

Introduction to CISM_DX and Overview of OpenDX

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Heliophysics Summer School
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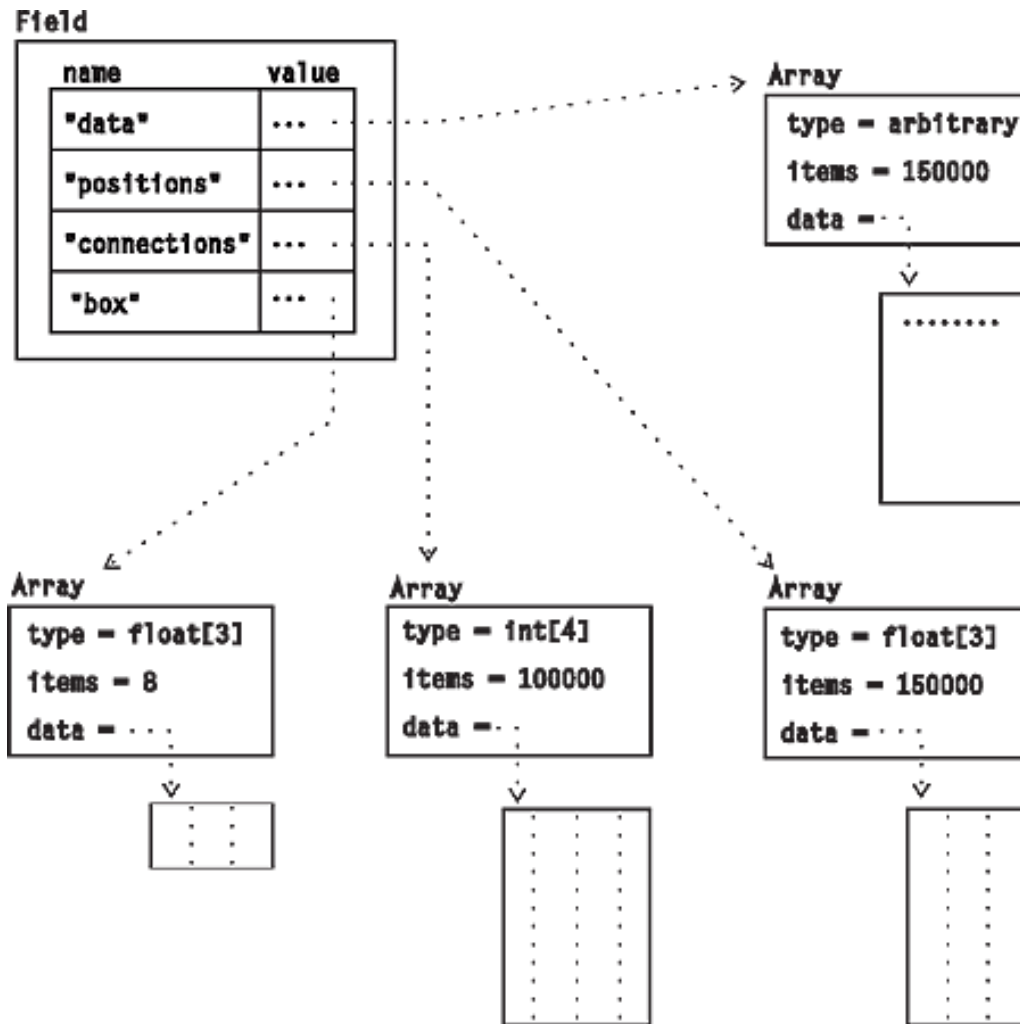
Outline

- Examples
 - Novice User Interface
 - Exploring the structure of the magnetosphere
 - Satellite and map views of geographic model data
 - Advanced Analysis
 - Energy Partitioning in the magnetosphere
 - Additional Features
 - Coordinate system transformations
 - Tools for making visualizations

What is OpenDX?

- An open source data visualization package based upon IBM's commercial Data Explorer (DX) visualization system
 - Full featured software package for visualization scientific, engineering, and analytic data
 - Open system design built upon standard interface environments which allow great flexibility in creating visualizations
 - Very active development community
 - Version 4.3 available and thoroughly tested
- www.opendx.org for more information

