Computer Aided Archaeology

08 - GIS I

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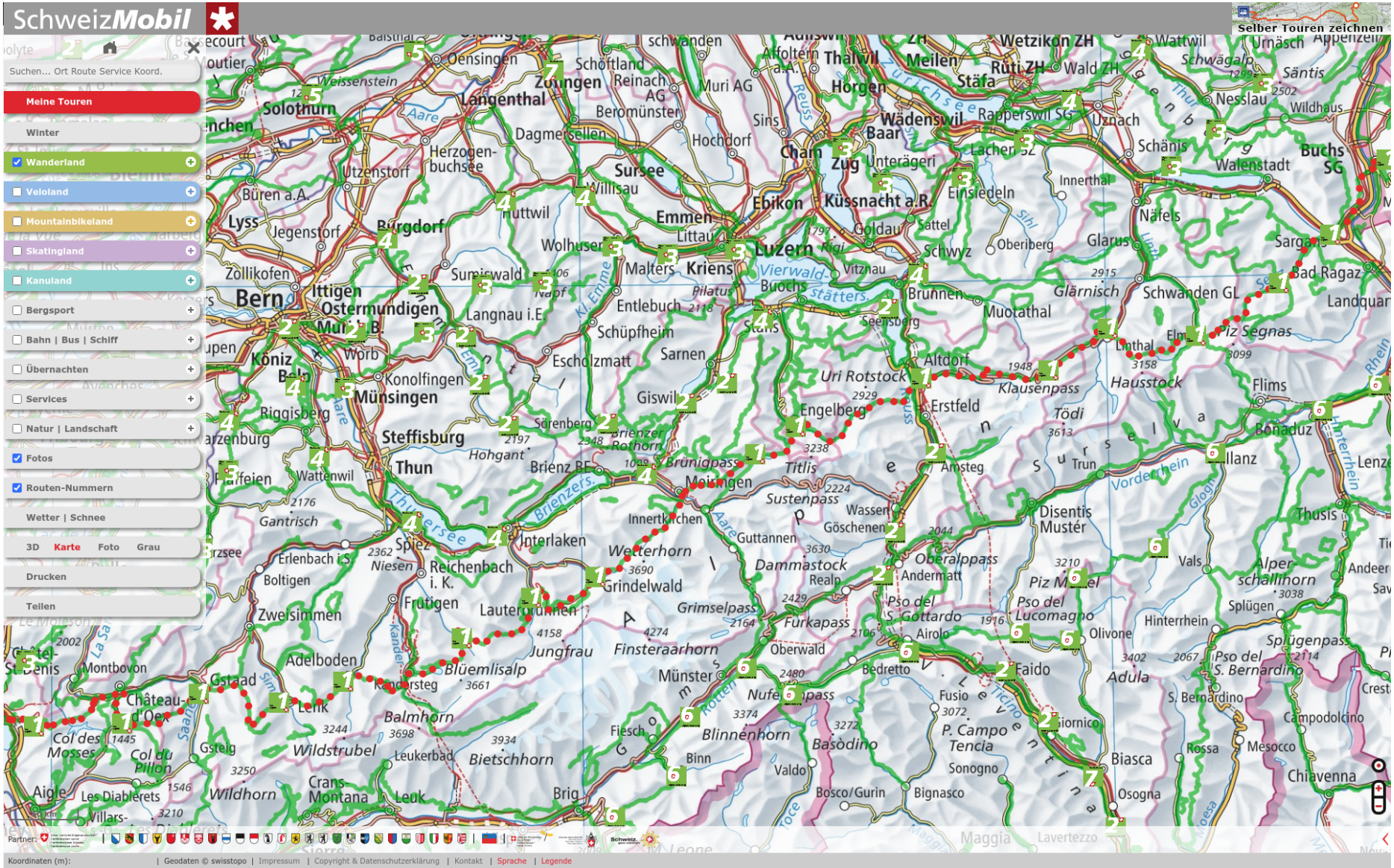
Why Do We Create Maps?

Types of Maps

General Reference Maps

- Show important physical features of an area
- Include natural and man-made features
- Usually meant to help aid in the navigation or discovery of locations
- Usually fairly simple
- Can be stylized based on the intended audience (tourists vs locals)



Source: https://map.schweizmobil.ch/

Thematic Maps

- Focuses on a specific theme or subject area
- Features on the map represent the phenomenon being mapped
- Spatial features used for reference

Distribution Map

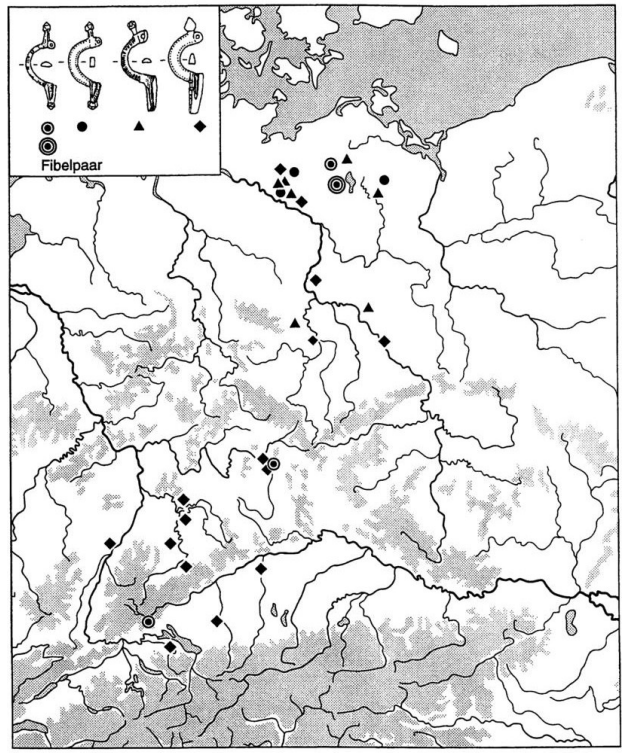


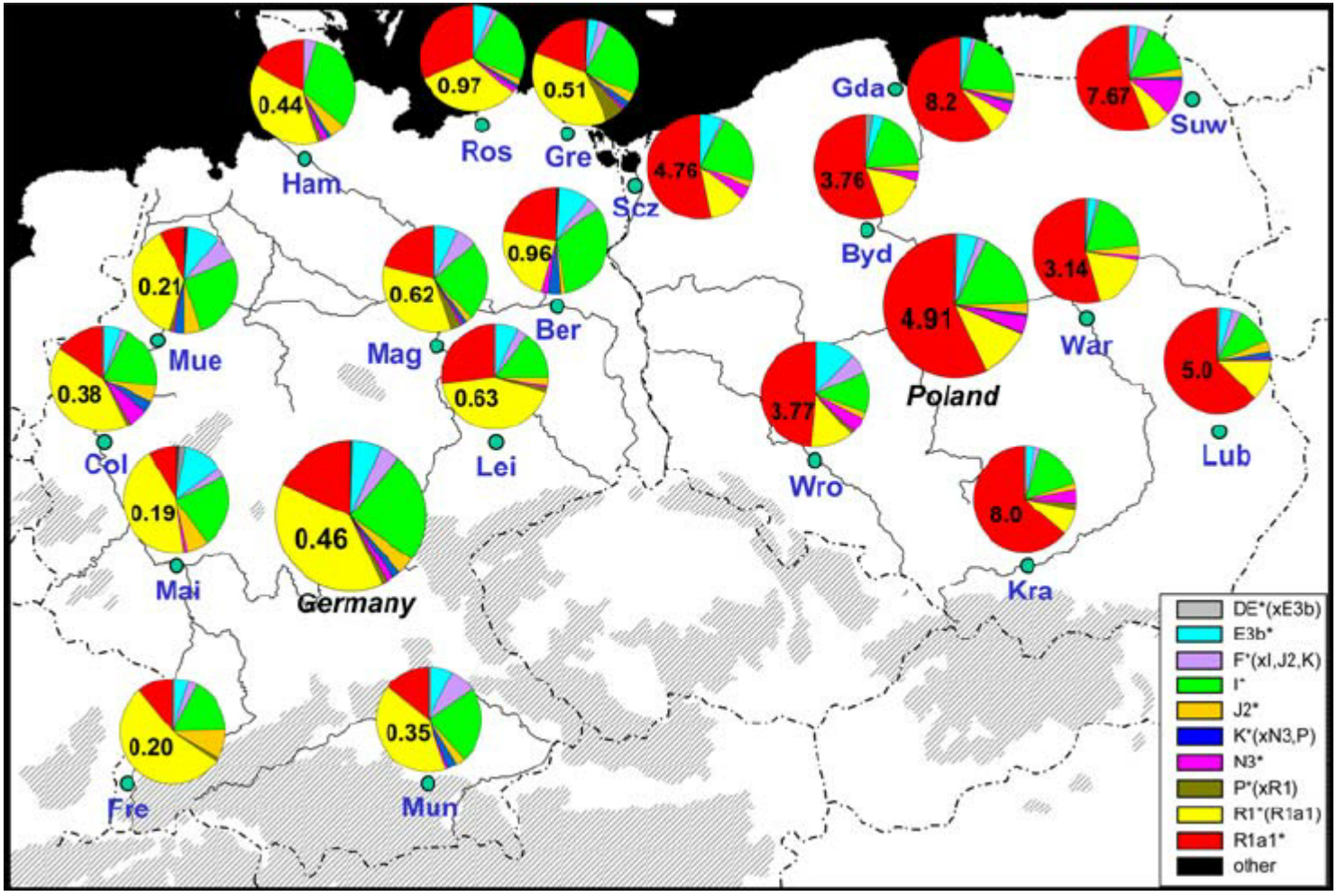
Abbildung 6. Verbreitungskarte der Bügelknopffibeln. Punktkreis: Typ Leipferdingen; Kreis: Typ Groß Nemerow; Dreieck: weitere Fibeln mit gestieltem Bügelknopf; Rhombus: Typ Leutkirch (nach Voß 1993, 174 Karte Abb. 27 mit Ergänzung).

