

Reading Spatial Data in R

HES 505 Fall 2023: Session 4

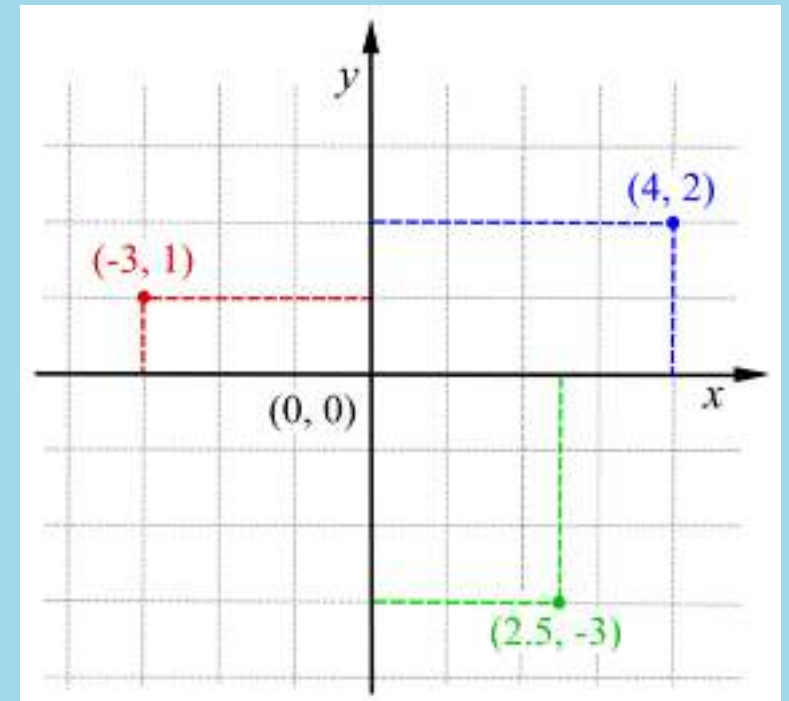
Matt Williamson

Objectives

1. Revisit the components of spatial data
2. Describe some of the key considerations for thinking about spatial data
3. Introduce the two primary **R** packages for spatial workflows
4. Learn to read and explore spatial objects in **R**

