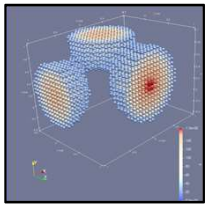
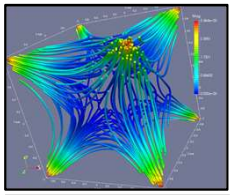
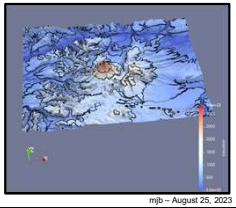
1

ParaView

http://cs.oregonstate.edu/~mjb/paraview







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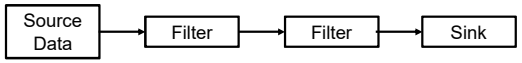
2

What is ParaView?

ParaView is a free interactive visualization package produced by **KitWare,** https://www.kitware.com/

It is built upon VTK, the Visualization Toolkit, https://vtk.org/

It uses a dataflow paradigm:



In which data arrives via sources (typically files), is filtered by various numeric algorithms, and is sent to various sinks (typically the computer graphics display).

Besides the interactive interface, ParaView also has a Python scripting interface, so that you can create these dataflow networks auto-magically.

These notes have been written against ParaView version 5.11

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3

http://www.paraview.org

Click here to download ParaView

4

In these notes, what do these icons mean?

scalar.csv

scalar.ogv

They tell you that if you go to our notes web site:

http://cs.oregonstate.edu/~mjb/paraview

you will find pre-created ParaView input data (*.csv) and pre-created animation movie files (*.ogv).

You can read a .csv file right into ParaView so that you can experiment with these examples without having to first create them yourself.

You can play an .ogv movie file right from your browser so that you can see how these examples look without having to run ParaView at all.

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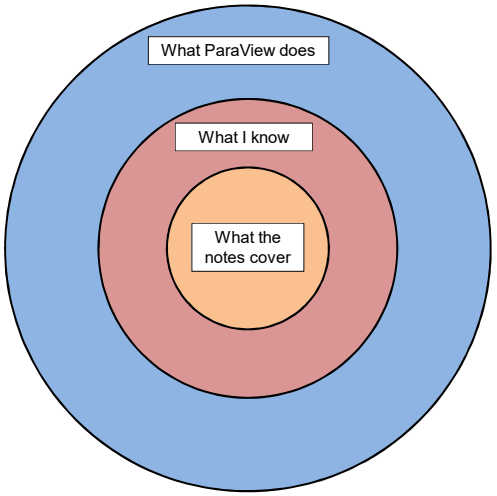
A warning about me and the Notes

5



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6

Screen Layout, Color Editor, and 3D Display

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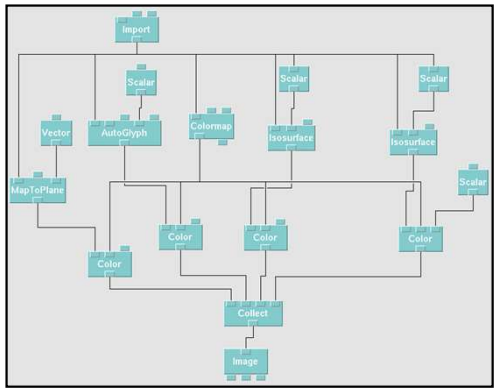
In the Beginning, there was OpenDX …

7



"DX" stands for "IBM Data Explorer". Like the name implies, it let you ***explore***! But, once it became "open" instead of commercial, all reliable support went away. Also, it required a lot of screen area just to hold the block diagram.

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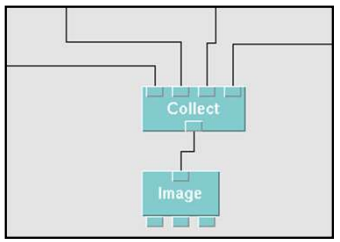
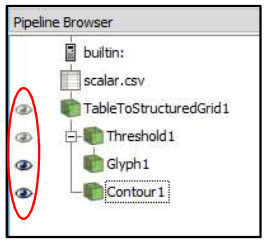
Fan-In to the Full Scene

8

OpenDX:



ParaView:



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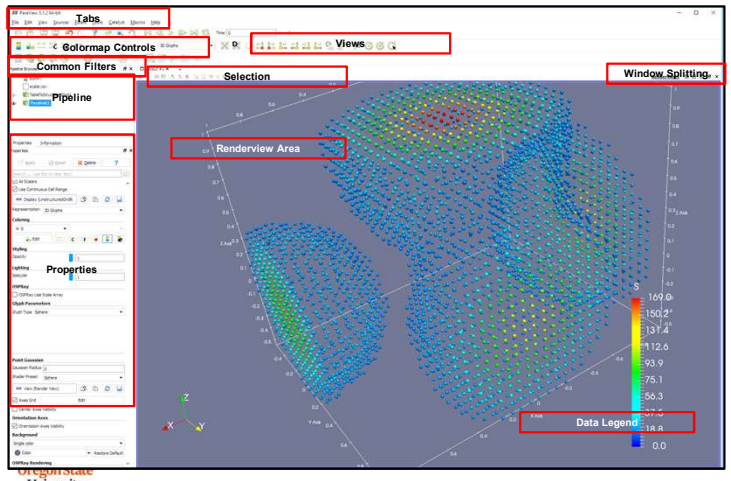
ParaView Screen Layout

9



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ParaView Menus

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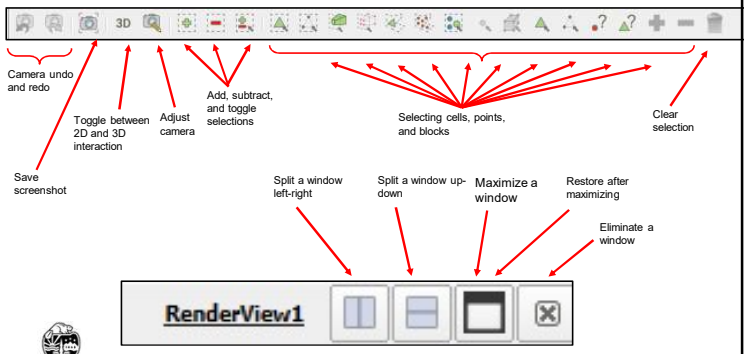
Window Layout Menu

11



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Commonly-used Filters Menu

12

Calculator
Clip
Threshold
Glyph
Warp by Vector
Extract Level
Contour
Slice
Extract Subset
Stream Tracer
Group Datasets

Some will be activated and some will be greyed-out, depending on what data you would be trying to use them for

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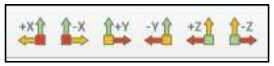
ParaView Menus

13

Animation Controls

Open
Save
Save State
Save Extracts
Save Catalyst State
Connect
Disconnect
Reset Session
Undo
Redo
Apply Changes Automatically
Find Data Matching
Load Color Palette



Directional Camera Positions

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ParaView Menus

14

Color Legend Visibility
Use Separate Color Map
Rescale to Custom Data Range
Rescale to Visible Data Range
Graphical Representation
Edit Color Map
Rescale to Data Range
Rescale to Data Range over all Time Steps
What to Color Based On

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ParaView Menus

15

Reset
Zoom to Data
Reset Camera Closest
Zoom Closest to Data
Zoom to Box

Compute Quantities
Extract Selection
Histogram
Plot Variables Over Time
Plot Over Line
Plot Selection Over Time
Probe Location
Programmable Filter
Ruler

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16

3D Scene Manipulation

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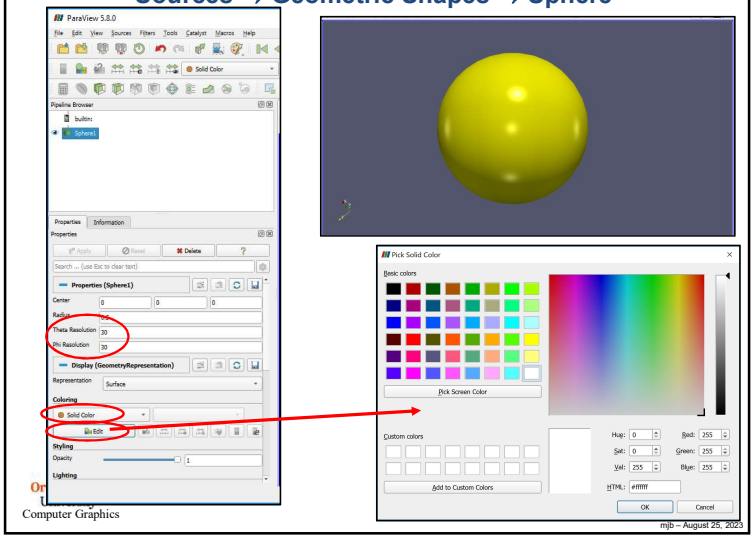
Sources → Geometric Shapes → Sphere

17



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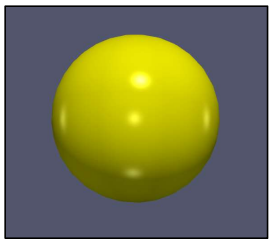
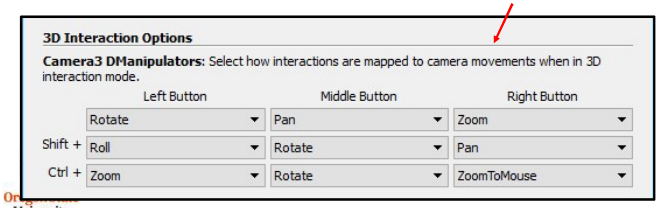
3D Scene Manipulation

18



By default, these are the 3D Scene Manipulators (plus the mouse wheel, which is also a Zoom):

(You can change these in the **Edit → Settings → Camera** menu)



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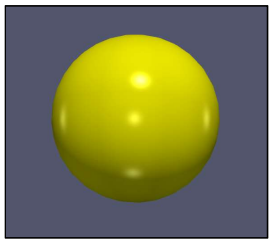
You Can Change Sphere Properties

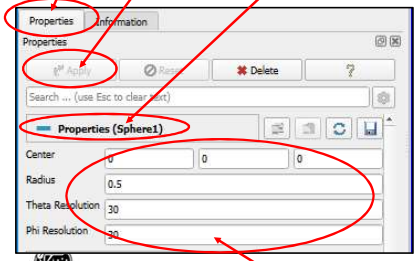
19

Properties Tab

If the **Apply** button is highlighted, click it to make your changes take effect

Show/Hide the Geometric Properties





The Geometric Properties of the Sphere

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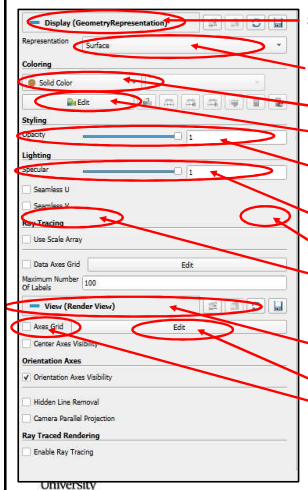
You Can Change the Sphere's Display Properties

20



Show/Hide the Display Properties

How to Represent the Sphere

How to Color the Sphere

Edit the Sphere Color

Set the Sphere Opacity

Set the Sphere Specular Lighting

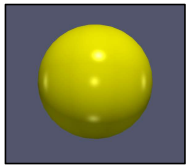
Bring up other Features to Color-Edit

Edit the Edge Color

Show/Hide the Render View Properties

Edit the Features of the **Axes Grid**

Turn on/off the **Axes Grid**



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The Axes Grid

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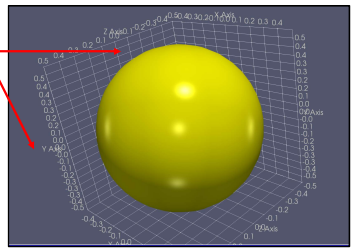
ParaView has a nice **Axes Grid** feature. Scroll way down in the Properties area to the **Render View menu** to turn it on.



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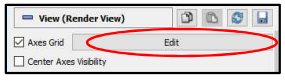
Editing the Axes Grid

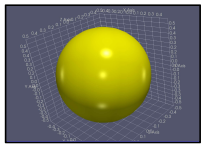
22

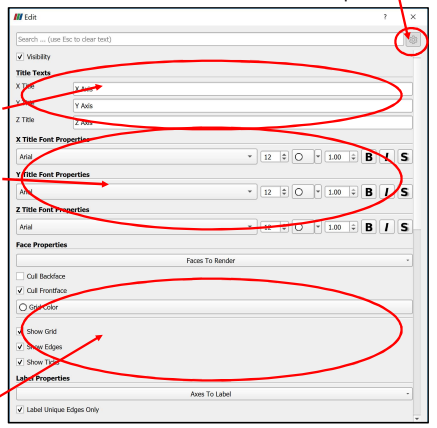
Show more/less options



Titles for the axes

Title font styles





Number label font styles

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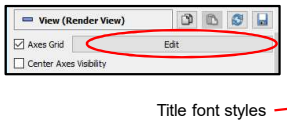
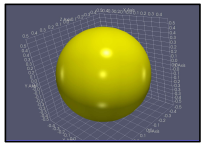
Editing the Axes Grid

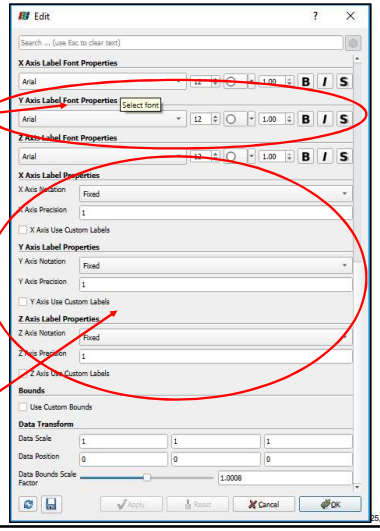
23



Title font styles



Number label font styles



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Filters → Alphabetical → Shrink

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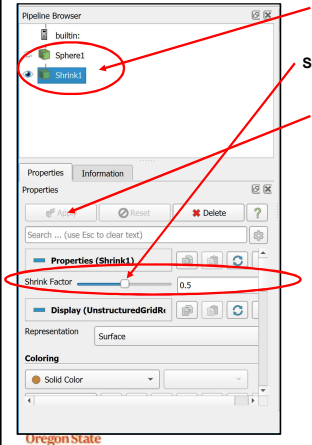
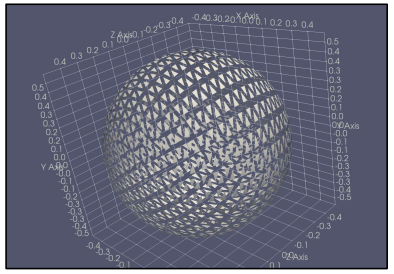
Be sure the Shrink eyeballs are clicked on and the Sphere eyeballs are clicked off

Step #1: Set the Shrink Factor (1. = no shrinking, 0. = all shrinking)

Step #2: Hit **Apply**





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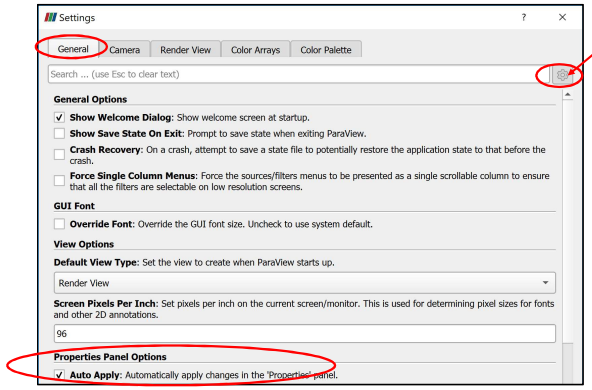
Are You Getting Tired of Hitting *Apply* All the Time?

