Introduction to…

ParaView

Parallel Visualization Application

for climate scientists.

www.paraview.org

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ARC CENTRE OF EXCELLENCE FOR
CLIMATE SYSTEM SCIENCE

What can it do?

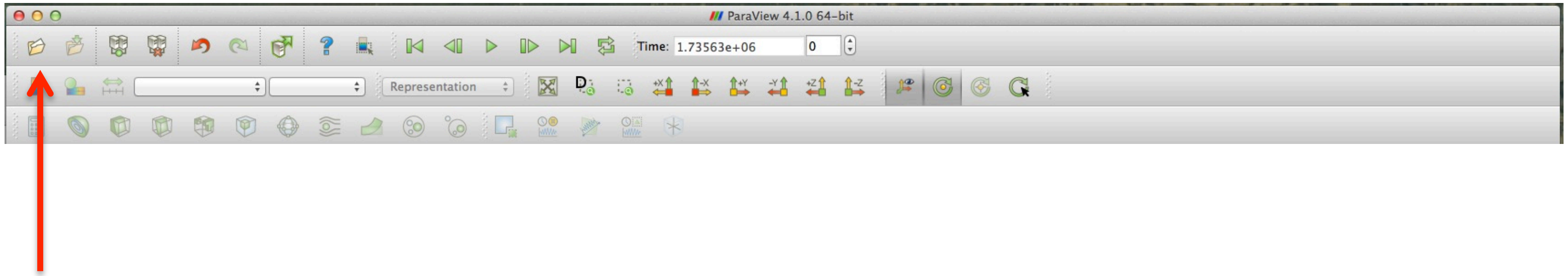
- See Martin Jucker's Work
  - Visualisations: http://cims.nyu.edu/~jucker/media.html
  - Python scripts for Paraview: https://github.com/mjucker/pv_atmos
  - Paper: *Jucker, M 2014 Scientific Visualisation of Atmospheric Data with ParaView. Journal of Open Research Software, 2(1): e4, DOI: http://dx.doi.org/10.5334/jors.al*

- Kane Stone's Movie on Ozone:
  - https://www.climatescience.org.au/content/779-why-we-celebrate-world-ozone-day

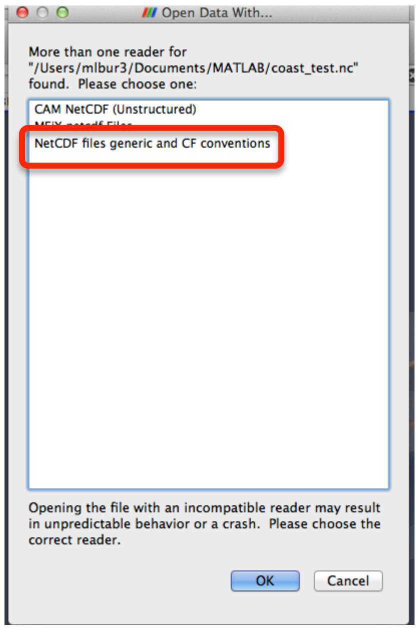
- David Kinniburgh's movie on pyro-tornadogenesis:

Open your NetCDF file

- Click open file on top left hand corner (or File -> Open)



- Select option: *NetCDF files generic and CF conventions*



Example: U_1998_01.nc

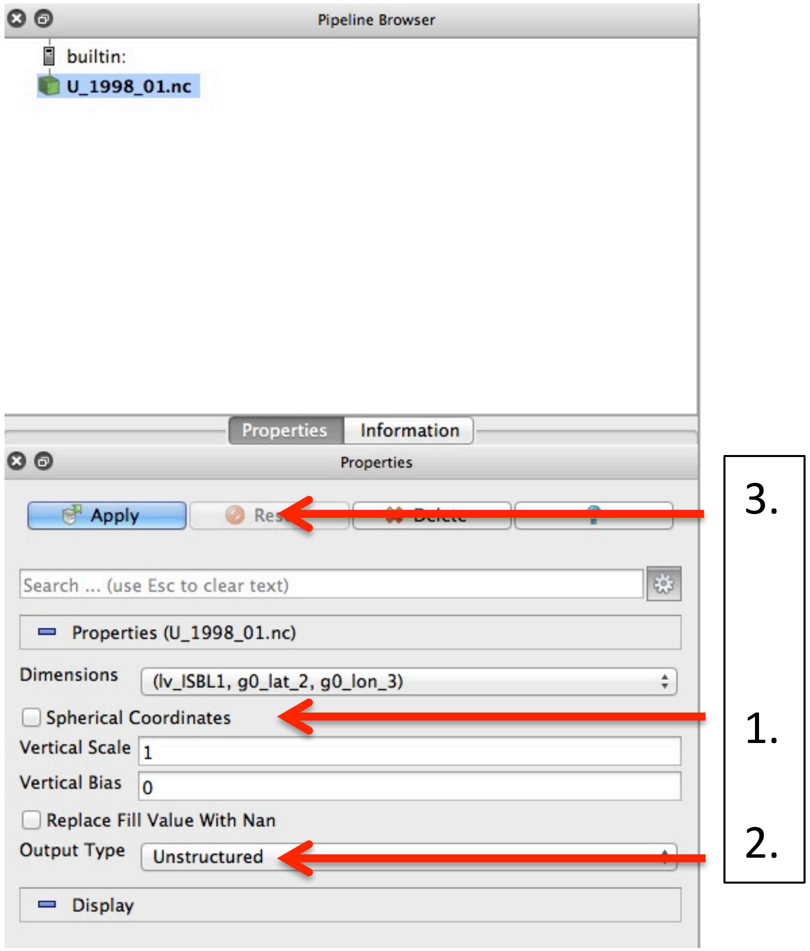
Dimensions: (lon, lat, pressure, time)

Size: (240, 121, 37, 124)

1. Unselect spherical coordinates

2. Set *Output Type* to *Unstructured*

3. Click Apply



<u>NOTE:</u>

Data appears in pipeline.

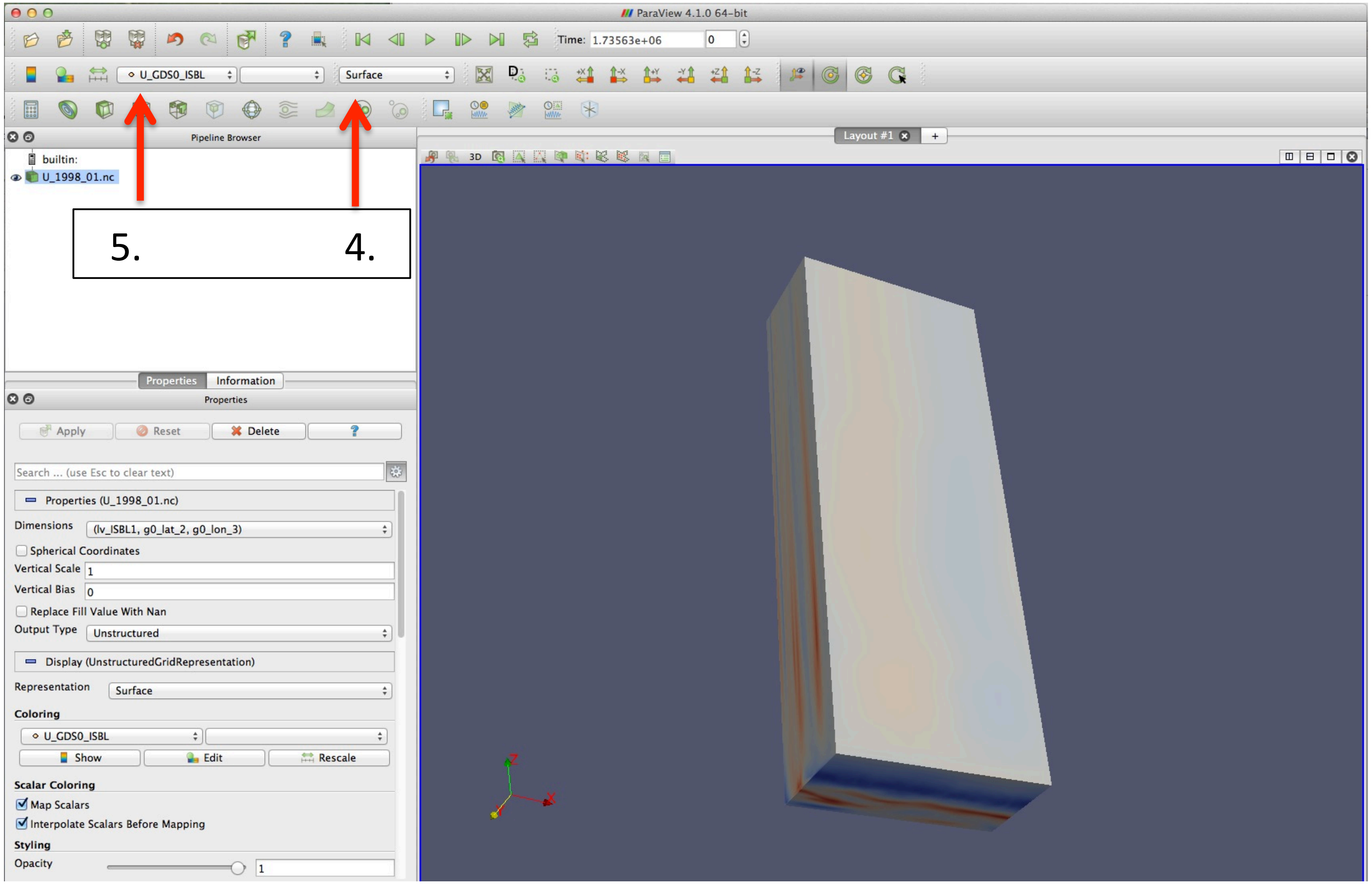
Always click 

for changes to take effect.

