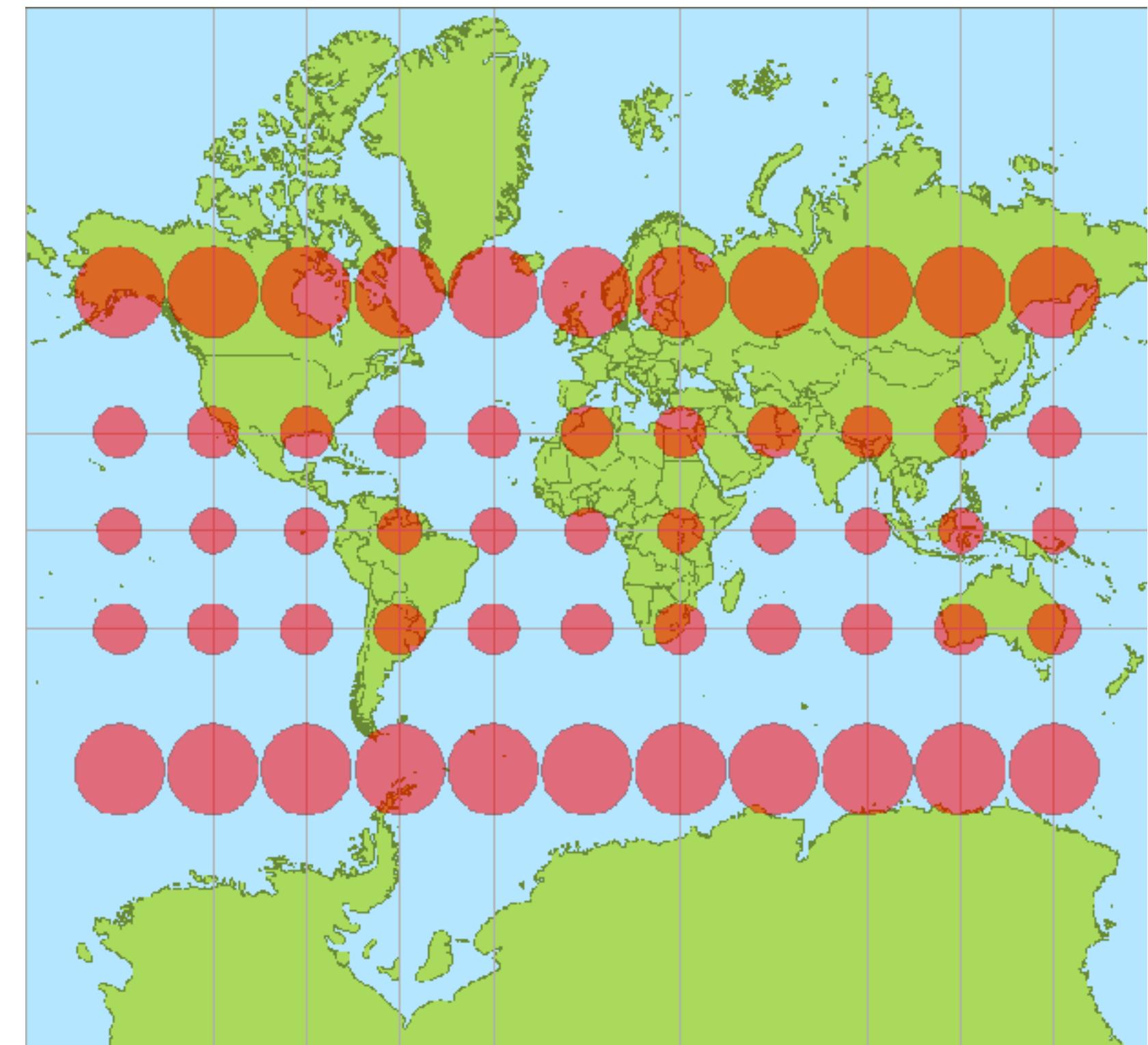


Lecture 2: Vector Data & Map Projections

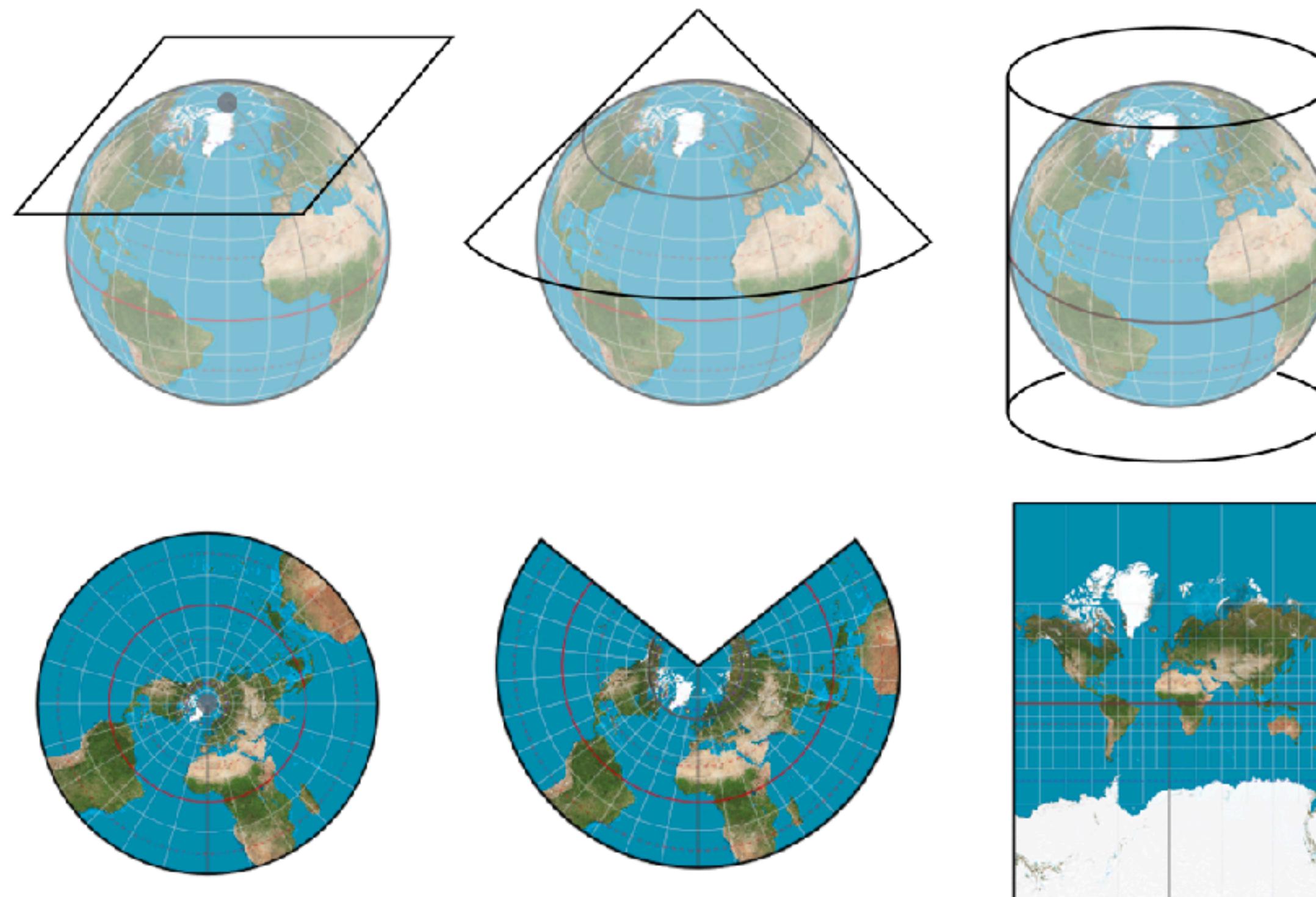
Instructor: Ane Rahbek Vierø

Feb 6, 2023

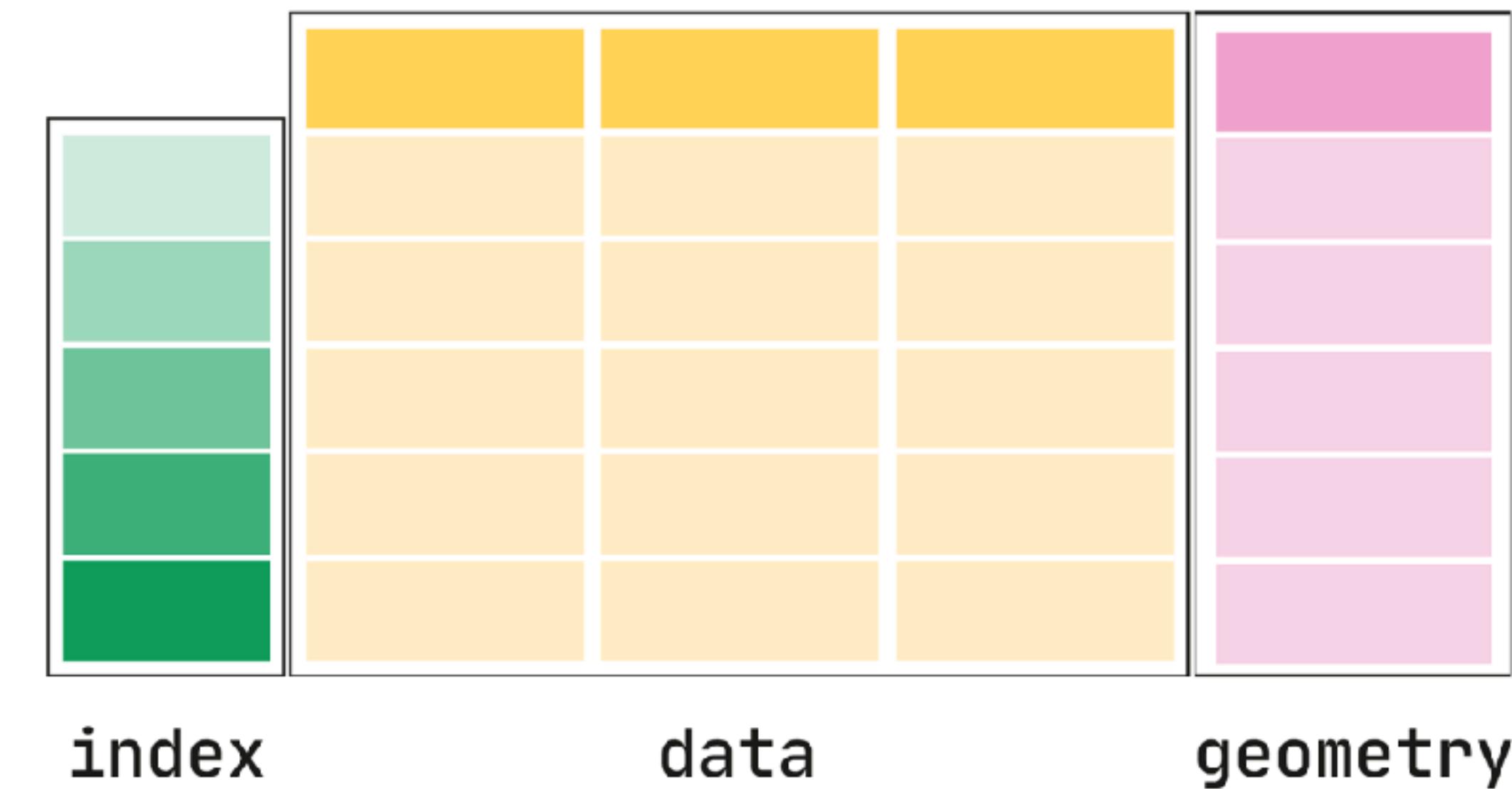


Today you will learn about....

