



# Advanced GIS

**Raphaëlle ROFFO**

Sciences Po - Urban School



# Today's plan

1. Tutorial feedback & questions
2. Raster data - examples
3. Georeferencing & Digitizing

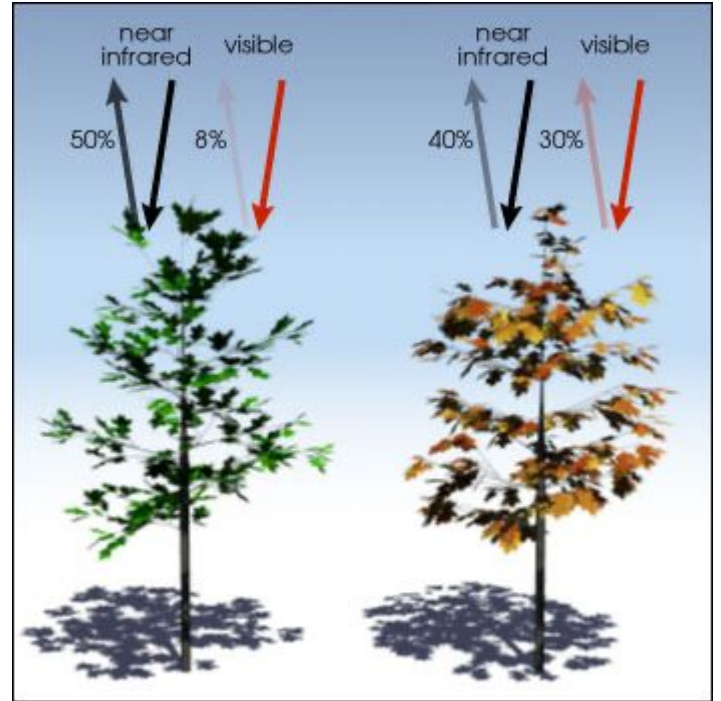
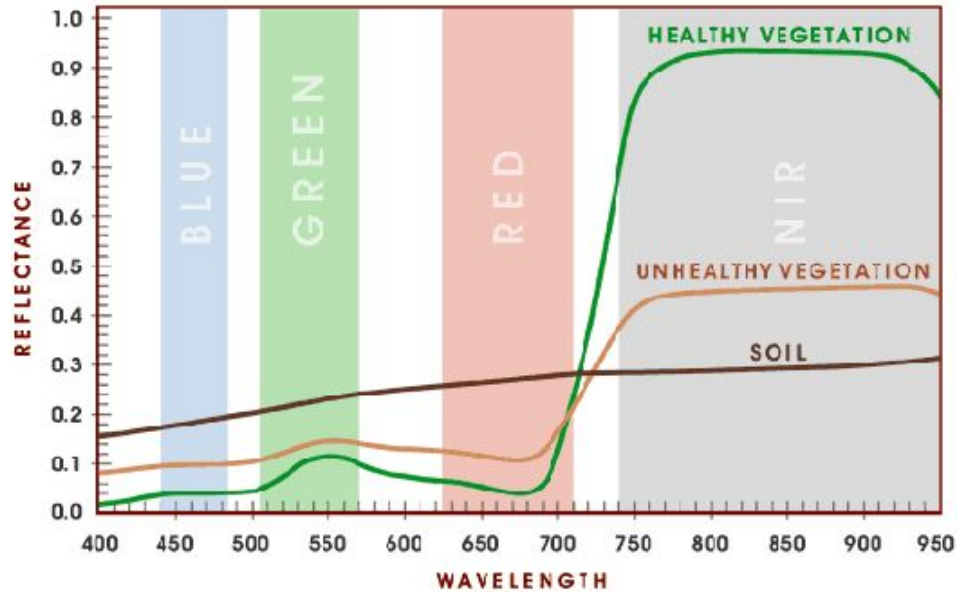


# 1. Tutorial feedback & questions

# Take-away from the tutorial

1. Downloading data from public satellite (choosing the satellite, filtering out for clouds, picking the date etc)
2. Importing satellite data into QGIS
3. Working with multiple raster bands
4. Using the raster calculator to build the NDVI
5. Reclassifying data

# The NDVI



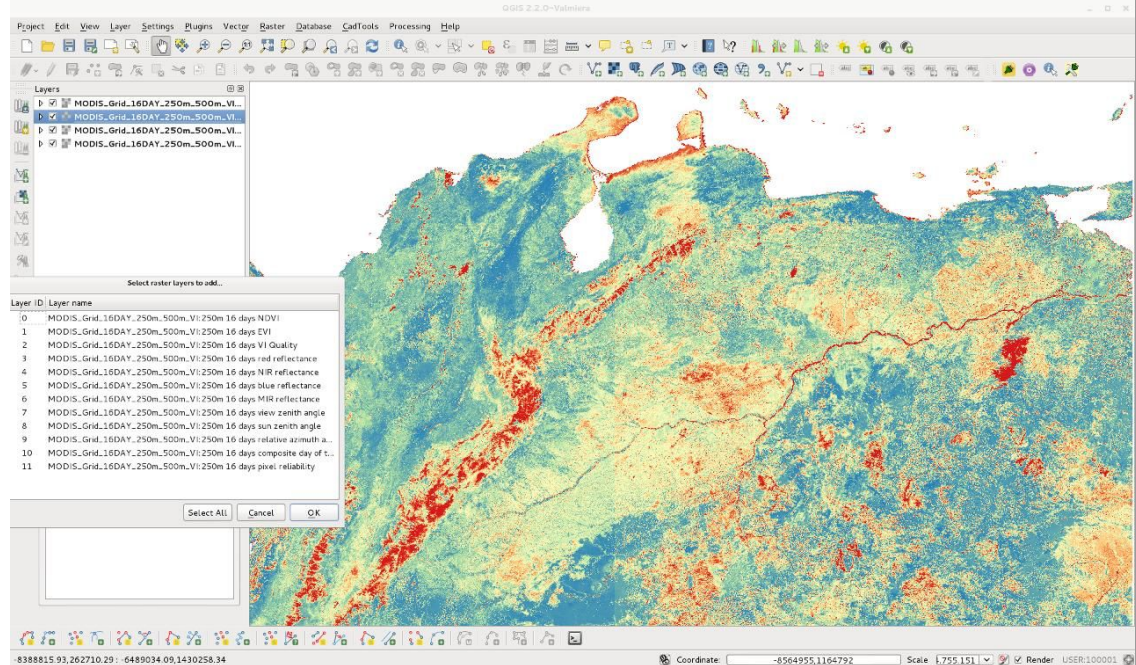
$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72$$