Describing Absolute Locations

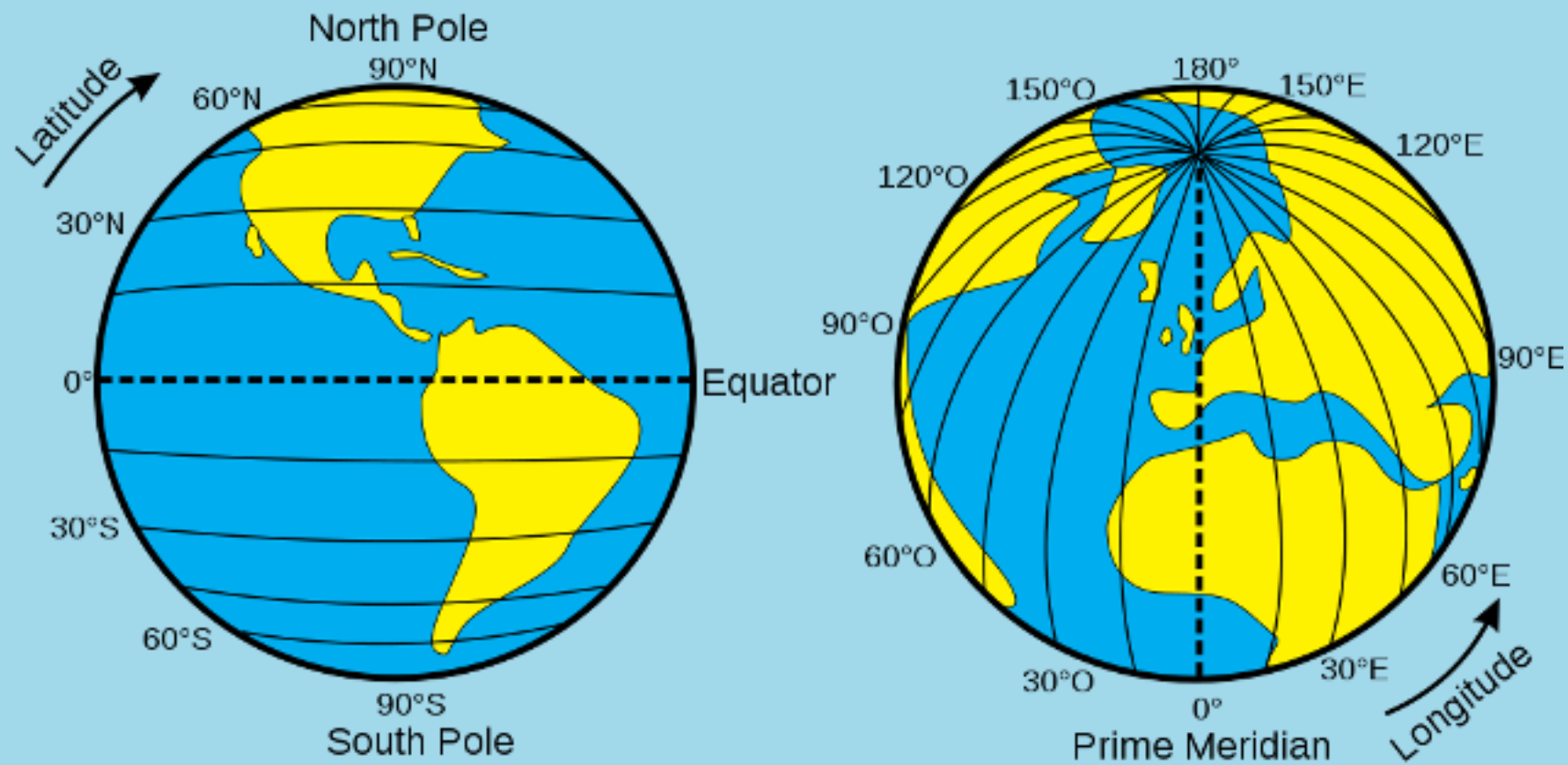
- **Coordinates:** 2 or more measurements that specify location relative to a *reference system*
- Cartesian coordinate system
- *origin* (O) = the point at which both measurement systems intersect
- Adaptable to multiple dimensions (e.g. z for altitude)



Cartesian Coordinate System

Locations on a Globe

- The earth is not flat...



Latitude and Longitude

Locations on a Globe

- The earth is not flat...
- Global Reference Systems (GRS)
- *Graticule*: the grid formed by the intersection of longitude and latitude
- The graticule is based on an ellipsoid model of earth's surface and contained in the *datum*

Global Reference Systems

The *datum* describes which ellipsoid to use and the precise relations between locations on earth's surface and Cartesian coordinates

- Geodetic datums (e.g., **WGS84**): distance from earth's center of gravity
- Local data (e.g., **NAD83**): better models for local variation in earth's surface