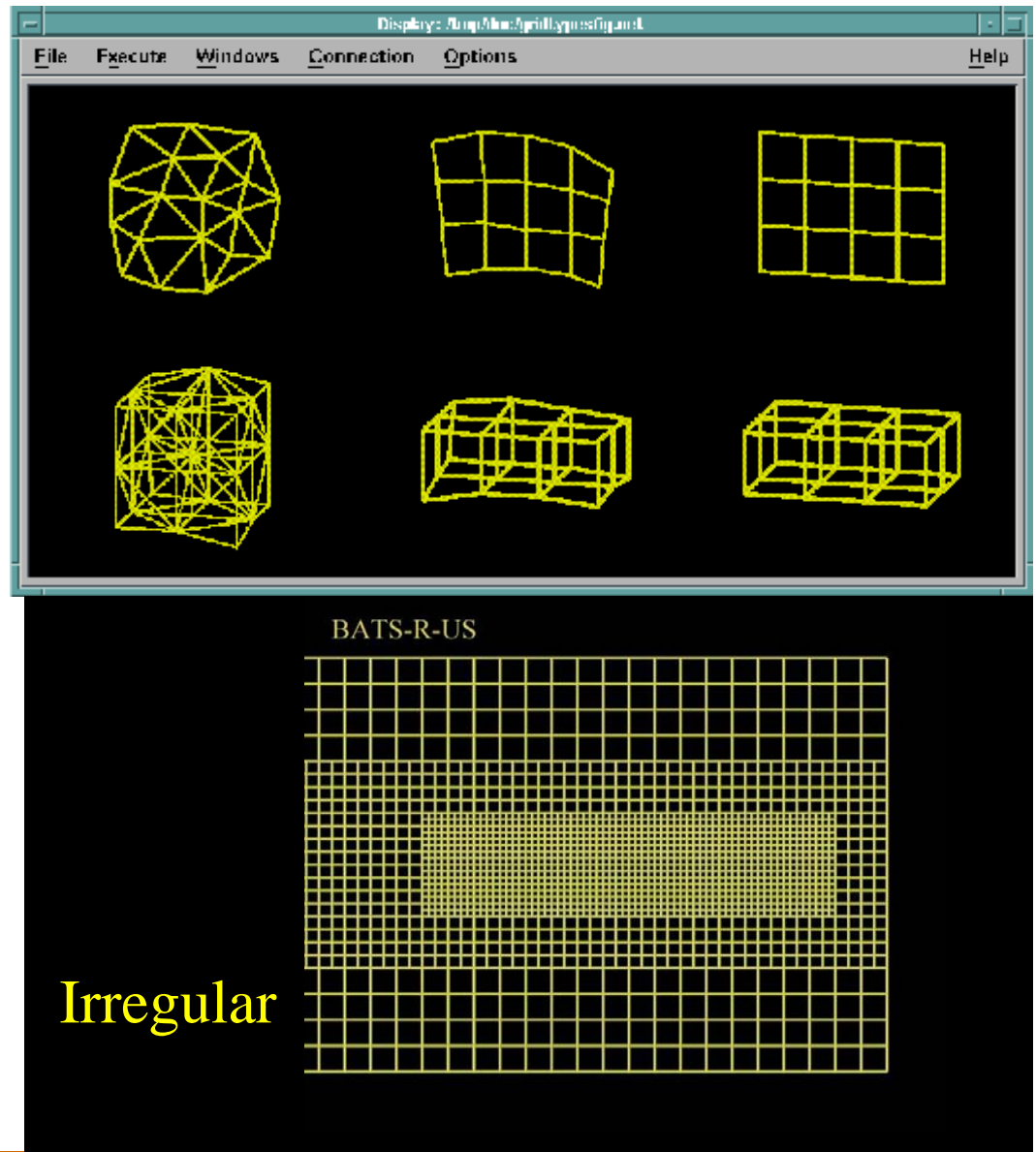
Data Structures: The Field Object



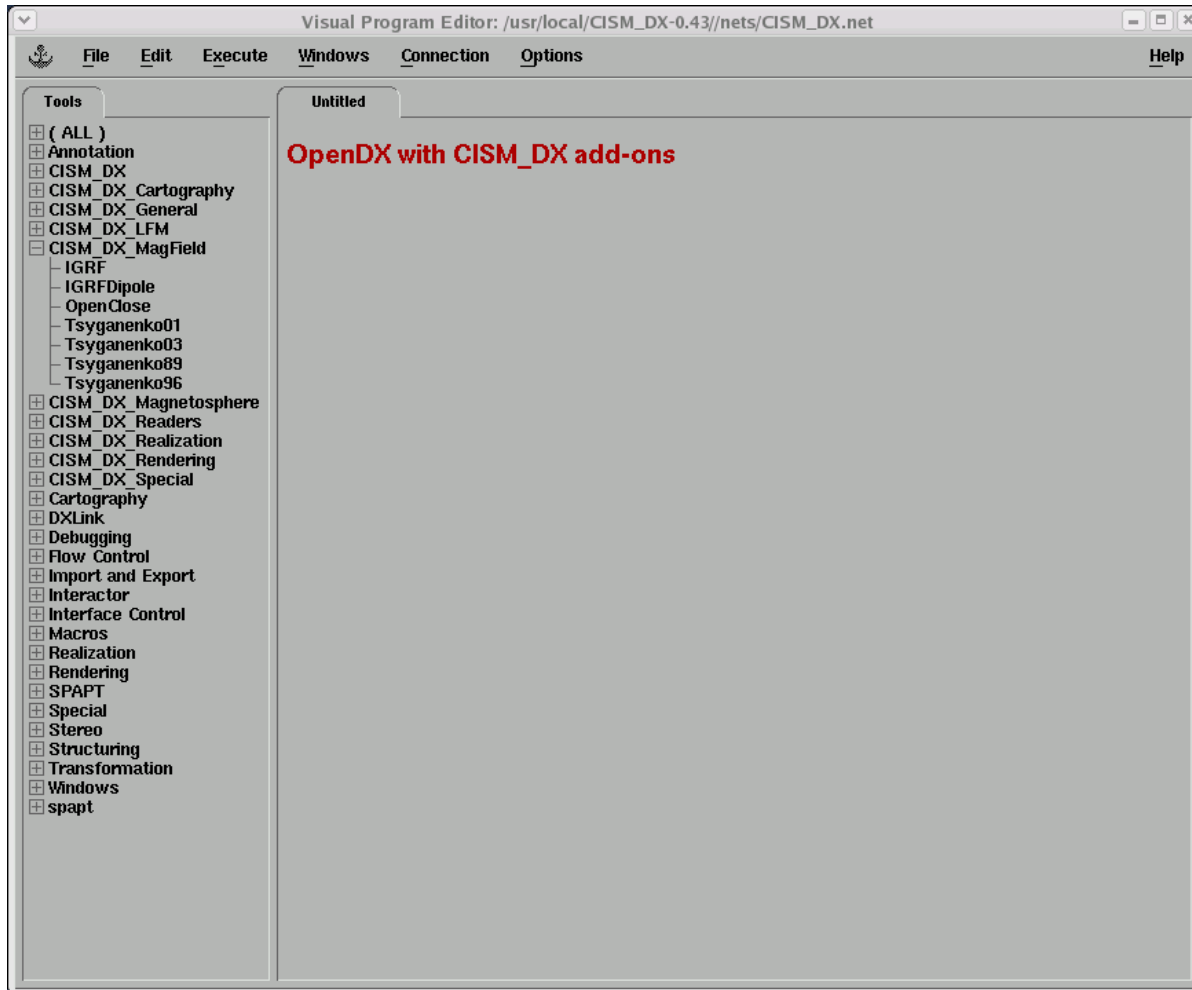
- A Field is the fundamental programming object in the OpenDX
- 3 main parts
 - Positions
 - Locations in space
 - Connections
 - Explains how the positions relate to each other
 - Data
 - Actual information can be scalar, 3-vector or beyond

Grids

- The connection between points forms the grid
- DX supports 3 grid types
 - irregular
 - irregular positions – irregular connections
 - deformed regular
 - irregular positions – regular connections
 - regular
 - regular positions – regular connections
- Some DX modules require regular connections
 - e.g. slab



Visual Program Environment (VPE)



- User ‘writes’ a visual program or net to create visualizations
- These programs use the modules provided by OpenDX or modules written by the user to accomplish specific tasks such as data importing, coordinate system rotations, etc

Modules

Visual Program Editor: /usr/local/CISM_DX-0.43//nets/CISM_DX.net

File Edit Execute Windows Connection Options Help

Tools

- (ALL)
- Annotation
- CISM_DX
- CISM_DX_Cartography
- CISM_DX_General
- CISM_DX_LFM
- CISM_DX_MagField
- CISM_DX_Magnetosphere
- CISM_DX_Readers
- CISM_DX_Realization
- CISM_DX_Rendering
- CISM_DX_Special
- Cartography
- DXLink
- Debugging
- Flow Control
- Import and Export
- Interactor
- Interface Control
- Macros
- Realization
 - AutoGrid
 - Band
 - Connect
 - Construct
 - Enumerate
 - Grid
 - Isolate
 - Isosurface
 - MapToPlane
 - Pie
 - Regrid
 - RubberSheet
 - Sample
 - ShowBoundary
 - ShowBox
 - ShowConnections
 - ShowPositions
 - Streakline
 - Streamline
- Rendering
- SPAPT
- Special
- Steren

Untitled

OpenDX with CISM_DX add-ons

Construct

Construct

Notation: Construct

Inputs:

Name	Hide	Type	Source	Value
<input type="checkbox"/> origin	<input type="checkbox"/>	vector list		(input dependent) ...
<input type="checkbox"/> deltas	<input type="checkbox"/>	vector list		(input dependent) ...
<input type="checkbox"/> counts	<input type="checkbox"/>	integer, vector		(input dependent) ...
<input type="checkbox"/> data	<input type="checkbox"/>	value list, string list		(no default) ...

Outputs:

Name	Type	Destination	Cache
output	field		All Results <input type="checkbox"/>

OK Apply Expand Collapse Description... Help on Syntax Restore Cancel

Visual Program Editor: /home/weigel/CISM_DX_Labs/IntroToOpenDX/nets/OpenDXRendering.net

File Edit Execute Windows Connection Options

Tools

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- Macros
- Realization
- Rendering
- SPAPT
- Special
- Stereo
- Structuring
- Transformation
- Windows
- spapt

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OpenDX Rendering

```

graph TD
    Construct --> Print
    Construct --> Glyph
    Construct --> ShowConnections
    Print --> Collect
    Glyph --> Collect
    ShowConnections --> Collect
    Collect --> Image
  
```

Message Window

File Edit Execute Commands Options Help

```

8
Attribute. Name 'dep':
String. "positions"
Component number 3, name 'box':
Generic Array. 8 items, float, real, 3-vector
data values:
0 0 0
0 0 1
0 1 0
0 1 1
1 0 0
1 0 1
1 1 0
1 1 1
Attribute. Name 'der':
String. "positions"
  
```

Image: /home/weigel/CISM_DX_Labs/IntroToOpenDX/nets/OpenDXRendering.net

File Execute Windows Connection Options Help

Construct

Notation: Construct

Inputs:

Name	Hide	Type	Source
<input checked="" type="checkbox"/> origin	<input type="checkbox"/>	vector list	
<input checked="" type="checkbox"/> deltas	<input type="checkbox"/>	vector list	
<input checked="" type="checkbox"/> counts	<input type="checkbox"/>	integer, vector	
<input checked="" type="checkbox"/> data	<input type="checkbox"/>	value list, string list	

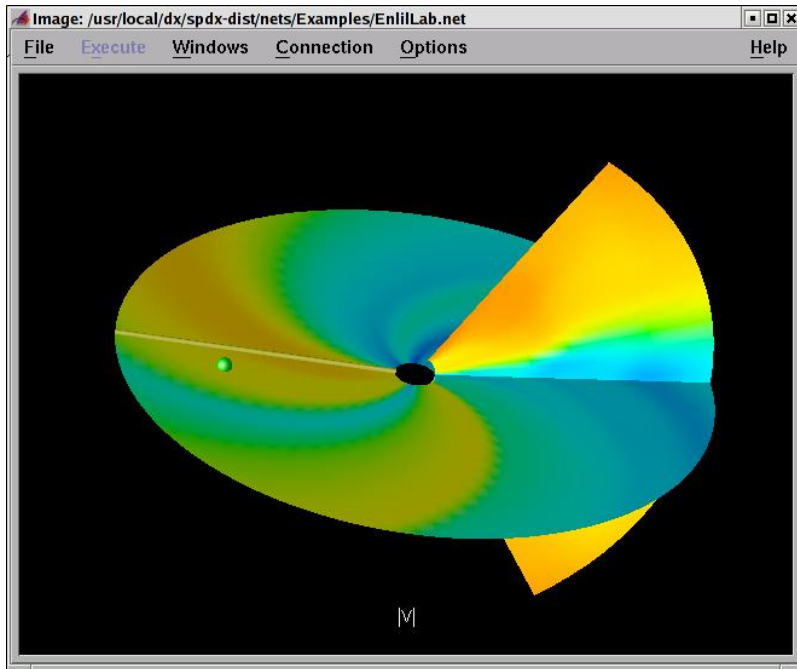
Outputs:

