

EDS 223: Geospatial Analysis & Remote Sensing



USGS via Unsplash

Course website

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 overview

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- Course overview
- Models of our world

Welcome!

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- Models of our world
- Course logistics

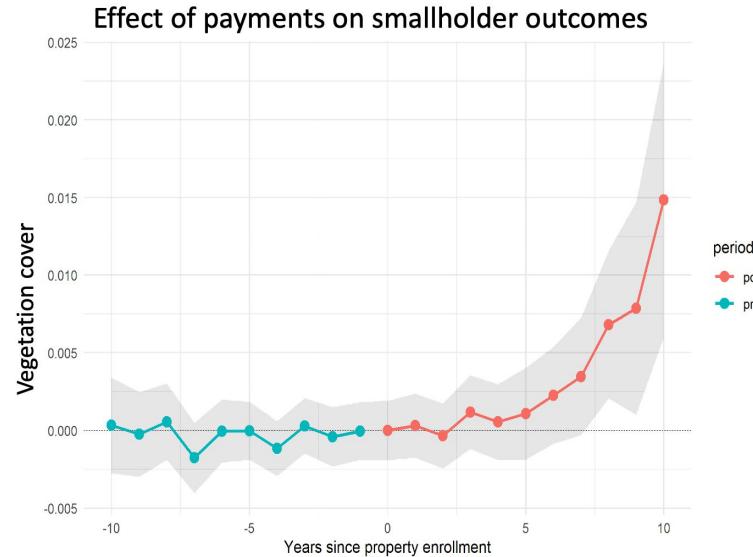
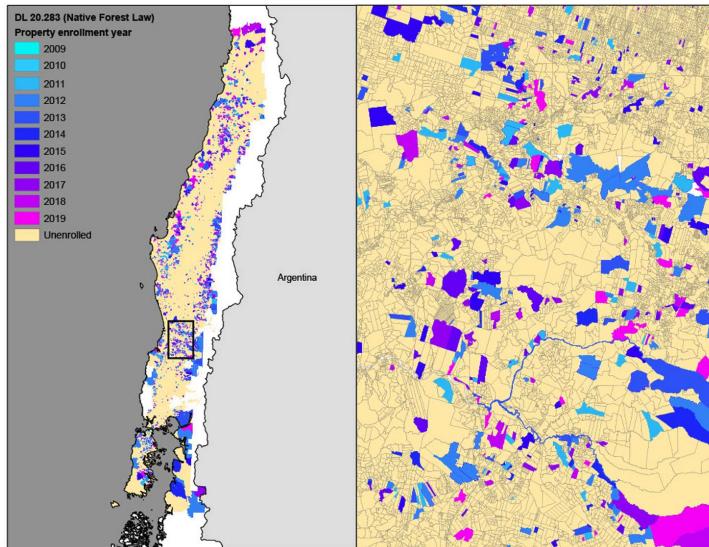
Instruction team

- **Ruth Oliver**
 - Email: rutholiver@bren.ucsb.edu
 - Office: Bren Hall 4512
 - Student hours: Wednesday 11-12 @ NCEAS
 - Contact me via: email
- **Albert Garcia**
 - Email: aqgarcia@bren.ucsb.edu
 - Student hours: Wednesday 3:30-4:30 @ NCEAS
 - Contact me via: email

Albert Garcia

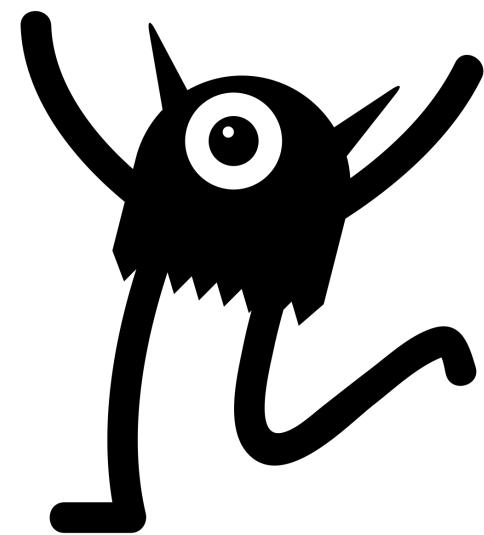
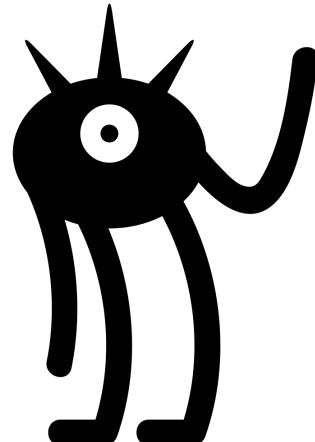
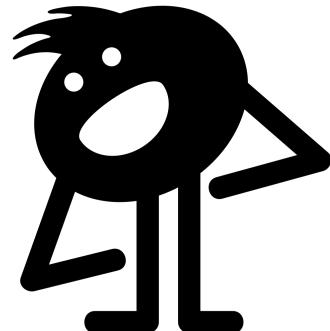
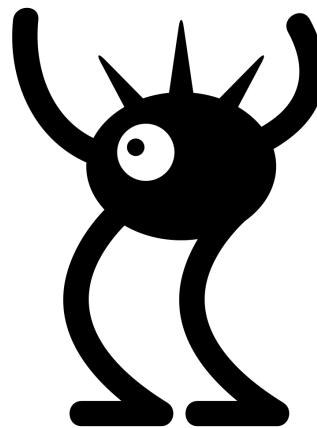


- Bren PhD student studying environmental economics
- Research:
 - Causal inference using satellite data
 - Payments for reforestation

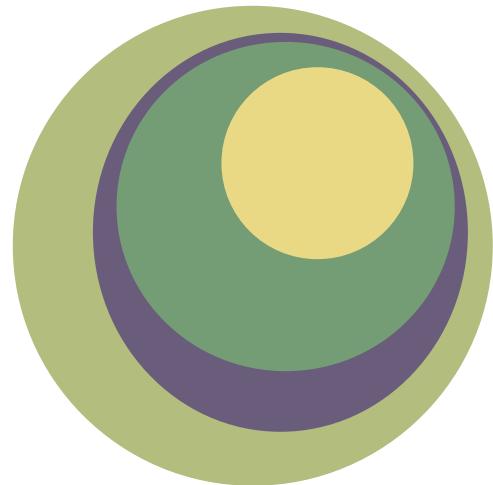


Introductions

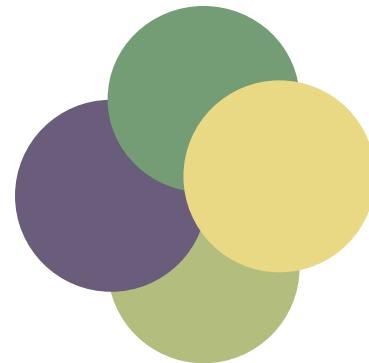
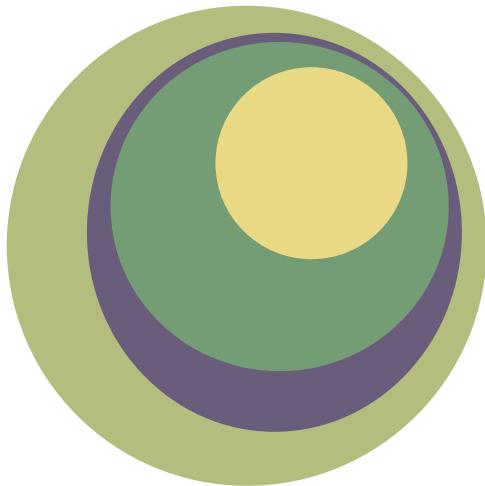
- Name
- Pronouns
- Program