Describing location: extent

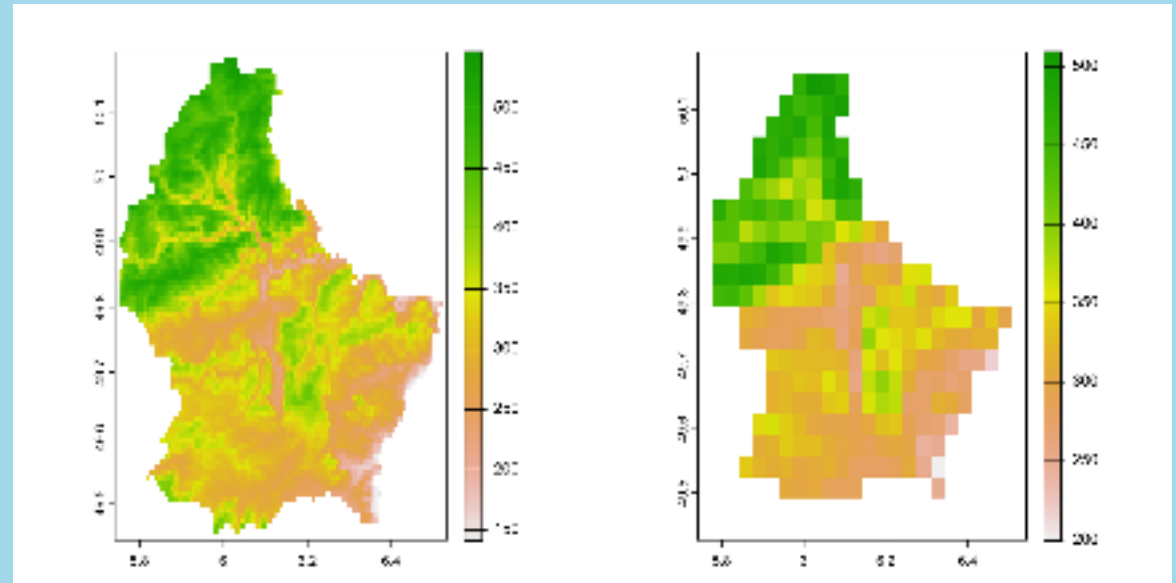
- How much of the world does the data cover?
- For rasters, these are the corners of the lattice
- For vectors, we call this the bounding box

Describing location: resolution

Resolution is the size of the smallest object that can be distinguished from its background.

Resolution is a function of the wavelength of the radiation used to observe the object.

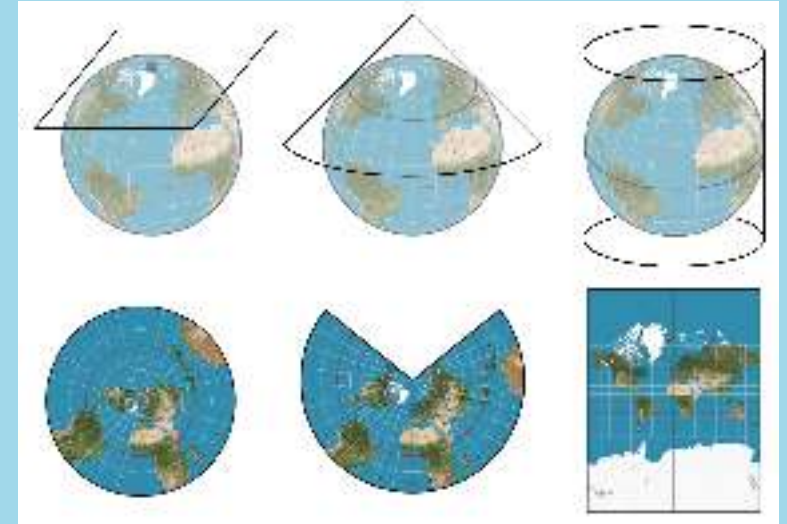
- **Resolution:** the accuracy that the location and shape of a map's features can be depicted
- **Minimum Mapping Unit:** The minimum size and dimensions that can be reliably represented at a given *map scale*.
- Map scale vs. scale of analysis



The earth is not flat...