Name	Type	Destination	Cache
output	field	Glyph, ShowConnections, Print	All Res

OK Apply Expand Collapse Description... Help on Syntax

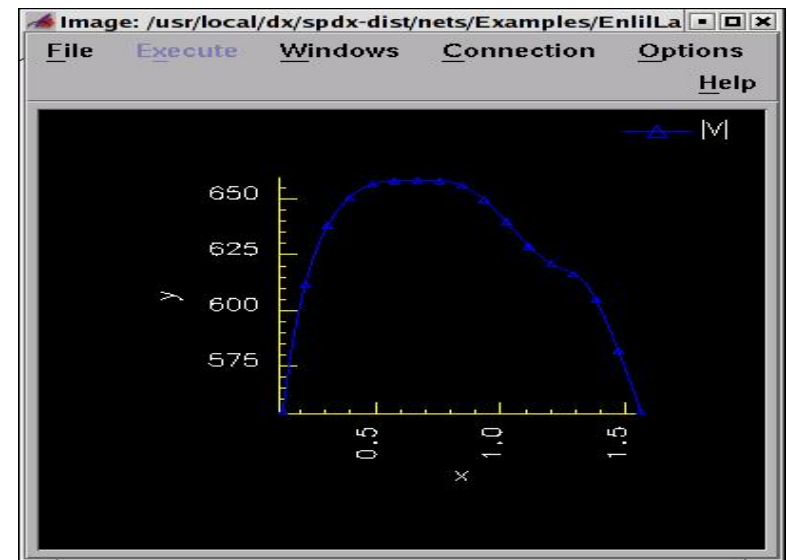
12:23 PM

The Map Module

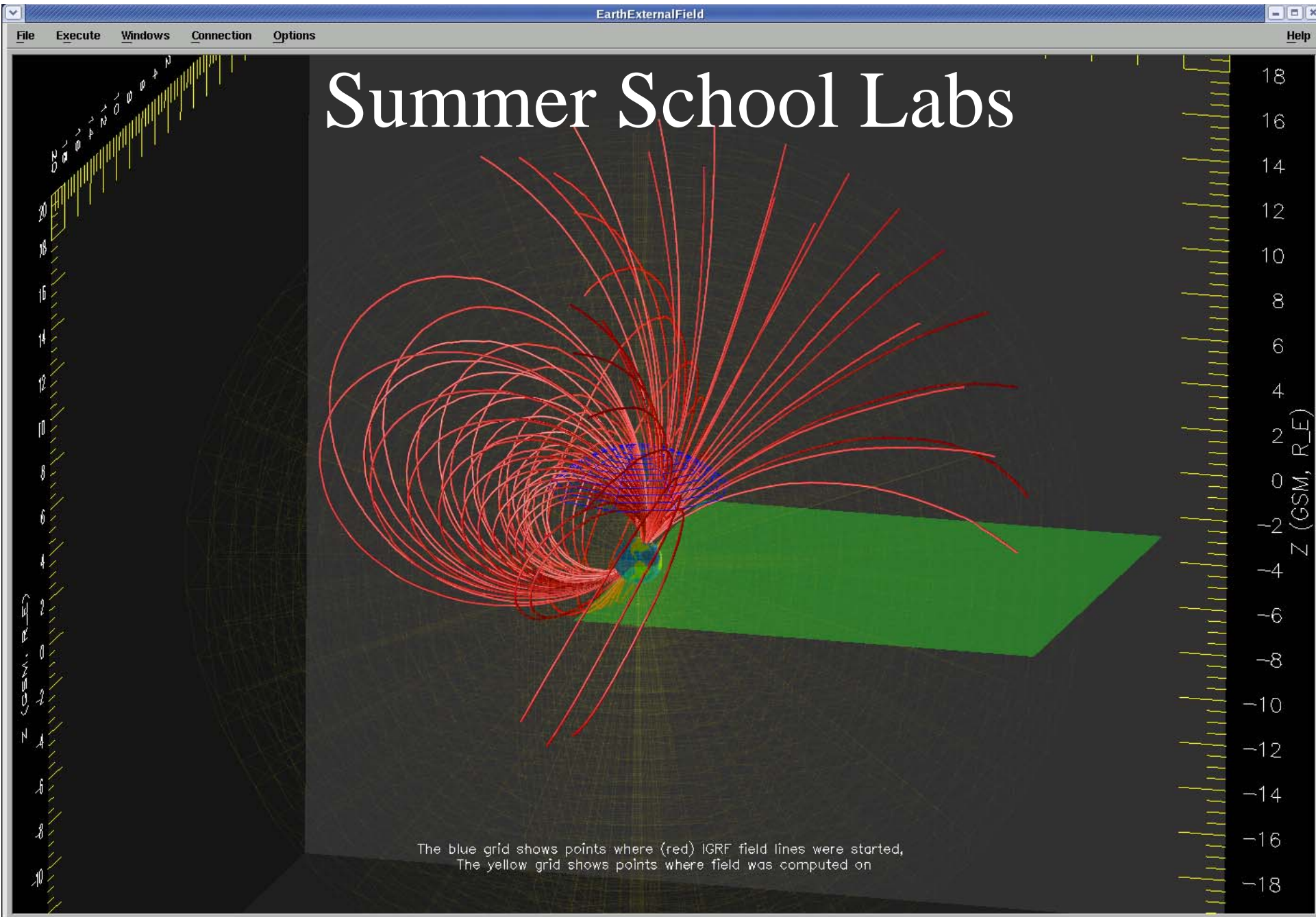


- Velocity data from the ENLIL model is interpolated along a radial line in the ecliptic plane and displayed in a second window

- The Map Module interpolates data from any DX Object to another DX Object
 - This includes field lines and isosurfaces
 - Relies on the Connections component of OpenDX Field

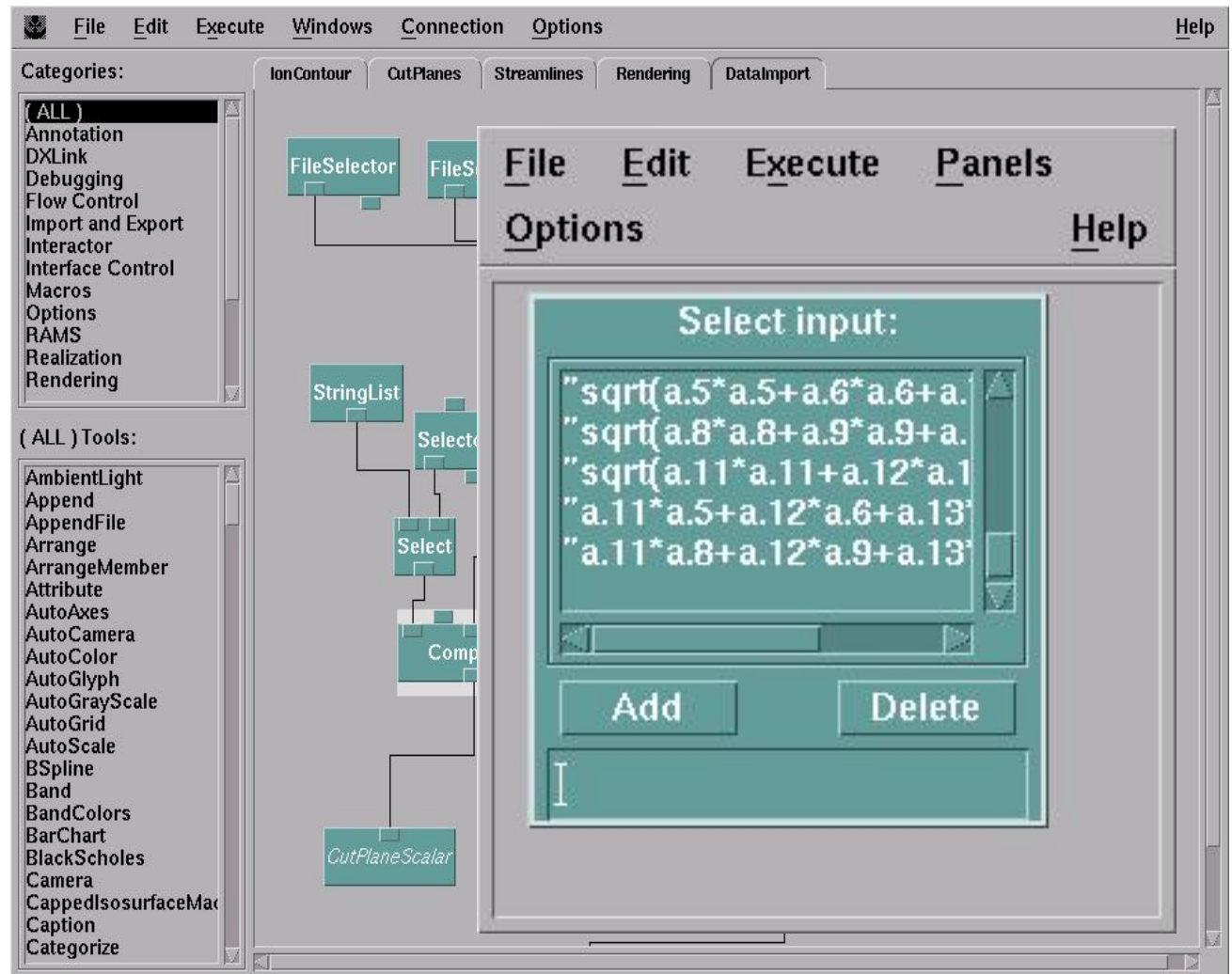


Thanks to Dusan Odstrcil and Nick Arge

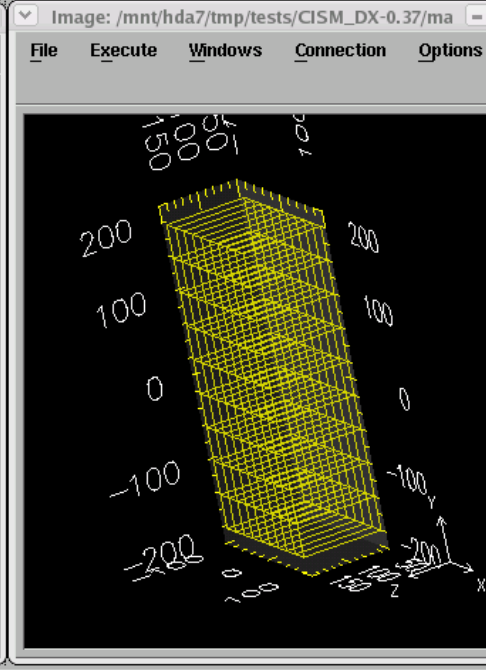
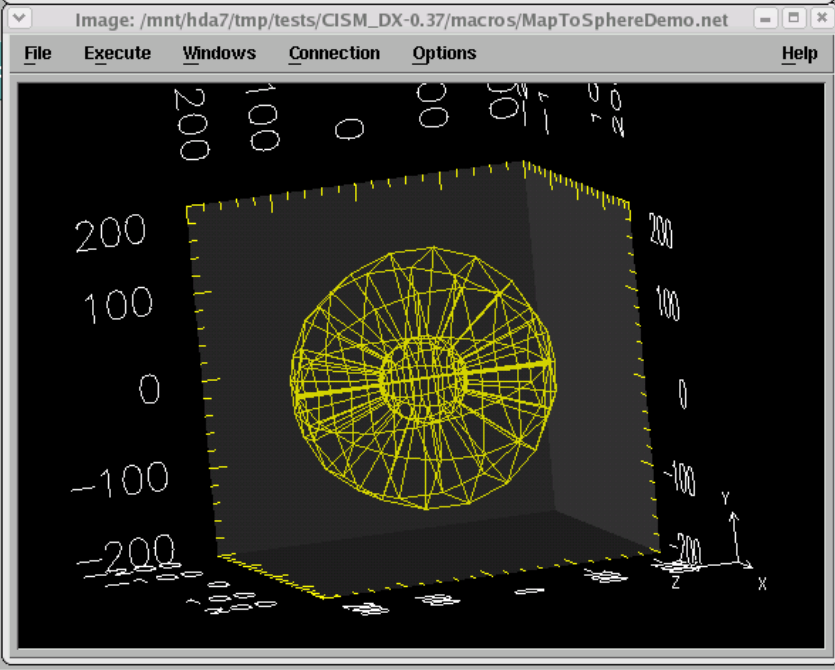
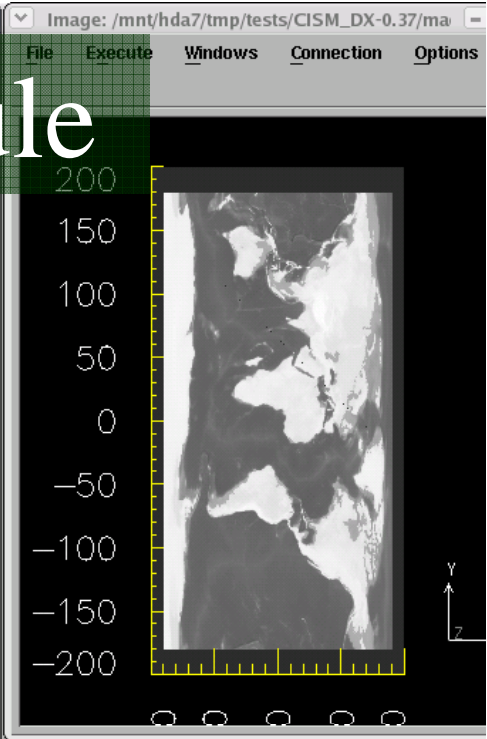
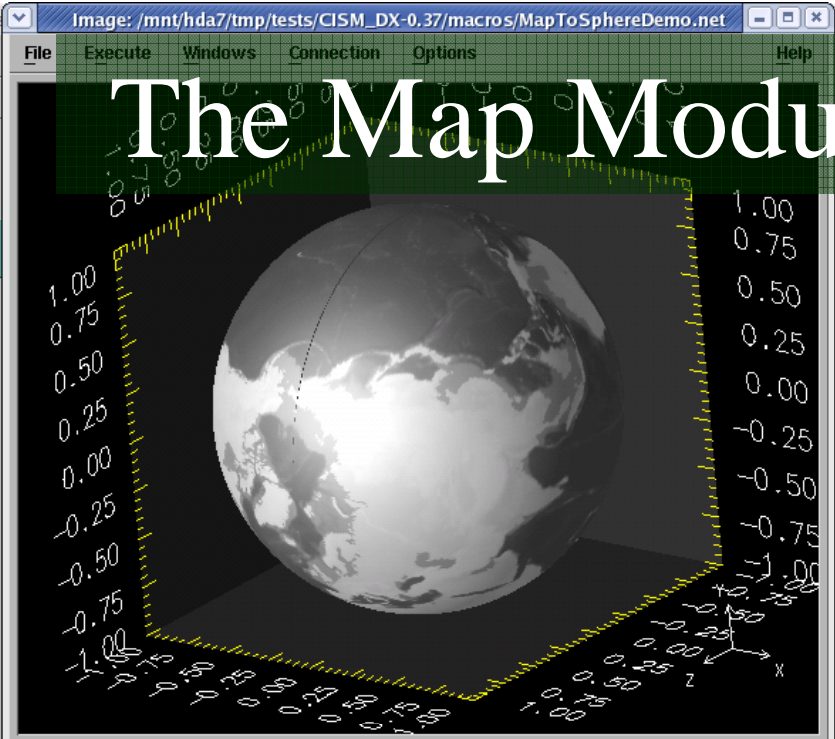
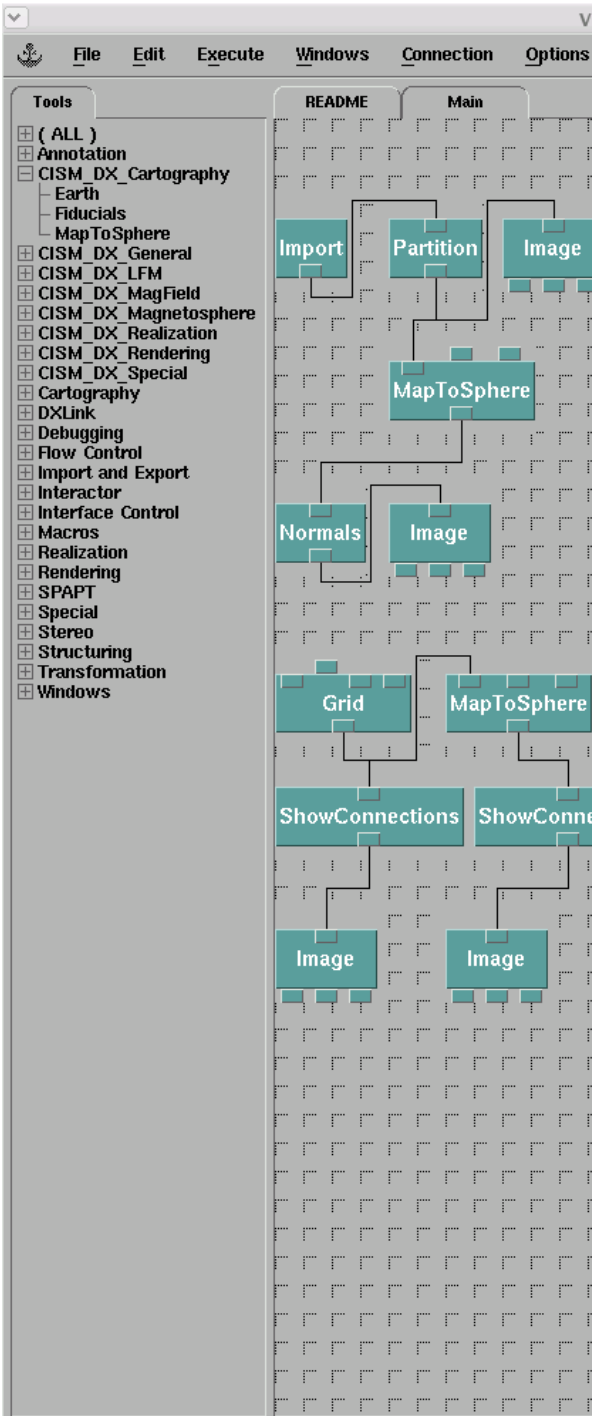


