Introduction to CISM_DX and Overview of OpenDX

Michael Gehmeyr

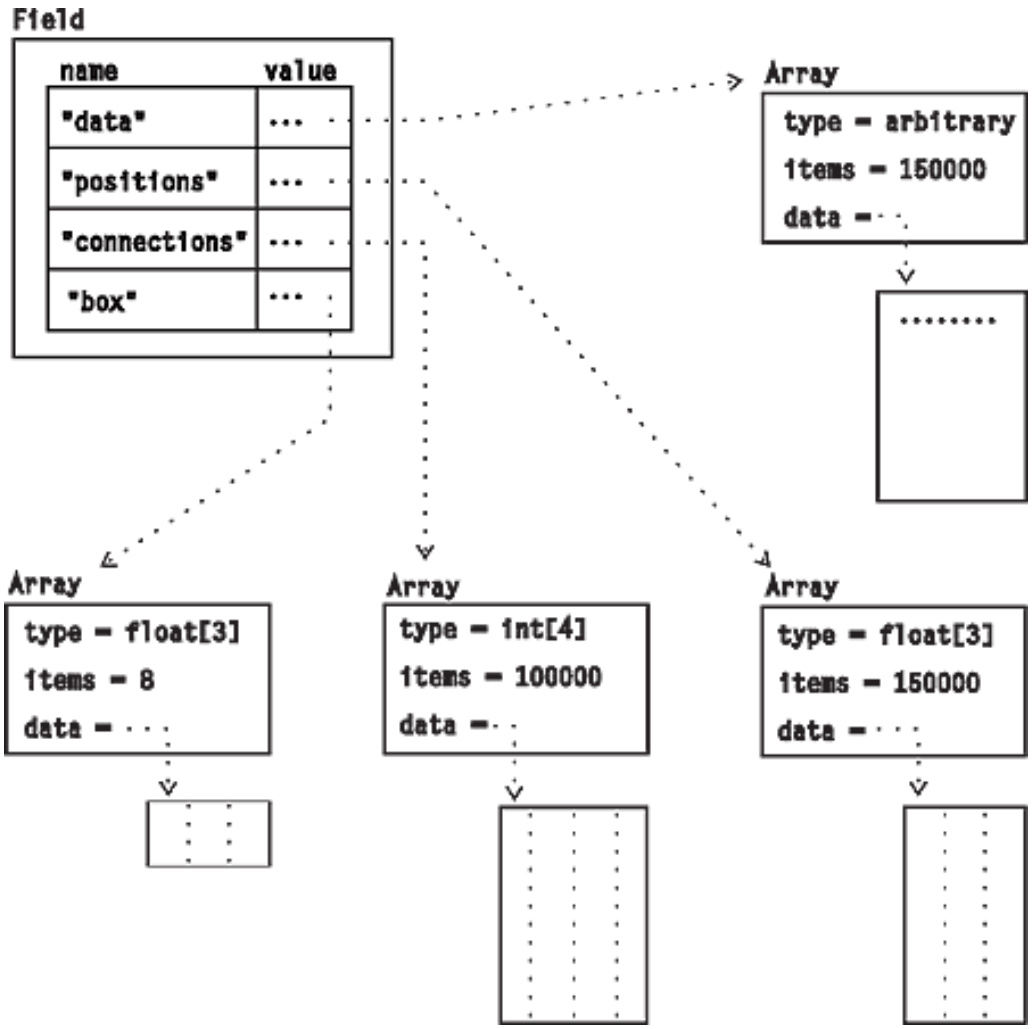
Outline

- 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

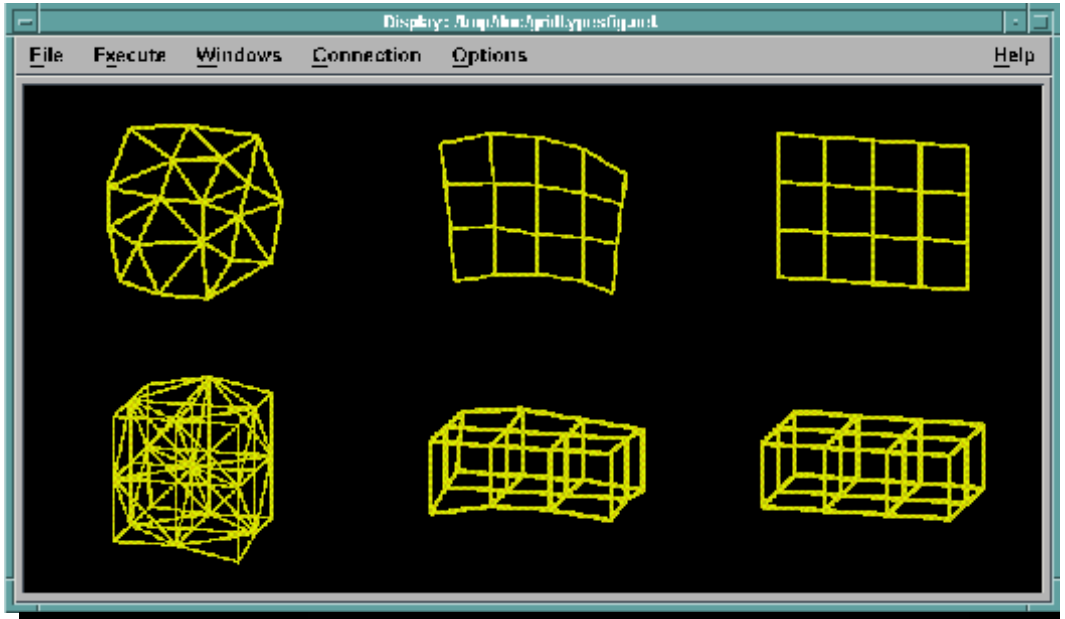
Data Structures: The Field Object

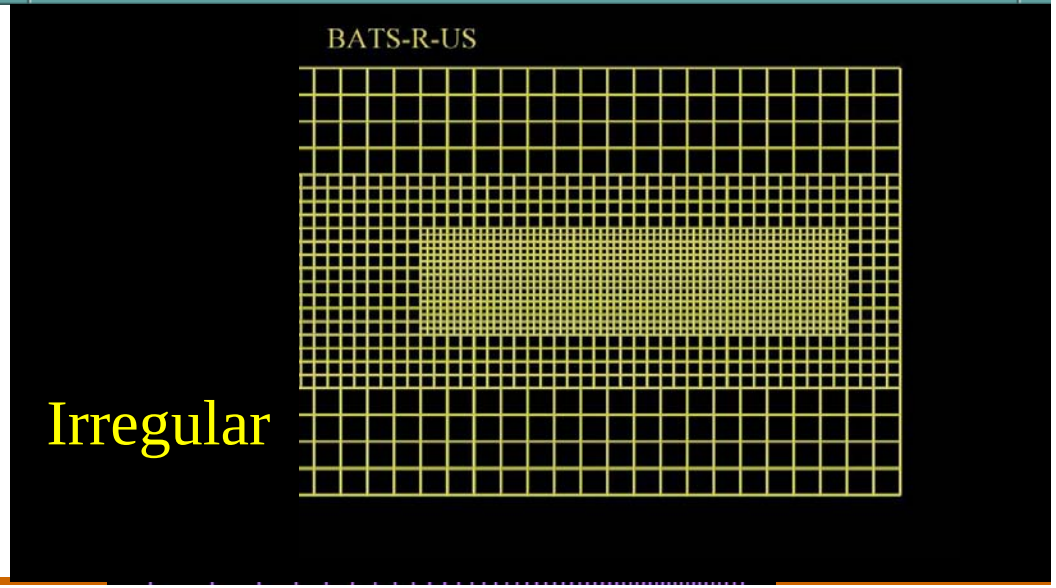


- A Field is the fundamental programming object in the OpenDX
- 3 main parts
  - Positions
    - Locations in space
  - Connections
    - Explains how the positions relate to each other
  - Data
    - Actual information can be scalar, 3-vector or beyond

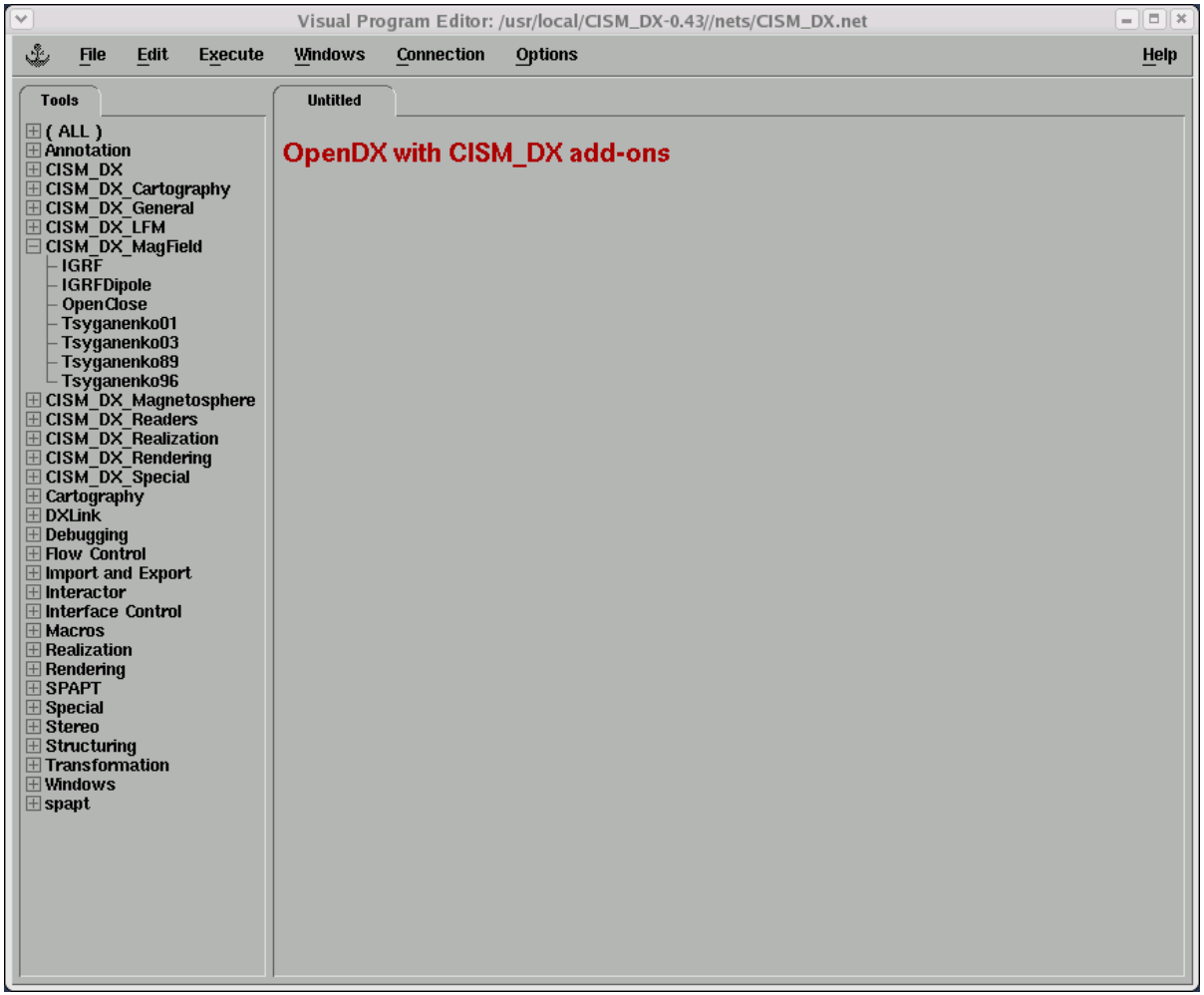
Grids

- 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

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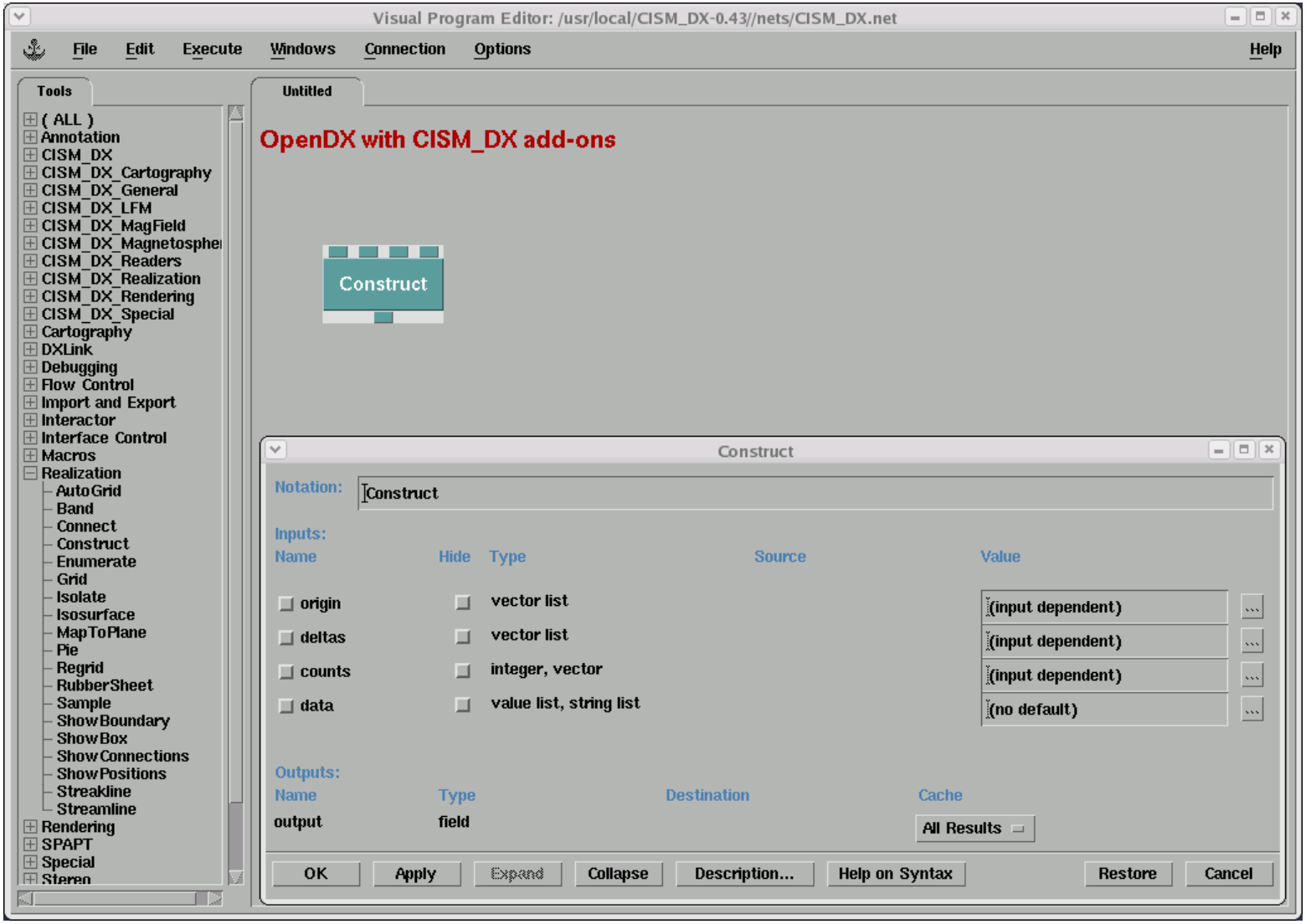
Modules



