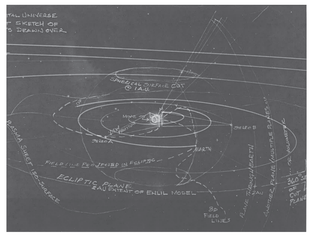
Interactive Visualization of Space Weather Data

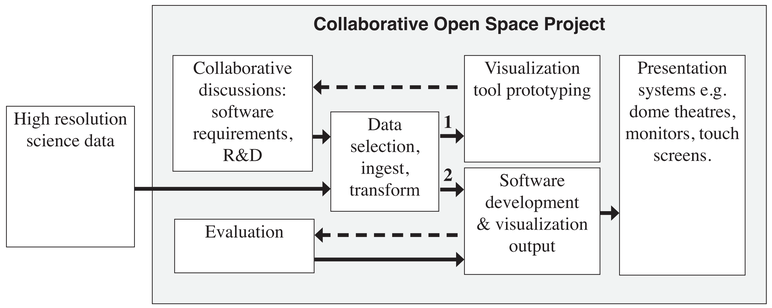
Martin Törnros[1,2] David Berrios[2] Alexander Bock[1] Carter Emmart[3] Robert Harberts[2] Anders Ynnerman[1]

1. Linköping University 2. NASA Goddard Space Flight Center (GSFC) 3. American Museum of Natural History (AMNH)

Synopsis

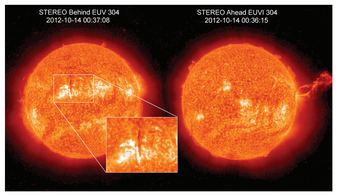


OBJECTIVE NASA's Integrated Space Weather Analysis team in collaboration with the American Museum of Natural History's Hayden Planetarium and Linköping University are exploring new tools for interactive, multi scale, multi display environment, networkable solutions to explore current understanding of space. The goal is an open source software called *Open Space* to be maintained at Linköping University and developed further through an open ended masters level thesis program.
IMAGE: AMNH, EMMART

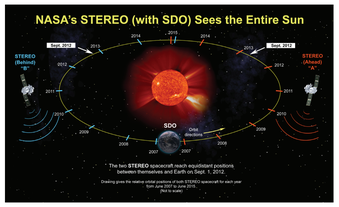


COLLABORATIVE PROJECT FLOW The diagram shows the foundation steps in the collaborative project. Continuous evaluation and discussions are held based on initial requirements and results from the prototyping phase. The final software output is a graphical representation of high resolution science data, for interactive presentations in a diverse set of display environments.

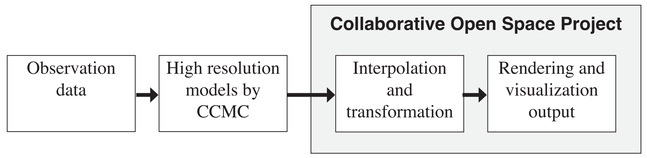
Space weather visualization



SPACE WEATHER Space weather understanding integrates solar imaging, in-situ spacecraft sensing of particles and fields, and modeling of the interplanetary medium, planetary magnetospheres and ionosphere interactions. Space weather can influence the performance and reliability of space-borne and ground-based technological systems such as telecommunication. IMAGE: NASA/STEREO

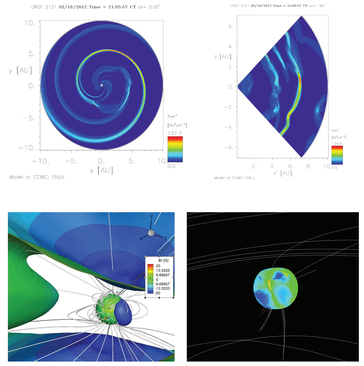


THE STEREO AND SOHO MISSIONS The two satellites *Stereo A* and *Stereo B* are both operated by NASA and travel in Earth's orbit. Together with the SOHO spacecraft located in the Earth-Sun line they observe the Sun and its activity, allowing scientists to explore the heliosphere in three dimensions.
IMAGE: NASA/GSFC

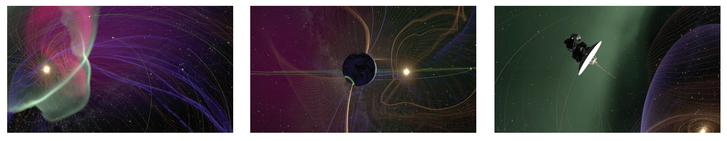


DATA FLOW Observation data is used as input for simulations at Community Coordinated Modeling Center (CCMC), resulting in high resolution output models. These are accessed using the Kameleon library developed at CCMC and transformed prior to rendering.