Source: Steuer 1998

"Cultural" Map

Terberger et al. 2014

"Genetic" Map



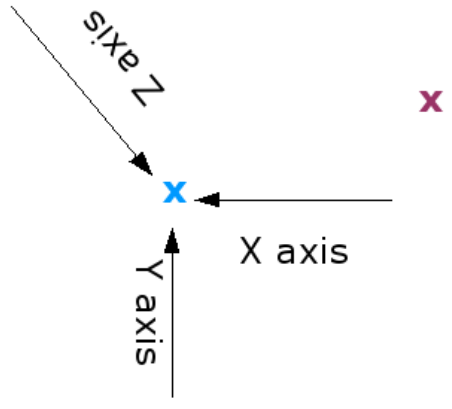
Kayser et al. 2005

Basic Map Elements

Points

Vector Point Feature

Point Geometry (indicates the x,y and z position of the feature)



Point attributes (describe the feature)

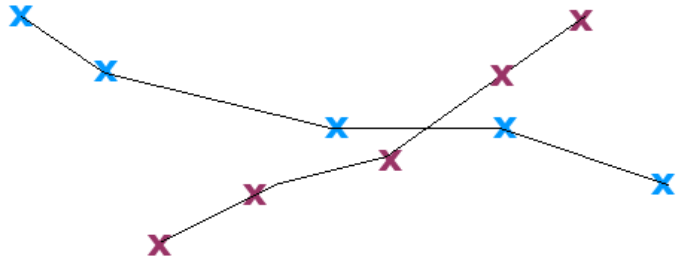
Id, Name, Description
1, Tree, Outside our classroom 2, Light post, At the school entrance

http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/vector_data.html#overview

Lines

Vector Polyline Feature

Polyline Geometry (a series of connected vertices that do not form an enclosed shape)



Polyline attributes (describe the feature)

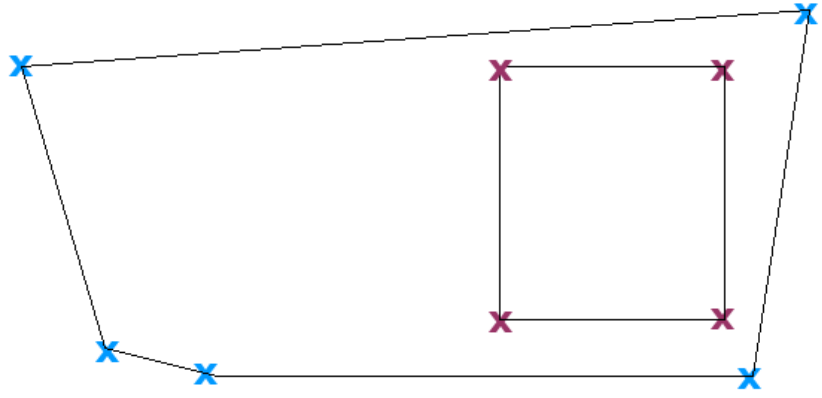
Id, Name, Description
1, Footpath 1, From class to the playground 2, Footpath 2, From the school gate to the hall

http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/vector_data.html#overview

Polygons

Vector Polygon Feature

Polygon Geometry (a series of connected vertices that do form an enclosed shape)



Polygon attributes (describe the feature)

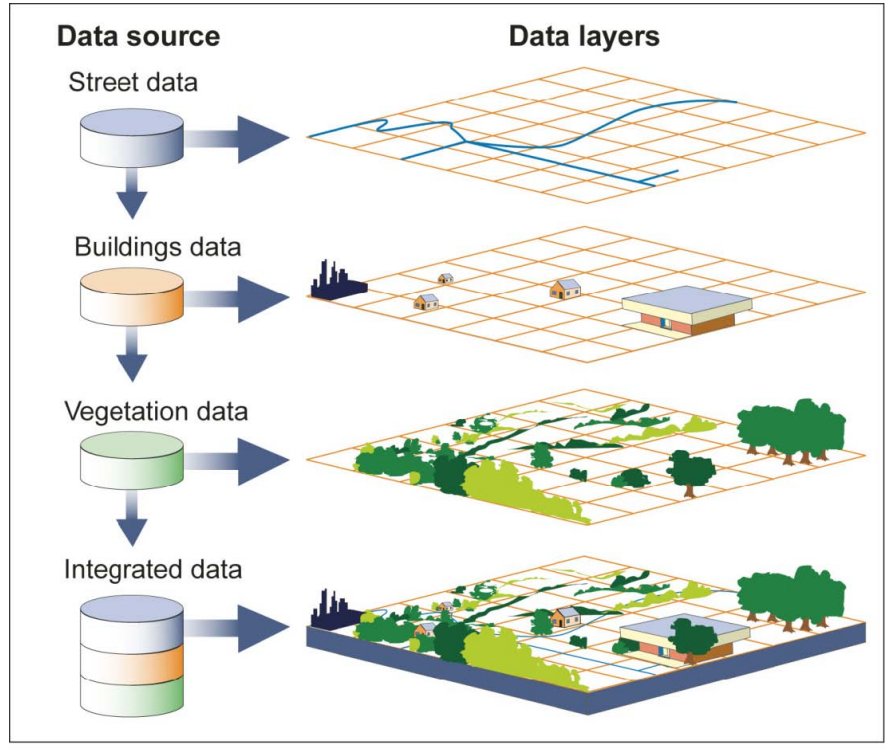
Id, Name, Description
1, School Boundary, Fenceline for the school 2, Sports Field, We play soccer here

http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/vector_data.html#overview

How do we make maps?

GIS [1]

> A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. - Wikipedia



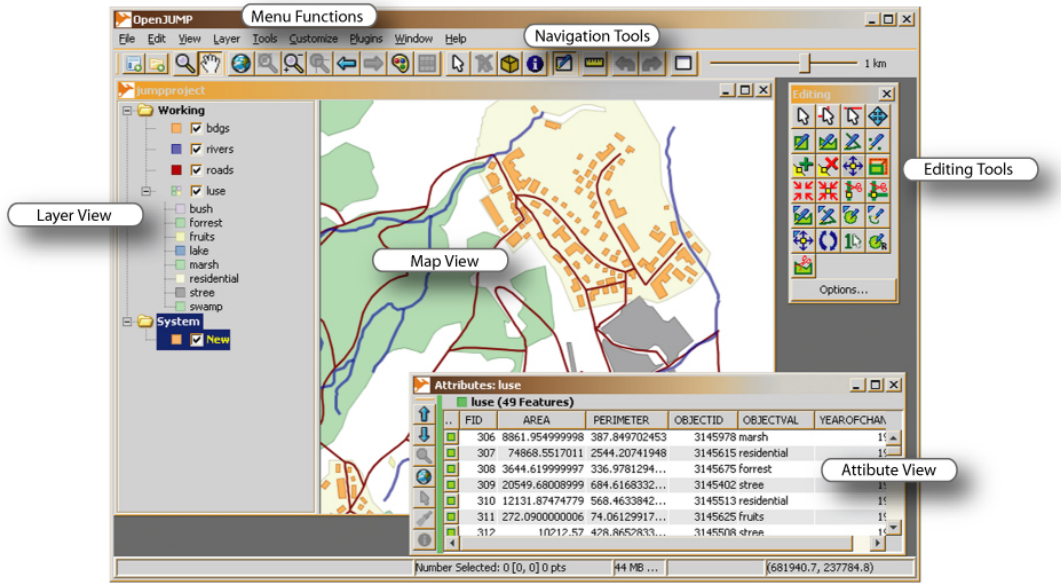
Source: GAO.

Or more simply

> In a GIS, you connect ***data*** with ***geography***. GISgeography.com

Geographic Information Systems (GIS)

- Create interactive queries (user-created searches)
- Analyze spatial information
- Edit data in maps
- Present the results of all these operations



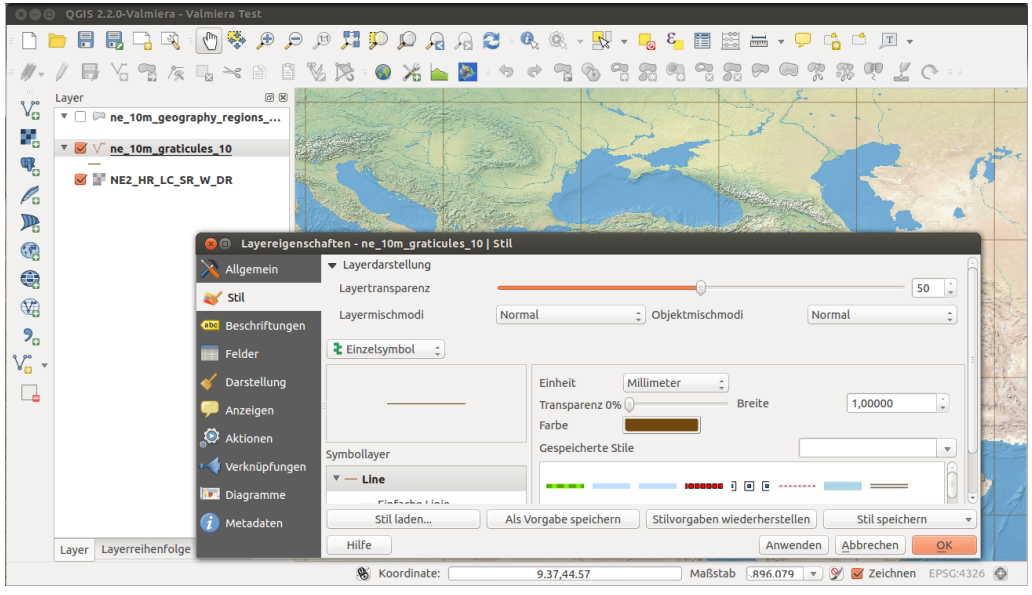
What can we do with a GIS?

