



Georeferencing

Lab_04: Georeferencing a Historical Map



A quick recap

Lab_01

Information

Coordinate Reference System (CRS)

Name	EPSG:32630 - WGS 84 / UTM zone 30N
Units	meters
Type	Projected
Method	Universal Transverse Mercator (UTM)
Celestial Body	Earth
Accuracy	Based on <i>World Geodetic System 1984 ensemble</i> (EPSG:6326), which has a limited accuracy of at best 2 meters .
Reference	Dynamic (relies on a datum which is not plate-fixed)

Lab_02

Information

Coordinate Reference System (CRS)

Name	EPSG:3857 - WGS 84 / Pseudo-Mercator
Units	meters
Type	Projected
Method	Mercator
Celestial Body	Earth
Accuracy	Based on <i>World Geodetic System 1984 ensemble</i> (EPSG:6326), which has a limited accuracy of at best 2 meters .
Reference	Dynamic (relies on a datum which is not plate-fixed)

Lab_03

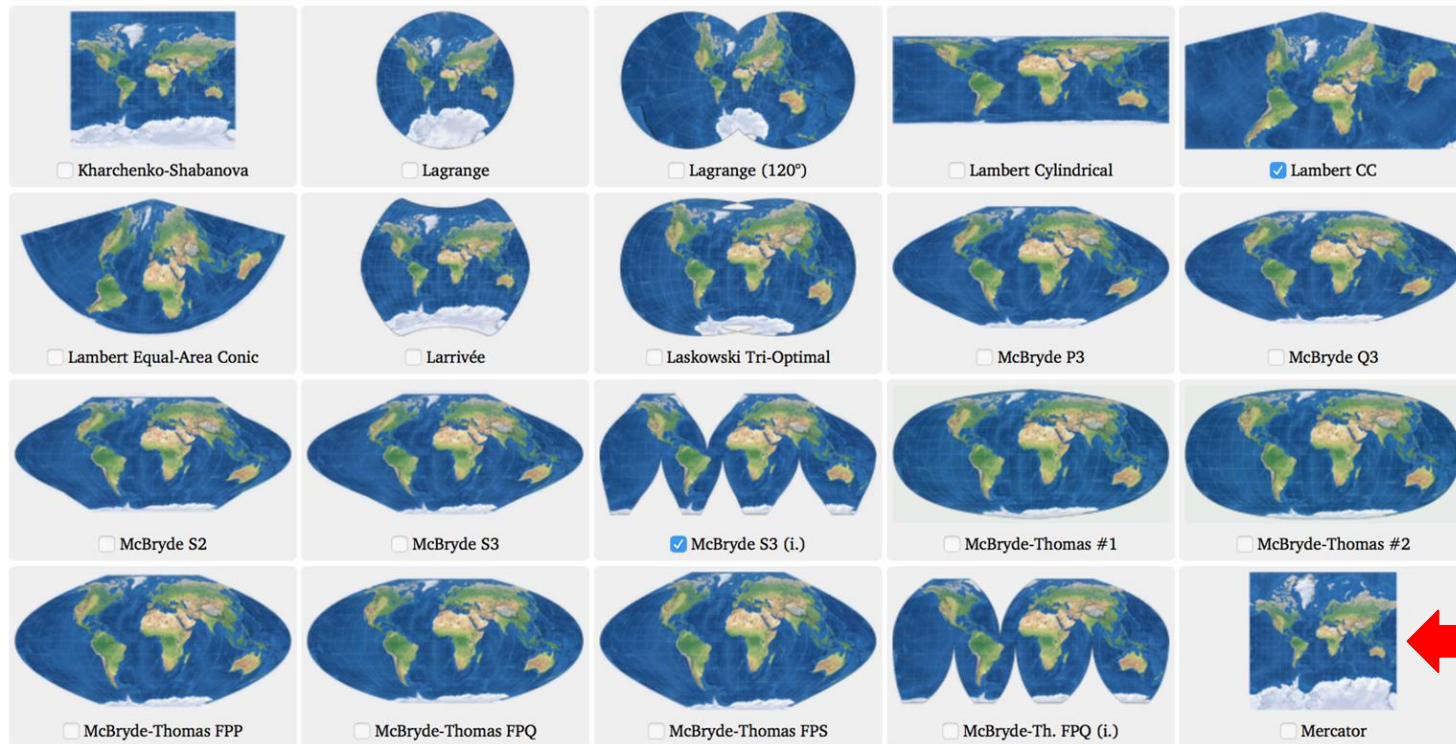
Information

Coordinate Reference System (CRS)

Name	EPSG:31287 - MGI / Austria Lambert
Units	meters
Type	Projected
Method	Lambert Conformal Conic
Celestial Body	Earth
Reference	Static (relies on a datum which is plate-fixed)

