

Texas A&M University Immersive Visualization Center

OpenDX Tutorial

This document provides an introduction to OpenDX. It demonstrates how to use OpenDX to visualize data in the Immersive Visualization Center at Texas A&M University.

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Using OpenDX 4.3.2

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Introduction

OpenDX, a full-featured visualization program, is the primary application used to visualize data in the Immersive Visualization Center. It is simple for beginners to use, yet it also provides advanced features for more sophisticated visualizations. OpenDX focuses on data visualization and analysis. Extensive computations on data should be done prior to loading data into OpenDX.

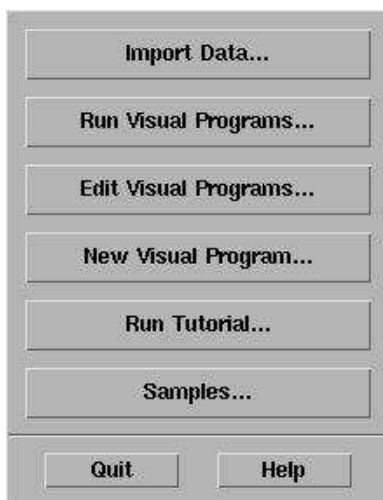
Originally created by IBM, OpenDX is now open source and freely available for download. This is advantageous because researchers can use OpenDX to view and modify their visualizations at anytime using their own computers, instead of scheduling an appointment in the IVC. OpenDX binaries are available for a variety of platforms, including Linux, Irix 6.5, and Solaris. OpenDX can be run on Windows using Cygwin. To download binaries or source code, please see <http://www.opendx.org/download.html>. The instructions included in this document are for UNIX platforms. The reader is expected to be familiar with basic UNIX commands.

Start OpenDX

The best way to learn OpenDX is to view sample programs and see first-hand how the visualizations are created. OpenDX programs are called “networks” and end with a “.net” extension. This section explains how to start OpenDX and view sample networks. We will start by opening OpenDX from a command prompt. See the IVC Specifics section for options to start OpenDX with maximum performance.

```
> dx &
```

This will open the Data Explorer User Interface (Figure 1).



Import Data – to load in your own data

Run Visual Programs – to view an existing OpenDX visualization program

Edit Visual Programs – to edit an existing OpenDX visualization program

New Visual Program – to create a new OpenDX visualization program

Run Tutorial – to view the built-in OpenDX tutorial

Samples – view OpenDX samples, if installed

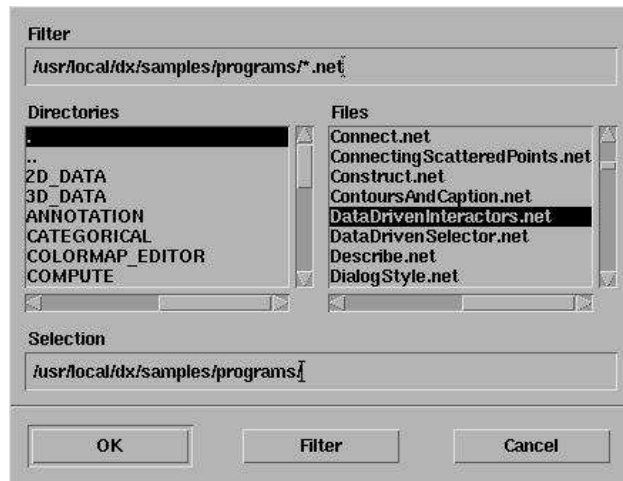
Figure 1: Startup User Interface

Example Visualization

1. Click the **Samples** button in the Startup User Interface to open the file selection window.
It should open to the folder where the OpenDX data is stored on your computer. Install the “dx-data” or “opendx-samples” package on your computer if the files are not present.

2. Select the **DataDrivenInteractors.net** file, as indicated in Figure 2.

3. Click **OK**.



The following windows will open:

Figure 2: File Selection Window

- **Application Comment:** Provides useful information about the visualization program.
- **Image:** Shows the visualization (Figure 3). It allows the user to interact with the image by rotating, panning, and zooming. We will talk more about this later.