In **Edit → Settings → General**, turn on **Auto Apply**



Show more/less options

Be careful about doing this with large datasets that are slow to display.

*Don't do this until after you have completed the entire **TableToStructuredGrid** operation.*

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Visualizing Scalar Data, I

scalar.csv

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What File Formats Can ParaView Read?

AVS UCD	BYU	CML Molecule	CSV
DEM	DICOM	ENZO AMR Particles	EnSight
Enzo	ExodusIIReader	FLASH AMR Particles	FacetReader
Flash	Fluent Case	Gaussian Cube	Image
JPEG Series	LSDynaReader	Legacy VTK	MFIXReader
MRC Series	Meta File Series	NetCDF	Nrrd
OpenFOAMReader	PDB	PLOT3D	PLY
PNG Series	PTS	PVD	Particles
Partitioned Legacy VTK	Phasta	ProSTAR (STARCD)	RTXMLPolyDataReader
Restarted Sim	SLAC	Spcth History	STL
Spy Plot	TIFF	Tecplot	Unstructured NetCDF POP
VPIC	VRML	Wavefront OBJ	WindBlade
XDMF	XML	XYZ	

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Creating Scalar Data in a CSV File


```
X32,Y32,Z32,S
-1.00,-1.00,-1.00,0.00
-0.94,-1.00,-1.00,0.00
-0.87,-1.00,-1.00,0.00
-0.81,-1.00,-1.00,0.00
-0.74,-1.00,-1.00,0.00
-0.68,-1.00,-1.00,0.00
-0.61,-1.00,-1.00,0.00
-0.55,-1.00,-1.00,0.00
-0.48,-1.00,-1.00,0.00
-0.42,-1.00,-1.00,0.00
-0.35,-1.00,-1.00,0.00
-0.29,-1.00,-1.00,0.00
-0.23,-1.00,-1.00,0.00
-0.16,-1.00,-1.00,0.00
-0.10,-1.00,-1.00,0.00
-0.03,-1.00,-1.00,0.00
```

Go to the **Edit → Settings** menu and turn on **Auto-Apply.**
Do a **File → Open** and navigate to your CSV file.
Hit the **Apply** button to actually do the read.

scalar.csv

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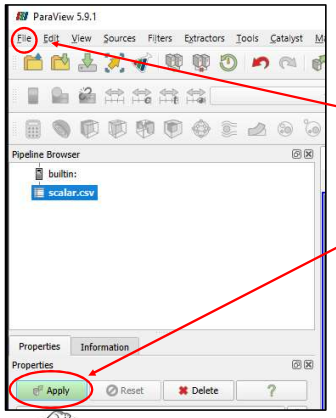
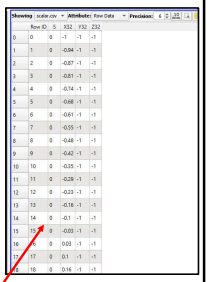
Reading and Converting the CSV File

29



1. Select **File → Open** and navigate to **scalar,csv**

2. Then, click **Apply**



3. This will bring up a table window to confirm that the data has been read properly. You can close it if you want.

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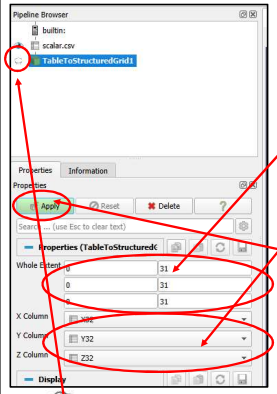
Reading and Converting the CSV File

30



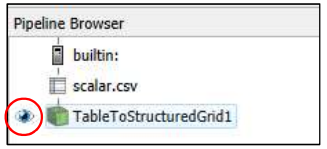
4. Now, go to **Filters → Alphabetical → TableToStructuredGrid**

5. Fill in the **Whole Extent** boxes showing the first and last index in each dimension (the last index is one less than the number of points in that dimension). In this case, the numbers are **0** and **31**.

6. Fill in the **{X,Y,Z} Column** information so ParaView knows how to make your 3D display. In this case, the names are **X32**, **Y32**, and **Z32**.

7. Hit the **Apply** button to actually do the conversion.

Turn on the "eyeballs" so that you can view this data



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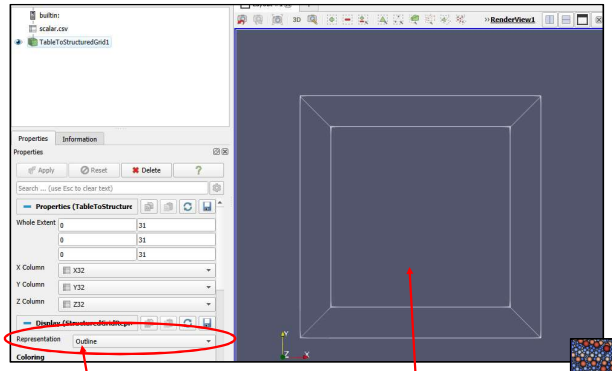
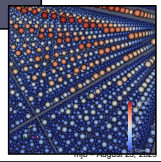
Reading and Converting the CSV File

31



The default Display Representation is **Outline**. Click here and try some of the others. **Point Gaussian** is cool!



At this point, you should probably go to the **Edit → Settings** menu and turn off **Auto-Apply**

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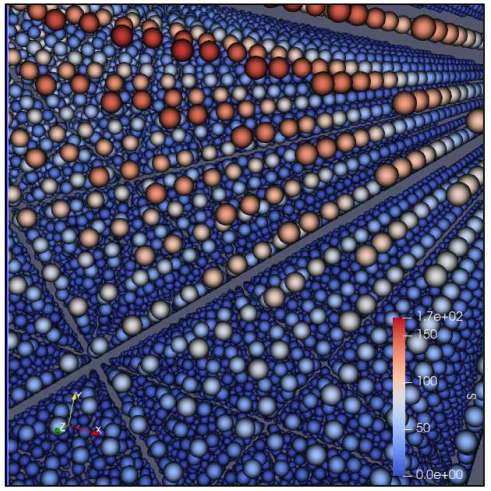
As Point Gaussian

32



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A Side Trip: Choosing Colors

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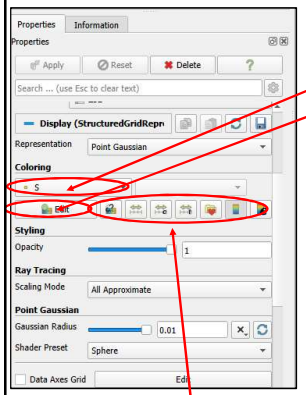
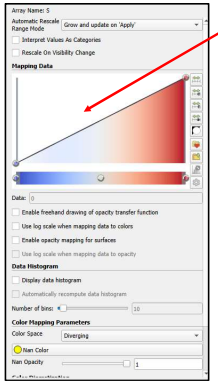
Turning on Color

34

The default coloring is by scalar value, **S** in this case.
You can also click here and change it to **Solid Coloring**.

The **Edit** button will bring up a color map editor





This is a row of color options.

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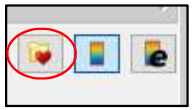
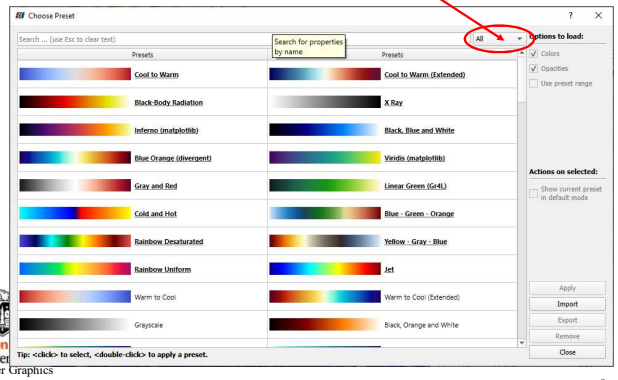
Choose Among Standard Color Transfer Functions

35



Click here to see all the categories of Transfer Functions available to you. Click **All** to see them all at once. (You will need to scroll down a lot.)



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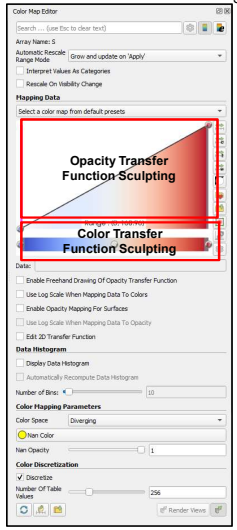
Color Map Editor

36



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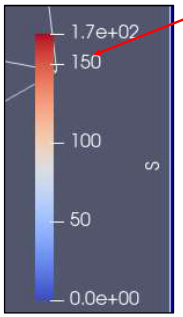
Changing the Legend

37



The default legend is good, but you can make it better. Start by clicking here.

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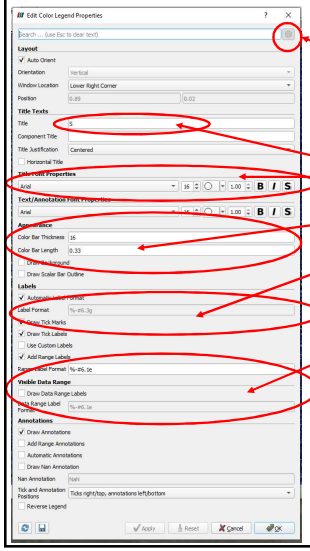
Changing the Legend

38



Click on the "gear" to bring up *all* of the options. (This is a good idea on *all* ParaView dialog boxes.)

Legend title and font

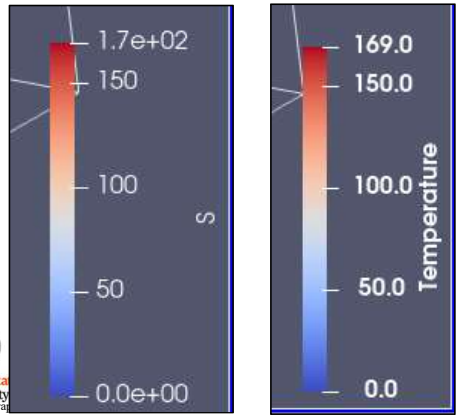
Color bar

Tick mark font and number format ("printf-style")

Range numbers at the end of the legend

39

From this, to this



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Visualizing Scalar Data, II

scalar.csv

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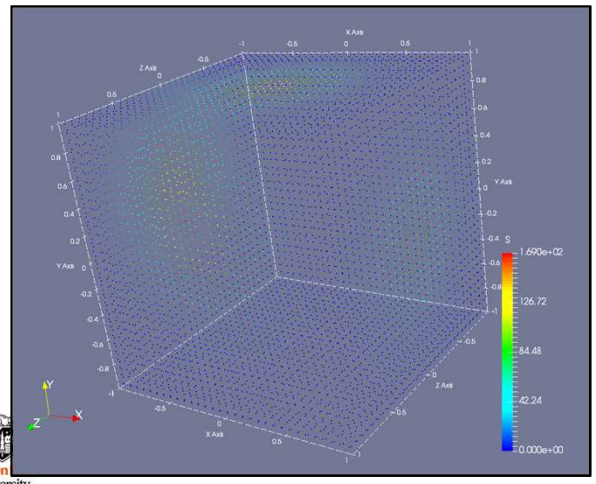
As Points

41



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Pipeline Element and Filter Observations

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- Whatever pipeline element you have most-recently clicked on, that's what Properties you will see.
- Whatever pipeline element you have most-recently clicked on, that will be the parent of the next Filter you select. The parent's output will become the Filter's input.
- Be careful of Filter order. In general, Filters are not commutative or associative.
- For data-size reasons, it is helpful if any datasize reduction Filters are included early in the pipeline.
- As far as I can tell, you can't inject a filter in the middle of a pipeline. You can re-parent it. You can delete it and pipeline elements around it and start over. But, adding a new Filter between two existing pipeline elements creates a tee from the parent, not a new pipeline.
- Whatever "eyeballs" you have clicked on, that's what pipeline elements' visual representations you will see in the display.
- Turn on the **TableToStructuredGrid** "eyeballs" and set the Representation to **Outline**. That keeps ParaView displaying the data as 3D-fullsize, regardless of what downstream pipeline elements do.

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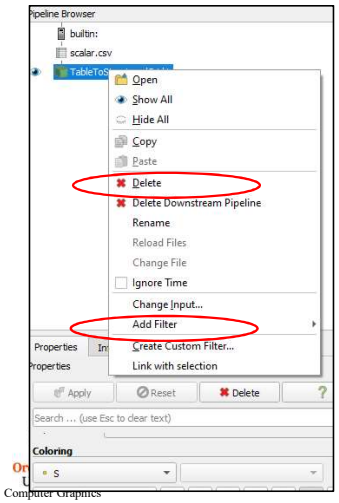
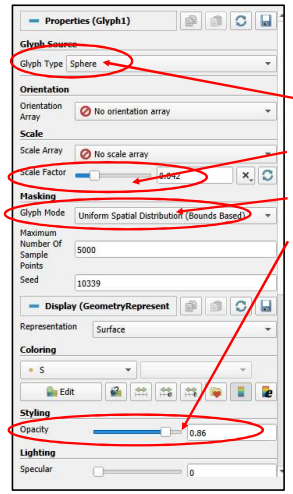
Right-clicking on a Pipeline Element

43



As a Glyph Cloud

44



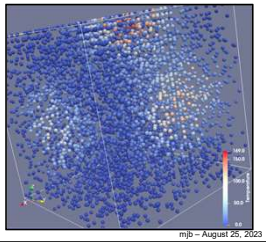
Filters → Alphabetical → Glyph adds the glyph cloud to the pipeline. Hide the **TableToStructuredGrid** (click off the eyeball) and un-hide the **Glyph.**

Set the **Glyph Type**

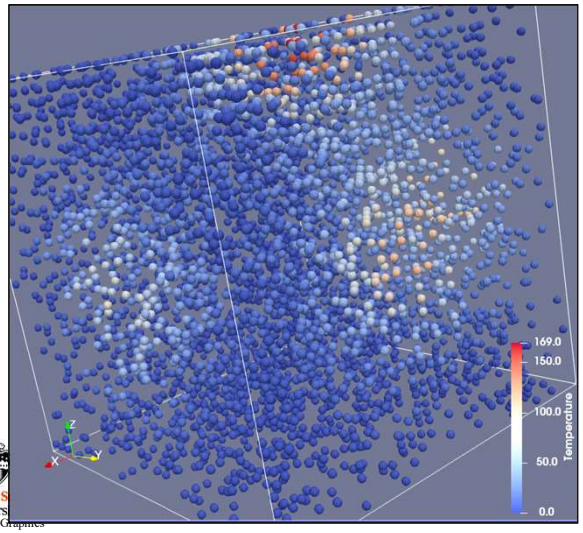
Play with the **Scale Factor**

Play with the **Glyph Mode**

Play with the **Opacity**



45



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As a Threshold Glyph Cloud

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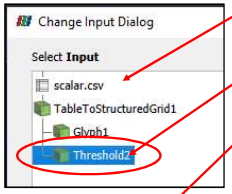
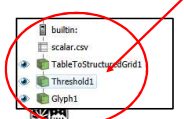
Click on **TableToStructuredGrid**, then **Right-click → Add Filter → Alphabetical → Threshold**.

