IMPEx Simulation Data Model
a simulation extention to the Spase data model

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Summary

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 observational data that have been gathered by spacecraft. As an interface between simulation databases and tools, IMPEx provide those entities a way to exchange data with each other. Part of it is a language describing the data exchanged : a data model (DM).

Only a few existing DM allow to describe simulation data and/or inputs. Most of those have been designed to describe a particular type of simulation models (not easily extendable) or expect to describe any simulation data (too complex). None of the existing DM matches to the needs of the IMPEx project.

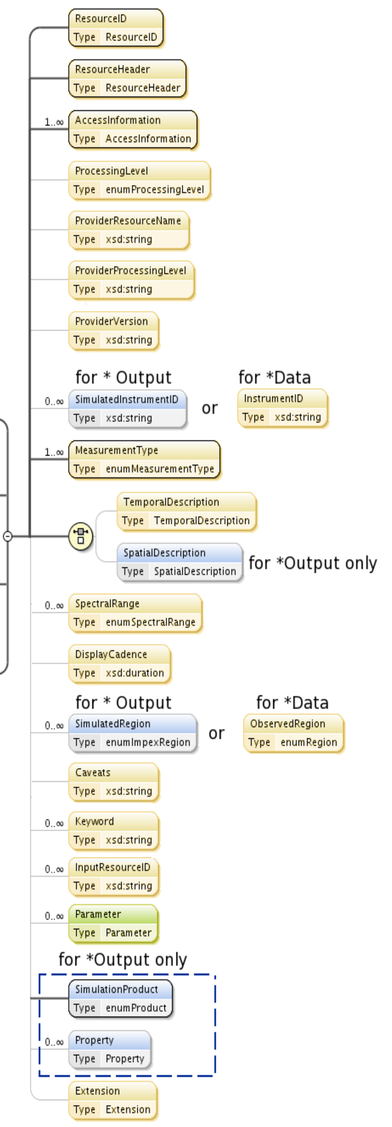
In developing IMPEx DM, we paid a particular attention to have as little complexity as needed to describe the numerical codes involved in the project, but also to make the DM generic enough to permit new simulation codes to latter join the IMPEx framework. The IMPEx DM expects to describe most of the numerical codes used for simulation solar system plasmas, in particular those describing the interaction of planets and satellites with a plasma flow.

A Common template for observational and numerical data

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. This latter DM is widely used by the solar system plasmas community to describe the data obtained by spacecraft.

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. 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 resource elements of the Spase DM. Moreover, multiple <Property> sub-elements can be inserted in the Spase elements, which permits one to add simulation related informations to the data description. Those simple and limited extention allows to describe in a satifying way all simulated data in a way similar to observational data.



A simple and complete description of the simulation runs

New ressource elements are added to Spase specifications which describes (2) the simulation model (i.e type of code, …) and the simulation runs (i.e. inputs).

