Introduction to CISM_DX and Overview of OpenDX

Michael Gehmeyr

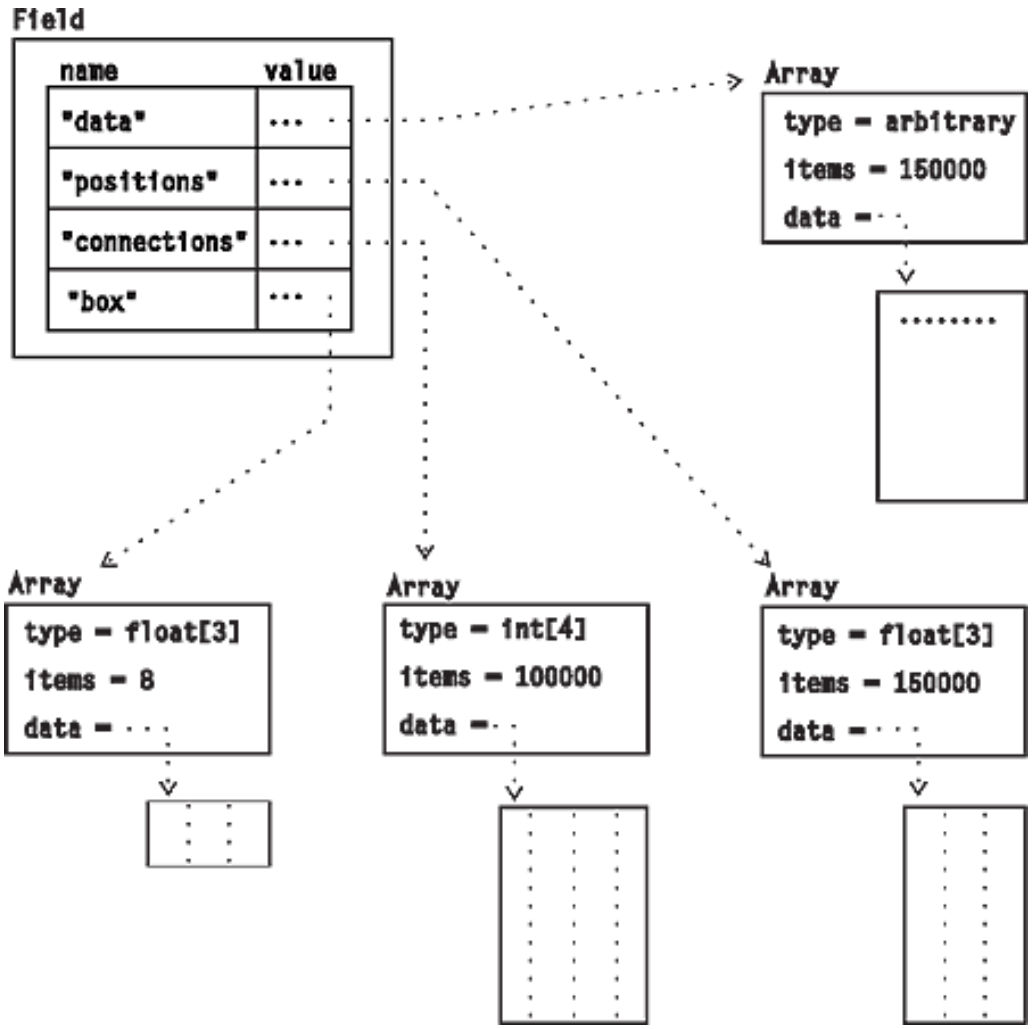
Outline

- 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

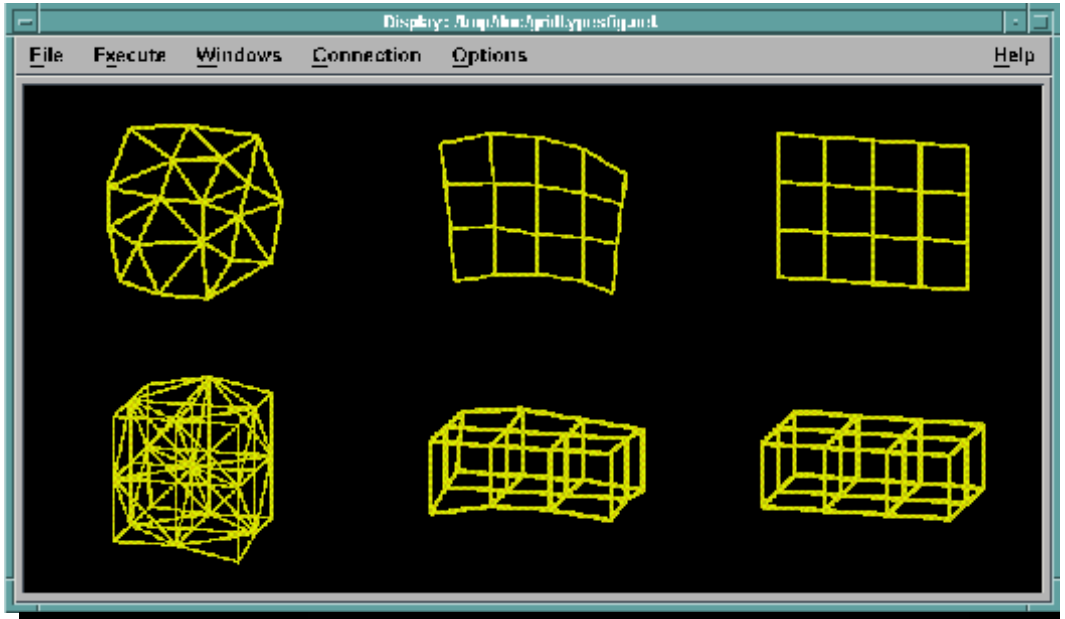
Data Structures: The Field Object

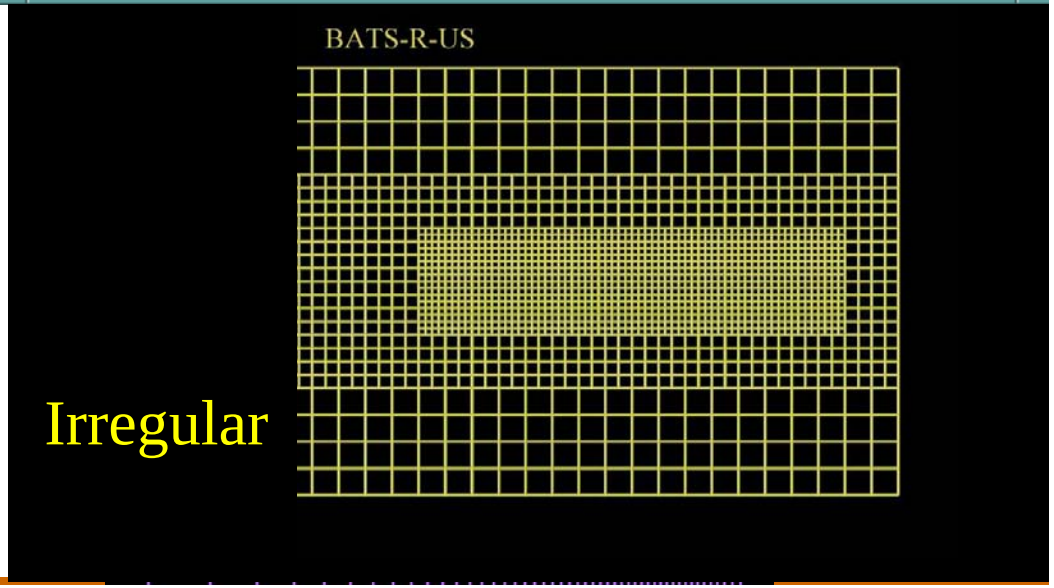


- A Field is the fundamental programming object in the OpenDX
- 3 main parts
  - Positions
    - Locations in space
  - Connections
    - Explains how the positions relate to each other
  - Data
    - Actual information can be scalar, 3-vector or beyond

