

Introduction to Spatial Data

HES 505 Fall 2023: Session 3

Matt Williamson

Today's Plan

1. Ways to view the world
2. What makes data (geo)spatial?
3. Coordinate Reference Systems
4. Geometries, support, and spatial messiness

How do you view the world?

...As a Series of Objects?

- The world is a series of *entities* located in space.
- Usually distinguishable, discrete, and bounded
- Some spaces can hold multiple entities, others are empty
- Objects are digital representations of entities



...As a Continuous Field

How did the data arise?

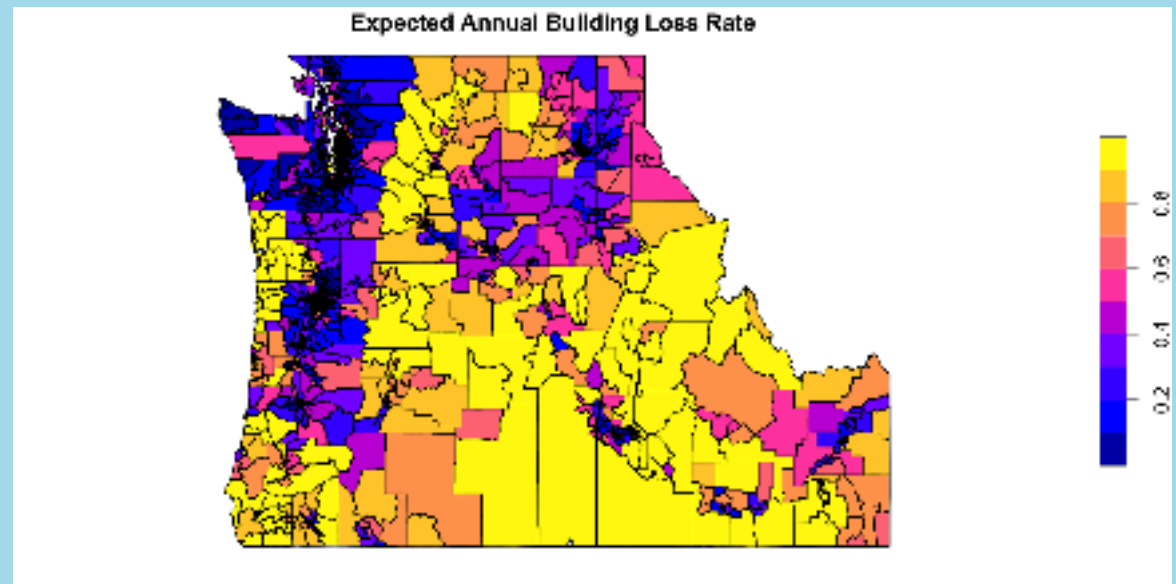
Spatial data as a stochastic process

$$Z(\mathbf{s}) : \mathbf{s} \in D \subset \mathbb{R}^d$$

Areal Data

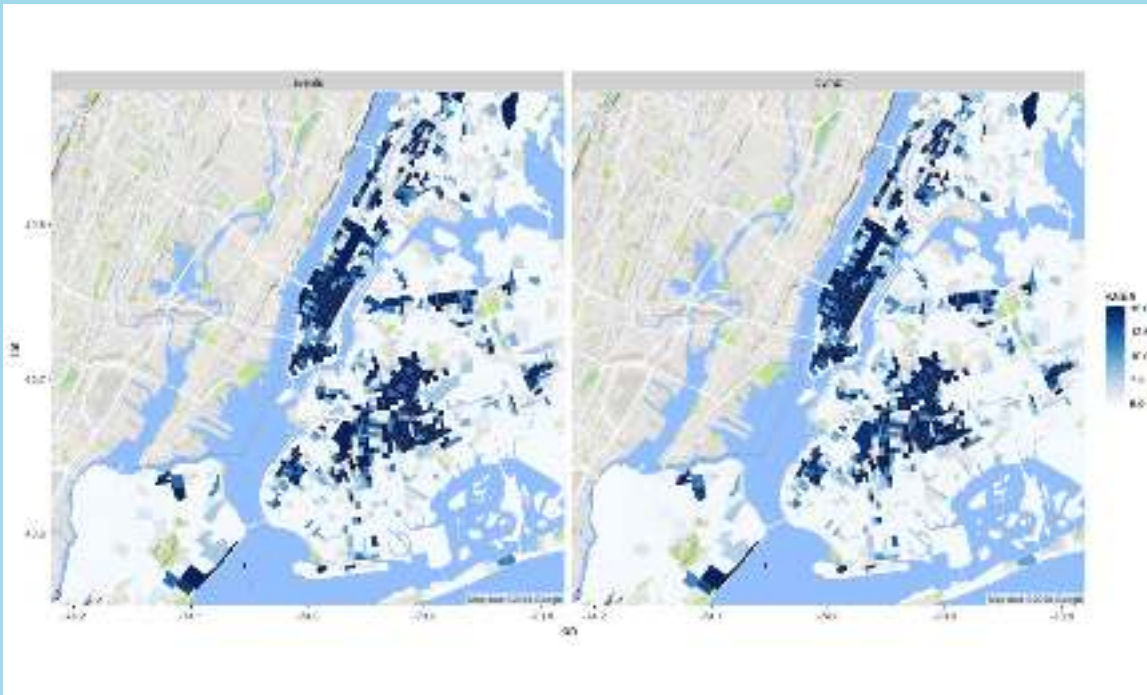
$$Z(\mathbf{s}) : \mathbf{s} \in D \subset \mathbb{R}^d$$

