KOMPENDIUM

Setting up and using QGIS for geomorphological exercises

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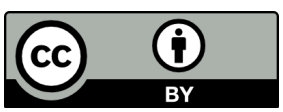
Contents



Preface

This instruction shows how you download and install QGIS as well as a add some necessary plugins to use in conjunction with exercises in Physical Geography. This is not a tutorial on how to use QGIS, nor an introduction to GIS, but will set you up to use QGIS for some specific purposes.

If you wish to explore the data of the exercises further you should resort to the wealth of online information given through the QGIS documentation site and the StackExchange GIS Q&A site.

In your continued education you may encounter ArcGIS which is a commercial GIS software. QGIS is freeware and always available to you. The way you process data in detail may vary but general GIS principles are the same. I suggest you always keep your eyes on Open Source software since such software is built by the community that uses it.

Note that you can install QGIS on all platforms, Linux, Macintosh and Windows. You can also keep several versions installed at the same time. QGIS maintains what they call a 'long term release' (2.18 at the time of writing) at the same time as their 'latest release' (3.2.3 at the time of writing). The long term version should be very stable whereas the latest version may include novel solutions but not be stable under all circumstances. I would strongly recommend that you keep both versions on your computer if you need to work in-depth with GIS. After all, the versions are quite similar. Availability of plug-ins may vary.

This instruction was written using LaTeX in Overleaf and preparing figures in GIMP (GNU Image Manipulation Program).

Support Open Source freeware!

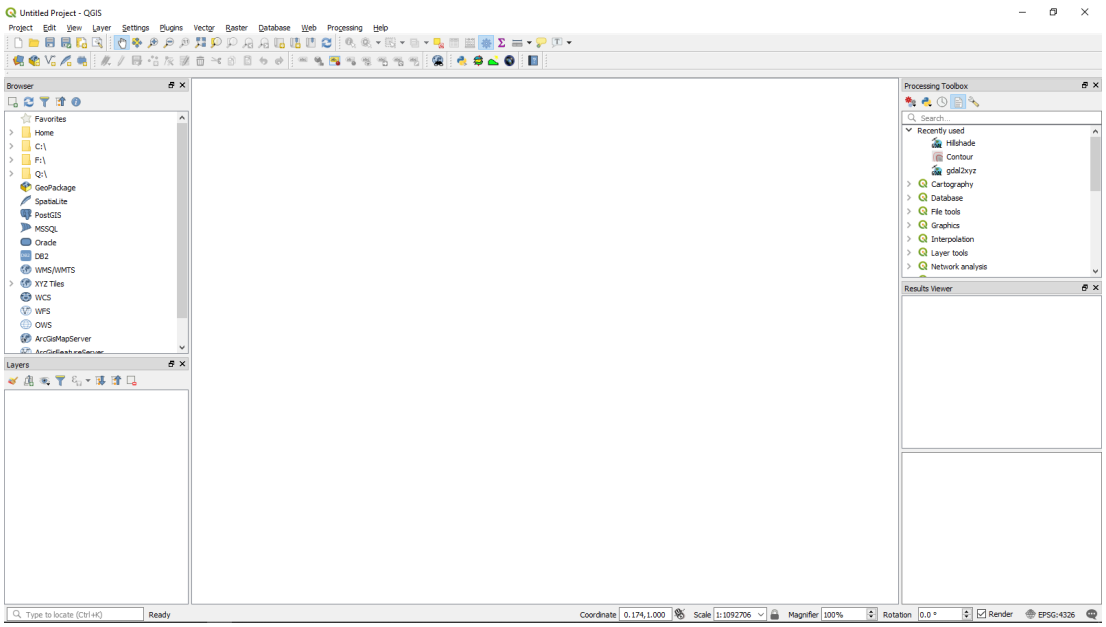
1 Installing QGIS

To install QGIS visit the QGIS web site and download the 'Latest Release' 32 or 64-bit QGIS Standalone installer (chose the version that fits your system). Once downloaded run the installation file and accept the default settings presented to you. Once the installer is done you have a fully functional free and open GIS system on your computer.

2 The graphical user interface

Once you have installed QGIS you will note that several programs seem to have been installed. For now you only need to concern yourself with the 'QGIS Desktop', which is what we will use.

Start QGIS by opening the QGIS Desktop. This will open a window looking like the following image



There are several panes in this window. The largest is the map window where your work will be shown. To the left you will see two panes called 'Browser' and 'Layers'. The Browser shows files and folders in your GIS project and the Layers show the different layers of data in your project. We will see this in detail below. To the right you see two panes called 'Processing Toolbox' and 'Results Viewer'. We will return to these later.

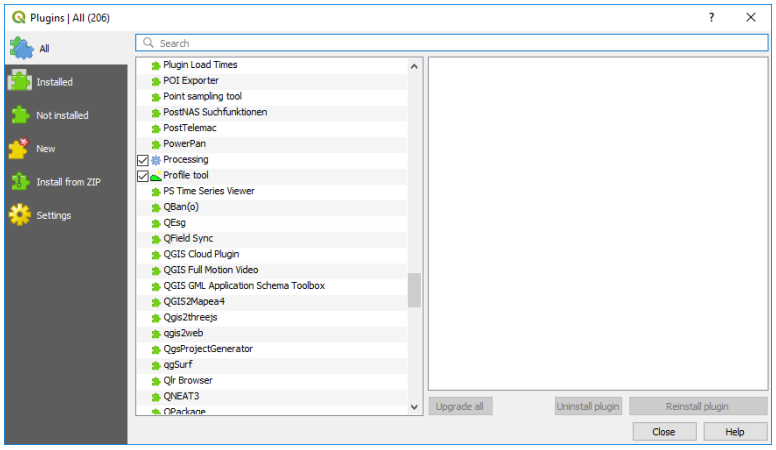
There are lots of tools in toolbars and menus and for the time being you should not concern yourself too much with these. We will return to everything you need when you need it.

3 Additional tools

QGIS provide means to use a large number of different tools provided as so-called 'plug-ins'. For the exercises you will perform you will need to install a plug-in called 'Profile tool' which allows you to view elevation profiles in the DEMs you will be working with.

To install this plug-in, you click on the plugins menu item and select the Manage and Install Plugins…. This opens a new window which lists all available plugins. Locate

the ‘Profile tool’ plugin entry in the list.



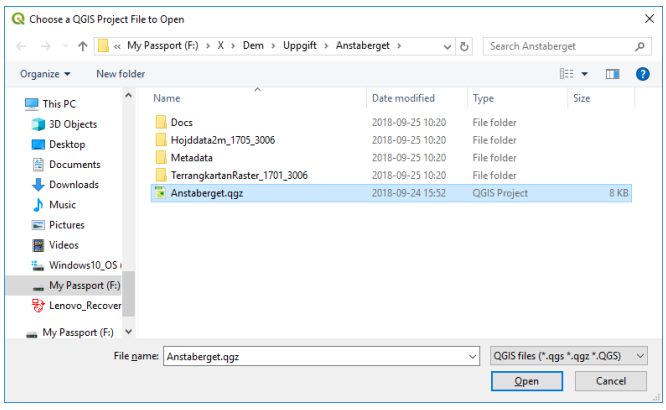
Click on the plugin name and click on the ‘Install plugin’ button that appears at the lower right in the window. the plugin will be installed and marked with a checked box to indicate it is installed.

You should now have all the necessary tools you need for the exercises.

4 Open a GIS project

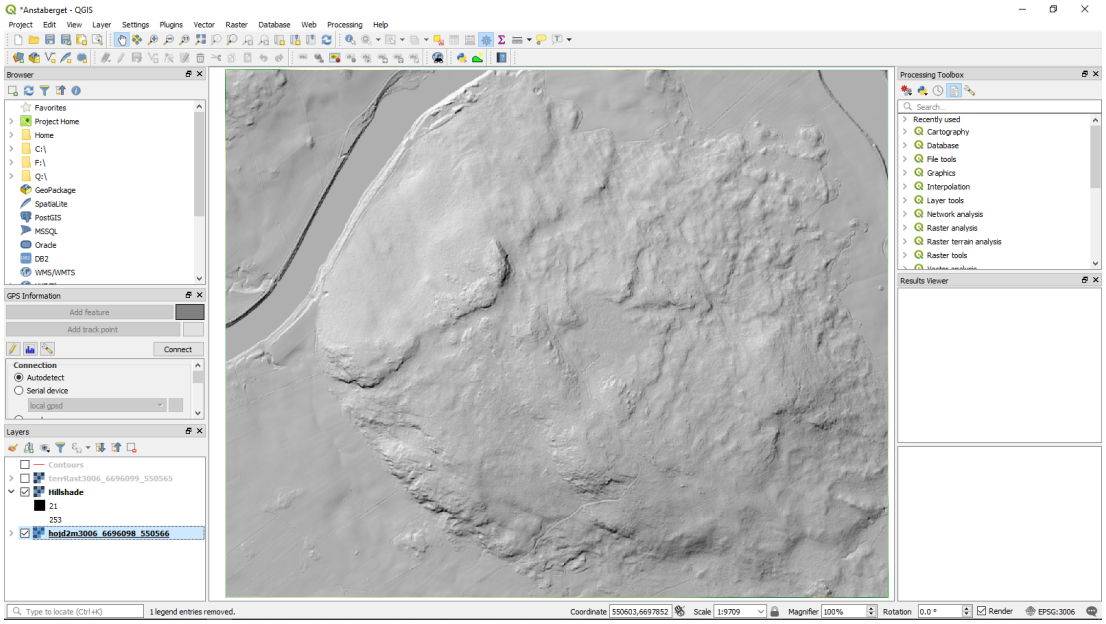
When you download a project you will receive it as a Zip-file. Simply unzip the content to some folder where you keep data. Each project will unzip as a folder with a name indicating the locality of the GIS project. So when you download several projects and unzip them in the same basic folder the different files will still be contained in a separate sub-folder.

In each project folder you will find a QGIS project file with the extension `qgz`[1]. To open a project simply click Project in the QGIS menu followed by Open and locate the project file.



In the figure we have a project file called `Anstaberget.qgz`. Open the project file and you will see the project in your main pane of QGIS:

[1] `.qgz` is a zipped file. In older versions of QGIS the project file had the extension `.qgs`. The current version of QGIS can read both whereas older versions can only read `.qgs` files. The current version can save projects in both formats.

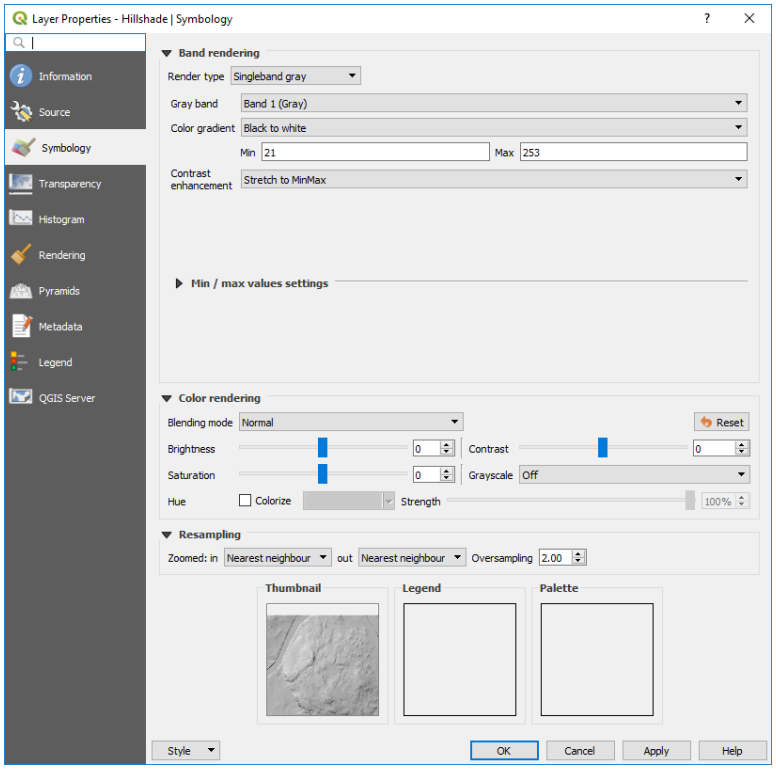


You will now see a map of the project in the main pane. In the lower left pane you see (in this case) four entries, two of which are ticked boxes and two that have empty boxes. Each box and explanatory text concern a layer in your project. This project has four layers which you can think of as four sheets of paper stacked on top of each other, each containing some information. You can turn each layer on or off by checking (clicking) the box. In the case above the lower two layers are checked which means the upper two are invisible at this point.

The layer names may be difficult to understand. The names can be changed but in these projects some layers have been left with the original names of the data. The layer starting with 'hojd2m3006...' is the 2-m resolution elevation data obtained from the Swedish Land Survey. The layer called 'Hillshade' contains the shaded relief that you see in the figure. The layer starting with 'terrRast2006...' is a terrain raster map also obtained from the Land Survey. The 'Contours' layer contains the elevation contours calculated in QGIS from the elevation data.

