Reading Spatial Data in R

HES 505 Fall 2024: Session 4

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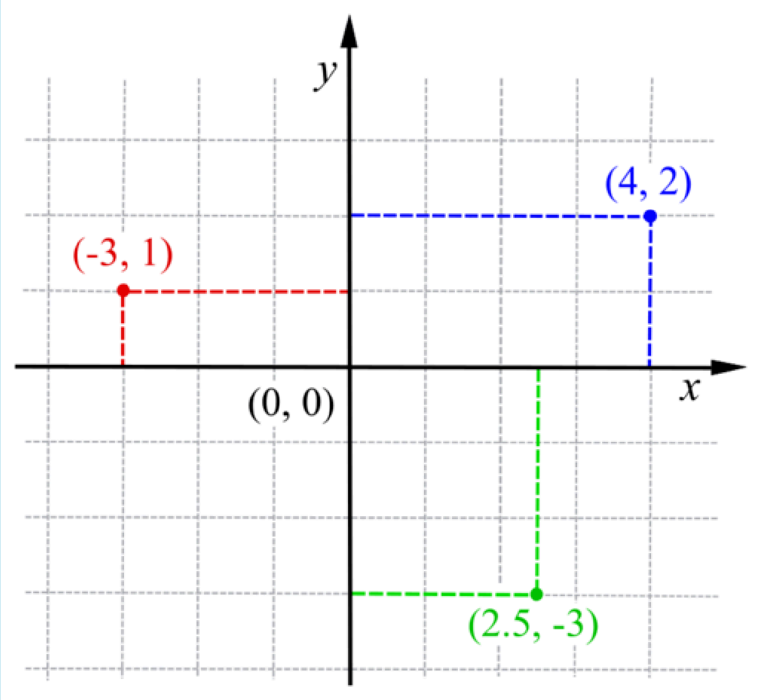
Objectives

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*

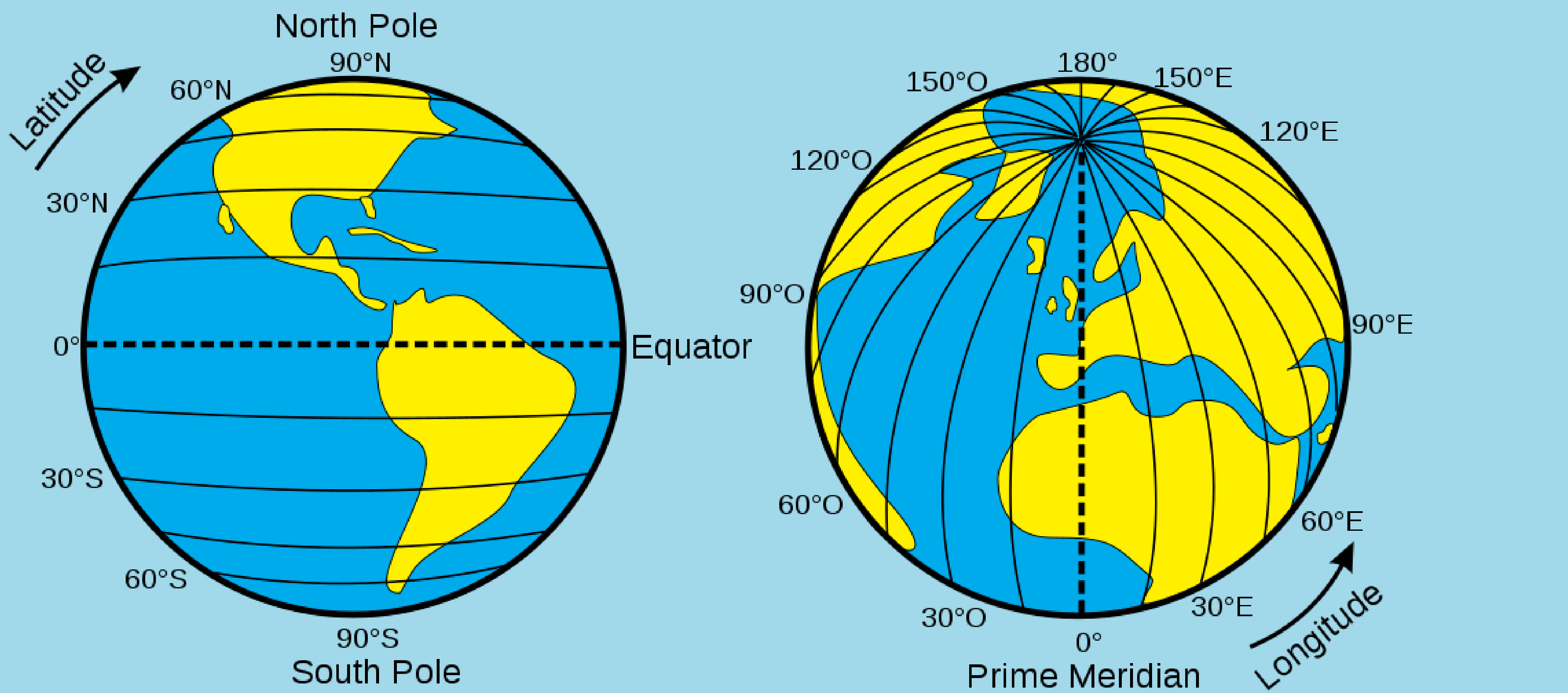
- Cartesian coordinate system
- *origin (O)* = the point at which both measurement systems intersect
- Adaptable to multiple dimensions (e.g. *z* for altitude)



