Part I

Week 1 - Introduction

In our first week, we will get acquainted to with basic GIS data manipulation using the QGIS software.

ILOs covered

1. Understand the structure of spatial data and choose appropriate data types and models for storing and representing it;
2. Obtain and assess the quality of spatial data from online and offline sources and produce new spatial data using computer and field methods;
3. Create map visualisations that adhere to cartographic principles and can be easily and unambiguously interpreted by the non-specialist public;

What will you learn

For every week, we will list the main theoretical and practical learning goals. Use these as a 'checklist' to gauge your learning for each week. If you don't feel confident you have learned any specific topic, then revisit the week's material!

Theoretical knowledge for Week 1:

- What are Geomatics, GIS, Remote Sensing and associated terms and fields?
- What is spatial data?
- What is a datum?
- What is a map projection?
- What is a Coordinate Reference System?

Practical knowledge:

Chapter 1

- How to launch QGIS
- How to load a spatial data file
- How to navigate the main QGIS interface
- How to identify features
- How to do basic measurements
- How to do basic styling of spatial data
- How to enter the layout editor
- How to make and export a simple map layout

Chapter 2

- How to check the Coordinate Reference System of a spatial file
- How to set the CRS of a QGIS project
- How to set the CRS of a spatial file when it is already known.
- How to reproject(convert) a spatial file from one CRS to another
- What are the main CRSs you should be familiar with.

1 Lab 1: QGIS overview and file management

The purpose of this lab is to give you a first overview of what a proper GIS workflow looks like, from start to end. As you progress on your exercises the projects will become more complex but the general workflow will not change.

Developing proper project and file management habits from the start is the *best* thing you can do to succeed in GIS. Speaking as someone who has been teaching and working with Geomatics for more than a decade, poor file/project management is the underlying cause of at least 50% of the GIS problems you may encounter.

1.1 Before you start!

1. Go through the Week 1 preparatory session on Canvas, and watch the seminar recording if you have missed it.
2. Read this document to understand how the British National Grid indexing system works.

1.2 Guided Exercise 1 - Managing and loading files

In this exercise, you will download some data, prepare a *folder structure* to organise the files in your GIS projects, then create a QGIS project file and add some GIS data to it.

1.2.1 Downloading the required data

For this practical you will use the "OS open road" and "OS Terrain 50 Digital Terrain Model" spatial datasets, specifically for the **NS89** tile of the Ordnance Survey British National Grid. (Read about what these datasets are here: OS Open Roads , OS Terrain 50).

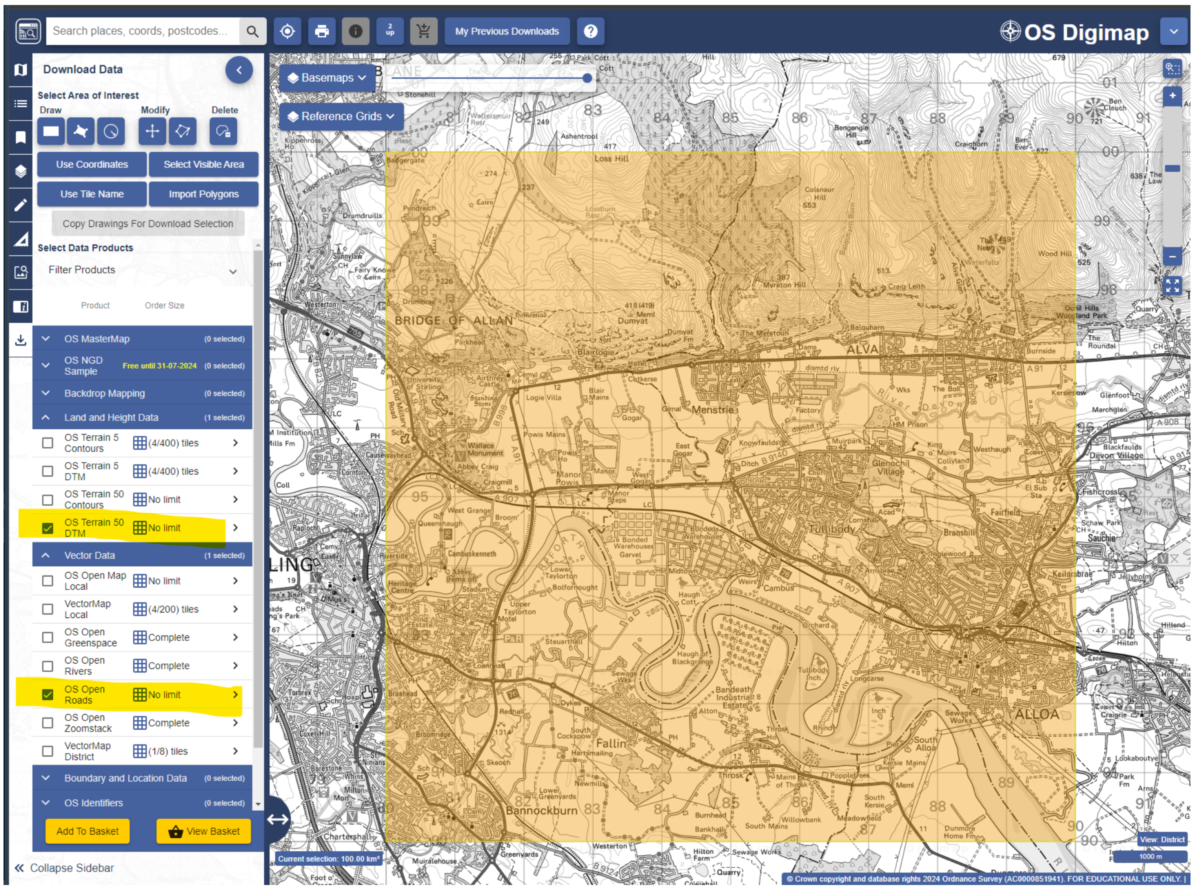
(1) Head to the Digimap website, and if you haven't already, make sure you accept the user licenses for all datasets, as show on the instructions video avaiable on Canvas.

(2) Go the `Ordnance Survey` section of the site, and then pick the `View maps and download data` option on the right.

(3) Following the steps shown on the instructions video, download the following datasets *for the NS89 BNG tile only*:

- OS Open Roads (under *Vector Data*) - choose the `SHP` format
- "OS Terrain 50 Digital Terrain Model" (*NOT Terrain 5 and NOT Contours!*, under Land and Height Data) - choose the `ASC` format

If you have correctly searched for tile NS89 and checked the required datatsets, you will see a screen like this:

