Due: Tuesday, April 28

Lab 16
GRASS GIS

Geographic Resources Analysis Support System (**GRASS**) is 3-D visualization software (FREEWARE) package used for geospatial data management and analysis, image processing, graphics/maps production, and spatial modeling. GRASS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies.

Originally developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL, 1982-1995), a branch of the US Army Corp of Engineers, as a tool for land management and environmental planning by the military, GRASS has evolved into a powerful utility with a wide range of applications in many different areas of scientific research. GRASS is currently used in academic and commercial settings around the world, as well as many governmental agencies including NASA, NOAA, USDA, DLR, CSIRO, the National Park Service, the U.S. Census Bureau, USGS, and many environmental consulting companies.

- Free download: http://grass.itc.it/download/index.php
- Additional download site: http://www.kyngchaos.com/software:grass
  → also follow link for **Unix Compatibility Frameworks** and download these.
- For more info and help:
  http://grass.itc.it/grass63/manuals/html63_user/

In this lab, you will learn how to import topography raster data, vector (points) data, and display both in 3-D. You will be working with data that has been pre-formatted for these types of applications – again, the SRTM (Shuttle Radar Topography Mission) data, and has a resolution of 90 m. You will also be downloading and formatting earthquake data from the USGS.

Step 0.

You can work on either a Mac or PC for this lab. Depending on which computer type you use, follow the setup instructions for running GRASS.

- **Macs**: Navigate to: **Macintosh HD → Applications → GRASS**
- **Macs**: drag-n-drop the GRASS icon desktop "dock", where several other icons are located at the bottom of your screen.

- **PCs**: Launch Cygwin, type **startxwin.bat** in the black window, then type **GRASS62** in the white window. (*note: GRASS is not fully functioning on the 409 PCs at this time, but will soon be*).
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Step 1. Example Exercise: Washington/Oregon Topography

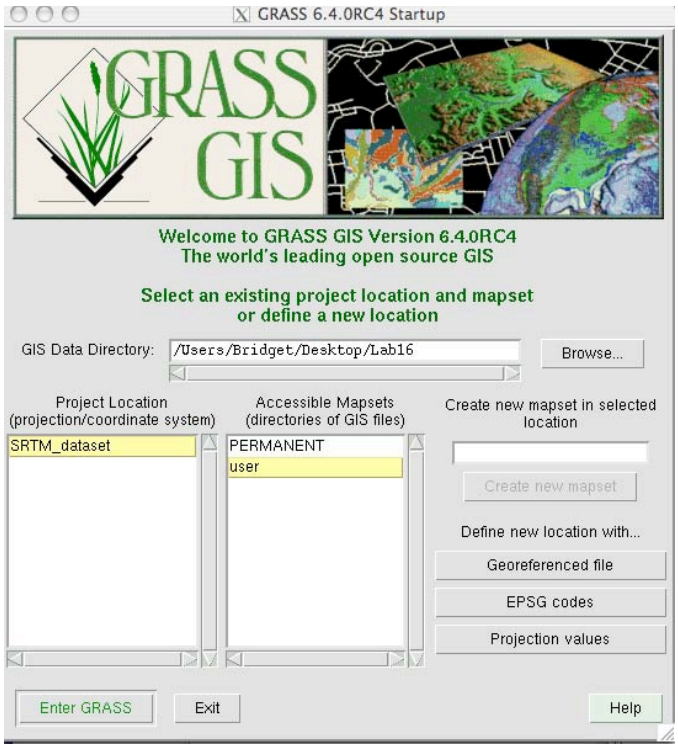
1.1 Obtaining Topography data

You will first practice the steps of this lab exercise on an ascii data file that contains the topography Washington and Oregon. Follow the following steps:

- Create a new **Lab16** folder on your Desktop.
- From the Instructor/Lab16 folder, copy/paste the folder **SRTM_dataset** to your Lab16 folder on your Desktop. This folder contains SRTM data of the Washington/Oregon region, preserved in a folder structure suitable for immediate GRASS import (= someone did some pre-formatting of data for you so that this lab wouldn't take forever).

1.2 Opening GRASS

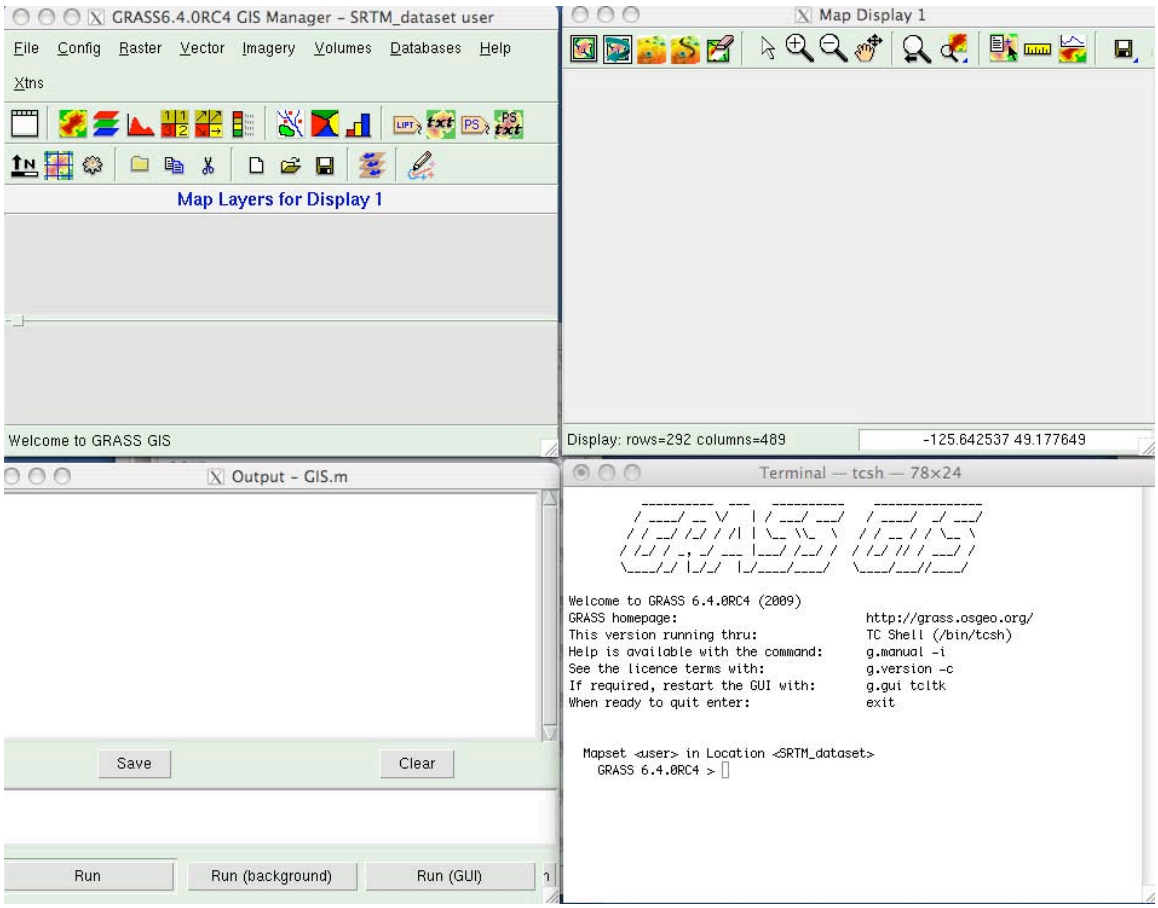
- Start GRASS as instructed above. This will launch a number of windows, including one like the graphic (right). You may have to hit **enter** a few times in a terminal window, if prompted.
- In the **GIS Data Directory** panel, click on the **Browse** button and navigate to your **Lab16** folder on your Desktop, and click **OK**.



