

LiDAR, DEM's and Landslides

Looking at landslides in the Greater Cincinnati (GC) and Northern Kentucky (NKY) area using DEM's in GIS



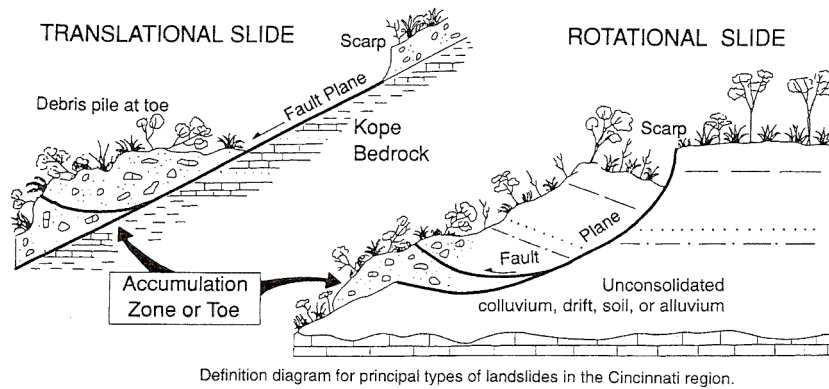
Part I: Introduction

1. LiDAR

- a) LiDAR allows for the creation of more accurate DEM's than previous technology
 - Increased resolving power due to increased return count using pulses of light (high wavelength) vs. pulses of radio waves (low wavelength)
 - Due to the extremely high number of point returns (some systems support up to $200,000s^{-1}$) even densely vegetated areas can be scanned to create accurate elevation data
 - It's also possible to sort the point returns by type (first return, last return, highest, lowest) to estimate other environmental variables such as vegetation density and average vegetation height
- b) LiDAR data is in high demand and it can be very expensive to fly
 - At the moment, the two most encompassing elevation data sets are
 - Shuttle Radar Topography Mission (SRTM) which covers from 56S to 60N (around 80% of the surface of the planet) at a resolution of 1 arc second (approximately 90m) (though data over the U.S. is available at an estimated resolution of 30m).
 - Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) which covers 99% of the surface of the planet which has a claimed resolution of 30m.
 - Many states have initiated projects to provide more accurate elevation models of their territory using LiDAR (Ohio, Pennsylvania, Kentucky is trying)

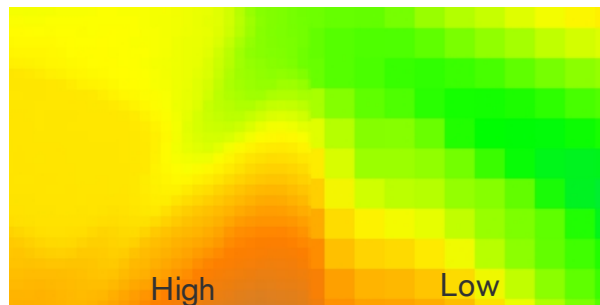
2. Common landslide types in GC/NKY

- a) Rotational
- b) Translational
- c) Block-extrusion



3. The ability to see landslides in a DEM depends on two primary factors:

- a) The size of the landslide and the features associated with the landslide
- b) The resolution of the data set (DEM) being used



4. Picking out features using topographic derivative maps

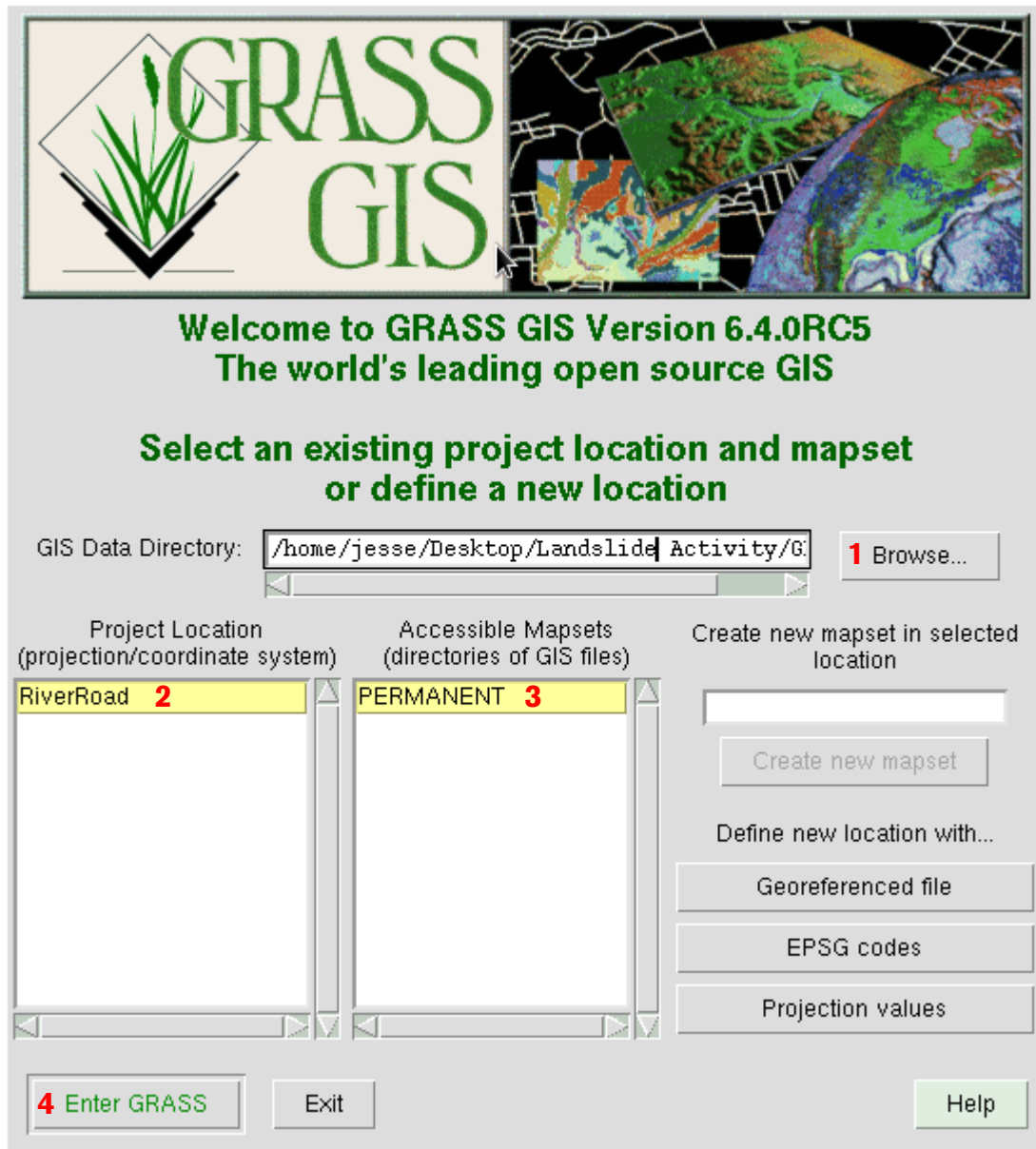
- a) A DEM represents elevation data, but it can be difficult to spot features using only a DEM. New data created using the original elevation data can aid in the identification of landslides.
 - Hillshades
 - Slope maps
 - Profiles
 - Contours
 - 3-dimensional visualization techniques