Projections

- But maps, screens, and publications are...
- **Projections** describe *how* the data should be translated to a flat surface
- Rely on ‘developable surfaces’
- Described by the Coordinate Reference System (CRS)

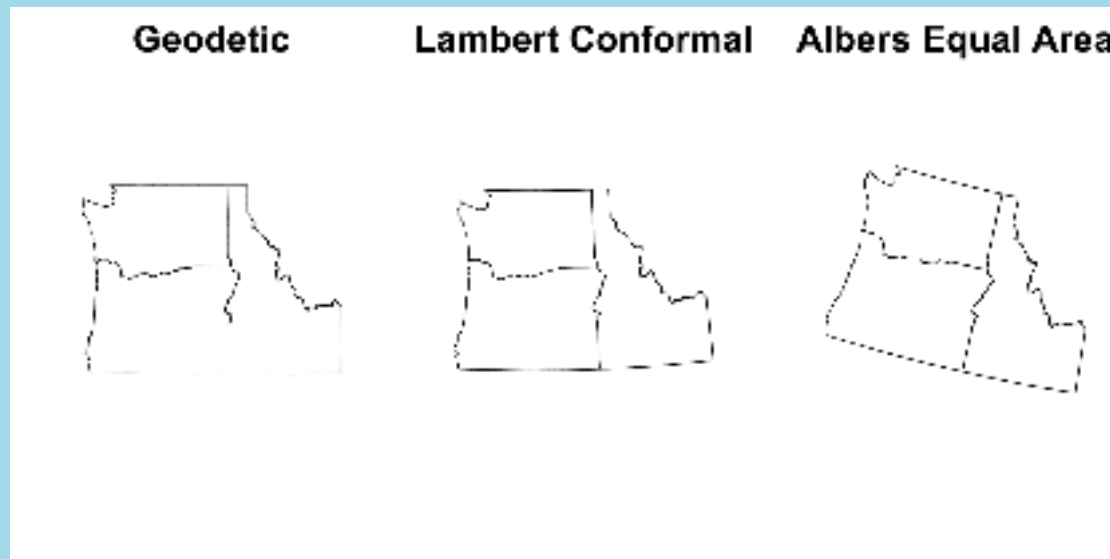


Developable Surfaces

Projection necessarily induces some form of distortion (tearing, compression, or shearing)

Coordinate Reference Systems

- Some projections minimize distortion of angle, area, or distance
- Others attempt to avoid extreme distortion of any kind
- Includes: Datum, ellipsoid, units, and other information (e.g., False Easting, Central Meridian) to further map the projection to the GCS
- Not all projections have / require all of the parameters



Choosing Projections



- Equal-area for thematic maps
- Conformal for presentations
- Mercator or equidistant for navigation and distance

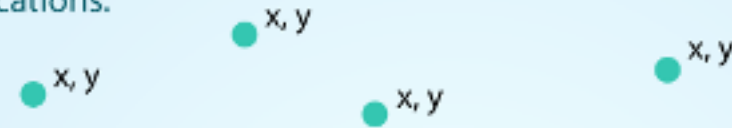
Geometries, support, and spatial messiness

Geometries

- Vectors store aggregate the locations of a feature into a geometry
- Most vector operations require simple, valid geometries

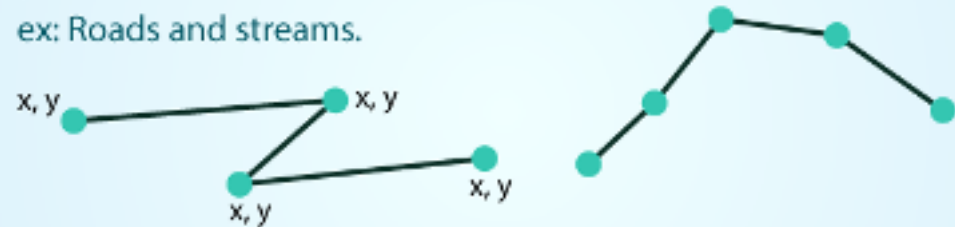
POINTS: Individual x, y locations.

ex: Center point of plot locations, tower locations, sampling locations.



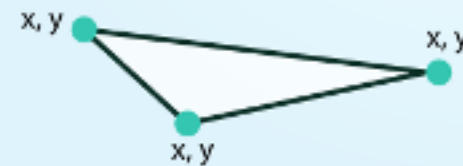
LINES: Composed of many (at least 2) vertices, or points, that are connected.

ex: Roads and streams.



