

# TAKING QGIS TO THE NEXT LEVEL

Getting more out of QGIS:  
beyond the basics

*with Alasdair Rae*



**QGIS version:** 3.16 (Hannover)

**Workbook date:** February 2022

**Automatic Knowledge Ltd**

[www.automaticknowledge.co.uk](http://www.automaticknowledge.co.uk)

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### A note about QGIS versions

This workbook was written for QGIS version 3.16. If any screenshots in the workbook look different to the ones on your screen it is probably because you're on a different version, or have your toolbars positioned differently, but this is unlikely to cause any problems. Most QGIS versions are named after a city (e.g. 3.16 is called Hannover). The long term release (LTR) version of QGIS is the most stable one, but you will also see a newer version of QGIS on the website – these often have more features but are not yet finalised for official long-term release.

This workbook is also available online, at:

<https://automaticknowledge.org/training/workbooks>

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Notes

## About Automatic Knowledge

Our philosophy is all about sharing data and knowledge, so that we can all be a bit better informed about the world. The way we do this is mainly through spatial data analysis and visualisation, and as part of this we offer training courses in geospatial software – mostly QGIS. Alasdair Rae (pictured) founded Automatic Knowledge in 2019 and also runs the training courses.



## Why 'automatic knowledge'?

The idea behind Automatic Knowledge is that we do the hard work of completing the journey from data to knowledge, so that you can then make more informed decisions. These training sessions will hopefully help you do that too.

## Other activities (e.g. free stuff)

In addition to training, we provide a range of consultancy services, specialising in data, spatial analysis, the built environment and cartography. We also publish free and open datasets that you may find useful, at:



[automaticknowledge.co.uk/resources](https://automaticknowledge.co.uk/resources)




We're also a 'sustaining member' of QGIS, which means that we donate money to the QGIS project on an annual basis, to help fund its development. By taking this course, you're helping too.

## Automatic Knowledge training sessions

The idea behind all our training sessions, and these workbooks, is to help you learn new things in an enjoyable way, without confusing you. We want everyone who takes one of our courses to come away with useful new skills that they can then put into practice in their day-to-day work, and build on in the future.

### About this workbook

Following a workbook can be a great way to learn new software skills, but there's also a risk that it turns us into robots, following step-by-step instructions in a linear way. During the session we'll go off at tangents and do some demos of useful skills –  among other things. *The emojis?* I add them in for a bit of colour, but they also serve a practical purpose because they can help us find key sections of the document quickly.

### Formatting

Most font is size 14. When switching between screen and workbook this is easier on the eyes. The following format will be used in relation to files/folders, websites, QGIS options/tools, click actions and any text I want you to input. I've also added a 'Notes' section on each page where you can jot things down.

**Files, folders and suchlike:** e.g. world\_countries.shp

**Websites:** e.g. [www.automaticknowledge.org/training](http://www.automaticknowledge.org/training)

**QGIS windows, tools, sections, options:** e.g. Coordinate

**Actions - click menu item/ button:** e.g. Vector > Research Tools

**Text input:** e.g. "roadClassificationNumber" = 'M8'

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Notes

## 1. Introduction

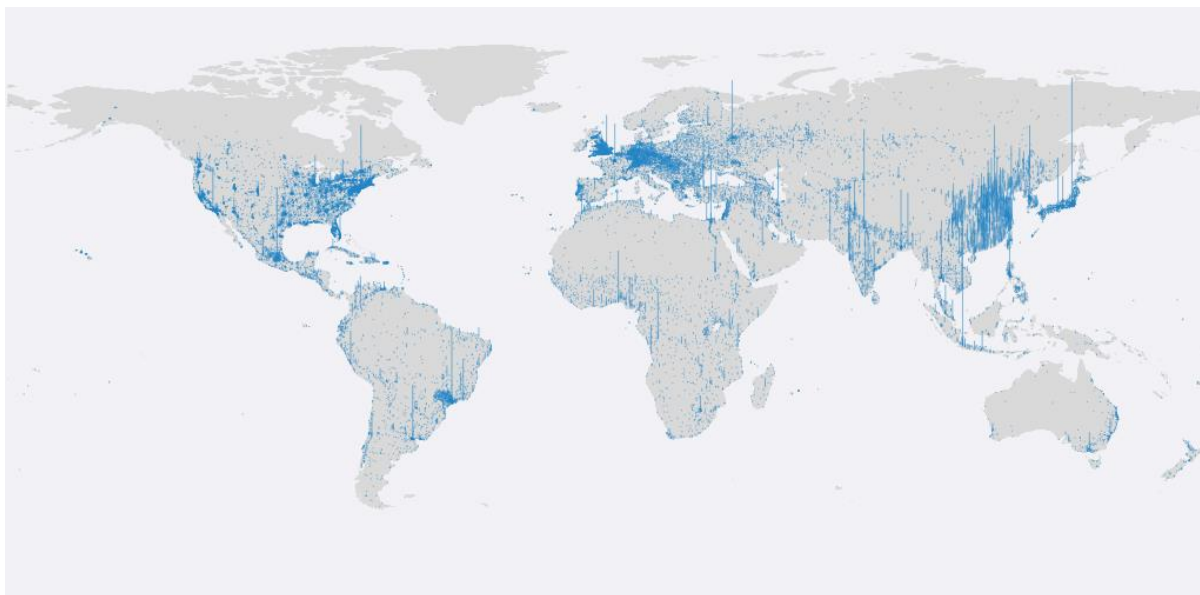
This training session is all about taking QGIS to the 'next level'. What is this mysterious 'next level'? Well, here's what I'm thinking.

- You learn how to do exciting new stuff.
- You learn things that will make you more productive.
- You learn how to ask questions of your data.
- You learn how to answer those questions.
- You end up thinking of *new* questions.
- You push yourself, even getting a bit confused.
- You move beyond confusion, to new understanding.
- You come away with useful new skills.
- You end up making more meaningful maps.
- You impress your colleagues with your new skills.

*The expectation is that you're already a proficient QGIS user and that you understand the fundamentals of how geospatial software works. That is, you understand that it's not just about making maps, even if maps do usually end up being the end result.*

With that in mind, this training session doesn't follow as much of a step-by-step format as our intro-level QGIS course. We'll do some of the step-by-step stuff but we'll also do more live demo follow alongs, as well as set tasks and going off at *tangents*.

We're mainly going to use global data and UK data today, for different purposes. We'll also create some new data.



**The map above?** We'll make this ourselves soon and we'll do all kinds of interesting things, but the main things I want you to learn from today are as follows.

1. How to use geometry generators in QGIS.
2. How to use the vector geoprocessing tools.
3. How to create/edit new data in QGIS.
4. How to use the Processing toolbox in QGIS.
5. How to use Plugins.
6. How to automate map production with QGIS Atlas.



The last of these is the most significant and will probably take up the most time – it's also the most impressive and useful once you get to grips with it.

But first, let's grab the data and make a population spike map.

Go to <https://automaticknowledge.org/training/data/> and download datasets 1 to 8 (one by one).

You may already have datasets 1 to 4 if you've previously done a session with us, but either way please download these files individually and put them into a folder for today's session – and make sure you know where you've saved them to!

The file names should be self-explanatory but here's a summary of the files we'll be using today:

1. A world countries layer (as a GeoPackage).
  2. A world countries layer (as a shapefile).
  3. A world cities csv (this is just a text file).
  4. A World Bank country population dataset (an Excel file).
  5. A Great Britain places layer.
  6. A Great Britain motorways layer.
  7. A Great Britain small area population data layer.
  8. A UK local authority boundary layer (with population data).
- Start QGIS now so that we can get going in a moment.

We have **point** layers (datasets 5 and 7 in the list above), **line** layers (dataset 6), **polygon** layers (datasets 1, 2 and 8) and two datasets with **no geometry** at all (datasets 3 (a csv file) and 4 (an Excel file)). These are some of the most common basic file types in we can use in QGIS.


## 2. When is a polygon not a polygon?

We know that in GIS, when we're talking about vector-based data, everyone talks about features in relation to points (e.g. cities), lines (e.g. roads) and polygons (e.g. countries), as I just said. This makes sense, but with QGIS we can actually make a polygon into a point, or a point into a line, or all sorts of other combinations.

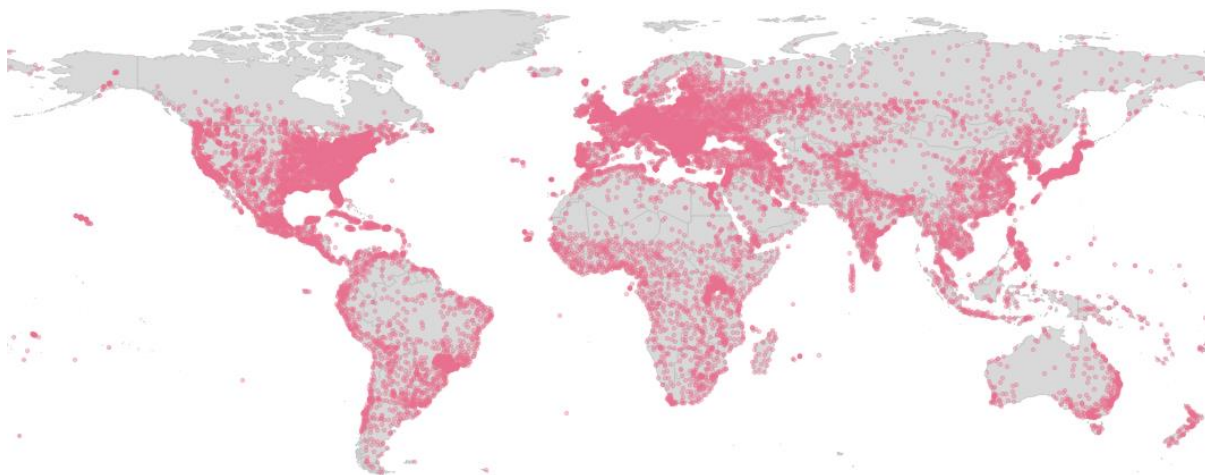
Let's look at this now with an interesting example, below.