5. The use of GIS software packages facilitate GIS analysis

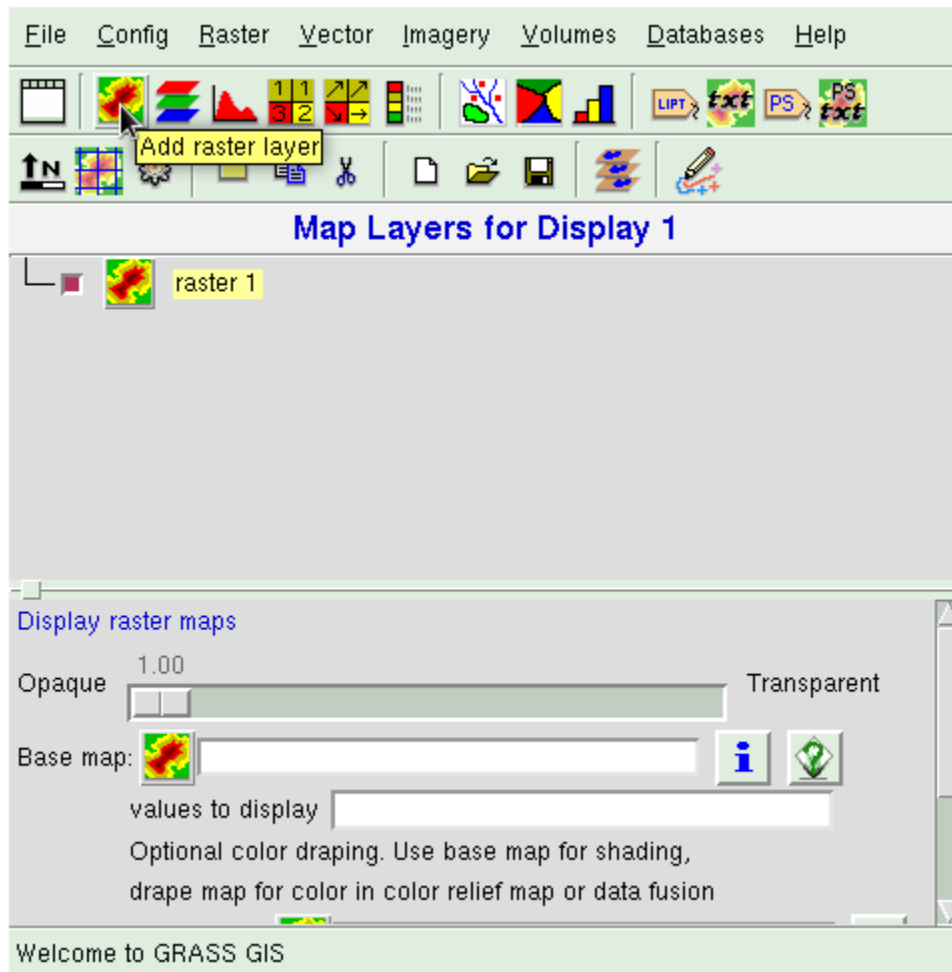
- a) GRASS, ESRI ArcSuite, LandSerf, Google Earth

Part II: Using GIS (GRASS)