GIS is relevant

It might become your job, or at least an important part of it...

QGIS

- a free and open source GIS software
- https://www.qgis.org/
- If you not have already installed QGIS, please do now!



Layers

Layers (Vector Data)

Basemap (Raster Data)

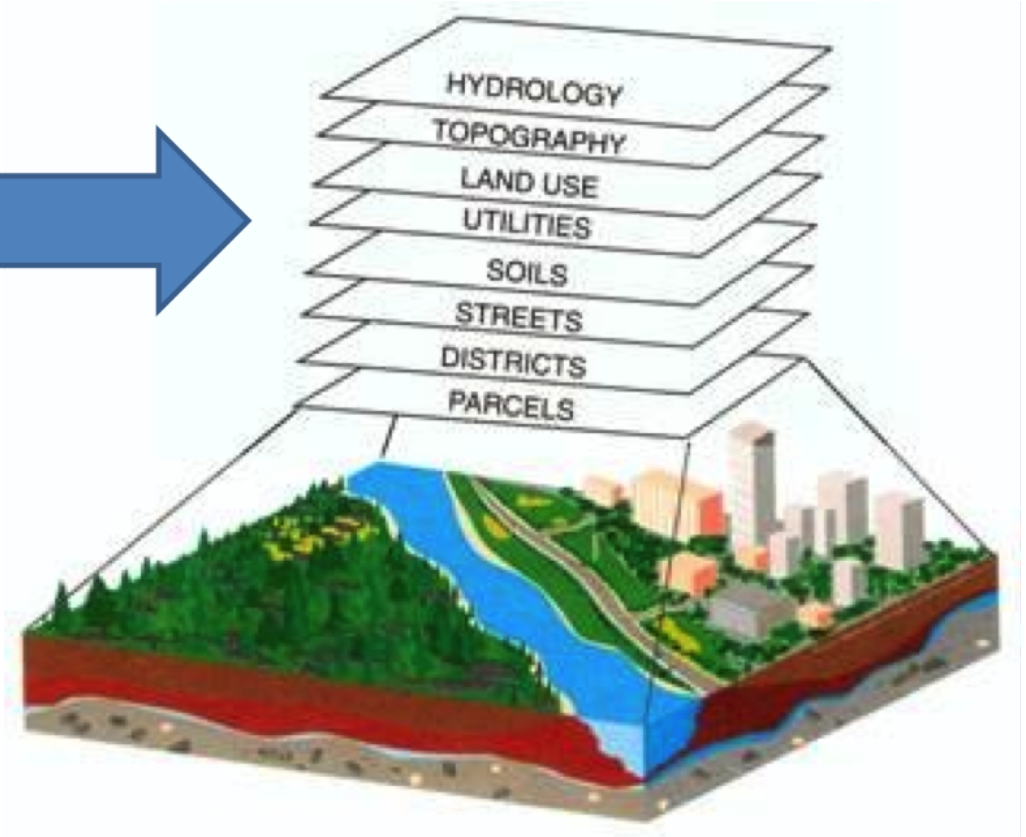
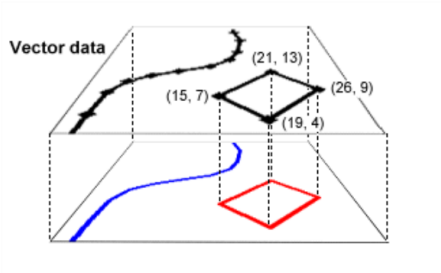
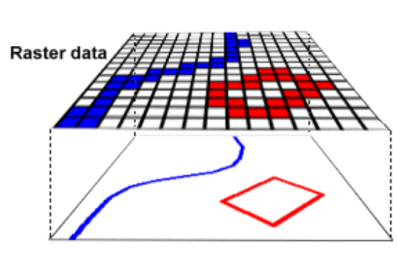
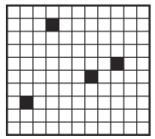
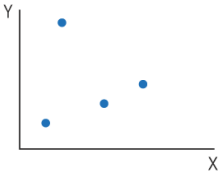
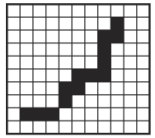
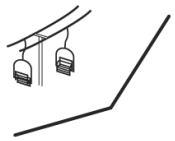
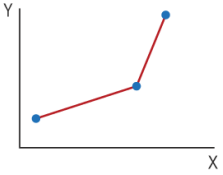
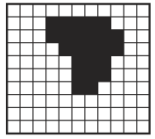
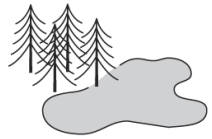
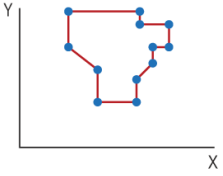


Image Source: http://www.geocontrolling.com/co-je-gis.htm

Raster vs. Vector





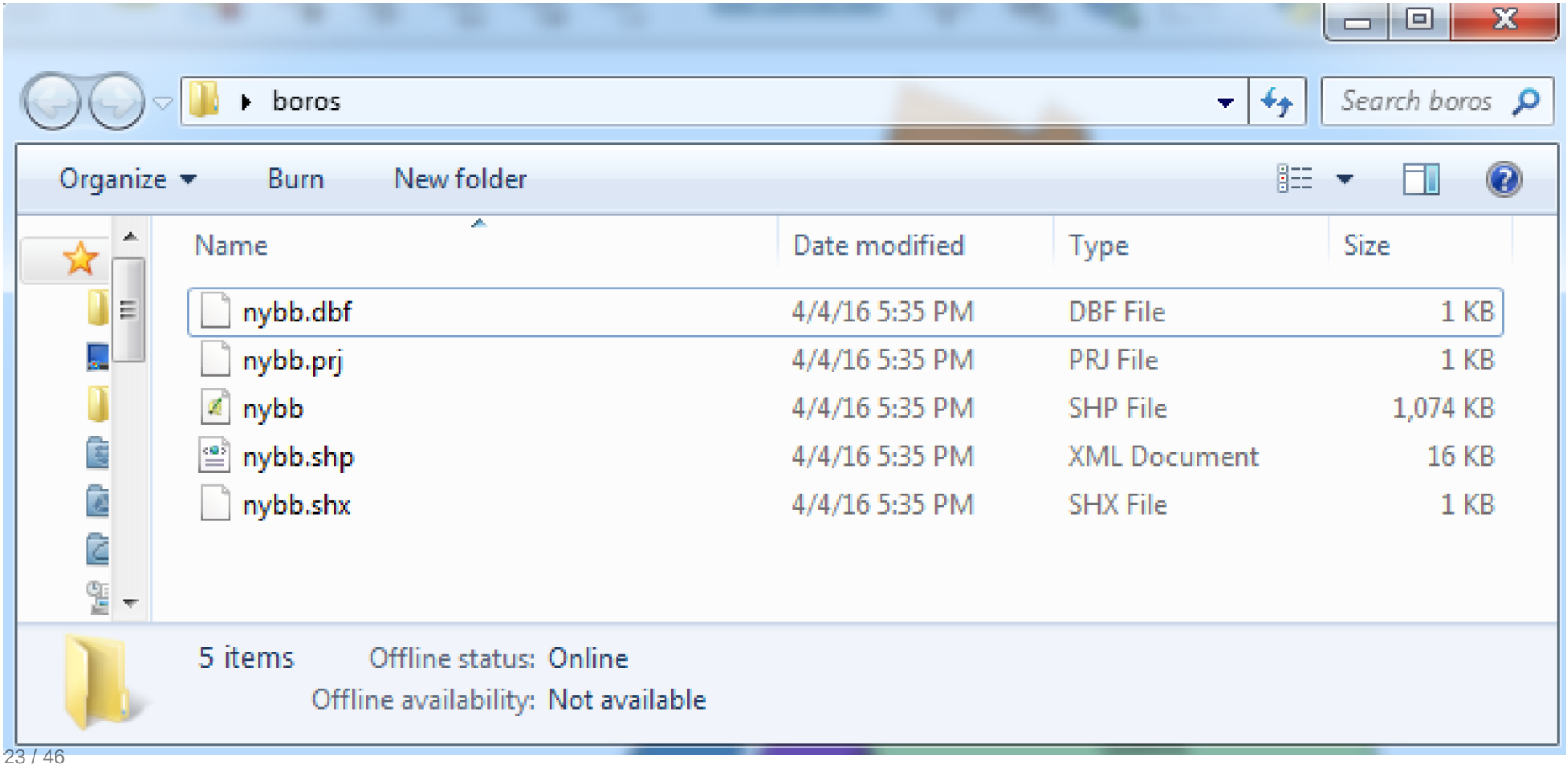
The raster view of the world	Happy Valley spatial entities	The vector view of the world
	 Points: hotels	
	 Lines: ski lifts	
	 Areas: forest	