- Under **Project Location**, the folder **SRTM_dataset** should be listed, and under **Accessible Mapsets**, two folders named **PERMANENT** and **user** should be listed.
- Highlight the **SRTM_dataset** Project Location and then **user** Accessible Mapset, then click the "**Enter GRASS**" button on the bottom of the window.
- You may have to wait a few seconds, but eventually 4 additional windows will pop up:

    1. **GRASS6.3.0 GIS Manager**
    2. **Map Display 1**
    3. **Output**
    4. **Terminal – bash**: showing a prompt:
       GRASS 6.4.0 (SRTM_dataset):>
       and above it "GRASS GIS" in *ascii art*.

The Output and Terminal windows show that GRASS has its original roots in a command line set of programs (like UNIX), which the newer versions now call through a graphical window.



- Before the next step, it is understand a few main points about GRASS: GRASS supports topography and other regularly spaced data as "rasters" (Reminder: raster means that there is a data point every x meters or degrees). For irregularly spaced data points (field locations, sample sites, etc.) and for actual vectors and ARC format shape files, GRASS uses a "vector" format. In the SRTM_dataset folder, you are provided an existing GRASS mapset with a raster topography file (**45N125W.r)** This data file spans 5 degrees in both longitude and latitude, and has a name corresponding to its lower-left corner of the grid (minimum west longitude, minimum latitude).

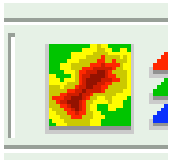
  What is the minimum longitude of this dataset? _____

  What is the maximum longitude of this dataset? _____

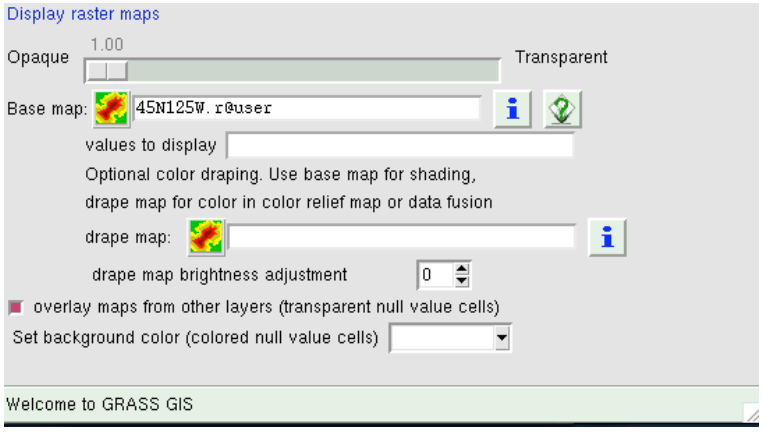
  What is the minimum latitude of this dataset? _____

  What is the maximum latitude of this dataset? _____

- In the **GRASS GIS Manager** window click on the second icon:



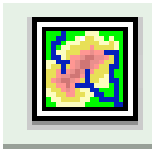
- A window subset with data definition options should appear in the lower half of the window:



