LFM

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Lyon Fedder Mobarry global MHD model

A scientific description of the model is available in The Lyon-Fedder-Mobarry (LFM) global MHD magnetospheric simulation code.

> **Note**
>
> We do not recommend running the LFM in a stand-alone configuration. This documentation is still relevant for coupling the LFM with other models (ie. LFM-MIX, CMIT, LFM-RCM, etc).

The Lyon-Fedder-Mobarry (LFM) Code is an integrated simulation model for the global magnetosphere-ionosphere system. The heart of the model is a time-dependent, ideal MHD calculation of the state of the magnetosphere. This magnetospheric model is tightly coupled to a realistic model for the polar ionospheres and is driven by solar wind plasma and magnetic field data upwind of the calculation domain. While lacking important physical processes in both the magnetosphere and ionosphere, the model is the simplest, self-consistent first principles model possible. With current computational capabilities, it is also the only type of model capable of providing reasonable quantitative accuracy in simulating the magnetosphere-ionosphere system.

The architecture of the LFM is based on a number of important design considerations.

- TVD transport with the highest possible resolving power.
- div B = 0 maintained to roundoff.
- grid adapted to the problem, packing more resolution where needed.
- integrated ionospheric model.

The outer boundary of the MHD calculation is handled as either inflow or outflow. The solar wind in the vicinity of the Earth is generally highly supersonic, so inflow is appropriate for those directions where the solar wind passes into the computational domain. The actual inflow conditions are usually described from an appropriately time shifted time series of solar wind data observed by satellite. Other regions of the outer boundary use simple outflow boundaries. The computational domain is large enough that flows have re-accelerated back to supersonic by the time they reach the edge of the grid.

The low altitude boundary of the LFM is handled by incorporating a tightly coupled model for the ionospheric electric field. The MHD calculation is stopped at some altitude between 2 and 3 RE. Field-aligned currents are calculated and mapped along dipole field lines to the ionosphere where they are used as the source term for the height-integrated potential equation. The calculated potential is then mapped back out to the MHD lower boundary where it is used to determine a boundary condition for the velocity and electric field. The algorithms used in the LFM code are described in some detail in Lyon et al. 2004. Details of the calculation of the ionospheric conductances can be found in Fedder et al. 1995.

The LFM grid is a distorted spherical grid with azimuthal symmetry about the polar axis. The polar axis points in the x-direction of the SM coordinate system (roughly toward the Sun). In the (r-?) planes the grid is distorted to place resolution where chosen by the user. The MHD grid usually covers the domain from about 30 RE upwind to 300 RE downwind of the Earth and roughly 100 RE out to the sides. The complementary ionospheric grid is a mapping of the inner surface of the MHD (magnetospheric) domain to the two polar ionospheres. This typically covers the region from the pole to 45-60 degrees latitude.

Summary

Strengths

- Only type of code currently capable of providing self-consistent physically based model of the global magnetosphere.
- Integral, self-consistent ionospheric model.
- Ionospheric conductance computed self-consistently.

Limitations

- Assumes ideal MHD description of magnetospheric plasma which leaves out many important processes, such as inner magnetospheric drifts and microscopic reconnection physics.
- Lack of drift physics leads to lack of trapped ring current.
- The auroral acceleration region is treated in an ad hoc, simplified fashion.
- No ionospheric outflow.

Code INPUTS

- XML file including run-time parameters (e.g., start and stop timesteps, target courant number, ionospheric conductance parameters)

- Solar wind (L1 satellite) data for the simulated time period including plasma density,velocities,and sound speed, magnetic field vector, and dipole tilt angle.
- If restart: previous step dump file
- If from scratch: file defining magnetospheric grid

Code OUTPUTS

- HDF 4 file containing grid information and MHD variables and ionospheric variables at each grid point in their respective grids for each dump time step.
- Log file with run information

Hardware and Software Requirements

- Written in extended FORTRAN 77.
- Requires HDF 4 libraries

Support Contact

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