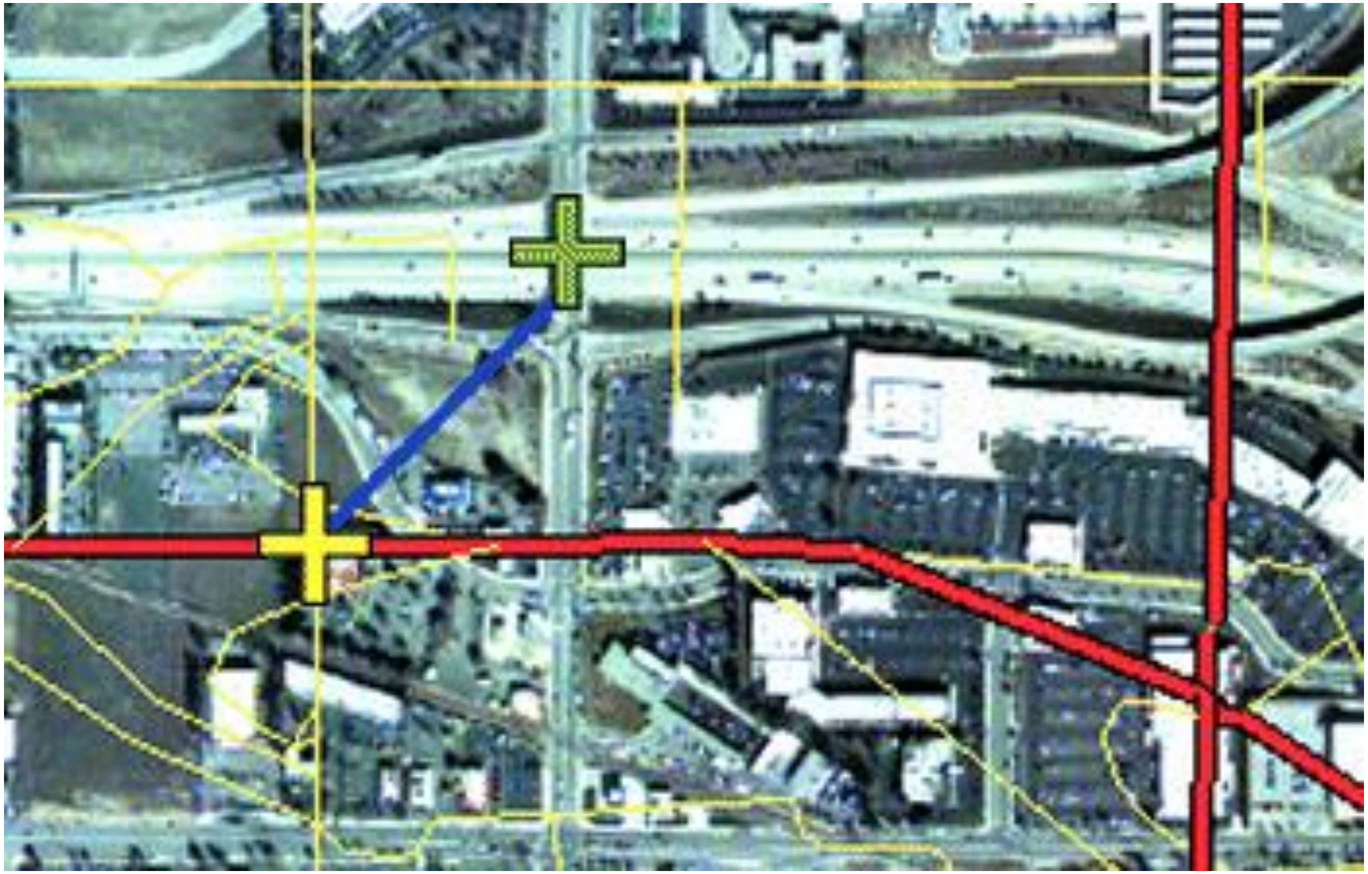
GEOGRAPHIC COORDINATE SYSTEMS

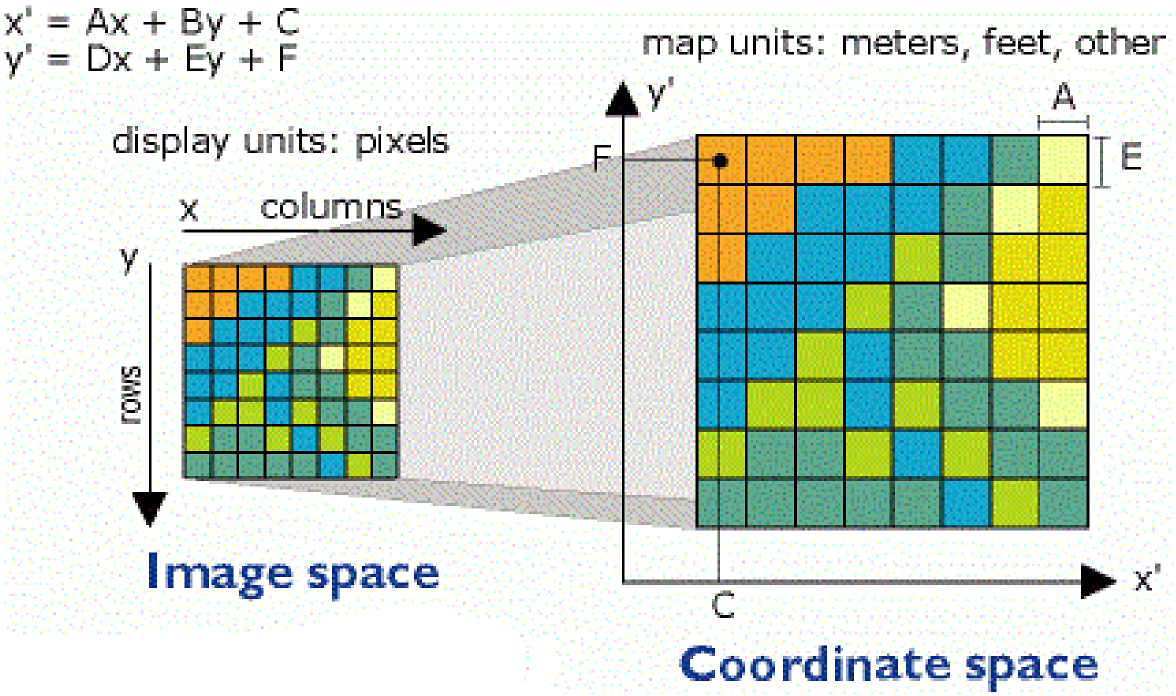