**When you see this symbol, it's time to follow what I'm doing on screen**, so with that in mind, let's get started. I will add text and screenshots for reference, but I won't do the same level of step-by-step instructions that you'd get in the intro-level workbook. Interrupt me, ask questions if needed.

- First we'll add the `1_world_countries.gpkg` file to QGIS – remember that as well as adding this via the `Data Source Manager`, you can just drag and drop it into QGIS directly from your system's file browser – that's how I usually do it. I can't abide looking at ugly colours, so I'll change that straight away! Open Layer Styling panel quickly with .
- Then we'll add the `3_world_cities.csv` file. This is just a text file so we'll need to do this via the `Data Source Manager` and then the `Delimited Text` option (stuck? Just ask me).
- Okay, so now we have lots of dots and lots of land.





Soon we're going to filter the dots and then use a **geometry generator** in QGIS to create vertical lines – the height of the vertical lines is going to be set based on the population of the points in this layer. Read on below for how to achieve this.

The **geometry generator** in QGIS is a way of displaying one kind of data as another – e.g. a *point* as a *line*, or a *polygon* as a *point*. But you can also use it in other ways, such as creating buffers. In fact, you can do just about anything with it but since we're only getting started we'll keep it simple for now.

- **Filter** your cities layer so you're only showing world cities with a population of 250,000 or greater.
- Use the text on the next page with **Geometry generator (LineString / MultiLineString)**, instead of **Simple marker**, to generate our spikes (if you copy/paste this from the pdf just watch out for it splitting geometry into two parts!):

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#### Notes

Hey, where do I find the **Geometry generator**? It's in the style for a layer. Select 'Simple marker' or 'Simple fill', then where it says 'Symbol layer type', change it to 'Geometry generator', make sure the Geometry type matches what you are trying to create (e.g. lines, points, polygons) and then the expression goes in the whitebox.

```
make_line($geometry,make_point(x($geometry),y($geometry)+ ("population" /1000000) ))
```

Ok, let's take a second to step back and figure out what's going on. The `make_line` function tells QGIS to make a line from the points we have plotted. It does this at the x and y coordinates of each point (that's what the `x($geometry)` and `y($geometry)` bits do). But that would essentially be a line of length 0 and would be invisible. No spike map yet? Just ask for help.

- Where it says `("population" /1000000)` delete this portion of text, including the brackets, and type in `100` after the plus instead. This will make every spike 100 map units high (the map units here are degrees, as in degrees of lat or long).
- Put the `("population" /1000000)` bit back in and instead of dividing by 1 million, change the figure to `500000`. We'll try different numbers here too just so you can see what's going on. We just use a number here to scale the spikes.
- Let's clear the `Filter` on the layer and then have a play around with the `Symbology` and do things like style by country or by population.
- Let's try a layer `Filter` so we're only showing one country and then zoom in and see what it looks like. After that we can clear the `Filter` and go back to full view.

**Time to save your work**

It's a good idea to save your work regularly as we go through this. I recommend saving the project now as `qgis_next_level_p9` and then saving as a new project with a different page number as you go through. That way you can go back to earlier parts and are okay if disaster strikes.

Okay, so this can be quite good fun. But it can also be useful. Let's say you have a layer that has many different parts (e.g. countries) but you want to show it as one big area (e.g. just one big landmass with no borders).

You can do this with a geometry generator as well.

- We'll turn off the population spikes layer now and make sure that we can see country borders in the `1_world_countries` layer.
- Let's try this in the geometry generator for the countries layer: `buffer(collect($geometry),0)`. What does this do? It dissolves all countries into one single polygon.

**Remember this**

The geometry generator tools in QGIS can be *immensely* useful.

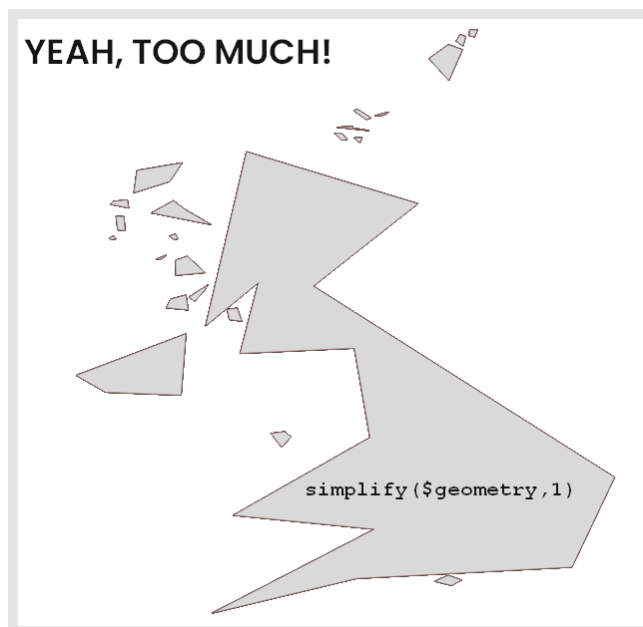
**But**, if you're working with complex geometries with thousands or millions of vertices – e.g. a high resolution coastline file from Ordnance Survey – then it may not be a good way to do it (too computationally demanding). It's best to use this approach on features with fewer vertices, if possible – but if you have a powerful computer it shouldn't be a problem.

- Let's **Filter** so we're only looking at the United Kingdom now and try some of the following:


```
simplify($geometry,0.5)
```

```
buffer($geometry,0.5)
```

And then we can try tweaking things here – and look in the **Geometry** section of the **Expression Dialog**. We just need to ensure that the **Geometry type** matches what we're trying to achieve.



### Time to save your work

I recommend saving the project now as `qgis_next_level_p11` and then saving as a new project with a different page number as you go through. 

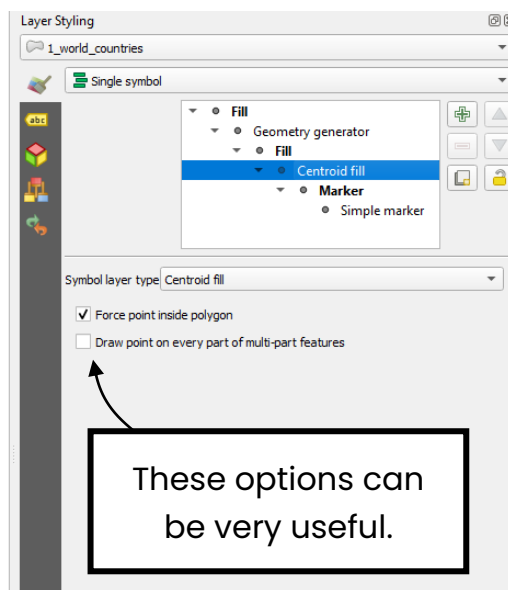
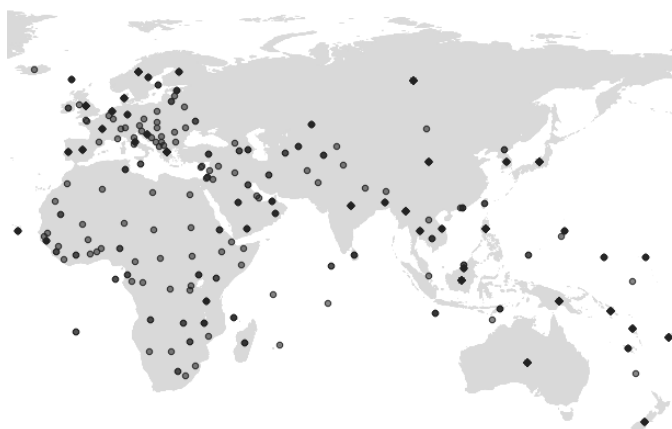
I won't add in this Save box again but I'll add the Save icon from time to time as a reminder. This kind of incremental saving is *really* useful and each QGIS project file of this kind will only take up a tiny portion of space on your hard drive – this one I just saved only takes up 16.7KB.

We can also use a geometry generator without typing anything in at all. For example, from the countries layer we could just show country centroids as points – like in the screenshot on the next page (I have the normal country polygon layer on too).

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### Notes

**Note:** in the examples at the top of the page, we used a value of 0.5. That is because the unit of the dataset we're using here is degrees – as in degrees north – south – east – west. You can see what units your data uses in Layer Properties > Information.



If you want to try this, remember to remove the layer filter first.

Okay, so you get the idea.

It's quite easy to generate one kind of geometry from another in QGIS, and it can be used to achieve some interesting and useful results (you could also use the above example for label placement)

The internet can be a confusing place, so if you want to learn more about this, I recommend the following two links.

**Klas Karlsson** - <https://www.youtube.com/watch?v=0YxjJ-9zIJ0>


**Hamish Campbell** - <https://polemic.nz/2019/11/18/foss4g-qgis-geometry-generators>



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Notes

### 3. Going deeper with geoprocessing in QGIS

Make sure you've saved the QGIS project from the previous page (e.g. as `qgis_next_level_p13`) and then open a  new project in QGIS.

In this part of the workbook we'll look at data from the UK, mostly covering Great Britain.

- First of all, let's add in datasets 5 to 8. They are all GeoPackages and you'll notice that they are pre-styled.
- Let's take a small detour to explore this styling – things like the scale dependent rendering, labelling, use of expressions to set symbol sizes and that kind of thing. I'll also explain how I saved these styles into the layer as well.
- Your layers should display in order from 5 at the top to 8 at the bottom, but if not just rearrange them in the Layers Panel so that 5 is at the top, followed by 6, 7 and 8.
- We're going to zoom in to the M25 area – for anyone not familiar with it, this is the motorway that encircles Greater London.
- Let's save this zoomed view as a Spatial Bookmark (`View > New Spatial Bookmark...`) and then zoom back out to view the whole layer again. Let's select and zoom to the M62 and save another Spatial Bookmark for that. And the M8.