Coordinate reference systems

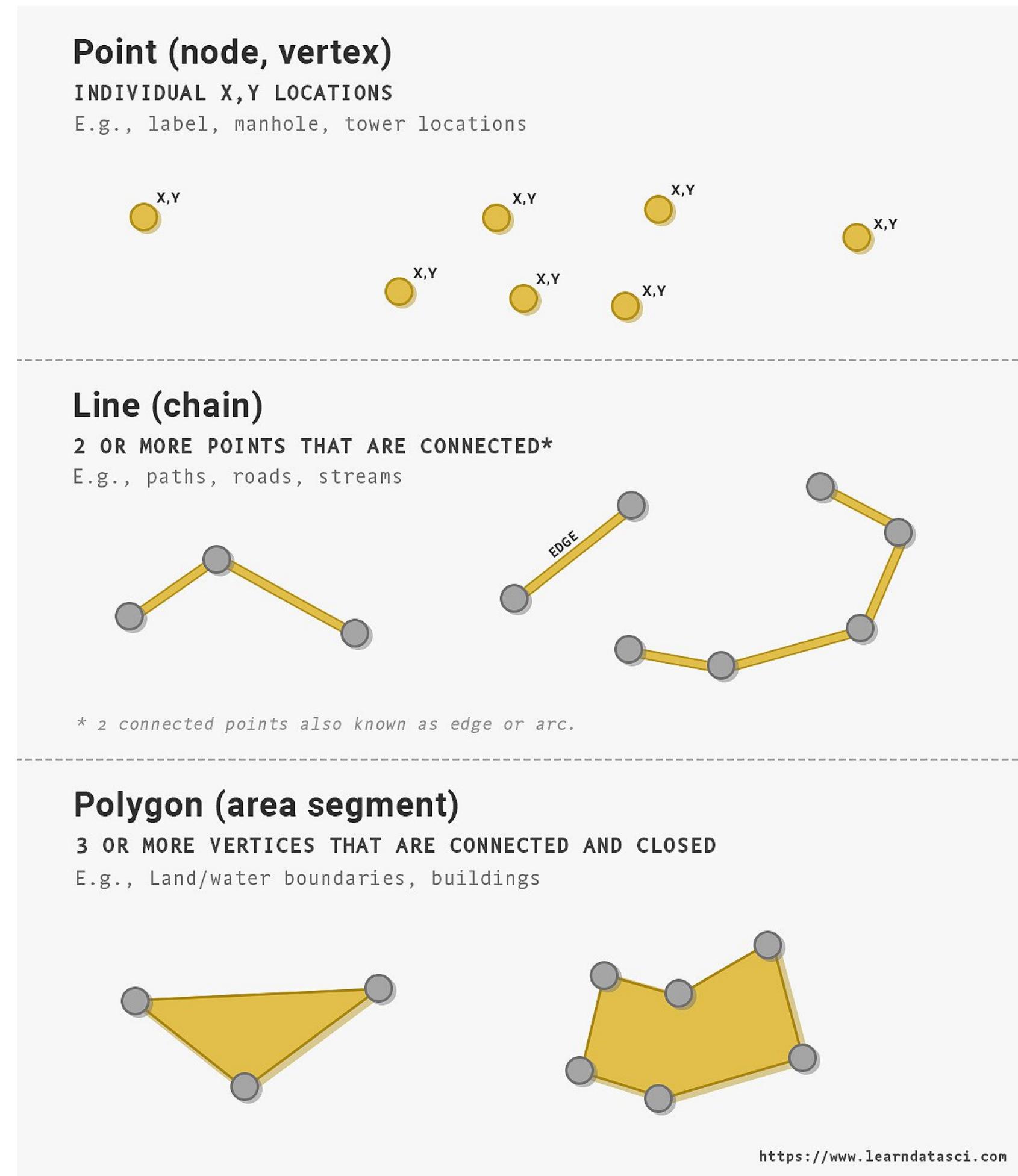


GeoPandas/ How to work with vector data

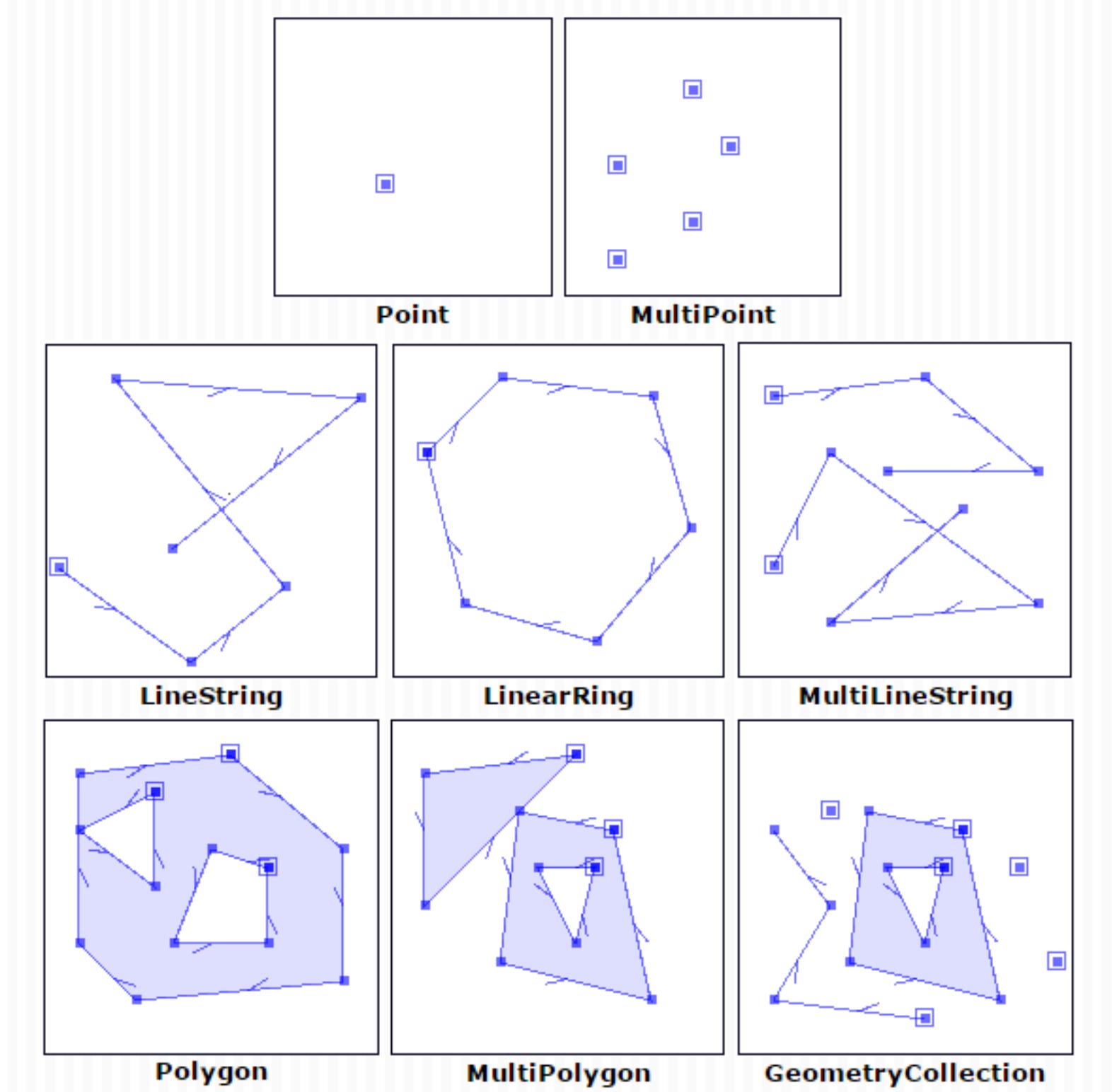


Recap from last time

Geometric objects



Shapely

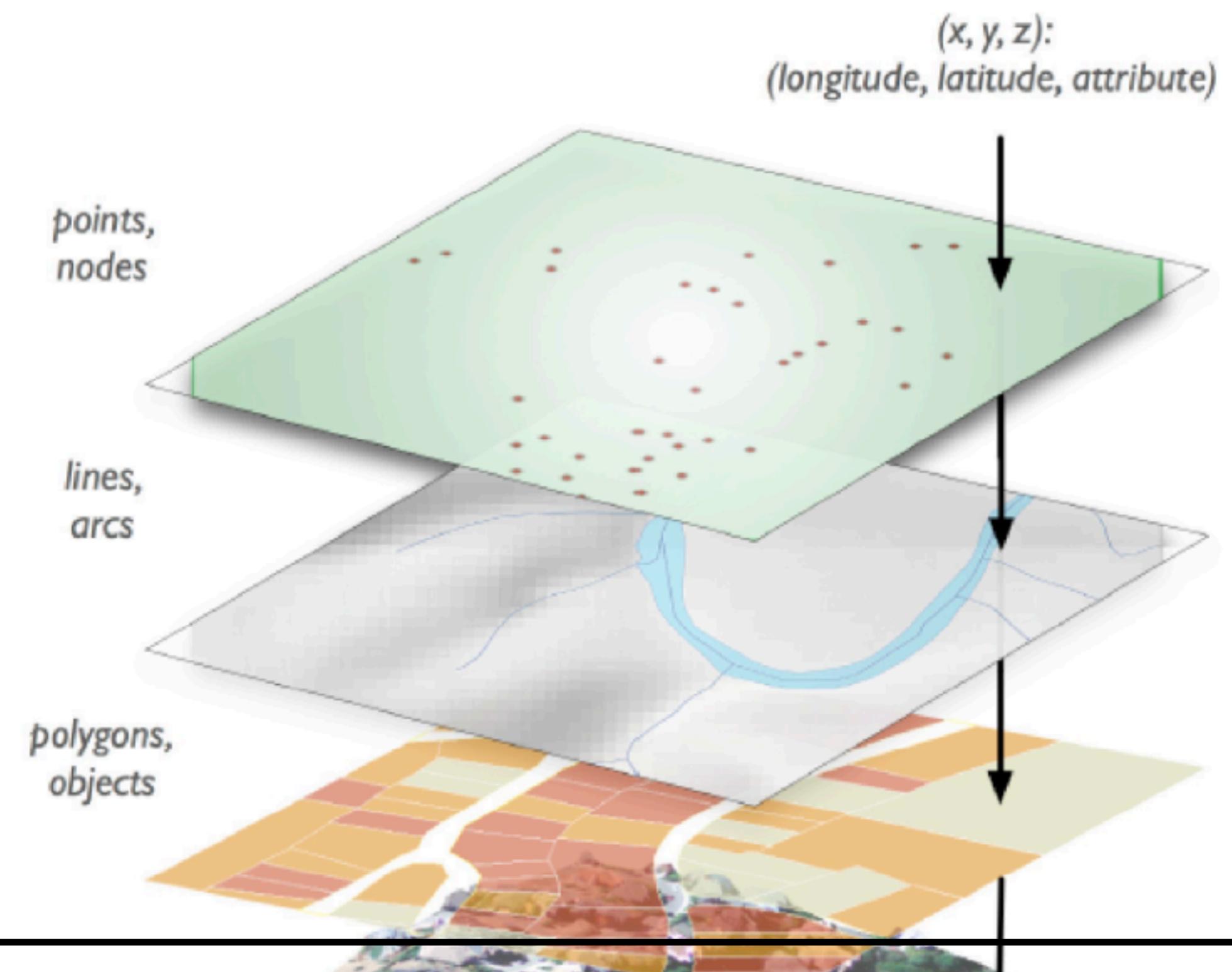


Coordinate tuples



There is **vector** and **raster** data

Vector: Geometric objects
.gpkg, .shp, .svg, geojson



Raster: Grid of pixels
.tif, .jpg, .png, .bmp



File formats matter (sometimes)

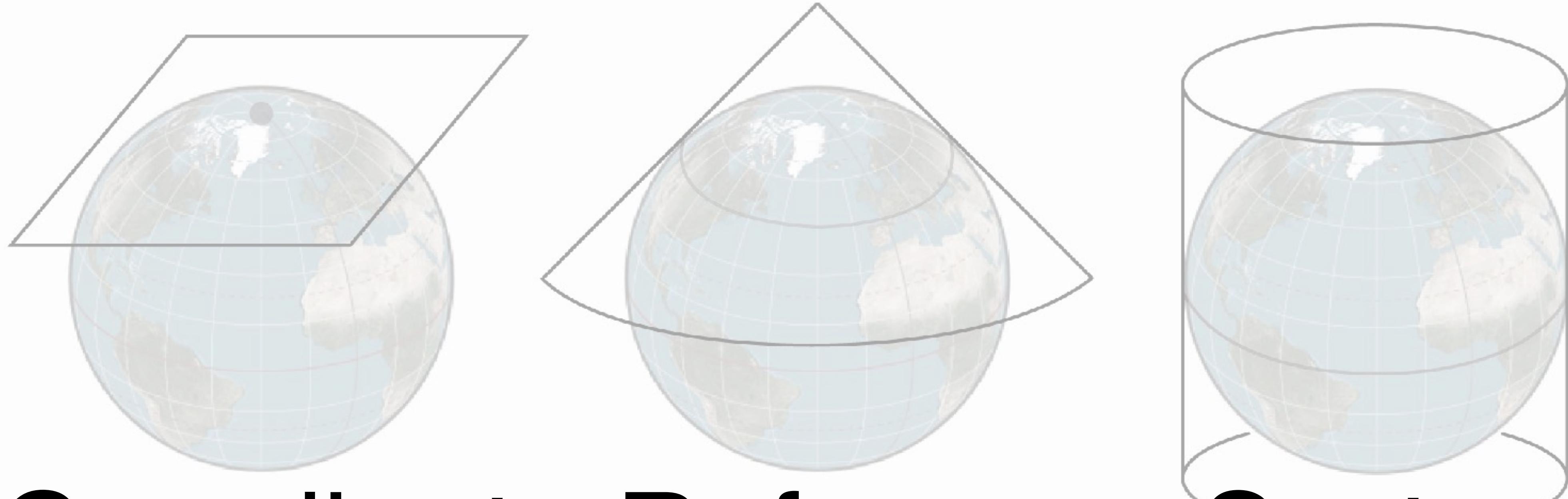
Geopackage - 'universal'

GeoJSON - web-optimized

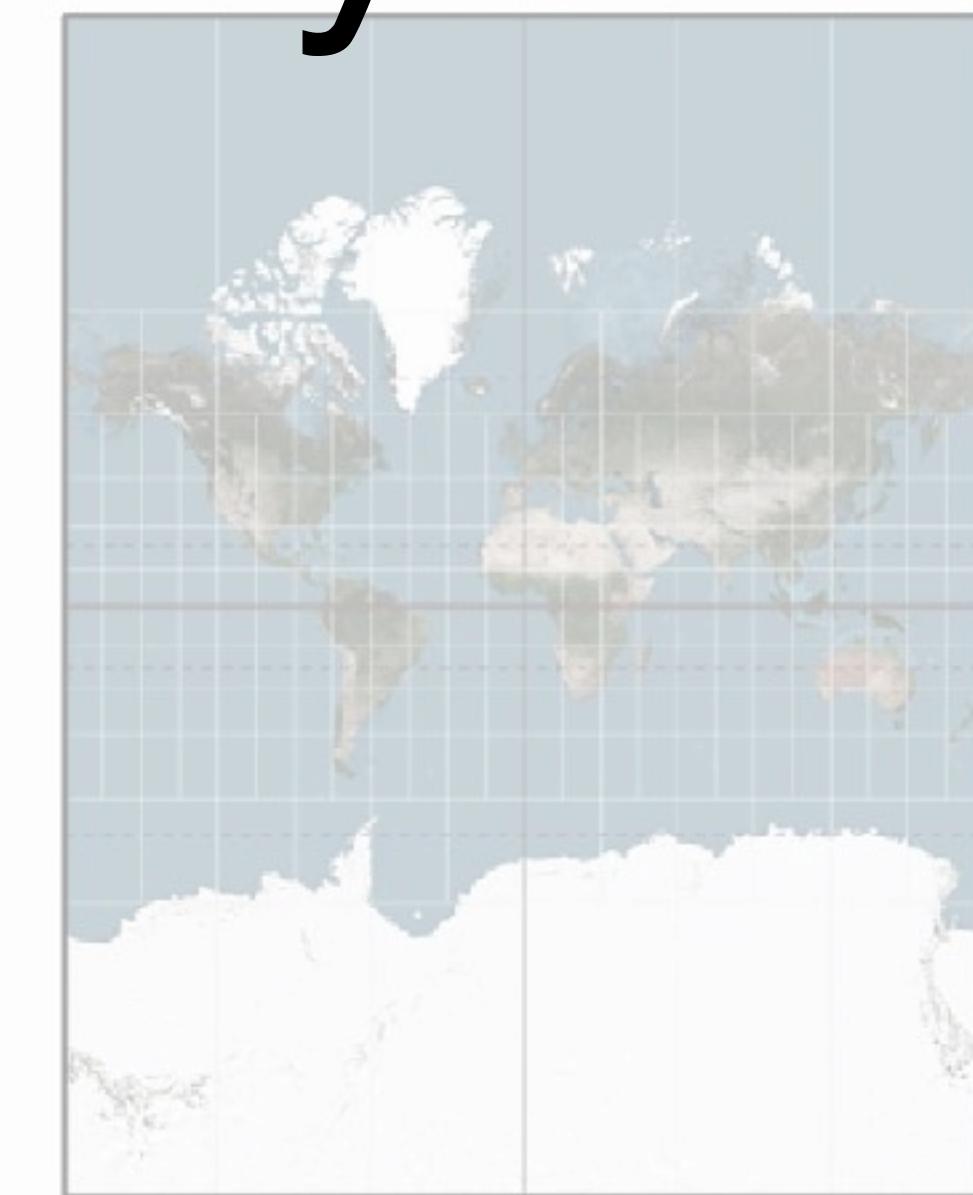
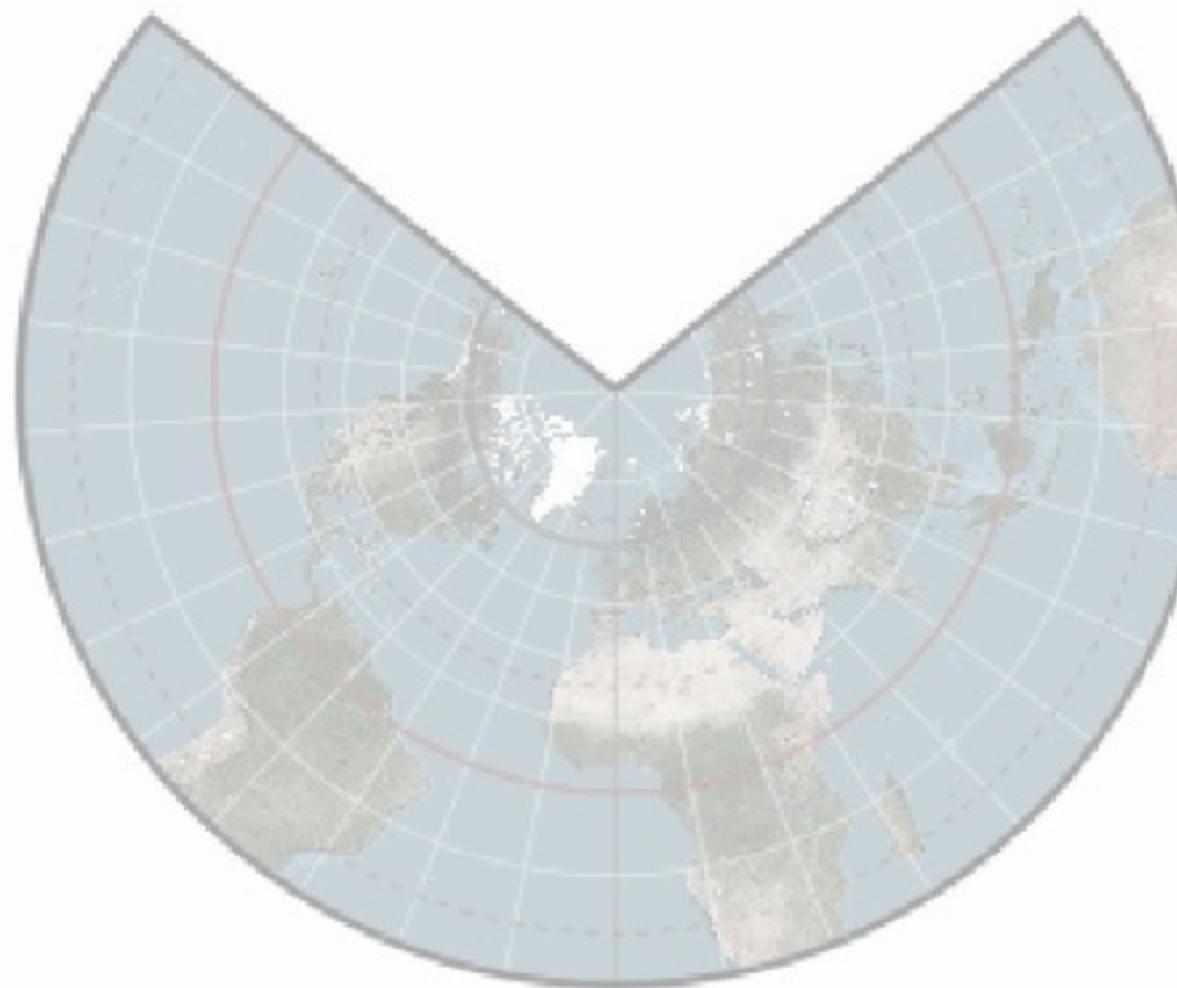
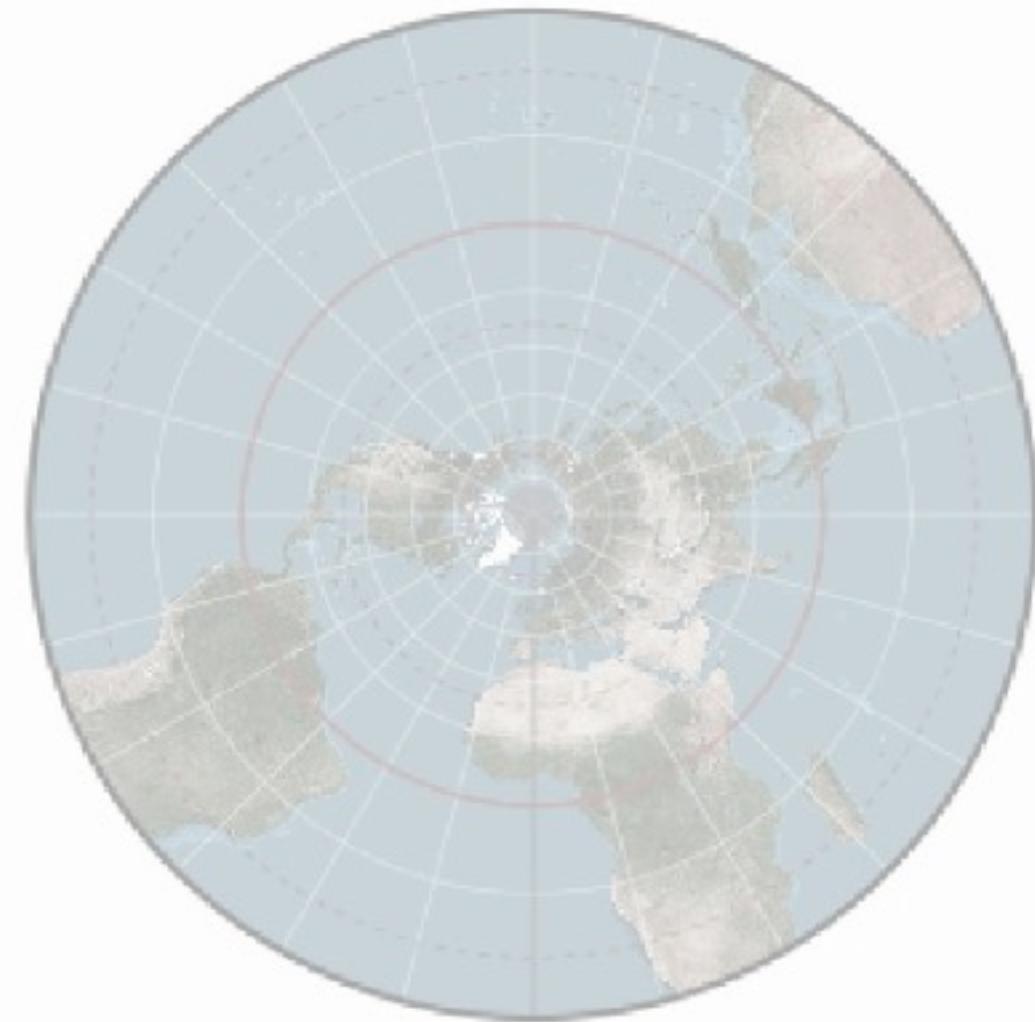
CSV

Shapefiles - old classic





Coordinate Reference Systems



Coordinate Reference System (CRS)

