Project Details

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Project Title:
Empirical specification and forecasting of the inner magnetosphere magnetic field

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Summary:
Science goals and objectives: The objective of this project is to investigate the influence of solar wind and IMF parameters on the structure and evolution of the magnetic field in the inner magnetosphere. This knowledge will be used to develop capabilities for quantitative prediction and specification of the inner magnetosphere environment. A distinctive feature of this study is the use of a new generation of empirical geomagnetic field models that (i) are free from ad hoc distortions characteristic of the past custom-tailored models; (ii) have the spatial resolution capable of resolving the key morphological features of the inner magnetosphere; (iii) respond to multiform variations of solar wind driving, including its trends and memory effects. Earlier empirical models (e.g., TS05) used global indices or pre-defined functions of the solar wind/IMF parameters as their input, as well as custom-tailored modules for the major current systems (e.g., partial and symmetric ring currents). A new approach, suitable for retrieving from data the actual shape of magnetospheric currents and taking consistently into account trends and integral effects of the solar wind driving was implemented in the new TS07D model. We propose another major advance in this direction with the main goal to 1) provide a high accuracy specification of the inner magnetosphere magnetic field and 2) determine key factors of the solar wind driving, which control the storm-time magnetic field.

Methodology: To achieve these goals we first propose to fit TS07D with modern Van Allen Probes and THEMIS data as well as historical data from the Polar mission to determine the number of basis functions describing the equatorial currents, which resolve the structure of the storm-time inner magnetosphere, including radial and local time current distributions around the pressure peak. Second, we will investigate the flexibility of the new system of field-aligned currents, assuming their variation in latitude and local time to match the present equatorial current expansion. The new system reproduces the Harang discontinuity effect. Third, we will investigate the sensitivity of the new empirical magnetic field specification to various factors of the solar wind driving. So far it was determined by the solar wind electric field parameter vBz, Sym-H index and its time derivative. In this project we investigate magnetospheric response to inputs using the preceding solar wind/IMF parameters only and thus providing empirical forecasting capability. We will also investigate the effects of the extension of the input state due to the IMF clock angle, solar wind density, velocity, and turbulence amplitude. Since all key elements of the model have already been designed and tested its further development will constitute only a minor part of the proposed effort.

Relevance: The project , " s objective is consistent with the overarching goal of the LWS SCOSTEP/VarSITI Program element SPeCIMEN to provide , "quantitative prediction and specification of the Earth , " s inner magnetospheric environment based on Sun/solar wind driving inputs , . The geomagnetic field is one of the main parameters that determine the state of the inner magnetosphere. It plays a key role in coupling the inner magnetosphere processes, because it determines the shape and evolution of radiation belts, provides the mapping between the inner magnetosphere and the ionosphere, allows one to reconstruct the global current systems, their 3D structure and closure paths, and even to assess the plasma pressure distribution from the quasi-static force balance equation. Thus, this project directly addresses SPeCIMEN , " s goal to , "understand how the inner magnetosphere responds as a coupled system to Sun/solar-wind driving , . Moreover, since the proposed empirical specifications are driven by data rather than by an ad hoc model structure, they are particularly suitable for integration with other models, both empirical and first-principles ones.

Publication References:

Summary: no summary

Reference: Stephens, G. K.; Sitnov, M. I.; Ukhorskiy, A. Y.; Roelof, E. C.; Tsyganenko, N. A.; Le, G.; (2016), Empirical modeling of the storm time innermost magnetosphere using Van Allen Probes and THEMIS data: Eastward and banana currents, Journal of Geophysical Research: Space Physics, Volume 121, Issue 1, pp. 157-170, doi: 10.1002/2015JA021700