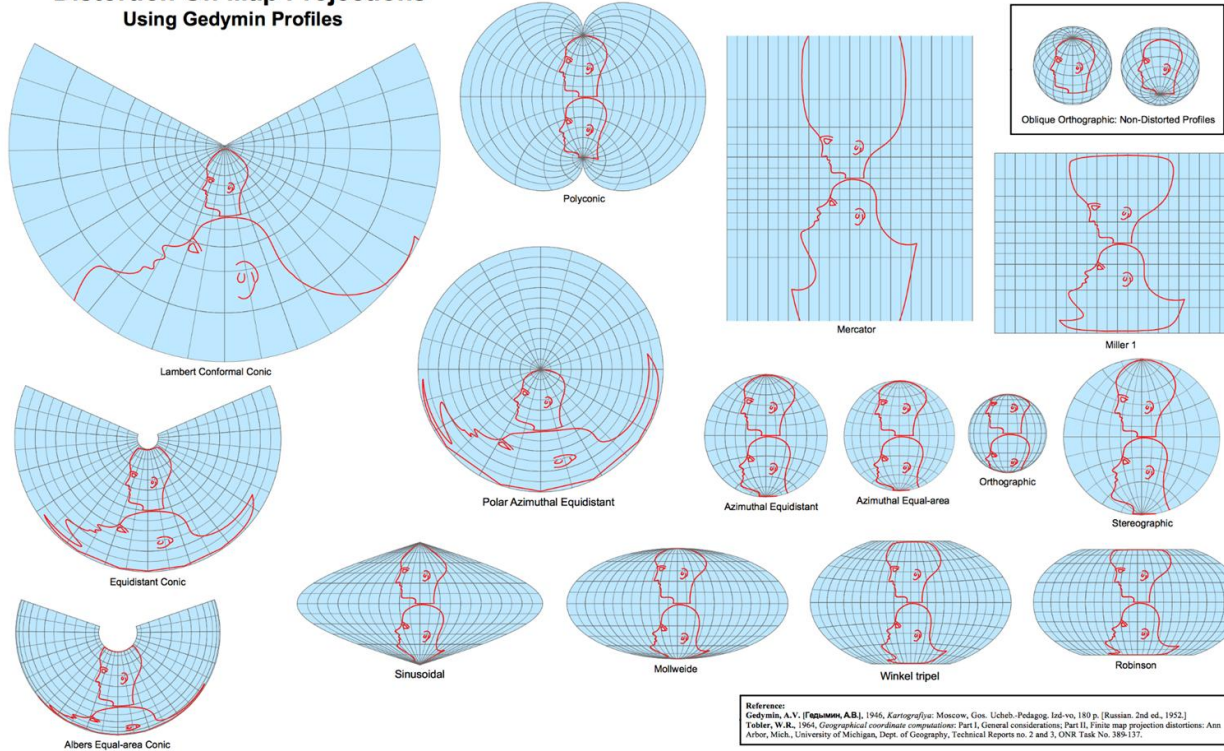
A quick recap

Map projections



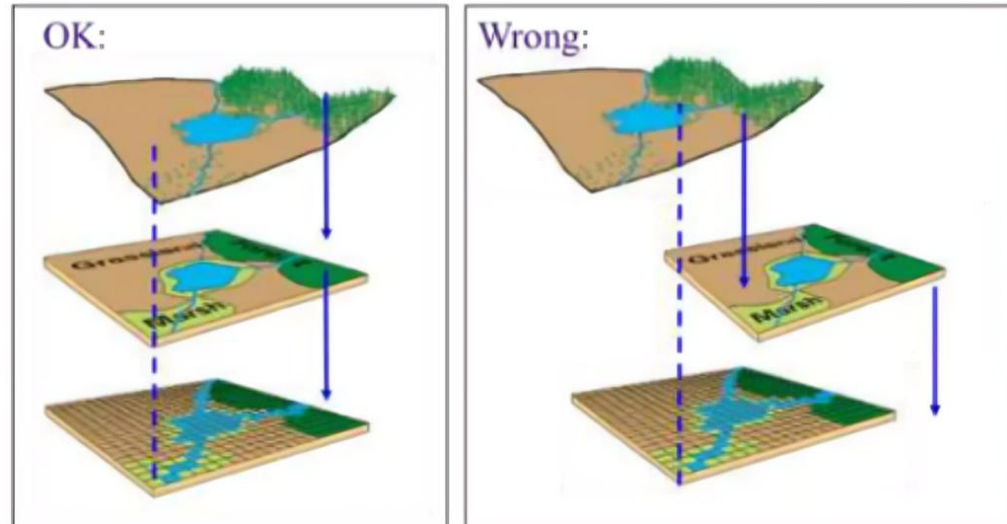
A quick recap

Distortion On Map Projections Using Gedymin Profiles



On the fly reprojection