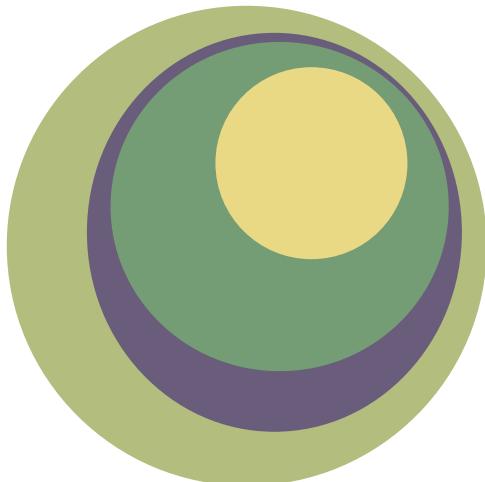
Growth mindset



Growth mindset



Growth mindset



Typos are the pedagogy

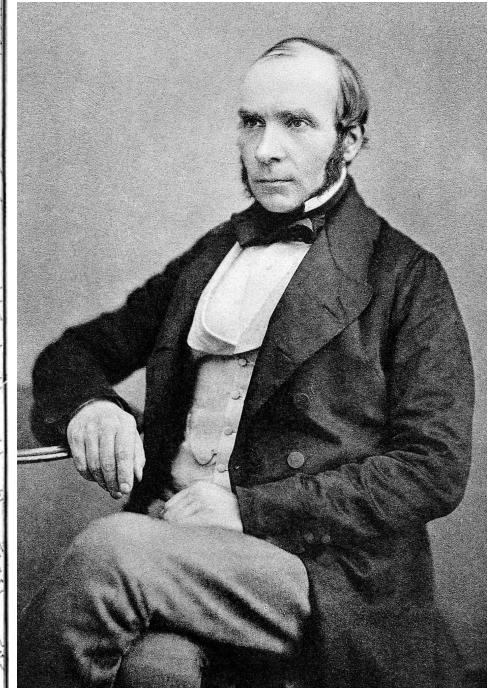
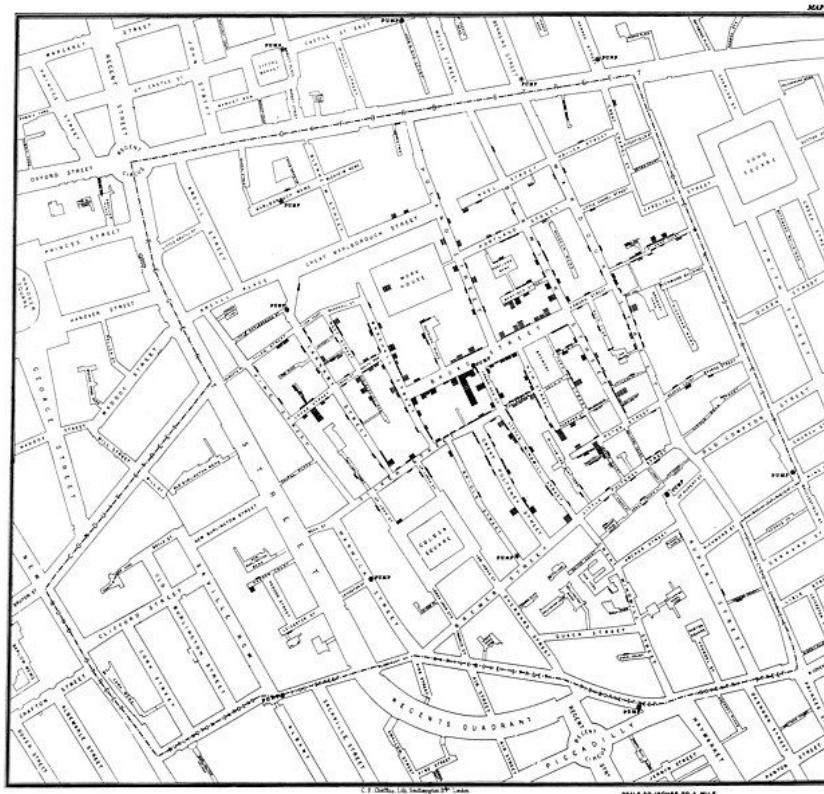
- Emily Jane McTavish

Why spatial?

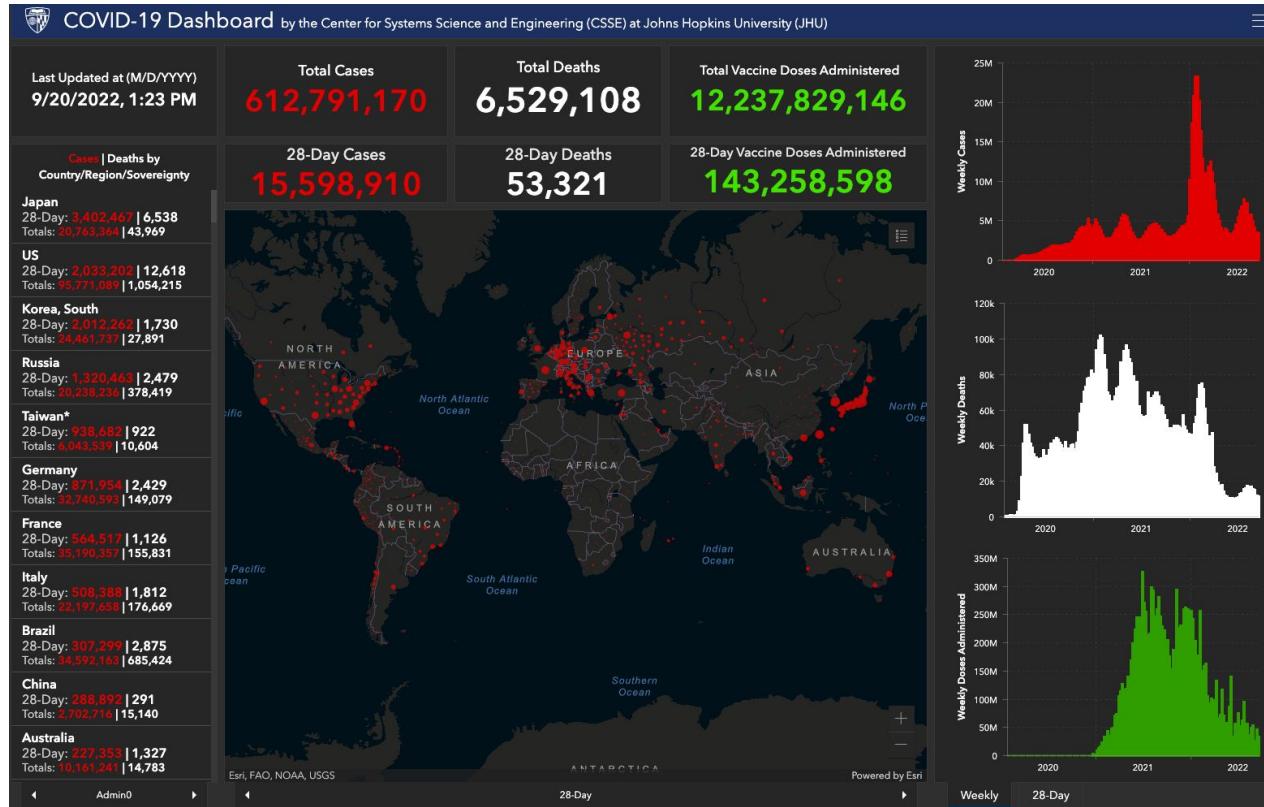
Everything is related to everything else, but near things are more.

- 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



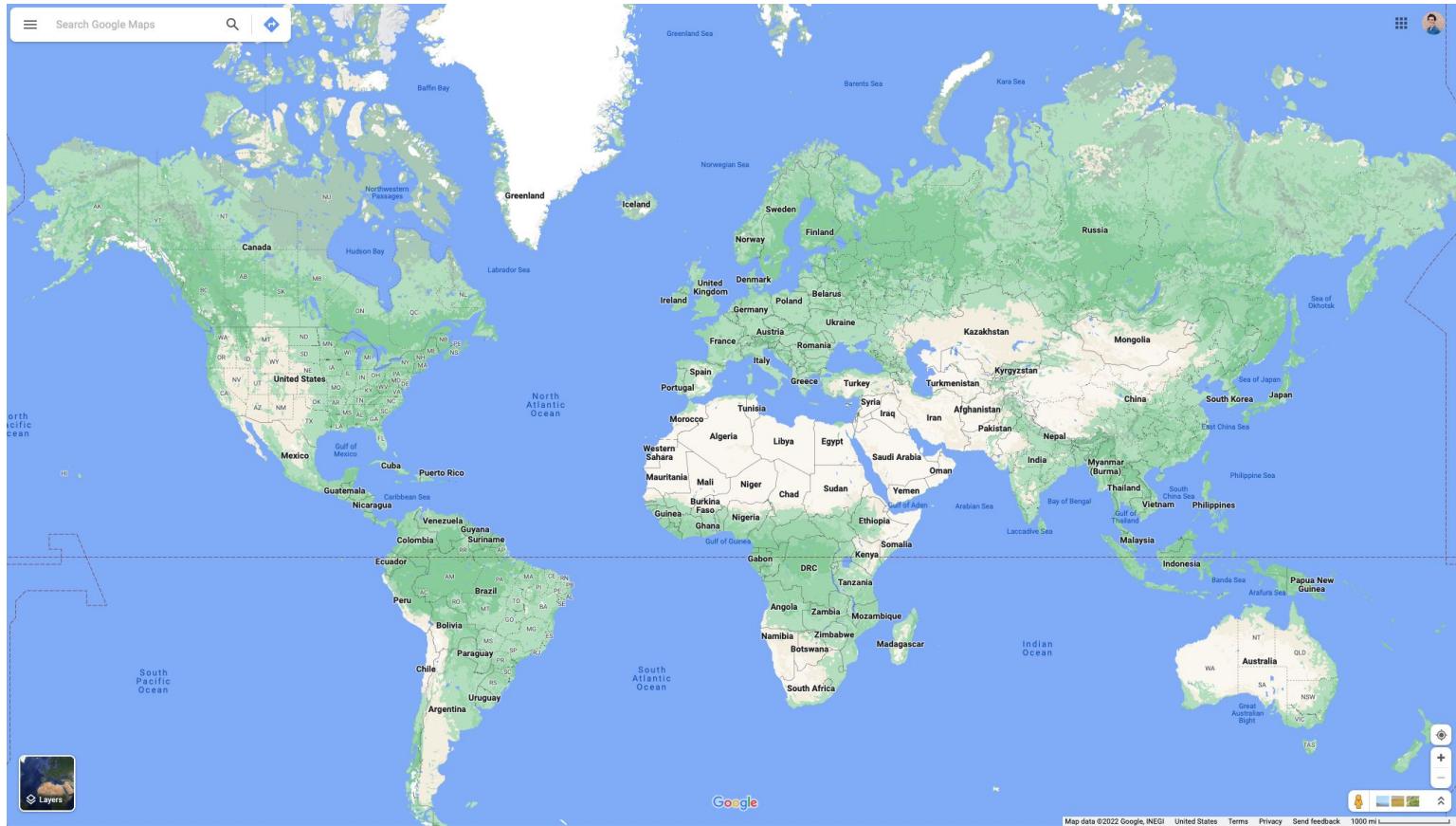
Note: Artist's impression; size of debris exaggerated as compared to the Earth