Raster (files)

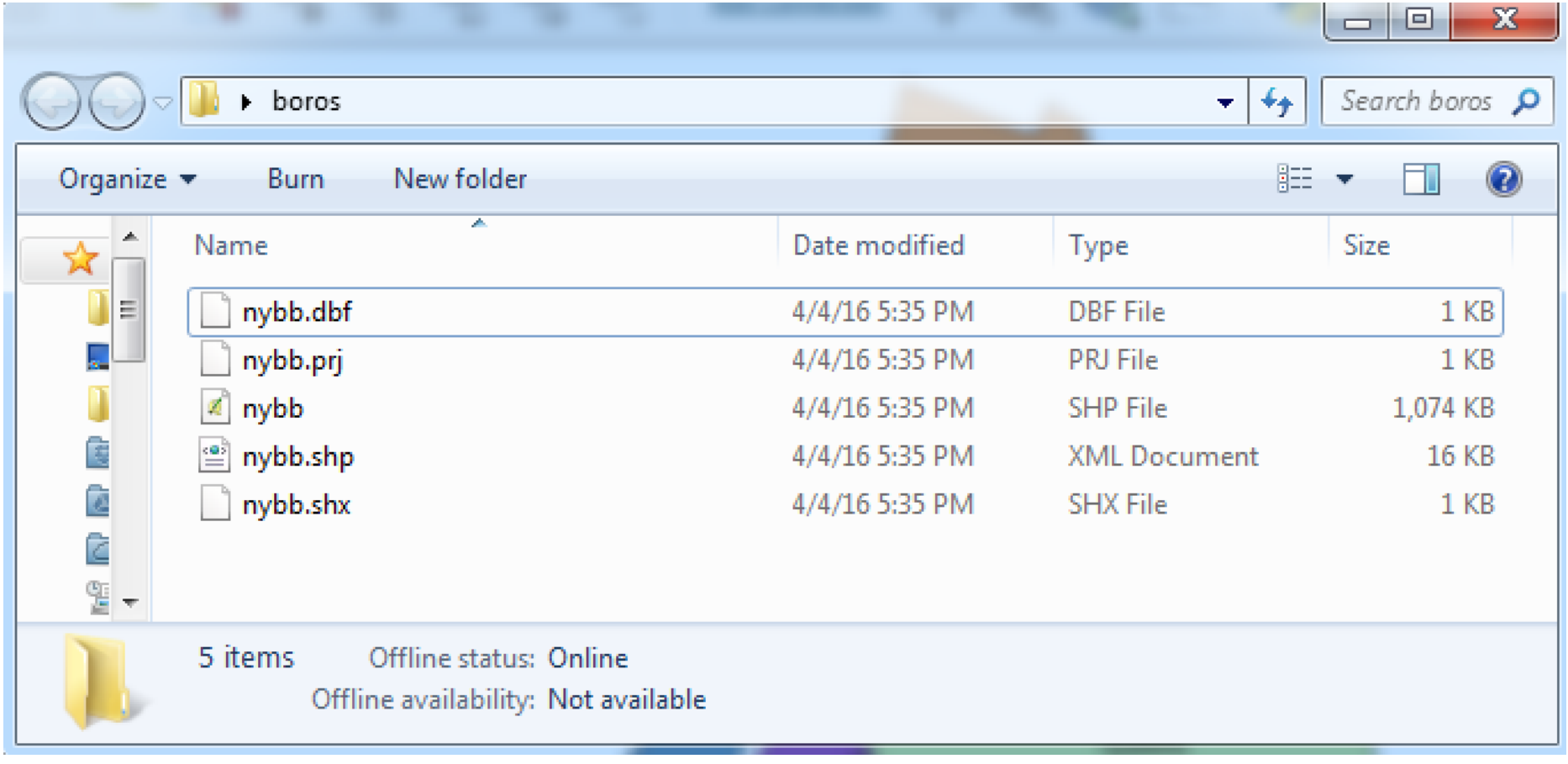
- essentially an image with geographic information, which is georefenced
- mostly used for background maps
- can also contain continouus spatial information (altitude, precipitation, site density, ...)
- Multiple formats are available (.img, .grid, .tiff, ...)
- GeoTiffs are a quasi standard

Shapefiles

- Basic file for storing map elements
- Stores spatial data, like points, lines, and polygons
- Multiple files comprise a "shapefile"

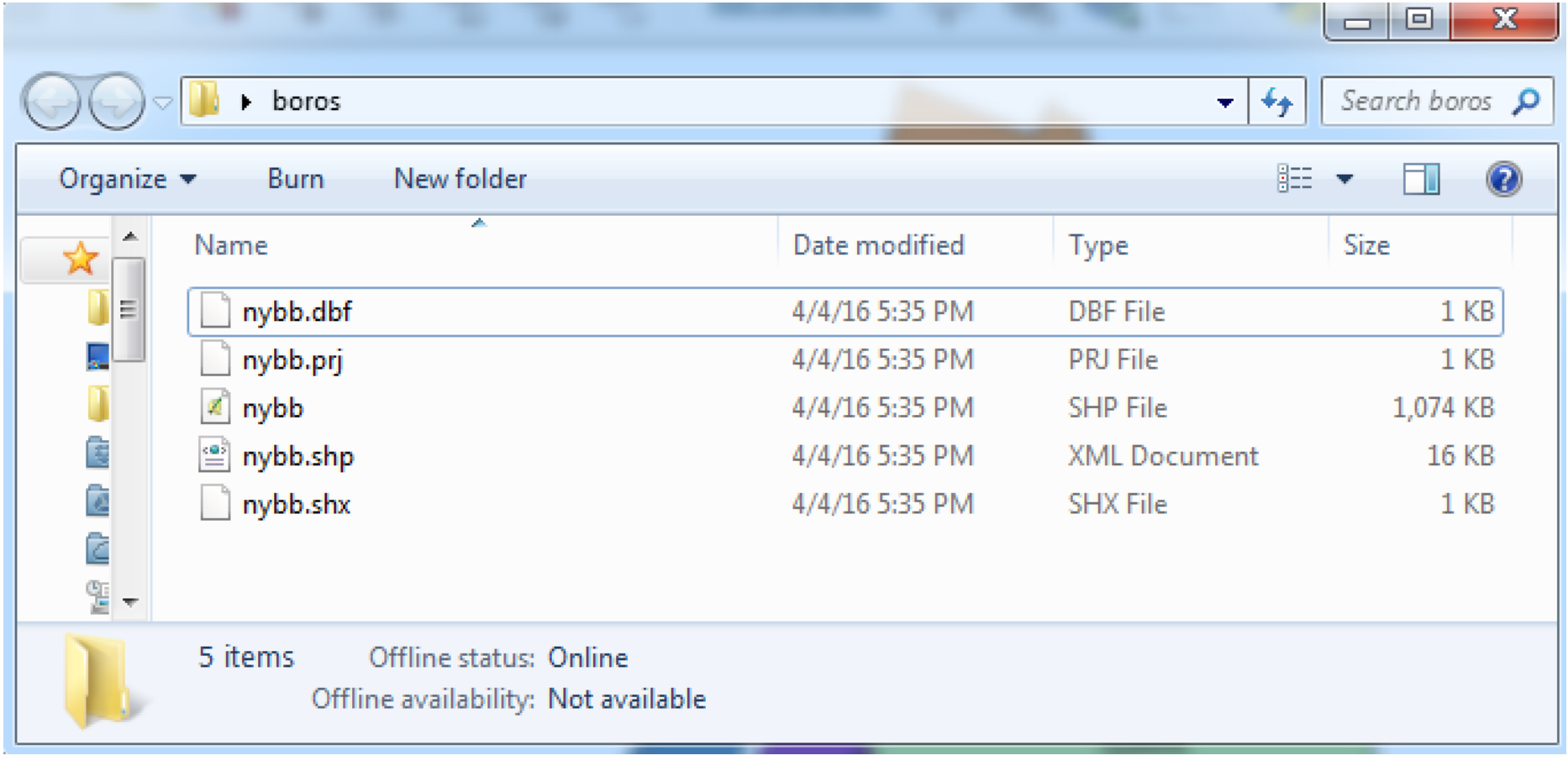


Shapefiles



- .shp—The main file that stores the feature geometry
- .dbf—The dBASE table that stores the attribute information of features