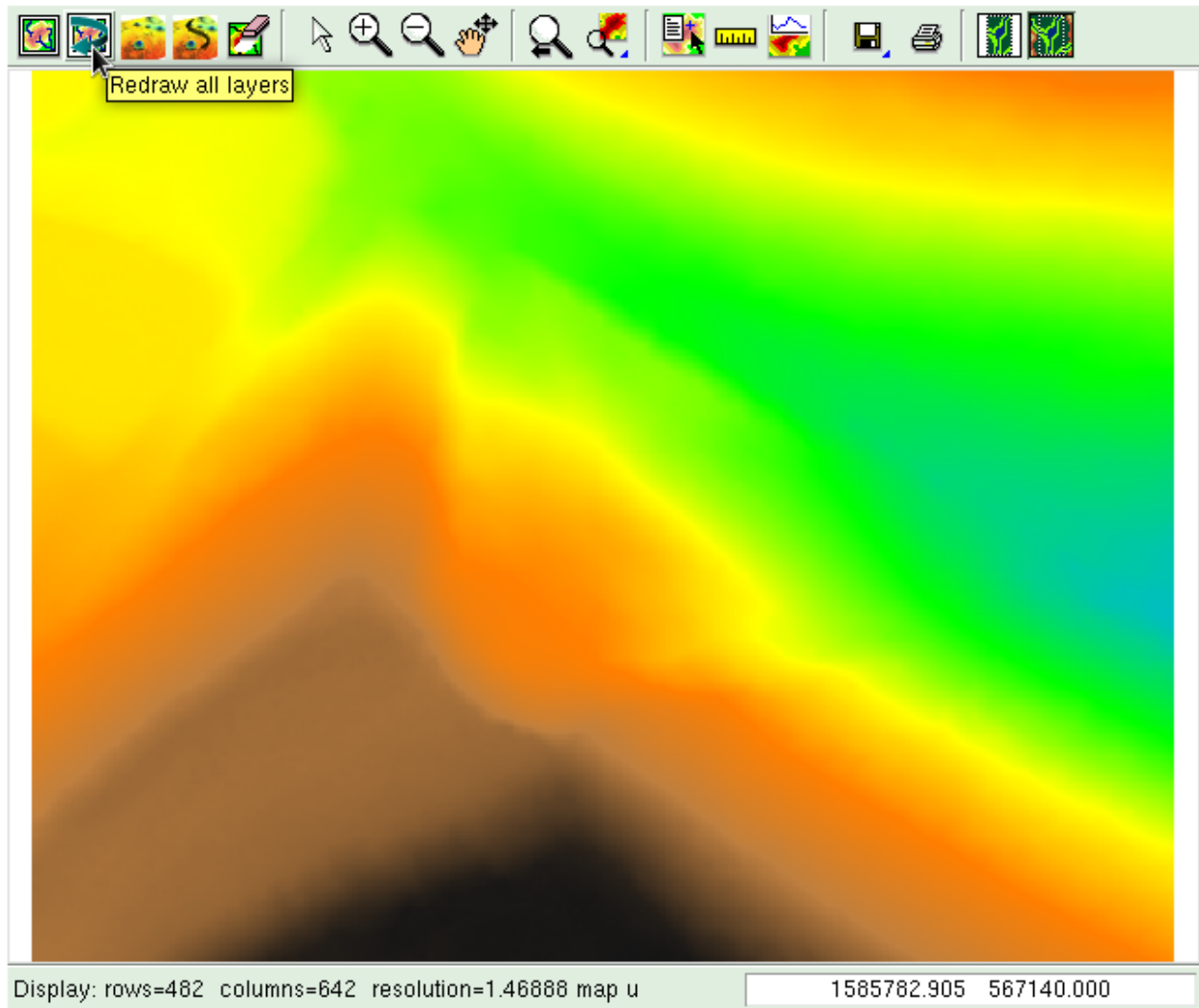
1. Set up a working environment in GRASS
 - a) Launch GRASS and click on the “Browse” button.
 - b) Browse to the folder that you extracted the provided zip to and make sure the “GRASS64” folder is selected and click “Open”. There should now be the “RiverRoad” project location and a “PERMANENT” mapset. Select both and then “Enter GRASS”.



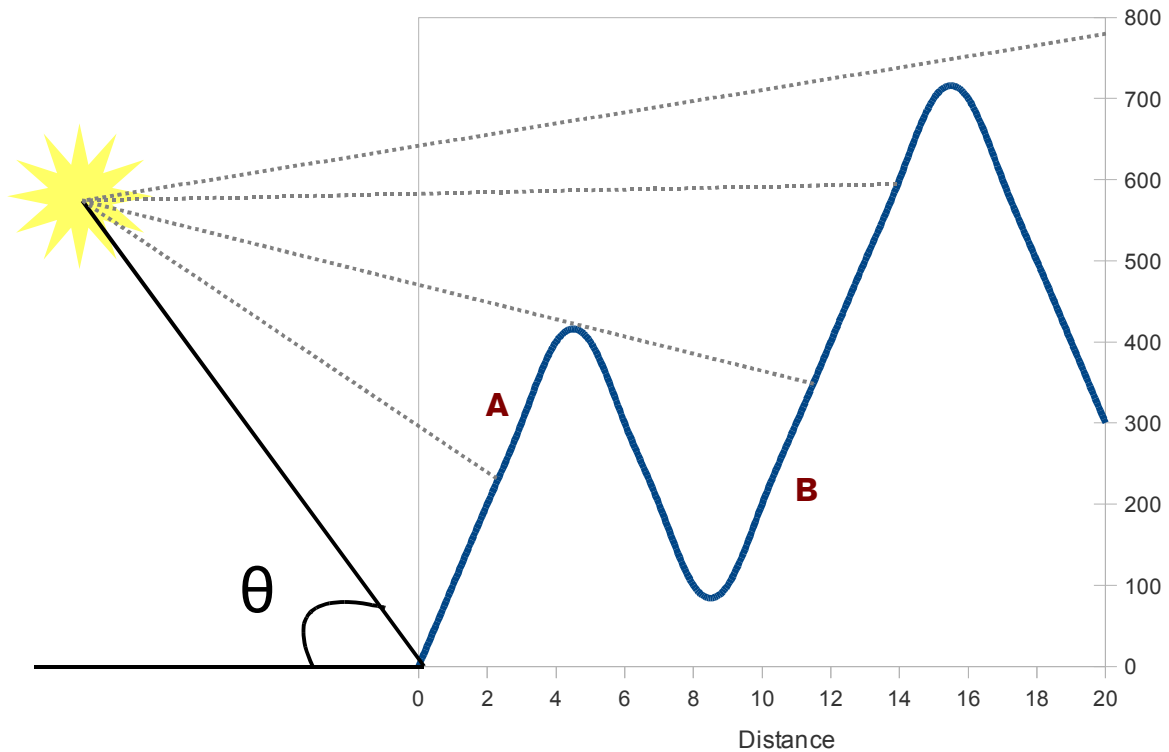
2. You should now be looking at the main GRASS interface which includes a Map Display, Output, and Control/Layers window.
3. Add a new raster layer by clicking on  the icon second to the left on the first row.



4. Add a Base map to this raster layer by clicking on the raster icon to the right of the text "Base map" and selecting "RR_lidar" as the raster source. At this point, it should rename the layer to "RR_Lidar@PERMANENT". Navigate to the map display window and click on the "Redraw all layers" button which is the second from the left. The data should appear on the screen.