Models of our world



Photo credit: Wikipedia

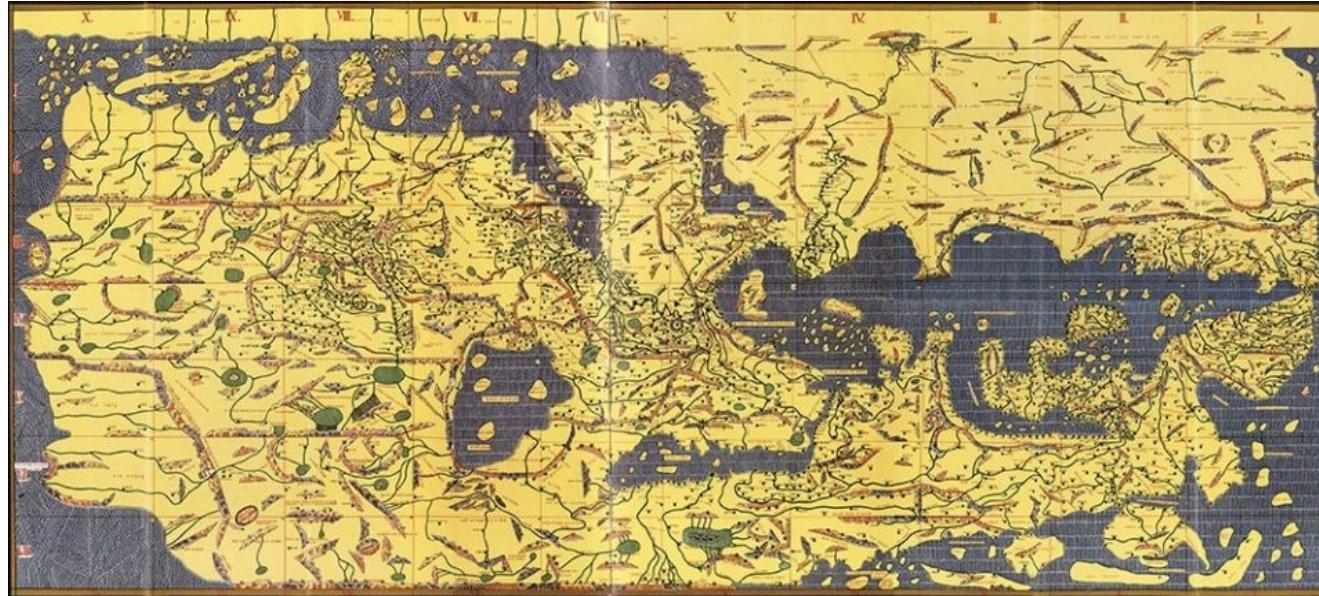
Models of our world



A non-historian's brief history of North

A non-historian's brief history of North

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) base 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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1. We perceive geography in two dimensions, but live in three

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We need a system!



- Coordinate system
- Datum
- Geodetic datum

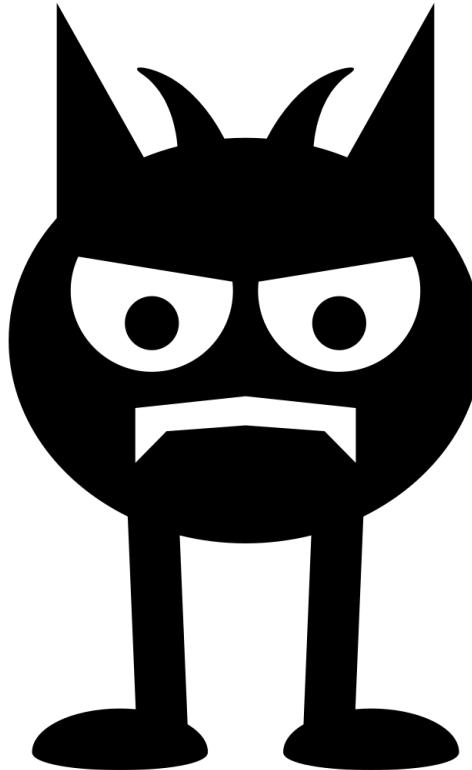
Coordinate reference system

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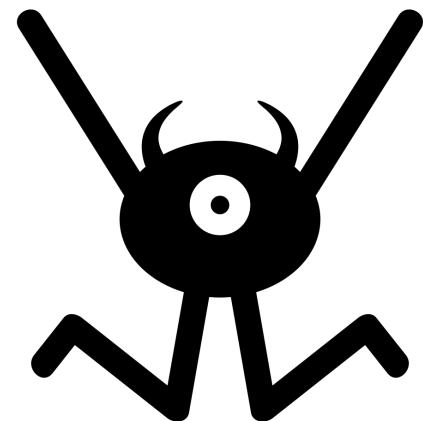


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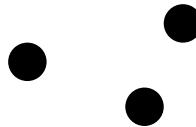
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Coordinate system

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

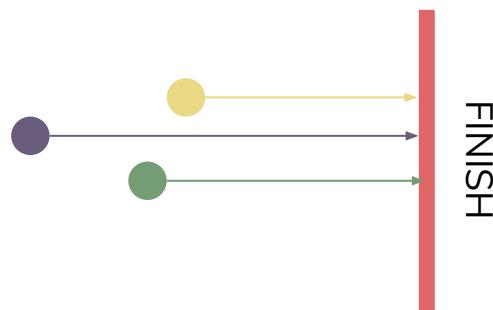
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 - Define points as a pair of numbers that specify signed distances from coordinate axes

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Coordinate systems

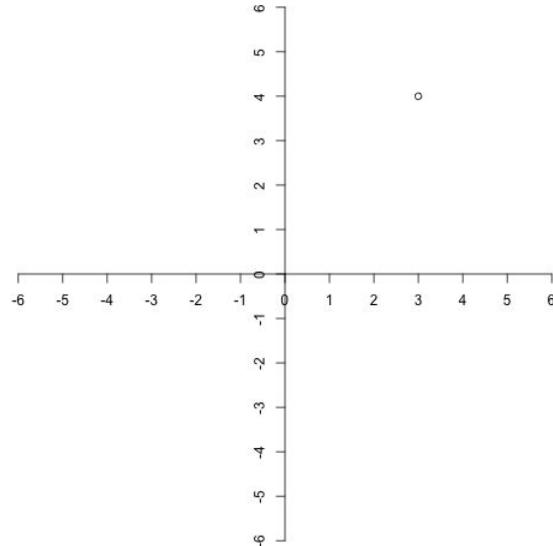
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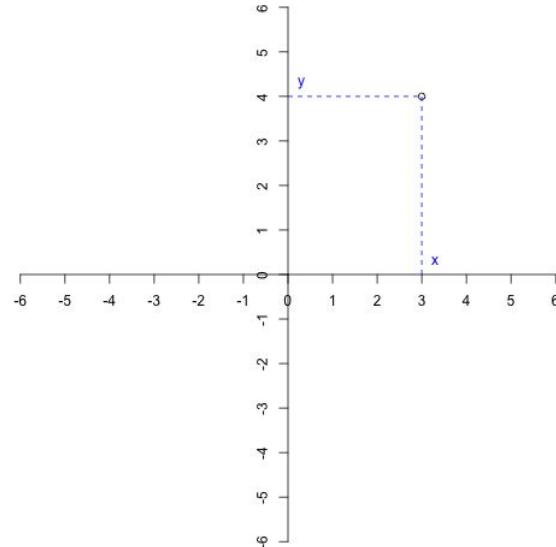
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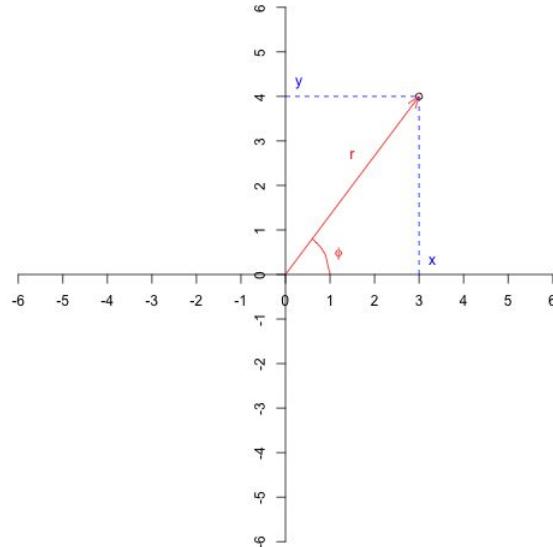
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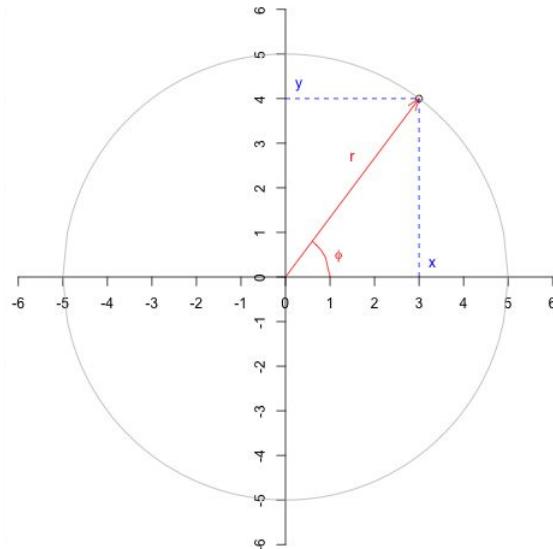
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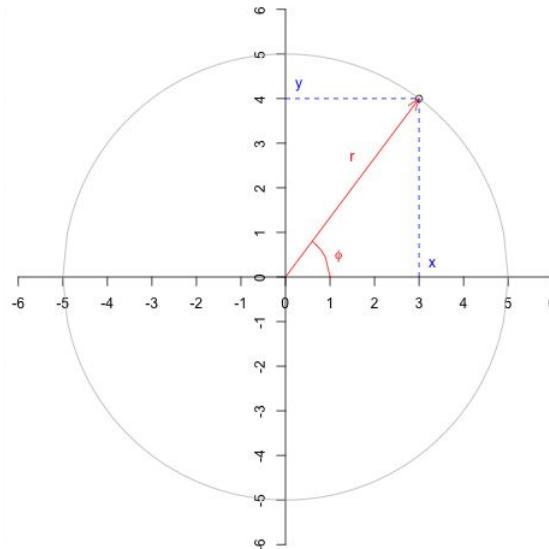
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$$x = r \cos\phi$$
$$y = r \sin\phi$$

$$r = \sqrt{x^2 + y^2}$$
$$\phi = \arctan(y, x)$$

Coordinate system

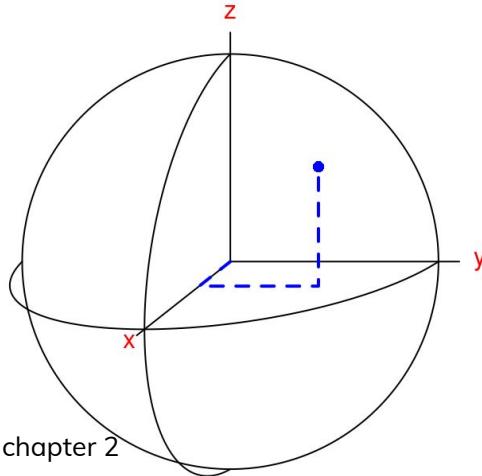
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Coordinate systems

