HWA modelling web services for the IMPEx infrastructure

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IMPEx = Integrated Medium for Planetary Exploration

- 4-year EU/FP7 project started on June 2011
- IMPEx is aimed at the creation of an integrated interactive computational framework where data from planetary missions will be interconnected with numerical models providing a possibility...
  1. ...to simulate planetary phenomena and interpret space missions measurements;
  2. ...to test models versus experimental data and perform further improvement of models;
  3. ...to fill gaps in the measurements by appropriate modelling runs;
  4. ...to perform preparation of specific mission operations and solve various technological tasks, including preparation of new missions.
- Simulation tools in IMPEx
  - FMI/HYB: Global hybrid model for planetary plasma interactions
  - FMI/GUMICS: Global MHD model of the Earth's Magnetosphere
  - SINP: Paraboloid model of the Earth's Magnetosphere
  - LATMOS: Global hybrid model for planetary plasma interactions

http://impex-fp7.oeaw.ac.at/
FMI/HYB: Global hybrid model

- HYB is a hybrid and kinetic plasma simulation platform for planetary plasma interactions developed at the FMI.
- Originally based on the quasi-neutral hybrid (QNH) description of plasma. Positively charged ions are treated explicitly as kinetic particles and electrons are modelled as a charge-neutralizing, massless MHD fluid. The ions and the electromagnetic fields are self-consistently coupled to each other.
The dynamics of the ions in the electromagnetic field are governed by the Lorentz force:

\[ m_i \frac{d\mathbf{v}_i}{dt} = q_i (\mathbf{E} + \mathbf{v}_i \times \mathbf{B}) \]

\[ \frac{d\mathbf{x}_i}{dt} = \mathbf{v}_i \]

The electrons are considered implicitly as an inertialess fluid by the fluid momentum equation:

\[ \mathbf{E} + \mathbf{U}_e \times \mathbf{B} = \eta_0 \mathbf{J} + \frac{\nabla p_e}{q_e n_e} \]

The ideal gas law as the electron equation of state is:

\[ p_e = n_e k_B T_e \]

The quasi-neutrality condition of the plasma is:

\[ \rho_q = \sum_i q_i n_i + q_e n_e = 0 \]

The electric current density is defined as:

\[ \mathbf{J} = \sum_i q_i n_i \mathbf{v}_i + q_e n_e \mathbf{U}_e \]

Electrodynamics comes from the non-radiative Maxwell equations:

\[ \nabla \times \mathbf{B} = \mu_0 \mathbf{J} \]

\[ \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \]

\[ (\nabla \cdot \mathbf{B} = 0) \]

\[ (\nabla \cdot \mathbf{E} = \frac{\rho_q}{\epsilon_0}) \]
FMI/GUMICS: Global MHD model

- Grand Unified Magnetosphere Ionosphere Coupling Simulation is state-of-the-art global MHD code for terrestrial space weather modelling developed at the FMI.

- Based on the ideal conservative MHD description of plasma

- Magnetosphere coupled to electrostatic ionosphere (MHD inner shell at 3.7 $R_E$)
Hybrid Web Archive (HWA)

HWA HYB main interface

Hybrid Web Archive (HWA)

HWA GUMICS main interface
Hybrid Web Archive (HWA)

HWA HYB
plotting interface

HWA GUMICS
plotting interface