Shapefiles



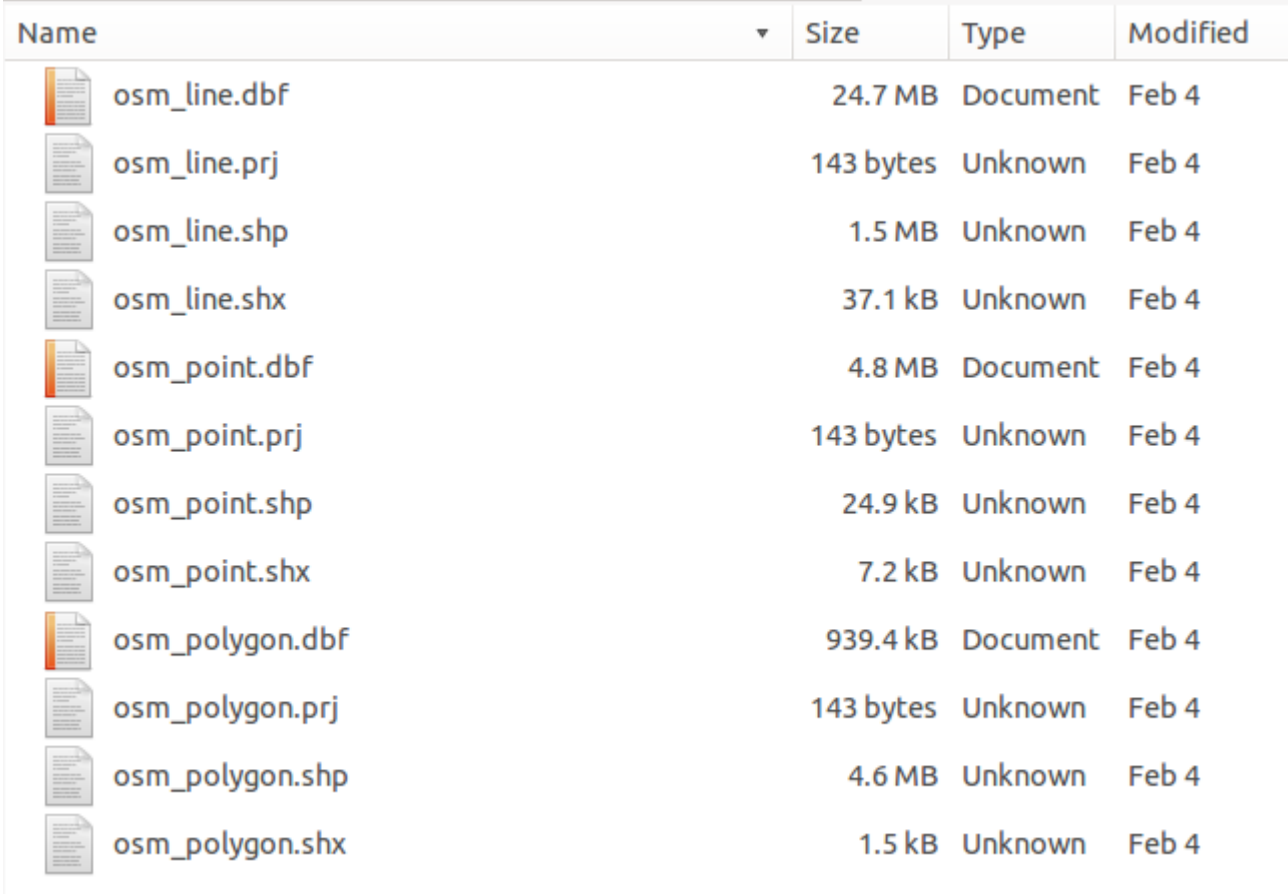
- .prj—The file that stores the coordinate system information
- .shx—The index file that stores the index of the feature geometry

You might also see

- .cpg—Identifies the character set to be used
- .sbn and .sbx—The files that store the spatial index of the features

Shapefiles

- Have a few limitations
- One geometry type (Point, Line, Polygon) per shapefile
- So sometimes you end up with this:



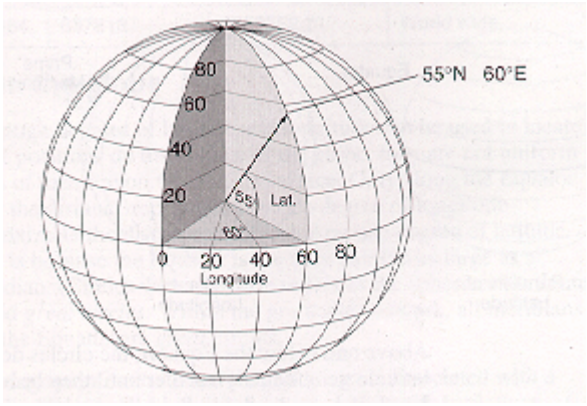
Name	Size	Type	Modified
osm_line.dbf	24.7 MB	Document	Feb 4
osm_line.prj	143 bytes	Unknown	Feb 4
osm_line.shp	1.5 MB	Unknown	Feb 4
osm_line.shx	37.1 kB	Unknown	Feb 4
osm_point.dbf	4.8 MB	Document	Feb 4
osm_point.prj	143 bytes	Unknown	Feb 4
osm_point.shp	24.9 kB	Unknown	Feb 4
osm_point.shx	7.2 kB	Unknown	Feb 4
osm_polygon.dbf	939.4 kB	Document	Feb 4
osm_polygon.prj	143 bytes	Unknown	Feb 4
osm_polygon.shp	4.6 MB	Unknown	Feb 4
osm_polygon.shx	1.5 kB	Unknown	Feb 4

Coordinates

Lat/long system measures angles on spherical surfaces

- 60º east of PM
- 55º north of equator
- Lat/long values are NOT Cartesian (X, Y) coordinates
- constant angular deviations do not have constant distance deviations
- 1° of longitude at the equator ≠ 1° of longitude near the poles

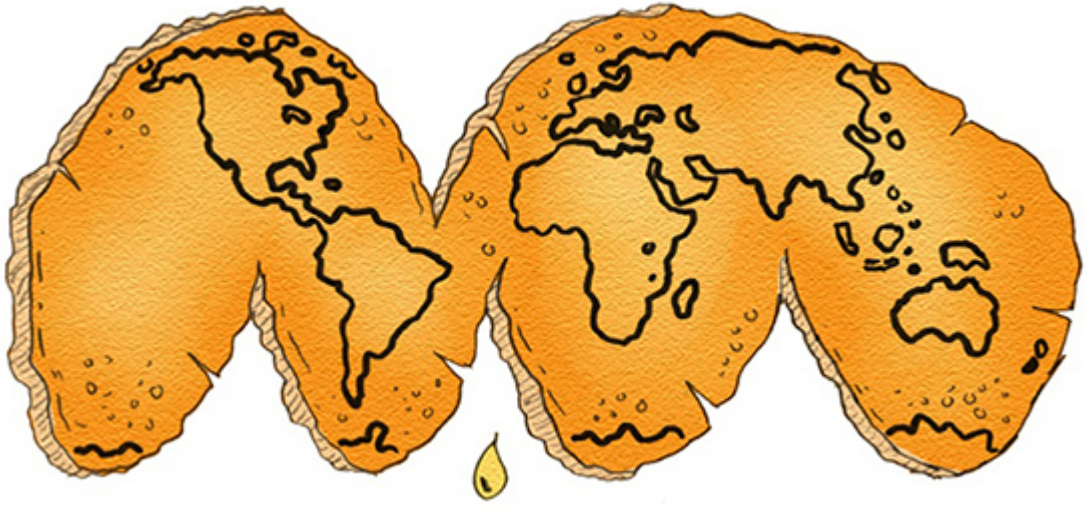
A basic Coordinate Reference System



So what is a Coordinate Reference System?

Projections

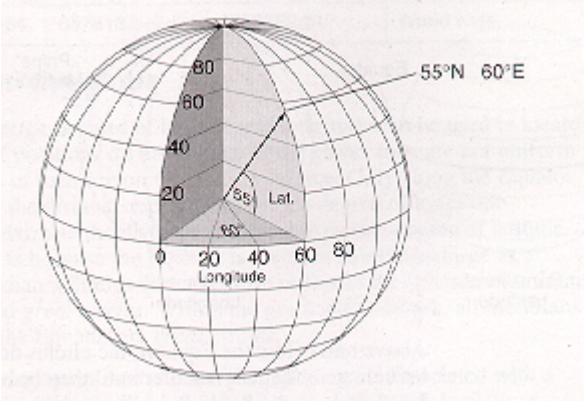
- No one's favorite part of GIS
- But a necessary part of it nonetheless
- Convert points on the 3-dimensional Earth (**latitude** and **longitude**) to x and y coordinates on a 2-dimensional map



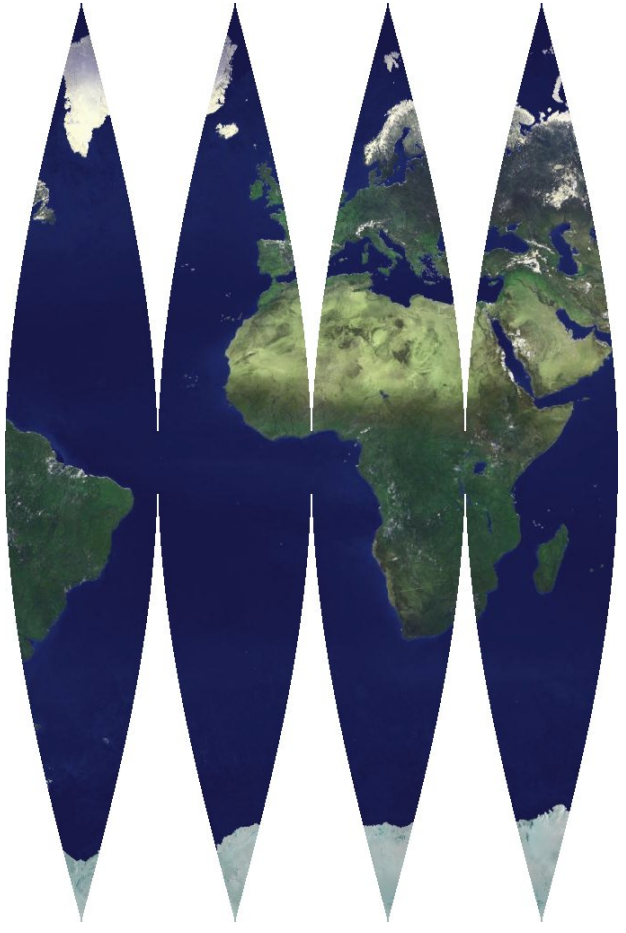
Digital Coast Geozone

Coordinate Reference Systems

- Features on spherical surfaces are not easy to measure
- Features on planes are easy to measure and calculate
  - distance
  - angle
  - area
- Coordinate systems provide a measurement framework