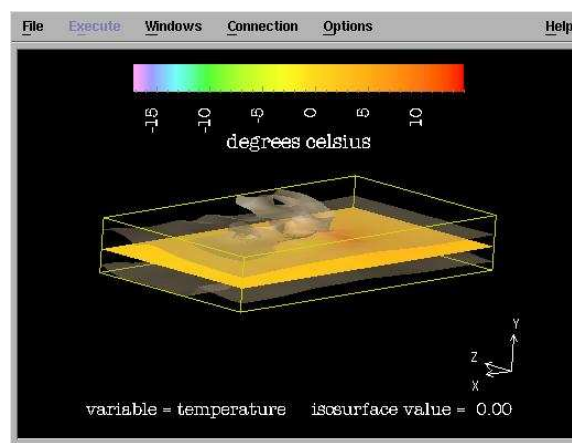


Figure 3: Visualization Image of Cloud Data

- **Control Panel:** Provides controllers to change visualization options (Figure 4).

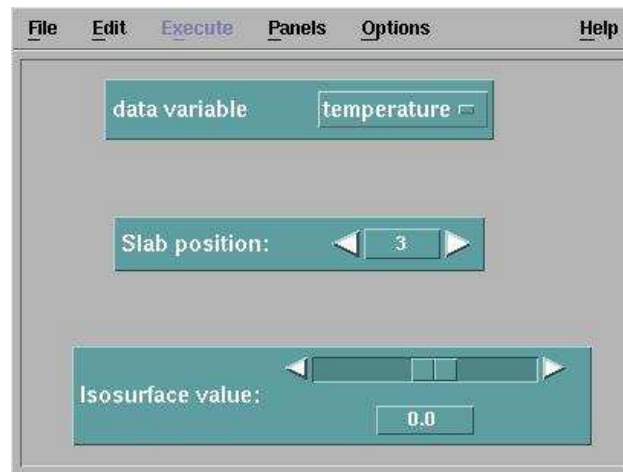


Figure 4: Cloud Data Control Panel

- **Data Explorer:** The main OpenDX control window (Figure 5). Notice the anchor in the top left corner. When this anchor window is closed, all other windows will be closed

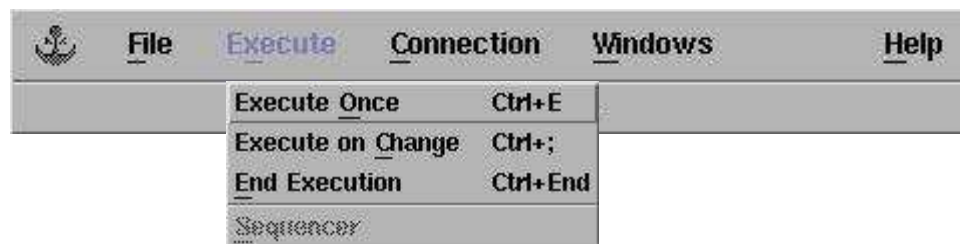


Figure 5: Data Explorer Window

Also notice the **Execute** menu. This controls how often the Image window is updated. **Execute on Change** will refresh the visualization window anytime a value is changed. If the visualization Image does not change when expected, choose the appropriate option from the Execute menu.

This particular data set, generated by the NCSA at the University of Illinois at Urbana-Champaign, contains data measured within a cloud. The data was generated on a regular, rectangular grid. One benefit of OpenDX is that it allows user to interact with their data:

1. In the Image window, click **Options...View Control** to open a window that allows you to interact with the data.
2. Choose the **Rotate Mode**.
3. Click in the Image window, hold the mouse button down, and move the mouse to rotate the image.
4. Experiment with other View modes.

Other aspects of the visualization can be changed using the Control Panel. If the Control Panel window is not visible, click **Windows...Open All Control Panels** from the Image window: This visualization shows three useful techniques

1. **Multiple Data Variables:** In the control panel, a drop-down list box allows the user to choose the data variable shown in the image. Choose between wind, temperature, cloud water, and rainwater to observe how the visualization changes to show the different variables.
2. **Slab:** This visualization also contains a slab through the data. The Control Panel allows you to move the slab through the data. OpenDX automatically interpolates between data points to display a continuous plane.
3. **Isosurface:** This visualization shows an isosurface (the beige surface), which plots all data points at a particular value. For example, by using the Control Panel slider, you can view the surface formed by all points at 0° Celsius.

