Session 5: Map Projections and Coordinate Systems

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Class Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
08/05/19 **Introduction to Geographical Information Systems** 10:45 am–12:15 am	08/06/19 **Cartography and Spatial Data Display** 8:30am – 11:00pm	08/07/19 **Querying Data for Spatial & Attribute Selections** 8:30am – 11:00pm	08/08/19 **Data Formats and Open-Source GIS** 8:30am – 11:00pm	08/09/19 **Map Projections and Coordinate Systems** 8:30am – 11:00pm
08/12/19 **Spatial Analysis Tool** 8:30am – 11:00pm	08/13/19 **Raster and Terrain Analysis** 8:30 am – 10:00 am **Scripps Institution of Oceanography** 1:00pm – 4:00pm	08/14/19 **Image Analysis** 8:30am – 11:00pm	08/15/19 **Editing Spatial Data and Geocoding** 8:30am – 11:00pm	08/16/19 **Web Mapping/ Wrap up** 8:30am – 11:30am

Outline: Map Projections and Coordinate Systems

- Introduction
- What is a map projection?
- Geographic Coordinate System (GCS)
- Datums
- Common map projections
- Demonstration
- Project

Introduction

- Map projections
- Why do we need map projections

Coordinate Systems

Coordinate system: Framework used to define unique position

Earth reference systems:

- **Geographic Coordinate System (GCS)**
  - Spherical (angular units of degrees)
  - Latitude and Longitude
- **Projection Coordinate System**
  - Cartesian (linear units)
  - Meters or Feet

Geographic Coordinates

GCS: Reference system for locations on the curved surface of the earth.

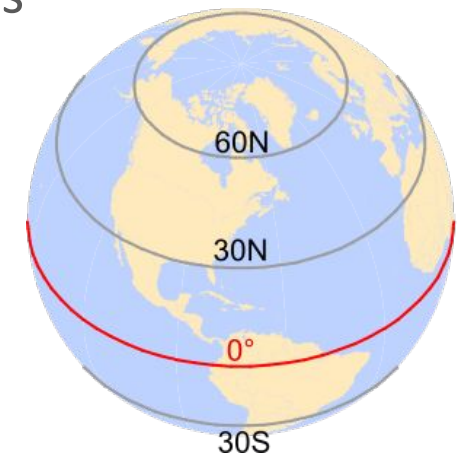
- Locations defined by a latitude and longitude value

UC San Diego is located:

Latitude: 32.87° North of Equator

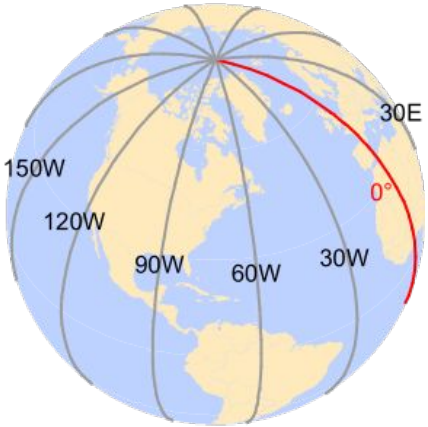
Longitude: 117.23° West or Prime Meridian

Latitude: North-South



Latitude = 0 degrees at Equator

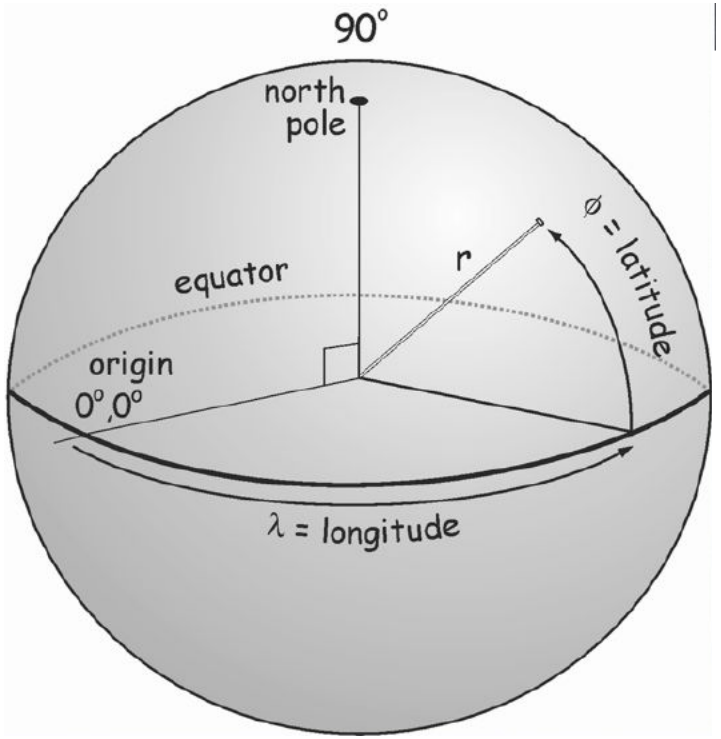
Longitude: East-West



Longitude = 0 degrees at Prime Meridian

GCS: Spherical System

- **Latitude** measures the angle from the equatorial plane to the location on the earth's surface.
- **Longitude** measures the angle between the prime meridian plane and the north-south plane that intersects the location of interest.