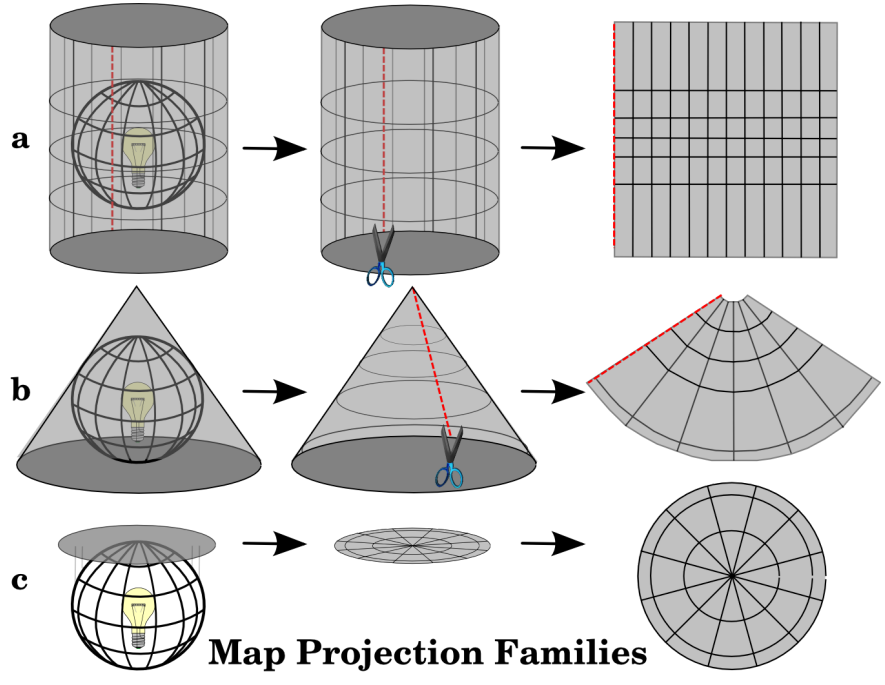


Coordinate Systems and Projection [1]



Coordinate Systems and Projection [2]

- an imaginary light is “projected” onto a “developable surface”
- a variety of different projection models exist
- Map projections always introduce error and distortion



Projections

- Every projection distorts some part of your map

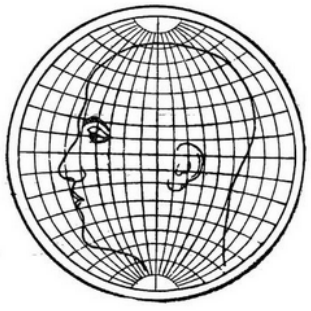


Fig. 42.—Man's head drawn on globular projection.

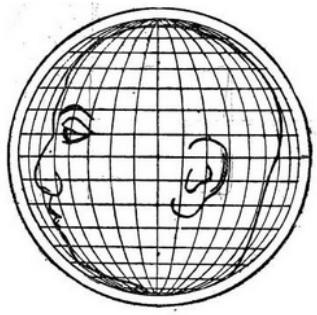


Fig. 43.—Man's head plotted on orthographic projection.

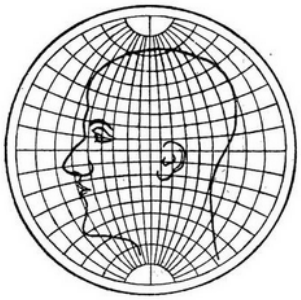


Fig. 44.—Man's head plotted on stereographic projection.

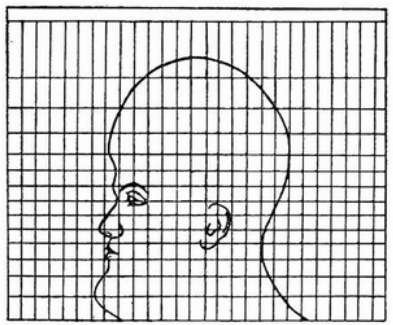
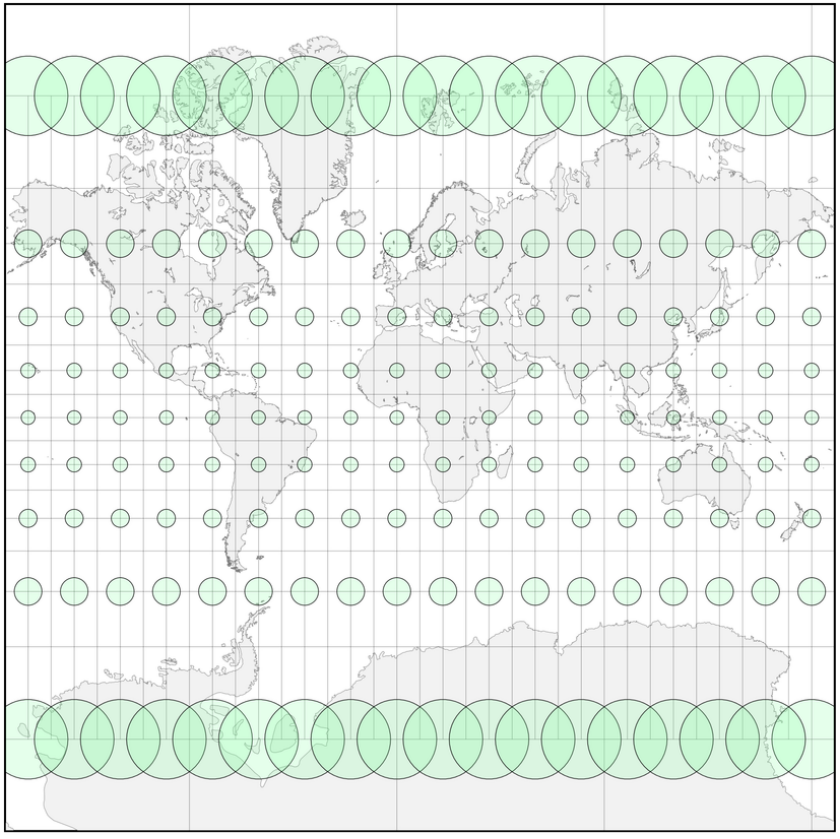


Fig. 45.—Man's head plotted on Mercator projection.

FlowingData

Projections Matter

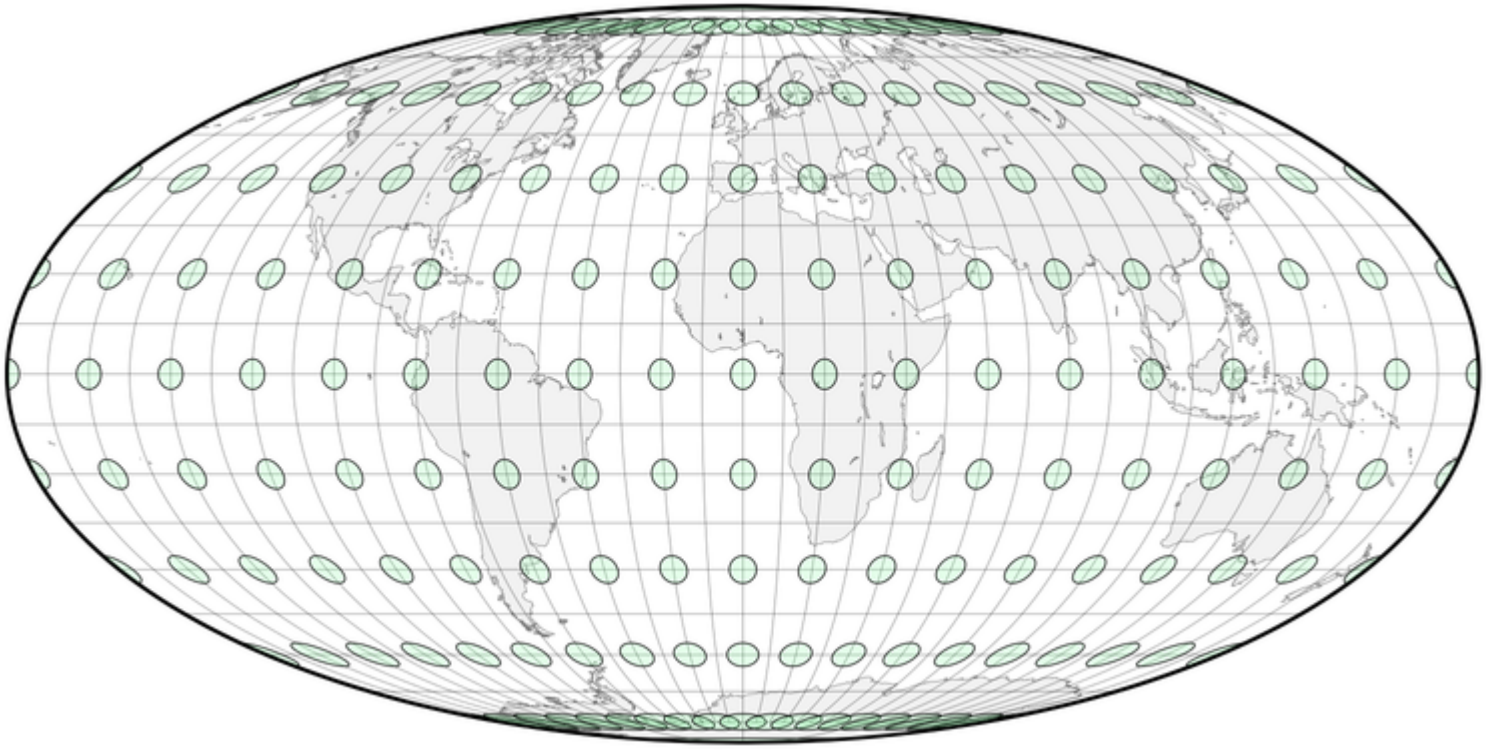
- These circles are all the same size on the globe:



Progonos

Projections Matter

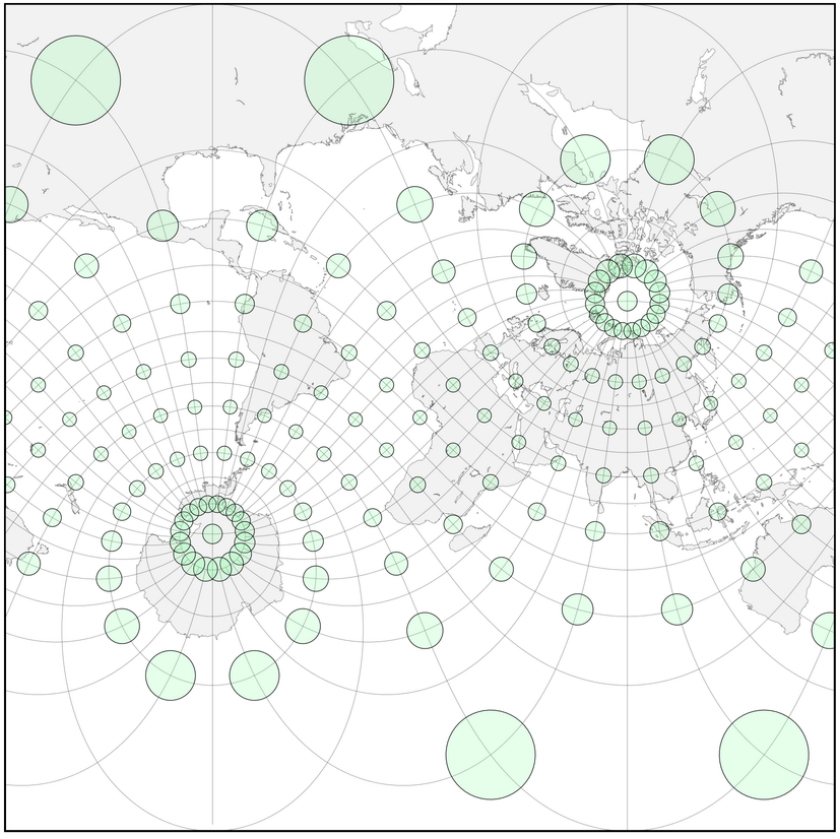
- As are these:



Progonos

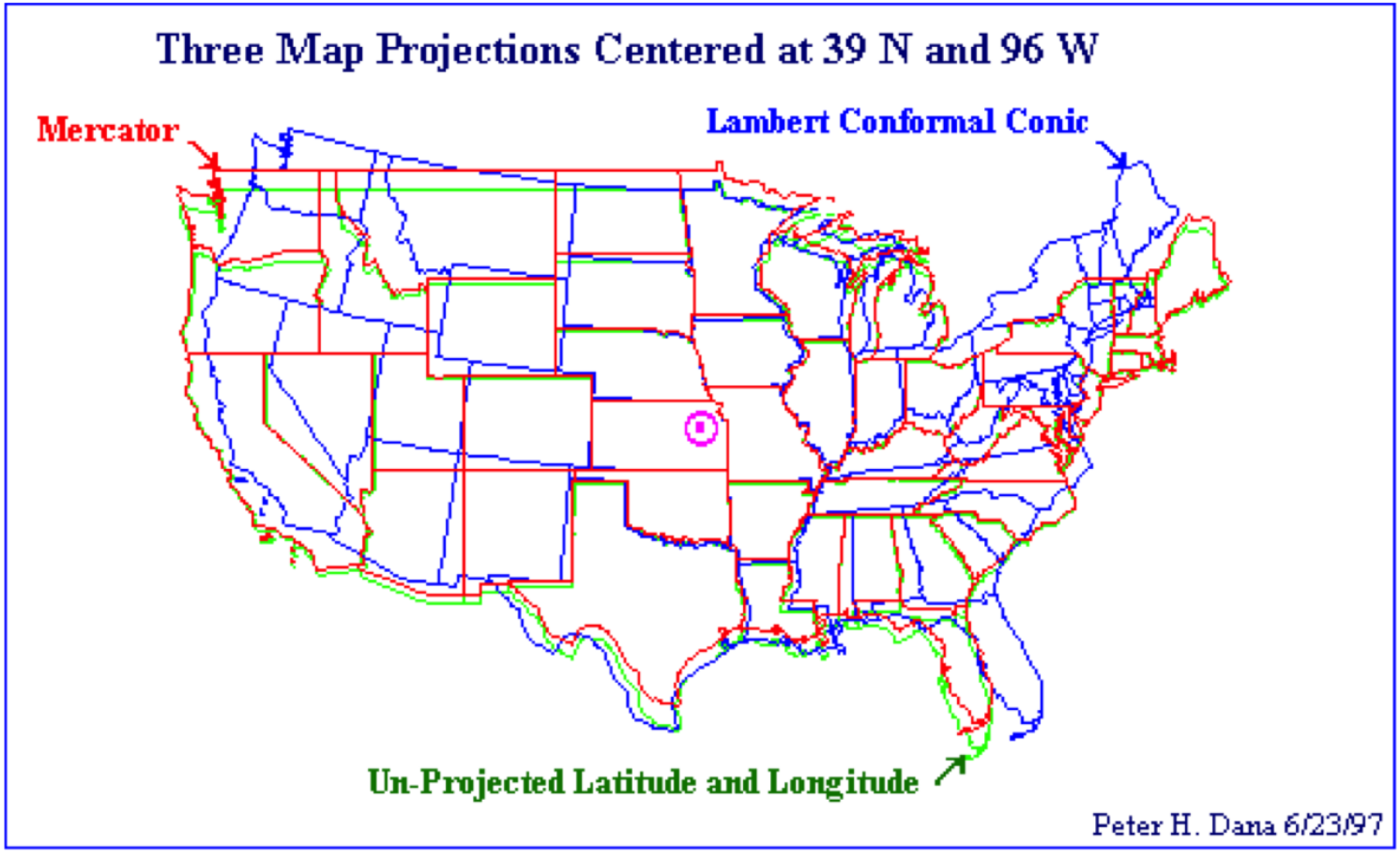
Projections Matter

- And these:



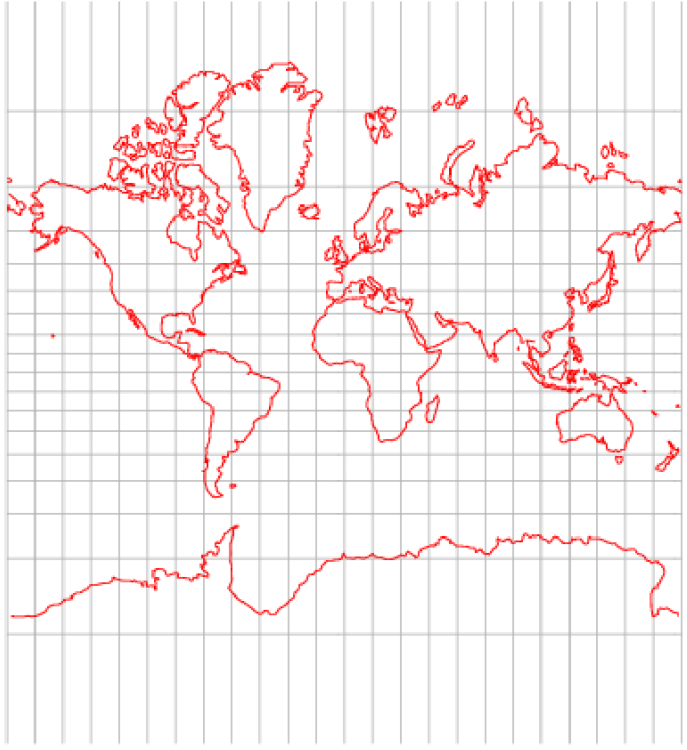
Progonos

Projections Matter



Mercator Projections

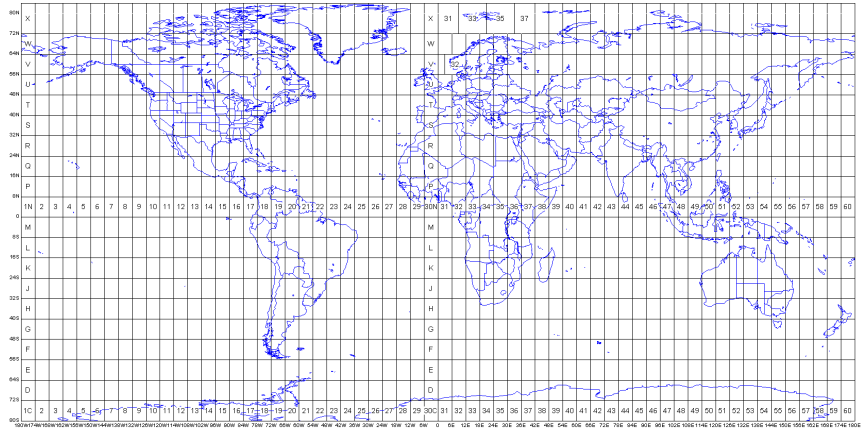
- A common map projection
- Makes geometries near poles look bigger than geometries near the equator



