Project Details

ROSES ID: NNH18ZDA001N
Selection Year: 2018
Program Element: Focused Science Topic

Topic: Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures

Project Title:
Ring current dynamics and associated wave activity in response to solar wind drivers using machine learning

PI Name: Jinxing Li
PI Email: jli@atmos.ucla.edu
Affiliation: University of California, Los Angeles
Project Member(s):
- Yue, Chao;Co-I;University of California, Los Angeles
- Bortnik, Jacob;Co-I;University of California, Los Angeles
- An, Xin;Co-I;University of California, Los Angeles

Summary:
science objectives:
This project aims to model and predict the dynamic evolution of ring current ions and the associated waves in response to different solar wind drivers using machine learning technique and wave-particle interaction simulations. The ring current enhancement is the direct cause of geomagnetic storms, which impact telecommunication and navigation systems, as well as power grids. The electromagnetic ion cyclotron (EMIC) waves and magnetosonic waves that grow from ring current ion instabilities can scatter the ring current ions and radiation belt electrons via wave-particle interactions. Therefore, quantitative understanding of the ring current dynamics is crucial in predicting global space weather and protecting spacecraft. The science goals of this project include:
1. Establishing a 3-D ring current ion energy distribution and pitch angle distribution model at different radial distances, magnetic latitude and local times in response to the solar wind drivers using machine learning technique.
2. Predicting the wave distribution due to ring current ions instabilities, including the EMIC waves and magnetosonic waves, and their response to solar wind drivers and geomagnetic indices.
3. Calculating the decay rates of ring current ions from the machine learned ring current model. Evaluating the ion loss caused by scattering from EMIC waves and magnetosonic waves.
4. Investigating the nonlinear ion scattering and acceleration caused by waves using test particle simulations.

Methodology:
1. We will utilize multi-point measurements to study the ring current dynamics and the associated wave activities from a global view. The data to be used includes ion fluxes, magnetic field, and wave spectra from 2 Van Allen Probes, 3 THEMIS satellites, and the Arase satellite.
2. We will use the machine learning technique to model the ion dynamics in response to different geomagnetic indices (Dst index, AE index, etc.) and solar wind drivers (IMF dynamic pressure, magnetic field, etc.).
3. We will use the quasi-linear diffusion simulations to model the ions loss rate caused by scattering from EMIC waves and magnetosonic waves.
4. We will use test particle simulations to study the linear/nonlinear interactions between ring current ions and waves.

Proposed Contributions to the Focused Science Team Effort:
Our proposed project directly targets Goal #3 of the FST, understanding the response of magnetospheric plasma populations to solar wind structures . By modeling the ring current dynamics using the machine learning technique and utilizing multi-spacecraft observations, we will target the goal of improving empirical models for the magnetospheric plasma environment as a function of solar wind and geomagnetic conditions . By modeling the wave growth from the ion instabilities, and simulating the linear and nonlinear scattering of ions and electrons caused by those waves, we will target the goal of improving our understanding of nonlinear response to different driving conditions, involving coupling and feedback between populations& wave particle interactions , and how particular structures in the solar wind affect global fields and particle populations from a whole systems approach .

Publication References:

no references