- **Planar (or Cartesian) coordinates**
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 - **What do we need to update?**

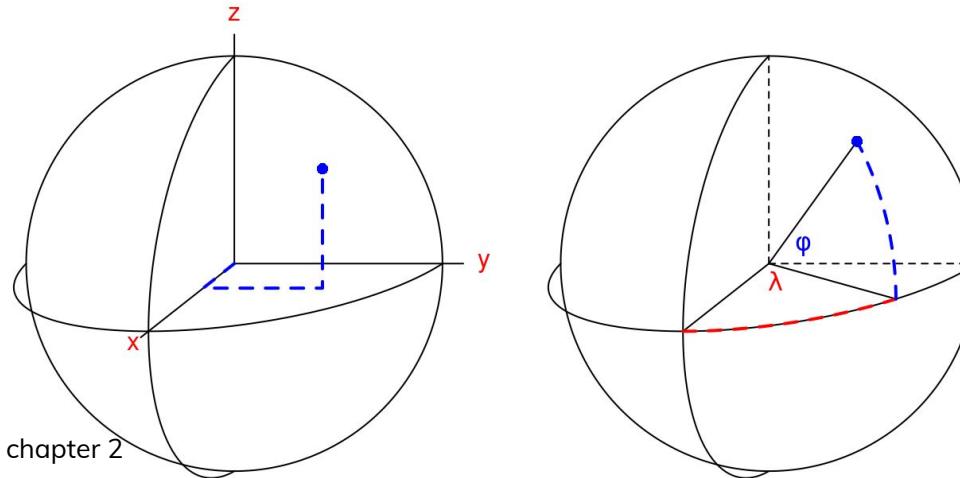
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Coordinate systems

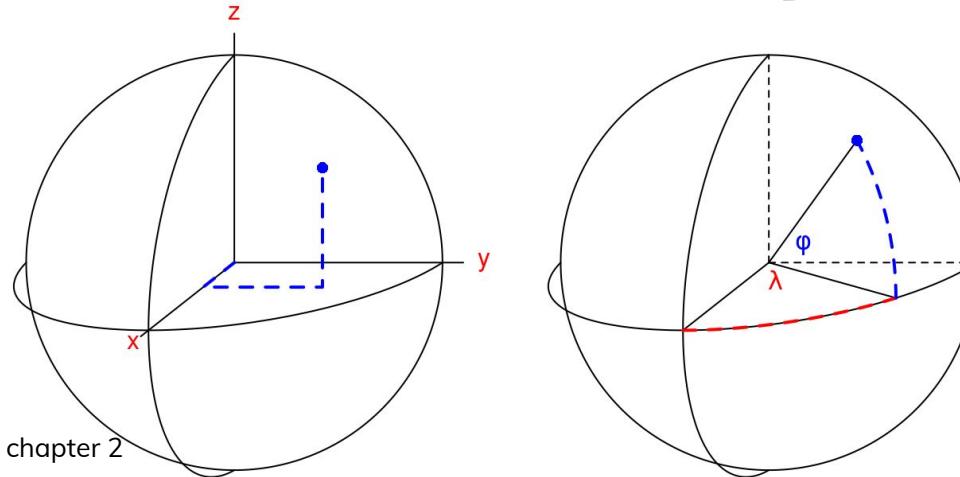
- **Planar (or Cartesian) coordinates**
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- **Polar coordinates**
 - r is the radius of the sphere
 - λ angle measured between the point and z plane
 - φ angle measured between the point and the (x,y) plane



Coordinate systems

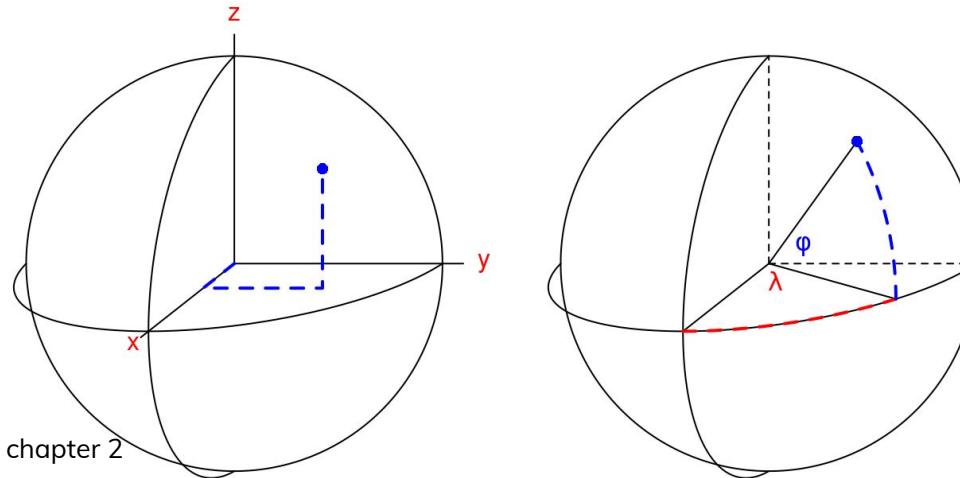
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Do these sound familiar?

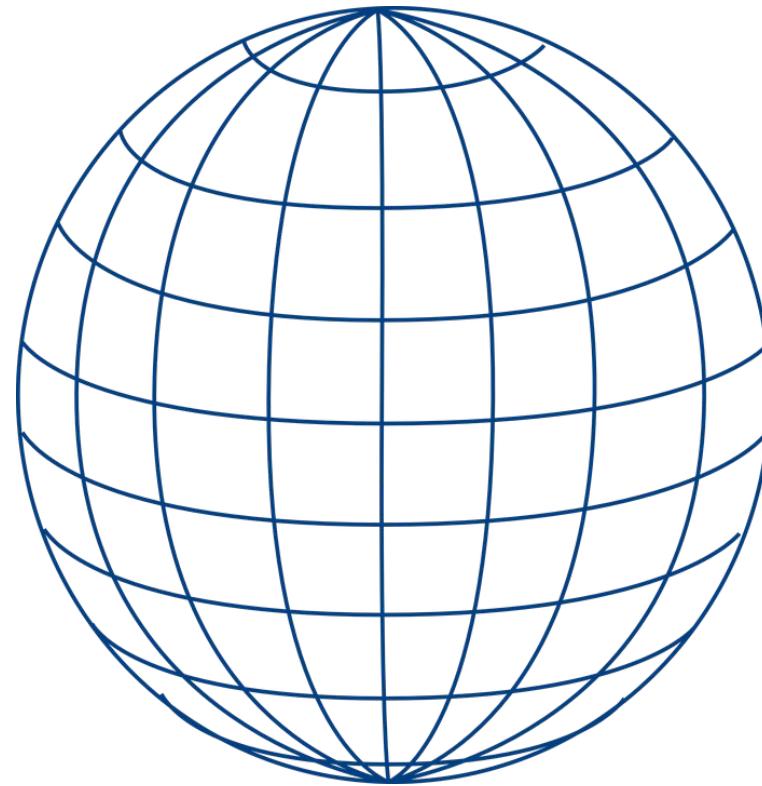


Coordinate systems

- Planar (or Cartesian) coordinates
 - Define points as a pair of numbers that specify signed distances from coordinate axes
- Polar coordinates
 - r is the radius of the sphere
 - λ longitude
 - φ latitude