The Compute Module

- Compute module moves OpenDX from just a visualization tool into an analysis tool
 - Basic math, trig functions, logical, & vector operations
- Works on both data and underlying grids



The Map Module



The Mark/Unmark modules

The screenshot displays a software interface with a menu bar (File, Edit, Execute, Windows, Connection, Options, Help) and a left sidebar containing two lists: "Categories:" and "(ALL) Tools:". The main workspace shows a hierarchical tree of modules under the "Untitled" window. The tree starts with "Input" at the top, which connects to a "Mark" module. Below "Mark" are three "Compute" modules. Further down, there is an "Include" module, followed by another "Compute" module, a "ShowBox" module, and an "Unmark" module. At the bottom of the tree are "Collect" and "Color" modules. To the right of the tree is a 3D visualization area. The top part of this area shows a grayscale image of a textured surface with red highlights at the top and bottom edges, and a vertical green line. Below this is a 3D sphere with a vertical green line passing through its center. The text "cr1912" is visible in the bottom right corner of the 3D area.

Categories:

- (ALL)
- Annotation
- DXLink
- Debugging
- Flow Control
- Import and Export
- Interactor
- Interface Control
- Macros
- Options
- RAMS
- Realization
- Rendering

(ALL) Tools:

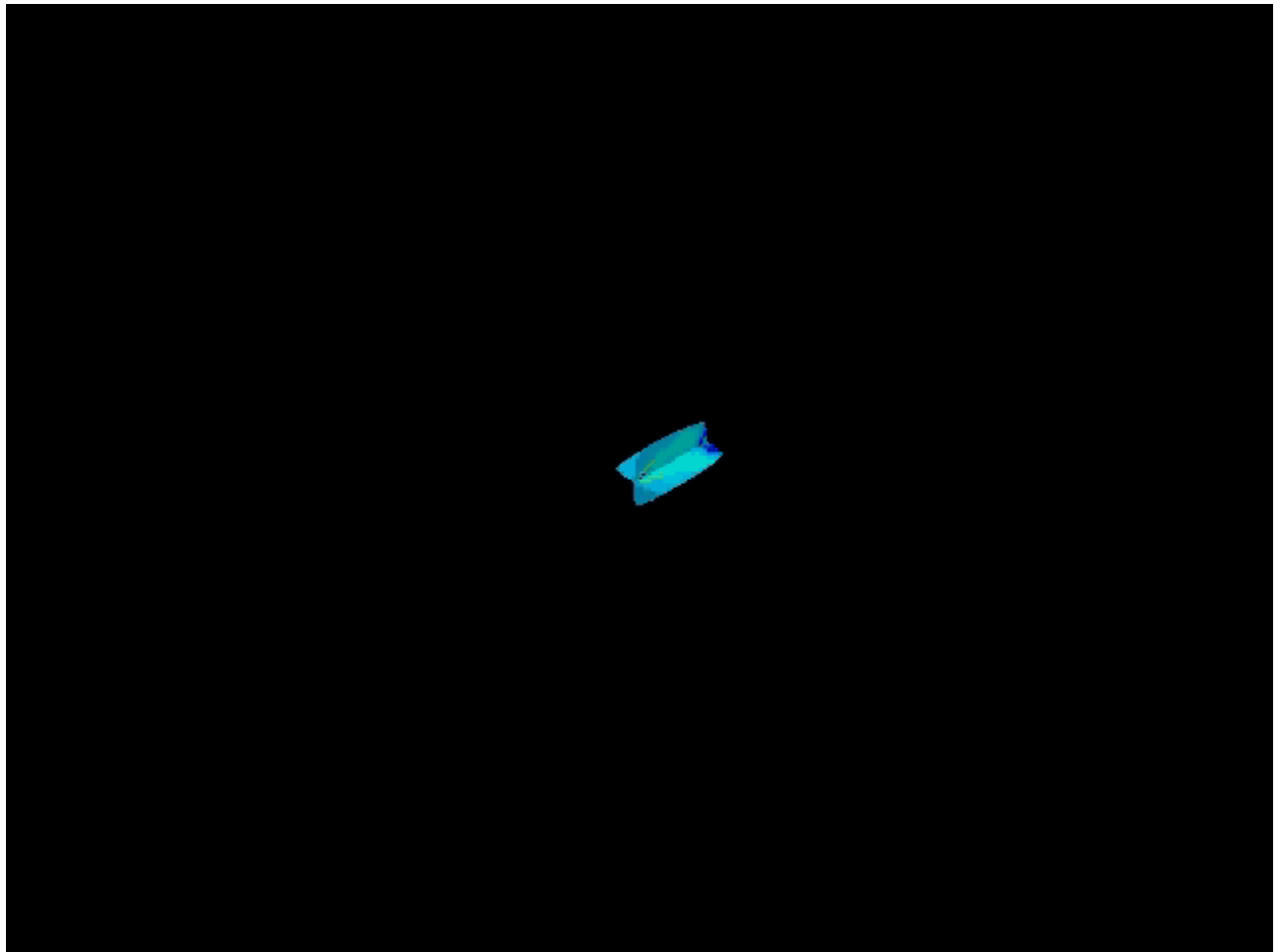
- AmbientLight
- Append
- AppendFile
- Arrange
- ArrangeMember
- Attribute
- AutoAxes
- AutoCamera
- AutoColor
- AutoGlyph
- AutoGrayScale
- AutoGrid
- AutoScale
- BSpline
- Band
- BandColors
- BarChart
- BlackScholes
- Camera
- CappedIsosurfaceMac
- Caption
- Categorize

cr1912

Thanks to S. McGregor

Movie Making

- Example networks and macro modules provide tools for generating movies
 - Easily define camera trajectory and look direction through computational domain
 - Sequencer and compute are used to synchronize camera motion and temporal evolution of model results