But, this is the wrong order. We want to threshold the data first. So, select **Glyph1**, right-click on it, select **Change Input…**



Then select **Threshhold1**

You now have this order



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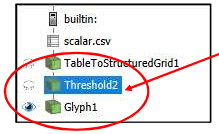
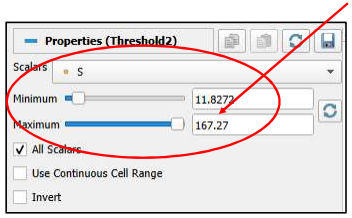
As a Threshold Glyph Cloud

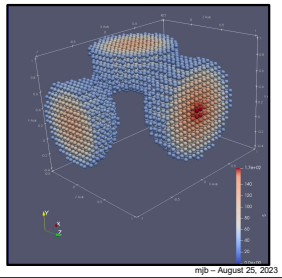
47



Hide the **TableToStructuredGrid** and the **Threshold**, then un-hide the **Glyph.**

Set the **Minimum** and **Maximum**. (Be sure to click on **Apply** if needed.)





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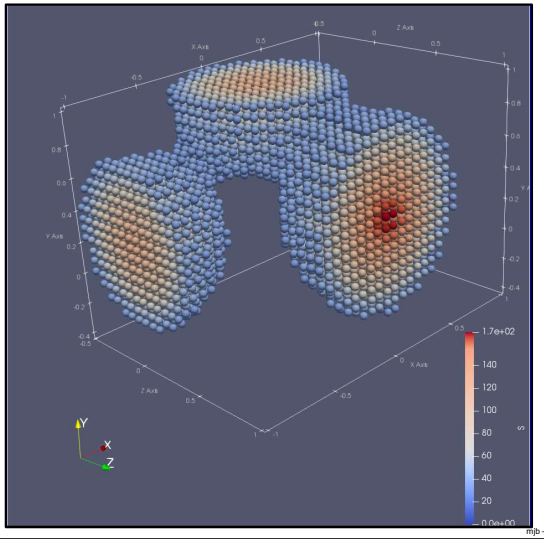

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As a Colored Cutting Plane

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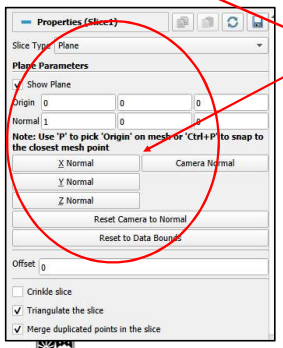
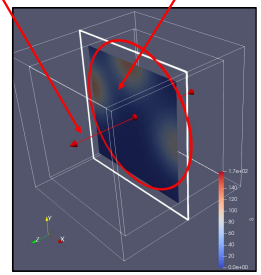
ParaView trick – turn on the **TableToStructuredGrid** display and set the Representation to **Outline**. That keeps ParaView from displaying the plane as 2D-only



Right-click on **TableToStructuredGrid**, then select **Add Filter → Alphabetical → Slice**

Click in here to change the slice parameters.
Click on the colored plane itself to move the plane.
Click on the arrow to rotate the plane.



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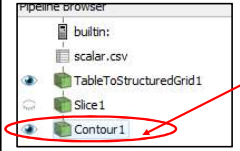
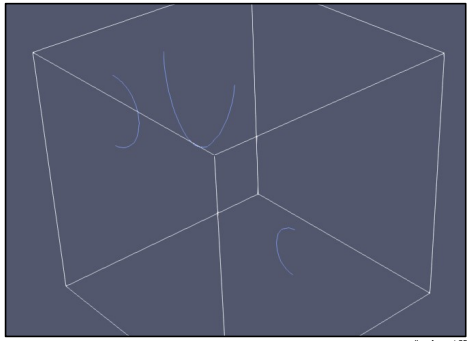
Turning the Slice into Contours

50



Right-click on **Slice1**, then select **Add Filter → Alphabetical → Contour**



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Changing the Contour Isovalue

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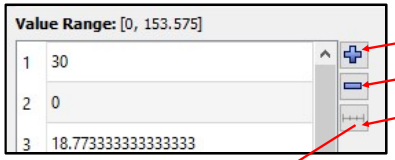
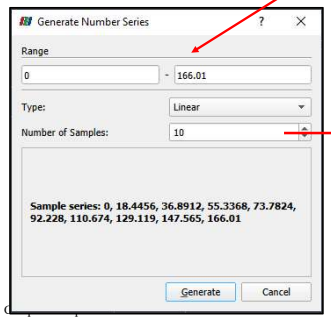
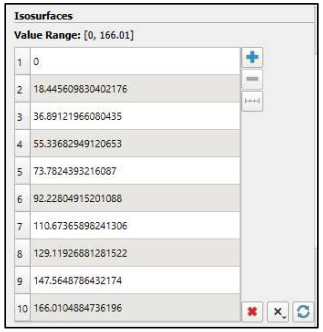


Add a contour isovalue

Delete a contour isovalue

Add a range of contour isovalues





As Contours

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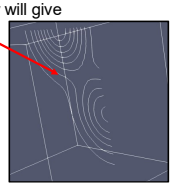
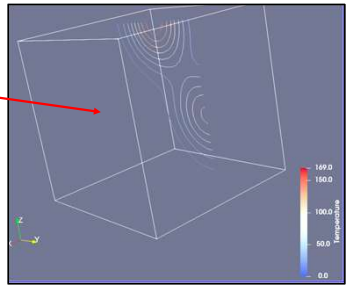
This needs to be **Wireframe** to get contour lines

Coloring by **S** will give you colored contour lines.

Coloring by **Solid Color** will give you a single color.





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As Contours

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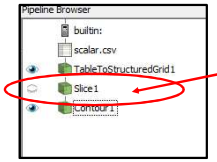
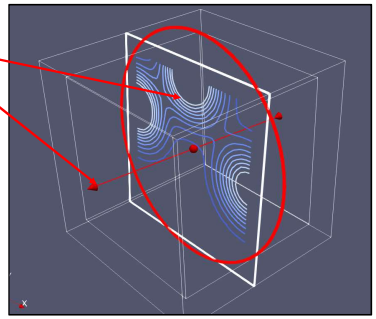


Clicking on the Slice filter will bring up these slice handles so that you can move and re-orient the slice plane

Click on the plane itself to move the plane.
Click on the arrow to rotate the plane.



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As Contours

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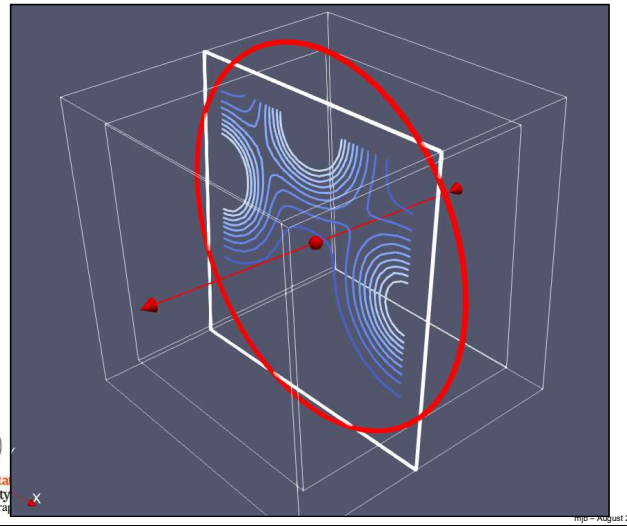

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As Contours

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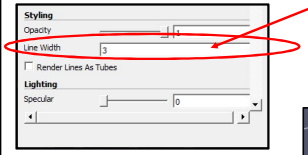
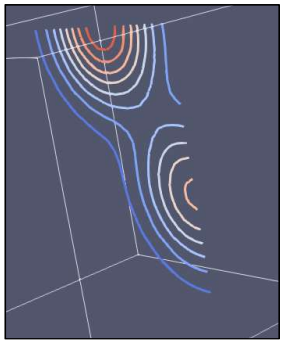


Adjusting the **Line Width**



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As 3D Isosurfaces

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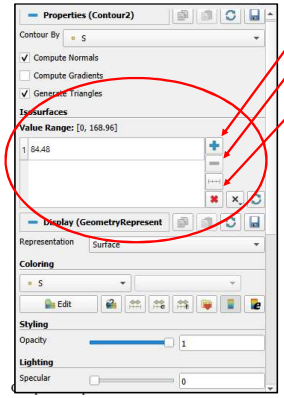
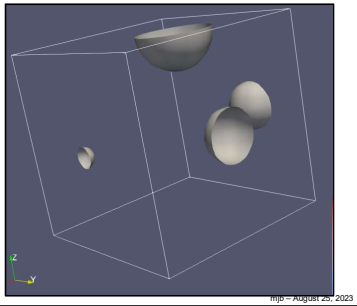
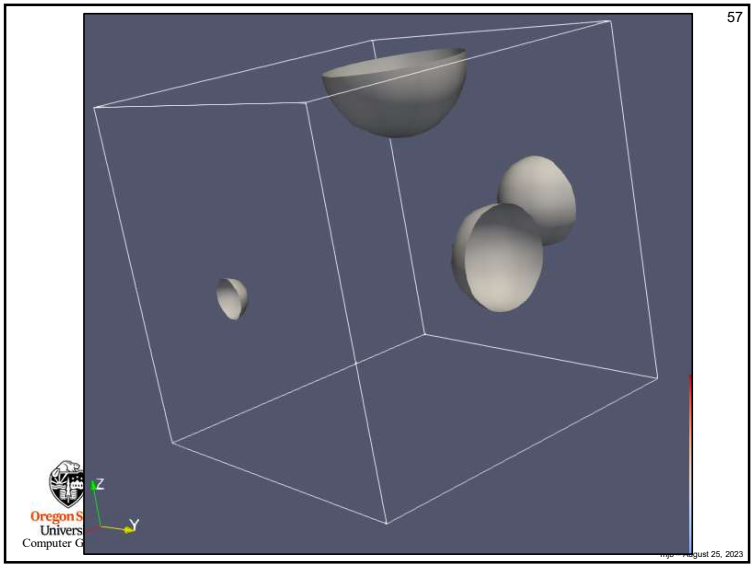
Note – This instance of **Contour** needs to be parented from **TableToStructuredGrid**, not **Slice**



Add an isosurface isovalue
Delete an isosurface isovalue
Add a range of isosurface isovalues

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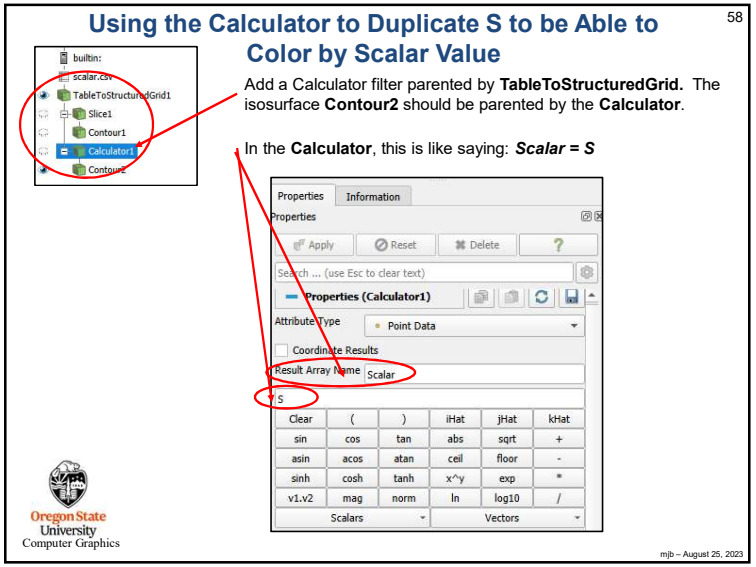
Using the Calculator to Duplicate S to be Able to Color by Scalar Value
58
builtin:
scalar.csv
TableToStructuredGrid1
Slice1
Contour1
Calculator1
Contour2
Add a Calculator filter parented by TableToStructuredGrid. The isosurface Contour2 should be parented by the Calculator.
In the Calculator, this is like saying: Scalar = S
Properties
Information
Properties
Apply
Reset
Delete
Properties (Calculator1)
Attribute Type
Point Data
Coordinate Results
Result Array Name
Scalar
S
Clear ( ) iHat jHat kHat
sin cos tan abs sqrt +
asin acos atan ceil floor -
sinh cosh tanh x^y exp *
v1.v2 mag norm ln log10 /
Scalars
Vectors
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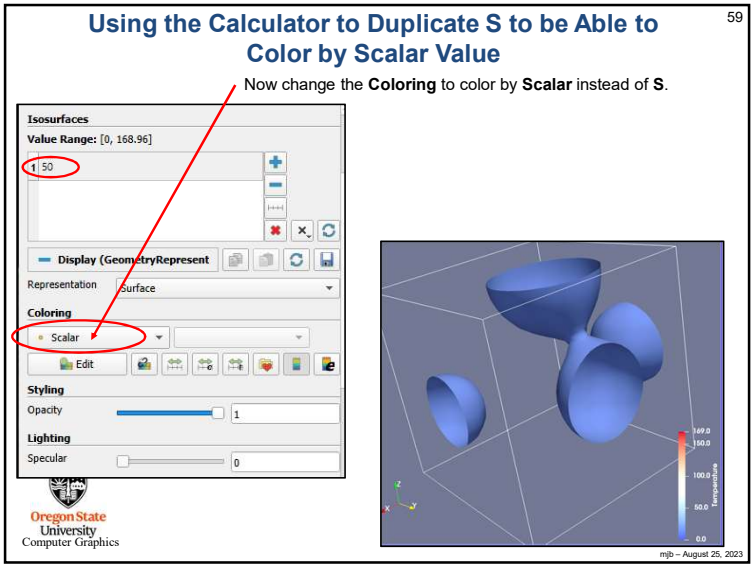
Using the Calculator to Duplicate S to be Able to Color by Scalar Value
59
Now change the Coloring to color by Scalar instead of S.
Isosurfaces
Value Range: [0, 168.96]
1 50
Display (GeometryRepresent
Representation
Surface
Coloring
Scalar
Edit
Styling
Opacity
1
Lighting
Specular
0
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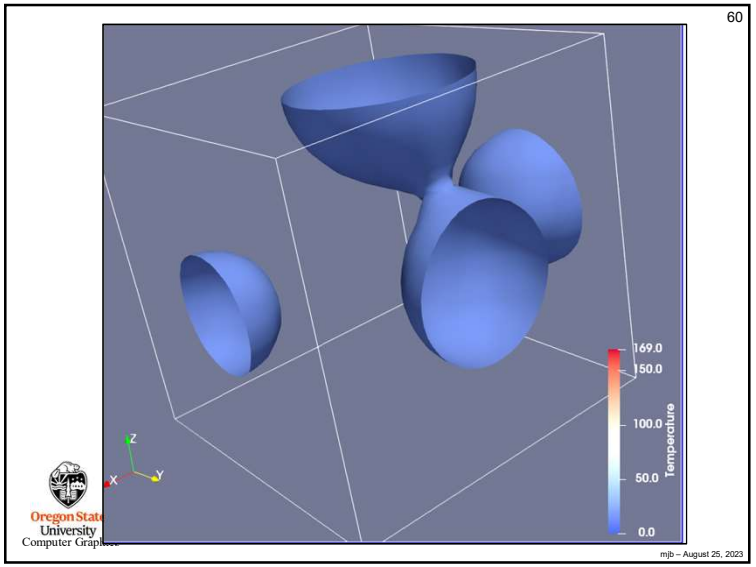
60
169.0
150.0
100.0
50.0
0.0
Temperature
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Experimenting with the Opacity and Specular is Fun Too