Example: U_1998_01.nc

4. Select how you want to view the data: *Surface*

5. Select the variable to colour the volume with: *U_GDS0_ISBL*



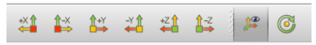
Example: U_1998_01.nc

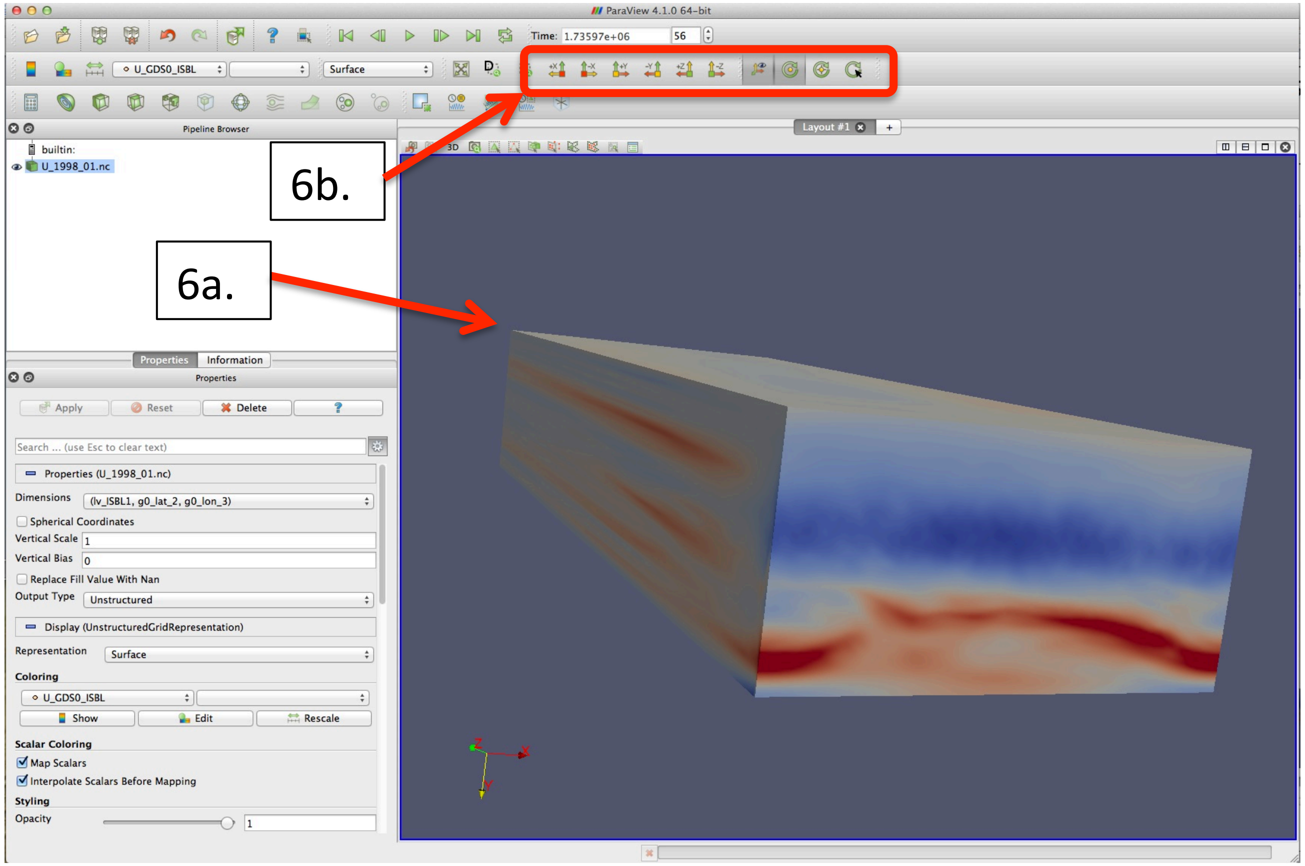
6a. Play around with rotating and zooming in/out of the volume.

Left click: changes orientation.

Scroll: zooms in/out.

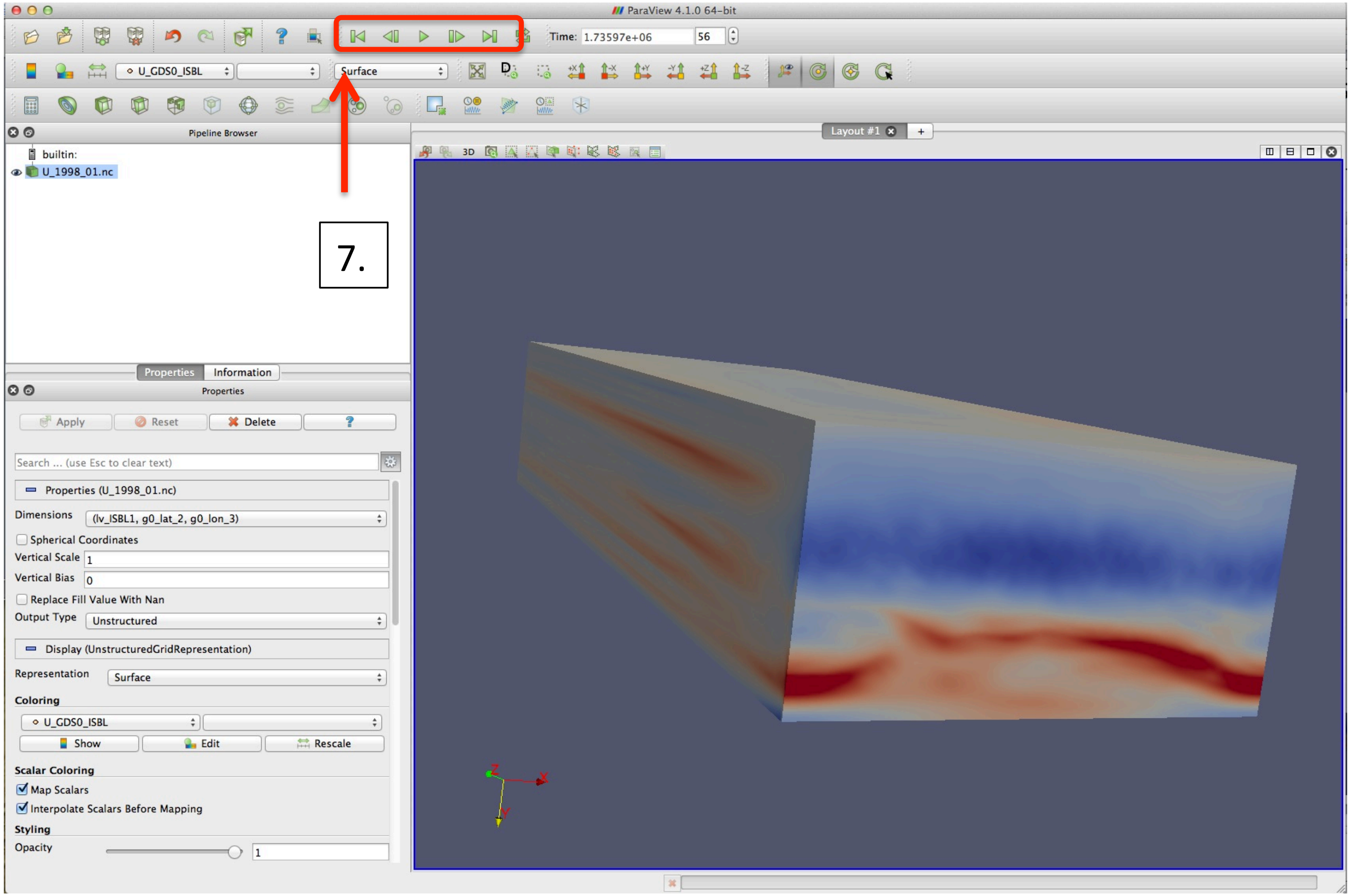
Right Click: picks up data to move to a new location.

6b. Play around with the axis positioning by clicking on the axis buttons 

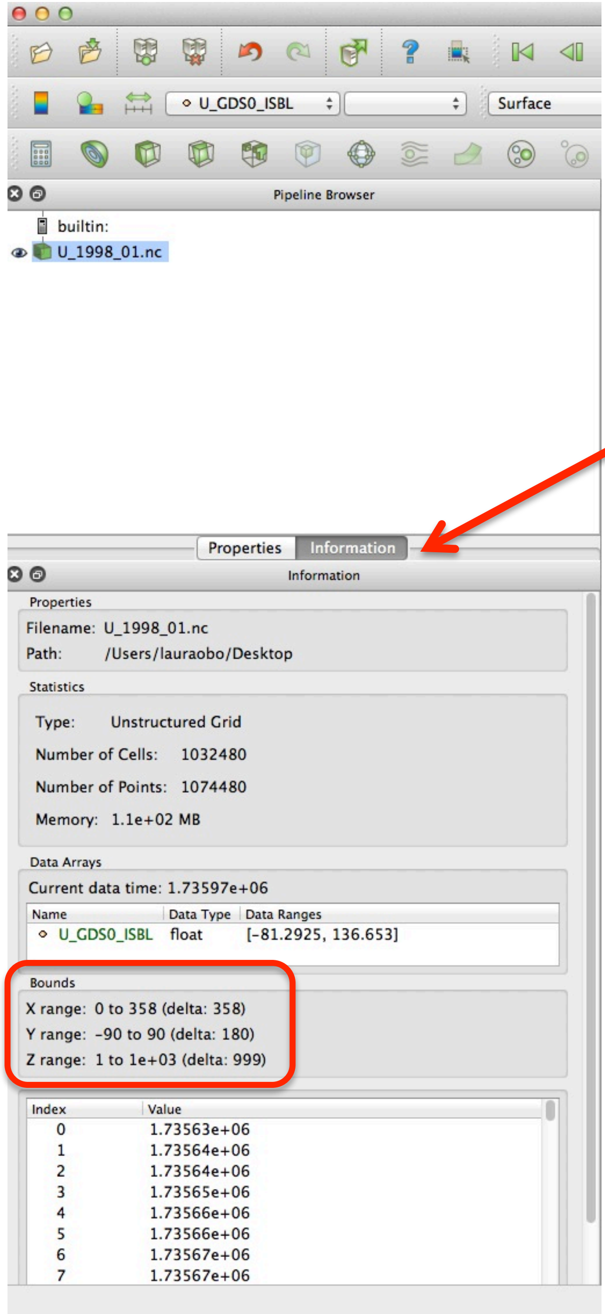


Example: U_1998_01.nc

7. Press *Play, Pause, Forward, Backward* to watch the volume change with time



Change from pressure to height coords



8. Click on the Information section, notice that the range of Z values are [1, 1000].

These are pressure levels (hPa) but Paraview plots them as a height variable so we need to transform the Z variable to scale with height:

$$Z \rightarrow |(\log_{10}(Z/1000))|$$

Since…

$$Z = -\frac{R\overline{T}}{g}\log_{10}(P/1000)$$

$\overline{T} = \text{Avg Temperature (K)}$ $\quad R = 287\ \text{J/Kg/K}$ $\quad g = 9.81\ \text{m/s}^2$

Change from pressure to height coords

9. Click on your variable

10. In menu, select Filter -> Calculator

11. In Properties, select ***Coordinate Results***, (if you can't see option this click on ) give your variable a ***name*** and insert the transformation:

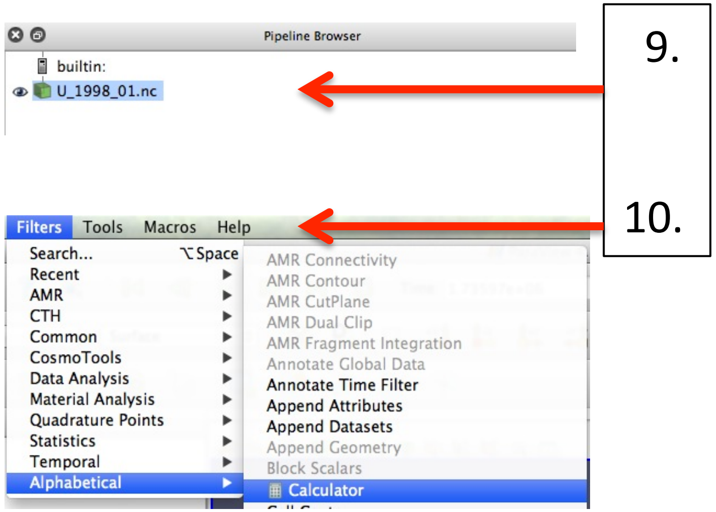
iHat*coordsX + jHat*coordsY + kHat*(abs(log10(coordsZ/1000)))