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Notes

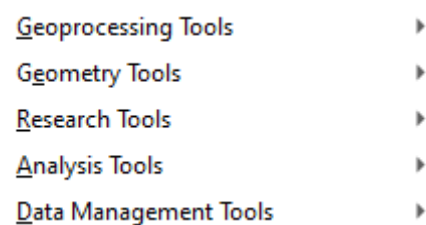
In QGIS, as with most software programs, there are multiple ways of doing the same thing.

You may already have noticed that I do some things differently from you, and that's fine. Just do what works best for you.

The same applies to geoprocessing in QGIS. We can do it via the **Processing Toolbox** (we'll look at that later) or via the **Vector** menu – which we'll do in a moment or two.

For the next little while we're going to be working via the **Vector** menu, using the following sub-menus:

- **Geoprocessing Tools**
- **Research Tools**
- **Analysis Tools**



**N.B.** We'd like to have data for Northern Ireland but because Ordnance Survey data only covers Great Britain we don't have complete UK coverage.

With geoprocessing we're able to ask, and *answer*, quite interesting and often complex geographical questions.

I've put some spatial analysis questions on the next page for you to answer – can you get them all? **(or just a couple?)**

How many people live within 100 miles of Norwich?

How many people live within 10 miles of the M25?

How many local authorities have a motorway?

How many people live within 30 miles of Birmingham?

...feel free to add more – once we've got the hang of this we'll move on to the next page.

Hopefully you're following this – if not, let me know and I'll be happy to help.



Okay, let's try the 'how many people live within 100 miles of Norwich?' question. We'll ignore any non-English bits. To answer this, here's what we'll do in a few moments – you can follow along as I do it (the list below is the basic workflow).


1. Select Norwich from the places layer.
2. Create a 100 mile buffer round Norwich.
3. Select all the population points within the buffer.
4. Use a tool to find out the total population.

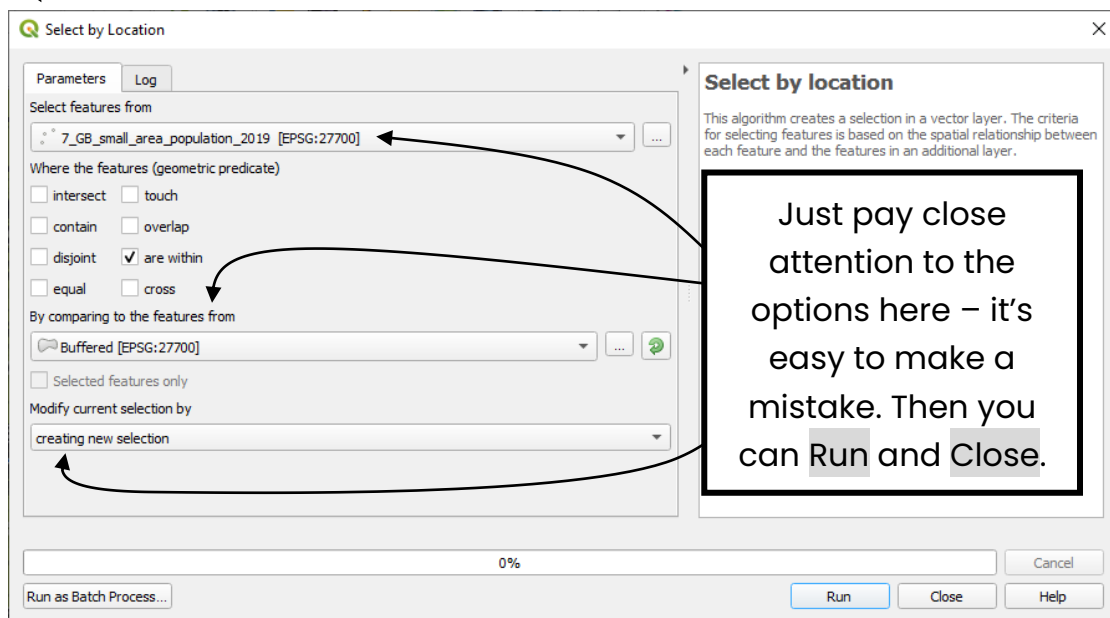
Is the answer that 15 million people live within 100 miles of Norwich? Could it be true? Let's find out.



First, make sure the places layer is selected in the Layers panel on the left of the screen. Then we can select Norwich from the places layer.

Notes

- Then it's **Vector > Geoprocessing Tools > Buffer...** and then using **only the selected feature** in the places layer, 50 Segments, and 100 miles. We could have chosen to save the Buffer to a new layer but I don't need to this time so it will appear as a 'scratch'  (**temporary**) layer only.
- Now you have your Norwich Megaregion! Then we'll want to use **Vector > Research Tools > Select by Location...** to **Select features** from the **small area population** layer that are within the Norwich buffer. See below for how this looks, and note that there are many **geometric predicate** options we can use in different situations. Then **Run** and then **Close**.
- Then **Vector > Analysis > Basic Statistics for Fields...** on **Selected features only** of the **small area population** layer, using **POP2019** as the **Field to calculate statistics on**.



Notes

**N.B.** Once you've clicked Run you can then click Close. After running Basic Statistics for Fields you'll see the results – looks complex, but it just contains y summary stats – see 'Sum' for the total figure, but you also get count, max, min, mean, std dev and so on.

**Top tip**

Need to re-do any of your geoprocessing tasks in QGIS?




If you need to re-run a tool in QGIS, instead of going back through all the menus and options you can instead go to **Processing > History** and then reload your query from the list and change your parameters if you need to.

It's REALLY useful, even if it does look a bit like a nerdfest.

- Using the **Processing > History** option let's re-run the **Buffer** analysis but this time based on population within 100 miles of London. Woah, that's a big number. **30 million!?!?**

If there's time, let's try one more of these together and then you can work away on others on your own.

- Zoom to the motorways layer by selecting it in the **Layers** panel on the left and then hitting  Zoom to Layer.
- Then we're going to use **Vector > Research Tools > Select by Location...** to Select features from the local authorities layer (8) By comparing to the features from the motorways layer, using the **intersect** predicate. Then we hit **Run** to see the result (in the lower left of the QGIS window, or open the **Attribute Table** and look at the top of that window).



Now have a go at some of the other questions from before, or even add some of your own. No question is too weird. You could even select multiple cities and buffer them simultaneously.

**Baffled?**

Wondering why we're doing this? Consider the following example.

Let's say the government want to widen the M1 to 5 lanes each way (eek) – they're going to want to find out pretty quickly what local authorities are affected and how many people might be impacted. This is can be done quickly and efficiently using spatial analysis.

Or maybe you have to decide between three locations for the site of a new nuclear power station that will be there for 100 years. You can be sure that some form of spatial analysis – among other things – will come in handy.

These are just basic examples, but the fundamental underlying issue here is the 'what's nearby?' question, and with spatial analysis we can do this by distance like we have done, or by time, using tools like TravelTime Platform (an excellent QGIS plugin).

As you know, this course is aimed at current QGIS users but even those who use QGIS a lot can still find it difficult to remember what's what and what's where.

As you're going through this, remember the two main Select buttons – using a click/drag/draw or by expression, plus the Deselect Features from All Layers button.

**Remember this**

The population data we're using is from mid-2019.

It's the latest small area data, using population-weighted LSOA (Eng & Wal) or data zone (Sco) centroids. There will inevitably be a little bit of mismatch at buffer boundaries, but the figures you get will be good approximations.

## 4. Creating and editing spatial data

Being able to create new data is a great skill to have and in QGIS it's really simple – though it doesn't necessarily appear that way.

### Remember this



You might see the term 'scratch layer' in QGIS quite a bit.

What is a 'scratch layer'? Here's the definition from the QGIS help text:

*'Temporary Scratch Layers are in-memory layers, meaning that they are not saved on disk and will be discarded when QGIS is closed'.*

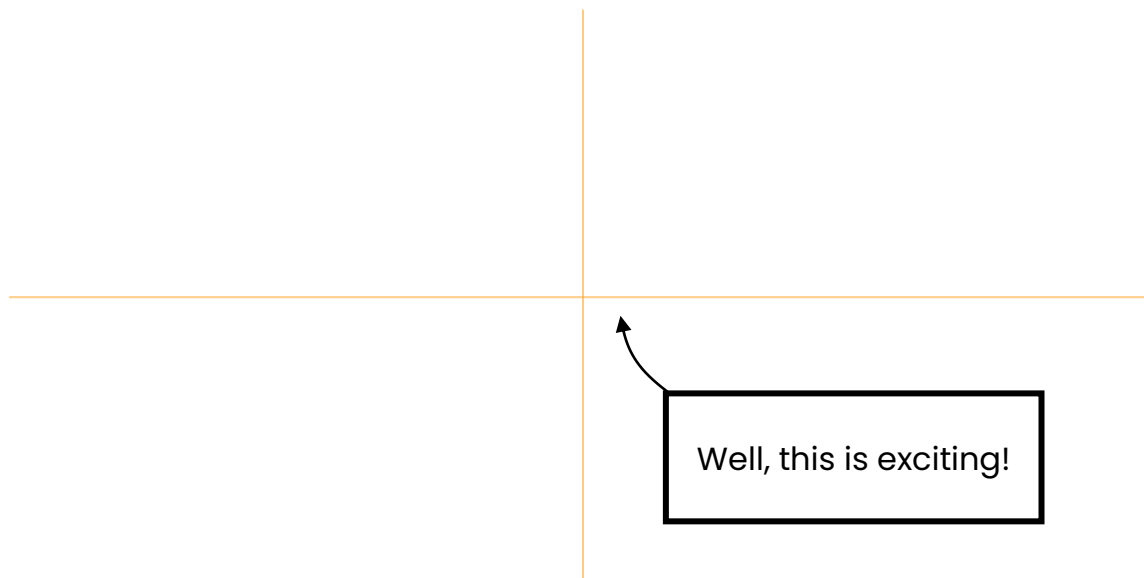
When I'm doing geoprocessing analysis and only need the final figures rather than any buffer layers, I may choose not to save them as permanent layers. But just remember that any scratch layers you use in a QGIS project will disappear when you close it – even if you save the project.

