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)

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

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’

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

Choosing Projections

- 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

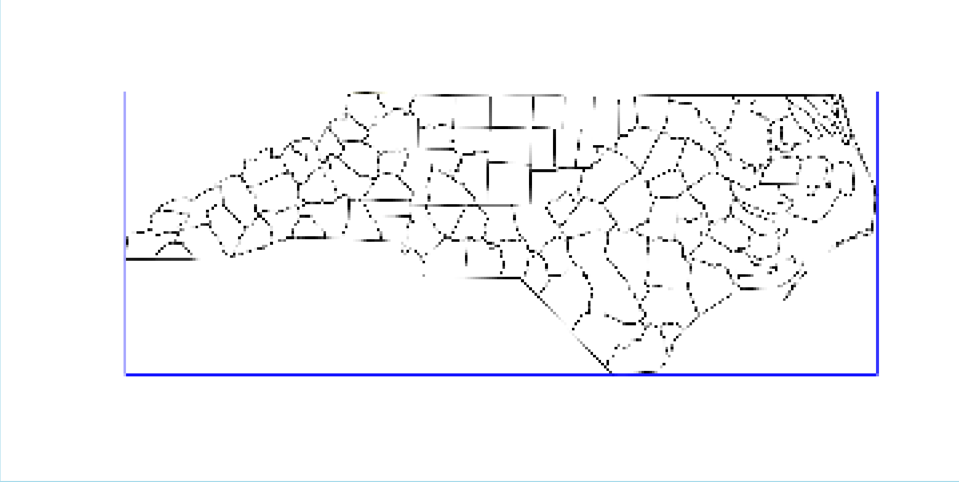
- Primarily accessed using `sf::st_crs()` or `terra::crs()`

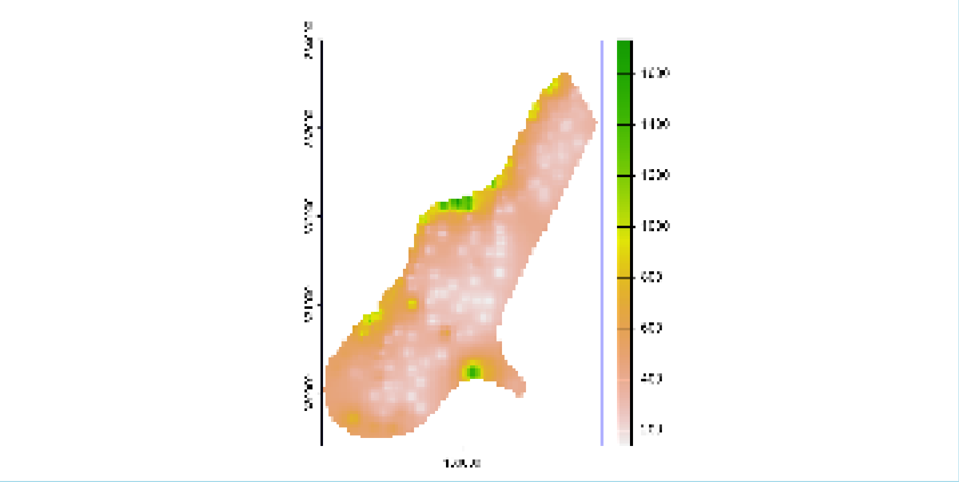
```
f <- rast(system.file("ex/meuse.tif", package="terra"))
nc <- st_read(system.file("shape/nc.shp", package="sf"))
st_crs(nc)
crs(nc)
```

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

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

```
Reading layer `nc' from data source
  `/Library/Frameworks/R.framework/Versions/4.3-x86_64/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
```

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

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

```r
st_bbox(meuse.rst)
```

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

Using R to access the extent

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

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

```
SpatExtent : -84.3238525390625, -75.4569778442383, 33.8819923400879,
36.5896492004395 (xmin, xmax, ymin, ymax)
```

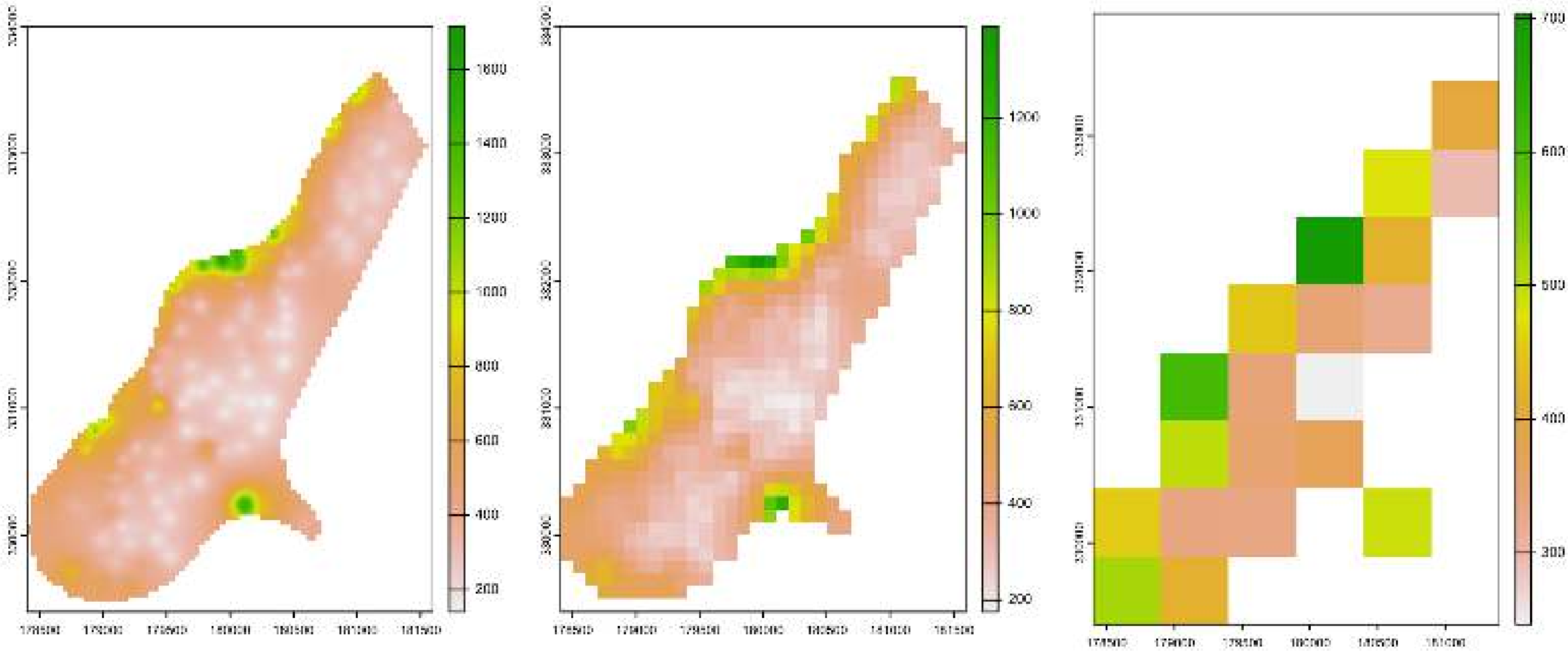
```
ext(meuse.rst)
```

```
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`

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

```
[1] 40 40
```

Recap

Today's goals

- Articulate why we care about space
- Describe elements of spatial data
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