You can select and unselect these layers to view or hide each layer. But, remember, you can only view a particular if layers above are first turned off, otherwise they will obscure the layer you wish to look at. It is possible to make layers translucent but we will return to this below.

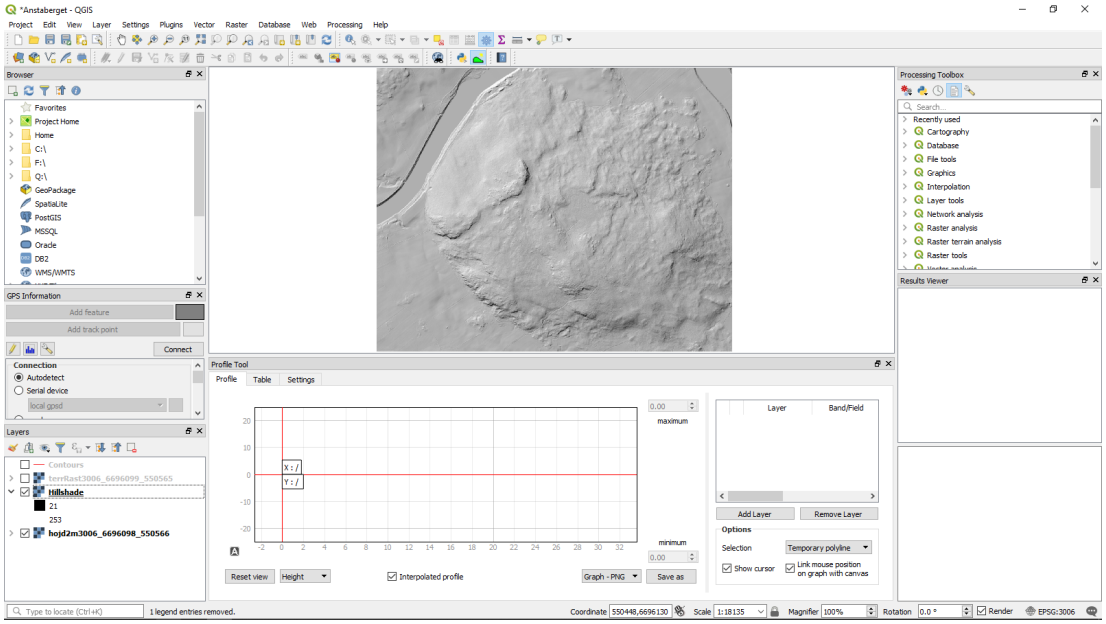
If you mark a layer and right click on the layer you will see a menu where one entry is called 'Properties'. Selecting this opens a window where you can make many changes to that layer



The content of the properties window will differ depending on what type of layer you are working on. One setting you can see to the left is 'Transparency'. In this setting you can change the setting for your layer from 'opaque' (default) to some percentage of transparency. this means you can set a layer so that you can see through it and hence see the layer below to some extent. Give it a try.

5 Using the profile tool

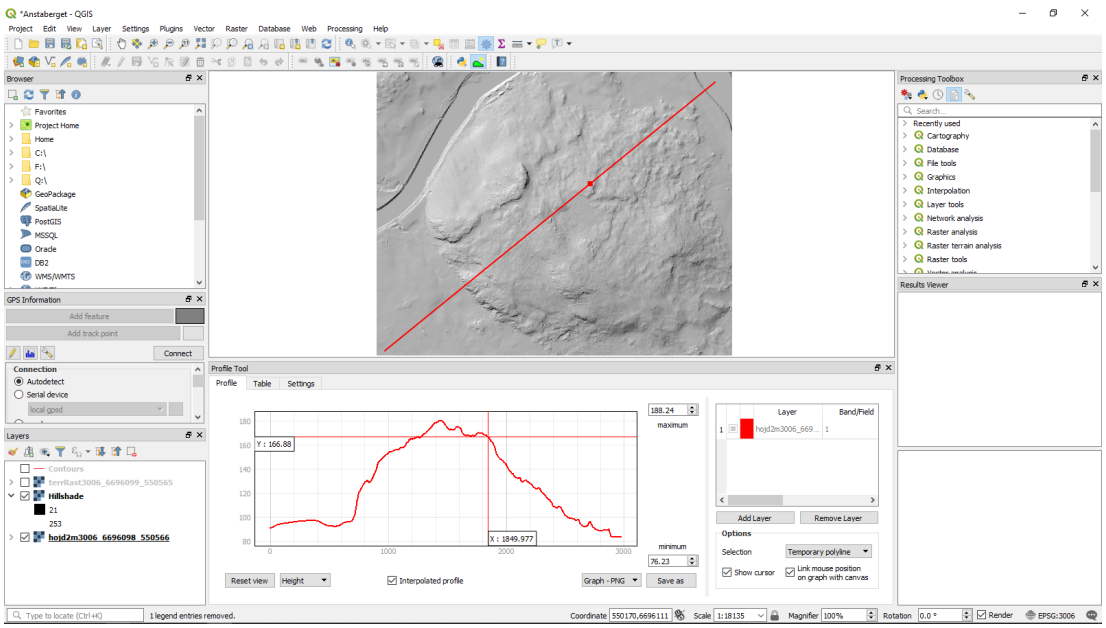
When you want to measure a profile in your terrain data, you need to click on Plugin and then select the Profile tool followed by Terrain profile. This opens a new pane below the main map pane



In this example we want to make a profile across the mountain from the top right to the bottom left corner of the map. Note that when you opened the profile tool the map was shrunk so that you see just as much of the map as you did before.

Start by clicking on the terrain data in the 'Layers' pane. Then click on the Add layer Button in the profile tool. The elevation data you selected in the layers pane will now be included in the profile tool. You are now ready to make a profile.

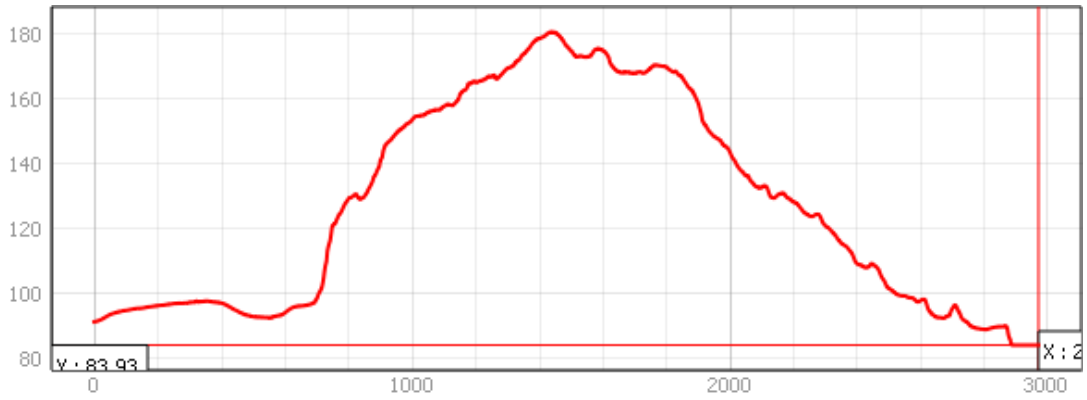
To create a profile you click once on the map and then move the cursor to the end point and double click. This establishes a straight line profile between the start and end point. as you double click to end the profile the profile will be visualised in the profile graph.



Note that the profile in the graph window is plotted from left to right as you started and stopped your profile. In this case I started the profile in the lower left corner and finished in the upper right corner so that the plotted profile depicts the general direction

of the profile in the map.

Once you have made a profile you can export the graph to a file. You have the option to chose a PNG bitmap graphics file, a SVG vector graphics file or a DXF CAD file. The simplest choice is to use the PNG option which yields a figure you can quickly save for additional study. The following figure was exported from the profile tool as a PNG graphics file:



Since the elevation model is measured in metres, the vertical and horizontal scales are in metres. The vertical is given as m a.s.l. (metre above sea level; the elevation) whereas the horizontal is given as metres from the starting point.

If you look at the Profile tool above you can see that there are two red lines in the graph window, one vertical, one horizontal. These lines move as you move the mouse cursor over the plot window. When you do so there will be a red square moving on the profile line in the map view. This means you can identify exactly what part of the profile is where on the map, or *vice verse*. You can also immediately see the values extracted from the DEM along the profile which means you can check, for example, elevation differences between two points along the profile.

The profile you established by clicking on the map is not permanent. If you click on the map again you can establish a new profile and the previous profile will be lost. Furthermore, you know you need to end the profile by double-clicking. If you do not you can extend the profile in a different direction and continue laying out a profile until you finish with a double click.

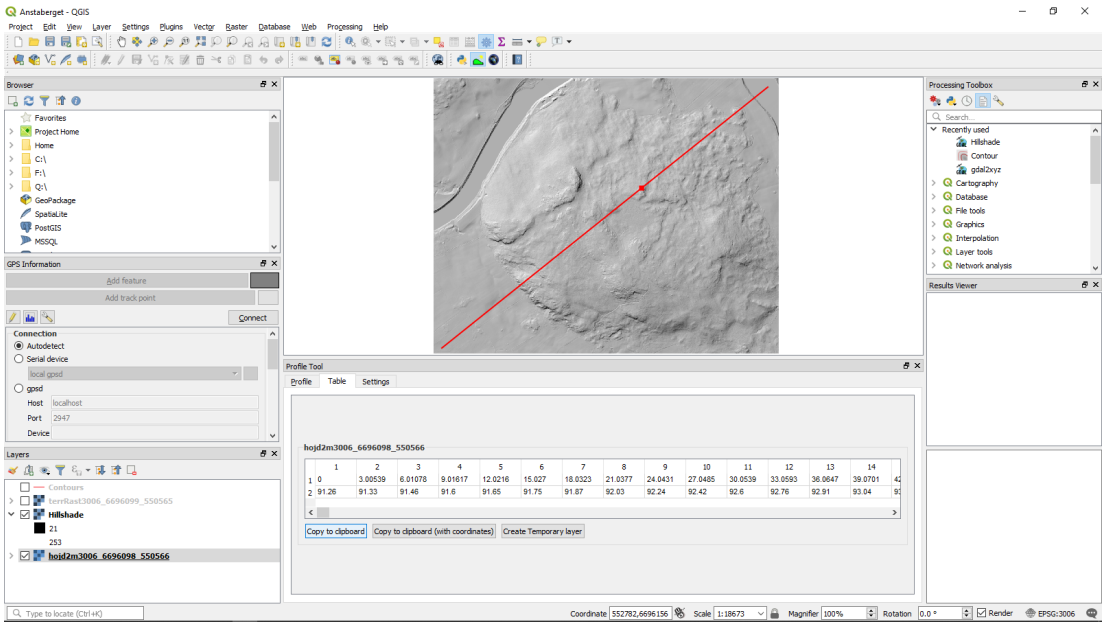
It is important to realise that the plot window will adapt to the maximum and minimum values of the profile. Hence you need to be careful when comparing two profiles since the vertical scale may vary between the two. The tool is nevertheless a very useful tool for examining and evaluating what the DEM shows.

Note that in this example we have used the elevation data for the profile but used the 'Hillshade' to view the topography. The reason for viewing the hill shade is that it provides a better 'feel' for the topographic changes that the pure elevation model. So do not forget what it is you are doing and what you see.

Once you close the profile tool window all profiles will be lost. You do, however, have the possibility to copy the profile data from QGIS to, for example, a spreadsheet software such as Excel or or Openoffice Calc software. In the following we will look at how to transfer data to Excel.

If you click on the 'Table' tab in the profile tool pane, you will see the data that makes up the profile. The data is distance along the profile and the elevation at each point. This is what makes up the profile in the profile view above. The data that is

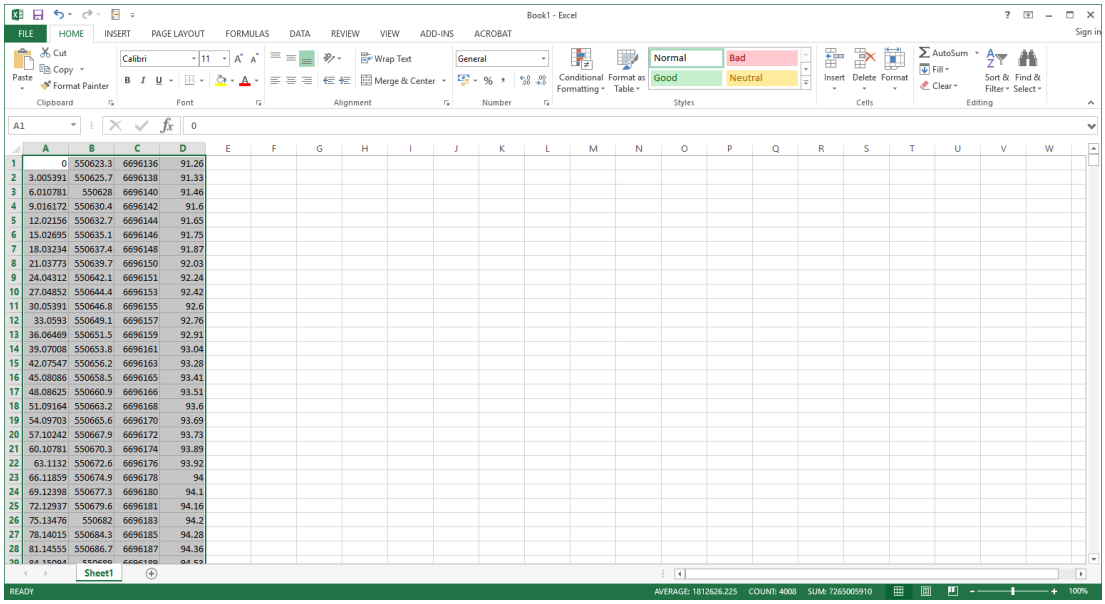
extracted along the profile consist of a maximum of 1000 equally spaced points. It is possible to obtain more data points by checking a box titled 'Full resolution enabled' on the 'Settings' tab. This will provide data that matches the full resolution of the elevation data (2 m). This may be necessary if profiles become very long so that the resolution with a 1000 points is deemed too poor. Remember, however, that, say a 1 km profile sampled at 2-m resolution will yield 500 data points. This will allow you to estimate how many data points will be obtained for a specific profile length you intend to store.