$$\frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

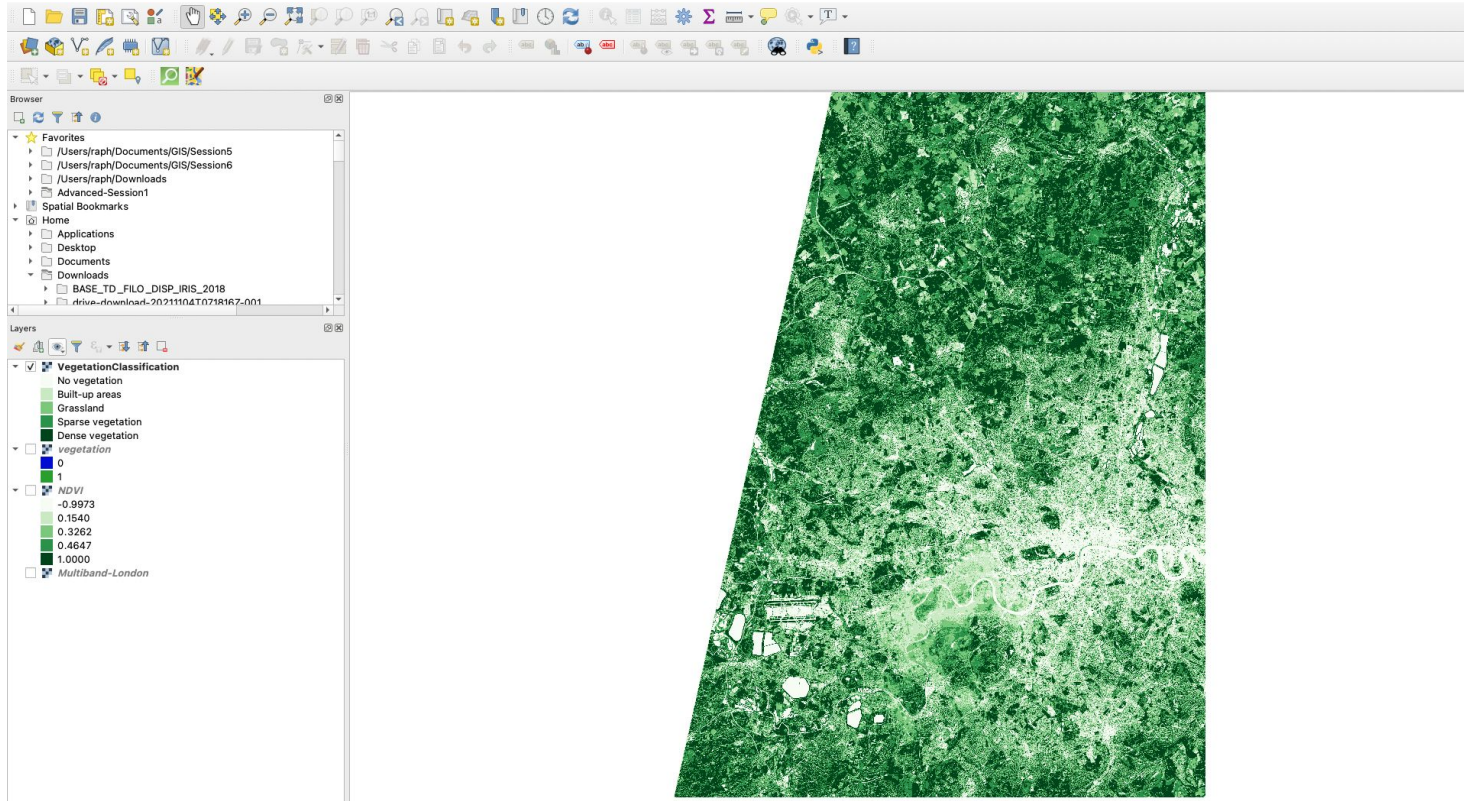
# The NDVI

The normalized difference vegetation index (NDVI) allows us to infer the presence of green (healthy) vegetation based on the amount of light and near infrared wavelengths reflected from the surface of the Earth.

This is an index you can calculate in QGIS from satellite data (Sentinel-2, Landsat, SPOT etc)



# Questions?





## 2. Raster data - use cases



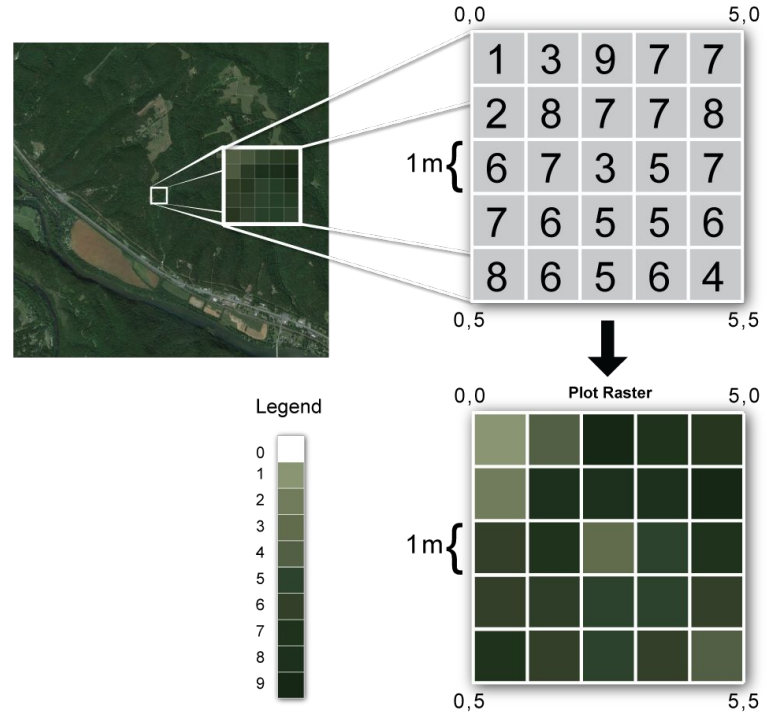


# 1. What is raster data?

## Raster vs vector

Spatial data can be represented in two ways:

- **Vector**: geometries: Point, Line, Polygon
- **Raster** : pixels, like a photo (each pixel is assigned a value)



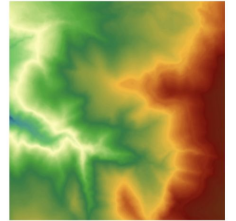
## 2. Continuous vs thematic raster data

Raster data models are used to represent continuous data like surface temperature or elevation...

But also thematic (= discrete = categorical) data such as land-use or soil class data.

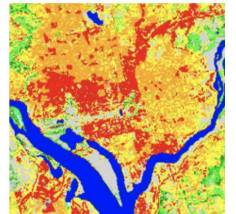
### Continuous Data:

- Elevation
- Temperatures
- Precipitation
- Reflectance (light)



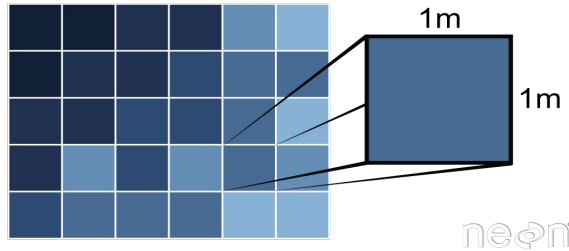
### Categorical Data:

- Land Cover Type
- Soil Type
- Vegetation Type

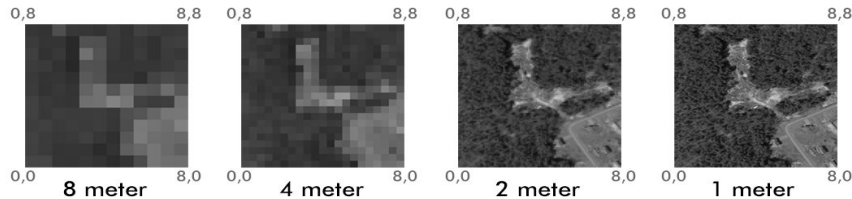


# 3. Spatial Resolution

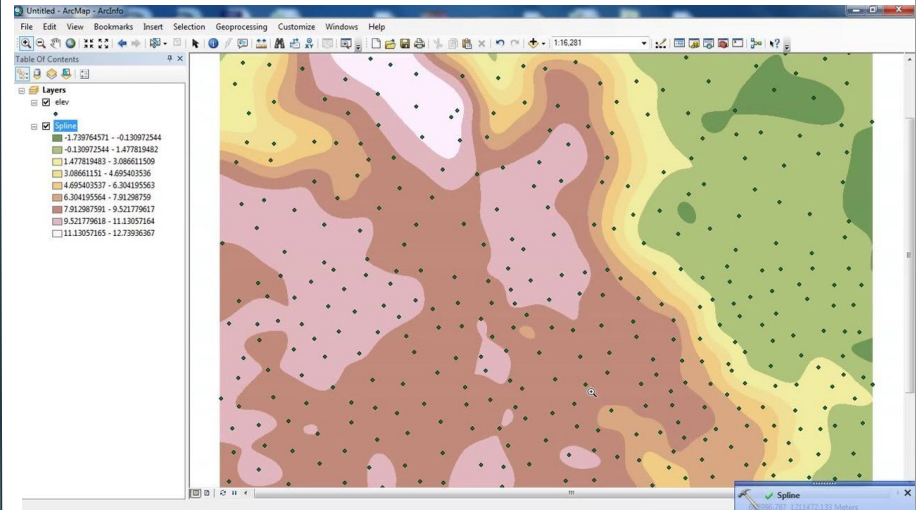
For remote sensing data, spatial resolution depends on the sensor used to take an image.



Raster over the same extent, at 4 different resolutions



For raster data computed by spatial analysis (e.g. rainfall), resolution will depend on your sampling scheme (e.g. number of weather stations).