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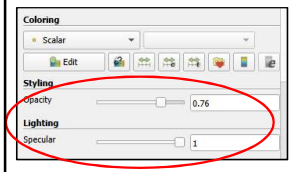

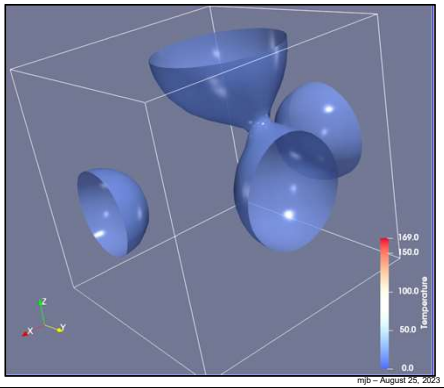

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How the Calculator Works

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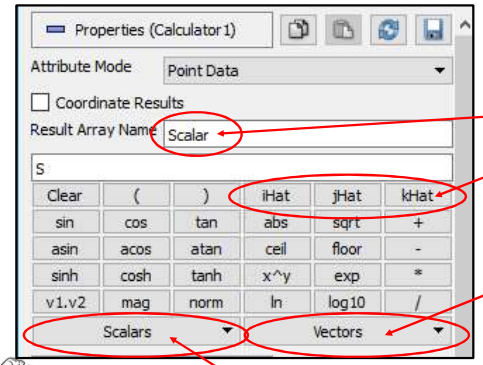

Name of the output field

X, Y, and Z unit vectors

A list of the current vector variables in the dataset

A list of the current scalar variables in the dataset

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As a Volume

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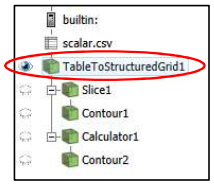

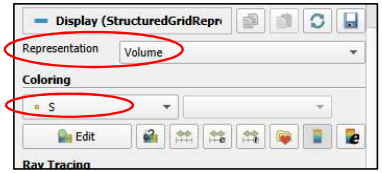

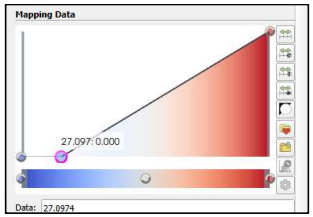

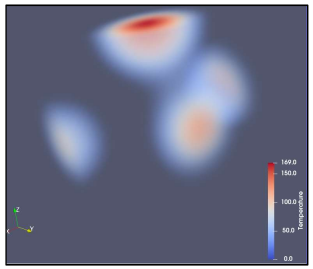

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Sculpting the Alpha Transfer Function

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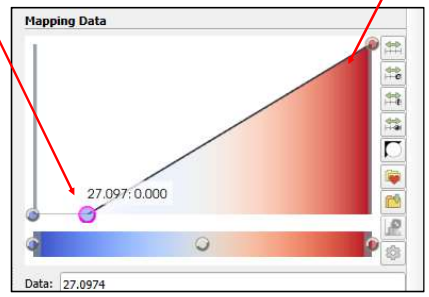
Hover over the black line and **left-click** to add a new sculpting point there

Hover over a point and hit the **Delete** key or **Middle Mouse Button** to delete a point



Alpha=1. (opaque)

Alpha=0. (transparent)

Data value range

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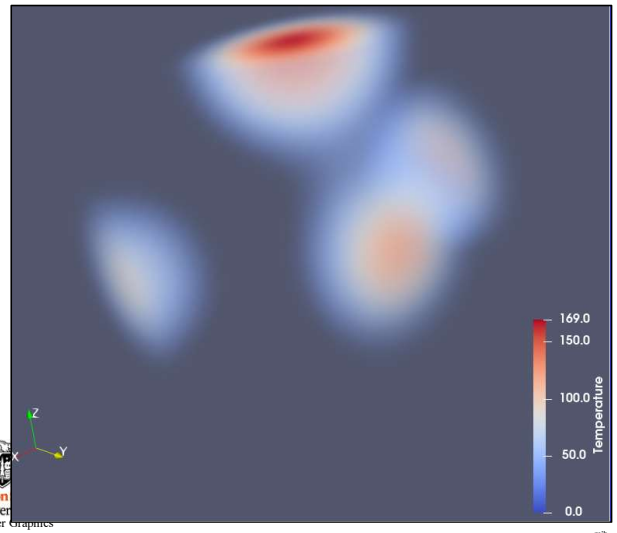

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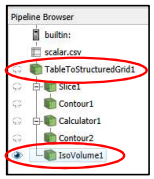
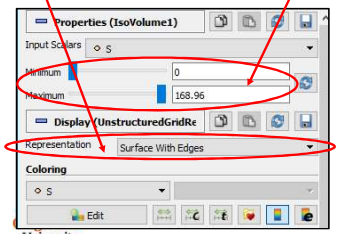
IsoVolumes

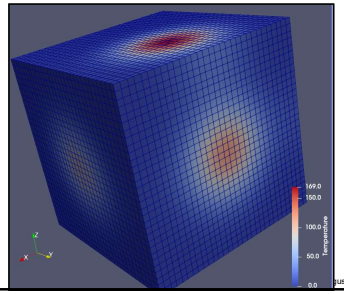


Start with this

The **IsoVolume** properties start out at "allow all values" to pass through. We're going to change this.

I chose the **Surfaces with Edges** representation so you can see the cells. You'll see why in a moment.





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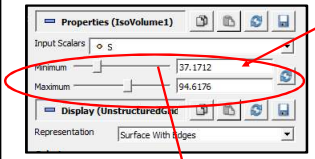
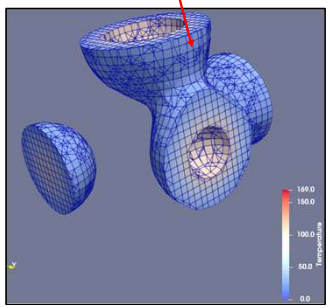
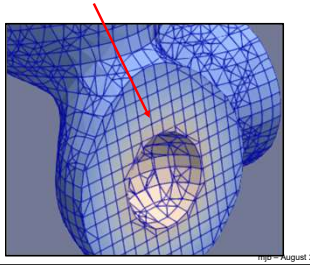
IsoVolumes



Now adjust the Minimum and Maximum to something else.



Note that the **IsoVolume** filter turned your nice, efficient structured grid into an unstructured grid. This can balloon the size of the data that is being operated on.



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Annotating

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Adding Titles

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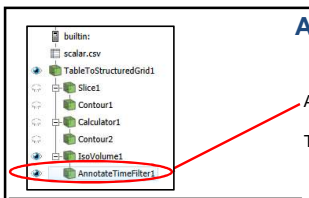
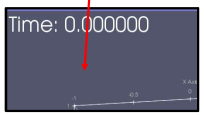
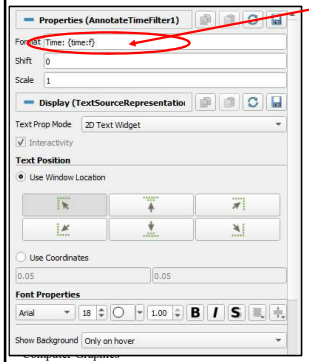


Add an **Annotate Time Filter** to the pipeline

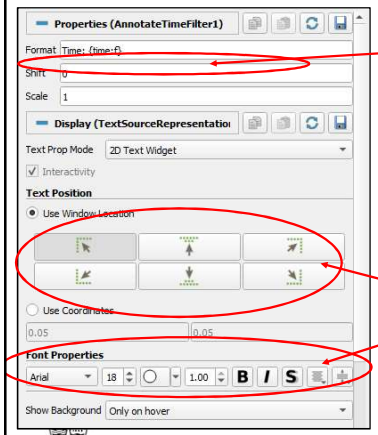
The default annotation looks like this. We will change that.





Adding Titles

70



The label to use (the printf-notation is to format the Time – get rid of this if you just want a title)

The position for the title

The font, size, color, opacity, style, and justification to use

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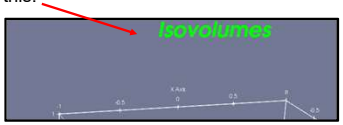
From this:

to this:



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Multiple Views

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Multiple Views

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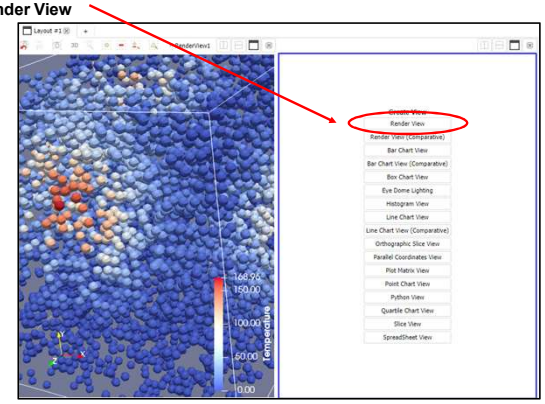
Step #1: Split the Window

Step #2: Click on **Render View**



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Multiple Views

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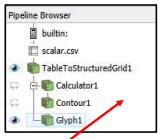
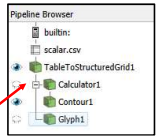
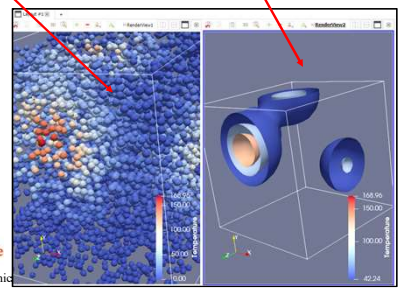




Step #3: Click in one Window and setup one visualization

Step #4: Click in the other Window and setup a separate visualization (stay aware of how the visualizations are parented!)



… and, you get this – with each Window being allowed its own viewing transformation

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Multiple Views with Linked Viewing Transformations

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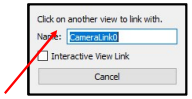
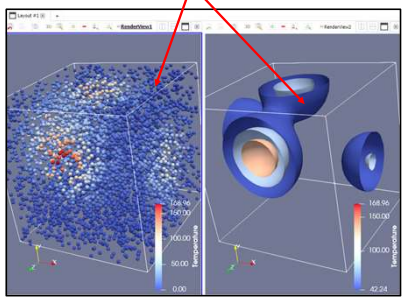
Step #5: Right-click in one of the Windows and select **Link Camera…**

Step #6: You get this dialog box – now click in the other Window that you want to be linked with



Your Windows now share a single transformation



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Multiple Views with Linked Viewing Transformations

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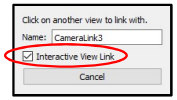
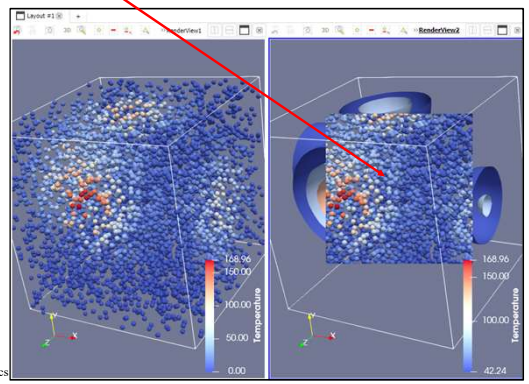
If you click on this checkbox and then click in another Window …



… you get a Magic Lens



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Order Matters!

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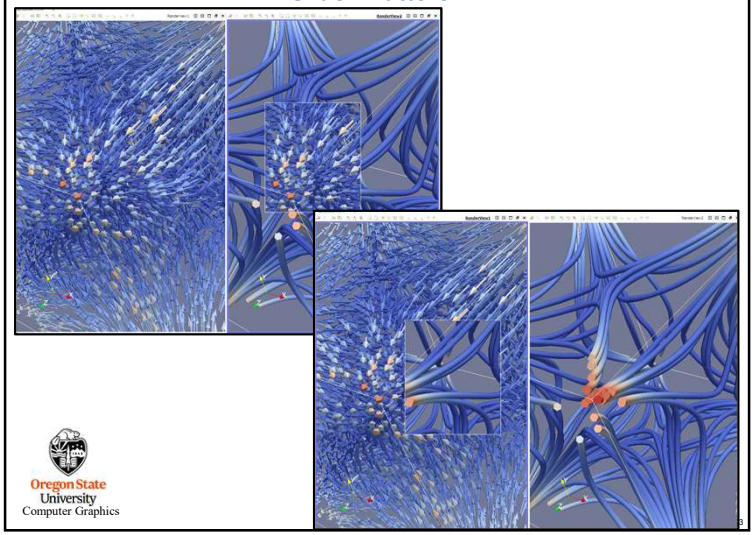

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Using Plot Over Line

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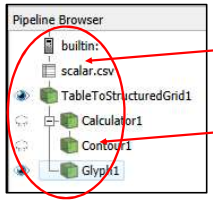
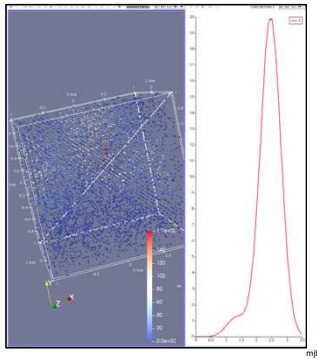


1. Create this Pipeline
2. Split the Render window and ask for a **Line Chart View**
3. When you click in the Render window, make the eyeballs look like this, with the **TableToStructuredGrid** representation set to **Outline** and the **Glyph** representation set to **Surface**



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Using Plot Over Line

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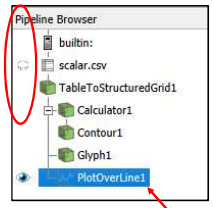
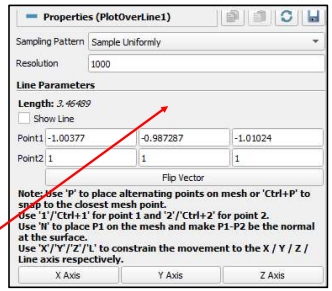


1. Click in the **Line Chart View** window. Add a **PlotOverLine** filter that is parented to the **TableToStructuredGrid**
2. Setup the PlotOverLine Properties like this
3. Be sure **Auto-Apply** is turned on



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Using Plot Over Line

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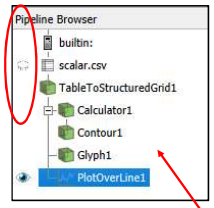
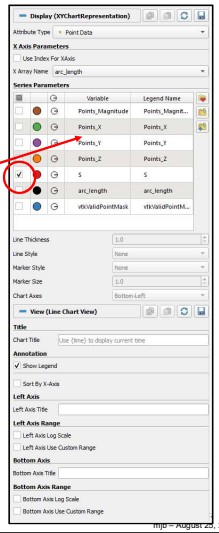


Setup the **Display (XYChartRepresentation)** Properties like this



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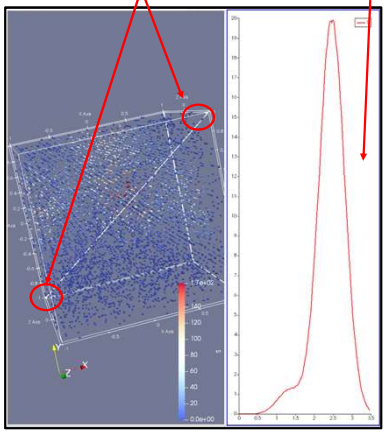
Using Plot Over Line

Now, when you click on the **Line** endpoints and move them, the graph changes



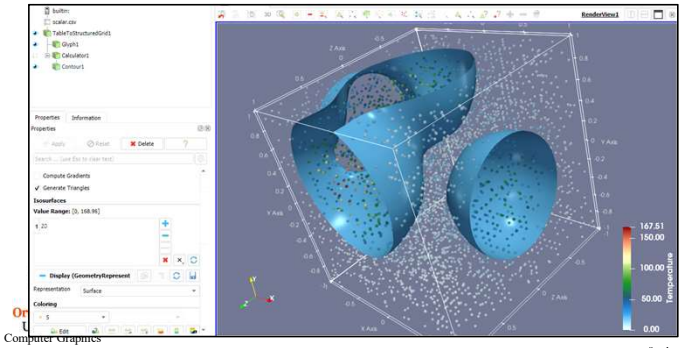
Comparative Visualization

scalarcompare.pvsm

Comparative Visualization

ParaView can setup a side-by-side visualization comparison with different vis parameters in each view.