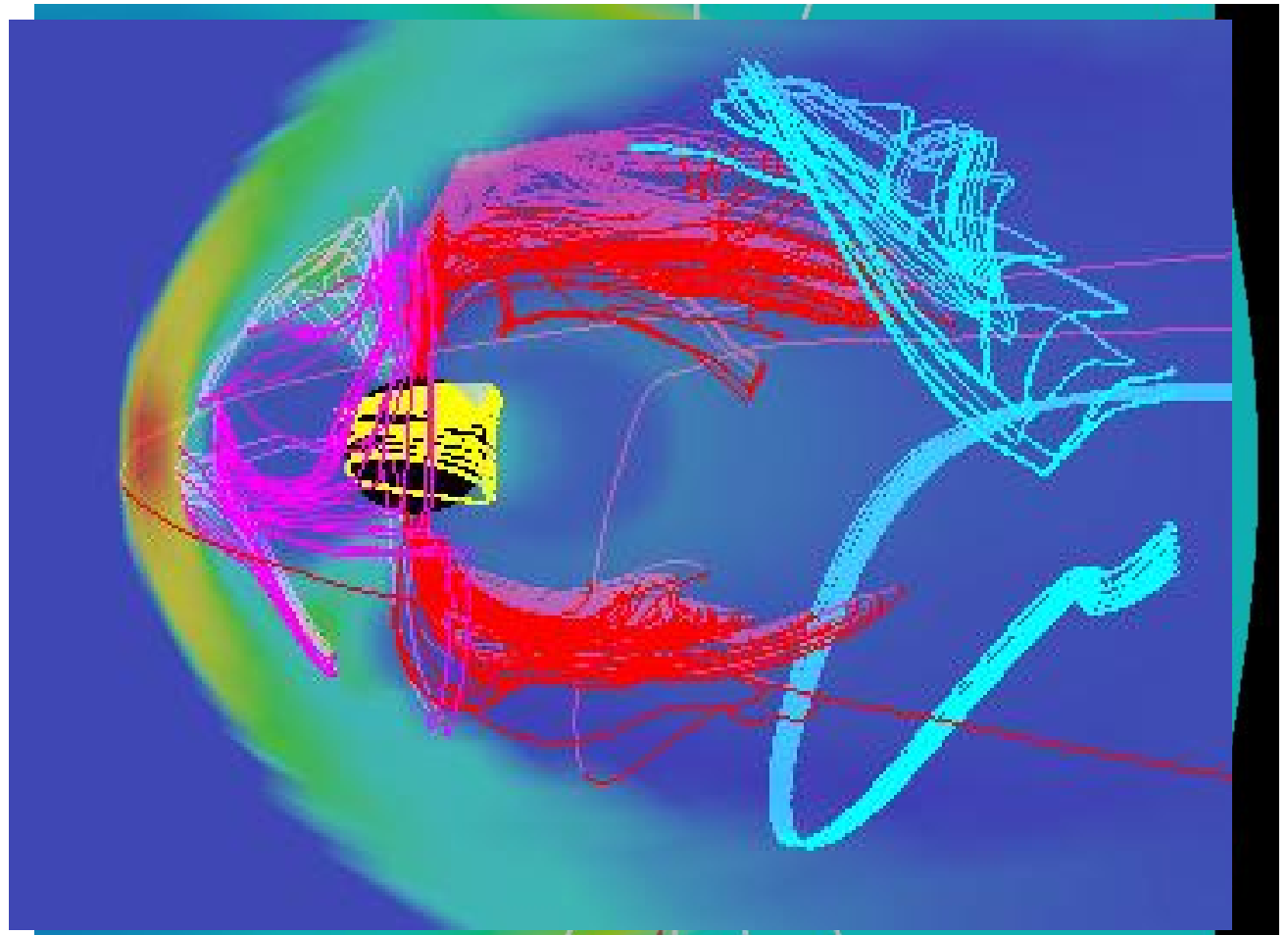
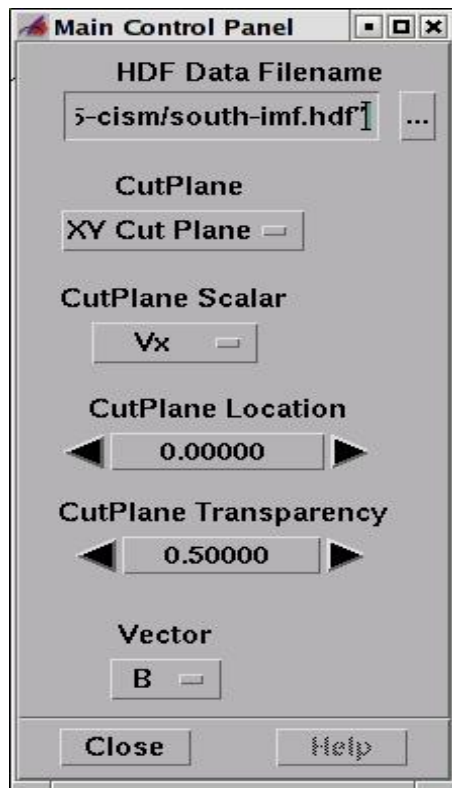


Thanks to Tim Guild

OpenDX applications in CISM_DX package

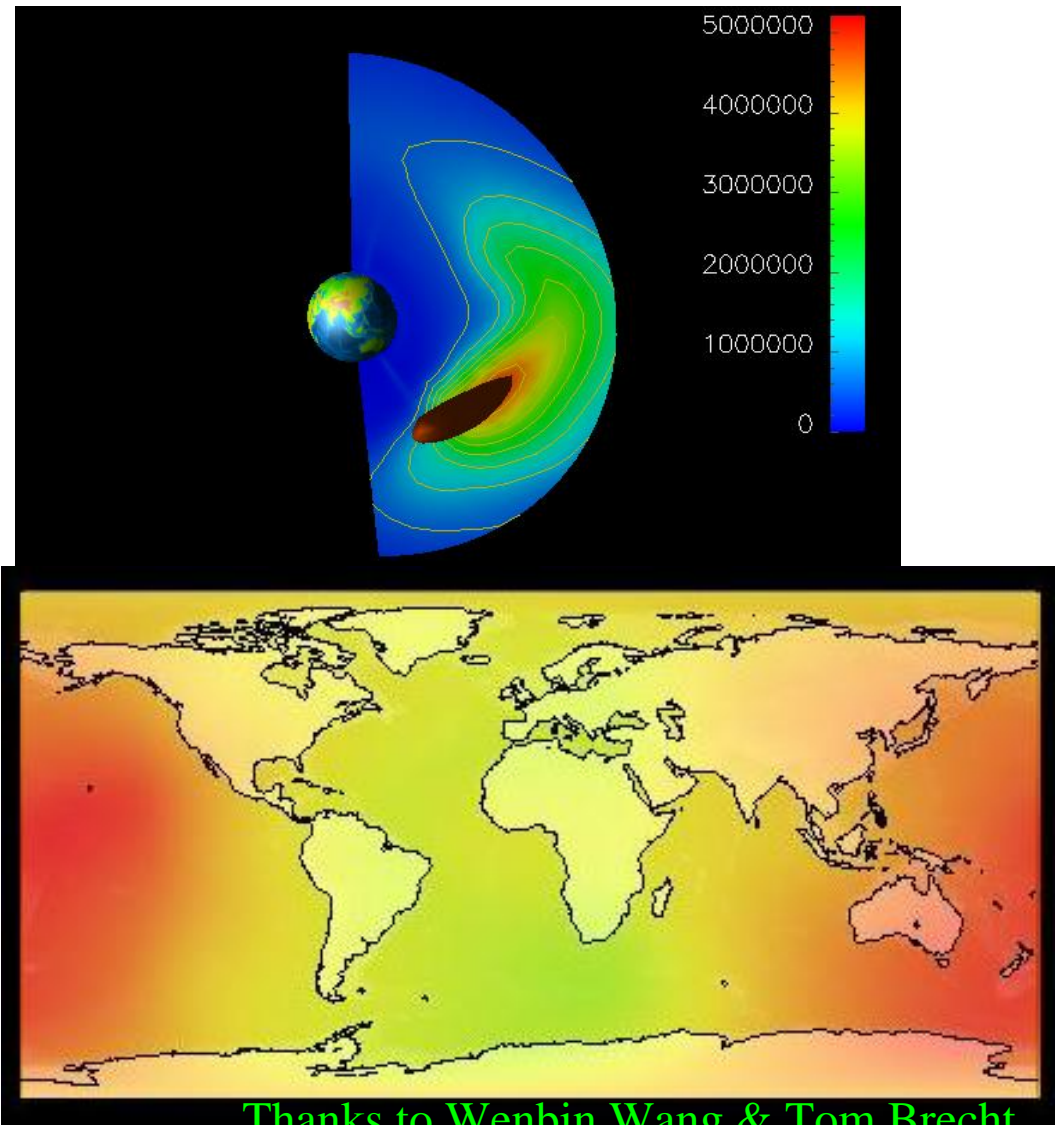
LFM – Magnetospheric Model

- CISM Summer School Students used this network to explore the 3D structure of the Magnetosphere