- Make sure you've saved the project with the UK data in it and then open a fresh, blank project.
- Let's start by creating some data from some text – kind of like we did before with the csv file, but even simpler. Copy the text below into a basic text editor on your computer (e.g. Notepad or TextEdit), save it as a text file and then import to QGIS using the Delimited Text tool.

```
name,geom
equator, "LINESTRING(-180.0 0.0, 180.0 0.0)"
prime meridian, "LINESTRING(0.0 90.0, 0.0 -90.0)"
```

I put this in the  
data folder –  
wkt\_text.txt

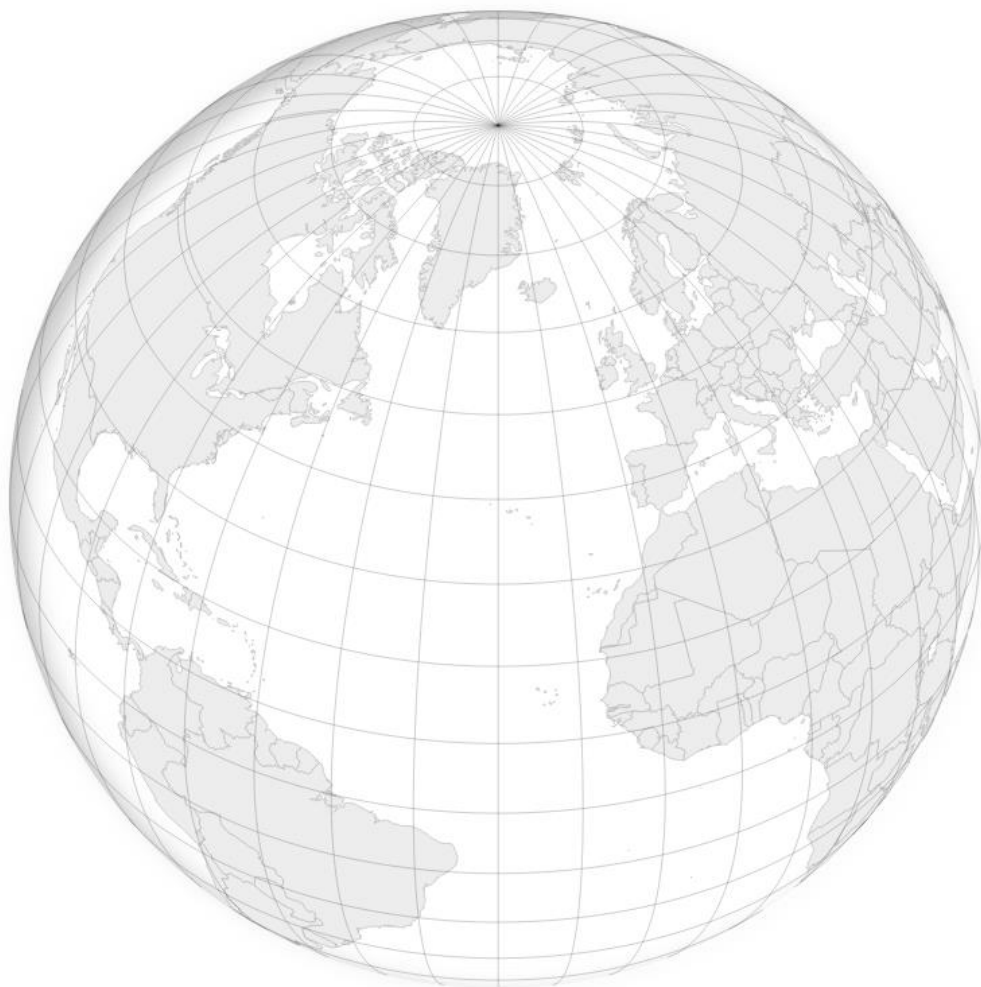
Now I'm going to explain what just happened and then we can all follow along:



Next steps – I'll do them now, for you to follow, via the **Vector** menu:

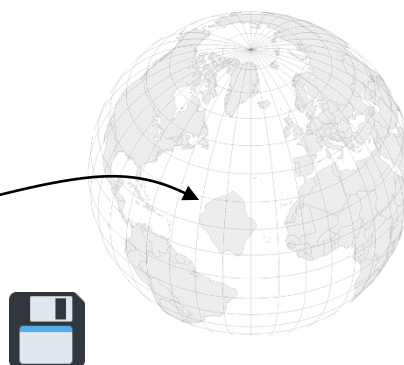
- We'll add the countries GeoPackage to the map.
- We'll use **Create grid (V>R)** to create a 10 degree world grid.
- We'll use **Densify by count (V>Geom)** (using 1000) so that our grid can be wrapped round a globe.
- We'll change the projection to **The\_World\_From\_Space**. We could also try the **Globe Builder** plugin if we have time – this is more likely to look perfect. It was created by Gispo Ltd, from Finland and I think it's really great.

Look at the next page for an example of what I just produced (using **Globe Builder**), with my globe centred at **-30, 40**.



The grid on the globe is one we created from text, based on our original import of the `wkt` text file.

- Let's change the projection back to `WGS84`.
- Now follow along as I create Atlantis and talk a bit about creating new vector layers.



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#### Notes

The basic process for creating a new layer is Layer > Create Layer > New Shapefile Layer (or > New Temporary Scratch Layer). Then select the geometry type (e.g. point, polygon). Then in Edit mode you use the editing tools to draw/place the new points, lines or polygons.

**If we have time**, let's try a bit of data crowdsourcing. I'm going to save a small text file where we have a name, latitude, longitude for all of us. Here's the first and second rows.

```
Name,lat,long  
Alasdair, 53.3956347,-1.6395383
```

I just need everyone to share with me a single line of text with their name then the lat/long of their location (I don't need your exact location, just the general area). Get the lat/long with a right-click straight off Google Maps or Bing Maps.

So, if your name is Dolly, please send me this:

```
Dolly, 35.797270, -83.533870
```

I'll then patch them all together, share the text and then we can map where we all are. It should only take a few minutes.

### Top tip

Need to include a brand new building in your GIS analysis? Hmm.



The only problem is that has not yet been mapped. I had this problem when I needed to map the new Tottenham Hotspur stadium in London. It wasn't yet included in the Ordnance Survey data (it is now) so I had to create it. I added a satellite XYZ base layer to QGIS and then created a new polygon shapefile and digitized it myself – just as I did for Atlantis above, exactly the same principle – just at a different spatial scale.

When you create a new layer, just be sure you choose the correct geometry type – either point, line or polygon feature.





## 5. The Processing Toolbox

Make sure you've saved the project from the previous page – and remember to keep saving it with the file name in the project in case you need to go back to it. I just saved mine as `qgis_next_level_p24`, and it takes up only 19.2KB of disk space so there's really no reason not to use this kind of incremental save – even if it does create a few more files for you.

We're going to take a closer look at the Processing Toolbox in QGIS now. It can be confusing, but once you know where to find it and what it does, you'll have opened a whole new world.

- Open a **New** project if you haven't already. If it's not already visible, activate it now via **Processing > Toolbox** and then dock it to the right of your screen by grabbing it and then dropping it when the right panel area is highlighted blue – sounds confusing but I can demo if need be.

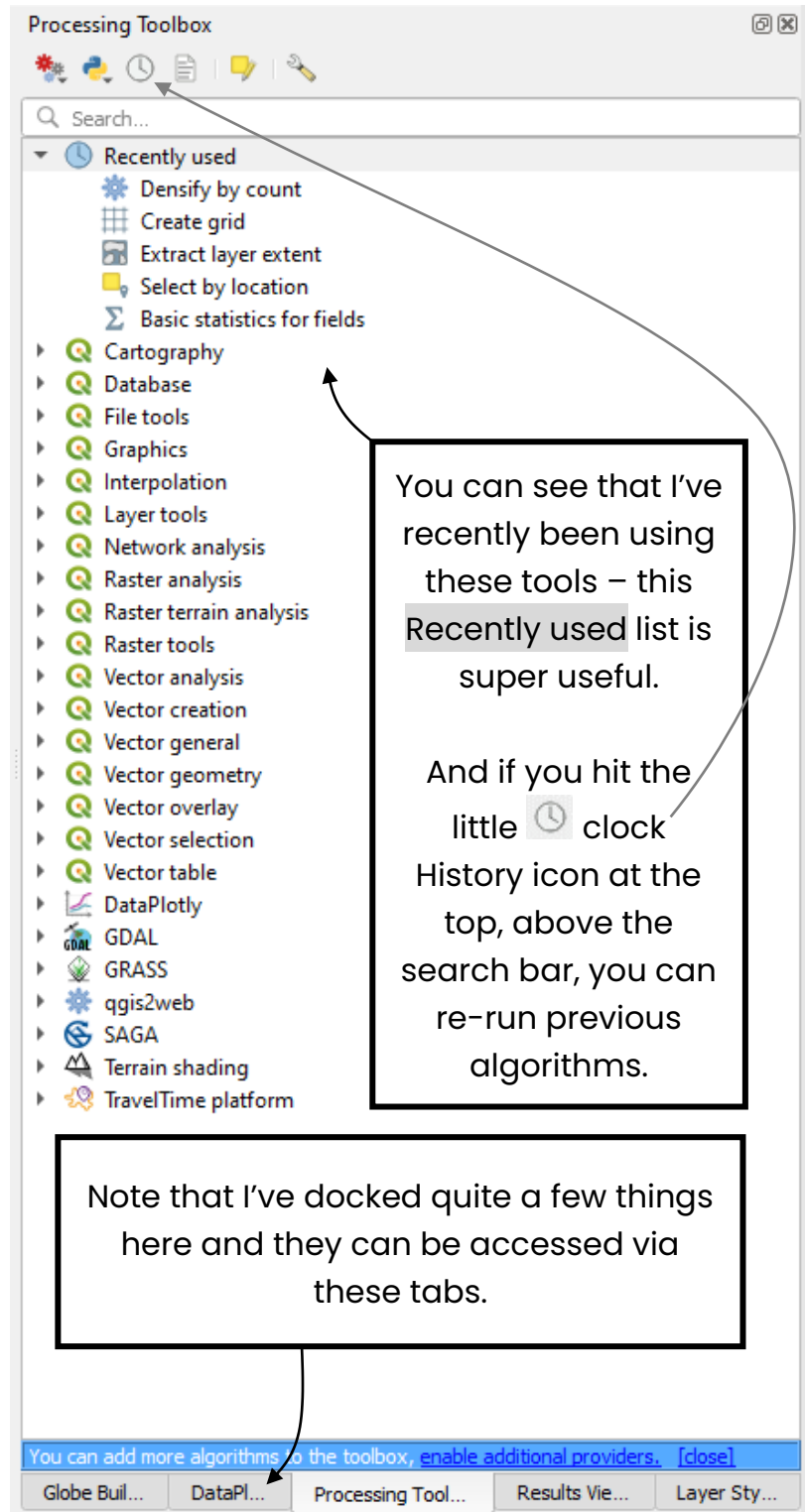
You can see what mine looks like on the next page, but **what exactly is it?** I always describe it as the gateway to geospatial analysis in QGIS. You can perform many tasks in QGIS via menus, but what you get here is many ways of doing things, from different tool and algorithm Providers. That is, in addition to the in-built QGIS tools, we can also access other geoprocessing tools from (e.g.) SAGA, GDAL and GRASS.