Below the the data you see three options for copying this data. The first copies the distance and elevation data so that you can paste it into a spreadsheet like Excel. The second does the same but also provide coordinates for each point. This may be useful since it will tell you where the terrain profile is located. It is also possible to make profiles that are not just a straight line in which case coordinates may be even more useful to store. The third option creates a temporary layer showing the points and the profile in your GIS project. The layer will contain all the points that the profile tool extracted.

The temporary layer created by the Profile tool is just that, temporary. If you save your QGIS project and reopen it the layer will exist but the information in the layer will be lost. In order to save the profile you can right-click on the temporary layer after it has been created and select 'Save as...'. Give the layer file a name and by default the layer will be named the same. Now your profile has been saved. Note that you will now see both the temporary layer and the copy you saved. You can safely delete the temporary layer and next time you open the project your saved layer will be included showing the profile points.

It is useful to be able to extract profile data to draw a better diagram of the data than what the profile tool can do. When you have copied the data using, for example, the incl coordinate button you should be able to paste straight into an Excel spreadsheet. The spreadsheet will look like this:

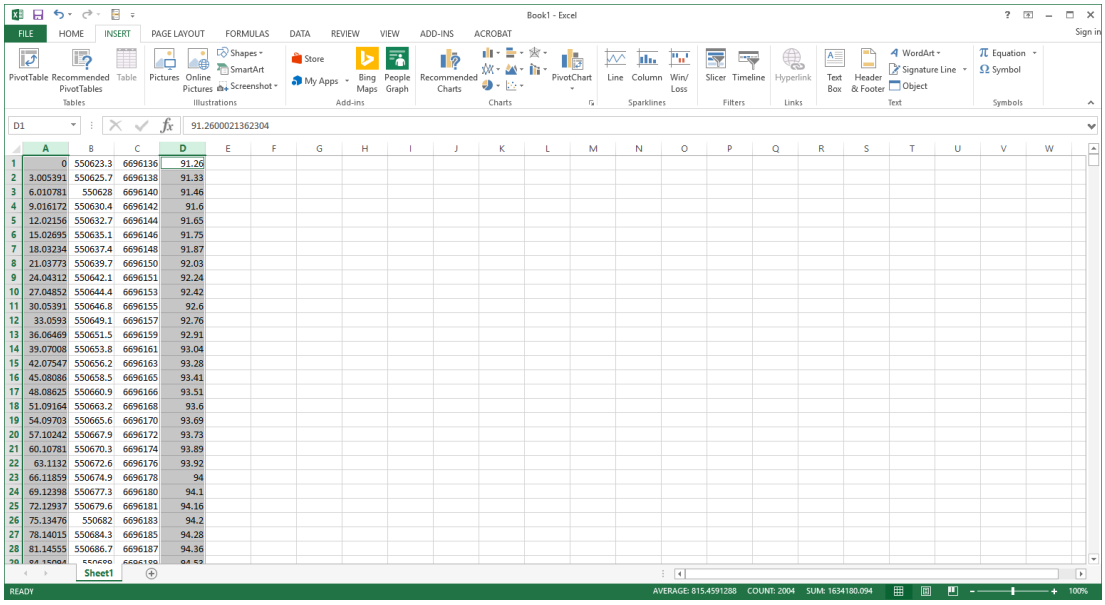


	A	B	C	D
1	0	550623.3	6696136	91.26
2	3.005391	550625.7	6696138	91.33
3	6.010781	550628	6696140	91.46
4	9.016172	550630.4	6696142	91.6
5	12.02156	550632.7	6696144	91.65
6	15.02695	550635.1	6696146	91.75
7	18.03234	550637.4	6696148	91.87
8	21.03773	550639.7	6696150	92.03
9	24.04312	550642.1	6696151	92.24
10	27.04852	550644.4	6696153	92.42
11	30.05391	550646.8	6696155	92.6
12	33.0593	550649.1	6696157	92.76
13	36.06469	550651.5	6696159	92.91
14	39.07008	550653.8	6696161	93.04
15	42.07547	550656.2	6696163	93.28
16	45.08086	550658.5	6696165	93.41
17	48.08625	550660.9	6696166	93.51
18	51.09164	550663.2	6696168	93.6
19	54.09703	550665.6	6696170	93.69
20	57.10242	550667.9	6696172	93.73
21	60.10781	550670.3	6696174	93.89
22	63.1132	550672.6	6696176	93.92
23	66.11859	550674.9	6696178	94
24	69.12398	550677.3	6696180	94.1
25	72.12937	550679.6	6696181	94.16
26	75.13476	550682	6696183	94.2
27	78.14015	550684.3	6696185	94.28
28	81.14555	550686.7	6696187	94.36

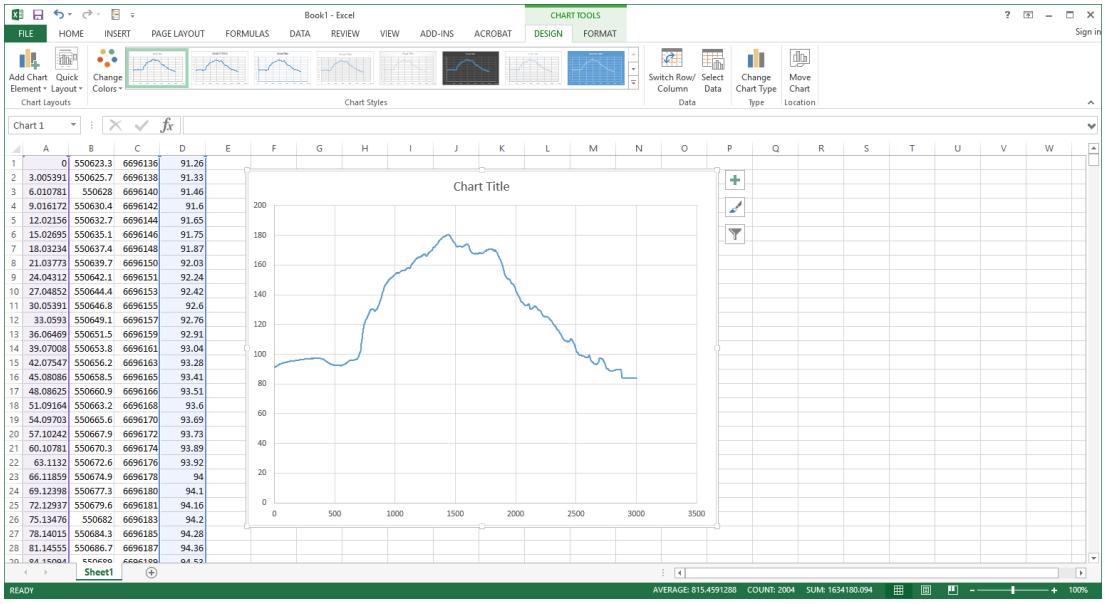
As you can see you receive four columns of data, the first is the distance along the profile, the second and third is the coordinate pair for the point and the fourth column shows the elevation of the point. The coordinates are in Sweref 99 TM with elevations in the RH 2000 model. You can find more information on these systems for reporting elevation data at the Swedish Land Survey (Lantmäteriet).

One issue that you may encounter is that the data you obtain from QGIS will have period (.) as decimal point whereas in many European countries comma (,) is used. Period has become a standard in programming and hence many software that handle data. When you paste data into Excel you can experience that the numbers with period as decimal point are treated as text and not a number which means you cannot make any calculations with the data and, in our case more importantly, make a diagram of the data. The problem, if it occurs, can easily be remedied by doing a 'find and replace' in Excel where you find all points and replace them with commas. Then the data should be considered numbers again by Excel.

Once you have your data in Excel, it is time to create a diagram of the data. We want to plot the profile using the distance (first column) and elevation (fourth column) data. Mark the first column and then mark the fourth column while pressing the Ctrl-button. The two columns should now be marked as shown below

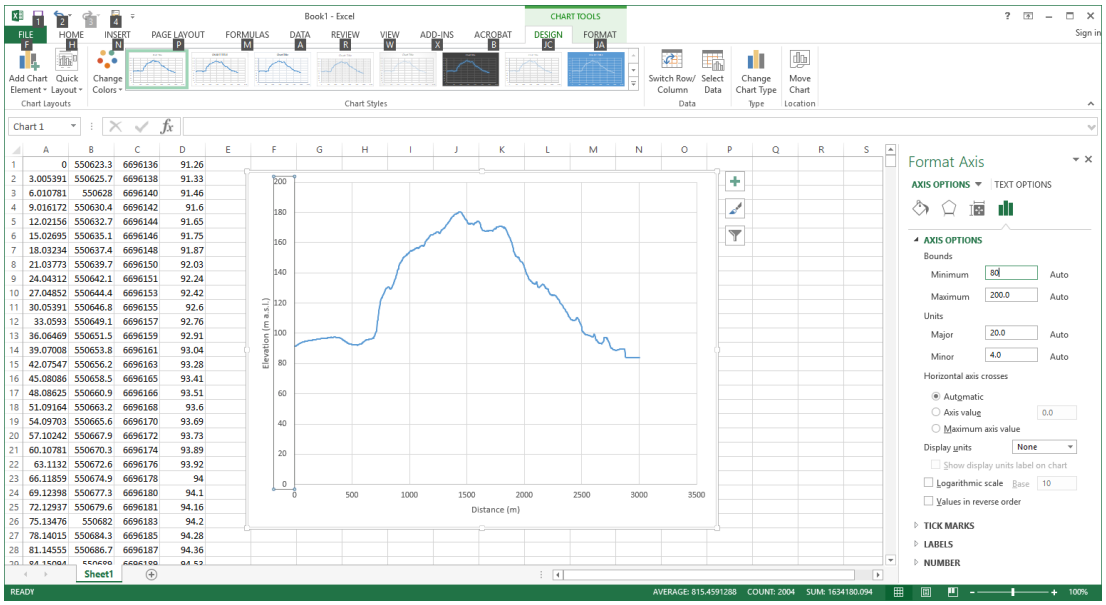


Select the ‘Insert’ tab and select the scatter plot as the type of chart. You then have several options for the type of scatter plot to make and you should chose the option with straight line segments and no markings for the data points. This will create a clean plot of the profile.

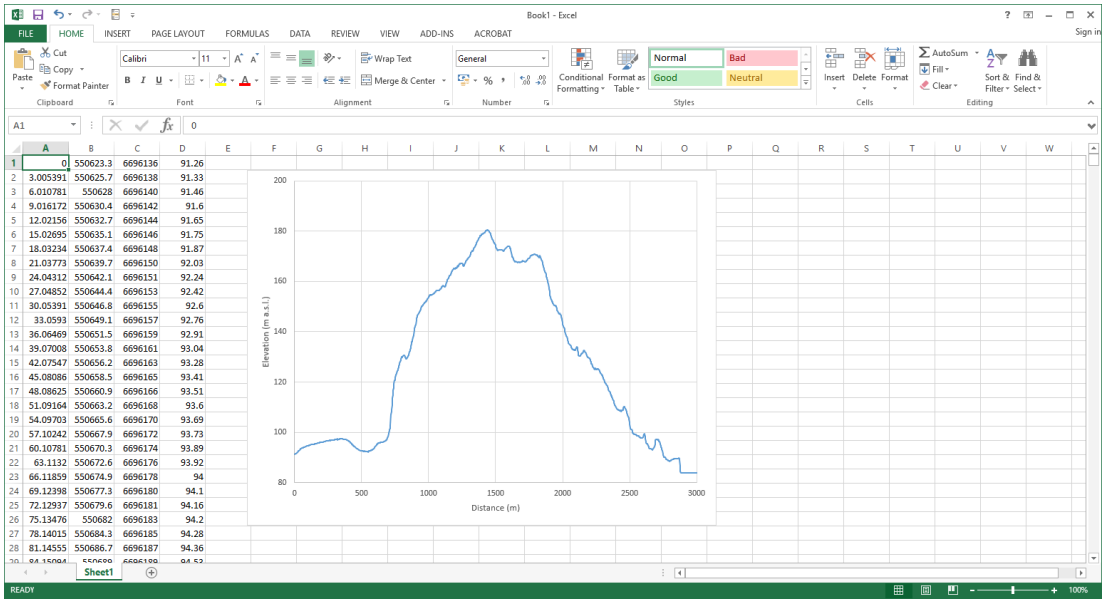


As you see from the picture above, the plot we receive is not yet in shape, some more work is needed. First we need to add titles to the axes. All plots MUST have axis titles that tell us what is being plotted and what units are shown on the axis. Click on the ‘Add Chart Element’ and select ‘Axis titles’. You then have the option to add a label to either the horizontal or vertical axis and you of course need to edit both. In our case we add the x-axis title ‘Distance (m)’ and the y-axis title ‘Elevation (m a.s.l.)’. The m a.s.l. means ‘metres above sea level’ and is the normal way to express elevations. In Swedish this is written m ö.h., ‘meter över havet’. Note how you punctuate the abbreviations. The SI unit ‘metre’ is abbreviated ‘m’ without a period while the ordinary words are abbreviated with a period. Units are never followed by periods.