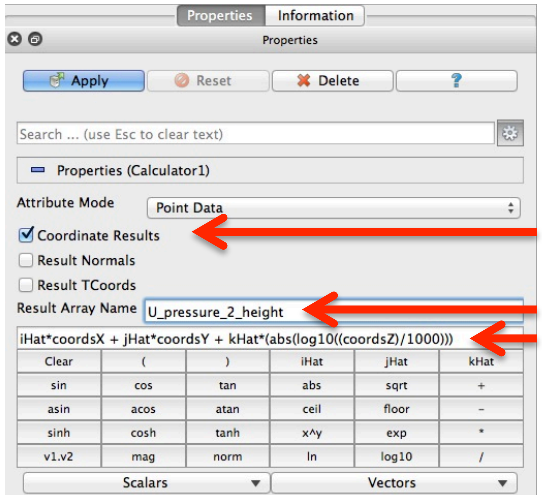
12. Click Apply

13. For a better view of the volume, scale up the Z coordinate by some scale (say 20) and to make space for the earth shift up by some value (say 100):

iHat*coordsX + jHat*coordsY + kHat*(abs(log10(coordsZ/1000))*20 + 100)

14. Click Apply





11.
- Select
- Name
- Transformation

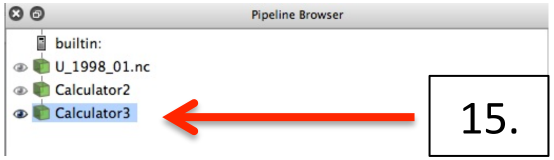
Transform your data onto a sphere

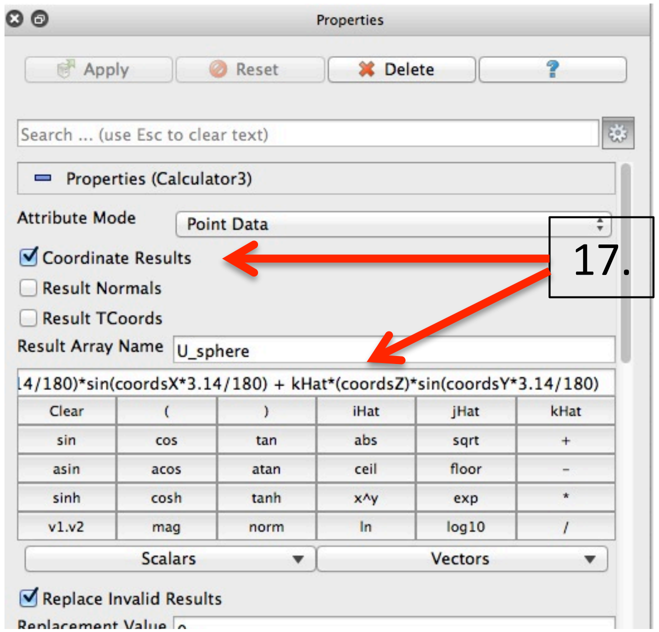
15. Click on your new variable to apply the transformation to (Calculator1)

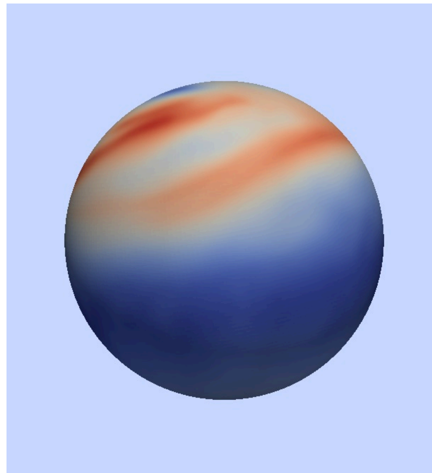
16. In menu, select Filter -> Calculator

17. In Properties, select ***Coordinate Results,*** give your variable a ***name*** and insert the transformation: ***iHat*(coordsZ)*cos(coordsY*3.14/180)*cos(coordsX*3.14/180) + jHat*(coordsZ)*cos(coordsY*3.14/180)*sin(coordsX*3.14/180) + kHat*(coordsZ)*sin(coordsY*3.14/180)***

18. Click Apply

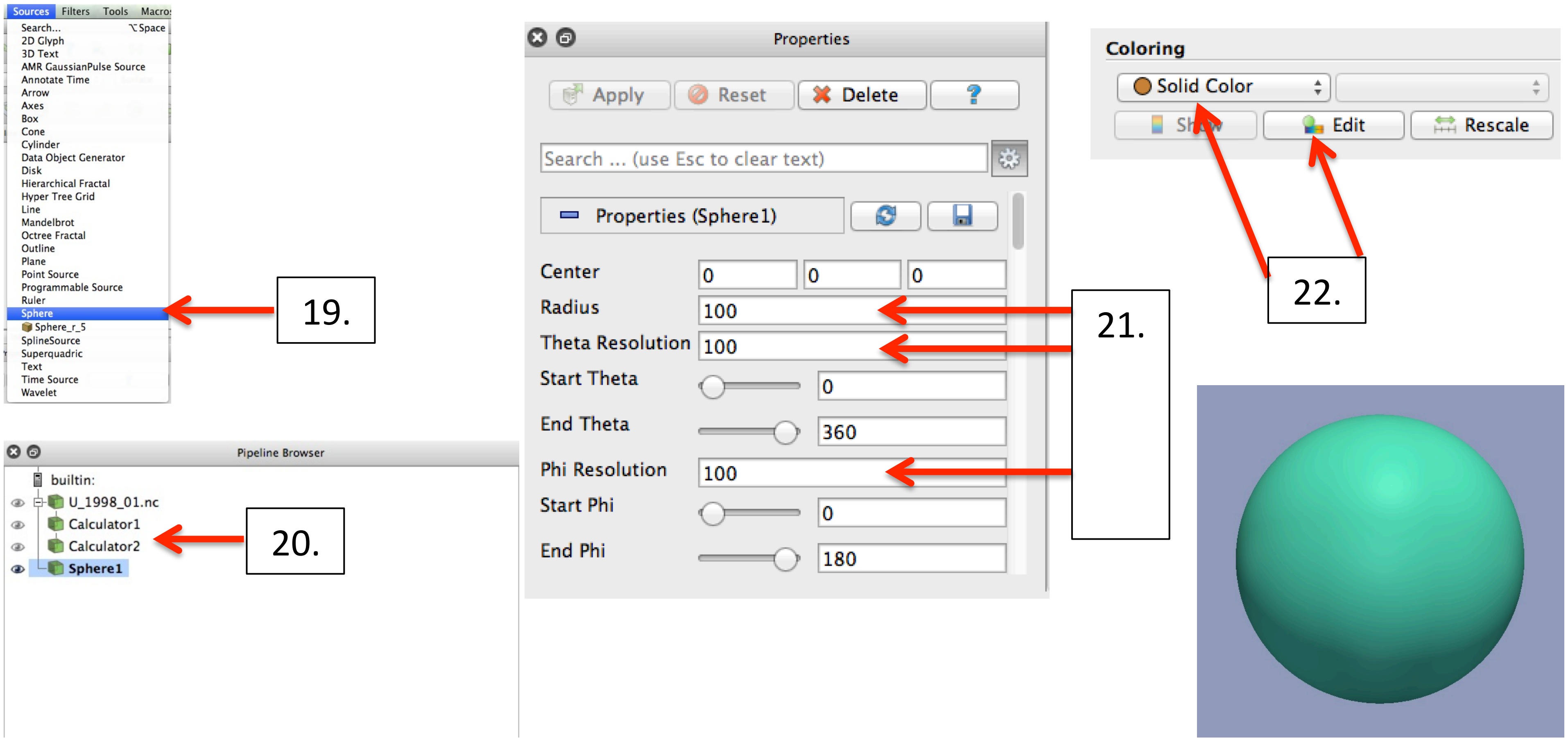






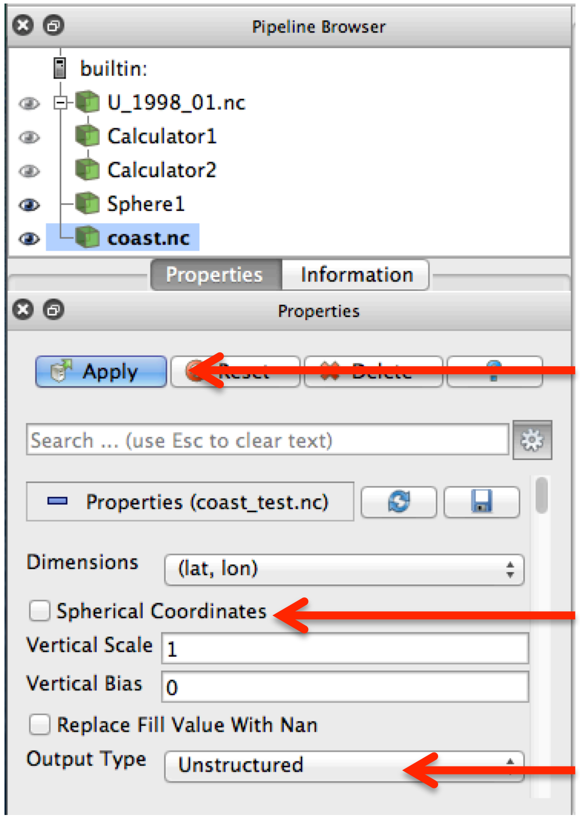
Add the Earth

19. Click Source: Sphere.
20. Click the eye beside Calculator2 to hide it from view so you can see your sphere.
21. Apply a Radius of 100 (same value as the vertical shift added to the data before) and Theta/Phi resolution of 100 to make a smooth sphere.
22. Add Color to your sphere by choosing *Solid Color* and click *Edit.*



Add the Coastline

23. Open coast.nc (again choosing: *NetCDF files generic and CF conventions*)
24. Untick *Spherical coordinates*, choose *Unstructured Output*, Click *Apply*

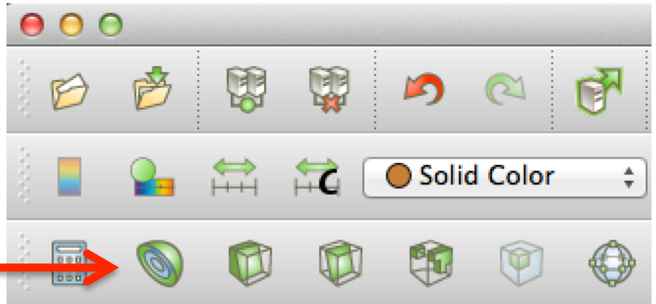


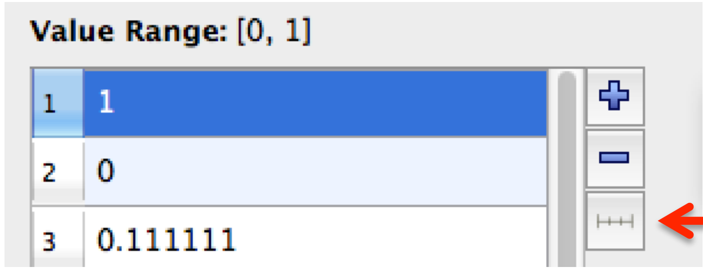
24.

