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IMPEx Data Model: a simulation extention to the Spase data model.

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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 and planetary physics. The purpose of this project is to create an interface between planetary simulation databases and online data processing tools hosted in different institutes. However, the tools involved in IMPEx were primarily built and are used to process 'real' data that have been gathered by spacecraft. The IMPEx project thus insert itself in a wider scheme involving a large part of the planetary environment community.

As an interface between simulation databases and tools, IMPEx must provide those entities a way to exchange data with each other. Part of it requires the specification of a language describing the data that are exchanged, that is a data model. We will present here the data model we developed for the IMPEx project. This data model extends the Spase data model which is widely used to describe observations and measurements in the space plasma domain.

1. Introduction

Although numerous Data Models (DM) have been developed to support the current effort to build large virtual observatories linking numerous databases worldwide, only a few of them allow to describe simulation data and/or inputs. Moreover, most of those have been designed to describe a particular type of simulation models and are not easily extendable. Others have a wider goal and expect to describe any simulation data, but those are still under developement and face difficulties due to the large variety of numerical codes. None of the existing DM were thus adaptable to the needs of the IMPEx project, which acts as an interface between simulation databases and data processing tools hosted in different institutes across Europe [1]. We thus developed a new data model for this project, which we present here. In developing IMPEx DM, we paid a particular attention to have as little complexity as needed to describe the numerical codes involved in the project, but also to make the DM generic enough to permit new simulation codes to latter join the IMPEx framework.

The IMPEx DM expects to describe most of the numerical codes used for simulation solar system plasmas, in particular those describing the interaction of planets and satellites with a plasma flow (solar wind or magnetopsheric plasma). This puts enough limits on the numerical code variety to avoid many of the difficulties that DMs with wider expectations are facing. The numerical codes currently involved in the IMPEx project are of three kinds: one MHD (FMI), two Hybrids (FMI and LATMOS) and a Paraboloid Magnetospheric (SINP) models.

One of the big challenges that IMPEx is facing, is to provide the opportunity of comparing simulated and measured data. To do so, tools involved in IMPEx must be able to handle both kind of data and to display them in similar ways. The simulation codes thus generate results similar to spacecraft measurements. To facilitate the tool duties, and to have a consistent approach of the problem, the IMPEx DM describes simulation outputs in a way which is as compliant as possible with the Spase DM [2]. This latter DM is widely used by the solar system plasmas community to describe the data obtained by spacecraft.

The Spase DM provides a large list of terms which have received a precise definition, several of which are useful for describing simulation inputs and data. Using Spase DM as a basis for the IMPEx DM both allows to skip a tedious part of the DM developement, and facilitates the integration of the IMPEx DM in preexisting tools which were already handling Spase metadata. Nevertheless, the Spase DM was developed for spacecraft data only, and does not permit the description the simulation runs (that is the simulation scheme and parameters) and some of the simulation results which are not usual spacecraft diagnosis (such as 2D cuts through the simulation domains). This is the motivation behind the developement of the IMPEx DM, which extends Spase DM on two main points: (1) it introduces a new element for the descrition of simulation runs and (2) it extends the data description capability of Spase for a wider variety of data.

2 Simulation Runs

This new element permits one to describe the simulation (e.g. the model used, the simulation spatial and temporal domains) and its parameters (e.g. fields imposed, particle populations). Several elements have been defined, but when it was possible we reused Spase DM terms – paying special attention to be consistent with their definition – to give as much as possible of consistency to the IMPEx DM and to facilitate the interpretation of the metadata by the tools.

Specific sub-elements were defined which permits one to describe fields imposed in the simulation, particle populations, physical and chemical processes (photoproduction, charge exchanges,...) and parameters about the simulation target (particular planet size or orientation used in the simulation). The elements are generic enough to describe correponding parameters in almost any numerical codes.

The IMPEx DM also permits one to define generic input parameters containing multiple Property elements. These elements associate a name, a value (optionally with units, ranges of applicability,...) and an optional Spase defined term which can be interpreted by the tools.

All of these elements permits one to define user-targeted information, such as references to publications.

3 Simulation Results

In addition to time series and energy spectra interpolated along spacecraft orbits, which are similar to that measured by actual spacecraft, simulations provide several other data types. The value of each parameter can be given in the whole simulation domain, or in 2D cuts through it, and field lines and isosurfaces can be computed. Basically, simulations add spatial dimensions that are not accessible to spacecraft measurements. The capability of describing this space dependent data has been given to the IMPEx DM model, by adding a SpatialDescription sub-element to each of the data describing elements of the Spase DM.

Moreover, multiple Property sub-elements can be inserted in the Extension part of the Spase elements, which permits one to add simulation related informations to the data description.

4 Conclusion

We present the data model we developed for the IMPEx project. This data model is an extension to the widely used Spase DM which permits one to describe simulation runs and results. This data model was designed to be both limited to space plasma and planetary environment physics – limiting its complexity – and generic enough to permit new numerical codes to join the IMPEx framework.

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References

[1] IMPEx Project Website: http://impex-fp7.oeaw.ac.at/

[2] Spase group Website: http://spase-group.org/