Introduction to GIS| Winter 2015

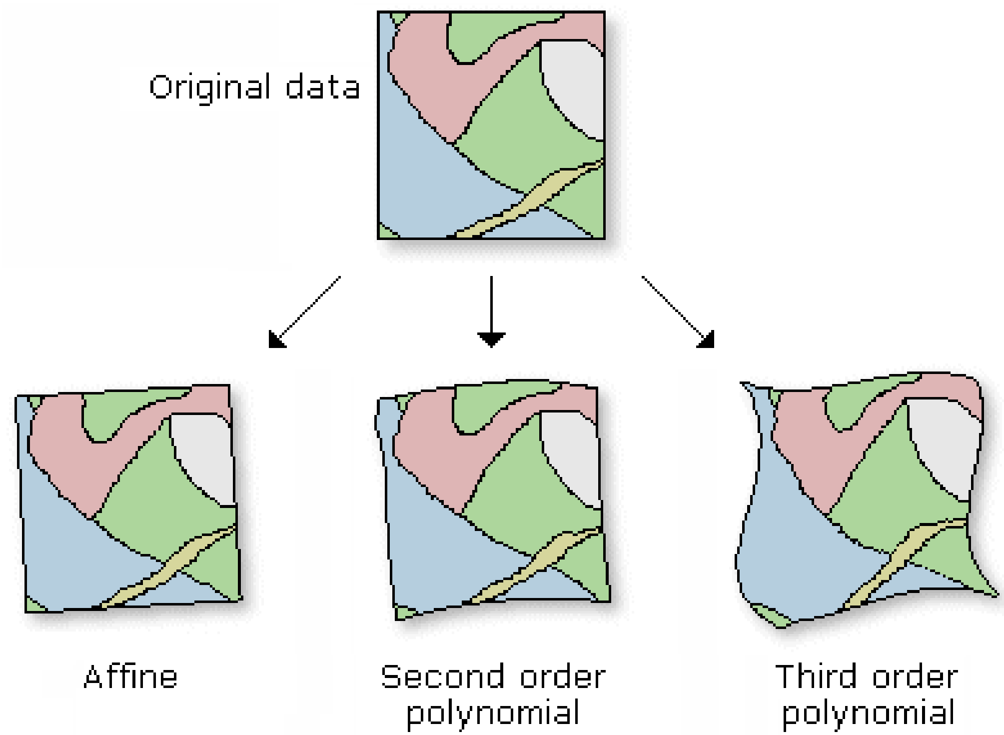
What is Georeferencing?