Source: GIS Fundamentals by P. Bolstad, 2015

GCS Representation

In decimal degrees:

Latitude > 0, north equator = Positive

Latitude < 0, south equator = Negative

Longitude > 0, east Prime Meridian = Positive

Longitude < 0, west Prime Meridian = Negative

UCSD Location

32.87° North and

117.23° West

+ 32.87, -117.23

GCS Representation

Latitude and longitude can be expressed as:

- degrees-minutes-seconds (DMS)
- degrees-minutes (DM)
- decimal degrees (DD)

GIS prefers decimal degrees

Conversion from DMS to DD

- 60’ = 1 deg
- 60’’ = 1 ‘

Nominal location	Absolute location (DMS)	Absolute location (DD)
Los Angeles, US	34° 3′ North, 118° 15′ West	+34.05, –118.25
Mumbai, India	18° 58′ North, 72° 49′ East	+18.975, +72.8258
Sydney, Australia	33° 51′ South, 151° 12′ East	–33.859, 151.211
Sao Paolo, Brazil	23° 33′ South, 46° 38′ West	–23.550, –46.634

Dimensional Analysis

GIS requires decimal degrees

Dimensional analysis

118° 15’ to 118.25°

(118 + 15/60)

- Express 73°57′48″ as decimal degrees:
  - Convert the 48 to minutes $\frac{48''}{1} \times \frac{1'}{60''} = 0.8'$
  - Add that to your minutes
    - So 57.8’
  - Now change that to degrees $\frac{57.8'}{1} \times \frac{1°}{60'} = 0.963°$
  - Add to the 73°
  - So 73.963°

Decimal Minutes (DM) popular for navigating the seas

1’ minute latitude = 1 nautical mile (nm)

1’ nm ~ 1852 meters

Question?

UC San Diego is located:

Latitude: 32.87°

Longitude: -117.23°

How much is 0.01 degrees in meters?

How precise is this for UCSD location?

Answer

0.01 deg = ? meters

$$X = \left(\frac{0.01\ \cancel{\text{deg}}}{1}\right)\left(\frac{60\ \cancel{\text{min}}}{1\ \cancel{\text{deg}}}\right)\left(\frac{1\ \cancel{\text{nm}}}{1\ \cancel{\text{min}}}\right)\left(\frac{1852\ \text{m}}{1\ \cancel{\text{nm}}}\right)$$

$$X \sim 1111.2\ \text{m}$$

How precise is this for UCSD location - Depends who is asking!!!

+/- 1 kilometer is large error for most applications.

Question

Latitude and Longitude are not considered Cartesian coordinates

Why?