Secondly we can see above that the axis are not optimal. There is a lot of dead space below the profile and also to the right where the profile ends. We should thus change the limits for the axes from the default values to something that better reflects the data. Simply double click on the one axis to open the 'Format axis' pane as you see below. Enter the desired max and min values for the axis in this case I wanted the y-axis to start at 80 m and stop at 200. Note that I have chosen even numbers. This is usually a good approach. Once you have completed the y-axis you can do a similar change on the x-axis.



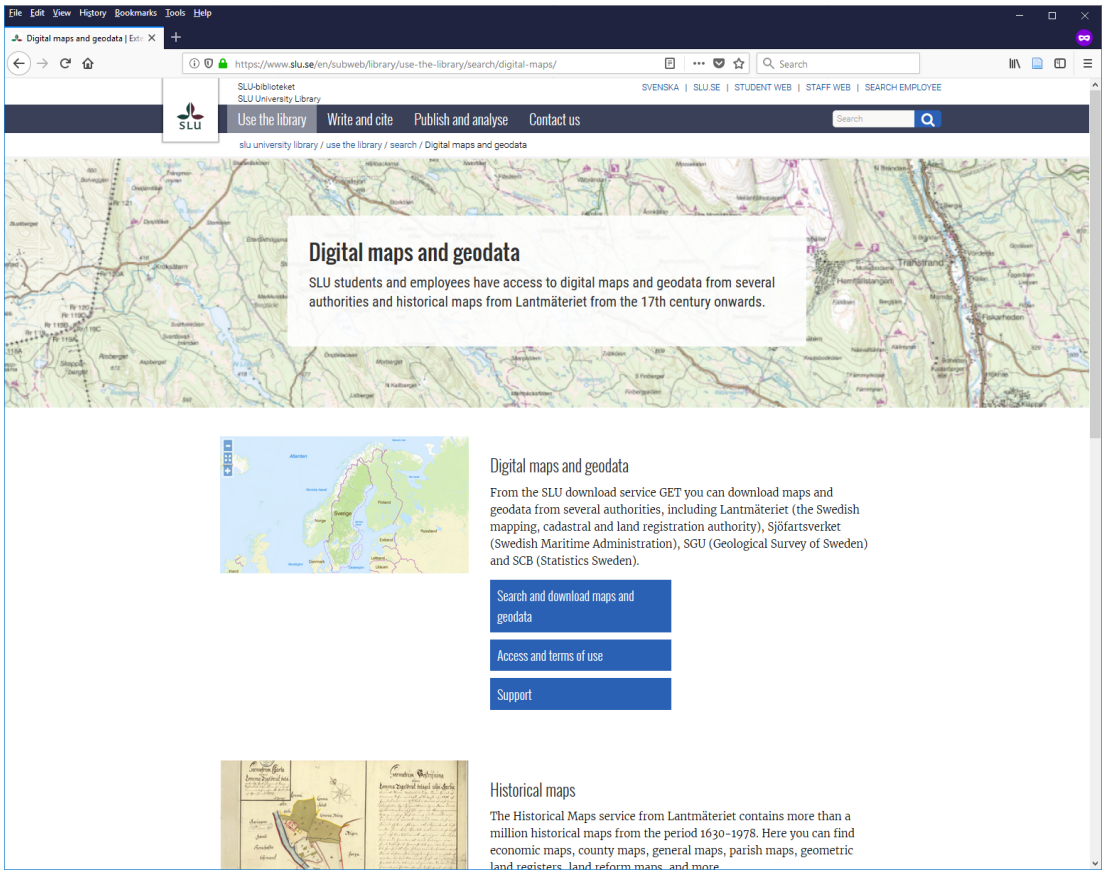
When you are done you have an acceptable chart showing the profile you extracted from the DEM. When you write a report you can safely include this diagram in the report. All diagrams you make and provide in reports must have the features we have edited, axis titles and axis ranges that shows the data properly.



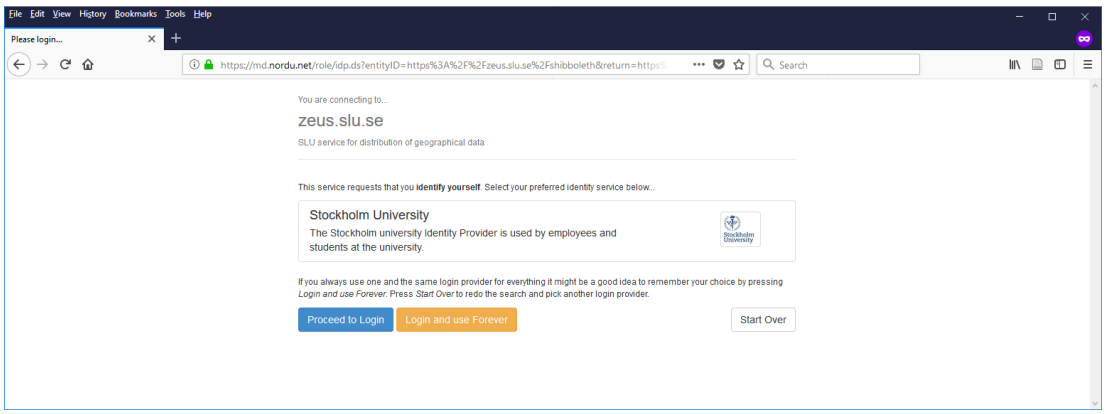
6 Downloading terrain data

In the geomorphological exercises we will primarily be working with Swedish terrain data based on the country wide laser scanning performed by the Swedish Land Survey. This data set is a 2-m resolution terrain model which can be accessed through Digital maps and geodata service provided by SLU (The Swedish Agricultural University). The following shows you how to download 2-m terrain data from the site.

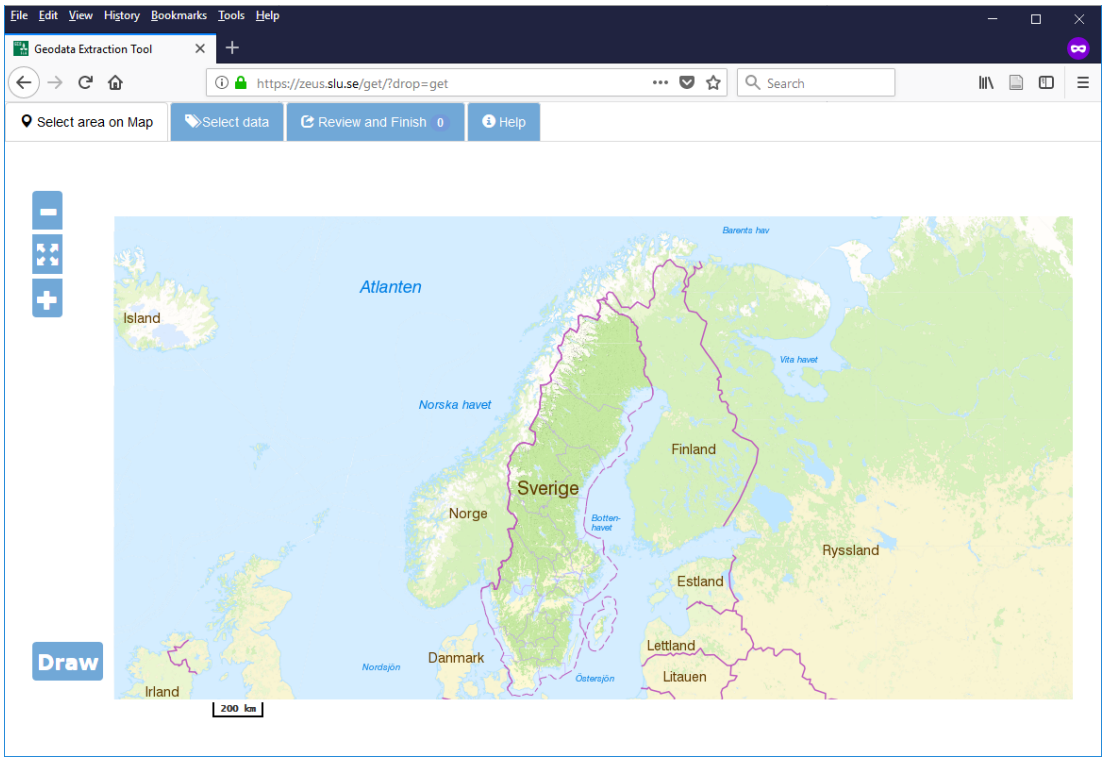
First Digital maps and geodata. The site is available in both Swedish and English.



Click on the blue 'Search and download maps and geodata' field. You will then be asked to identify your affiliation in a long list of choices. Select 'Stockholm University' which will yield the following screen:

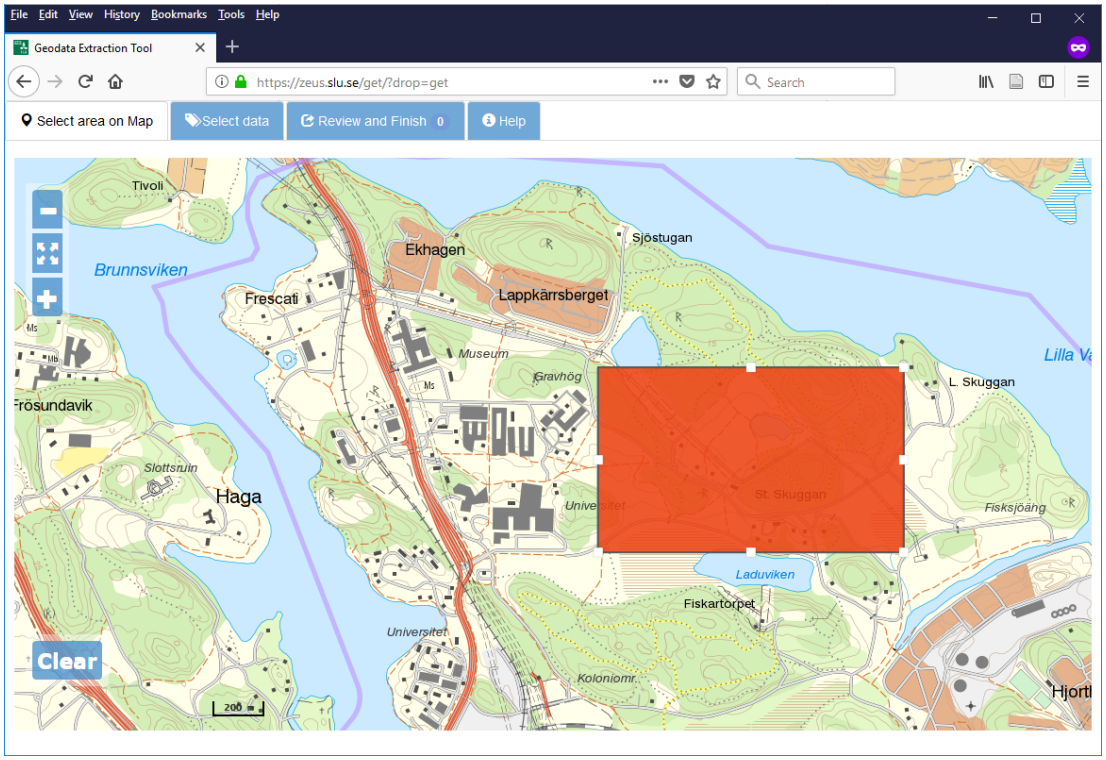


Click on ‘Proceed to Login’. A new screen will open where you provide your Stockholm University login details. Once you have completed the login a new screen will open with an over view map:

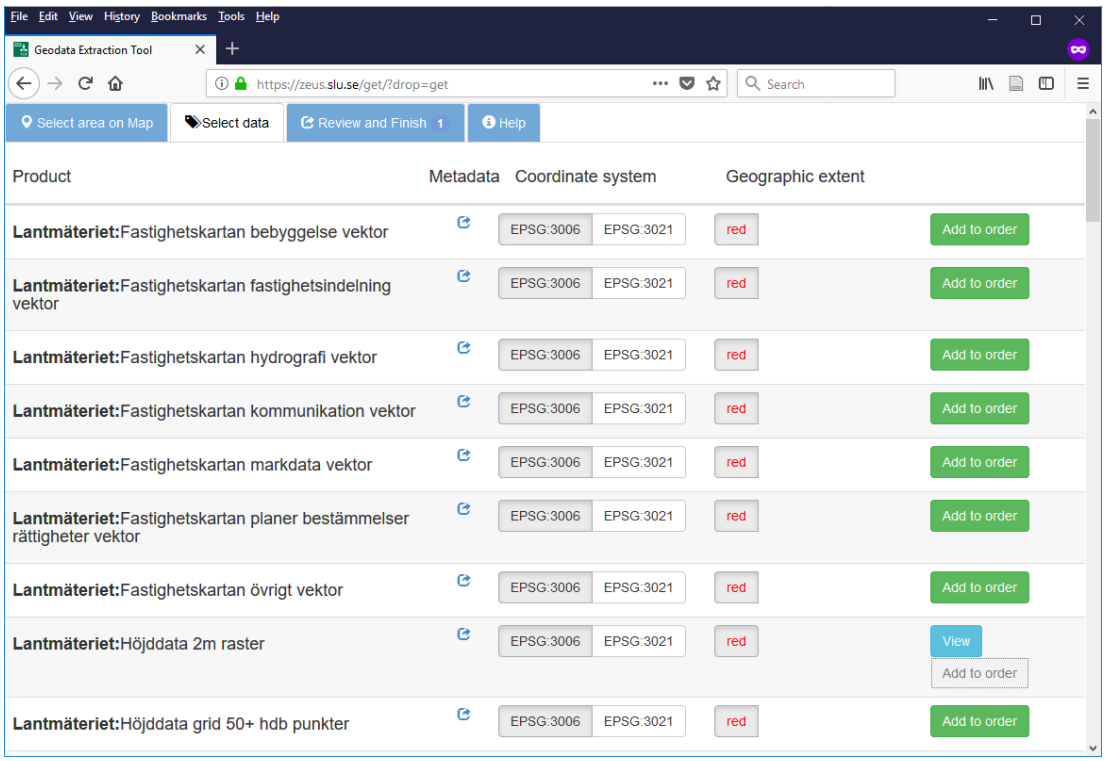


At the top of the screen you see four fields: ‘Select area on map’ (which is the current screen), ‘Select data’, ‘Review and Finish’ and ‘Help’. The first three are the steps will will need to go through to extract our data. To the right you see three buttons with zooming (+, −) and panning tools. You can use these to move around and zoom in and out in the map. You can also ‘grab’ the map with the mouse pointer and move around and use the mouse wheel (or other zooming feature on your mouse or computer) to zoom. Finally there is a button called ‘Draw’. When you click on this button you can use the mouse to draw a red rectangle on the map. This rectangle will be the area of data you will be able to select. Note that there is a limit to how much data you can download so if you select too large an area, you will get a rectangle that is only partially red. You will then only receive the data covered by the red portion. The maximum area is still quite large so you will not likely run into this problem.

Let us now look at an example. I have selected an area near the university to download according to the rectangle on the map:



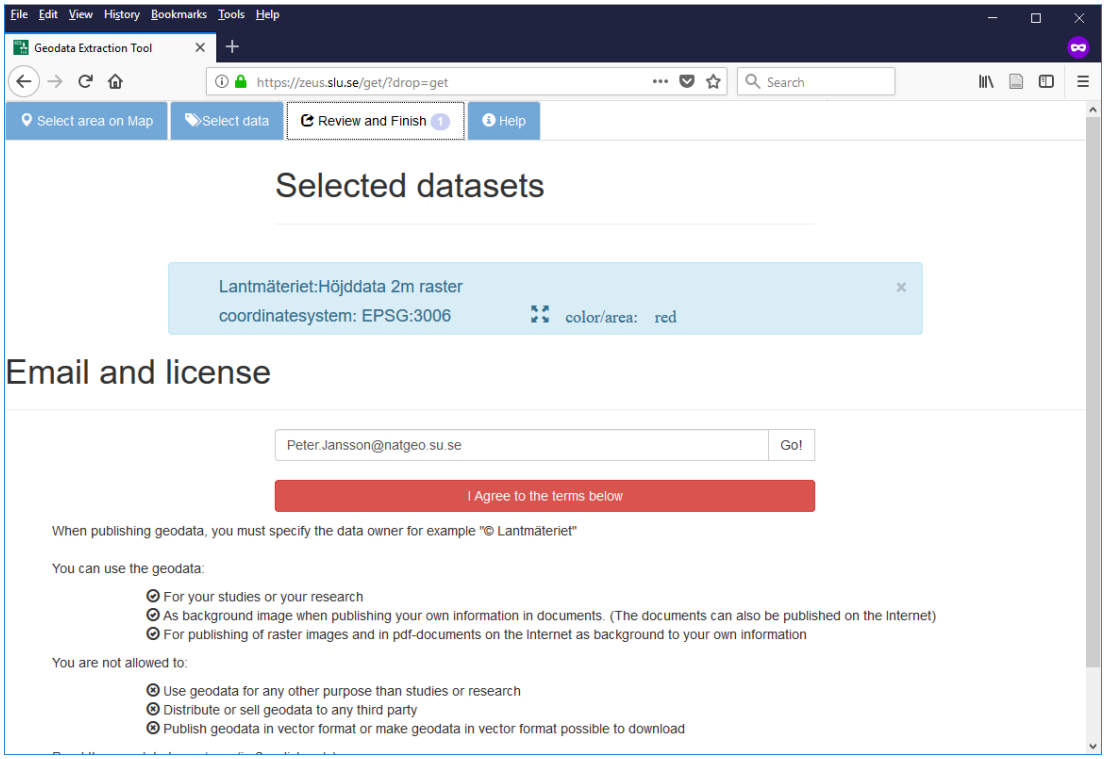
Once we have selected an area, we need to select what data to download. We therefore press the 'Select Data' field at the top which changes the screen to the following:



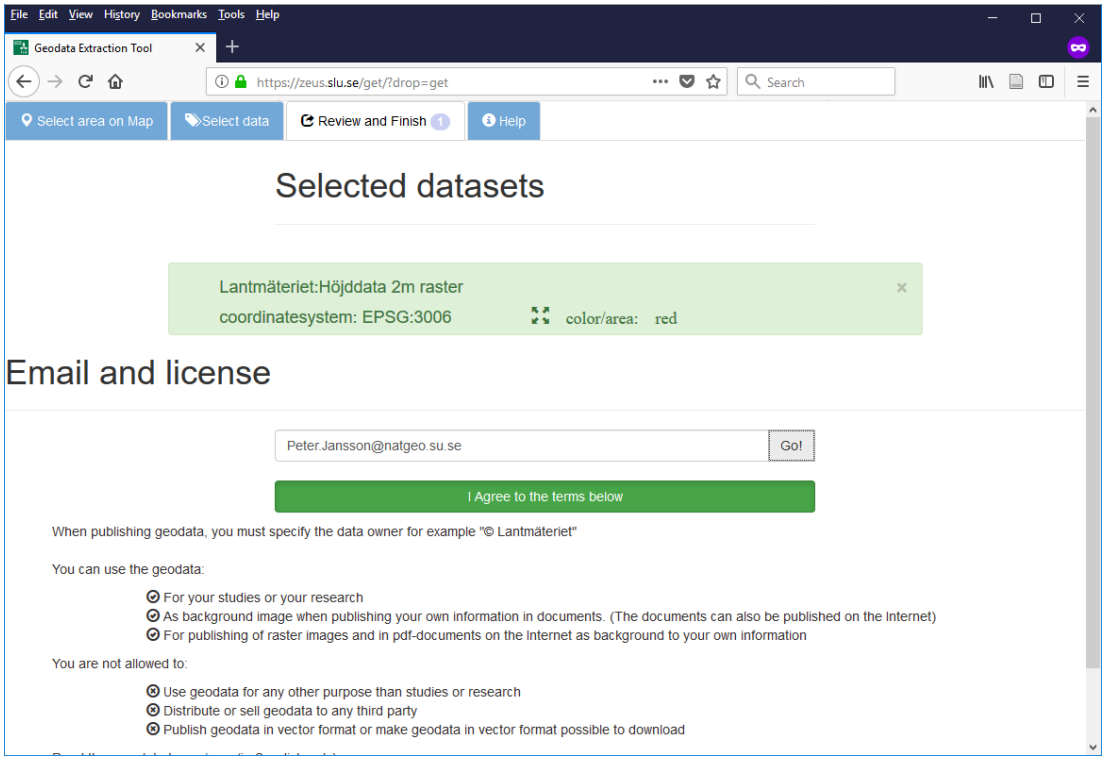
What you see here is a long list of different data sets open for download. In this exercise we will focus on the 'Höjddata 2m raster'. Other useful data sets include the

'Terrängkartan raster' which you may recognise as the normal topographic map and 'Ortofoto raster RGB 0.5 m' which is a photographic map showing the ground. These can be useful when interpreting the terrain data.

You can select from the list by pressing the green 'Add to order' button. Once you press it it will turn white. If you want to select several different data sets for the same area you simply continue adding data sets to 'order'. When the data set has been selected I press the 'Review and Finish' field. Note that the field now shows a '1' indicating I have chosen one data set. A new screen will open showing the selected data sets:



This screen shows the selected data set(s) as blue fields. In order to download data you now have to accept the license agreement (please read and understand the terms!) by pressing the red bar with the text 'I Agree to the terms below'. You then press the 'Go!' field to the right of your mail address (which should be shown). The processing is then started and the blue data field turns green:



Which indicates that your order has been processed.

The data we have selected will now be provided as a zip file which can be downloaded through a link in an e-mail you will receive. The e-mail subject message will read *Your Hojddata2mRaster data is ready*. Simply click on the link in the e-mail and save the zip-file on your computer. The file will have a long name similar to `FME_12616C74_1538391193873_18951_pjans_Hojddata2mRaster.zip`.

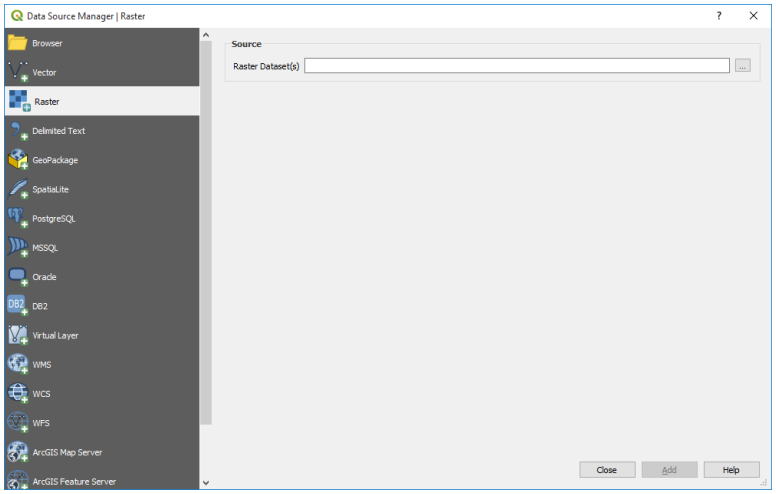
The zip-file contains three folders 'Docs', 'Hojddata2m_1705_3006', and 'Metadata'. You should unzip the content to a new empty folder. Name the folder by using a name that allows you to recognise what it contains. Note that the name of the folder cannot contain any accented letters such as å, ä, ö etc. We will get back to this later. The elevation data is located in the 'Hojddata2m_1705_3006' folder. If you look into the folder you will see four files and the data is the `.tif` file starting with `hojd2m3006`….

Let us now look at how to work with this data in QGIS.

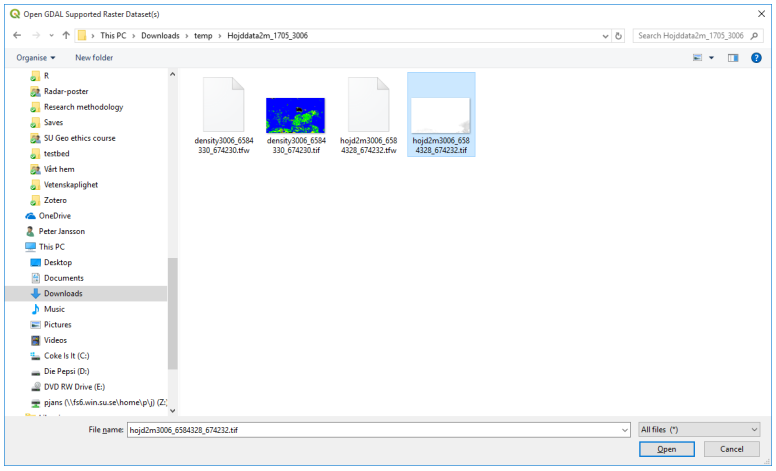
7 Working with elevation data in QGIS

In this section we will look at how to get the elevation data into QGIS and to create a shaded relief from the elevation data.