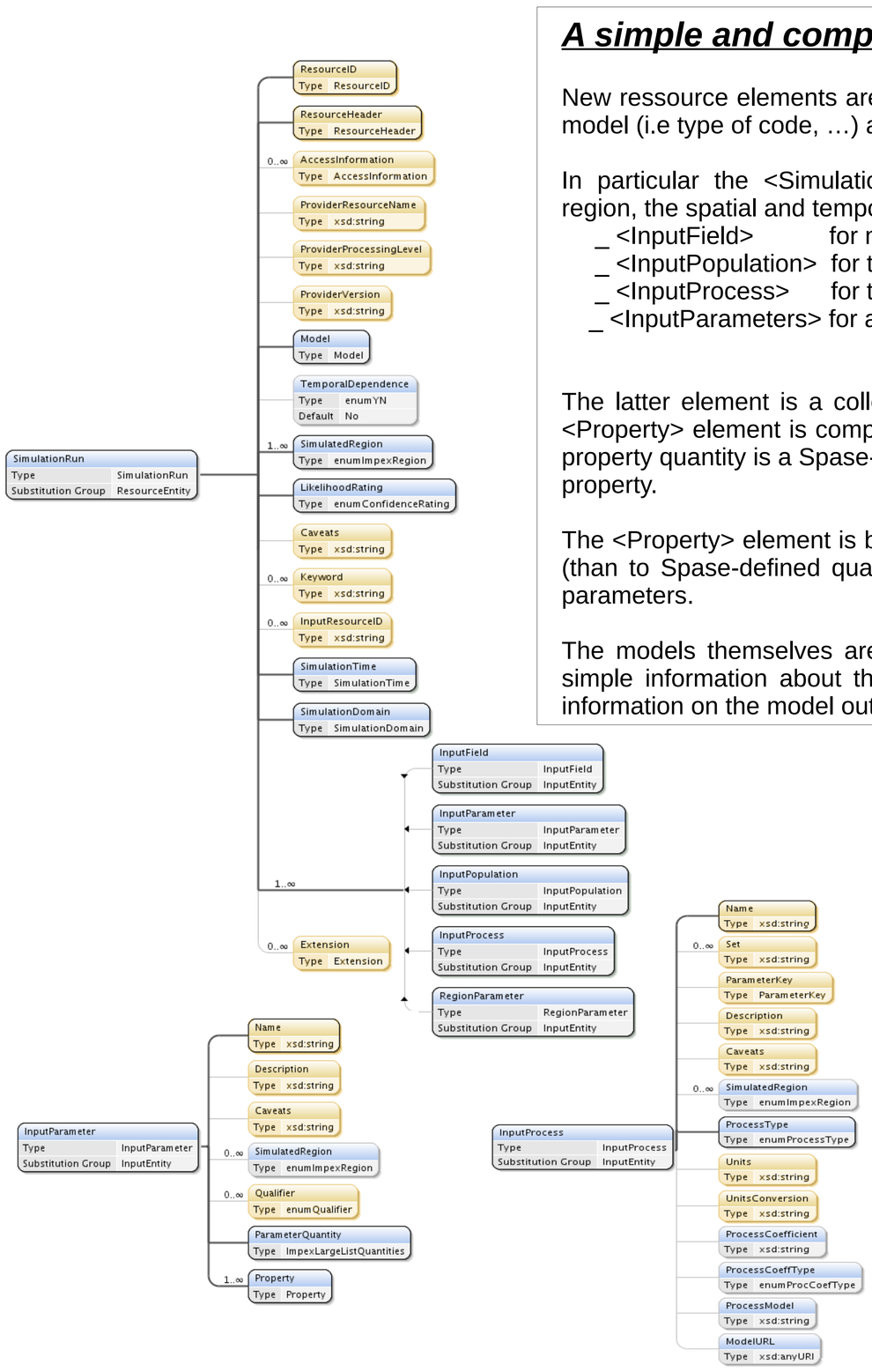
In particular the <SimulationRun> elements posses sub-elements describing the targeted region, the spatial and temporal domains of the simulation and several types of inputs :