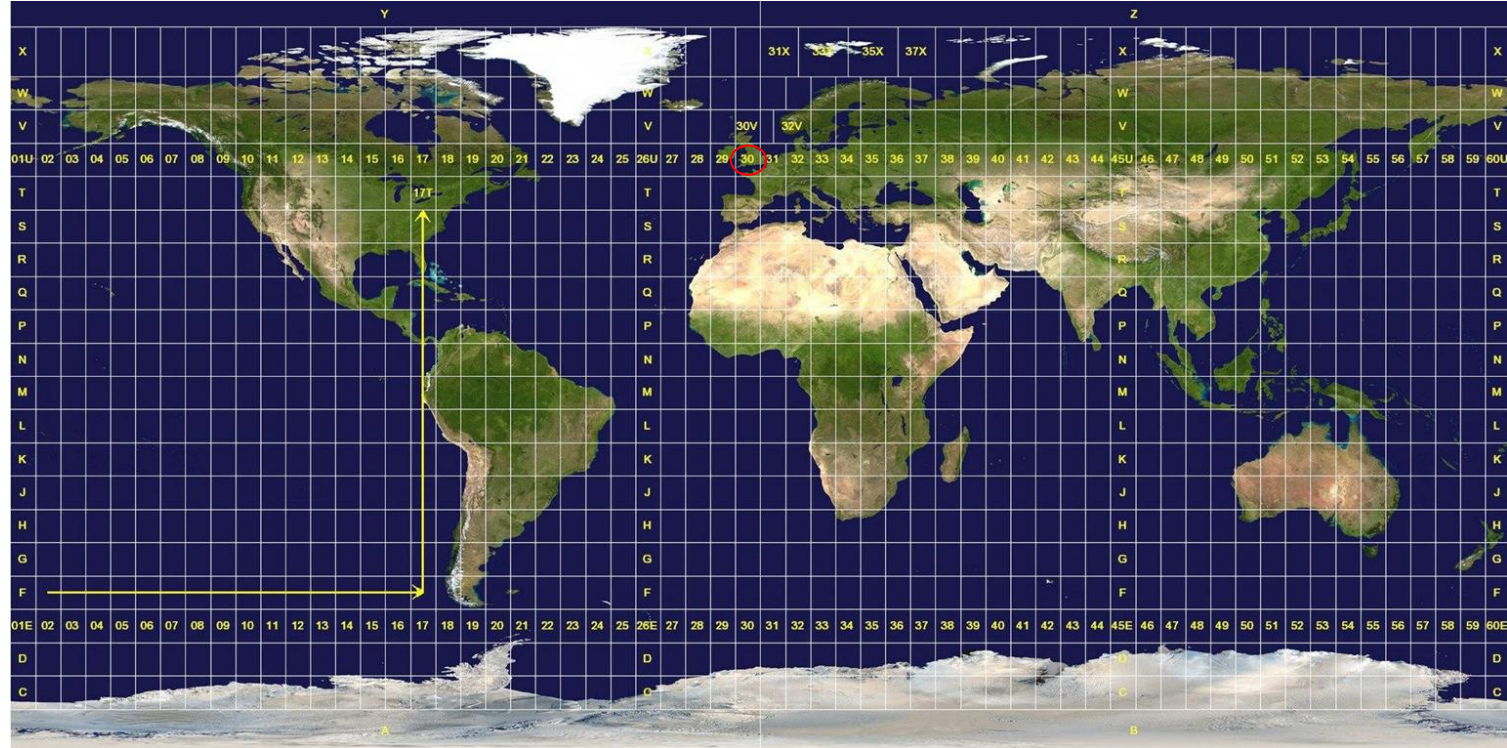
- All layers visualised in a GIS application need to be in the same projection
- Instead of reprojecting all layers to the same projection, GIS applications use '*on the fly reprojection*'