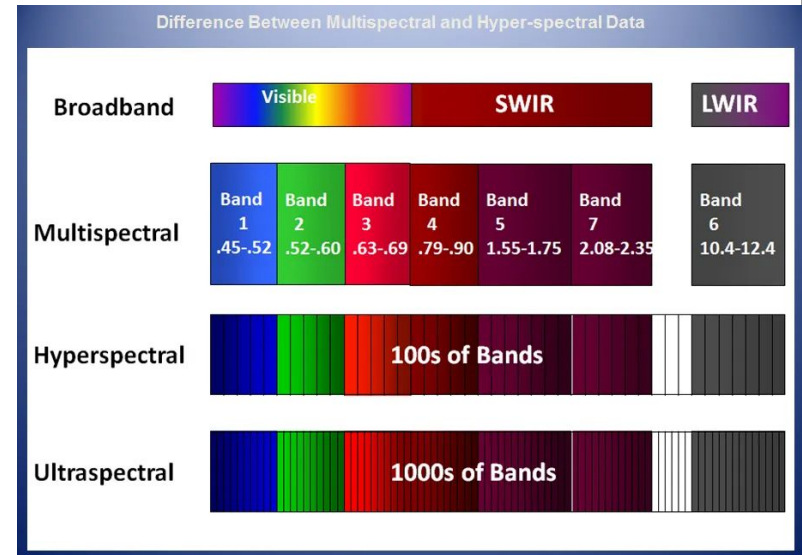


# 4. Remote Sensing: Spectral Resolution

With digital pictures, the camera uses electronic sensors to detect red, green and blue light. The red, green and blue (RGB) information is combined to show you an image that your eyes can interpret, but in fact RGB information is stored in **separate colour bands**.

This is the case for satellite images.

But remote sensing devices can also capture other wavelengths. They can record infra-red for instance (very useful in environmental science to detect bodies of water).



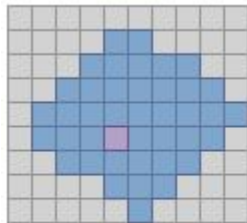
# 5. Raster can be converted to vector

(and vice versa)

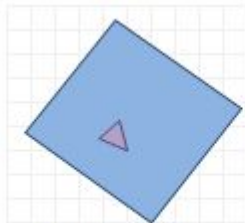
You may want to convert your raster to vector:

- Because some operations can only be carried out on vector data
- Because raster data uses a lot of storage space

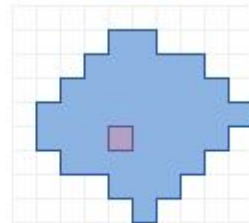
There are various options such as simplifying or not the output



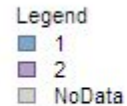
Input raster



Simplified output



Non-simplified output

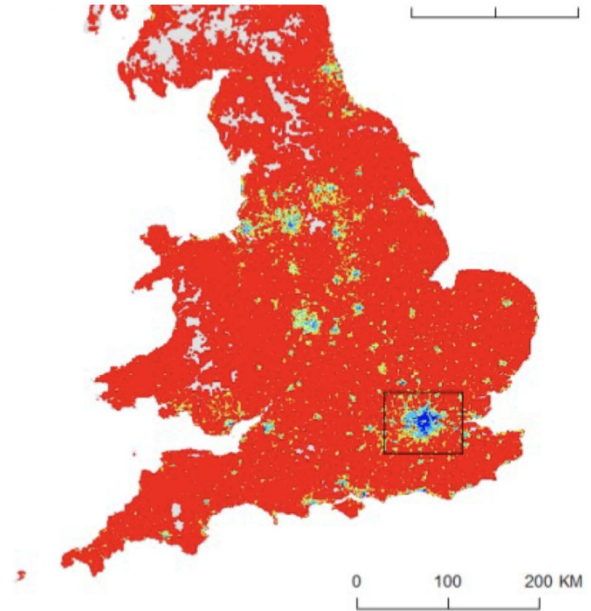
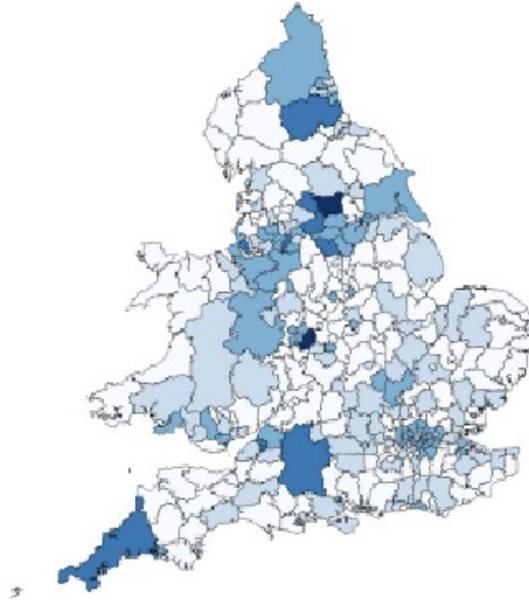




# Examples of raster datasets

## 6. Examples: Population grids

These two maps represent population density. On the left, the unit is output areas. On the right, it's a 1kmx1km grid. You can notice that these two maps depict a very different image. Rural areas look especially bad when aggregating data into output areas.



# 6. Examples: Population grids

Population is often represented as **vector**, where population is grouped in **output areas** (census, etc)

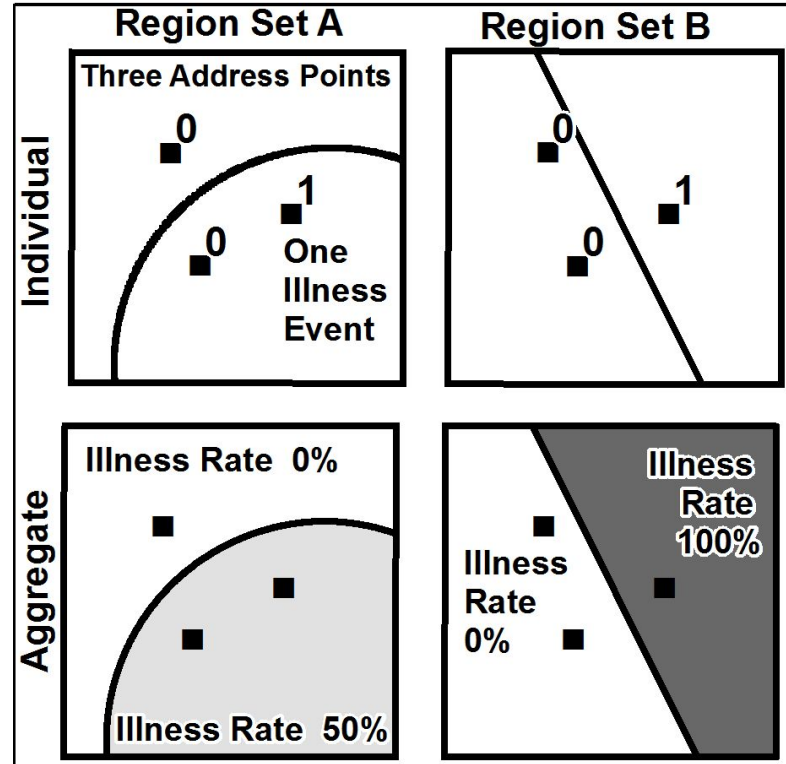
But there are many advantages to representing population as raster grids:

- They **minimize ecological fallacy and MAUP** (see Martin et al (2001) The Application of Zone-Design Methodology in the 2001 UK Census, Environment and Planning A, 33:11, pp. 1949 – 1962, <https://doi.org/10.1068/a3497> )
- We can clearly see where **nobody lives**
- They allow us to easily **calculate change over time**. On the contrary, output area boundaries are redefined frequently.

A famous population grid dataset is the one [released by Facebook](#); you can read up on the methodology [here](#).



# Reminder: Modifiable Area Unit Problem - MAUP



# 6. Examples: Population grids



<https://popchange.liverpool.ac.uk/>

(you need to register)

Researchers at the University of Liverpool have taken census data since 1971 and rasterized it into 1km grid. The purpose is to be able to compare **the evolution of a variable across time**, regardless of how much the admin area boundaries changed.



Welcome to our visualisation tool for Census data.

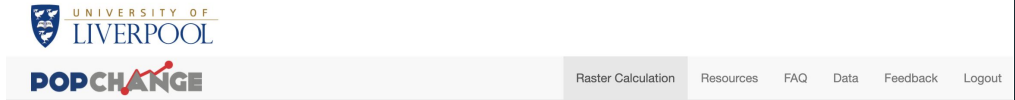
Compare any Census population data, such as deprivation, ethnicity or health, for years between 1971 to 2011, on a map of your local area.

This is a FREE tool, but please register above to utilise fully.

# 6. Examples: Population grids

You can select an area (here I picked all of Great Britain), a variable you're interested in, and two dates to compare.

You can choose to see absolute values or percentage.