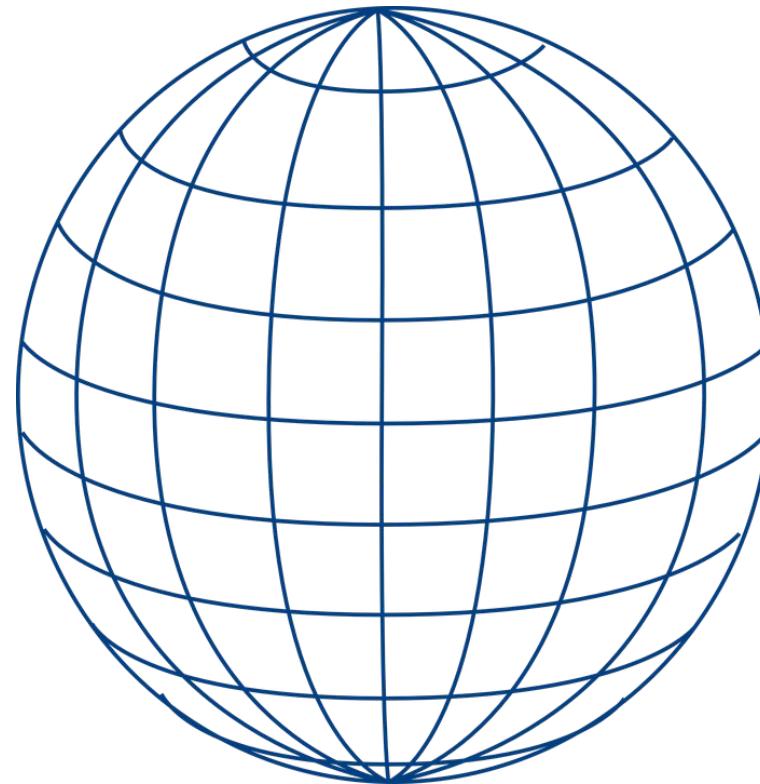


Mini latitude/longitude refresher



Mini latitude/longitude refresher

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



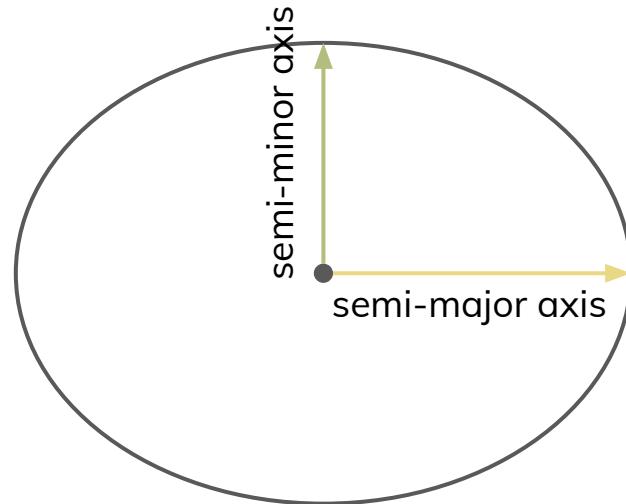
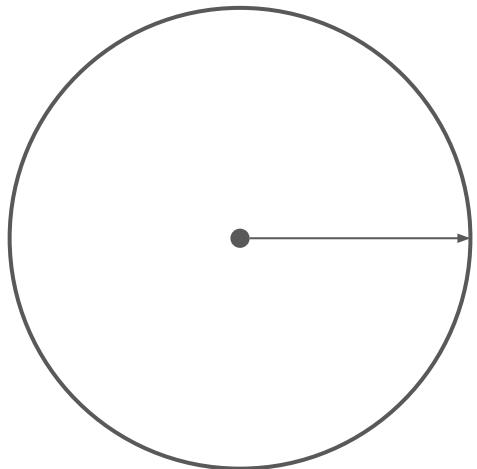
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4 (main) challenges to spatial analysis

1. We perceive geography in two dimensions, but live in three
2. Earth is irregular
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Coordinate system



We need a system!

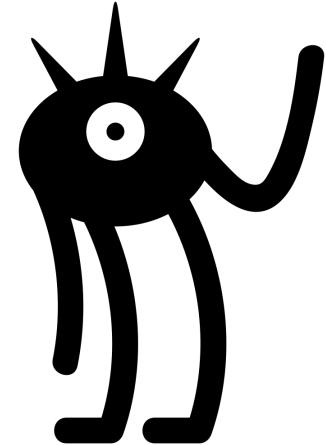
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- **Coordinate system**
 - A set of mathematical rules for specifying how coordinates are to be assigned to points
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 - **Geodetic datum**

Coordinate reference system

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Coordinate reference system



How are we feeling?

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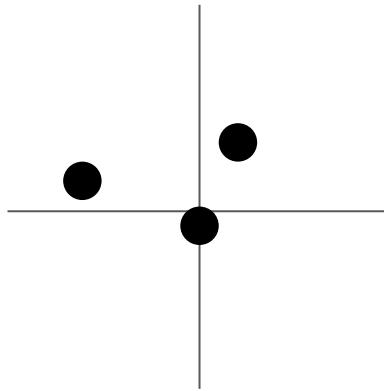
Coordinate reference system

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)

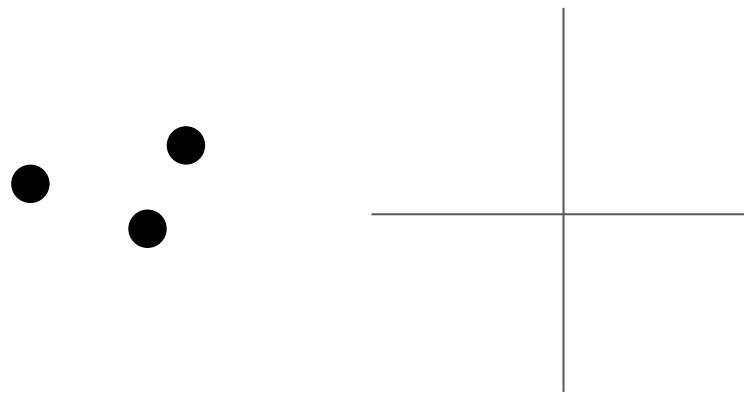
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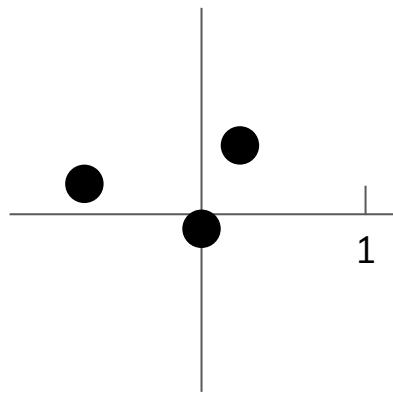
Datum

- A parameter or set of parameters that define the **position of the origin, the scale, and the orientation of a coordinate system**



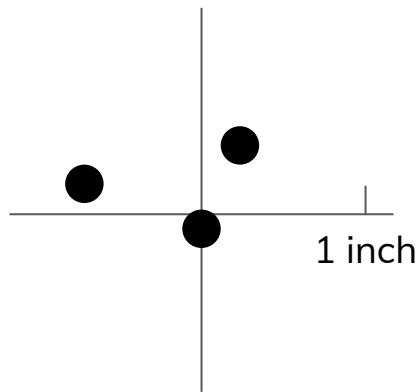
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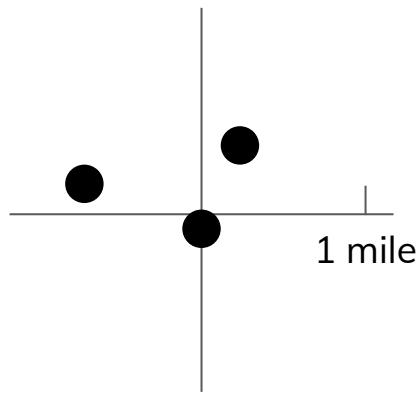
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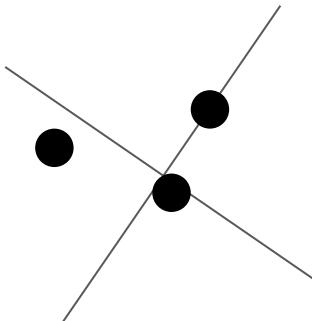
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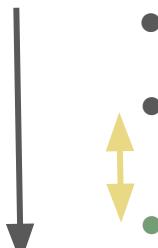
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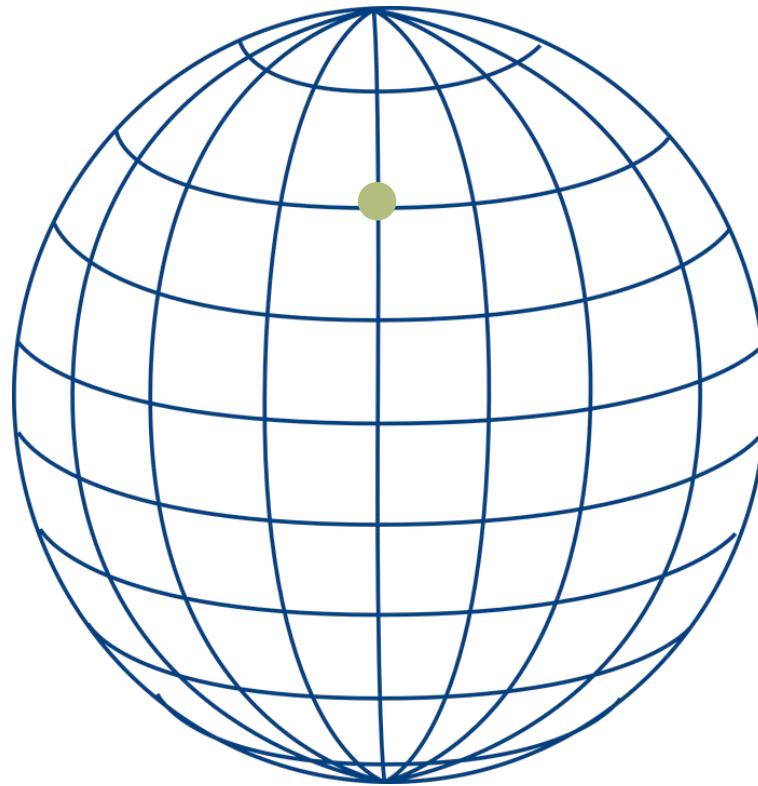
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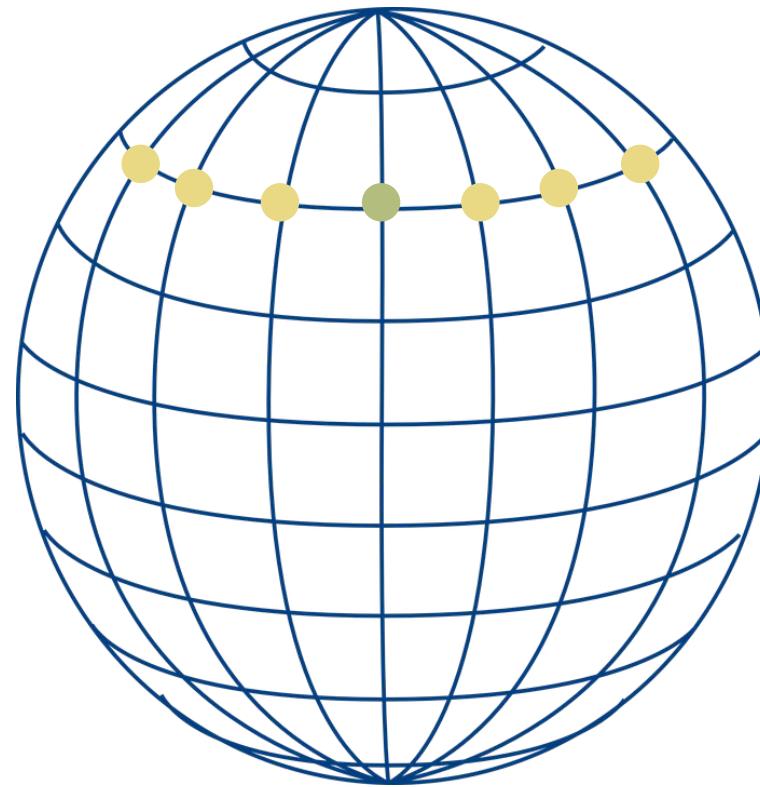
Geodetic datum