- D is fixed domain of countable units
- Typically involve some aggregation



Geostatistical data

$$Z(s) : s \in D \subset \mathbb{R}^d$$

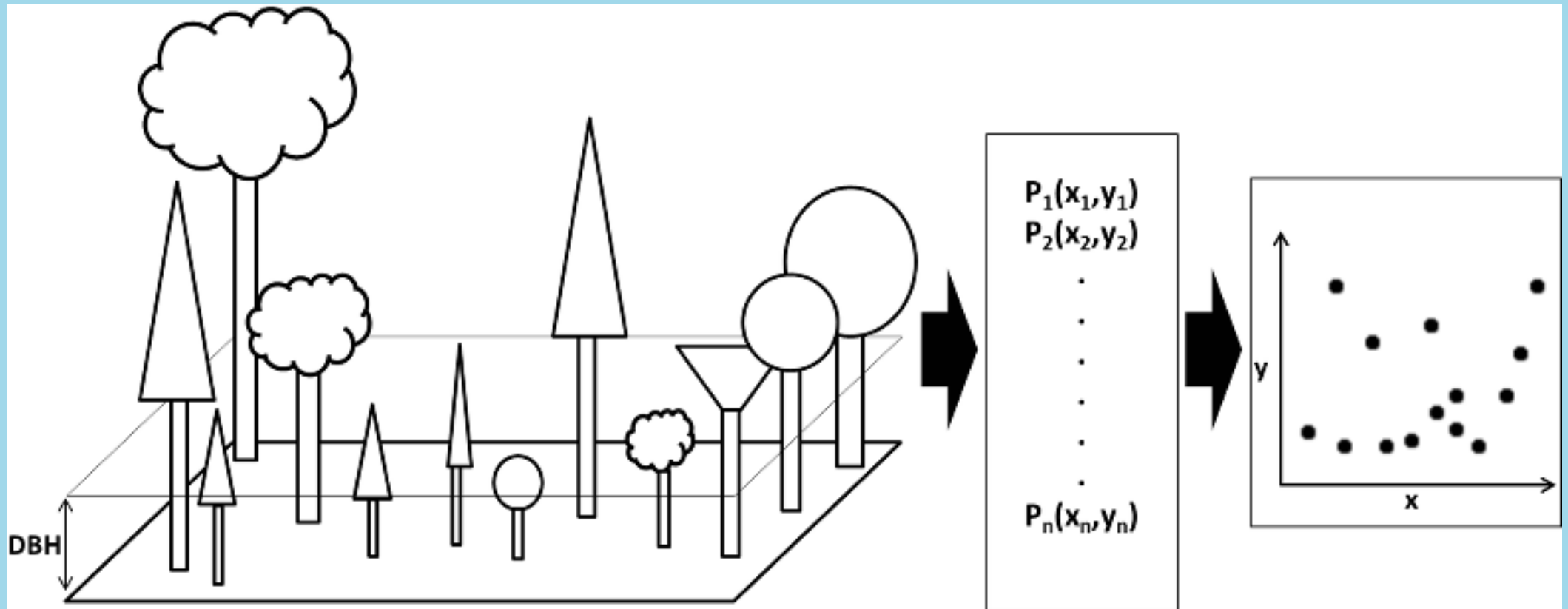


- D is a fixed subset of \mathbb{R}^d
- $Z(s)$ could be observed at any location within D .
- Models predict unobserved locations

Point patterns

$$Z(s) : s \in D \subset \mathbb{R}^d$$

- D is random; where s depicts the location of events



How is the data stored?

What is a data model?

- **Data:** a collection of discrete values that describe phenomena
- Your brain stores millions of pieces of data
- Computers are not your brain
 - Need to organize data systematically
 - Be able to display and access efficiently
 - Need to be able to store and access repeatedly
- Data models solve this problem

2 Types of Spatial Data Models

- **Raster:** grid-cell tessellation of an area. Each raster describes the value of a single phenomenon. More next week...
- **Vector:** (many) attributes associated with locations defined by coordinates

The Vector Data Model

- **Vertices** (i.e., discrete x-y locations) define the shape of the vector
- The organization of those vertices define the *shape* of the vector
- General types: points, lines, polygons