Add the Coastline

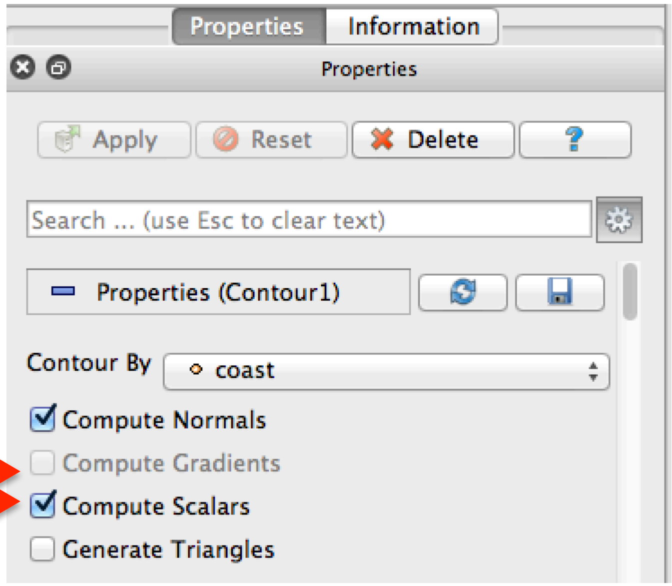
25. Take a contour of the coastline (making sure coast.nc is highlighted first)
26. Tick *Compute Scalars*. Untick *Generate triangles.*
27. Click on the range symbol to add the range of values for the contour.
28. In this case, coast has values in the range 0:1 so input ***From 0, To 1, Steps 10***
29. Click *Apply.*

25.

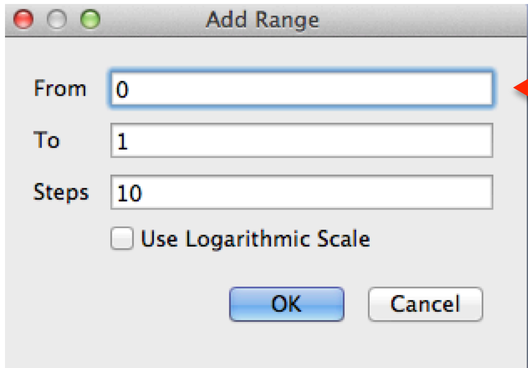




27.



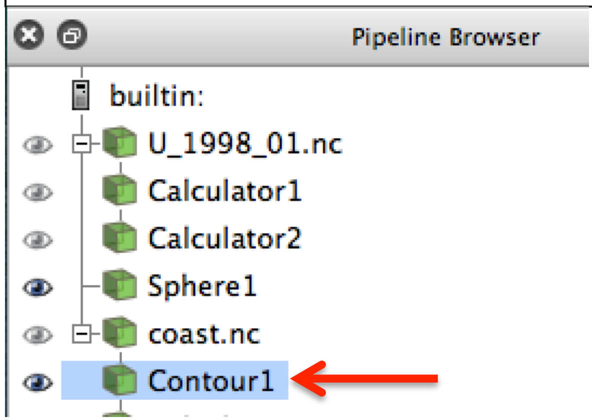
26.

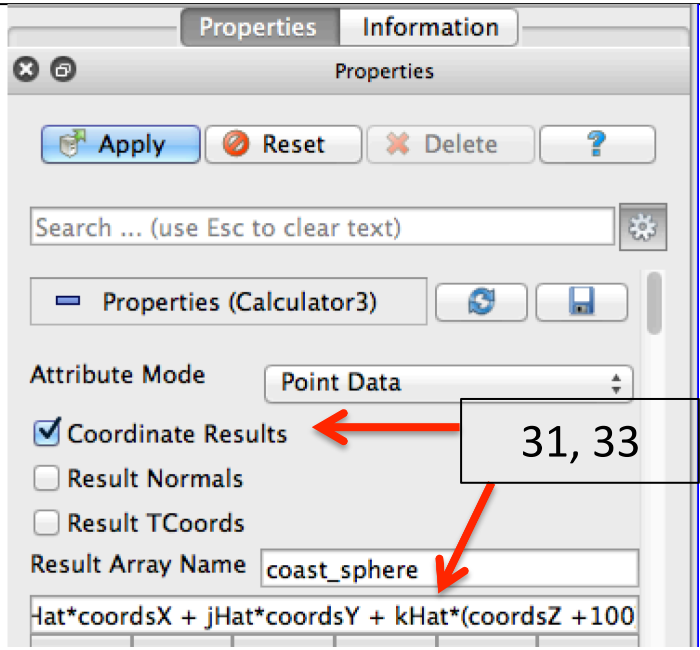


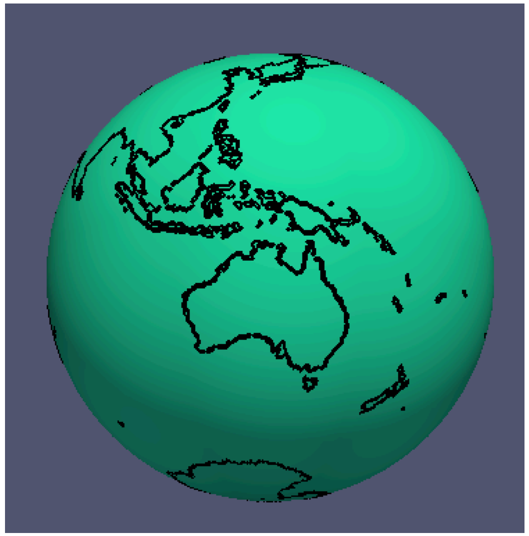
28.

Transform the coast onto the sphere

30. In menu, select Filter -> Calculator (making sure Contour1 is highlighted first)
31. First shift the coastline vertically: Select ***Coordinate Results*** and insert:
iHat*coordsX + jHat*coordsY + kHat*(coordsZ +100)
32. Click Apply
33. Next transform coastline onto the sphere: again, select ***Coordinate Results*** and insert the transformation: ***iHat*(coordsZ)*cos(coordsY*3.14/180)*cos(coordsX*3.14/180) + jHat*(coordsZ)*cos(coordsY*3.14/180)*sin(coordsX*3.14/180) + kHat*(coordsZ)*sin(coordsY*3.14/180)***