If you search for **buffer** in the search bar you'll see buffer tools from these different providers.

We can do other things from here – like Python scripts and models – but we won't go into that today.

I normally have my Processing Toolbox on all the time because it's so useful and I do so much spatial analysis with the tools in it.

Another reason to use it is because you don't have to remember which menu things are in – e.g. if you want to use Basic statistics for fields, just type it in to the search box.



Notes

Let's try some tools (below) using datasets 5 to 8. We'll begin with the following tasks – you can follow along – and then experiment further yourself **if we have time**.

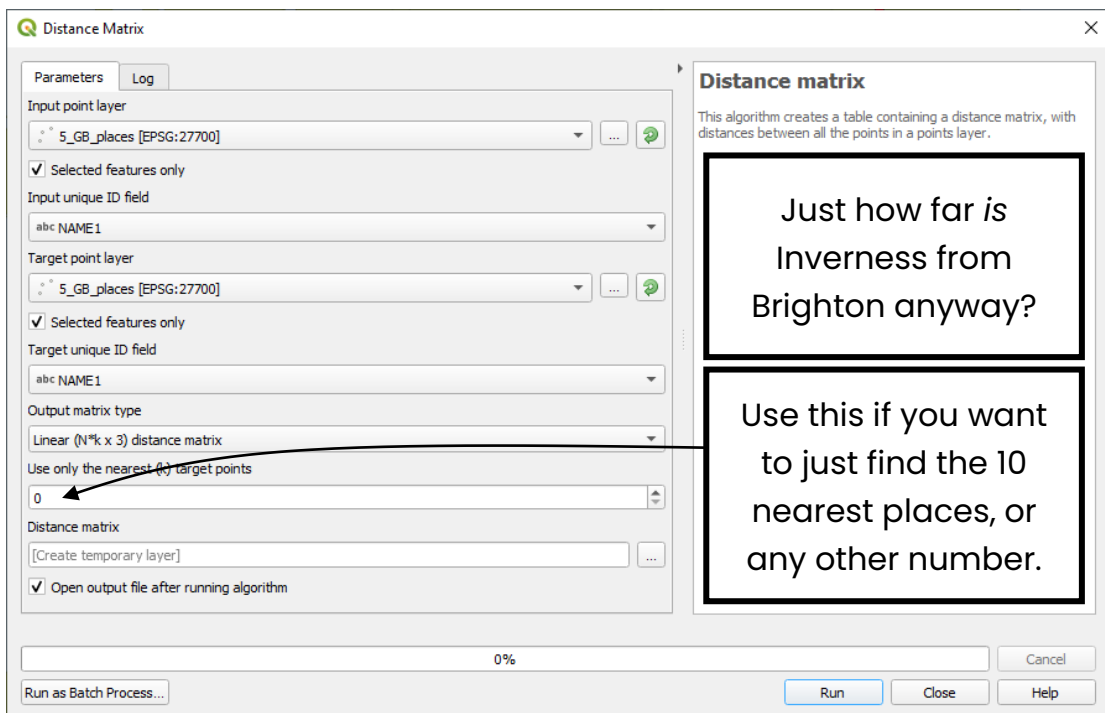


- We'll do a **Select by expression** here (on the M1). Then we'll do a **Select by location (intersect)**, extracting features from **8\_UK\_LAD\_with\_population** that intersect the M1.
- Then use **Basic statistics for fields** on the **popmid2019** field
- Then we'll use another **Select by location (intersect)** on the new layer we created above – this time a **point in polygon** operation to extract places from the **5\_GB\_places** layer.
- We'll use **Interpolation** to create a **Heatmap** using our **7\_GB\_small\_area\_population\_2019** layer – using a 10km radius, 1000m X and Y **Pixel size** and **POP2019** as the weight.

### **PLEASE ASK IF YOU NEED ME TO GO OVER ANYTHING AGAIN**

- Let's try the **Extract layer extent** tool too – that can be useful (we can add **buffer(\$geometry,100000)** to it).
- Let's use the **Dissolve** tool now – a good example of where there are several options (we'll use the QGIS default).
- Then we'll use the **Pole of inaccessibility** tool. Let's look at the result and think about why it might be weird/wrong.

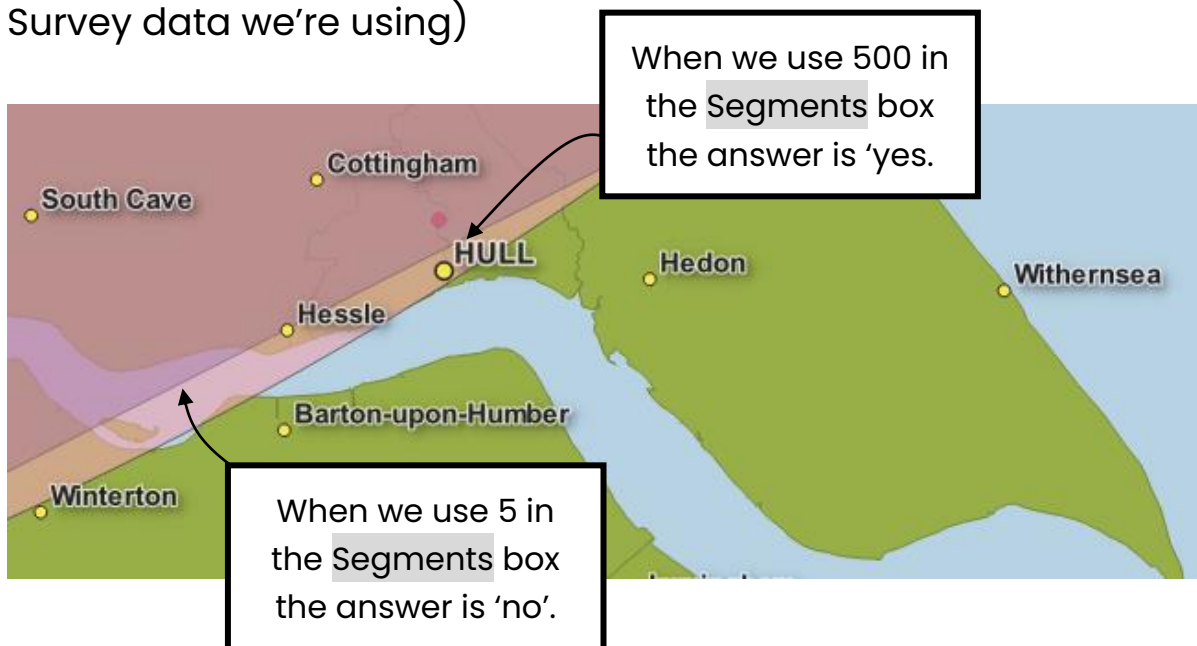
- Then we'll create Centroids for our UK local authorities layer. Let's then zoom in to North Ayrshire and figure out why this centroid is in the sea.
- After running Point on surface we'll compare the results to our Centroids analysis. This is a good example of where different geoprocessing approaches can produce different results – but not for every location.
- Now we'll create a Distance matrix for those places identified as being a City in our places layer (we'll also add a new column to convert the distances to miles (using `format_number("Distance" / 1609.34,2)`)).



Notes

I'll briefly look at the results from the distance matrix and then compare it to a 100 mile Newcastle/Hull buffer – because doing this kind of thing is helpful. It is a good sense check but it also tells us more about the tools we use – in this case what the **Segments** option does in **Buffer**.

**Is Hull within 100 miles of Newcastle?** (based on the Ordnance Survey data we're using)



We're done with the spatial analysis now, but the final point I want to make is that when you're doing any kind of spatial analysis it's wise to *a)* check the results and *b)* make sure you understand what the tools do. One of the great things about QGIS geoprocessing tools is that you get a text description within each tool window explaining what it does. Not everyone remembers to read these, but it's important to do so.



## 6. My top 5 7 QGIS Plugins

This section is about QGIS Plugins.

These are tools written by software developers that add extra functionality to QGIS. Things that you can't currently do with the default, built-in features in QGIS are often possible with Plugins.

You can see the full list at the following link – there are more than 1,000 and some of them are just amazing.

<https://plugins.qgis.org/plugins/>

It really is worth spending some time browsing the Plugins page, and sorting by number of downloads to see the most popular tools. These are my top 5.