Hans van der Kwast. (2019, March 6). Map projections in GIS (theory) [Video]. YouTube.
https://www.youtube.com/watch?v=jVn1uCuH0_4

https://docs.qgis.org/3.40/en/docs/training_manual/vector_analysis/reproject_transform.html

Universal Transverse Mercator (UTM)



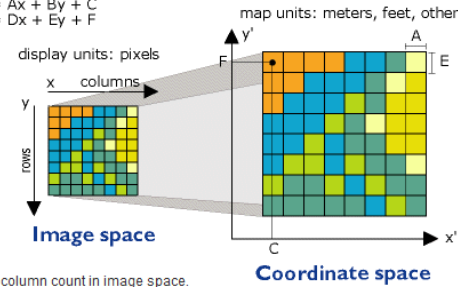
Georeferencing

~To georeference means to associate something (e.g., images, maps) with locations to the physical space

~Georeferencing is the process of associating a physical map or raster image of a map with spatial locations

$$x' = Ax + By + C$$

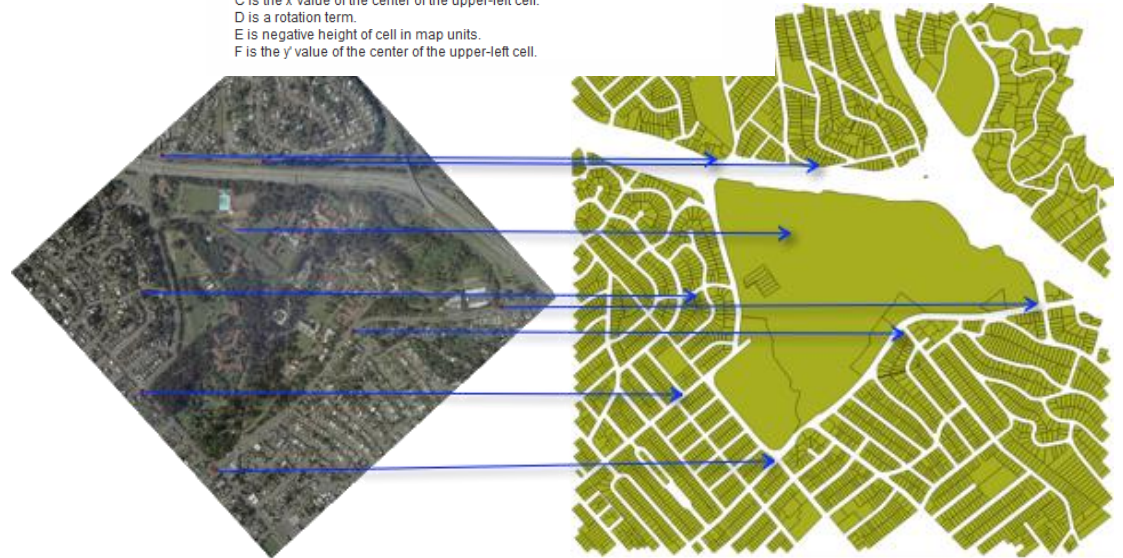
$$y' = Dx + Ey + F$$



x is column count in image space.
y is row count in image space.
x' is horizontal value in coordinate space.
y' is vertical value in coordinate space.

A is width of cell in map units.
B is a rotation term.
C is the x' value of the center of the upper-left cell.
D is a rotation term.
E is negative height of cell in map units.
F is the y' value of the center of the upper-left cell.

<https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/fundamentals-for-georeferencing-a-raster-dataset.htm>



Georeferencing raster images

- ~Register a map with the correct real world coordinates