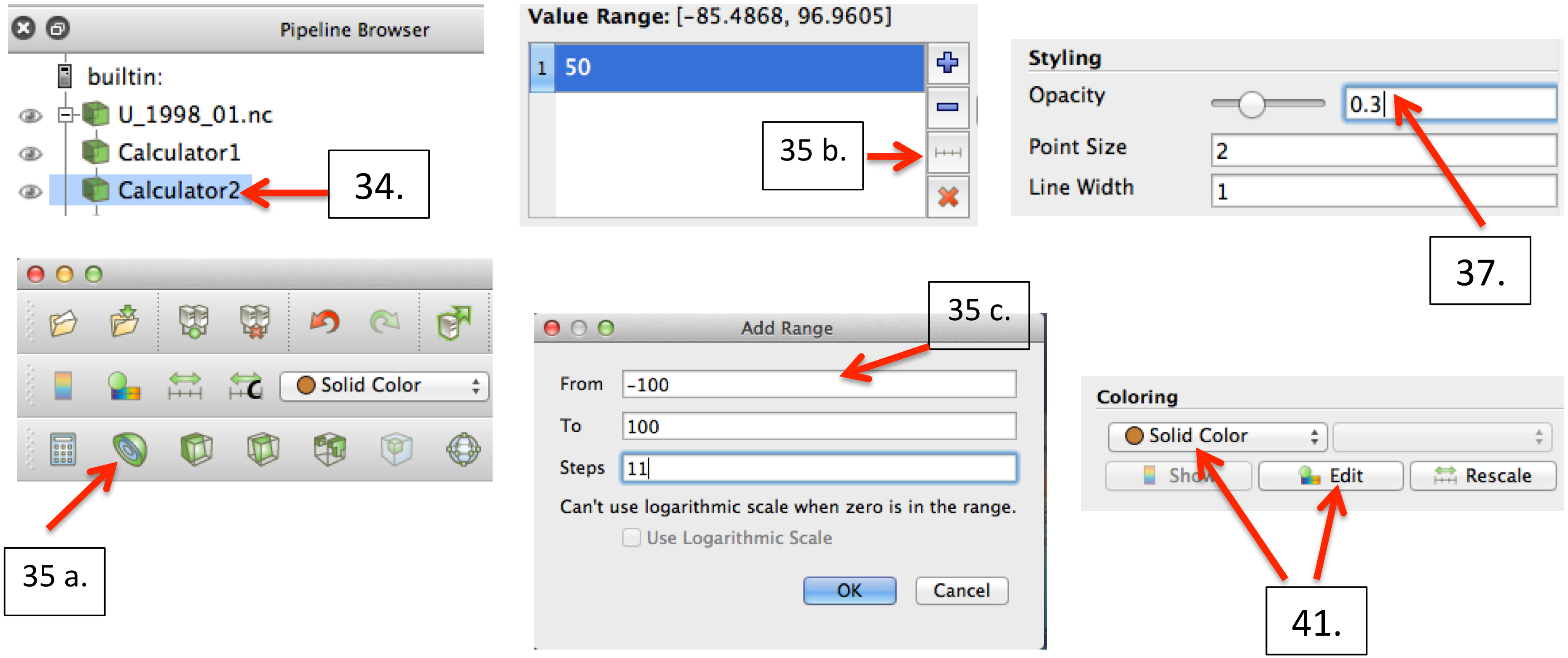




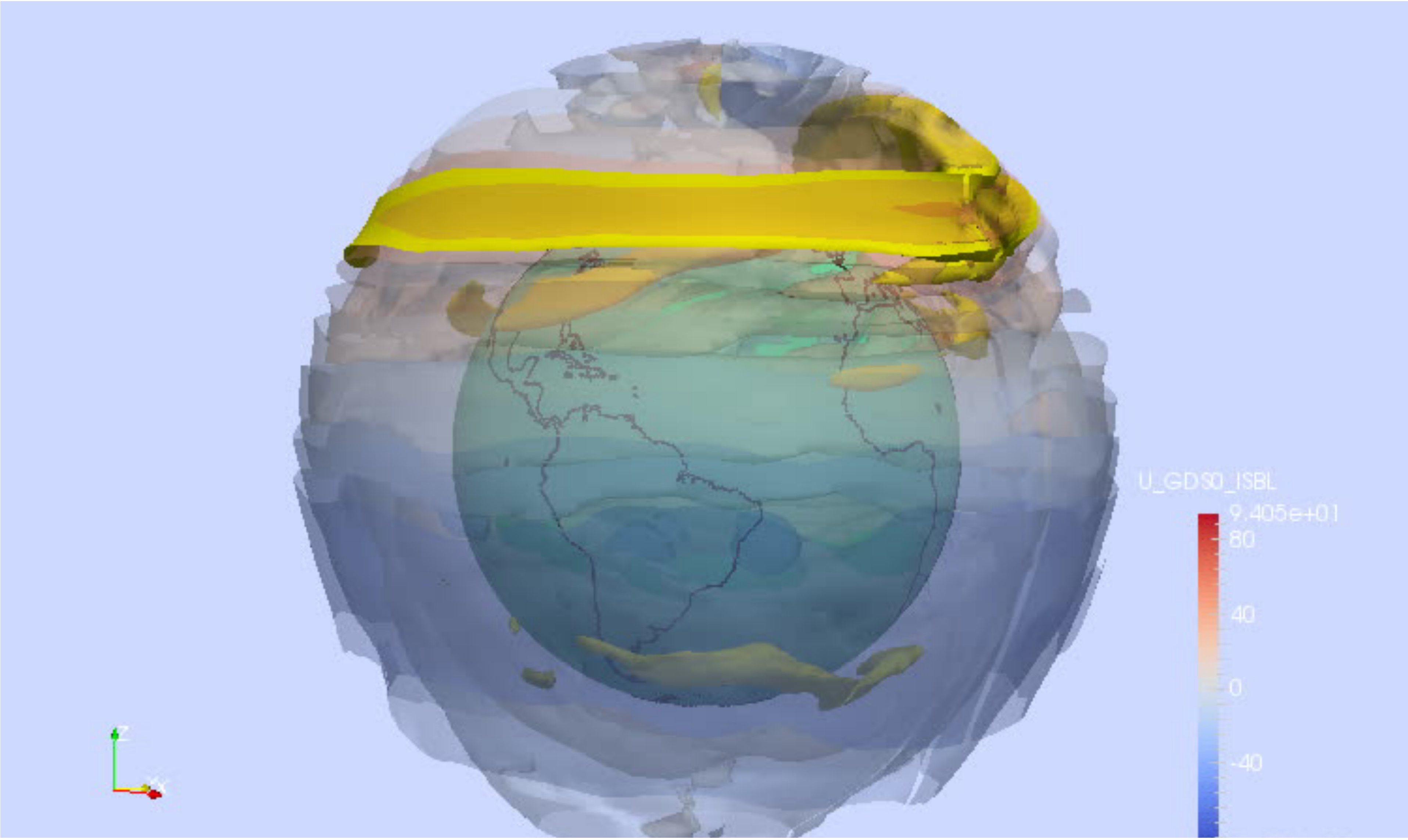


View Data of interest

34. Highlight Calculator2
35. Create a contour in the range **-100:100 with 11 steps**
36. Click Apply
37. Change the opacity to 0.3
38. Highlight Calculator2 again
39 Create another contour (following the same steps) this time manually enter **50**
40. Click Apply
41. Select a color for it (something that stands out)

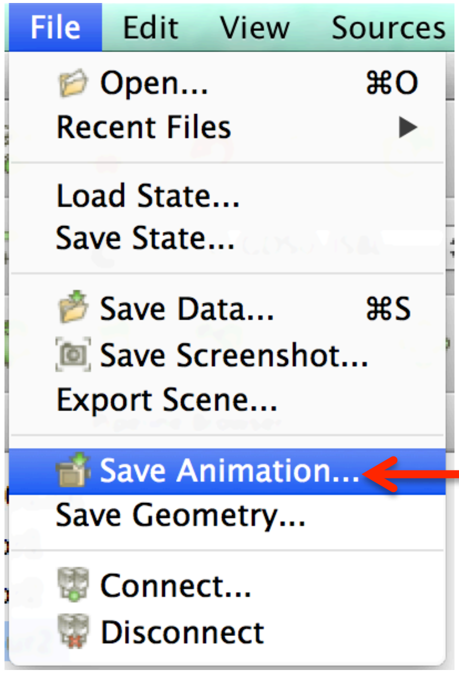


Save an animation

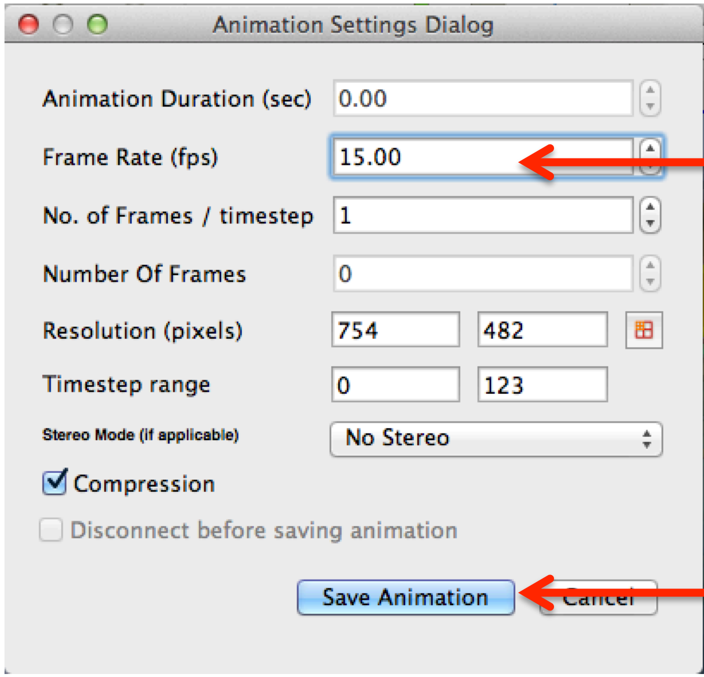


Save an animation

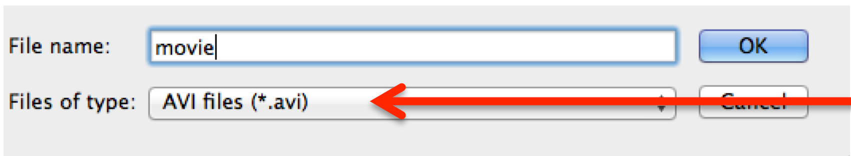
42. Click File -> Save Animation
43. Select frame rate (say 15) and click *Save Animation*
44. If you get a message about resolution/size then just click OK
45. Save your movie (as a .avi file)
46. Wait……



42.



43.

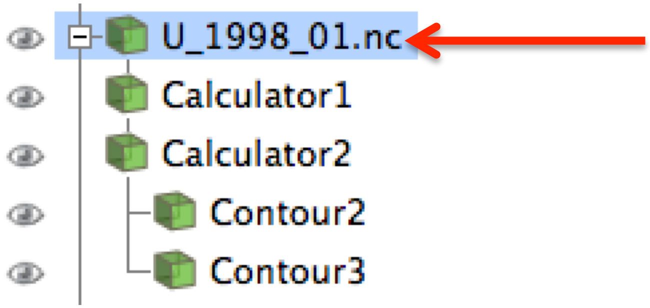


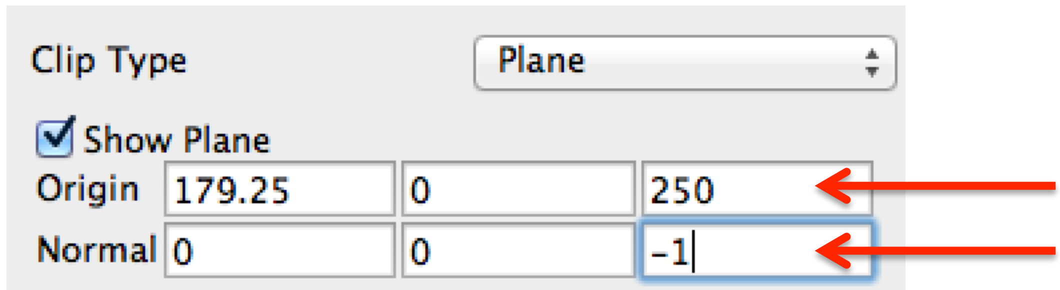
45.

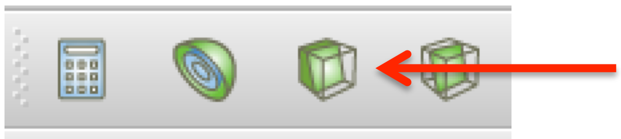
If you have extra time…

Split Upper and Lower Level Winds

- First, turn off the wind contours currently on show (Coutour2 and Contour3) by clicking the eye next to them
- Then select your original data set (U_1998_01.nc) and apply a Clip
- Inset **Origin (179.25,0,250)** and **Normal (0,0,-1)**
- Click Apply
- This selects winds in pressure levels between 250 and 1hPa (ie. ***Upper level Winds***)

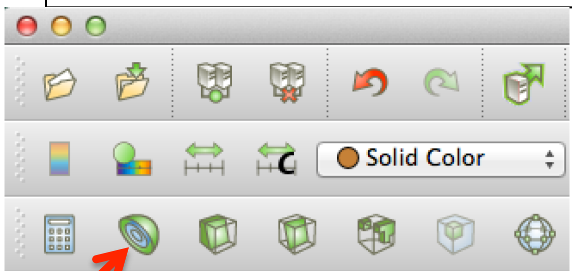


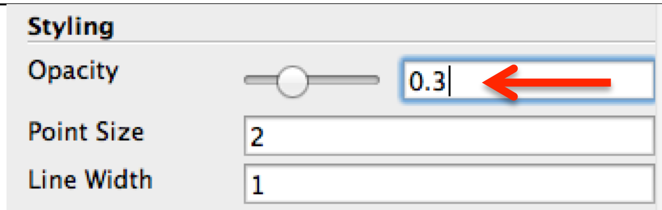


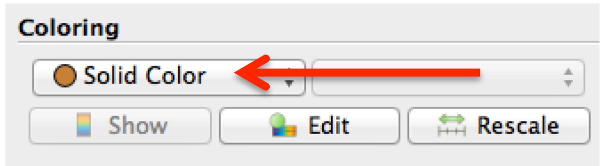


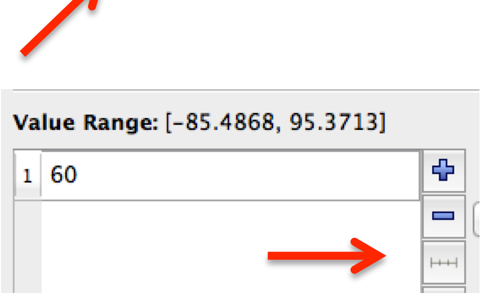
Split Upper and Lower Level Winds

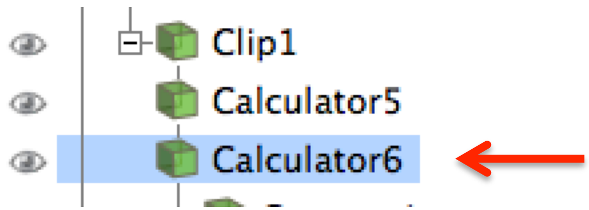
- Next apply the same transformations as before…
- Calculator (coordinate results):
  iHat*coordsX + jHat*coordsY + kHat*(abs(log10(coordsZ/1000))*20 + 100)
- Calculator (coordinate results):
  iHat*(coordsZ)*cos(coordsY*3.14/180)*cos(coordsX*3.14/180) + jHat*(coordsZ)*cos(coordsY*3.14/180)*sin(coordsX*3.14/180) + kHat*(coordsZ)*sin(coordsY*3.14/180)
- Take a contour in the range -100:100, steps 11
- Change opacity (to around 0.3)
- Click back onto the transformed data (Calculator6) and apply another contour, this time just **60** and colour it red