POLYGONS: 3 or more vertices that are connected and **closed**.

ex: Building boundaries and lakes.

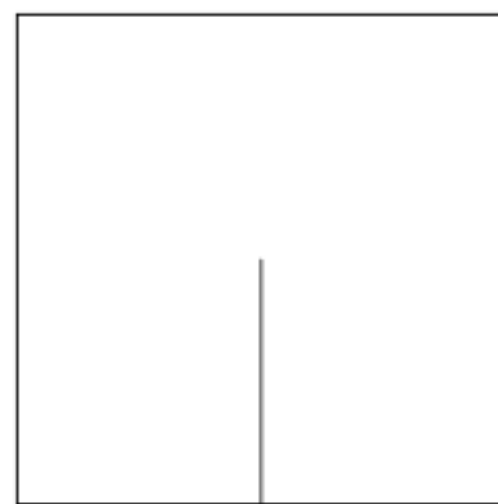
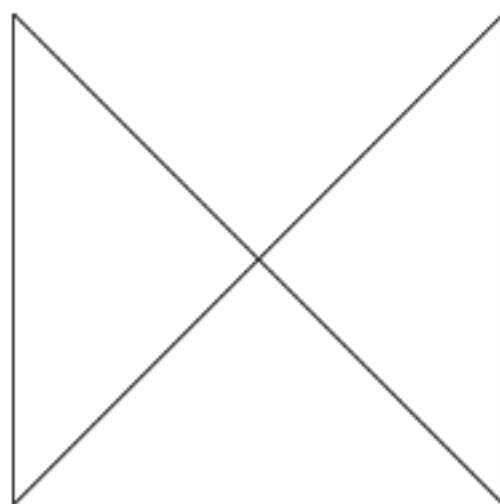
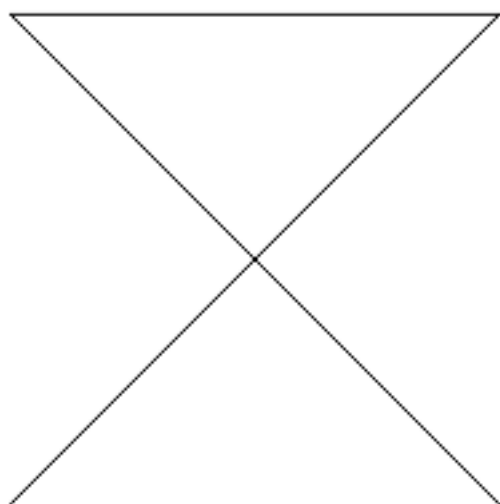


neon

Image Source: Colin Williams (NEON)

Valid Geometries

- A **linestring** is *simple* if it does not intersect
- Valid polygons
- Are closed (i.e., the last vertex equals the first)
- Have holes (inner rings) that inside the the exterior boundary
- Have holes that touch the exterior at no more than one vertex (they don't extend across a line) - For multipolygons, adjacent polygons touch only at points
- Do not repeat their own path



Empty Geometries

- Empty geometries arise when an operation produces **NULL** outcomes (like looking for the intersection between two non-intersecting polygons)
- **sf** allows empty geometries to make sure that information about the data type is retained
- Similar to a **data.frame** with no rows or a **list** with **NULL** values
- Most vector operations require simple, valid geometries

Support

- **Support** is the area to which an attribute applies.