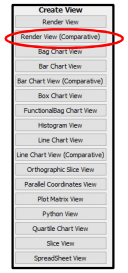
Start by creating a 3D Render view visualization. This case is using the isosurface demonstration shown earlier.

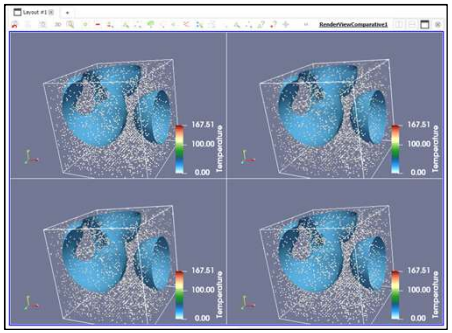


Comparative Visualization

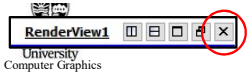
Now, split the window

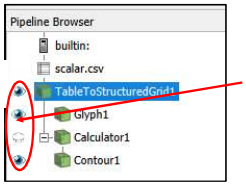
and select:
Render View (Comparative).





You can now eliminate the left-hand window if you want.





Click all the eyeballs on for the visualization features you want to see.

Comparative Visualization

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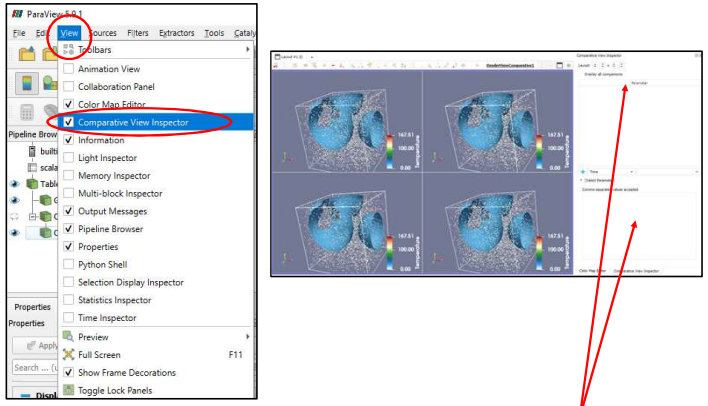

Select **View → Comparative View Inspector**

These two areas are created

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Comparative Visualization

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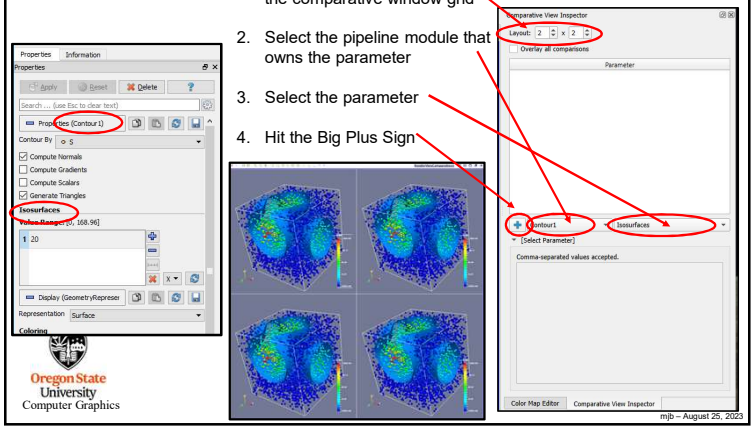
Here's where you get to select how to vary the parameter(s).

1. Select the layout dimensions of the comparative window grid
2. Select the pipeline module that owns the parameter
3. Select the parameter
4. Hit the Big Plus Sign



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Comparative Visualization

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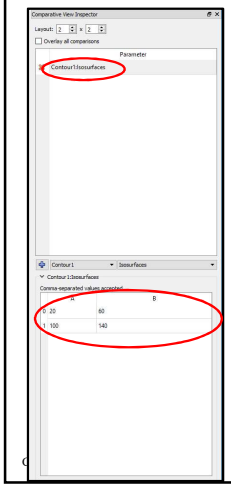
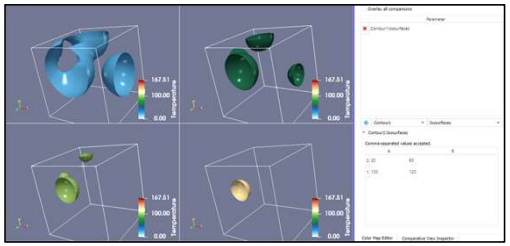


ParaView stocks the number grid with evenly-spaced values and applies them to each visualization, respectively.

Usually, these are not what you wanted to see. But you can type your own numbers in each cell

(I eliminated the Glyphs to better see the isosurfaces)

The windows are all transform-linked



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Comparative Visualization

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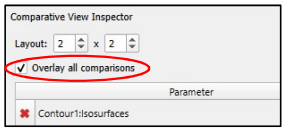
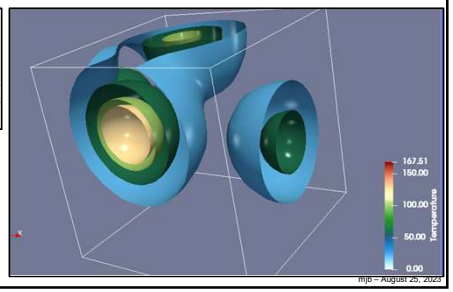
Clicking **Overlay all comparisons**, well, overlays all comparisons

You can vary multiple parameters – just setup multiple pipeline elements and parameters and put numbers separated by commas in the cells

In this case, now could be a good time to also vary the opacity of the isosurfaces





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Comparative Visualization

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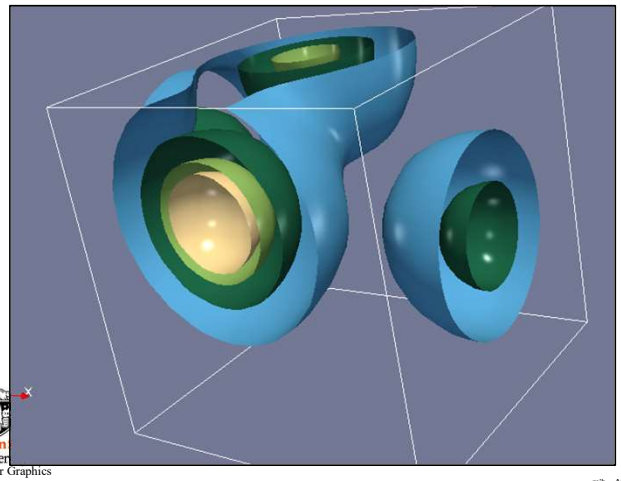

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Visualizing Vector Data

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vector.csv

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Creating Vector Data in a CSV File