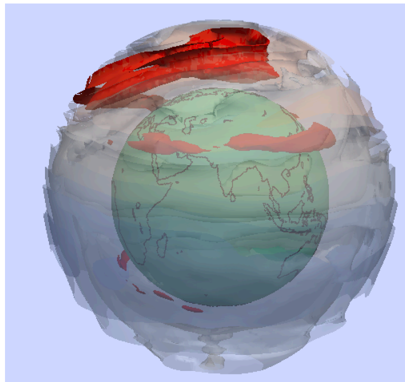






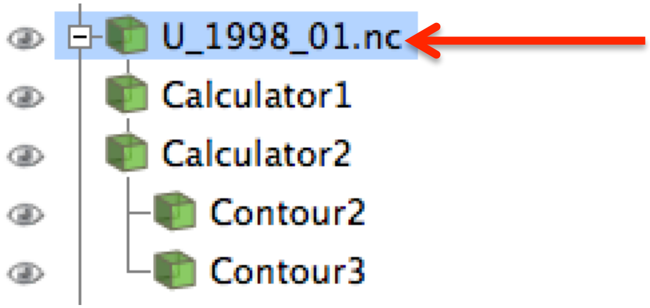


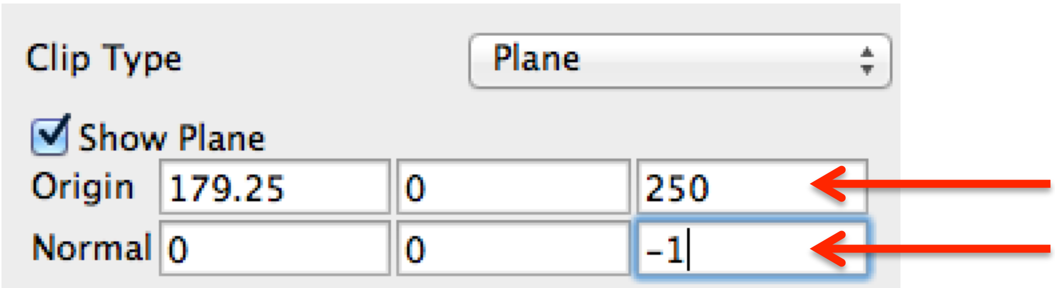




Split Upper and Lower Level Winds

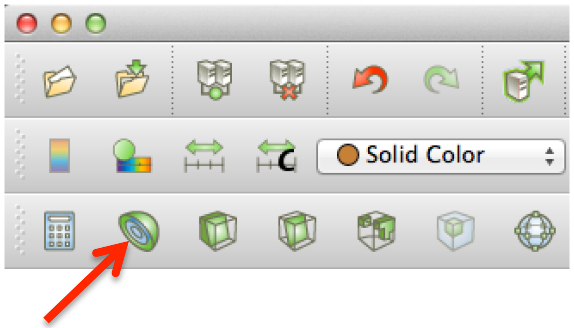
- Now repeat but for **lower level winds**....
- Select your original data set (U_1998_01.nc) and apply a Clip
- Inset **Origin (179.25,0,250)** and **Normal (0,0,1)**
- Click Apply

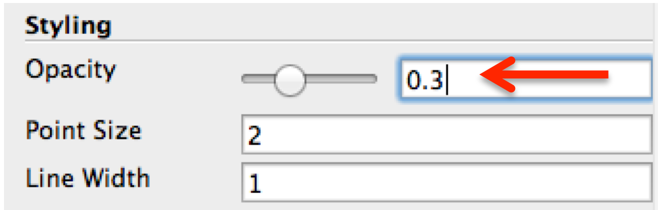


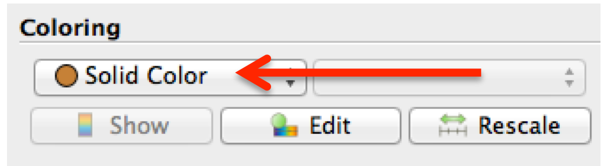


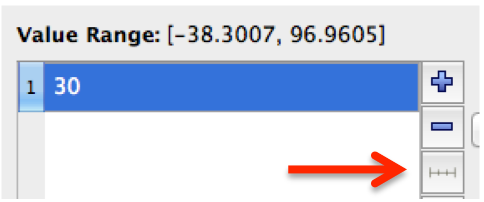
Split Upper and Lower Level Winds

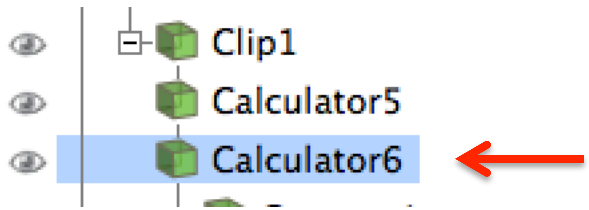
- Next apply the same transformations as before…
- Calculator (coordinate results):
  iHat*coordsX + jHat*coordsY + kHat*(abs(log10(coordsZ/1000))*20 + 100)
- Calculator (coordinate results):
  iHat*(coordsZ)*cos(coordsY*3.14/180)*cos(coordsX*3.14/180) +
  jHat*(coordsZ)*cos(coordsY*3.14/180)*sin(coordsX*3.14/180) +
  kHat*(coordsZ)*sin(coordsY*3.14/180)
- Take a contour in the range -100:100, steps 11
- Change opacity (to around 0.3)
- Click back onto the transformed data (Calculator6) and apply another contour, this time just **30** and colour it yellow





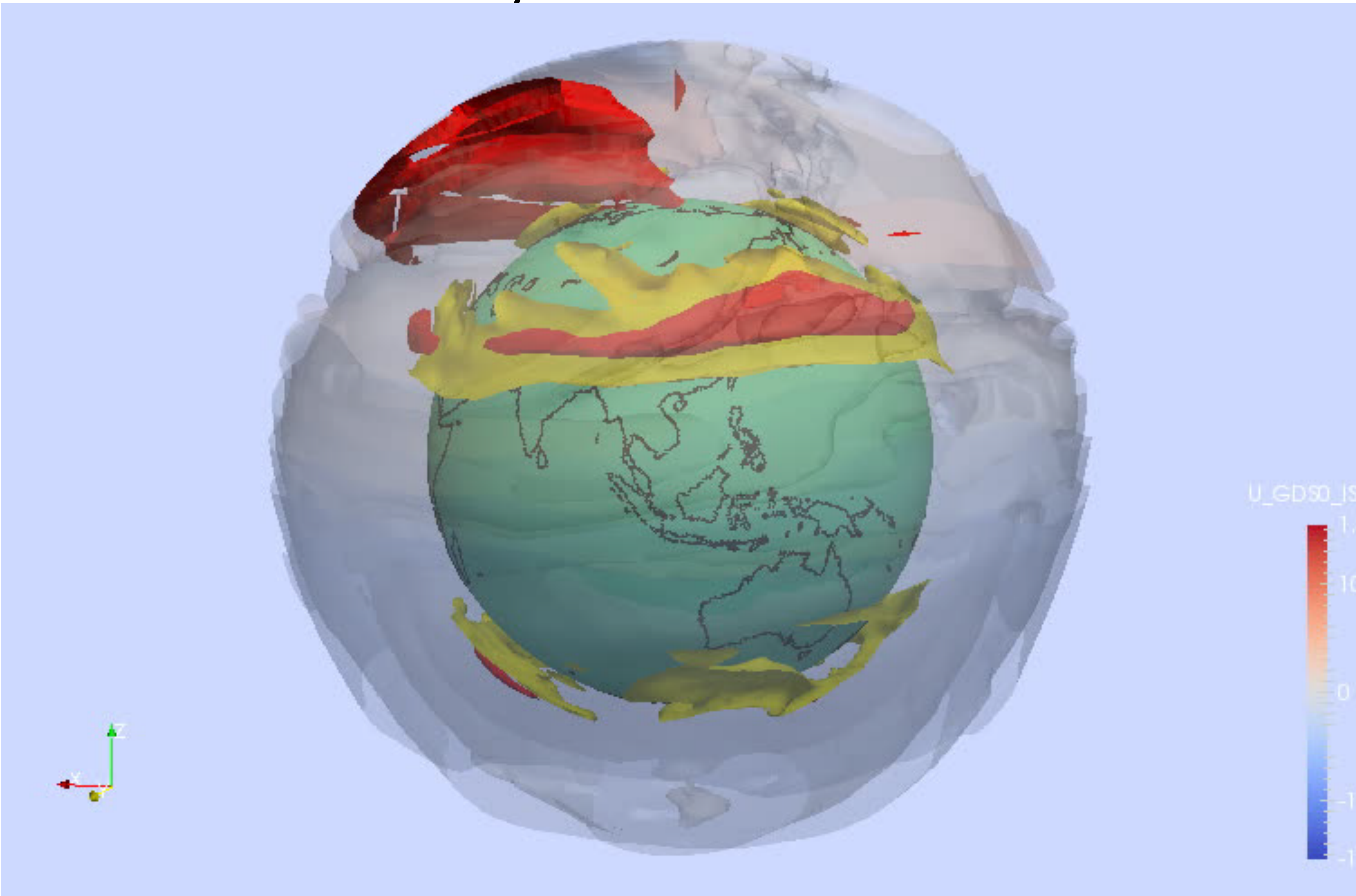






Split Upper and Lower Level Winds

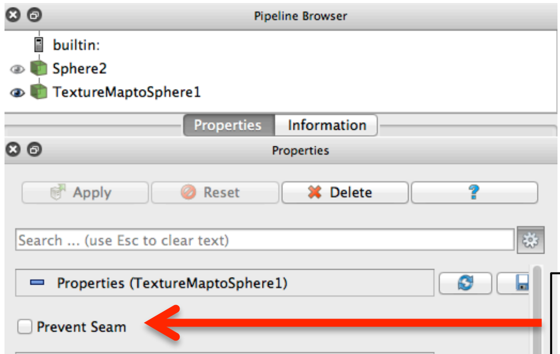
Save your animation! ☺

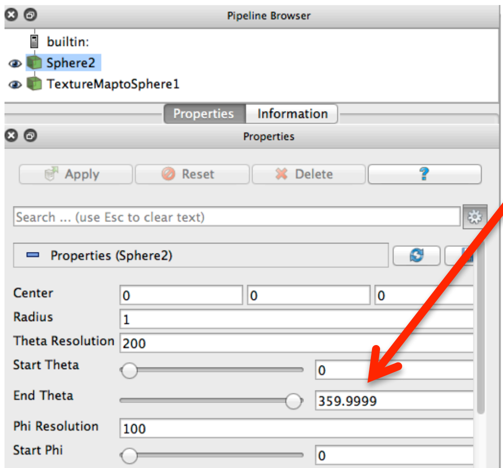


Some extra tips from Kane about mapping and animations….

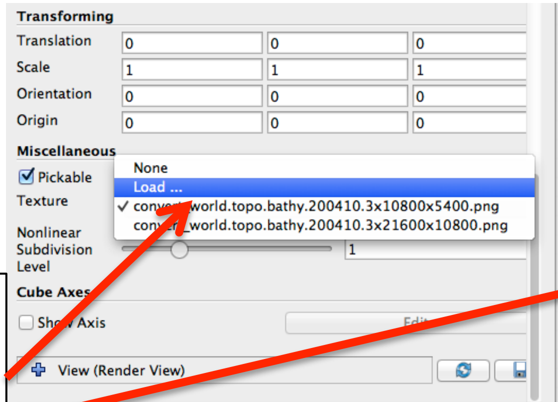
Adding a texture map

1. Click Source: Sphere.
2. Click Filter: Alphabetical: TextureMaptoSphere and click apply
3. Unclick: prevent seam
4. Scroll down in properties browser. Under Miscellaneous: load in texture
5. If the texture map does not perfectly conform to a sphere, it will create a seam. In some cases this can be solved by adjusted the end longitude of your sphere
6. For the example image: Click on your sphere in the pipeline browser and adjust the end longitude to 359.9999.