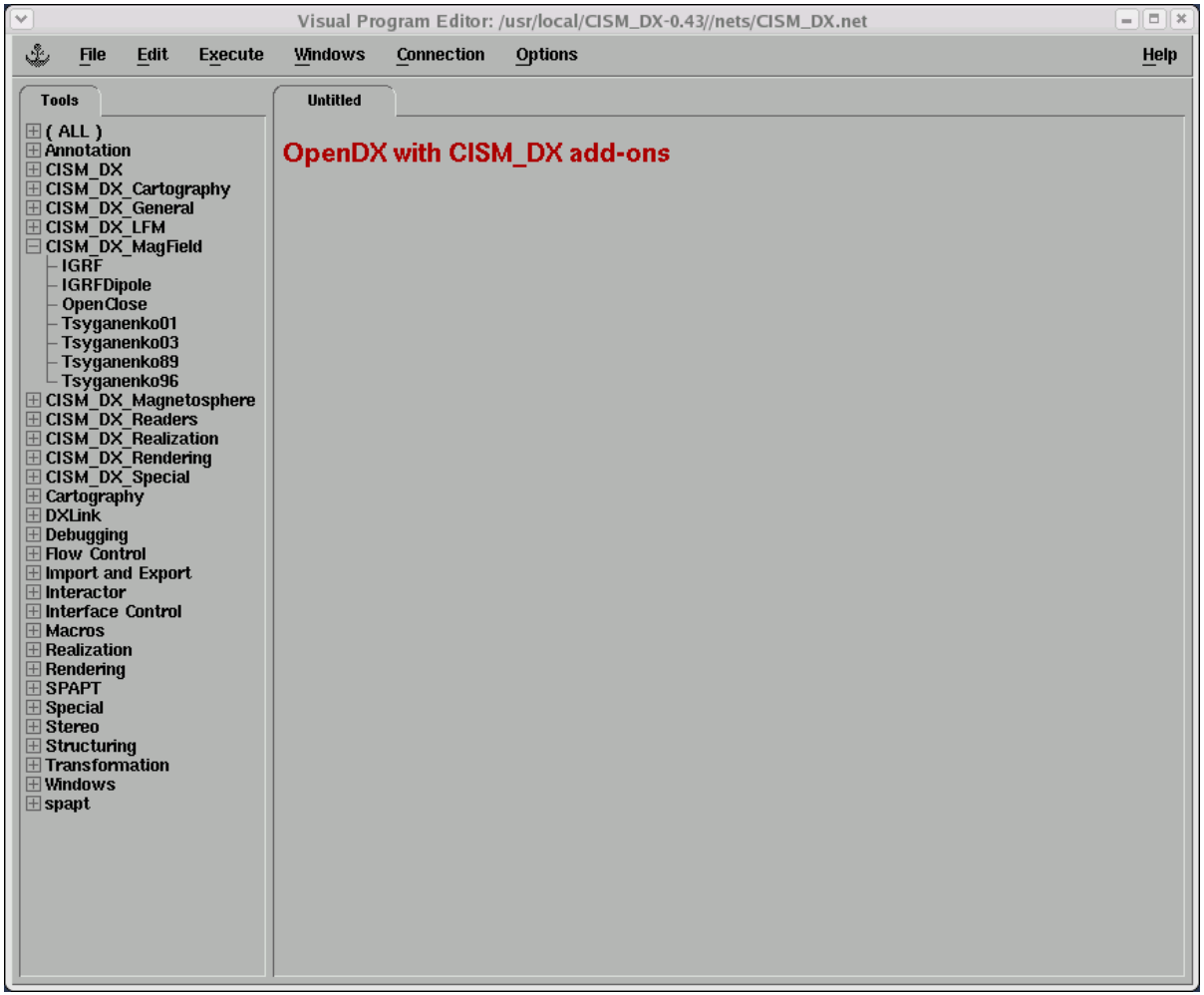
Grids

- 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





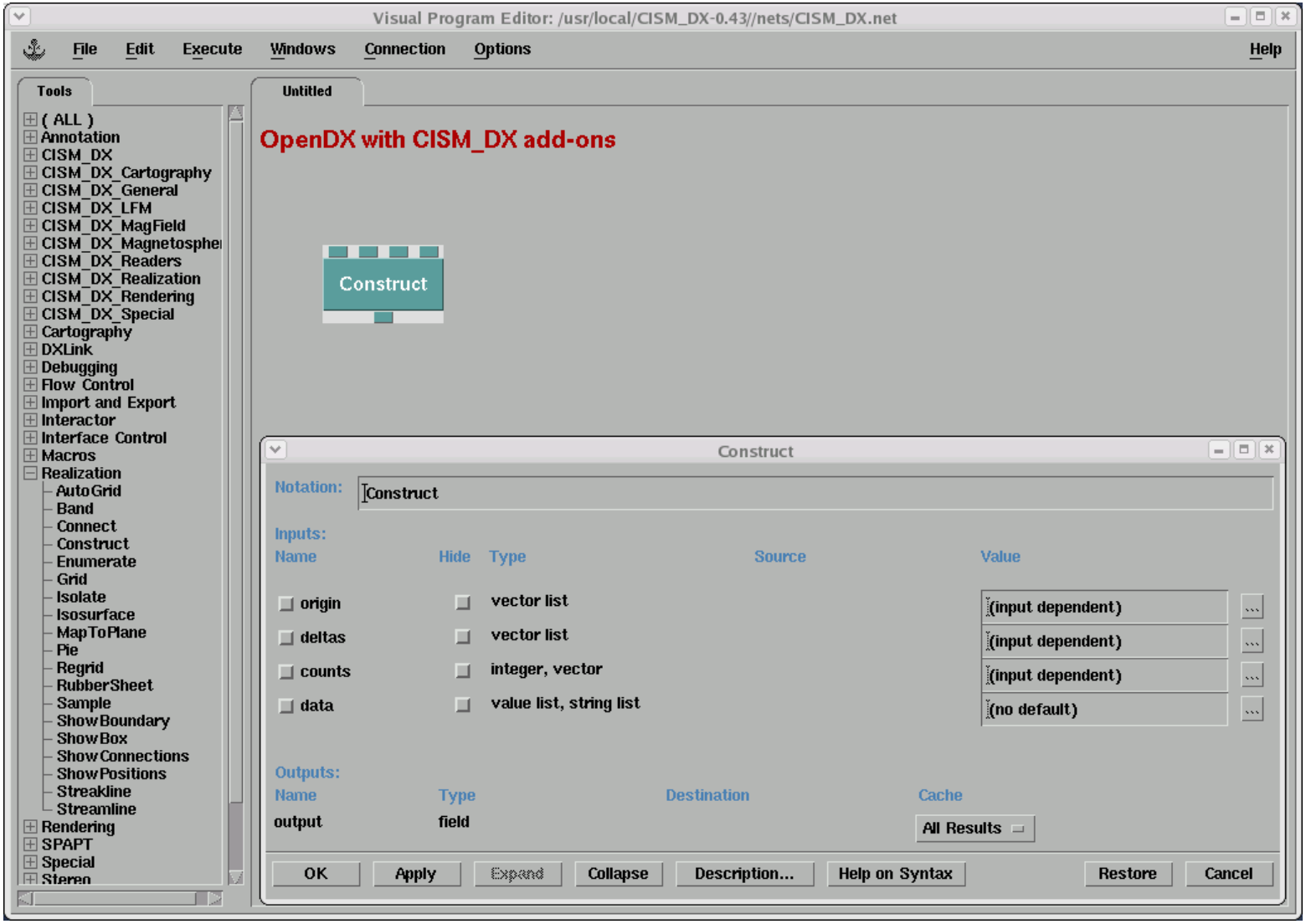
Visual Program Environment (VPE)



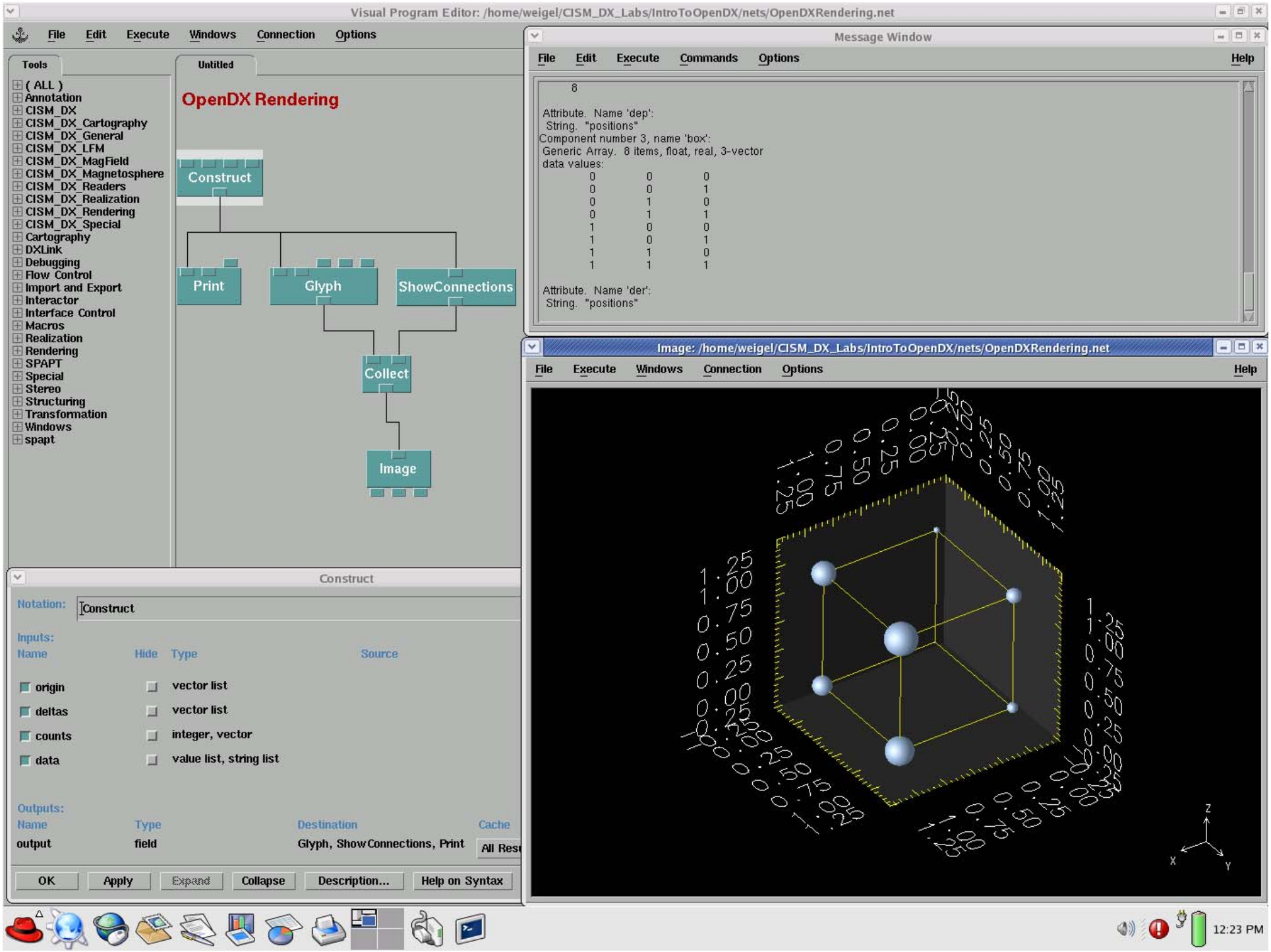
- User ‘writes’ a visual program or net to create visualizations
- These programs use the modules provided by OpenDX or modules written by the user to accomplish specific tasks such as data importing, coordinate system rotations, etc

