Vis5d as a 3D Numerical Model Data Interrogation Tool

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Background

Vis5d is an interactive data visualization and interrogation program. The '5' in 'Vis5d' refers to five dimensions: three spatial dimensions, time, and variables; multiple variables can be visualized simultaneously.

Any 3D data can be visualized with Vis5d although it was designed to visualize gridded numerical model data. If you can get your data into 3D floating point arrays, you can visualize it with Vis5d.

Vis5d was developed at SSEC by Bill Hibbard, now retired, and development on the original Vis5d code has ceased. However, Bill released the source code of Vis5d 5.2 under the GPL, and a community-driven version of Vis5d now exists called Vis5d+. However, development on Vis5d+ has not occurred since 2002. A Vis5d mailing list exists which may assist you in any Vis5d problems you may encounter (Google is your friend).

The version of Vis5d you are using in this workshop is Vis5d+-1.3.0beta. This version contains some features and improvements over Vis5d5.2 but the code is perhaps not as stable. Either version will suffice for casual use.

How do I get my data into Vis5d?

Creating Vis5d files is pretty straightforward and documentation exists on how to do this. I would recommend the doc files in the Vis5d+ distribution for guidance on this. There are some community models which have a Vis5d output option and some existing programs to convert files to Vis5d format.

If you are looking to create your own Vis5d files from your own data, the Vis5d API includes the following calls you will need to examine:

v5dCreate and v5dCreateSimple - create a Vis5d file
v5dWrite - write 3D data to the Vis5d file
v5dClose - close the Vis5d file.

You can call these from either C or FORTRAN. Example programs are in the documentation.

Vis5d runs under Unix/Linux. A version for Windows does not exist as far as I know. Vis5d will run under MacOSX if you first install the developer tools.

Starting Vis5d

If you simply type

```
% vis5d
```

a long list of options will be presented to you. Normally, all you need to pass to vis5d is the name of your existing vis5d file, i.e.:

```
% vis5d wkshp_2hr.v5d
```

will open the first file we will be examining in this workshop.

Using Vis5d

Our dataset for this workshop is from a numerical simulation of a supercell thunderstorm. We will be examining vector and scalar quantities as well as observing wind trajectories.

1. Start with the file wkshp_2hr.v5d. When you first start vis5d, you are presented with a panel on the left, containing many buttons, and the box on the right containing the visualization.

   Place the cursor in the vis window and click and hold the **left** mouse button. Move the mouse and observe how the cube responds. Do the same with the middle and right mouse buttons. Get used to manipulating the cube. Note: for those of you used to IDV, the Vis5d cube responds differently to the IDV cube! This can be enough to make your head explode. As a long-time Vis5d user I have a hard time getting used to the IDV way, which I believe is based upon VisAD, which was also written by Bill Hibbard.

   To restore the cube to its original position, click on the TOP button near the upper left hand corner of the panel. SOUTH and WEST do what you would expect. Right-clicking on these will give you the 180 degrees-opposite view.

   Perhaps one the most powerful features of Vis5d is its ability to render isosurfaces quickly. Isosurfaces can be though of as three-dimensional contours. All along an isosurface, values of a quantity are constant. Values inside an isosurface are either larger than or smaller than the value of the isosurface.

2. Select qcqi (cloud water+ice in g/kg) in the Isosurf column in the lower part of the panel beneath the column of buttons. The widget which pops up contains a slider with a range from the minimum value found in the data to the maximum. Slide the slider over to a value of 0.2 g/kg and click OK. Examine the isosurface manipulating the cube.

3. Now, I don't know about you but I think that is one ugly-colored cloud. Let's make it white. If you right-click on the qcqi Isosurface widget, a control panel comes up with RGB sliders. If you move them all over to the right you'll have a white cloud.

4. Try sliding the Opacity slider to the left and see what happens. Transparent isosurfaces are useful when you have stuff going on inside an isosurface.

5. Try experimenting with different values of qcqi.

6. De-select qcqi (cloud goes away) and let's find the supercell updraft. Choose a value around 35 m/s for W. Now, bring back the cloud but make it transparent. You should be able to see the relationship between the cloud itself and the updraft inside the cloud.

7. By now you are probably getting the hang of isosurfaces. Try looking at reflectivity (dbz) and vertical vorticity (zeta). You should be able to find a very prominent weak echo

region looking at dbz, along with some interesting looking regions of vertical vorticity. The structure of the cold pool is evident choosing a value of about 307 K for Theta.

8. Vis5d can render 3D wind vectors. Select Hwind1 (located above the Isosurf buttons you have been playing with). Drag the plane down to the surface to examine the storm-relative surface winds. You may wish to zoom in as there are a lot of vectors.

9. In the HWind widget, change the value of the HWind 1 Scale to something smaller, say 0.5. Press Enter or move the cursor out of the box for the change to take effect. You can do the same for vector density; if you wish to remove every other vector, put a value of 0.5 in the Density box.

10. You can look at vertical cross sections of wind vectors in the same way (click on Vwind1). However, to move the vertical slice, you need to change the context of the mouse functions from Normal (currently selected) to Slice. You can now drag a slice around by selecting its corners with the right mouse button or the tab in the top/bottom center of the slice. Remember to change your context back to Normal once you are done manipulating the slice.

    Other 2D slices are available to view: "Contour Slice Horiz." "Contour Slice Vert." "Colored Slice Horiz." "Colored Slice Vert." all do what you would expect.

11. Let's look at a colored slice of surface potential temperature (Theta). Since potential temperature has such a large range but along a horizontal plane its range is small, we need to manipulate the default colormap in order to see variations in potential temperature.

    Place your cursor above the colormap (with the RGB curves) and use the left, center, and right arrow keyboard keys to manipulate the colormap to your liking. You should be able to clearly delineate the cold pool by doing this.

12. Quit Vis5d and let's look at the second file: wkshp_60.v5d. This file contains a sequence of model states (separated in 1 minute intervals) and can be animated.

    Note: When you select an isosurface, slice, etc., when viewing a file containing several time levels, Vis5d may load all of the time levels into memory and do the rendering immediately. It is best to wait for everything to load (as indicated by the hourglass or "wait a sec" cursor) before manipulating the cube in this case. If you would prefer that Vis5d only render the current frame of a file containing several frames, you can pass the -verylarge 1 option to vis5d, i.e.:

    ```
    % vis5d wkshp_60.v5d -verylarge 1
    ```

    Now that you are examining a file with a sequence of model states which can be animated, you may also examine the behavior of trajectories.

13. Stop the model state at frame 25 of 36 as is indicated in the top left corner of the vis panel (containing the clock).

14. Select the Trajectory context widget. Click on the Ribbon button and change the value of Length to 15.

15. The 3D crosshairs can be moved around by right-clicking. Once you are satisfied with its location, middle click ONCE to drop a trajectory. Vis5d will churn away for a while as it calculates the trajectory location based upon the three components of wind. The trajectory ribbon will appear once the calculation is complete.

16. Interesting places to put trajectories include: The updraft at mid levels. The rear flank downdraft (RFD) near the ground. Try dropping a few trajectories from Set 1 in the updraft, and a few from Set 2 in the RFD. Animate it.

Final Notes

Vis5d is a powerful tool which can be used to give students and researchers the ability to interactively examine 3D model data and see what is going on in a fully three-dimensional context. This lab has only showcased some of Vis5d's functionality. In my experience, undergraduates take to it very quickly and find it to be a very educational experience. With community models such as WRF, ARPS, RAMS etc. available to universities, anyone can create their own simulations running on consumer hardware and make Vis5d files. Good luck, and have fun!