## Raster Calculation Visualisation

Generate a visualisation based on the calculation between two data sets to identify areas of positive or negative growth. To compute a map of differences between two years enter the most recent year (e.g., 2011) first (**[set 1]**) and the older year (e.g., 1991) second (**[set 2]**). Negative values will represent decreases and positive values will represent increases.

Area

Set 1

Set 2

Counts  Percentage

Exclude low count cells

# 6. Examples: Population grids

The output is a layer that contains the **DIFFERENCE** between those two dates (i.e. how the percentage of unemployed people in the UK changed between 1991 and 2011).

You can also download the layer as GeoTIFF and use them in QGIS.

## Raster Calculation Visualisation

Generate a visualisation based on the calculation between two data sets to identify areas of positive or negative growth. To compute a map of differences between two years enter the most recent year (e.g., 2011) first ( **[set 1]** ) and the older year (e.g., 1991) second ( **[set 2]** ). Negative values will represent decreases and positive values will represent increases.

Area:

Set 1:

Set 2:

Counts  Percentage

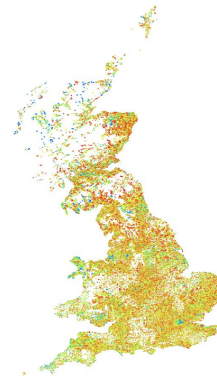
OK

Exclude low count cells

Generate



Max: 27.565  
Min: -91.421  
Mean: -2.116  
Median: nul  
StdDev: 3.747



[Download PDF](#)  
[Download PNG](#)  
[Download GeoTIFF](#)  
[Download Shapefile](#)

Browser

- WhatsApp Image 2021-01-01 at 14.24.20.jpeg
- Dropbox
- Movies
- Music
- Pictures
- Public
- /
- /Volumes
- GeoPackage
- SpatialLite
- PostGIS
- MSSQL
- DB2
- WMS/WMTS
- Vector Tiles
- XYZ Tiles
  - Bing VirtualEarth
  - CartoDb Dark Matter
  - CartoDb Positron
  - Esri Boundaries Places
  - Esri Gray (dark)
  - Esri Gray (light)
  - Esri National Geographic
  - Esri Ocean
  - Esri Satellite
  - Esri Standard
  - Esri Terrain
  - Esri Topo World
  - Esri Transportation
  - Google Maps
  - Google Satellite
  - Google Satellite Hybrid
  - Google Terrain
  - Google Terrain Hybrid
  - Open Weather Map Clouds
  - Open Weather Map Temperature

Layers

- PopChange
  - 67.8665
  - 44.146775
  - 20.42705
  - 3.292675
  - 27.0124
- CartoDb Positron

Type to locate (⌘K)

Coordinate: 216875,625910 Scale: 1:608684 Magnifier: 100% Rotation: 0.0° Render EPSG:27700

In red are areas where unemployment increased a lot, in blue areas where unemployment rates decreased. We used single band pseudocolour and made the layer a bit transparent to get context from the basemap.

GRASS

Identify Results

Feature	Value
---------	-------

Mode: Current Layer

View: Tree

Help

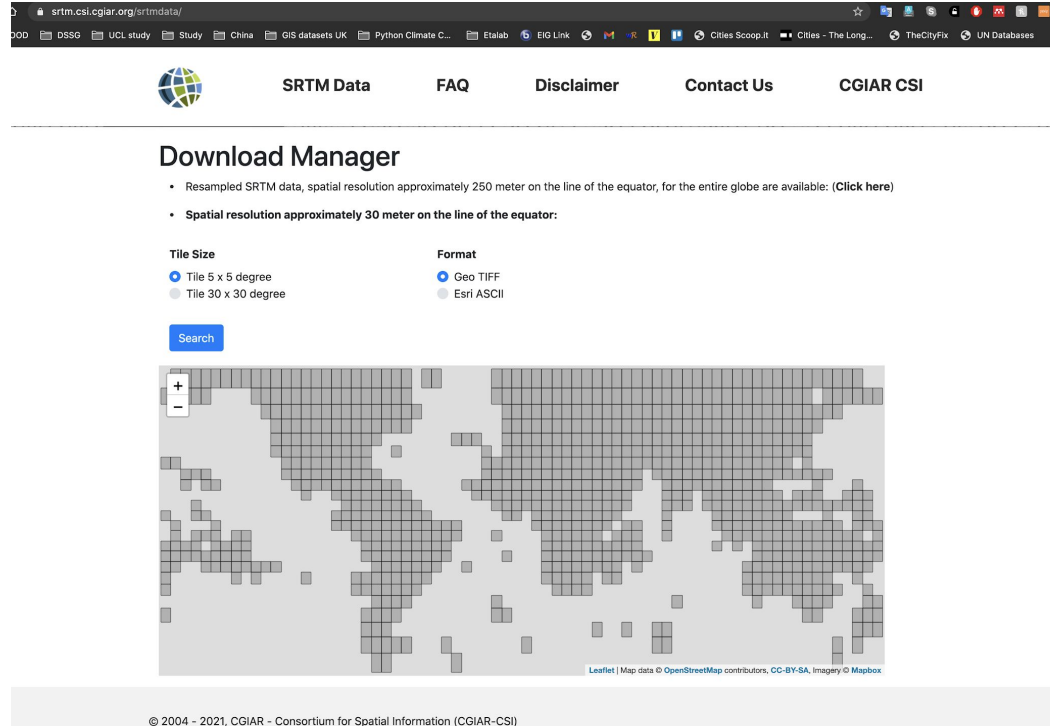
# 7. Example: elevation raster from SRTM

Elevation data: the SRTM dataset.

In 2000, NASA's **Shuttle Radar Topography Mission** collected the most complete high-resolution digital topographic database of Earth (later topped by ASTER GDEM in 2009). It covers most of the planet, with a resolution of roughly 30 meters.

You can download tiles here:

<https://srtm.csi.cgiar.org/srtmdata/>

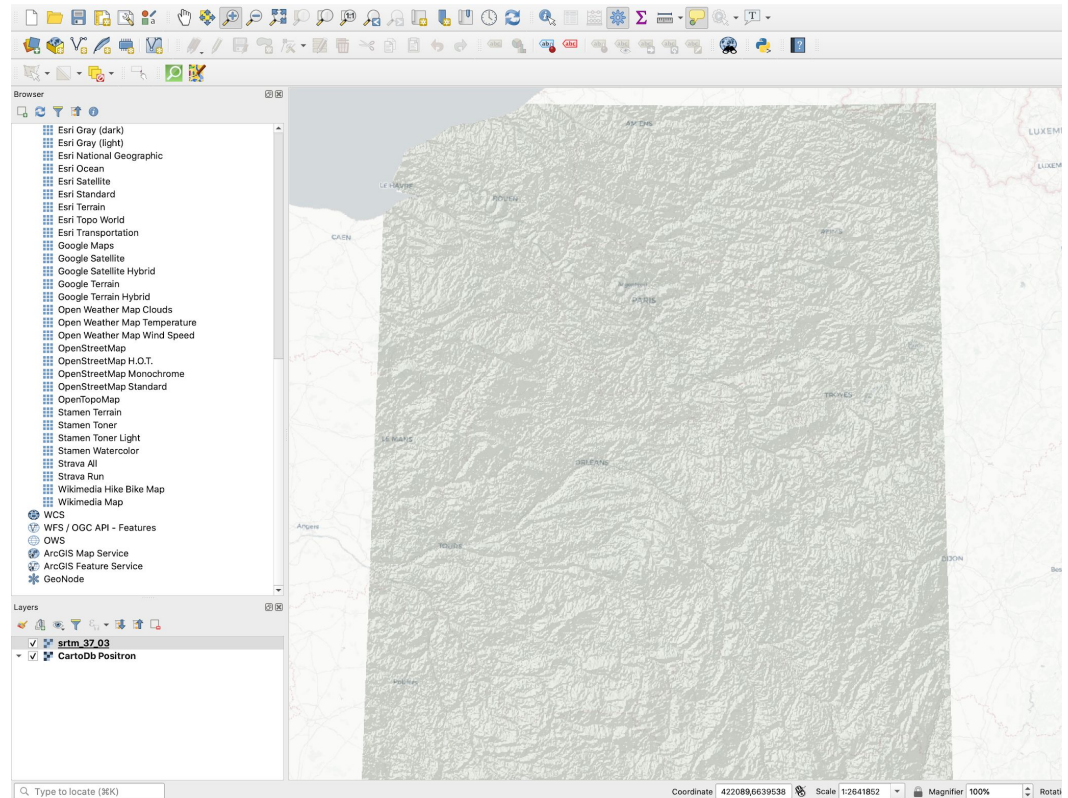


The screenshot shows the SRTM Data Download Manager website. The browser address bar displays [srtm.csi.cgiar.org/srtmdata/](https://srtm.csi.cgiar.org/srtmdata/). The website header includes a globe icon, navigation links for "SRTM Data", "FAQ", "Disclaimer", "Contact Us", and "CGIAR CSI". The main content area is titled "Download Manager" and lists two bullet points: "Resampled SRTM data, spatial resolution approximately 250 meter on the line of the equator, for the entire globe are available: (Click here)" and "Spatial resolution approximately 30 meter on the line of the equator:". Below this, there are two sections: "Tile Size" with radio buttons for "Tile 5 x 5 degree" (selected) and "Tile 30 x 30 degree", and "Format" with radio buttons for "Geo TIFF" (selected) and "Esri ASCII". A blue "Search" button is positioned below these options. The main visual is a world map showing a grid of grey squares representing available data tiles. A zoom control with "+" and "-" buttons is in the top-left corner of the map. At the bottom right of the map, there is a small attribution: "Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox". The footer of the page contains the copyright notice: "© 2004 - 2021, CGIAR - Consortium for Spatial Information (CGIAR-CSI)".