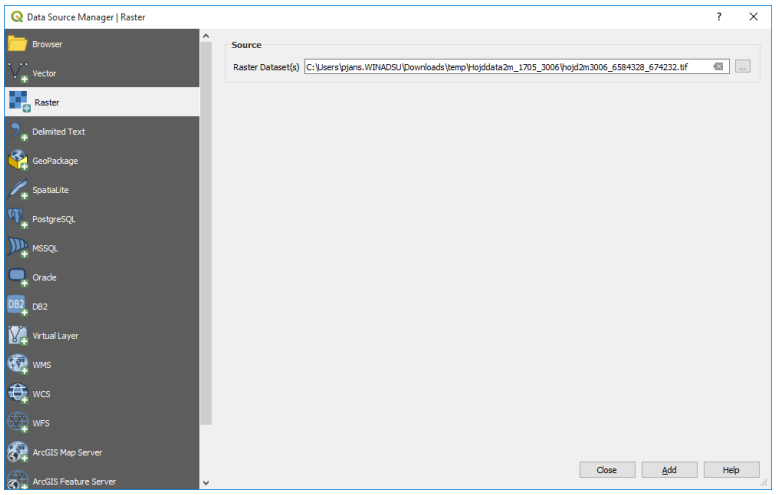
We start by opening QGIS and make sure we have a new project open (menu: Project/New). To add the elevation data we need to select Layer, Add Layer and Add Raster layer…. This will open a dialog called 'Data Source Manager|Raster':



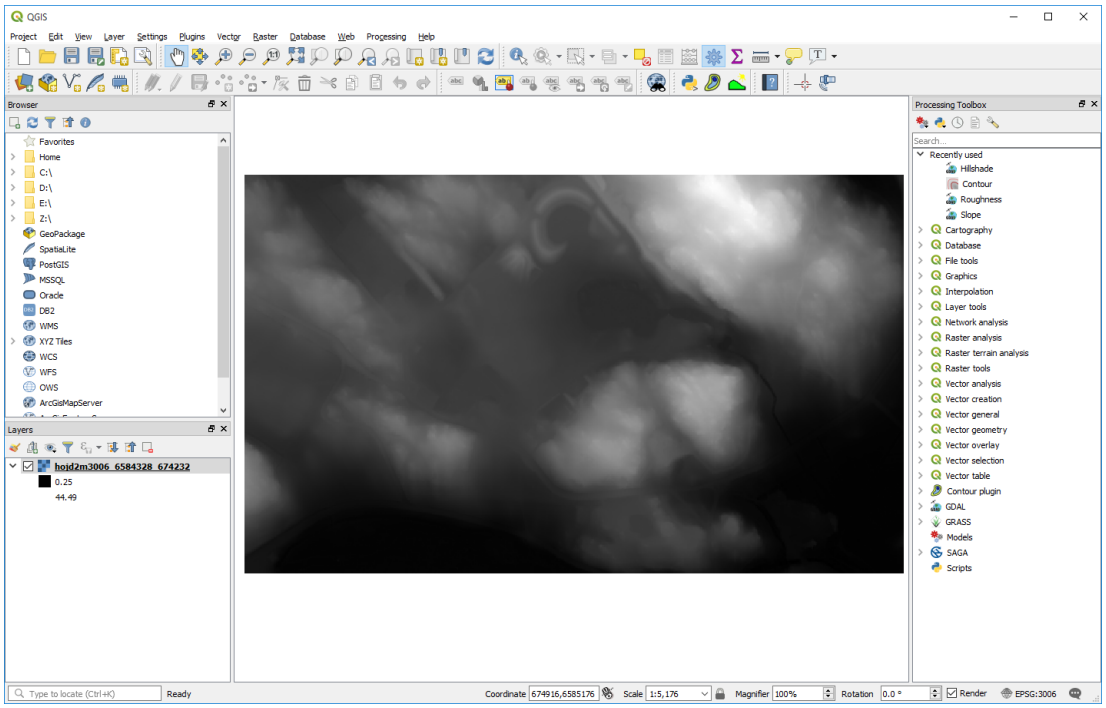
The 'Raster' entry will be marked and you can now select a source file by pressing the ... button to the right and locate the data you downloaded.



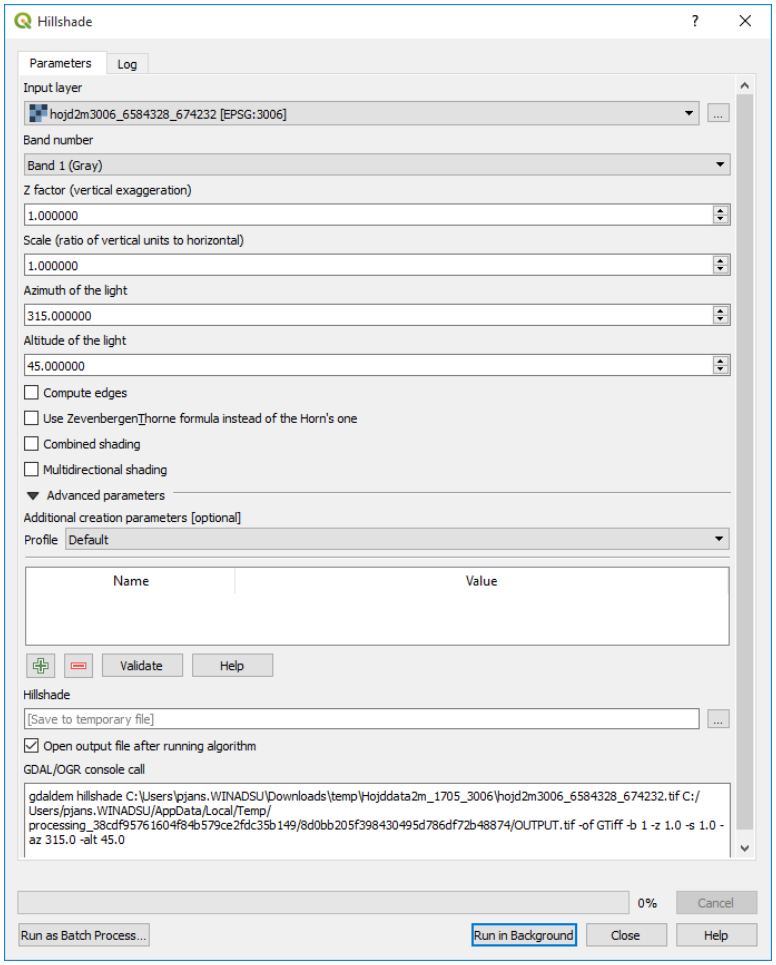
The file you should upload will be the `.tif` starting with `hojd2m3006…`



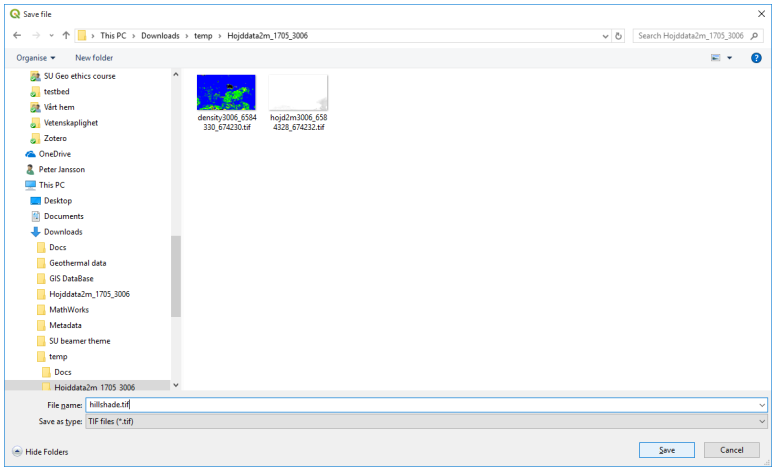
The Data Source Manager dialog will now show the file name. You then press Add and Close at the bottom of the dialog. Your QGIS window should now show the digital elevation model (DEM) based on the data as a black and white picture where black is low elevation and white is high.



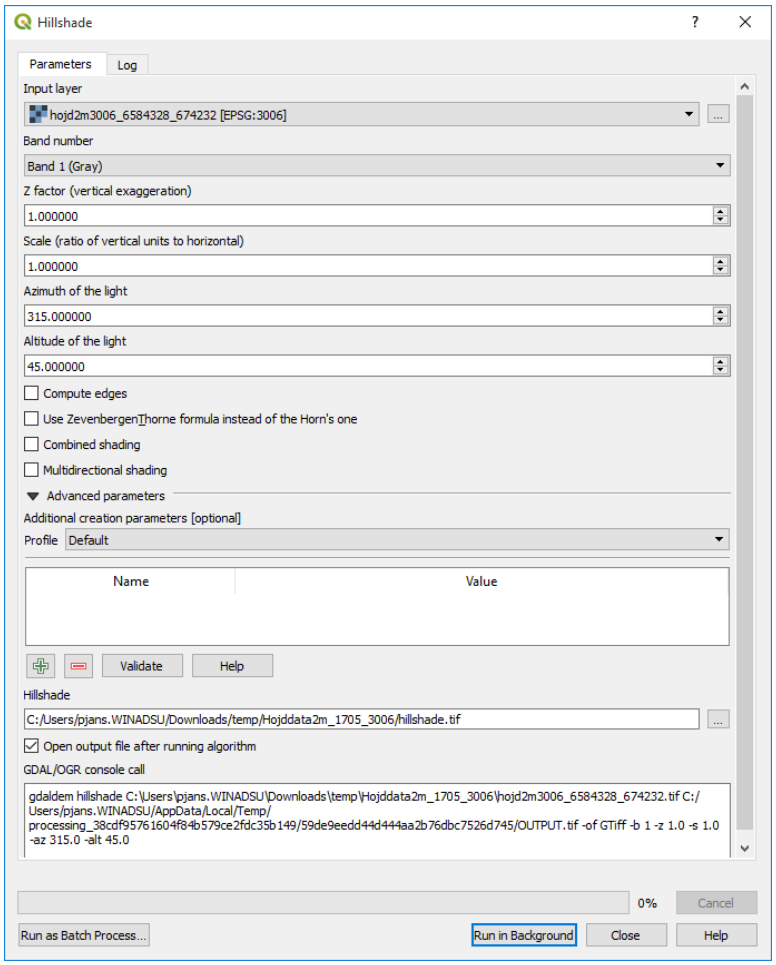
We will now analyse the DEM to produce a so-called hillshade layer. A hillshade is a technique that simulates the highlights and shades of a surface when lit from a specific location. As humans we have the ability to use such shading to experience the three-dimensionality of an object, or in this case our DEM. To start the processing we need to select Raster, Analysis and Hillshade in the menu. This opens the Hillshade dialog:



There are many options in this dialog but we will just use the default values which usually work very well. We first need to make sure that the Ìnput layer' shows the name of the elevation data. If the elevation data is the only layer you have in your project (as is the case in this demonstration) then this will be chosen automatically. The only thing we need to enter is the name and location of the resulting hillshade file. In the lower half of the dialog you find a field called 'Hillshade' where you can add a file name. Click on the …… button and select 'Save to File…' option that appears in a small temporary dialog. You should then locate the folder where your original elevation data was located and type in a name for your hillshade file in the 'File name' pane. I have chosen to just call it `hillshade.tif` in this example.

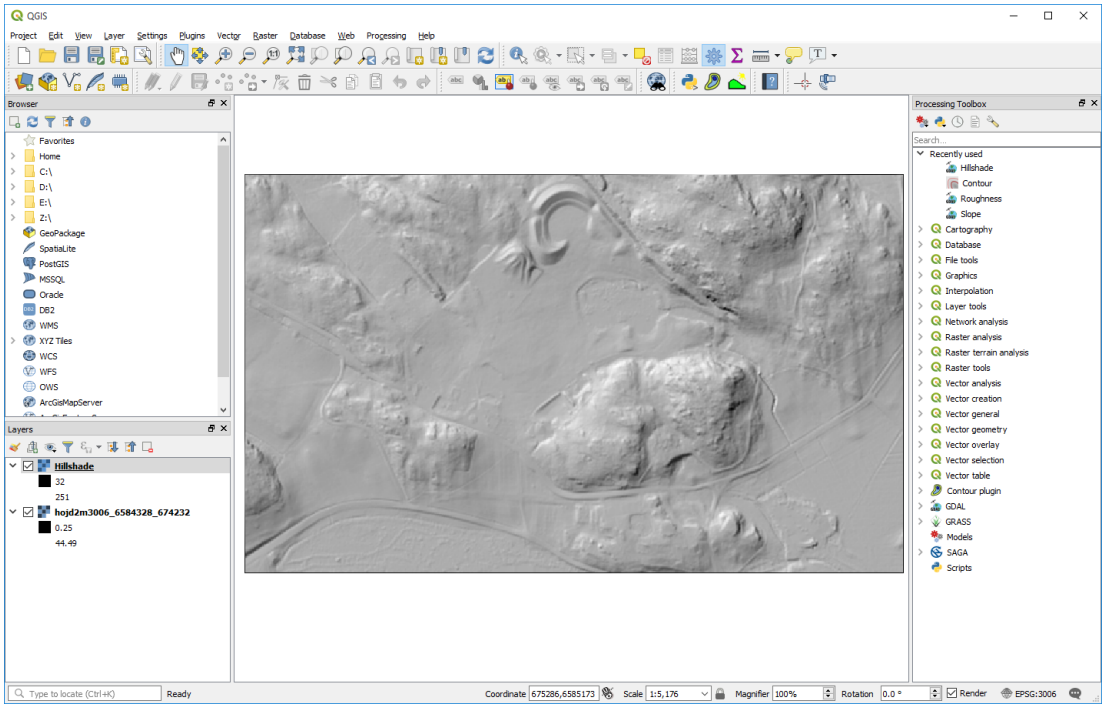


The reason for saving the hillshade file in the same place as the original elevation data is to keep all your files together. Once you have typed in your file name, press 'Save'. The file name shows in the Hillshade dialog.