CISM
Center for Integrated Space Weather Modelling

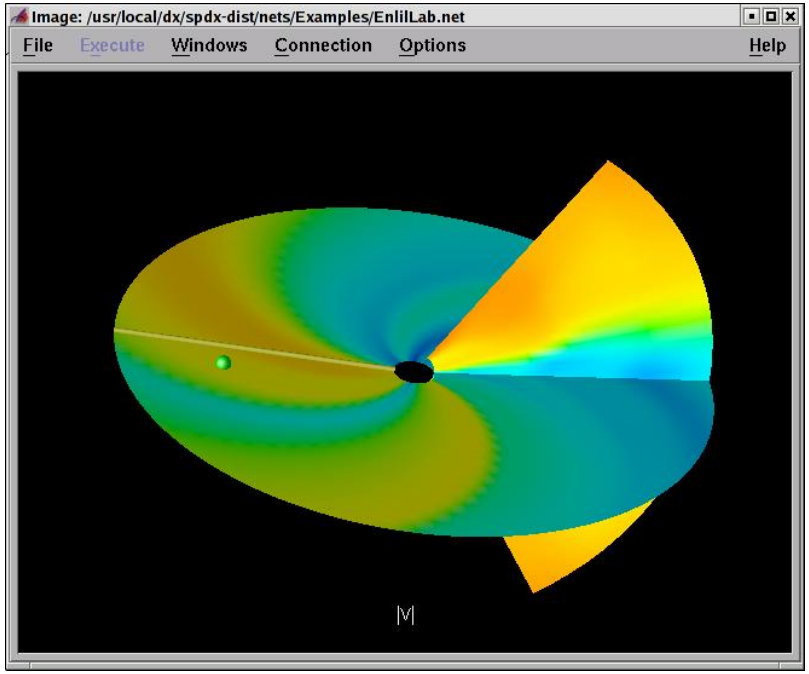
Modules



CISM
Center for Integrated Space Weather Modelling

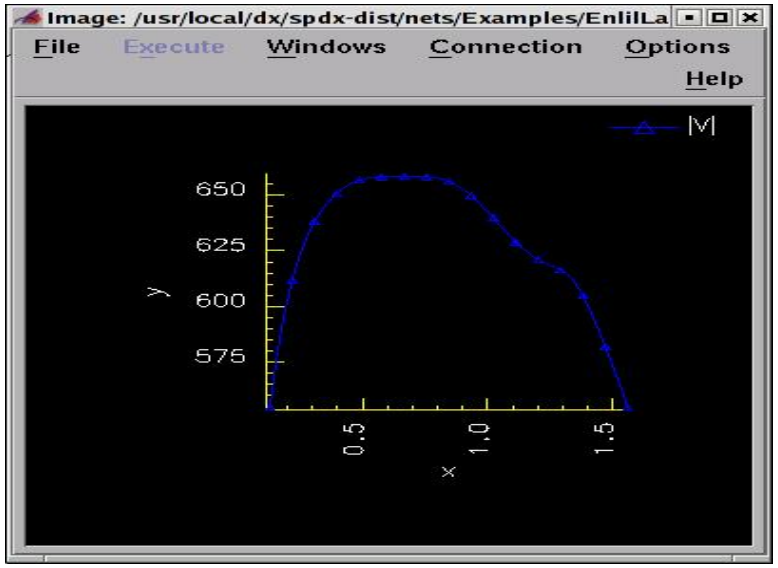

Visual Program Editor: /home/weigel/CISM_DX_Labs/IntroToOpenDX/nets/OpenDXRendering.net
File Edit Execute Windows Connection Options
Tools
(ALL)
Annotation
CISM_DX
CISM_DX_Cartography
CISM_DX_General
CISM_DX_LFM
CISM_DX_MagField
CISM_DX_Magnetosphere
CISM_DX_Readers
CISM_DX_Realization
CISM_DX_Rendering
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
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
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
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

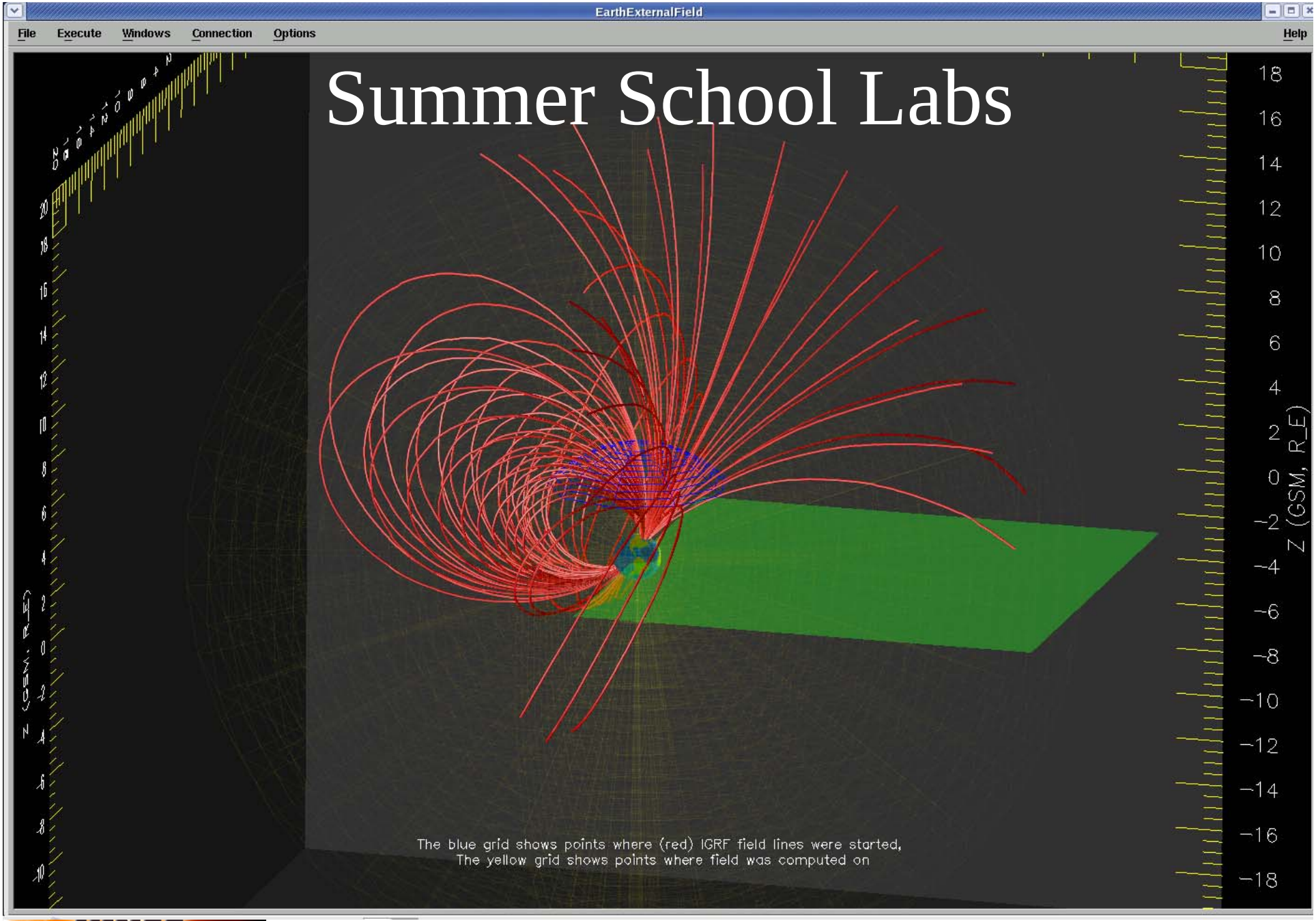
- The Map Module interpolates data from any DX Object to another DX Object
  - This includes field lines and isosurfaces
  - Relies on the Connections component of OpenDX Field



