

Big Data Ecology

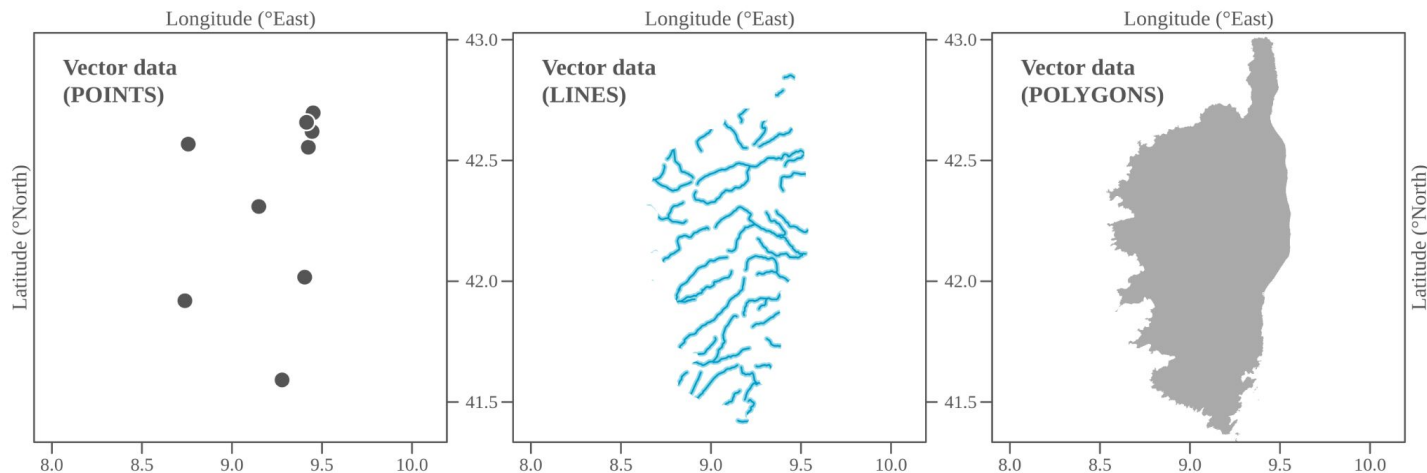
Spatial Data

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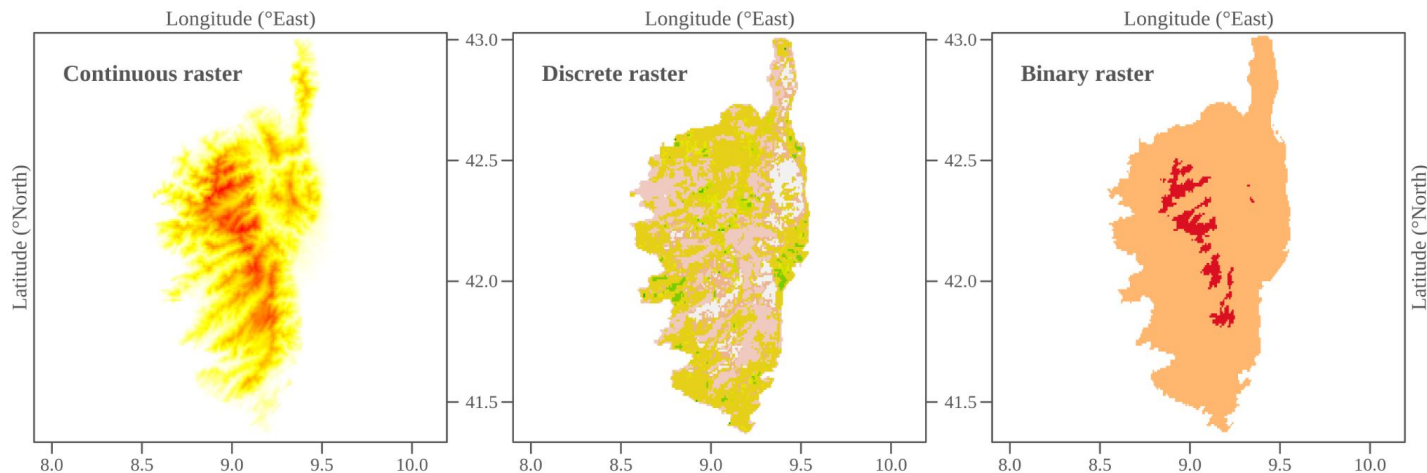
Vector data

- Spatial features defined by **vertices and paths**
- Attribute table may contain additional (non-spatial) information
- Vector data types:



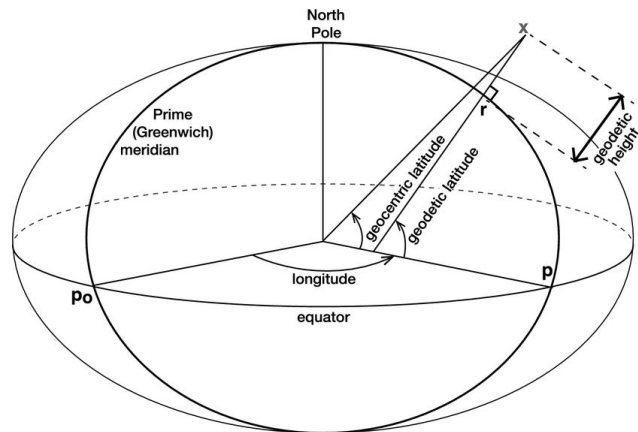
Raster data

- Continuous spatial surfaces defined by a matrix/grid of values
- Spatial extent and resolution
- Raster value types:



Coordinate Systems

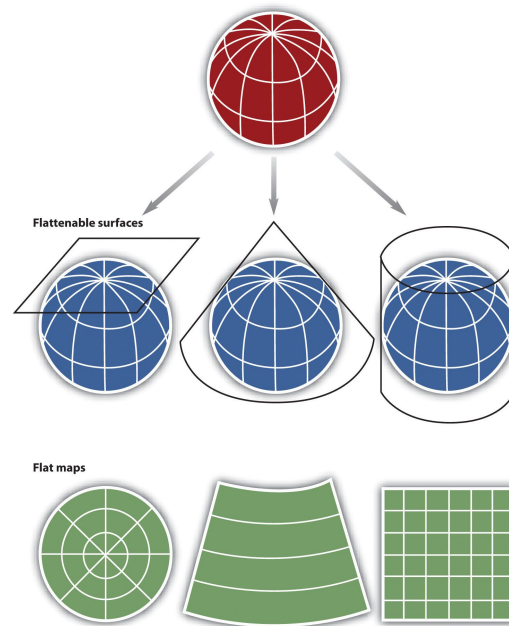
- **Ellipse:** Mathematical representation of the Earth as a geometrical object (radius, flattening).
- **Datum:** Defines the position of the origin, the scale, and the orientation of the coordinate system relative to the Earth
- Coordinates can be expressed in angular units relative to the equator and prime meridian of the reference ellipsoid



Source: Gregory et al. (2019) 10.1007/s10712-019-09525-z

Projections

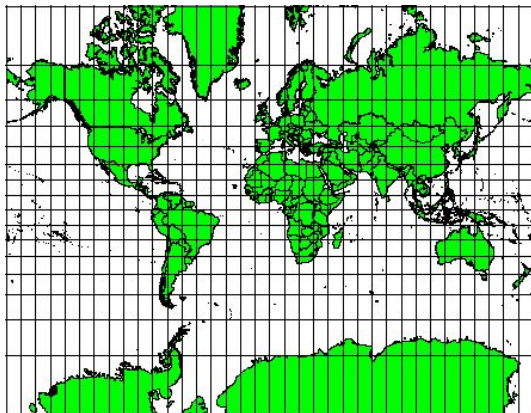
- Projections map the coordinates from a 3D surface (as defined by the ellipsoid and reference datum) to a 2D plane
- Different families: azimuthal, conical, cylindrical
- Projections may preserve direction, area, or distances, but **never all of them!**
- The true size of geographical entities may be not what you think it is



Source:
<https://www.blendspace.com/lessons/p45LnYc6Gx13DA/location-map-projections-and-types>

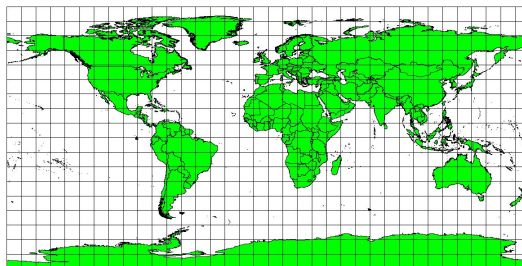
Projections

Conformal
preserves angles



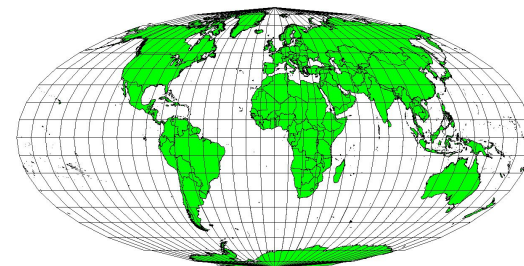
Mercator projection

Equidistant
preserves distances



*Plate Carrée equidistant
cylindrical projection*

Equal area
preserves area



*Mollweide equal area cylindrical
projection*

Coordinate Reference Systems (CRS)