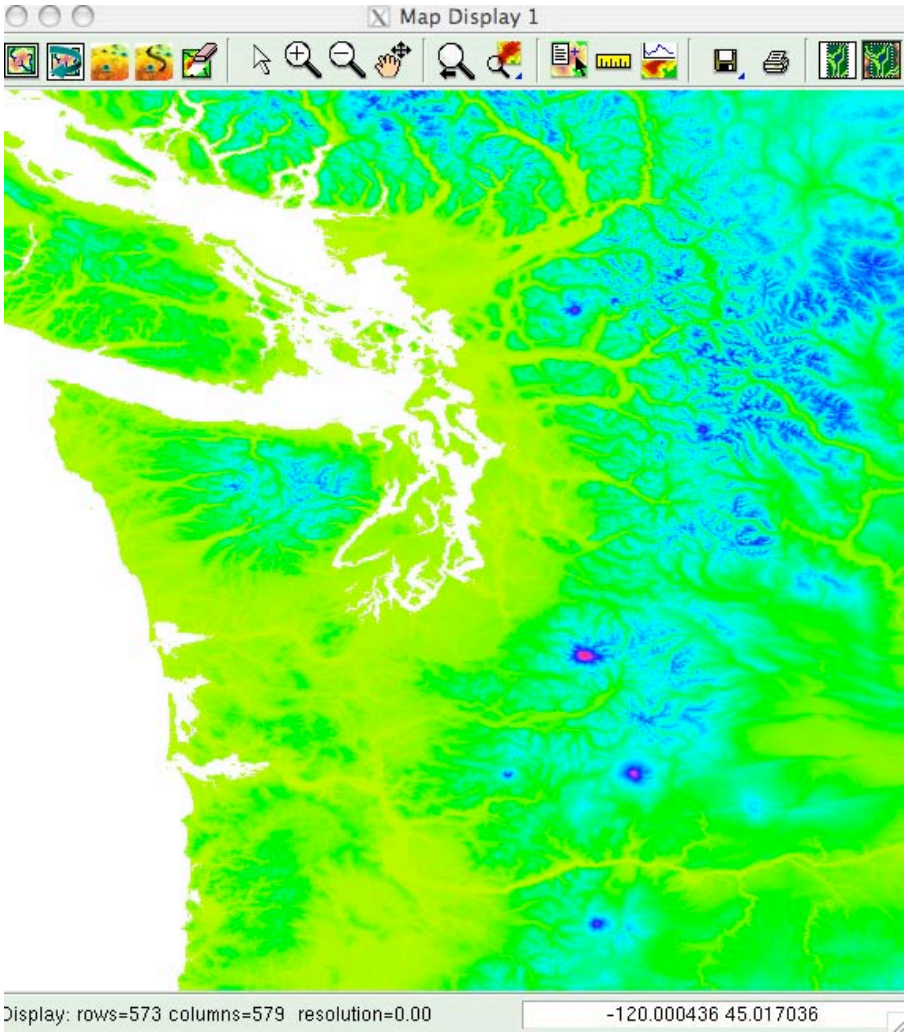
- In the lower part of the window click on the button next to "**Base map**"

and select the raster file: **45N125W.r**

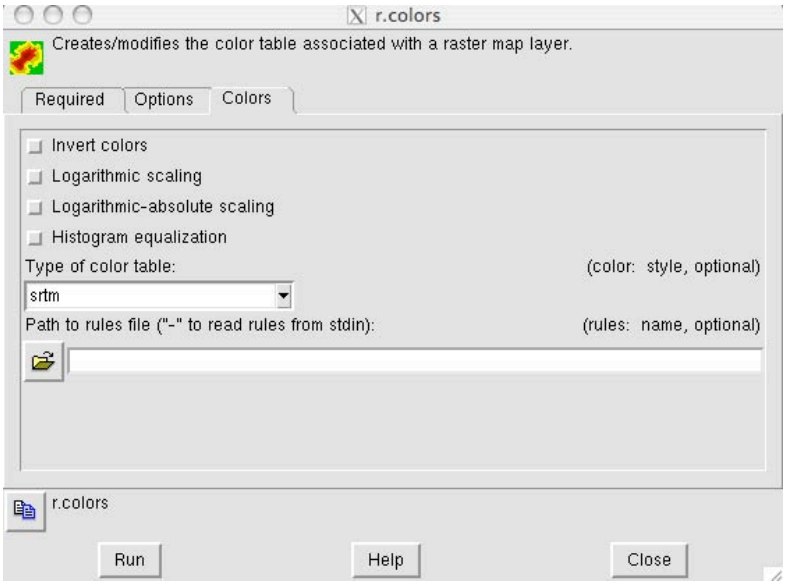
- Now you are ready to display your first topography image. Go to the **Map Display 1** window and click on the **Display Active Layers** button:



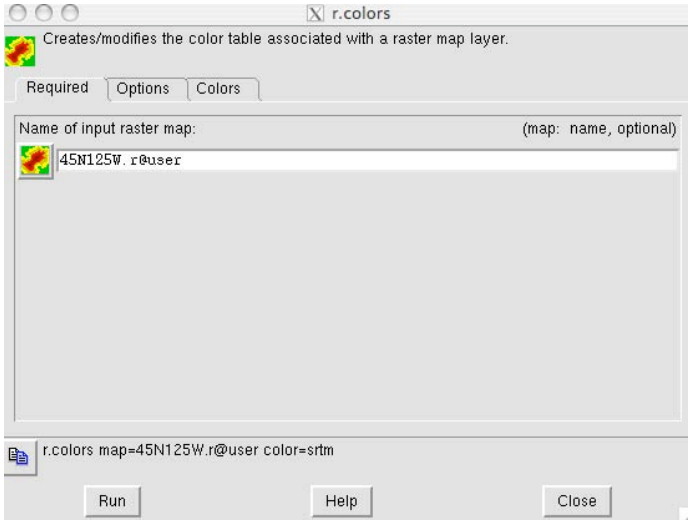
- Now the image will be rendered and should look something like the graphic below.
- Notice that the bottom right part of the window shows the latitude and longitude of the mouse (cursor) on the map. You can also zoom in and out with the magnifying glass icon pan with the hand icon.



- To change the colors of the map, in the **GRASS GIS Manager** window click: → **Raster** → **Manage map colors** → **Color tables**
- A new window (**r.colors**) should open up. Under the "**Colors**" tab select a table from the **Type of color table** drop-down menu (e.g. elevation, etopo2, or srtm). For the example below, the table "srtm" was selected.