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```
X32,Y32,Z32,Vx,Vy,Vz
-1.00,-1.00,-1.00,2.00,2.00,2.00
-1.00,-1.00,-0.94,1.75,1.75,2.00
-1.00,-1.00,-0.87,1.53,1.53,2.00
-1.00,-1.00,-0.81,1.33,1.33,2.00
-1.00,-1.00,-0.74,1.15,1.15,2.00
-1.00,-1.00,-0.68,0.99,0.99,2.00
-1.00,-1.00,-0.61,0.84,0.84,2.00
-1.00,-1.00,-0.55,0.71,0.71,2.00
-1.00,-1.00,-0.48,0.60,0.60,2.00
-1.00,-1.00,-0.42,0.49,0.49,2.00
-1.00,-1.00,-0.35,0.40,0.40,2.00
-1.00,-1.00,-0.29,0.31,0.31,2.00
-1.00,-1.00,-0.23,0.24,0.24,2.00
-1.00,-1.00,-0.16,0.17,0.17,2.00
-1.00,-1.00,-0.10,0.10,0.10,2.00
-1.00,-1.00,-0.03,0.03,0.03,2.00
```

Do a **File → Open** and navigate to your CSV file.
Hit the **Apply** button to actually do the read.

vector.csv

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How to Read the Vector Data in the CSV File

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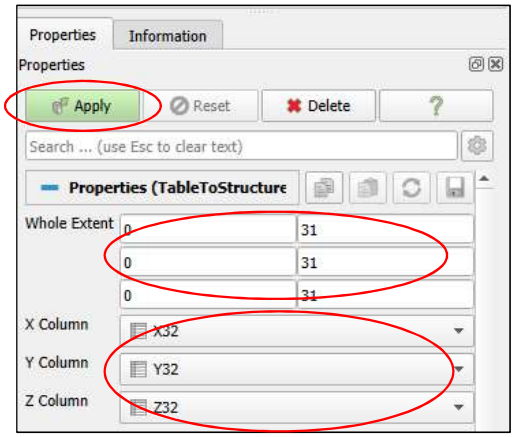
vector.csv



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Vector Visualization As Glyphs

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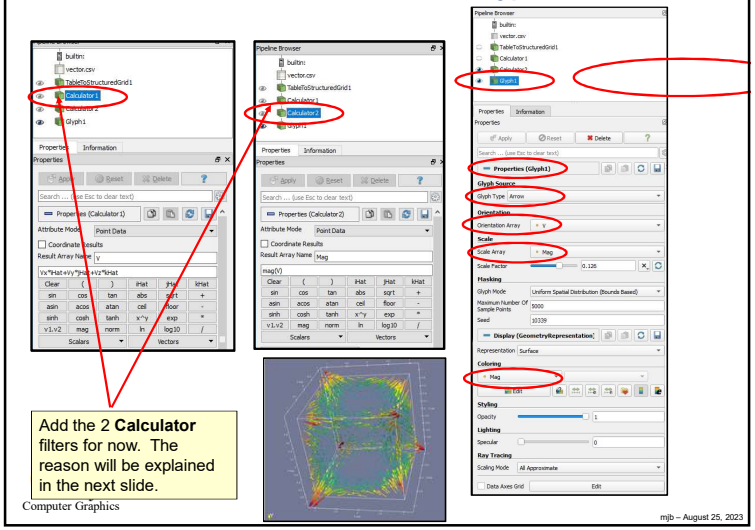

Add the 2 **Calculator** filters for now. The reason will be explained in the next slide.

Why Are the Two Calculator Filters There?

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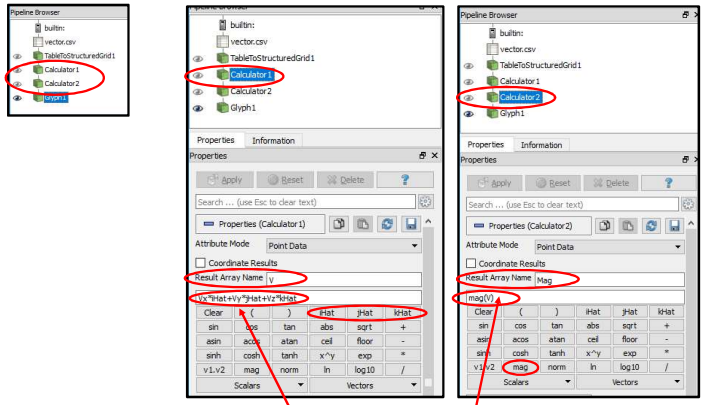

The **vector.csv** file brought in the three vector components **Vx**, **Vy**, and **Vz**. ParaView's vector vis filters want a 3-element vector instead. **Calculator1** is used to create that 3-element vector using the **iHat**, **jHat**, and **kHat** buttons (unit vectors in x, y, and z) :

$$\boldsymbol{V = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}}$$

We want to color the vector visualizations by the magnitude of the vector. **Calculator2** computes that magnitude using the **mag** button:

$$\boldsymbol{Mag = \|V\|}$$

Why Are the Two Calculator Filters There?

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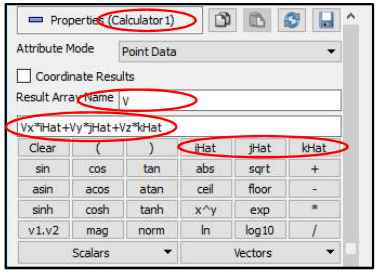
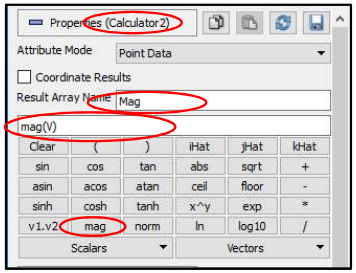


$$\boldsymbol{V = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}}$$



$$\boldsymbol{Mag = \|V\|}$$

Setting Up the Glyph and its Coloring

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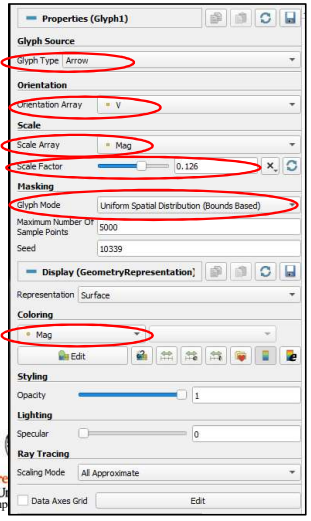
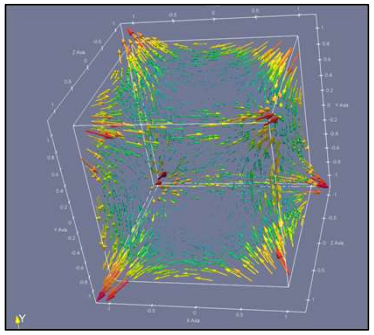
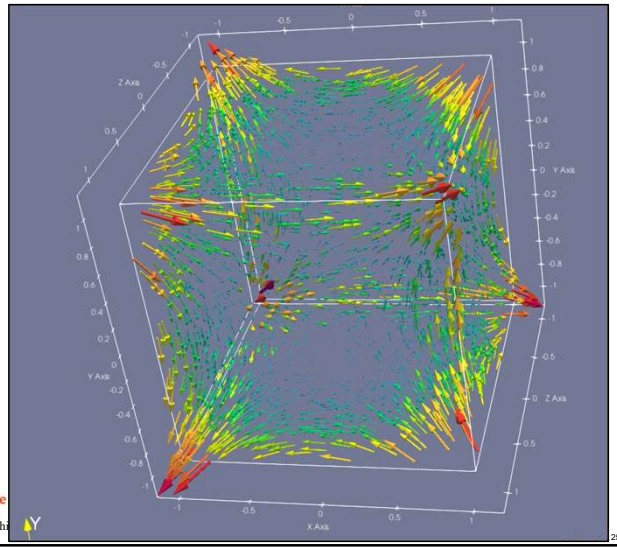




97



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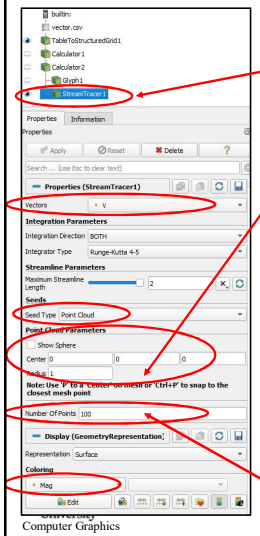
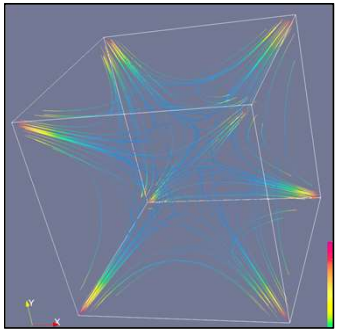
As Streamlines



StreamTracer filter, *parented from the second* ***Calculator***

Will start the streamlines from within this sphere. You can move it and resize it.



Number of points to start from

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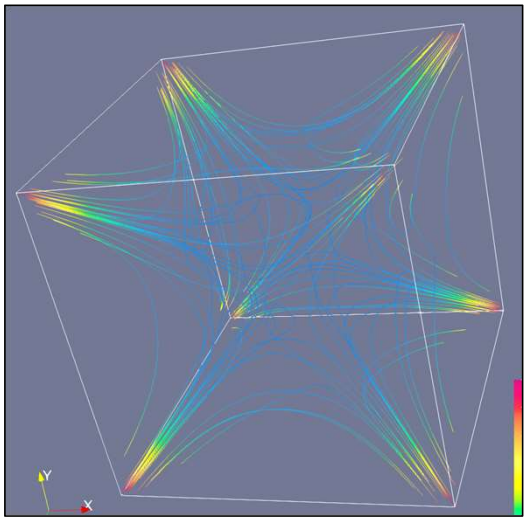

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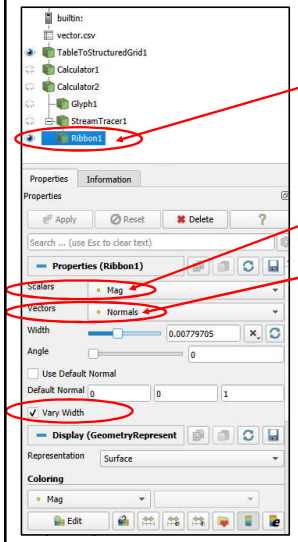
As Ribbon Traces

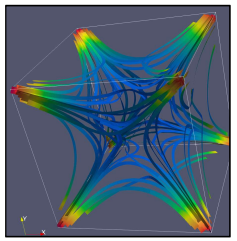


Note – **Ribbon** is *parented from* ***StreamTracer.***

Ribbon Traces are especially good for showing ***twisting*** in the vector field. This dataset is not a great example of that.

The **Scalar** setting tells what will be used to size the width of the ribbons.

The **Vector** setting tells what will be used to decide which way the ribbon is facing.



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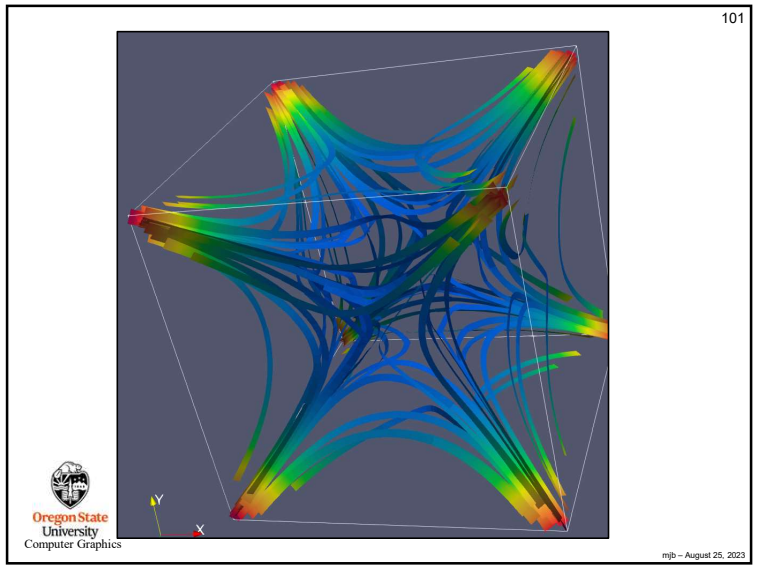
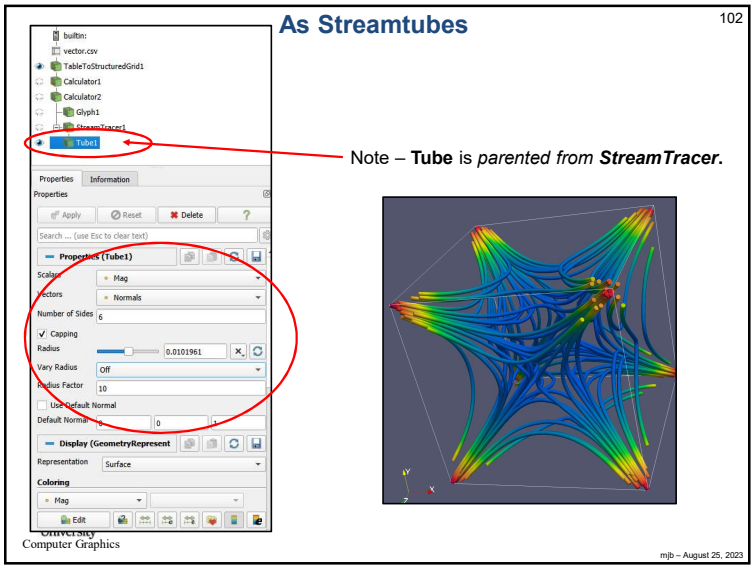
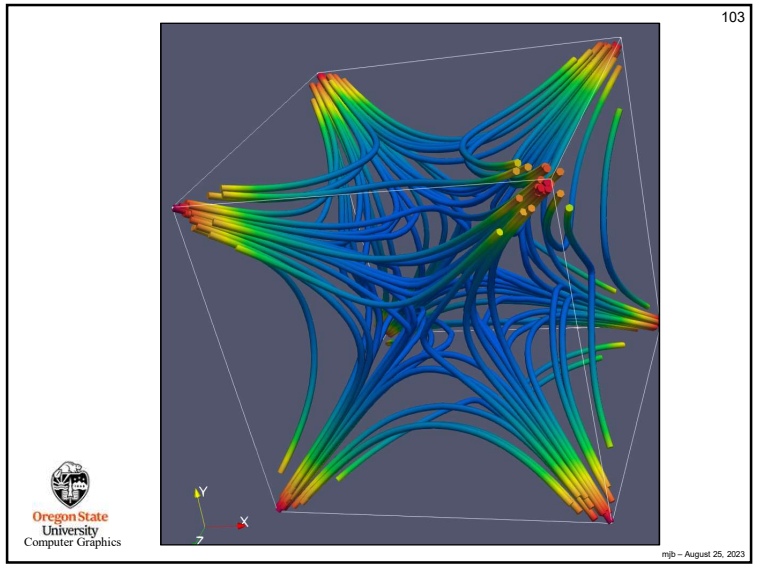
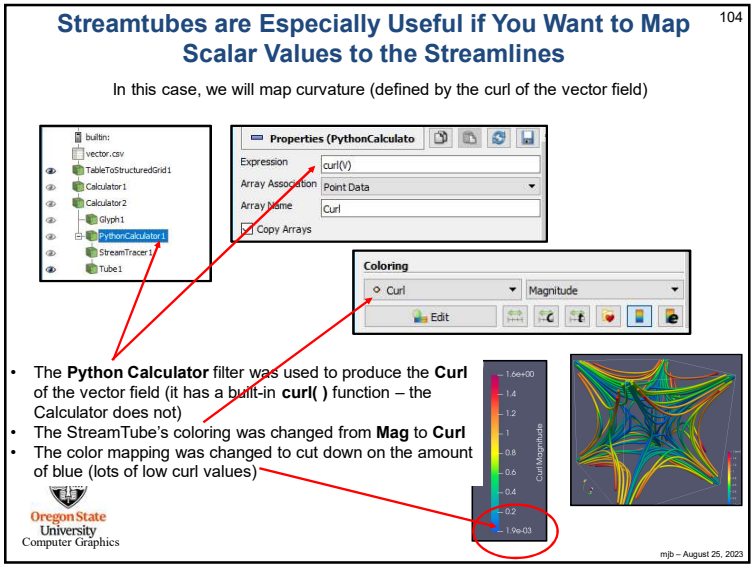

101
Oregon State University
Computer Graphics
mjb – August 25, 2023


As Streamtubes
102
Note – Tube is parented from StreamTracer.
Oregon State University
Computer Graphics
mjb – August 25, 2023


103
Oregon State University
Computer Graphics
mjb – August 25, 2023


Streamtubes are Especially Useful if You Want to Map Scalar Values to the Streamlines
104
In this case, we will map curvature (defined by the curl of the vector field)
The Python Calculator filter was used to produce the Curl of the vector field (it has a built-in curl( ) function – the Calculator does not)
The StreamTube's coloring was changed from Mag to Curl
The color mapping was changed to cut down on the amount of blue (lots of low curl values)
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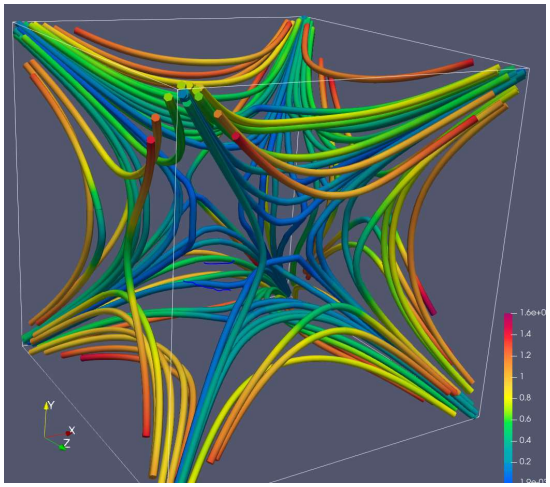
mjb – August 25, 2023



Functions Available in the Python Calculator

- area(dataset)
- aspect(dataset)
- cos(array)
- cross(X,Y) where X and Y are two 3D vector arrays
- curl(array)
- divergence(array)
- dot(a1,a2)
- eigenvalue(array)
- eigenvector(array)
- gradient(array)
- max(array)
- mean(array)
- min(array)
- norm(array)
- sin(array)
- strain(array)
- volume(array)
- vorticity(array)

From: https://www.paraview.org/Wiki/Python_calculator_and_programmable_filter

Visualizing Terrain Data

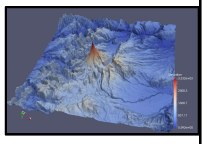
terrain.csv

Creating Terrain Data in a CSV File