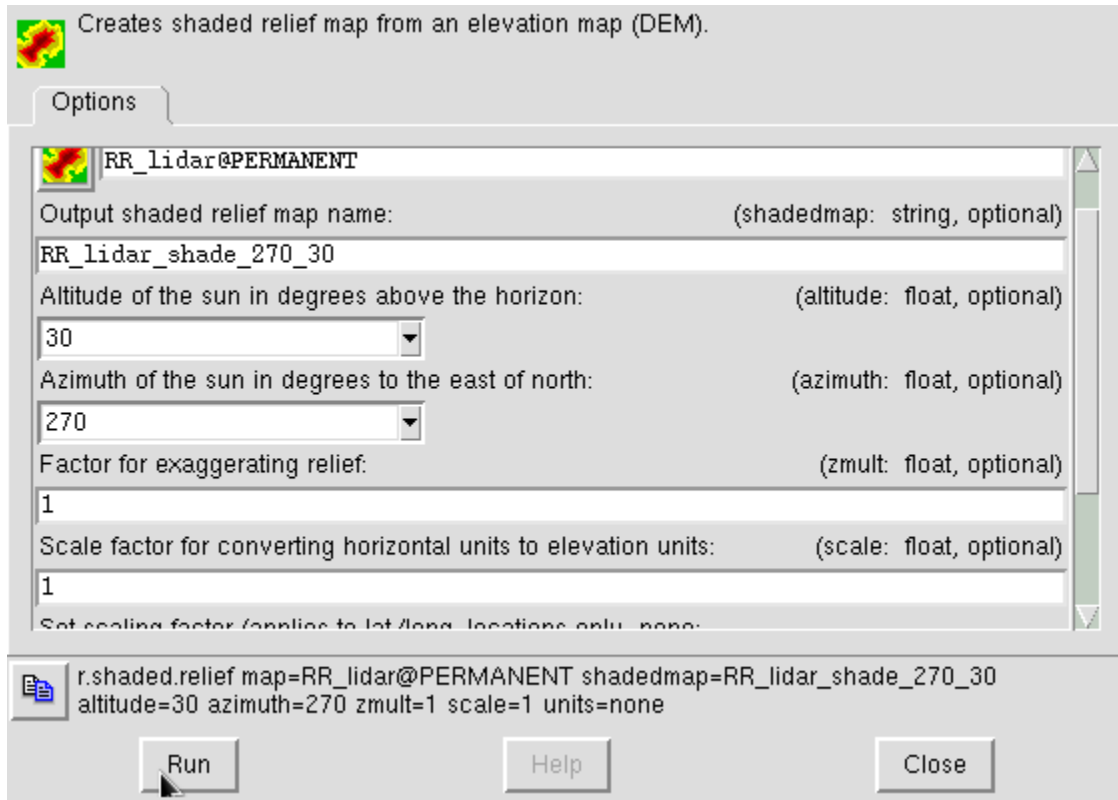



5. This landslide is particularly well-defined, but we would like to enhance its visibility. Hillshades are commonly generated and draped over DEM's to create a 3-dimensional effect. By lightening or darkening areas on the DEM based on a user-defined azimuth and sun angle it is possible to generate a shaded map.

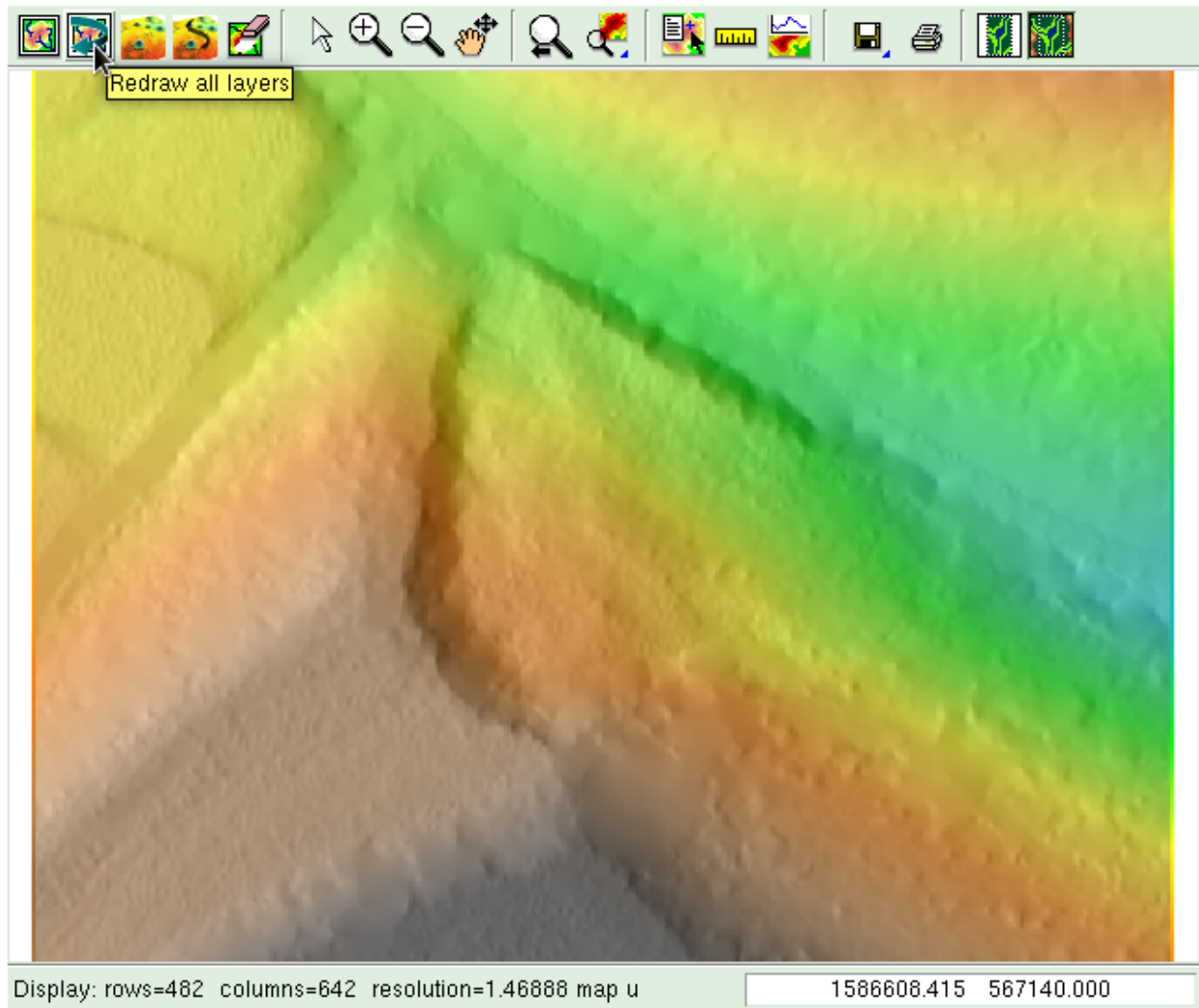


The above diagram is an example of how a hillshade operation determines the shading of features based on a sun angle (θ). At point A the topography is lightened by the sunlight, but at point B it is blocked and the region is darkened.

6. To create a hillshade layer, navigate to the control/layers window and click on “Raster > Terrain Analysis > Shaded Relief”.
 - a) Select the RR_lidar layer as the input elevation map.
 - b) Name the output shaded relief map RR_lidar_shade_270_30
 - c) You can leave the other options alone and just click “Run”.
 - Optional: You can experiment by changing the Azimuth and sun angle fields

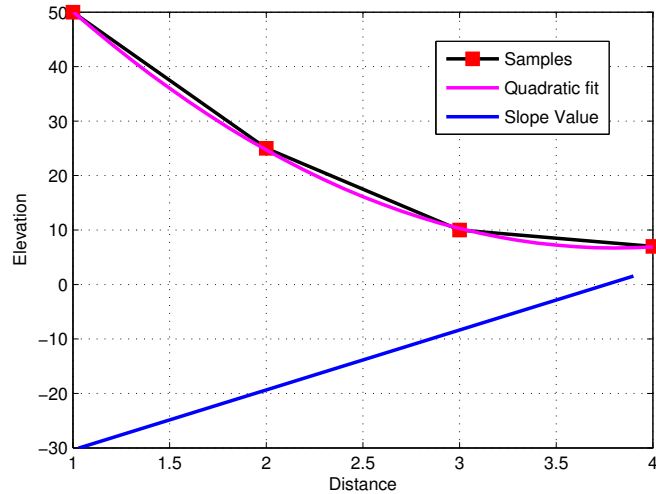


7. To display this new layer, go to the controls/layers window and add another raster layer  above the RR_lidar layer (refer to step #3). Choose the RR_lidar_shade_270_30 map as the base map. When you refresh the map display (refer to step #4) it should display the hillshade.
 - a) Viewing the hillshade by itself is useful, but it can also be useful to drape it over the topography. Select the RR_lidar_shade_270_30 layer in the controls/layers window and adjust it's Opacity/Transparency to 0.50. Refresh the map display window.



8. Another useful topographic derivative map is the slope map. By approximating the slope at varying points on the map, a new raster map can be generated which indicates the slope angle continuously across the study area.
- a) Question: How do you think the scarp will differ from the surrounding area on the slope map?

The diagram to the right shows some theoretical elevation samples from a DEM, a second order polynomial regression to approximate slope at locations between the samples, and the value of the slope at each location. The slope tool in GRASS uses similar methods to generate the resulting slope map.




9. To create a slope map click on “Raster > Terrain Analysis > Slope and Aspect”. Select RR_lidar as the elevation raster map and type in “RR_slope” for the name of the output slope raster map. No other options are necessary. Click the “Run” button.

Generates raster map layers of slope, aspect, curvatures and partial derivatives from a raster map layer of true elevation values. Aspect is calculated counterclockwise from east.

Options Settings Advanced

Quiet

Name of elevation raster map: (elevation: name, required)

 RR_lidar@PERMANENT


Name for output slope raster map: (slope: string, optional)

RR_slope


Name for output aspect raster map: (aspect: string, optional)


Allow overwrite

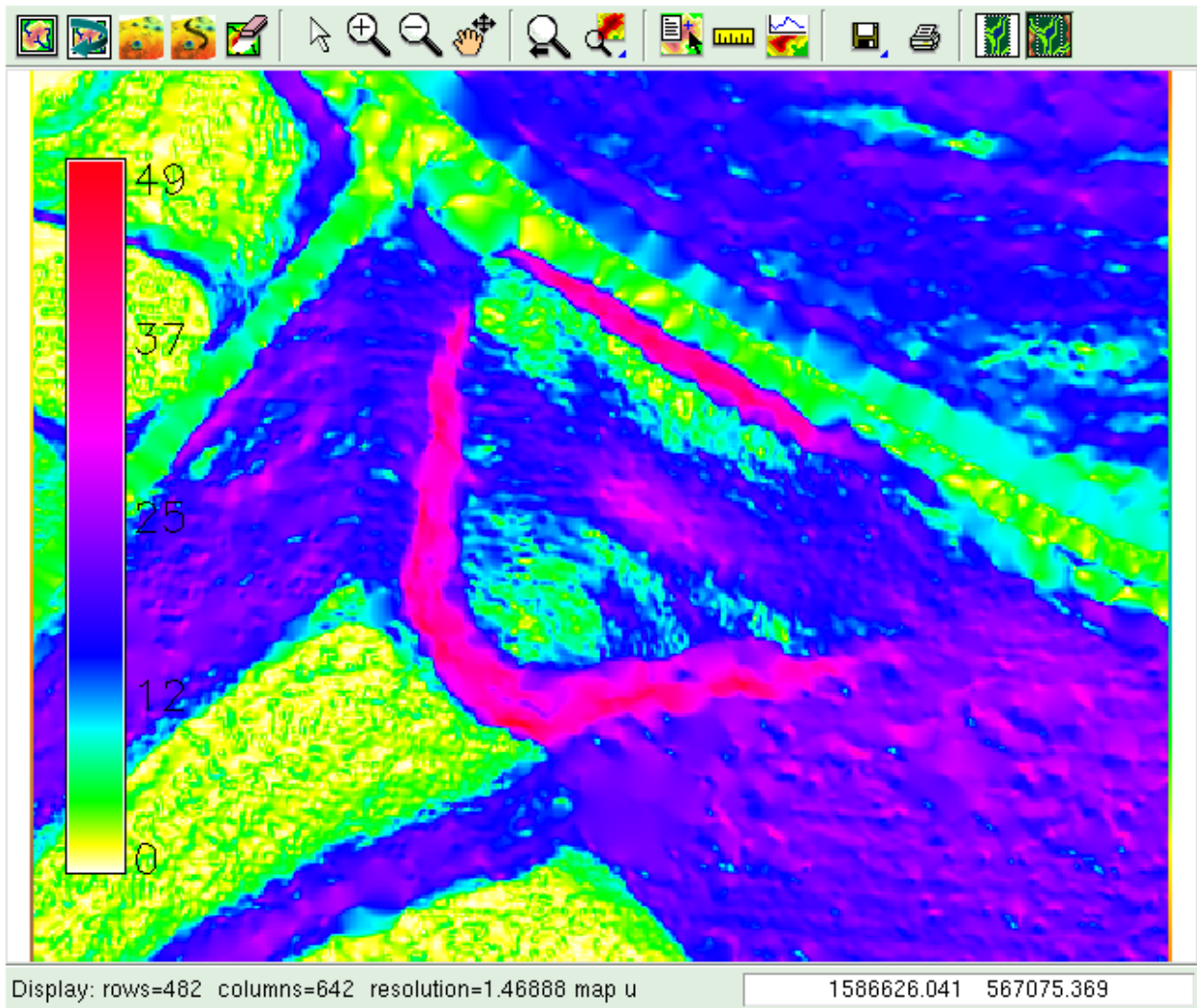
Run quietly

 r.slope.aspect elevation=RR_lidar@PERMANENT slope=RR_slope format=degrees prec=float zfactor=1.0 min_slp_allowed=0.0