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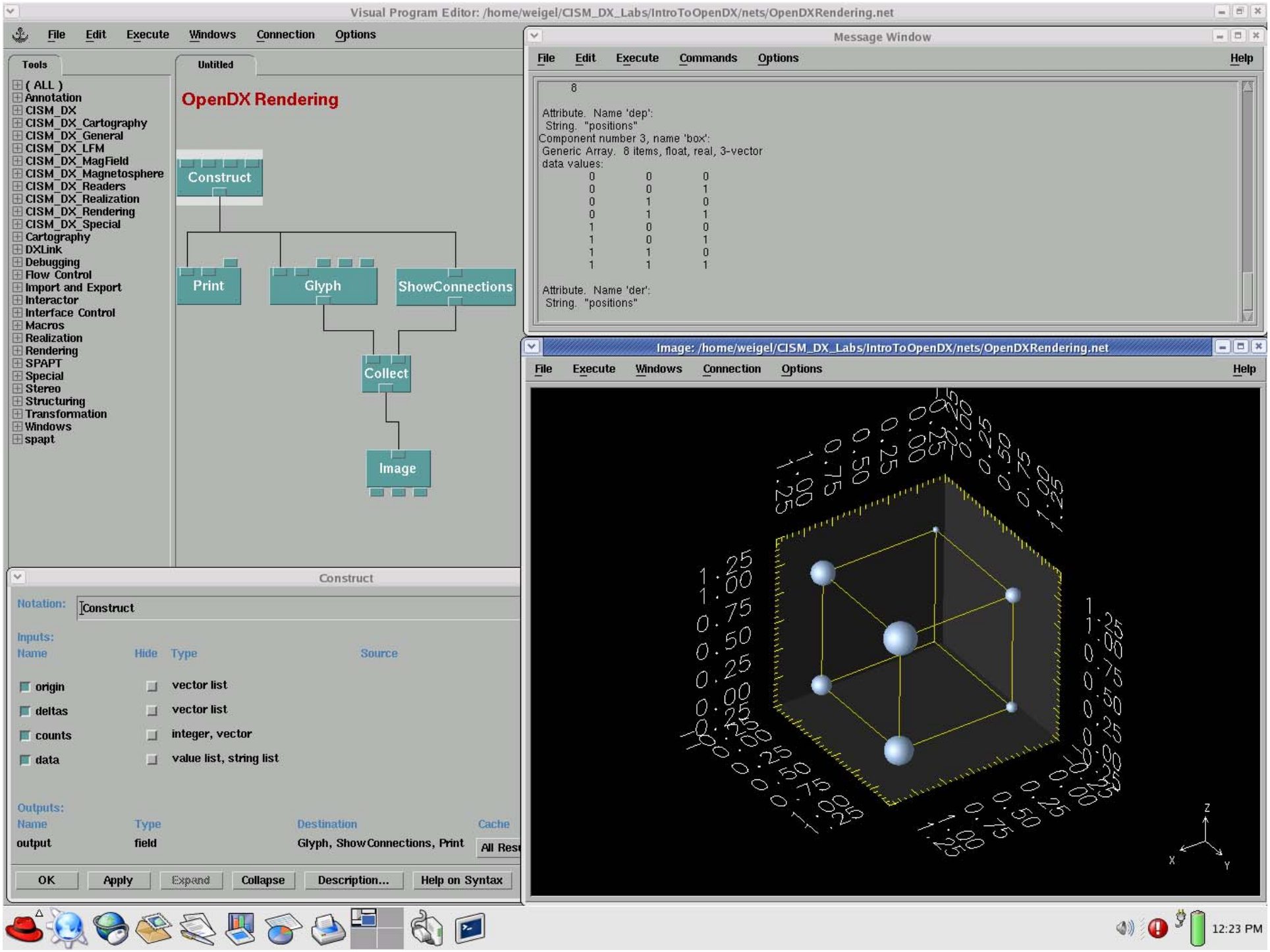
Visual Program Editor: /home/weigel/CISM_DX_Labs/IntroToOpenDX/nets/OpenDXRendering.net
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Tools
(ALL)
Annotation
CISM_DX
CISM_DX_Cartography
CISM_DX_General
CISM_DX_LFM
CISM_DX_MagField
CISM_DX_Magnetosphere
CISM_DX_Readers
CISM_DX_Realization
CISM_DX_Rendering
CISM_DX_Special
Cartography
DXLink
Debugging
Flow Control
Import and Export
Interactor
Interface Control
Macros
Realization
Rendering
SPAPT
Special
Stereo
Structuring
Transformation
Windows
spapt
Untitled
OpenDX Rendering
Construct
Print
Glyph
ShowConnections
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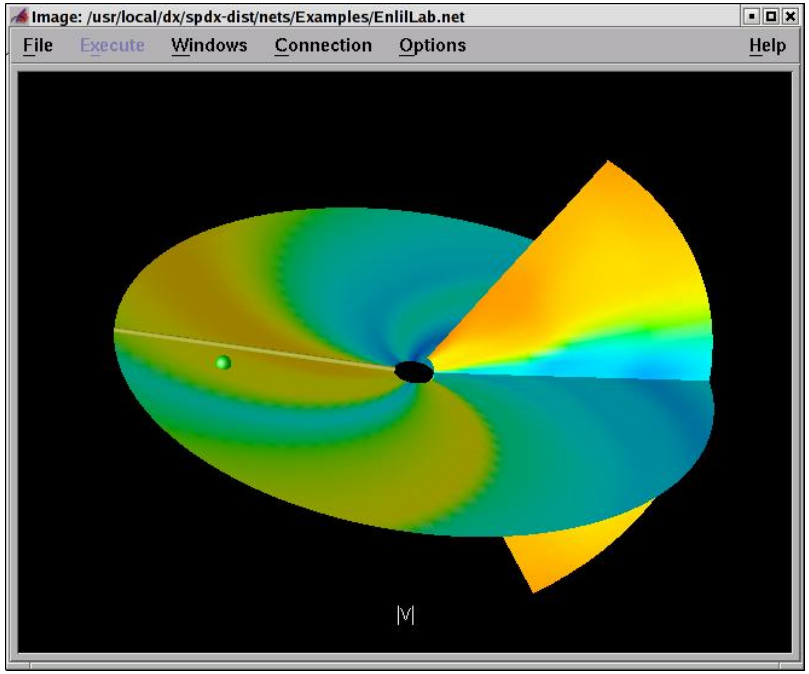
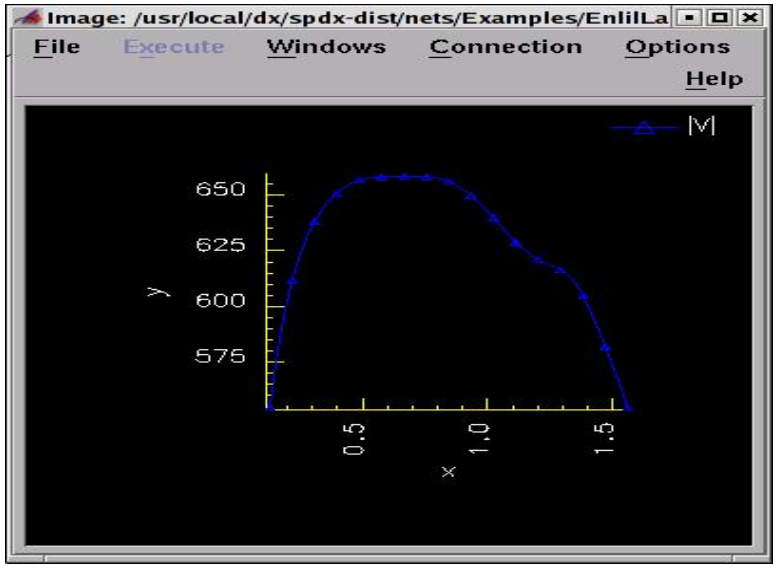
Image
Construct
Notation:
Construct
Inputs:
Name Hide Type Source
origin vector list
deltas vector list
counts integer, vector
data value list, string list
Outputs:
Name Type Destination Cache
output field Glyph, ShowConnections, Print
All Res
OK Apply Expand Collapse Description... Help on Syntax
Message 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
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