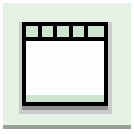


- Under the "**Required**" tab, click on the map icon and select **45N125W.r**

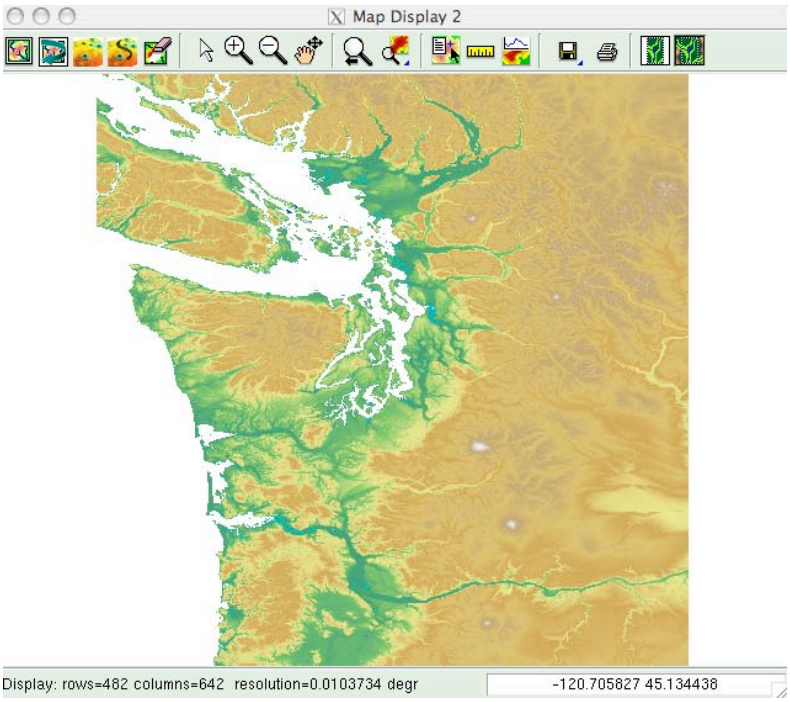


- Next click the "**Run**" button. An **Output – GIS.m** window should appear, but your map probably won't be updated. For the map display to realize

this a change has been made (like color), you need to kill/close the **Map Display** window and start a new Display window. To do this, in the **GRASS GIS Manager,** click on the left-most icon:

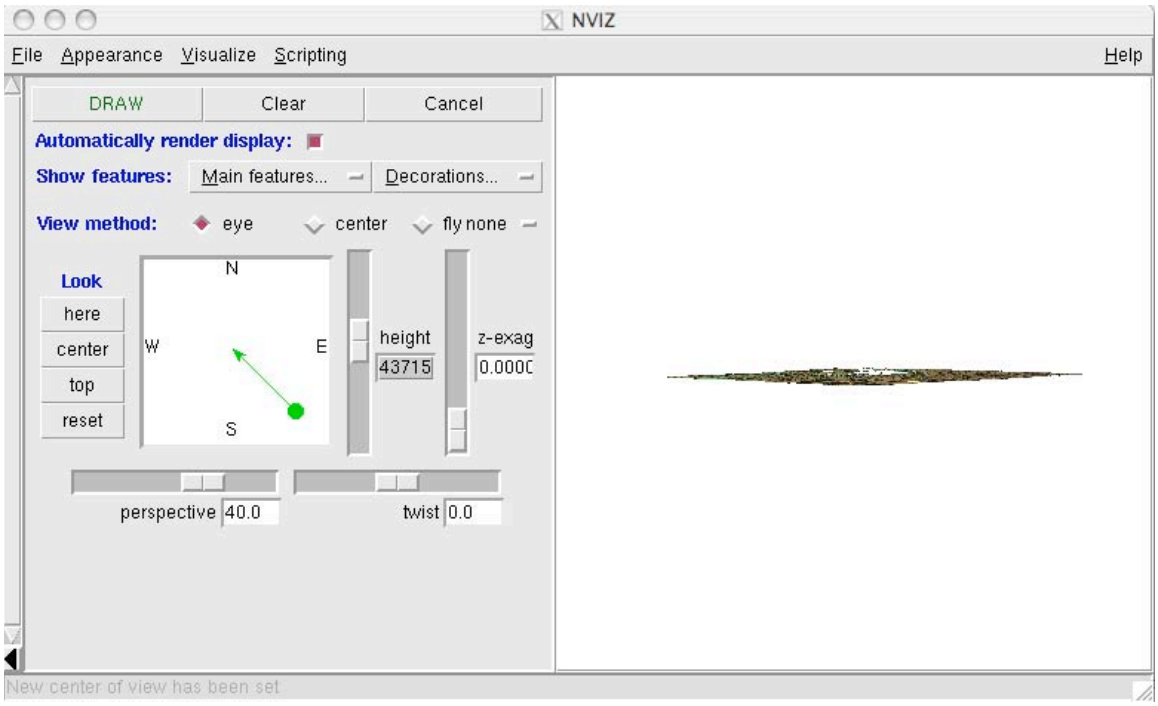


- This will launch a new **Map Display** window. To re-display the topography, repeat the steps beginning on **page 4** (1/2 way down).



- Next you will display this dataset in 3D. In the **Map Display,** window press the "**Start NVIZ**..." button:

- This may take a little time to load, but eventually an **NVIZ** window will open:



- Experiment with the menus and options provided. Change the "**height**" of your data by changing the number to ten times as large (for example, if it says 40000 make it 400000). Practice zooming in with the "**perspective**" slider. Change the angle of **view** with the dot-and-arrow in the **N-E-S-W box**. Change the vertical exaggeration (**z-exag**) to see the topography better.
- To modify the resolution of the data, select

  → Visualize → Raster Surfaces.

  The "**coarse**" resolution is the resolution while you rotate the image, the "**fine**" resolution is the resolution GRASS renders when you stop moving. Number "**1**" will render at the best resolution (90 m of the dataset), but this will take longer to render, and you probably won't see much of a difference compared with a "5" at a zoomed-out view. Sometimes you have to move the dot-and-arrow (angle of view) to make it render again (or press **clear** and **draw** buttons near the left top).
- Background: If you don't like the white background and prefer black for visualizations (as is used in most programs), select `

  → Appearance → Background Color

  and click on the white square and change it to your favorite color.

- Shading: You can also change the direction of shading by selecting

  → Appearance → Lighting

This will bring up another angle of view for the direction of the sun/lighting.