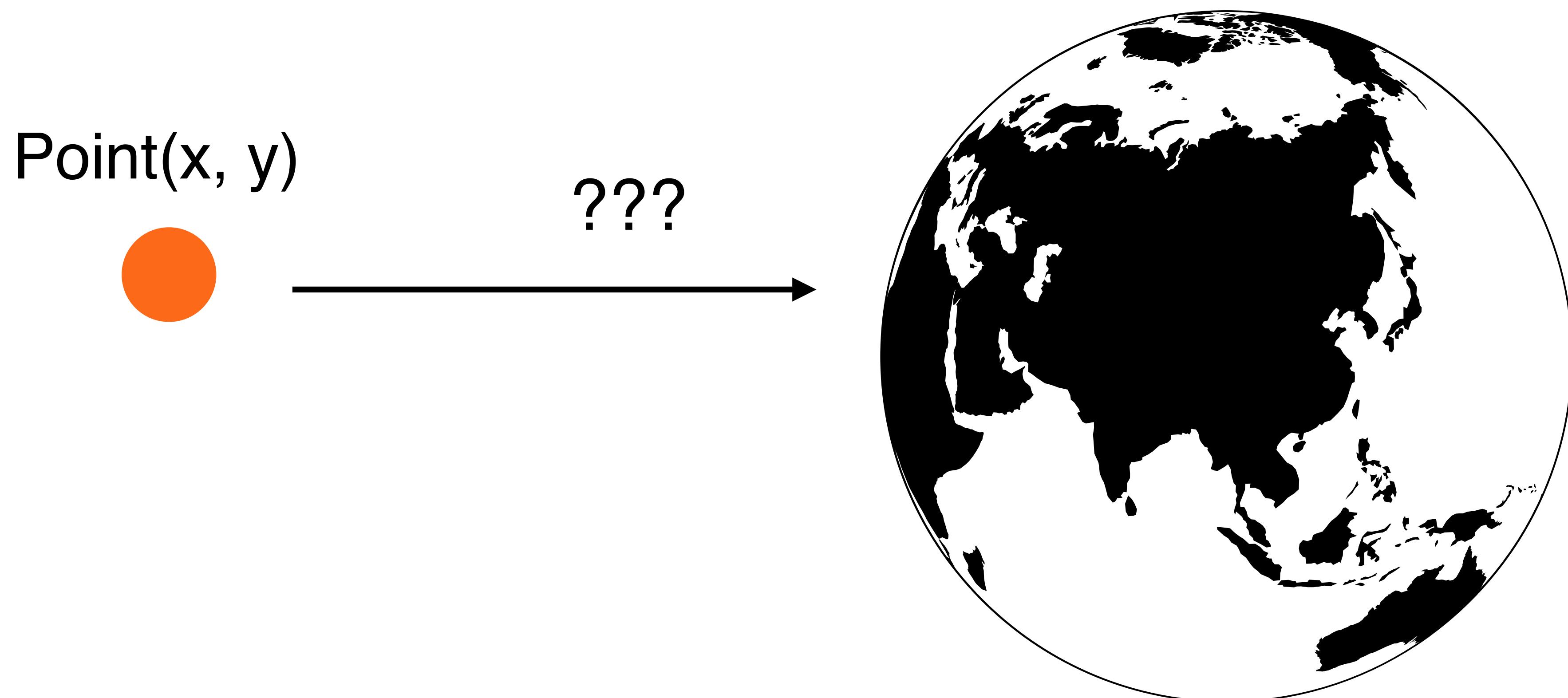
"Without a CRS, the geometries would simply be a collection of coordinates in an arbitrary space"

Coordinate Reference System (CRS)

"Without a CRS, the geometries would simply be a collection of coordinates in an arbitrary space"

Map projections = CRS

Coordinate Reference System (CRS)



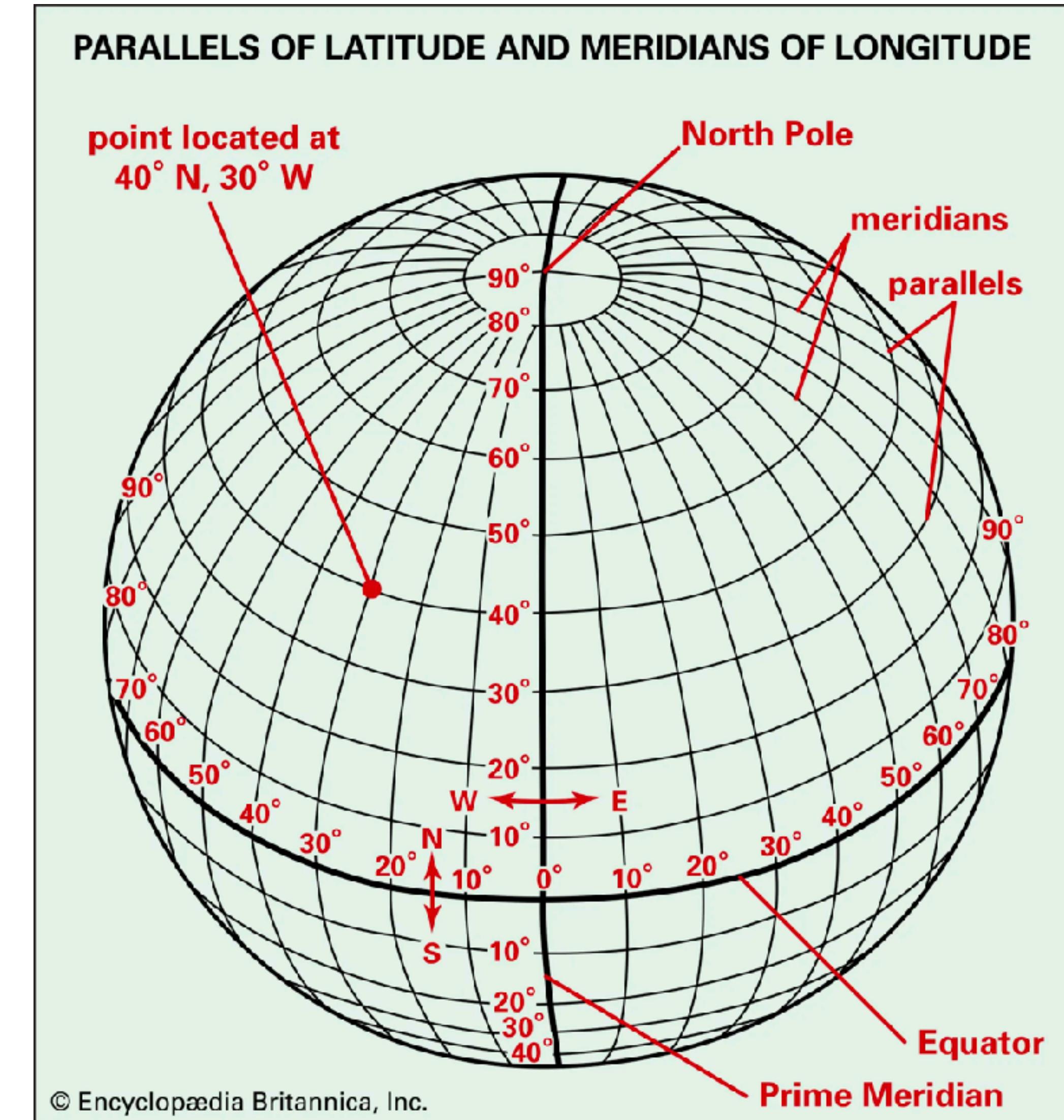
Geographic reference systems

Longitude (x) (meridians)

Latitude (y) (parallels)

Units: Degrees

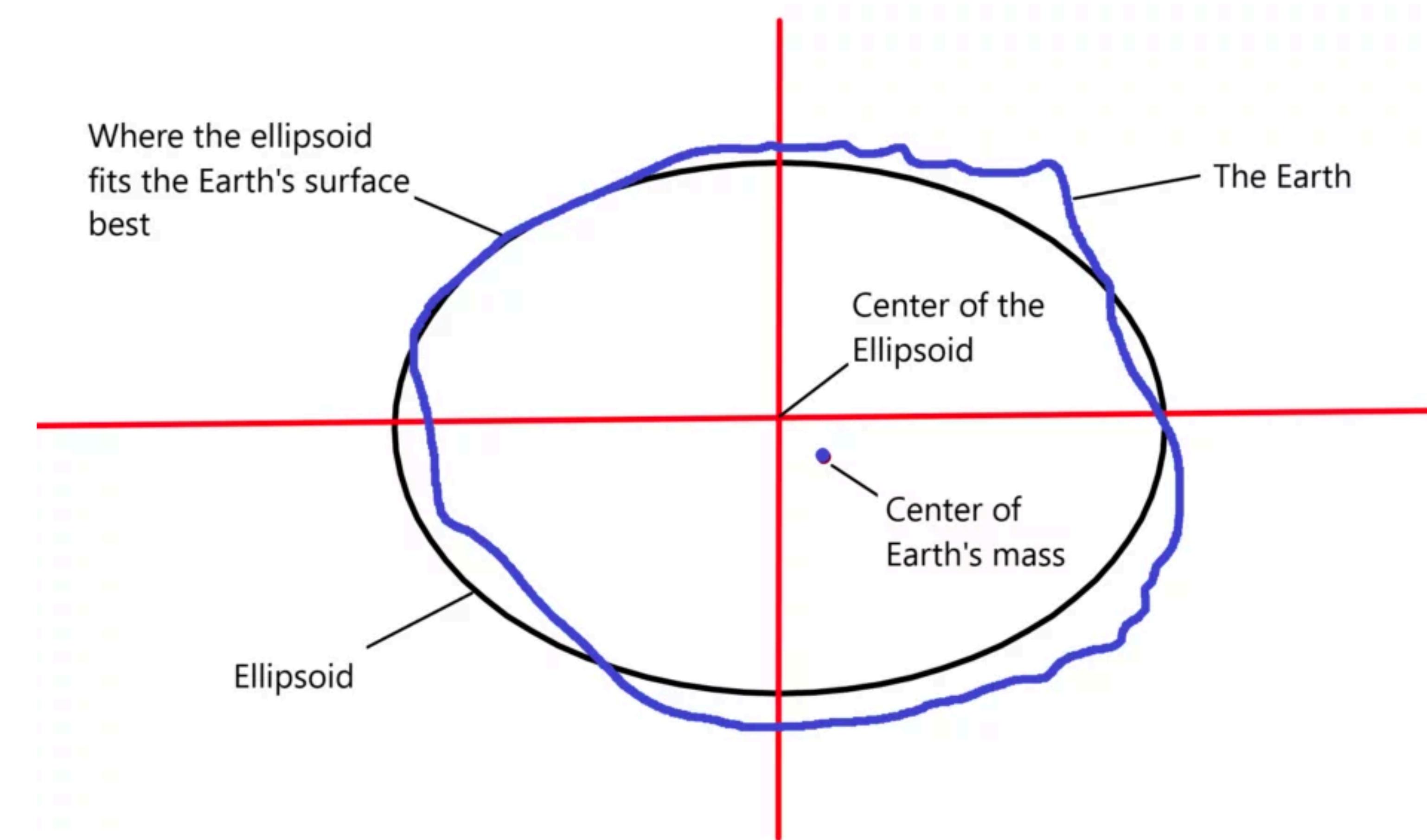
12.591074 E 55.659632 N



Unfortunately the Earth is not round

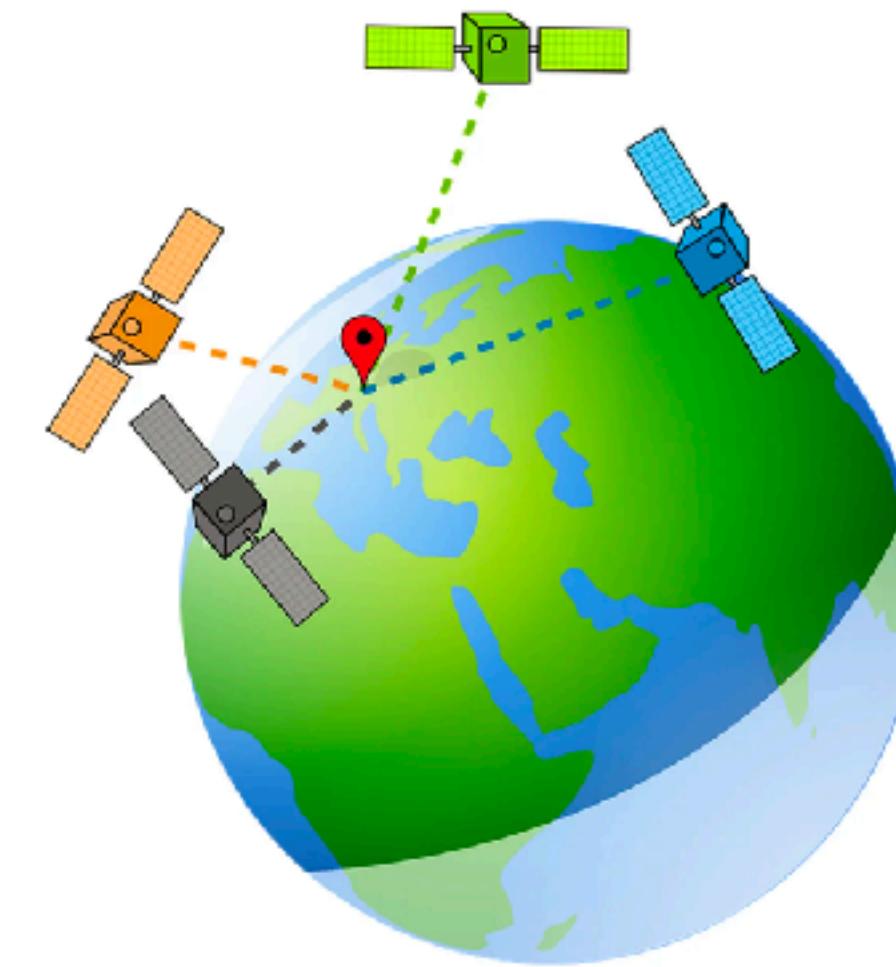
A ‘datum’ is a model of the shape of the Earth

WGS 84 is the most common one



Geographic reference systems

WGS 84 (World Geodetic System 1984) / EPSG:4326

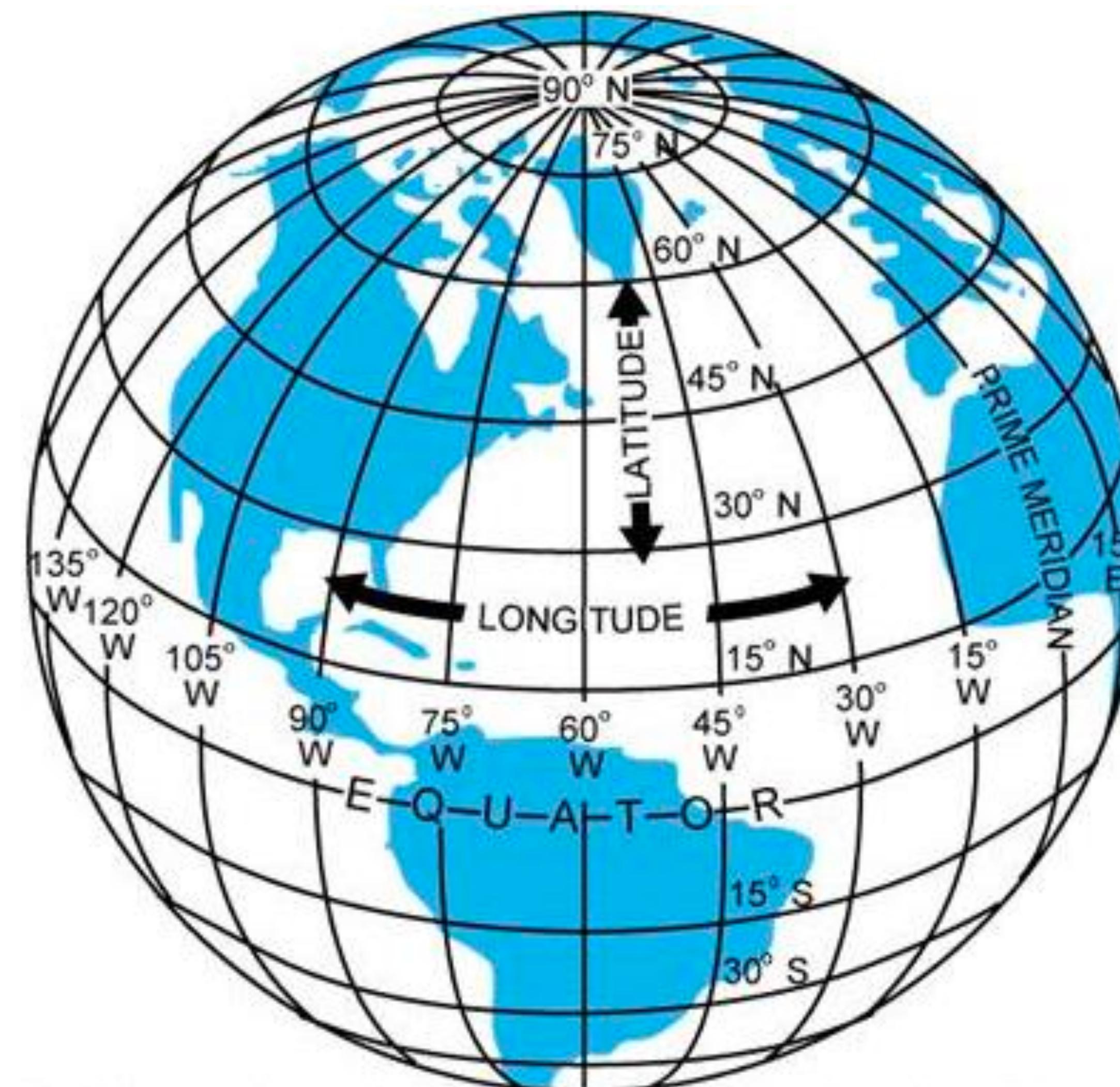


WGS 84 - Web/Pseudo-Mercator / EPSG:3857



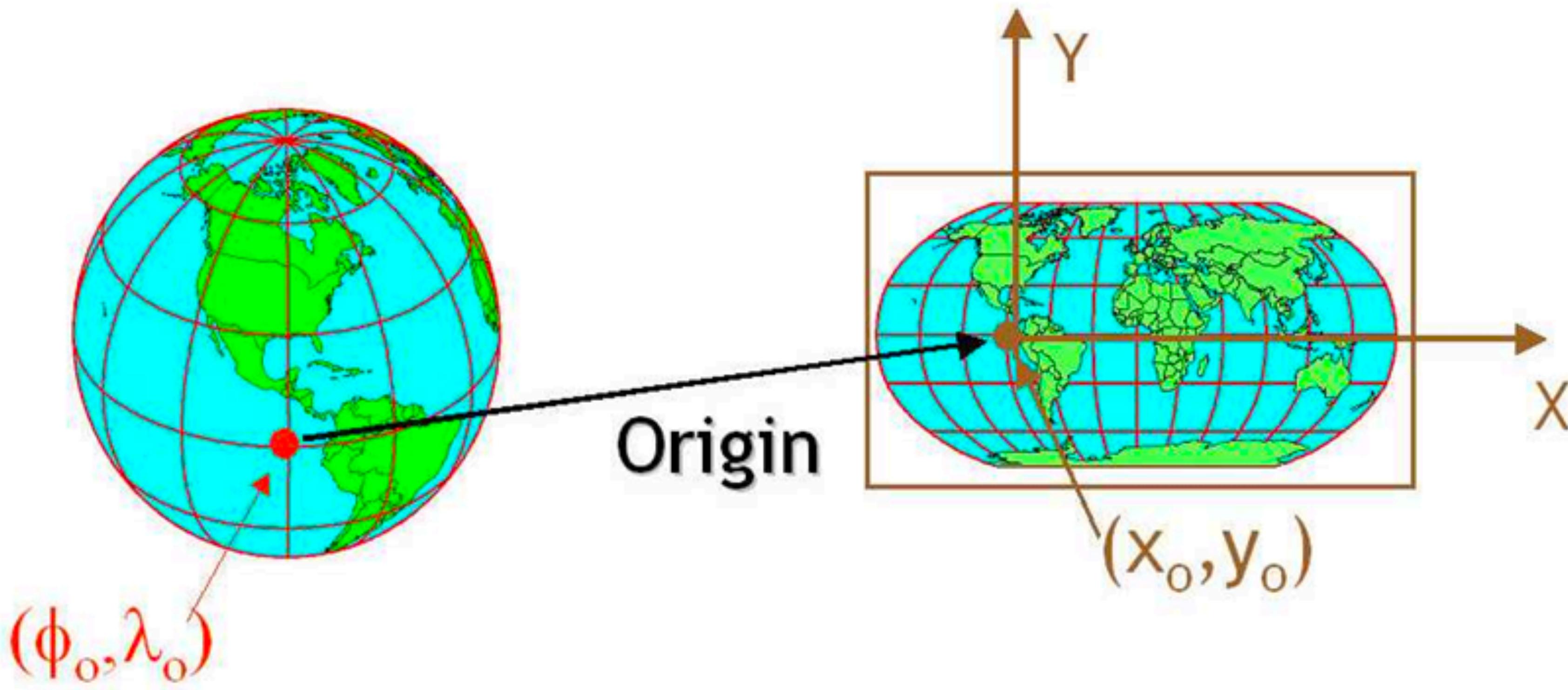
Google Maps

Distance calculations with degrees are not ideal



Projected reference systems (= map projection)