Program Editor

Now that you have interacted with an OpenDX visualization, let's find out what's going on behind the scenes. OpenDX is a visual program editor, which means you do not need to write lines of code. Instead, OpenDX provides an easy to use graphical interface to create your visualization. OpenDX provides a set of preconfigured modules to display certain aspects of your data. You simply choose the modules you want, connect the inputs and outputs, and you are on your way to creating your own custom visualization. To see the modules used to create the cloud data visualization discussed in the previous section, open the Program Editor:

From the Image window, click **Windows...Open Visual Program Editor**. A window will appear resembling Figure 6.

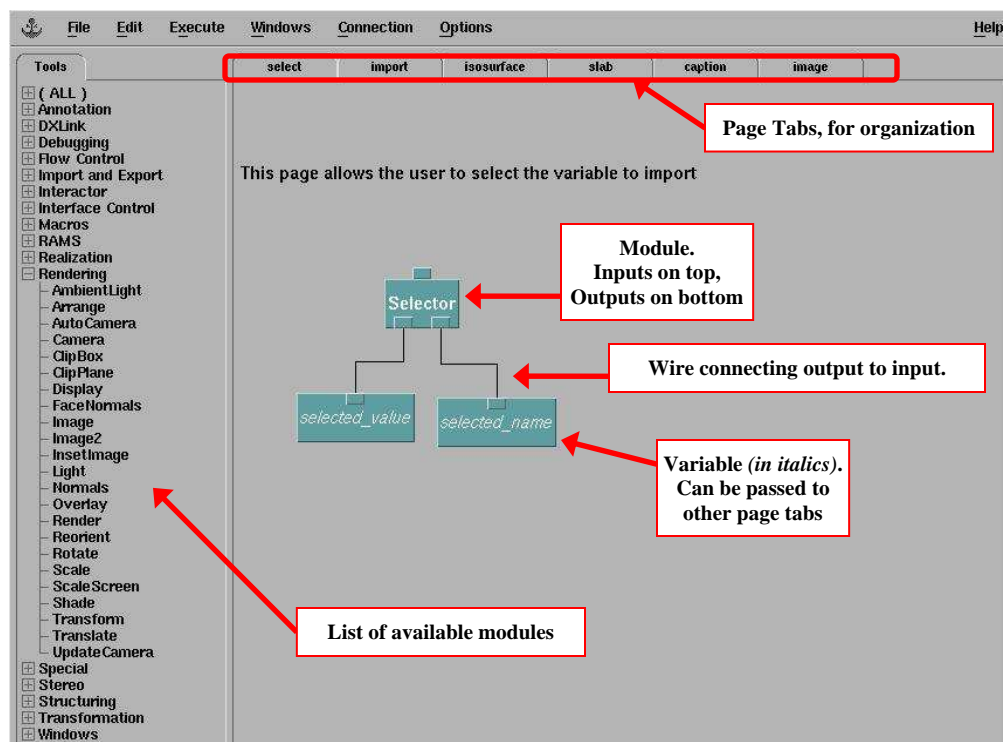


Figure 6: Program Editor

There are many important elements in the Program Editor, as indicated in red on Figure 6:

- Modules:** Modules are the heart of OpenDX. A module is a function that takes input, performs a task, and creates outputs. Tabs on the top of the module represent the inputs. The outputs are represented as tabs at the bottom of the module. All available OpenDX modules are listed in the Tools section on the left. To add a module to your program, highlight the module name on the left, and then left-click where you want the new module to appear. Connect an input to an output by clicking the output tab and dragging your mouse over the desired input tab while holding the mouse button down.
- Module Parameters:** Double-clicking on a module will open a window showing the input and output details for that module. Figure 7 shows the Isosurface module options.