Cartesian Coordinate System

Locations on a Globe

- The earth is not flat…



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

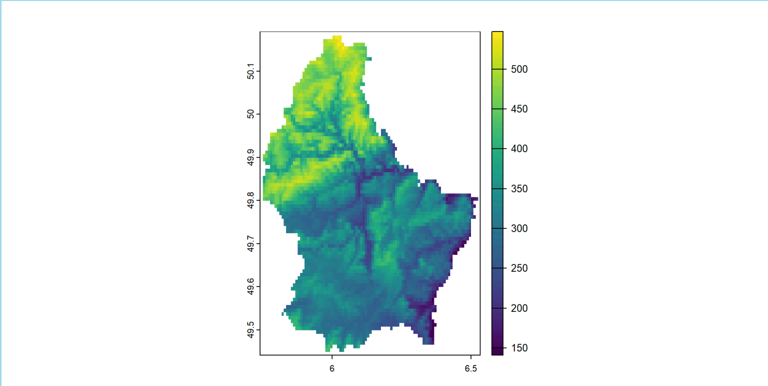
- Geodetic datums (e.g., `WGS84`): distance from earth's center of gravity
- Local data (e.g., `NAD83`): better models for local variation in earth's surface

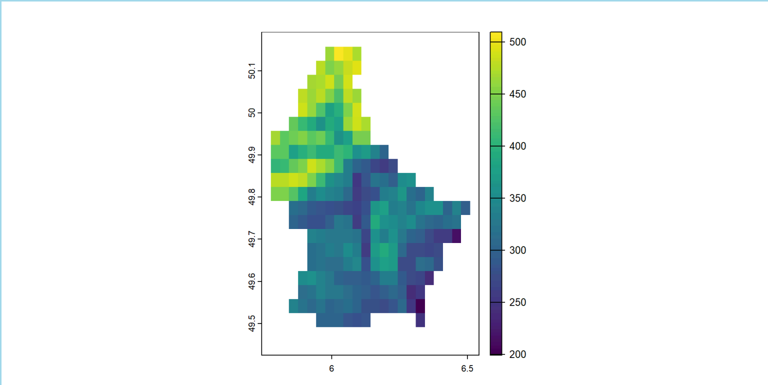
Describing location: extent

- 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:** 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

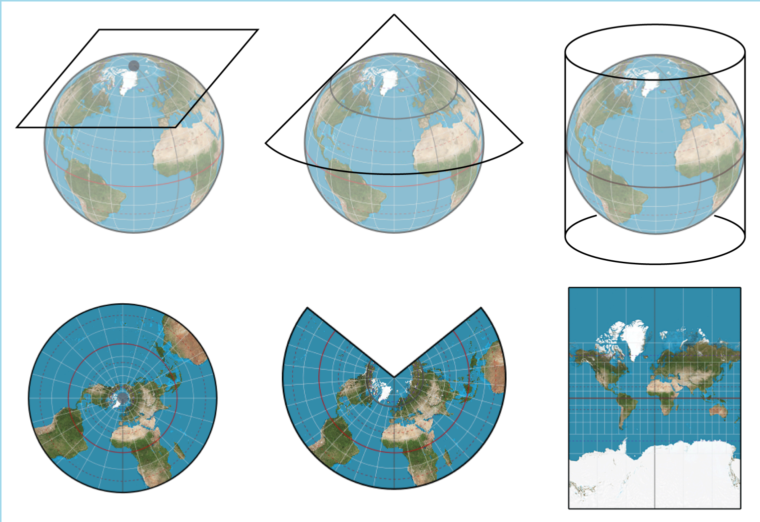




The earth is not flat…

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)

