

# Newcastle University Geography Continuous Professional Development Day for Geography Teachers: Geographic Information Systems (GIS) session

## Landscape evolution of the Gígjökull Basin, Iceland

The aims of this practical are to:

1. Use Terrestrial Laser Scan (TLS)-derived digital elevation models (DEMs), and satellite imagery to: (a) determine the geomorphology of the Gígjökull Basin, Iceland; (b) quantify surface elevation change of the Gígjökull Basin as a result of the 2010 Eyjafjallajökull eruption; and (c) evaluate the possible geomorphic processes that have caused elevation change.
2. Introduce you to the GIS software QGIS, developing your GIS skills for use as a potential teaching resource.

Which software are we using?

In this practical we will be using the software QGIS ([www.qgis.org](http://www.qgis.org)). QGIS is similar to some other GIS software that you might be familiar with or introduced to. It has several important differences, however: (a) QGIS is **free**; (b) QGIS is user-friendly; and (b) you, and your pupils, can download and install QGIS on Windows, Mac, Android and Linux machines (for **free**!) from <https://qgis.org/en/site/forusers/download.html>.

What is the source of the data we will use?

In this practical we will also be using ground-based TLS DEM data acquired by Newcastle University's Dr Stuart Dunning in 2010 (Figure 1) (Dunning et al., 2013) and Landsat 5 & 8 satellite imagery available to download from <https://landsat.visibleearth.nasa.gov/view.php?id=84707>.



Figure 1: Total Laser Scanner (TLS) acquiring data in Iceland.

We will import these data products into QGIS and use them to visualise, and quantify, how the Gígjökull Basin has evolved since the Eyjafjallajökull eruption in 2010.

## **Section 1: Importing and viewing satellite imagery using QGIS**

1. Locate, on your USB stick, the zipfolder 'gigjokull.zip' containing the DEM data and the satellite imagery. Unzip the files in that folder to a suitable location on your USB stick (e.g. E:\qgis-iceland).
2. Open the QGIS software version 3.6.
3. Save (Project/Save As) your project: e.g. as 'qgis\_gigjokull' in the folder E:\qgis-iceland'
4. The first, and very important, step of all GIS is to give your project the correct coordinate reference system (CRS), and projection for the majority of the data that you are working with. To do this, go to the drop-down list 'project/ properties'. In the filter box type 'UTM zone 27N', select "WGS 84 / UTM zone 27N", click 'apply' and 'OK'. It is very important that you use the correct CRS and projection for your data, otherwise your data may not plot in the correct location, and some GIS tools will not work correctly.
5. Add the two NASA satellite images from 1986 to 2014 to the project by:
  - a. Selecting the 'Open Data Source Manager' (or press Ctrl+L)
  - b. Select 'Raster'
  - c. Select the square with the three dots to the right of 'Source/Raster Dataset(s)'
  - d. Navigate to the folder 'qgis\_iceland/SatelliteImagery/LANDSAT' and select the files:
    - i. katla\_oli\_2014263\_geo.tiff (Landsat 8 satellite image from 2014)
    - ii. katla\_tm5\_1986259\_geo.tiff (Landsat 5 satellite image from 1986)
  - e. Click 'Open' then 'Add' and 'Close'
6. SAVE YOUR QGIS PROJECT (Project/Save)- you should do this regularly in case the software crashes and you lose your project!
7. Right-click on each of the satellite images in the Layers panel in turn and select properties.
  - a. Under the 'symbolology' tab change the resampling when zoomed in from 'Nearest Neighbour' to 'Bilinear'.
  - b. Click 'Apply' and 'OK'.
  - c. This step will sharpen up the satellite images.
8. Get a general feel for the QGIS software and the maps by experimenting with the satellite imagery data (e.g. try 'activating' and 'deactivating' the individual layers, changing their order in the 'Layers' subwindow by selecting the layer name and dragging it up or down, and or changing the transparency of individual layers).
9. Zoom into the Eyjafjallajökull ice cap in the left hand side of the georeferenced images (Figure 2).