Thanks to Dusan Odstrcil and Nick Arge

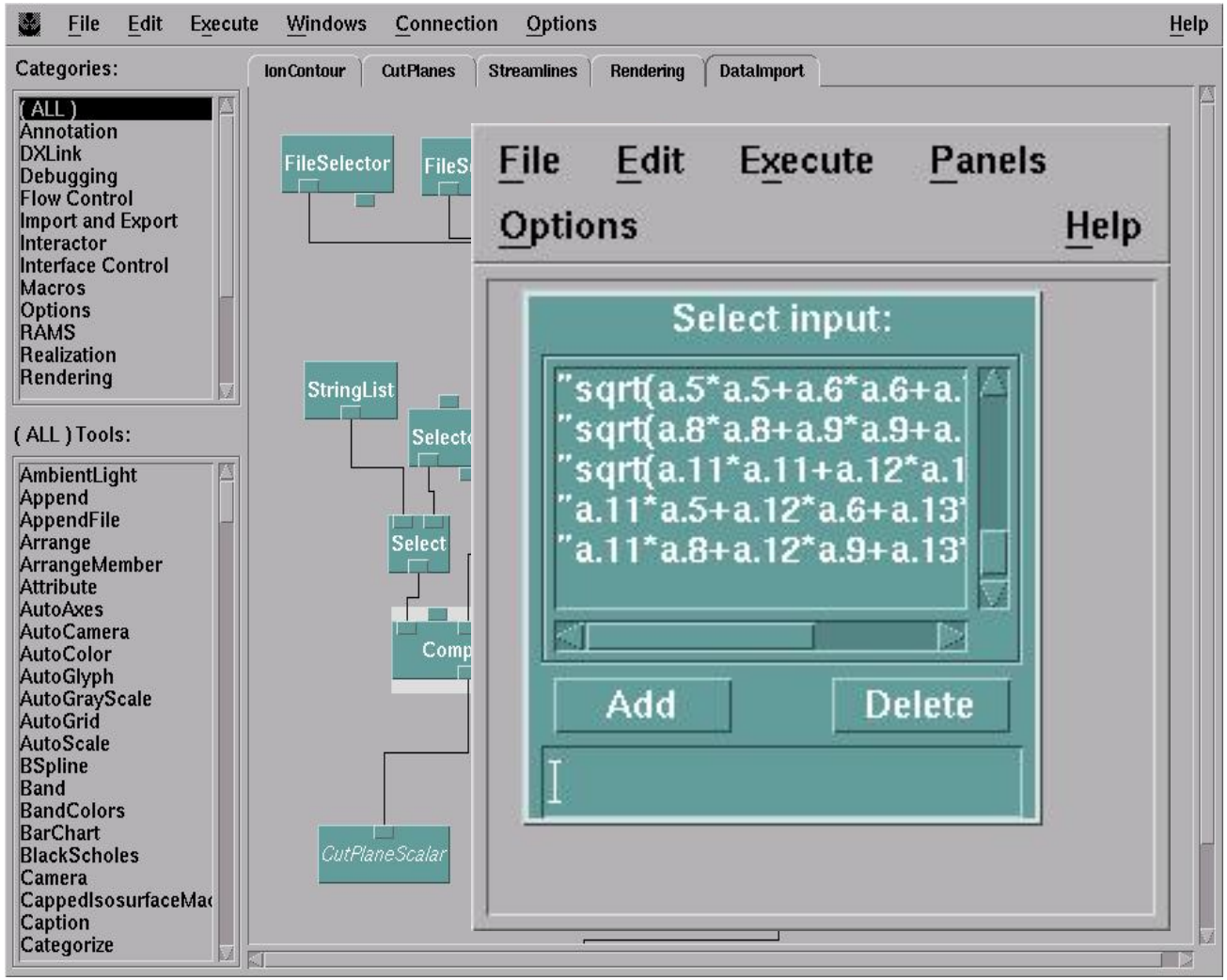
CISM
Center for Integrated Space Weather Modelling

