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LMSU contribution to PSWS prototype

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PU	Public	x
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

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Abstract: Lomonosov Moscow State University PSWS prototype is working in terms of generalized paraboloid model of the magnetosphere. MSU develop a generalized approach for description of magnetospheric processes while using a paraboloid of revolution to define the magnetopause shape in all scenarios. Web-portal http://www.magnetosphere.ru allows to calculate the magnetic field in the magnetospheres of magnetized planets: Mercury, Earth, Jupiter and Saturn. The magnetic field in the Earth's magnetosphere can be obtained in the real-time mode using concurrent measurements of the solar wind monitoring satellites. This model can be calibrated to be used for analysis of the magnetosphere of any solar system planet possessing an intrinsic magnetic field. The parameters of the magnetic field models for Mercury, Jupiter and Saturn magnetospheres can be obtained from in situ satellite measurements.

1. Generalized paraboloid model of the magnetosphere

The model is intended for describing the magnetospheric dynamics taking into account the intrinsic planetary magnetic field, the magnetopause current magnetic field, the tail current system magnetic field, the magnetodisc magnetic field, the ring current magnetic field, and the interplanetary magnetic field penetrated from solar wind. Such modular structure allows to represent the magnetic field inside the magnetospheres of Mercury, Earth, Jupiter, and Saturn.

2. Upgrade the paraboloid magnetospheric models of the Solar system planets

LMSU team has improved the paraboloid magnetospheric model and has continued working on a generalized magnetospheric model. This model can be calibrated to be used for analysis of the magnetosphere of any solar system planet possessing an intrinsic magnetic field. Consequently, we aim to develop a generalized approach for description of magnetospheric processes while using a paraboloid of revolution to define the magnetopause shape in all scenarios. Once successful, we can test the model using spacecraft data from European and US missions (MESSENGER, Cassini, Galileo, Juno); additionally, it may be used to investigate exoplanetary magnetospheres and to interpret the role of magnetic field in planetary atmosphere evolution and potential habitability.

2.1 The combined model of Mercury’s magnetosphere

The combined model (comprised of a numerical hybrid simulation and the empirical paraboloid model) of Mercury’s magnetosphere has been constructed. It gives us the possibility to refine the global parameters of magnetosphere using MESSENGER’s magnetometer data from each of over 4100 orbits of the spacecraft around Mercury (see Parunakian, D., S. Dyadechkin, I. Alexeev, E. Belenkaya, M. Khodachenko, E. Kallio, and M. Alho (2017), Simulation of Mercury's magnetosheath with a combined hybrid-paraboloid model, J. Geophys. Res. Space Physics, 122, 8310–8326, doi: 10.1002/2017JA024105).

We have performed calculation of the initial magnetospheric magnetic field of Mercury and the boundary conditions for subsequent hybrid modeling and defined the initial parameters of the global magnetospheric current systems in a way that allows us to minimize paraboloid magnetic field deviation along the trajectory of MESSENGER from the experimental data. We have modelled the magnetosheath magnetic field and calculated the portion of the interplanetary magnetic field penetrating the magnetosphere (see Alexeev I., Parunakian, D., Dyadechkin, S. et al. Cosmic Res (2018) 56: 108. https://doi.org/10.1134/S0010952518020028).

2.2 Optimal parameters of the Jovian magnetodisc

Juno measurements of the magnetic field during the Perijove 1 pass have allowed us to determine optimal parameters of the magnetodisc using the paraboloid magnetospheric magnetic field model which employs analytic expressions for the magnetospheric current systems. Specifically, within the model we determine the size of the Jovian magnetodisc and the magnetic field strength at its outer edge (Pensionerov et al., 2019,. Ann. Geophys., 37, 101-109, https://doi.org/10.5194/angeo-37-101-2019). We have also researched alternative magnetodisc descriptions, including the 1/r azimuthal current density dependence on the radial distance to the planet and $1/r^2$ dependence.

2.3 An open and a partially closed models of the Saturn’s magnetosphere.

We have continued our work on the determination of the main features of Saturn's magnetosphere using Cassini magnetic field data. We have compared 2012/2013 Saturn northern spring interval of highly inclined orbits with similar data from late southern summer in 2008, thus providing unique information on the seasonality of the currents that couple momentum between Saturn's ionosphere and magnetosphere.
Inferred meridional ionospheric currents in both cases consist of a steady component related to plasma subcorotation, together with the rotating current systems of the northern and southern planetary period oscillations. This can help us to develop a correct model of the field-aligned currents in the magnetosphere (see Bradley, T. J., Cowley, S. W. H., Provan, G., Hunt, G. J., Bunce, E. J., Wharton, S. J., Alexeev, I. I., Belenkaya, E.S., Kalegaev, V.V., Dougherty, M.K. (2018). Field-aligned currents in Saturn's nightside magnetosphere: Subcorotation and planetary period oscillation components during northern spring, JGR, v122, issue 5, 3602-3636, https://doi.org/10.1029/2017JA024885).

Lomonosov Moscow State University team considered two magnetospheric magnetic field models for the case of Saturn: an open model in which the IMF penetrates the magnetosphere, and a partially closed model in which field lines from the ionosphere go to the distant tail and interact with the solar wind at its end. To that end we have used Cassini magnetometer data, images of Saturn's ultraviolet aurora obtained by the HST, and the paraboloid model of Saturn's magnetospheric magnetic field. We have concluded that the open model is preferable, which is more obvious for southward IMF; this result will be used in the generalized paraboloid model for the case of Saturn. Different magnetospheric topologies determine different mapping of the open-closed boundary in the ionosphere, which can be considered as a proxy for the poleward edge of the auroral oval (see Belenkaya, E. S., Cowley, S. W. H., Alexeev, I. I., Kalegaev, V. V., Pensionerov, I. A., Blokhina, M. S., and Parunakian, D. A.: Open and partially closed models of the solar wind interaction with outer planet magnetospheres: the case of Saturn, Ann. Geophys., 35, 1293-1308, https://doi.org/10.5194/angeo-35-1293-2017, 2017).

2.4 Access to PSWS prototype

Models can be accessed through http://www.magnetosphere.ru Web-site. This is prototype of planetary space weather service that allows to represent the magnetic field structure in the magnetosphere for a given time moment.

3 Future development

At this moment only the Earth's magnetosphere can work in operational mode using data from solar wind. Operational regime for the other magnetospheres can be realized after implementation of propagation tool that give input data for the model.

Bibliography

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