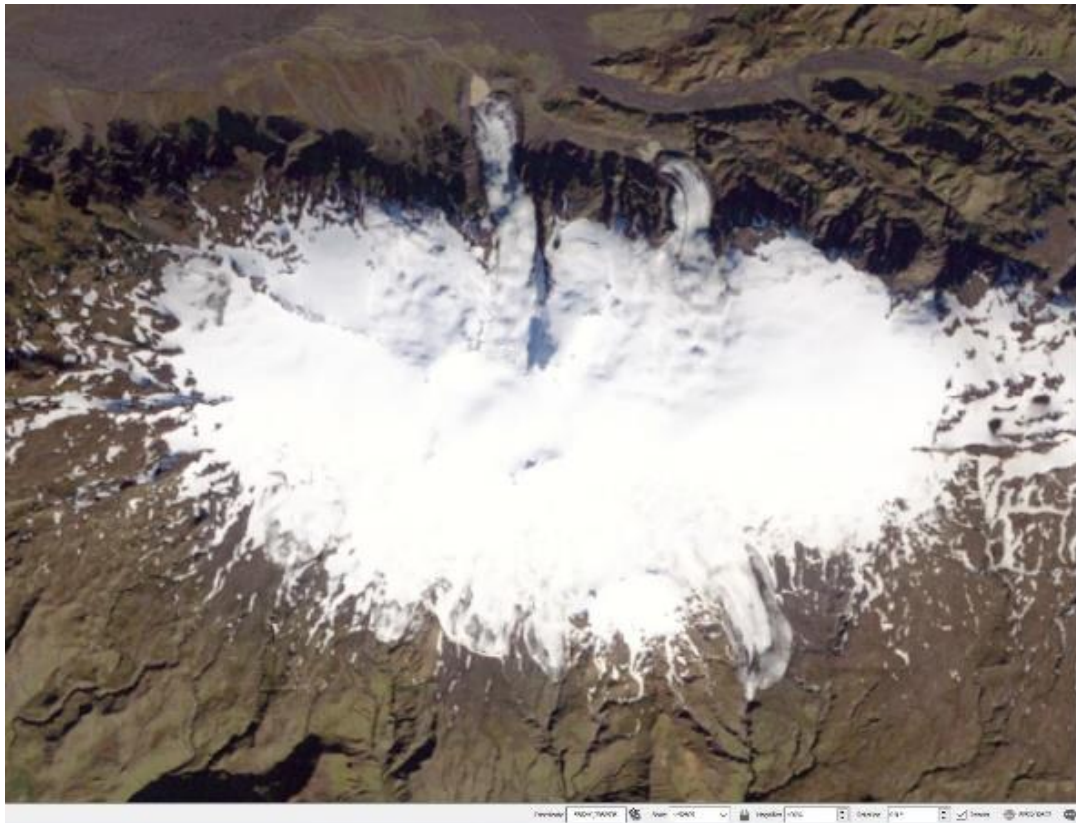


Figure 2: Landsat 5 satellite image of the Eyjafjallajökull ice cap from 1986.

10. Find the 'coordinate' box located on the toolbar at the bottom of the viewing window, and type in the following: 567853, 7061528 & hit return. This will centre the view on our study area, the Gígjökull Basin at the northern margin of Eyjafjallajökull.
11. Find the 'scale' box located on the toolbar at the bottom of the viewing window. Using the drop down list set the scale to 1:25,000.
12. Switch between the 1986 and 2014 satellite images in the layers window.
13. **Scientific Question 1: How did Eyjafjallajökull and the Gígjökull Basin change between 1986 and 2014?**
14. **HELPFUL TIP:** Useful tools for recovering your 'position' in the GIS are 'Zoom Last', 'Zoom to Layer' and 'Zoom Full' (all found on top toolbar).
15. Landsat imagery is relatively low resolution (15-30 m), so a high-resolution georeferenced satellite image of the Gígjökull Basin from 5<sup>th</sup> September 2013 is also available in the Satellite Imagery folder (i.e. GE\_Georef\_img.tiff). Add that to your QGIS project. You can change the brightness of the image under Properties/Symbology/Brightness (e.g. increase brightness by 50%).
16. **SAVE YOUR QGIS PROJECT (Project/Save).**