Projection: “the process of transforming angular (spherical / elliptical) coordinates into planar coordinates.” *Battersby, S. (2017)*

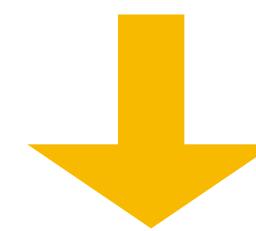


Units usually in **meters**

All map projections are wrong

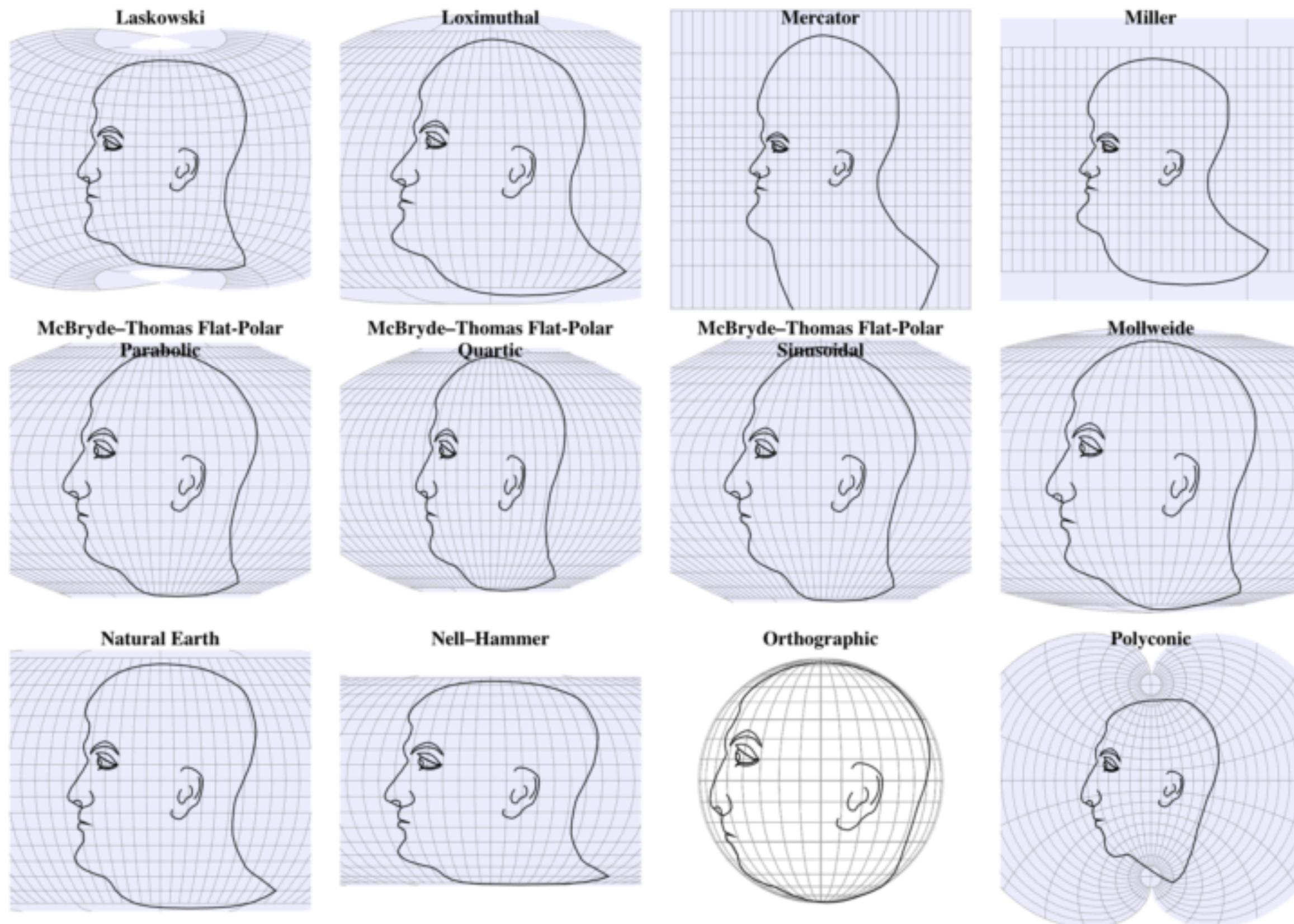


"All models are wrong, but some are useful" (George E P Box)



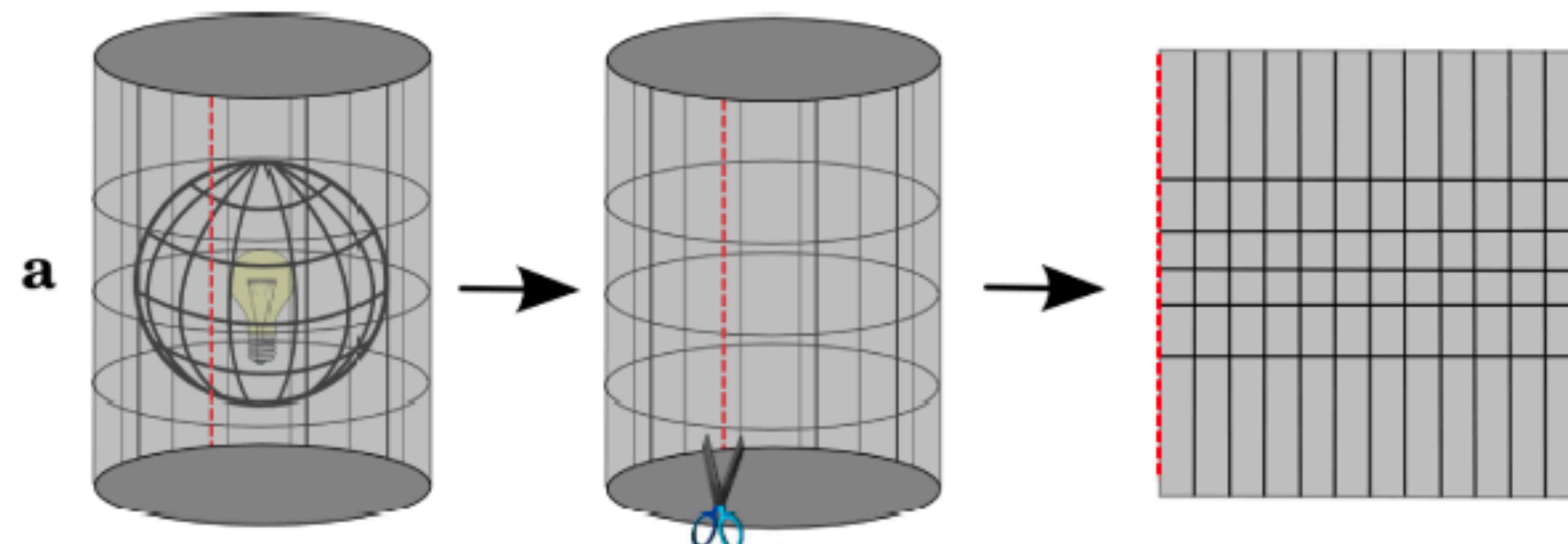
"All maps are wrong, but some are useful" (Keith Ord)

All map projections are wrong

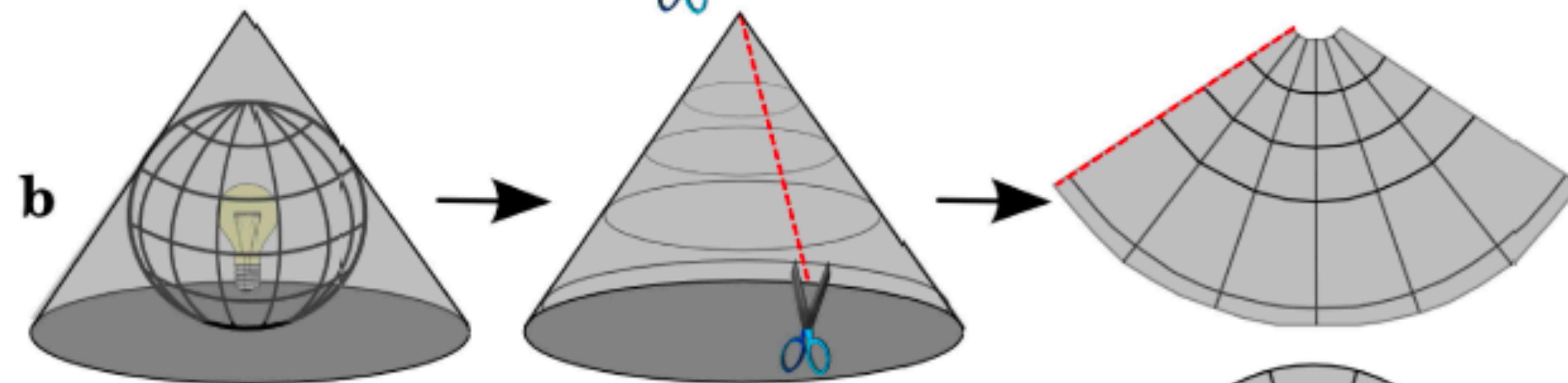


3 families of map projections

Cylindrical



Conical

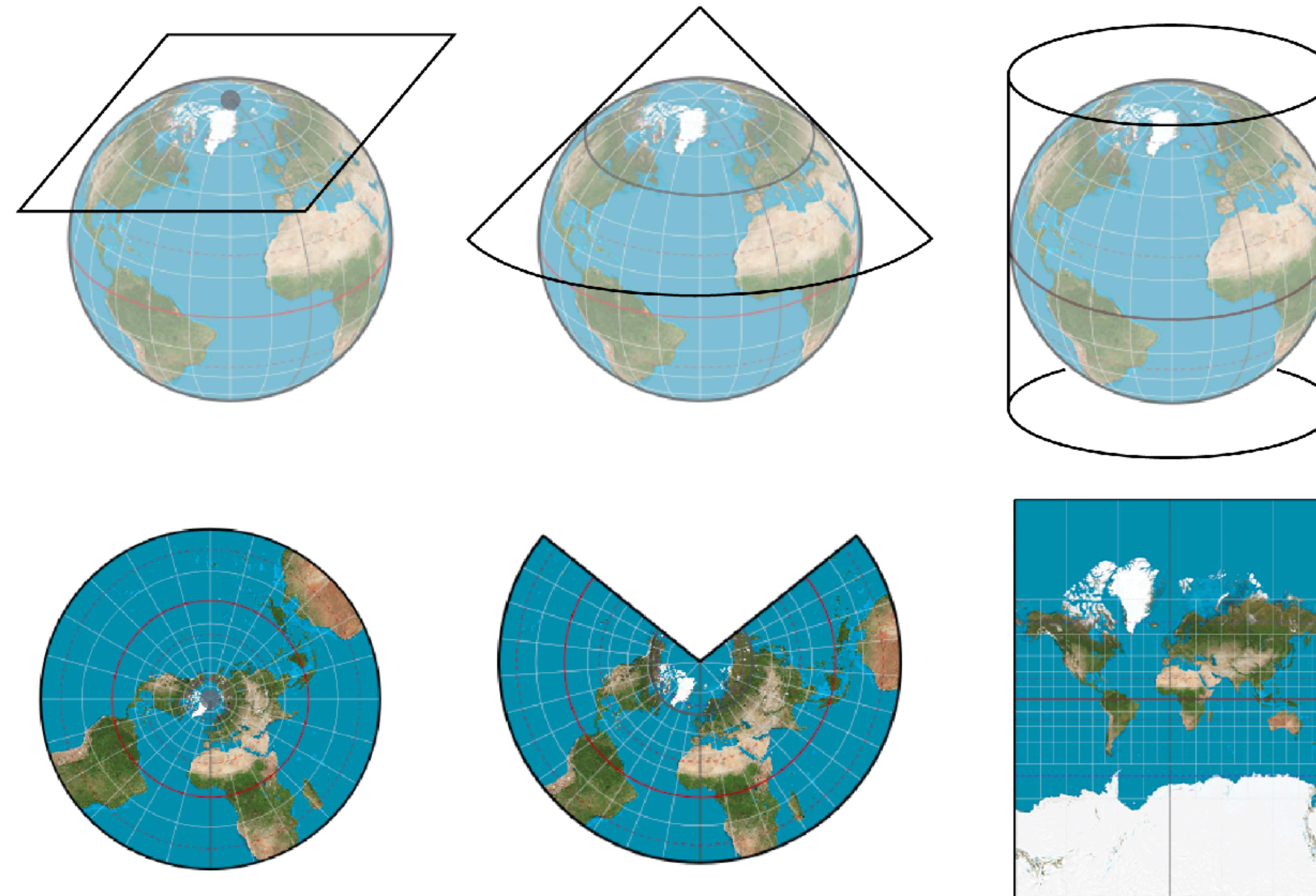


Planar



Map Projection Families

3 families of map projections



Map projects are optimized for different things

Azimuthal: preserve directions from the center to any other point on the plane.

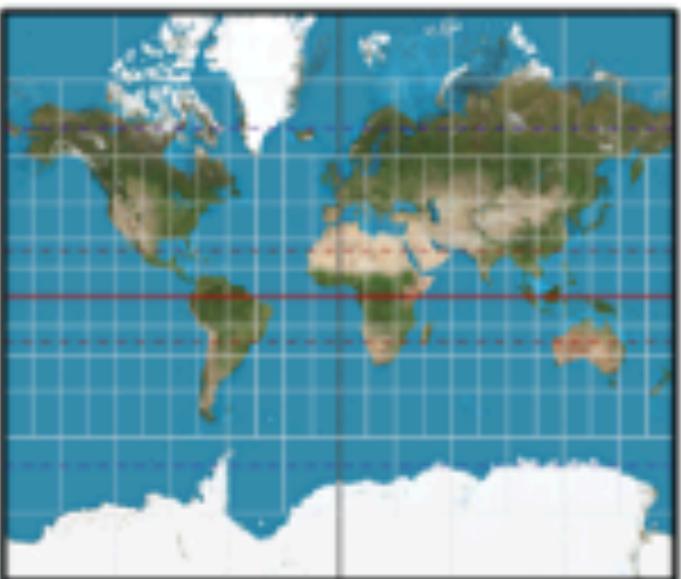
Conformal: preserve local angular relationships across the projection.

Equal area or equivalent: preserve relative areas across the projection.