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

Geodetic datum



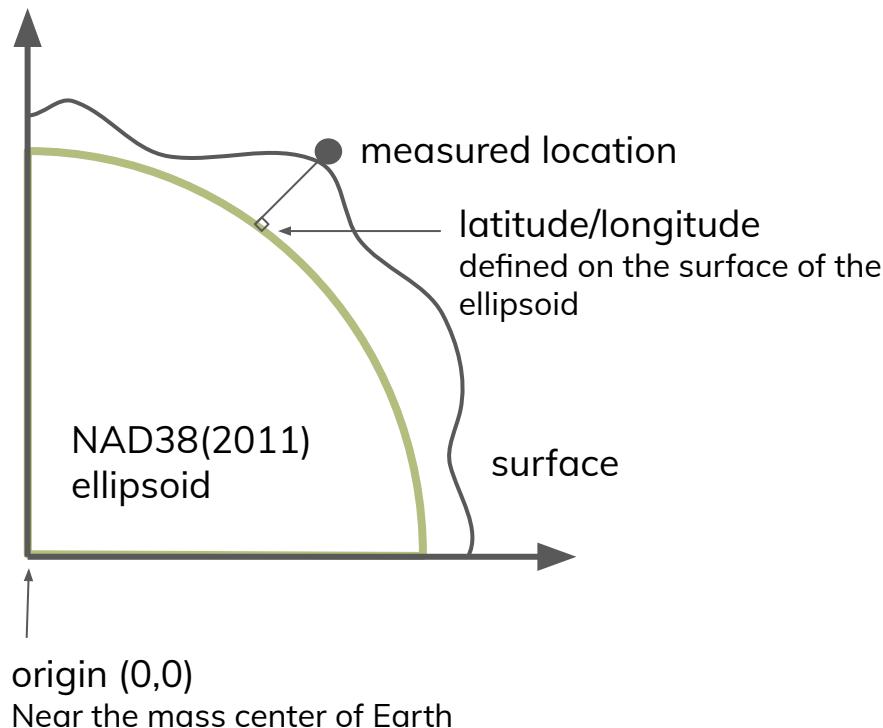
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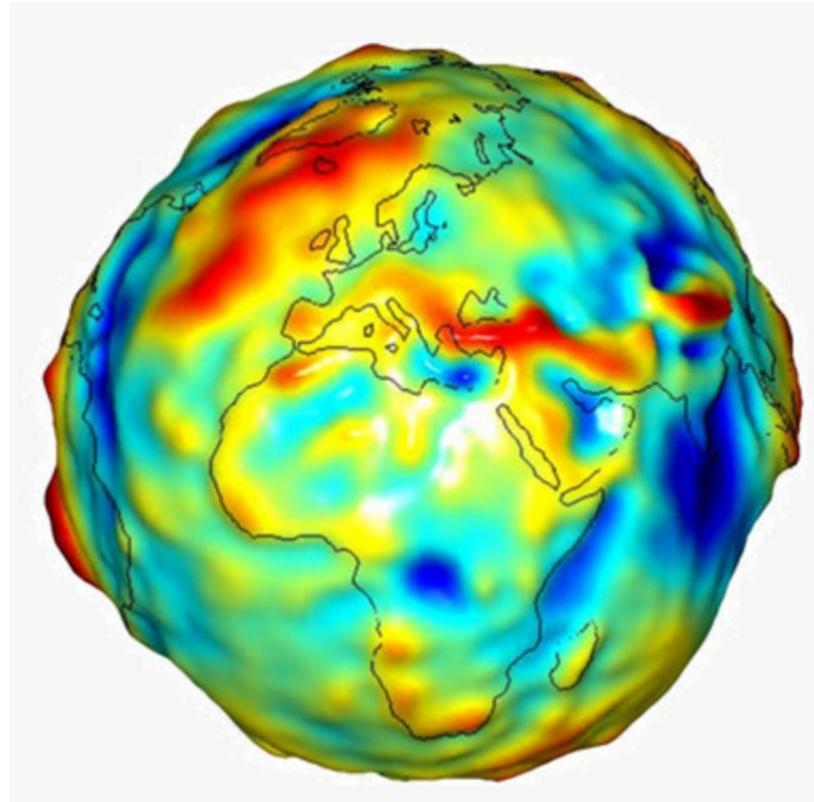
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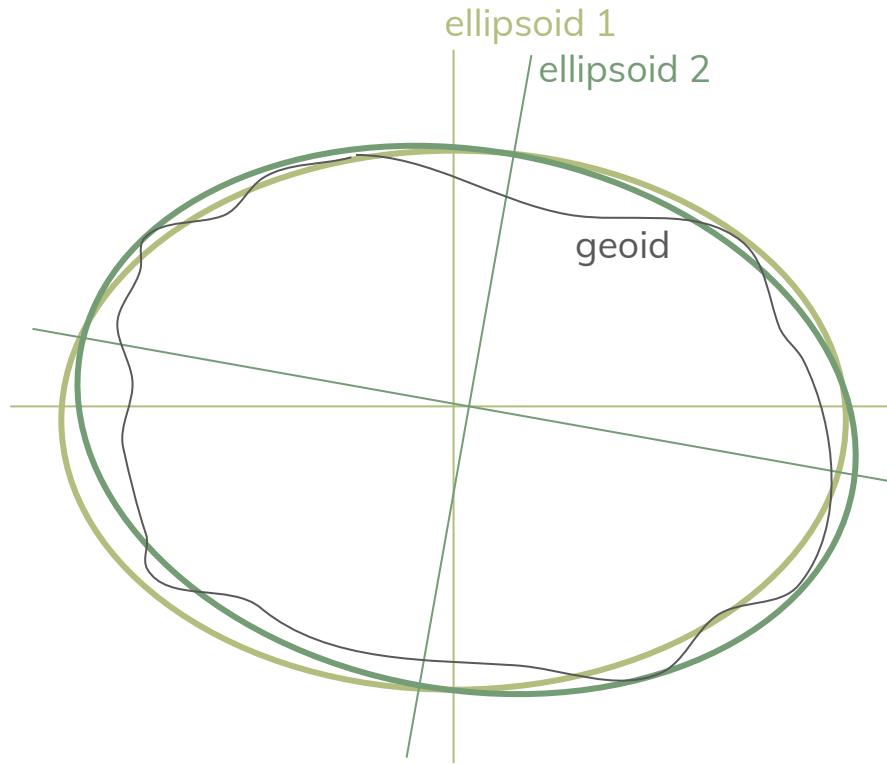
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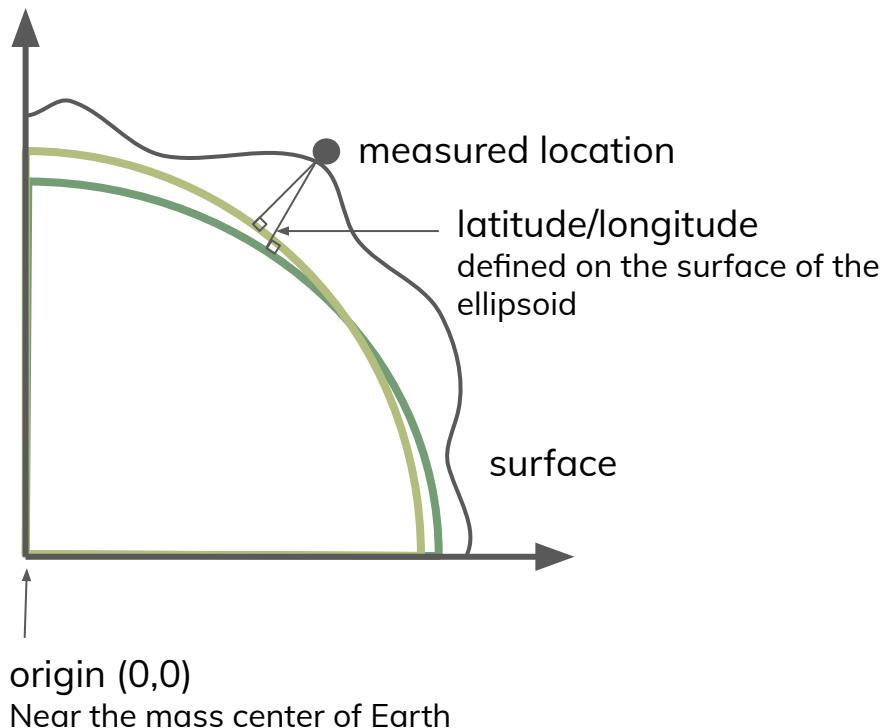
Geodetic datum



Geodetic datum



Geodetic datum



Coordinate reference systems

What does this look like in the real world?

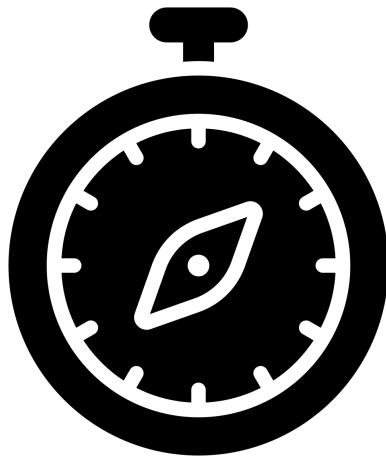
Coordinate reference systems

What does this look like in the real world?



Coordinate reference systems

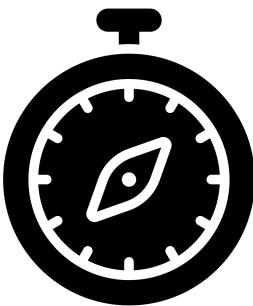
What does this look like in the real world?