# 7. Example: elevation raster from SRTM

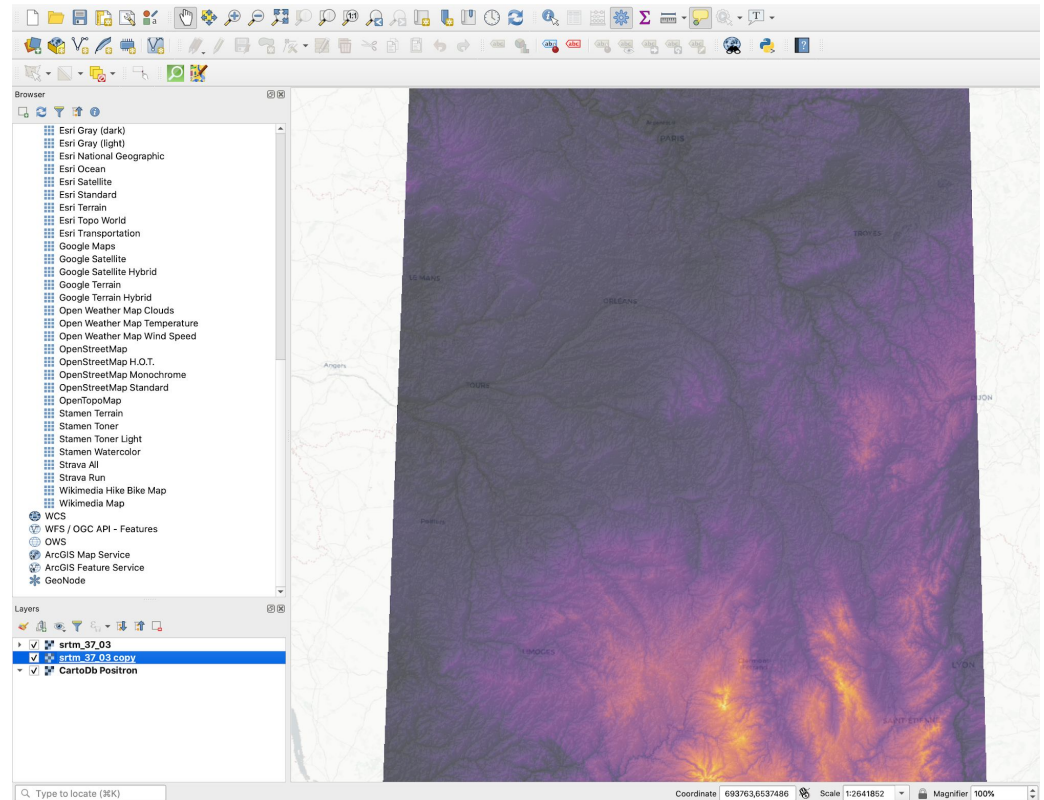
Several symbology options for elevation data.

This is hillshade ; it simulates the shadows of the sun on the relief.



# 7. Example: elevation raster from SRTM

You can also duplicate the layer and combine two different symbologies. For instance here I used singleband pseudo-colour and hillshade, and played with transparency of each layer.

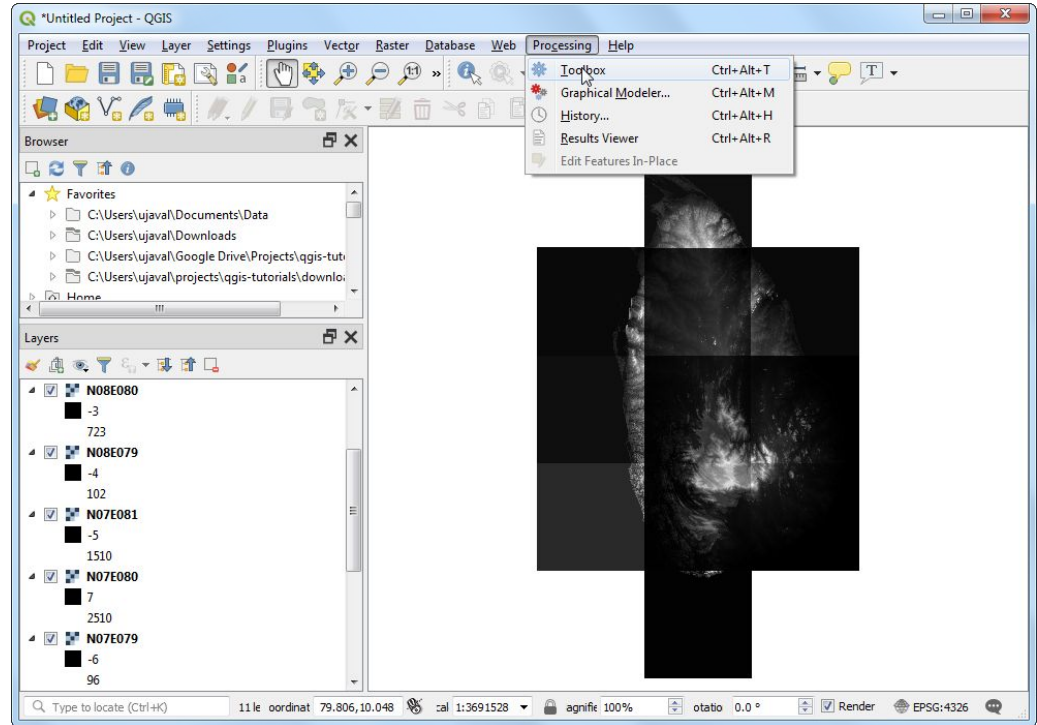




# 7. Example: elevation raster from SRTM

If you are interested in using topography data, you can give this tutorial a try and learn how to build a raster mosaic to cover a larger extent, then clip it to the shape of your area of interest.

[http://www.qgistutorials.com/en/docs/3/raster\\_mosaicing\\_and\\_clipping.html](http://www.qgistutorials.com/en/docs/3/raster_mosaicing_and_clipping.html)