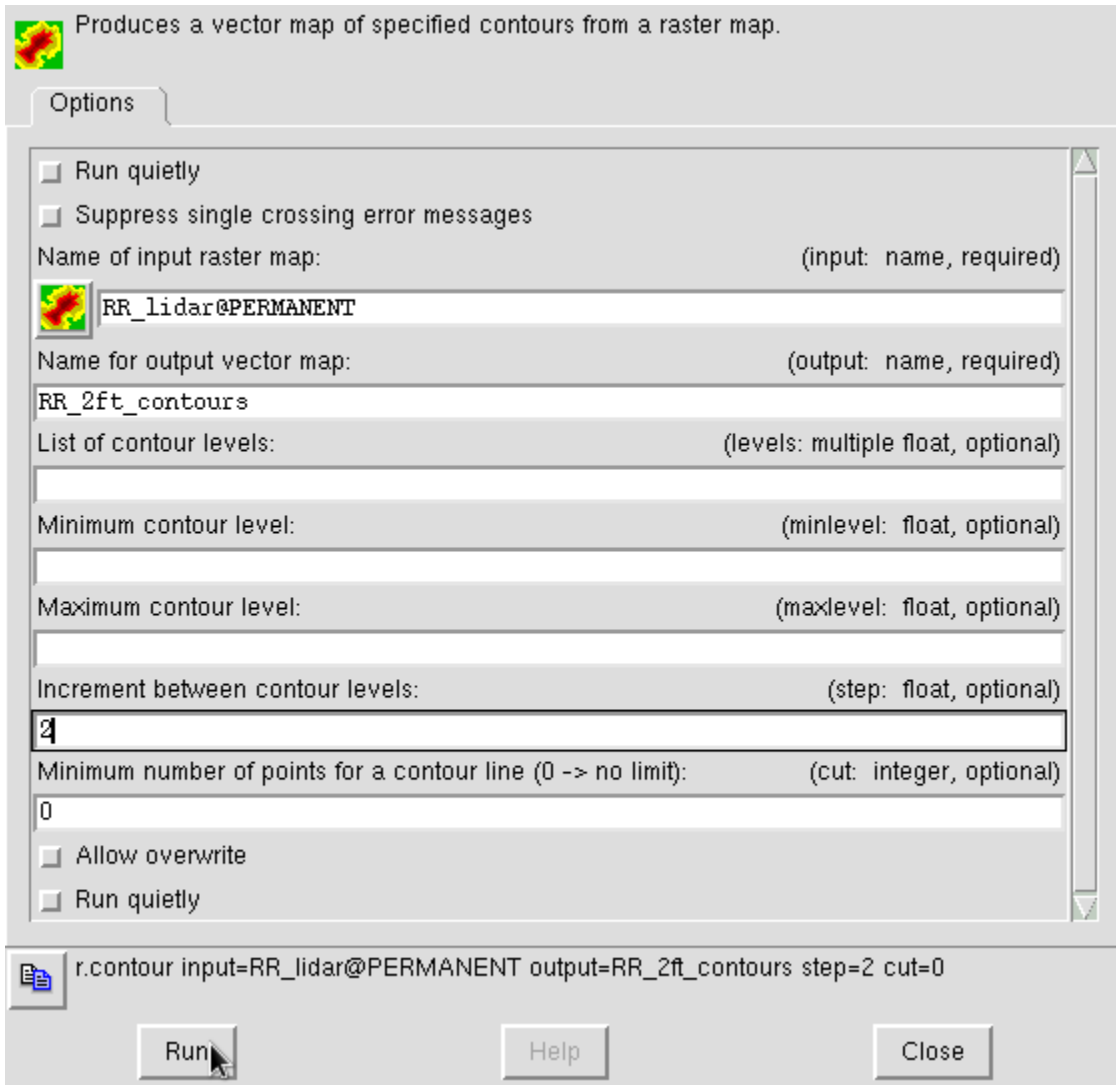
Run Help Close


10. Add a new raster layer  and choose RR_slope as the base map for it. Refresh the map display window.

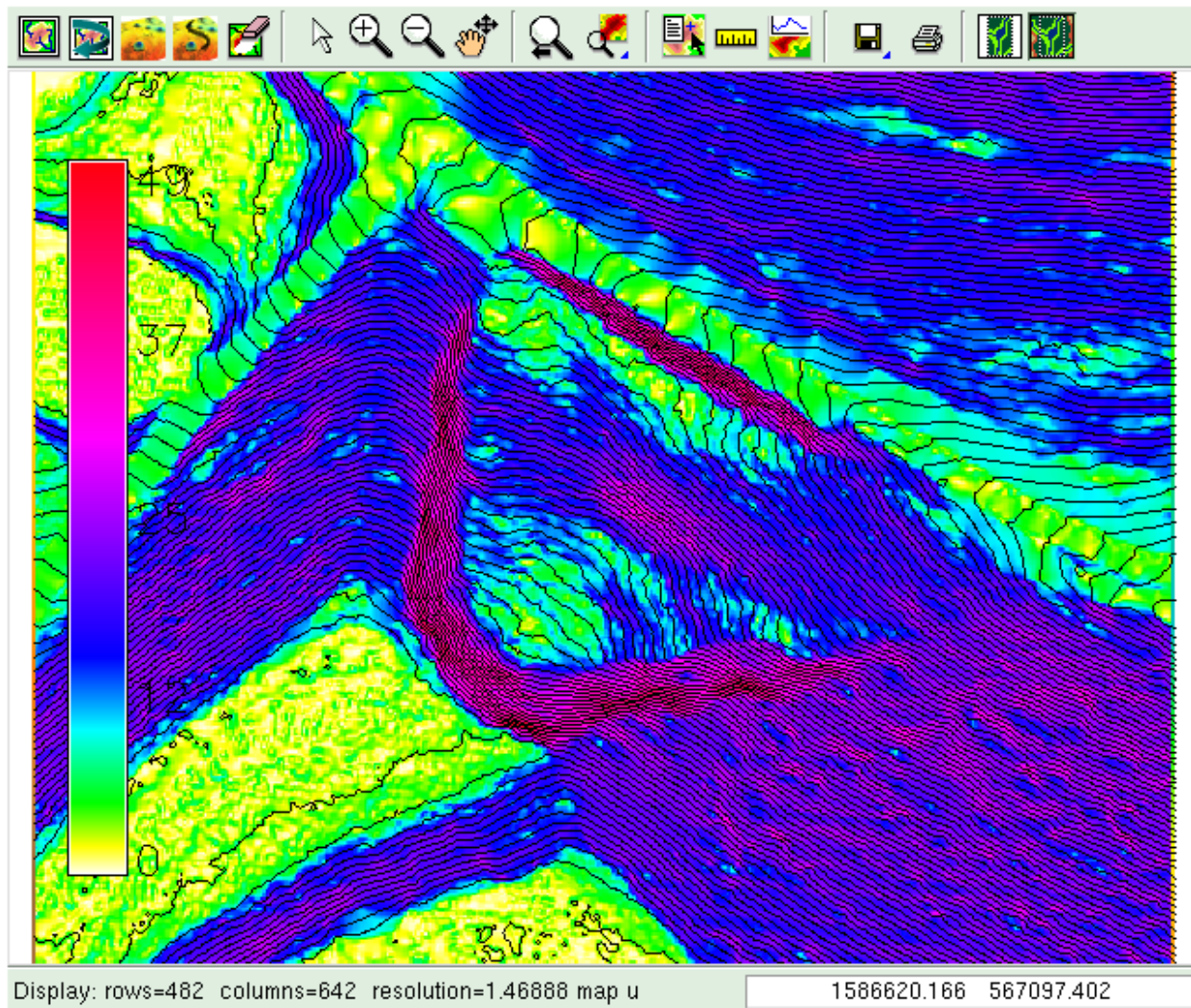
- a) To get a better idea of what the slope map is showing, add a new raster legend layer by clicking on the “Add raster legend layer”  button which is the 8th button from the left on the top row of buttons in the controls/layers window. Choose “RR_slope” as the Raster map for the scale. Refresh the map display window.




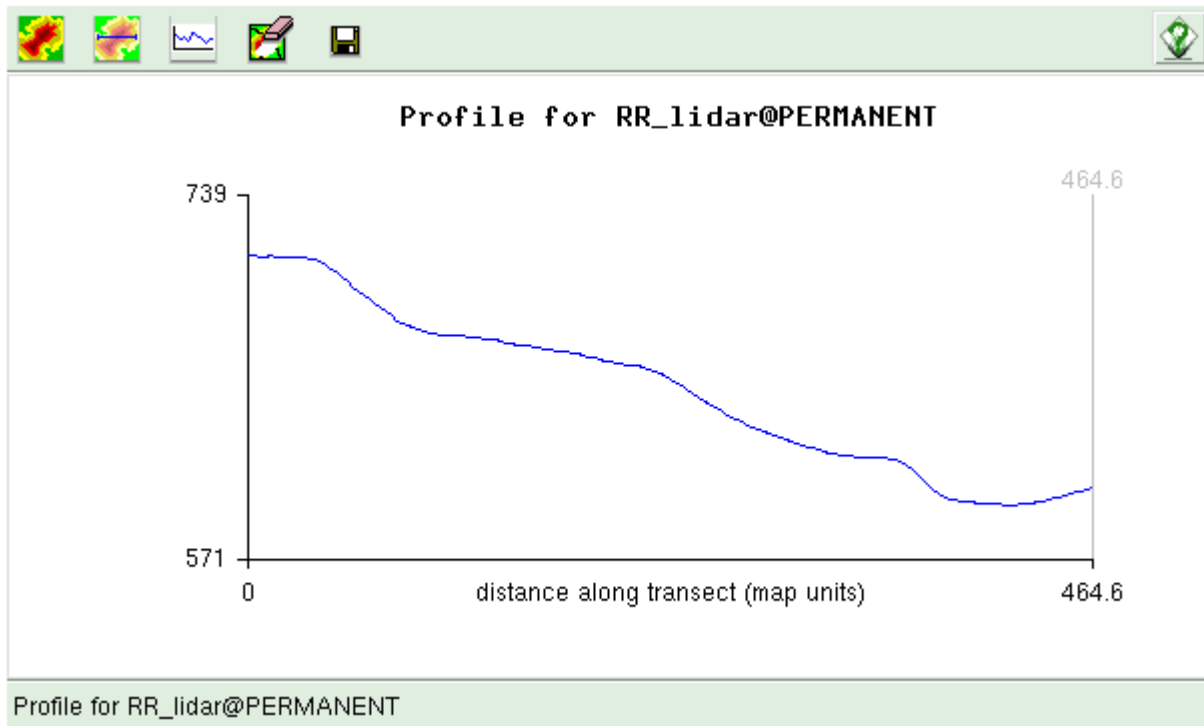
11. Elevation contours can also be useful when inspecting the geomorphology of an area. To create contours, go to the controls/layers window and click on “Raster > Contour Lines”. Choose RR_lidar as the input raster map, RR_2ft_contours as the output raster map name, and type in “2” for the increment between contour levels. Click run.