```
UTMx512,UTMy361,Z,Longitude,Latitude,Elevation
-6909.865,-6870.170,1174.991,-122.200,45.010,1174.991
-6882.896,-6870.356,1268.436,-122.198,45.010,1268.436
-6855.759,-6870.542,1308.478,-122.196, 5.010,1308.478
-6828.789,-6870.728,1266.755,-122.193,45.010,1266.755
-6801.820,-6870.911,1203.239,-122.191,45.010,1203.239
-6774.682,-6871.095,1127.675,-122.189,45.010,1127.675
-6747.544,-6871.279,1074.388,-122.187,45.010,1074.388
-6720.575,-6871.461,1060.748,-122.185,45.010,1060.748
-6693.606,-6871.642,1056.135,-122.182,45.010,1056.135
-6666.468,-6871.823,1050.158,-122.180,45.010,1050.158
-6639.499,-6872.002,1029.548,-122.178,45.010,1029.548
-6612.361,-6872.182,1001.763,-122.176,45.010,1001.763
-6585.391,-6872.360,975.069,-122.174,45.010,975.069
-6558.254,-6872.539,980.551,-122.172,45.010,980.551
-6531.284,-6872.715,1029.739,-122.169,45.010,1029.739
```

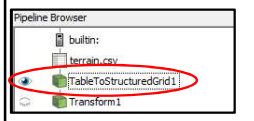
Do a **File → Open** and navigate to your CSV file.
Hit the **Apply** button to actually do the read.

UTM data is in meters, which makes a more reality-looking base than longitude and latitude do. It is good to have both Z and Elevation, even though they are the same number because once you use a variable for a geometric dimension, you can't also use it again for a data value (e.g., to color or contour by elevation).

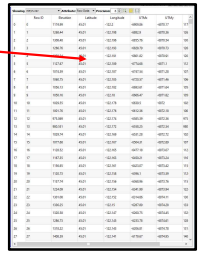


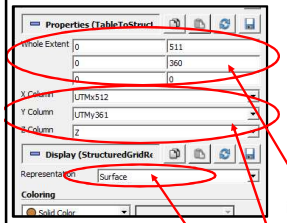
Reading and Converting the CSV File

109



This will bring up a table window to confirm that the data has been read properly. You can delete this now if you want.





Now, go to
Filters → Alphabetical → TableToStructuredGrid

Fill in the **Whole Extent** boxes showing the first and last index in each dimension (the last index is one less than the number of points in that dimension).

Fill in the **{X,Y,Z} Column** information so ParaView knows how to make your 3D display.

Hit the **Apply** button to actually do the conversion.

Be sure the **Representation** is **Surface**

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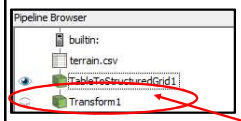
Computer Graphics

The Correct Scale Factor

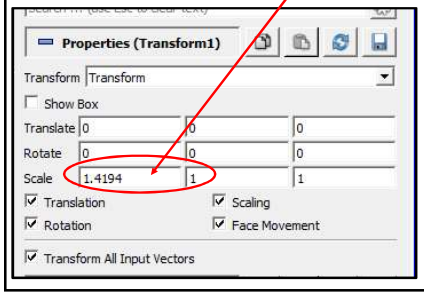
110



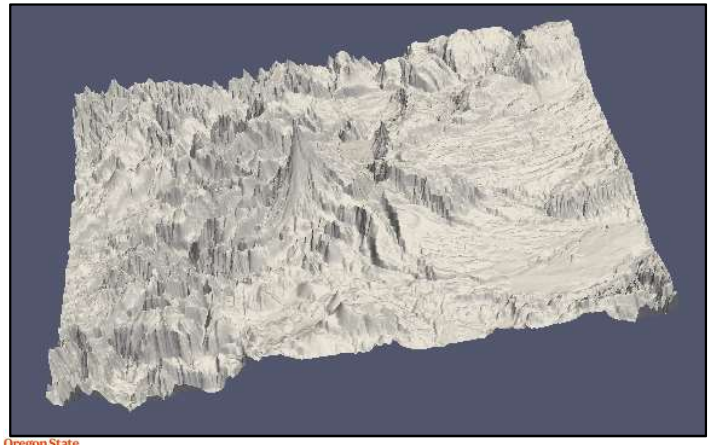
This will bring up a square terrain, which isn't what we want. We notice that the UTM coordinates are 511 and 360, so we really want to scale by $^{511}/_{360}$ = 1.4194 in the X direction.

Now, go to
Filters → Alphabetical → Transform

Set the X scale factor to 1.4194



111



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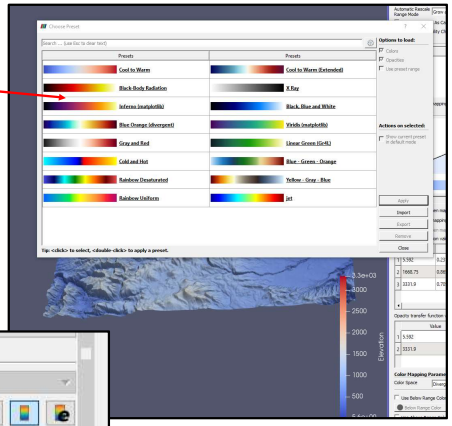
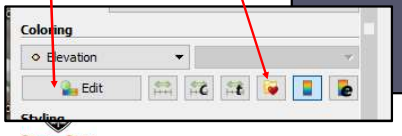
Color by Elevation

112

Try coloring by **Elevation**. The heart icon brings up popular color scales. You can pick one of these or sculpt your own.





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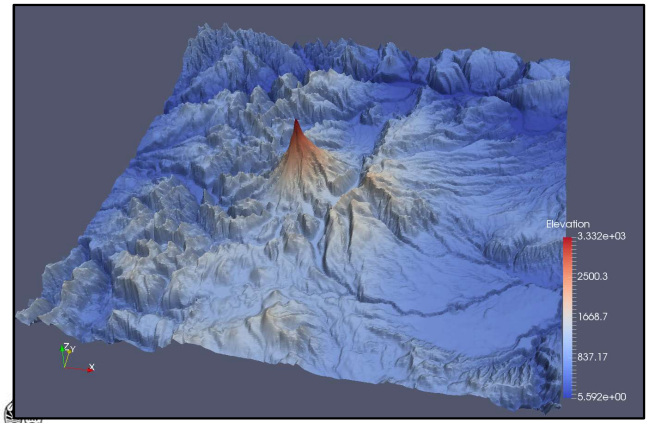

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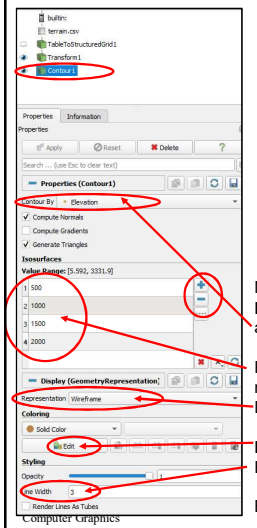
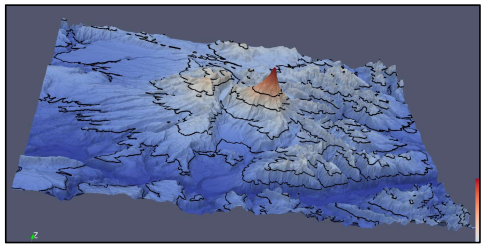
Contouring





Now, go to
Filters → Alphabetical → Contour
and select **Contour by Elevation**

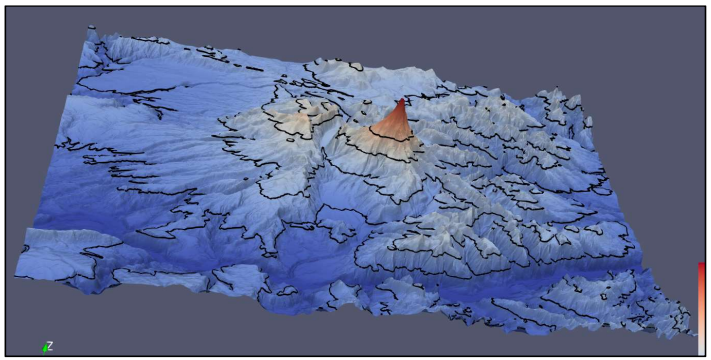
ParaView gives one default contour elevation, but you can add more.

Display as Wireframe.

Edit to select a contour color.
Enter a **Line Width**.

Be sure the eyeballs are turned on.

Computer Graphics



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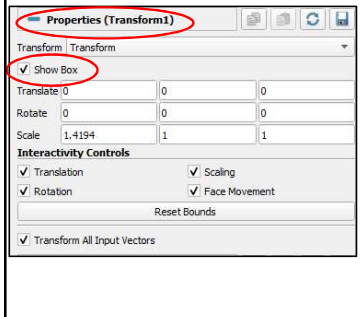
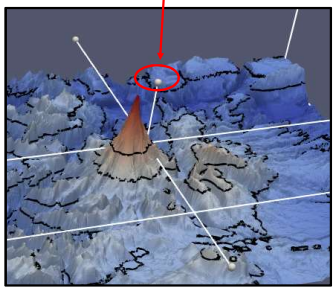
Computer Graphics

Changing the Vertical Exaggerations

Re-click on the **Transform** filter, turn on the Box, and move the scaling knob





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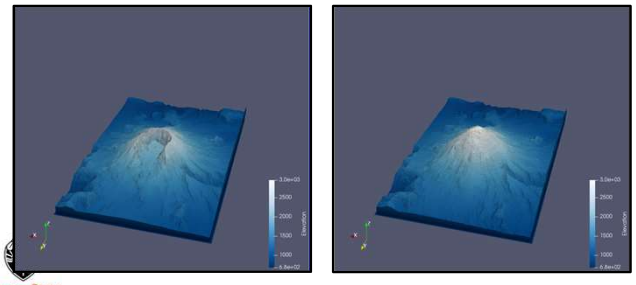
Reading ARCGIS DEM Files

117

I was able to get to get two DEM files loaded into ParaView, and while not straightforward it's not too hard to do. You need to load in the file, add the **Extract Surface** filter to it, and then the **Warp By Scalar** filter.

Without these filters, ParaView will leave your data as a 2D surface.



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Louis Panton

118

Parallel Coordinates

vector.pvsm
parallelcoords.pvsm

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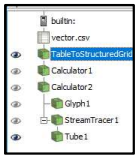
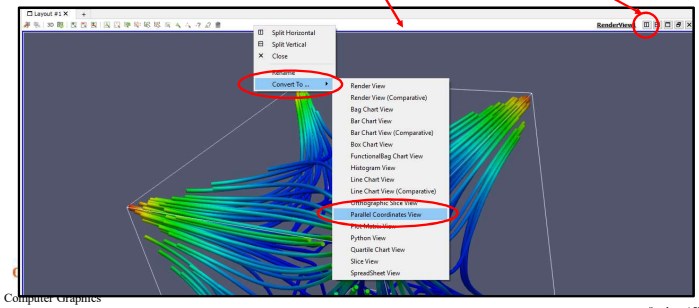
Parallel Coordinates – Correlating Fields

119

Let's say you were to start with this:



Either convert the **Render View** window to a **Parallel Coordinate View** window by **right-clicking** anywhere in the window header bar, or by splitting the window



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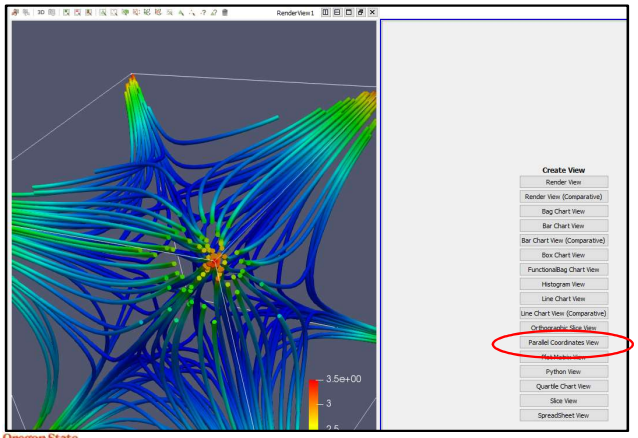
Parallel Coordinates

120

Splitting the window looks like this. Select **Parallel Coordinates View.**

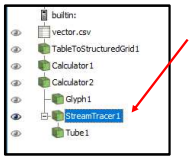


Oregon State Univer
Computer G

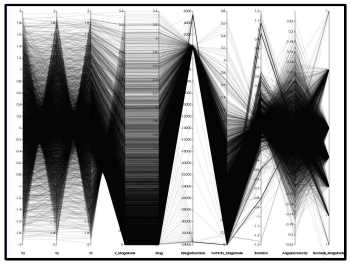
I'm going to do it the first way to give more room for the Parallel Coordinates display.

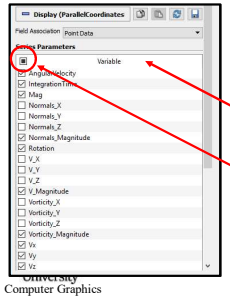
Parallel Coordinates

121



Turn the eyeballs on for the **StreamTracer**. It turns out StreamTracer creates a bunch of derived variables, so this will give us more to look at.



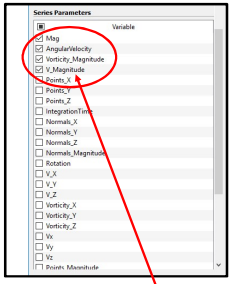


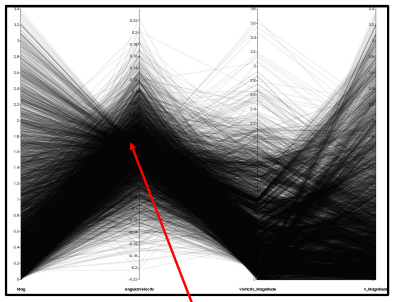
The **Parallel Coordinates Display Properties** shows what variables will be displayed. No matter what, they are probably not exactly the variables you wanted to see and they are not in the desired horizontal order.

So, click them all off and turn them back on in the horizontal order you want to see them.

Parallel Coordinates

122





So, click them all off and turn them back on in the horizontal order you want to see them.

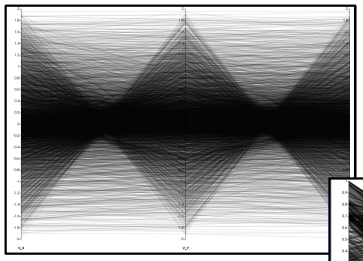
You can left-click-drag them to a new vertical position in the list to make re-clicking on them in a different order much easier.

The narrowness of the bundle of lines shows the strength of the positive and negative correlations.

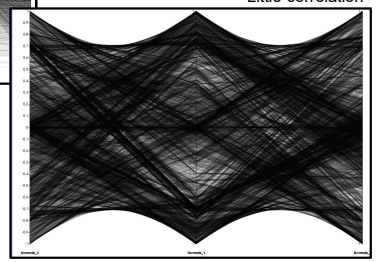
Parallel Coordinates

123

Lots of (negative) correlation



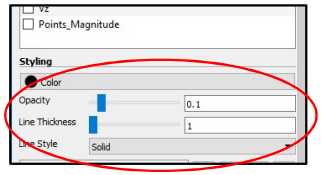
Little correlation



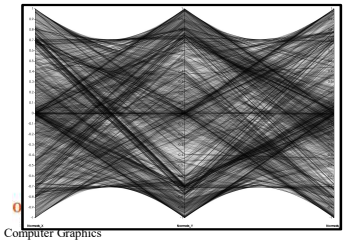
Parallel Coordinates

124

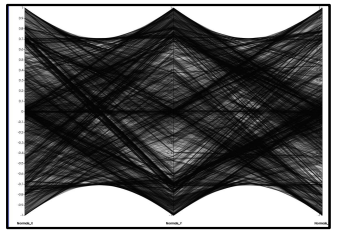
Scroll down a little more in the properties menu and you will find the **Parallel Coordinates Styling** menu:



Line Thickness = 1

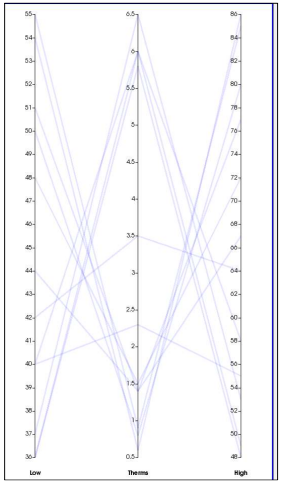


Line Thickness = 2



Therms on my Natural Gas Bill vs. Average Corvallis Low and High Temperatures

125



These Parallel Coordinates show that when temperatures are high, natural gas consumption goes down. (Duh, …)

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126

Saving an Image of the Screen

scalar.pvsm

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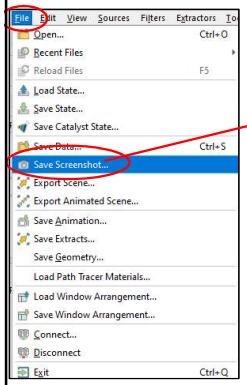
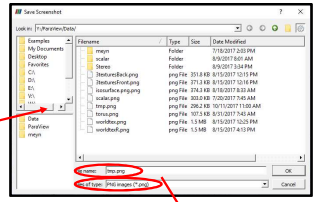
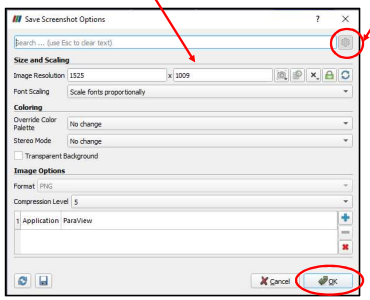
File → Save Screenshot

127







Select the gear to show all options (I recommend this)

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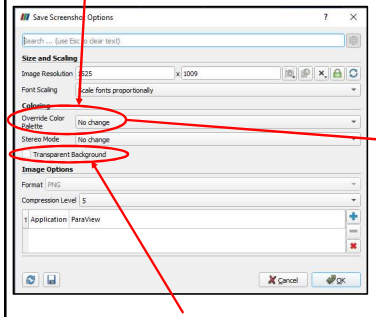
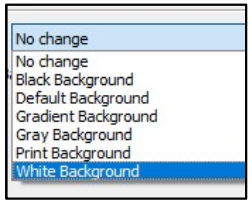
Changing the Background Color

128

You can override the existing background color just long enough to create the screenshot





You can also force the image background to be transparent. (This only works on some image file formats, such as PNG.)

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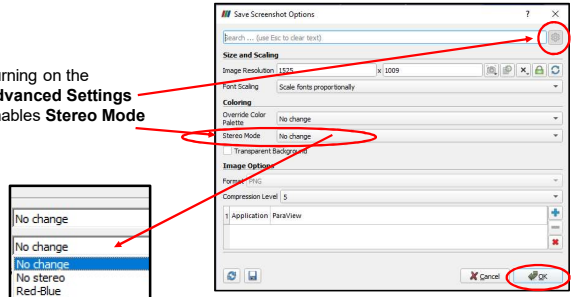
Creating Stereographics Images

129

Turning on the **Advanced Settings** enables **Stereo Mode**



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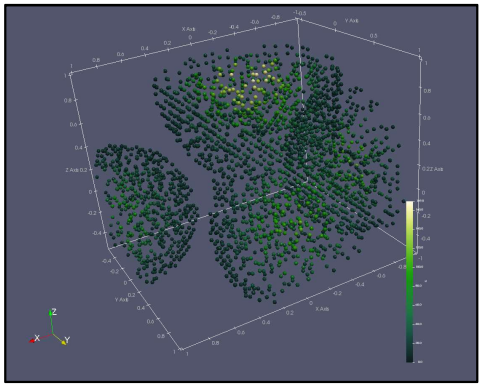
An Original Visualization

130



This is using the **Linear Green** color scale because it seems to work better for Red-Cyan Anaglyphs than do color scales with blue or red in them

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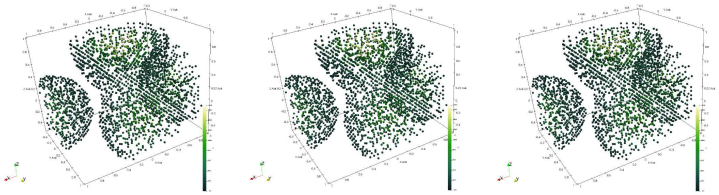
Side-by-Side Stereopairs

131

L R L



If you can parallel freeview, use the left two images.
If you can cross-eyes freeview, use the right two images
If you can't do either, then never mind

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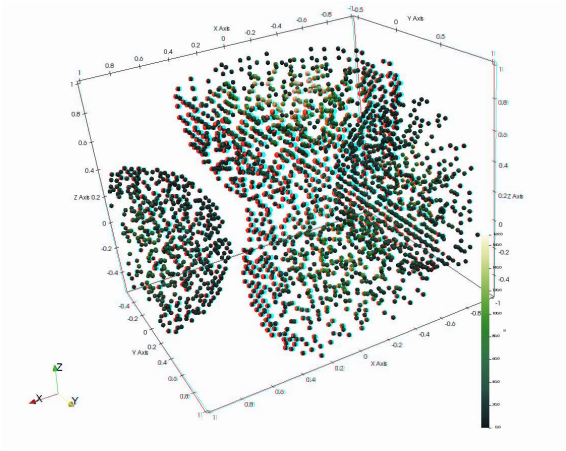
Red-Cyan Anaglyph

132



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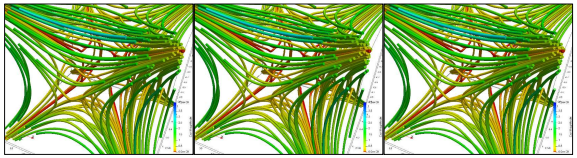
The Left Two Images Work Well Together in my Handheld Stereo Viewer

133

L R L



Print this page and cut out the left two images

Note to self: don't resize these images, as much as you are tempted to – they fit perfectly in the viewer as they are now.

Exporting the Scene Geometry

134

scalar.pvsm

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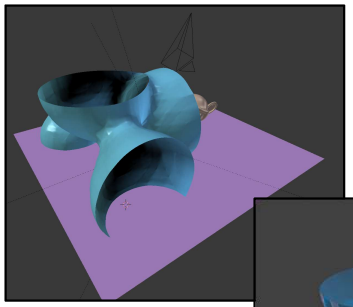
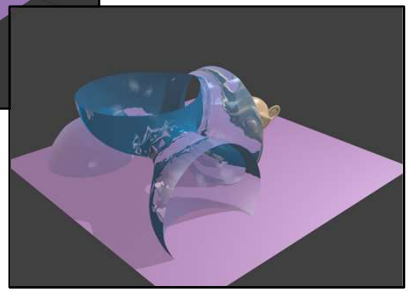
You can export the scene *geometry* (in this case to Blender) via X3D files

135





File → Export Scene

You can also export the scene as a GLTF file. I would guess that USD isn't far off.

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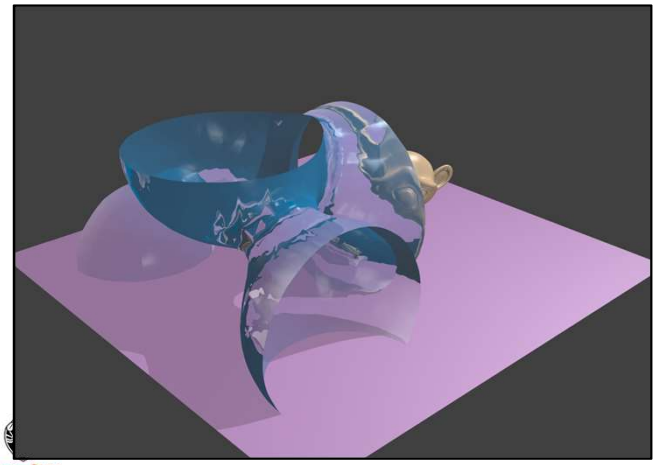
You can export the scene *geometry* (in this case to Blender) via X3D files

136



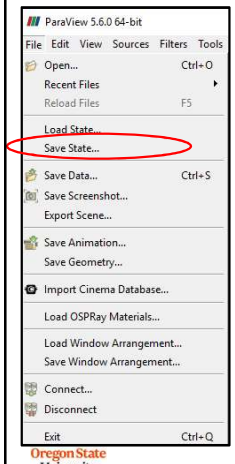
"Should" be able to create STL files from legal solid geometry (e.g., isovolumes) this way, too

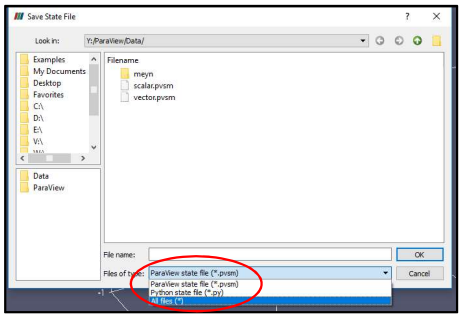
Computer Graphics

Saving the ParaView State

anim.pvsm
scalar.csv
scalar.pvsm
scalar.py
vector.csv
vector.pvsm
vector.py
terrain.csv
terrain.pvsm
terrain.py

Saving the State in Either a Native Format or as a Python Script





"State" means the entire state of the user interface (pipeline, properties, etc.). The data is not part of the state. When you read the state back in, ParaView will prompt you to show it what data file you want included with this state.

scalar.py