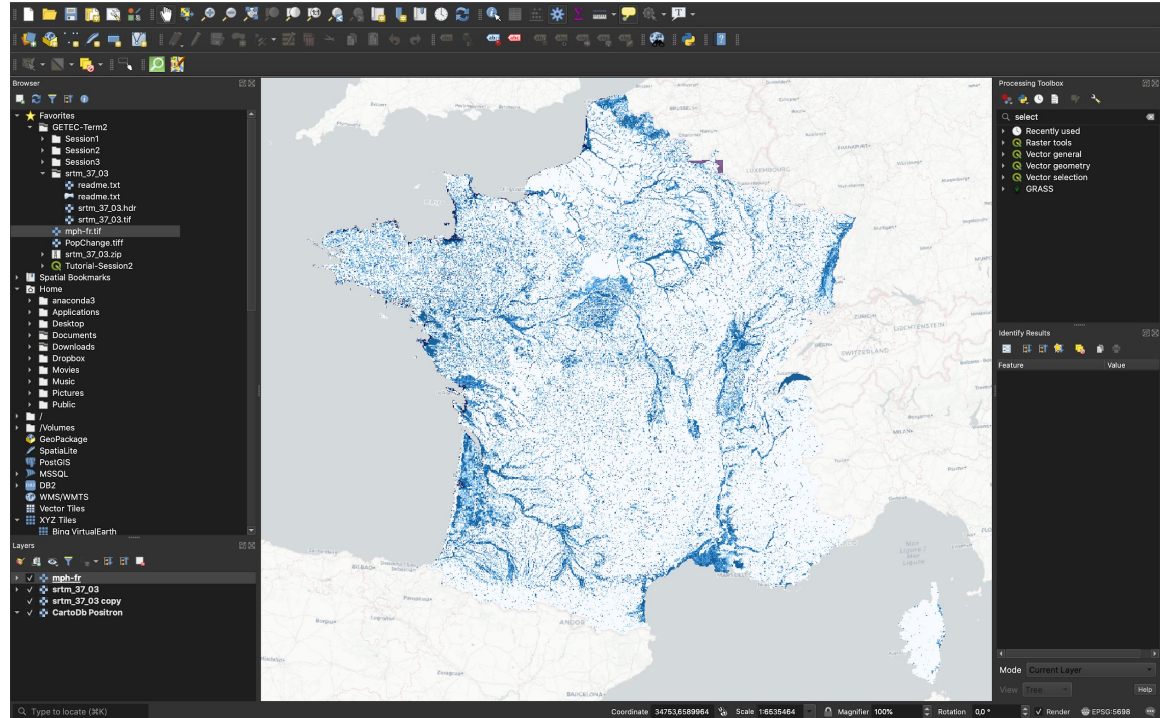
# 8. Example: Humid zones in France

Humid zones in France

<https://geo.data.gouv.fr/fr/datasets/c2645280e85133c68fa7179b6b1feda6bbba63dc>

Each pixel holds a score of 0, 1, 2 or 3 depending on the probability that the soil is rich in water.

(0= very low probability that the soil contains water  
3= highest probability that the soil contains water)

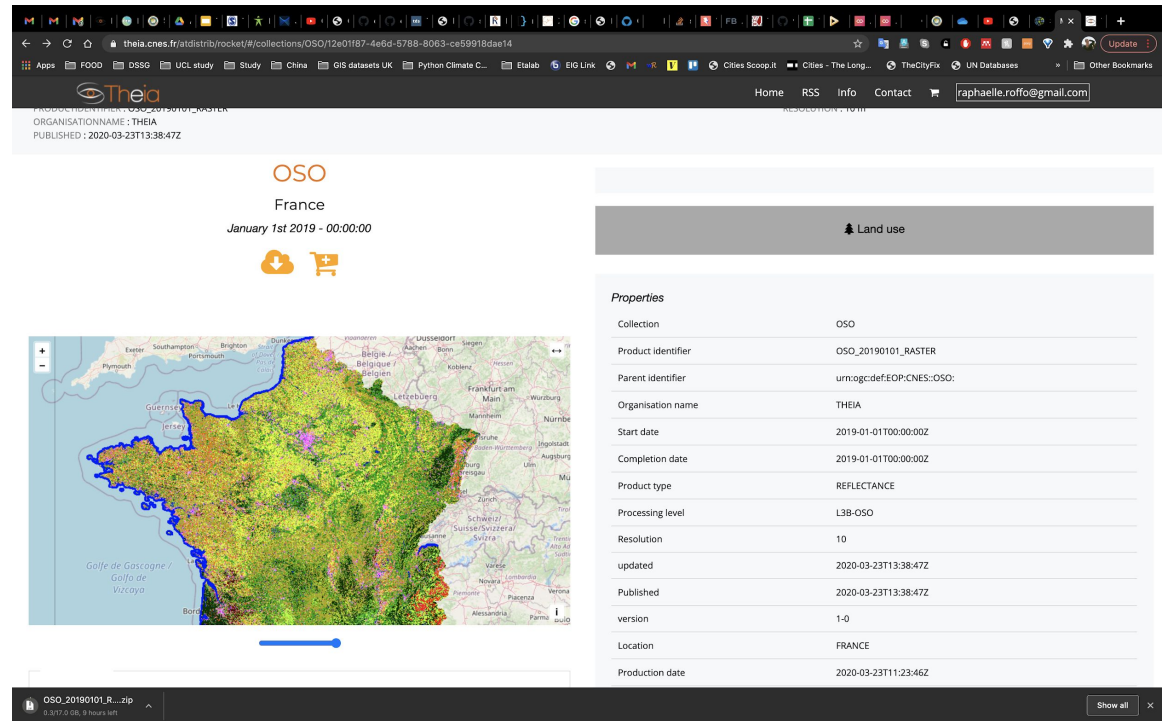


# 9. Example: land cover

You could download the [Land Cover dataset](https://theia.cnes.fr/) on Theia (<https://theia.cnes.fr/>).

It uses reflectance to infer the nature of the surface (vegetation, concrete, water, etc)

Careful, due to their high resolution, these are VERY large datasets (17GB for France alone)



The screenshot shows the Theia web interface for the land cover dataset. The main content area displays the following information:

- OSO**
- France**
- January 1st 2019 - 00:00:00**
- Download and share icons
- A map of France showing land cover data with a color-coded overlay.
- A sidebar on the right with a 'Land use' button.
- A 'Properties' table with the following data:

Properties	
Collection	OSO
Product identifier	OSO_20190101_RASTER
Parent identifier	urn:ogc:def:EOP:CNES:OSO:
Organisation name	THEIA
Start date	2019-01-01T00:00:00Z
Completion date	2019-01-01T00:00:00Z
Product type	REFLECTANCE
Processing level	L3B-OSO
Resolution	10
updated	2020-03-23T13:38:47Z
Published	2020-03-23T13:38:47Z
version	1-0
Location	FRANCE
Production date	2020-03-23T11:23:46Z

At the bottom of the interface, there is a download button for 'OSO\_20190101\_R...zip' with a size of 0.317.0 GB and 9 hours left. A 'Show all' button is also visible.



### 3. Georeferencing & Digitizing



# Georeferencing

Many real life GIS projects require georeferencing some raster data. For example you may need to update the information for a forestry area for which you only have a paper inventory of the area. If you want to be able to look at the way the forest evolves over time, you will want to digitize that map and update it in the future. You may also have a satellite image that hasn't been georeferenced.

***Georeferencing* = assigning real-world coordinates to each pixel of a raster image, allowing it to be viewed, queried and analyzed with your other geographic data.**

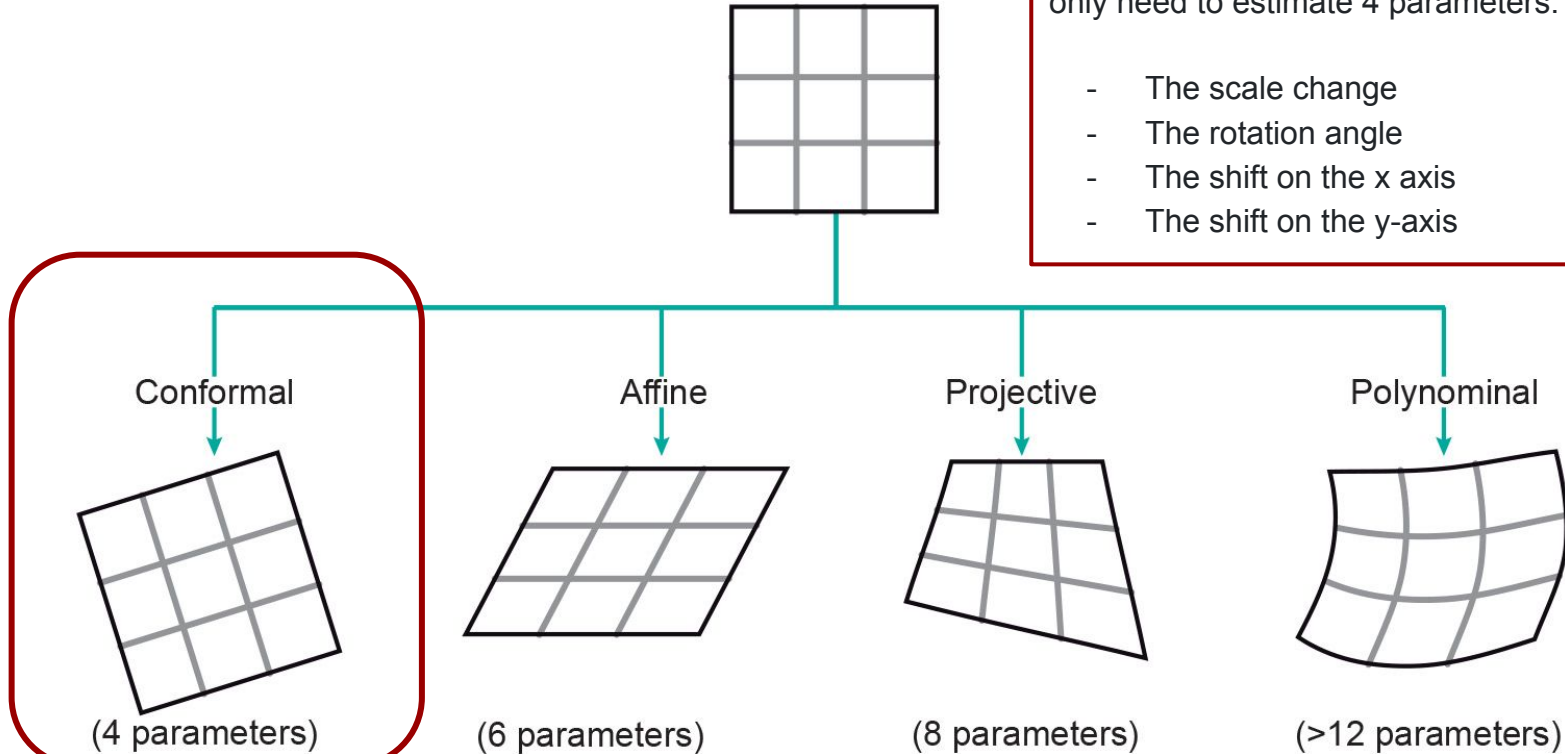
To do so, you will first scan that paper map (or get a digital picture of a map of your choice). Then, you will identify a few points (at least 3) for which you have precise coordinates (because you have those coordinates, or because you can identify those points on a basemap).

