Spatial Data is Special Data

HES 505 Fall 2022: Session 6

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Space Exploration

Objectives

- Articulate why we care about space

- Describe elements of spatial data

- Define a coordinate reference system and its importance

- Describe several ways to load spatial data into R

- Identify projections in R

Locations, Relations, and Understanding

- **Geography** uses *location* to understand how social and physical processes give rise to the environment we experience

- **Geographic Information Systems** provide a structure for storing, visualizing, and describing *location* data.

- **GeoComputation** and **GIScience** integrate math, stats, and high-performance computing to move beyond description.

Location lets us ask:

- Questions about geographic distribution

- Questions about geographic interaction

- Questions about geographic change

- Questions about geographic association

- *Questions about causation?*

Location vs. Place

- **Place:** an area having unique **physical** and **human** characteristics **interconnected** with other places

- **Location:** the actual position on the earth's surface

- **Sense of Place:** the emotions someone attaches to an area based on experiences

- Place is *location plus meaning*

Describing Location

- **nominal: (potentially contested) place names**

- **absolute: the physical location on the earth's surface**

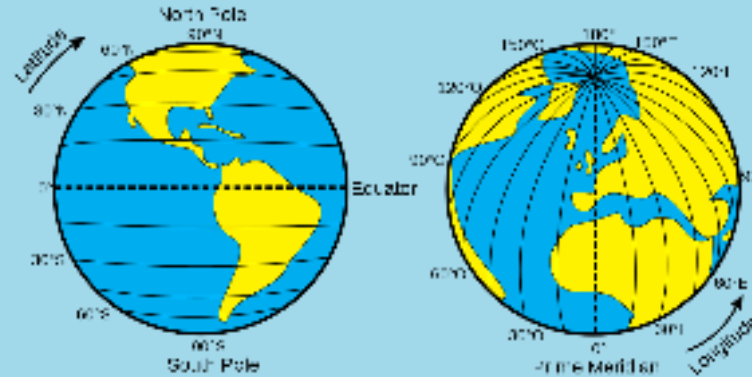# Describing Absolute Locations

- **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)
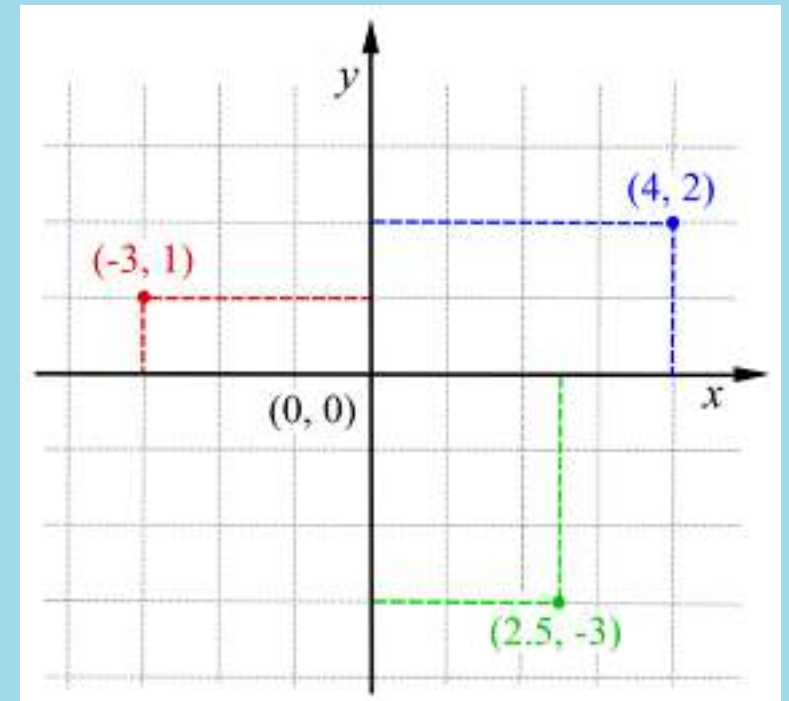
Cartesian Coordinate System