1. MMQGIS – a collection of great vector layer tools.
2. Globe Builder – turn your flat world into a globe
3. agis2web – create an interactive web map
4. Qgis2threejs – create an interactive 3D web map (so cool!)
5. SRTM-Downloader – NASA elevation data (free, but sign up)
6. Data Plotly – create D3 charts from your data, in QGIS
7. TravelTime platform – my go-to for travel time maps + more

You can see that I couldn't keep my top 5 to just 5 – there are just too many good ones. I often use other tools as well but just make sure you know where to find them. We'll explore some of these, based on how much time we have left.

---

Notes

## 7. Automating map production with QGIS Atlas

Now it's time for the main event. First, let's just reflect a bit on where we're up to right now, before moving on.

- You can make maps with QGIS ✓
- You can make them look good 👍
- You're now faster at it than you used to be 🕒
- You're getting pretty good with expressions 😎
- You've learned some great new tricks ✨

Okay then, so now it's time to move things to the next level 🚀 to become something of a 'power user' 💪 who can map the world 🌍 in a day, in just about any way 🕶️ - via automated mapping.

**The Atlas tool allows you to automate map production in QGIS and is AMAZING.** This is what we'll focus on for the rest of the session 🤗. I'll go a bit easier on the emojis now as well.

Here's what we're going to do (below) – I'll give you a brief summary of what we'll work towards, then I'll get us started with a follow along demo, and then you can experiment, tinker and take it from there. It goes a little something like this.

1. We'll download the data we need
2. We'll start to style our data first (and add a **Filter**)
3. Then we'll turn on the Atlas tool in QGIS
4. Then we'll keep working on it with styling and expressions
5. Then we'll try to export some maps

- If you haven't done so already, **Save** whatever you were working on previously (e.g. a project with UK data, possibly some Plugins as well) and open a **New** project in QGIS.
- Go to the link below and download the five **atlas\_** datasets: <https://automaticknowledge.org/training/data/>
- Now, **load them into QGIS** – you may notice that if you drag and drop them in they display with 1 at bottom and 5 at the top, but if you add them via the **Data Source Manager** they will be ordered from 1 to 5 (the correct order). Before moving on, just make sure they are ordered with 1 at the top, then 2, all the way to 5. **Switch 1 and 2? Yes? Why?**
- Here's an explanation of what the layers are:
  - atlas\_1...** – this layer contains country borders.
  - atlas\_2...** – this layer contains world cities.
  - atlas\_3...** – this is world lakes layer.
  - atlas\_4...** – this contains countries + data, for the Atlas.
  - atlas\_5...** – same as 5, but it has more in it (e.g. Greenland).
- Right now, your map will look quite ugly. Rather than spend lots of time on styling, download the **qml** style files for each layer from the **data/styles** folder (right-click and **Save link as...**) and apply them to each layer via **Layer Properties** and the **Style** button at the bottom, then **Load Style...** **If your layers disappear when you apply the styles, don't worry – they'll come back!**

---

#### Notes

Somebody ask me about qml names and paths at this point – it's a nifty trick.




We can explore what's going on with the styles later on if we have time, and you can investigate further in your own time, but for now we'll focus on creating a series of maps – one for each country in the world – that look something like the one below – I made this using the data you have now.



On the next page I'll walk us through the steps of creating an Atlas in QGIS, but almost everything you see above – the map, the flag, the data – comes from the Attribute Table of atlas dataset 4. The cities are from atlas\_2, the borders are from 1, the lakes from 3 and the underlying land backdrop from 5. **There is a filter on my cities layer** (add it now – it's in filter\_text.txt in the data folder) and the layer styles use quite a few expressions, but the whole thing is driven by one main layer – dataset 4.

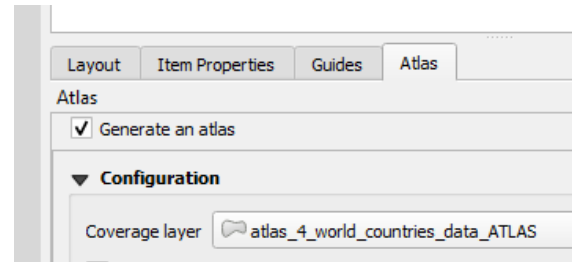
Okay, so let's follow along as I build up an Atlas that gets us somewhere close to what we have above. Then for the rest of the time you can experiment further.



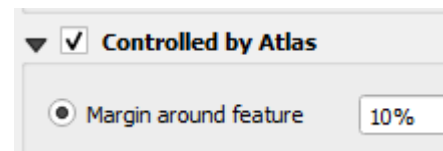
- I actually ordered my layers as follows, so make sure yours are like this too: 2, 1, 3, 4, 5.
- I used #83b7d9 as the blue colour for the project background, so you can do this too now via Project > Properties > General.
- Before you go any further, Save your project again –  appending the page number to the name, as before – e.g. qgis\_next\_level\_p.33.
- Go to Project > New Print Layout... and then give it a name (e.g. Atlas) and hit OK.
- At this point I normally re-size my page to 320mm x 180mm (to match the 16:9 aspect ratio of most screens). You don't have to, but given that most people will view these things on a computer or phone, it often makes sense.
- Let's add a map, then re-size it to take up most of the page – like the example above.
- Then add a text box for where the country name will go. You can leave it with the default Lorem ipsum text for now.

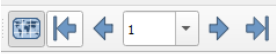
- Now we need to go to the Atlas tab then we tick the Generate an atlas box (see screenshot below), and choose atlas\_4\_world\_countries\_ATLAS as our Coverage layer. When you make an Atlas, you need to tell QGIS which layer the Atlas is based on – once you do this you can pull data from that layer's Attribute Table into the map layout.

- With the map area selected on the main Print Layout page, go to the Item Properties tab and then scroll down until you can see the Controlled by Atlas box and then tick it.



- What this will do is pan and zoom the map to each individual feature (i.e. each row) in the Coverage layer. Since our Coverage layer has countries in it, and since each row is a country, what this does is put one country at a time in the map frame as you advance through the Atlas. **So now you need to turn the Atlas on!**



- Hit the Preview Atlas button (or Atlas > Preview) and watch the magic happen 🗺️. Be patient, it may take a moment.
- To see a preview of each of the different countries, use the Atlas Toolbar  e.g. click the forward arrow.

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#### Notes

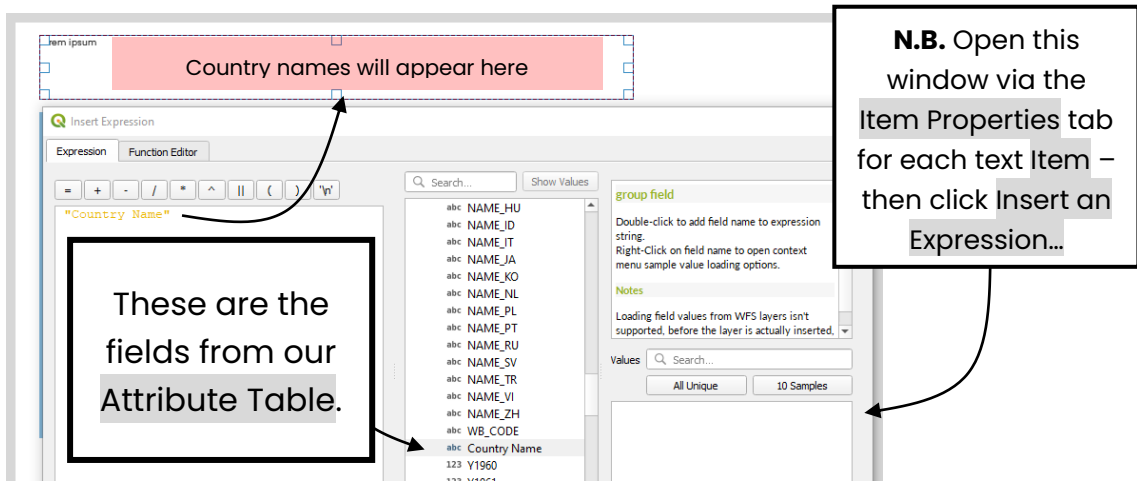
Make sure you have the Filter on your cities layer – if things are running really slowly for you, you could adjust the filter to just show capital cities, for example – "capital" = 'primary'

**Baffled?**



Don't worry if you're scratching your head a lot at this point. This is a really powerful tool, but it can take a while to figure out exactly what is going on. If you need me to walk back through the steps so far, just let me know. If you're almost there but not quite, that's totally fine too. The only really important things so far are that you've ticked the **Generate an atlas** box, told QGIS what to use as the **Coverage layer**, and turned the Atlas on by hitting the **Preview Atlas** button.



- Now we're going to add one of our fields from the **Attribute Table** to our main text box that we already added – this is going to be the **"Country Name"** column and once we add this to the text box each time we move to the next ➡ map QGIS will pull in the country name of the country shown on the map, as if by magic – see the screenshot below.



