Introduction to CISM_DX and Overview of OpenDX

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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
OpenDX with CISM_DX add-ons

Construct

Notation: Construct

Inputs:
- Name
- Hide
- Type
- Source
- Value

- origin: vector list
- deltas: vector list
- counts: integer, vector
- data: value list, string list

Outputs:
- Name
- Type
- Destination
- Cache

- output: field

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

Construct

Print

Glyph

ShowConnections

Collect

Image

Attribute: Name 'dir'
String: "positions"
Component number 3, name 'box'
Generic Array: 0 home, float, real, 3-vector
data values:
0 0 0 1
0 0 0 1
0 1 0 1
0 1 0 1
1 0 0 1
1 0 0 1

Attribute: Name 'dir'
String: "positions"

The Map Module

- 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

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

Thanks to Dusan Odstrcil and Nick Arge
Summer School Labs

The blue grid shows points where (red) IGRF field lines were started.
The yellow grid shows points where field was computed on.
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

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
• 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

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
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