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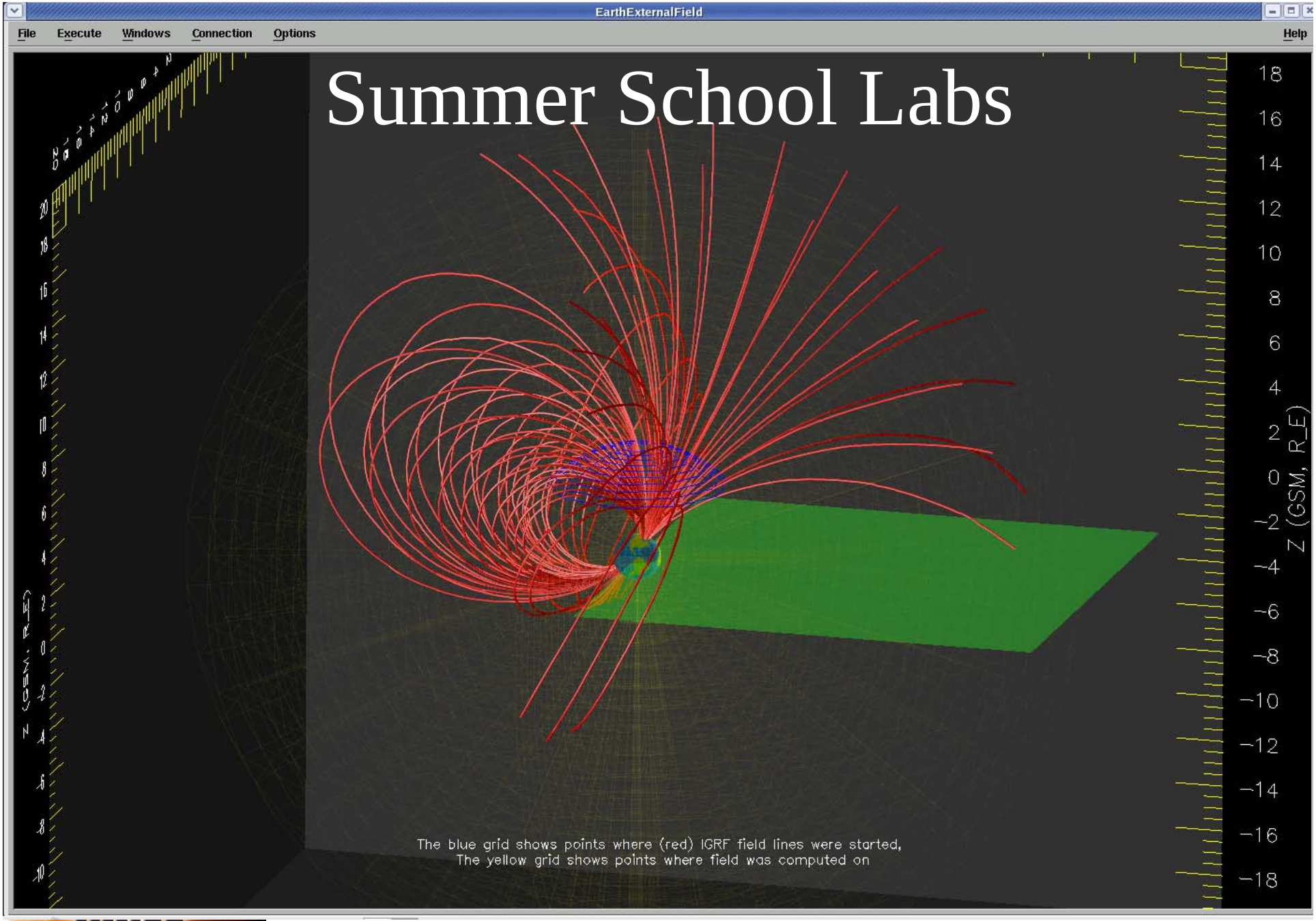
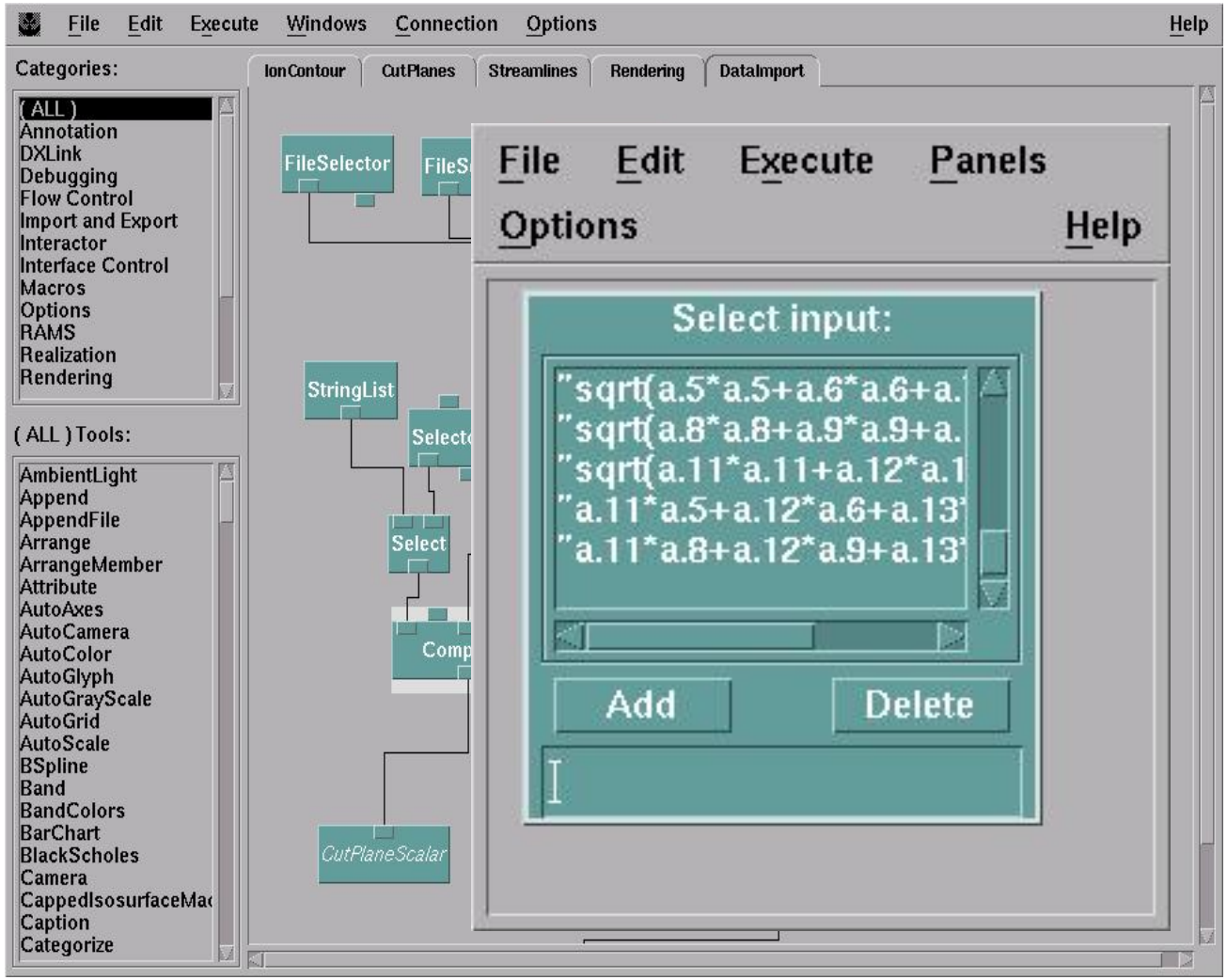
Summer School Labs