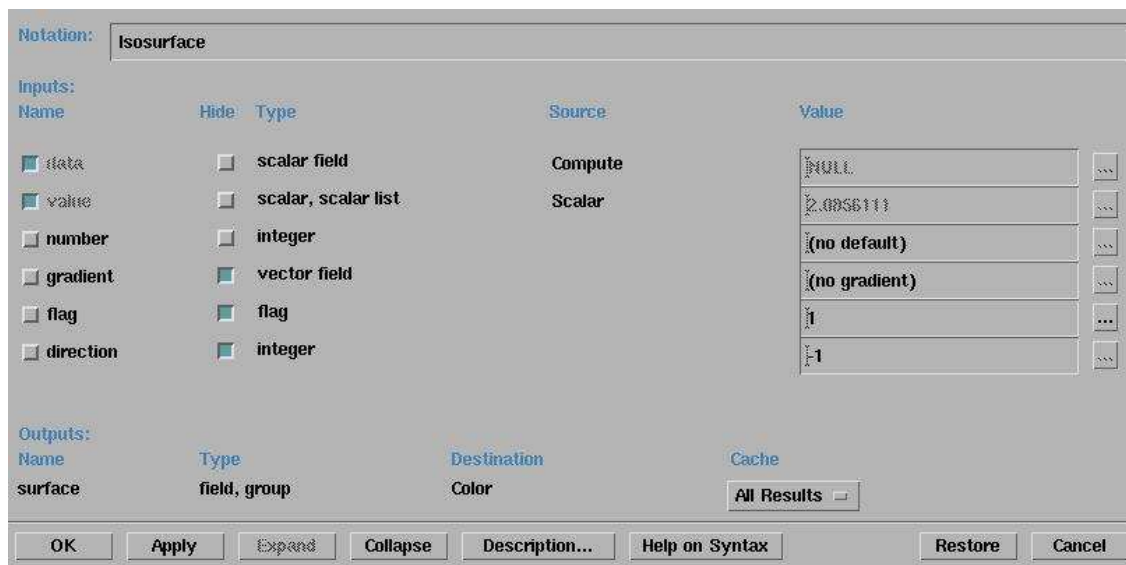


Figure 7: Isosurface Module Parameters

Inputs can be set to specific values, can receive data from a previous module, or can be left at the default value. Click the **Expand** button to show all available inputs. Click **Description...** for information about the inputs and outputs. Click **OK** to return to the Program Editor.

- **Module Help:** OpenDX provides detailed help for each module. To access the help, click the **Help** menu. Select **Context-Sensitive Help**. The mouse cursor will change to an arrow with a question mark. Click on a module. A window will open with detailed information about that particular module.
- **Page Tabs:** The Visual Program editor provides page tabs to help you organize your program. In the example program, six page tabs are used. Click each of the tabs to view the program network used to create the cloud visualization.
- **Variables:** Information is passed from one page to the next using OpenDX variables.

Figure 6 above shows the “selected_name” variable used on the “Select” page. When the user selects the data to be shown, such as temperature, the selected value “temperature” is

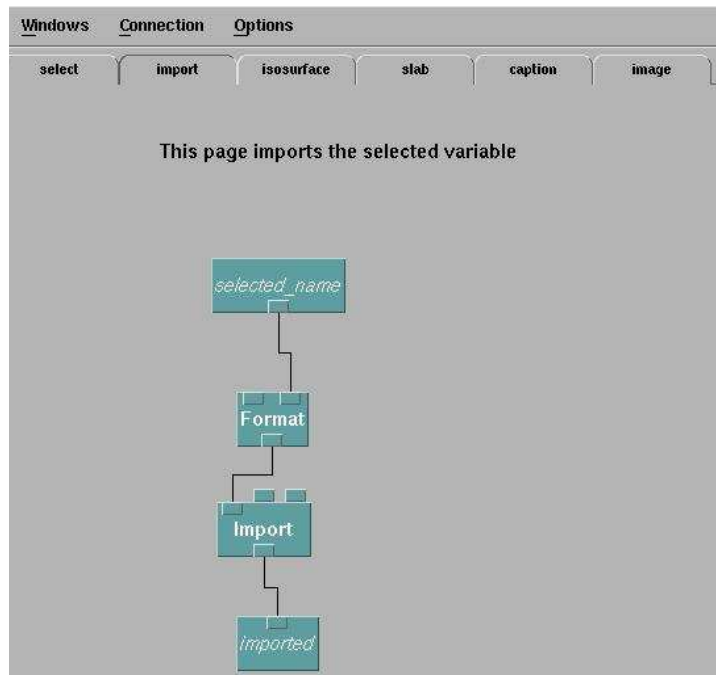


Figure 8: Import Page in the Example Visualization

passed to the variable and given to the Format module on the “Import” page. This is shown in Figure 8. The Format module puts the string in the correct format so that the Import module can load the requested data.