## Section 2: Importing and viewing DEM data with QGIS

1. Add the TLS-derived DEMs (i.e. land surface elevation from March and August 2010) to your existing QGIS project by:
  - a. Selecting the 'Open Data Source Manager' (Ctrl L)
  - b. Select 'Raster'
  - c. Select the square with the three dots to the right of 'Raster Dataset(s)'
  - d. Navigate to the TLS\_DEMs folder (qgis\_iceland/TLS\_DEMs) and select the files:
    - i. TLS\_DEM\_March10.tif (pre-eruption DEM with lake water removed)
    - ii. TLS\_DEM\_July10.tif (post eruption DEM)
  - e. Click 'Open' then 'Add' after each file is imported, and once all data are imported click 'Close'.
2. In the Layers panel, right-click on the name of one of the imported DEMs and select 'Zoom to Layer'
3. Go into properties/Symbology and change the settings as follows:
  - a. Render type 'Singleband pseudocolor'
  - b. Mode = 'Equal interval'
  - c. Min = 200, Max = 325
  - d. Classes = 9
  - e. Click 'Apply' and 'OK'
4. You should now be able to see something like this:

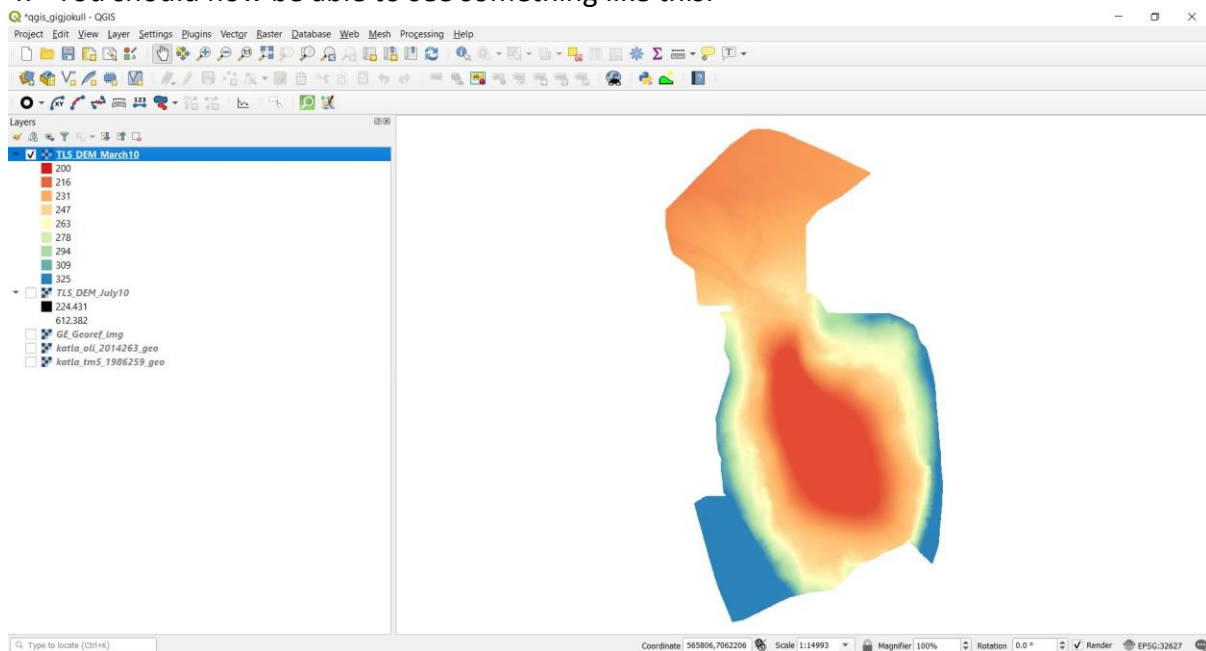


Figure 3: Land surface elevation of the Gígjökull Basin before the 2010 eruption and associated jokulhaups.