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



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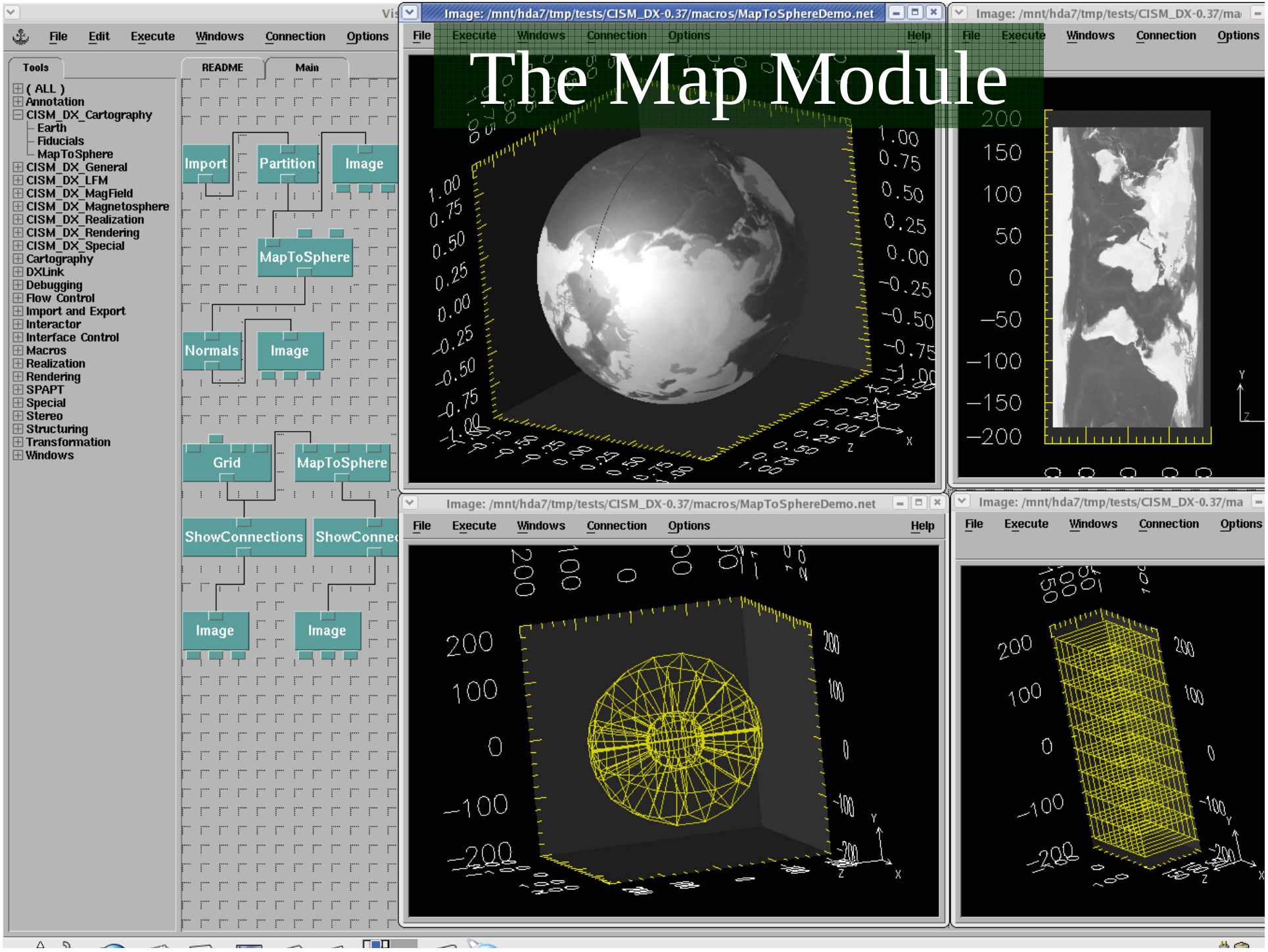
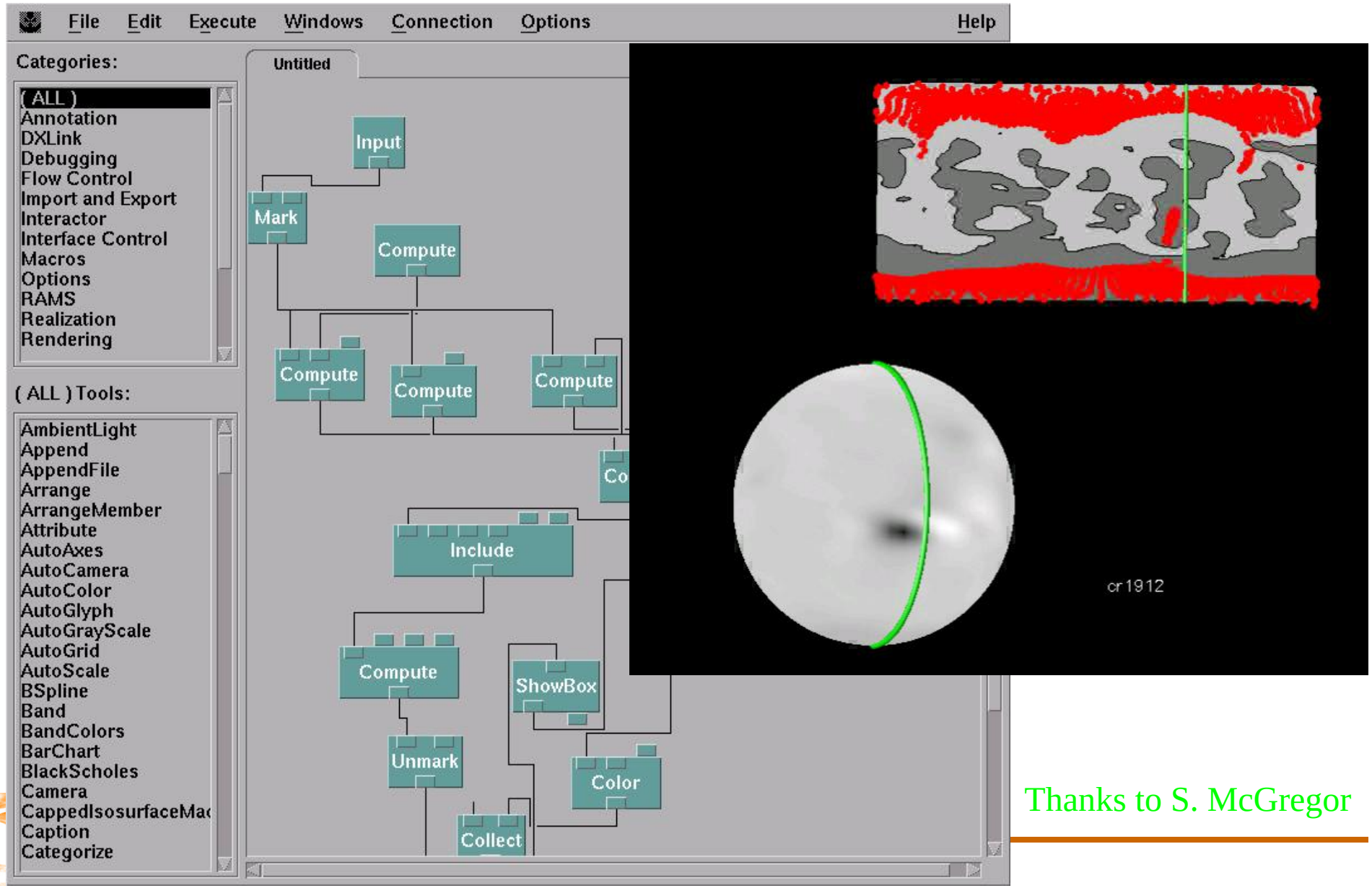
The Map Module