- ~If the maps are not georeferenced, no other information can be displayed over or positioned under the map coverage
- ~Depending on the source materials & specifications of the project, maps can be registered to either a coordinate system or to another basemap such a digital ortho photo



<https://community.opendronemap.org/t/processing-historical-aerial-photos-revisited/19273>

Entering GCPs

Ground Control Points are the foundation for accurately georeferencing a raster image

They are known locations on the Earth's surface and are identified by their own latitude & longitude


💡 Use multiple GCPs across an area & distribute them evenly for better accuracy

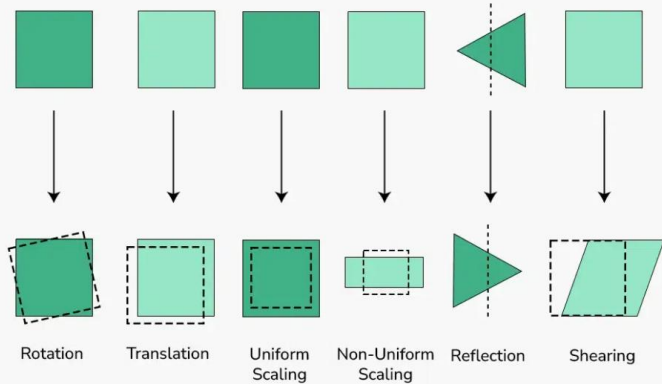


GCP	Pixel X	Pixel Y	Longitude	Latitude
1	4203.7	2347.0	4.2946	52.0825
2	3830.5	1673.9	4.2744	52.0888
3	5122.7	1611.8	4.3054	52.1025
4	5522.5	2981.5	4.3371	52.0862
5	3593.9	2691.5	4.2849	52.0710
6	6560.4	4341.7	4.3844	52.0761
7	4432.0	4929.8	4.3406	52.0464
8	486.8	2458.7	4.2042	52.0447
9	1171.9	4210.5	4.2483	52.0252
10	6704.4	907.2	4.3332	52.1289
11	1880.0	1993.3	4.2314	52.0650

<https://kokoalberti.com/articles/georeferencing-and-digitizing-old-maps-with-gdal/>