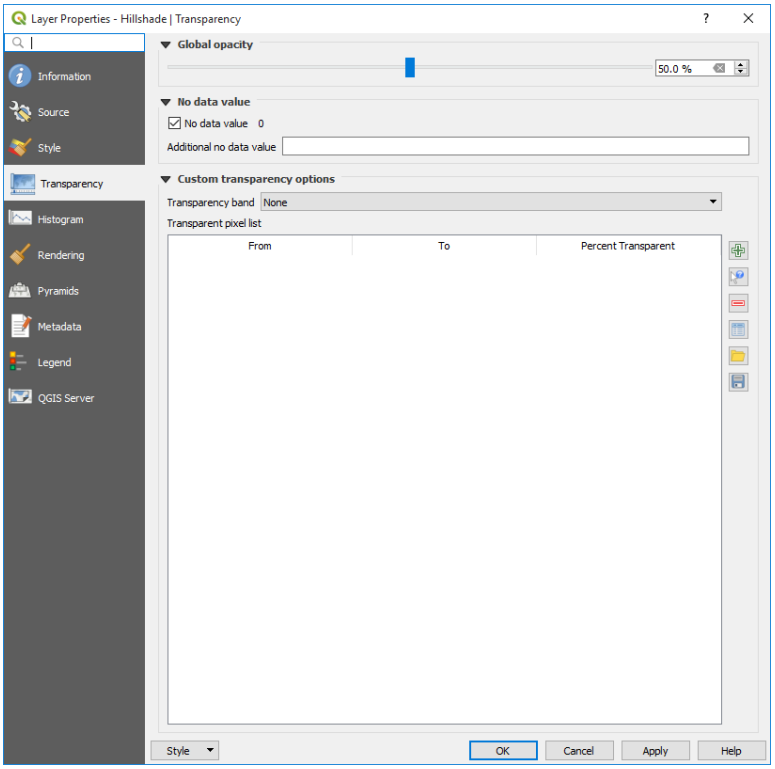
To process the Hillshade press the Run in Background button followed by the Close button at the bottom of the dialog.

The QGIS window should now show the shaded relief instead of the black-and-white DEM.

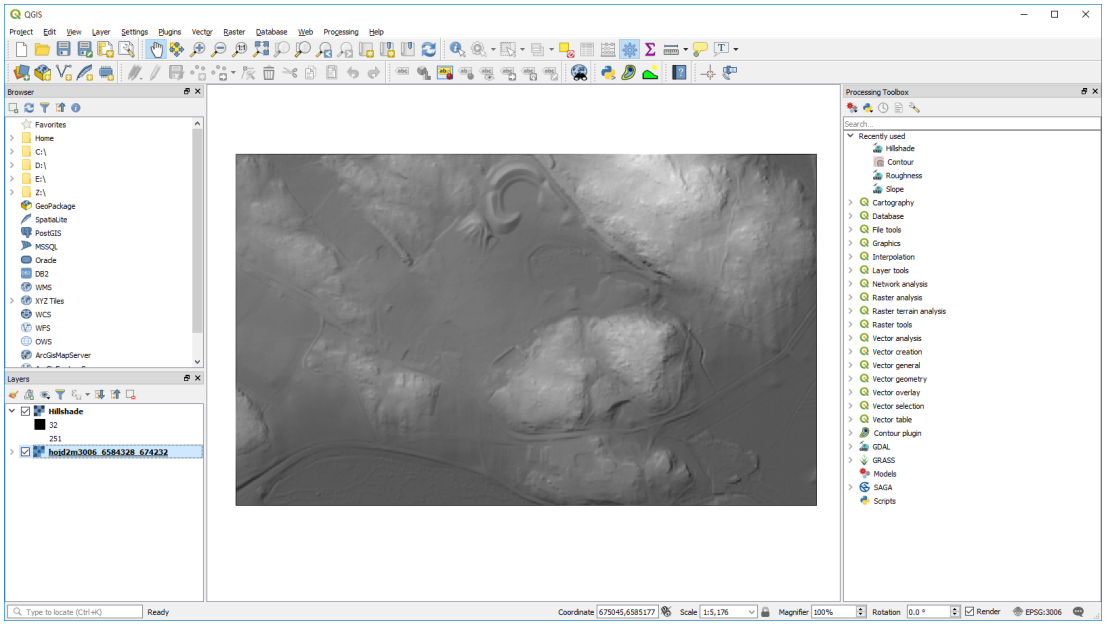


At this point it is worth noting that in the lower left of the QGIS window you see two entries, the elevation data file and the Hillshade. These are layers. The reason the Hillshade is shown is because this layer is on top of the DEM. You can turn the Hillshade on and off by checking and unchecking the Hillshade layer. You can also reorder the layers by dragging and dropping the layers in the order you want them. For now the original order makes most sense.

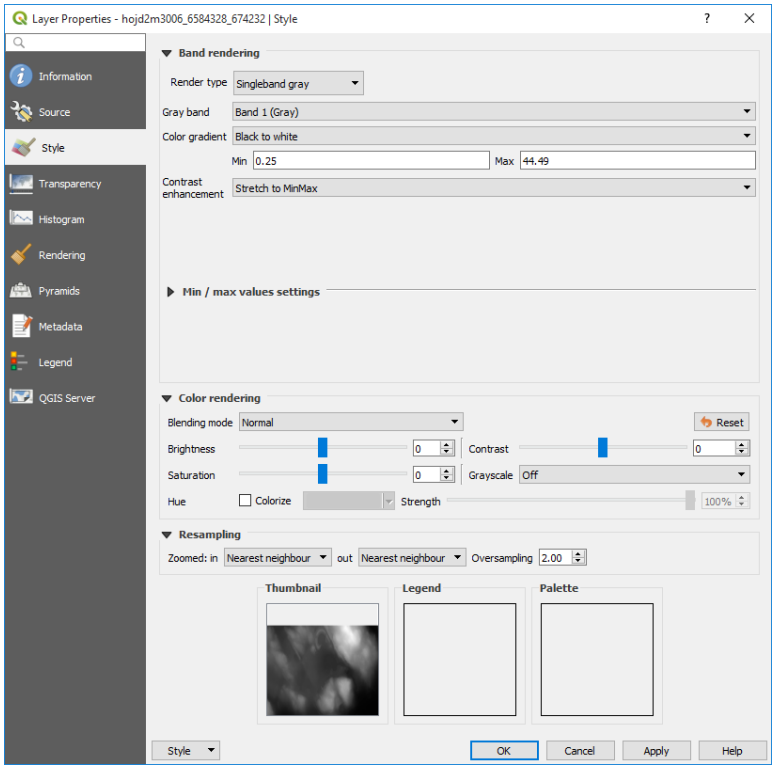
Once we have established the DEM and hillshade layers we can start modifying them a little. We will begin by looking at 'Transparency'. If you 'right-click' on the Hillshade layer You will get a dialog with several options. Select the 'Transparency' option by clicking on it.



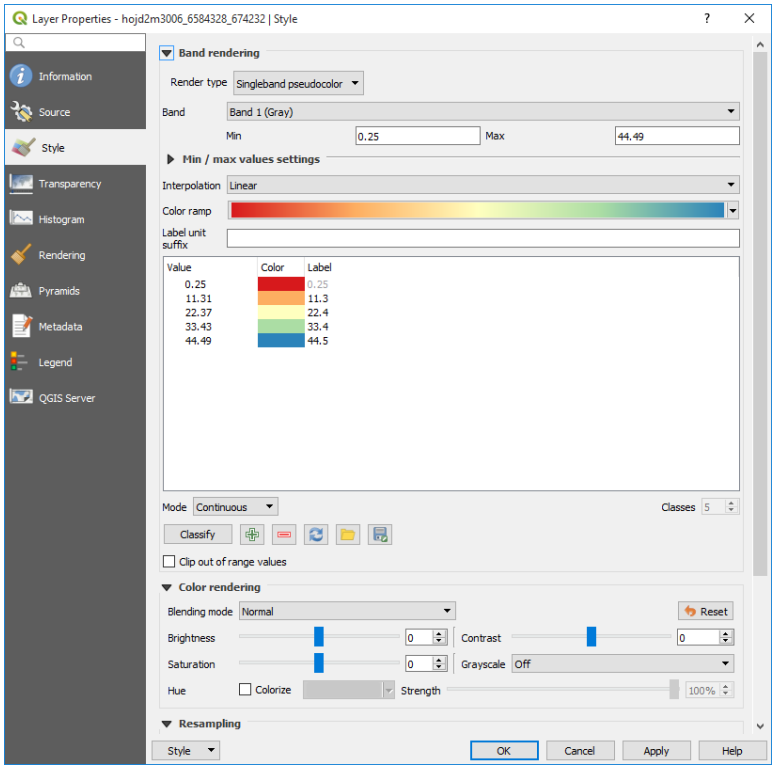
This allows you to change the transparency of the hillshade layer. The default is 100% 'Global opacity' which means the layer is totally opaque or has no transparency. Change the value in the box at the top right corner from 100% to 50% and press Apply and Close at the bottom of the dialog to see the result:



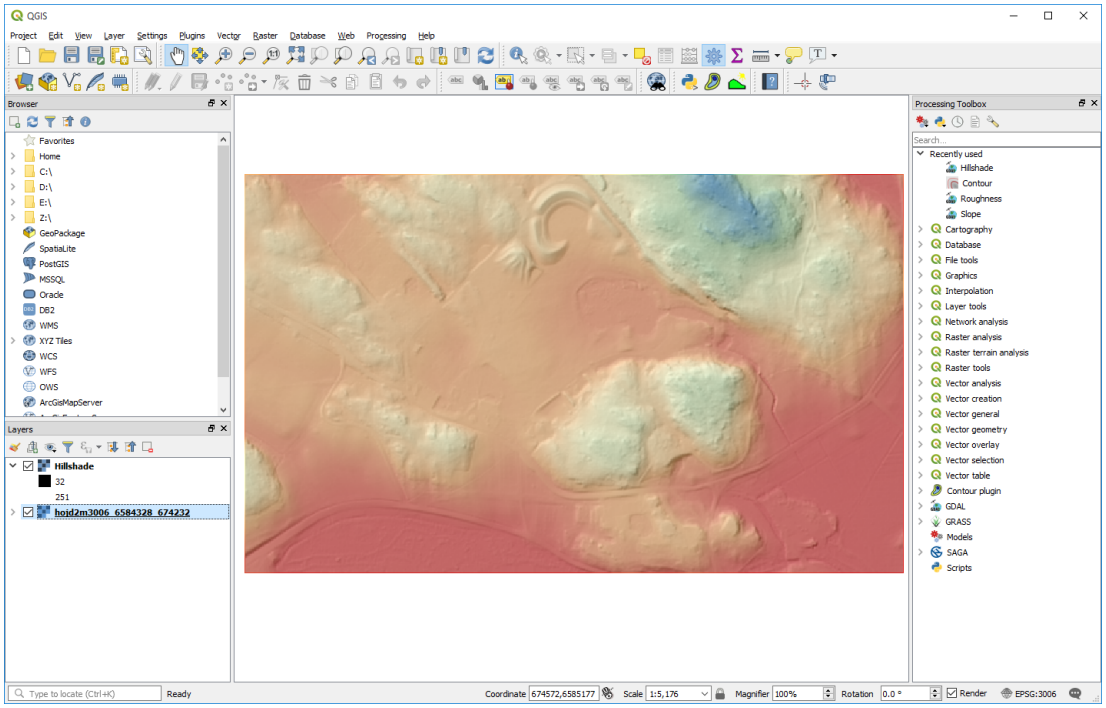
We can also modify the DEM layer. Let us add some colour to it by 'right-clicking' on the elevation layer. This opens the Layer properties dialog for the layer. Select the 'Style' option by clicking on it.