UTM

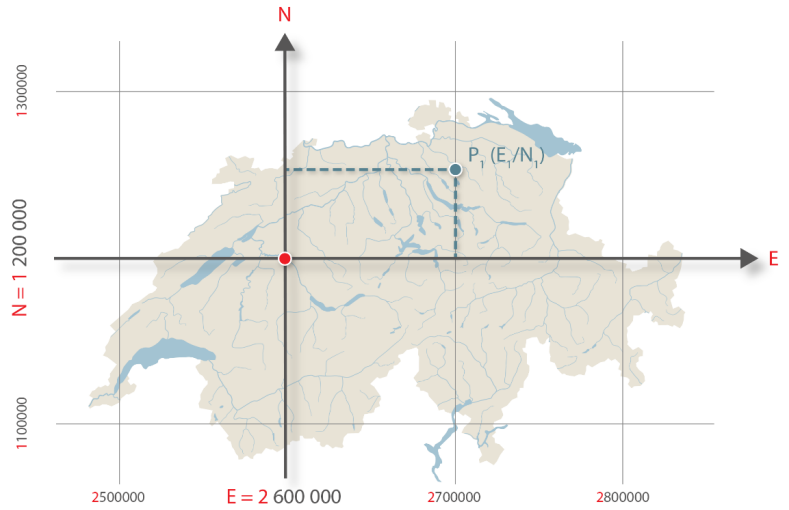
Universal Transverse Mercator (UTM)

- Based on the Transverse Mercator projection
- 60 zones (each 6° wide)
- false eastings
- Y-0 set at south pole or equator



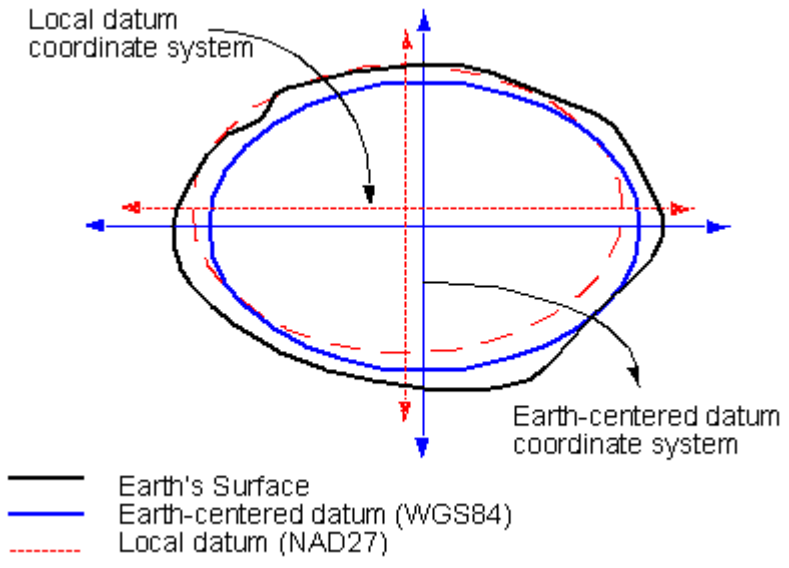
Schweizer Landeskoordinaten

- a geographic coordinate system used in Switzerland for maps and surveying by the Swiss Federal Office of Topography (Swisstopo)
- The map projection used is Oblique Mercator on an 1841 Bessel ellipsoid.
- All coordinates are always positive, since Switzerland is located in the 1st quadrant of the coordinate system.



Datums and Ellipsoids

- The earth is essentially a potatoe...
- Ellipsoids are geometric estimations of the shape of the earth with more or less accurary
- a datum is a system that allows us to place a coordinate system on the earth’s surface based on a specific ellipsoid
- examples:
  - WGS84 (Lat/Lng, UTM)
  - Bessel 1841 (Schweizer Landeskoordinaten)



Projections

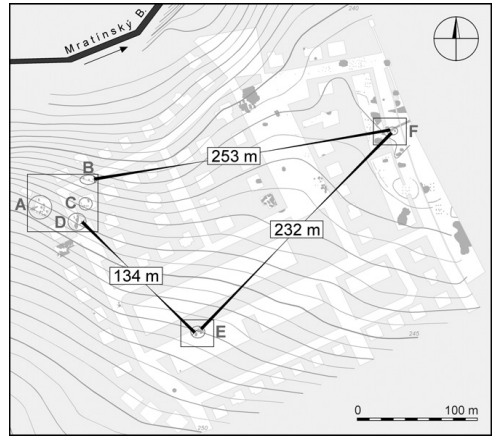
- Identified by unique IDs (**EPSG**) that make it easier to talk about them
- EPSG: European Petroleum Survey Group Geodesy (it was introduced, because Oil companies were annoyed by the incredible number of different systems)
- WGS 84 is referred to as **EPSG:4326**
- Google Maps and other online sources often uses WGS 84 / Pseudo-Mercator (**EPSG:3857**)
- CHTRS95 is referred to as **EPSG:2056**

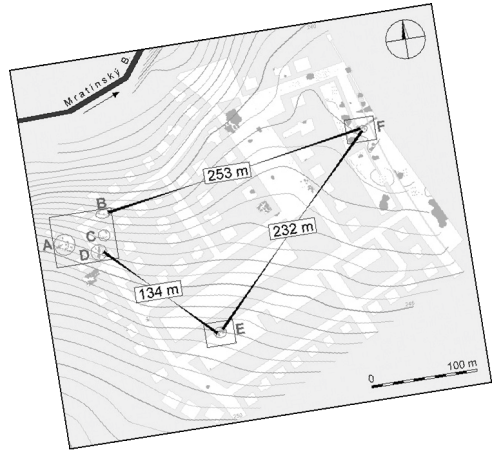
Remember these three and you should be set

Georeferencing

The process of orienting a image in geographical space

- Every map comes with its own projection. Sometimes known, more often not
- Every mapping results in errors or imprecision. Every digitalisation adds errors up to that.
- Scale matters: digitised information on large scale might be precise enough, on small scale not. It is necessary to keep meta-data to know how the data were digitised (on what scale) to be able to understand on what scale they might be used.



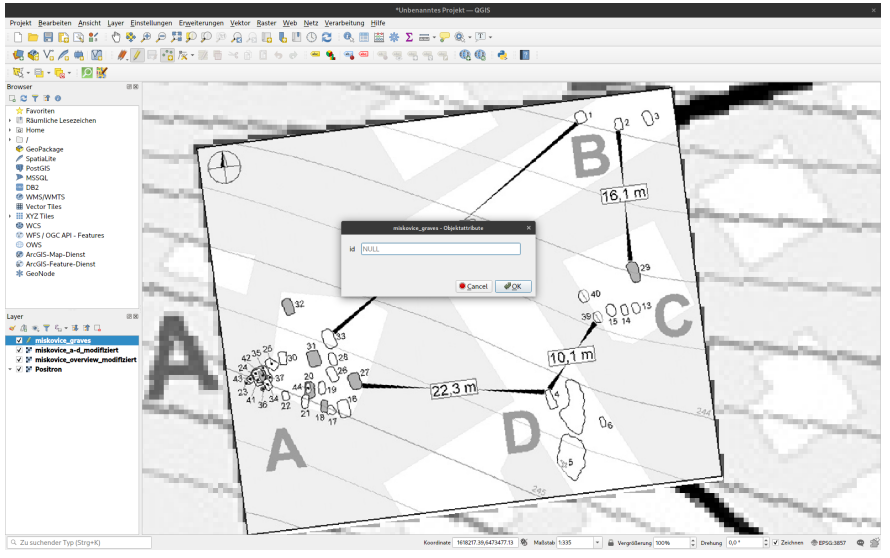


Digitising

The process of attaching geocoordinates to points on georeferenced maps

Rather straight forward:

- You have a layer of a certain geometry
- You make it editable
- You click on the feature of the scanned map
- You specify additional information for that point
- Rinse and repeat
- Finally, save the layer



Any questions?

You might find the course material (including the presentations) at

https://berncodalab.github.io/caa

You can contact me at

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- Steiniger 2009, Free and Open Source Desktop GIS Projects and Software
- Briggs 2019, GIS Fundamentals
- Leeds, Raster GIS
- Lawler/Schiess 2010, Projections and Coordinate Systems