Current tools

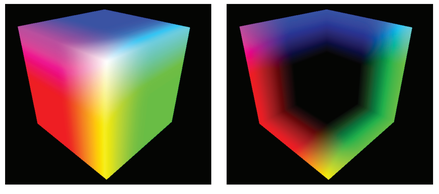


SPACE WEATHER FORECASTING Scientists at CCMC are today using a wide range of tools for space weather forecasting. The tools provide two or three dimensional renderings but often lack in interactivity, and physical phenomenas are typically visualized in isolation from one another. The upper two images show CCMC's public online tool *Request a Run*. The tool provides easy access to large data sets, but provides little understanding of the three dimensional structure of the data. The bottom images show the software *Tecplot 360* and *Space Weather Explorer 2*. Both software render three dimensional objects, using geometric rendering.
IMAGES TOP: CCMC
IMAGE B.L.: TECPLOT, INC.
IMAGE B.R.: CCMC

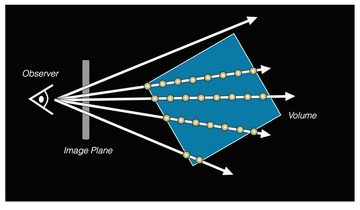


PUBLIC PRESENTATIONS Still images from the production *A Journey To The Stars* shown at AMNH. The production is pre rendered and non-interactive. Interactive software currently in use lacks ability to integrate such multiple elements and scales as depicted here, and lacks software extensibility. IMAGES: AMNH

Image ordered volumetric rendering

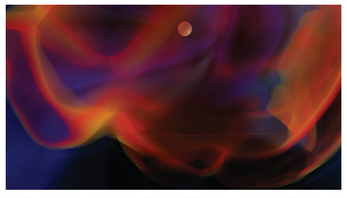


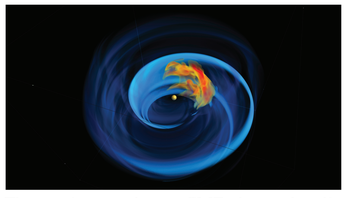
VOXELS AND RAYCASTING Each volume is defined by a three dimensional grid of voxels, each representing one or more scalar or vector values. For every pixel on the screen a ray is cast through the volume defined by the entry (left) and exit (right) points of the volume's bounding box. IMAGES: VOREEN



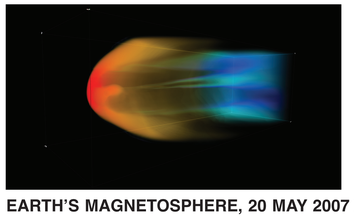
PIXEL VALUES For each ray that is cast the pixel value is set by sampling the voxel values along the ray. Transfer functions allow the user to set the opacity and color for each intensity value. Lighting, shading and other rendering settings can be applied for desired image results. IMAGE: LINKÖPING UNIVERSITY

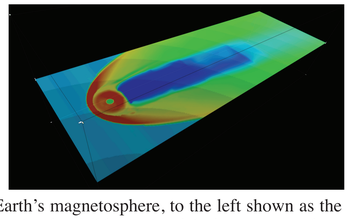
Case studies





CORONAL MASS EJECTION, 17 MARCH 2012 The two images show a CME observed earlier this year, modeled to 10AU at CCMC. The CME is viewed from Earth's orbit (left) and from beyond the 10AU model of the interplanetary medium (right). Variables: density and dp. *Note: The Sun is currently not in accurate scale*.





EARTH'S MAGNETOSPHERE, 20 MAY 2007 Earth's magnetosphere, to the left shown as the full model in which the low pressure tail lobes are clearly visible. In the right image a cut plane has been applied to the same data set. Variable: pressure.

PROTOTYPE RESULTS The above are results from the prototyping phase. The cases are currently studied separately, however, visualizing the models in a common space-time coordinate system with correct scaling will help understand the wider context. Additional elements such as vector fields, orbits and legends will provide further insight to the data.

Ongoing work

General visualization tool for large data sets
- Multi scale models
- Plug-in architecture
- Open source code

Wide range of visualization tools
- Fully interactive to explore space-time continuum models
- Combine observed and modeled data

Volumetric rendering on non-Cartesian grids
- No coordinate system transformation needed at load time
- Decreased data size

Immersive environments
- Interactive presentations e.g. in the Hayden Planetarium
- Synchronized presentations across the world

Export movies
- High resolution for pre-rendered presentations
- Useful for both scientists and public presentations

SPECIAL THANKS

LINKÖPING UNIVERSITY
Timo Ropinski

NASA
Tom Bridgeman
Rebekah Evans
Masha Kuznetsova
Peter Macneice
Marlo Maddox
Leila Mays
Dusan Odstrcil
Lutz Rastaetter
Everyone at CCMC

ADDITIONAL READING

www.itn.liu.se/?l=en
www.nasa.gov/
www.haydenplanetarium.org/universe/
www.amnh.org/
ccmc.gsfc.nasa.gov/
www.voreen.org/

CONTACT
martin.e.tornros@nasa.gov

LINKÖPINGS UNIVERSITET
NASA
AMERICAN MUSEUM OF NATURAL HISTORY
COMMUNITY COORDINATED MODELING CENTER
voreen volume rendering engine www.voreen.org