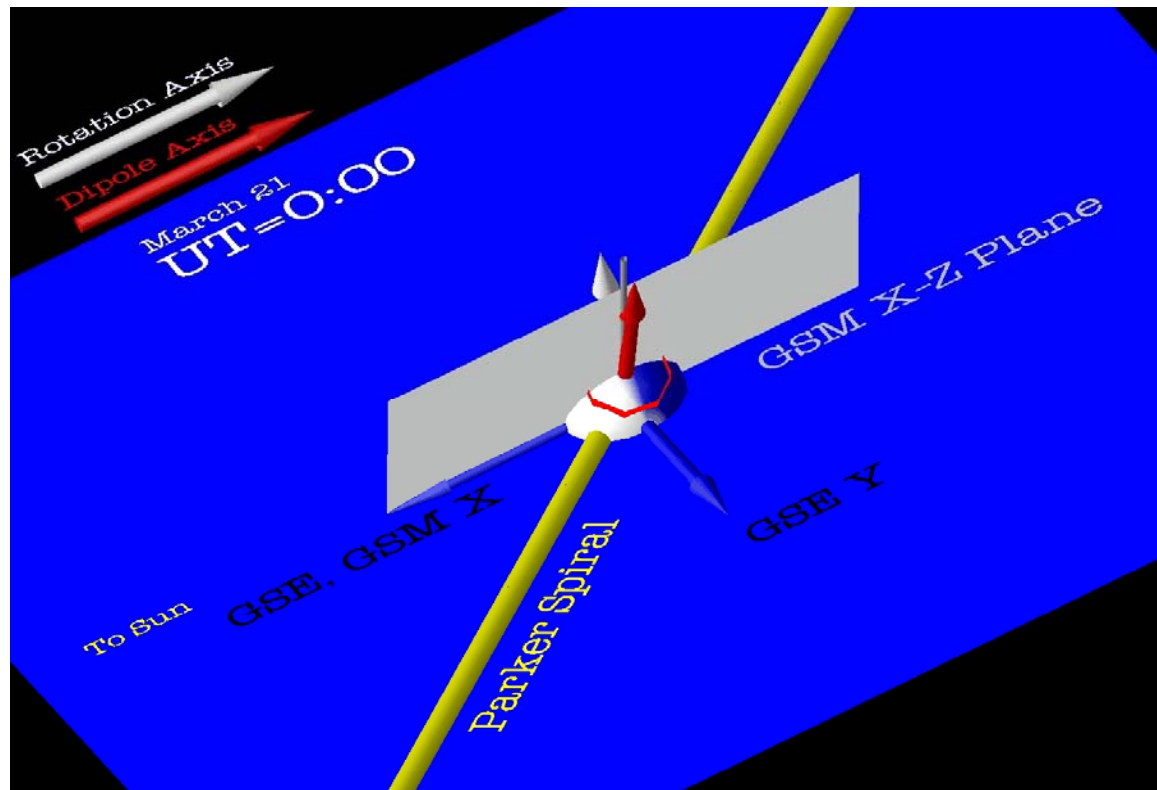
TING Visualizations

- TING is a 3D Global Circulation Model for the Earth's Thermosphere and Ionosphere
 - Variables describing the action of the neutral and ion species in these domains are stored in HDF files
- Networks support satellite views as well as map projections



Thanks to Wenbin Wang & Tom Brecht

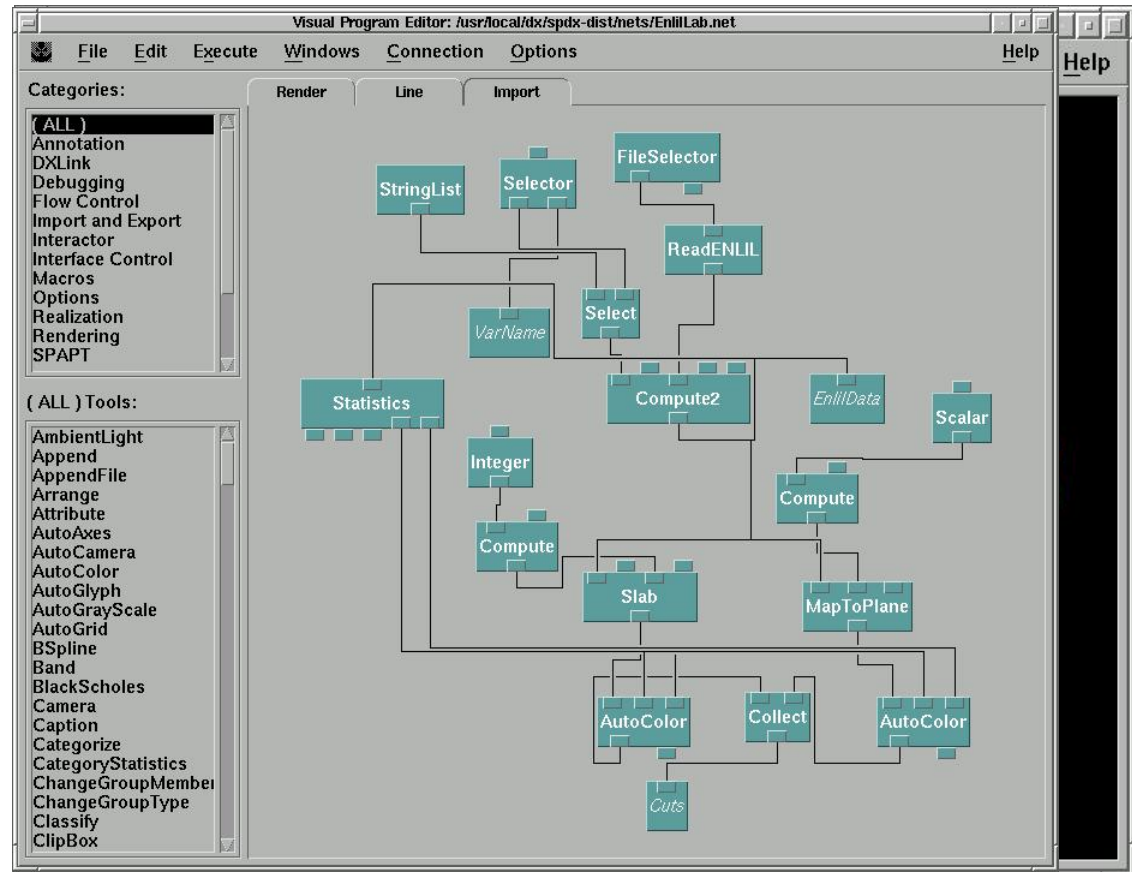
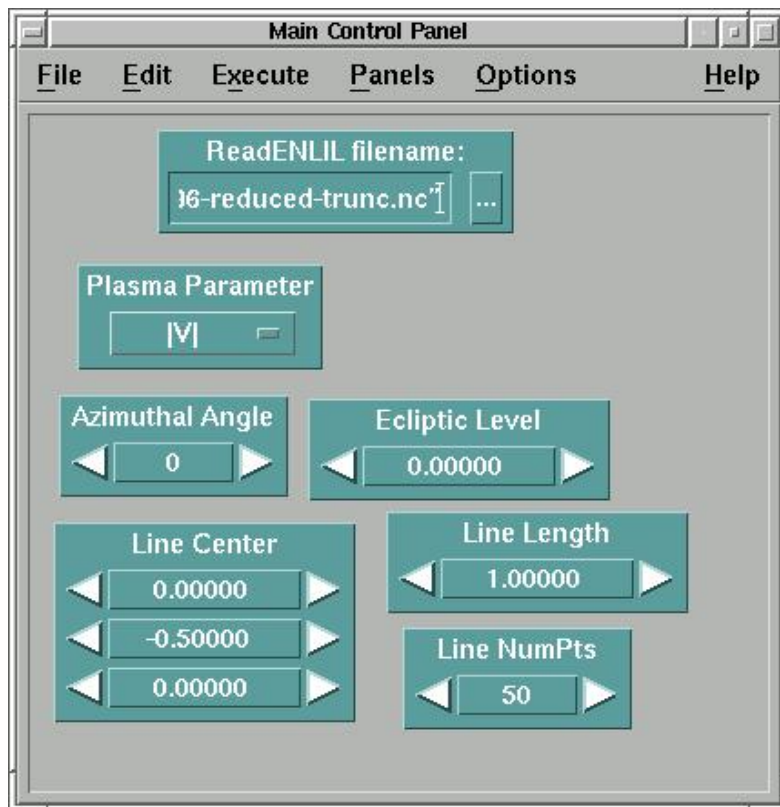
Coordinate Systems