Importing Data

Once you are comfortable interacting with OpenDX visualizations and the Program Editor, you are ready to begin importing your own data. OpenDX can read a variety of file formats. Start OpenDX and click the **Import Data** button from the Startup User Interface to open the Data Prompter, shown in Figure 9.

The Data Prompter allows you to easily import and visualize your data. Simply type in the location of your data file, select the file format, and click the “Visualize Data” button to see an automatically generated visualization of your data.

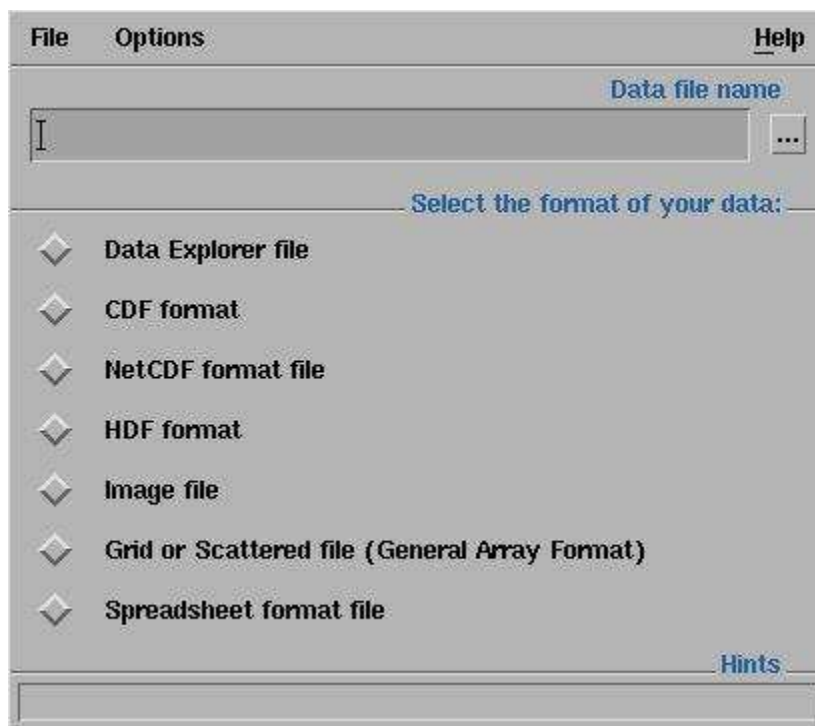


Figure 9: Data Prompter

Specific File Formats

When your data is in a specific file format, such as NetCDF or OpenDX's native file format, importing data is very easy. Here's an example to show you how to load data that is in OpenDX's native .dx file format:

- 1) Download the "temperature.dx" file from <http://ivc.tamu.edu/docs/tutorial/opendx/temperature.dx> and save it to your hard drive.'
- 2) In the Data Prompter, click the "..." button and browse to select the temperature.dx file.
- 3) Click the radio button next to **Data Explorer file**.
- 4) Click the **Visualize Data...** button. If the button is grayed out, the filename listed in the textbox is incorrect.

This dataset is the temperature data of the cloud visualization discussed earlier. The image looks slightly different because different options are applied to the data. Experiment with the options:

- Click **Execute...Execute on Change** to update the Image as you change values.
- In the Control Panel, change the isosurface value and observe how the visualization changes. This should remind you of the example visualization viewed earlier in this document.
- In the Control Panel, change the MapToPlane value and observe how the plane through the data changes accordingly. Set it at (0, 1, 0) to resemble the earlier cloud visualization.
- Click **Windows...Open Program Editor** to view the program that was automatically generated to visualize the data. This network is a good place to begin when you want to customize your visualization and add additional modules and features.

General File Formats

Often times data is not generated in a specific file format. The data file may contain only points and data values along a specific grid. OpenDX is very flexible when importing this type of data, and will read in regular, skewed, or irregular grids

1) Download the “temperature.data” file from

<http://ivc.tamu.edu/docs/tutorial/opendx/temperature.data>

2) In the Data Prompter, click the “...” button and locate the “temperature.data” file.

