Advances in Understanding Stormtime Magnetotail Dynamics

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Abstract

The Center for Geospace Storms (CGS) is dedicated to advancing our understanding of stormtime dynamics within geospace. Through the development of the Multiscale Atmosphere Geospace Environment (MAGE) model and by utilizing multi-spacecraft in-situ observations, remote sensing and ground measurements, the CGS team investigates the complex interactions and processes that occur during geomagnetic storms.

In this presentation, we focus on a series of recent scientific advancements in understanding magnetotail dynamics that highlight the multiscale nature of plasma sheet transport and ring current buildup. Observationally, a dawn-dusk asymmetry in ring current indices has been identified, revealing the existence of a dawnside current wedge (DCW) similar to a substorm current wedge but shifted toward dawn during the main phase of the storm. Furthermore, using data from the Geotail and Magnetospheric Multiscale (MMS) missions, an elevated convection electric field manifests in the dawn magnetotail through faster flows and at dusk through more dipolar field. MAGE simulations have phenomenologically reproduced the DCW and demonstrated that the dawnside plasma sheet is characterized by deeper penetrating bursty bulk flows (BBFs) due to asymmetric reconnection caused by the stormtime ring current asymmetry. Additionally, simulations indicated that at least 50% of the plasma energy enhancement within 6 RE during strong storms can be attributed to the presence of BBFs. To complement the global geospace simulations, as well as *in-situ* and ground measurements, we have also been developing a synthetic Energetic Neutral Atom (ENA) experiment within our global model both to help interpret prior ENA measurements (e.g., from the TWINS mission) of nightside energetic particle injections and to inform future instrumentation of this powerful remote sensing technique.

By examining phenomena across various spatial and temporal scales, and through all available means, CGS aims to improve predictions of geomagnetic storm effects on Earth's space environment and to provide a global understanding of the magnetosphere’s 3D geometry and its response to external drivers during storms. This comprehensive approach is required to address the challenges of space weather and to understand the Earth’s magnetosphere.