EPSC Abstracts
Vol. 7 EPSC2012-337 2012
European Planetary Science Congress 2012

Numeric Simulation Tools of the IMPEx Infrastructure

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Abstract

The EU-FP7 Project "Integrated Medium for Planetary Exploration" (IMPEx) was established as a result of scientific collaboration between institutions across Europe and is working on the integration of a set of interactive data analysis and modeling tools in the field of space plasma physics. These tools are comprised of numerical Hybrid/MHD and analytical Paraboloid magnetospheric models from the simulation sector as well as AMDA, ClWeb and 3DView from the data analysis and visualization sector. The basic feature of IMPEx consists in connection of different data sources, including archived computational simulation results and observational data, in order to analyse and visualize scientific data by means of interactive web-based tools.
In this presentation we introduce Hybrid and Magnetohydrodynamic Modelling (HMM) environment which is an example of simulation services within IMPEx. HMM includes two global numerical hybrid models (a hybrid model HYB from FMI and a hybrid model from LATMOS) and magnetohydrodynamic model (GUMICS) from FMI. Especially, we introduce the web service, Hybrid Web Archive[1] which enables access to the simulation runs made by HYB and GUMICS models in the IMPEx HMM environment.

1. Introduction

Solar wind interactions of Solar System objects are simulated numerically commonly by two approaches: by hybrid models or by magnetohydrodynamic (MHD) models.
A hybrid approach provides an efficient way to model how the cosmic plasma interacts with non-magnetized and magnetized planetary objects. In a hybrid model ions are treated as particles, while electrons form a massless, charge neutralizing fluid. In an MHD model the solar wind and planetary plasmas are modelled as a fluid.
In the HMM environment of IMPEx the solar wind interaction with the Earth is modelled as a single fluid MHD model GUMICS[2] developed at FMI. Solar wind interactions with other Solar System objects are modelled by hybrid models.
The HYB hybrid model family has been developed at the Finnish Meteorological Institute (FMI) during the last decade (Fig. 1) and it has been used successfully to describe how the flowing plasma interacts with various solar system bodies such as Mercury[3], Venus[4], the Moon[5], Mars[6], Saturnian moon Titan[7], asteroids[8] and comets.

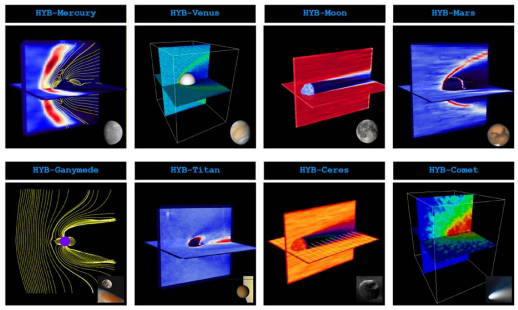

Figure 1: Computational modelling of planetary magnetospheres by Finnish Meteorological Institute's (FMI) 3D hybrid model platform (HYB). The figure shows examples of the Solar System objects which plasma environments can be modeled self-consistently with the HYB platform: Mercury (HYB-Mercury), Venus (HYB-Venus), the Moon (HYB-Moon), Mars (HYB-Mars), Ganymede (HYB-Ganymede), Titan (HYB-Titan), asteroids (e.g. HYB-Ceres) and comets (HYB-Comet). The Earth will be modeled with FMI's 3D MHD model GUMICS (figure not shown). These models are part of the "demonstration models" in the IMPEx project.

In this paper we describe the infrastructure build within IMPEx to enable a simple user-friendly access to HYB and GUMICS simulation runs.

2. Modelling environment within IMPEx

The IMPEx modeling sector includes three global models and their computing infrastructures for simulation of plasma environments of different solar system objects [9, 10, 11]. These models stay in the basis of two IMPEx modeling work packages: 'Hybrid & MHD models (HMM)' and 'Paraboloid Magnetospheric Models (PMM).

The HMM environment build in IMPEx will provide hybrid and MHD models for the following applications:

• Creation and continuous fill-in of the modelling runs database which will be accessible via the user friendly interface AMDA (Automated Multi-Dataset Analysis) [12]
• Delivery of the modelling data to a 3D data visualization environment
• Build-up of a direct access to the models and their data by external users
• Providing of modeling demonstrators for public education purposes

Acknowledgements

The authors are thankful to the EU FP7 project IMPEx (Integrated Medium for Planetary Exploration), project number 262863, for providing a platform for their research collaboration and communication.

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