134.577°E, 24.006°S

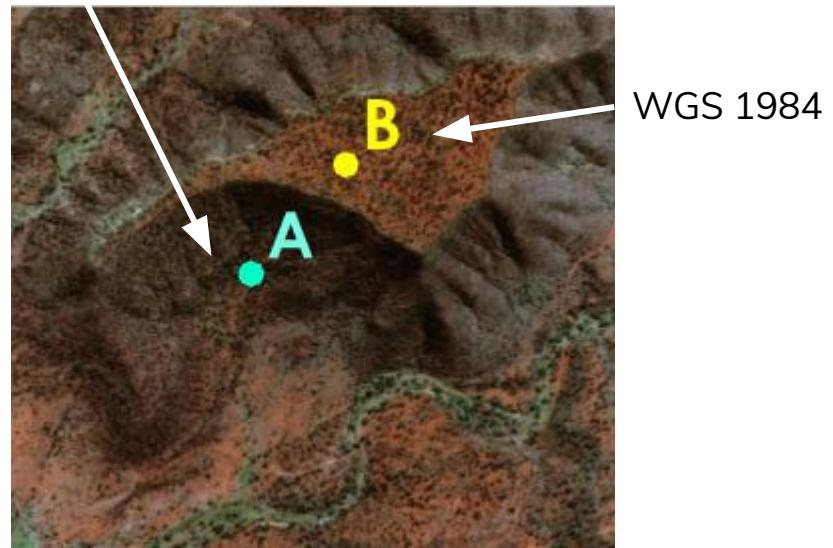
Coordinate reference systems

What does this look like in the real world?



134.577°E, 24.006°S

Australian Geodetic Datum 1984



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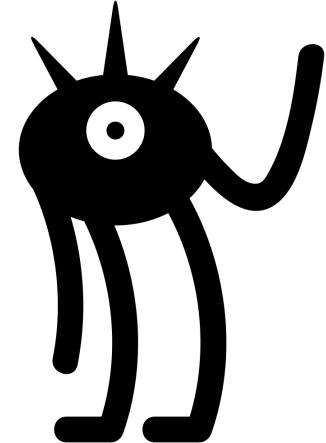
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Coordinate reference system

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



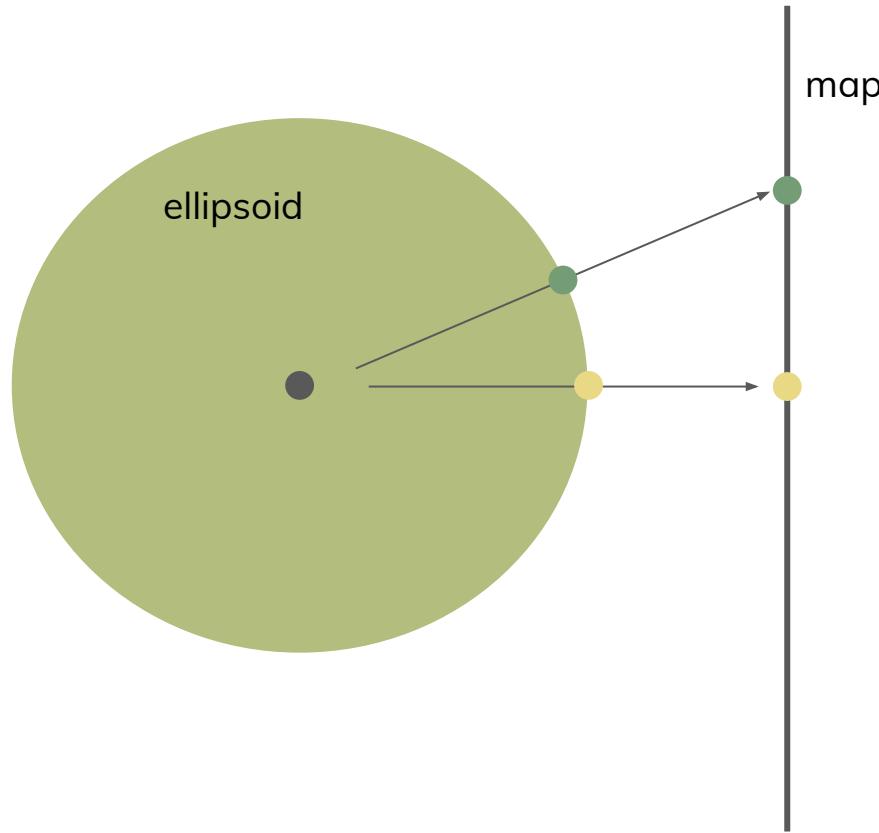
map



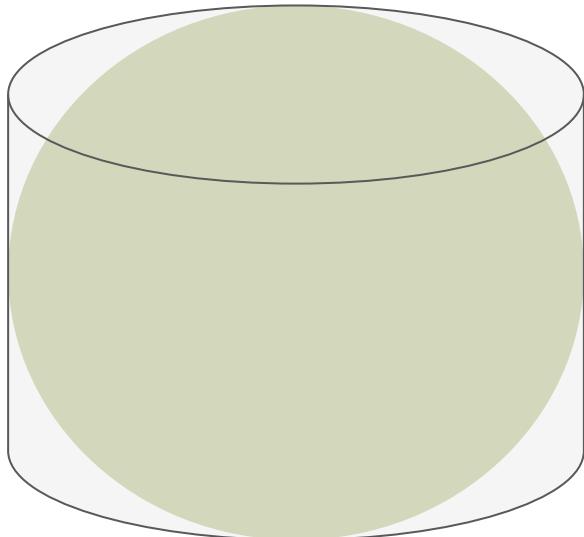
Projections



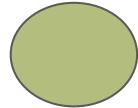
Projections



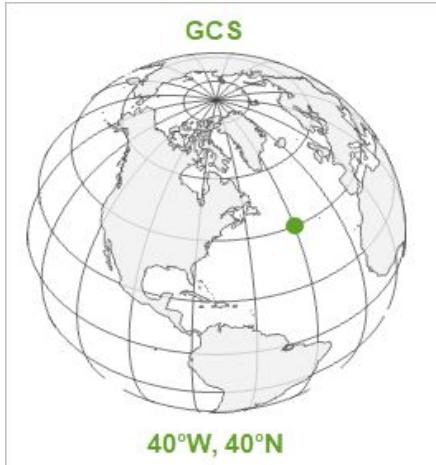
Projections



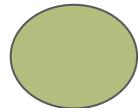
Geographic vs. projected coordinate system



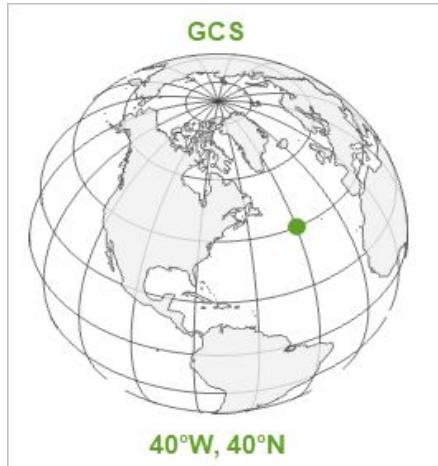
Geographic
Defines where the data is located on Earth
3D
Describes locations as angles



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

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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

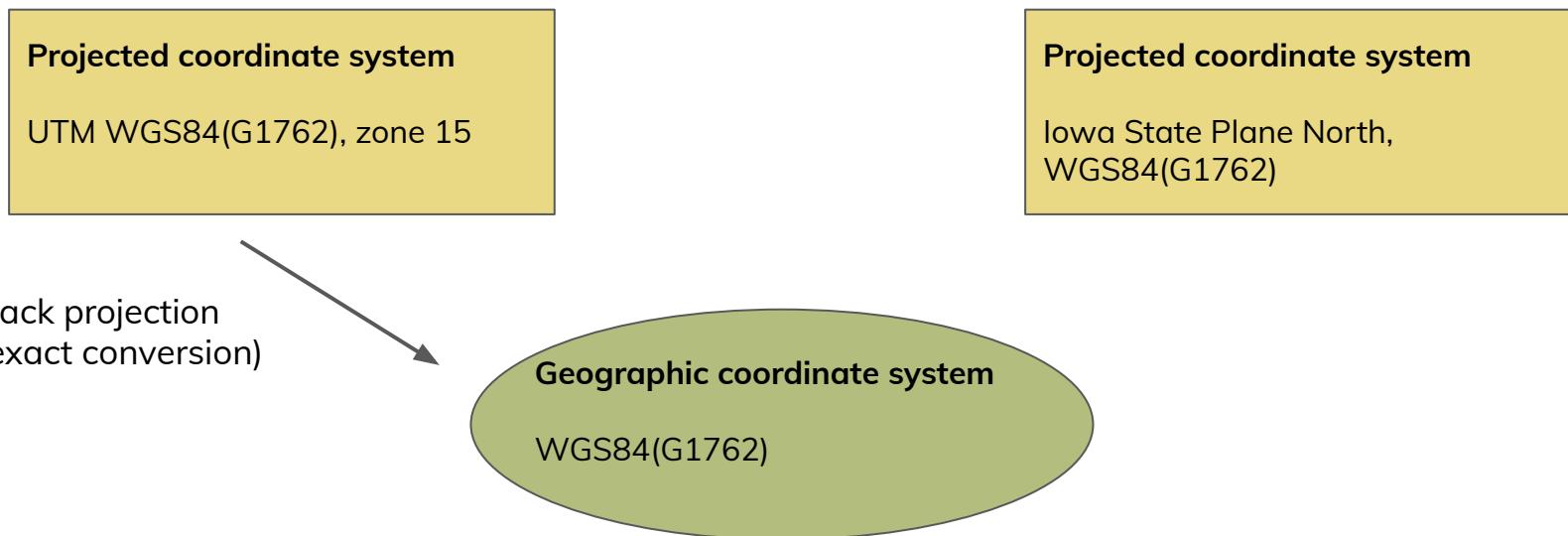
UTM WGS84(G1762), zone 15

Projected coordinate system

Iowa State Plane North,
WGS84(G1762)

