Visualization with ParaView
Before we begin...

- Make sure you have ParaView 3.10.1 installed so you can follow along in the lab section
  - [http://paraview.org/paraview/resources/software.html](http://paraview.org/paraview/resources/software.html)
Background

- Open-source, multi-platform parallel data analysis and visualization application
- Mature, feature-rich interface
- Good for general-purpose, rapid visualization
- Built upon the Visualization ToolKit (VTK) library
- Primary contributors:
  - Kitware, Inc.
  - Sandia National Laboratory
  - Los Alamos National Laboratory
  - Army Research Laboratory
Data Types

• Supports a wide variety of data types
  – Structured grids
    • uniform rectilinear, non-uniform rectilinear, and curvilinear
  – Unstructured grids
  – Polygonal data
  – Images
  – Multi-block
  – AMR
• Time series support
Visualization Algorithms

• Supports a wide variety of visualization algorithms
  – Isosurfaces
  – Cutting planes
  – Streamlines
  – Glyphs
  – Volume rendering
  – Clipping
  – Height maps
  – …
Special Features

• Supports derived variables
  – New scalar / vector variables that are functions of existing variables in your data set
• Scriptable via Python
• Saves animations
• Can run in parallel / distributed mode for large data visualization
Data Formats

• Supports a wide variety of data formats
  – VTK (http://www.vtk.org/VTK/img/file-formats.pdf)
  – EnSight
  – Plot3D
  – Various polygonal formats
• Users can write data readers to extend support to other formats
• Conversion to the VTK format is straightforward
Data Formats

• VTK Simple Legacy Format
  • ASCII or binary
  • Supports all VTK grid types
  • Easiest for data conversion

• Note: use VTK XML format for parallel I/O

VTK simple legacy format (http://www.vtk.org/VTK/img/file-formats.pdf)
Data Formatting Example

- Data set: 4x4x4 rectilinear grid with one scalar variable

```
# vtk DataFile Version 2.0
one scalar variable on a rectilinear grid
ASCII
DATASET RECTILINEAR_GRID
DIMENSIONS 4 4 4
X_COORDINATES 4 float
 0 1 2.5 4.5
Y_COORDINATES 4 float
 0 2 4 6
Z_COORDINATES 4 float
 0 3 6 9
POINT_DATA 64
SCALARS scalar_variable float 1
LOOKUP_TABLE default
 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
17 18 19 20 21 22 23 24 25 26 27 28 29 30
31 32 33 34 35 36 37 38 39 40 41 42 43 44
45 46 47 48 49 50 51 52 53 54 55 56 57 58
59 60 61 62 63
```
ParaView Visualization Pipeline

• All processing operations (filters) produce data sets
• Can further process the result of every operation to build complex visualizations
  – e.g. can extract a cutting plane, and apply glyphs (i.e. vector arrows) to the result
  • Gives a plane of glyphs through your 3D volume
Demonstration

- WRF weather forecast data set
  - Rectilinear grid
  - Multiple scalar and vector variables
  - Time series

- Can show:
  - Clouds
  - Wind
  - Temperature
  - …
ParaView Test-Drive
Getting Started

• Download example data file ‘RectGrid2.vtk’
  – http://portal.longhorn.tacc.utexas.edu/training/
  – Right-click, Save link as…

• Open ParaView
Today we will:

• Create isosurfaces for a scalar variable
• Clip and slice the isosurfaces
• Use glyphs to display a vector field
• Use streamlines to show flow through a vector field
• Edit color maps
• Add slices to show variable values over a plane
• Adjust opacities of filters
• Add color legends
• Create volume rendering
ParaView

Open the file
RectGrid2.vtk

• **Click** File -> Open
• **Select** RectGrid2.vtk
• **Click** OK
• **Click** blue **Apply**
• **Box outline of dataset extent displayed**
ParaView

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Create isosurfaces

- **Click** Filters -> Common -> Contour
- In Isosurfaces box, click Delete All
- **Click** New Range
- Keep defaults, click OK
- **Click** blue Apply
- **Click** Display tab
- In Color by box, select vectors
ParaView