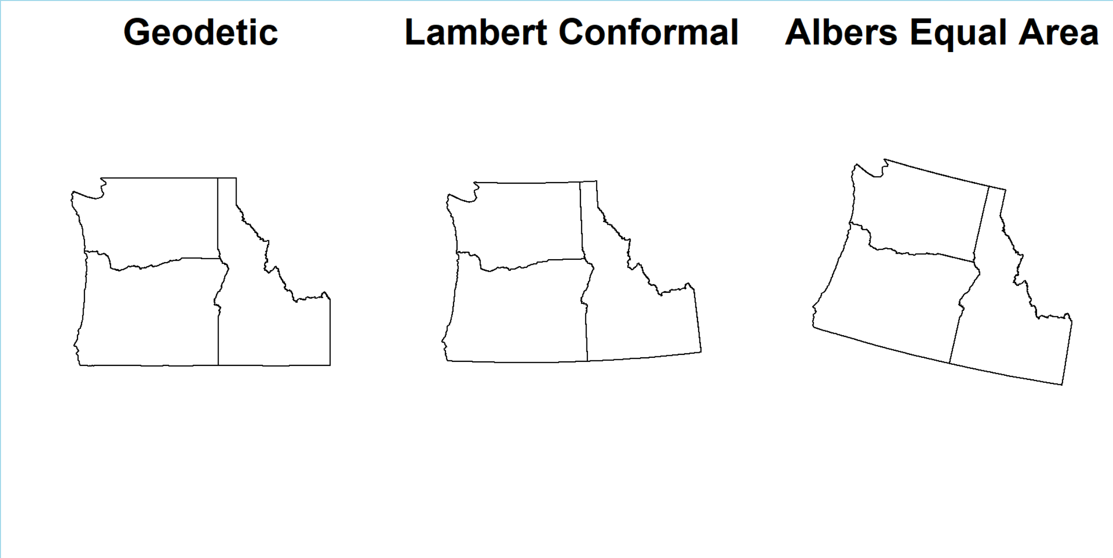


Developable Surfaces

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


Neil Kaye/@neilrkaye

The Mercator Map Projection with the true size and shape of the country overlaid.