Finally, you can “pin” those Ground Control Points (GCP), and choose the way you want to warp the image to fit your coordinate reference system.

# Georeferencing

In a **conformal or Helmert transformation**, the shape and angles of your image are retained; to describe your transformation in an equation you only need to estimate 4 parameters:

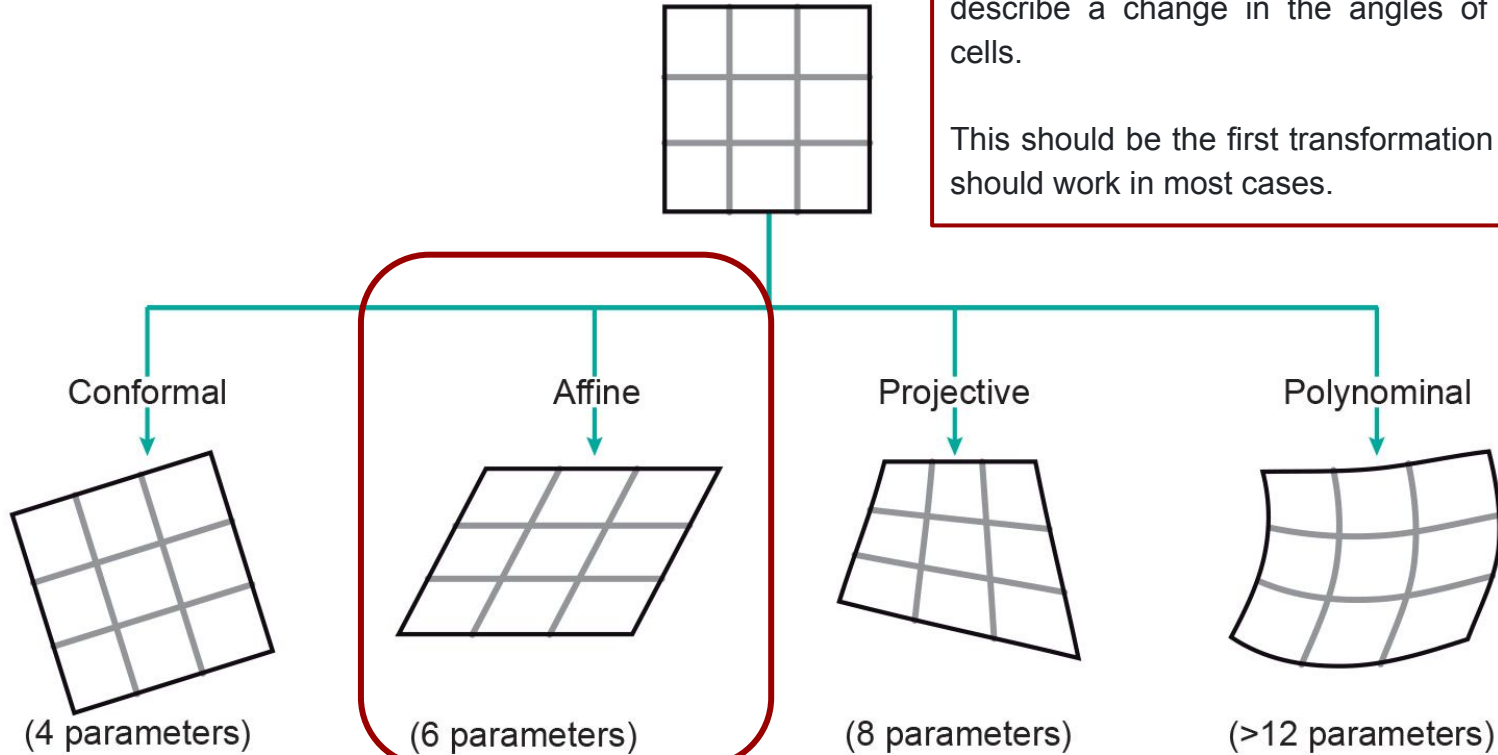
- The scale change
- The rotation angle
- The shift on the x axis
- The shift on the y-axis



# Georeferencing

With **affine (= Polynomial 1) transformation**, you introduce another set of parameters to describe a change in the angles of your raster cells.

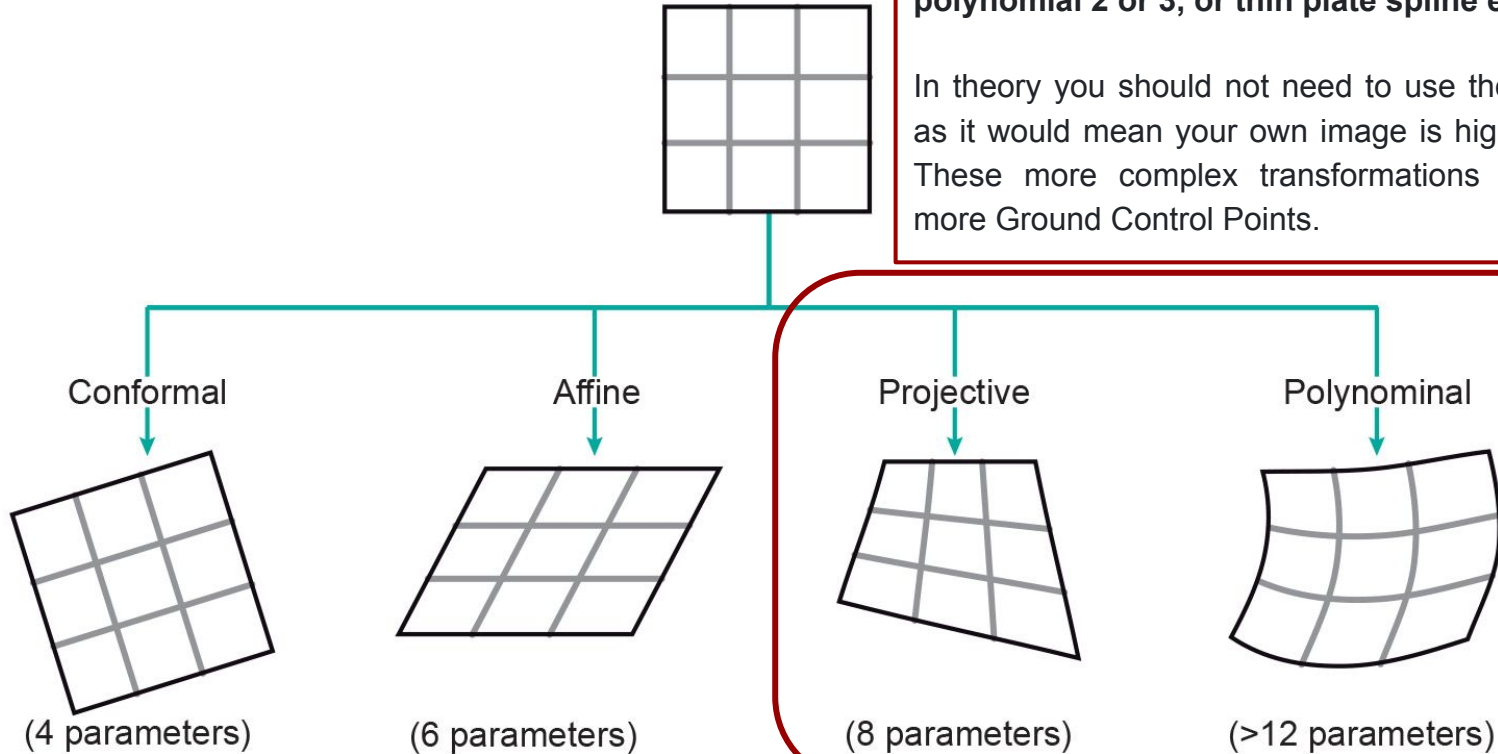
This should be the first transformation you try and should work in most cases.



