The LatHyS database for planetary plasma environment investigations: Overview and a case study of data/model comparisons


Summary:
We present the Latmos Hybrid Simulation (LatHyS) database, which is dedicated to the investigations of planetary plasma environment. Simulation results of several planetary objects (Mars, Mercury, Ganymede) are available in an online catalogue. The full description of the simulations and their results is compliant with a data model developed in the framework of the FP7 IMPEx project. The catalogue is interfaced with VO-visualization tools such as AMDA, 3DView, TOPCAT, Clweb or the IMPEx portal. Web services ensure the possibilities of accessing and extracting simulated quantities/data. We illustrate the interoperability between the simulation database and VO-tools using a detailed science case that focuses on a three-dimensional representation of the solar wind interaction with the Martian upper atmosphere, combining MAVEN and Mars Express observations and simulation results.


The LatHyS Model and database

Hybrid formalism:
- Ions → kinetic description: represented by a population of weighted macro-particles. 6 ion species are included (H+, He++, H+2+, O+, O2+, CO2+).
- Electrons → fluid description: contribute to quasi-neutrality, current and pressure calculation. (2 electron fluids: solar wind and ionospheric electrons)

Coupled to Maxwell’s equations

Data description and webservices
- Files are generated automatically with generic IMPEx post-treatment routines
- MetaData saved automatically for each Run
  ⇒ Creation of Tree.xml regenerated automatically – easy to add new simulation run in the catalogue

The SPASE-data model has been extended to described space plasma simulations and their data products in the frame of the FP7 IMPEx project (Khodachenko et al).

⇒ Archived simulations are compliant with the SPASE-data model

The LatHyS web interface proposed an interactive catalogue connected to various visualisation tools through web-services

Science case: Comparison of space plasma observations from MAVEN/Mars Express and global hybrid simulation results using VO-tools AMDA, 3Dview, TOPCAT

- Determination of the solar wind conditions using AMDA and TOPCAT and the SAMP application (Genot et al., 2014)

- Pearson’s correlation coefficient determined between MAVEN observation and simulation results:
  \[ r(X_{MAVEN}) = 0.67 \]
  \[ r(Y_{SIM}) = 0.86 \]
  \[ r(Z_{SIM}) = 0.36 \]
  \[ r(U_{SW}) = 0.44 \]

- MAVEN observations and simulation results on December 30th, 2014. From top to bottom: Mars-MAVEN distance in Martian radii, the proton density determined from SWIA (yellow) and the simulated solar wind proton density (black), the next three panels represent the plasma velocity components measured by SWIA (in color) and simulated (in black), and the last panel displays the total magnetic field measured by MAG (in cyan) and simulated (in black)

- Comparison between simulations results and MAVEN observations from 15:30 to 19:30 UT. From top to bottom, the first panel displays the total magnetic field, the second panel shows the ion density while the last panel shows the velocity components.

- 3D scene of the MAVEN, MEX observations and simulation results. Simulated speed is plotted in a 2D XZ plane and along MAVEN track (light green vectors) and compared to MAVEN SWIA velocity observations (light blue vectors). A simulated magnetic field line is displayed at MEX location.

LatHyS database http://impex.latmos.ipsl.fr

webservises