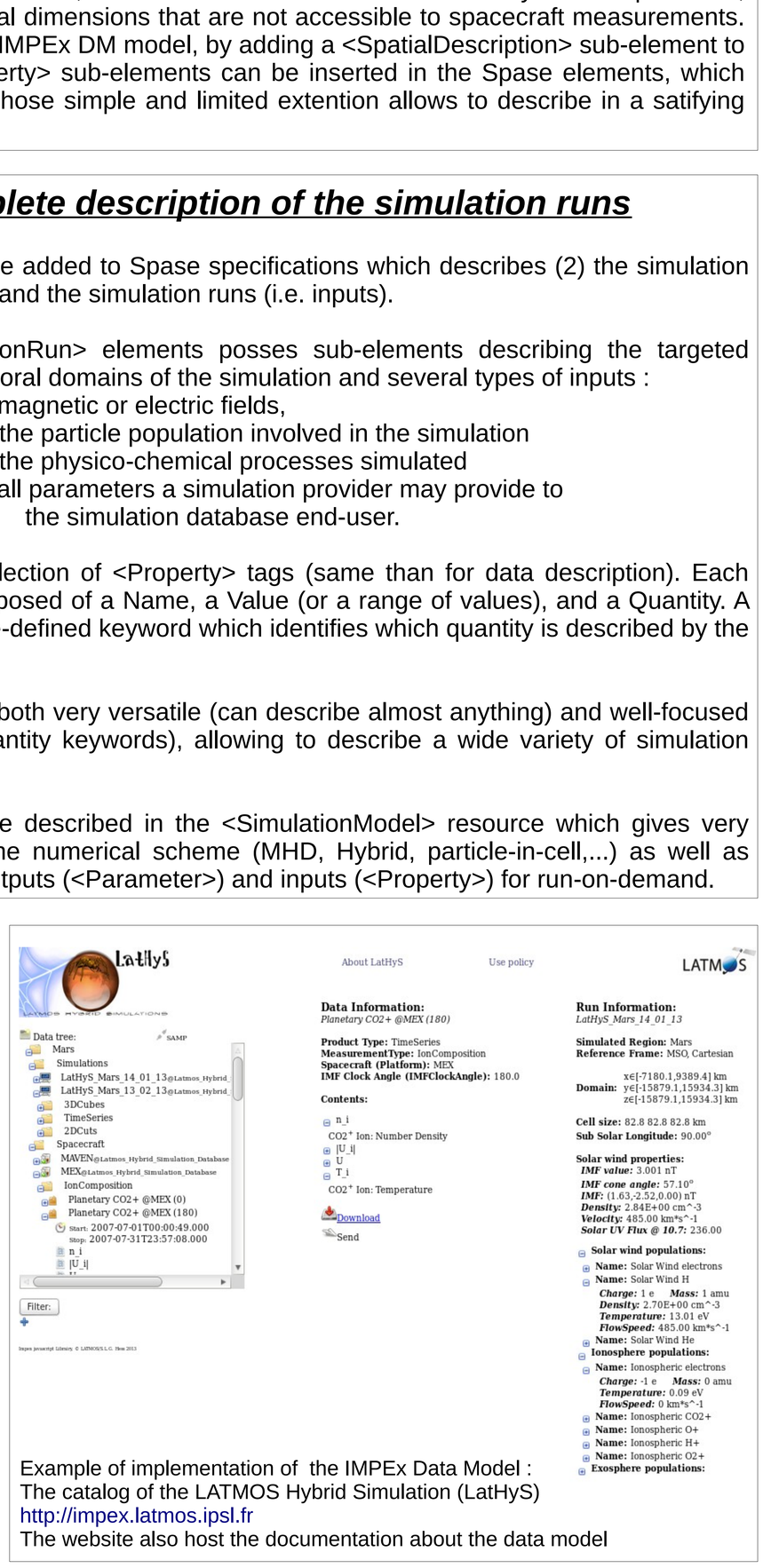
- _ <InputField> for magnetic or electric fields,
- _ <InputPopulation> for the particle population involved in the simulation
- _ <InputProcess> for the physico-chemical processes simulated
- _ <InputParameters> for all parameters a simulation provider may provide to the simulation database end-user.

The latter element is a collection of <Property> tags (same than for data description). Each <Property> element is composed of a Name, a Value (or a range of values), and a Quantity. A property quantity is a Spase-defined keyword which identifies which quantity is described by the property.

The <Property> element is both very versatile (can describe almost anything) and well-focused (than to Spase-defined quantity keywords), allowing to describe a wide variety of simulation parameters.

The models themselves are described in the <SimulationModel> resource which gives very simple information about the numerical scheme (MHD, Hybrid, particle-in-cell,...) as well as information on the model outputs (<Parameter>) and inputs (<Property>) for run-on-demand.





Example of implementation of the IMPEx Data Model :
The catalog of the LATMOS Hybrid Simulation (LatHyS)
http://impex.latmos.ipsl.fr
The website also host the documentation about the data model