3D Archaeology Summer School
Durham 17-19th June 2010

Using QGIS and GRASS for Processing and Analysing Lidar Data

Lab Session 1

Lab Session 2

Course Materials designed by Rebecca Bennett June 2010

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Using QGIS and GRASS for Processing and Analysing Lidar Data

Lab 1 – 14.00 – 16.00

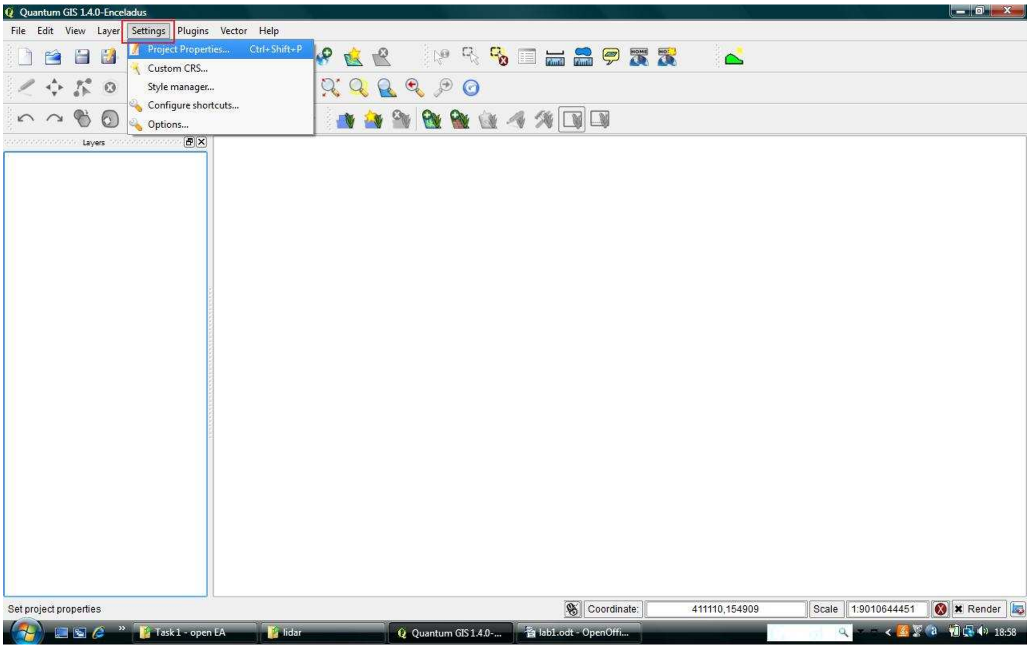
The aim of this lab is familiarise yourself with both QGIS and the GRASS plugin. In this session you will undertake the following tasks:

- view ArcGIS ascii raster files in QGIS
- edit the properties of a raster in QGIS
- create a vector file in QGIS
- edit a vector file in QGIS
- set up a location with the GRASS plugin
- import a vector file using the GRASS plugin
- import an ArcGIS file using the GRASS plugin
- set a region of interest using the GRASS plugin
- create a hillshaded model of the lidar raster using the GRASS plugin
- digitise features identified in the lidar model to a shapefile

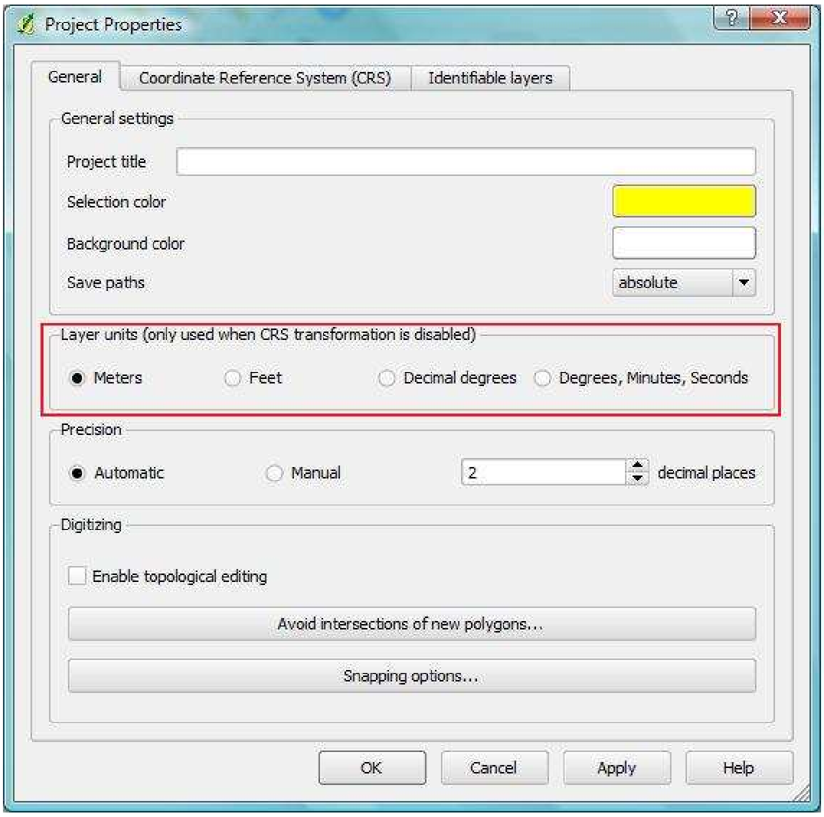
Each of these tasks stand alone as useful GIS tools but together they provide a workflow for visualising lidar raster data and recording the features from it. Illustrations in this booklet show the icons on screen for each task. The full menu options are included as follows: File > Open.

Task 1 – Opening ArcGIS ascii raster files in QGIS and editing their properties

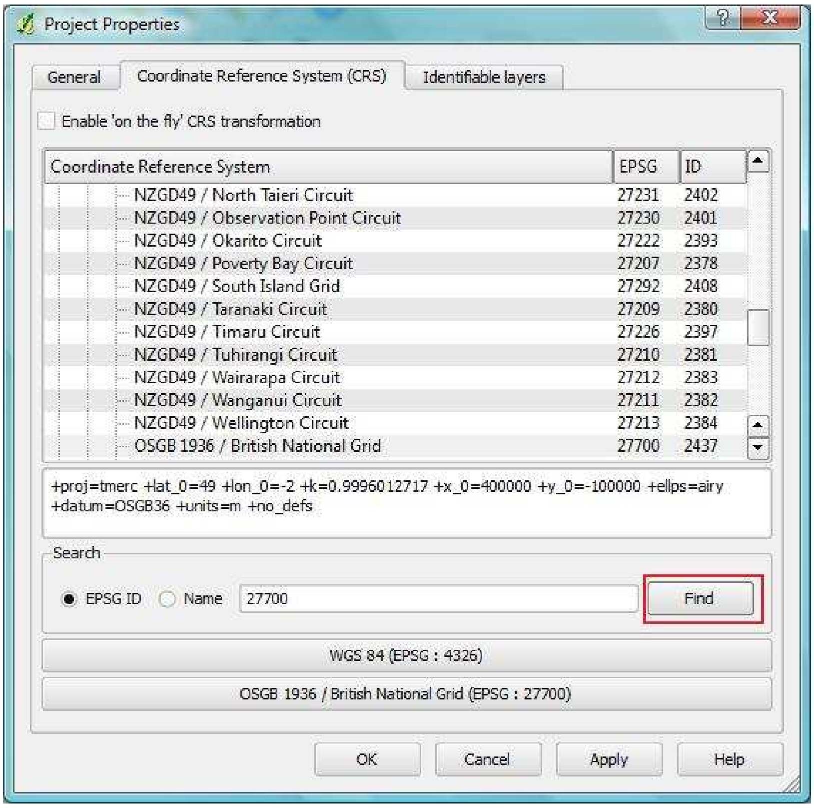
1. Start QGIS. The first task will be to set the project properties and save the project.
2. From the settings menu select Project Properties



3. To set the units in the General tab of the Project Properties box select metres and click apply

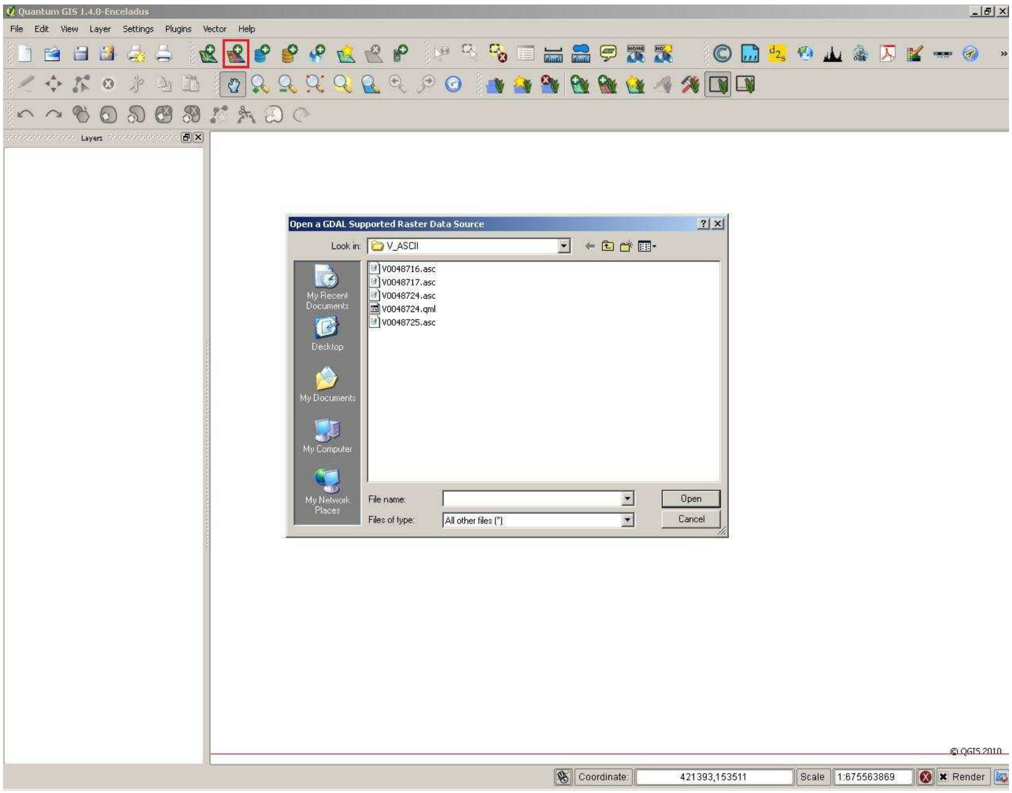


4. To set the coordinate reference system (CRS) click on the CRS tab. Search through the list for OSGB 1936. A quick way to do this is to type in the EPSG ID code 27700 and click find. Click apply to set the CRS.

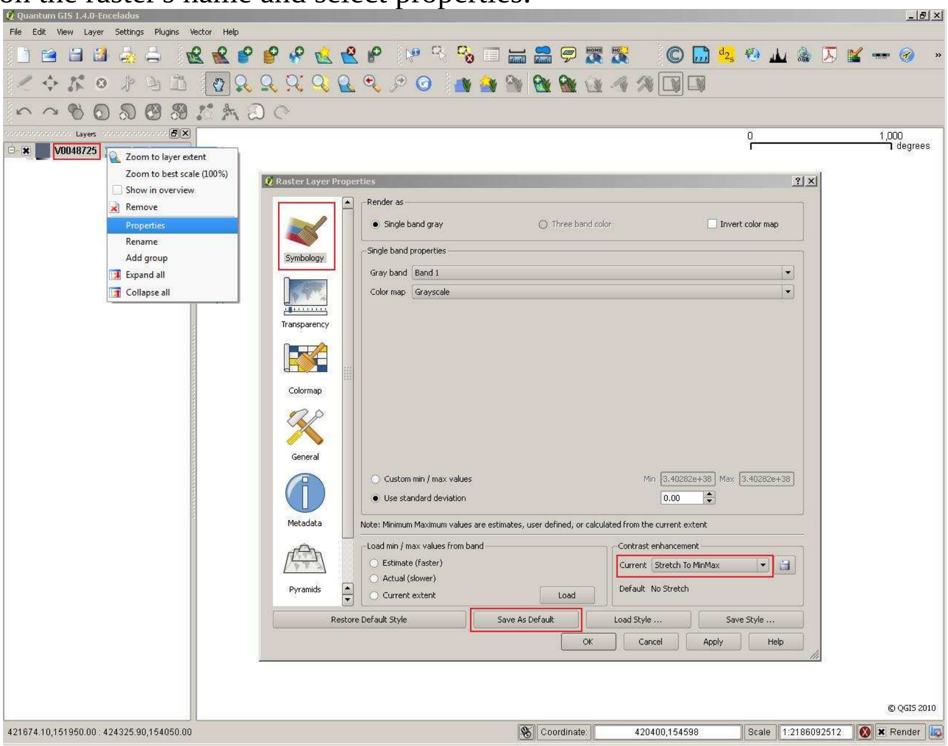


5. Click OK to close Project Properties and return to the main screen.

6. Use File>save to save the project
7. Next we will open an ArcGIS ascii raster using the tool bar icon (layer > add raster layer). Be sure to select the correct file type from the drop down menu.

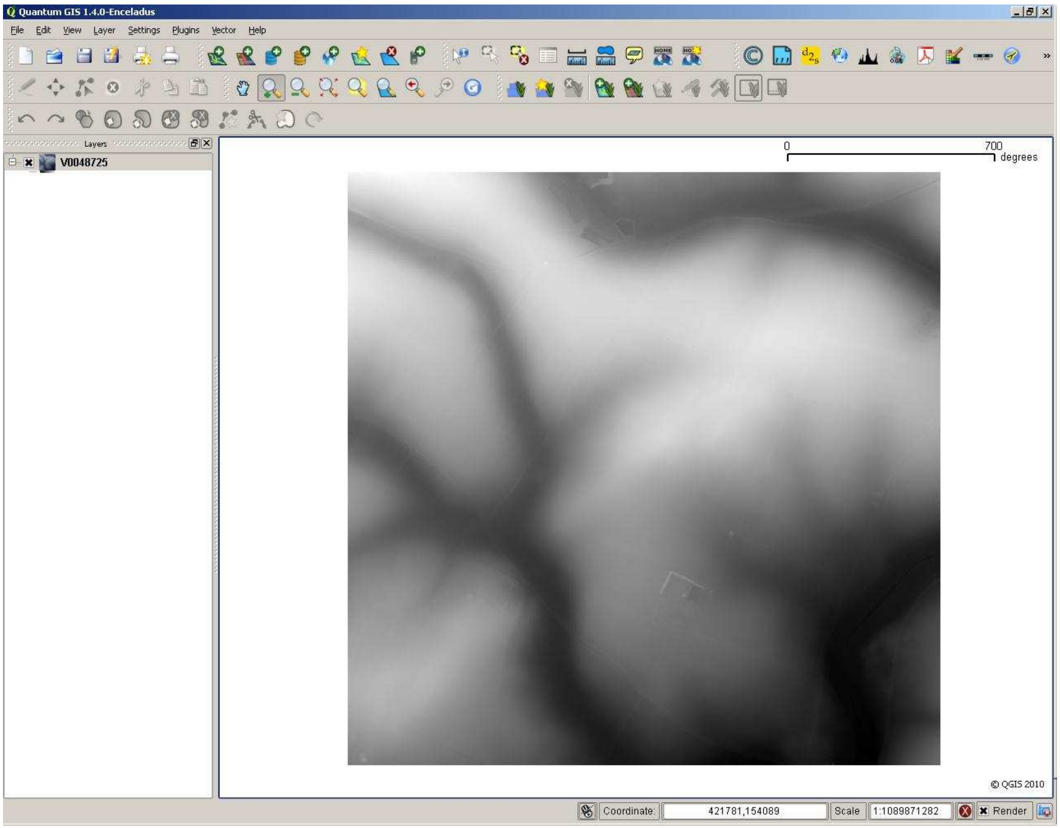


8. To improve the raster display we will now edit the raster properties. In the menu bar, right click on the raster's name and select properties.



9. Edit the symbology so that the image is stretched to min and max values. This preference

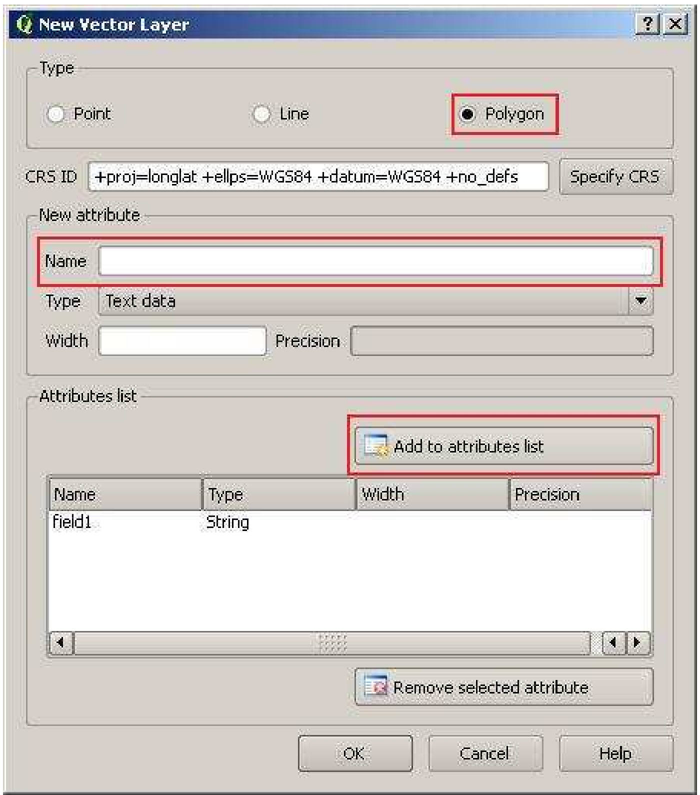
can be saved as the default for the file. The raster display should now resemble the image below.



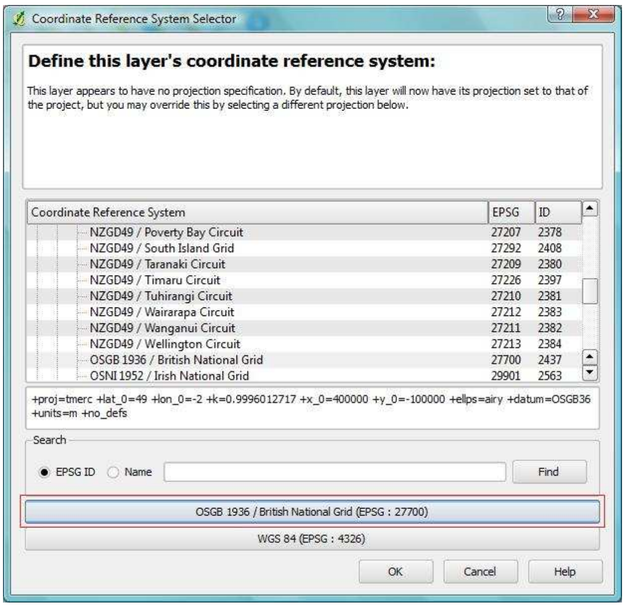
10. Return to the properties menu. In this menu can be found a variety of options for colouring the map, editing transparency and viewing metadata. Take some time to familiarise yourself with these options.
11. Repeat the steps above for the other three rasters until you have four displayed on screen. Don't forget to save your project!

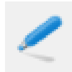
Task 2 – Creating a vector file in QGIS

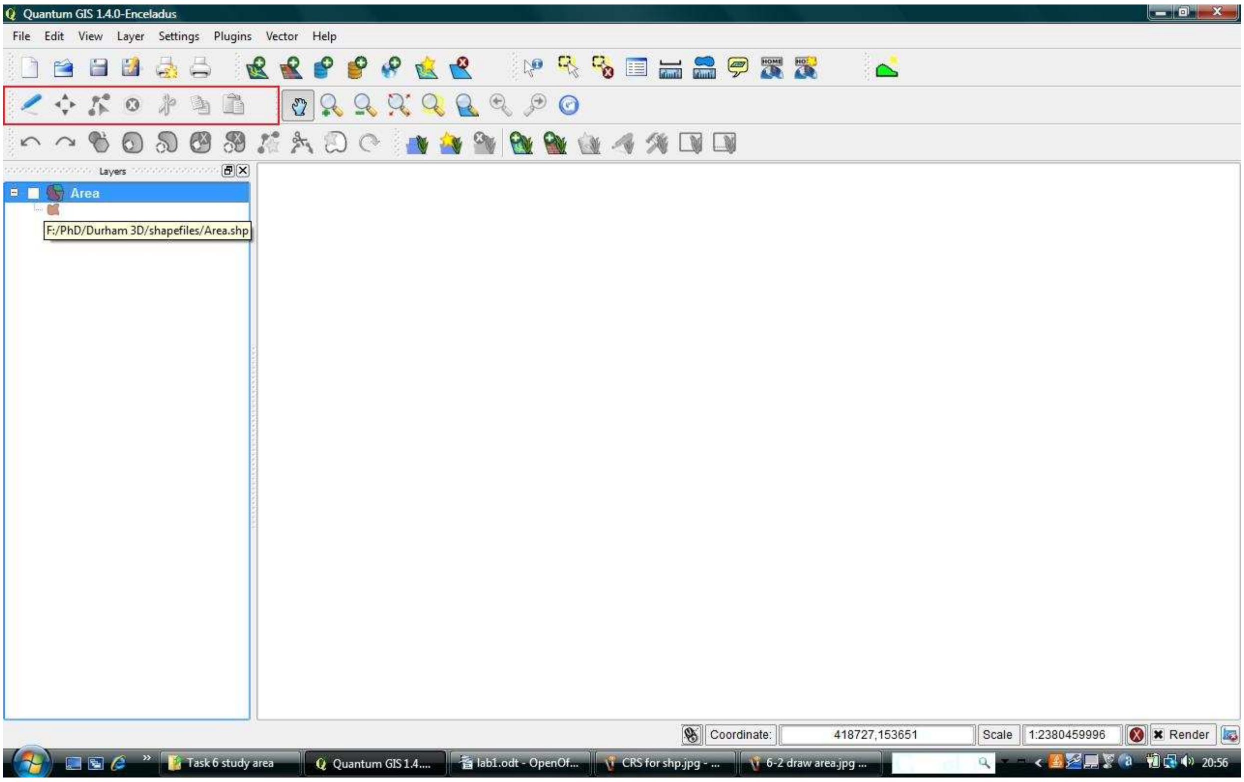
1. For this task you are going to create a shapefile in QGIS that provides a boundary for the area covered by the lidar rasters. From the toolbar select the create new vector layer icon to open the box below

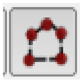


2. Select the type of file you want to create (point / line / polygon). We want to define an area so a polygon will be most appropriate.
3. Specify the CRS (OSGB as in Task 1). Notice that the CRS is available for quick selection

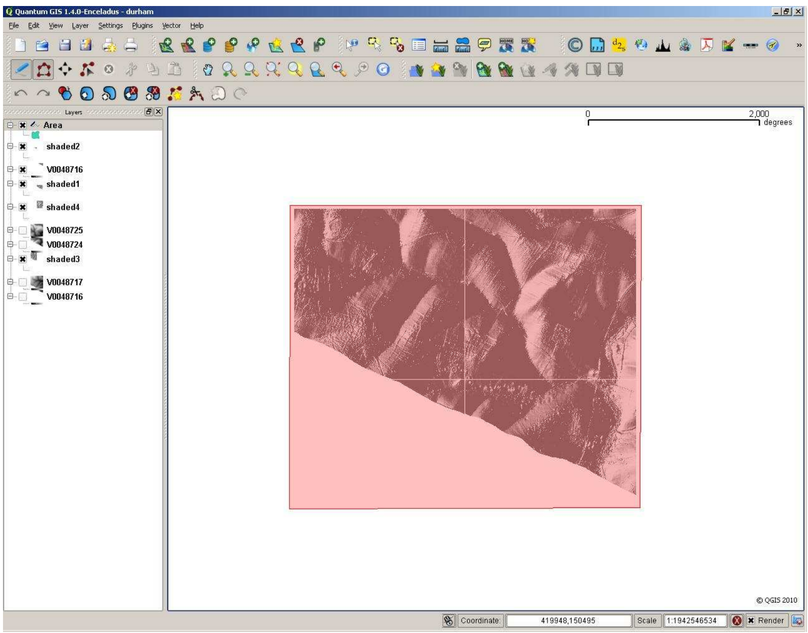


4. Add the attribute fields you want in the new attribute section. In this case we will make a text field call it "field1". Click add to attributes list to save the attribute field
5. Choose a name and location for the shapefile. Click OK to create the shapefile. It will automatically be added to the navigation menu on the left of your screen.
6. To edit the shapefile highlight its name in the menu and click on the Toggle Edit icon  in the toolbar.