Step 2. Collecting data: Global Earthquakes

In a web browser, navigate to the USGS earthquake website:
http://earthquake.usgs.gov/eqcenter/

- Along the left column menu, click on **Search EQ Database**.
- Then click on **Rectangular Area** for your **Search Area**.
- Select **Screen File Format (80 columns)** as your **Output File Type**.
- Under **Data Base**, select the **USGS/NEIC (PDE) 1973-Present Data Base**.
- Enter the latitude/longitude coordinates that span your search region under **Input Rectangular Area Search Parameters**. For the following example, you should use the NW USA test region that spans our topograhy: **top latitude**: 50, **bottom latitude**: 45, **left longitude**: -125, **right longitude**: -120.
- Under **Optional Search Parameters**, enter a date range of seismicity that you want to search. For example, to look for seismicity over the last 2 years, you'll enter: **2006/01/01** to **2008/01/01**.
- Also under **Optional Search Parameters,** you can enter a range of earthquake magnitudes that you want to search. For example, you CAN enter 3.0 and 5.0 as your minimum and maximum magnitudes if you want to search these ranges of magnitudes.
- Leave the rest of the boxes blank and click the **Submit Search** button.

- Your data should appear on the next screen. You will have to determine if your search criteria produce a significant data set – you may have to go back and re-search the database for more events. Note that you can also repeat this process to gather files of different data ranges. For example, you can collect all of the magnitude 3-5 earthquakes in one data set. Then collect magnitude 5-7 earthquakes in another. You can also do this for various date ranges. This is helpful if you want to highlight different magnitudes in different colors/sizes.
- Select (highlight) and copy all of the column data from our web search result. Then paste the data into a simple text editor:

PCs: Use the "Notepad" application. Notepad will save as a *.txt file.

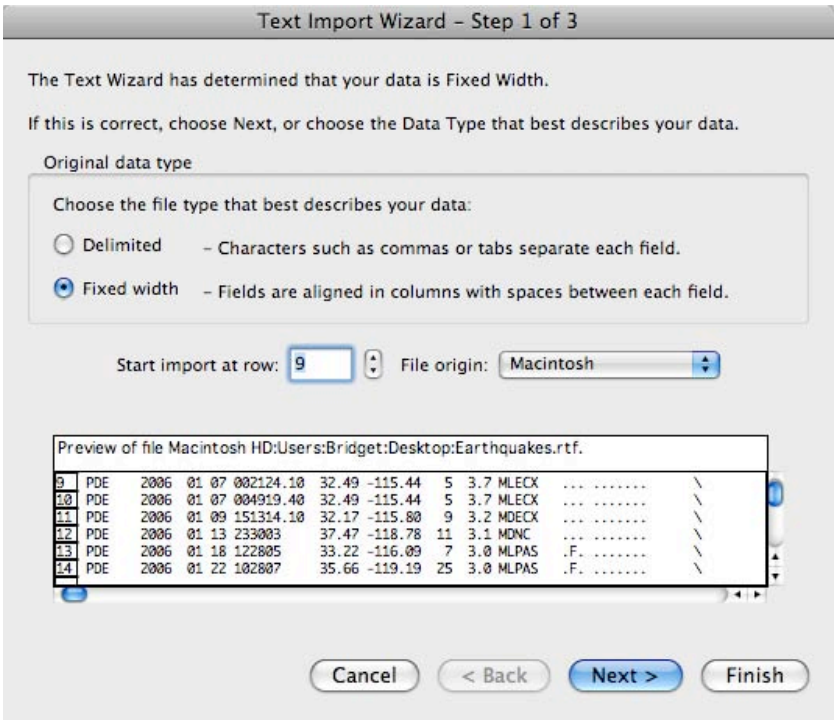
Macs: Use the TextEdit application. When you save the file, select the Rich Text Format (RTF).

Save the file (name it earthquake_data) to your Lab16 folder on your Desktop.

Step 3. Importing data into Excel

Open Excel and a new blank spreadsheet should appear. To open the new file you just created, click on File→Open. In your Open window, change the file type option to "all files/documents":

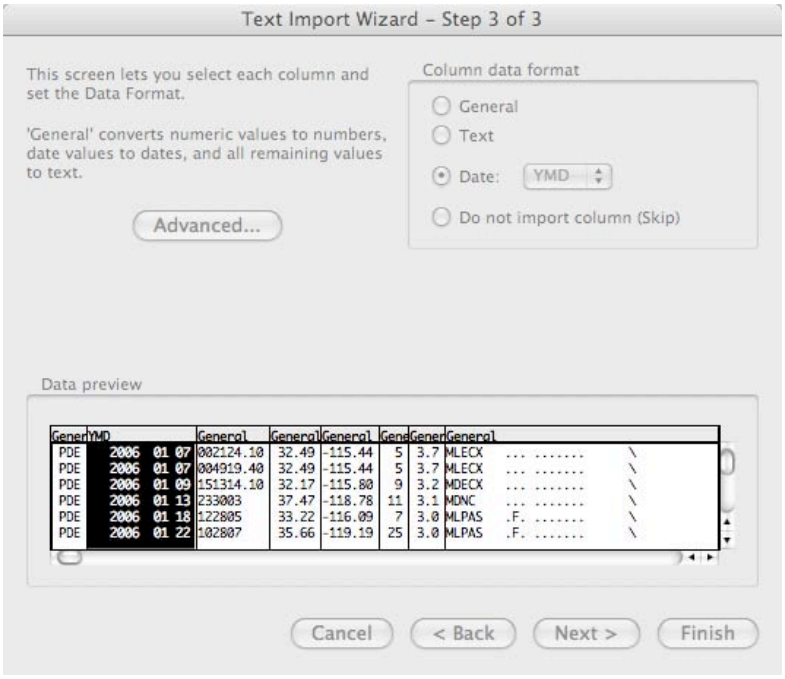
PCs: Files of type → select "All Files (*.*) → select your text file → Open
Macs: Office 2008: File → Import → Text File → Import →
Enable: All Files → select your text file → Get Data
or
Office 2004: Enable → select "All (Readable) Documents" → select your text file → Open



You will next be greated by the "Text Import Wizard" screen. Follow the instructions on the wizard's screen to import your data in the Excel format. Inspect all of the options presented to you in each Step of the Wizard, making sure you understand how each operates. You may see some garbage text in the Preview panel of the screen – this is okay for now, and you'll get rid of it

later, however scroll down to check that the rest of you data is in column format.