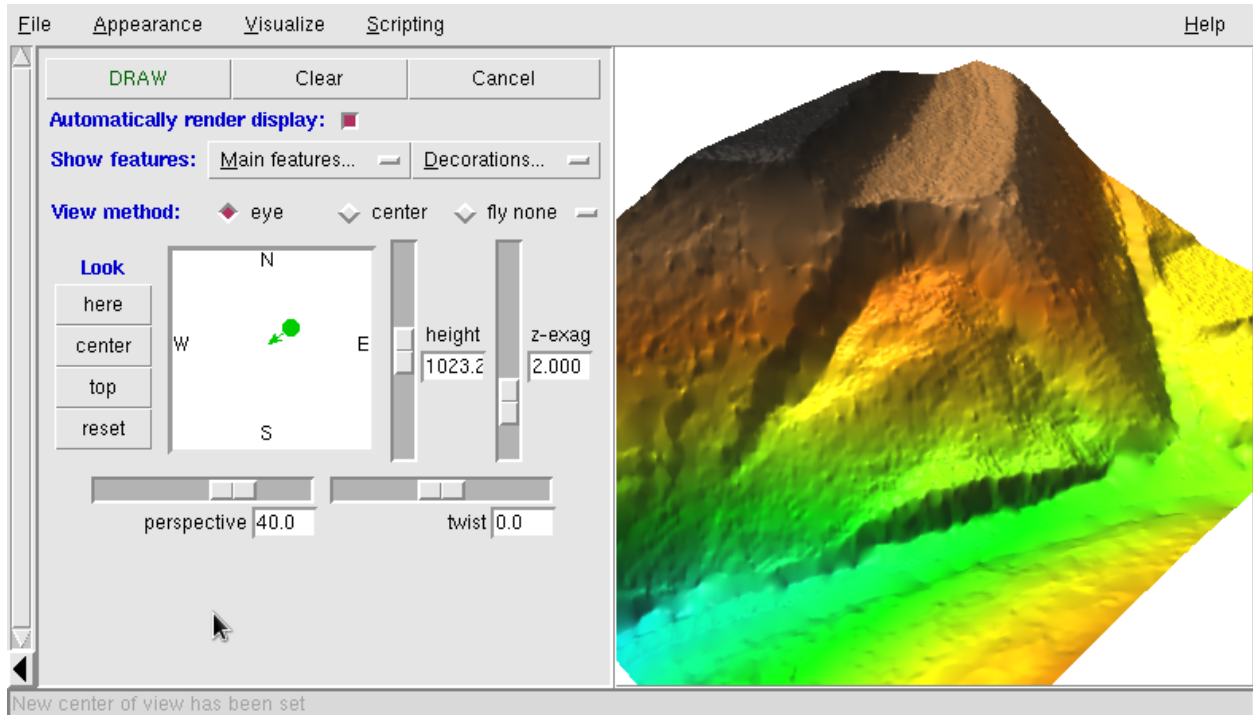
12. Go to the controls/layers window and add a new vector layer . It is the button to the immediate right of the add raster legend layer button. Choose the RR_2ft_contours vector map as the base map. Make sure the raster legend layer is above the contour layer. Refresh the display.



13. GRASS can also generate topographic profiles automatically. In the map display window, click on the “Create profile of raster map” button  . Click on the raster button to the far left and select RR_lidar as the base map. Then click on the second button from the left. In the map display window, you can now click, hold, and drag to a new location. Have GRASS draw a transect from above the head scarp to just behind the road near the toe.



14. Optional: It is also possible to visualize elevation data in a 3-dimensional exploration tool called NVIZ. The controls for the tool are sometimes difficult to come to terms with, but it can help in visualizing the terrain. In the controls/layers window, disable all the layers except the RR_lidar layer, then click on the NVIZ button in the map display window . It's the third from the left. There are a lot of options to play with in NVIZ.



Part III: Landslide analysis

Using the analysis techniques that were covered in the second part of this activity, it is now your responsibility to further characterize the River Road landslide and delineate landslides at a new location. The new location data set is called "Unknown".

The Unknown data set has an existing workspace associated with it that will help get you started. To load this workspace, click on File in the controls/layers window and browse to the GRASS64 directory where you extracted the lab files and open "Unknown.grc".

When working with the Unknown data set, operations performed on the entire region may take up to 30 seconds to complete so be patient when performing them.

Questions for the River Road landslide

1. Using Google Earth, go to 39.0559881992, -84.4411951076 and look at the River Road landslide. Why do you think this landslide can be easily seen using aerial imagery?

2. At the same location as in question #1, rotate the view in three dimensions (x, y, z). Why do you think Google Earth does not show any indication of the head scarp of this landslide?





3. Earlier, we created a hillshade at an azimuth of 270° (due west) with a sun angle of 30° for the River Road landslide. Create at least three more hillshades with sun angles of 30°. Create a hillshade with light coming from the north (0°/360°), east (90°) and south (180°). Which one of these azimuths provides the best view of the landslide? Explain why this is the case.

4. Approximate the length and width of the River Road landslide using tools within GRASS. (Hint: 1 map unit = 1 foot)

5. Estimate the height of the scarp of the River Road landslide. (there are multiple ways of doing this)

6. What type of landslide does the River Road landslide appear to be? Cite evidence to support your claim.

Exploring an unknown area

1. For the Unknown location in GRASS, enable the imagery layer to get an aerial photograph of the region. You can use the Zoom In , Zoom Out , and Pan  buttons to explore the image. To set the view back to the default, click on  and then “zoom display to selected map”. Can you see any landslides on the image? If so, describe their morphology and general location (sketch, make a mental note).

2. Using the techniques from the second part of the assignment, see if you can more confidently delineate any landslides in the region.

3. You may have noticed that the elevation data for this location looks slightly different than the elevation data from the River Road landslide. Particularly, what are the triangles and why are they present in this data? Why do you suppose some areas have more triangles than others?