3) Click the radio button next to **Grid or Scattered File (General Array Format)**. Additional options will appear. Select the options as shown in Figure 10. Read below for a description of each option.

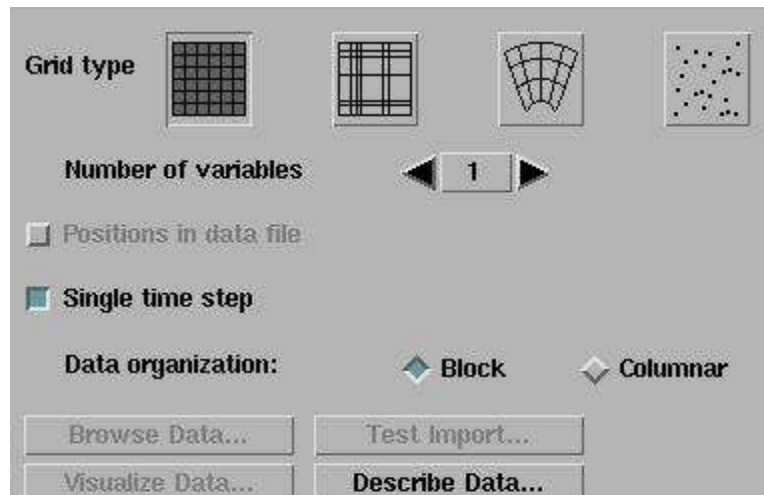


Figure 10: Grid or Scattered File Options

Grid Type: Choose the type of grid your data is measured on: Regular, Irregular, Warped, or Scattered. In this case, click on the **Regular** grid picture.

Number of Variables: Select the number of variables stored in your data file. In this case, we will only have one data variable: the temperature within the cloud.

Positions in data file: This option is grayed out in our case, because we are using a Regular grid. When using a warped or irregular grid, choose this option if your data points are stored in the file along with the data values.

Single time step: Select this option when your data includes only one time step.

Data organization: This option has more significance when multiple time steps are involved.

- 5) Click the **Browse Data...** button to see what the data file looks like. You will see the OpenDX headers and attributes. We do not need to change any options here, so close the window.
- 6) Click **Describe Data...** to provide more details about your data. This will open a detailed Data Prompter window. Select the options as shown in Figure 11. Read below for a description of each option.