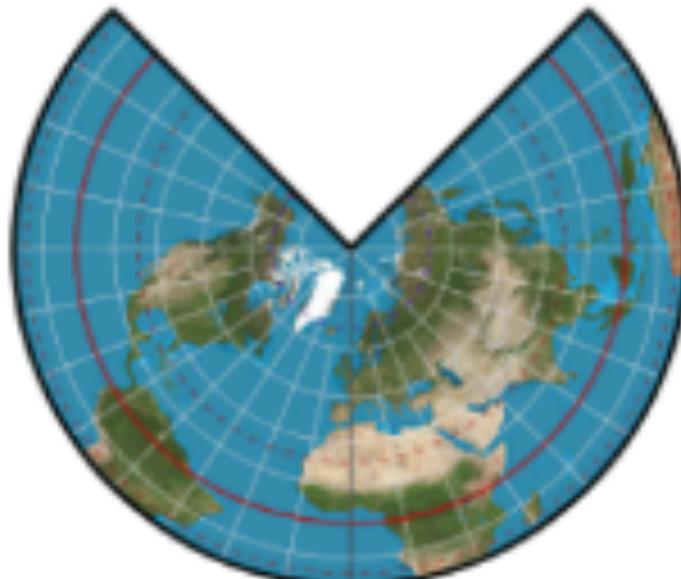
Equidistant: preserve distances from one or two specified points to any other point on the plane

Compromise: does not preserve either areas or angles, but finds a compromise between the two, typically to present a more aesthetically pleasing map while reducing excessive distortion

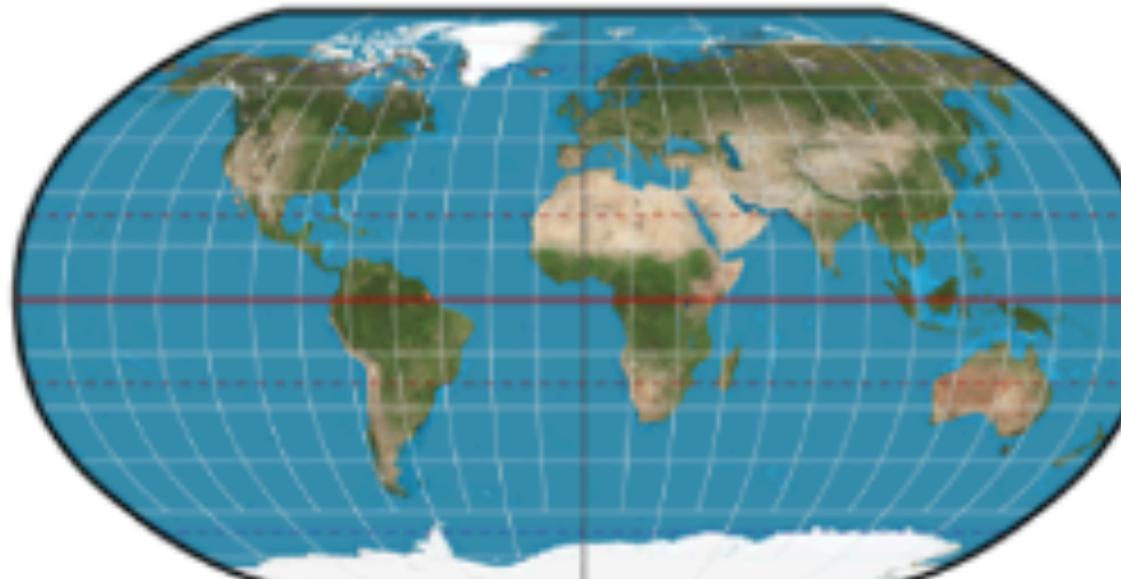
Mercator (conformal)



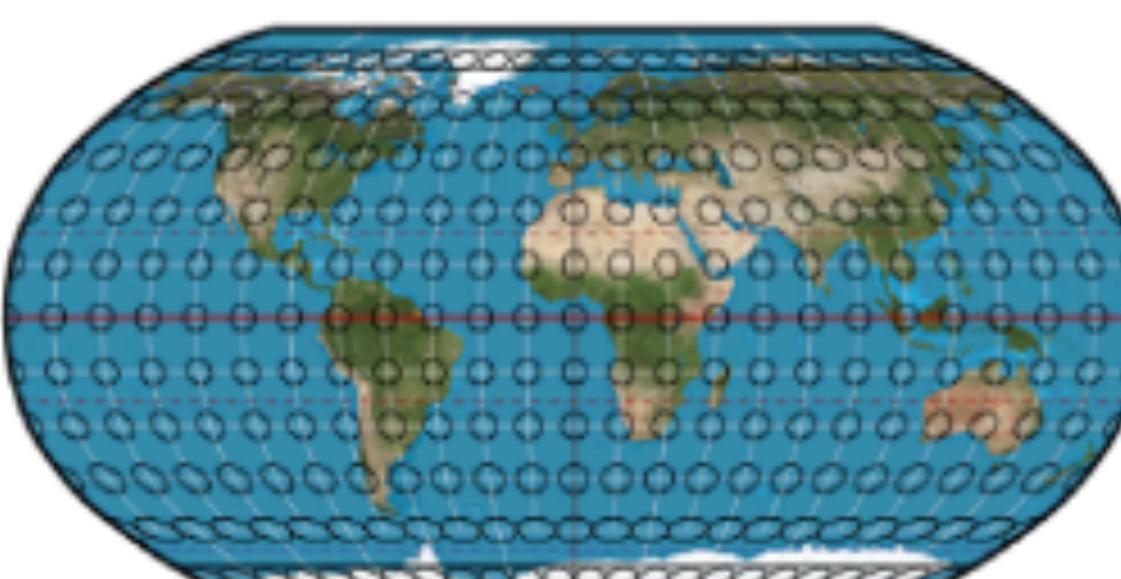
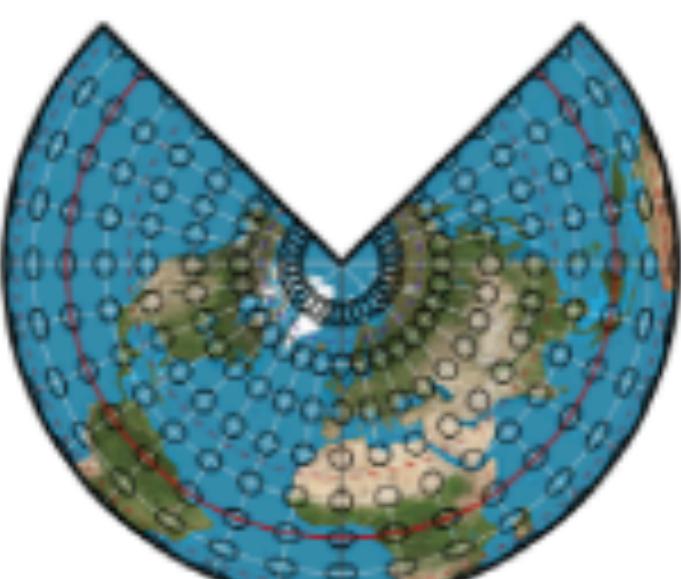
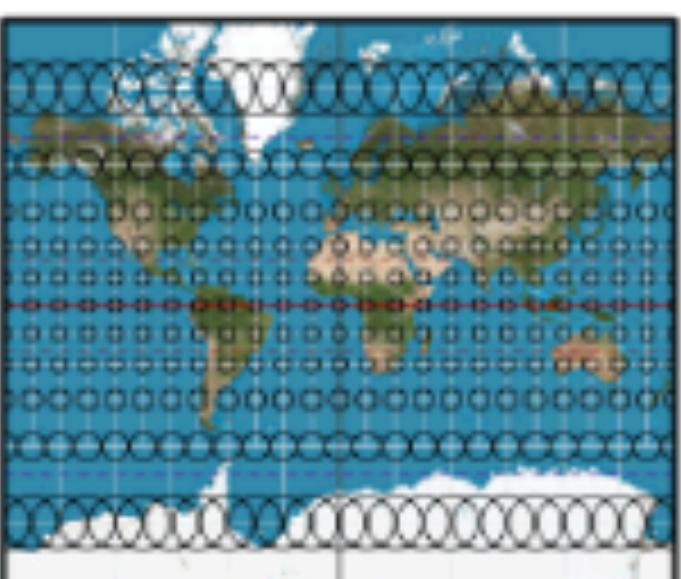
Lambert Conic (equal area)



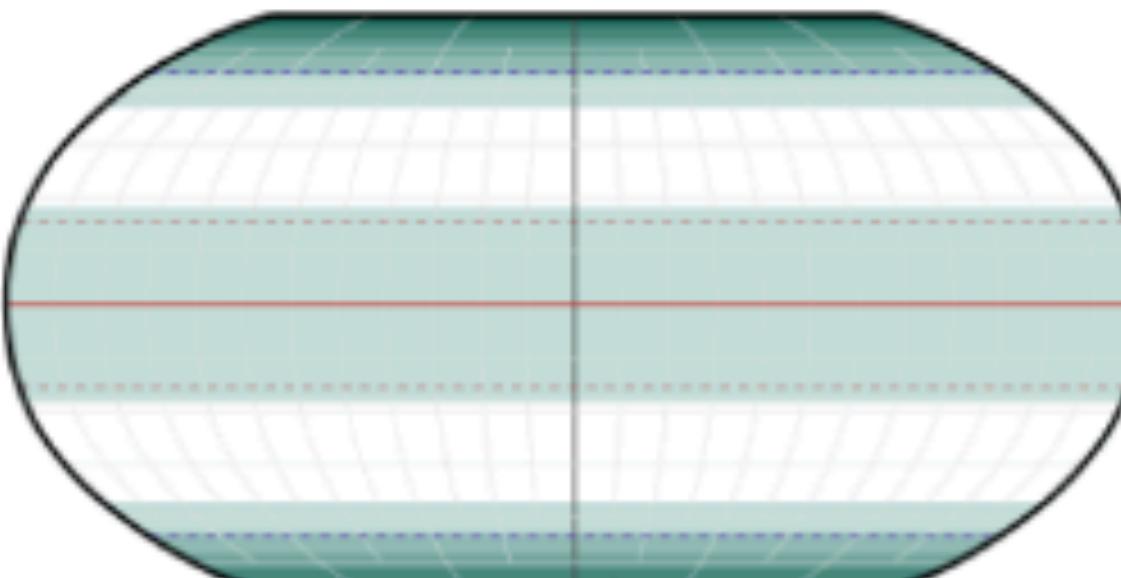
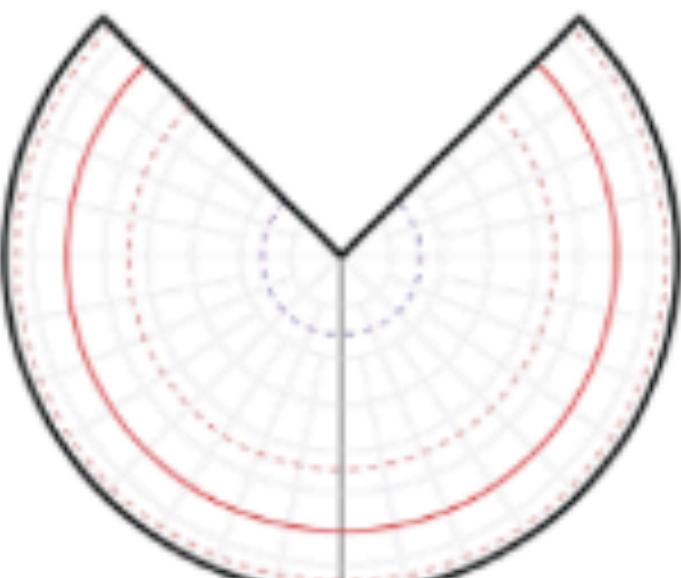
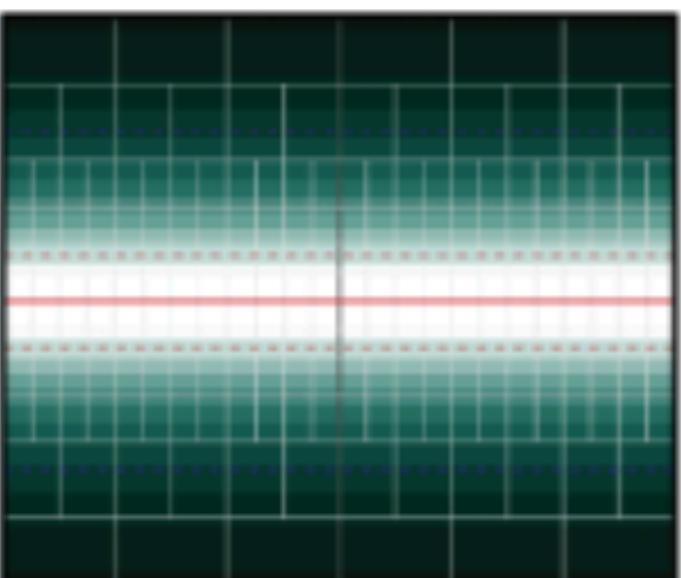
Robinson (compromise)



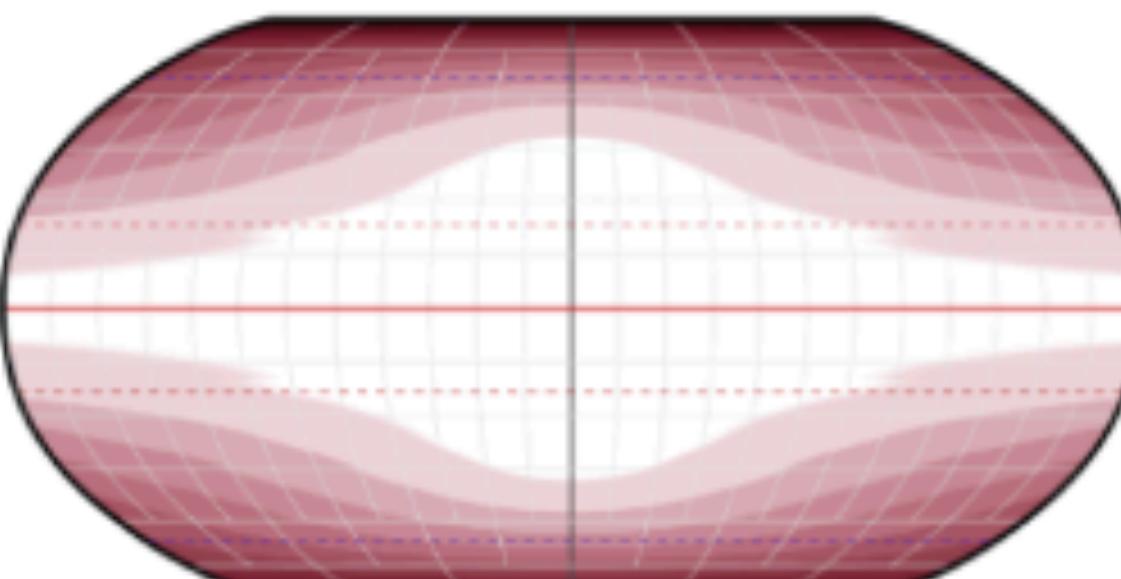
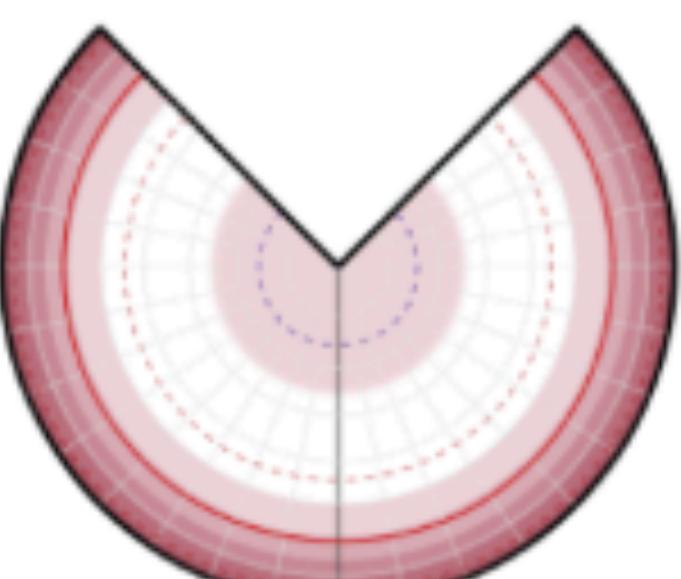
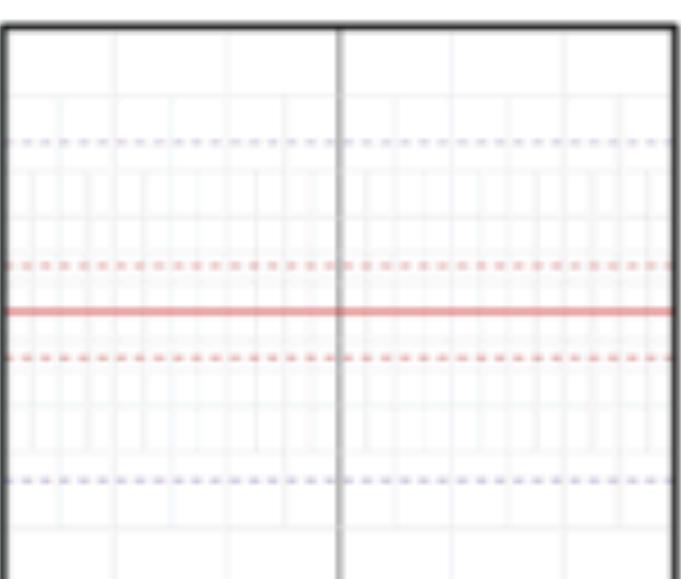
Tissot's Indicatrices
showing distortion
of both area and
angle



Areal distortion

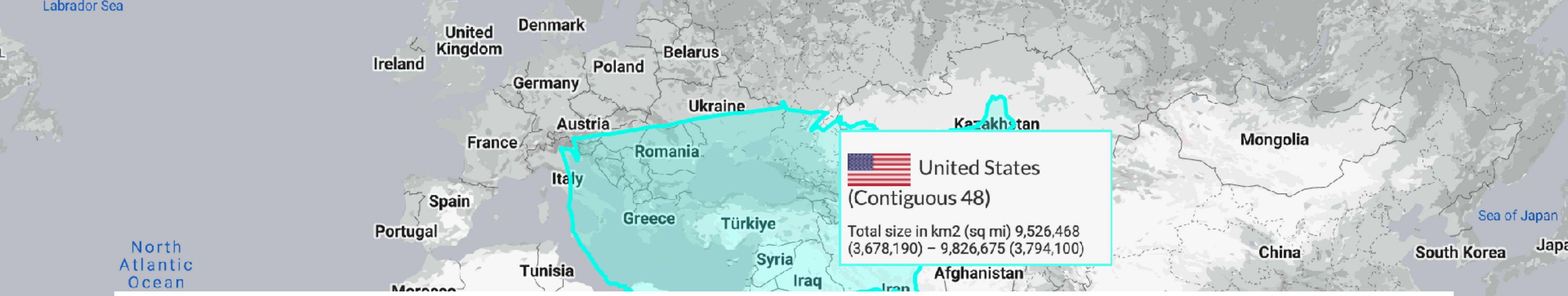


Angular distortion



Map projections matter!