- 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

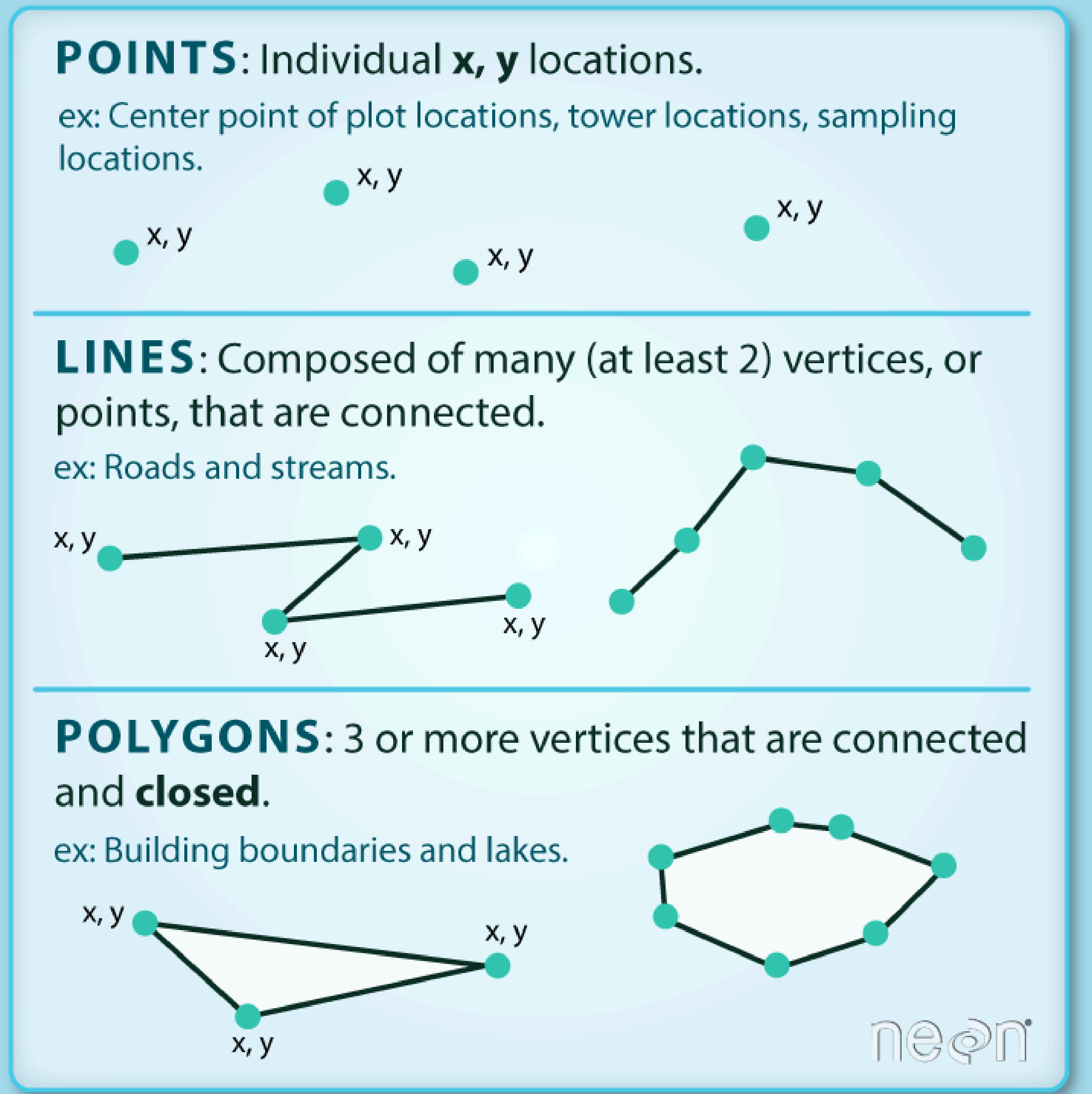
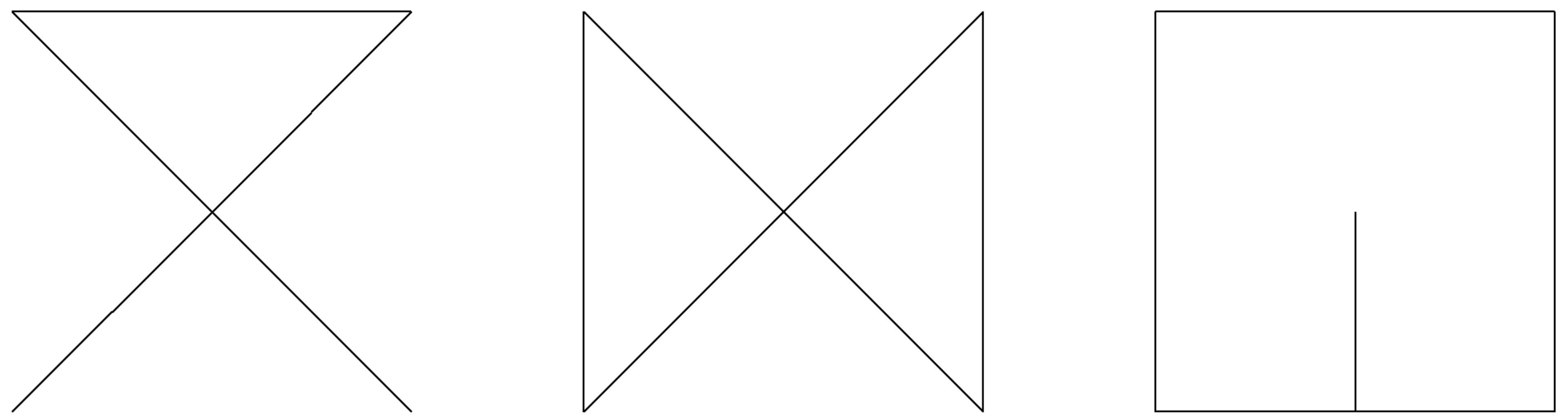


Image Source: Colin Williams (NEON)

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

```
library(tidyverse)
library(sf)

file.to.read <- read_csv(file = "path/to/your/file",
                         col_names = TRUE, col_types = NULL,
                         na =na = c("", "NA"))

file.as.sf <- st_as_sf(file.to.read,
                       coords = c("longitude", "latitude"),
                       crs=4326)
```

Reading in Spatial Data: shapefiles

Reading in Spatial Data: shapefiles

```r
library(sf)
shapefile.inR <- read_sf(dsn = "path/to/fi
                          layer=NULL, geome
```

Reading in Spatial Data: rasters

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

```
library(terra)
raster.inR <- rast(x = "path/to/file.tif"
                              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`

```
library(sf)
library(terra)

write_sf(object = object.to.save, dsn = "path/to/save/object", appe
writeRaster(x=object, filename = "path/to/save")
```