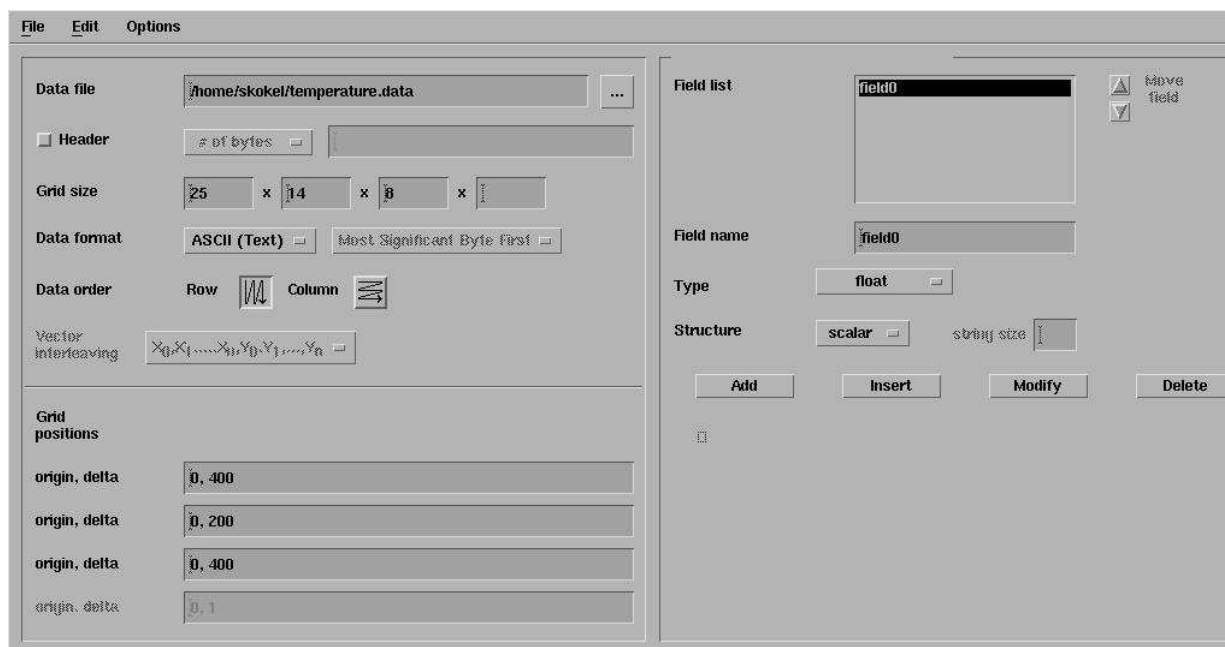


Figure 11: Detailed Data Prompter

Header: Select this if your data file contains header information

Grid Size: Enter the size of your grid. In our case, the grid is 25 x 14 x 8.

Data Format: OpenDX can read ASCII or binary data. Our temperature data is stored in
ASCII

Data Order: Specify if your data is row-majority or column-majority. In this case, choose
Row

Grid Positions: Used with regular grids to specify the origin and delta along each
dimension. In our case, every dimension starts at 0. The X and Z dimensions increase by
400. The Y dimension increase by 200.

Field List: Lists the variables that will be read in from the file. You can change the variable
name, type, or structure. In our case, we will be reading scalar temperature values stored
as floats, so we do not need to change the default options.

- 7) The information in this window needs to be saved to a .general file so that it can be
referenced when creating the visualization. In the detailed Data Prompter, click **File...**
Save As. Save the header file in the same directory as your data file. Click **OK** to create a
.general file that contains all this information.
- 8) Click **File...Close** to close the detailed Data Prompter
- 9) Click the **Visualize Data...** button to view the automatically generated visualization. If the
button is grayed out, then your .general header file was not saved correctly. Repeat steps 5
and 6 to create the .general header file. The resulting visualization should look similar to that
obtained using the DX file format. You have successfully imported the data!

IVC Specifics

- For maximum performance in the IVC, use the following environment variables and parameters to start OpenDX from the command prompt. The examples given below use Bash shell syntax.

```
> export DXHWMOD=DXhwddOGL.o
> dx -execute_on_change -hwrender opengl &
```

- When viewing an image using the Image module, make sure hardware rendering is being used:
 - 1) In the Image window, click **Options... Rendering Options**
 - 2) In the Rendering window, click the radio button next to **Hardware**.
 - 3) Click Close
- Many researchers utilize complex grid structures. OpenDX is capable of dealing with many complex structures, but often times the native DX file format is needed to provide the necessary data descriptions. This file format is very easy to use. Please see the OpenDX User's Guide for more details on the options provided by the native file format. For assistance with your data set, contact the IVC staff on <http://ivc.tamu.edu/contact.html>
- For information on who can use the IVC and how to get an account, see our Access page at <http://ivc.tamu.edu/access.html>

References

OpenDX provides many more options than the ones discussed in this document. To learn more about OpenDX, I recommend the resources listed below, which I consulted when creating this document.

- **Built-in Tutorial:** Start OpenDX and click the **Tutorial** button from the Startup User Interface. This will take you step-by-step through useful OpenDX techniques.
- **Quick Start Guide:** Official “Hands on” introduction to OpenDX to help you start working with it immediately.
<http://opendx.npaci.edu/docs/html/qikguide.htm>
- **A Fast Approach to Importing Data:** This website provides a quick example on how to load your data into OpenDX using the Data Prompter.
<http://www-lsp.ujf-grenoble.fr/recherche/a3t2/a3t2a2/bahram/OpenDX>
- **CTC Virtual Workshop Modules:** Provides six workshop modules to help you get started with OpenDX.
<http://www.tc.cornell.edu/CTC-Main/Services/Education/Topics/OpenDX/>
- **User’s Guide:** The official OpenDX User’s Guide.
<http://opendx.npaci.edu/docs/html/usrguide.htm>
- **Reference Guide:** An in-depth description of OpenDX tools and modules.
<http://opendx.npaci.edu/docs/html/refguide.htm>