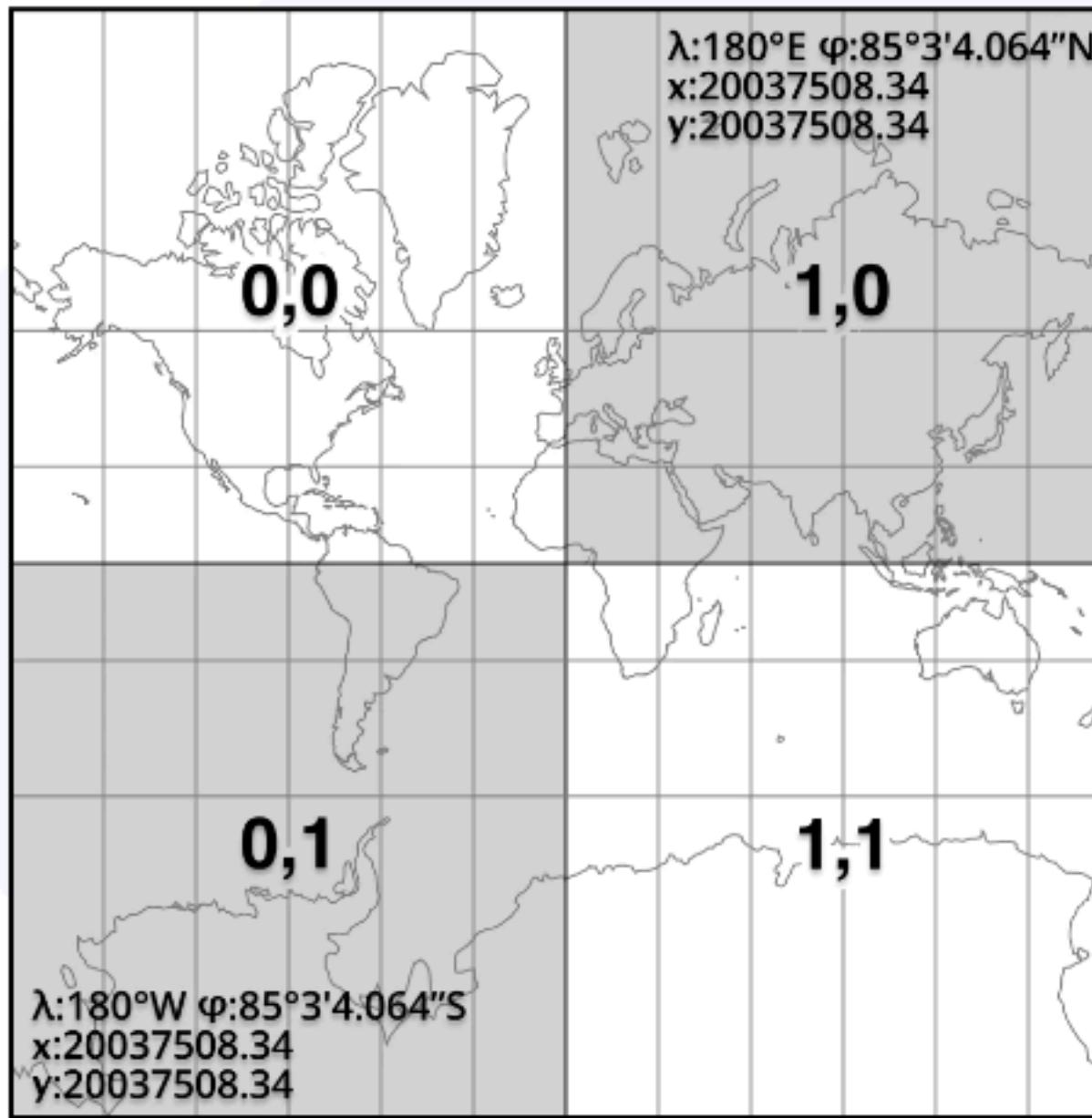


THE TRUE SIZE OF...

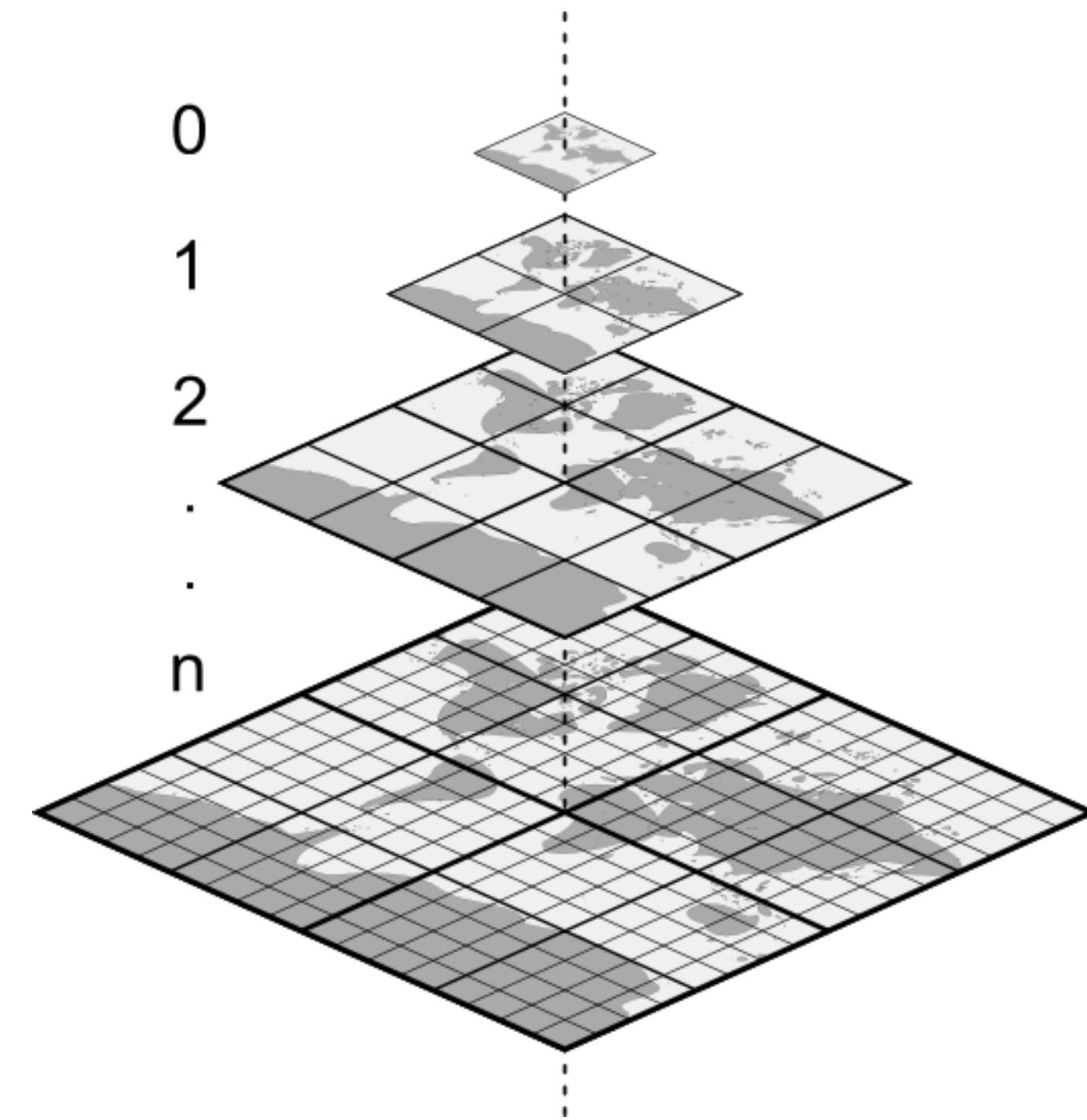


Why is Mercator still around?

Web-Mercator (EPSG:3857) still used for Google Maps, OpenStreetMap, + most other web maps



MAP TILES



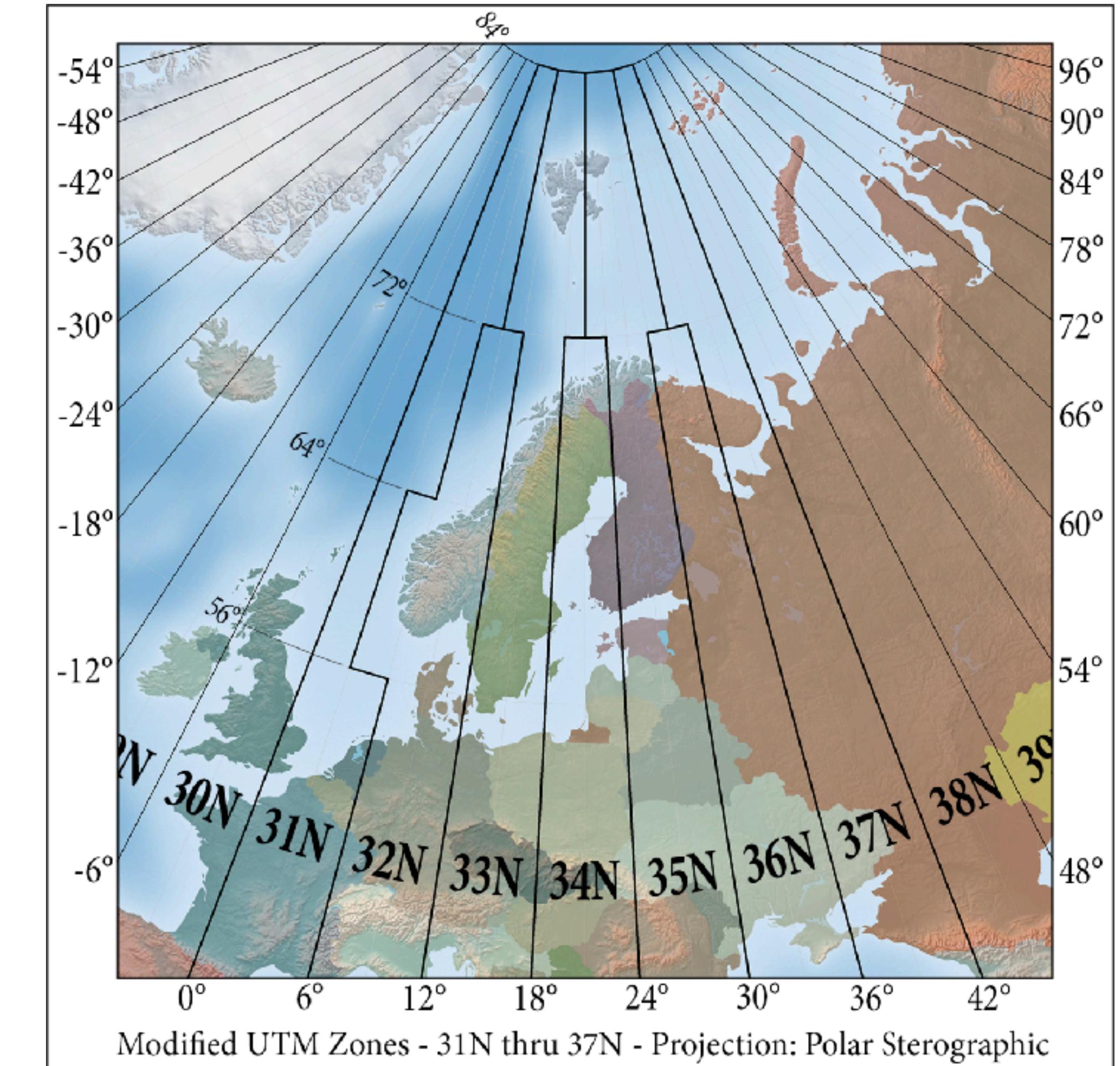
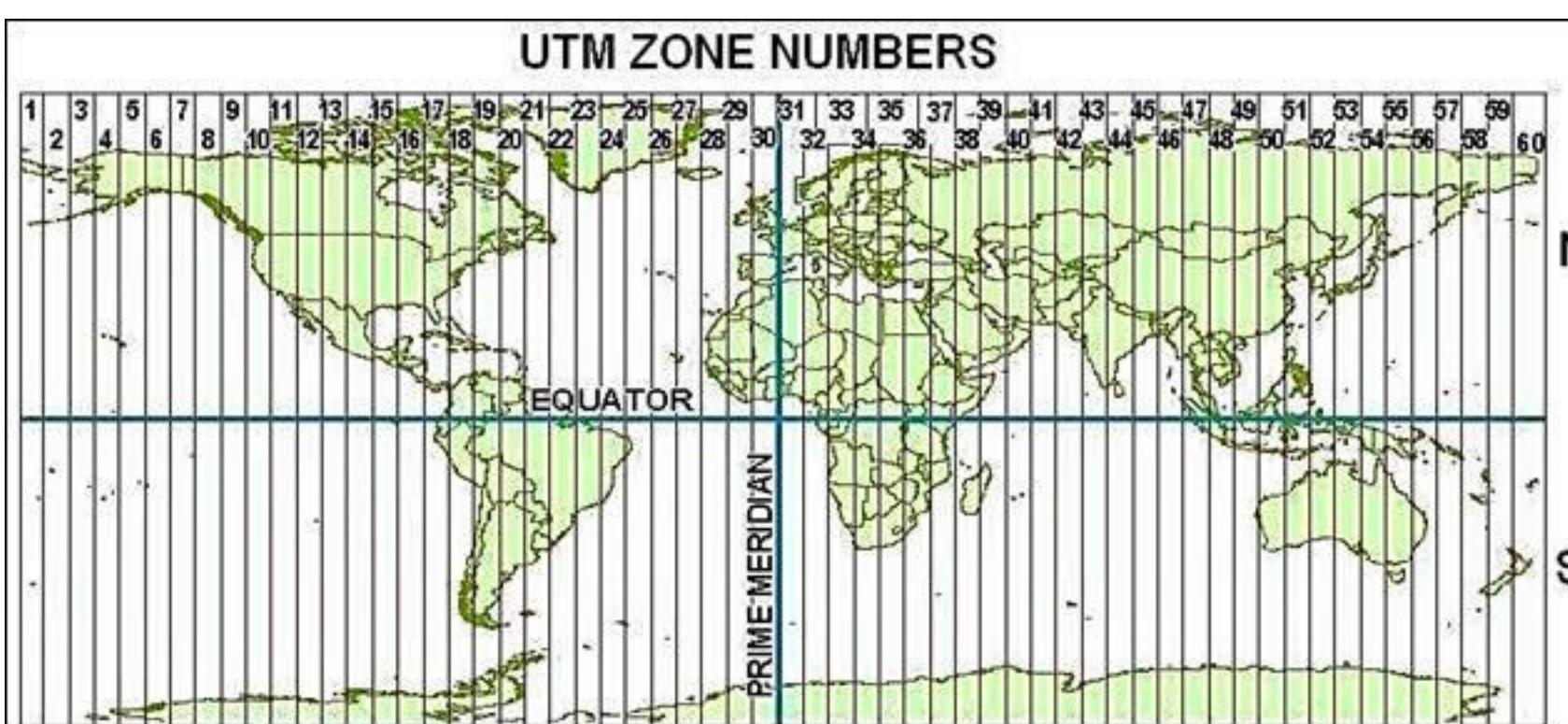
How to choose your map projection?

- The *location* of your data
- The *purpose* of the map/analysis
- The *norm/tradition*

Web maps: Usually Web-Mercator (EPSG:3857)

EU: Lambert Azimuthal Equal Area (EPSG:3035)

Denmark: UTM Zone32N (EPSG:25832)



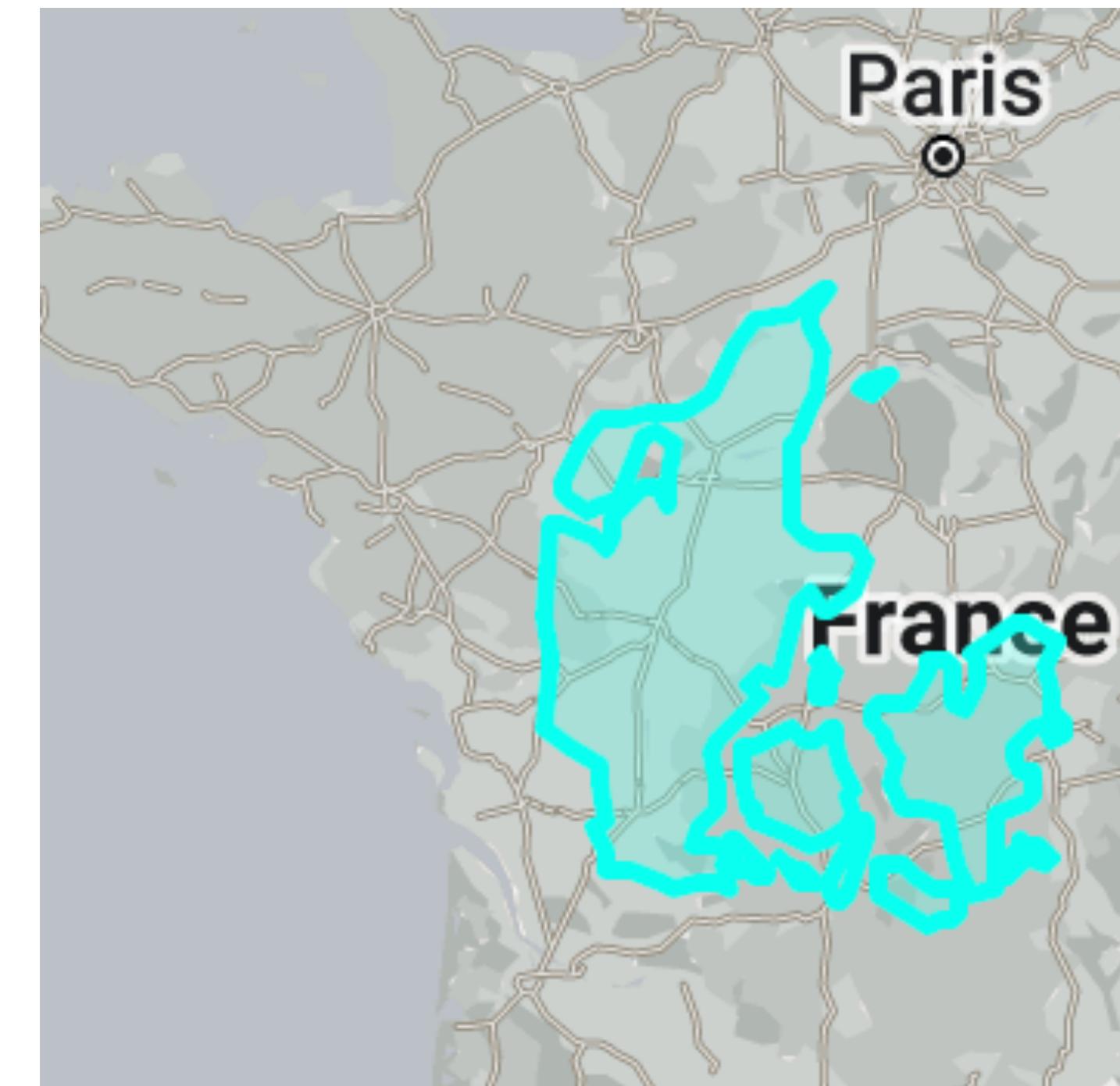
We identify map projections with their EPSG code

European Petroleum Survey Group



Debugging coordinate data

Check your CRS!