Summer School Labs



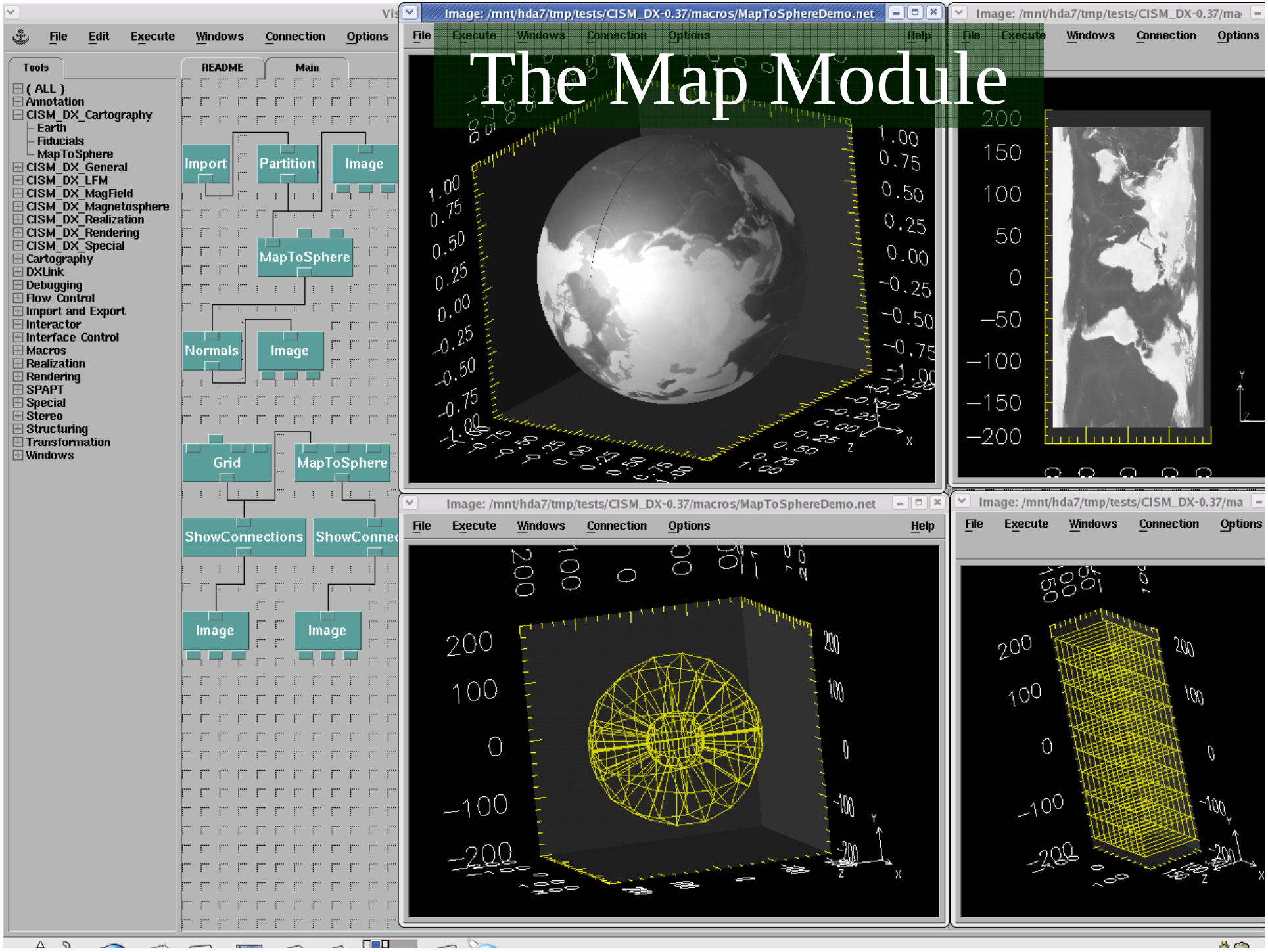
The Compute Module

- 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

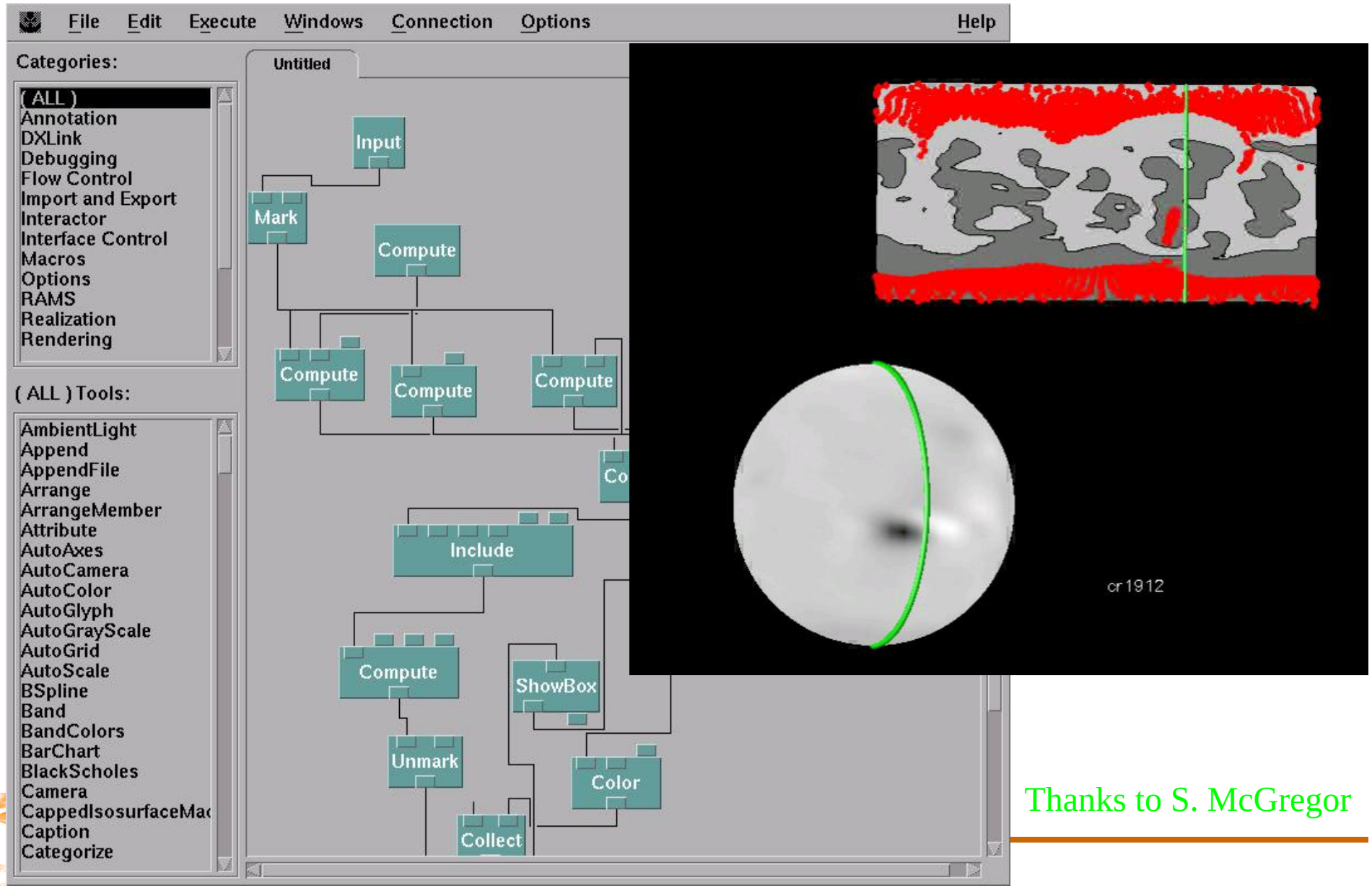


CISM
Center for Integrated Space Weather Modelling

The Map Module



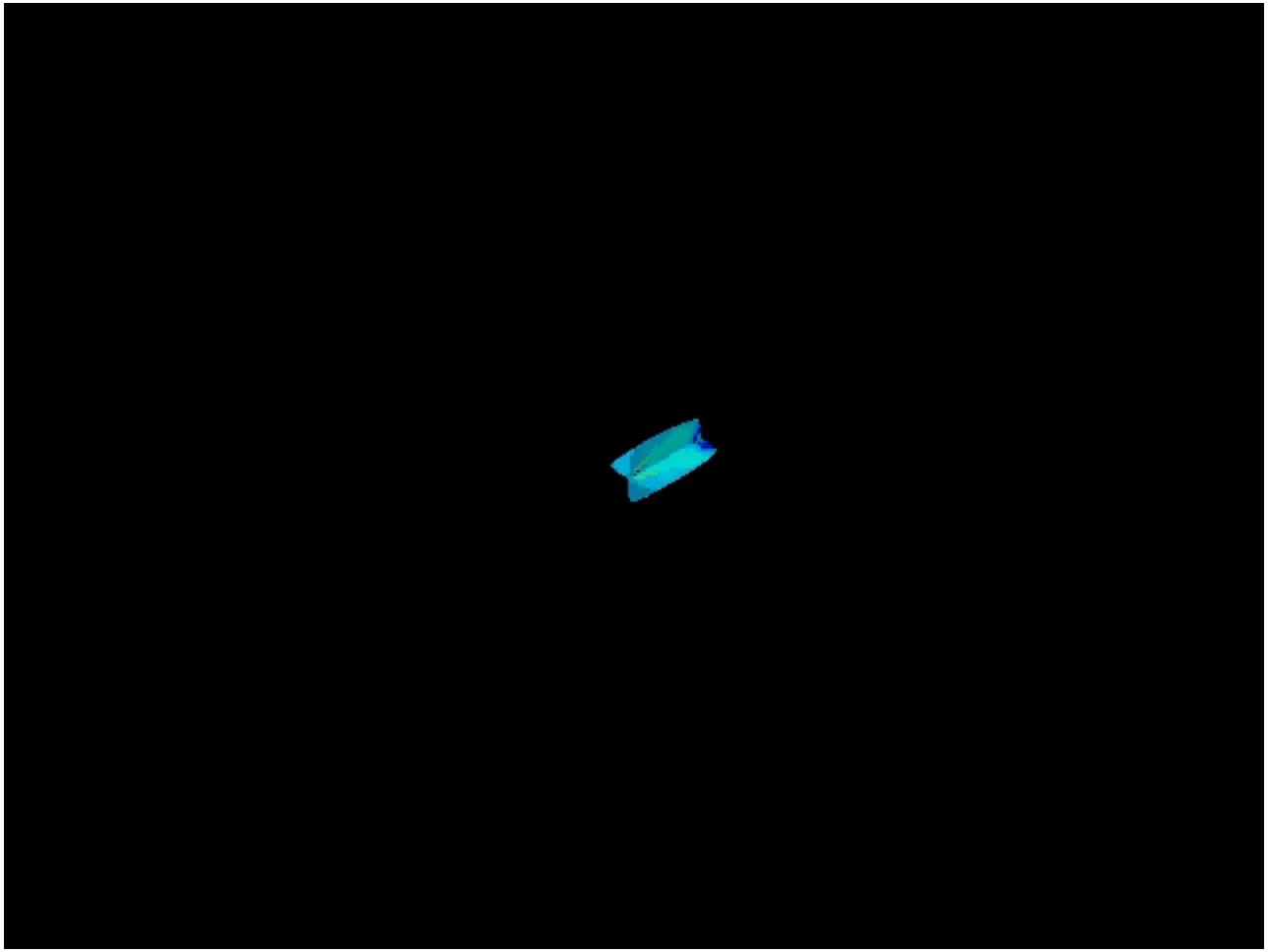
The Mark/Unmark modules



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

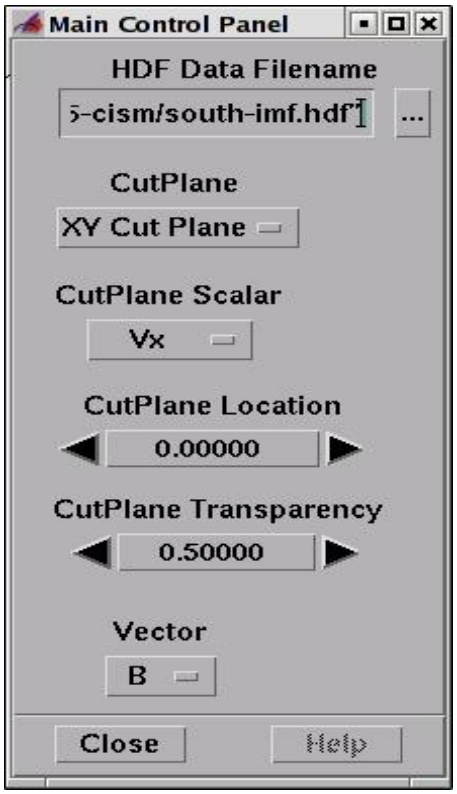


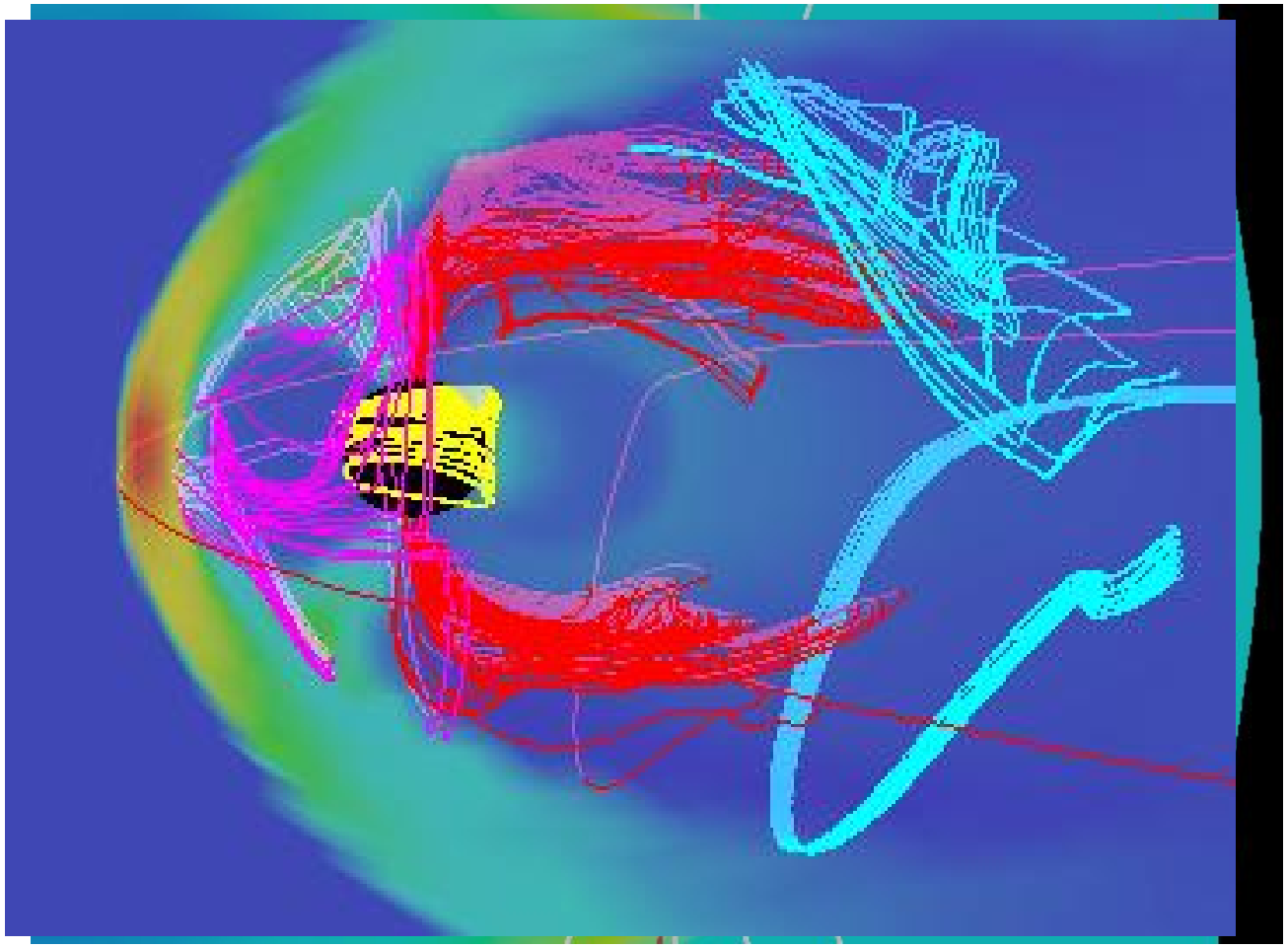
Thanks to Tim Guild

OpenDX applications in CISM_DX package

