiation belts. The key to the theoretical understanding and modeling of the radiation belts is detailed information about the Earth's magnetic field. The geomagnetic field is dynamic and is distorted by complex interactions with the solar wind. The magnetic drift invariant, known as L* (pronounced L-star) is used to model radiation belt dynamics. L* is directly related to the magnetic flux enclosed by a charged particle trajectory. Current applications and models either use a computationally intensive numerical integration to calculate L* or apply inadequate static models that are fast and easy to compute. Long computing times have been a long standing pitfall to accurate radiation belt research and the advancement of predictive models.

We propose to develop a new and faster tool that holds the potential to reveal underlying physical processes and mechanisms responsible for the storm-time variations in the radiation belts. Our tool will be using a novel approach of calculating adiabatic coordinates as an important stepping-stone towards answering the motivating science questions:

(1) What is the relative contribution of radial transport, localized acceleration, and loss process that cause the storm-time dynamics of radiation belt electrons?

(2) Do different types of solar wind events (high-speed streams, coronal mass ejections) lead to different dynamics and acceleration processes in the radiation belt environment during different phases of the solar cycle?

(3) Are the increased flux levels due to radial transport or a localized acceleration process and can they be linked to the different driving conditions in the solar wind?

In this project we will apply a neural network technique to calculate L* with a high degree of fidelity several orders of magnitude faster that with the standard integration technique. We have tested and validated a preliminary version of this tool, thus demonstrating its feasibility. This is a highly innovative approach that will enable the broad radiation belt research community to study a large amount of radiation belt data as a function of solar wind condition surpassing any degree of fidelity ever attempted before.

This work is both advantageous and timely for the LWS TR&T program goal of understanding the integral system linking the Sun to the Earth's magnetosphere. Specifically, our technique will be able to address the origin of radiation belt enhancements - a research task that will directly contribute to the NASA research objective of "developing the capability to predict the extreme and dynamic conditions in space in order to maximize the safety and productivity of human and robotic explorers".

In Summary:

Deliverable: the neural network as part of a software library including documentation

Delivery Site: Virtual Radiation Belt Observatory (ViRBO)

Schedule: three months before completion to allow for implementation support