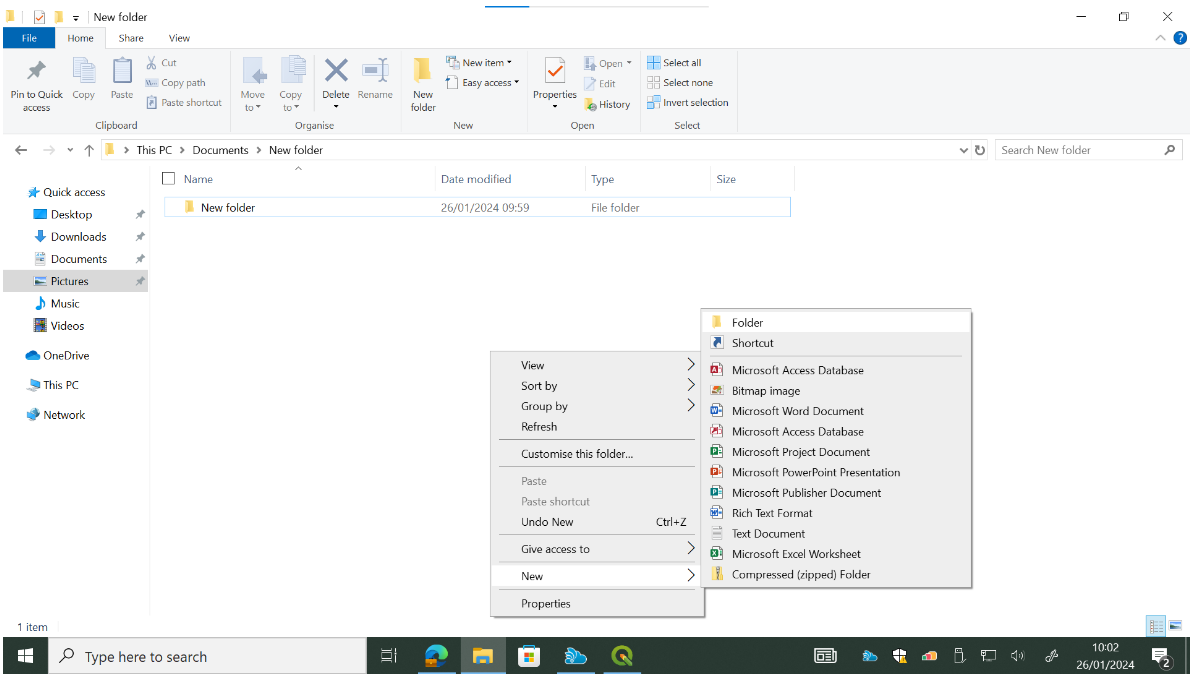


1.2.2 Creating a project structure

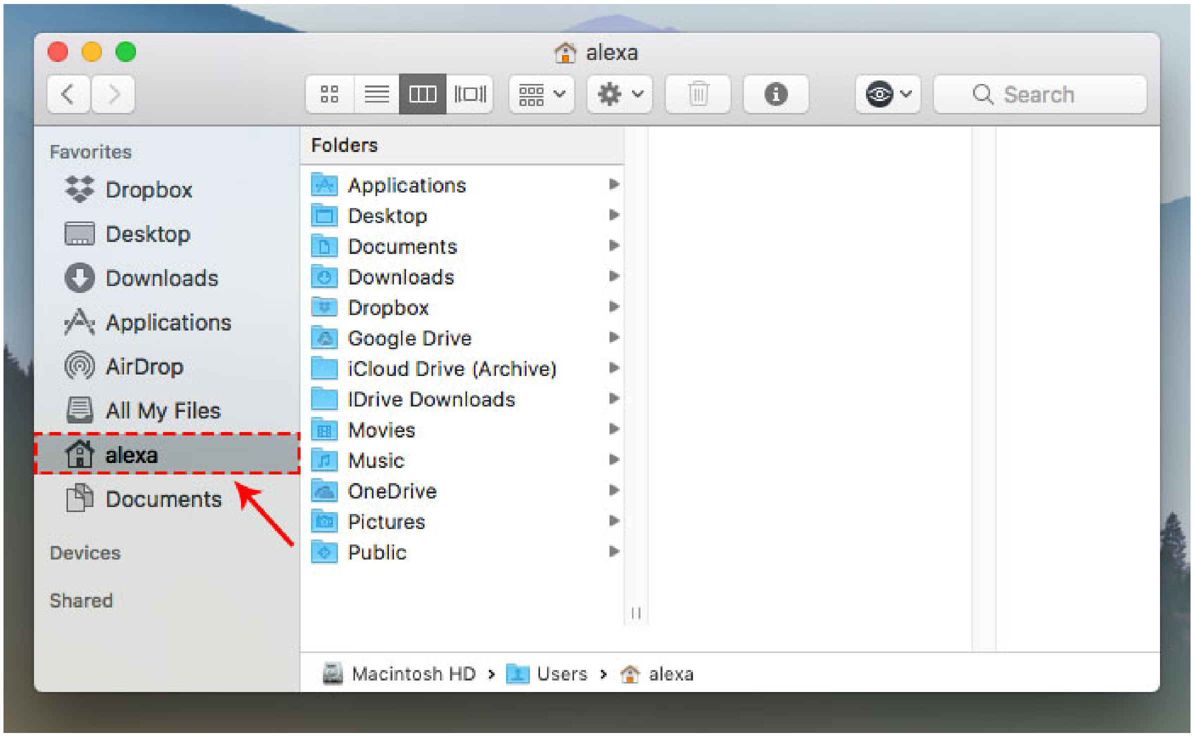
GIS projects generate a lot of different files, and quickly, so project organization is **essential**. The folder structure below is my personal suggestion for organizing GIS projects files and associated data. As you get comfortable managing your own projects, feel free to change the organization structure to something that best suits your own workflow and the specific project you are working on!

(4) Create a folder on your computer with the module name (`GEOU9SP`), off of your main work folder. For **Windows** this will usually be `Documents`. For **Linux** and **Mac**, create it on you `home` folder. (If you prefer and are comfortable with saving at another location on your computer, go for it!)

Windows:



mac OS:



⚠ Warning

- Having complex file paths can sometimes create problems. That is why we try to keep our main projects on a base folder. If you would like to keep a copy of your data on your OneDrive folder you are encouraged to do so, but I don't recommend working directly from it. That is because the full path to a OneDrive folder will to be very long and likely contain spaces. Mine, for example is `C:\Users\Thiago\OneDrive - University of Stirling\Documents`. Those spaces in the name may create problems later. So I recommend instead to *copy* the completed lab data to your OneDrive folder at the end of each lab.

- For the same reason, **never** use spaces or special symbols on your folder and file names. Limit yourself to using letters A-Z and a-z, numbers 1-9 and just the *underline* (_) and *dash* (-) symbols.

- Windows **does not** differentiate letter case, so if you create a file named `filename1.txt` and then a second file named `Filename1.txt` in the same folder, the second will overwrite the first. Mac OS does differentiate upper and lower case letters, so `Filename1.txt` and `filename1.txt` are considered different names and can co-exist in the same folder.

(5) Inside the new `GEOU9SP` folder, create a subfolder called `lab_1` (notice I am avoiding

spaces by using the underline)

(6) Inside `lab_1`, create the following folder structure. On the diagram below, the folder `raster` is a folder inside the folder `01_raw_data`, which is inside `lab_1` and so on.

```
.
 GEOU9SP/
     lab_1/
         00_qgis
         01_raw_data/
             raster
             vector
         02_processing
         03_final_products
         04_notes
```

I like to start folder names start with double digits so they are kept in order. These folders will be used as follows:

- `00_qgis`: we will use this folder to save our QGIS project files.
- `01_raw_data`: this folder will keep all the original data files you download. This way you can always go back to the start if something goes wrong. You can optionally use the subfolders `vector` and `raster` to easily know which kind of data you are working with, but this may not be necessary for small projects. As you obtain data you will create additional subfolders for each individual dataset to keep data organized.
- `02_processing`: here we will keep all the intermediate files you generate as part of your work. Make ample use of subfolders to identify each step of the workflow.
- `03_final_products`: here we will keep the final products of our intended analysis. This makes it easy for us to find the latest version of our final results, without risking confusing it with intermediate files. This can also include maps, reports and any other 'deliverable'resulting from your analysis.
- `04_notes`: here we will keep all our *non-GIS* files. For example, it may be a good idea to keep a text file documenting the project steps as you work on it. You could also save here screen grabs of specific steps. Again, use subfolders as needed to keep your data tidy.

(7) Now move the data you've downloaded into your organized project folders and extract (unzip) them if necessary. The terrain data folder (`terrain-50-dtm_xxxxxxx`) should go into the `raster` folder within `01_raw_data` and the roads folder (`open-roads_xxxxxxx`) into the `vector` folder. The `citations_orders.xxxx.txt` and `contents_order_xxx` text files should go into your `04_notes` folder. Your folder structure should look like this:

```
.
  GEOU9SP/
      lab_1/
          00_qgis
          01_raw_data/
              raster/
                  OS_terrain_50/
                      ...
              vector/
                  OS_roads/
                      ...
          02_processing
          03_final_products
          04_notes
```

! Stop and Think

What are the `citations_orders.xxxx.txt` and `contents_order_xxx` files? What information do they contain?

Click for answer

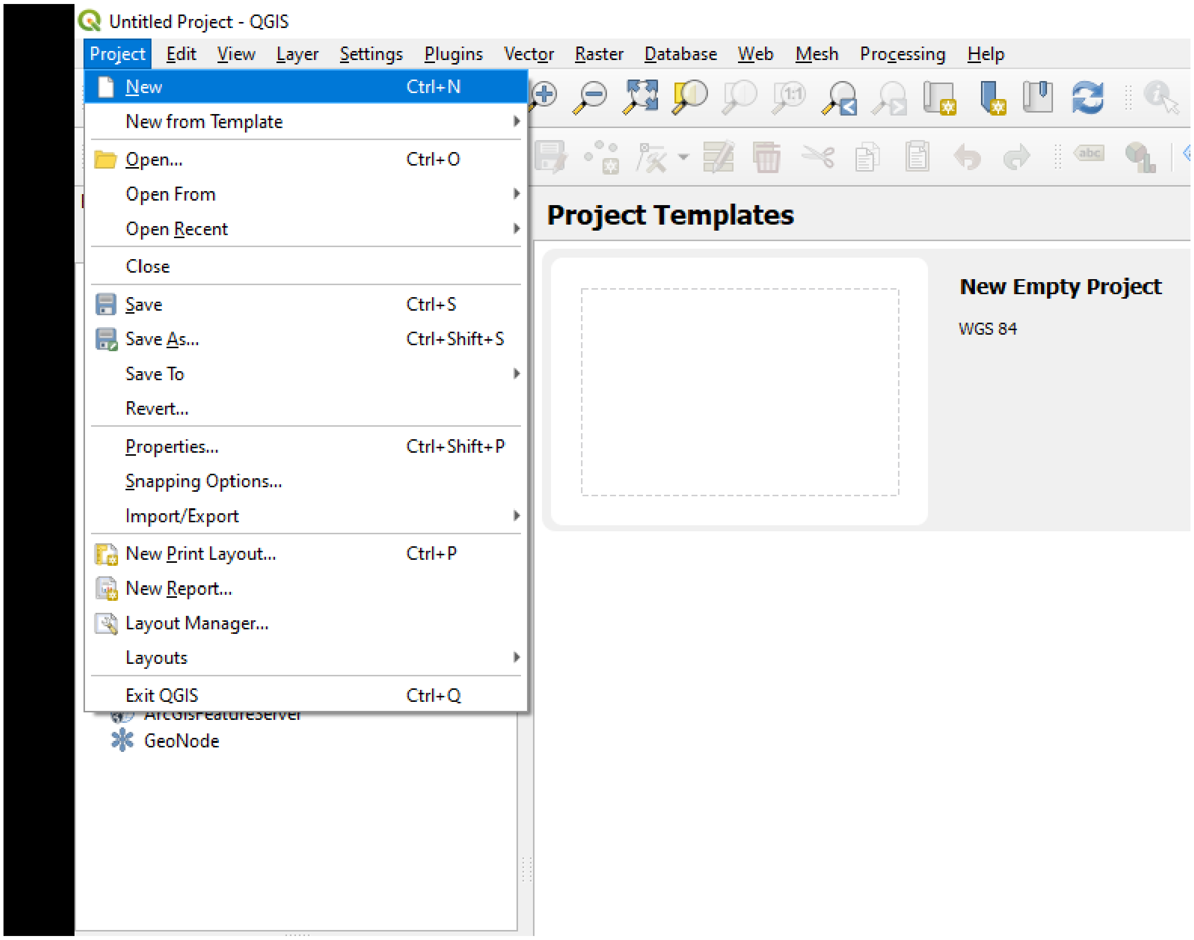
They are both plain text files. `citations_orders.xxxx.txt` is very handy as it gives us the proper way to cite the data sources on reports. `contents_order_xxx` is just a summary of your Digimap order.

(8) Start a new text file (a Word *.doc* file or a Notepad *.txt* file) in your `04_notes` folder, and write a few lines documenting the steps you took until now. If you prefer handwritten notes on a paper notebook, feel free to use it instead! The important thing is to keep track of the steps you are taking. As projects get more complicated, it is easy to forget which steps we took, and in what order!

1.2.3 Creating a QGIS project and adding data to it

A QGIS project is a file, which will remember all the data layers you have loaded, their stacking order, the styling of each layer, and some other information such as the coordinate reference system. It will also keep any map layouts that you create. **But he project file will NOT store the data files themselves!!**. It will only link to the data. That is why we need good project folder organisation. If a data file is moved or renamed, the QGIS project file will lose track of it.

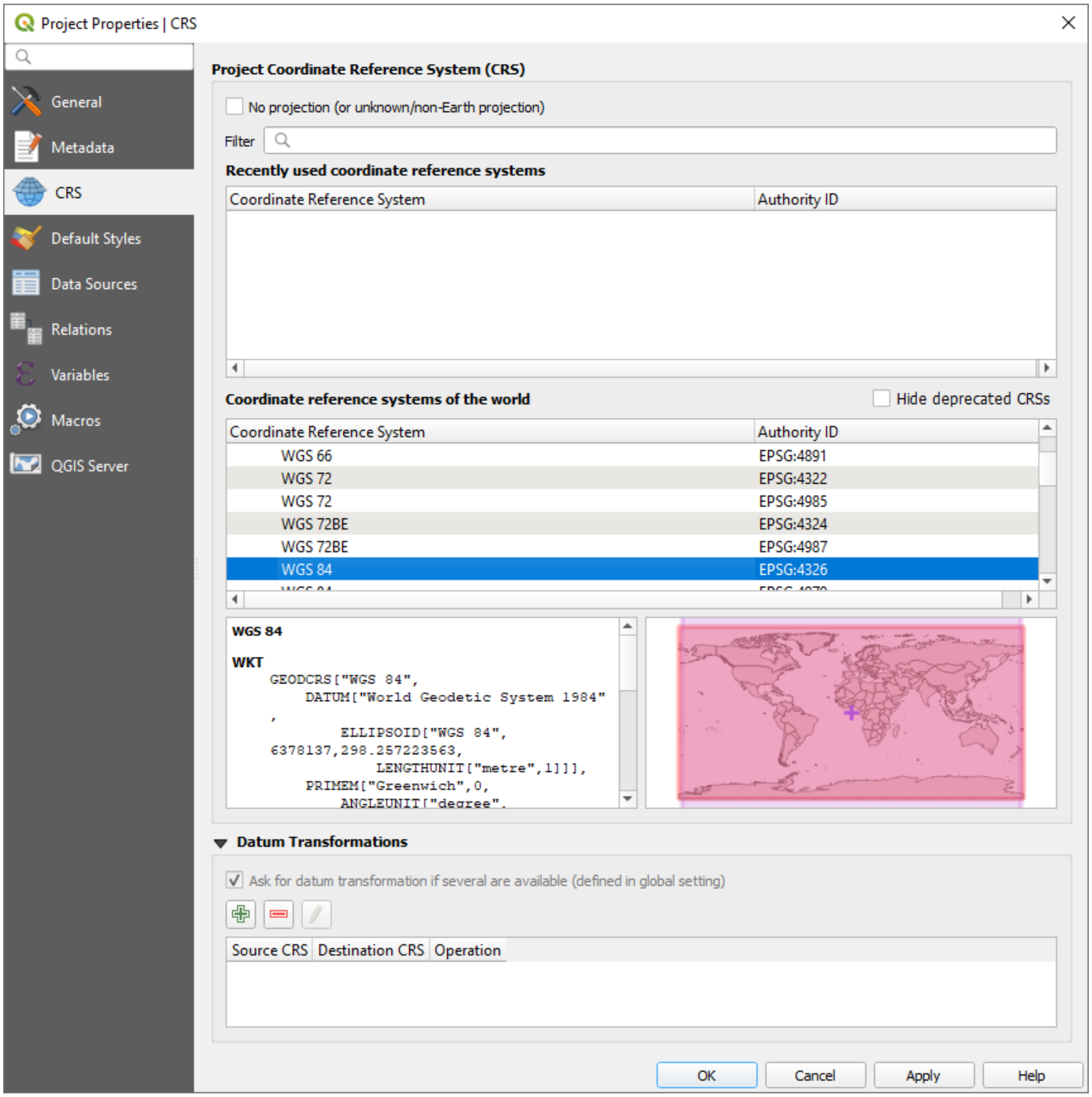
6. Create a new project in QGIS by clicking on `Project > New...` or pressing *Ctrl-N*:



(9) Add to your project the layers `NS_RoadLink.shp` from the OS Roads dataset and the `NS89.asc` terrain data from your organized project folders. Don't worry if the extents don't match - it's just that the OS DEM and the OS Roads are distributed in different sized 'chunks'.

(10) Save your project inside the `00_qgis` folder. You can save your project by clicking on the *Save* button, going to `Project > Save` menu, or by holding the keys `Ctrl+S` `(Command+S on Mac)`.

(11) Open the project settings by clicking on the menu `Project > Properties...`. You will then see this window:



(12) The main things to set on your new project are the project home folder, the coordinate reference system (CRS) and the measurement units.

- As the *project home* on the `General` tab, select the `lab_1` folder you created. This helps quick navigation when opening and saving data.
- For *measurement units*, make sure distance units are set in meters, and area units in squared meters, also on the `General` tab. Any QGIS operations that calculate distances or areas will use the units set by the project.

- For the CRS, go to the `CRS` tab (to the left) and search for **27700** in the `Filter` box. That is the *EPSG code* that identifies the *OSGB 1936 British National Grid* coordinate reference system (CRS). Select it by clicking on it - you may need to expand your search results by clicking on the small arrows besides `Projected` and `Transverse Mercator`.

> **Note**
>
> EPSG stands for "European Petroleum Survey Group", and designates a database with standard codes for hundreds of coordinate reference systems. Over time, you will probably memorize the EPSG codes for the CRSs you use more often.

(13) Save your project again.

1.3 Guided Exercise 2 - Organizing and styling your layers

One of the most powerful aspects of GIS software is the ability to *style* spatial data in very specific ways, by specifying colors, line widths, line types, simbols, etc. As we progress in the module you will learn more and more ways to style your data.

(14) On the `Layers panel` to the left of the screen, select the `NS89` layer, and drag it to the bottom of the layers list if not there already.

(15) Turn the roads layer off for now, by unchecking the box besides its name.

(16) Right-click on the `NS89` layer name and choose `Rename Layer`. Rename it to `Digital Elevation Model (50m)`.

(17) Open the file explorer in your system, and find the `NS89.asc` file that holds the actual elevation data, which you downloaded from Digimap.

> **Stop and Think**
>
> Will changing a layer name in the layer panel also change the name of the source data file for that layer?

> **Click for answer**
>
> No, layer names within the project are independent of file names - but as default QGIS will use the file name as layer name when you add new data. But you should always change them into nice, readable and properly spelled names within your project, where you are free to use spaces. The actual file name linked by the project will stay the same and can always be seen by right-clicking on the layer name and selecting `Properties...> Information`.

(18) Right click on the newly renamed terrain layer and choose `Zoom to Layer`. This is a very handy tool to "find yourself" if you end up zooming or panning the map too far.

(19) Right click on the terrain layer name again and select `Properties...`, then go to the `Symbology` tab.

(20) On the `Min` and `Max` boxes, type `0` and `500` respectively. This determines the range of layer values to be visualised.

(21) Select `Rendering type` to be `Single Band Pseudocolor`, and change the `Color ramp` option by clicling on the down-arrow button to the right and picking the `spectral` colour ramp. If you click on the colour ramp itself it will open a new window to custmize it. This is now what we need for now, so just close it and use the down-arrow.

(22) Click on `Classify` (under the dropdown menu that says * Mode: continuous*). The colours will be matched to the range of elevation values in the layer.

(23) Click again on the little down-arrow button beside the colour palette button and select `Invert Color Ramp` at the top of the options, so that the lowest heights are coloured blue. Then click on `OK`.

(24) Note how the legend for you terrain layer has changed on the Layers panel. it now shows the minimum and maximum elevations and the colour ramp. Save your project.

! Stop and Think

Why do we bother inverting the colour ramp for this dataset?

Click for answer

We should always try to use colours that reinforce map interpretation. The color blue is usually associated with water, and water accumulates on the lowest elevations, so setting the lowest elevations to blue helps map users read and interpret the map.

(25) Rename the `NS_RoadLink` layer to `Road Network`.

(26) Go to its `Symbology` properties, like you did for the terrain layer, Notice that the symbology options are data-specific (vector vs. raster). Seclet `Simple Line` in the symbology window (under the main `Line` option). Then under the window, go to the `Color` option an click on the down-arrow menu to change the line color to a dark grey. If you click on the actual colour, a more complex colour-picking window will appear. You can use either the quicker colour dropdown or the main colour window, whatever you prefer.

(27) Change the `Stroke width` (line width) to 0.3. Click `OK`. Reactivate the layer if needed to visualise it.

1.4 Guided Exercise 3: Processing data using GIS operations

The core of GIS work is to use the many built-in operations (also known as functions or tools) of GIS software to *process* the data in some way, and thus create additional information. For this exercise, we will use an operation that creates a new layer representing the boundaries of the terrain data layer, and then use a second operation to cut the roads layer to the same shape and extent as this new layer.

(28) Go to the `Vector` menu and select `Research Tools > Extract Layer Extent...`. Select the terrain layer as your `Input layer`, and click `Run` to generate a *temporary layer*. Temporary layers are not kept once you close QGIS, unless you save it manually later. The `Extract Layer Extent` window will not close automatically after you run the operation, so click on `Close` when you are done.

(29) Go to `Vector > Geoprocessing Tools > Clip...`. Select the roads layer as the `Input Layer` and the new temporary layer as the `Overlay Layer`.

(30) This time, we will save the output. Click on the `...` button to the right of the `Clipped` text box, and then choose `Save to file`. Save your new layer on the folder `GEOU9SP/lab_1/02_processing/`, naming it `clipped_roads.shp`. Make sure the `SHP file` format is selected below the file name. Then click on `Run` to execute the operation. Close the window.

(31) Turn the original roads layer on and off to see the result of your operation. Then right-click on the original roads layer, and select `Styles > Copy Style > All Style Categories`. Then right click on the new (`Clipped`) roads layer and select `Styles > Paste Style > All Style Categories`. This is a great way top style several layers ion the same way wirthout effort.

(32) Remove the original roads layer from your project by right clicking on it and selecting `Remove Layer...`, and then rename you clipped layer to “Roads”. Save your project.

(33) Close QGIS. **It will give you a warning** - read it carefully and then confirm it.

(34) Reopen QGIS, and load back your project. Notice it remembers exactly where you last saved it, including zoom level, layer names and layer styles. The “Extent” layer will still be on your list, but will appear empty - it has been deleted once you closed QGIS. Remove it from the project and save again.

! Stop and Think

a) What are the names of the two GIS functions you just used in this exercise?

b) Why did you have to create a new layer representing the extent of the terrain data before *clipping* the roads layer?

c) What does the warning given by QGIS when you closed your project means?

Click for answer

a) The functions are called `Clip` and `Extract Layer Extent`.

b) The `Clip` function requires two *vector* files as input, but the terrain data is a *raster* file (i.e. an image). The `Extract Layer Extent` creates a vector file representing the extent of any given layer. Each specific tool will require different kinds of data to work properly. We will learn more about vectors and rasters on weeks 2 and 3.

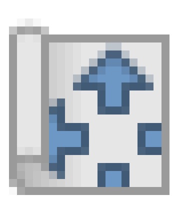
c) When we created the extent layer, we produced a *temporary layer*, which is discarded by QGIS when the program is closed. QGIS was letting you know that will happen, to give you the chance to go back and save it. Temporary layers are also lost when QGIS crashes (yes when, not if - it will happen). So never use them for important stuff - only for quick tests if you are not sure what the output of a function will be.

1.5 Guided Exercise 4: Creating a map layout

The main QGIS interface (or any other GIS software) is developed and optimised for interactive work. But very often as part of our GIS analysis we will want to generate nice maps and figures following proper design rules (and not just grabbing a screen capture of the QGIS window and dumping it on a page - hint for your assignment reports). For that, we use the QGIS **Map Layout Editor**.

(35) Click on `Project > New Print Layout` and name it `Lab 1 Layout`. A new window will open showing the QGIS Layout Editor. Notice that the main QGIS window remains open as well. These windows are 'linked', so that the map layout reflects any styling changes you make on the main window.

(36) Add a new map to the layout by clicking on the  icon. Drag it through the page so it covers about 2/3 of it horizontally, and the full height of the page (minus some borders).

(37) Use the `Interactive Extent` tool  to pan (click and grag) and zoom (mouse wheel) until your data covers the entire map box. But make sure you don't hide

the edges of the data by zooming in too much!

(38) Now fine tune the map scale by changing the `Scale` value on the bottom right panel. Remember that this value means "1:value", i.e. one unit on the page is equal to that many units (value) in the real world. This means larger numbers will "zoom out", and smaller numbers will "zoom in". Try to make the map fill as much as possible of the map box, without clipping the edges.

(39) Go to the menu `Add Item > Add Legend...` in the Map Layout Window (or guess the icon for this option on the side toolbar). Click the area beside the map box and drag to add a legend.

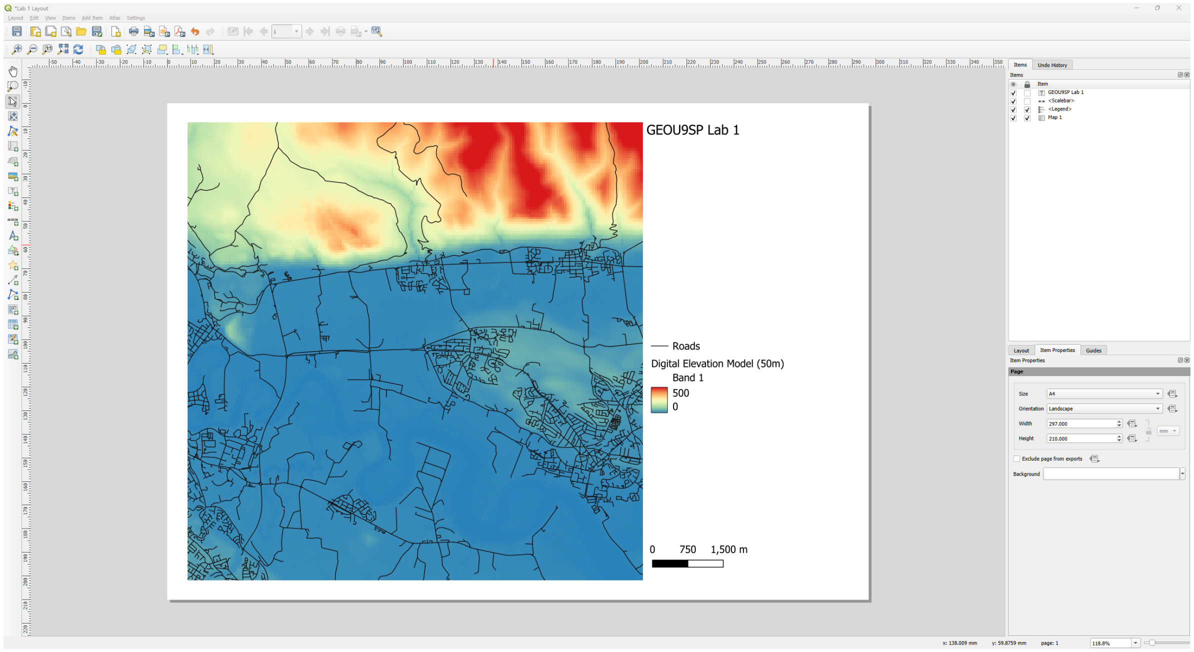
(40) Go back to the main QGIS window, right click on the terrain layer name, then select `Properties...`, and on the `Symbology` tab, change the `Mode` under the class color box to `Equal Interval`. Then select the number of `Classes` to 10 (to the right of the `Equal Interval` box). Go back top the Map Layout editor.

(41) Go to the menu `Add Item > Add Scalebar` in the Map Layout Window (or guess the icon for this option on the side toolbar). Click and drag in the area below the legend to add it to the map layout.

(42) Add a title to your map using the `Add Label...` tool (either on the `Add Item` menu or selecting the tool directly from the left sidebar). You can change the text by replacing the "Lorem ipsum" placeholder text with your own text on the left pane. Try to make it **bold** with a font size of 16 (hint: always use the down-arrow buttons for 'quick settings').

(43) Rearrange the items on the page until you are pleased with the results. Then go to `Layout > Export as PDF...`, and export your map, naming it properly and saving it on `GEOU9SP/lab_1/final_products`. It is a good idea to export as PDF if you want your map to be a standalone document. If you are exporting to insert the map into a report, then use `Layout > Export as Image...` instead.

For reference, my map looked like this at this stage:



(44) Then close the Map Layout window, save your project on the main QGIS window, and close QGIS. Reopen QGIS, and go to `Project > Layout Manager`. The layout you created previously should appear on the list. Select it and click on `Show` to reopen the Map Layout window.

Congratulations! You have successfully finished your first GIS project, using proper file management practices! As a final suggestion, create a "workflow_notes" file on `GEOU9SP/lab1/notes` and write up a quick overview of what you did, along with any specific notes you would like to remember later.

1.6 Independent Exercise 1

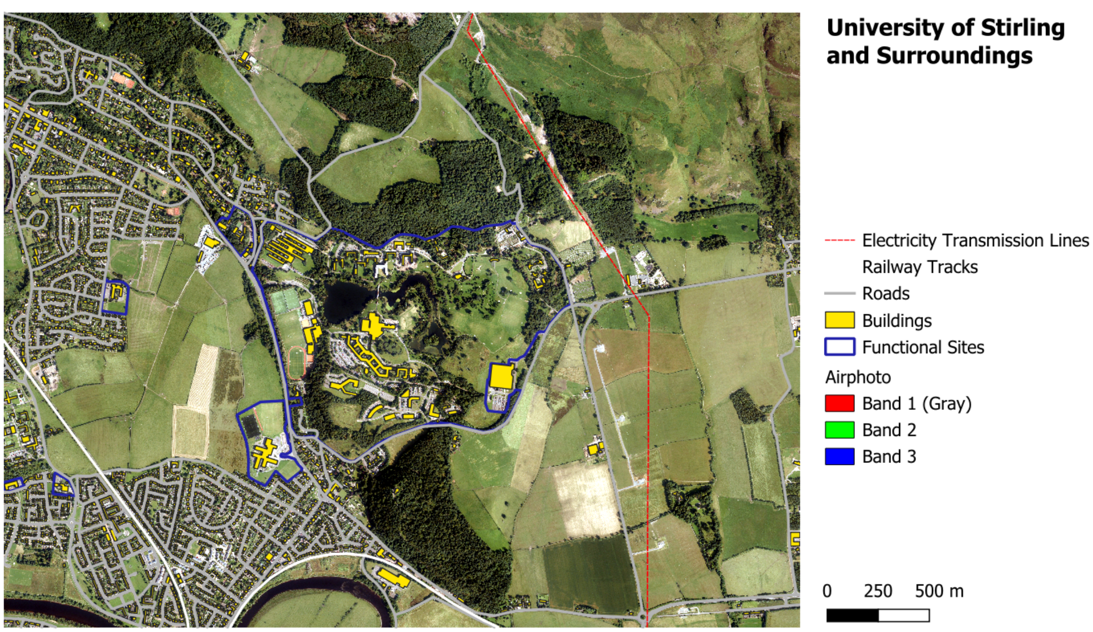
At the end of each lab, you will have the opportunity to reinforce what you learned by going through 'independent' exercises. These will use the same operations you learned with the guided exercises, but it may require you to figure out small bits of new functionality, and will not have step by step instructions.

As the module progresses, the independent exercises will give you less and less directions, to reflect real-world GIs usage. **Make sure you do the independent exercises** - it is easy to fall into a false sense of '*I got this*' when only following step-by-step directions.

1. Create a new project folder structure for this project, under your main GEOU9SP work folder.

2. Download the zipfile containing the Air Photo Mosaic and the Stirling Council Geospatial Data from here.
3. Extract the data from the zipfiles and move them to the proper project folders.
4. Open QGIS and create a new project that uses the OSGB British Grid (EPSG 27700) coordinate reference system.
5. Import the airphoto raster image and the vector files for Buildings, Roads, Railway Track, Electricity Transmission Lines, and Functional Sites into your QGIS project.
6. Organize your layers so that, from top to bottom, you have transmission lines, railways, roads, buildings, functional sites, and then the airphoto image.
7. Style your layers so that transmission lines are styled as thin dashed red lines, railways as thick white lines, roads as thick grey lines, buildings as filled yellow polygons and functional sites with a thick dark blue outline and no fill colour (hint: check the `Fill style` options).
8. `Clip` all your vector layers to the extent of the airphoto image.
9. Create a map layout covering the entire extent of the airphoto. Add a title, legend and scale bar to your layout and export it as a PNG image. Then insert your exported file as a figure into a MS Word document.

Click here to see what the final layout should look like.



10. Now answer the questions below:

- How far is the Pathfoot Building from the Cottrell Bulding? Calculate it both “as the crow flies” (linear distance) and as if you were walking. (Hint: use the Measuring tool).
- What is the total surface area of the water bodies in the University of Stirling Campus? (Hint: also the Measuring tool).
- What is the classification of the UoS campus polygon within the “Functional Site” layer? (Hint: use the Indentify Features tool).

2 Lab 2: Coordinate Reference Systems

The purpose of this lab is to help you understand why we need to pay attention to Coordinate Reference Systems (CRS) when working with spatial data. CRS's are what make data *spatial* - they associate the actual data to locations on the surface of the Earth (or other planets!). But there are dozens of CRS's in existence, each adapted for a specific world region and purpose. So quite often you will obtain spatial data in different coordinate systems, which can cause problems if not normalised before analysis.

2.1 Guided Exercise 1: Understanding Coordinate Reference Systems

In this exercise, you will learn how to use QGIS to identify the coordinate reference system (CRS, sometimes wrongly called as just "projection") of spatial data you acquire, and also how to manage data and project coordinate reference systems.

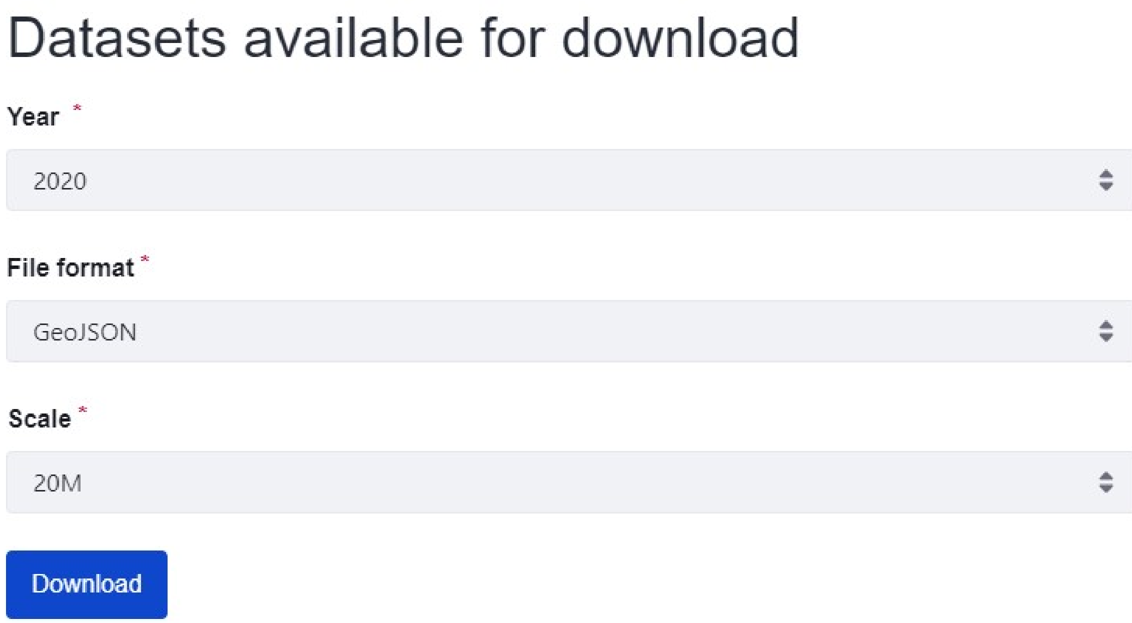
> **!** Stop and Think
>
> Why are coordinate reference systems and 'projections' not the same thing?

> **Click for answer**
>
> Coordinate reference systems combine a **datum**, which defines a geometric representation of the Earth's shape and how it 'intersects' with the real surface of the Earth, a **coordinate system** (for example latitude and longitude or northings and eastings) and a **map projection** which is a set of mathematical rules to project the 3D surface of the datum's *ellpisoid* into a flat plane (such as a screen or a map).

2.1.1 Obtaining the required data

(45) Download the **2020** country boundary data in **GeoJSON** format, at the **1:20** million scale, from the link below. The GeoJSON format is a more recent GIS file format, commonly used for web-based mapping. It is derived from the JavaScript Object Notation (JSON) data file format, widely used to exchange data among websites and web servers. More info here.

https://ec.europa.eu/eurostat/web/gisco/geodata/administrative-units/countries



! Stop and Think

a) What is the source of the data you are downloading? Does it seem reliable?

b) What are the conditions (provisions) of use for the data?

Click for answer

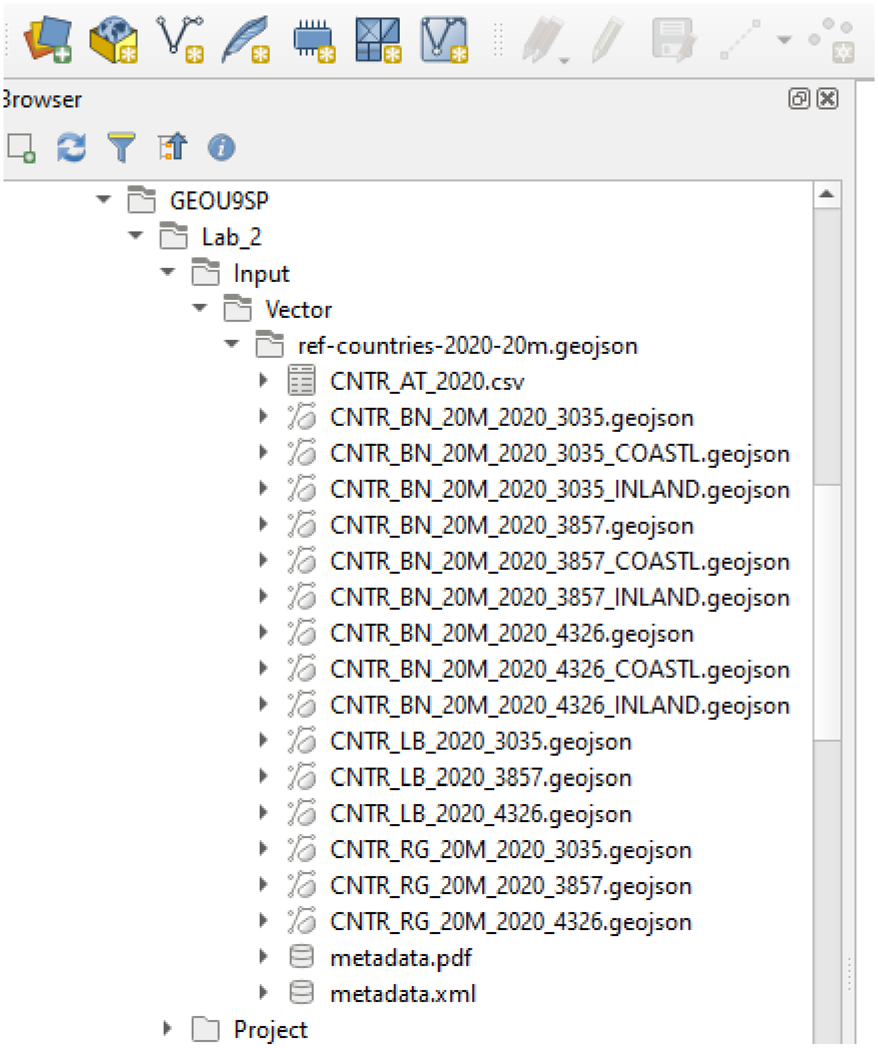
a) The page providing the data is managed by Eurostat, the statistical office of the European Union. Therefore you would be inclined to trust in the quality and correctness of the data provided.

b) The webpage presents a link to "dowload rules' which describe the authorised uses of the data. This informartion can also be found in the data's *metadata* file.

(46) Create a lab_2 folder in your GEOU9SP main folder. Then create a simple folder structure to organise the data, and extract the zipped downloaded data in its proper location. If you are not sure how to do this, please revisit Chapter 1.

(47) Open QGIS and start a new project. Save it as `lab_2` in its proper folder. Then look at the contents of the folder holding the country data, using the QGIS browser panel. If the panel is not available, you can enable it by going to the `View > Panels` menu and

checking the box for `browser`. You should see several layers on tghe folder:



(48) Load the `CNTR_BN_20M_2020_4326` file into your project. Pay attention to the file name as there are many files with similar names.

! Stop and Think

Good file names are always informative of their content. Can you gess the contents of the different GeoJSON files you have downloaded based on their names?

Click for answer

All file names start with `CNTR` for 'countries', followed by a two letter code. `BN` seems to stand for 'boundary'(vector lines), `RG` for 'region'(vector polygons), and `LB` for 'labels' (vector points). Then `2020` specified the reference year, and `20M` indicates the 1:20 million mapping scale. the final four-letter number indicates the EPSG code for the data CRS: 4326 ('unprojected' WGS84), 3857 (WGS 84 with Pseudo-Mercator projection) or 3035 (ETRS89-extended / Lambert Azimuthal Equal Area for Europe).

2.1.2 Visualising data with different CRS

(49) Set the symbology for the outline and fill as you prefer. Try to manipulate more visual variables than just colour.

! Stop and Think

Why can't you set a fill color for the countries?

Click for answer

Because the `BN` files are vector lines, not polygons. Lines only have one dimension, and thus the inner parts of the countries in this dataset are actually empty. If you load the `RG` dataset instead, you can set the fill, as vector polygons represent 2D areas.

(50) Right-click on this layer's name and go to `Properties > Information`.

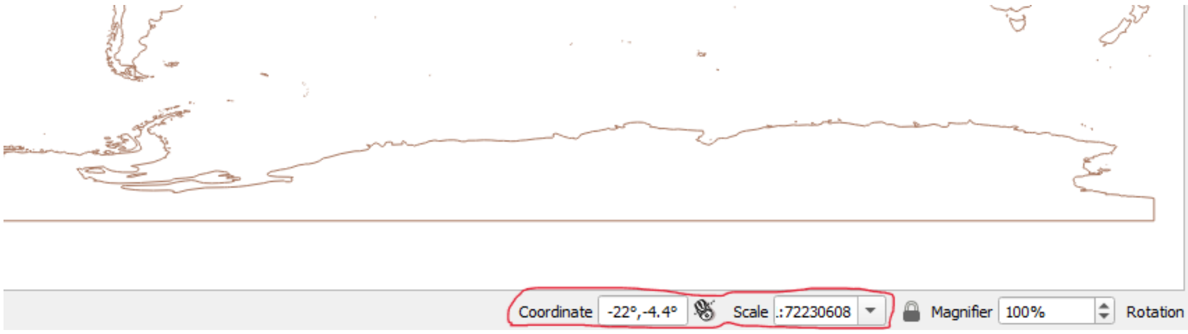
! Stop and Think

What is the Coordinate Reference System (CRS) for this dataset?

Click for answer

The information tab will have a section called Coordinate Reference System, as below: Name: EPSG:4326 - WGS 84 Units: Geographic (uses latitude and longitude for coordinates) Type: Geographic (2D) Method: Lat/long (Geodetic alias) Celestial Body: Earth Accuracy: Based on World Geodetic System 1984 ensemble (EPSG:6326), which has a limited accuracy of at best 2 meters. Reference: Dynamic (relies on a datum which is not plate-fixed)

(51) Note, on the bottom QGIS status bar, that as you move your mouse pointer around, the coordinates for the mouse position are updated in real time. Also note what the map scale is, how it changes as zoom in and out. You can also type the second part of a scale nuber to zoom at the desired map scale (for example 50000 if you want to see the map at a 1:50000 scale)



! Stop and Think

a) Why doesn't the scale shown on the bar match the "advertised" scale for the dataset (1:10 million)?

b) The box on the very bottom right of the QGIS status bar tells you what is the current project CRS. How is it different from a layer CRS?

Click for answer

a) The 20M scale refers to the scale used when digitising the coastline, i.e., what is the 'closest' you can view the dataset without loss of detail.

b) The project CRS defines the 'viewing' CRS for the map canvas. Any data that uses a different CRS than the project will be re-projected 'on the fly' to match the CRS of the project - but continue with the exercise to learn why that can be a problem.

(52) Zoom to the UK in the shown layer. Note how the scale at the bottom status bar changes with your zoom.

! Stop and Think

Does the shape of the UK look "right" to you? If not, what is the issue and what is the cause?

Click for answer

The UK looks 'squished' vertically. That is because the data is being viewed in the EPSG 4326 ('unprjected' WGS84) CRS. EPSG 4236 uses what is effectively the *Plate Carrée* or *Equidistant cylindrical* projection, the simplest possible map projection - lat and long degrees are just linearly converted to x,y coordinates. This projection does not preserve area nor shape (conformal) and increasingly distorts features as you approach the poles.

(53) Click on the project projection box at the bottom right of the status bar (or go to `Project > Properties... > CRS tab`). On the `Filter` text box, search for EPSG:3035. Select this projection for the project and click `OK`. A warning box will appear, make sure you read it through before selecting `OK` again.

! Stop and Think

a) what is the name of the Coordinate Reference System specified by EPSG 3035?

b) What did the warning window warned you about?

