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Three-dimensional Integration, Analysis, and Visualization of Simulated and Observed Heliophysics Data

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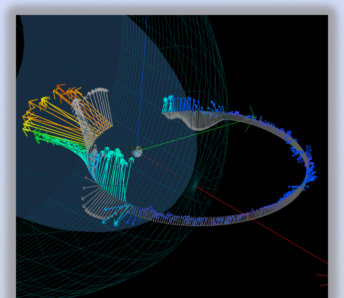
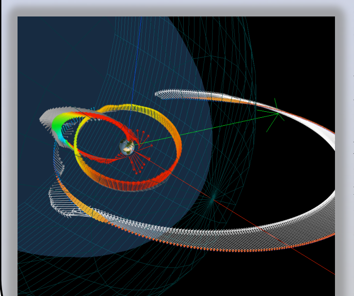
Objective I
Validate simulation results with observed data

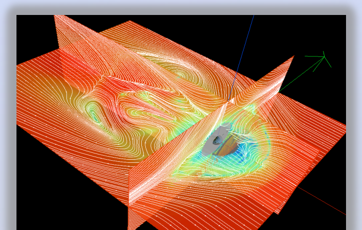


We enable comparison between spacecraft observations and magnetohydrodynamic (MHD) model results as shown in this Geotail orbit: observed magnetic field data is shown as rainbow colored vectors and model results in grayscale.

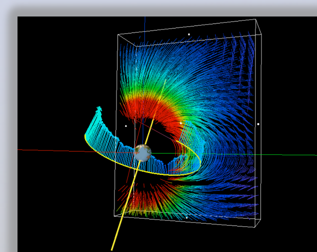


GOES-10 and Polar orbits are added to the above Geotail orbit. In this case, MHD data from the OpenGGCM model is interpolated along those positions with the original, observed data removed. Magnetic field is represented by rainbow colored vectors, plasma flow as grayscale vectors, and density as glyph size and color.

Objective II
Use simulated data to provide a global context for the sparse, observed data

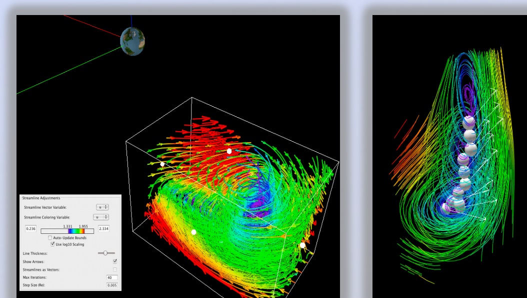


Axis-aligned cut planes of OpenGGCM MHD data show plasma flow velocity. Scalar and vector quantities can be arbitrarily mapped to colors, vectors, streamlines, and contour lines.



GOES-10 spacecraft passing through magnetic field lines generated from a BATS-R-US MHD model run. Streamline variables, color mapping, seeding, and the region of interest can be adjusted interactively.

Objective III
Apply feature detection techniques to the simulated data



Feature detection algorithms are used to rapidly find regions of interest in these massive data sets. A vortex-finding algorithm clustered its results as shown at right; vortex centers are shown as spheres and its vorticity at that point as a vector. Plasma flow velocity is mapped to a rainbow color palette in both cases.

Our current algorithm takes a multi-staged approach to locate vortices in 3-D flows. The second invariant of the velocity gradient tensor is used to identify points where the rotational strength exceeds the strain-rate. At these points, the vorticity vector is used to define the z-axis of a local coordinate system. A point is classified as a vortex if a small neighborhood exhibits both closed streamlines in the X-Y plane and a relative velocity magnitude minimum at the center.

Background
Understanding the physical processes at work in the Earth's magnetosphere is crucial to space weather prediction. Observational data is sparse, so global computational models driven by observed solar wind conditions play an important role in this research.

Therefore we have created an interactive environment to simultaneously visualize magnetohydrodynamic (MHD) and observed data in the same context. These capabilities have been added to the existing software tool, ViSBARD, the Visual System for Browsing, Analysis, and Retrieval of Data for multi-spacecraft data visualization.

Technical
- ViSBARD is publicly available for Mac, PC, and Linux platforms via Java Web Start
- Source code has recently been released to SourceForge and uses the NASA Open Source Agreement (NOSA)
- Multiple MHD models (OpenGGCM, BATS-R-US, etc) are supported via the Kameleon interpolation libraries from the NASA/GSFC Community Coordinated Modeling Center
- Spacecraft data is directly accessed within ViSBARD via Java Web Services link to CDAWeb