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Data-Based Mapping of Our Dynamical Magnetosphere (Julius Bartels Medal Lecture)

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The geomagnetic field is a principal agent connecting our planet's ionosphere with thehighly variable interplanetary medium, incessantly disturbed by dynamical processesat the Sun. The Earth's magnetosphere serves as a giant storage reservoir of energy pumped in from the solar wind and intermittently spilled into the upperatmosphere during space storms. As the humankindgets more and more dependent on space technologies, it becomes increasingly important to be able to accurately map the distant geomagnetic field and predict its dynamicsusing data of upstream solar wind monitors. Two approaches to the problem have beensuccessfully pursued over last decades. The first one is to treat the solar wind asa flow of magnetized conducting fluid and to numerically solve first-principle equations,governing its interaction with the terrestrial magnetic dipole. Based on pure theory, that approachaddresses the question: "What the magnetosphere would look like and behaveunder assumption thatthe underlying approximations and techniques were universally accurate?" This lecturewill focus on the other, completely different approach, based on direct observations. Its essence is to develop an empirical description of the global geomagnetic field and its response to the solar wind driving by fitting model parameters to large multi-year sets of spacecraft data. Models of that kind seek to answer the question: "What can in situ measurements tell us about the global magnetospheric configuration and its storm-time dynamics, provided our approximations are realistic, flexible, and the data coverage is sufficiently dense and broad?" Five decades of spaceflight produced enormous amount of archived data anda number of empirical models have already been developed on that basis. Recent and ongoing multi-spacecraft missions keep pouring in new data and further expandthe huge and yet largely untapped resource of valuable information. The main goal of the data-based modeling is to extract the largest possible knowledge from the accumulated data, thus synergistically maximizing the output of present and past space experiments.