Locations on a Globe

- The earth is not flat…

Latitude and Longitude

- 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

The Earth is Not Flat

- But maps, screens, and publications are…

- **Projections** describe *how* the data should be translated to a flat surface

- Rely on 'developable surfaces'
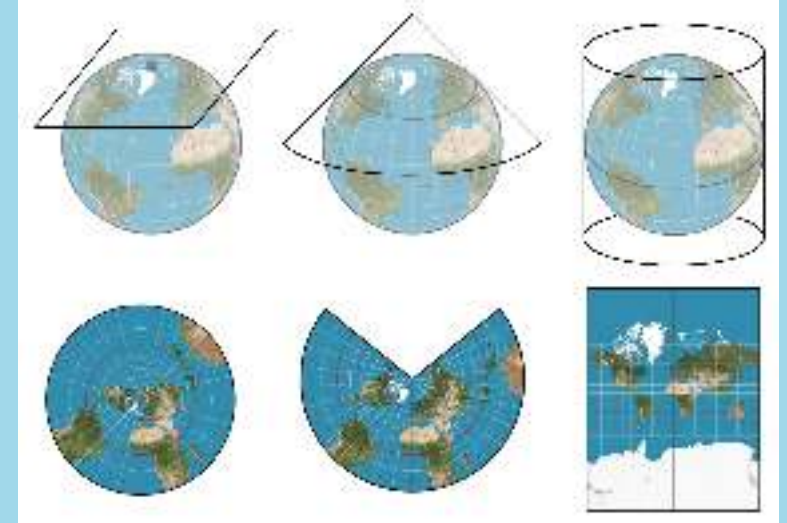
Developable Surfaces

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

Choosing Projections

Neil Kaye/@neilrkaye

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

- Some projections minimize distortion of angle, area, or distance

- Others attempt to avoid extreme distortion of any kind

- Particularly challenging for raster data
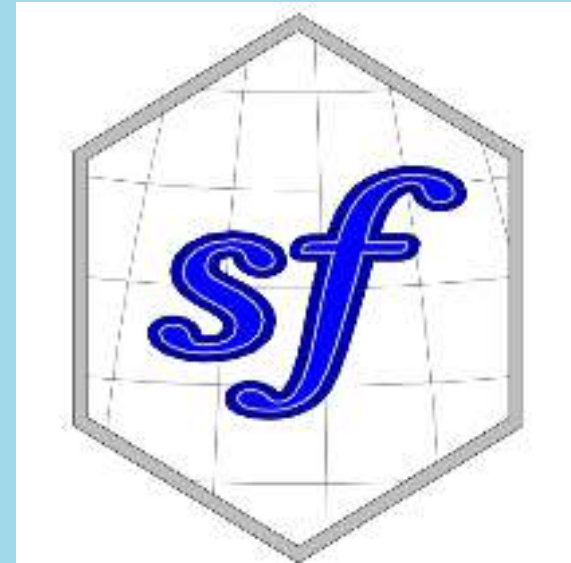
Choosing Projections

- Equal-area for thematic maps

- Conformal for presentations

- Mercator or equidistant for navigation and distance

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)

Mapping loaction: Coordinate Reference Systems

- 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

- R stores these data in several formats (EPSG, Proj, and WKT)

- Lots of projection info available at spatialreference.org

# Mapping loaction: Coordinate Reference Systems

- Primarily accessed using `sf::st_crs()` or `terra::crs()`

```
1  f <- rast(system.file("ex/meuse.tif", package="terra"))
2  nc <- st_read(system.file("shape/nc.shp", package="sf"))
3  st_crs(nc)
4  crs(nc)
```

Mapping location: Extent

- **Extent:** The amount of the Earth's surface represented by the mapped features