- Used to establish a location on the Earth's surface

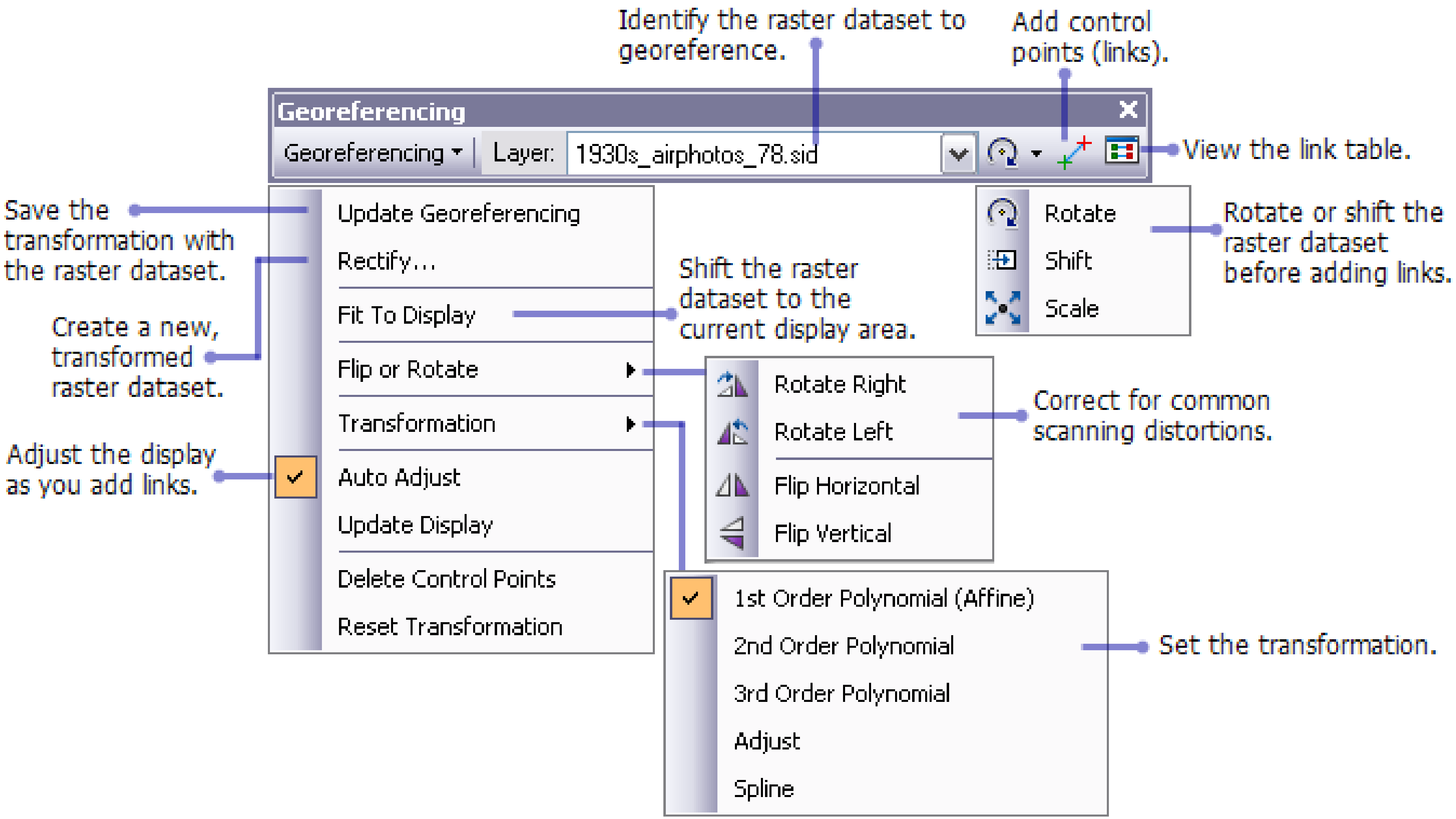


1st order polynomial transformation




Original data
Affine
Second order polynomial
Third order polynomial

Georeferencing toolbar



What is the shape of the Earth?