When you encounter the **select field breaks (column width)** window **(Step 2)**, create breaks at every obvious column (by clicking), however group the date (year/month/day) columns into one break, and select the appropriate format for the date **(Step 3**). You can also skip importing the last few columns on the right that appear useless (symbols, etc.). After completion of the Wizard steps, you should have a series of columns with nicely organized data.



If you have any garbage text remaining in your worksheet, simply remove it by highlighting the text and then go to Edit → Clear → All.

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4. Formatting the data (getting rid of the stuff you don't need)

Now you will delete all of the unnecessary data. All you eventually want to end up with is a file with three columns:

Longitude Latitude Depth(meters).

Below are highlighted columns that you'll want to delete (if you imported your data correctly). To delete these, highlight them, then go to Edit → Clear → All.

Latitude Longitude Depth (km)

	A	B	C	D	E	F	G	H	I
1	PDE	1/7/06	2124.1	32.49	-115.44	5	3.7	MLECX	... . \
2	PDE	1/7/06	4919.4	32.49	-115.44	5	3.7	MLECX	... . \
3	PDE	1/9/06	151314.1	32.17	-115.8	9	3.2	MDECX	... . \
4	PDE	1/13/06	233003	37.47	-118.78	11	3.1	MDNC	... . \
5	PDE	1/18/06	122805	33.22	-116.09	7	3	MLPAS	.F. ..... \
6	PDE	1/22/06	102807	35.66	-119.19	25	3	MLPAS	.F. ..... \
7	PDE	1/22/06	231852	32.33	-115.18	30	3	MLECX	... . \
8	PDE	1/26/06	230330	32.34	-115.14	9	3.3	MLECX	... . \
9	PDE	1/27/06	52245.5	32.35	-115.13	8	3.9	MLECX	.F. ..... \
10	PDE	1/27/06	54402.8	32.33	-115.13	9	3.7	MLECX	... . \
11	PDE	1/27/06	54928.6	32.34	-115.14	8	4.1	MLECX	3F. ..... \
12	PDE	1/27/06	65942.23	32.45	-115.27	5	3	MLPAS	... . \
13	PDE	1/27/06	2258	32.35	-115.14	6	3.6	MLECX	... . \
14	PDE	1/28/06	80532.4	32.39	-115.05	7	3.5	MLECX	... . \
15	PDE	2/4/06	103234.7	32.36	-115.15	6	3.4	MLECX	... . \
16	PDE	2/4/06	123832.2	32.37	-115.13	7	3.6	MLECX	... . \
17	PDE	2/5/06	154333.95	34.24	-119.81	7	3.2	MLPAS	2F. ..... \
18	PDE	2/6/06	45539.29	35.82	-119.91	12	3.3	MDNC	... . \
19	PDE	2/7/06	101152	32.82	-115.7	16	3	MLPAS	.F. ..... \
20	PDE	2/7/06	182356.7	32.34	-115.21	9	3.9	MDECX	.F. ..... \
21	PDE	2/7/06	182712.9	32.35	-115.1	9	3	MLPAS	... . \
22	PDE	2/8/06	200614.9	32.31	-115.11	14	4	MDECX	... . \
23	PDE	2/8/06	220446	32.28	-115.06	4	3.1	MLPAS	... . \
24	PDE	2/13/06	202152.5	32.21	-115.04	9	3	MLECX	... . \
25	PDE	2/13/06	210557.89	32.12	-115.02	6	3.1	MLECX	... . \
26	PDE	2/14/06	104019	32.07	-115.81	2	3.1	MLPAS	... . \
27	PDE	2/15/06	225642.8	32.07	-115.96	5	3	MLPAS	... . \

Next you'll need to convert the **Depth** column from **km to meters**, since the topography uses elevation in meters. To do this, double click in the first cell of the empty column next to your Depth column. Type "=" in the cell, then click on the first entry of your depth column. Your empty "=" cell should fill with the letter-column designation you just clicked in. Then click back in your "=" cell and type " *-1000 ", to multiply the cell by 1000. Then hit Enter. Your cell should now represent your depth entry in meters. To repeat this process for the rest of the cells in your column, click on the new cell that you just converted and hover your mouse in the bottom right corner of the cell box. When a "+" sign appears, hold down your mouse button and drag to the bottom of the column. When you release the mouse, the remaining column cells in your column should fill with the proper depth in meters.

Now you'll want to **Copy → Paste** your longitude column to the 1st available column (labeled **A**). Then **Copy → Paste** your latitude column to the 2nd available column (labeled **B**). Then **Copy → Paste Special (select the Values button, then OK)** your new **(meters)** depth column to the 3rd available column (labeled **C**). If you have any remaining data, like your old depth (km) column, just delete it.

The first few rows of your final Excel sheet should look something like the following:

	A	B	C	D
1	-115.44	32.49	-5000	
2	-115.44	32.49	-5000	
3	-115.8	32.17	-9000	
4	-118.78	37.47	-11000	
5	-116.09	33.22	-7000	
6	-119.19	35.66	-25000	
7	-115.18	32.33	-30000	
8	-115.14	32.34	-9000	
9	-115.13	32.35	-8000	
10	-115.13	32.33	-9000	
11	-115.14	32.34	-8000	
12	-115.27	32.45	-5000	
13	-115.14	32.35	-6000	

5. Saving the file

- To save your file, select **File → Save As →**
- On the "Save As" screen, look for the "Save as type" or "Format" option and select "CSV (Comma delimited)". The default suffix should be (*.csv). Give your file a name (**Earthquakes.csv**) and click "Save". Make sure to save it in your **Lab16** directory on your Desktop. **NOTE**: Excel will probably warn you that saving in this format may ruin the file, just ignore this and click yes (you are sure): there is nothing in this file that csv cannot handle.