- The coordinate reference system holds all information relevant to represent geospatial data: reference ellipsoid, datum and projection
- Different standards defining the CRS, e.g.:
 - [EPSG code](#): four to five digit numeric code for widely used CRS's, e.g. 4326 for lon/lat on WGS84 ellipsoid
 - [Proj4 String](#): explicit definition of the CRS, e.g. ``+proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs'` lon/lat on WGS84 ellipsoid
 - [WKT2](#): more modern and structured definition of the CRS, see e.g. [here](#) for the WKT2 definition of lon/lat on WGS84 ellipsoid

Spatial Data in R

- Rich ecosystem of spatial R-packages
- Vector Data:
 - [sp](#) - “classical” framework for spatial data in R
 - [sf](#) - modern implementation of simple features, supports `dplyr` syntax
- Raster Data:
 - [raster](#) - powerful, most widely used R-package for raster data manipulation
 - [stars](#) - recent project with focus on multidimensional arrays and integration with `sf`
- There are [countless packages](#) for more specialized geospatial applications in R, e.g. for advanced data I/O, cartography, geostatistics, visualization, and more

```
## Simple feature collection with 100 features and 6 fields
## geometry type: MULTIPOLYGON
## dimension: XY
## bbox: xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
## epsg (SRID): 4267
## proj4string: +proj=longlat +datum=NAD27 +no_defs
## precision: double (default; no precision model)
## First 3 features:
##   BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79 geom
## 1  1091    1      10  1364    0      19 MULTIPOLYGON((( -81.47275543...
## 2   487    0      10   542    3      12 MULTIPOLYGON((( -81.23989105...
## 3  3188    5      208  3616    6     260 MULTIPOLYGON((( -80.45634460...
```

Simple feature

Simple feature geometry list-column (sfc)

Simple feature geometry (sfg)

Attribute data operations

- Manipulate spatial (vector) data based on their attributes in much the same way as non-spatial data, e.g.:
 - **Join** information based on shared attributes/columns
 - **Subset** the dataset based on column values
 - **Select** or remove specific attributes/columns
 - **Aggregate** features based on their attributes/columns
 - ...

Spatial data operations - vectors

- Manipulate spatial (vector) data based on their spatial characteristics and relationships, rather than their attributes, e.g.:
 - **Join** information from different features based on their shared position
 - **Subset** the dataset based on topological relations with other features (e.g. intersection, adjacency)
 - **Aggregate** features based on their spatial grouping
 - ...

Spatial data operations - rasters

- Manipulate spatial raster data, e.g.:
 - **Subset** raster based on cell-IDs
 - use efficient **map algebra** algorithms, e.g. to perform arithmetic operations with multiple raster, reclassify values, calculate summary statistics or apply moving window approaches
 - **Merge** overlapping or neighbouring rasters

Geometry operations

- Manipulation of spatial data based on their geometry, not their attributes/data, e.g.:
 - **Dissolve** boundaries of neighbouring polygon features
 - **Crop** spatial data to a different extent or clip it by another polygon features
 - **Buffer** vector data or calculate their **centroid**
 - **Aggregate** or **Disaggregate** raster data to a different resolution
 - **Extract** raster values for a given set of vector features

Practical

Work through the R practical `spatial_data.Rmd`
(30 min)

Further readings

E-Books and tutorials:

https://saylordotorg.github.io/text_essentials-of-geographic-information-systems/index.html

https://docs.qgis.org/3.16/en/docs/gentle_gis_introduction

<https://geocompr.robinlovelace.net/>

<https://r-spatial.github.io/sf/>

Overview of spatial packages in R:

<https://cran.r-project.org/web/views/Spatial.html>

Coordinate Reference Systems:

<https://www.nceas.ucsb.edu/sites/default/files/2020-04/OverviewCoordinateReferenceSystems.pdf>

Cheatsheets:

<https://github.com/rstudio/cheatsheets/blob/master/sf.pdf>

<https://www.maths.lancs.ac.uk/~rowlings/Teaching/UseR2012/cheatsheet.html>