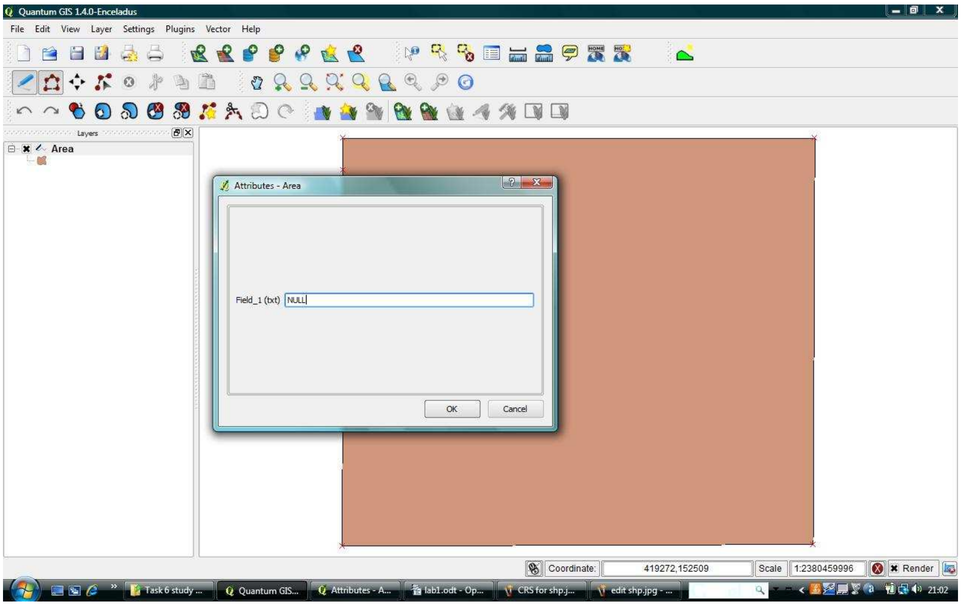


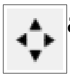
7. Select the draw polygon tool 

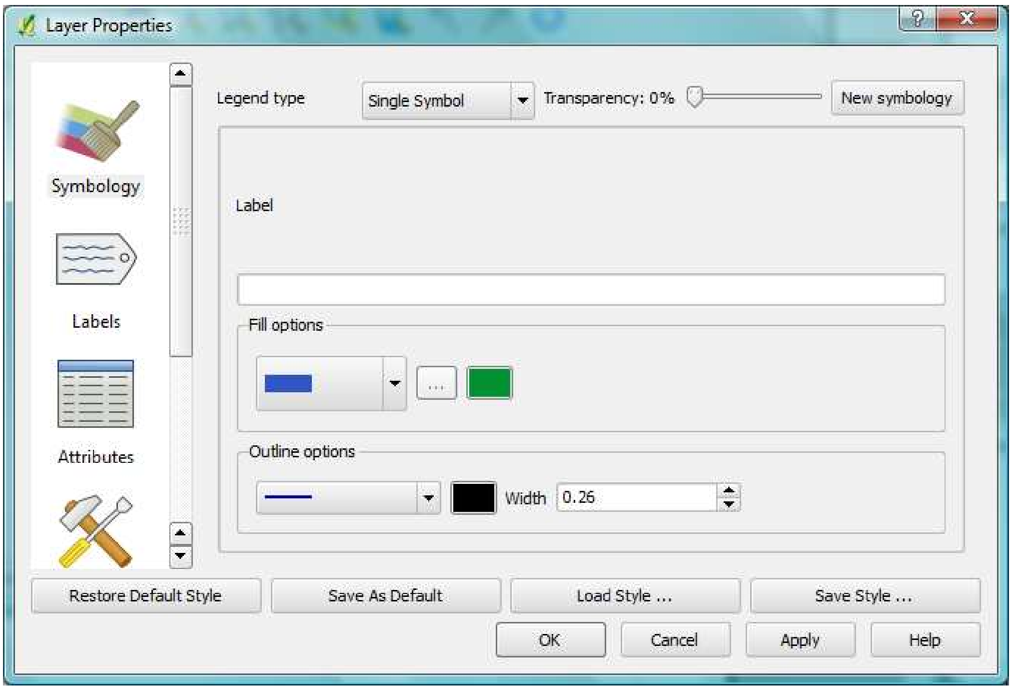
8. Draw your study area around the four lidar tiles, right click to finish the square.



9. You will be given the option to record attribute data for Field1.



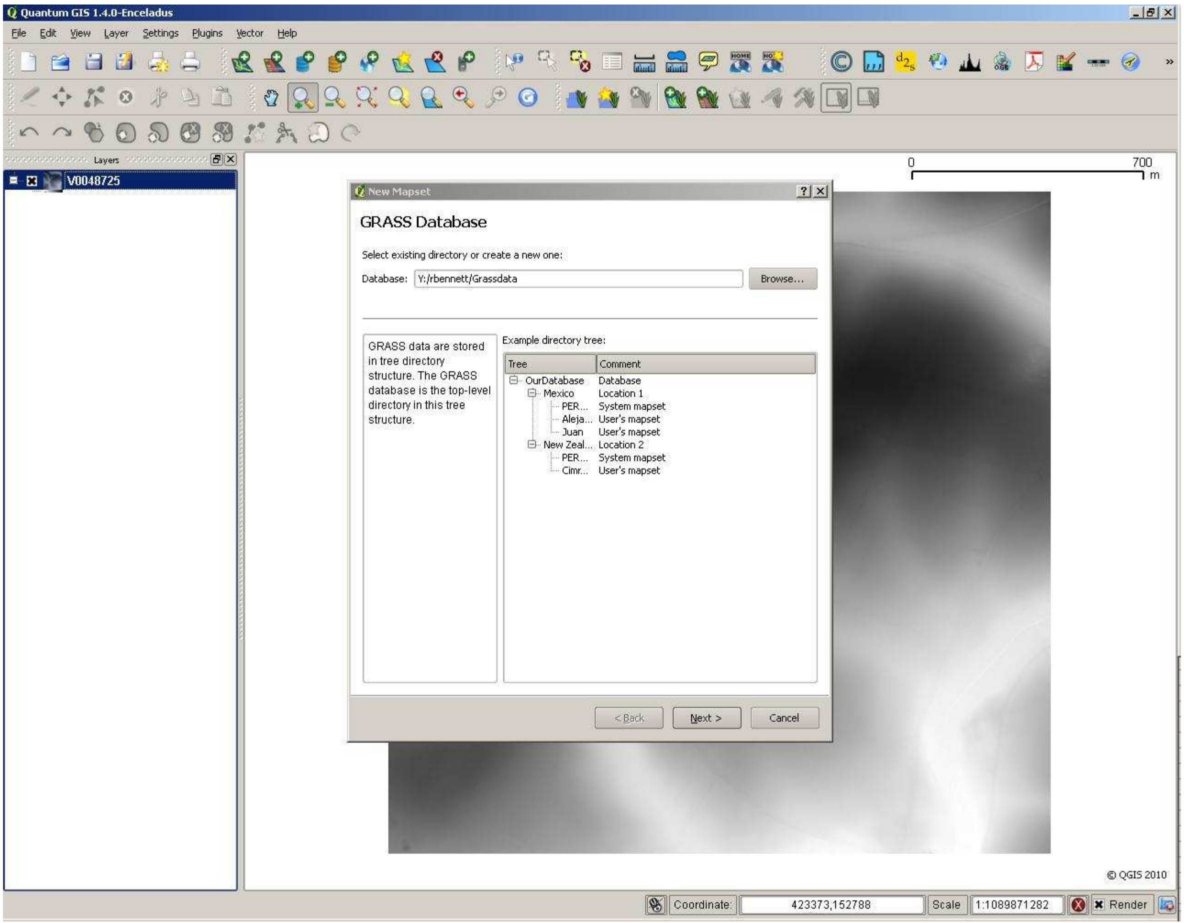
10. Click on the Toggle Edit icon again to finish drawing and save your edits.
11. Make the vector file editable again and experiment with moving the area using the move feature icon  and editing the nodes using the node tool 
12. Save your edits, making sure that the area still represents the coverage of the lidar rasters.
13. By right clicking on the name of the file in the navigation bar and selecting Properties you can edit the symbology. Experiment with different display options.



Task 3 – Creating a GRASS location

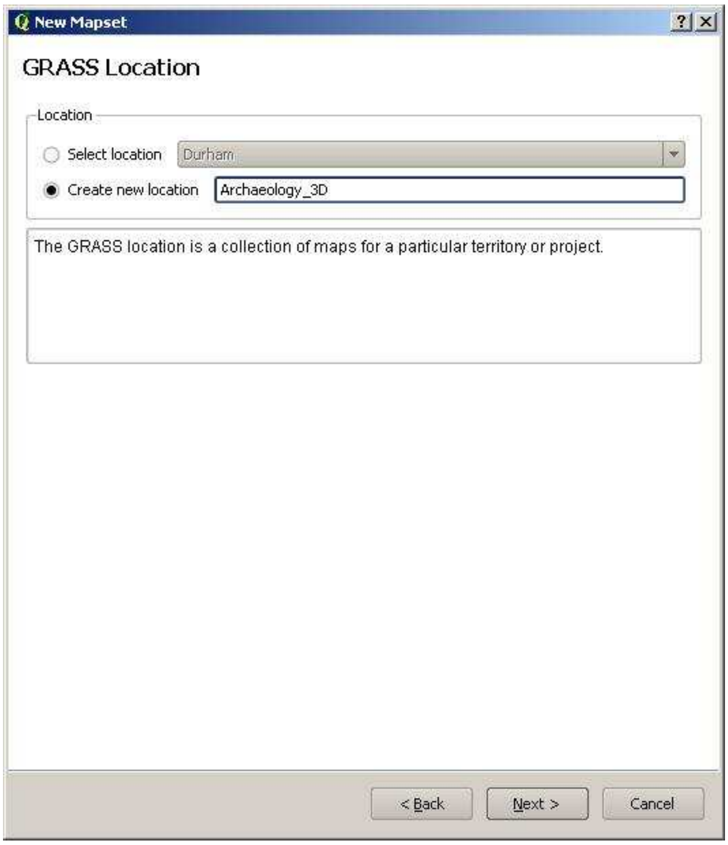
1. To create a hillshade from the rasters in QGIS requires use of the GRASS plugin. The toolbar is shown below.

2. The first step is to create Location, which is essentially a directory in which GRASS will store the files you will make. The structure of this directory is very important and can be fiddly to get right in GRASS itself – the QGIS plugin makes the process of establishing a location much easier. Click on the Create new mapset icon  to open the box below

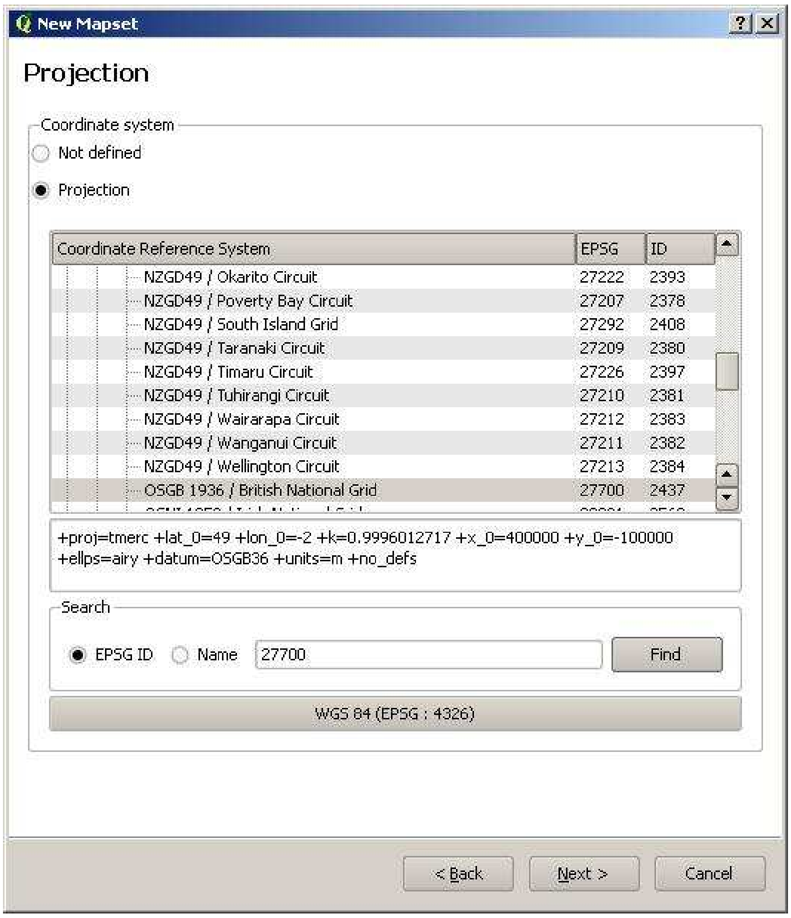


3. Browse to a directory in which to store your data. When using for the first time you should create a directory called "grassdata" to keep all your GRASS locations in. Click next.

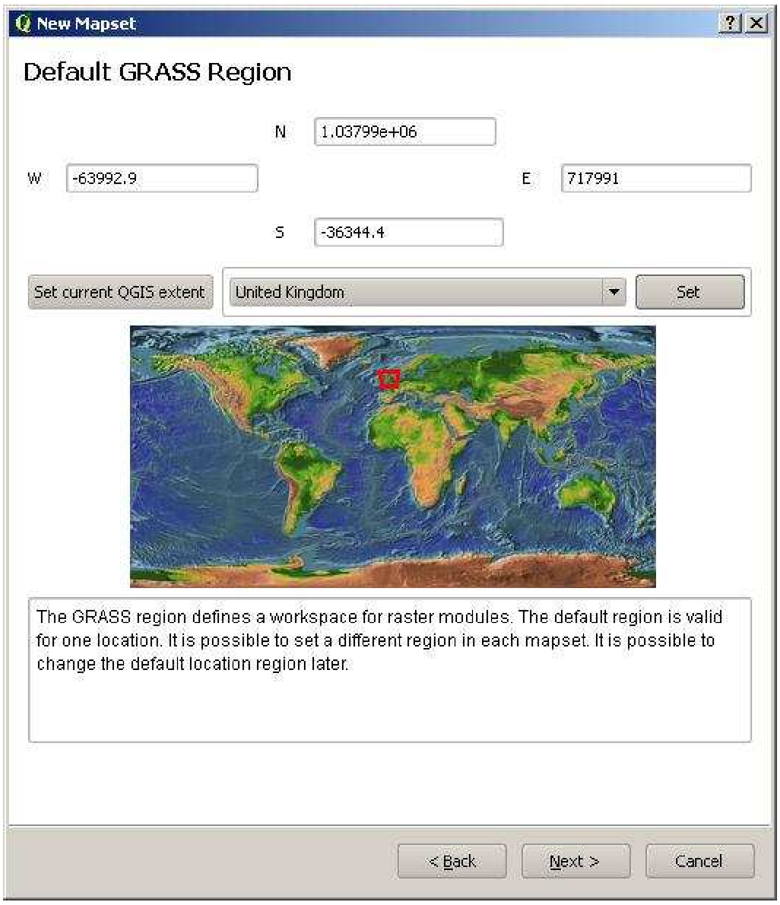
4. Create a new location or project directory, name it (with no spaces) and click next



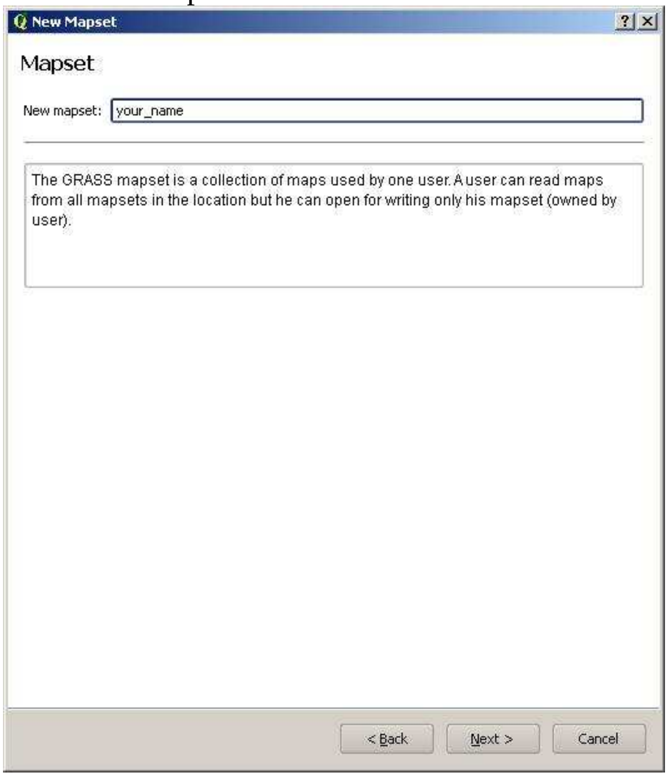
5. select the CRS using the same ESPG ID as before. Click next.



6. Set the Region. This part is particularly important as GRASS only performs its operations within the bounds of this region of interest. For simplicity here select the UK as the region form the drop down menu. (For practical reasons we will redefine this later to represent our study area)



7. Within the location create a mapset to work in.

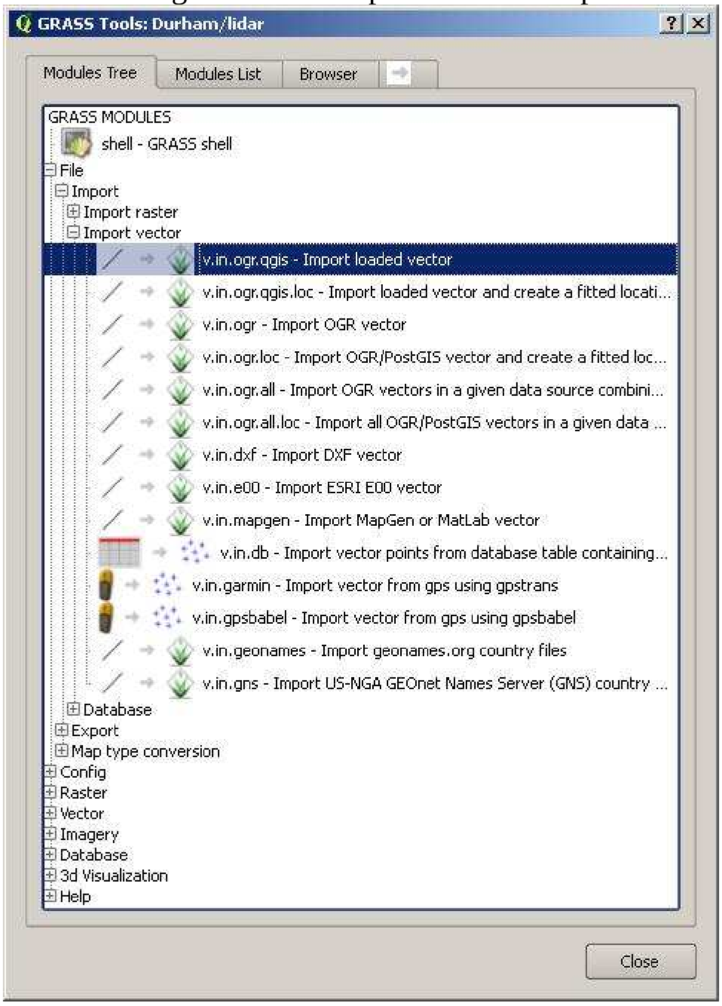


14. click next and the final screen confirms the location and mapset you have created. Click finish to return to the QGIS main screen. The mapset will now be open and the GRASS toolbar icons active.

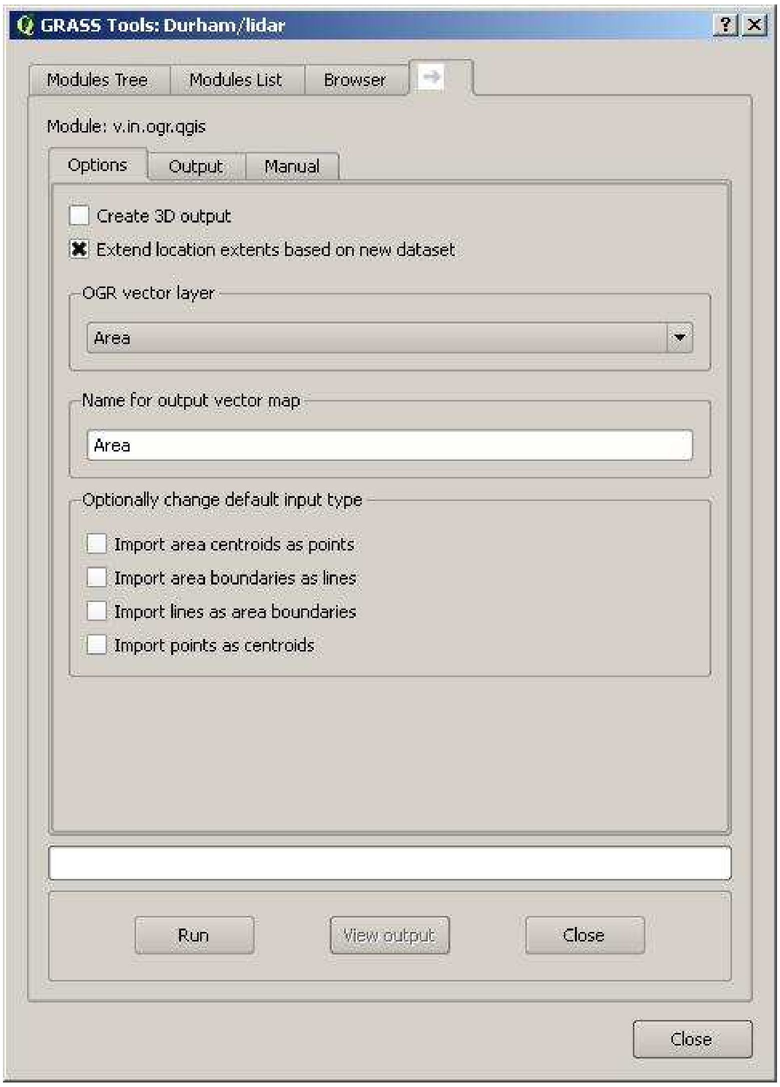
Task 4 - Changing the GRASS Region

1. We now need to change the region to reflect our study area to ensure any processes we undertake in GRASS function correctly. To do this we will import the vector file we created in task 2 into the GRASS mapset and set the region to match it. On the GRASS tool bar select the GRASS tools icon

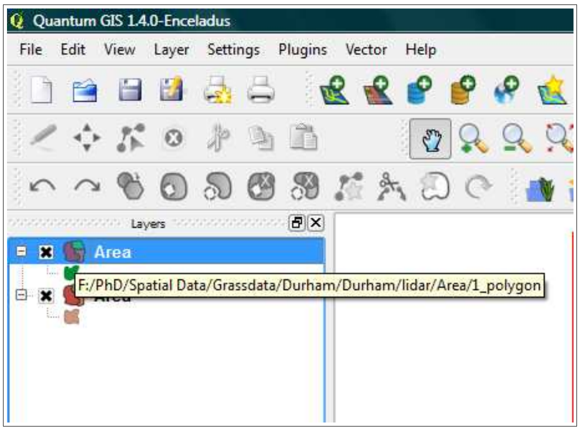
2. In the modules tree tab navigate to File>Import Vector > Import Loaded Vector



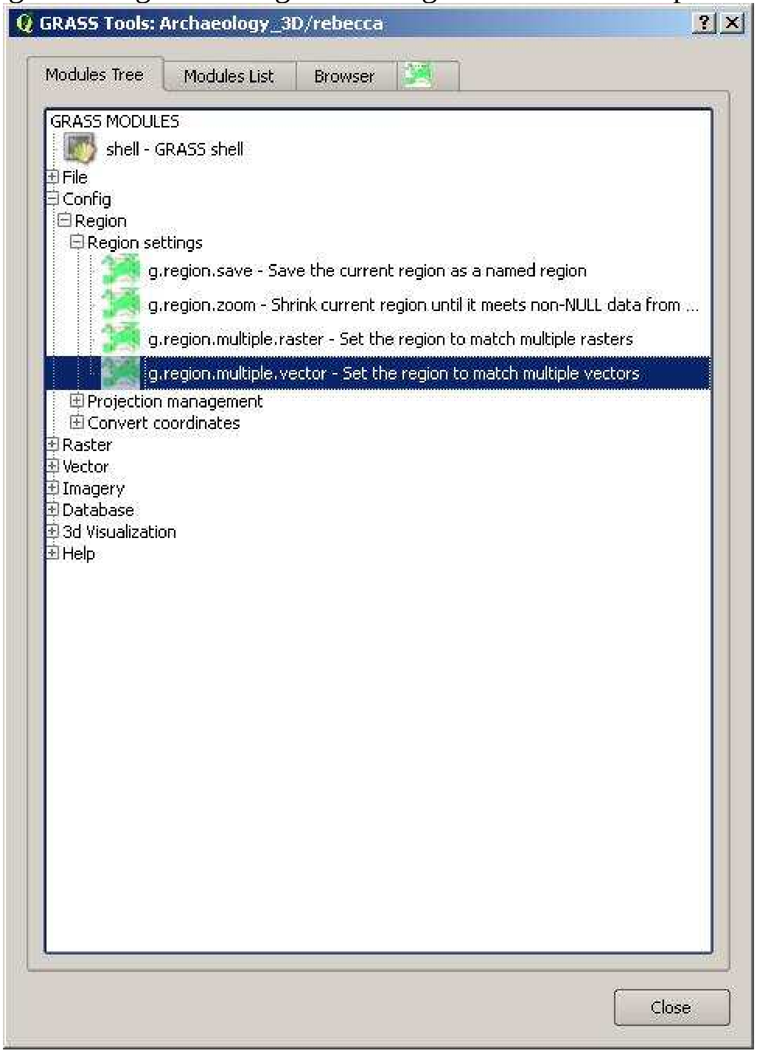
3. Select your vector file (created in task 2) from the drop down menu. Give the GRASS vector you will create a name (you may wish to prefix this with “G” if you intend to use the same name to denote that it is a GRASS vector e.g Garea). Click run then View Output to add the GRASS vector to the navigation menu to the left of the screen.



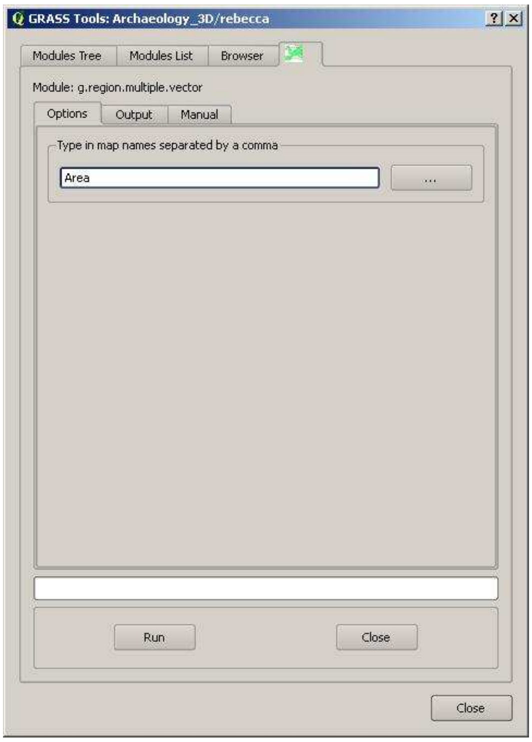
4. You can check the source of a file by hovering you mouse over its name in the navigation bar. The symbology of the GRASS vector can also be edited in the same way as for QGIS vectors (See task 2).



5. To set the region to match this vector select the GRASS tools Icon again and navigate to File >Config > Region > Region Settings > Set Region to match multiple vectors

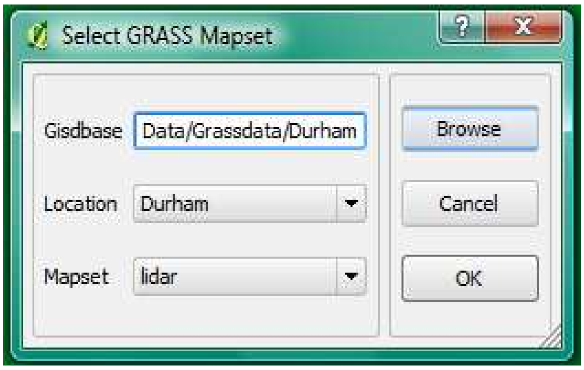


6. Type in the name of your vector file. Click Run and close.

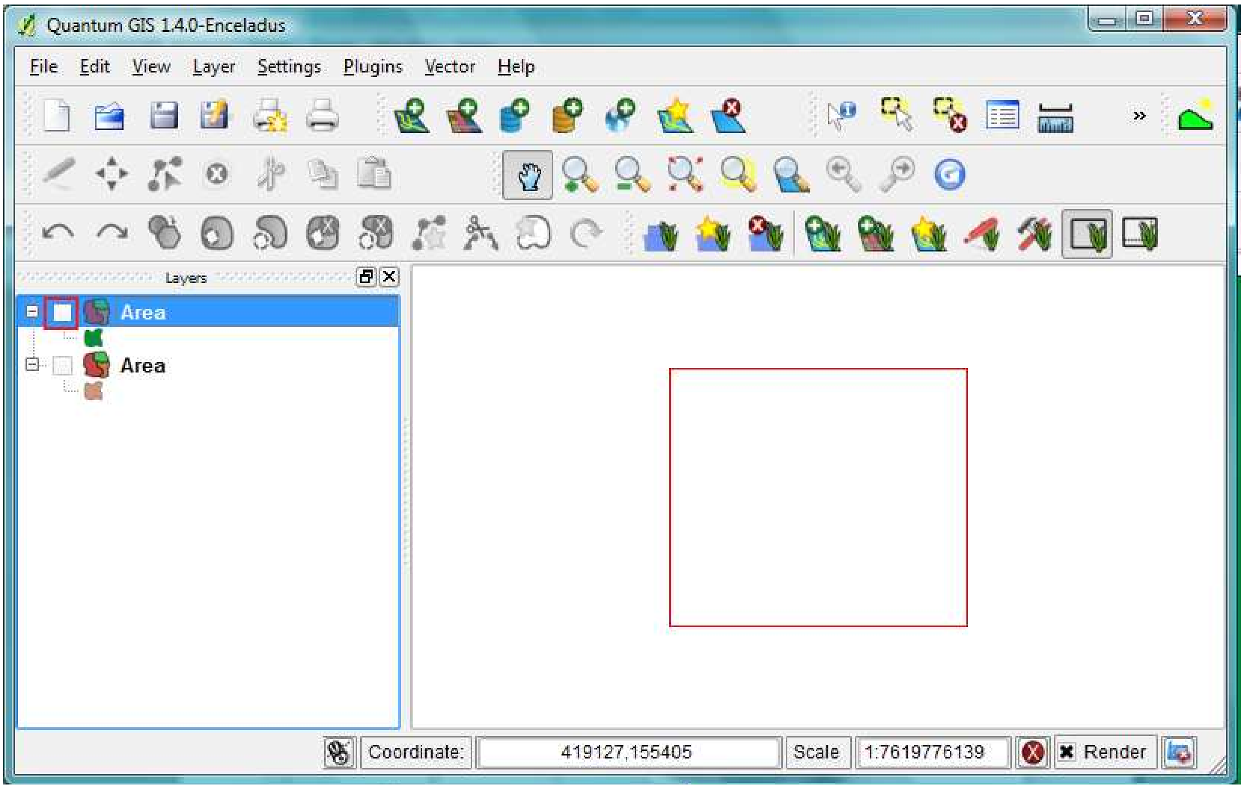


7. To make sure that the region is set. Close the GRASS mapset using the Close Mapset Icon

8. Re-open the mapset using the Open Mapset Icon. Select your mapset.



9. A red line will now appear on your scree showing the current GRASS region. Close the vector files by unchecking the box beside them in the navigation menu to see this more clearly.



Quantum GIS 1.4.0-Enceladus
File
Edit
View
Layer
Settings
Plugins
Vector
Help
Layers
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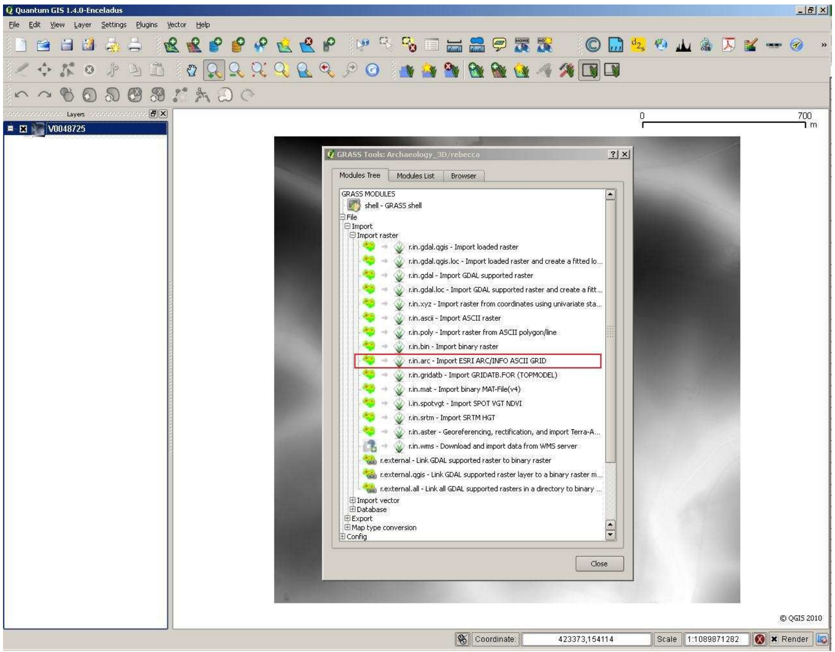
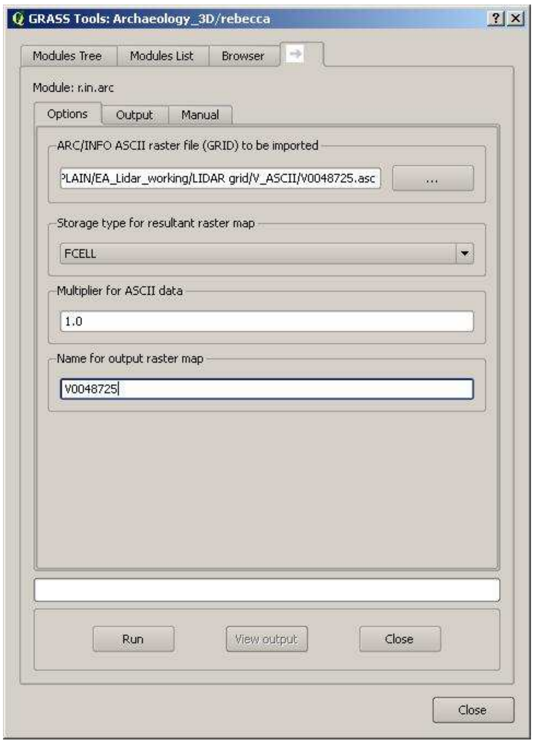
Area
Coordinate:
419127,155405
Scale
1:7619776139
Render

Task 5 - Creating a Hillshade of the lidar Rasters

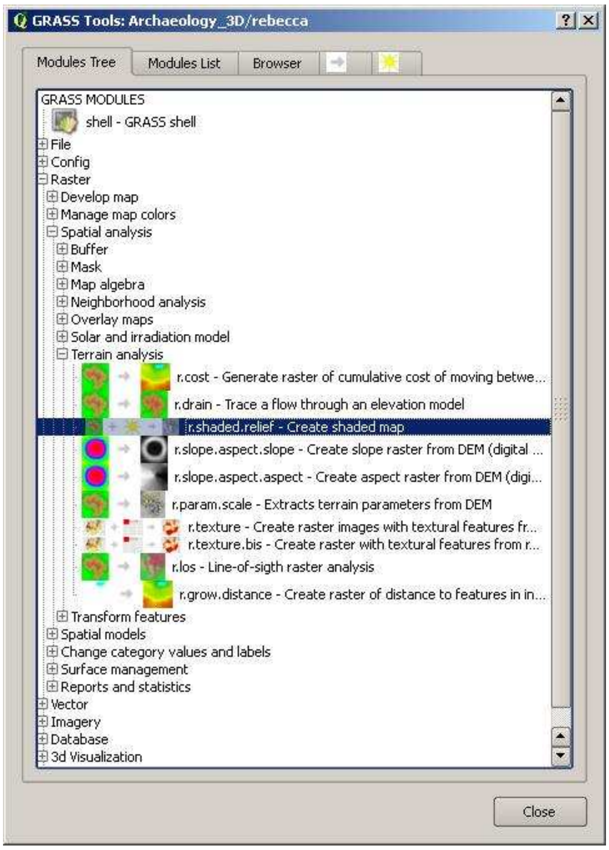
1. For this task we will import the lidar rasters to our GRASS mapset and create a hillshaded image. Open the GRASS tools menu as in Task 4. Navigate to File >Import > Import Raster> Import ESRI ARC / INFO ASCII GRID



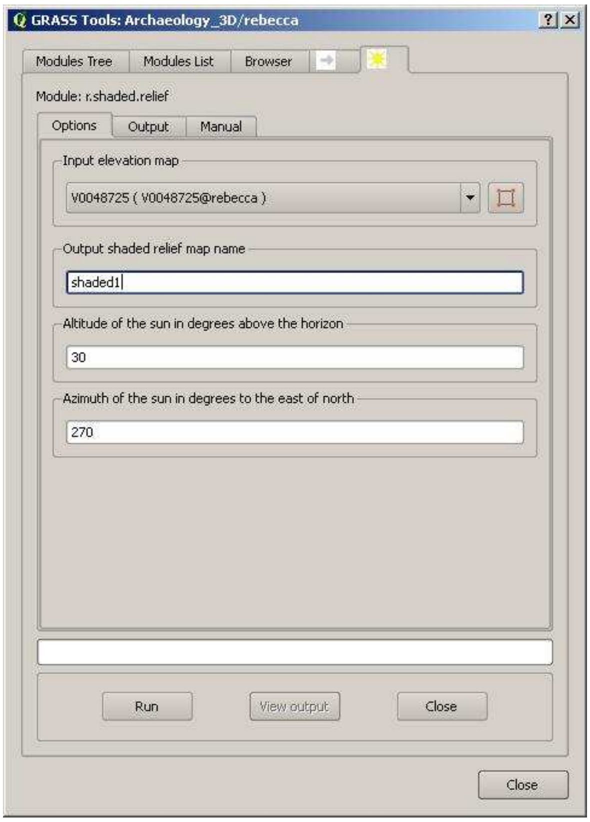
2. select the loaded raster you wish to import to GRASS. Leave all the default settings and give your output raster a name. Click Run then View Output. Edit the raster properties as before.



3. Now we can use GRASS to create a shaded relief model. In the GRASS tools menu navigate to Raster> Spatial Analysis > Terrain Analysis> Shaded Relief



4. Add the raster map from the drop down menu, give your output map a name. For now leave the default values for the Altitude and Azimouth of the sun. Click Run. Close GRASS tools.



5. To add the hillshaded raster to QGIS use the Add GRASS Raster Layer icon.

6. Wilson (2000) recommends that archaeological features are best viewed in low light levels. We will now re-run the hillshade altering the altitude of the sun to <30 degrees (the default level). Repeat Steps 1-4 opening the Hillshade tool. Alter the altitude value in the box highlighted. Save the raster with the new altitude as part of the name for quick reference e.g hillshade1_10.

INSERT IMAGE

7. By switching these layers on and off in the navigation bar examine the differences between them in terms of the visibility of features. Has the visibility improved unilaterally? What hampers visibility in this image?

8. We will now look at the impact of altering the direction of the sun. Repeat steps 1-4 to open the Hillshade tool. In the Azimuth box change the value to 0 (i.e. North). Save the raster with the new azimuth as part of the name for quick reference e.g hillshade1_N and re-run the processing.

   INSERT IMAGE

9. Once again by comparing this layer with the previous hillshaded images what can be said about the differences / similarities between them? Is the visibility of features strongly dependent on the direction of illumination?

10. Once you have decided on an "optimal" altitude and azimuth for your hillshade model rerun the process on the other raster images and display them all together in QGIS. How does the tiling of this data affect your interpretations of the archaeological features at 421992,152029?

Task 6 – Digitising Archaeological features from a hillshaded image.

We are now going to look at how you might record archaeological features. This task is technically quite simple repeating the vector file creation and editing we undertook in task 2 but requires you to plan what exactly you wish to record about a feature.

Before we create a new file we need to decide the attributes that it should have and how to standardise our recording so that we can mine the data for our own research aims and crucially so that others can understand it. There is a lot of information on this topic mostly relating to Historic Environment Records. A good starting point for ensuring compatibility are the FISH INSCRIPTION wordlists which can be found here http://www.fish-forum.info/i_lists.htm.

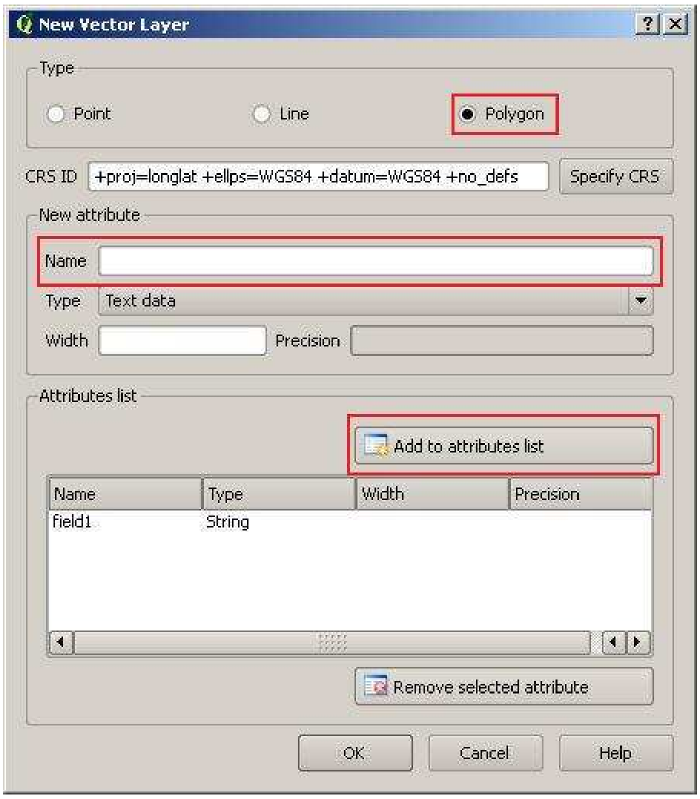
Use the space below to think about the type of information you would like to record about a feature from the lidar. Think about both its metric properties and its interpretation. Each of these pieces of information will become an attribute.

Once you have decided what you wish to record you need to think about how you will map it. There are three digitising options here - point, line and polygon (though of course you can map features in more than one file to take advantages of different types if you wish). Think carefully about the aims of your research before choosing - if you will need to record the area of a feature this will not be possible with a point or line.

Armed with these decisions you are now ready to start digitising!

1. Click on the Create New Vector icon 

2. Select the type of file you wish to create. Add the Attributes you wish to record (ensure you get the correct type of field e.g text, whole number, integer).



3. Click OK to create your shapefile and use the toggle editing to begin digitising features.

Using QGIS and GRASS for Processing and Analysing Lidar Data

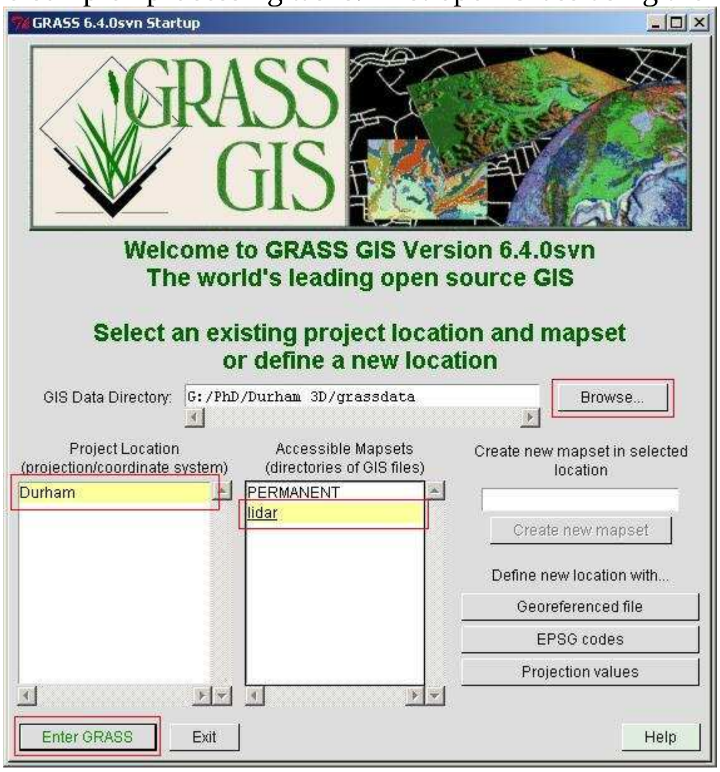
Lab 2 – 16.30 – 18.00

The aim of this session is to introduce GRASS as a tool for processing lidar data. In this session you will undertake the following tasks:

- create a new raster for the study area by combining existing tiled rasters
- import lidar point data
- visualise the lidar point cloud uisng NViz
- create an interpolation from lidar point data.
- Look at the process of vegetation filtering
- Export your work in a variety of formats (ESRI)

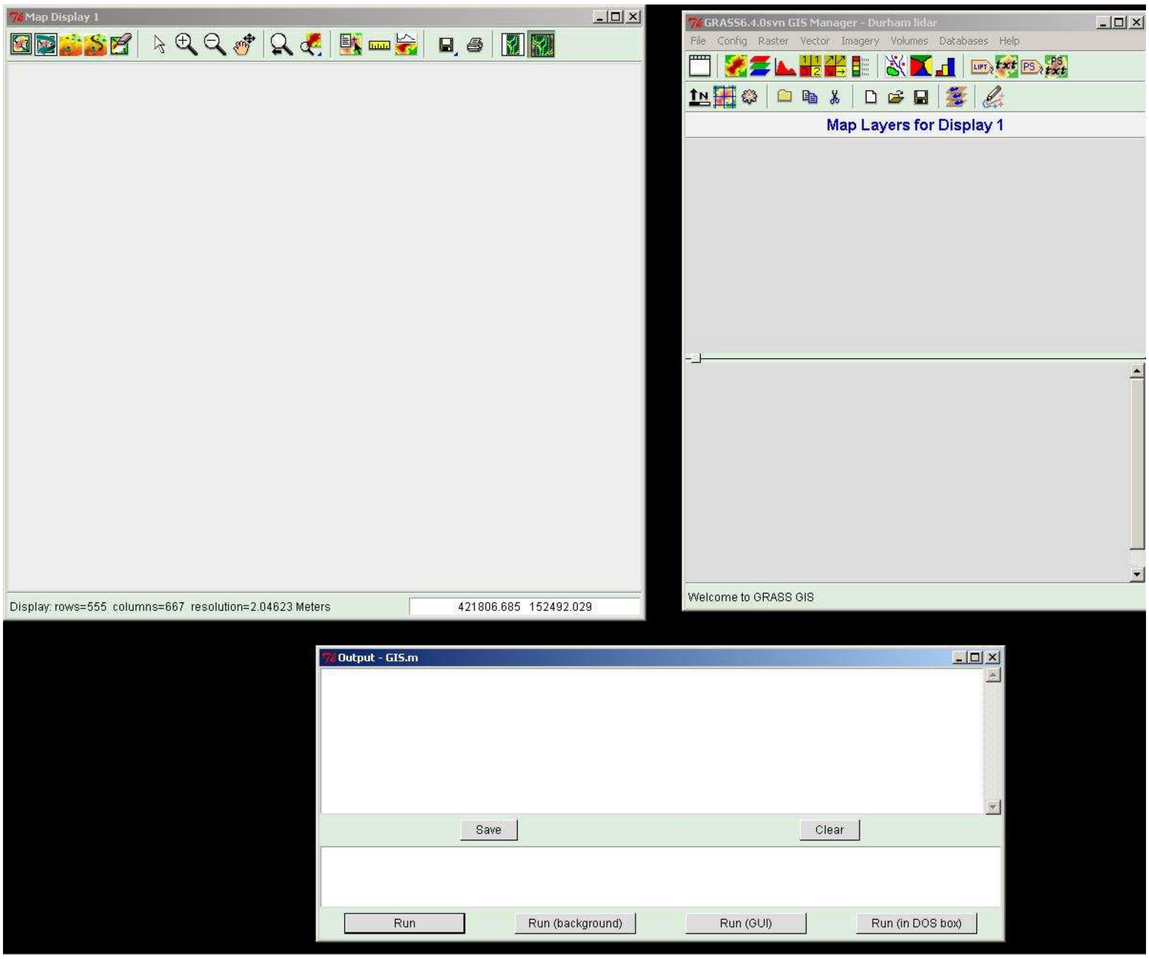
Task 7 – Opening GRASS

1. We will now leave QGIS for a while and take a look at GRASS GIS directly to undertake a number of more complex processing tasks. First open Grass using the Icon



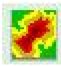
2. Your will need to navigate to the Location and Mapset you created in lab 1 in QGIS. When you have browsed to the directory select the location then the mapset. Then click enter GRASS

3. Grass will then open three windows as shown below. On the left is the Map Display, to the right is the GIS or Layer Manager where layers are added and modified and where the menus are found for each function. Below these is the Output Screen where commands and processes are printed and commands can also be entered.



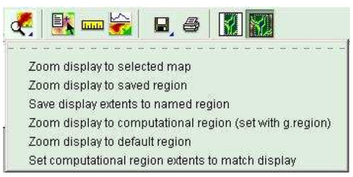
4. First we will add a vector and a raster to the display. In the GIS Manager click on the Add Vector Icon in the same window and select the vector file you created in the first lab representing the study area.

5. Then click on the Add Raster icon and pick a raster from the drop down menu.

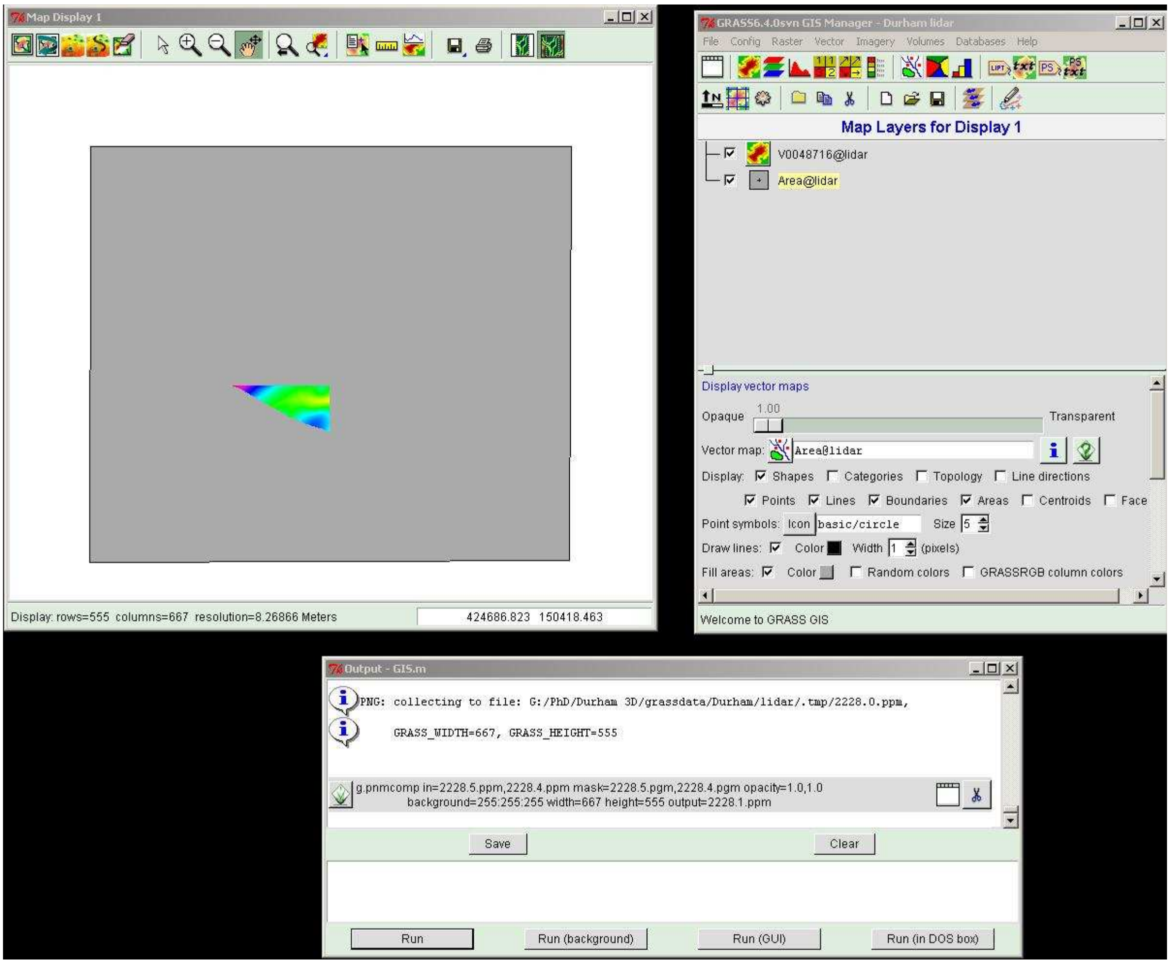


6. You will notice that the map display does not automatically update as you add layers (to save processing time). In the map display window click on the Display Active Layers icon.

Tip: if your loaded files do not display use the Zoom To icon to relocate your window



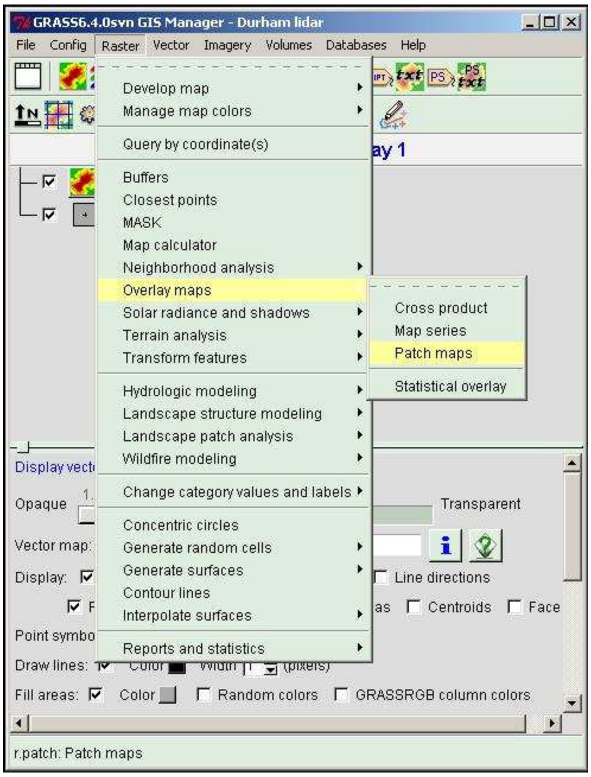
7. Your screen should now look something like the image below. You will note that the command is replicated in the Output screen below.



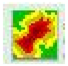
8. In the lower section of the GIS manager are the display options for each layer. Take a moment to explore these options to improve the display.

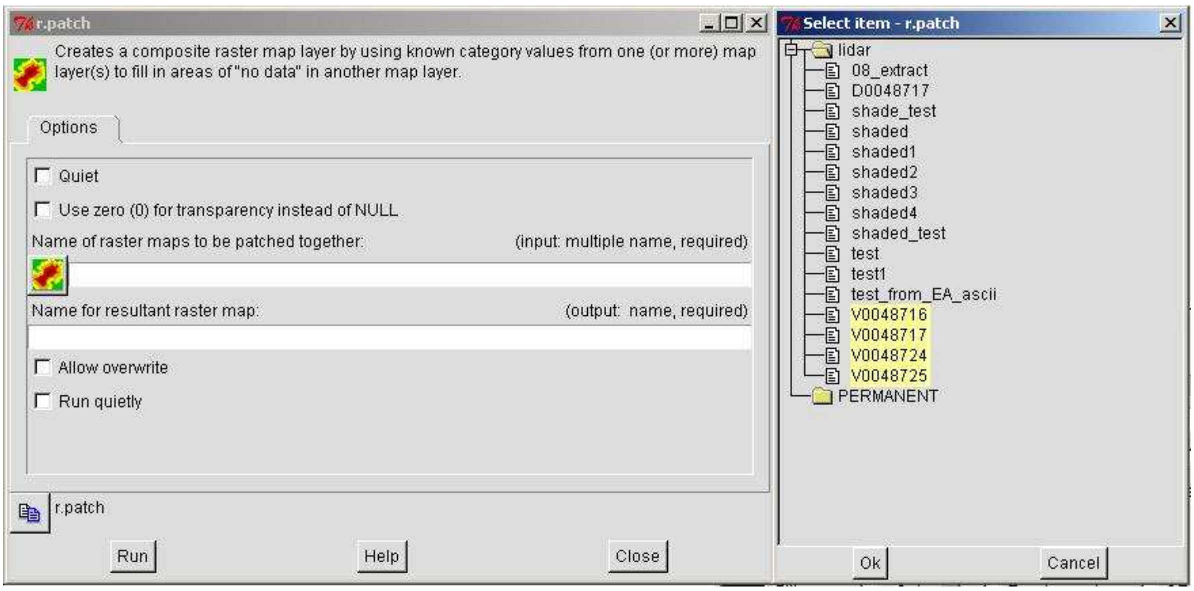
Task 8 – Combining the Tiled Rasters

1. To improve the visualisation of the tiled lidar data it is possible to combine the lidar tiles supplied and re-run the hillshade analysis on the whole study area. In the GIS Manager navigate to Raster> Overlay Maps > Patch Maps.

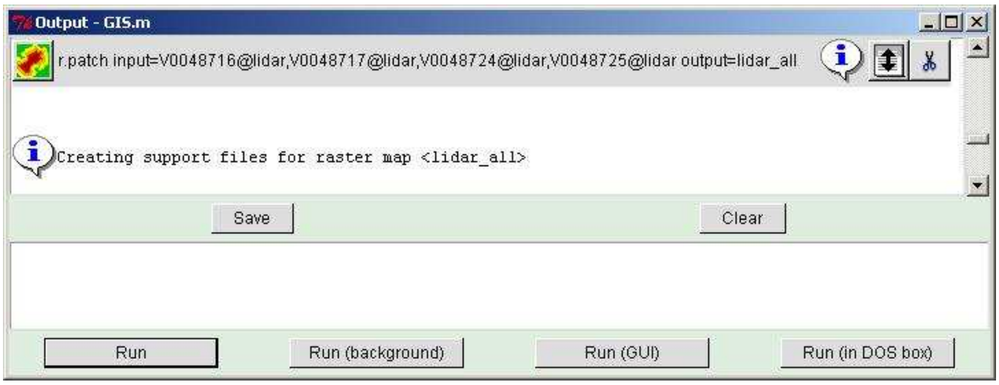


2. The r.patch tool will be opened. Add the rasters you wish to patch (use the original rasters not the hillshaded models) using the add raster icon and select multiple rasters by using Ctrl.

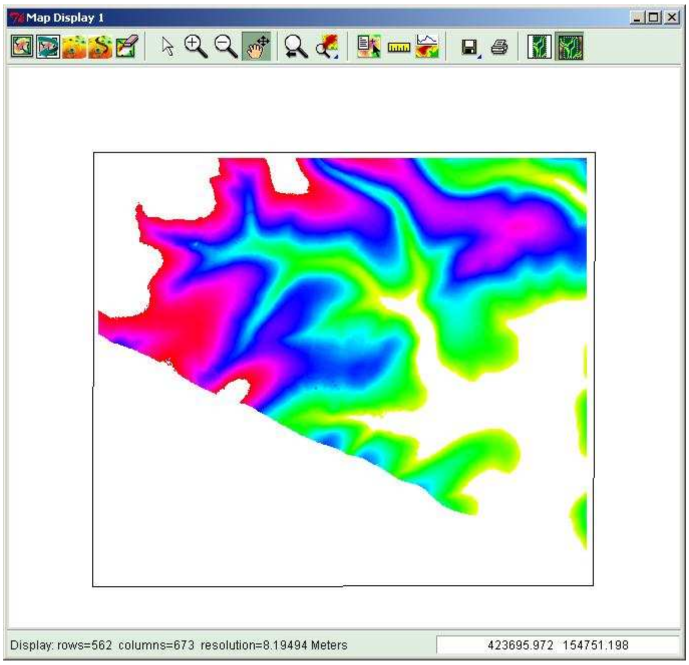


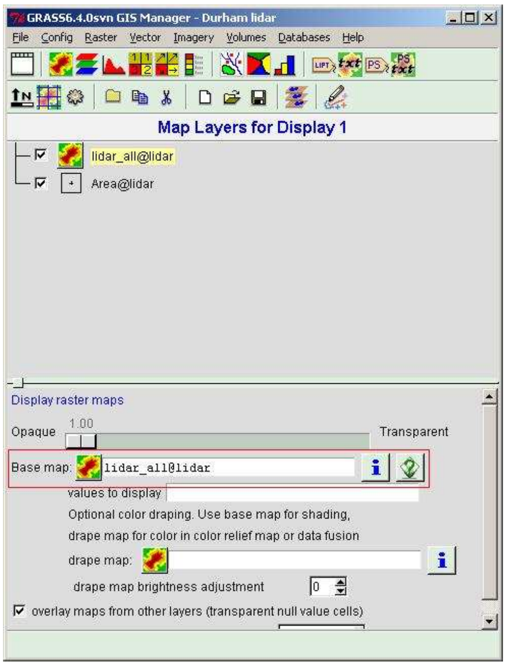


3. Give your new raster a name and run the tool. The output window will show the processing steps of the tool.

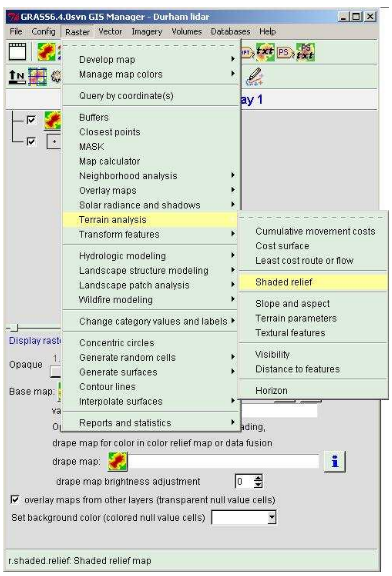


4. Change the raster you displayed to the raster you have just created and redisplay in the map window.

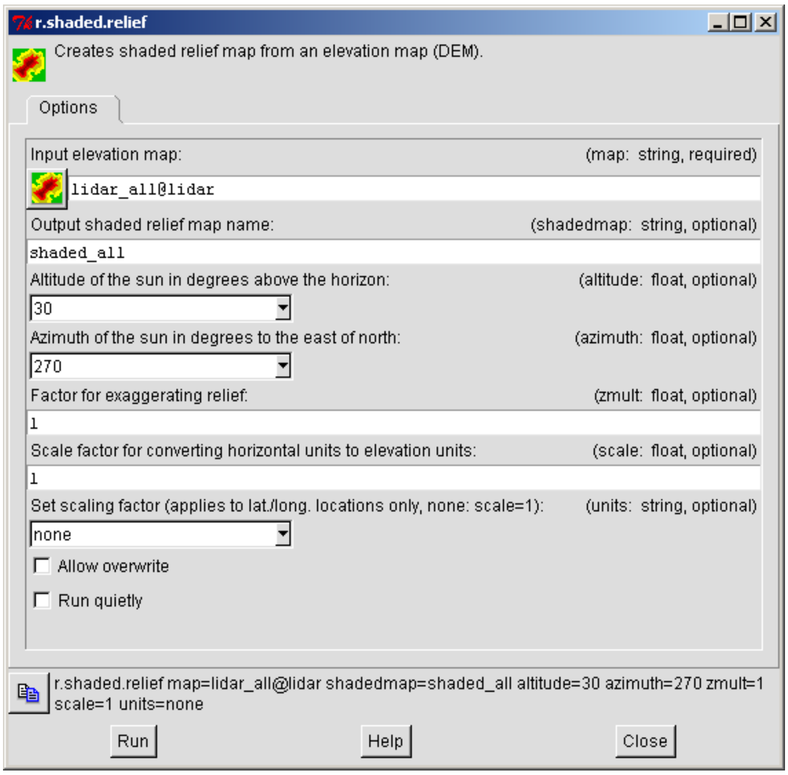




5. Next we will run the hillshade analysis. Navigate to Raster> Terrain Analysis > Shaded relief



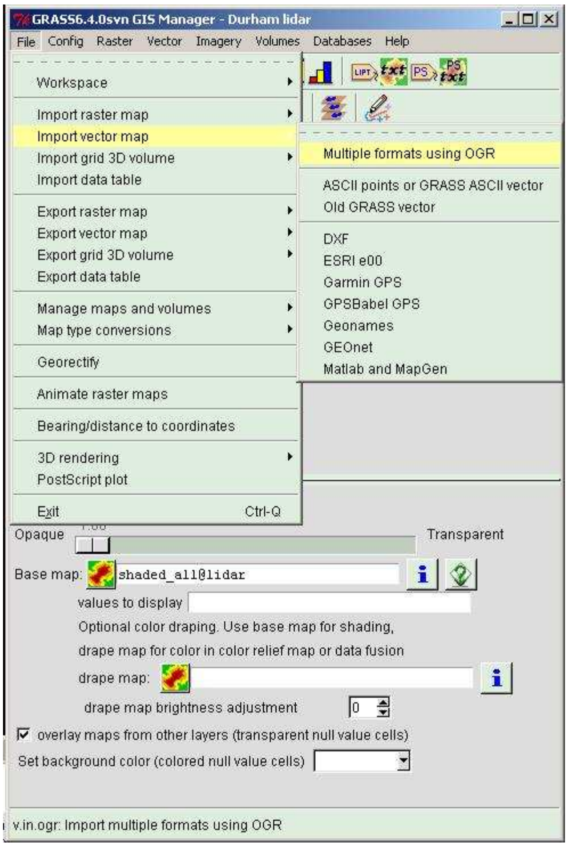
6. Enter the base raster and the name of the output raster in the r.shaded.relief window. Choose your Altitude and Azimuth variables. Notice here that you can also exaggerate the Z values of the data to enhance features. When you are happy with the variables selected, run the tool.



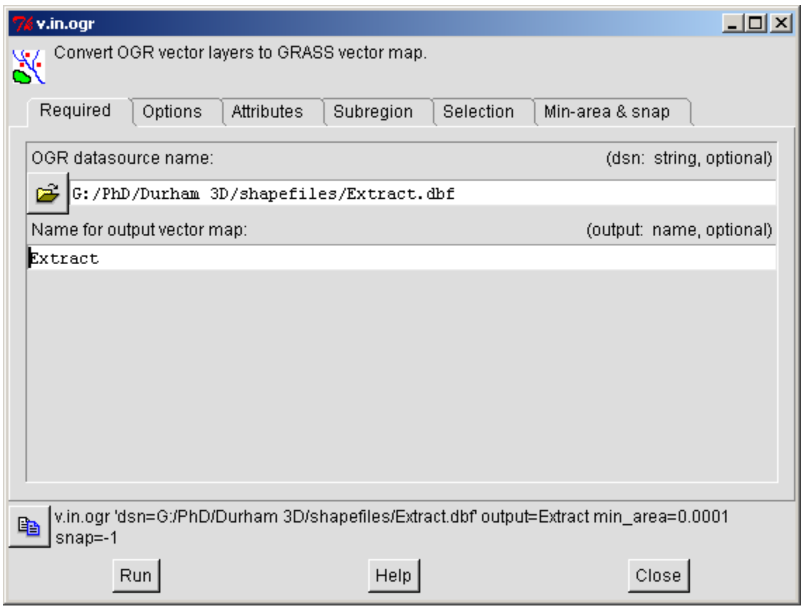
7. As before add the new raster to the display window. Use the navigation tools to explore the raster

Task 9 – Import Point Data

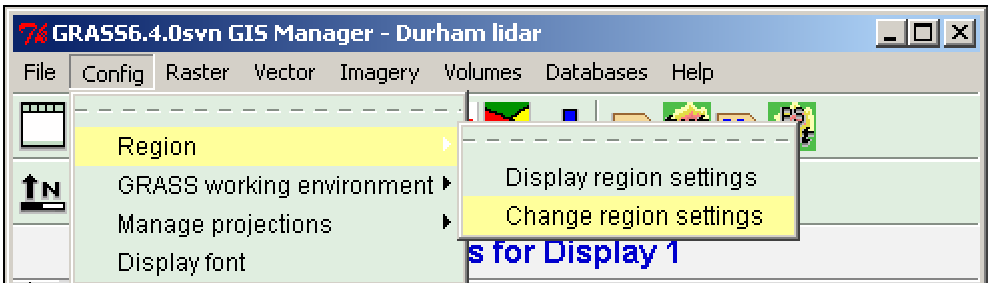
1. For this task we will look at a subset of the data so we need to set up a new region for our mapset. We will do this as in the previous lab by importing a shapefile of our area of interest into GRASS. In the GIS manager window go to File> Import> Vector> Multiple Formats using OGR



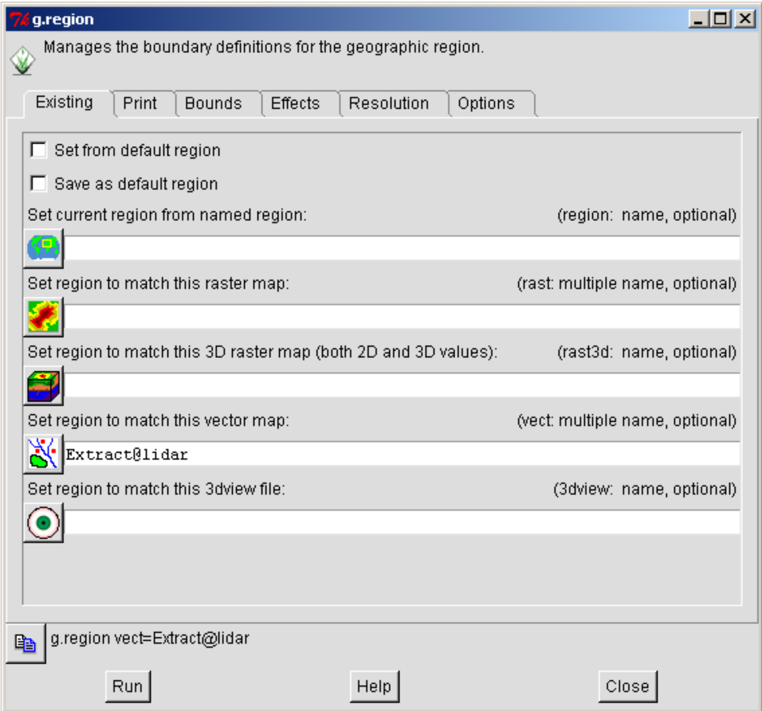
2. In the v.in.ogr tool, navigate to the shapefiles folder in the Durham 3D directory and select the extract. Name the new file and run the tool. Add the vector as a layer in the GIS manager and display it on screen.



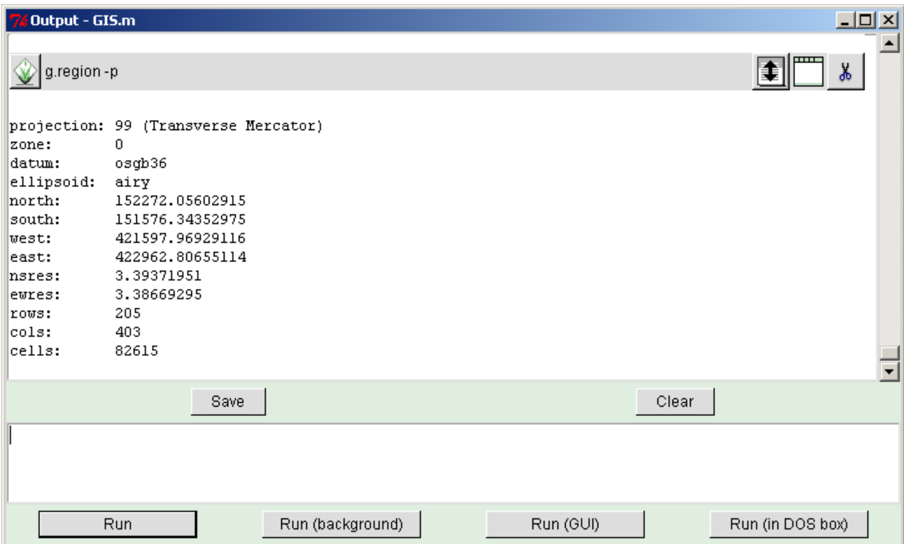
3. To change the region to match the extract area, navigate to Config > Region > Change region settings in the GIS Manager



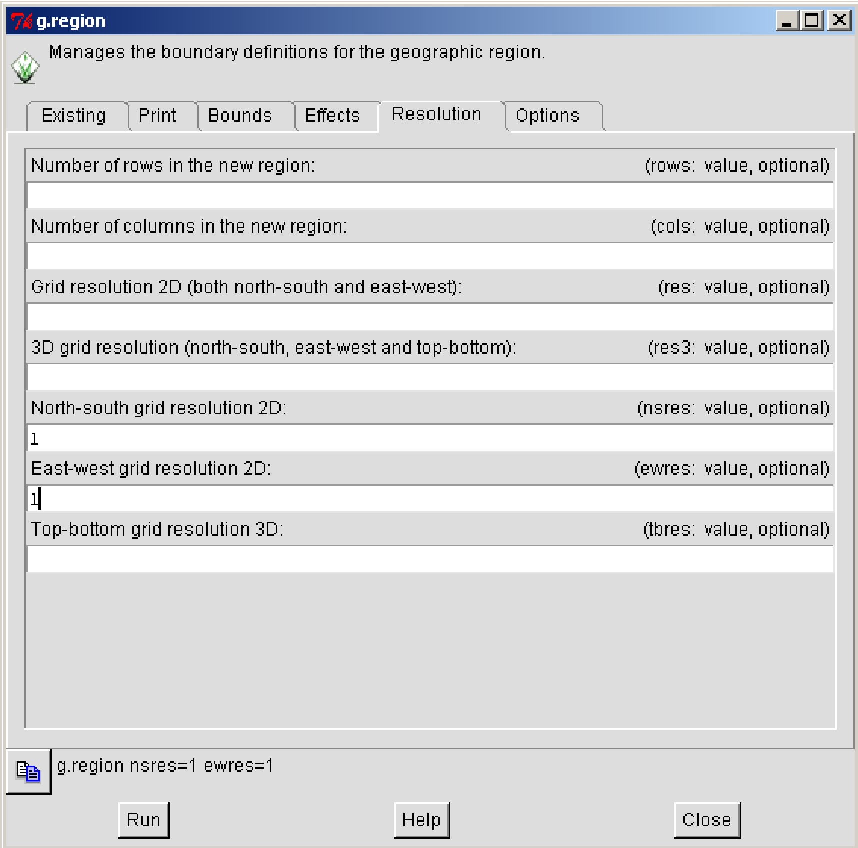
4. Select the Extract vector and click run.



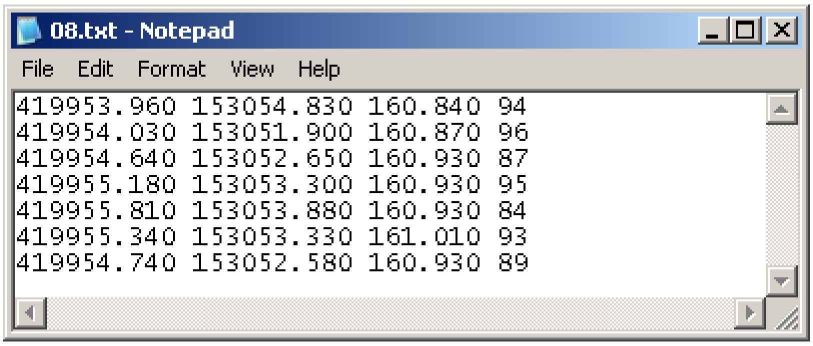
5. In the GIS Manager return to the Config >Region menu and select display region. The details of the region will be displayed in the Output window.



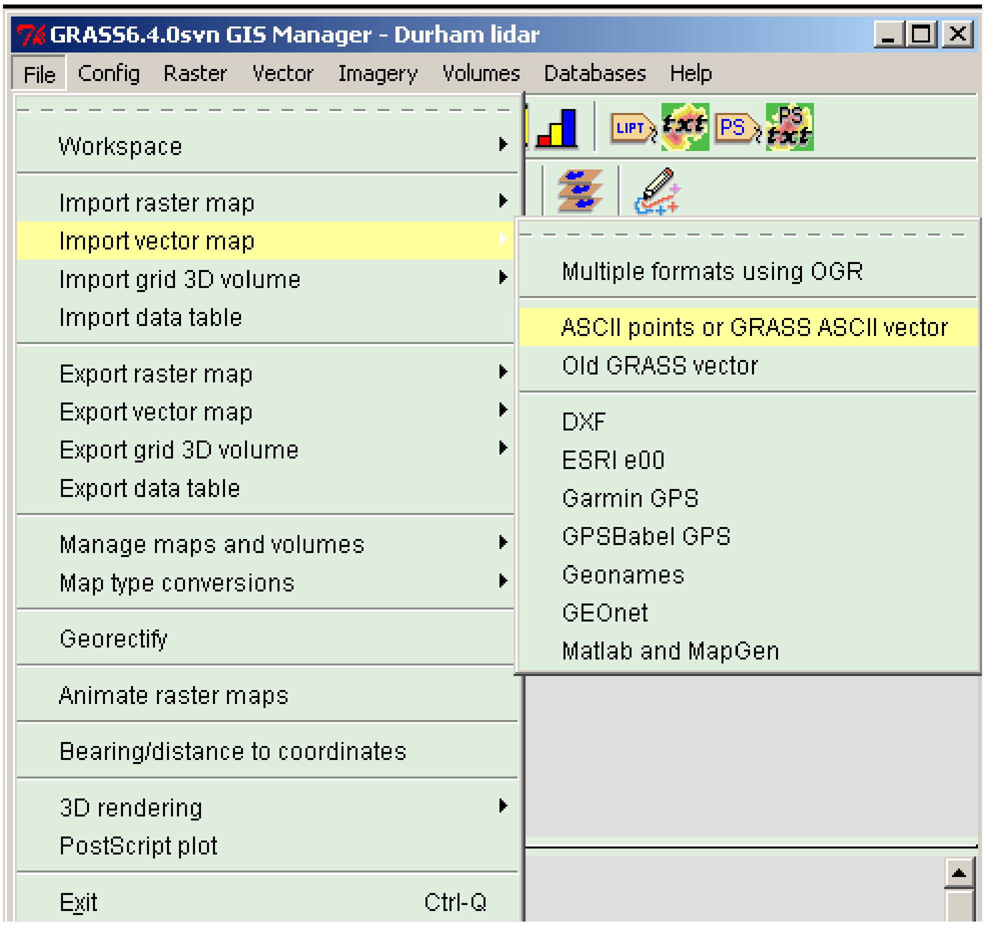
6. Notice that the spatial resolution of the region has also been set, in this instance to 3.39. This resolution will affect the creation of raster images from our point data and can be changed by returning to the Edit Region tool, under the resolution tab.



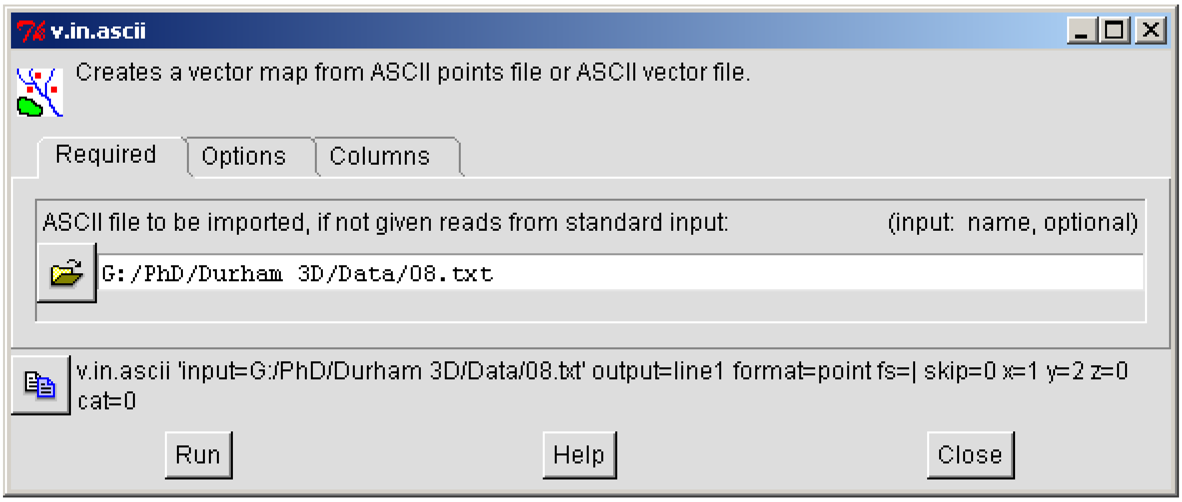
7. We will now import some X Y Z I flight line data from a .txt file, shown below.



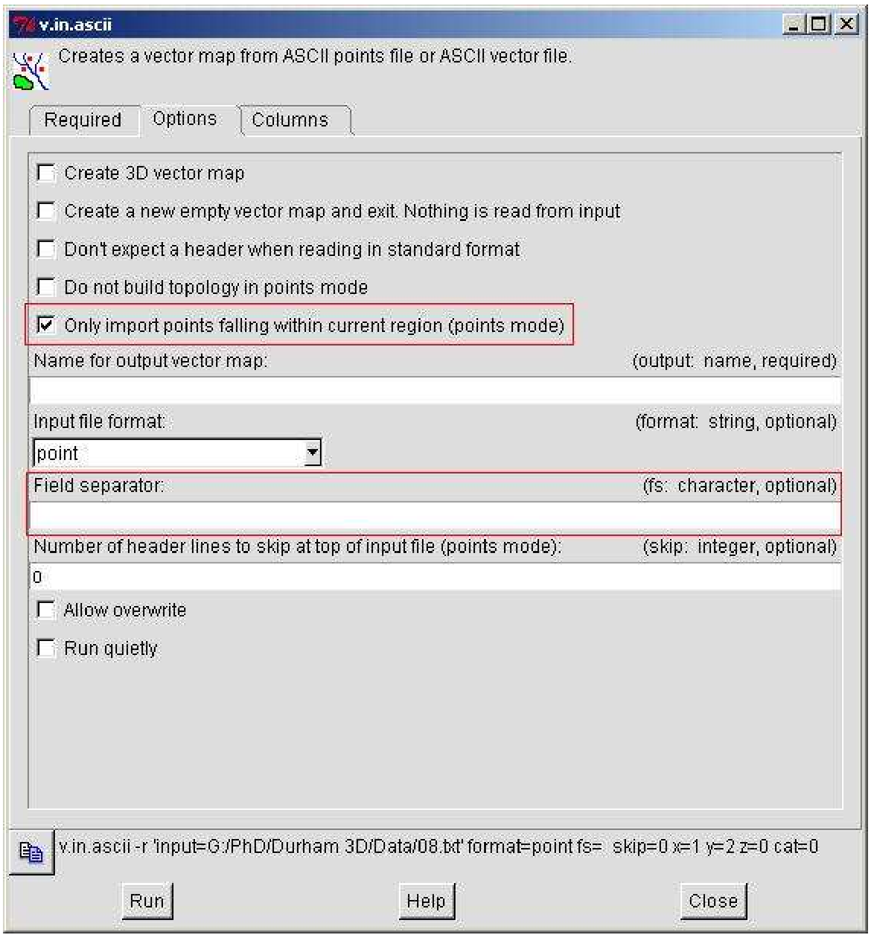
Each flightline has over 2 million data points so we will want to work only with those that fall within the region of interest. Navigate to File > Import > ASCII points or GRASS ASCII vector.


GRASS6.4.0svn GIS Manager - Durham lidar
File
Config
Raster
Vector
Imagery
Volumes
Databases
Help
Workspace
Import raster map
Import vector map
Import grid 3D volume
Import data table
Export raster map
Export vector map
Export grid 3D volume
Export data table
Manage maps and volumes
Map type conversions
Georectify
Animate raster maps
Bearing/distance to coordinates
3D rendering
PostScript plot
Exit
Ctrl-Q
Multiple formats using OGR
ASCII points or GRASS ASCII vector
Old GRASS vector
DXF
ESRI e00
Garmin GPS
GPSBabel GPS
Geonames
GEOnet
Matlab and MapGen

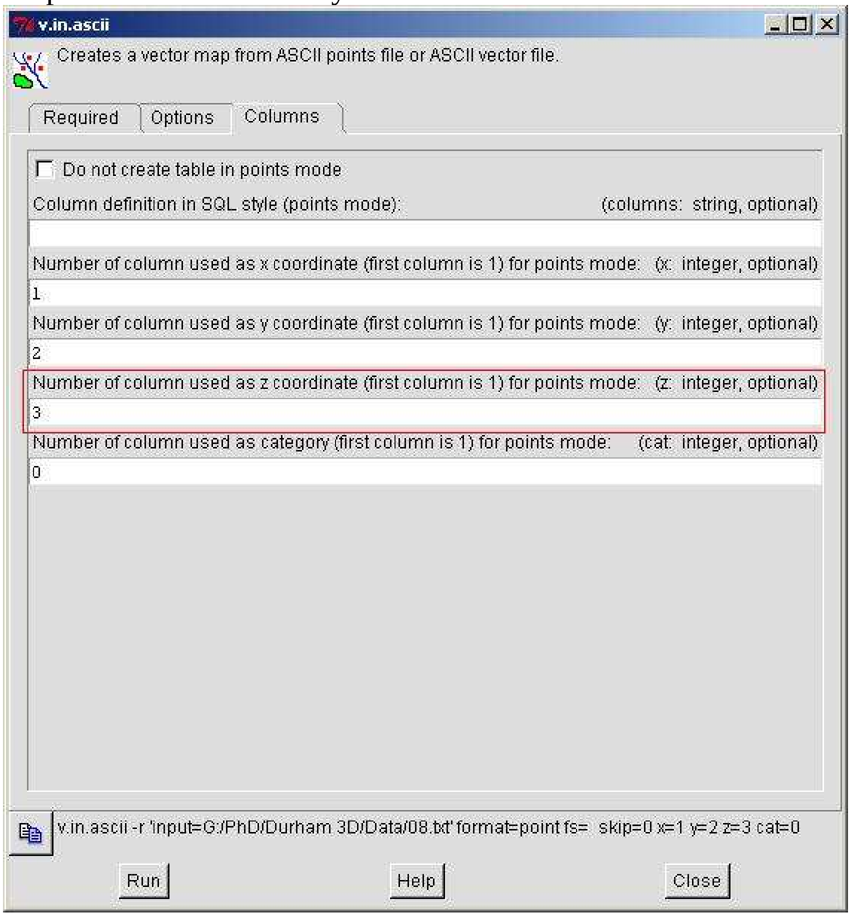
8. Add the file to be imported from Data folder in the Durham 3D



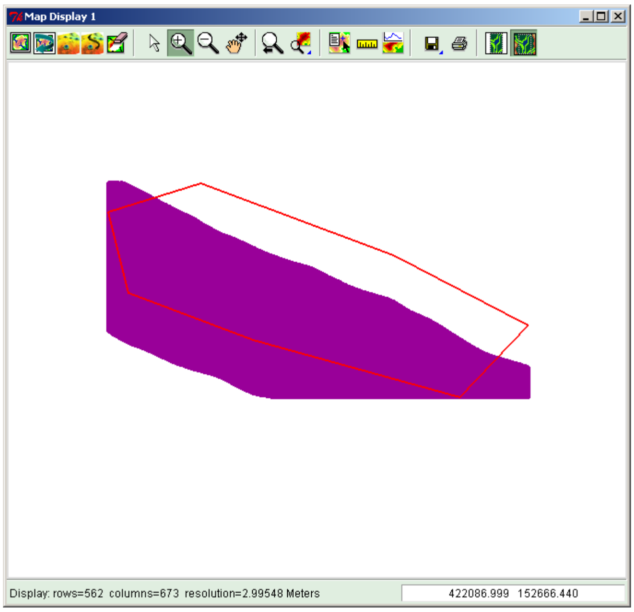
9. In the Options Tab, check the box for importing only points that fall within the current region. Name the output file and edit the field separator. The default value for field separation is the 'pipe' symbol “ | ” but the values in our file are separated by spaces.



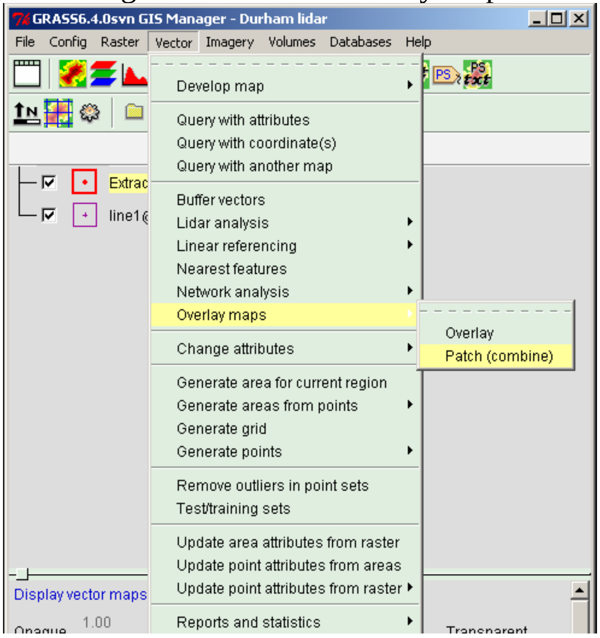
10. In the columns tab enter the column in which the Z data is stored (3). At this stage if you wanted to import the I data instead you would enter the 4.



11. When you are happy with the variables run the tool. This will take a few minutes (no more than 3 on an average PC). The output window reports that 508,959 points fell within the current area of interest.
12. Add the new layer to the GIS Manager and Display in the Map Window along with the Extract area file. It is clear that this flightline doesn't cover all of our interest area so we will repeat the process for the next flight line (09.txt)



13. We need to combine these two files into a single large file before we can convert them into raster data for analysis. Navigate to Vector > Overlay Maps > Patch Maps



14. In the v.patch tool check the copy attribute table box. Enter the names of the input maps, give the output file a name. The process will run for a few minutes building a file with almost 1 million points. When it is completed display the map.

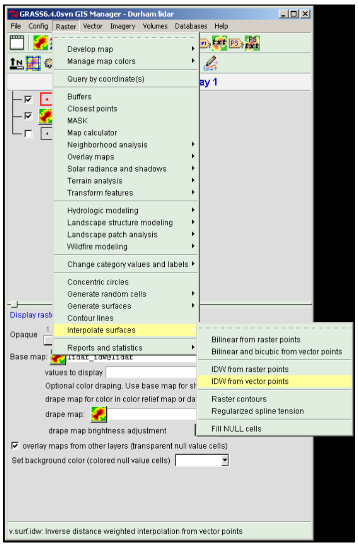
Task 10 – Creating a Raster from the lidar points

1. Having successfully imported the raw data for our area of interest, we can now create a raster file to allow us to analyse the topography. GRASS has a number of options for interpolating point data, we will use the simplest here an Inverse Distance Weighted interpolation. The choice of model you create is important as it will affect the accuracy of your results – more information for each of the interpolation methods this can be found on the GRASS wiki

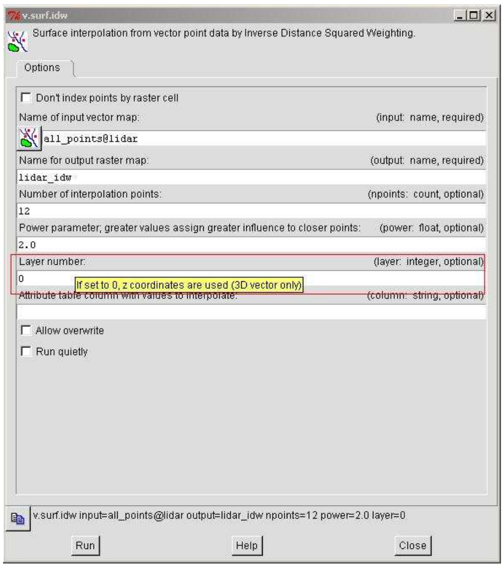
   http://grass.itc.it/gdp/html_grass63/v.surf.idw.html

   http://grass.itc.it/gdp/html_grass63/v.surf.rst.html

2. Navigate to Raster > Interpolate Surfaces > IDW from vector points

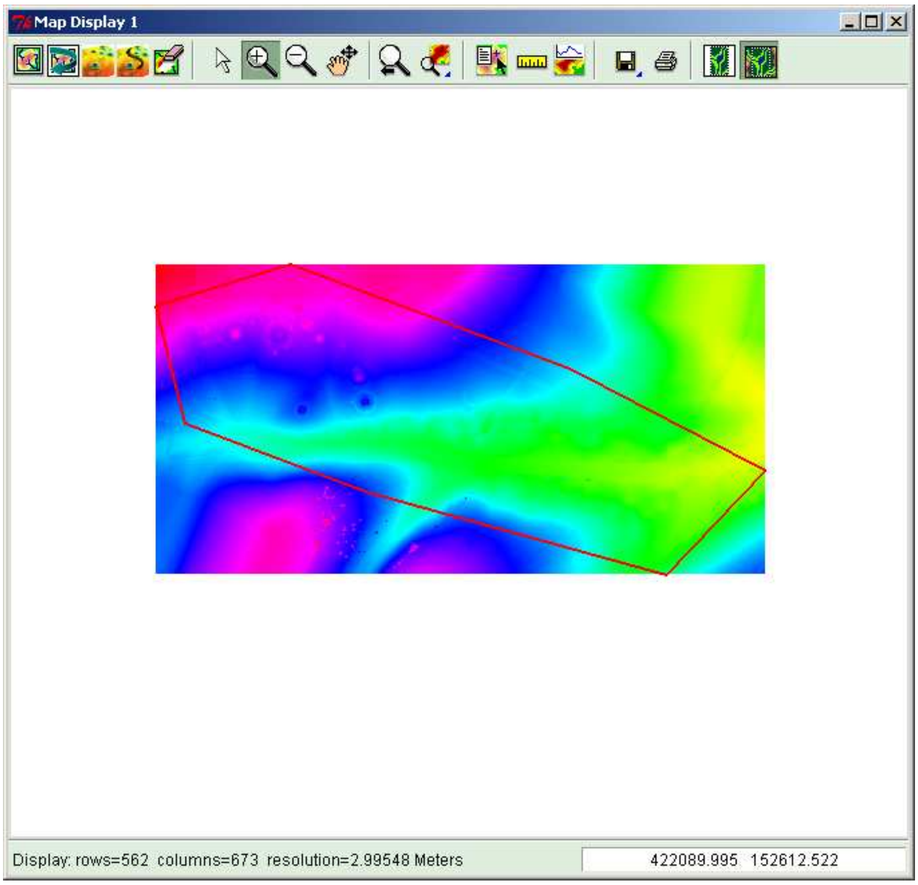


3. In the v.surf.idw tool select the input vector (created in Task 3). Give your output raster a name and change the layer number to 0 as we want to use the z coordinates. Run the tool.

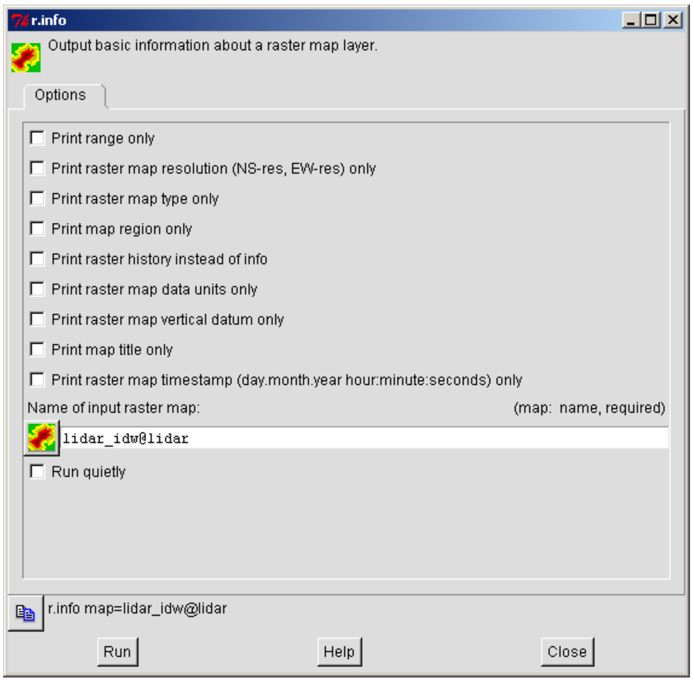


Remember the resolution of the raster created is determined by the region settings, not in this tool!

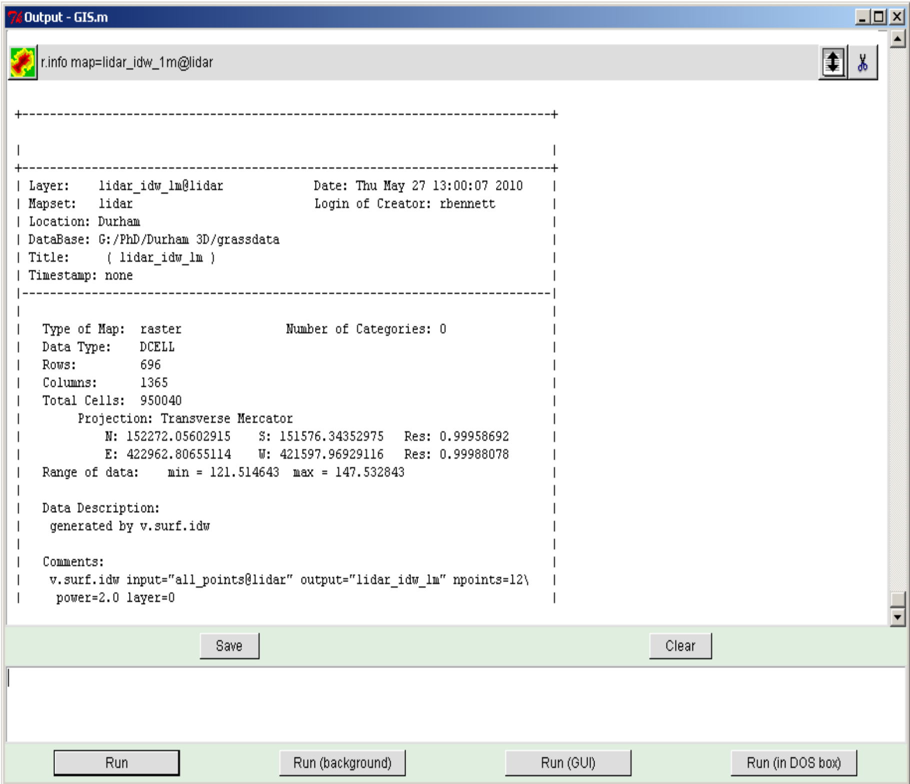
4. Display the raster and take some time to explore it in the Map Display window.



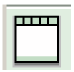
5. To check the metadata of the raster you have created go to Raster > Reports and Statistics > Report Basic File Information. Add the raster file and run the tool.



6. The results will be shown in the Output window, including the method of interpolation and the resolution of the raster.



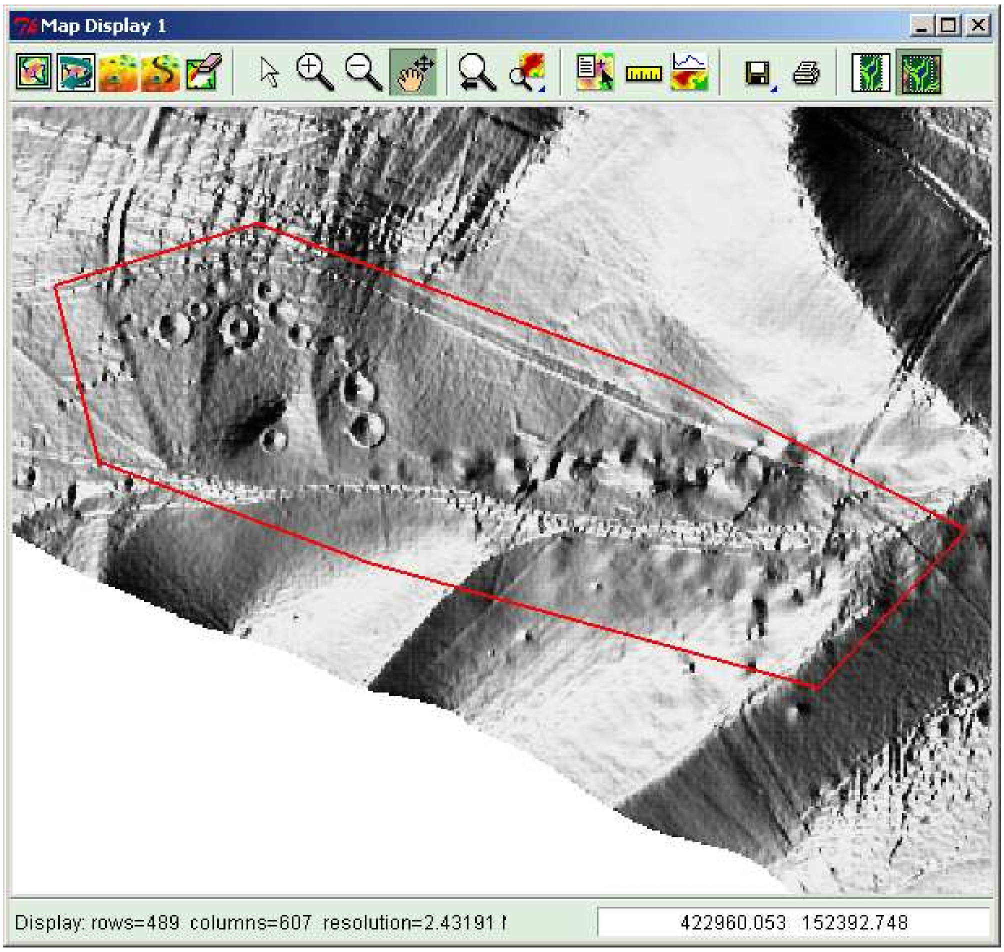
7. We can create a hillshade of the new raster and compare it to the one we created for Task 2. Navigate to Raster> Terrain Analysis > Shaded relief and create a map with the same parameters as in Task 2. We can load this into new Map display using the New Map Display Icon

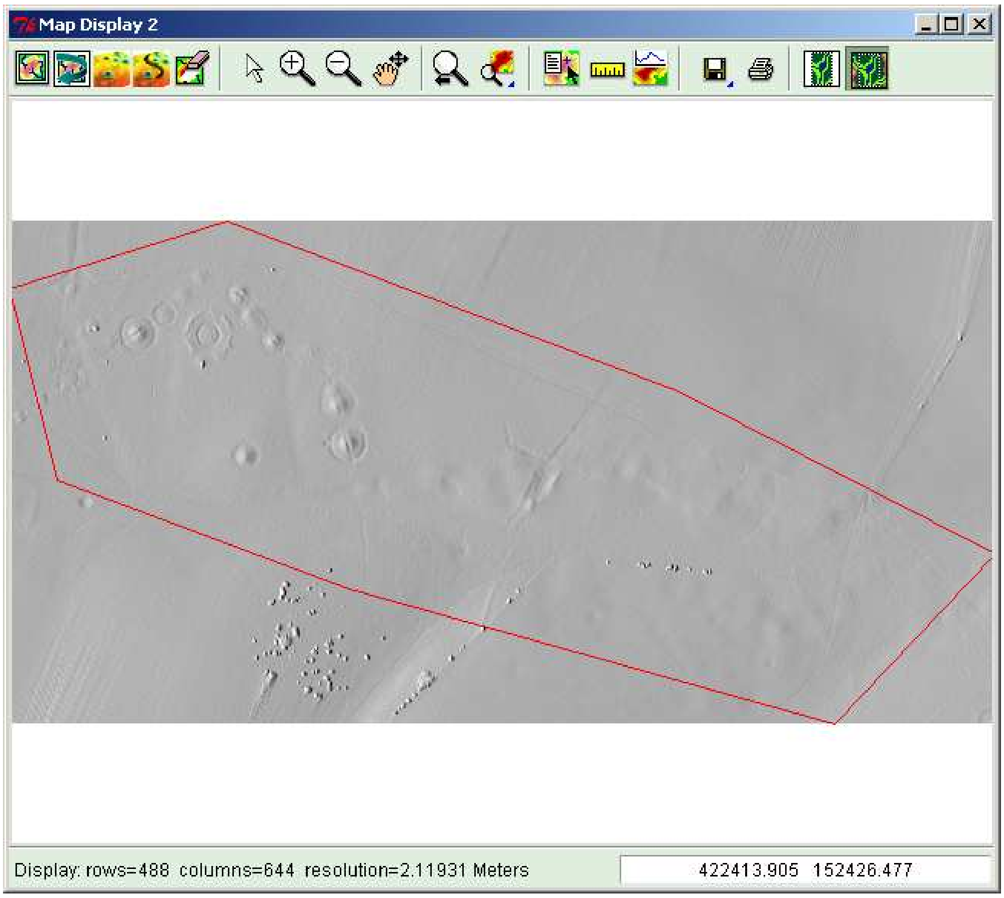


8. To display 2 add your new shaded image and the study area vector

9. Click on Map Display 1 and change your raster layer to the original shaded image from the tiled data. Display the windows side by side – what do you notice about the difference between the models?

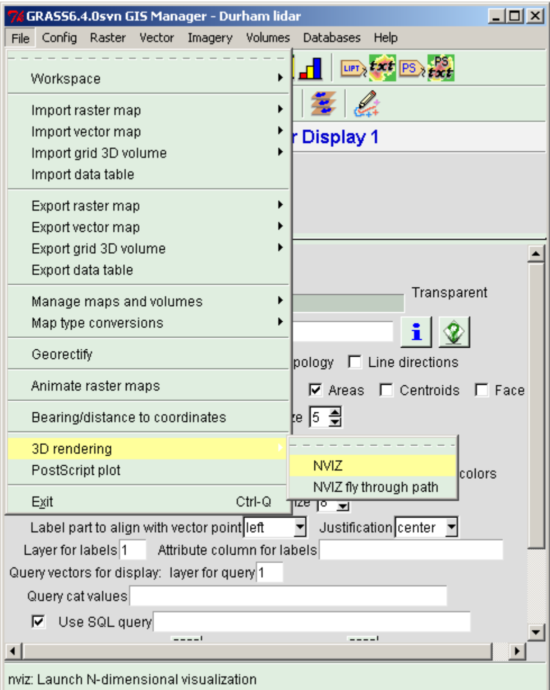
10. Re-run the hillshade of the raster derived from the point data and change the Z exaggeration. What difference do this make to the visibility of the archaeological features?


Map Display 1
Display: rows=489 columns=607 resolution=2.43191 I
422960.053 152392.748

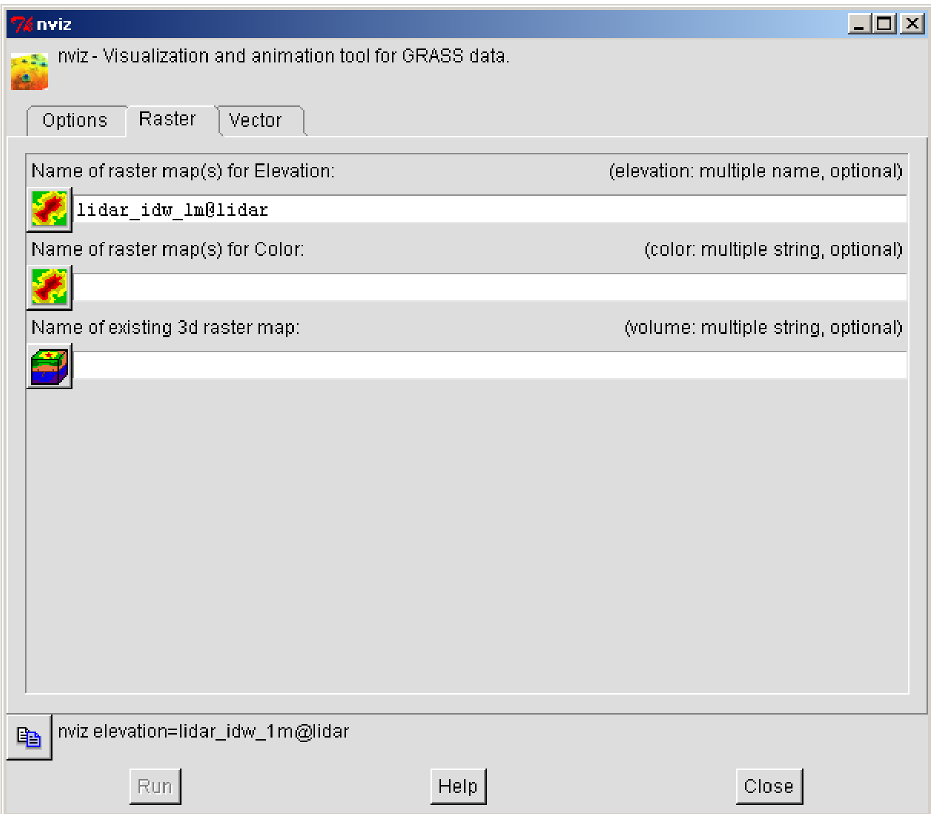

Map Display 2
Display: rows=488 columns=644 resolution=2.11931 Meters
422413.905 152426.477

Task 11 – Using NVIZ to visualise Lidar Data

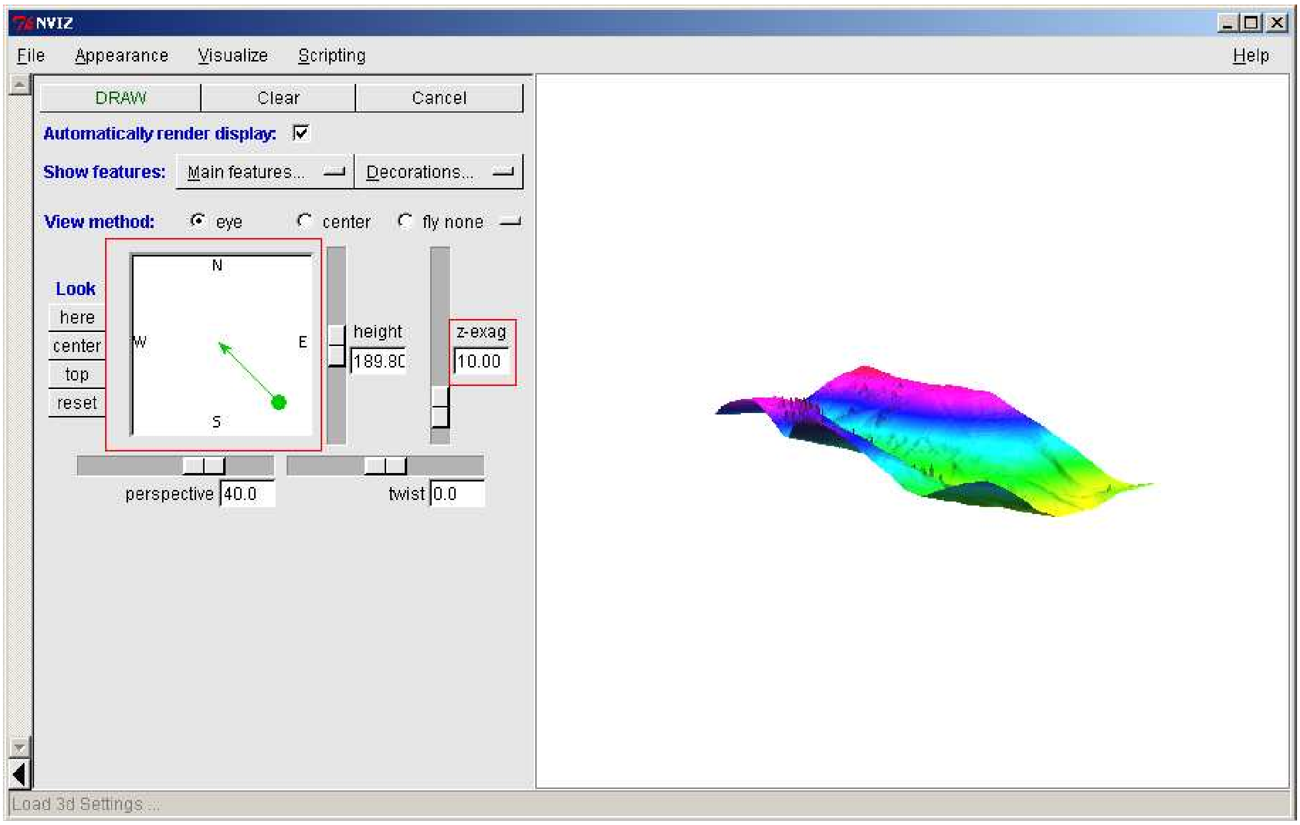
1. It is often useful to visualise the raster created from the lidar data in 3D. For the we can use a tool called NVIZ. Navigate to File > 3D Rendering > Nviz



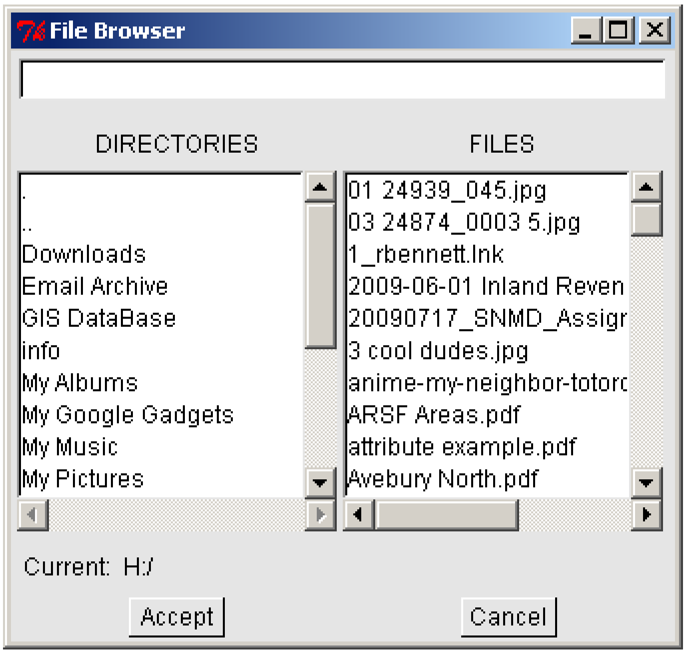
2. Leave the Options tab with the default settings. In the Raster tab add the raster layer created in Task 4. Click Run to open NVIZ with the raster loaded.



3. Take some time to explore moving around the data using the green arrow to the left of the screen. Experiment with changing the z-exaggeration.



4. Save the current view to a .tif file by navigating to File > Save Image As > TIFF Image.

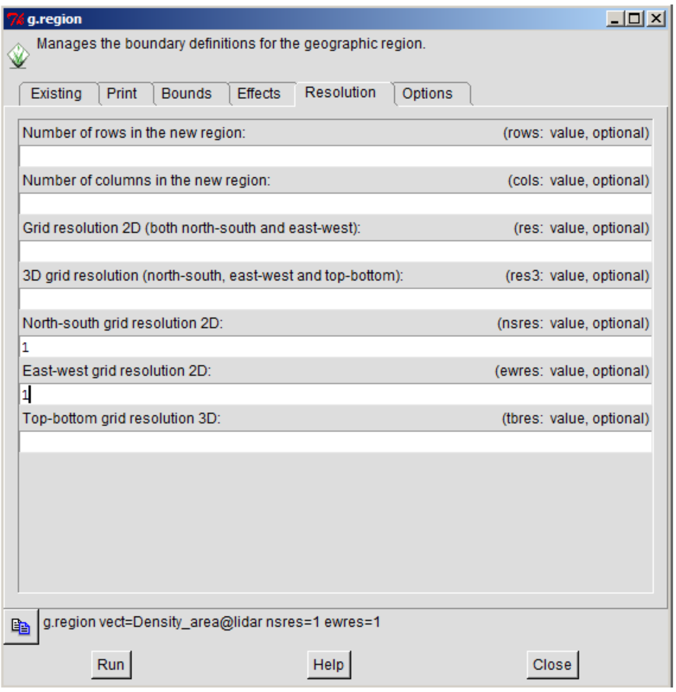


5. Nviz can be used to visualise point files as well but the large number of lidar data points for a landscape area makes the program run slowly.

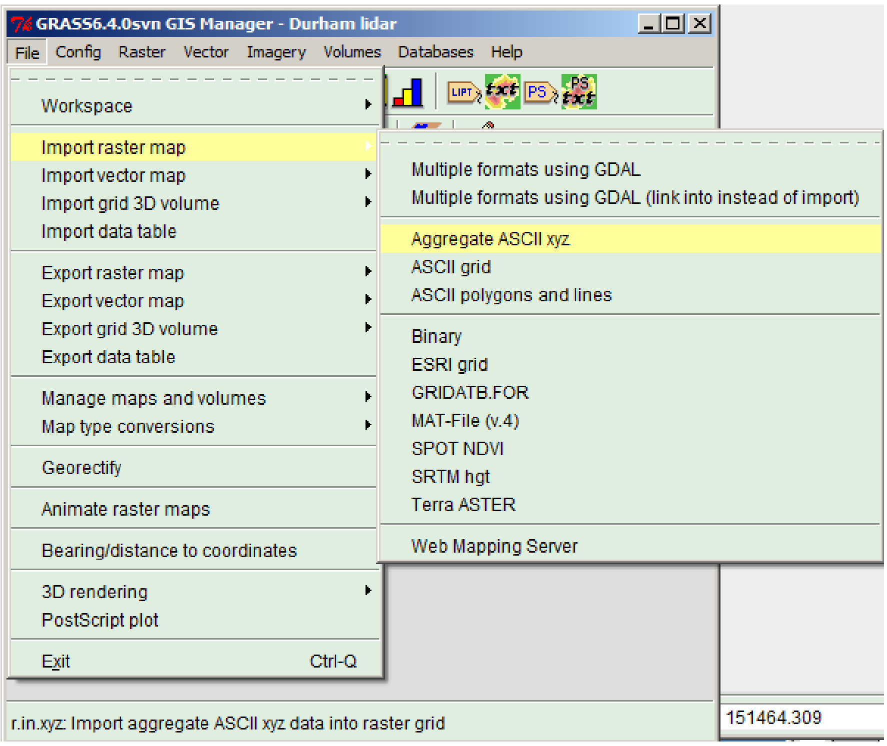
Task 12 – Checking the resolution of the point data

1. When receiving lidar in point cloud form it is advisable to check the resolution of the data. In GRASS you can do this quickly by creating a raster map of the number of points per cell. First we will import a sample area on which to work from the shapefile Density. Navigate to File > Import Vector Map > Multiple Formats using OGR. Add the shapefile Density.

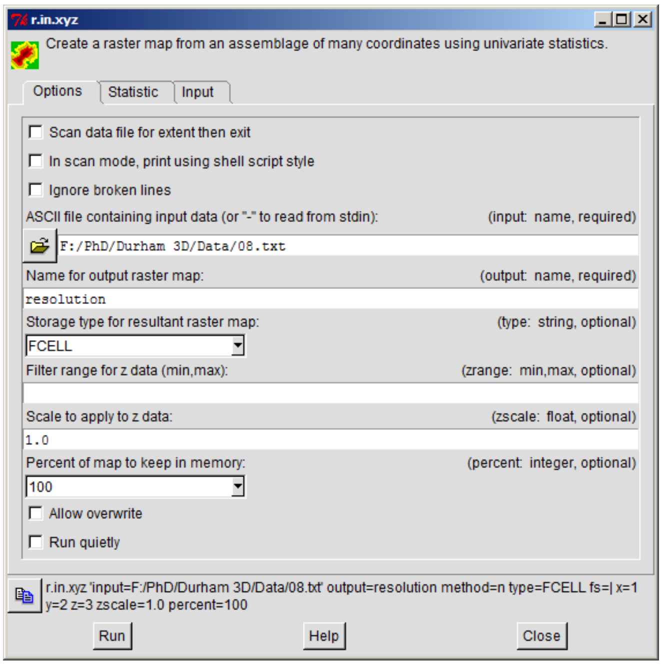
2. Change the region settings to match the Density vector using Config > Region > Change Region settings. In the resolution tab set the North-south and east-west resolutions (cell size) to 1



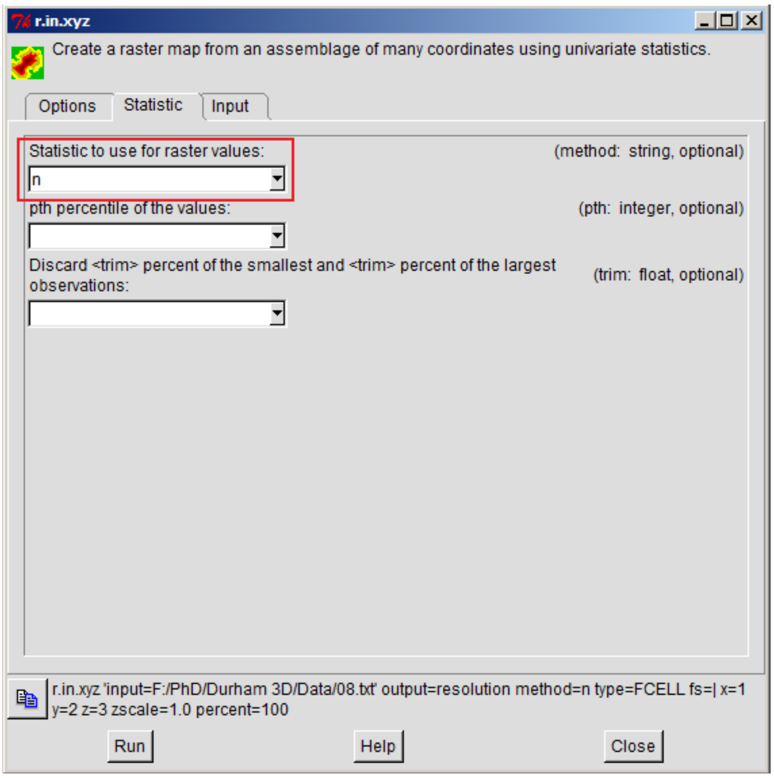
3. We will now create a raster that illustrates the number of points per cell. Navigate to File > Import Raster > Aggregate ASCII xyz



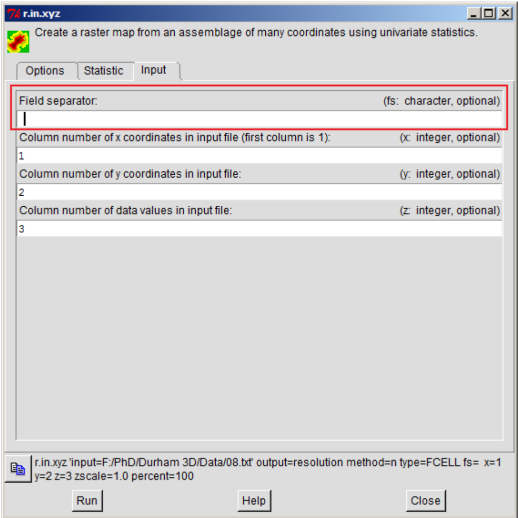
4. In the r.in.xyz tool navigate to the .txt file with the raw lidar data. Enter a name for your output file



5. In the Statistic tab change the statistic for raster values to n

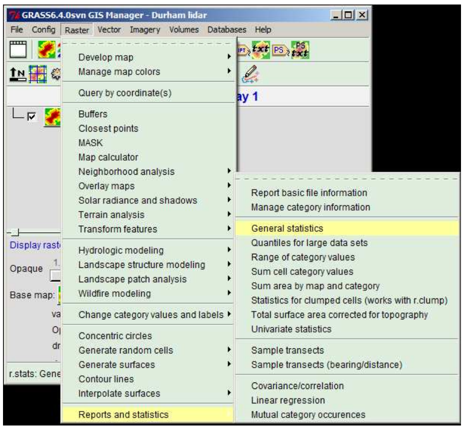


6. In the Input tab, change the separator to a space and leave the rest of the settings as default. Run the tool.

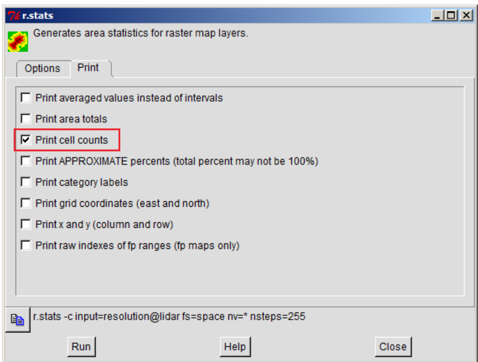


7. Add the raster to the display window

8. Now we will look at how many point were found per cell. Navigate to Raster > Reports and Statistics > General statistics



9. Add the raster map in the Options tab. In the Print tab check Print Cell Counts and run the tool



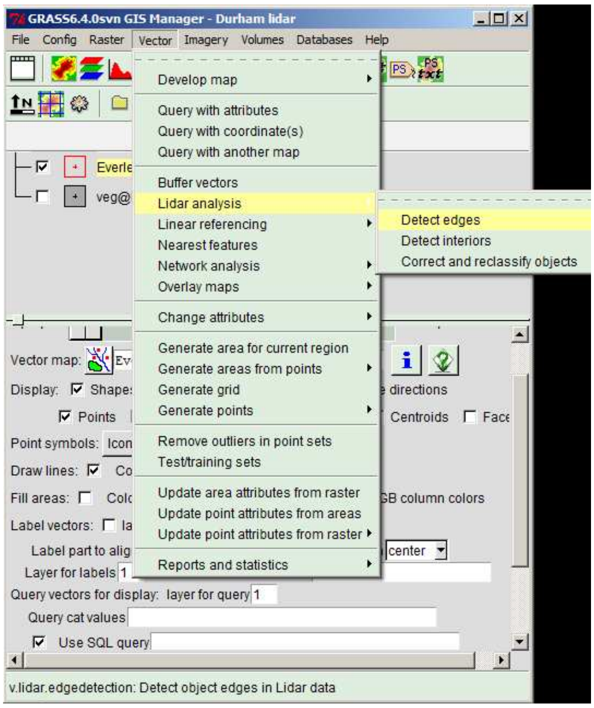
In the output window you will see the results of the cell count. What does this tell you about the quality of the data at 1m resolution? At what raster resolution would you have a point in every cell?

Task 13 – Filtering Vegetation

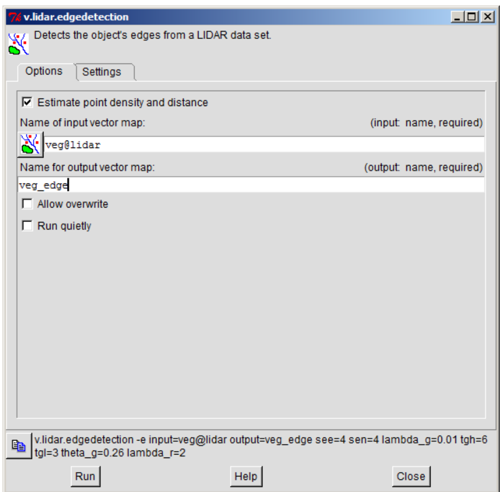
1. We will now look at the tools for filtering vegetation in GRASS for the XYZI data we have used in the previous tasks. In reality, lidar point data is distributed in a number of forms, often with first point / last point returns as a single file. More information on how to handle lidar files in other formats can be found on http://grass.osgeo.org/wiki/LIDAR

   First we will establish a new region of interest by importing a shapefile. As in Task 9 import the shapefile Everleigh using File> Import> Vector> Multiple Formats using OGR. Then use Config > Region > Change region settings to make this vector the current region. Import the .txt file Veg from the Data folder using the same process as in task 9

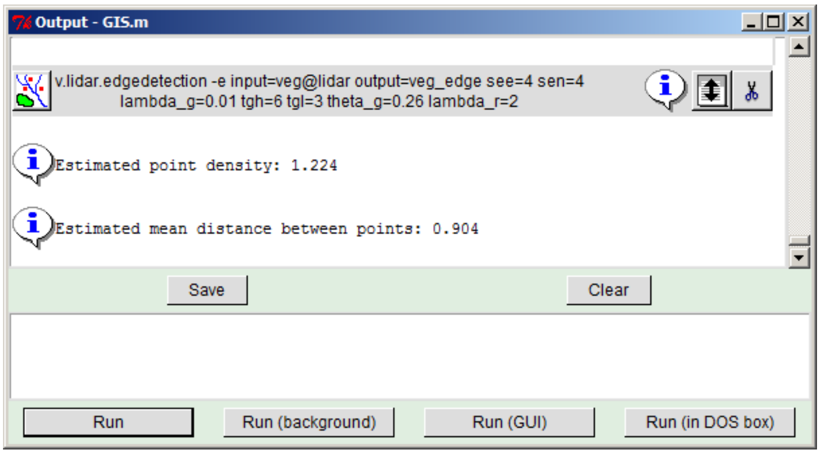
2. We will now use the GRASS lidar tools to detect returns that do not represent the ground surface. Navigate to Vector > Lidar Analysis > Detect Edges



3. In the v.lidar.edgedetection tool select the vector file you imported in the last step and enter an output filename.

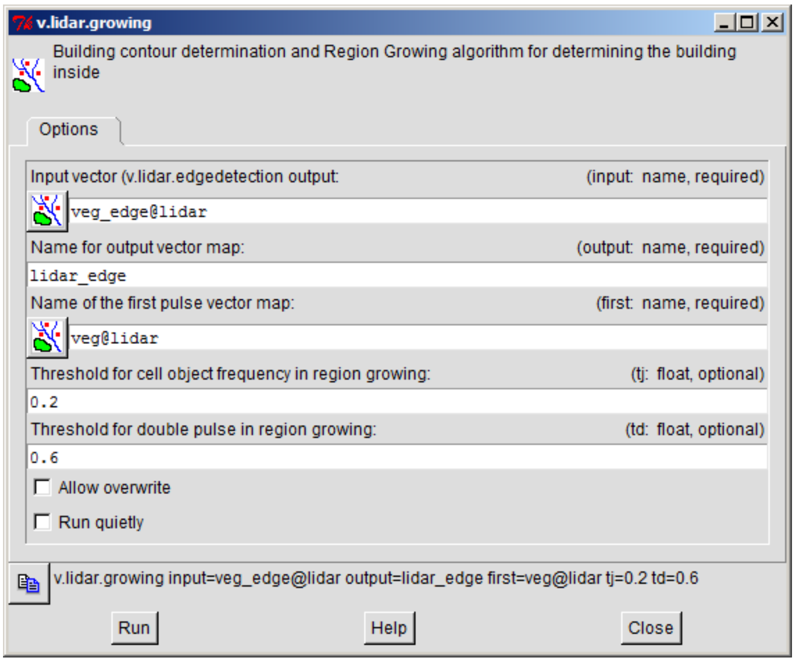


4. By checking the Estimate Point Density and Distance box you can also check the quality of the data before you run the tool. The results of this will be shown in the output window.

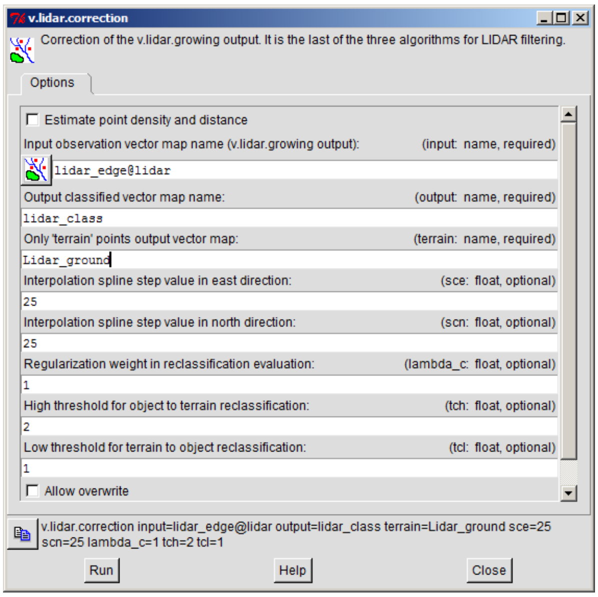


5. Uncheck the box and run the tool.

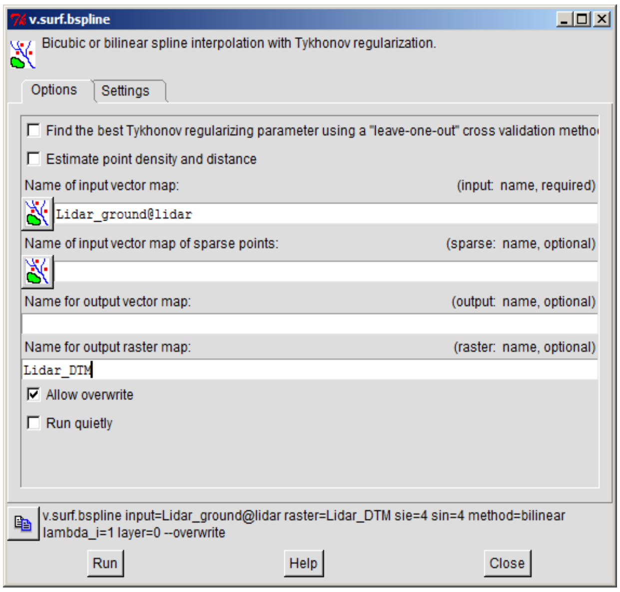
6. Next we will build contours for determining the areas of vegetation. Navigate to Vector > Lidar Analysis > Detect Interiors. Select the vector created from the edge detection and the vector with the original points. Name the output vector and run the tool.

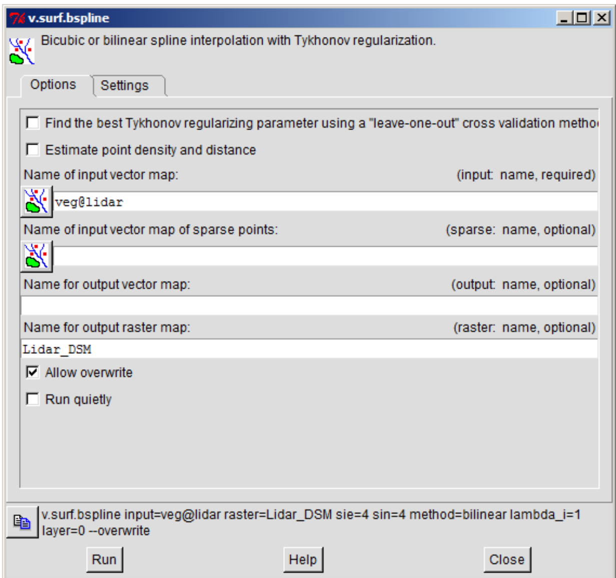


7. Now we will classify the point identified as being vegetation Navigate to Vector > Lidar Analysis > Correct and Reclassify Objects.



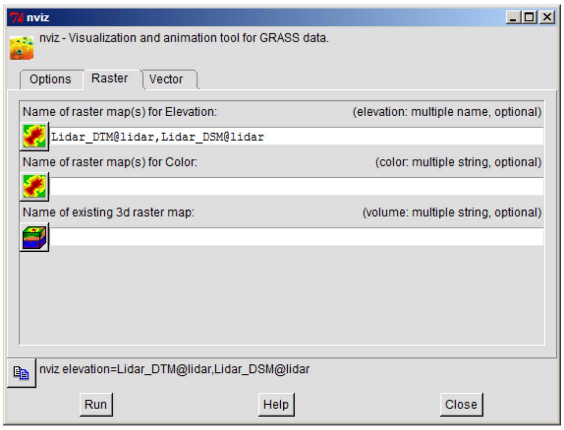
8. Now we will build two rasters – the first from the reclassified points (DTM) and the second (for comparison) from the original points (DSM).



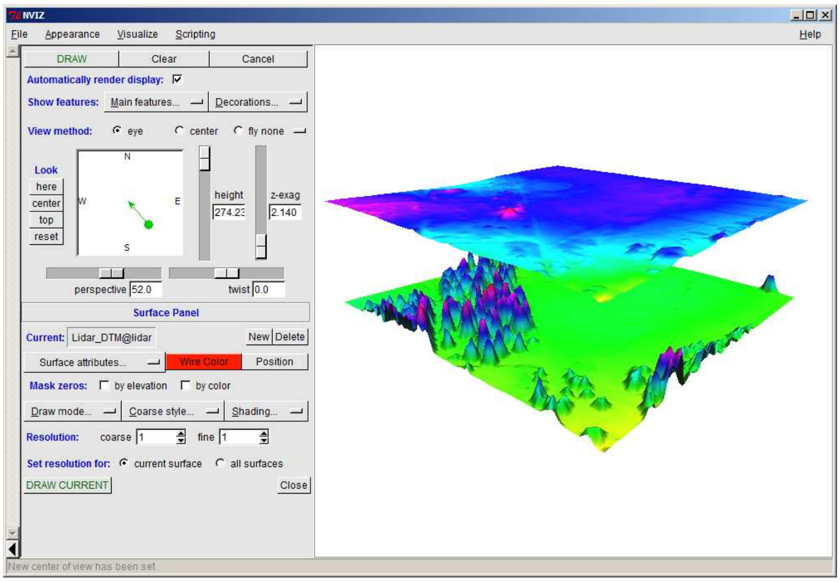


9. Add the DSM and DTM rasters to the Map display to view the results of the filter process.

10. You can also view the rasters in 3D using Nviz as in Task 11. Add both rasters to the NVIZ tool



11. Using the Visualize > Raster Surfaces > Position menu in Nviz the two rasters can be separated to view the results of the filtering

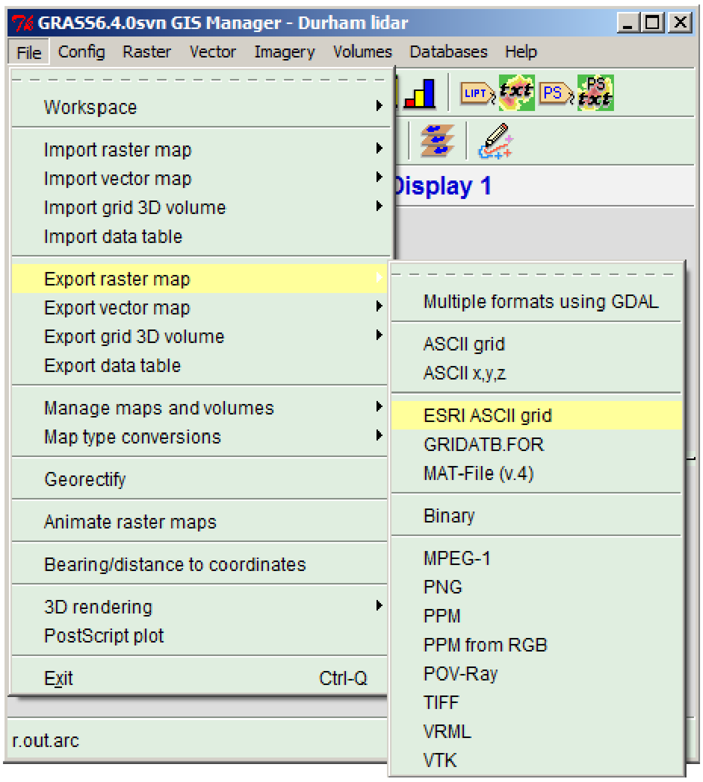


Task 14 – Exporting GRASS data

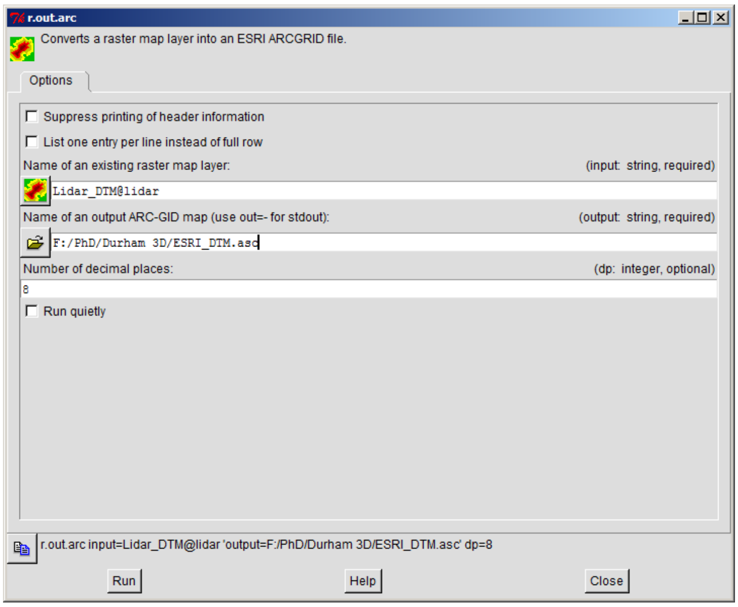
GRASS is able to export vector and raster data in many formats including ESRI (grid and shapefile), Matlab (.mat), DXF, KML, text file and Tiff. Most of the options for export are found in File > Export Raster Map > Multiple Formats using GDAL or File > Export Raster Map > Multiple Formats Using OGR. Some like the ESRI grid require separate tools which are also listed in the menus File > Export Raster / Vector Map.

In this task we will export both vector and raster data. The key thing to remember is to ensure that the region of interest is configured to encompass the whole of the data you wish to export.

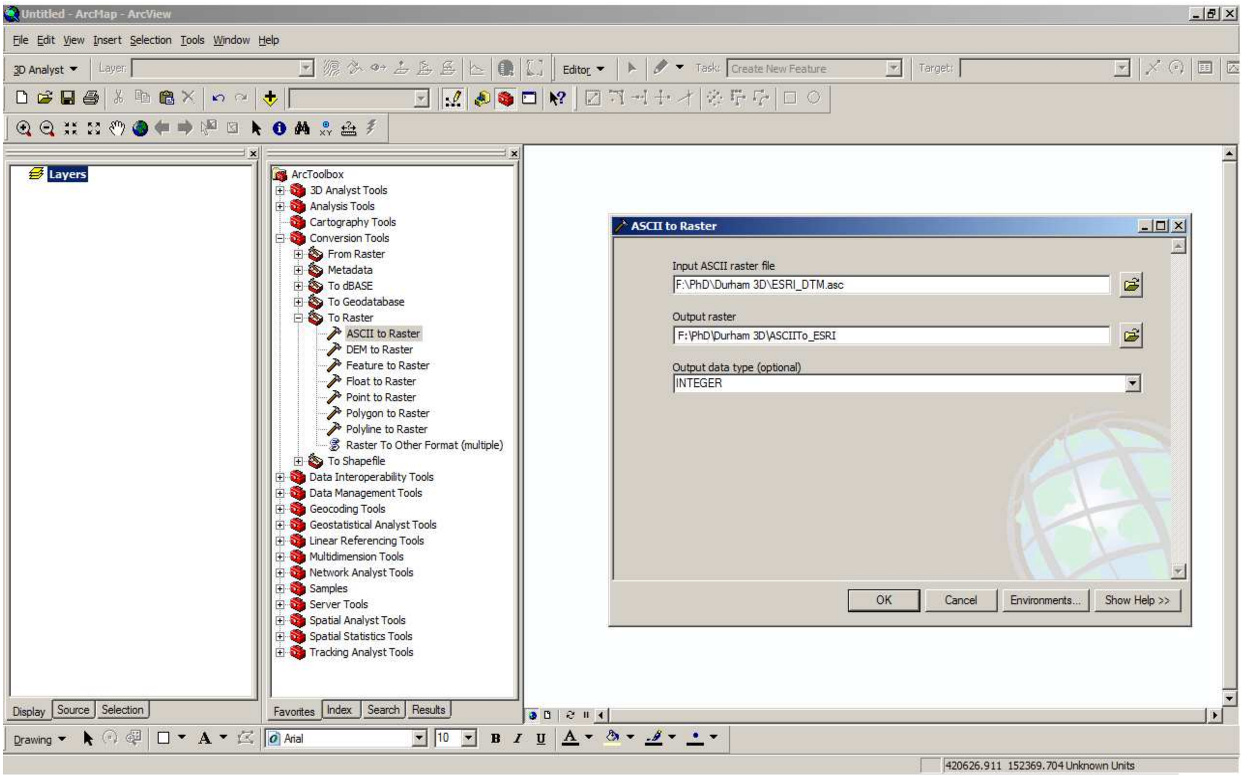
1. First we will export the DTM raster we have just created into an ESRI (ArcGIS) raster. In the GIS manager navigate to File > Export Raster Map > ESRI ASCII Grid



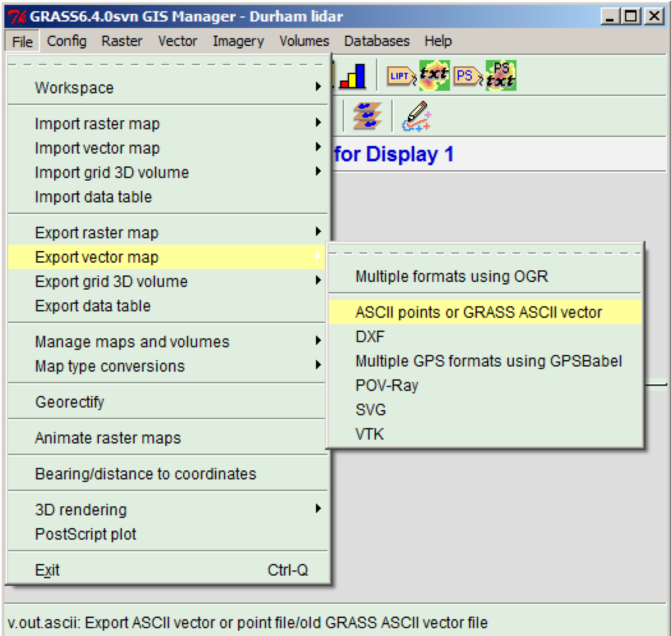
2. Select the file to export and chose a location and name for the ESRI raster. Append the file with .asc or .txt



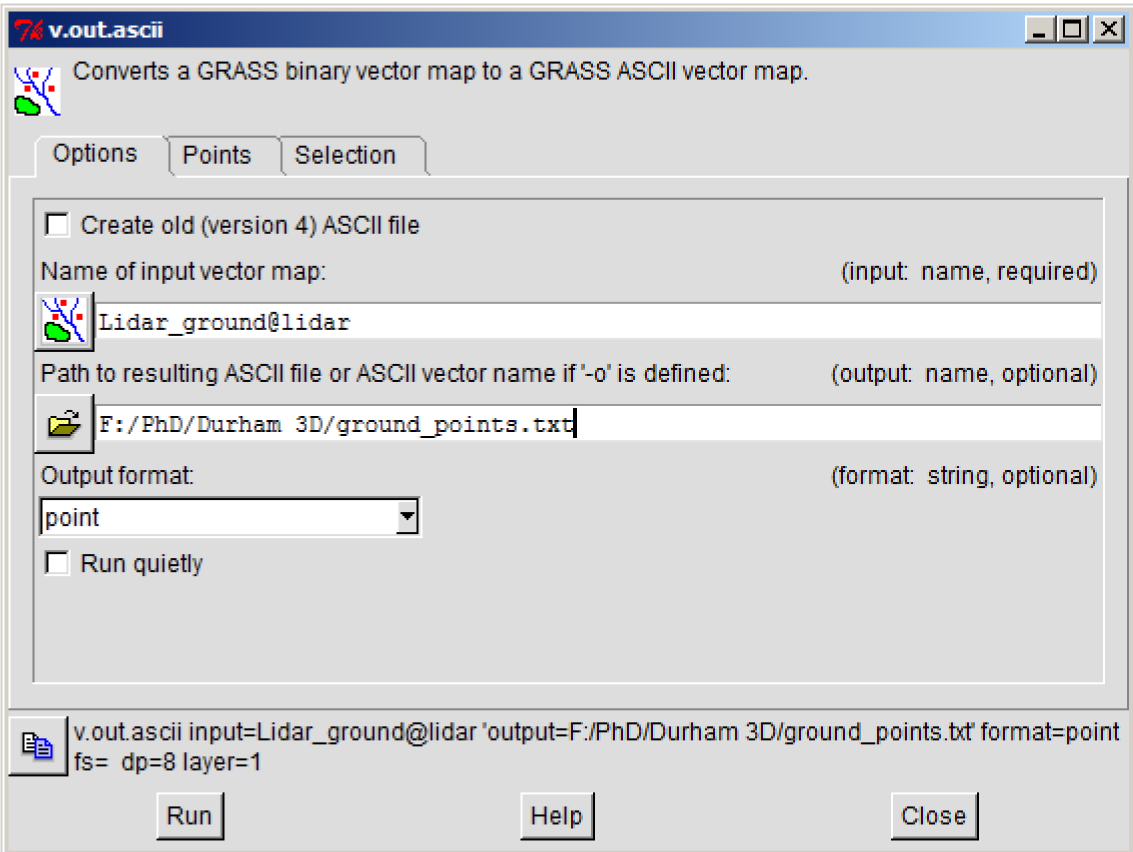
3. The ascii file created can now be read by ArcGIS. Open ArcGIS and in the tool box navigate to Conversion Tools > To Raster > ASCII to raster tool.



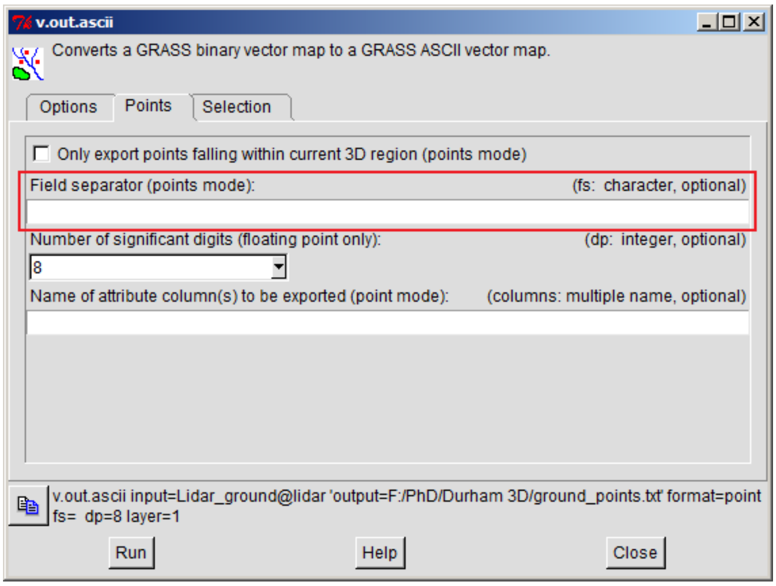
4. We will also export the filtered vector points as a text file. Navigate to File > Export Vector Map > ASCII Points or GRASS ASCII Vector



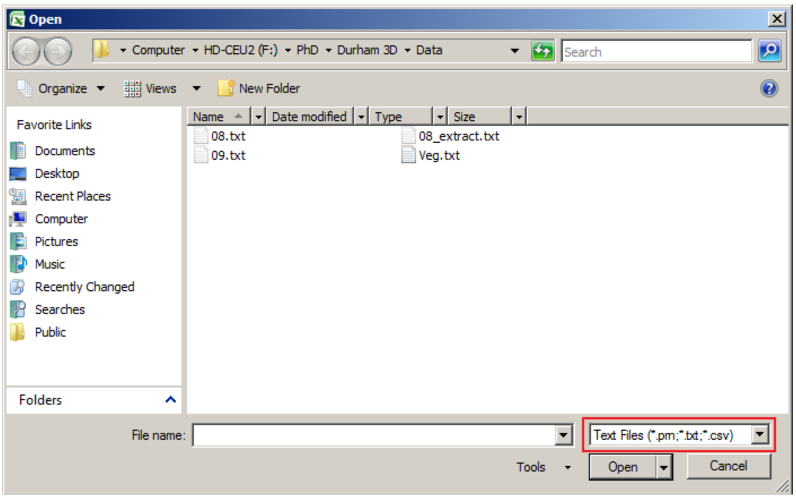
5. Add the vector to be exported and give the export file a name (appended with .txt)



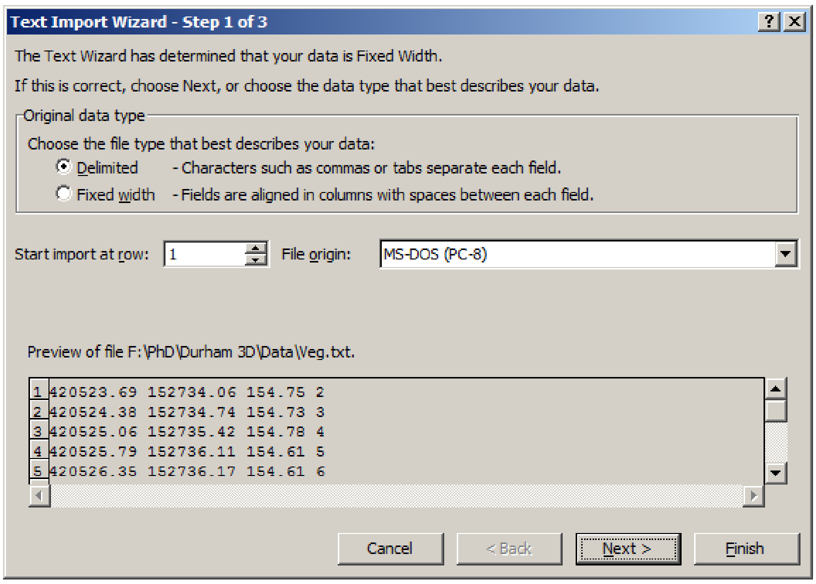
6. In the Points tab, choose the field separator you wish to use (the default is “|”)



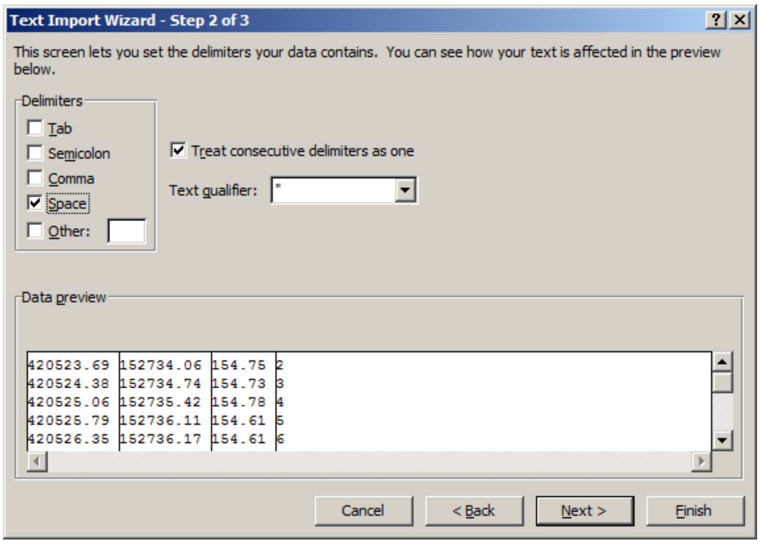
7. The .txt file created can be opened in Excel or OpenOffice Calc. In Excel navigate to File > Open. Change the file type to csv.

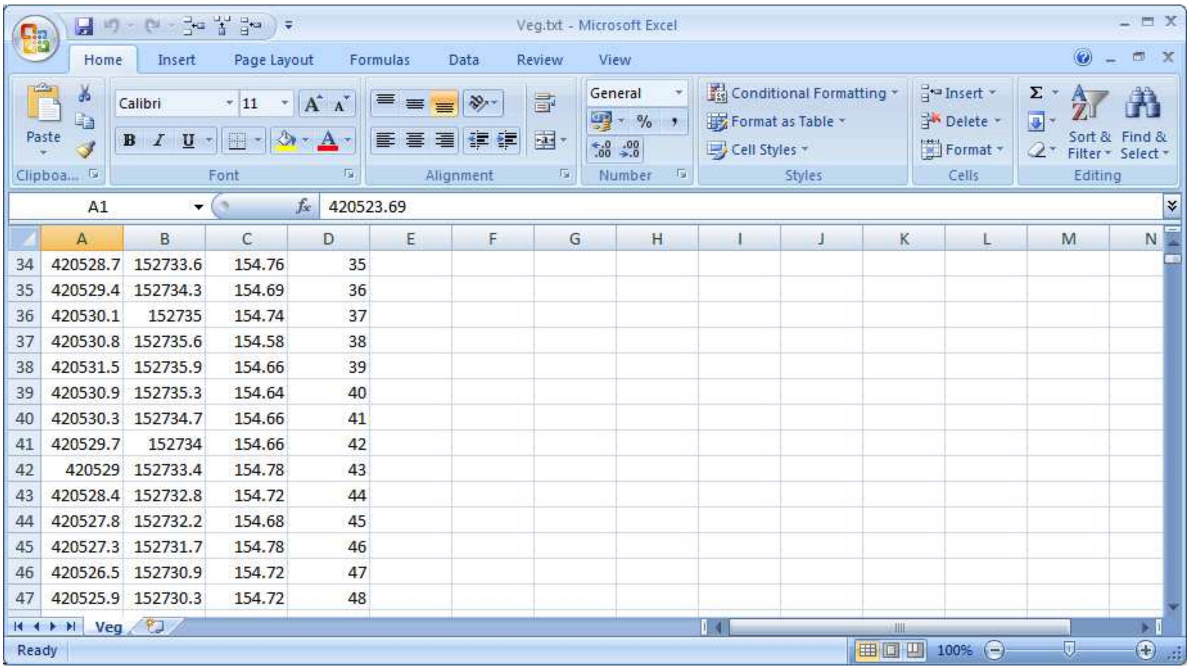


8. Choose Delimited and click next



9. Select the delimiter (in this case a space) and click finish to view the data.





Useful Information / Resources

A how to list for QGIS.... http://dl.dropbox.com/u/2858167/Selected%20How%20To_withEmail.pdf

The QGIS forum - http://forum.qgis.org/ full of lovely helpful people.

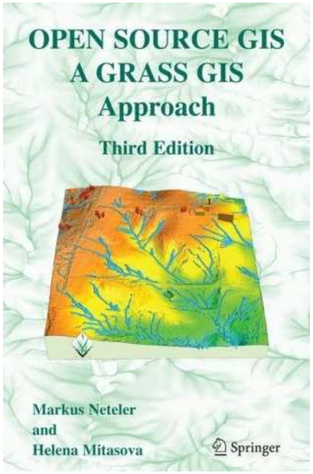
The QGIS project homepage http://www.qgis.org/

The GRASS wiki - http://grass.osgeo.org/wiki/GRASS-Wiki particularly the lidar page http://grass.osgeo.org/wiki/LIDAR

GRASS reference manual, http://grass.itc.it/gdp/html_grass63/index.html for detailed information, sources and usage tips on each of the tools.

GRASS tutorials http://grass.osgeo.org/gdp/tutorials.php

The GRASS users mailing list - http://grass.ibiblio.org/community/support.php check the archives for useful tips



The GRASS bible – hard work to get through at times but certainly the most comprehensive guide to using GRASS

Markus Neteler and Helena Mitasova, 2008,
Open Source GIS: A GRASS GIS Approach. Third Edition.
The International Series in Engineering and Computer Science: Volume 773. 406 pages, 80 illus., Springer, New York
ISBN: 038735767X | ISBN-13: 978-0-387-35767-6 | eBook
e-ISBN-13: 978-0-387-68574-8
Published 1st Nov. 2007

OSGeo http://www.osgeo.org/ - a portal for all thinks OS and Geographical in the UK

OSGeo4W - http://trac.osgeo.org/osgeo4w/ where to download QGIS and GRASS for Windows

OS GIS Professionals...

For examples of how OSGeo software is being used commercially in archaeology and heritage management -

http://thehumanjourney.net/index.php?option=com_content&task=view&id=316&Itemid=201