LFM – Magnetospheric Model

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



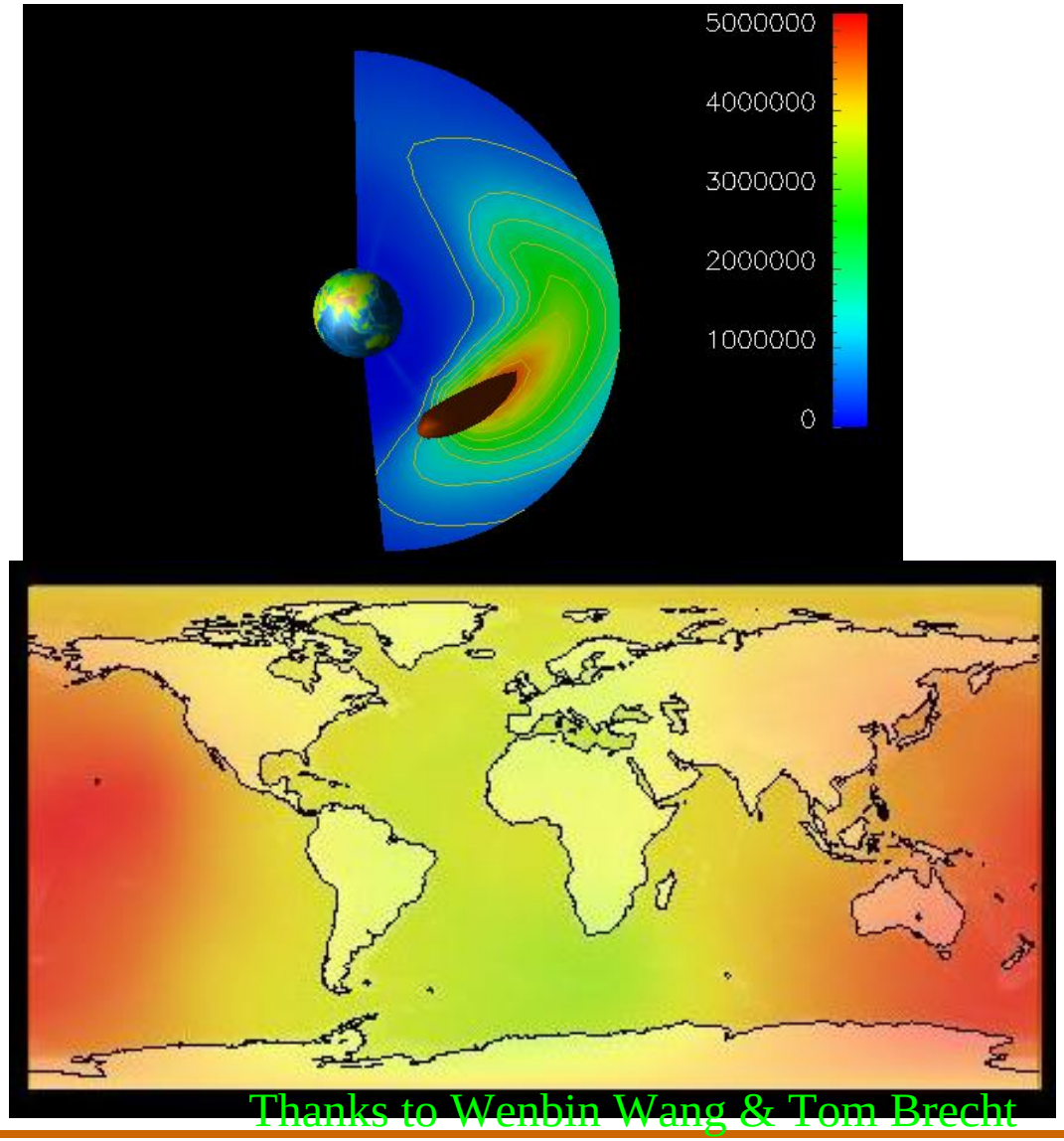


Thanks to John Lyon and Sarah McGregor

CISM
Center for Integrated Space Weather Modelling

TING Visualizations

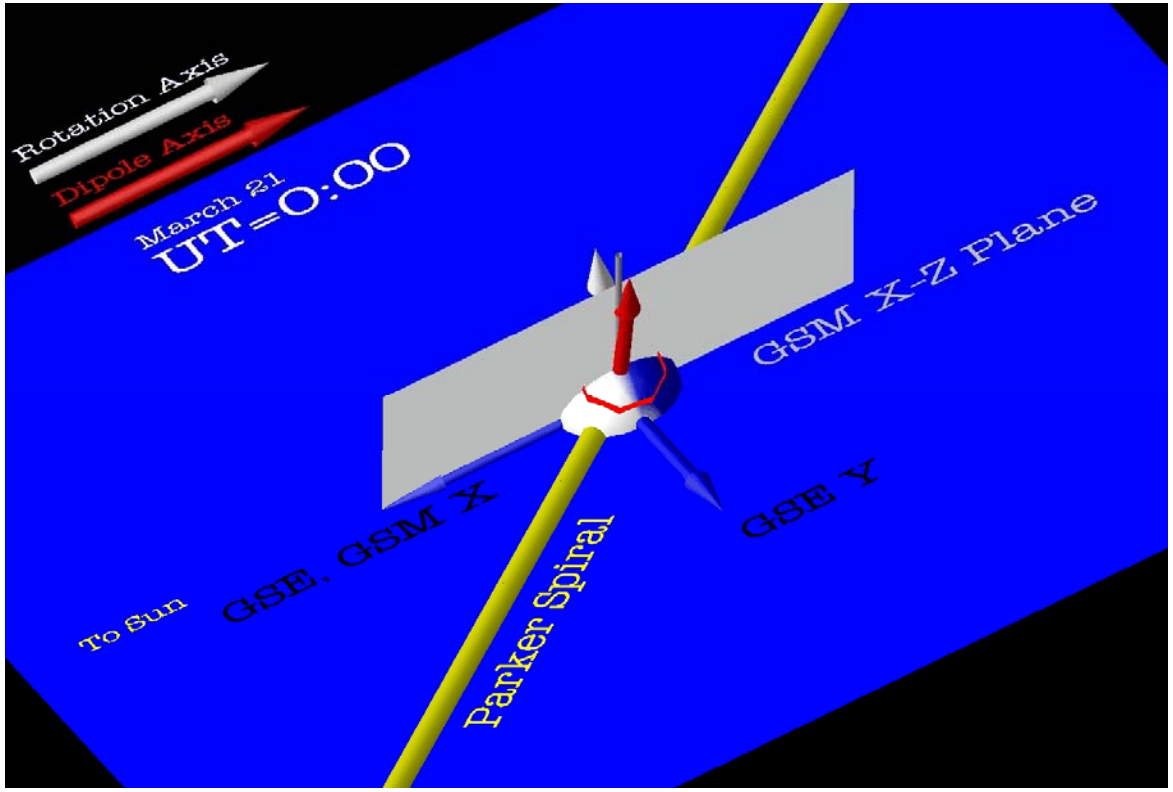
- TING is a 3D Global Circulation Model for the Earth's Thermosphere and Ionosphere
  - Variables describing the action of the neutral and ion species in these domains are stored in HDF files
- Networks support satellite views as well as map projections