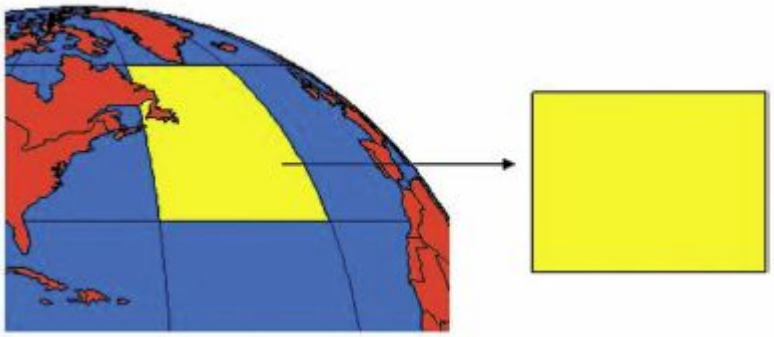

Convergence

Projected Coordinate Systems

- Positions on curved Earth's surface projected to "flat" map

- GCS ⟺ Projection
  - Mathematical transformations

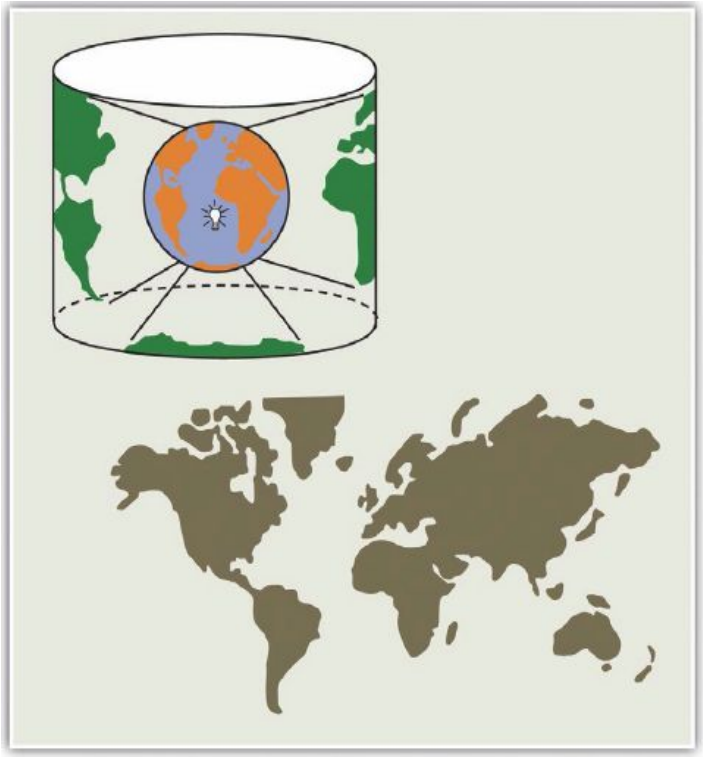
- GIS offers on-the-fly projections



Source: GIS: An Introduction by P. McHaffie, 2019

Projections: Illustrated

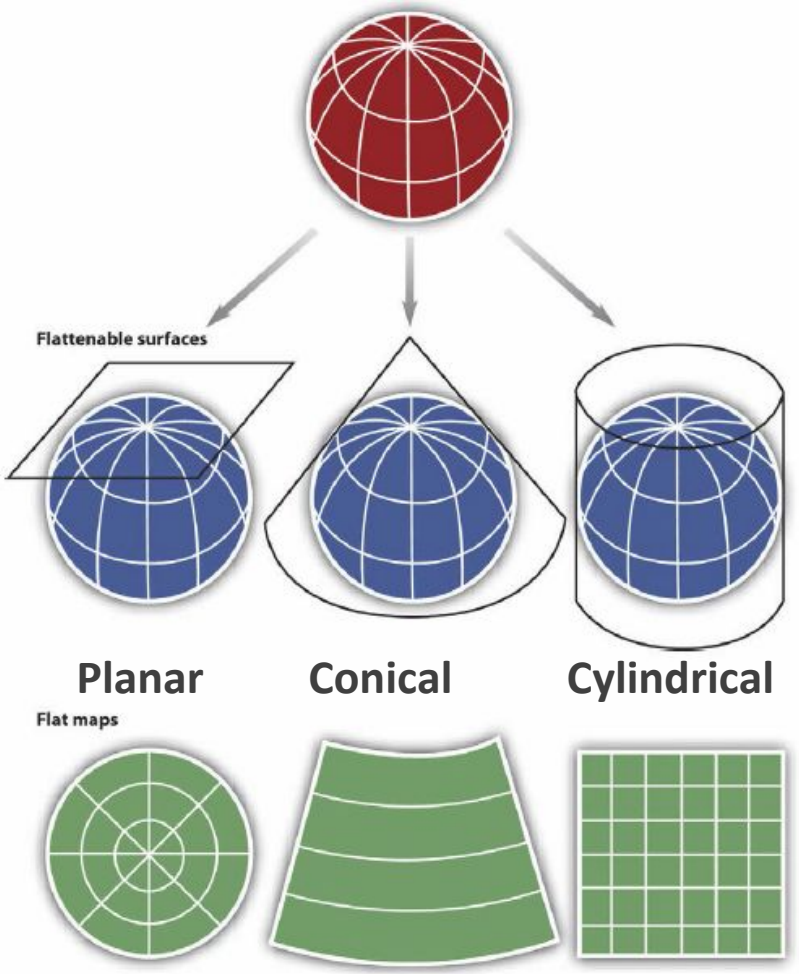
- Imagine light bulb in center of translucent globe
- Outline of continents will be “projected” as shadows on wall or ceiling
- 3-d to 2-d transformation



Source: Essentials of GIS by J. Campbell, 2011

Map Projections

- **Planar**: Use planes
- **Conical**: Use cones
- **Cylindrical**: Use cylinders



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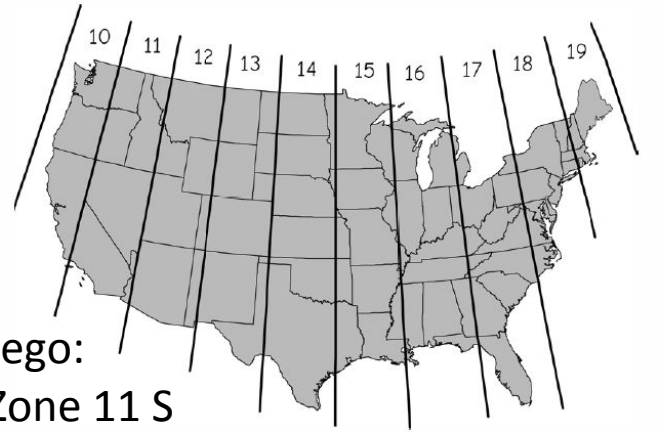
Common Map Projections

Transverse Mercator

- Cylindrical
- Many flavors: including UTM
- Google Maps and Web Mapping



San Diego:
UTM Zone 11 S

State Plane Coordinate System

- Cartesian “blend”
- Multiple “zones” per state
- County and state agencies

San Diego:
CA STPL VI

Source: GIS Fundamentals by P. Bolstad, 2015

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On The Fly Projection

Video (5 min): On The Fly Projections in ArcGIS Pro