- SPTransform Module
 - utilizes the Geopack coordinate system library
 - allows transformation of vectors between virtually all Space Physics coordinate systems

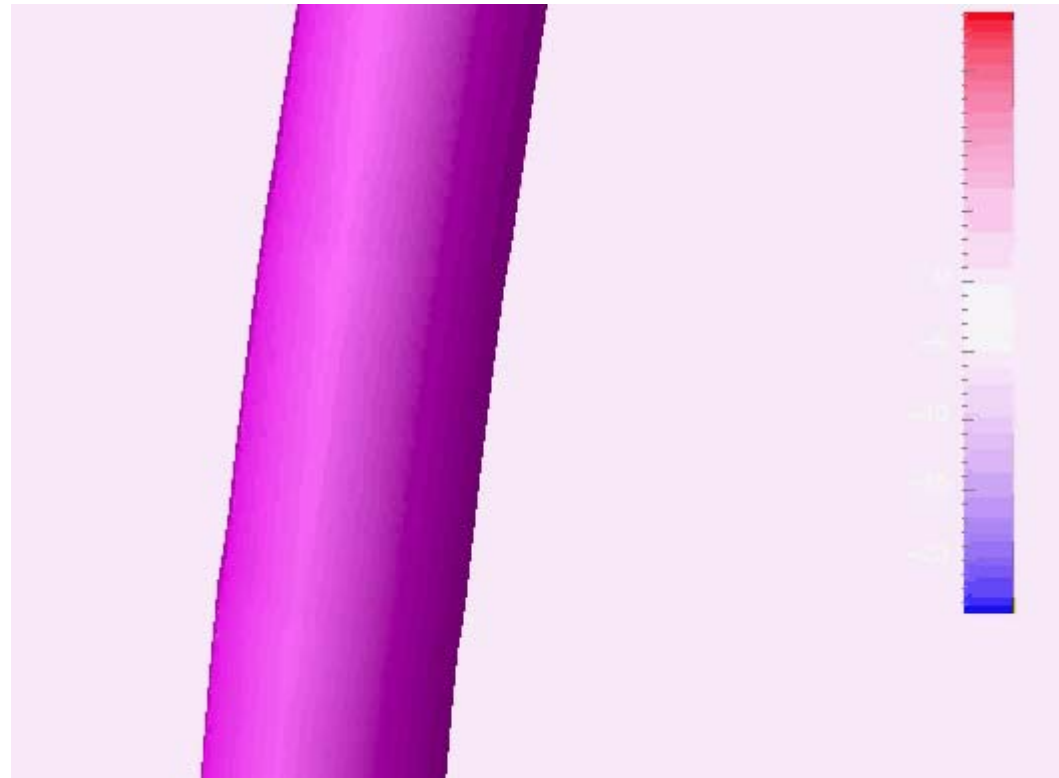
ENLIL – Solar Wind Model

- Network was used as basis for graduate student lab in CISM Summer School

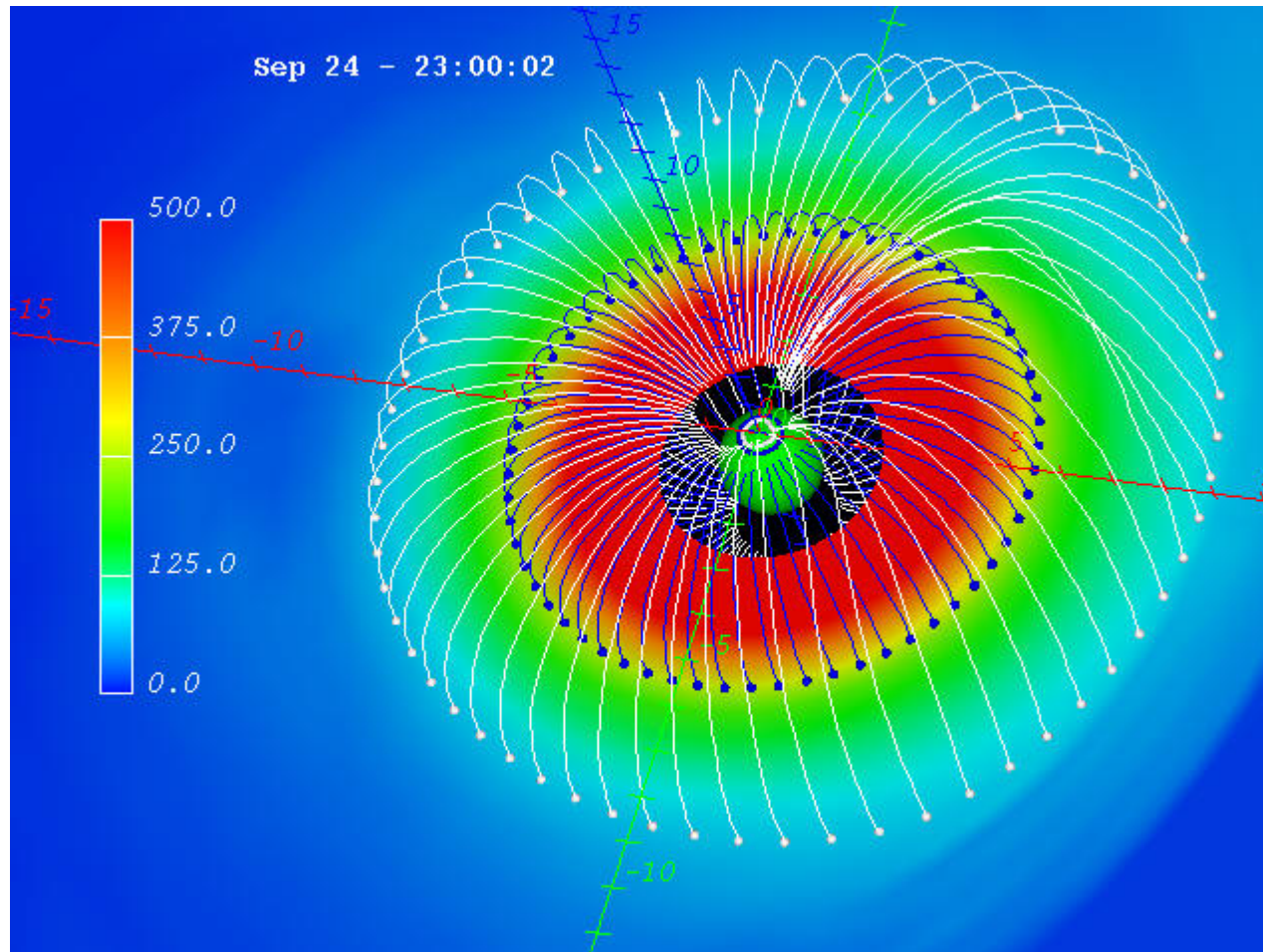


MAS – Coronal Results

- Complicated staggered mesh required writing import module
 - also required transformation from Spherical to Cartesian Coordinates
 - OpenDX modules allowed for implementation of periodic connections in phi direction



LFM – L* Calculation



- Electron drift trajectories are used as source points for field line tracing
 - End points are mapped from inner edge into ionosphere
 - L^* is determined by calculating flux enclosed in orbit
 - In DX the field line is an object that can be used for interpolation
- Thanks to Scot Elkington

LFM – Pathlines

- Streamline
 - Path through vector field that is tangent to vectors throughout
 - magnetic field lines
- Pathline
 - Path of fluid element over a period of time
 - reverse time to see where elements come from
- Combine pathline with streamline object to monitor flux tube volume as a function of time