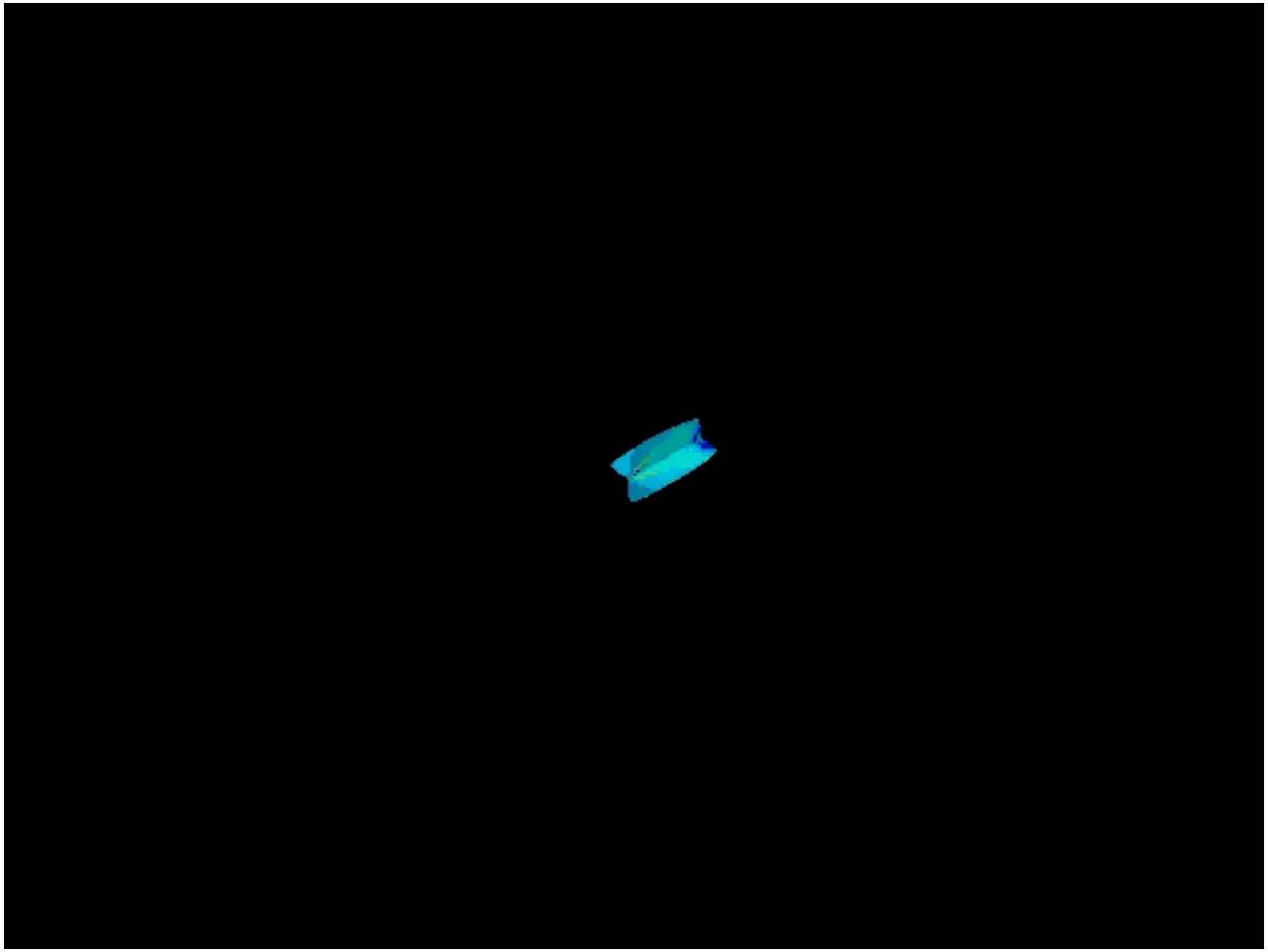
The Mark/Unmark modules



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

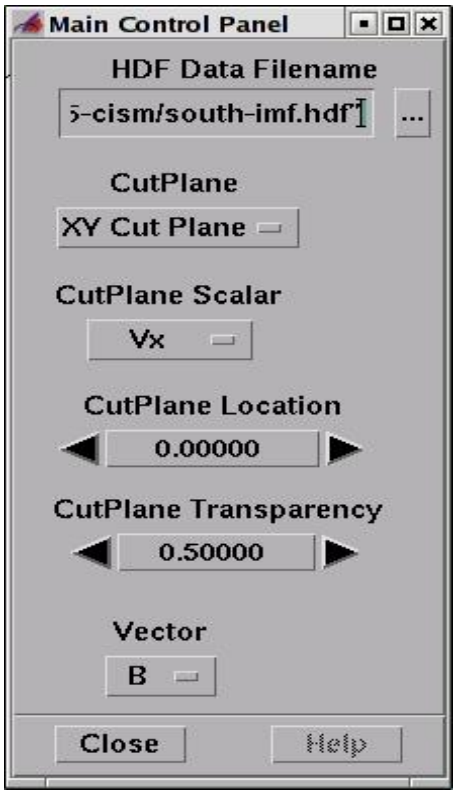


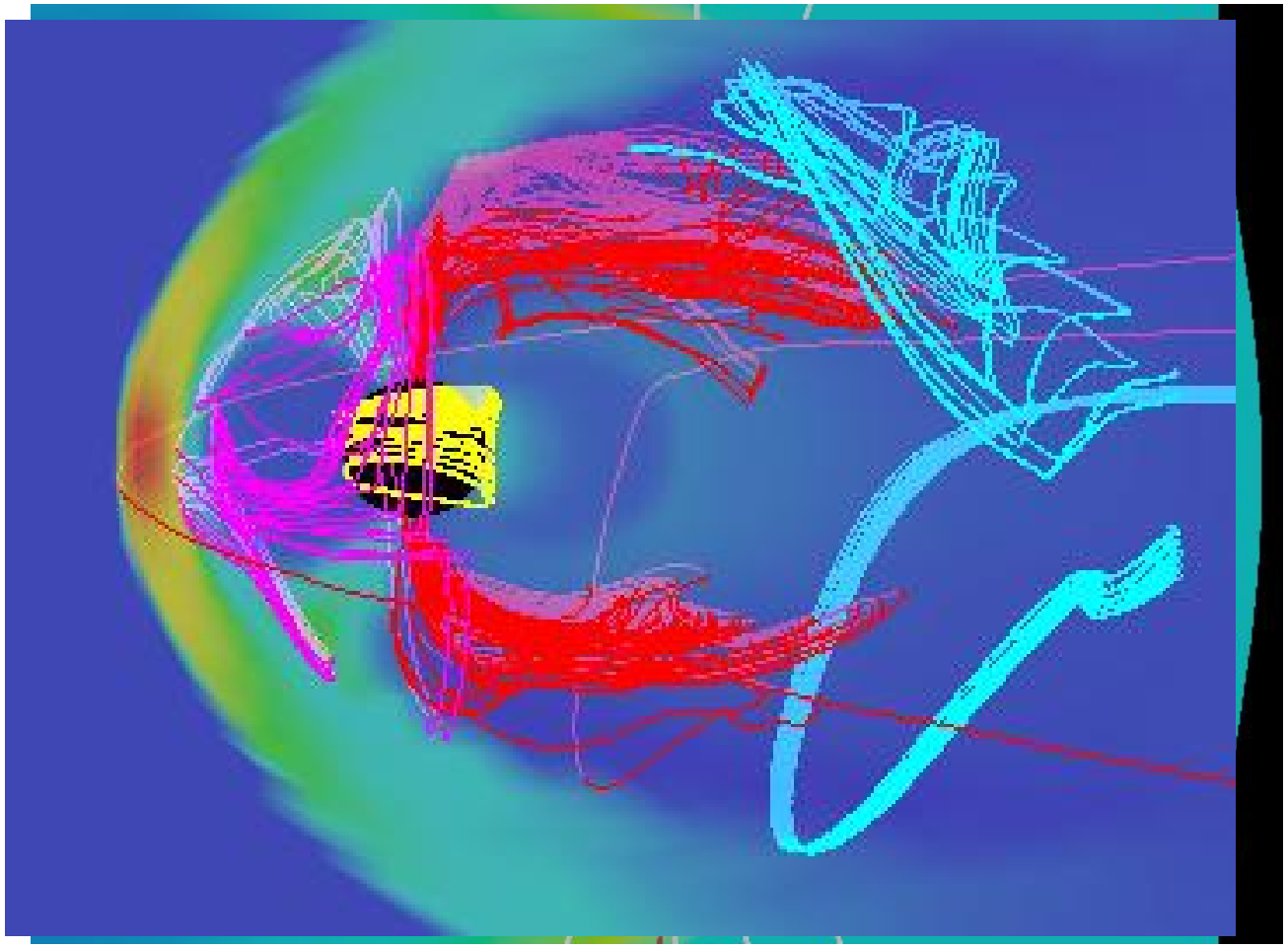
Thanks to Tim Guild

OpenDX applications in CISM_DX package

LFM – Magnetospheric Model

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





Thanks to John Lyon and Sarah McGregor

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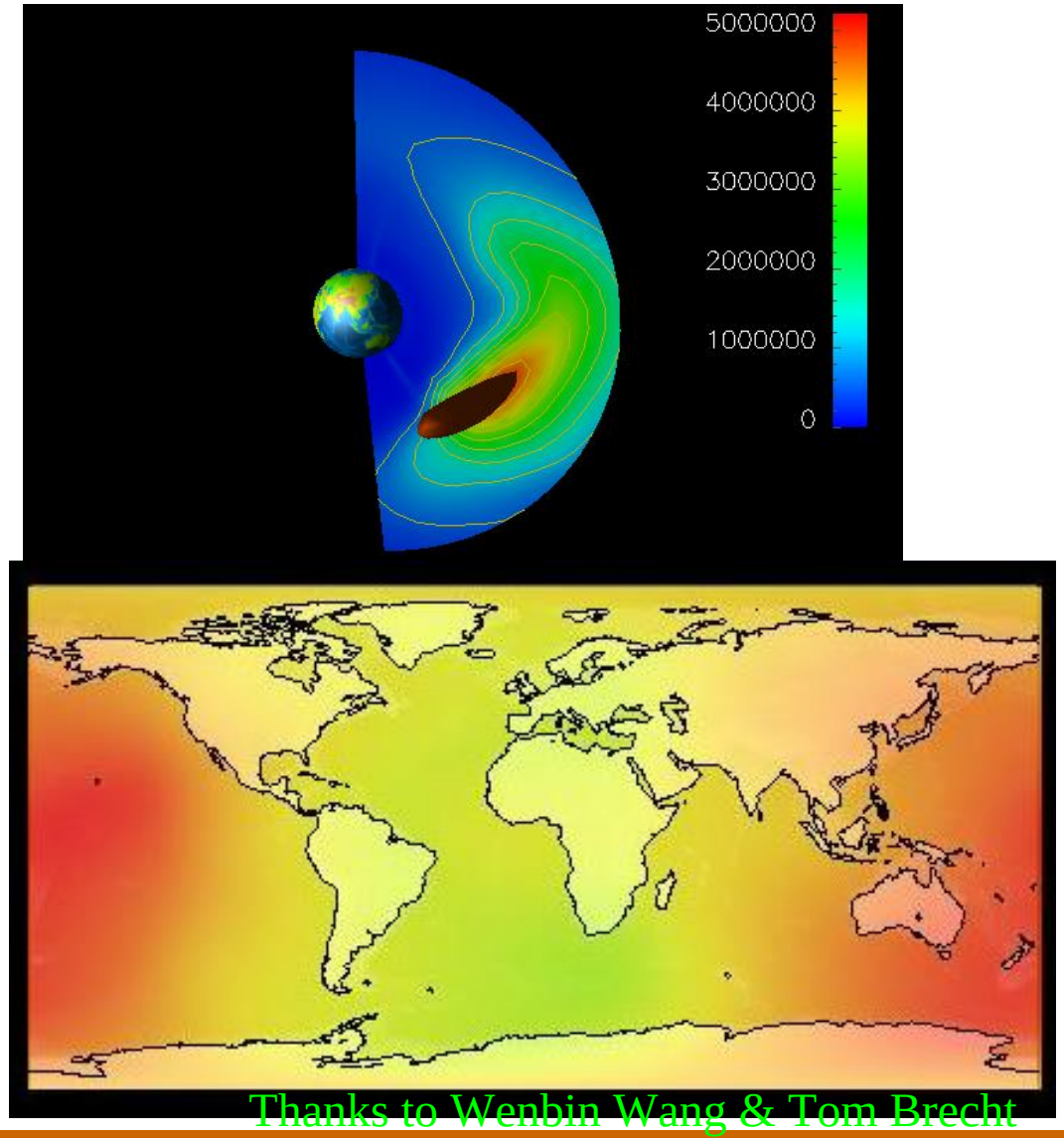
TING Visualizations

- 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

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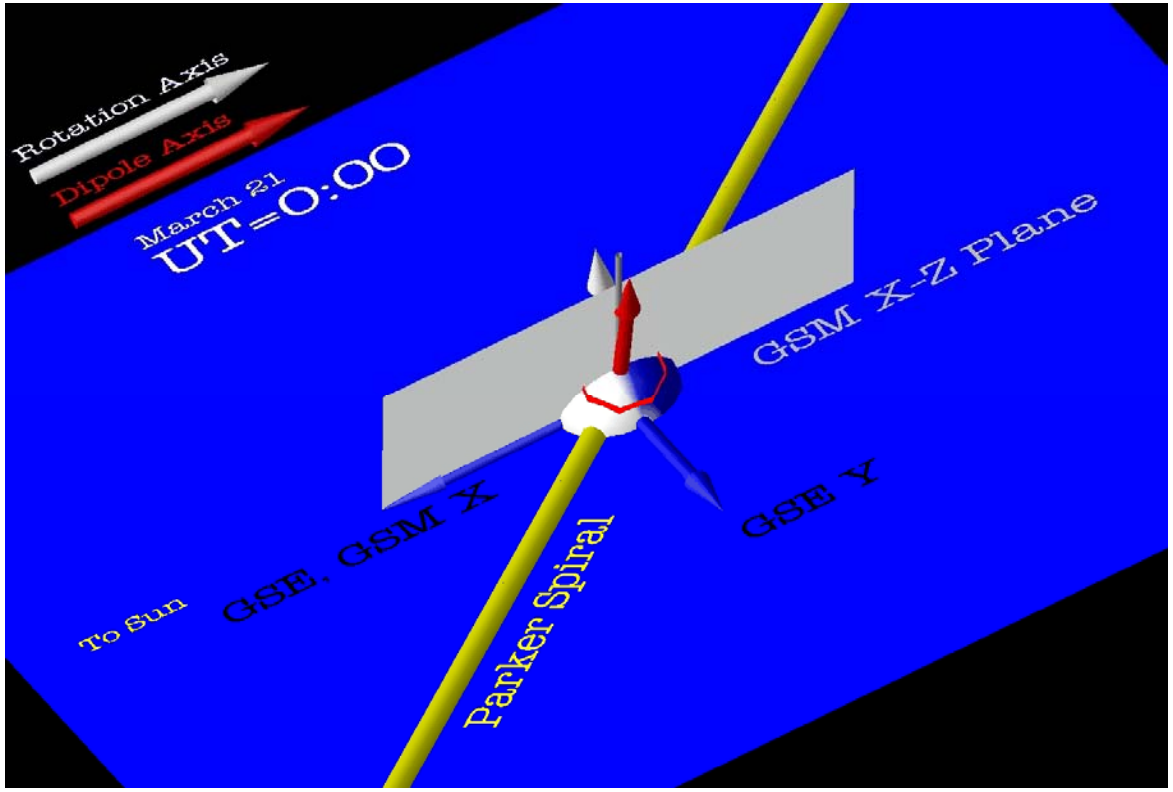
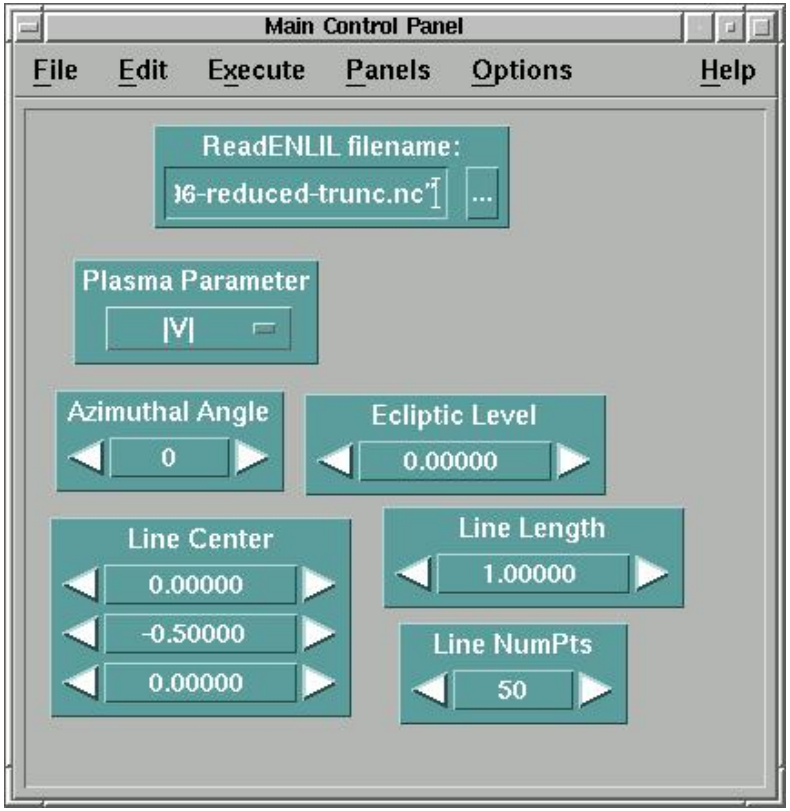
Coordinate Systems

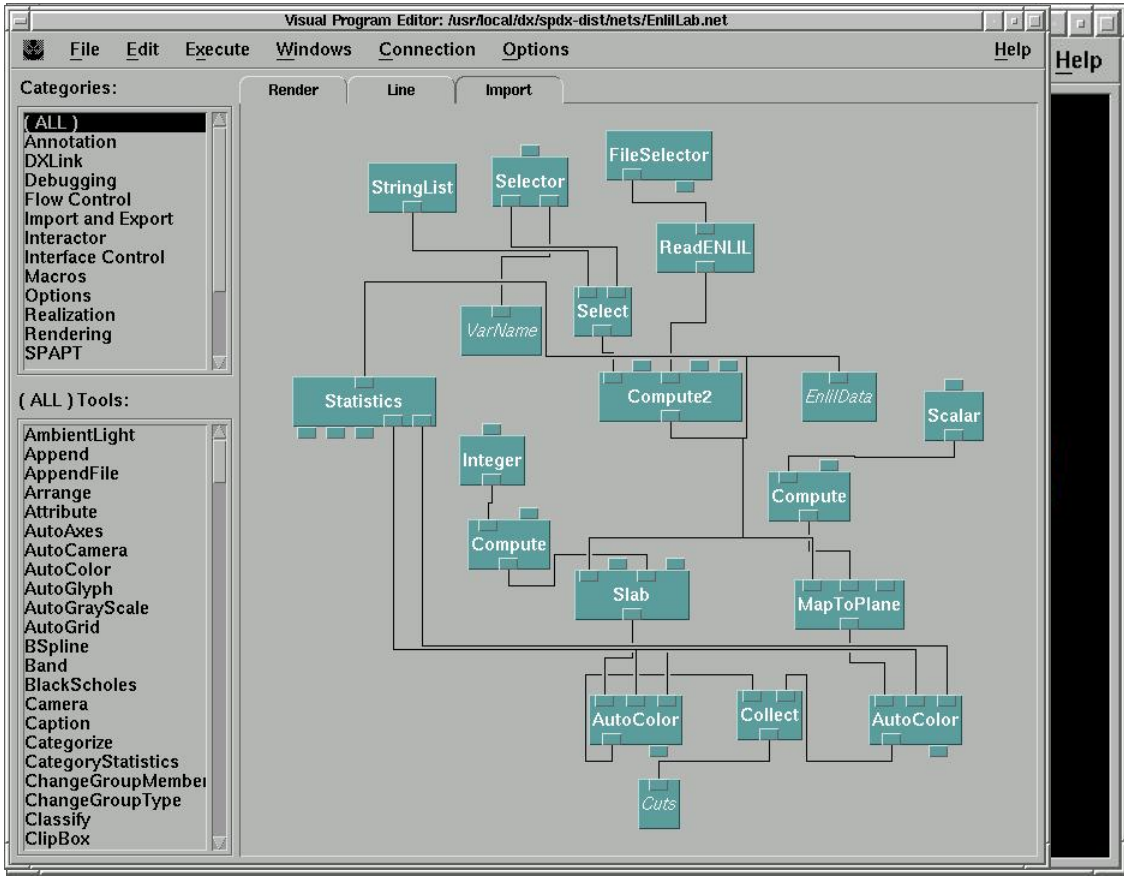


- SPTransform Module
  - utilizes the Geopack coordinate system library
  - allows transformation of vectors between virtually all Space Physics coordinate systems

ENLIL – Solar Wind Model

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

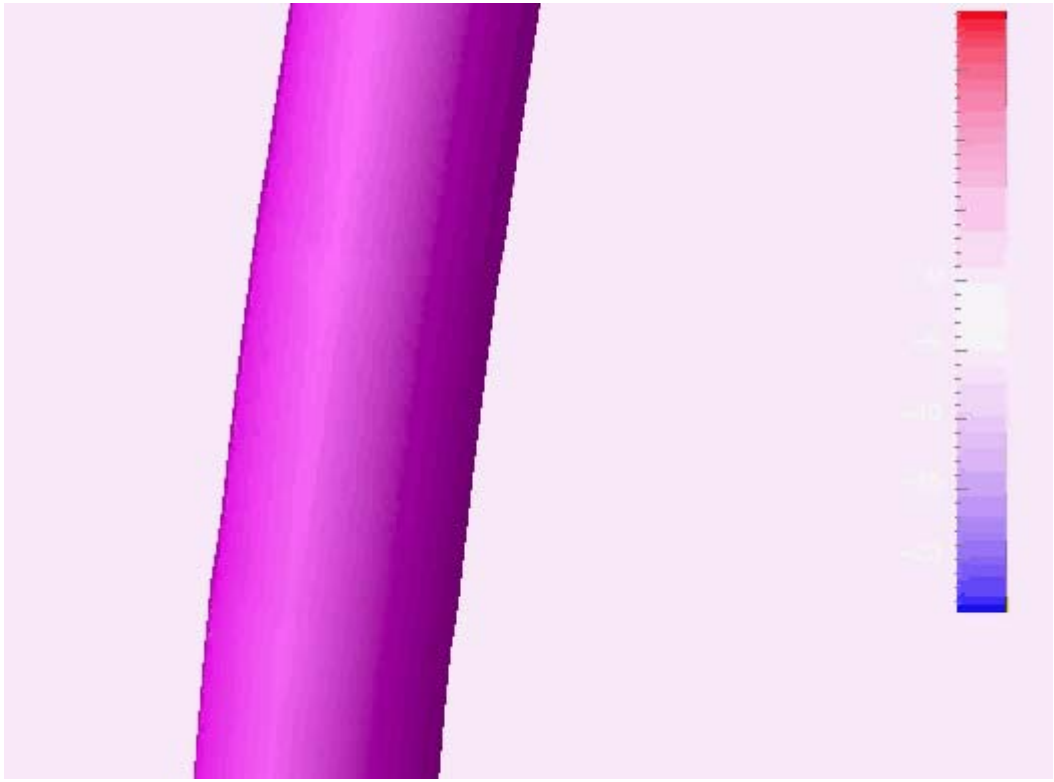




Thanks to Dusan Odstrcil

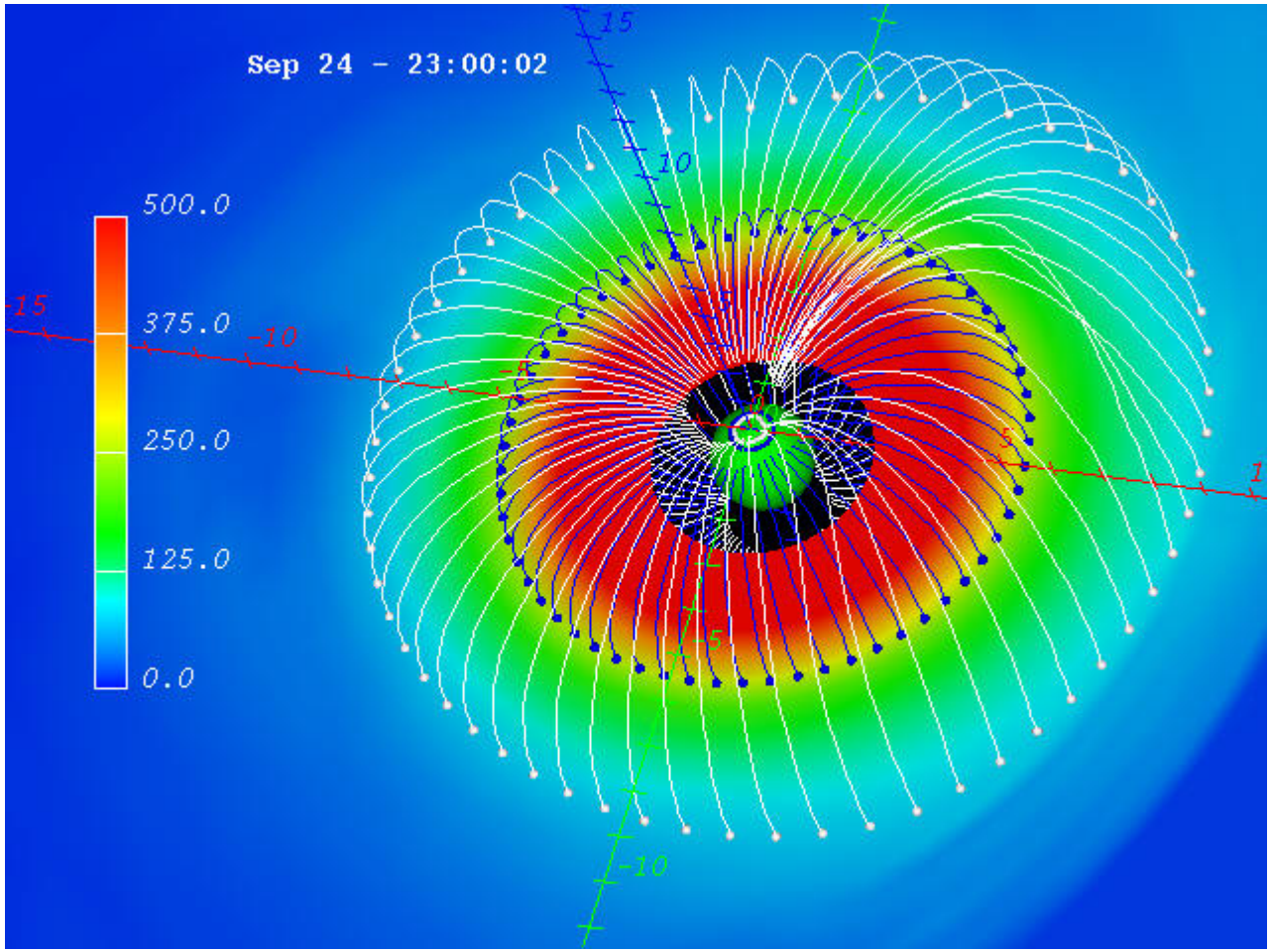
MAS – Coronal Results

- 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



Thanks to Pete Riley and Jon Linker

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

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LFM – Pathlines

- Streamline
  - Path through vector field that is tanget 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