3.
4.
5.
6.



More texture maps can be found here: http://visibleearth.nasa.gov/view_cat.php?categoryID=1484

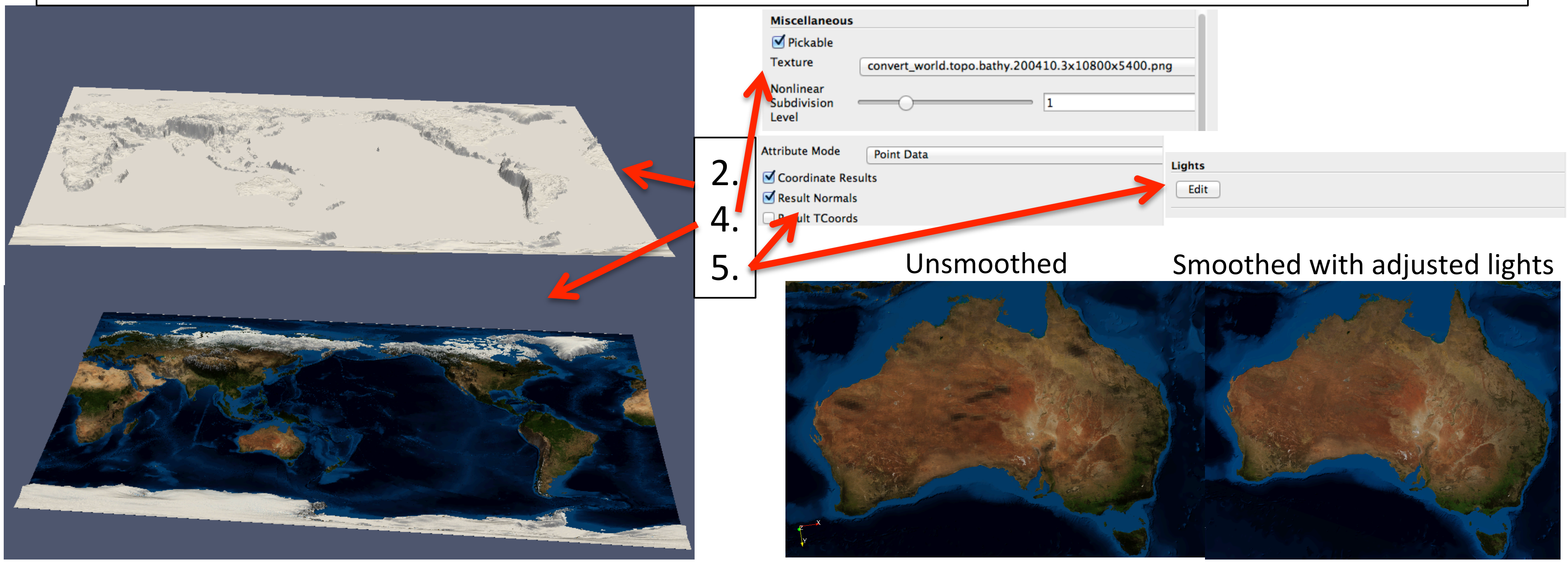
Mapping orography to a plane

1. Load in test Orography data. Un-tick spherical coordinates and select Unstructured.
2. To map orography to a plane, select the calculator filter and input: (make sure you tick coordinate results)

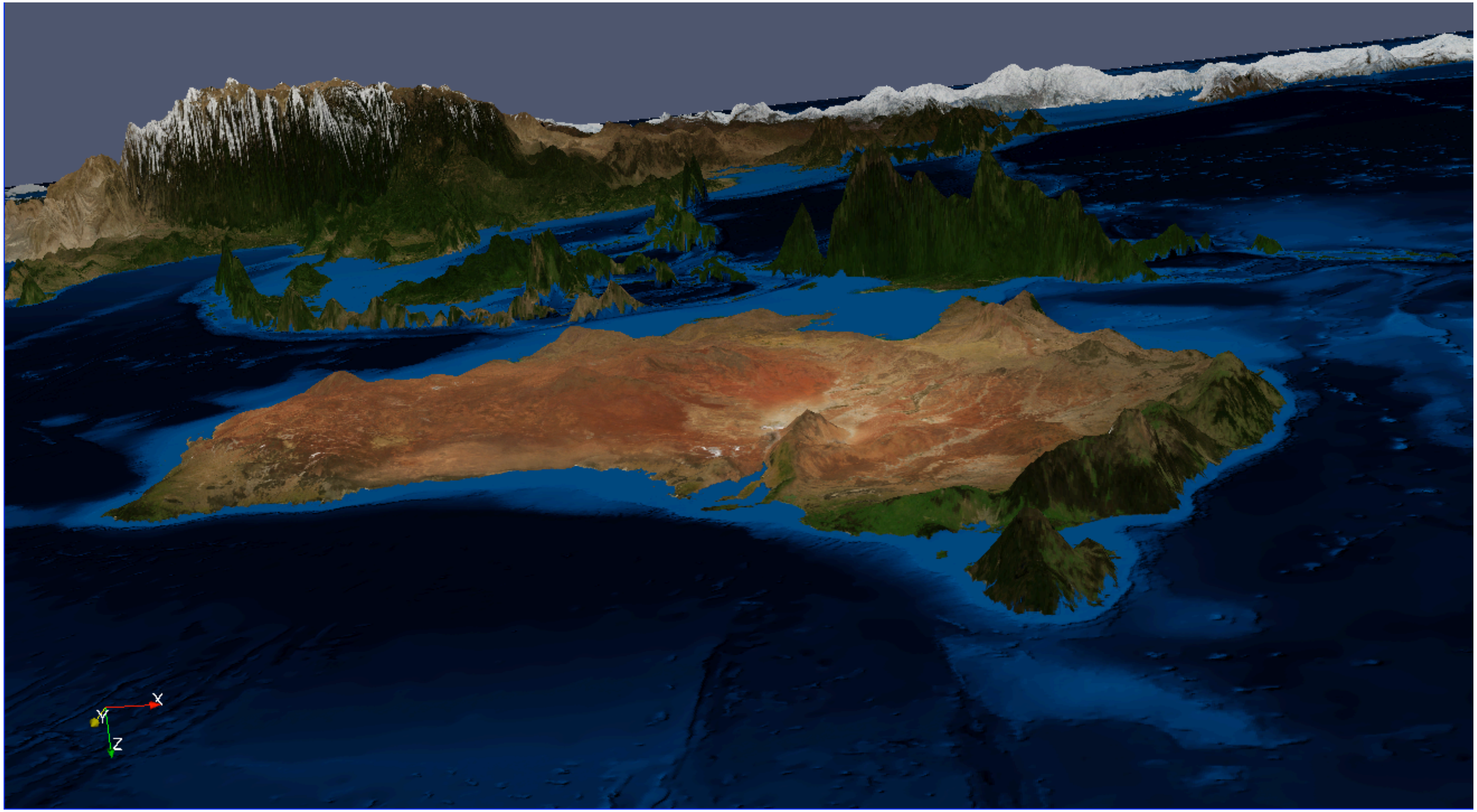
iHat*coordsX+(-jHat*coordsY)+(kHat*(coordsZ+ht))*-.002

Where **ht** is the Orography altitude data and **-.002** is the scale factor.

3. In this case, the latitude coordinates (**jHat*coordsY**) and the height scale factor (**.002**) are reversed to match up with the sample image.
4. Select Filter: TextureMaptoPlane, and load in the texture file under Miscellaneous
5. Click result normals in the Calculator to smooth data. And if necessary adjust the lights



Sample Image



Mapping orography to a sphere

1. Load in test Orography data. Un-tick spherical coordinates and select Unstructured.

2. Convert to spherical coordinates using the calculator filter: (make sure you select coordinate results)

iHat*(coordsZ)*cos(coordsY*3.14/180)*cos(coordsX*3.14/180) +
jHat*(coordsZ)*cos(coordsY*3.14/180)*sin(coordsX*3.14/180) + kHat*(coordsZ)*sin(coordsY*3.14/180)

3. To map orography to a sphere select the calculator filter and input: (make sure you select coordinate results)

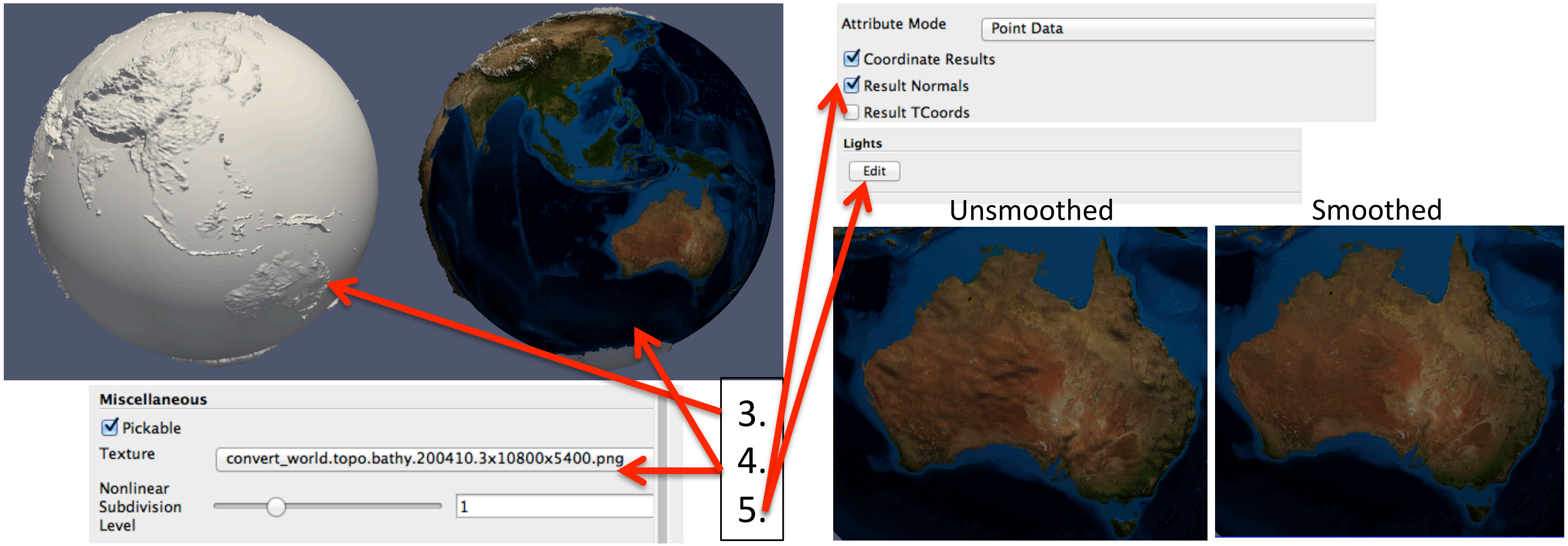
(1 + (ht/6540000)*100)*(iHat*cos(asin(coordsZ))*cos(atan(coordsY/coordsX))*coordsX/abs(coordsX) +
jHat*cos(asin(coordsZ))*sin(atan(coordsY/coordsX))*coordsX/abs(coordsX) + kHat*coordsZ)