Sounds simple enough….

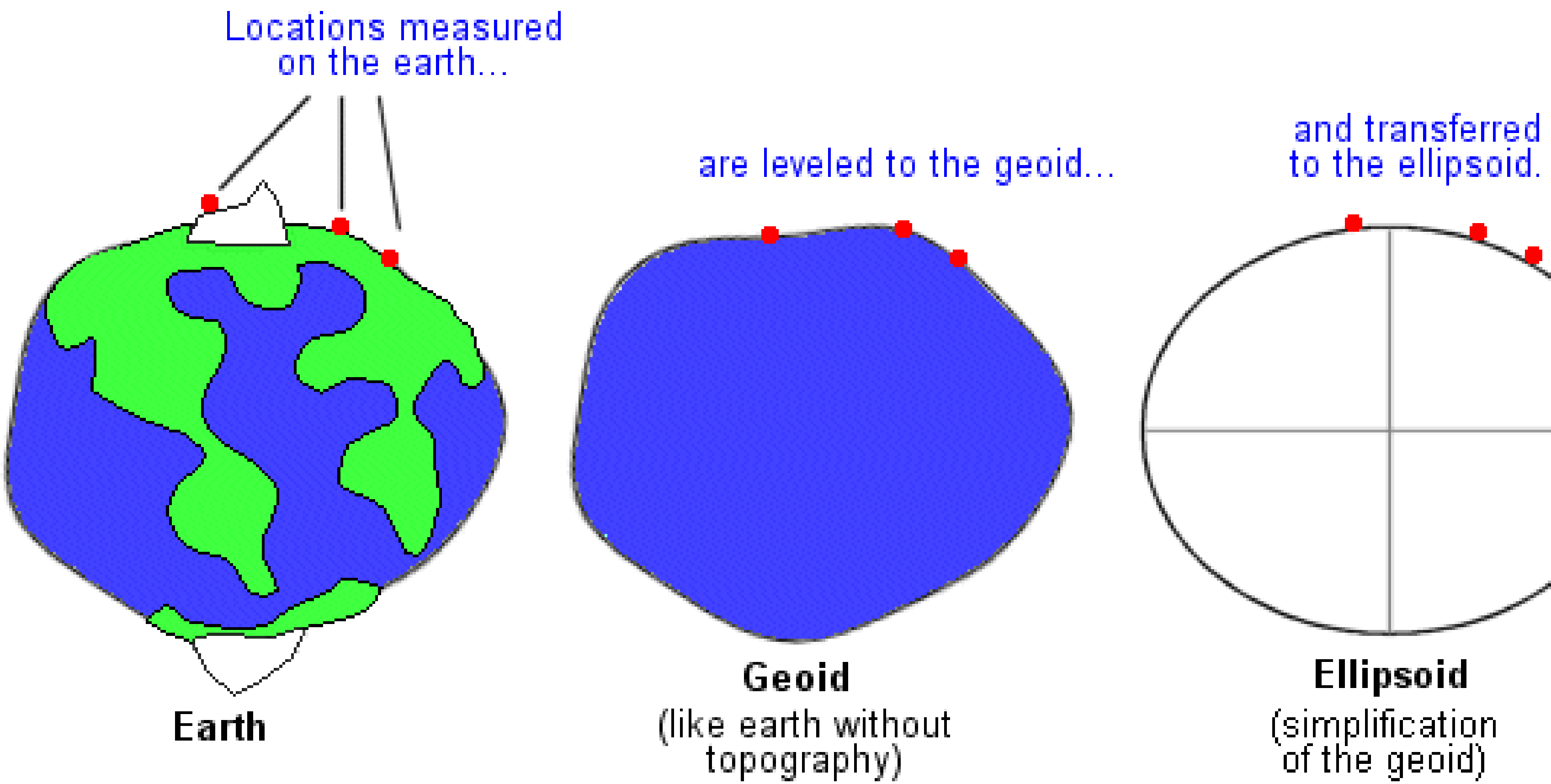
Erathosthenes & the circumference of the Earth