R has a very specific definition of extent: the rectangular region encompassed by the data
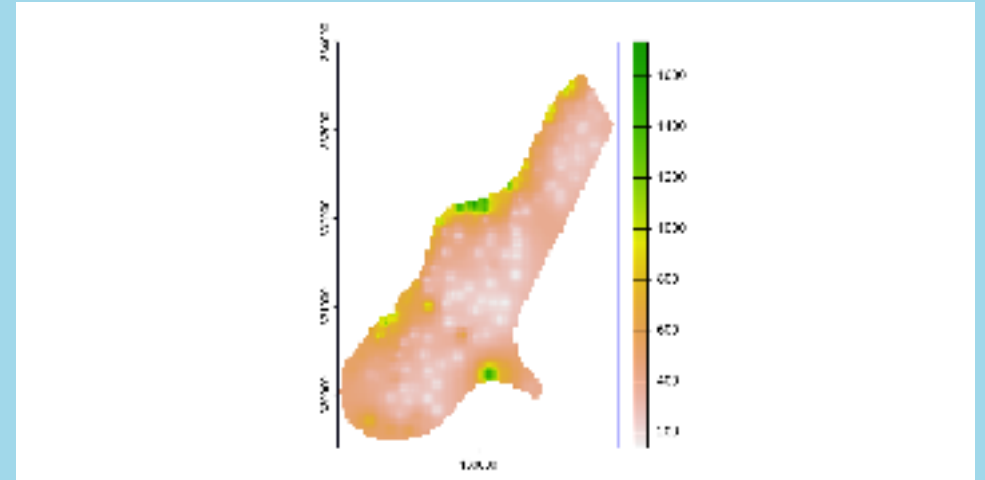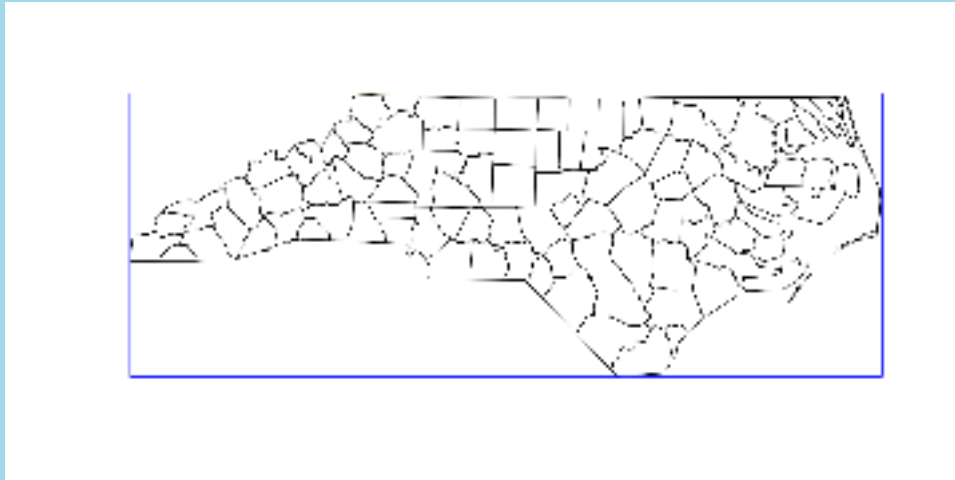
Using **R** to access the extent

- Using `st_bbox()` from the `sf` package

```
1  nc.shp <- st_read(system.file("shape/nc.shp", package="sf"))
```

```
Reading layer `nc' from data source

`/Library/Frameworks/R.framework/Versions/4.2/Resources/library/sf/shape/nc.shp
  using driver `ESRI Shapefile'
Simple feature collection with 100 features and 14 fields
Geometry type: MULTIPOLYGON
Dimension:      XY
Bounding box:   xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
Geodetic CRS:   NAD27
```

```
1  meuse.rst <- rast(system.file("ex/meuse.tif", package="terra"))
2  st_bbox(nc.shp)
```

```
    xmin        ymin       xmax        ymax
-84.32385   33.88199 -75.45698   36.58965
```

```
1  st_bbox(meuse.rst)
```

```
  xmin    ymin    xmax    ymax
178400  329400  181600  334000
```