Thanks to Wenbin Wang & Tom Brecht

CISM
Center for Integrated Space Weather Modelling

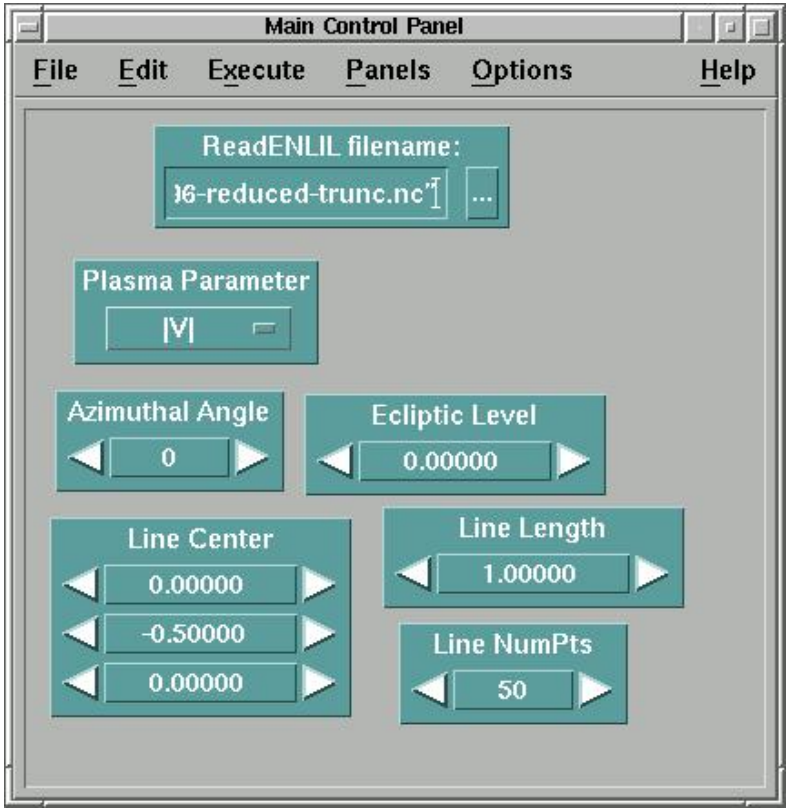
Coordinate Systems

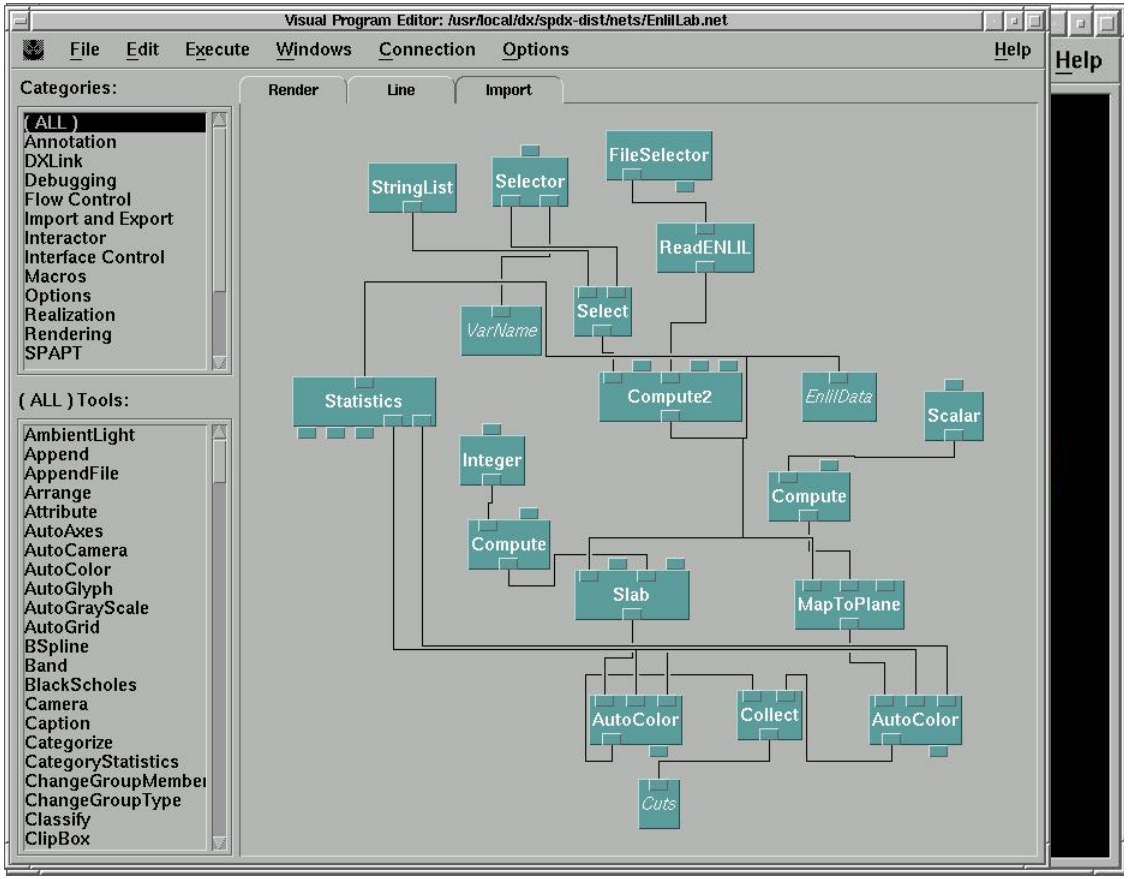


- SPTransform Module
  - utilizes the Geopack coordinate system library
  - allows transformation of vectors between virtually all Space Physics coordinate systems