6. Importing into GRASS GIS

To import this dataset into GRASS, switch to GRASS and look for the terminal window, which is the window with the GRASS GIS ascii art. This window should have a prompt that looks like:

GRASS 6.3.0 (SRTM_grass):

First you will want to change to the working directory (Lab16):

- type: **cd ~/Desktop/Lab16**

Check for your file (Earthquakes.csv):

- type: **ls**

Make sure the region will import everything (a standard GRASS command):

- type: **g.region -d**

Now for the importing:

- type: **v.in.ascii –zn input=Earthquakes.csv output=Earthquakes format=point fs=, z=3**

The –zn flag above tells the import function that there will be a z-coordinate, while the n tells it that the file does not have a header (text above the lat, lon, depth) The format=point flag tells the import function that these are individual points. The fs flag tells the import function that the columns are separated by a ",". The z=3 flag tells the import function that the z-coordinate is in the 3rd column

Overall, the import should be relatively quick, and GRASS will tell you that **v.in.ascii** is complete.

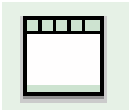
- Before plotting you will first want to reset the region in GRASS to only the raster you are interested in: For the example NW USA region:

- **Type**: **g.region rast=45N125W.r**

7. Plotting the events in GRASS GIS

GRASS does not update any parameters on the "Map Display" window, so close an open Display windows.

- Now you want to start a new Map display, press in the GRASS GIS Manager window:

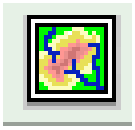


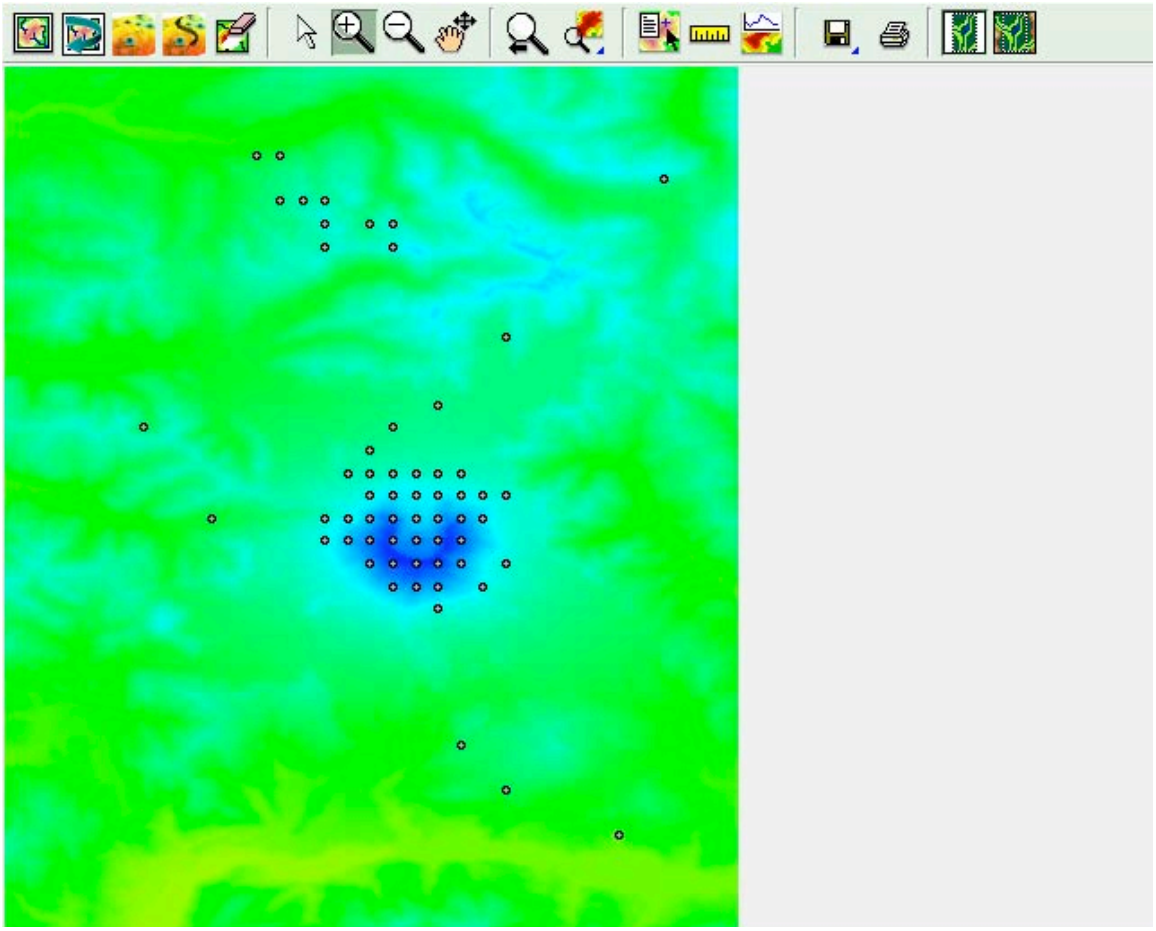
- First display the topography:
- In the bottom half of the screen, select your raster file.
- To plot the earthquake locations: click on the **add vector layer** button in the GRASS GIS Manager window, the add vector layer button:

- In the bottom half of the window, click on the button next to "**Vector Map**:" Select the **Earthquakes** file and press OK. You can also change

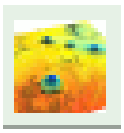
the type of symbols ("Icon" button) and the size (Size: 5). GRASS will use in the plot.