Where **ht** is the Orography altitude data and the scale height factor is ***100**

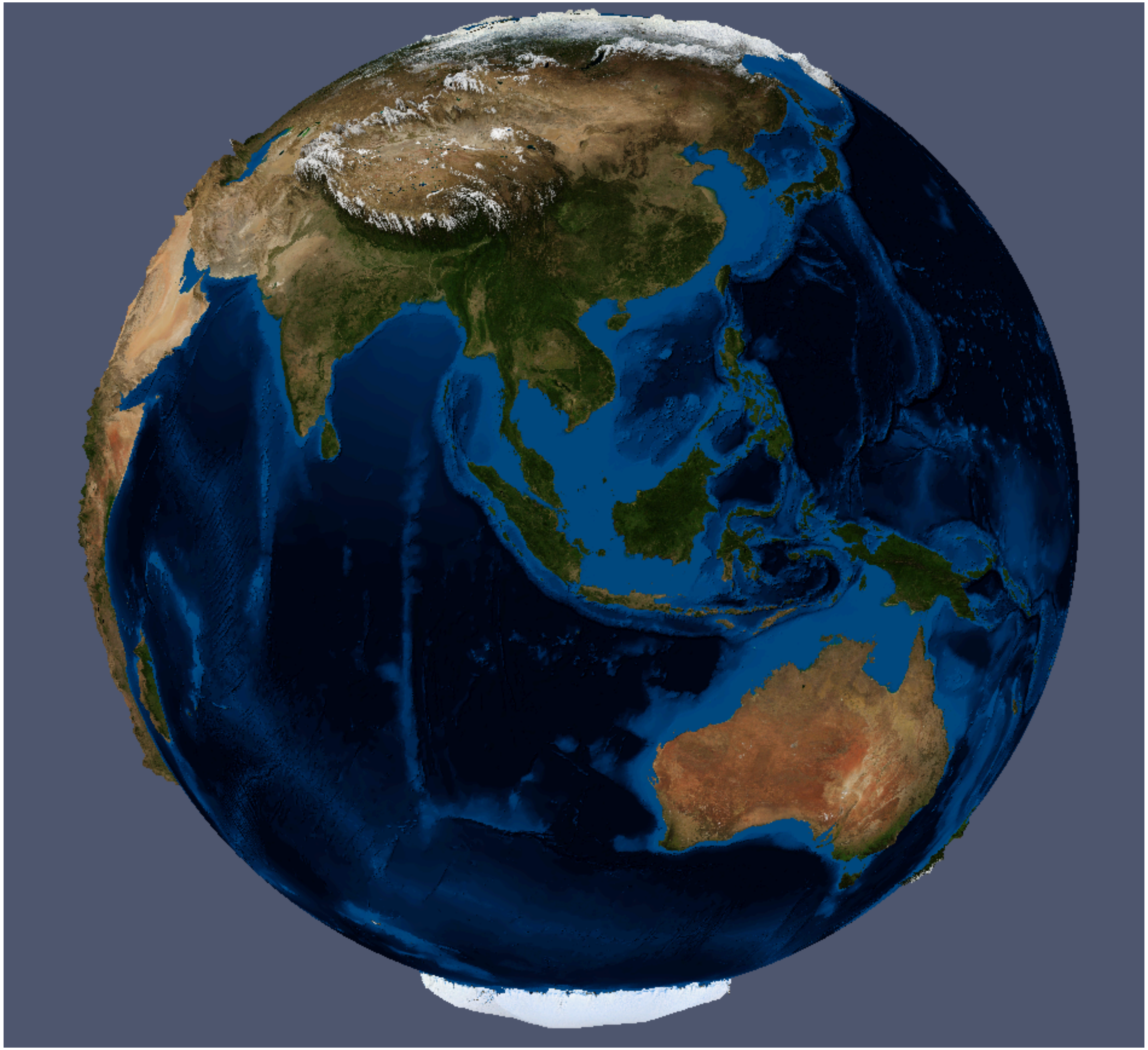
4. Select Filter: TextureMaptoSphere, and load in the texture file under Miscellaneous

5. Click result normals in the Calculators to smooth data. And if necessary, adjust the lights

6. The sample data may produce a seam at the meridian. This is not so easily solved. I get around this by removing the 0 longitude point in the orography data, then underlying a source:sphere with a texture map.



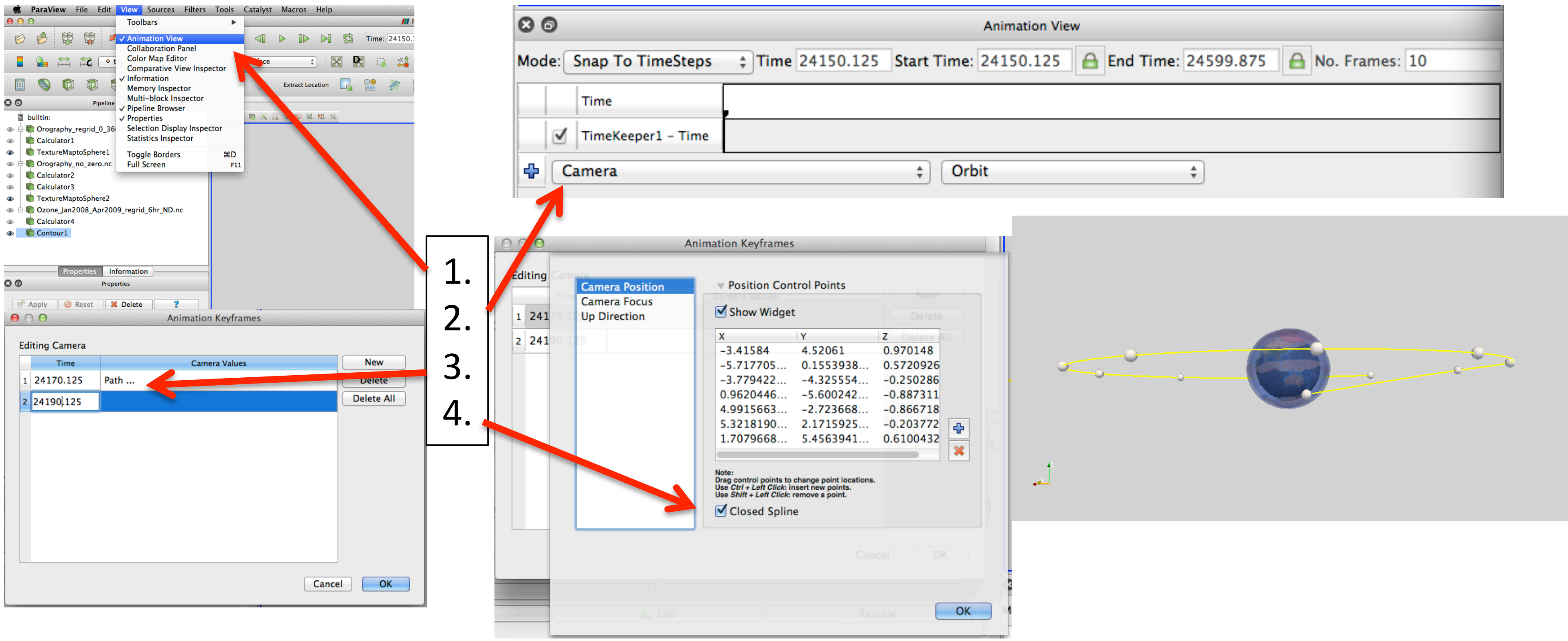
Sample Image



Animation View

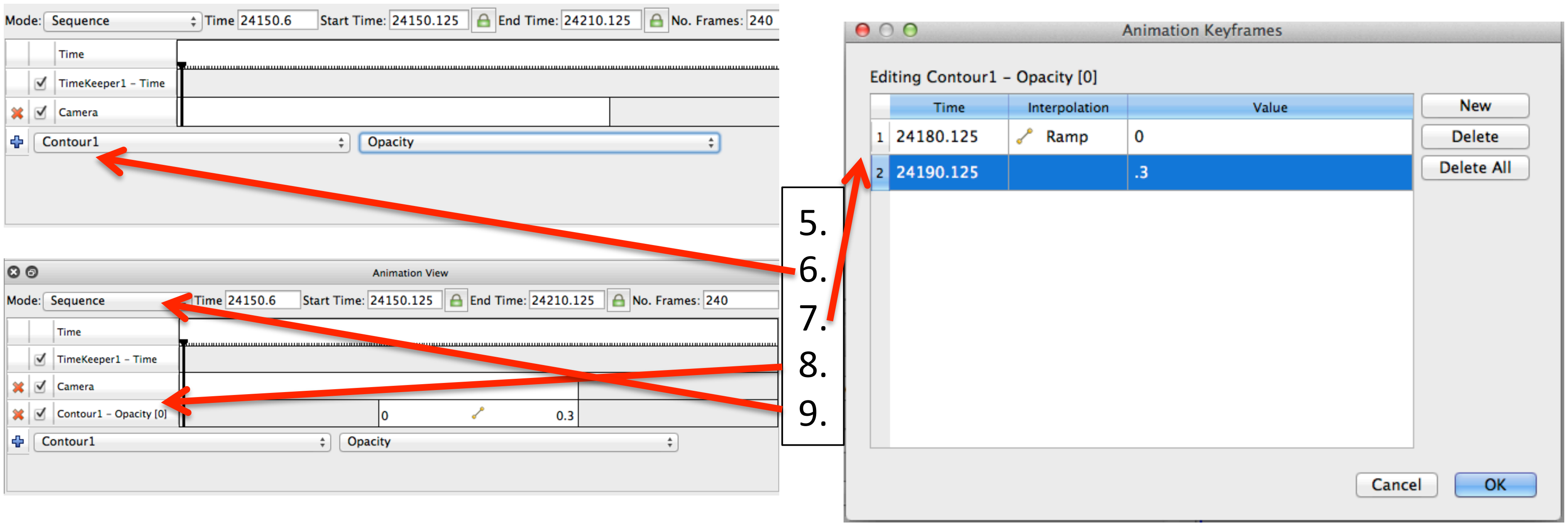
Animation view has many different tools for adjusting data fields or camera locations throughout the animation. For example you can interpolate camera locations between time steps, or change the opacity or visibility of fields throughout the animation.

1. To open animation view, select view: animation view
2. To create an camera orbit, select camera and orbit (or follow path) in the drop down menus, and click the plus button
3. Double click on camera to change the orbit time options, then double click on Path to change the orbit location.
4. Unclick closed spline to have open ends



Animation View

5. You can also change the opacity of your contour through time.
6. Click your contour field and opacity from the drop down menus, then click the plus button.
7. Double click on contour and change your start and end times and your opacity values.
8. Your animation view should now have multiple inputs
9. Change the mode to sequence (snap to time steps sometimes causes problems) and adjust the start and end times, and the number of frames (This will correspond to your data time steps.) For example I am showing an ozone field over two months (60 days) at 6 hourly time steps = 240 time steps (or frames in sequence mode). This will need to be adjusted, depending on your own data.



Sample Movie