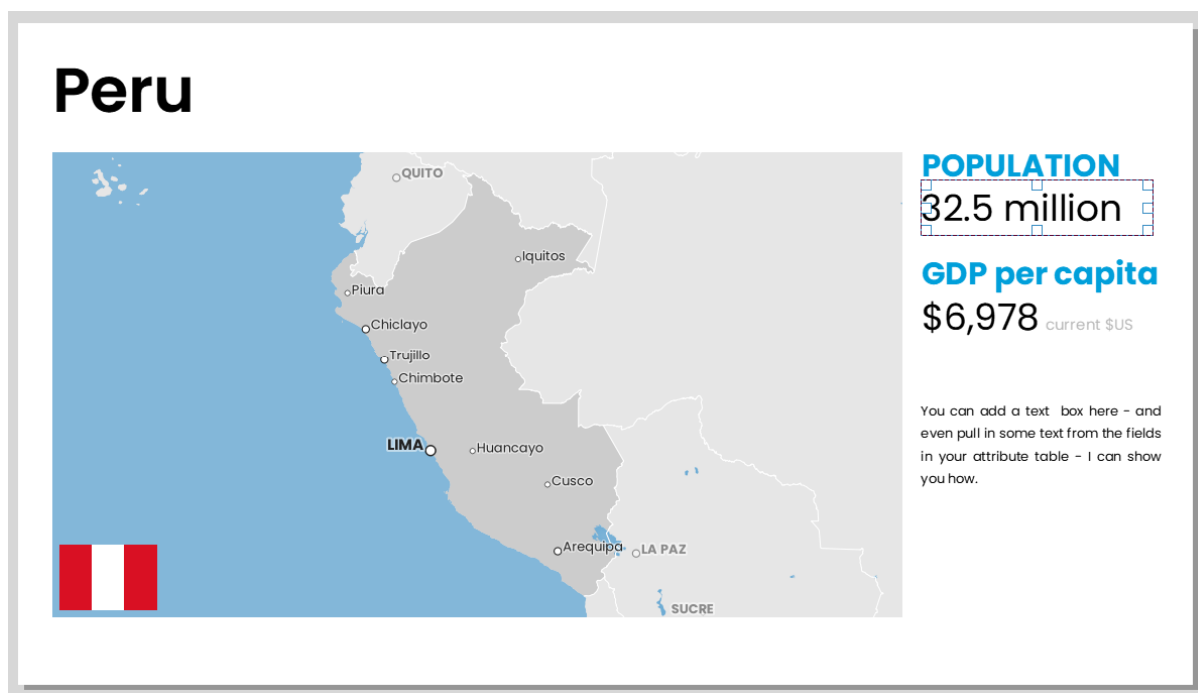
- The basic principle when using the **Atlas** is that instead of doing things manually, like typing in the name of a country,

Notes

we can generate things automatically by pulling in data from the Attribute Table using the Insert an Expression... button, deleting the default Lorem ipsum text and then adding the name of the field we want to add data from, using the Insert Expression dialog.

- Using this principle, we'll add an image box  and set the source of the image via Item Properties  to the "ImageURL" column from our Attribute Table – I added a url for each country's flag in svg format to our country dataset. A few (e.g. South Africa, Brazil) seem to render weirdly in QGIS, so watch out for any quirks.
- After you've added a title, map, image (for the flags) see if you can also add in figures for GDP and population, as shown in my example above. As you know, in the Print Layout anything you add is an Item and you edit all Item Properties on the tab on the right.

Once you've added the items, change the text size and/or colour where necessary and you should then have something like the screenshot below – we can talk about how to add other elements after that, and how to format them. The bars in my example above are just shapes, sized using our data.



The map above is starting to look half decent. When you add a number – like population – by default you will probably see something like this: 32510453. This is correct, but it's not very easy for us to quickly determine that the population of Peru is 32.5 million. I prefer to use the latter format for populations.

To format the number as I have above, see below for what you'd enter in the box after hitting Insert an Expression... – just note that once you hit OK it will have [square brackets] and % signs around it in the Main Properties whitebox. I've shown you on the next page what I mean – follow the 1, 2, 3 text circles.

- `format_number("Y2019"/1000000,1) || ' million'`


**1** Text that I actually entered.

**2** How it appears in Main Properties.

**3** The end result!

**Remember this**




Before the Atlas becomes live in QGIS, you need to activate it. As we saw above, this is done via the **Preview Atlas** button (or **Atlas > Preview**) .

What you should also know is that when you re-open a QGIS project with an Atlas in it, you will need to hit the Atlas button again, otherwise you'll just see something that looks broken – e.g. instead of seeing a country name you may just see the name of the column (“Country Name”) in our case.

This sometimes catches people out, so I thought I'd add this warning in.

You should be making a nice bit of progress with the Atlas now, but either way, remember to save your project.



When it comes to the Atlas in QGIS, the real power is unleashed when you set it to export all your images. This is done via Atlas > Export Atlas as Images... (note that you can also export to pdf or svg). You can also export individual Atlas frames as well, via the Export as image button . My normal method is to export all images as 300dpi png files.

**Before exporting your Atlas it's a good idea to save your project, in case of unexpected crashes – sometimes we might try to export more than our computer can handle!** 

We can also use some other options to configure our Atlas – e.g. we can use expressions to tell QGIS how to name our Atlas files (after all, if they're all called Output\_1, Output\_2 etc. we'll have trouble finding the files for the country we want).

At the top of the next page you'll see that in my Atlas tab I have used Country Name as the Page name. I have also chosen not to include countries where there is no GDP data for 2019, and I have sorted my Atlas by the GEOUNIT column, so that countries are in alphabetical order.

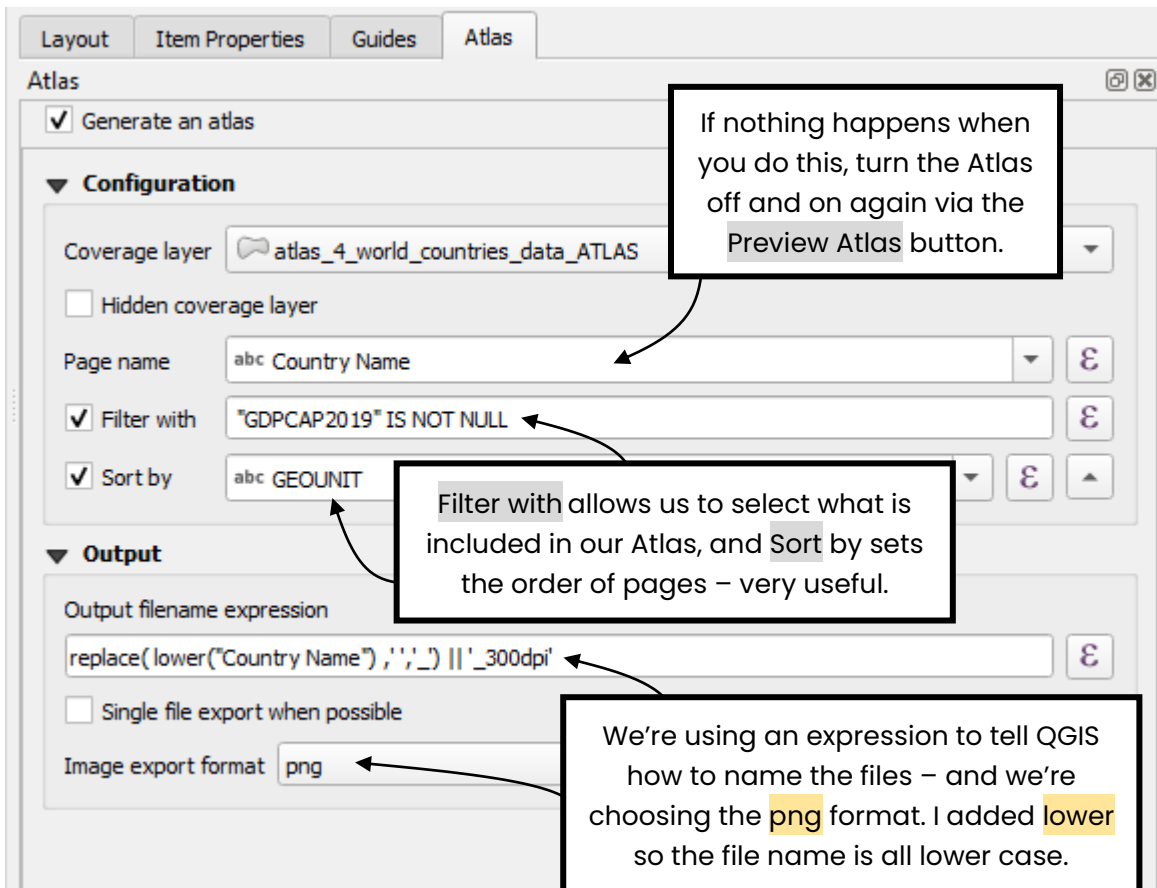
For the file name I don't want spaces so I have used the replace() function to replace spaces with underscores and then added 300dpi to the file name, so I can see from the file name exactly what the resolution is. The export format I chose is png and I have unticked the Single file export when possible box.

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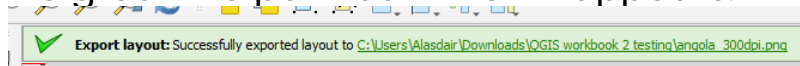
#### Notes

Instead of using the drop-down lists to find a field to use, you can actually just manually type in the name of the field if you know it – (e.g. start typing country to find the Country Name field) – this saves time when our Coverage layer has tons of fields.





- When you're happy with your layout, export an individual Atlas image via **Layout > Export as Image**. View the image via the green file path bar when it appears.



- Once this works, let's export a file for countries beginning with A, by entering this into the **Filter with** box `left("Country Name",1) = 'A'` then **Atlas > Export Atlas as Images**. It's best not to try to export the entire Atlas now but once you've exported a few, check the results.

**That's the basics of the Atlas – now it's time to experiment.**

Notes

Sometimes with the Atlas you need to hit the forward or back button to see a change take effect – or sometimes refresh the page.

## 8. Customising and perfecting your Atlas

This is the final section of the workbook, and the idea is (all being well, and time-permitting) that we work on customising and perfecting our Atlas and then try and export a few more images. Feel free to go back to other bits as well if you like.

Here are a few tips, thoughts and ideas that might be useful.

- I use the colour picker to select nice colours from a web browser. Sometimes I literally type in 'nice blue colour' or 'nice reds html' and then go to the image results in Google. This works well a lot of the time. I also pick colours from organisations – e.g. if I'm making election maps I use the exact colours from political party websites by using the QGIS colour picker – after all, some colours are hard-wired in our brains so there is no need to use different ones.
- Always add a 'data sources' note – at least enough so that someone can use the information to find your source, but possibly even a full url. My World Bank datasets are very easy to find on Google so I've just added in that as the source in our example.
- When we make a map it's often useful to be able to know exactly when it was made – so for mine I used this expression in a text box at the top right of my map: 'Map created: ' || format\_date( now(), 'ddd d MMM yyyy', 'en' ).