```
# state file generated using paraview version 5.1.2

# ----------------------------------------------------------------
# setup views used in the visualization
# ----------------------------------------------------------------

#### import the simple module from the paraview
from paraview.simple import *
#### disable automatic camera reset on 'Show'
paraview.simple._DisableFirstRenderCameraReset()

# Create a new 'Render View'
renderView1 = CreateView('RenderView')
renderView1.ViewSize = [1160, 912]
renderView1.AxesGrid = 'GridAxes3DActor'
renderView1.StereoType = 0
renderView1.CameraPosition = [3.76687547966054, 5.62637881722241, 4.44163730510425]
renderView1.CameraFocalPoint = [0.0241978424871666, -0.0474471125809167, 0.0405907851464954]
renderView1.CameraViewUp = [-0.384789750616684, -0.393723993522038, 0.834816305989173]
renderView1.CameraParallelScale = 1.73205080756888
renderView1.Background = [0.32, 0.34, 0.43]
# init the 'GridAxes3DActor' selected for 'AxesGrid'
renderView1.AxesGrid.Visibility = 1
# ----------------------------------------------------------------
# setup the data processing pipelines
# ----------------------------------------------------------------
# create a new 'CSV'
scalarcsv = CSVReader(FileName=['Y:\\ParaView\\Data\\scalar.csv'])
 . . .
```

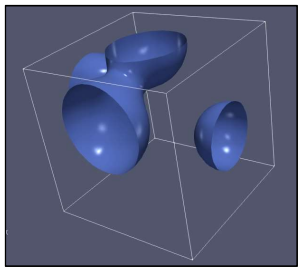

Animation in ParaView

anim.pvsm

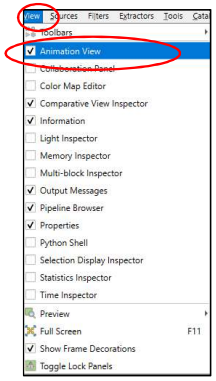
Animation in ParaView

141

Start with this:

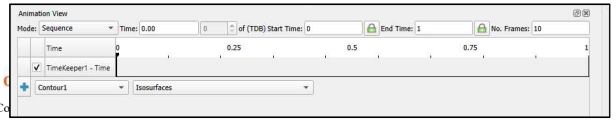


Select this:



anim.pvsm

And this appears at the bottom:



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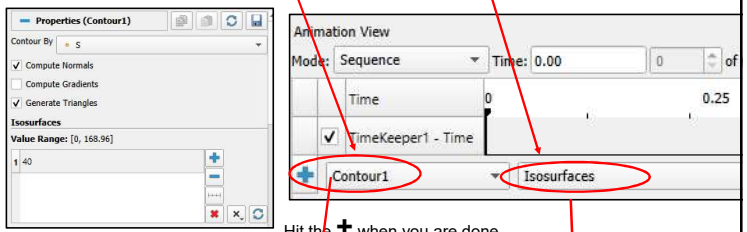
Animation in ParaView – Pick Something to Animate

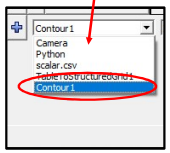
142

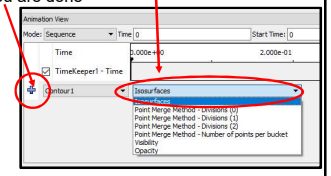
Conveniently, the user interface for animation in ParaView looks a lot like the user interface for Comparative Visualization:

Select a Pipeline Element and a Parameter within that Element



Hit the + when you are done





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Animation in ParaView – Bring up a Keyframe Menu

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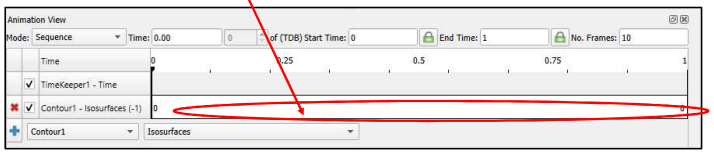
The, double-click in the white space to the right of the Property-Parameter you selected:



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Animation in ParaView – Setting Parameter Keyframes

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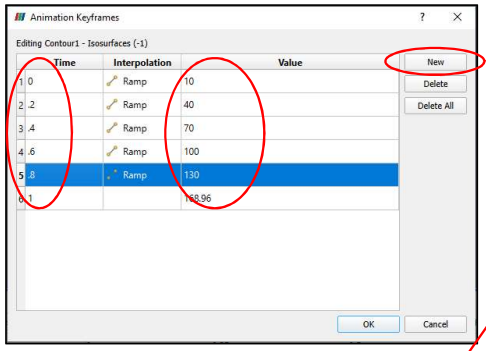
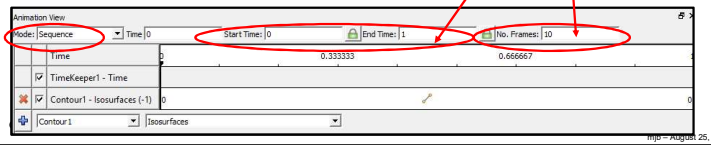


Click **New** to add a new row

The first column is the **Time**, the third column is the **Parameter** value at that time.

By default, the **Time** starts at **0.** and goes to **1**. – I just left it that way.

I did change the **10** frames to **100** frames, though.



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Animation in ParaView – the Time Inspector

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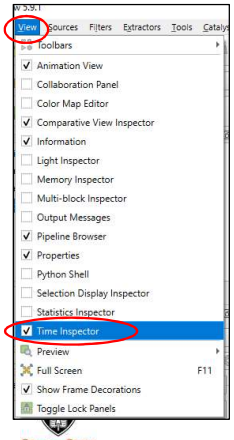
Select this:



Unless you've been living in a cave, you know what to do with these – hit **Play**:

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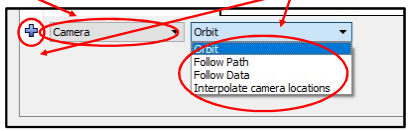
Animation in ParaView -- Animating the Camera

146

Here's how to animate the **Camera** – select **Camera** from the list of **Properties** and select one of these from the list of **Parameters,** then hit the **+**:



Orbit: animate the camera in a circle around a specific point
Follow Path: set keyframes for the camera position and look-at point
Follow Data: ??
Interpolate camera locations: Manually specify keyframe camera locations

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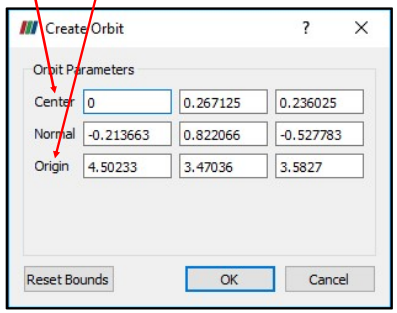
Animation in ParaView -- Orbiting the Camera

147

By default, the **Center** (look-at point) is the center of the data currently selected in the Pipeline. The Camera starts at its **Origin** and orbits at its current radius around that point.



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Saving the Animation

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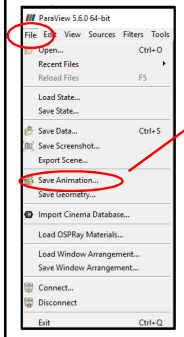
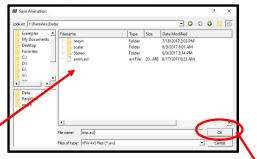
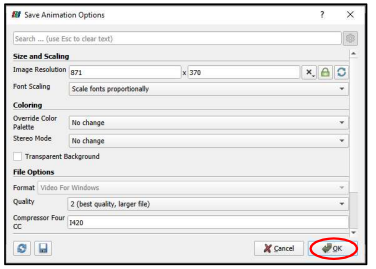




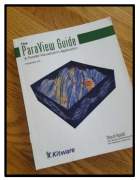
Clicking **Save Animation** brings up a file navigator dialog. You can save the animation in either **AVI** or **OGV** formats.

You can then set some animation parameters.



I haven't done an exhaustive study of this, but I can tell you that OGV files play in Firefox, Edge, and Chrome – but not in PowerPoint. AVI files play in PowerPoint. The OGV files are much smaller than the AVI files.

References



http://cs.oregonstate.edu/~mjb/paraview

Utkarsh Ayachit. *The ParaView Guide: A Parallel Visualization Application*, Kitware, 2015.

A free PDF of the book can be found here:
https://www.paraview.org/paraview-guide/

The ParaView tutorial:
https://www.paraview.org/Wiki/The_ParaView_Tutorial

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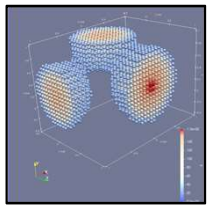
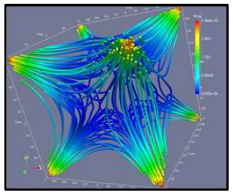
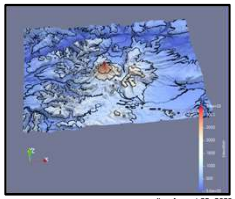
Computer Graphics

ParaView

http://cs.oregonstate.edu/~mjb/paraview







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