- A short guide to our planet…

Shape of the Earth

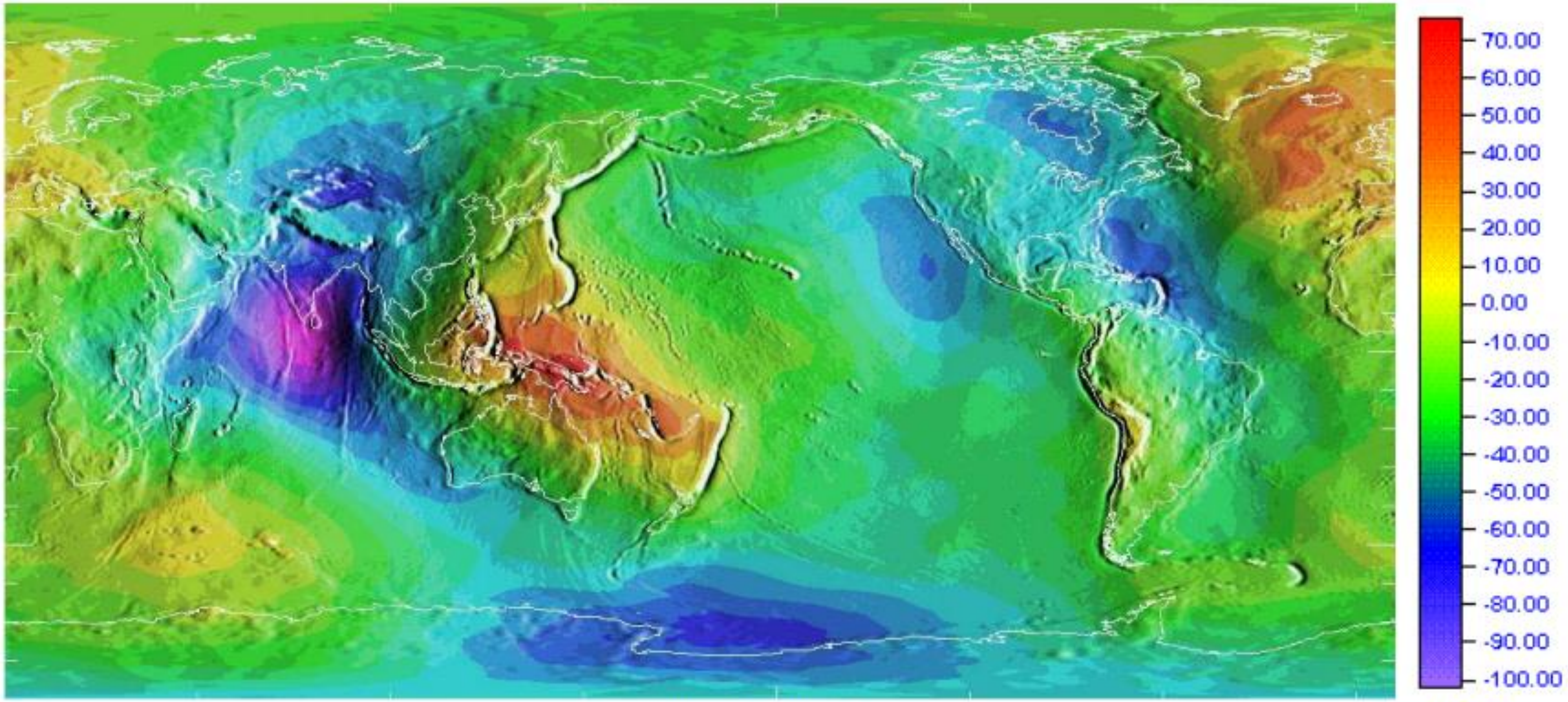
- Geoid
  - Mathematical figure of the Earth
  - Shape of average ocean surface across the entire Earth
  - Smoother than actual Earth's surface, but highly irregular due to local variations in gravity
- Ellipsoid
  - Elongated sphere used to represent the Geoid
  - Used for mapping purposes
  - +/- 110m variation from Geoid
- Geodesy
  - Study of the Earth's shape & representation

Shape of the Earth



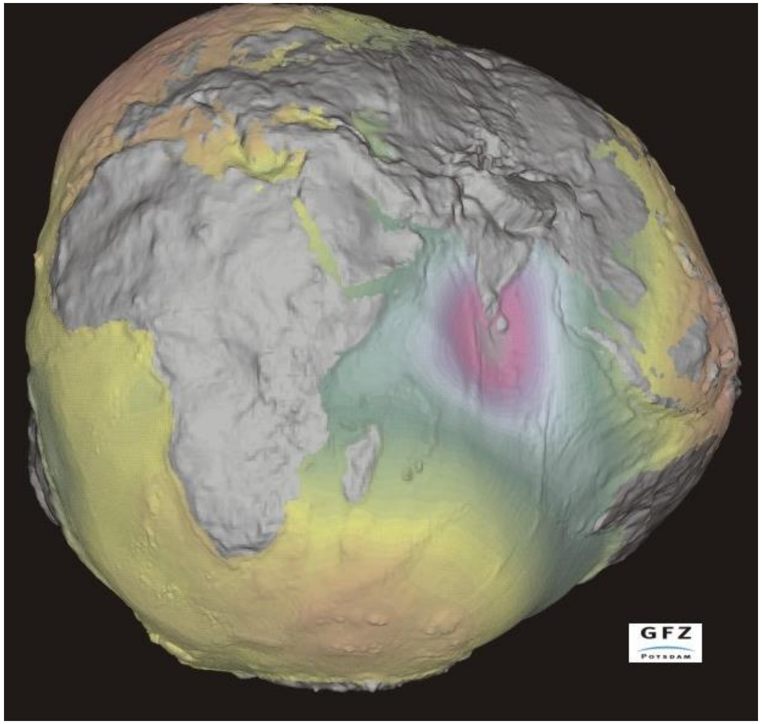
Shape of the Earth

- Geoid height varies of a global scale +/- 100m
- In the U.S. geoid height varies from 51m (Atlantic) to 7m (Rockies)



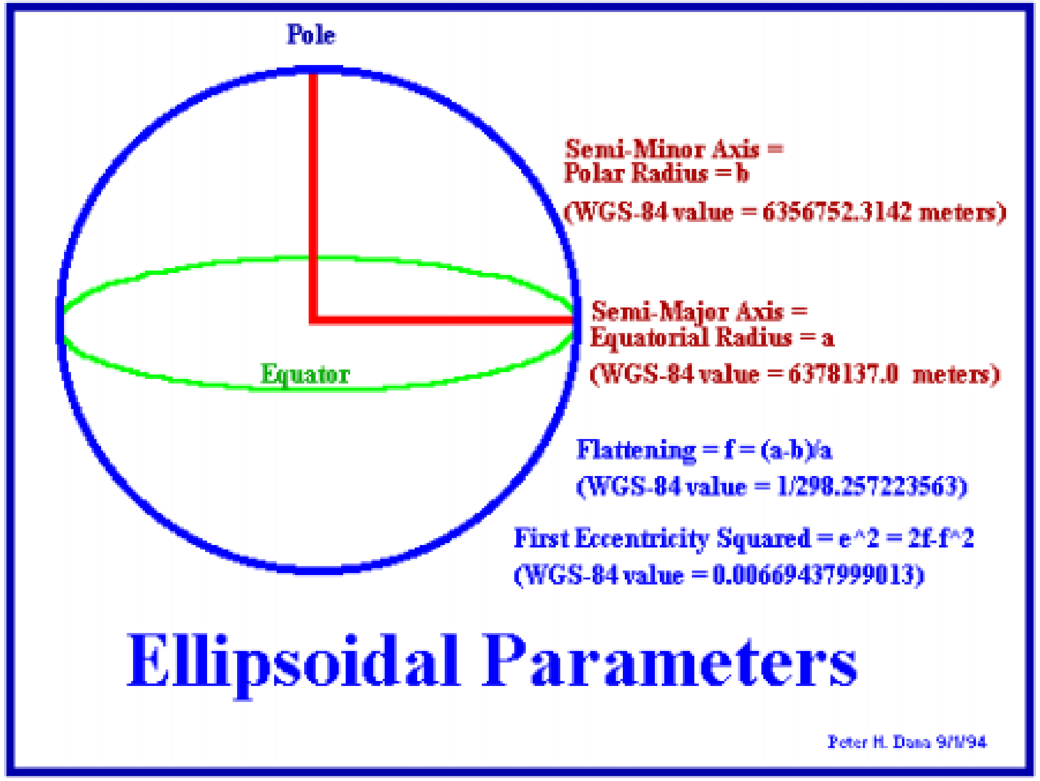
Global geoid undulations

Geoid or Potatoid?



Shape of the Earth

- Different ellipsoids are based on different estimates
- Advent of the GPS has increased our understanding of the Earth's true shape
- Use Major & Minor axes to determine flattening and eccentricity

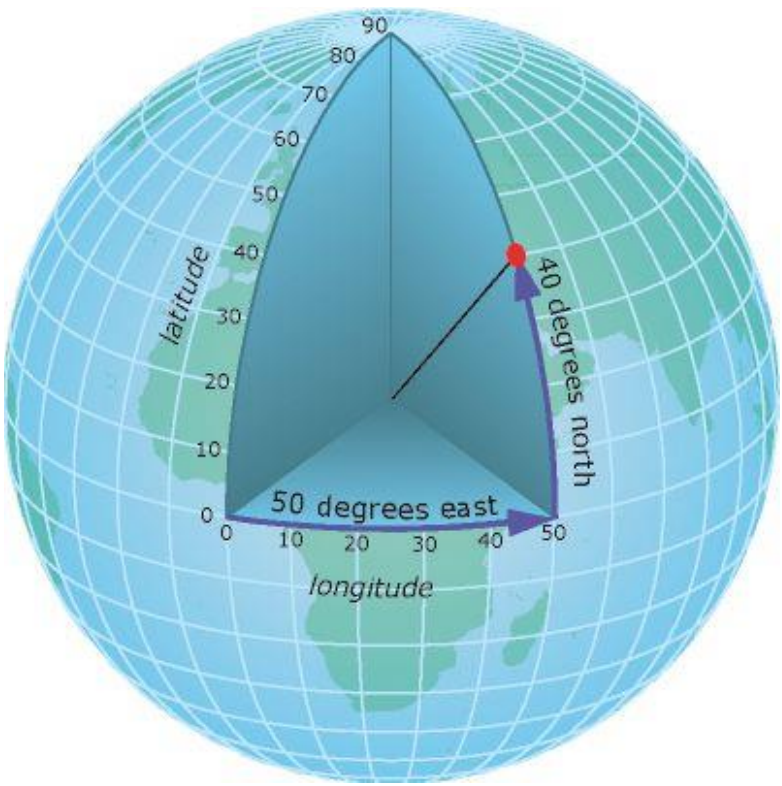


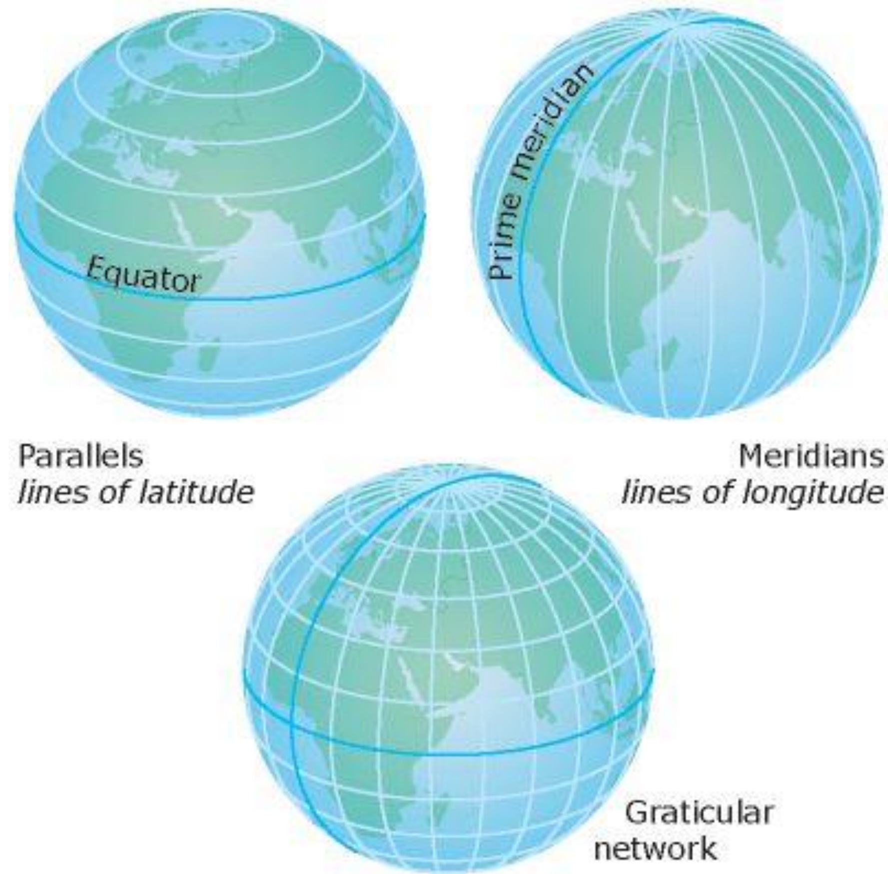
How do we measure points on the Earth’s Ellipsoid?