ENLIL – Solar Wind Model

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

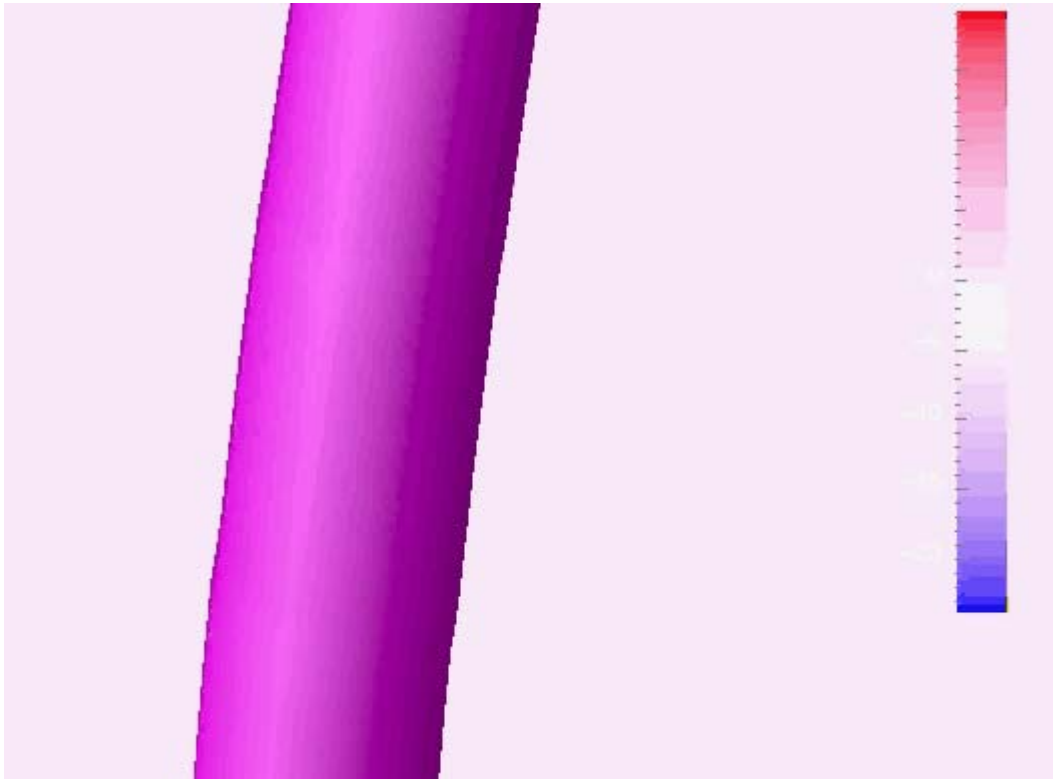




Thanks to Dusan Odstrcil

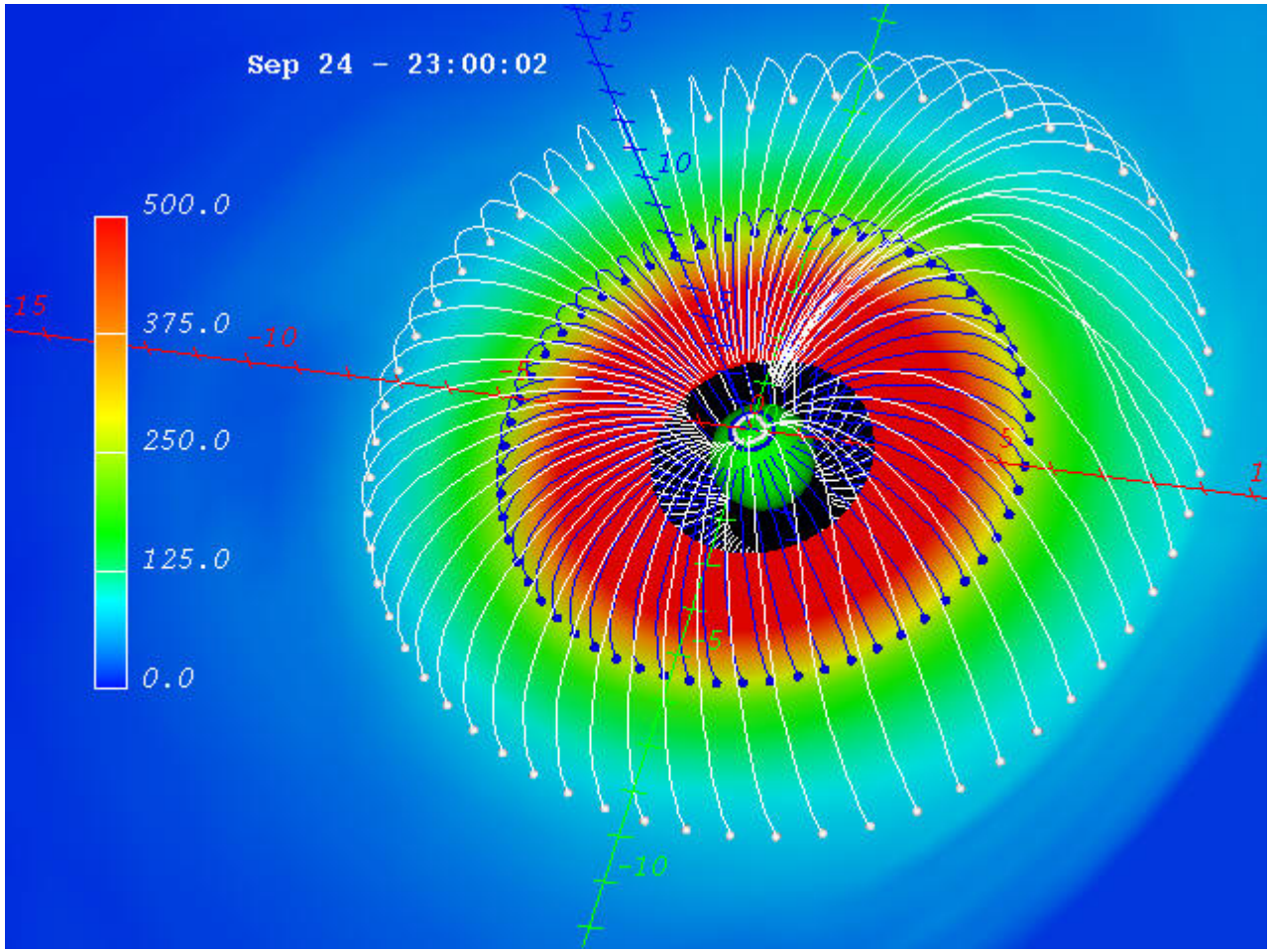
MAS – Coronal Results

- 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



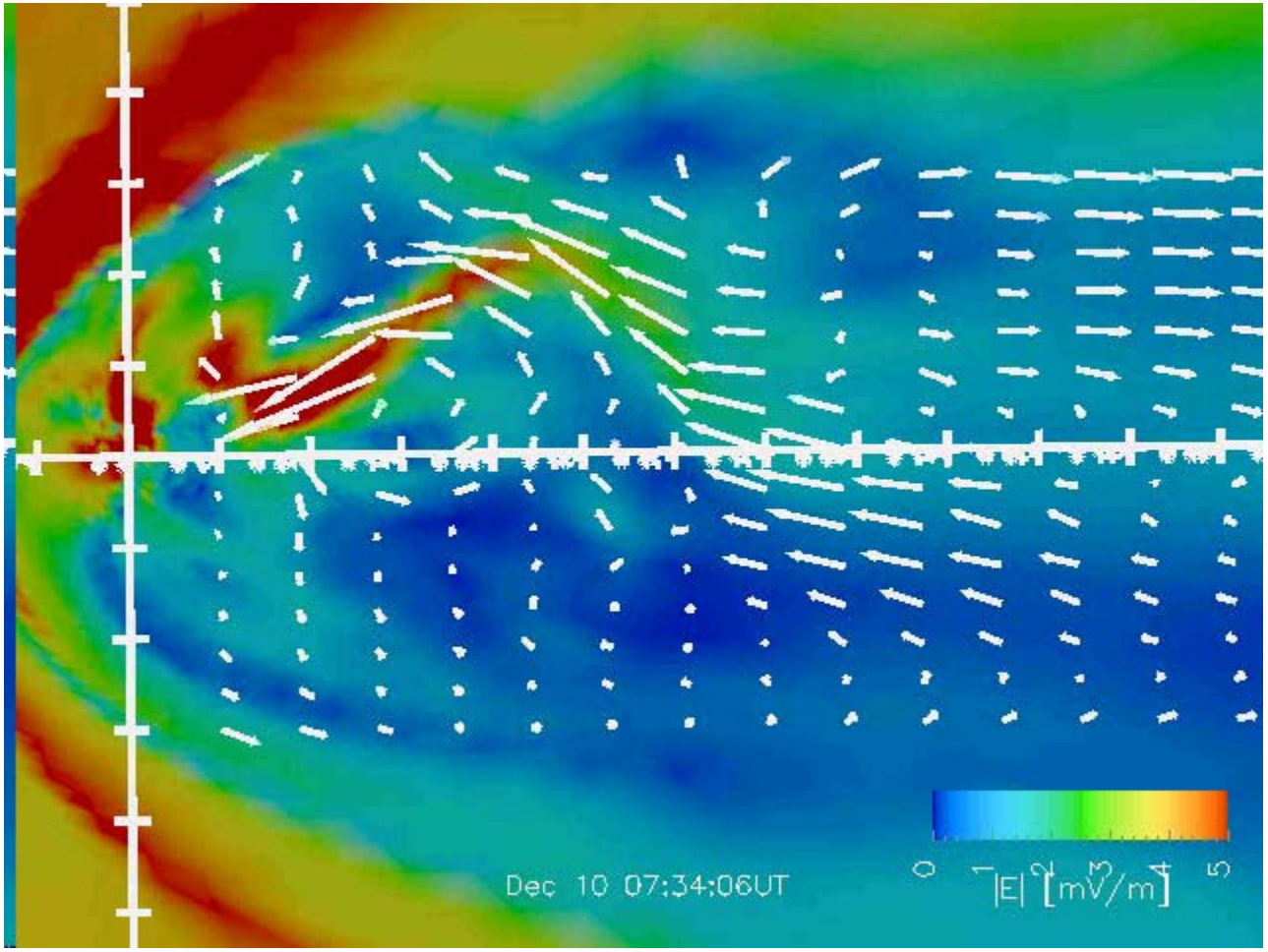
- Electron drift trajectories are used as source points for field line tracing
  - End points are mapped from inner edge into ionosphere
  - L* is determined by calculating flux enclosed in orbit
- In DX the field line is an object that can be used for interpolation

Thanks to Scot Elkington

CISM
Center for Integrated Space Weather Modelling

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



CISM
Center for Integrated Space Weather Modelling