Spatial Messiness

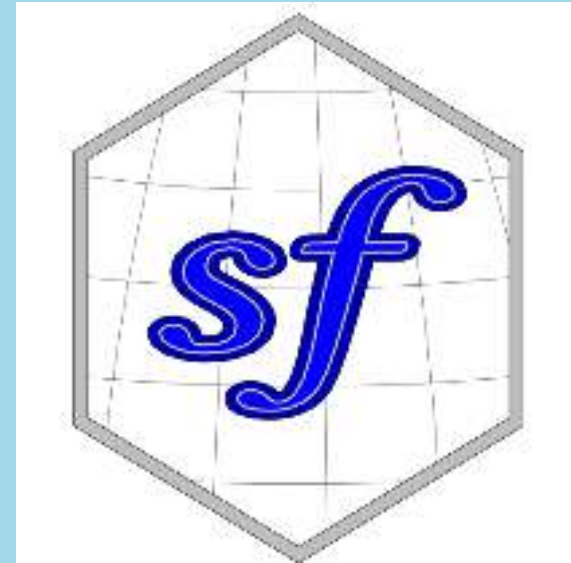
- Quantitative geography requires that our data are aligned
- Achieving alignment is part of reproducible workflows
- Making principled decisions about projections, resolution, extent, etc

Mapping Location in R

Data Types and **R** Packages

Data Types

- Vector Data
 - Point features
 - Line features
 - Area features (polygons)
- Raster Data
 - Spatially continuous field
 - Based on pixels (not points)



Reading in Spatial Data: spreadsheets

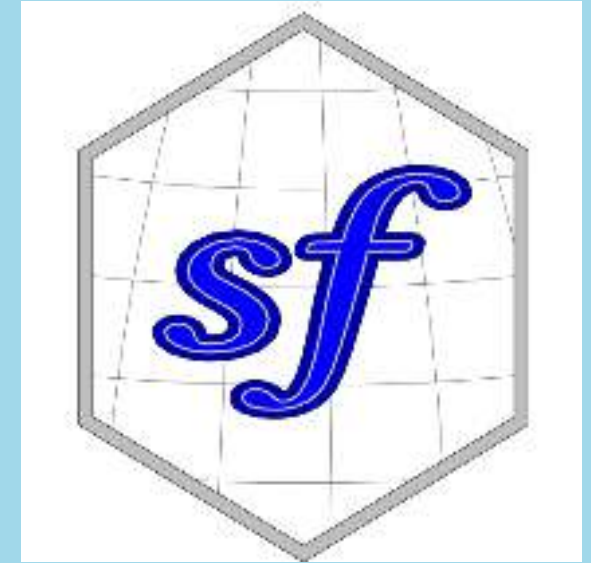
- Most basic form of spatial data
- Need **x** (longitude) and **y** (latitude) as columns
- Need to know your CRS
- **read_***** necessary to bring in the data

```
1 library(tidyverse)
2 library(sf)
3
4 file.to.read <- read_csv(file = "path/to/your/file",
5                           col_names = TRUE, col_types = NULL,
6                           na = na = c("", "NA"))
7
8 file.as.sf <- st_as_sf(file.to.read,
9                        coords = c("longitude", "latitude"),
10                        crs=4326)
```

Reading in Spatial Data: shapefiles

Reading in Spatial Data: shapefiles

```
1 library(sf)
2 shapefile.inR <- read_sf(dsn = "path/to/file.shp",
3                           layer=NULL, geometry_colu
```



Reading in Spatial Data: rasters

- **rast** will read rasters using the **terra** package
- Also used to create rasters from scratch
- Returns **SpatRaster** object

```
1 library(sf)
2 raster.inR <- rast(x = "path/to/file.shp",
3                   lyrs=NULL)
```



Introducing the Data

- Good idea to get to know your data before manipulating it
- `str`, `summary`, `nrow`, `ncol` are good places to start
- `st_crs` (for `sf` class objects) and `crs` (for `SpatRaster` objects)
- We'll practice a few of these now...

Saving your data

- `write_sf` for `sf` objects; `writeRaster` for `SpatRasters`

```
1 library(sf)
2 library(terra)
3
4 write_sf(object = object.to.save, dsn = "path/to/save/object", append = FALSE)
5 writeRaster(x=object, filename = "path/to/save")
```