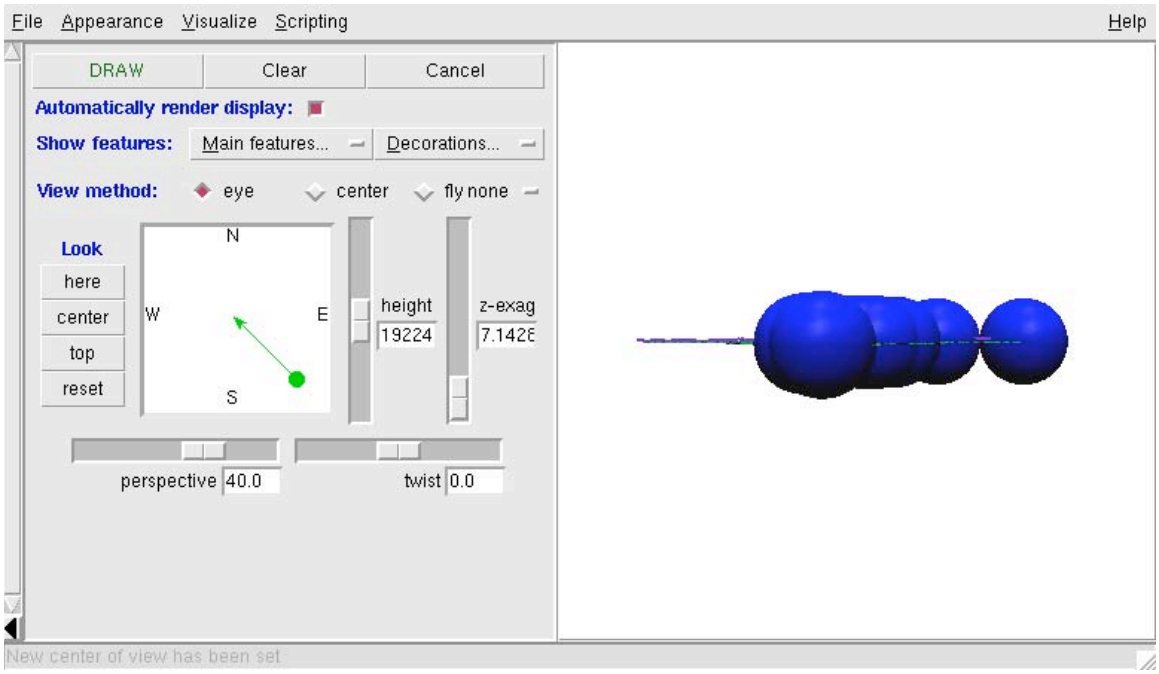
- Finally, to complete theplot, go to the Map Display window and hit the "Display active layers" button:



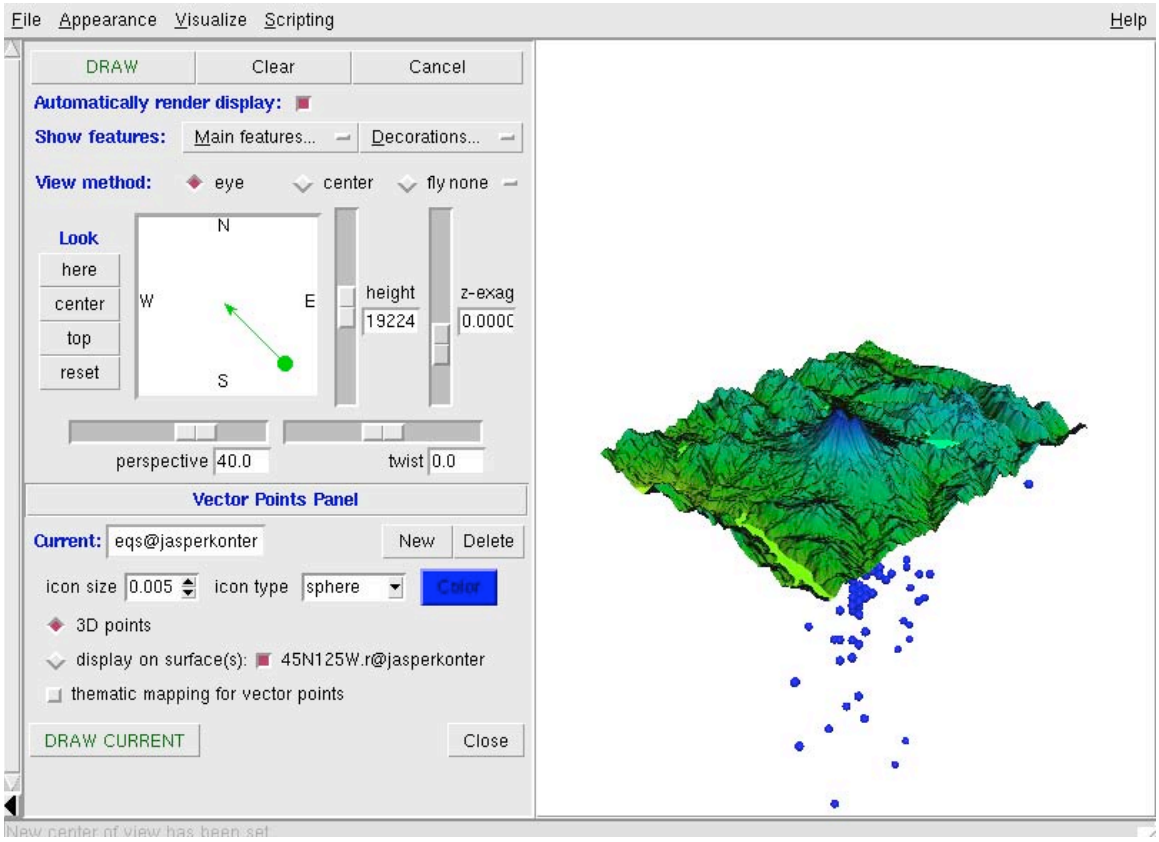


To plot your earthquakes in 3-D, in the Map Display window press the "**Start NVIZ**..." button:





- Adjust the features that you have used before to change exaggeration, view angle, perspective, background color, etc. In addition, you can adjust the earthquake symbols (they start out a little big) by clicking **Visualize → Vector Points**.
- Make the window bigger to see all the options (drag right-bottom corner).
- To display the points properly, click on the "**3D Points**" button (instead of "display on surface(s)"
- Change the topography surface to transparent by clicking **Visualize → Raster surfaces**. Then, under the "current" raster name click on the "Surface attributes" pull-down menu, and select "Transparency". This will open up a window in which you click "New constant" and use a slider to find a good number (try ~50, then play around). Click accept (twice) and click "Draw current" in the very left-bottom to make the screen update (you may have to do this more often, since the monitor doesn't always update the graphics).



8. Save your visualization

- To save your work, select **File → Save Image as → TIFF IMAGE**
- This will open up a box where you enter a filename (yournameLab16.tif), and save to your Lab16 folder. Make a copy of this image and drop it in the **DropBox**