Using **R** to access the extent

- Using `ext()` from the `terra` package

```
1  ext(nc.shp)
```

SpatExtent : -84.3238525390625, -75.4569778442383, 33.8819923400879, 36.5896492004395 (xmin, xmax, ymin, ymax)
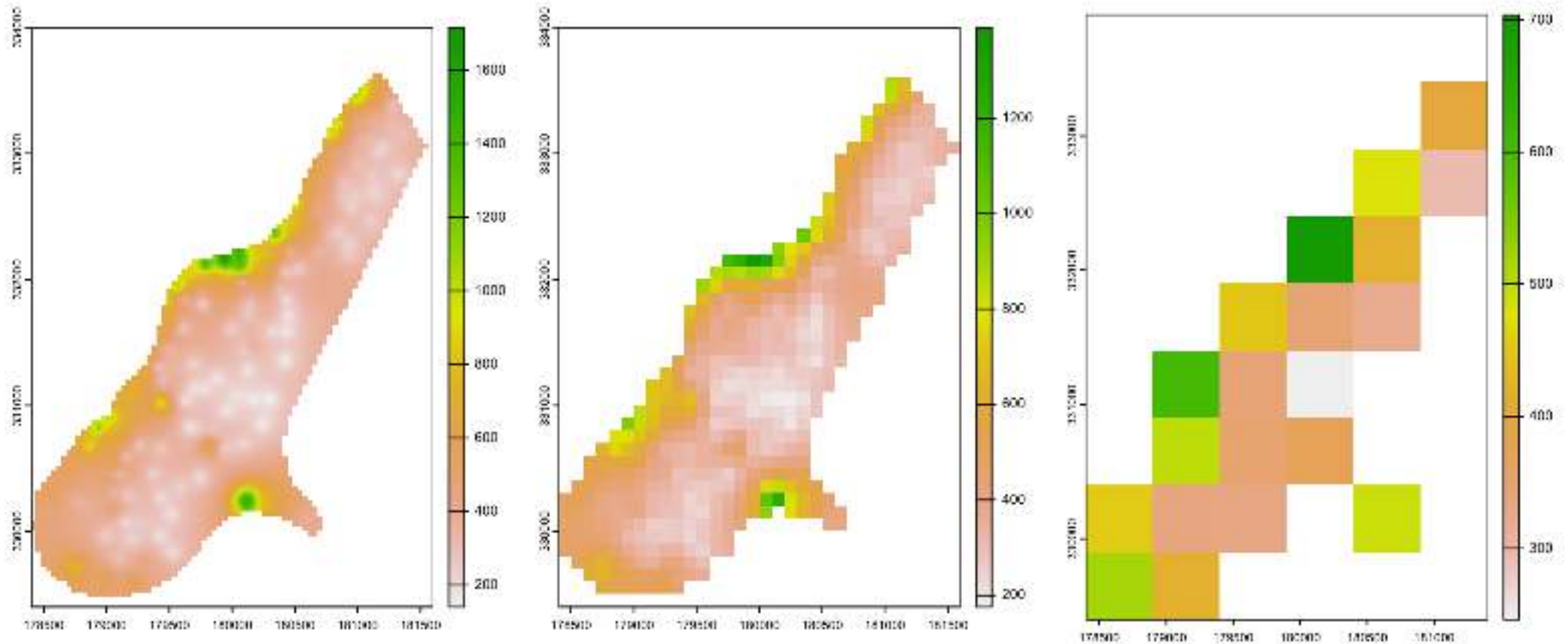
```
1  ext(meuse.rst)
```

SpatExtent : 178400, 181600, 329400, 334000 (xmin, xmax, ymin, ymax)

Mapping 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

Mapping location: Resolution

Using **R** to access resolution

- Thematically defined for `vector` datasets (check your metadata!!)

- Using `res()` in `terra`

```
1  f <- rast(system.file("ex/meuse.tif", package="terra"))
2  res(f)
```

```
[1] 40 40
```

Recap

Today's goals

- Articulate why we care about space

- Describe elements of spatial data

- Define a coordinate reference system and its importance

- Describe several ways to load spatial data into R

- Identify projections in R