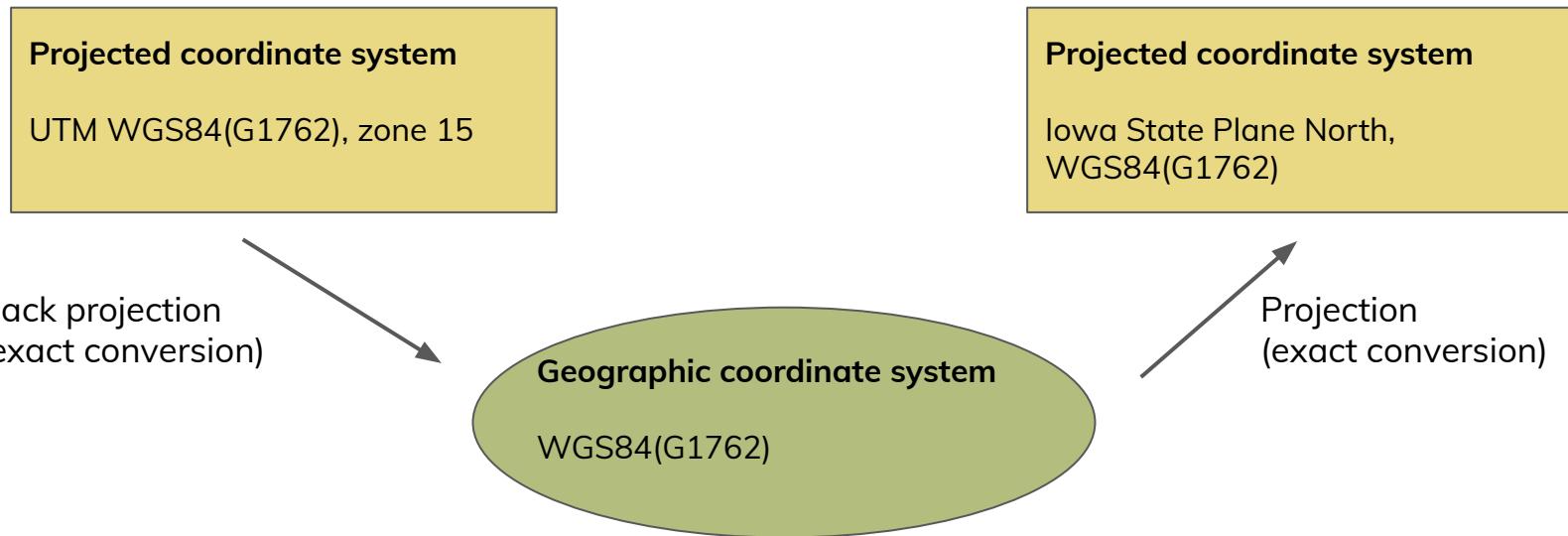
Projections

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)

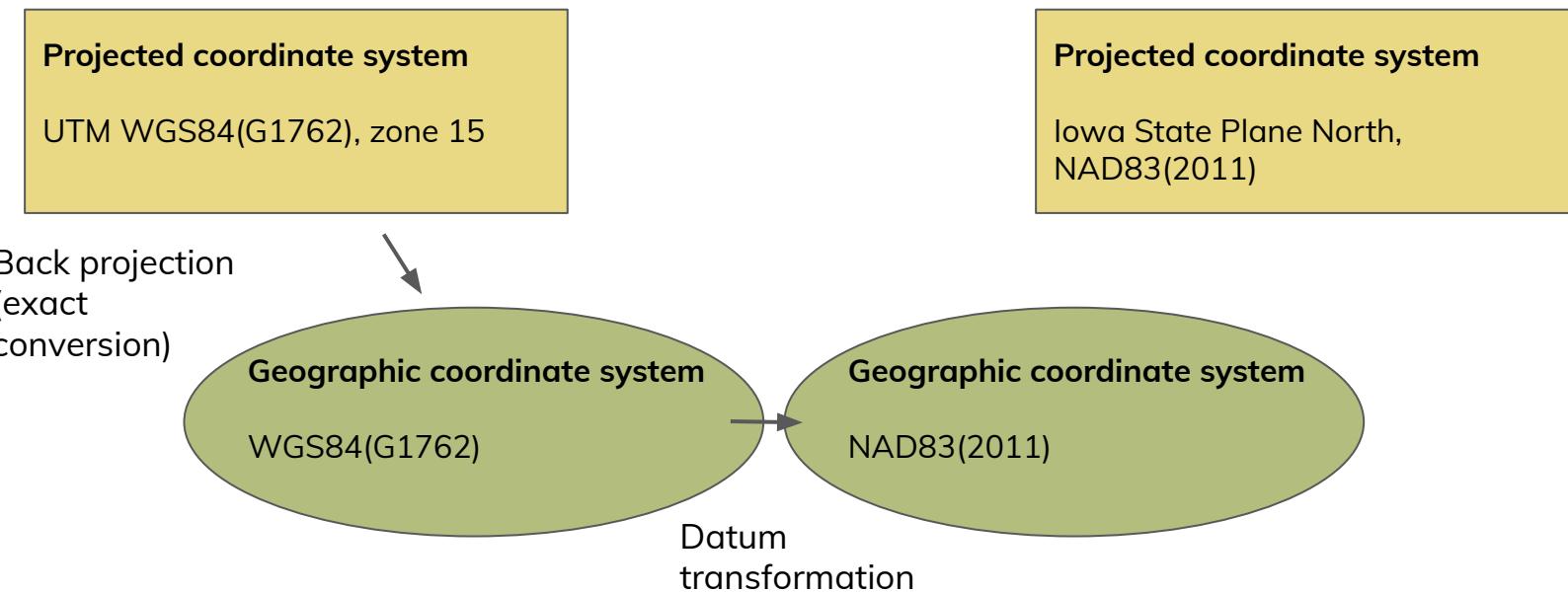
Geographic coordinate system

WGS84(G1762)



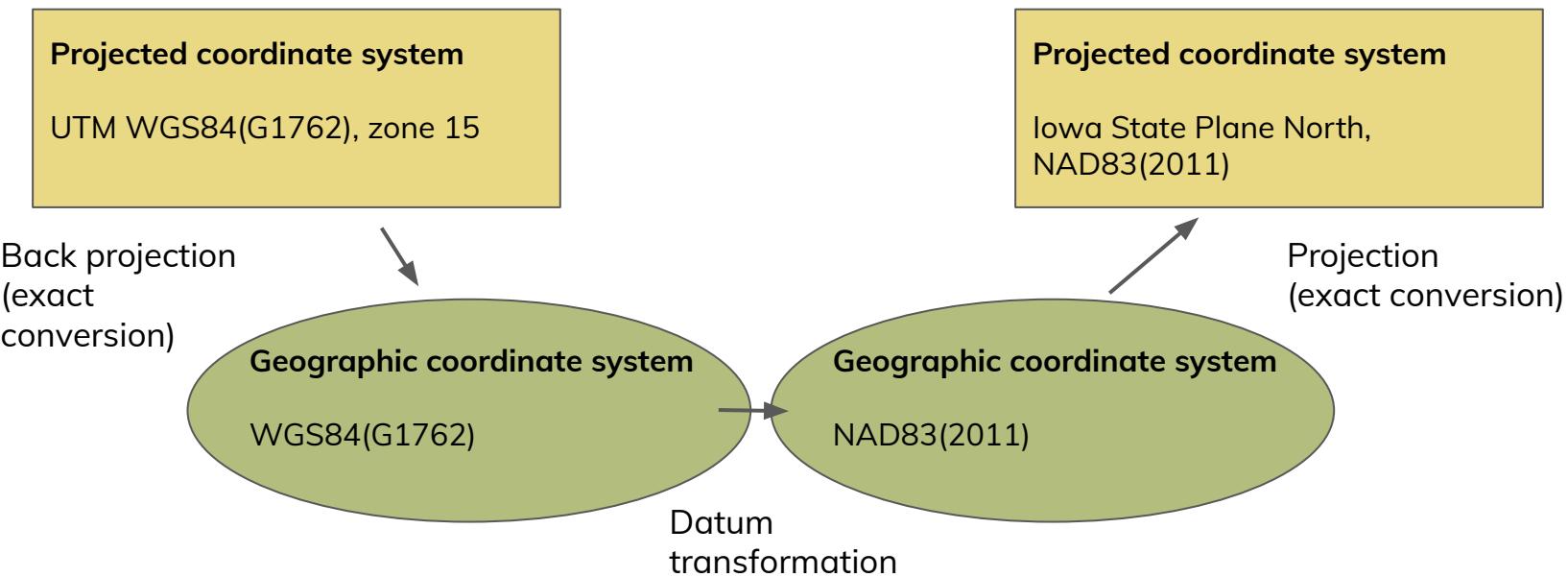
Projections

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

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 - Geographic vs. projected coordinate systems

Summary

- **Coordinate reference systems**
 - Coordinate systems
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 - Geographic vs. projected coordinate systems
 - Basic trade-offs in projections

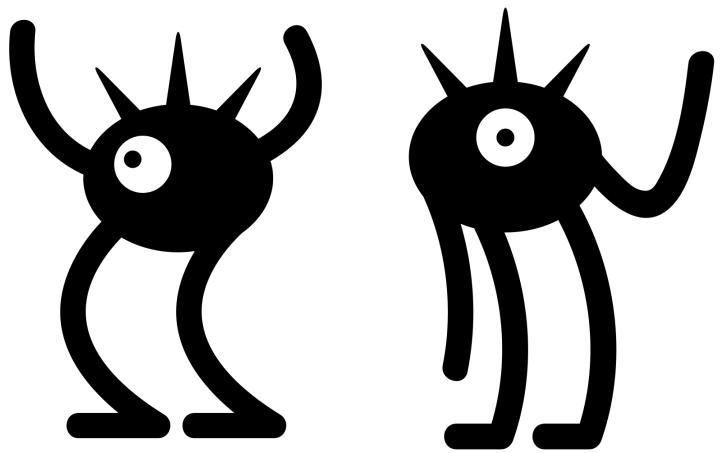
Summary

- **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?



Course logistics

ryoliver.github.io/EDS_223_spatial_analysis