- See below for how to add in text that is a mix of text typed in plus text pulled in from your Atlas Coverage layer. Basically, anything in between single quotes will appear as it is written. To add in a value from your Attribute Table in the middle of it (and you can add as many as you like) you just need to separate it with the double `||` pipe symbol. When you want to write something with an apostrophe in it, you need to add in two – as in `it''s` below.

'This text box is intended to demonstrate how you can mix any text you want with data from your Atlas coverage layer. The map of ' || "Country Name" || ' to the left may not be perfect, but it''s a decent start. Boundaries shown on the map are sourced from Natural Earth and are not indicative of any territorial claims.'

- I can demo adding the inset map if there's time – it's shown at a fixed global zoom level using the Overviews tool – that's where the black locator box comes from. The *small map* frame has the overview added *to it*, via the green plus sign in Overviews in the map frame's Item Properties.
- You can also adjust/edit/tweak the expressions and filters that I provided for you. This is a good way to figure out what's going on. In particular, pay attention to these expressions: `$id = @atlas_featureid` and `NOT $id = @atlas_featureid` – they tell QGIS to either show only the active Atlas feature, or everything *but* the active feature.

- For my cities layer, I added a Rule-based symbology so that QGIS displays the city points differently, depending upon whether they intersect the current Atlas feature – you can see this in the atlas\_2\_world\_cities\_natranks Layer Properties when you view the Symbology of it.
- This next expression tells QGIS to display features that intersect the current Atlas feature: `intersects($geometry, @atlas_geometry )`. It then has a style applied to it.
- This one tells QGIS to display features that do **NOT** intersect the current Atlas feature, and they are also styled: `NOT intersects($geometry, @atlas_geometry ) AND "capital" = 'primary' AND "CITYRANK" <= 5`.
- And the expression I used as a Filter on the cities layer? See below for the text and also an explanation:

```
NOT "city" IN  
( 'Roodepoort','Randburg','Vereeniging','Lanús','Callao','Klang',  
Shah Alam','Petaling  
Jaya','Birstall','Depok','Tangerang','Bekasi' ) AND "CITYRANK"  
<= 10 AND "population" >= 200000 OR "capital" IN ('primary')  
OR "city" IN ('Honolulu','Anchorage')
```

The list of places after the **NOT** bit is all places I want to *exclude* – either because they shouldn't be there or

because they are obscuring more important places. The "CITYRANK" bit makes sure I'm only ever displaying, at most, the top 10 cities by population within a country – I added this column in myself in Excel. The "population" bit ensures I'm only displaying cities with a reasonably high population and the OR "capital" bit makes sure I'm displaying all country capitals. The cities after OR "city" IN bit at the end is my way of adding in cities that wouldn't otherwise appear on the map – in this case Honolulu and Anchorage. They are not main US capitals and although they have more than 200,000 people, they are not among the top 10 most populous US cities, so they don't appear by default.

You can use an expression like the one below to add 'no data' in places where you have missing data for GDP, or other variables.

```
CASE  
WHEN "GDPCAP2019" IS NOT NULL THEN  
'$' || format_number("GDPCAP2019",0)  
ELSE 'no data'  
END
```

**Translation:** in cases where my GDP 2019 column has data in it (aka IS NOT NULL) then please format it with a thousand separator and zero decimal places, with a dollar sign before it. Otherwise, just put in the words 'no data'. Ta.

- In some cases the Atlas page looks a little sparse, so you may want to consider getting (e.g.) some road or rail line data and adding that in (from Natural Earth).

**Remember this**

Anything we create here – or elsewhere – is only as good as our data.



For example, see the Russia map, the US one, or the Norway one – they need some work. Also, what about Taiwan's data? That's due to how the World Bank approach it – they don't publish Taiwan data. I have manually added in some population data for Taiwan but there is no GDP data.

**There is a lot in this workbook – on purpose.**



**I want you to come away with new skills today, but then keep the workbook handy so that you can build on these skills.**

I absolutely don't expect everyone to have fully absorbed everything by the end of the day – but if you have, great!

My hope is that you've learned about a selection of useful new tools that will enable you to be more productive, ask new and interesting geographic questions, and even save yourself some time (and pain) while doing so.

I also hope you have enough knowledge to begin exploring the things you could do with the Atlas tool – it really does open up all kinds of possibilities for analysis and visualisation.

I don't like to leave people high and dry after a training session so if you're stuck or need me to clarify anything, feel free to get in touch – email, website contact form, Twitter DM, whatever.

**Thanks for joining in!**

## 9. Credits

**QGIS** – QGIS is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo).

<https://www.qgis.org/en/site/about/index.html>

**Natural Earth** – ‘no permission is needed to use Natural Earth data’. All versions of Natural Earth raster + vector map data found on this website are in the public domain.

<https://www.naturalearthdata.com/about/terms-of-use/>

**SimpleMaps** – World Cities Database (Basic), used under the Creative Commons Attribution 4.0 licence.

<https://simplemaps.com/data/world-cities>

**World Bank** – Population data, used under the Creative Commons Attribution 4.0 licence.

<https://data.worldbank.org/indicator/SP.POP.TOTL>

**Emojis** are from Twemoji, at twemoji.twitter.com, licenced under the CC-BY 4.0 licence.

<https://twemoji.twitter.com/>

**Poppins Font** – Designed by Indian Type Foundry, Jonny Pinhorn, licenced under the Open Font Licence.

[https://scripts.sil.org/cms/scripts/page.php?site\\_id=nrsi&id=OFL](https://scripts.sil.org/cms/scripts/page.php?site_id=nrsi&id=OFL)

**Flags** – the svg files we used in the Atlas task were from Wikipedia.

[https://en.wikipedia.org/wiki/Gallery\\_of\\_sovereign\\_state\\_flags](https://en.wikipedia.org/wiki/Gallery_of_sovereign_state_flags)

## 10. Useful links

**Natural Earth** – the best source for easy-to-use global map data, e.g. countries, places, states, roads, coastlines and much more.

<https://www.naturalearthdata.com>

**simplemaps** – world cities csv files, with lat/long coordinates. This is a great source for place name data.

<https://simplemaps.com/data/world-cities>

**Sentinel-2 cloudless** – for adding satellite imagery to QGIS. Right-click **WMS/WMTS** in the QGIS browser panel, then click **New Connection...** add **Sentinel-2 cloudless** to the Name and the second url below to the URL field.

<https://s2maps.eu/>

<https://tiles.maps.eox.at/wms?service=wms&request=getcapabilities>

**OS OpenData Downloads (Ordnance Survey)** – a huge amount of free, open geospatial data are now available from Ordnance Survey via their Open Data Hub. The data covers Great Britain and no registration is required.

<https://osdatahub.os.uk/downloads/open>

**ONS Geography Portal (UK)** – see the Boundaries section of this website for a wide range of UK boundary data. This site includes data for the whole of the UK, whereas Ordnance Survey data only covers Great Britain. A great resource.

<https://geoportal.statistics.gov.uk/>

**QGIS Documentation** – the official help docs from the people who make QGIS.

<https://www.qgis.org/en/docs/index.html>



## Back page cheat sheet



These are things I use myself – to make things work faster, better, smoother.

- **CTRL+Tab** turns panels on/off so the map area is full screen width.
- Select some features, **Edit > Copy Features** then **Edit > Paste Features As a new temporary layer** (called a 'scratch' layer) or a new vector layer.
- **F11** for full screen mode, **F1** for QGIS User Guide, **F6** to open Attribute table (on Windows).
- **CTRL+Shift+Tab** for full screen map mode (on Windows). Same again to undo.
- Change projection for project (it doesn't alter any data) via **EPSG** button, bottom right.
- Black is too harsh, try **#222222** / RGB 34, 34, 34 instead. Go beyond default colours!
- Where is your layer stored? Double-click a layer, go to **Information** and see **Path**.
- Turn on the thousand separator (1,000 vs 1000) – **Settings > Options > General**, tick box.
- Want to save the position of your map? Use **View > New Spatial Bookmark**.
- **Print Layout** looking fuzzy? Just hit refresh and that will fix it.
- **Print Layout** page not zooming to full extent? Re-size your page, then reset to original.
- Save your most commonly used data source paths as **Favorites** in the **Browser**.
- When styling layers, you don't have to use only the columns you already have – e.g. you can style based on calculations or even by extracting portions of text.
- Hey, my lovely XYZ base map looks a bit fuzzy! Set projection to **EPSG:3857**.
- Hey, my joined layer has weird column header names! Go back into **Joins**, and edit the join so that the **Custom Field Name Prefix** is ticked and the box is blank.
- How do you do those glowing lines/polygons? That's via **Blending mode** in **Symbology**.
- Help! My side panel things have disappeared. Go to **View > Panels**.
- Use **Inverted polygons** with a filter and a satellite base layer to create nice area maps – make layer white/black and use about 75% **Opacity**.
- Go to **Processing > History** to view or re-run your recent geoprocessing tasks.
- A general carto tip: try to make your map as simple as possible, remove any junk.
- Type **world** into the **Coordinate** box if you want a world countries layer to use.
- Use a 16:9 aspect ratio if your maps are mainly for screens (e.g. 320mm x 180mm).
- Map a list of x and y coordinates quickly via **Delimited Text** in **Data Source Manager**.
- Drag and drop files from your file browser directly into QGIS (e.g. **shp**, **gpkg** etc).
- You can add layers via the **WMS/WMTS** option in **Browser**. Just Google it.
- Want to save/re-use a map style for a layer? **Layer Properties > Style > Save Style...**
- If you give the **qml** file the same name as a layer file and put it in the same folder as the file then when you add it to QGIS that style will be applied by default.
- Learn about **Draw effects**! Use them to add a glow or a shadow to features.
- **View > Preview Mode** to see your map in colour-blind safe modes or greyscale.
- Best Plugins? **MMQGIS**, **SRTM Downloader**, **Build Globe View**, **Qgis2threejs**, **qgis2web**.
- Add base maps via **XYZ Tiles** in **Browser** panel. **OpenStreetMap** is there by default.

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Notes