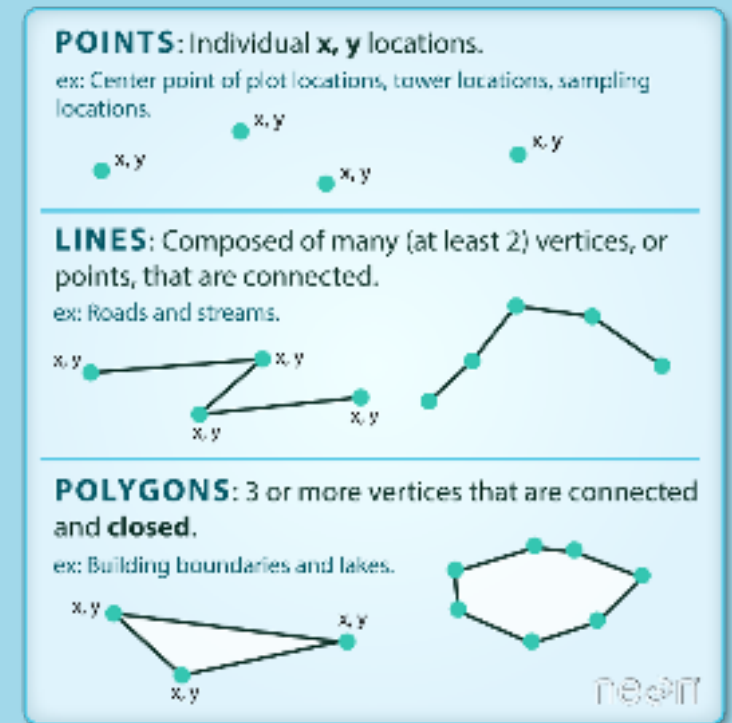
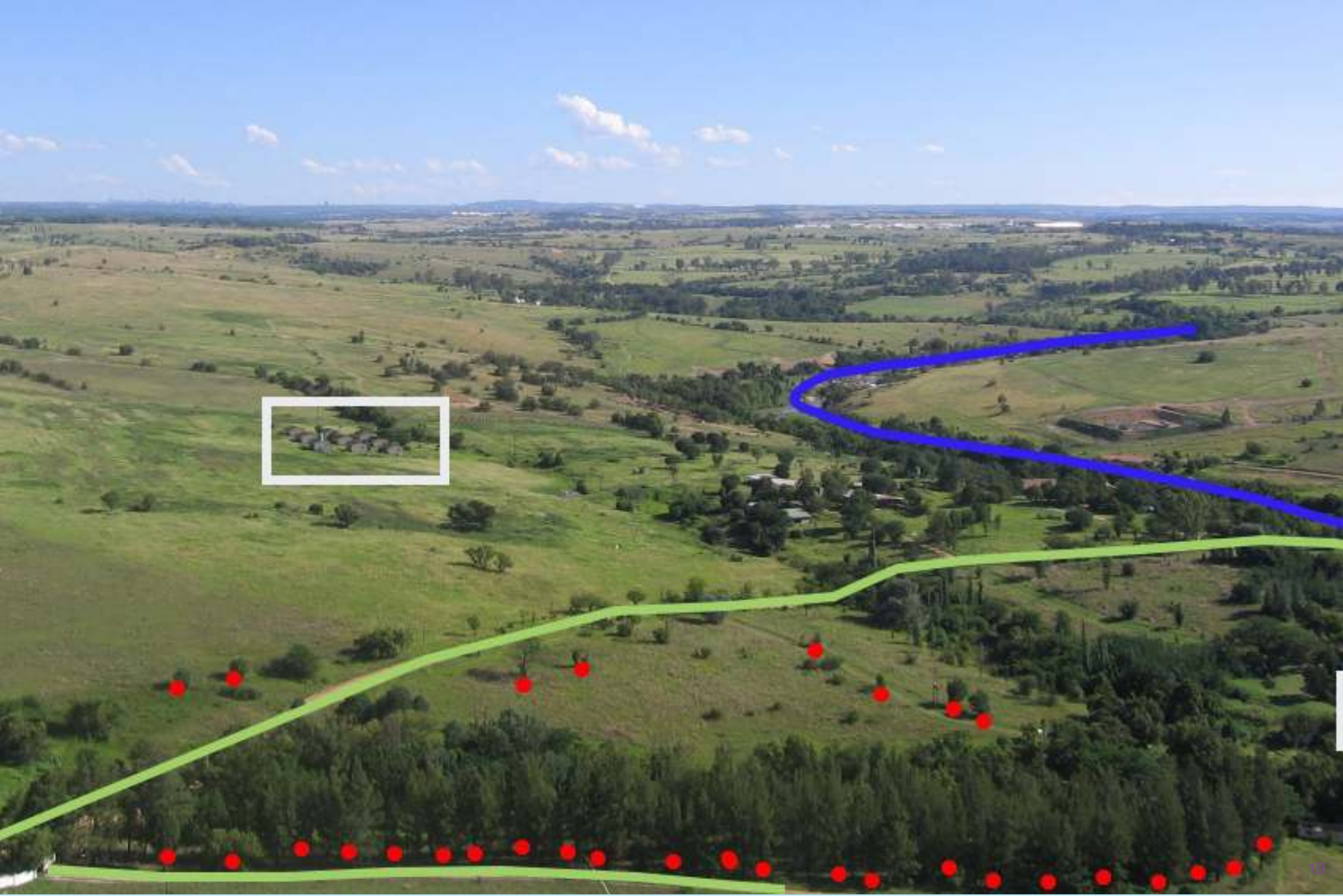


Image Source: Colin Williams
(NEON)



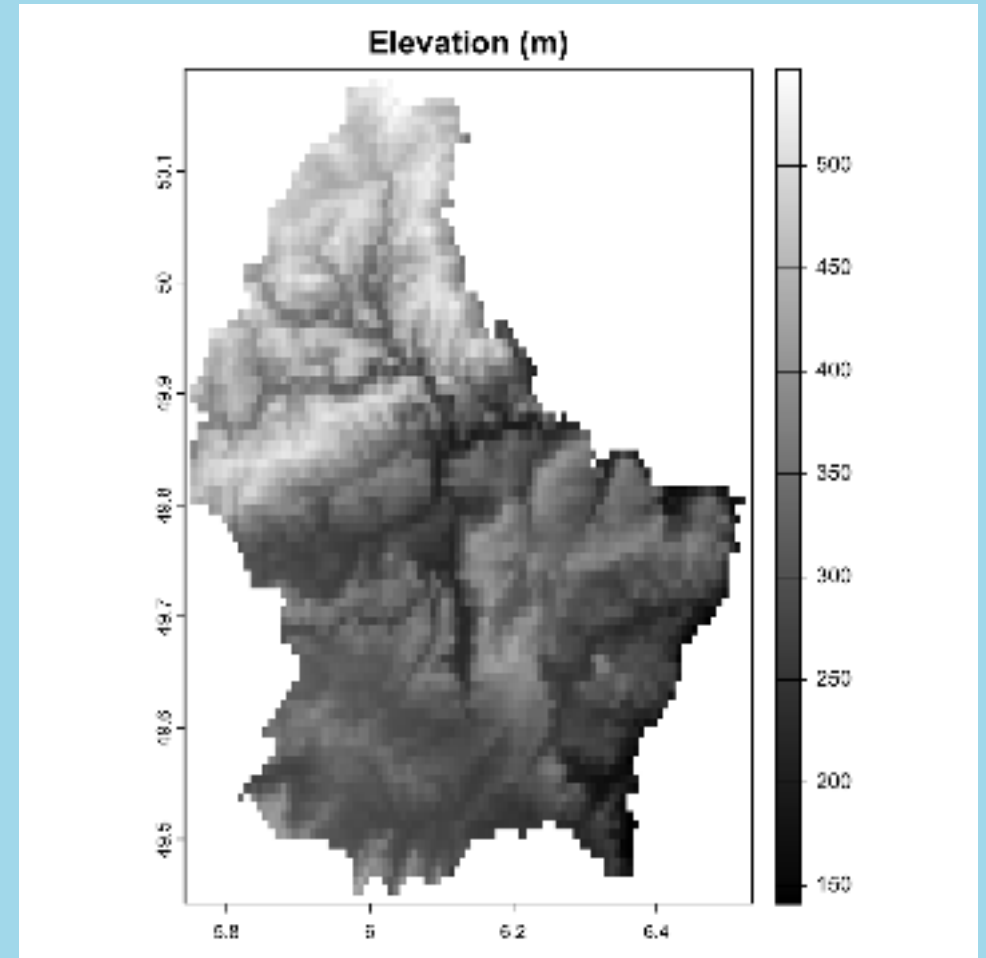
Vectors in Action

- Useful for locations with discrete, well-defined boundaries
- Very precise (not necessarily accurate)

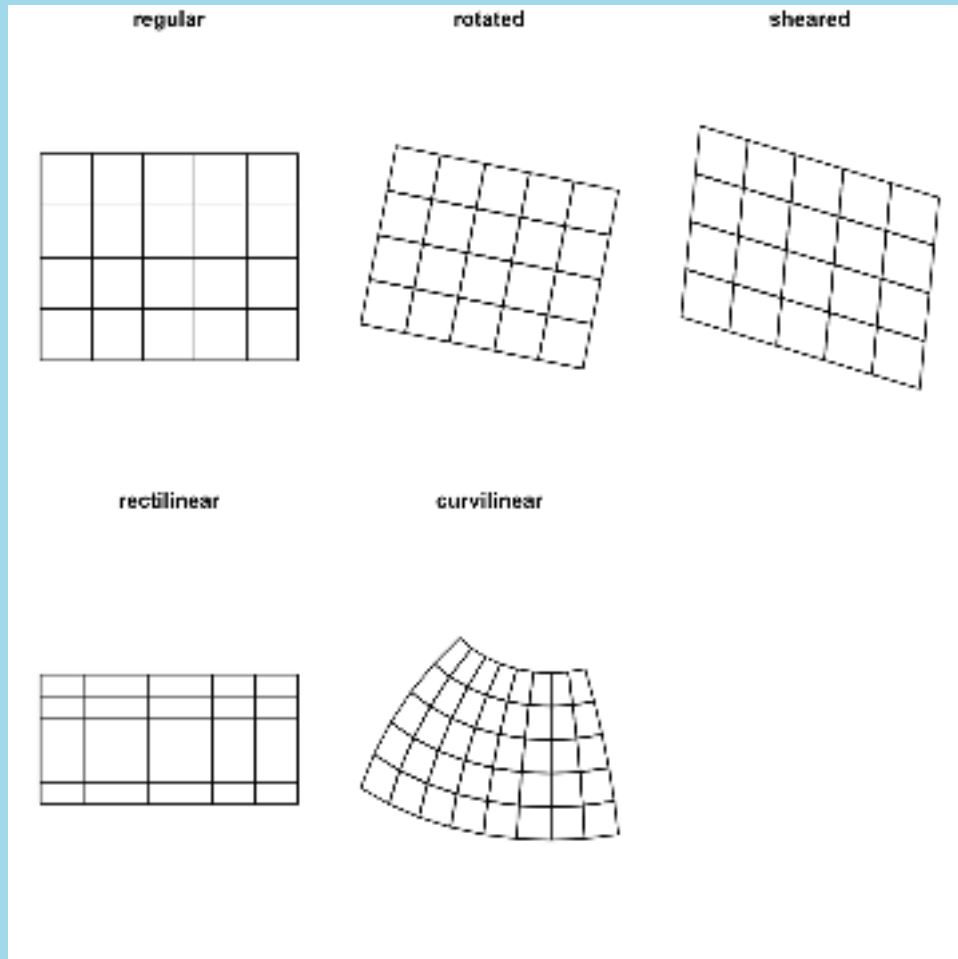


The Raster Data Model

- **Raster data** represent spatially continuous phenomena (**NA** is possible)
- Depict the alignment of data on a regular lattice (often a square)
- Geometry is implicit; the spatial extent and number of rows and columns define the cell size



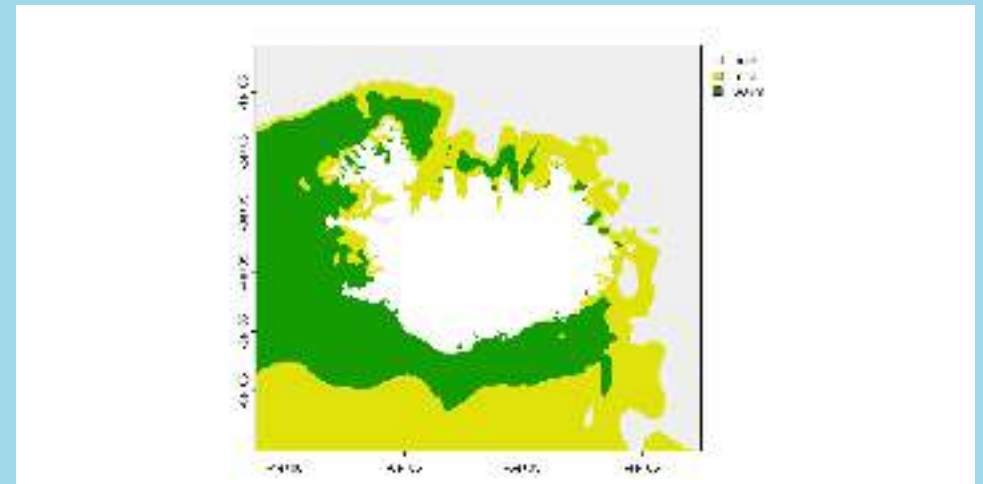
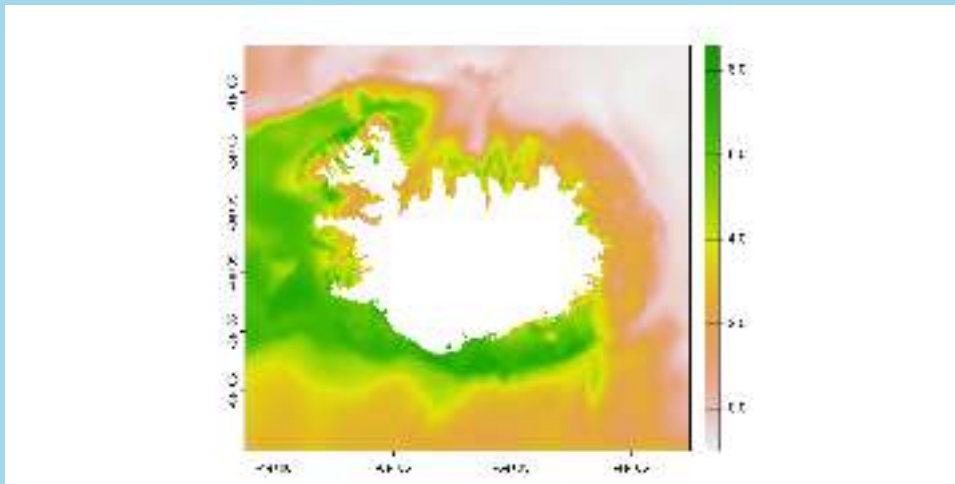
Types of Raster Data



- **Regular**: constant cell size; axes aligned with Easting and Northing
- **Rotated**: constant cell size; axes not aligned with Easting and Northing
- **Sheared**: constant cell size; axes not parallel
- **Rectilinear**: cell size varies along a dimension
- **Curvilinear**: cell size and orientation dependent on the other dimension

Types of Raster Data

- **Continuous:** numeric data representing a measurement (e.g., elevation, precipitation)
- **Categorical:** integer data representing factors (e.g., land use, land cover)



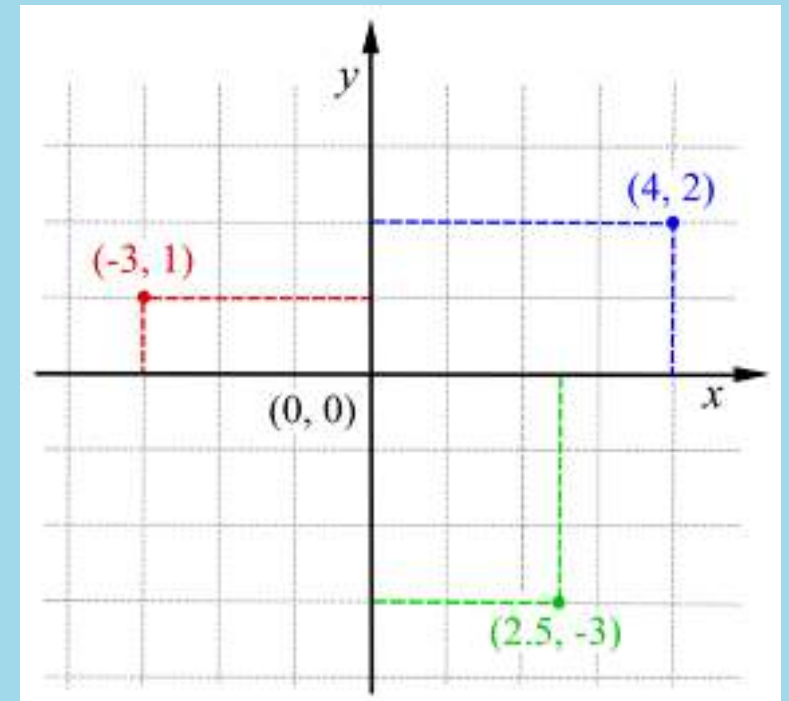
What makes data (geo)spatial?

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*
- **nominal:** (potentially contested) place names
- **absolute:** the physical location on the earth's surface

Describing Absolute Locations

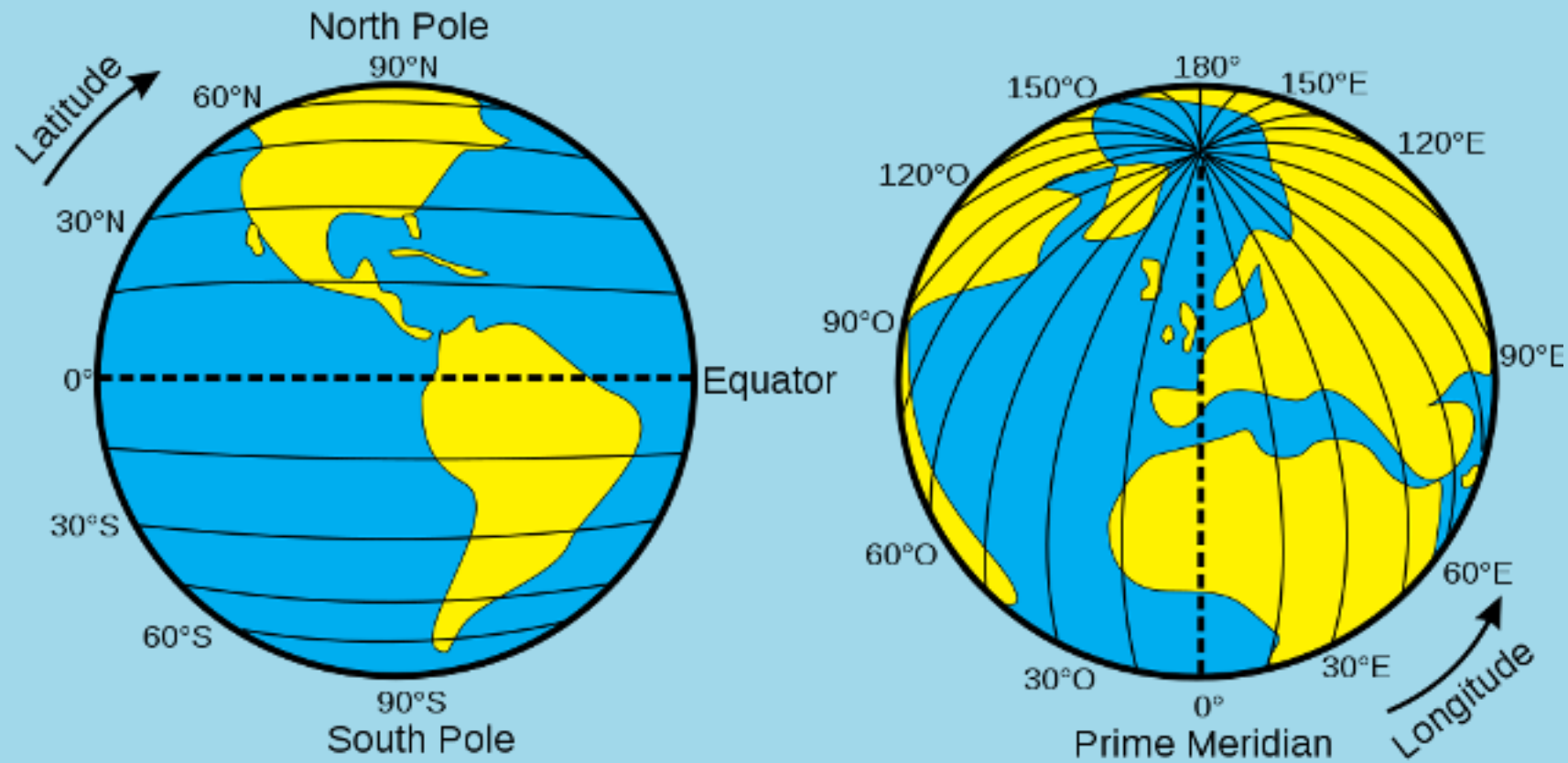
- **Coordinates:** 2 or more measurements that specify location relative to a *reference system*
- Cartesian coordinate system
- *origin* (O) = the point at which both measurement systems intersect
- Adaptable to multiple dimensions (e.g. z for altitude)



Cartesian Coordinate System

Locations on a Globe

- The earth is not flat...



Latitude and Longitude

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

3. Coordinate Reference Systems

4. Geometries, support, and spatial messiness