Transformation types

Geometric Transformation in Image Processing 

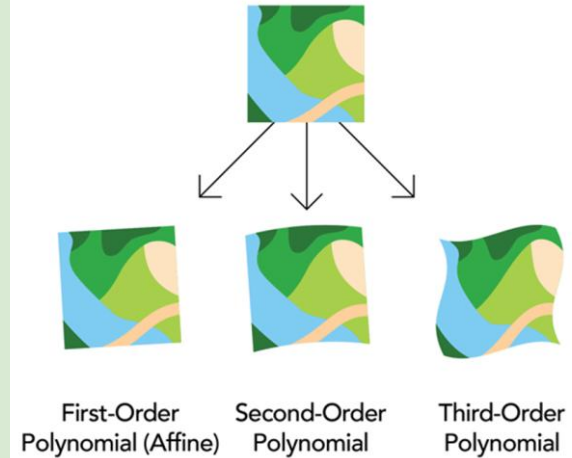


GCPs are used to create a **mathematical equation** for aligning raster data to real-world coordinates

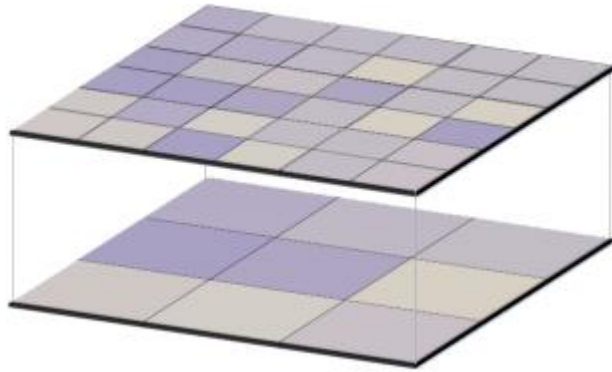
Most common method: **affine transformations** (first-order polynomial = linear), allows

- **Translation** (shifting)
- **Scaling** (resizing)
- **Rotation** (turning)
- **Shearing** (skewing)

Original Data



Resampling method



✓ Nearest Neighbor

✓ Bilinear

✓ Cubic Convolution

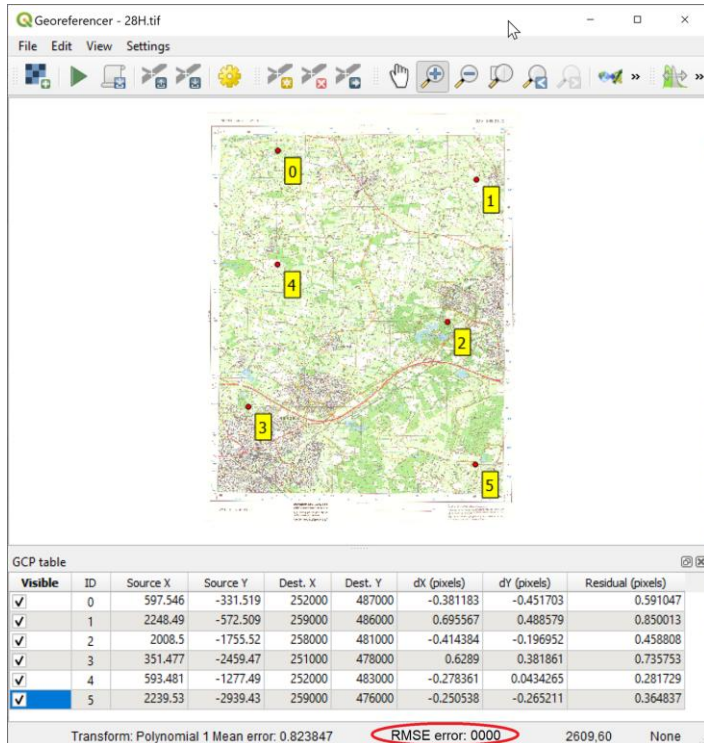
✓ Majority

~Choosing the correct resampling method determines how new pixel values are calculated for the output image

~Each method has different effects on the output image's appearance, accuracy and processing time