5. Right click on the name of that DEM in the layers panel. Go to style/copy style. Right-click on the name of the other DEM and go to style/paste style. Both DEMs will then have the same elevation colour scheme.
6. You should now have DEMs of the topography of the Gígjökull Basin before (March 2010) and after (July 2010) the eruption of Eyjafjallajökull and the associated jokulhaups in your

QGIS project. You can now see qualitatively what the elevation difference was between March and July 2010.

### Section 3 (optional) – create hillshaded DEMs

1. Create a hillshade of the TLS DEMs using the following steps:
  - a. Go to 'Raster/Analysis/Hillshade'
  - b. Select the DEM you want to process in the 'Input Layer' dropdown.
  - c. Set the Z factor (vertical exaggeration) to 3
  - d. Save the Hillshade to an appropriate location on your USB stick (Hillshade/.../Save to file).
  - e. Press run
  - f. Repeat steps a-e for the second TLS DEM.
  - g. Switch between the two hillshade DEMs you have created to view the differences in the landscape between March and July 2010.
2. Combine one of the elevation TLS DEMs with the associated hillshade TLS DEM by:
  - a. Select both layers in the layers window whilst holding down the Ctrl key on your keyboard.
  - b. Right mouse-click and select 'Group selected'
  - c. Give the group or sub-group an appropriate name
  - d. Right-click on the elevation DEM, go into properties/transparency and reduce the global opacity to 80%. You will then be able to see the elevation of the topography in colour, with the hillshade below visible. This allows you to view the elevation of your study area, whilst also seeing the detailed geomorphology of the landscape.

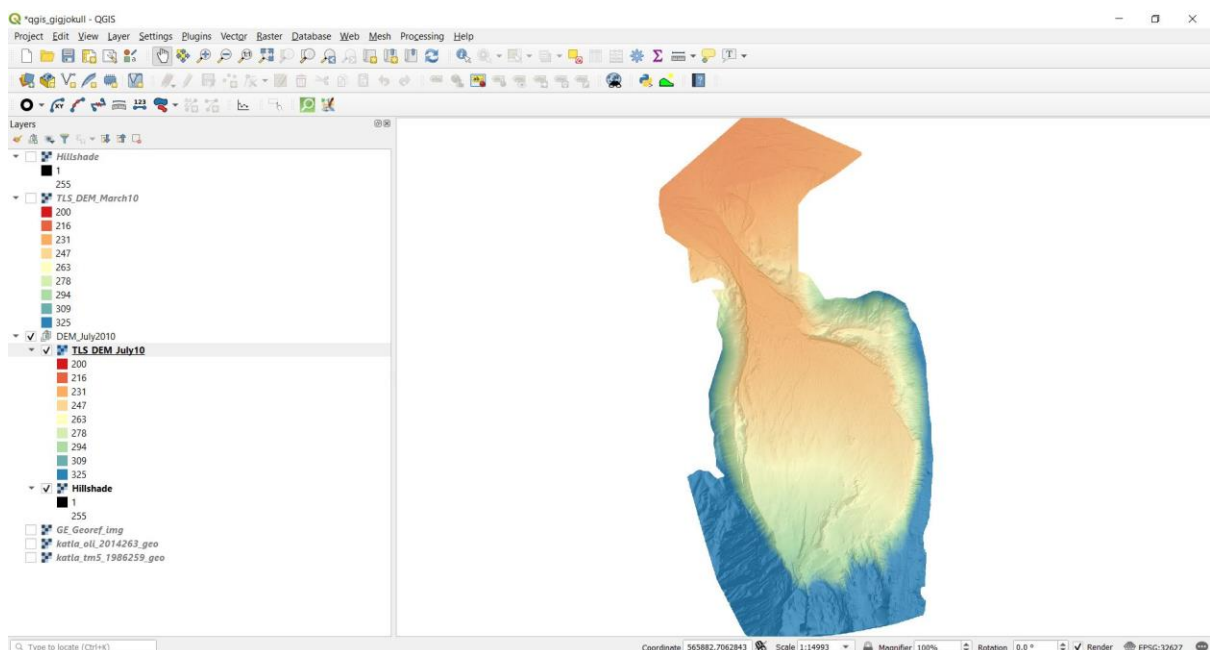


Figure 4: Hillshade and DEM of Gígjökull Basin in July 2010.