As you can see there are several things we can change. We will start by clicking on the 'Render type' selector and chose 'Singleband pseudocolor' from the options. Then we will click on the 'color ramp' and select the 'Spectral' option. The dialog will then look like this:

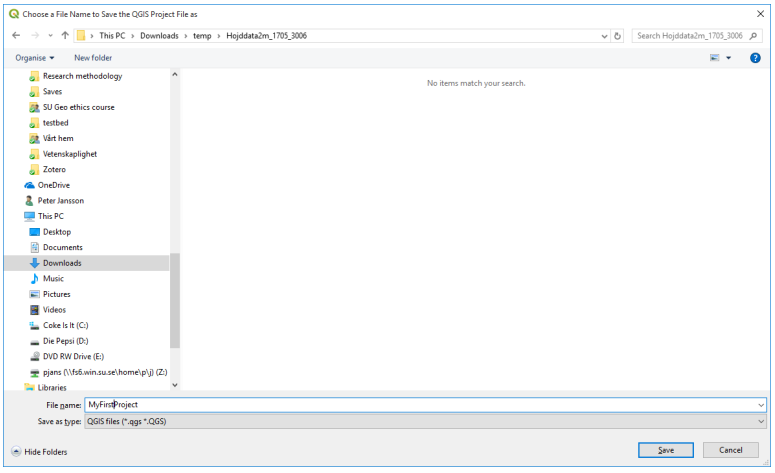


Now click on Apply and Close and the GIS project will look like this:



What you see now is that the elevation data goes from red at low elevations to blue at high elevations and that the shaded relief effect is still there but 50% translucent to show the coloured DEM. This indicates how you can work with the layers to create a good end product that gives the viewer information on elevation and relief.

A final point before ending our session is of course to save the work we have done in a QGIS project file. Click on Project, Save As... and locate the folder where your data is located. Add a name for your project file in the 'File name' field. QGIS adds the extension `.qgz` automatically



click Save and you now have the project saved. I have given the project the name 'Skuggan' since it covers the area Stora Skuggan in Frescati. All you need to do later to open the project is to open this QGIS project file.

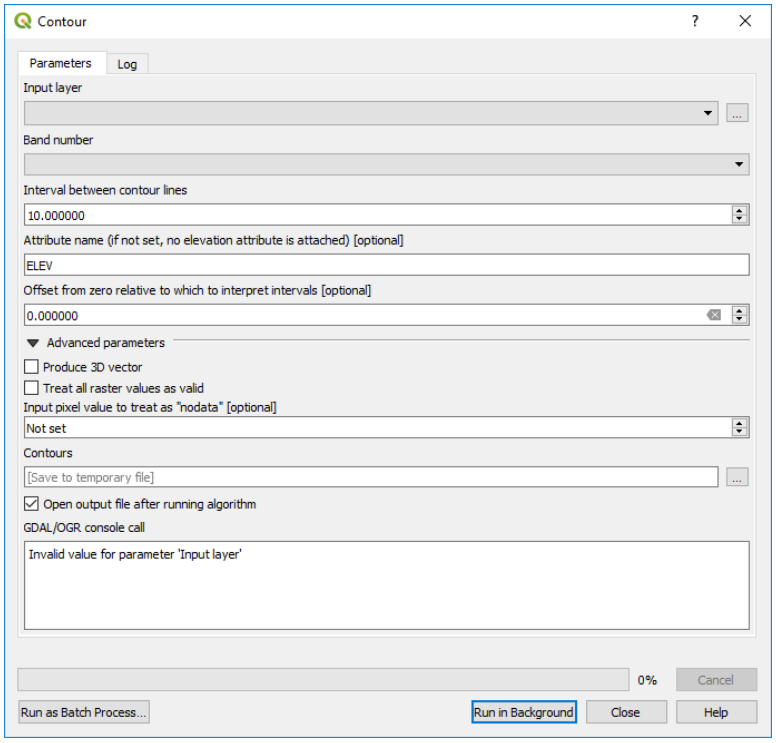
One word of warning is due here. QGIS has problems with accented letters such as å, ä, ö, é, etc. in names so please use only non-accented names. If you, for example, have

a map over Åmål you may need to name the project file `Amal.qgz` or `Aamaal.qgz`. The same applies to the folder name on your computer if they are involved in the project.

8 Creating contours

When you have an elevation model, it is useful to add contour lines to visualise the topography. This is easy in QGIS. Let us add contours to our project 'Skuggan'.

Click on Raster menu item and select Extraction/Countour. This opens a window with settings for the contouring as follows

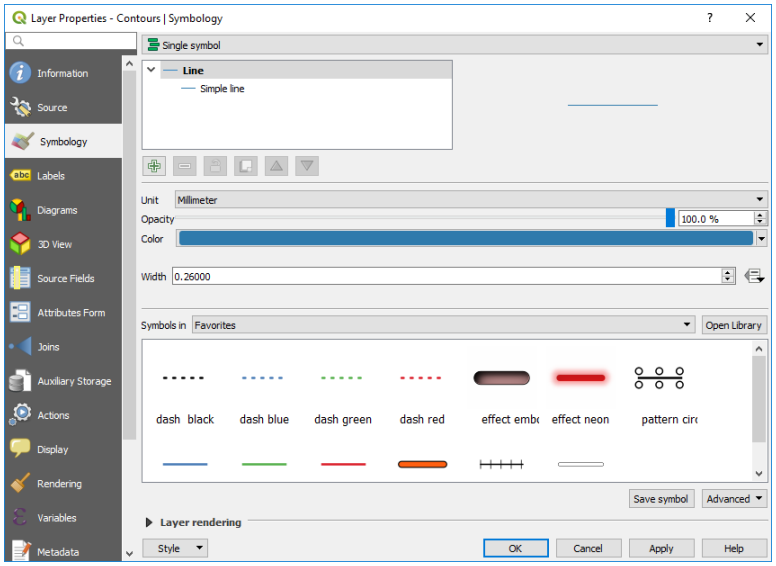


Here you need to, check, change and add a few items. First you need to select the input layer in the first field of the window. Make sure you select the elevation data as input. Second, you need to decide what elevation contour interval you want. This is done in the field conveniently labelled 'Interval between contour lines'. The default is 10 m. The third item is the field labelled 'Contours'. This is where you can add the file name of a file that will contain your contour information. If you do not enter a name so that QGIS saves the contour information, it will be stored in a temporary file that will be lost once you close the project.

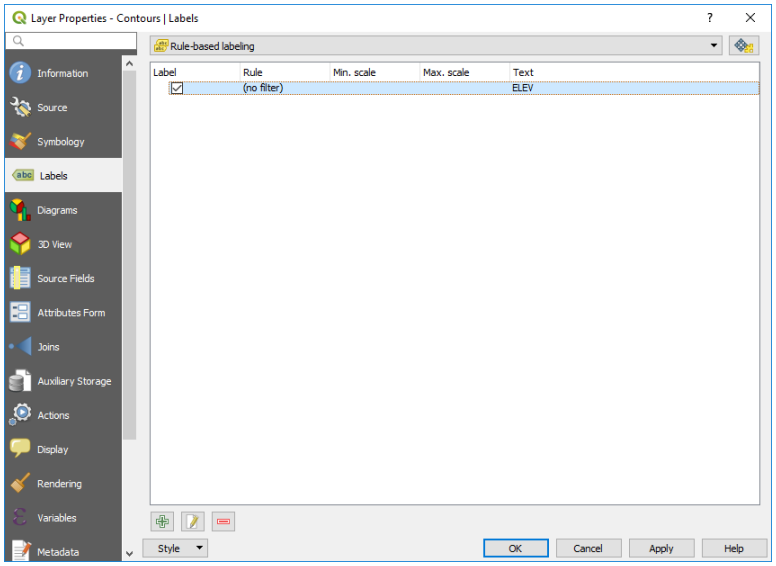
Once you have completed the fields you can press the Run in Background button followed by the Close button. QGIS will now calculate and add a layer with contours. For a large map and large number of contours, this may take a while. This layer will appear above the elevation data layer so if you have a hillshade layer this may obscure the contour layer. You can simply grab the contour layer in the Layers pane and move it to be overlaying the hillshade if that is what you want.

We can now make changes to the the look of the contours layer. The contours will be given a colour by default which sometimes is not useful, it may, for example, be to light and not contrast the background. To make any changes, right-click the Contour layer in the Layers pane. This opens the 'Layer Properties' window.

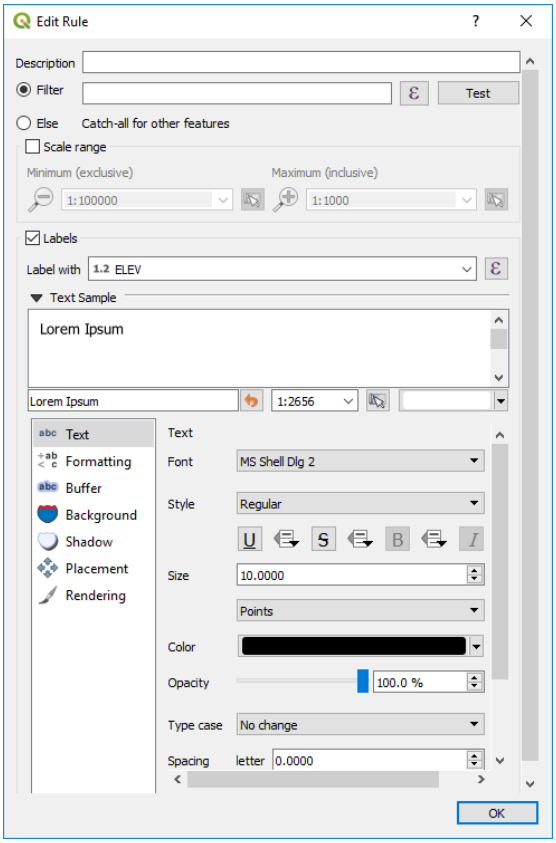
To change the colour of the contours click on ‘Symbology’ in the list of different properties to the left in the window. Here you can change the colour and width of the contour lines as well as other aspects of the lines.



Select the colour you want by clicking om the ‘Color’ selector and make any other changes you may want. You can always go back and change these settings later. Finish the changes you have made by pressing the Apply and OK buttons.

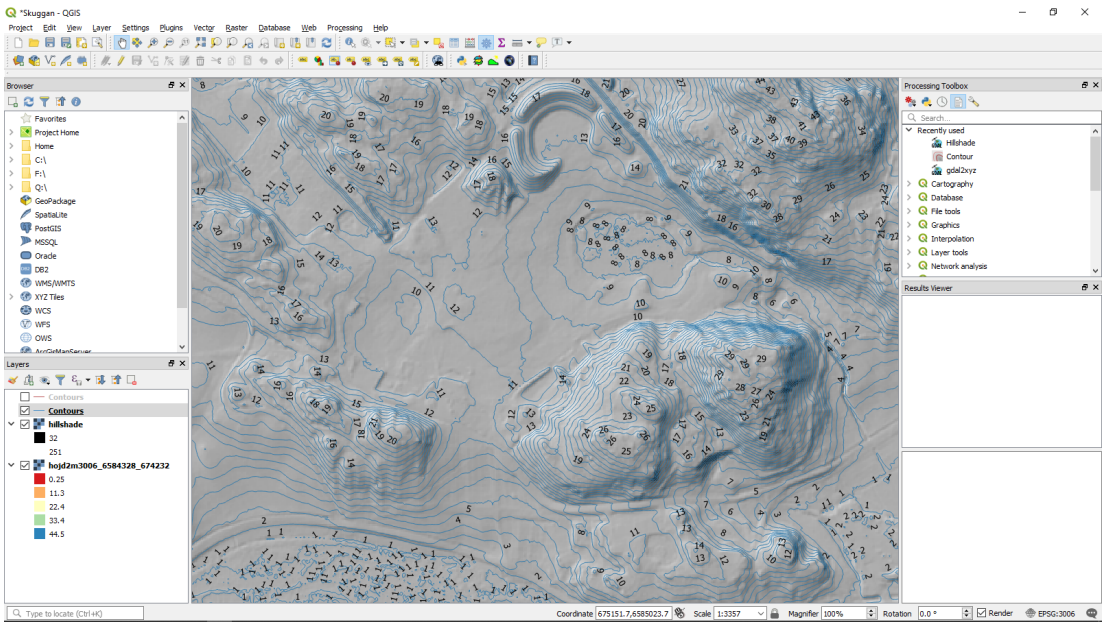


Once we have changes the colour of our lines we might consider adding contour labels. This can be done in the ‘Labels’ section of the properties. Here you will start by adding a label through pressing the + button at the bottom of the window. This opens a new window where you can add the details of what you want to display.



Here you can name the labels so that you know what they are in the 'Description' field. More important is to chose the correct field to use to display values. In our case we accepted the default attribute name of `ELEV` when we started the contouring (see above). We thus select `ELEV` as the data to create labels. You can then play around with all the other settings for how the labels should be type set. In this case I have simply accepted the defaults. Finish by clicking the OK button.

The resulting map shows contours and labels on the contours.



It is evident that the labelling is not optimal. By default each individual loop of a contour is labelled which, for example, yields a large number of 1-m labels in the irregular micro-topography in the lower left corner of the map. For the purpose of what we want to achieve, to investigate topography, we can live with this. With time during your education you will learn how to make maps that are nicely formatted so this is just a start.

9 Postscript

When you run through this introduction, you can easily expand your knowledge by trying out different settings to see what effect these may have. You should also search the internet for hints on how to accomplish specific results in your analysis.

Version description

Ver.	Date	Description
1	November 3, 2018	First version