Debugging coordinate data

Are your data (x,y) or (y,x)?

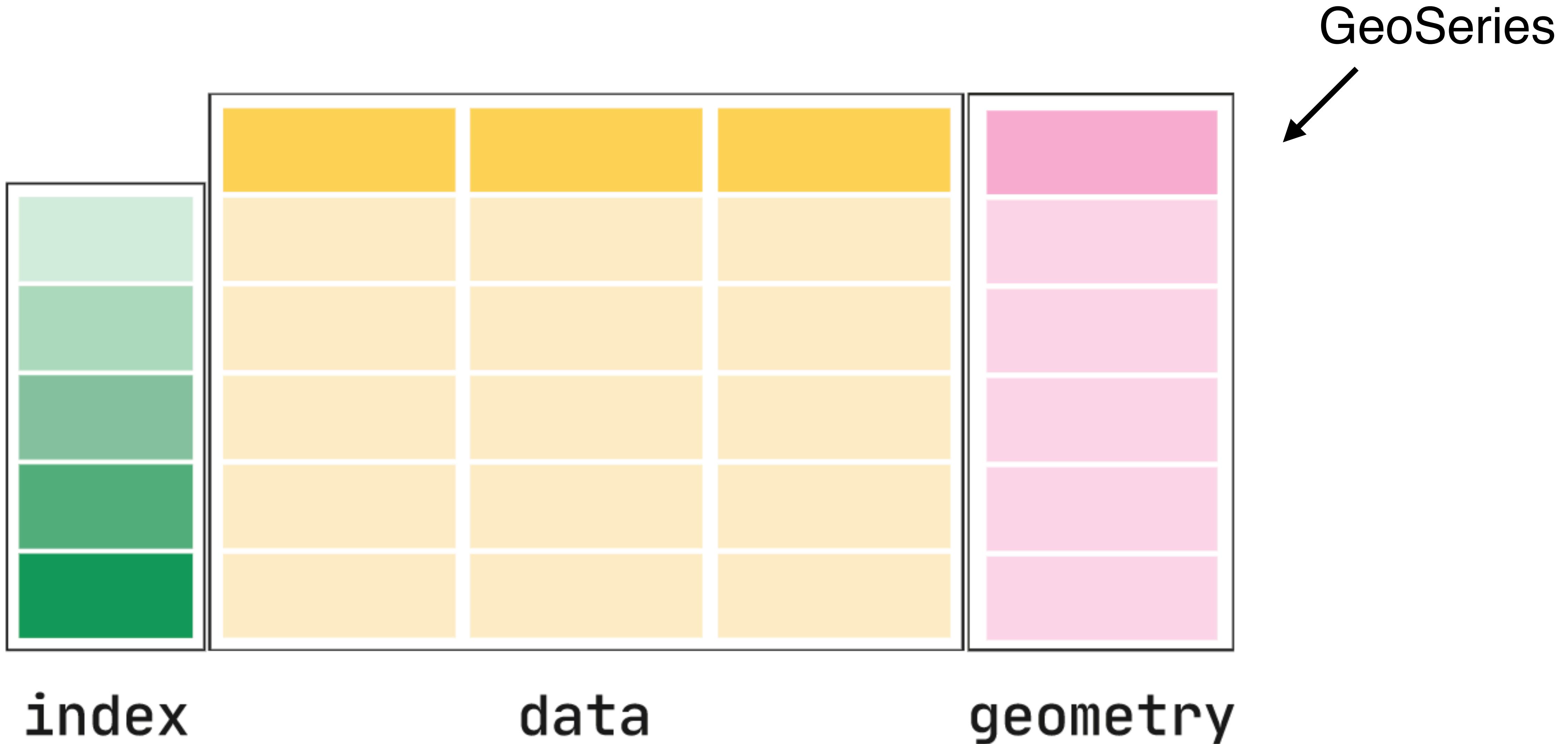
lon, lat	lat, lon
formats <ul style="list-style-type: none">• GeoJSON ref• KML ref• Shapefile ref• WKT ref• WKB ref• geobuf ref	formats <ul style="list-style-type: none">• GeoRSS ref• Encoded Polylines (Google) ref• iCalendar ref
javascript apis <ul style="list-style-type: none">• OpenLayers ref• d3 ref• ArcGIS API for JavaScript ref• Mapbox GL JS ref	javascript apis <ul style="list-style-type: none">• Leaflet ref• Google Maps API ref



GeoPandas

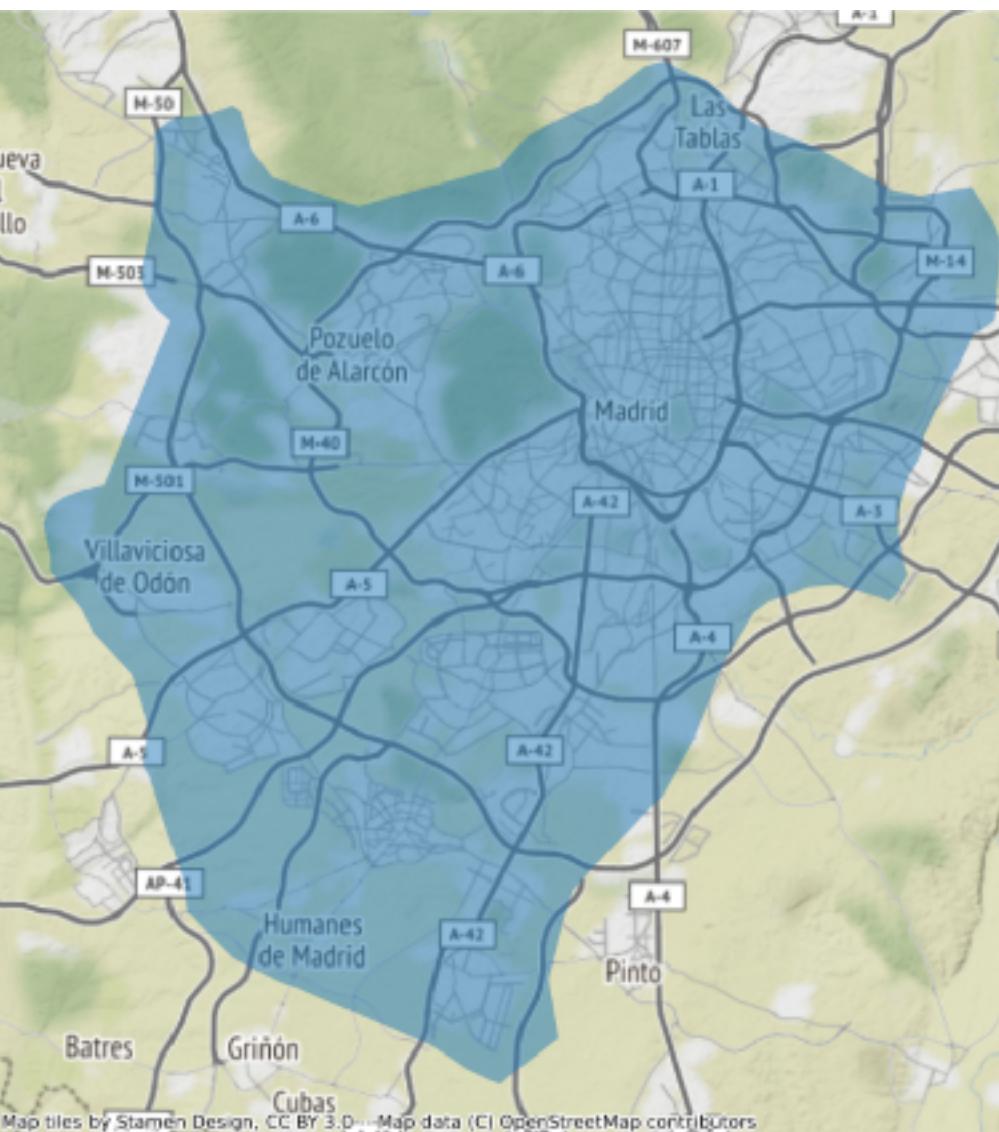
The spatial extension of pandas

GeoPandas

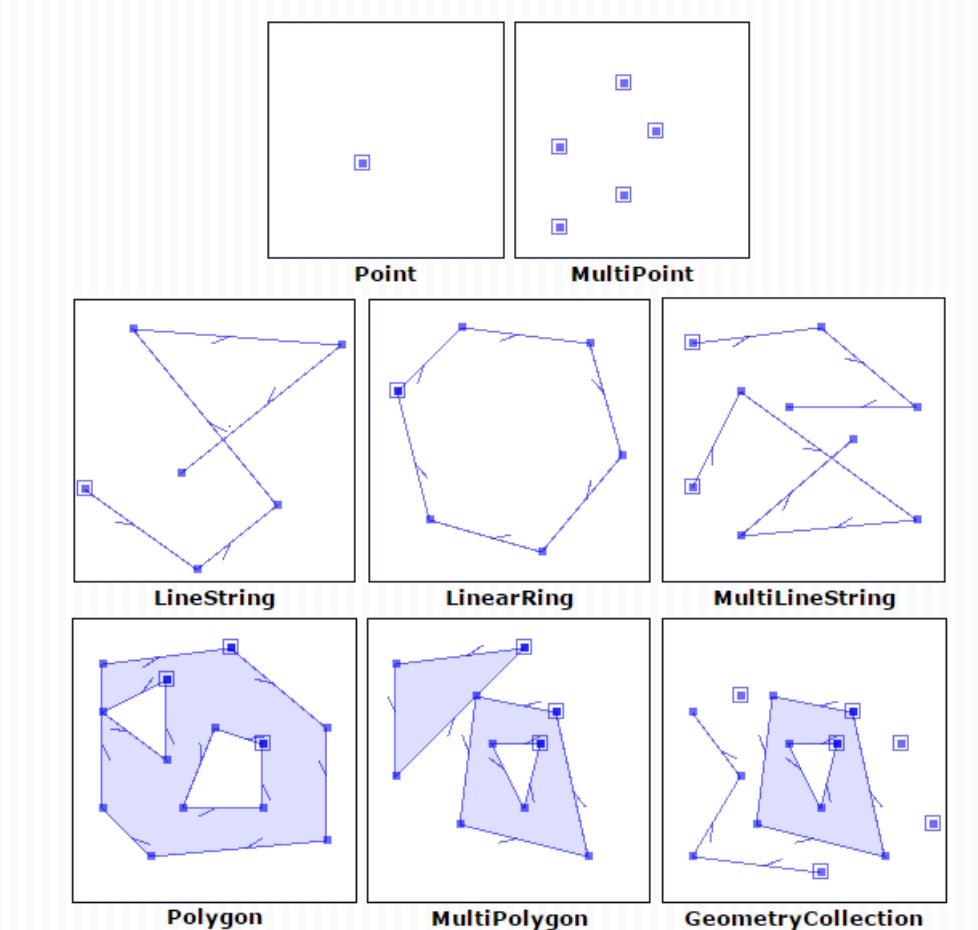


GeoPandas

Uses Shapely for geometries



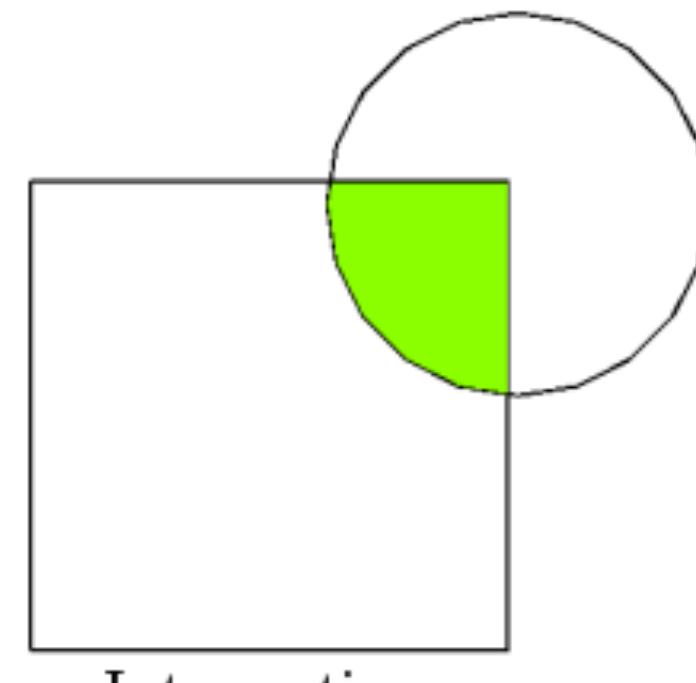
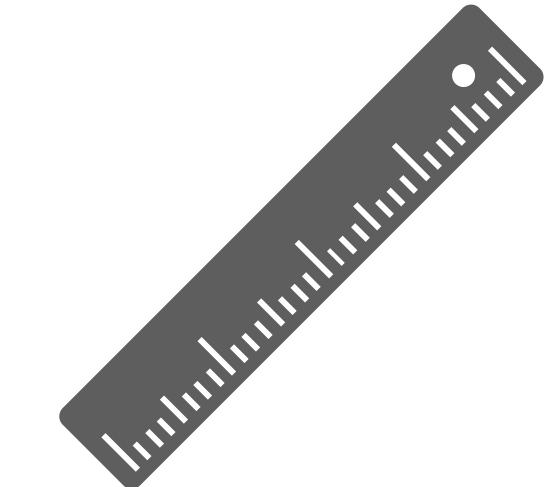
Static maps