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Clip isosurfaces

- **Click** +Y view button
- **Click** Filters -> Common -> Clip
- **Show Plane** should be checked
- Drag arrow point around to front of surface (arrow turns red when selected)
- **Click** Inside Out checkbox
- **Click** blue Apply
- **Click** Show Center button to remove crosshairs
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Slice isosurfaces

- Click eye next to **Clip1** to hide clip plot
- Click **Contour1** in Pipeline Browser
- Click **Filters** -> **Common** -> **Slice**
- Drag arrow point around to front of surface (arrow turns red when selected)
- Click blue **Apply**
ParaView

Slice isosurfaces

• Click eye next to Clip1 to hide clip plot

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Create Glyph of Vector Field

- **Click** *RectGrid2.vtk* in Pipeline Browser
- **Click** Filters -> Common -> Glyph
- **Click** blue Apply
ParaView

Create Glyph of Vector Field

- Click `RectGrid2.vtk` in Pipeline Browser
- Click `Filters` -> `Common` -> `Glyph`
- Click blue `Apply`
ParaView

Create Glyph of Vector Field

- **Click** `RectGrid2.vtk` in Pipeline Browser
- **Click** Filters -> Common -> Glyph
- **Click blue** Apply
ParaView

Create Glyph of Vector Field

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ParaView

Create Streamlines

- **Click eye next to Glyph1 to hide glyph plot**
- **Click RectGrid2.vtk in Pipeline Browser**
- **Click Filters -> Common -> Stream Tracer**
- **Click blue Apply**
- **Under Display tab, in the Color by box, select Vorticity**
Create Streamlines

- **Click** eye next to **Glyph1** to hide glyph plot
- **Click** **RectGrid2.vtk** in **Pipeline Browser**
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ParaView

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ParaView

Create Tubes

- **Click** **StreamTracer1** in Pipeline Browser
- **Click** Filters -> Alphabetical -> Tube
- **Click** blue **Apply**
ParaView

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- **Click** Filters → Alphabetical → Tube
- **Click** blue Apply
ParaView

Create Tubes

- **Click** `StreamTracer1` in Pipeline Browser
- **Click** Filters -> Alphabetical -> Tube
- **Click blue** Apply
ParaView

Create Tubes

- **Click** StreamTracer1 in Pipeline Browser
- **Click** Filters -> Alphabetical -> Tube
- **Click blue Apply**
Edit Color Map

- Click **Edit Color Map**
- Click **Choose Preset**
- Select **BLUE...HSV**
- Click blue **OK**
- Click blue **Close**
ParaView

Edit Color Map

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- **Select** **BLUE...HSV**
- **Click blue OK**
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ParaView

Create Slice

- **Click** *RectGrid2.vtk* in Pipeline Browser
- **Click** Filters -> Common -> Slice
- Drag arrow point around to front of surface (arrow turns red when selected)
- Or click *Y Normal*
- **Click** blue *Apply*
- **Click** Show Plane
ParaView

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ParaView

Background Color

- Click the button above the 3D view
- Click Choose Color
- Drag box to black
- Click blue Ok
- Click blue Ok
ParaView

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Object Opacity

- Click **Slice2** in Pipeline Browser
- Click **Display**
- Change **Opacity** to 0.70 -> Enter
- Click **Color by vectors**
- Click eye next to **RectGrid2.vtk** to hide box outline
ParaView

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Enable Color Legend

- **Click** Display
- **Click** Edit Color Map
- **Click** Color Legend
- **Click** Show Color Legend
- **Click** → Blue Close
- **Select** Color Legend (notice white rectangle) and move to top of 3D viewer
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Create Volume Rendering

- **Click** `RectGrid2.vtk` in Pipeline Browser
- **Click** Filters -> Alphabetical -> Tetrahedralize
- **Click** -> Apply
- **Click** Display
- **Click** Representation
- **Select** Volume
- **Click** -> Edit Color Map (To edit transfer function)
ParaView

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Questions?

• More tutorials available: