

# EDS 223: Geospatial Analysis & Remote Sensing



USGS via Unsplash

# Course website

[https://ryoliver.github.io/EDS\\_223\\_spatial\\_analysis/](https://ryoliver.github.io/EDS_223_spatial_analysis/)

EDS 223

Home Topics Assignments Resources ⓘ

## Geospatial Analysis & Remote Sensing

Master's of Environmental Data Science, UC Santa Barbara

### Contents

- Welcome to EDS 223
- Teaching team
- Important links
- Weekly course schedule
- Course requirements
- Tentative topics



Figure 1: Image: Mississippi River south of Memphis, TN, from USGS shared on Unsplash (<https://unsplash.com/photos/35Z2ylLRC08>).

### Welcome to EDS 223

EDS 223

## Topics

### Contents

Week 1: Intro to spatial data

#### Lecture

##### Class materials

### Week 1: Intro to spatial data

#### Lecture

##### Class materials

- Lecture slides to be posted prior to class

##### Background reading

- [GIS Fundamentals, chapter 2](#)
- [GIS Fundamentals, chapter 3](#)
- [Spatial Data Science, chapter 2](#)
- [A Gentle Introduction to GIS, chapter 8](#)
- [Esri, Geographic vs. projected coordinate systems](#)

# Welcome!

- Introductions

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- Course logistics + overview

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- Course logistics + overview
- Models of our world

# Welcome!

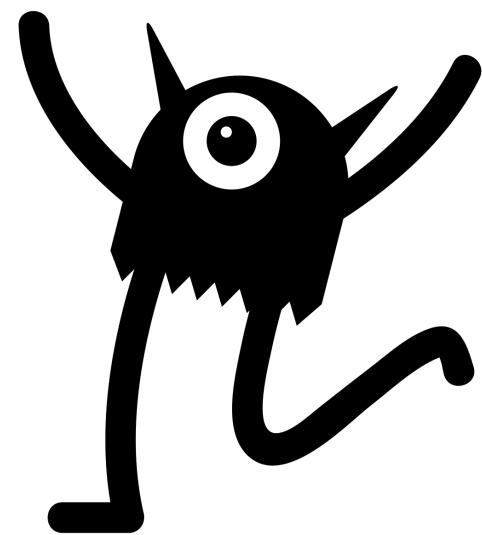
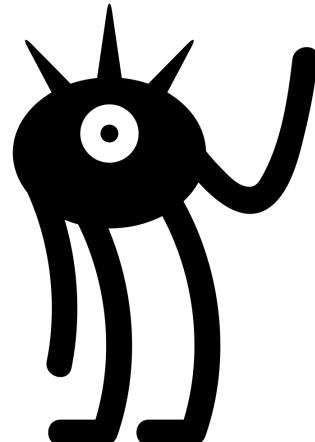
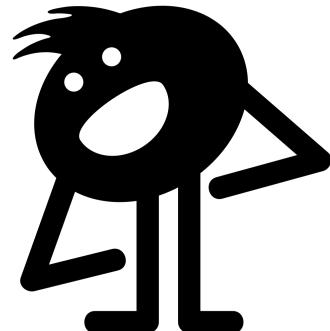
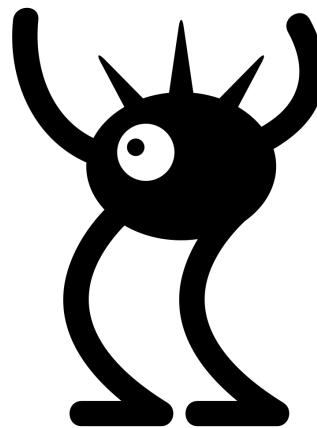
- Introductions
- Course logistics + overview
- Models of our world
- Map making in R

# Instruction team

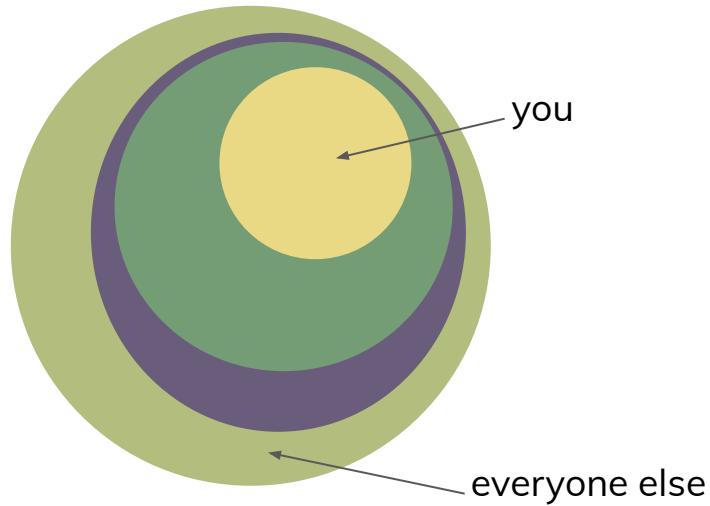
- **Ruth Oliver**
  - Email: [rutholiver@bren.ucsb.edu](mailto:rutholiver@bren.ucsb.edu)
  - Office: Bren Hall 4512
  - Student hours: Friday 3-4 @ Bren
  - Contact me via: email
- **Allie Caughman**
  - Email: [acaughman@bren.ucsb.edu](mailto:acaughman@bren.ucsb.edu)
  - Student hours: Tuesday 12:30-1:30 @Bren
  - Contact me via: email

# Introductions

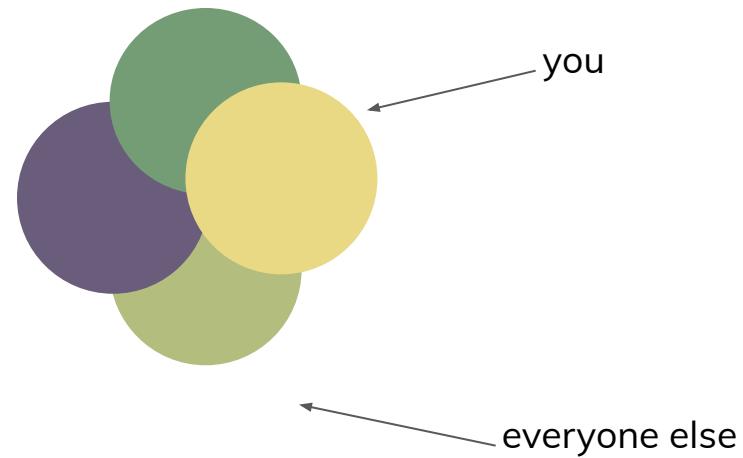
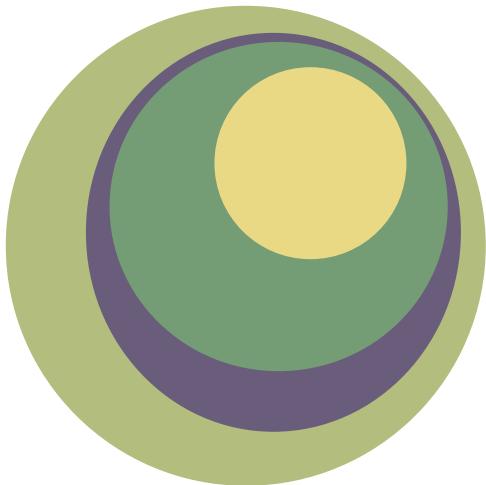
- Name
- Pronouns
- Program



# Growth mindset



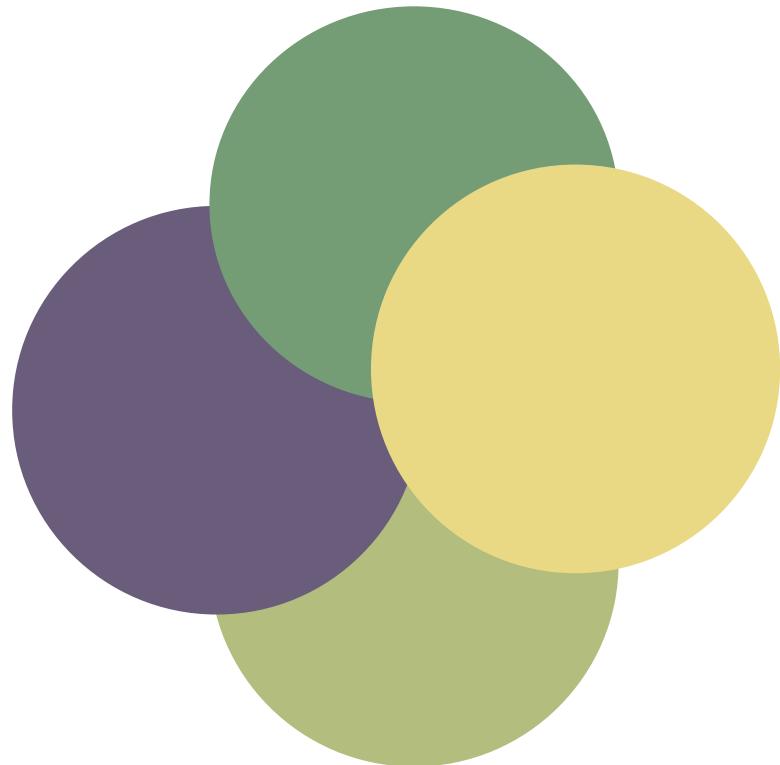
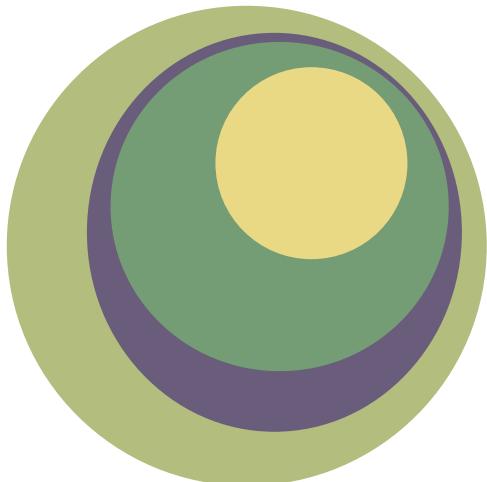
# Growth mindset



you

everyone else

# Growth mindset



Typos are the pedagogy.

- Emily Jane McTavish

# Course logistics

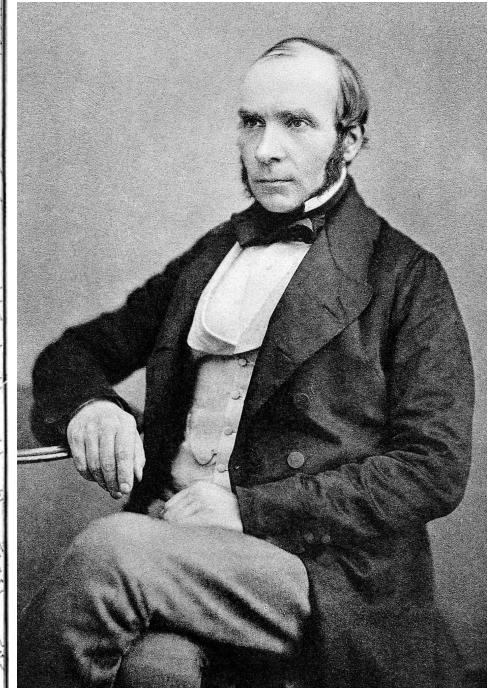
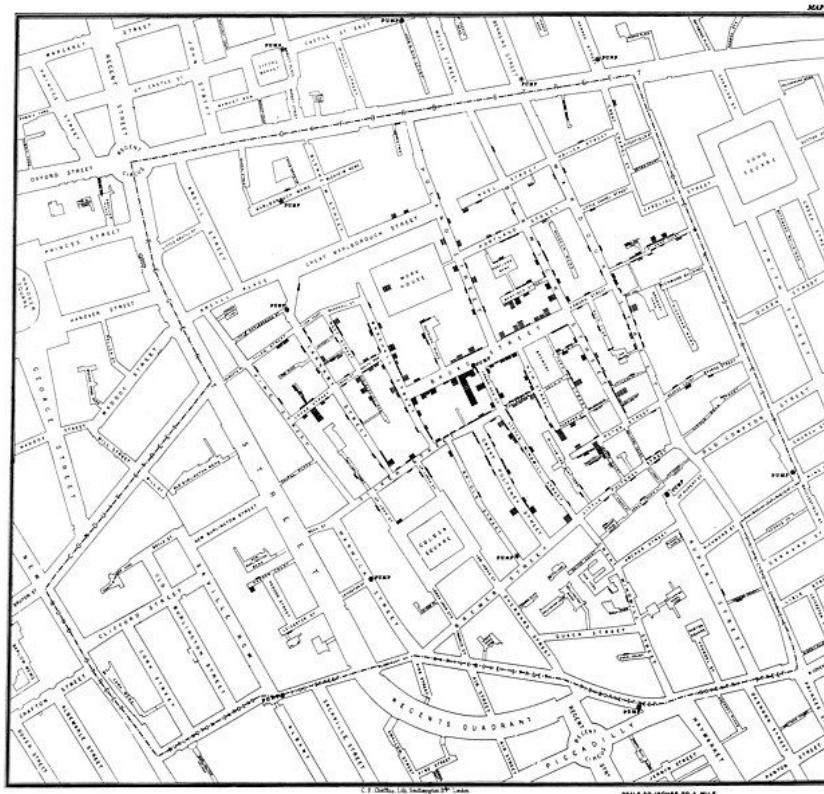
[ryoliver.github.io/EDS\\_223\\_spatial\\_analysis](https://ryoliver.github.io/EDS_223_spatial_analysis)

# Why spatial?

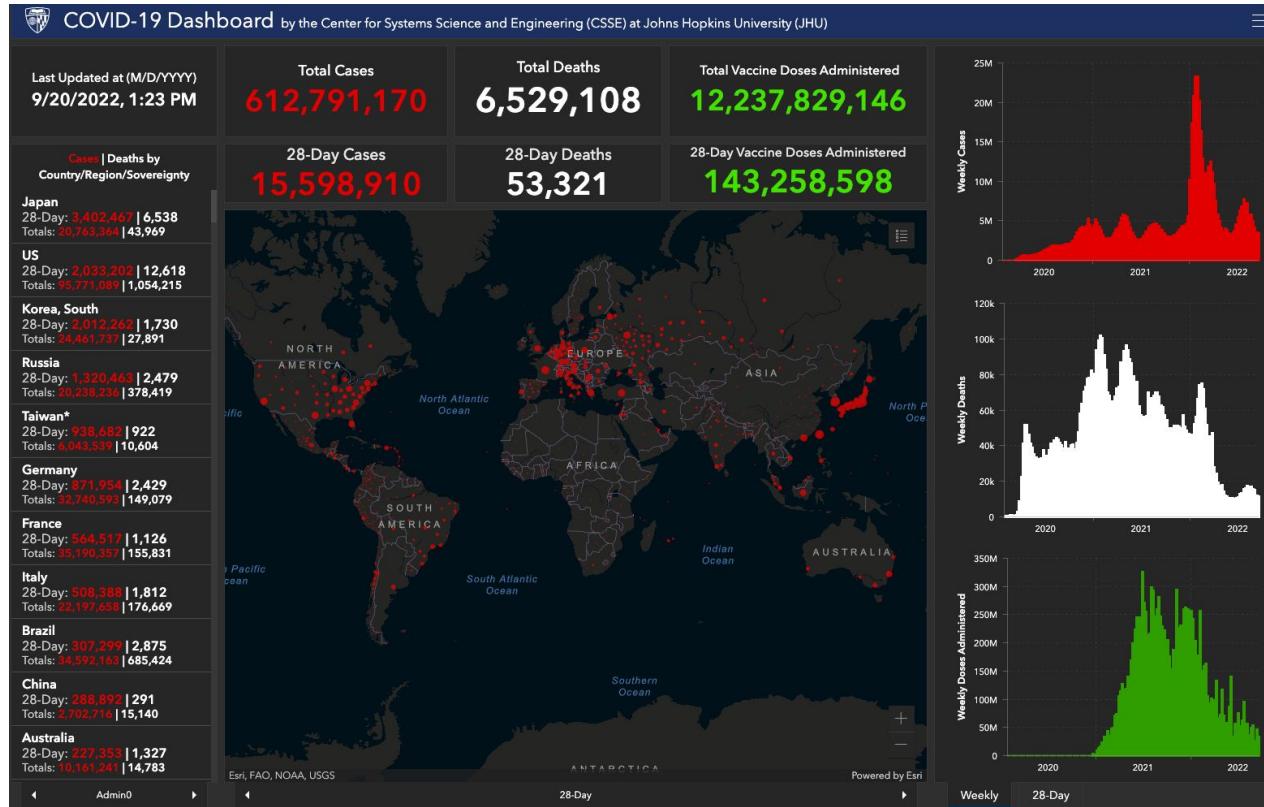
**Everything is related to everything else, but near things are more.**

- Waldo Tobler

# We live in space, and so does everything else



# We live in space, and so does everything else



# Our approach



# (very, very) Brief intro to remote sensing



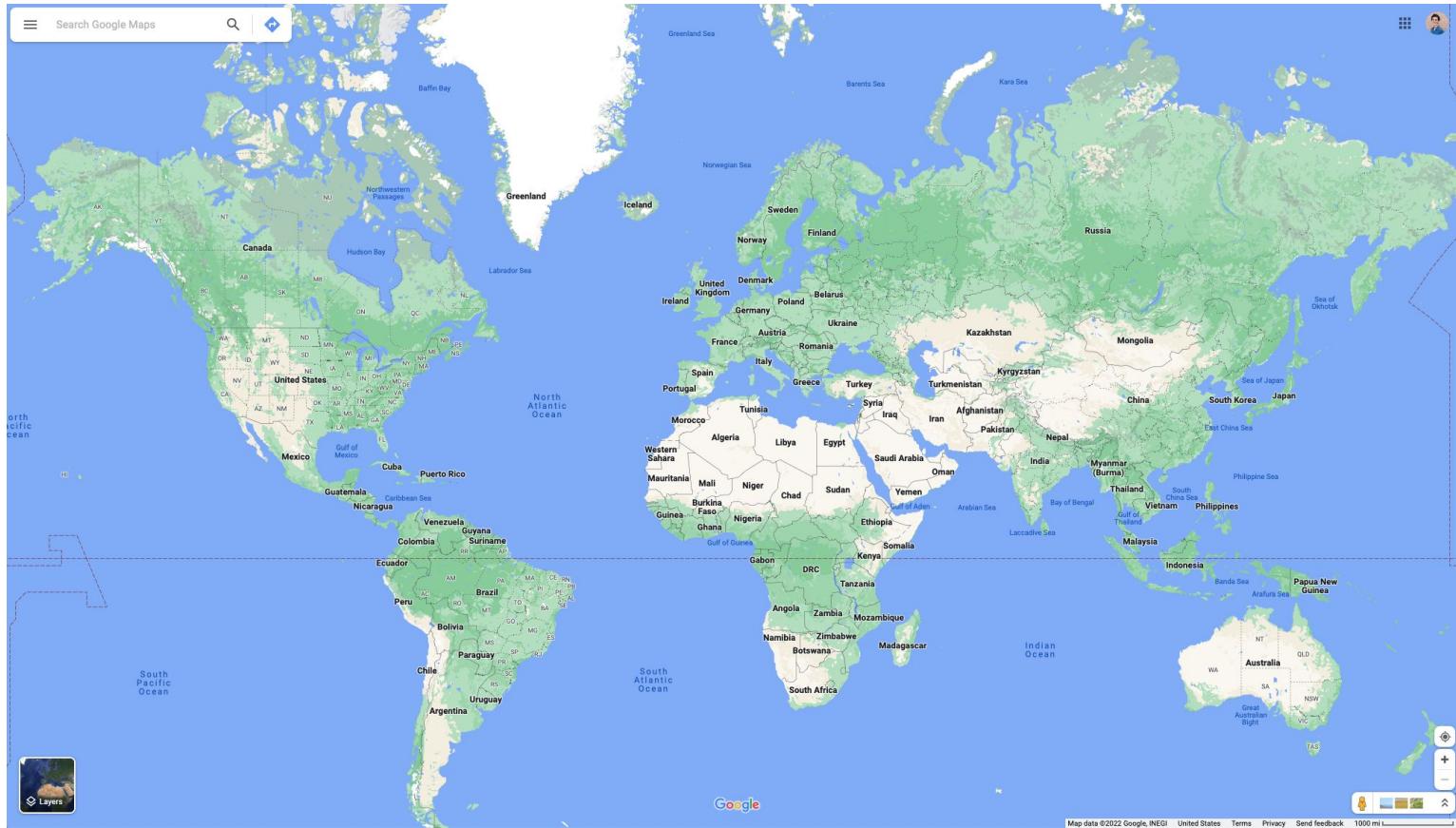
Note: Artist's impression; size of debris exaggerated as compared to the Earth

# Models of our world



Photo credit: Wikipedia

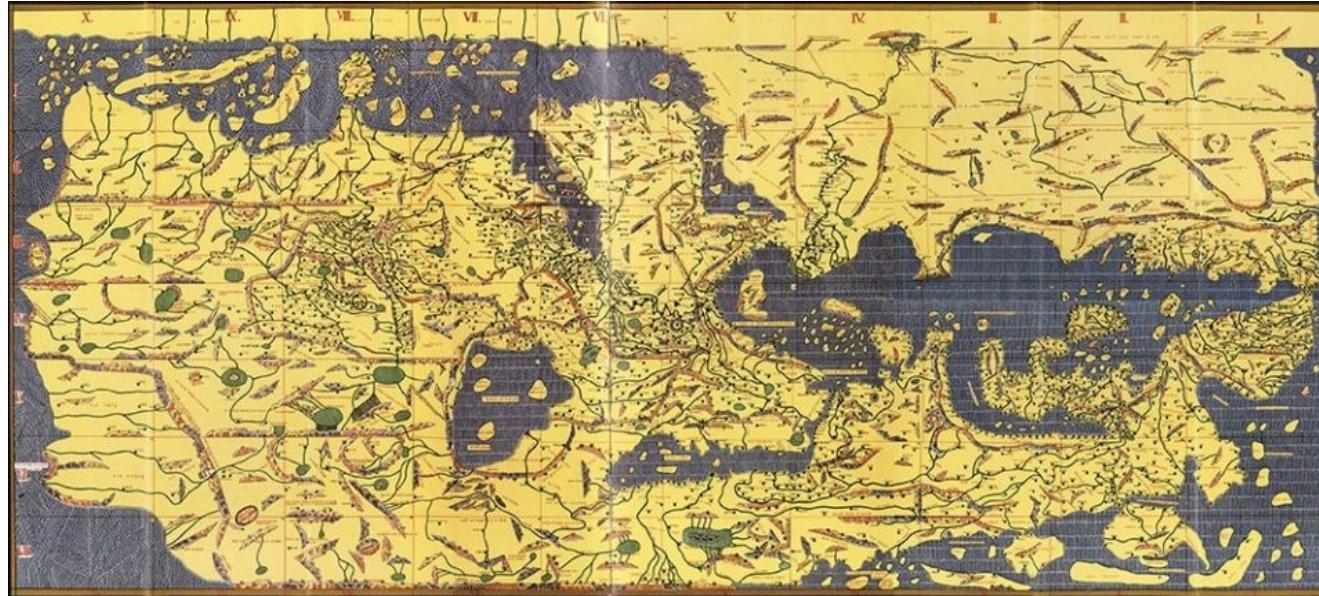
# Models of our world



# A non-historian's brief history of North

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Recreation of Moroccan cartographer's Muhammad al-Idrisi's Tabula Rogeriana (1154)



Source: Bibliotheque nationale de France/Wikipedia

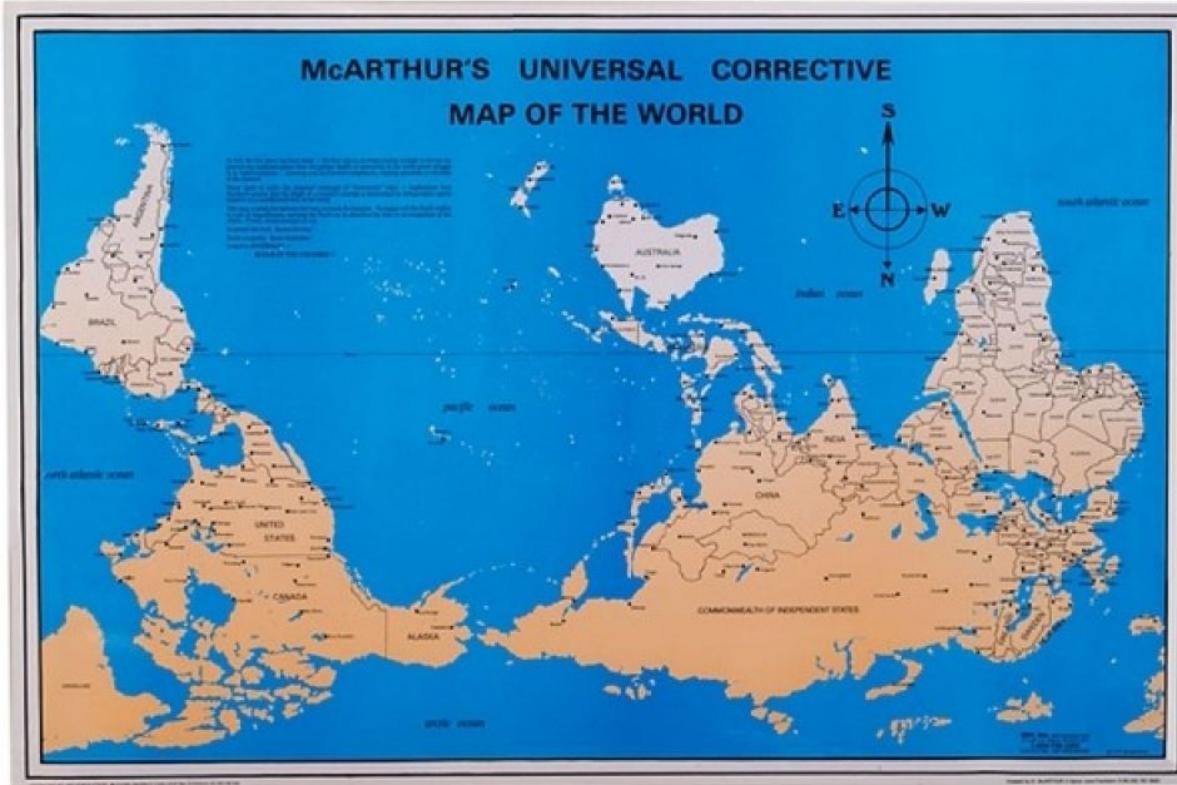
# A non-historian's brief history of North

Recreation of map (1407) based on the work of Ptolemy (c. 100-178)



Source: The British Library Board/Getty Images

# A non-historian's brief history of North



Source: Flickr

We need a system!

# 4 (main) challenges to spatial analysis

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# We need a system!



- Coordinate system
- Datum
- Geodetic datum

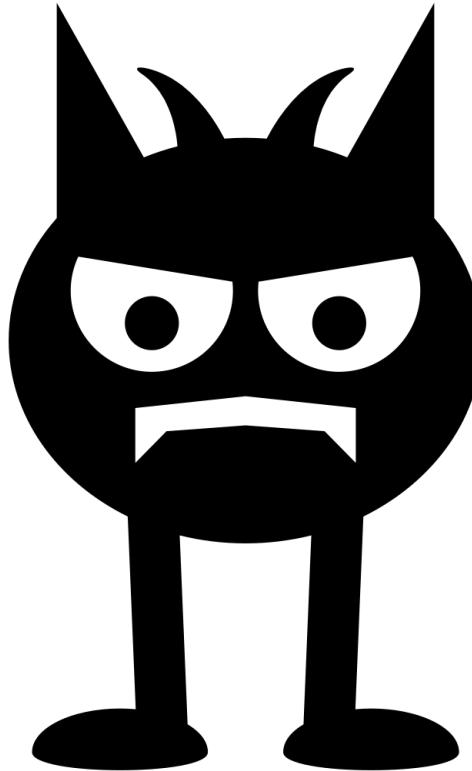
Coordinate reference system

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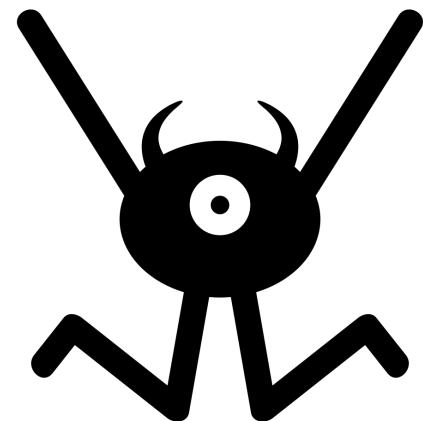


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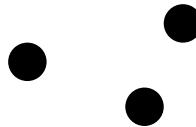
- A set of mathematical rules for specifying how coordinates are to be assigned to points (Lott 2015)

# Coordinate system

- A set of mathematical rules for specifying how coordinates are to be assigned to points
  - Language to talk about locations

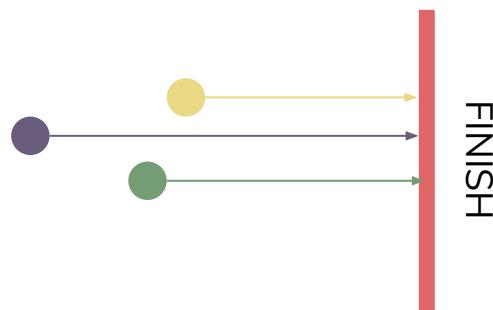
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# Coordinate systems

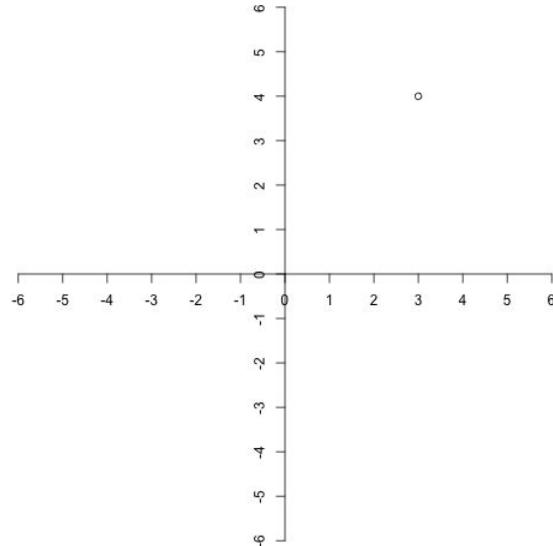
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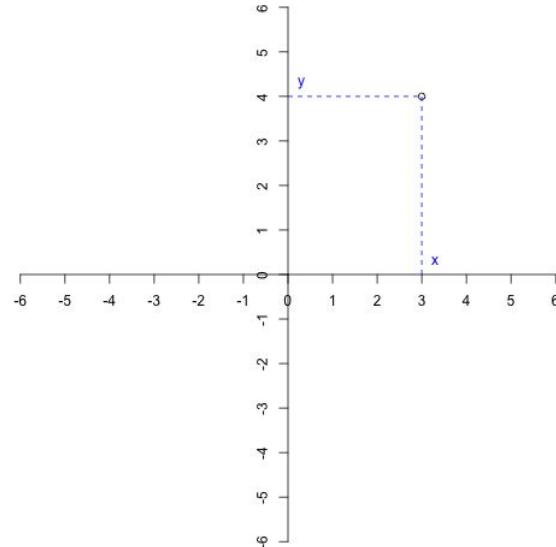
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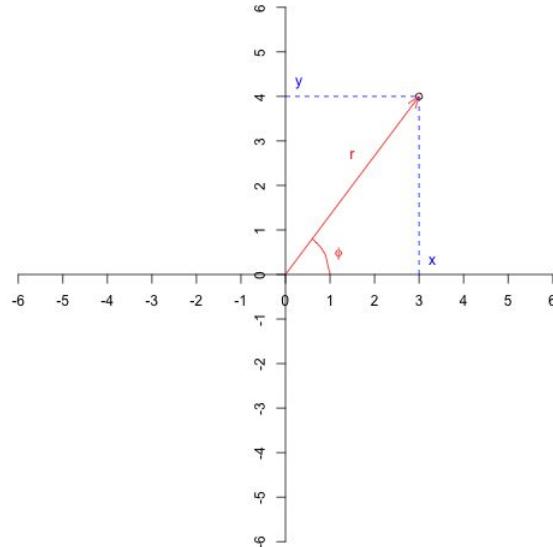
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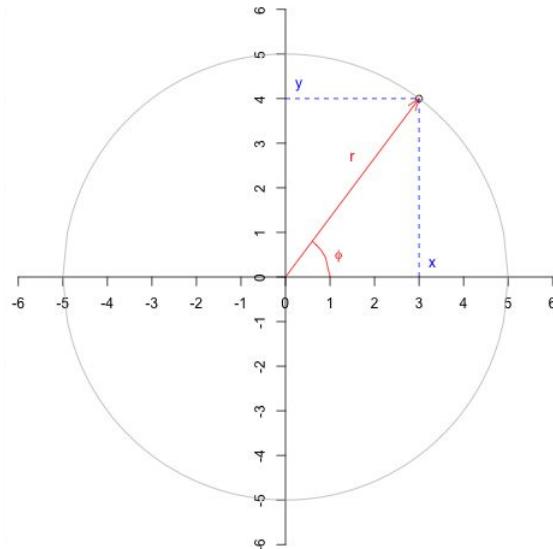
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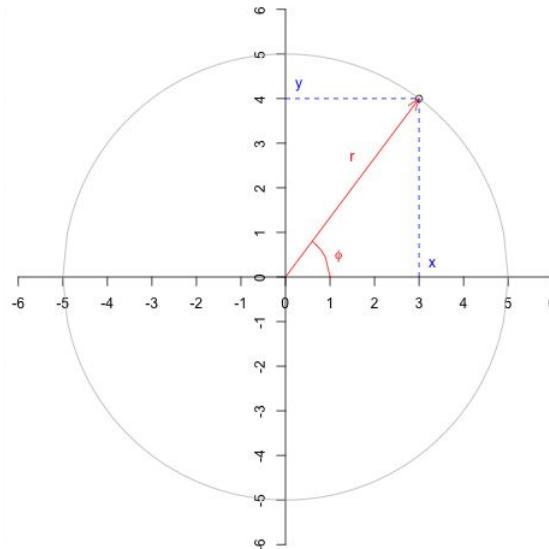
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$$x = r \cos\phi$$

$$y = r \sin\phi$$

$$r = \sqrt{x^2 + y^2}$$

$$\phi = \arctan(y, x)$$

# Coordinate system

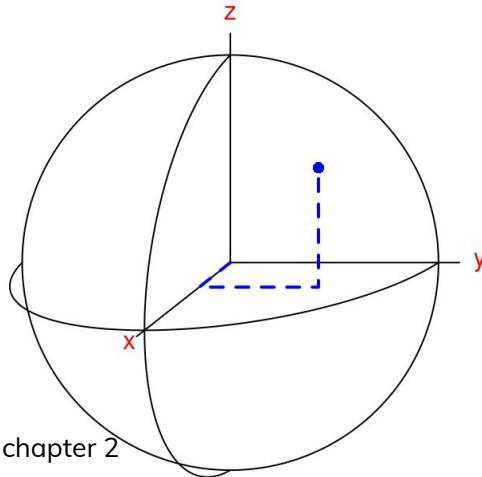
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# Coordinate systems

- **Planar (or Cartesian) coordinates**
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  - Define points by a distance from a reference point and angle from a reference direction
    - **What do we need to update?**

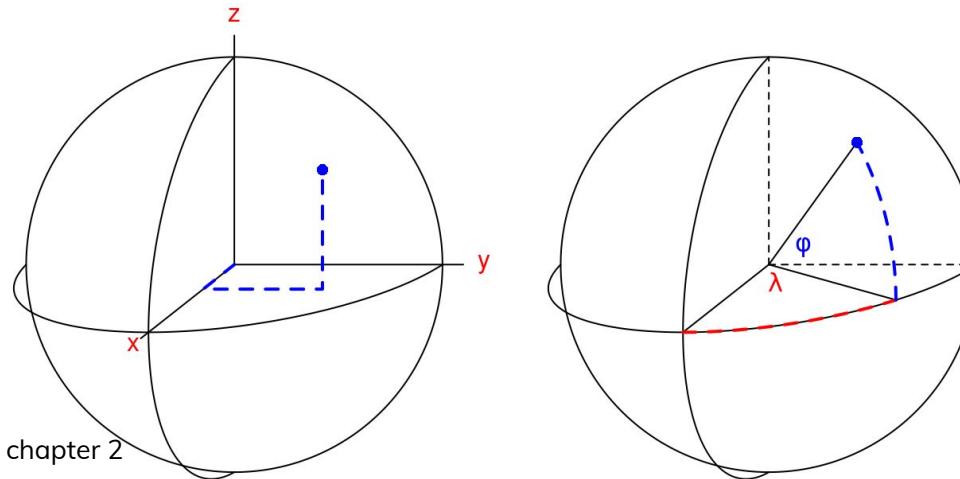
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# Coordinate systems

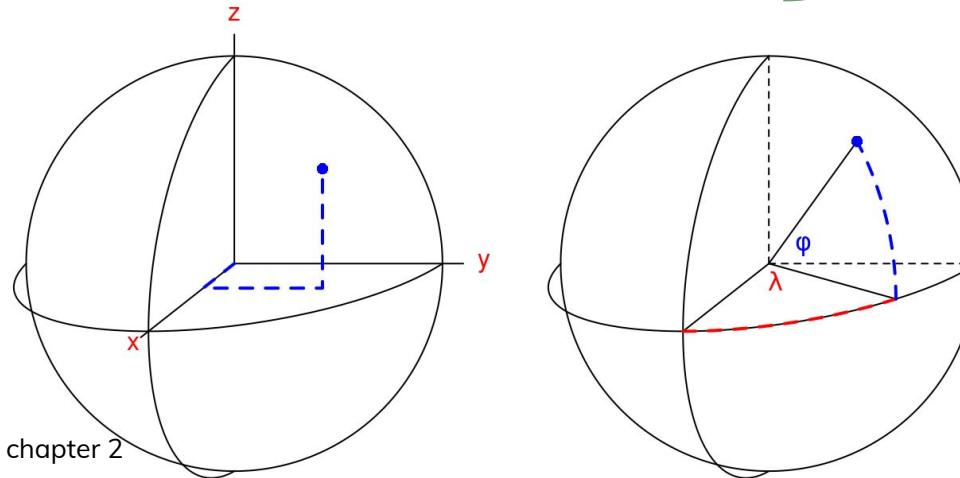
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- **Polar coordinates**
  - $r$  is the radius of the sphere
  - $\lambda$  angle measured between the point and z plane
  - $\varphi$  angle measured between the point and the (x,y) plane



# Coordinate systems

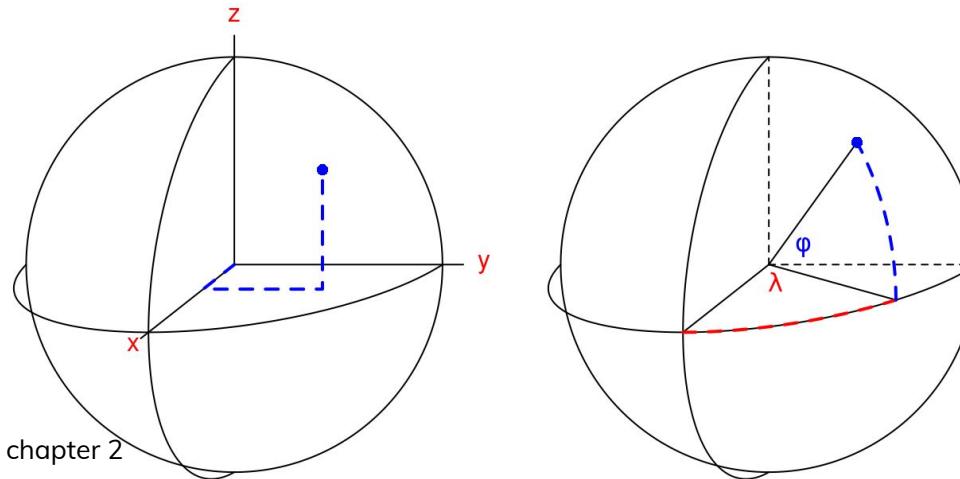
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Do these sound familiar?

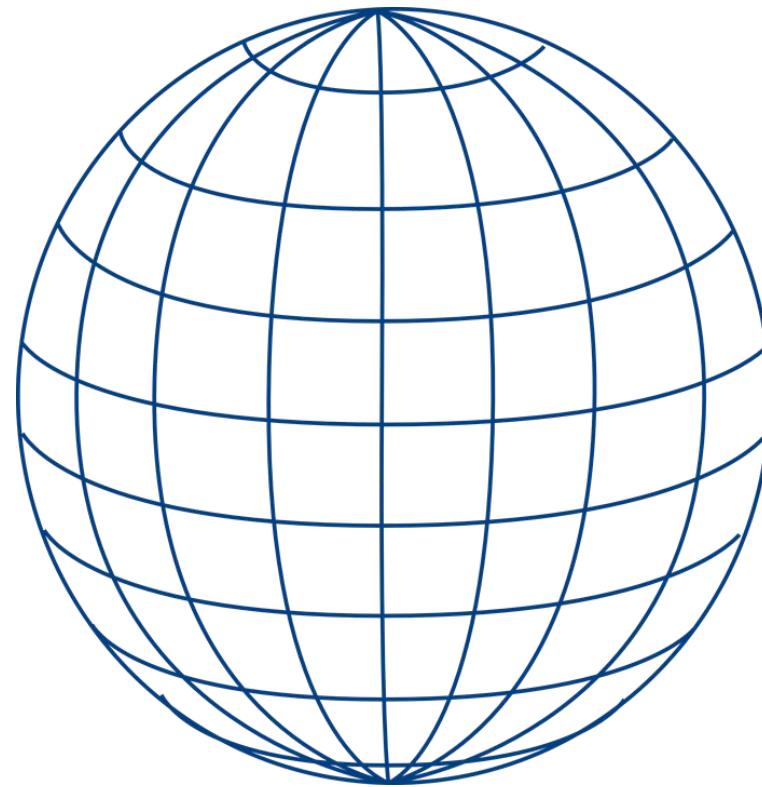


# Coordinate systems

- Planar (or Cartesian) coordinates
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- Polar coordinates
  - $r$  is the radius of the sphere
  - $\lambda$  longitude
  - $\varphi$  latitude

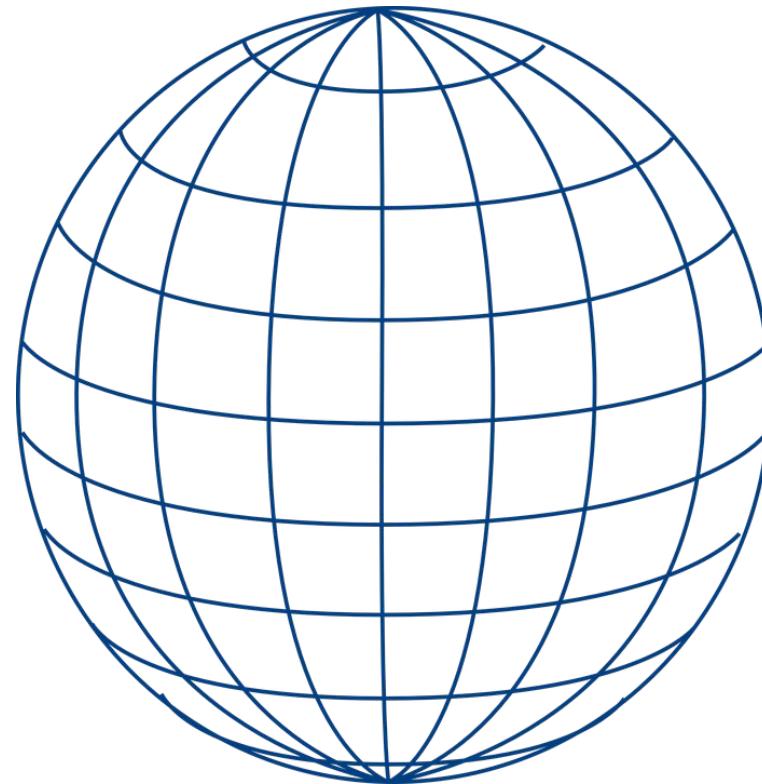


# Mini latitude/longitude refresher



# Mini latitude/longitude refresher

- **Latitude**
  - ranges from -90 to 90
  - “y”
  - Parallel
- **Longitude**
  - ranges from -180 to 180
  - “x”
  - converge



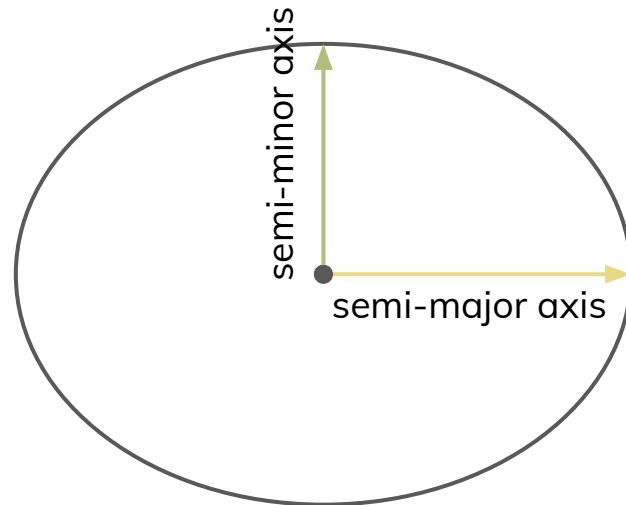
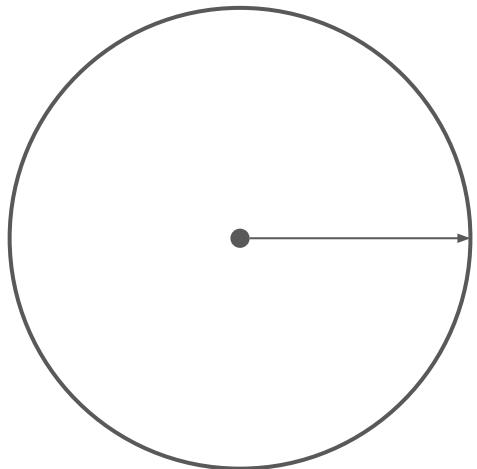
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# 4 (main) challenges to spatial analysis

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# Coordinate system



# We need a system!

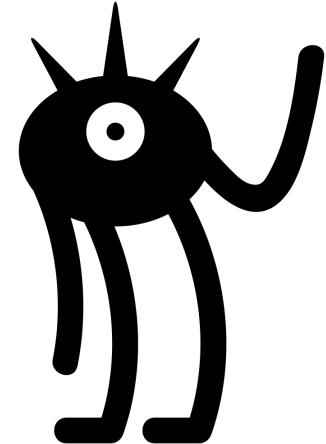
- 
- **Coordinate system**
    - A set of mathematical rules for specifying how coordinates are to be assigned to points
  - **Datum**
  - **Geodetic datum**

## Coordinate reference system

# We need a system!

- ↓
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Coordinate reference system



How are we feeling?

# We need a system!

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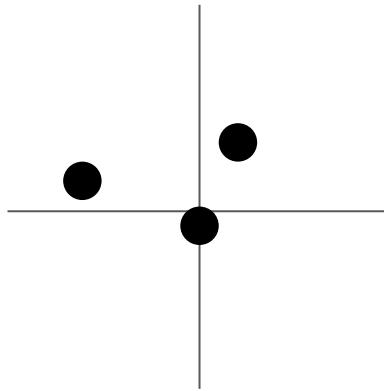
## Coordinate reference system

# Datum

- A parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system (Lott 2015)

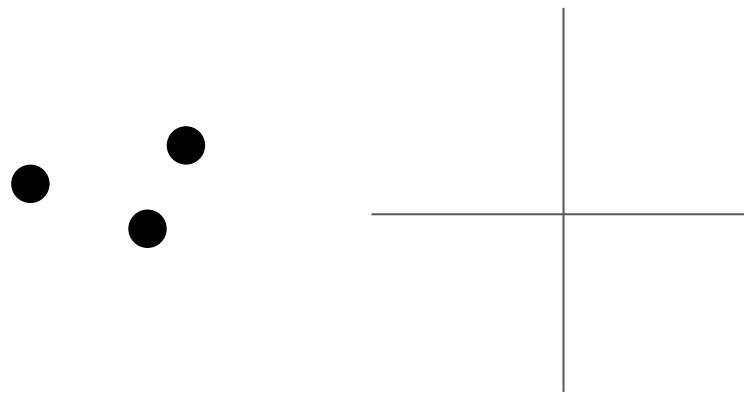
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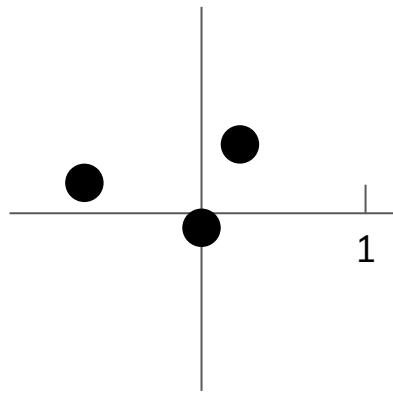
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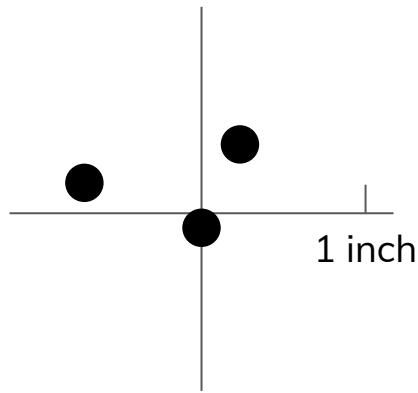
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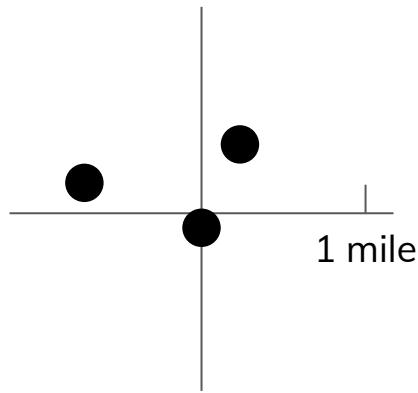
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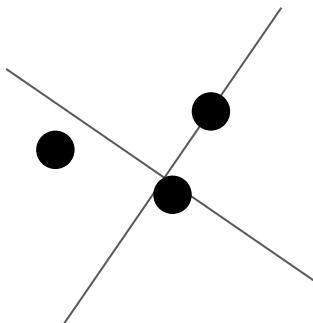
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  - **Geodetic datum**

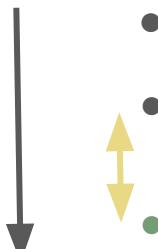
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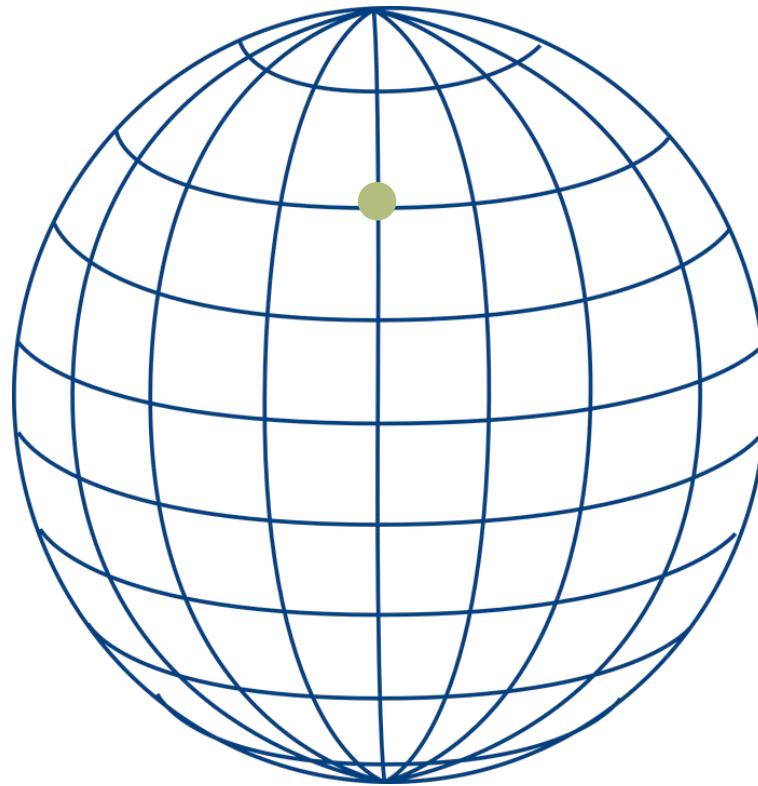
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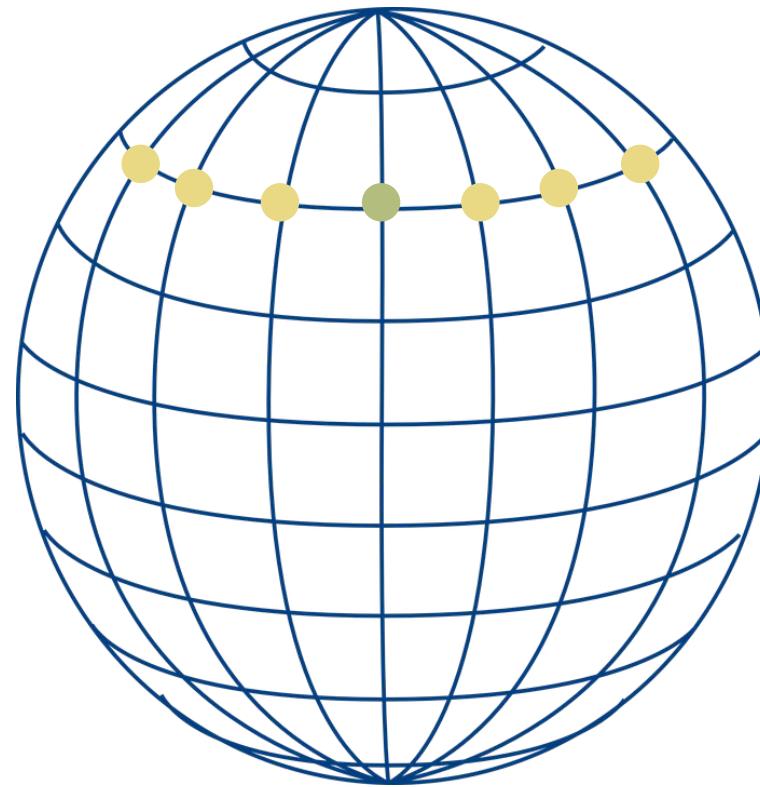
# Geodetic datum

- A datum describing the relationship of a two- or three- dimensional coordinate system to Earth (Lott 2015)

# Geodetic datum



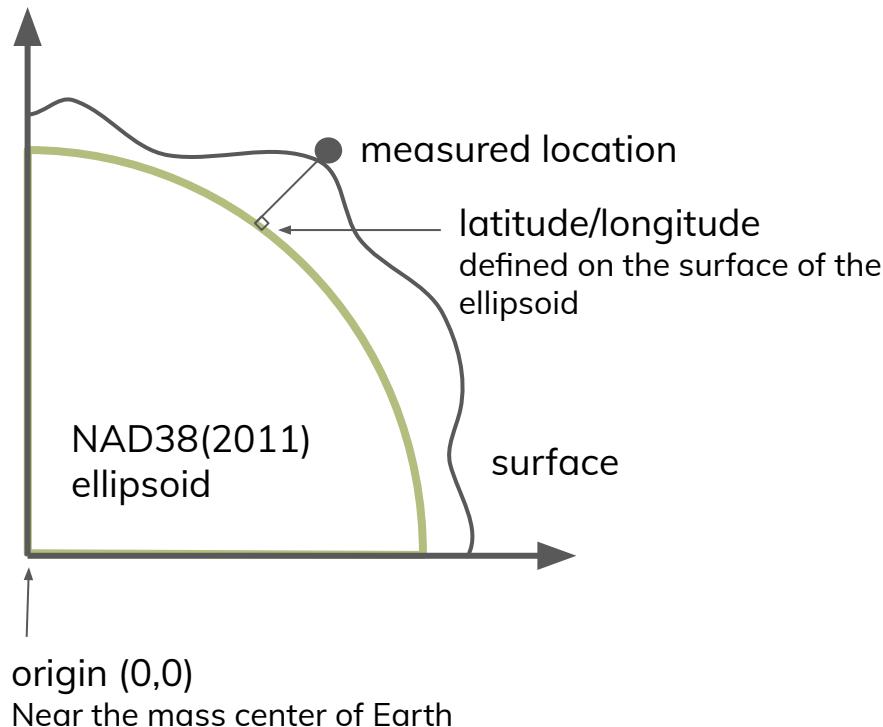
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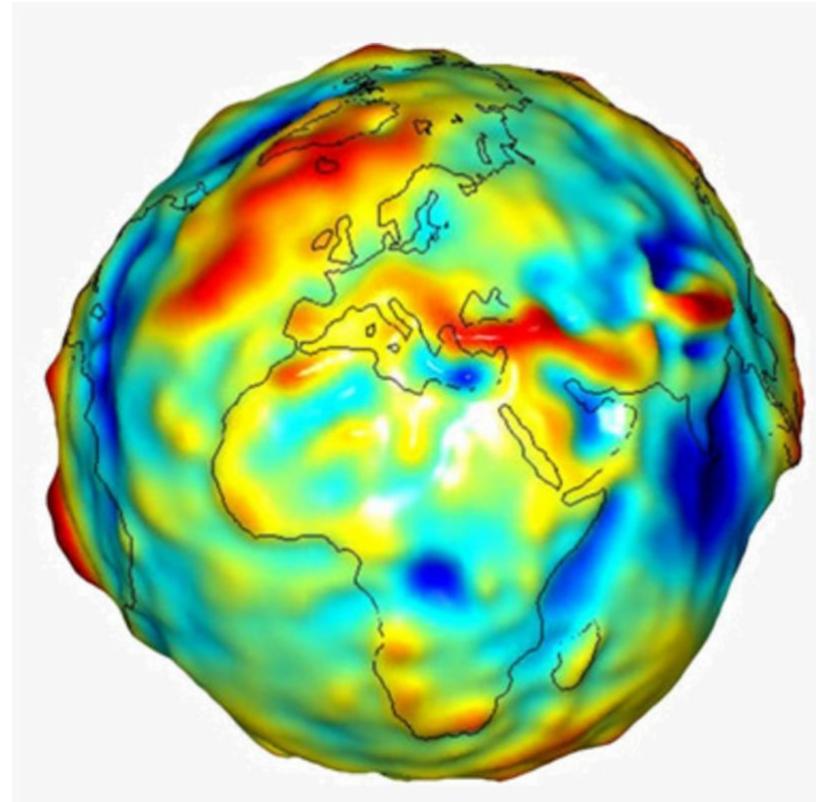
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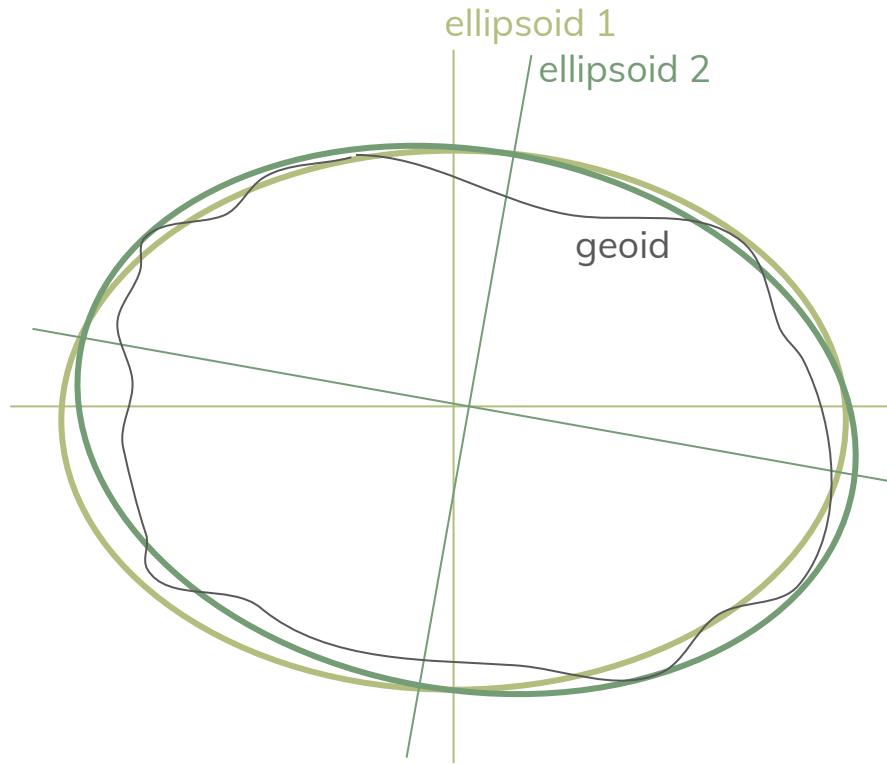
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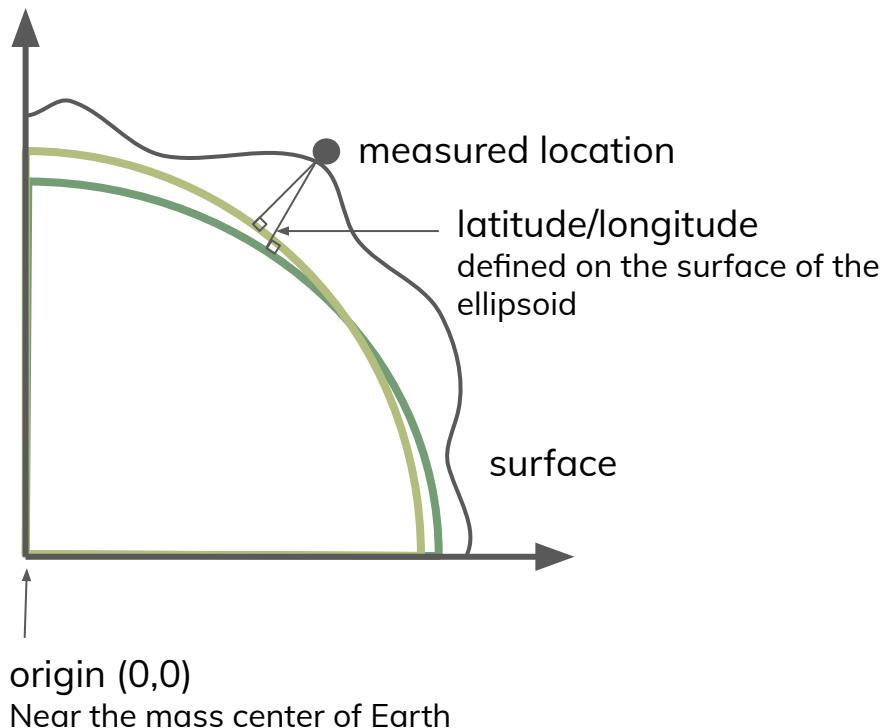
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# Coordinate reference systems

What does this look like in the real world?

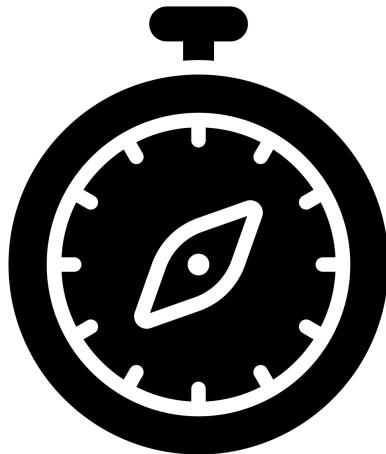
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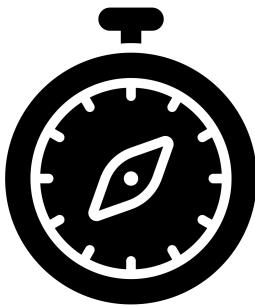
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134.577°E, 24.006°S

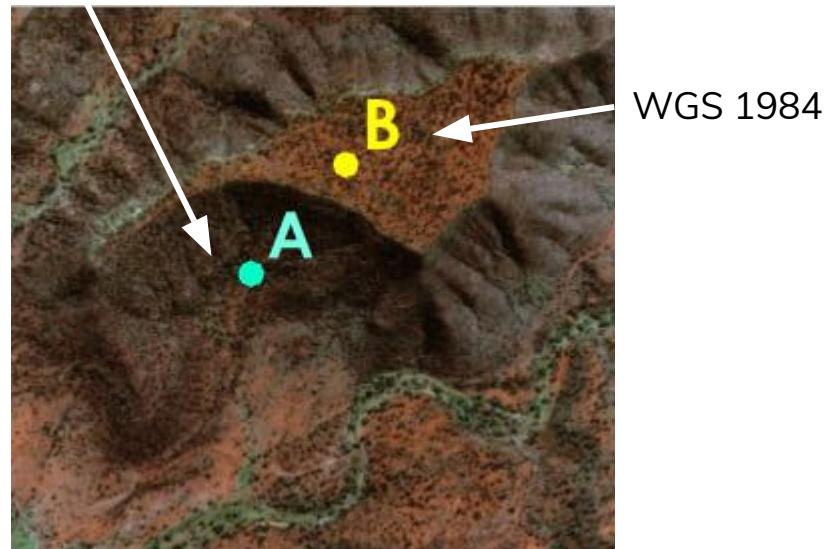
# Coordinate reference systems

What does this look like in the real world?



134.577°E, 24.006°S

Australian Geodetic Datum 1984



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    - A set of mathematical rules for specifying how coordinates are to be assigned to points
  - **Datum**
    - A parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system
  - **Geodetic datum**
    - A datum describing the relationship of a two- or three- dimensional coordinate system to Earth

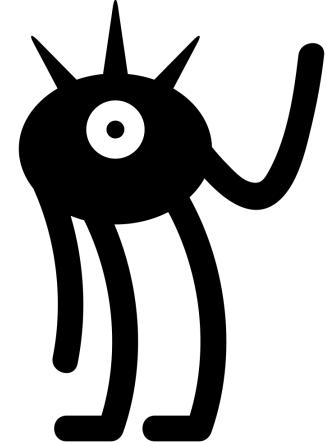
## Coordinate reference system

# We need a system!

- **Coordinate system**
    - A set of mathematical rules for specifying how coordinates are to be assigned to points
  - **Datum**
    - A parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system
  - **Geodetic datum**
    - A datum describing the relationship of a two- or three- dimensional coordinate system to Earth
- 

## Coordinate reference system

## How are we feeling?



# Coordinate reference system

- A framework to measure locations on Earth as coordinates

# Coordinate reference system

- Framework to measure locations on Earth as coordinates
- A specific CRS comprises the following:
  - Earth ellipsoid
  - Geodetic datum
    - Origin point
    - Unit of measure
  - Map projection (in most but not all cases)

# 4 challenges to spatial analysis

1. We perceive geography in two dimensions, but live in three
2. Earth is irregular
3. Measurements are imperfect
4. Earth's surface is constantly changing

# Projection

- Mathematical transformation employed to translate a curved surface of a globe on a two-dimensional plane

# All maps are wrong



<https://www.youtube.com/watch?v=kIID5FDi2JQ&t=3s>

# Projections



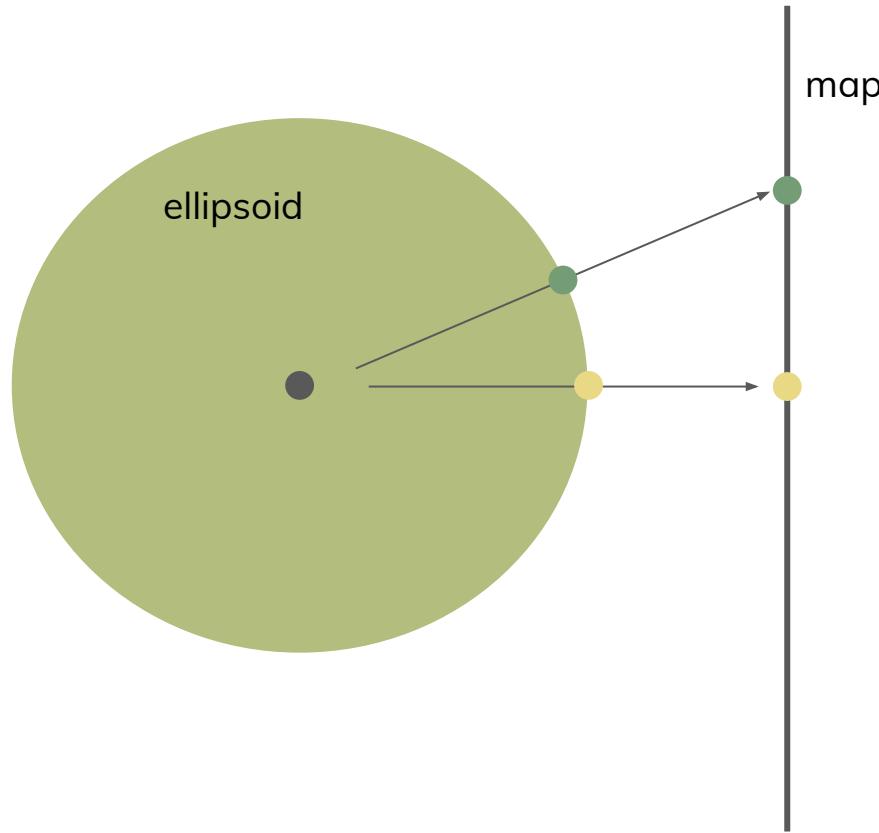
map



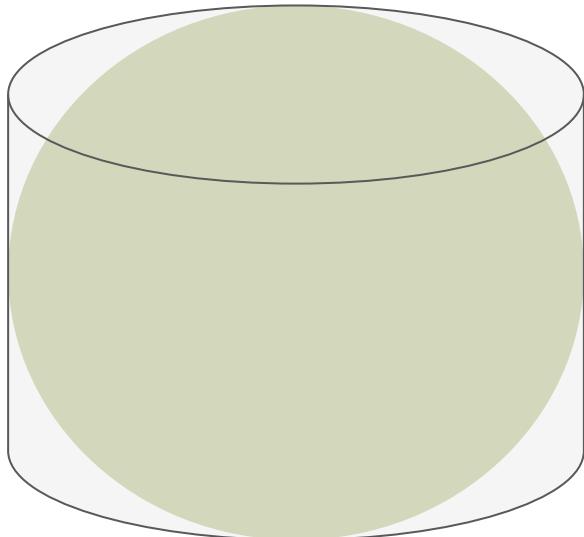
# Projections



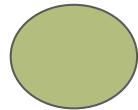
# Projections



# Projections



# Geographic vs. projected coordinate system

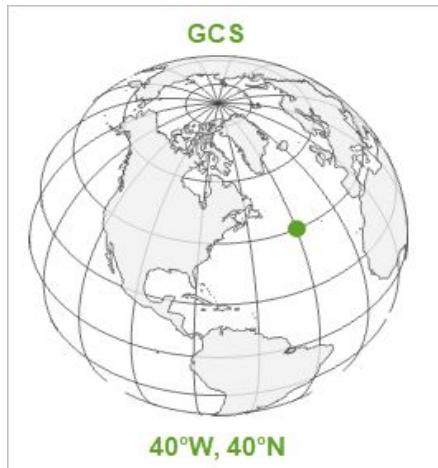


## Geographic

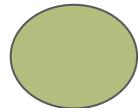
Defines where the data is located on Earth

3D

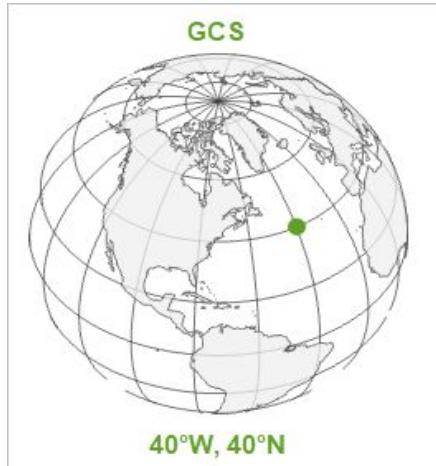
Describes locations as angles



# Geographic vs. projected coordinate system



Geographic	Projected
Defines where the data is located on Earth	Provides instructions on how to draw the data onto a flat surface
3D	2D
Describes locations as angles	Describes locations in linear units



# Geographic vs. projected coordinate system

- A PCS is a GCS that has been flattened using a map projection



# Geographic vs. projected coordinate system

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- You can store data in a GCS, but you can't draw it on a flat map without a PCS

# Geographic vs. projected coordinate system

- A PCS is a GCS that has been flattened using a map projection
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- Picking a GCS depends on where you are mapping

# Geographic vs. projected coordinate system

- A PCS is a GCS that has been flattened using a map projection
- You can store data in a GCS, but you can't draw it on a flat map without a PCS
- Picking a GCS depends on where you are mapping
- Picking a PCS depends on where you are mapping AND the nature of the map you want to make

# Projections

- Distortion is inevitable, so it's all about compromise
- Properties
  - Area
  - Form
  - Distance
  - Direction

# Projections

Changing between projections using the same datum and version:

**Projected coordinate system**

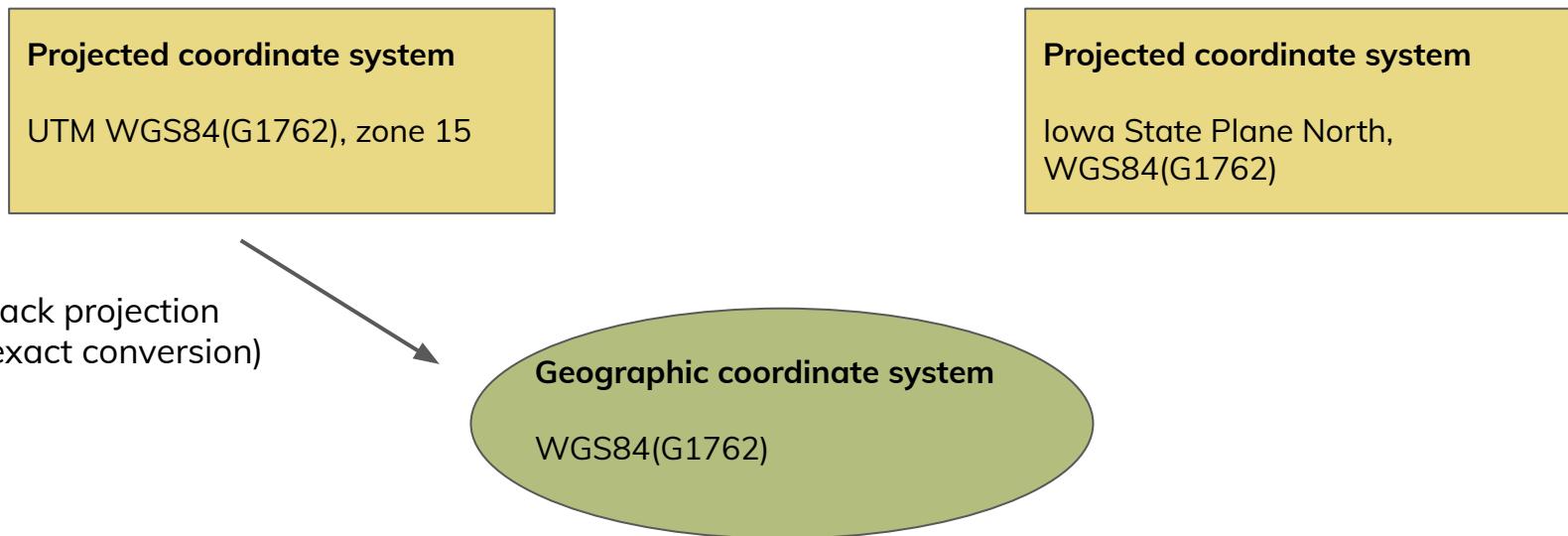
UTM WGS84(G1762), zone 15

**Projected coordinate system**

Iowa State Plane North,  
WGS84(G1762)

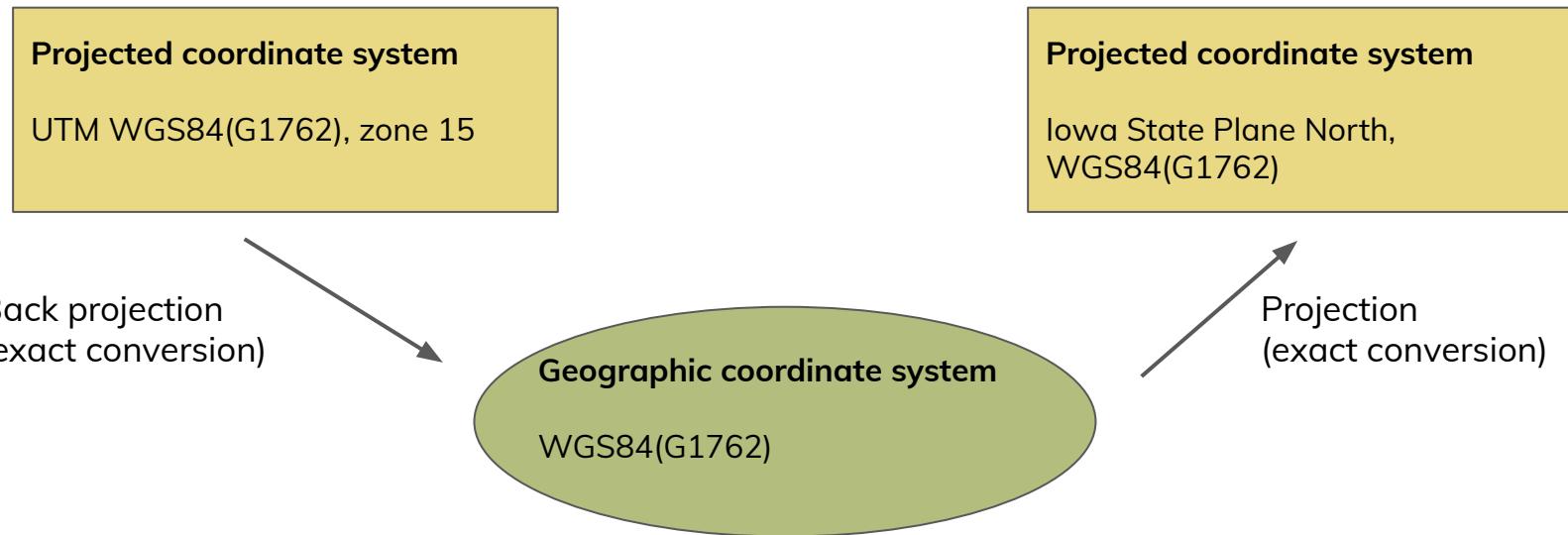
# Projections

Changing between projections using the same datum and version:



# Projections

Changing between projections using the same datum and version:



# Projections

**Changing between projections using different datums:**

**Projected coordinate system**

UTM WGS84(G1762), zone 15

**Projected coordinate system**

Iowa State Plane North,  
NAD83(2011)

# Projections

Changing between projections using different datums:

**Projected coordinate system**

UTM WGS84(G1762), zone 15

**Projected coordinate system**

Iowa State Plane North,  
NAD83(2011)

Back projection  
(exact  
conversion)

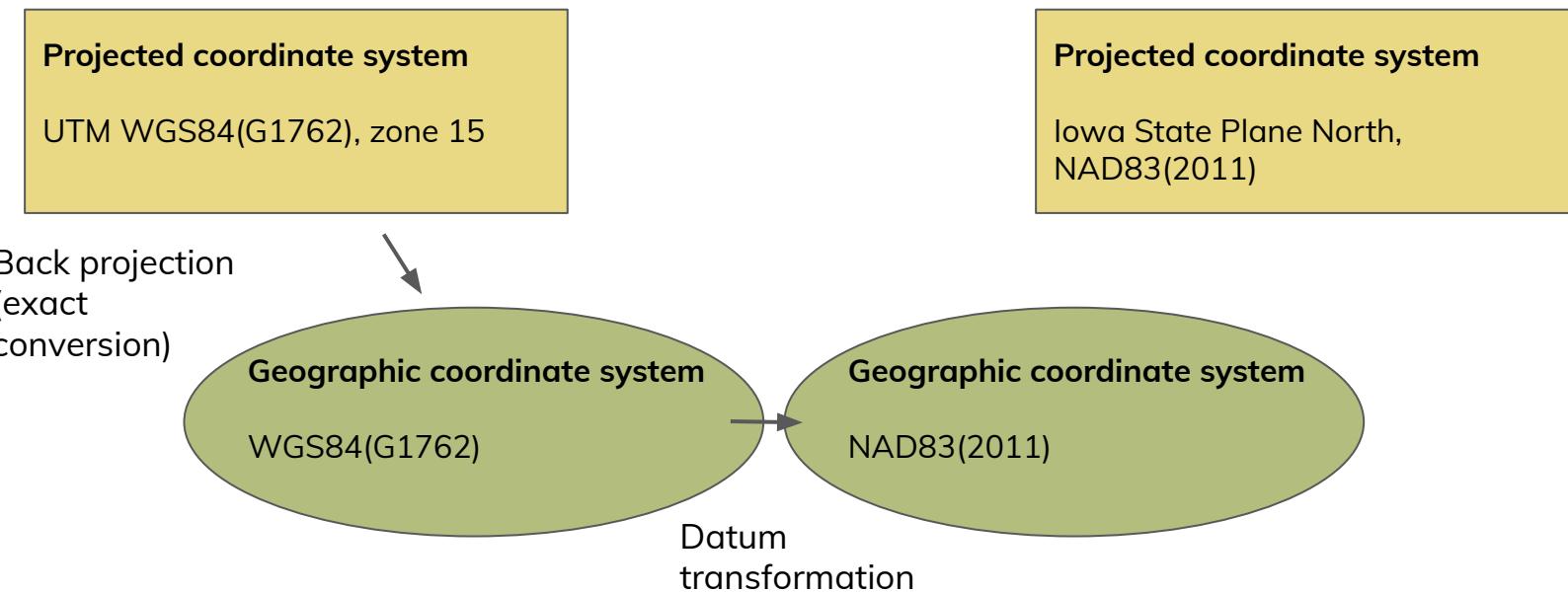
**Geographic coordinate system**

WGS84(G1762)



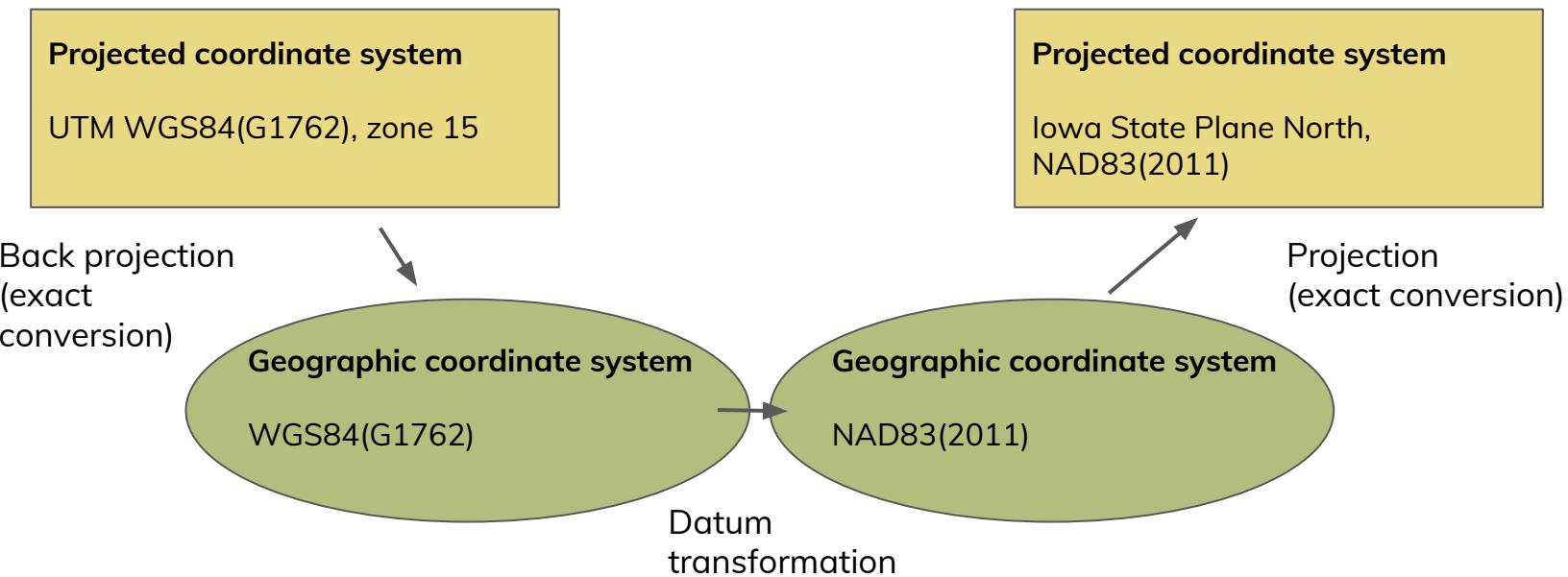
# Projections

Changing between projections using different datums:



# Projections

Changing between projections using different datums:



# Summary

- Coordinate reference systems

# Summary

- Coordinate reference systems
  - Coordinate systems

# Summary

- **Coordinate reference systems**
  - Coordinate systems
  - Datums and geodetic datums

# Summary

- Coordinate reference systems
  - Coordinate systems
  - Datums and geodetic datums
- Projections

# Summary

- **Coordinate reference systems**
  - Coordinate systems
  - Datums and geodetic datums
- **Projections**
  - Geographic vs. projected coordinate systems

# Summary

- **Coordinate reference systems**
  - Coordinate systems
  - Datums and geodetic datums
- **Projections**
  - Geographic vs. projected coordinate systems
  - Basic trade-offs in projections

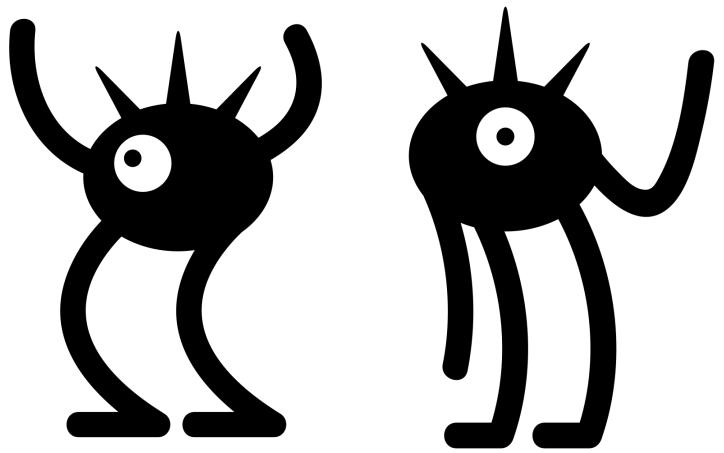
# Summary

- **Coordinate reference systems**  **Language for describing locations**
  - Coordinate systems
  - Datums and geodetic datums  **Working model of Earth**
- **Projections**  **Translation from 3D to 2D**
  - Geographic vs. projected coordinate systems
  - Basic trade-offs in projections

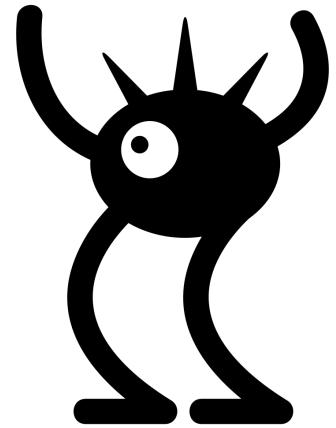
# Summary

- **Coordinate reference systems** → **Language for describing locations**
  - Coordinate systems
  - Datums and geodetic datums
- **Projections** → **Working model of Earth**
  - Geographic vs. projected coordinate systems
  - Basic trade-offs in projections
- **North isn't up and all maps are wrong!**

**How are we feeling?**



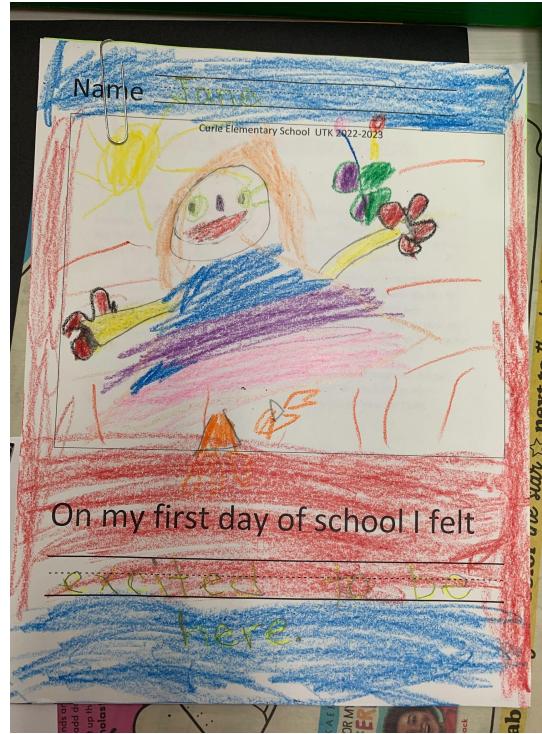
# BREAK



# Plan for today?



**Jane Oliver**  
Curriculum Development Consultant



**Pedagogical aspiration**  
“On my first day of school I felt excited to be here”

# Assignment 1

US EPA definition of environmental justice:

**Environmental justice (EJ)** is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.

**Fair treatment** means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies.

The screenshot shows the official website of the United States Environmental Protection Agency (EPA). The header includes the EPA logo and navigation links for Environmental Topics, Laws & Regulations, Report a Violation, and About EPA. A search bar is also present. Below the header, a large banner for "EJSscreen: Environmental Justice Screening and Mapping Tool" is displayed, featuring a photo of diverse children playing in a field. A call-to-action button says "Launch the EJSscreen Tool". A descriptive text box below the banner explains the tool's purpose: "In order to better meet the Agency's responsibilities related to the protection of public health and the environment, EPA has developed a new environmental justice (EJ) mapping and screening tool called EJSscreen. It is based on nationally consistent data and an approach that combines environmental and demographic indicators in maps and reports. [Learn more about Environmental Justice at EPA](#)".

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