## Section 4: quantifying surface elevation change using raster calculator

1. We will now quantify the change in surface elevation of the Gígjökull Basin between March 2010 and July 2010. We will do this by using the two TLS-derived DEMs to calculate the elevation change caused by the jokulhaups from the April 2010 eruption of Eyjafjallajökull.
2. Go to Raster/Raster Calculator, and left mouse click on:
  - a. Raster Band = TLS\_DEM\_July10@1 (double mouse click)
  - b. Operators = - (single left mouse click)
  - c. Raster Band = TLS\_DEM\_March10@1 (double mouse click)
3. In the Raster Calculator Expression box you should then have: "TLS\_DEM\_July10@1" - "TLS\_DEM\_March10 @1"
4. Define the name and location of your output layer (click on 3 dots to right of output layer box to access where to do this) and click Save. Then click 'OK' when you return to the Raster Calculator window.
5. This will produce a 'DEM of difference' that will show the surface elevation change between March and July 2010.
6. Right-click on the DEM of difference, go into properties/symbology and change the settings as follows:
  - i. Render type 'Singleband pseudocolor'
  - ii. Left mouse click on colour ramp down arrow and 'Invert Color Ramp'
  - iii. Mode = 'Equal interval'
  - iv. Min = -20, Max = 60 (this sets the colour scale from blue at -20 m, to red at +60 m)
  - v. Classes = 9
  - vi. Click 'Apply' and OK