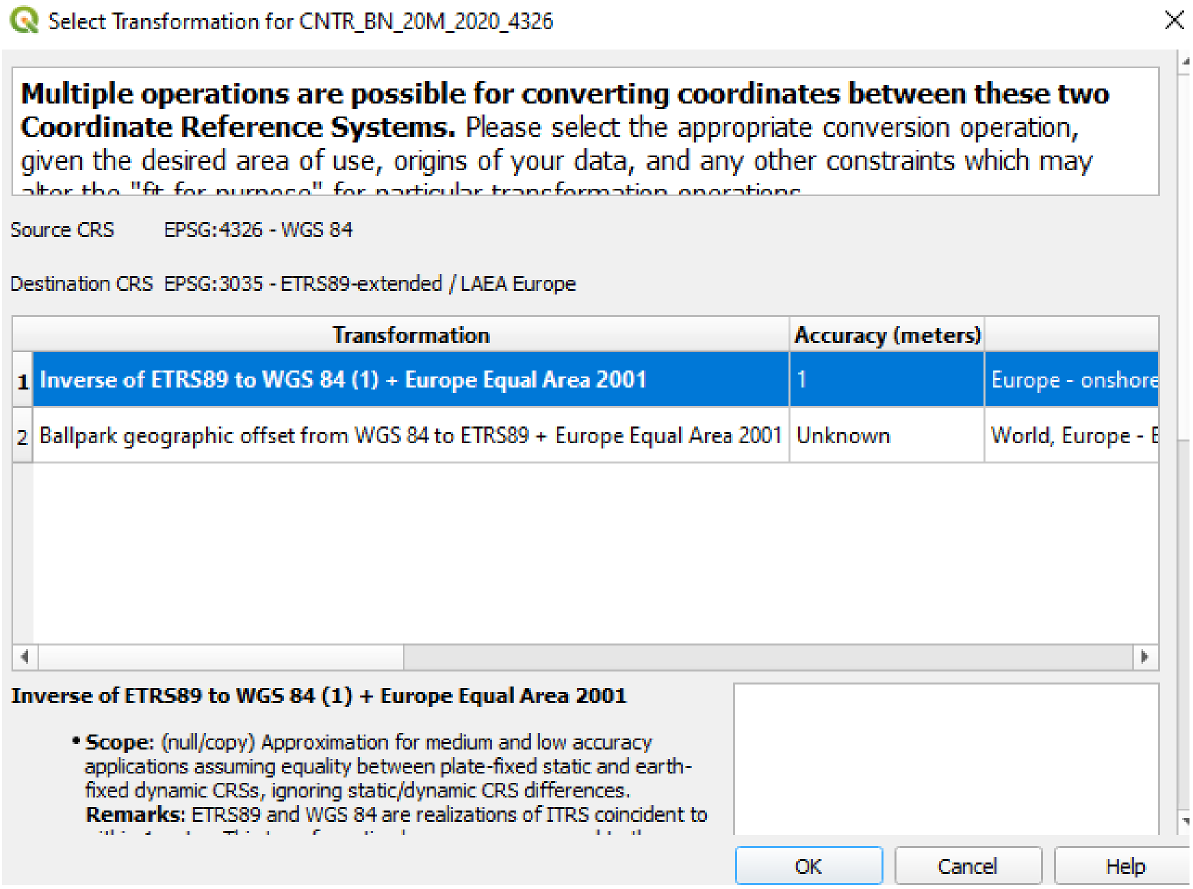
Click for answer

a) EPSG 3035 is called ETRS89-extended / LAEA Europe and is the official projection for cartographic data from the European Union. It uses the European Terrestrial Reference System 1989 datum and the Lambert Azimuthal Equal Area projection, which preserves areas and can be considered conformal for Europe.

b) It warned you that there is more than one option for the 'on the fly' reprojection of your layer from ESPG 4326 to EPSG 3035. It showed you the options with the most accurate (1m) selected by default. But this option is only valid for Europe.

It is important to not "freak out" when an unexpected warning or error appear. Take a breath, and read through the window or error message, most often the explanation is right there. You just have to dare to look.

If you did click through it without looking, here is a screen capture of it:



(54) Look at the shape of the UK again after changing the project CRS. Then right click on the layer name and select “Zoom to Layer(s).”

! Stop and Think

a) How does the rest of the world look now? Why?

b) When you move your mouse, what unit are the coordinates in?

Click for answer

a) As you move further away from the centre of the projection, shape gets progressively more distorted. This is because the LAEA projection is only conformal at its centre. But areas are all correct.

b) In metres. You can check that on the layer’s `Properties > Information` tab.

(55) Now add to the project the file called CNTR_BN_10M_2020_3035.geojson. Notice the different last four numbers on the file name.

! Stop and Think

What is the CRS for this new layer, and how well dos it visually align with the p[revious layer.

Click for answer

This second layers uses the EPSG 3035 CRS, while the previous layer used EPSG 4326. Notice how ech layer maintains its original CRS when added to the project, but if necessary they are reprojected 'on the fly' to match up visually.

(56) Change the project CRS back to EPSG:4326.

(57) Now go back to the project CRS properties and check the box that says `No CRS` at the top of the window. This disables the on-the-fly projection. Then click OK and go back to your map.

(58) Right click on the 4326 layer and select `Zoom to Layer`. Then select the zoom out tool (the loupe with a minus sign) at the top button row, and start clicking at the centre of the map. Keep clicking as it gets really smalll - you should click about 17 times until the second dataset is fully visible. Check the properties of each layer to make sure they still have the same CRS of when you loaded them.

! Stop and Think

What has happened? Why are the two datasets suddenly very different in size?

Click for answer

Since you turned off on-the-fly reprojection, each dataset is now drawn at their original coordinates - but one is in meters and the other in degrees, so their x,y positions and scale become very different.

2.1.3 Potential issues with using mismatched data

(59) Download this vector shapefile (link), unzip it and add it to your QGIS project. Check what is the CRS of this layer.

(60) Set the Project CRS back to EPSG:3035. Then go to the top menu bar and select `Vector > Geoprocessing > Clip`. Select the layer that has the EPSG 3035 projection as your

`Input` Layer, and the new “clip_bounds” layer as your `Overlay` Layer. You can just leave the output as a temporary file. Click Run.

(61) Turn off the visibility of all layers except the new “Clipped” layer to see the result of the Clip operation.

(62) Rename the “Clipped” layer to “Clipped_3035” by right clicking on it and selecting `Rename layer`. Then repeat the `Clip` operation, this time selecting the 4326 world layer as `Input`, and “clip_bounds” as `Overlay` again. Rename the result to “Clipped_4326.”

Using what you learned on the previous lab activities, pick two contrasting colours for each “Clipped_...” layer, and make the lines thicker. Zoom in at the lines of each clipped layer and check if they overlap perfectly.

> **!** Stop and Think
>
> Why are the clipping results different even though the initial 3035 and 4236 layers looked perfectly aligned?

> **Click for answer**
>
> Because although they have been reprojected visually to match on screen, the files still have different CRSs, and this affects the lining up of the `Input` and overlay layers. To get proper results, you need permanently translate (reproject) both datasets to the same CRS.

(63) Now go to `Vector > Data Management Tools > Reproject Data`. Select the 4326 world layer as your `Input Layer`, and EPSG:3035 as your `Target CRS`. Let the result be a temporary file and click `OK`. The new layer will be automatically named as “Reprojected”. What is the CRS of this new layer (check on the layer properties window)?

(64) Now repeat the use of the `Clip` tool using “Reprojected” as the `Input Layer` and “clip_bounds” as the `Overlay Layer`. Rename the resulting layer to ‘Clipped_Reprojected’. Which of the two originally clipped layers (“Clipped_3035” or “Clipped_4236?) better matches the”Clipped_Reprojected” layer?

> **!** Stop and Think
>
> What does the `Reproject` operation do?

> **Click for answer**
>
> It actually applies a permament mathematical transformation to the coordinates of the input data, translating the data from one CRS to another. For any GIS project that involves multiple data layers with different CRSs, you should pick the CRS that makes

> more sense for your project as the 'project CRS', and then reproject all layers to the same CRS before anything else.

This is the end of Lab 2! You shoudl now understand why different datasets may have different Coordinate Reference Systems, what are the problems with working with data that has mismatched CRSs, and how to reproject data to match a given CRS. As this is your first week, there are no additional independent exercises - lets take it easy!

If you still want to practice more, check the exercises from the QGIS Training Manual!