RM SE

- **What is the Root Mean Square Error (RM SE) ?**
- **It is a statistical measure of the difference between the GCPs & their true more accurate coordinates**



$$RMSE = \sqrt{\frac{\sum_{i=1}^n (P_i - O_i)^2}{n}}$$

A **lower RM SE** indicates a **better fit** / more accurate georeferencing. A **high RM SE** suggests **poor GCP selection**, an **inappropriate transformation model**, or **inherent distortions** in the source raster

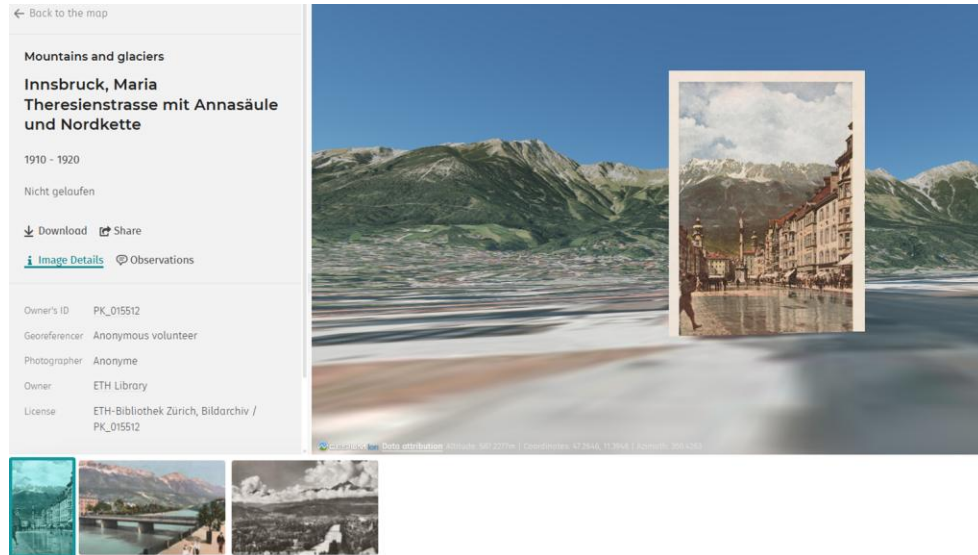
29 October 2025

<https://github.com/qgis/QGIS/issues/47122>

<https://gisgeography.com/georeferencing/>

Examples

Snapshot: The participative time machine



<https://snapshot.heig-vd.ch/>

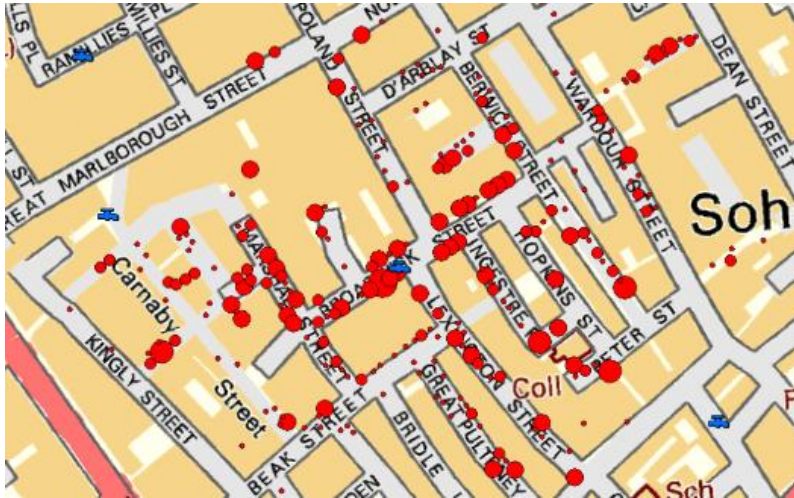
Map Wrapper



https://mapwarper.net/maps/geosearch?show_warped=1

Georeferencing vs Geocoding

Geocoding: Matching addresses to geographic coordinates (latitude & longitude)



Georeferencing: Matching geographic images to coordinates