# Georeferencing

But if you need to warp or stretch your image to make it fit onto your basemap, then you will need a more complex transformation, described by **projective**, **polynomial 2 or 3**, or **thin plate spline equations**.

In theory you should not need to use those methods as it would mean your own image is highly distorted. These more complex transformations also require more Ground Control Points.

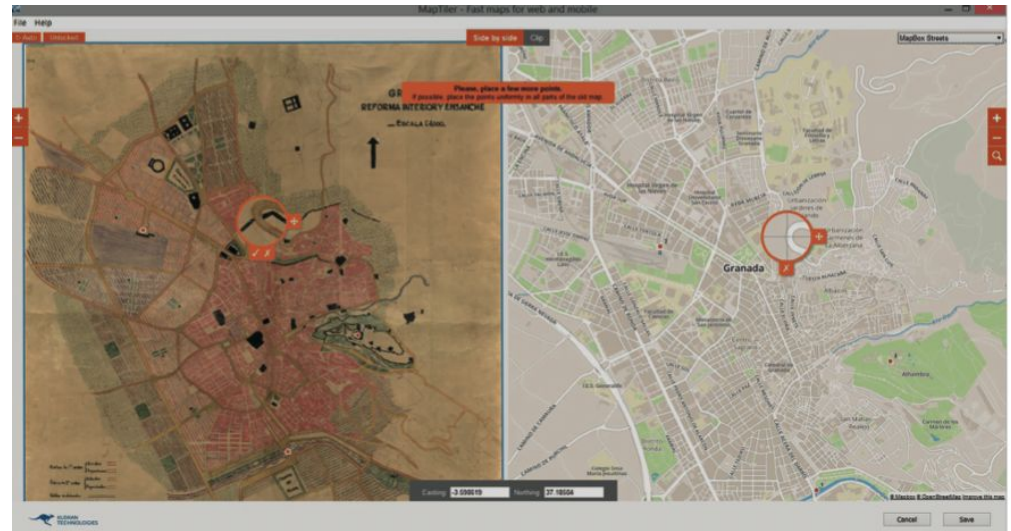




# Georeferencing: use cases

Georeferencing allows to revitalise and give new purpose to ancient cartography that remains in archive deposits, libraries and cultural centres.

This facilitates access for non-expert users to geographical, heritage, urban or environmental information of interest. Making those maps machine-readable and queryable also allows for interactivity: web mapping of photographs, mobile geolocation on old maps etc.

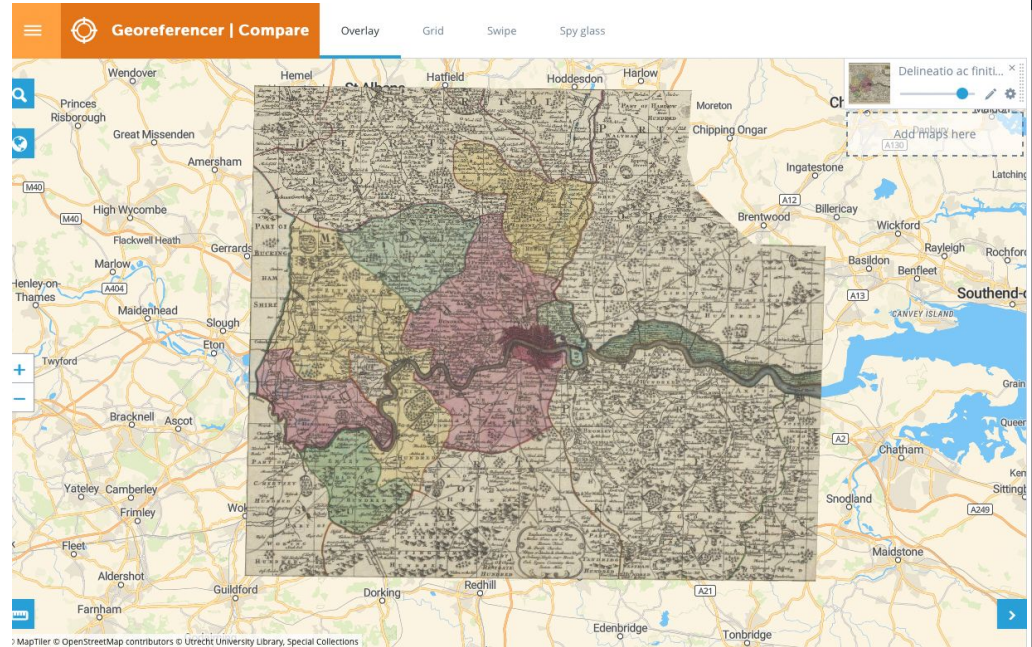


# Georeferencing: use cases

See: <https://www.oldmapsonline.org>

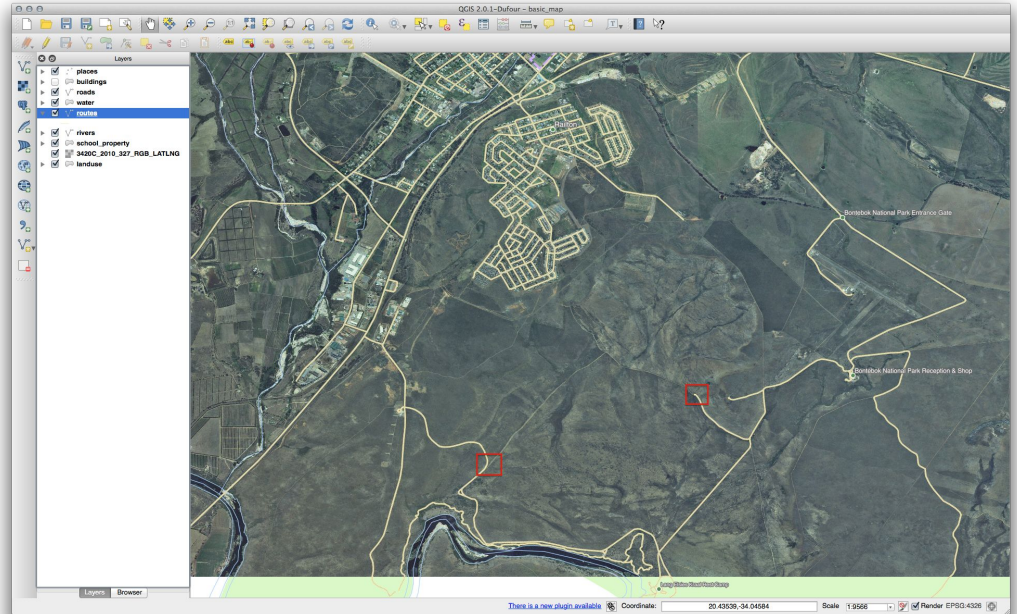
In this example, you might then be interested in extracting the boundaries of the boroughs in this ancient map in a new vector dataset.

In order to do so, you would use digitizing to draw the vertices of the polygons and save them in a new vector dataset (or update an existing one)



# Digitizing

Digitization is an even more common task in GIS workflows. When working with environmental data in particular, it happens that you do not have access to recent data. A way to create your own data is to import satellite images into QGIS, and draw the boundaries of the features you're interested in (Points, Lines or Polygons). You can thereby create your own dataset and populate the attribute table with the information you want.





Next week

# Homework

- Do the [Session 2 Tutorial](#)
- If you want to explore raster symbology, you can try and import some of the example datasets listed on these slides (Popchange, HumidZones, land cover) into QGIS and adjust the symbology.
- You can also try the [SRTM tutorial](#), with an area of your choice!