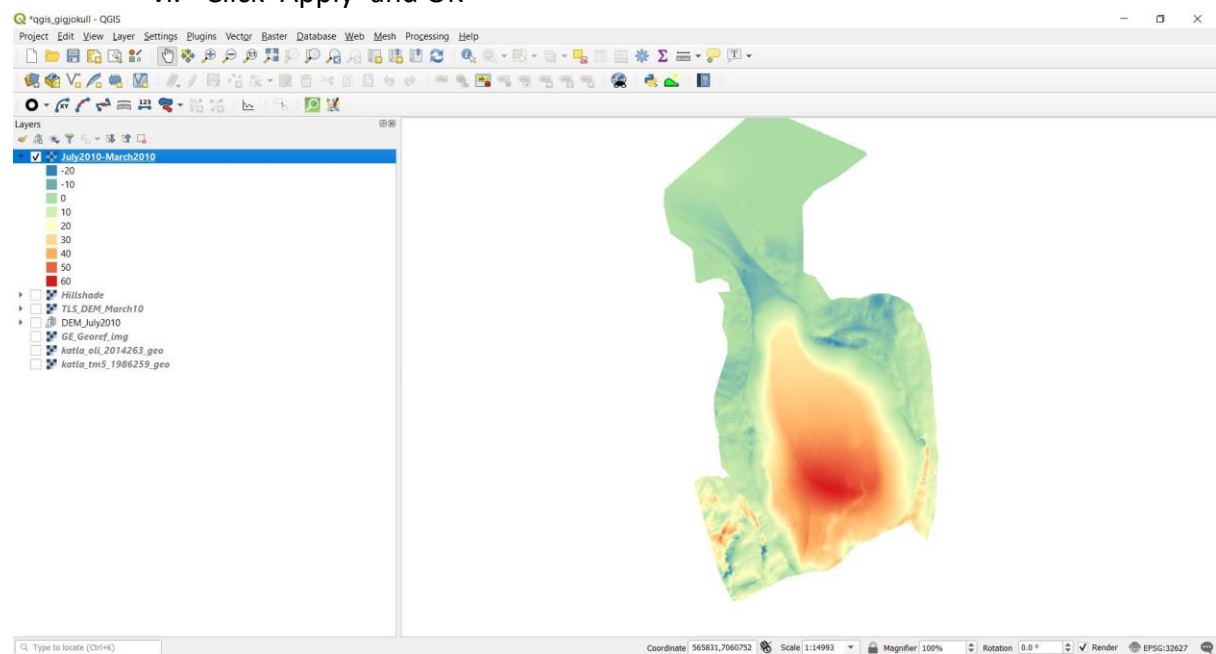


Figure 5: Elevation change of Gígjökull Basin between March and July 2010.

## 7. TASK: Describe the change in surface elevation in and around the Gígjökull Basin.



8. **Science Question 2: How did the surface elevation of the Gígjökull Basin change between March and July 2010? What could be the explanation for this change?**
9. SAVE YOUR QGIS PROJECT (Project/Save).

### **Section 5: Some geographic questions to consider:**

1. How did Eyjafjallajökull and the Gígjökull Basin change between 1986 and 2014?
2. How did (i.e. quantify) the surface elevation of the Gígjökull Basin change between March and August 2010?
3. What geomorphic processes were likely responsible for the surface elevation change?

We hope that you enjoyed this practical (and that it worked without any IT/practical glitches!). Now you can go home, download QGIS (<https://qgis.org/en/site/>) and practice your GIS skills (e.g. try the tasks in the appendix)!

**Dr Neil Ross**  
**2<sup>nd</sup> July 2019**

### **References**

Dunning SA, Large AR, Russell AJ, Roberts MJ, Duller R, Woodward J, Mériaux AS, Tweed FS and Lim M (2013). The role of multiple glacier outburst floods in proglacial landscape evolution: The 2010 Eyjafjallajökull eruption, Iceland. *Geology*, 41, 1123–1126.

### **Acknowledgements**

We would like to thank the following: Natural Environment Research Council (NERC) for the grant funding that facilitated TLS data acquisition; and the students of the 2019 GEO2052 Physical Geography Field Course: Iceland module that road-tested an earlier version of this practical.

### **Useful miscellaneous GIS-related resources**

National Land Survey of Iceland: <http://www.lmi.is/en/>

National Land Survey of Iceland datasets :

<https://atlas.lmi.is/LmiData/index.php?id=795089400704>

ArcticDEM: <https://www.pgc.umn.edu/data/arcticdem/>

National Snow and Ice Data Center: <https://nsidc.org/>

Historical imagery:

<https://gisgeography.com/free-historical-imagery-viewers/>

<https://gisgeography.com/free-satellite-imagery-data-list/>

## APPENDIX: Optional additional activities

### Appendix 1 (optional): Produce a publication-quality map for export from QGIS

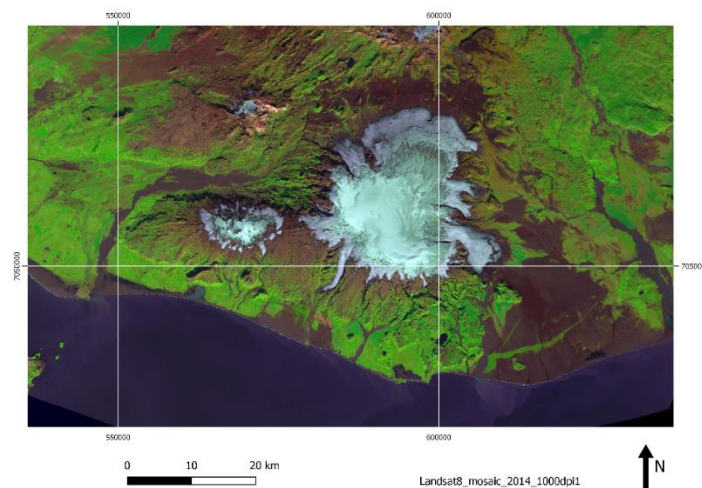
We will now learn how to export maps from QGIS:

1. Go to 'Project/Layout Manager'
2. Click 'create'
3. Give your layout a name (e.g. Iceland1) and click OK. A new window will open.
4. Go to 'Add Item/Add Map' and draw a box on the page.
5. The datasets apparent in your GIS workspace will now display in the layout view.
6. Tip: you can swop between the standard project view and the print composer, as both are 'open' at the same time (using the buttons 'Alt' and 'Tab' together are a handy keyboard shortcut for this in Windows).
7. Use the tools found in the 'Add Item' drop down list (or the icon on the left-hand-side of the layout window) to add: (i) a north arrow; (ii) a scale bar; and (iii) a legend; to your map. These three items are essential for any map and must be included in all maps in your GEO2052 assessment, and maps and diagrams in your dissertation, other module reports etc.
  - a. **Tip (North Arrow):** to import a north arrow, the best way can be to 'add an image' (left-hand toolbar) to your composer window, and then select a suitable north arrow from 'Search directories' section of the right-hand side 'Item Properties' tab. You can align the arrow with true or grid north using the 'Image Rotation' section, by ticking 'sync with map', selecting the map from the drop down list and then selecting the appropriate North alignment.
  - b. **Tip (Scalebar):** You can edit the number of intervals in your scalebar by changing the number of segments etc. in the Item Properties/Scalebar tab (right-hand side of screen).
  - c. **Tip (Legend):** When you add your legend it might have a lot of unnecessary layers listed in it. The easiest way to control this is to use the 'Legend items' in the 'Item Properties/Legend' tab to delete (i.e. using the red minus symbol) the items you don't want to list in the legend. Note: you will need to untick 'Auto-update' to be able to do this.
  - d. **Tip (Zooming in and out):** to zoom in and out of your Print Layout map, you need to select the map (e.g. by left-clicking on it until the outer border of the map is selected), changing the value in the 'Scale' box in 'Item Properties/Map' and pressing 'return'. A larger value (e.g. 500,000) will zoom you out, whilst a smaller value (e.g. 100,000) will zoom you in. Note, if you do this, you may need to adjust the properties of your scalebar.
  - e. **Tip: (Scrolling around your data in Print Layout):** If you want to move/adjust your map, you can do this using 'Move item content' (4th from top on left-hand toolbar).
8. An important component of any map is the requirement to add grid graticules that allow the viewer to locate them self geographically. An example of this are the Eastings and Northings on an Ordnance Survey map of the UK. To add these in QGIS:
  - a. Select the map in the Layout view



- b. Go to item properties
  - c. Scroll down to 'Grids', click the green cross and then click 'modify grid'
  - d. Under 'Appearance', edit the X and Y 'Interval' to 50,000 and 50,000, and change the line style to a white line
  - e. Under 'Map Grid Properties' scroll down to 'Draw Coordinates' and tick the box. Change coordinate precision to 0. Format is decimal (in this case as UTM grid is in metres).
9. Once you are happy with your map then go to 'Layout/Export as image', save your map as an appropriate image format (e.g. jpeg, png, tiff etc.). The image file you save, can then be added to your report (e.g. by adding to your Word documents). Note that a jpeg file will tend to be a smaller file than a png or tiff file. Depending on the resolution of output you require, you should use a DPI between 150-300.

Here is a (not very good) example of a Print Composer output:



## Appendix 2 (optional): Create a 3D view of the Gígjökull Basin

1. In the layers window, ensure that only the TLS-derived elevation DEM and hillshade that you grouped in section 2 are switched on.
2. Go to View/New 3D Map View
3. Enlarge the pop-up window by dragging it's edges.
4. Select the spanner symbol
  - a. Elevation = the name of the DEM switched on in your layers window
  - b. Vertical scale = 1
  - c. Click OK
5. Use the mouse (all buttons and roller-ball), in conjunction with the keys Ctrl+Shift to rotate, manipulate and move around, the 3D image. More info on the 3D view tool is available at: <https://www.lutraconsulting.co.uk/blog/2018/03/01/working-with-qgis-3d-part-1/>