CRS support

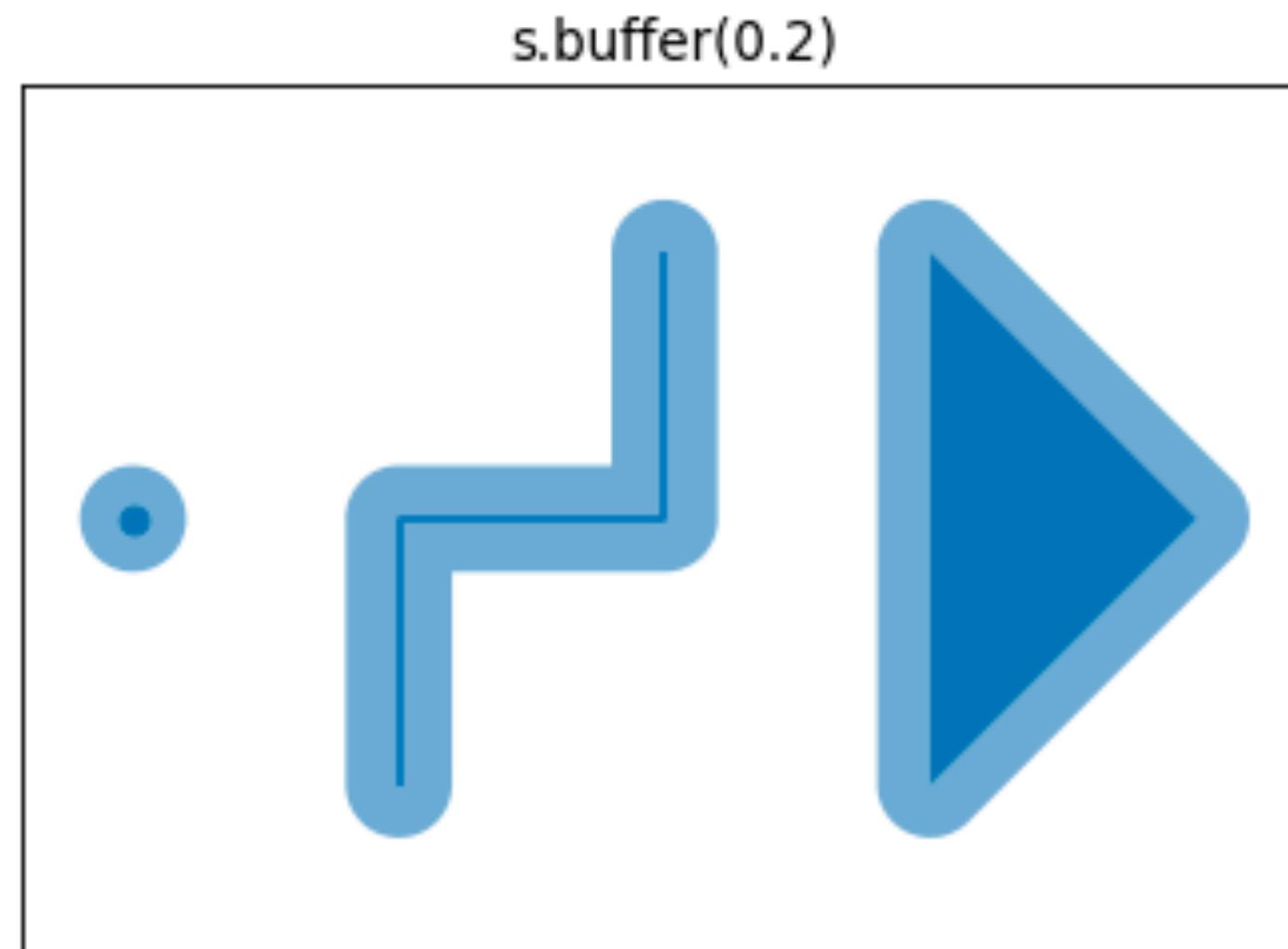


Spatial operations

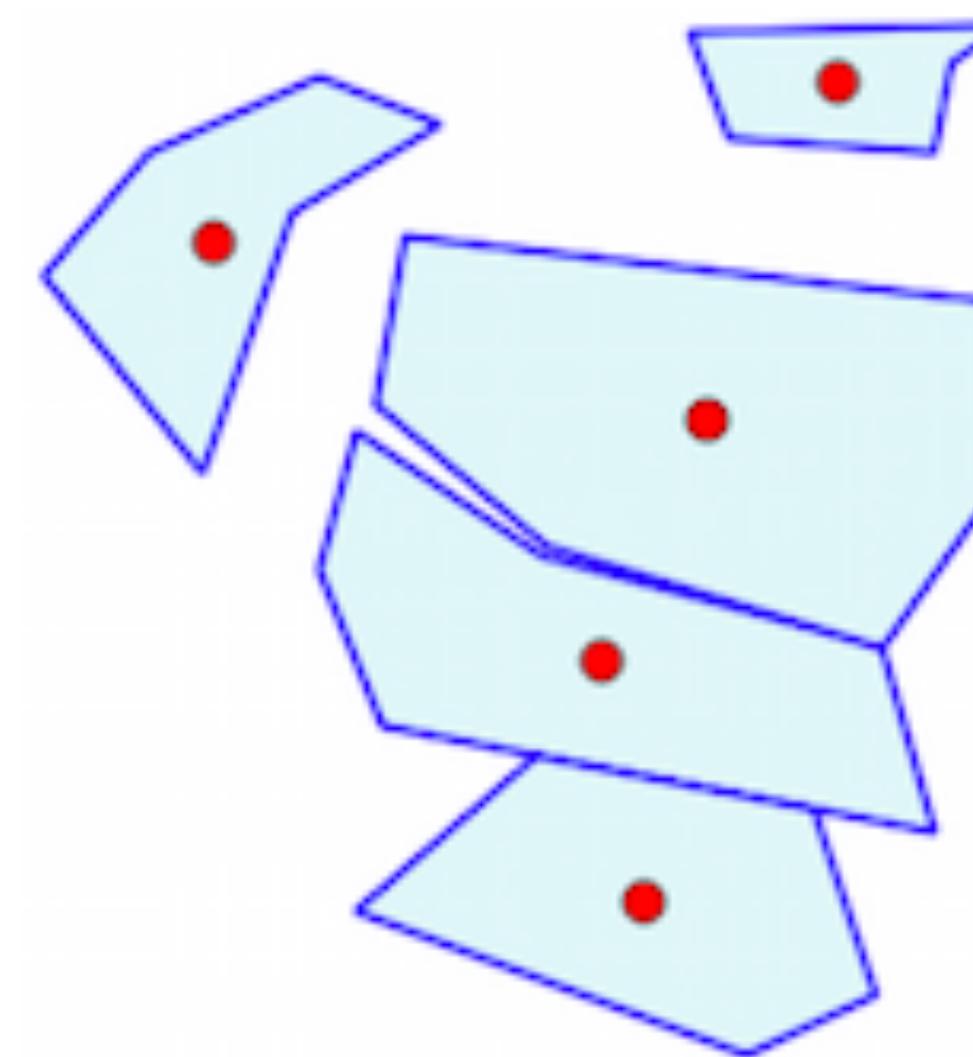


Intersection

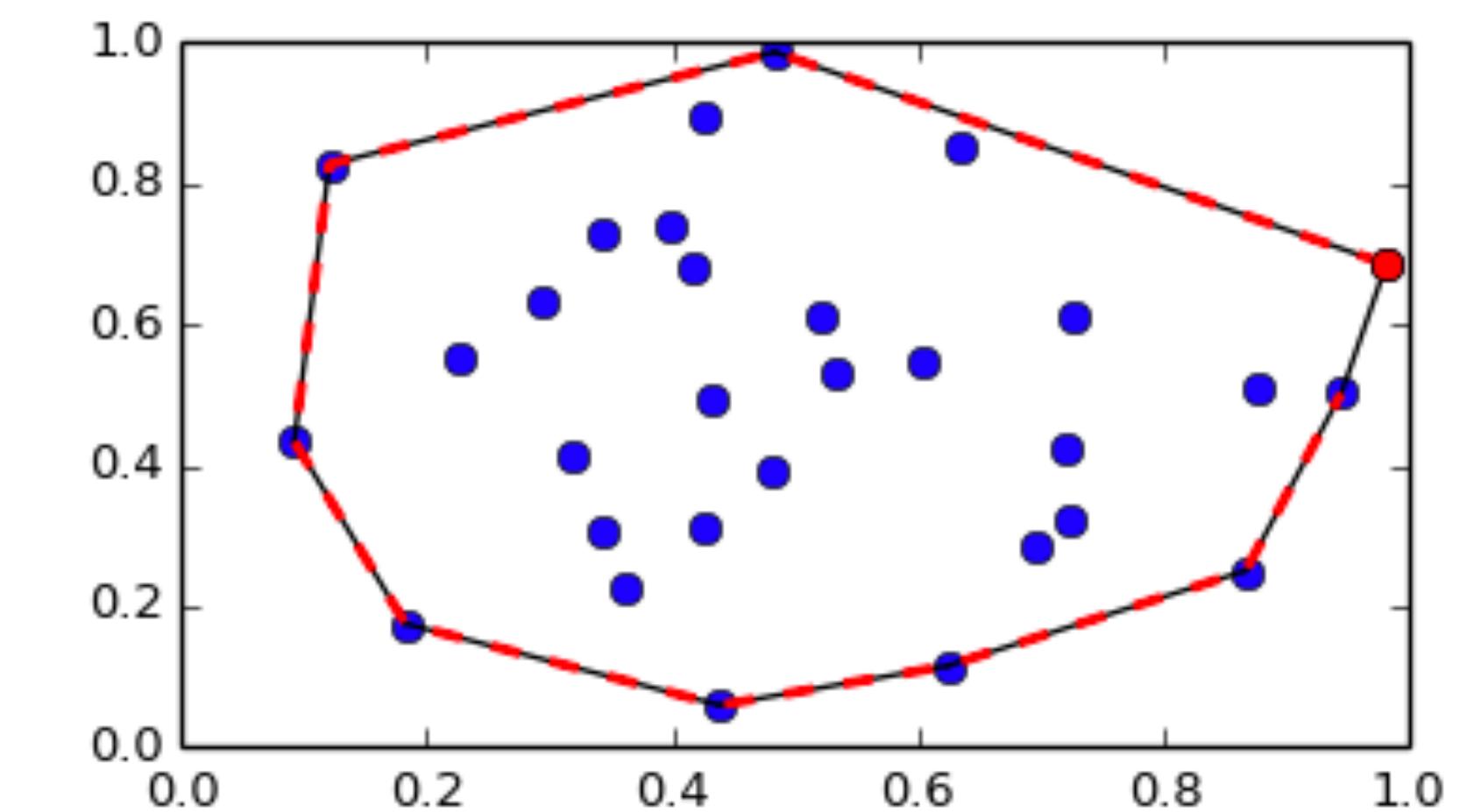
Geometric Manipulations



`gdf.buffer(10)`

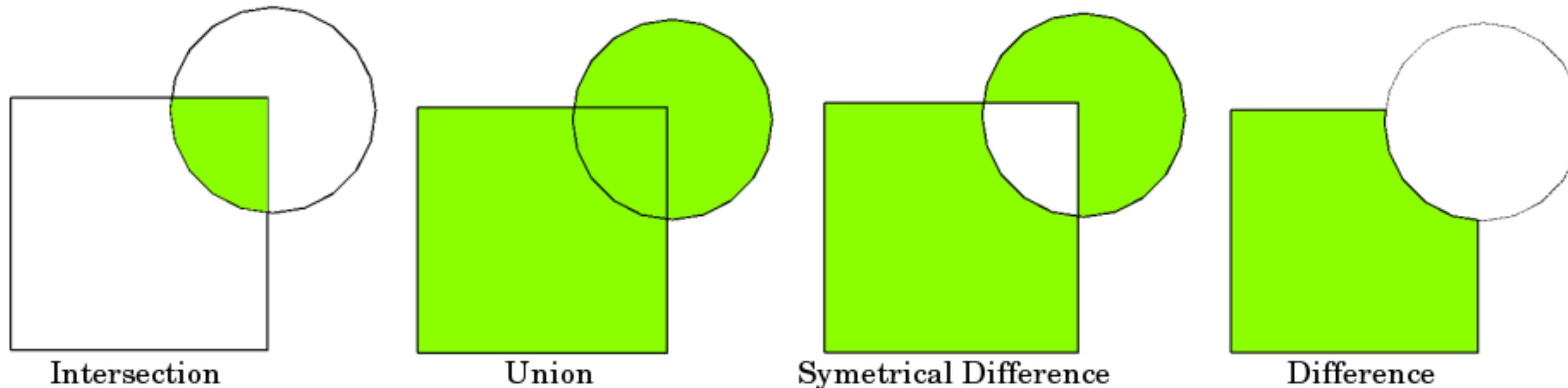


`gdf.centroid`



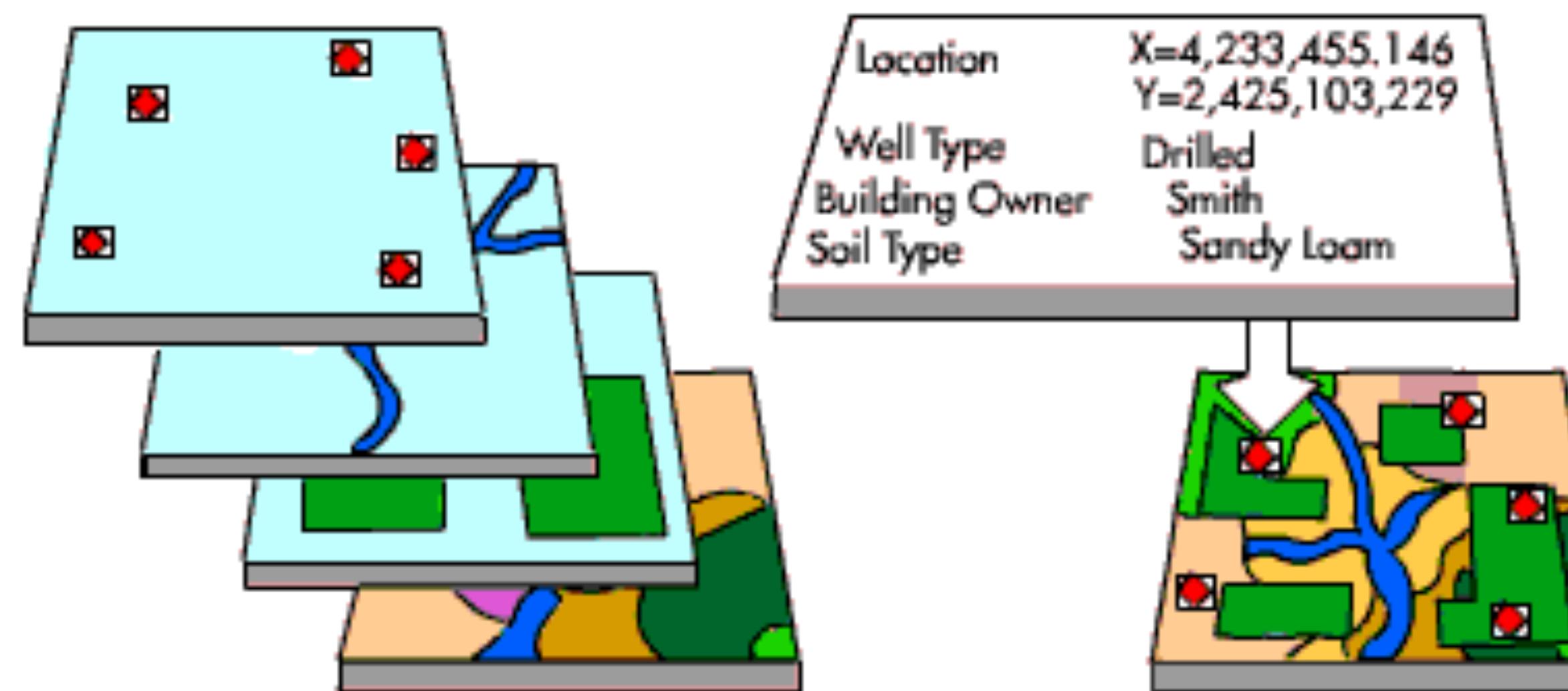
`gdf.convex_hull`

Set based operations



```
intersection = gdf1.overlay(gdf2, how='intersection')
```

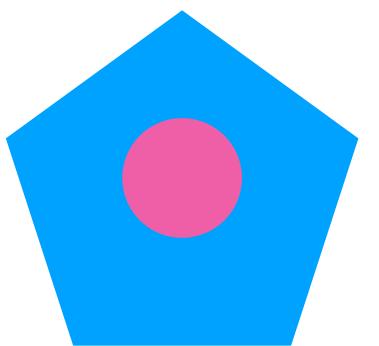
Spatial join



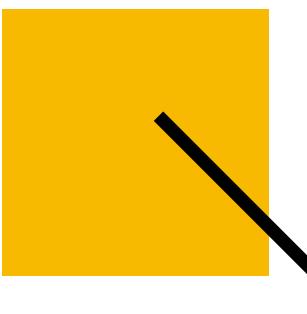
```
join = point_gdf.sjoin(poly_gdf)
```

Spatial queries

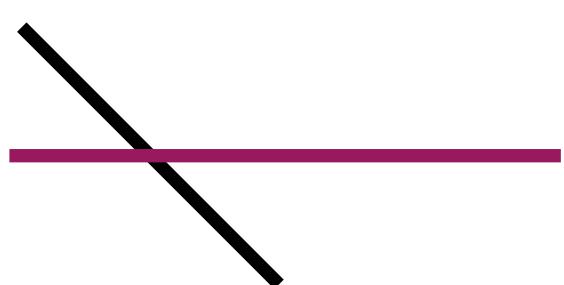
`point.within(poly)`



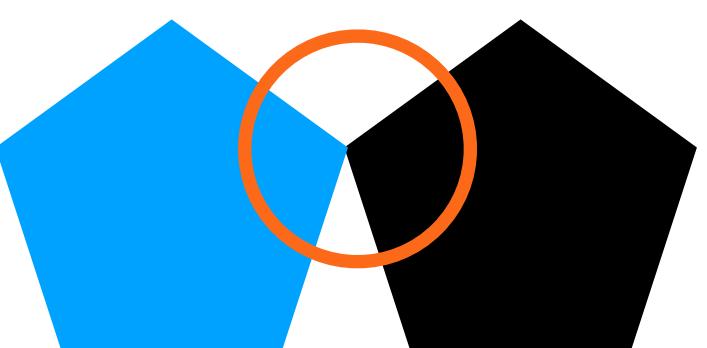
`line.intersects(poly)`



`line1.crosses(line2)`



`poly1.touches(poly2)`



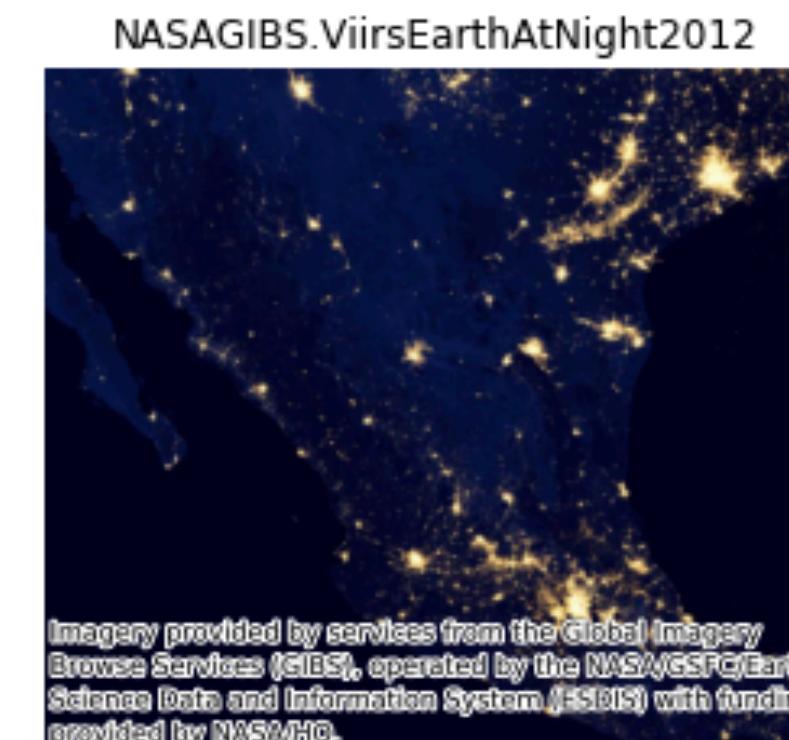
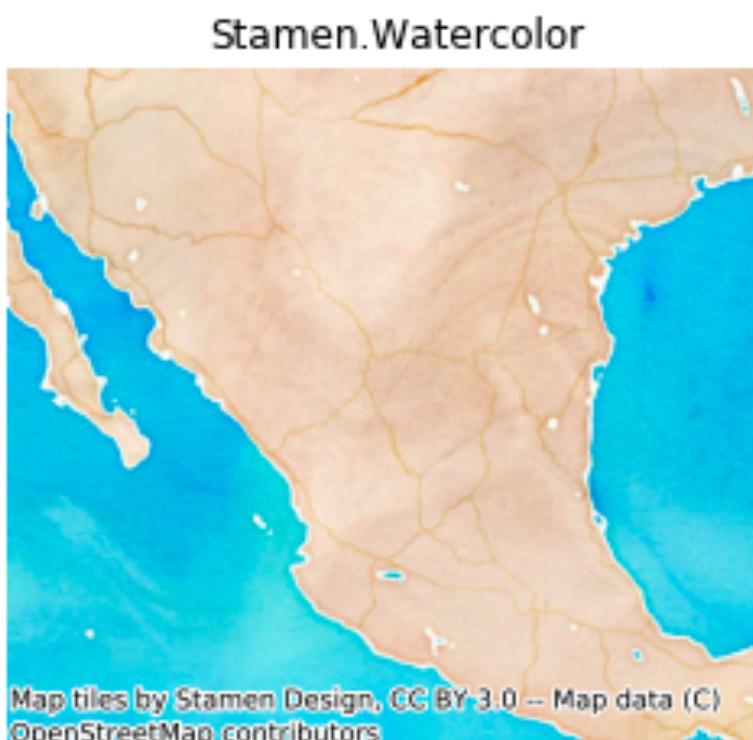
`etc....`

GeoPandas/Shapely are slow....
but improvements are coming!



Shapely 2.0

Contextily



Contextily

```
import contextily as cx\n\nax = gdf.plot(color="red")\ncx.add_basemap(\n    ax,\n    crs=gdf.crs,\n    source=cx.providers.Esri.WorldImagery\n)
```

Axis to plot basemap on

CRS to align data with basemap

Source of basemap
(online provider or image file from disk)

The diagram consists of three black arrows originating from the explanatory text on the right and pointing to specific parameters in the Python code. The first arrow points to the 'ax' parameter in the 'add_basemap' call. The second arrow points to the 'crs' parameter, which is preceded by 'gdf.crs'. The third arrow points to the 'source' parameter, which is preceded by 'cx.providers.Esri.WorldImagery'.

Jupyter

We now know how to...

- Read vector data with *GeoPandas*
- Make simple maps with *matplotlib* and *contextily*
- Do spatial operations like buffering
- Modify the data's CRS

Next week: Choropleth maps & map classification

Denmark's coronavirus hotspots (by municipality), December 14th

Coronavirus cases per 100,000 residents over past 7 days as at December 14th (Source: SSI)