Geographic Coordinate System (GCS)

Geographic Coordinate System

- Uses latitude & longitude to identify location

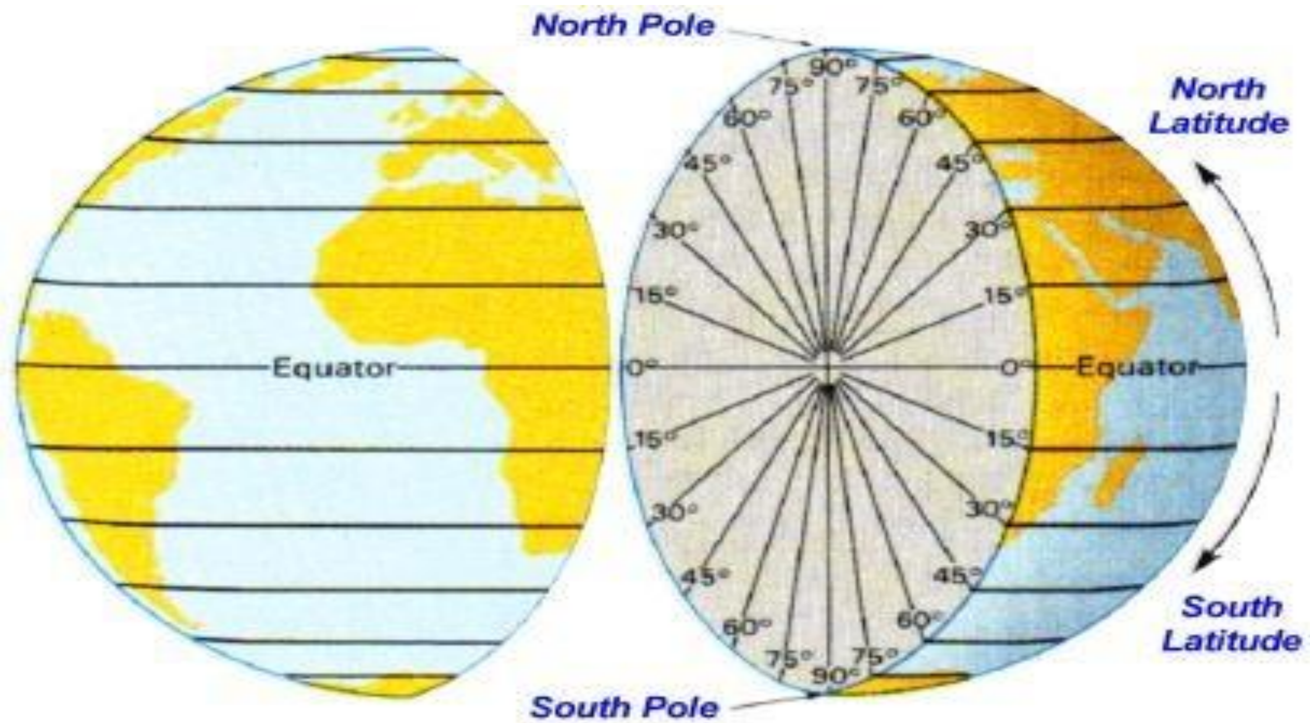




Geographic Coordinate System - Latitude

- **Parallel** is a constant line of latitude
- **Equator** is 0° latitude and separates the Northern and Southern hemispheres
- **Latitude.**
  - 45° 45’ 33” (degrees, minutes, seconds)
  - 45.759167 (decimal degrees)

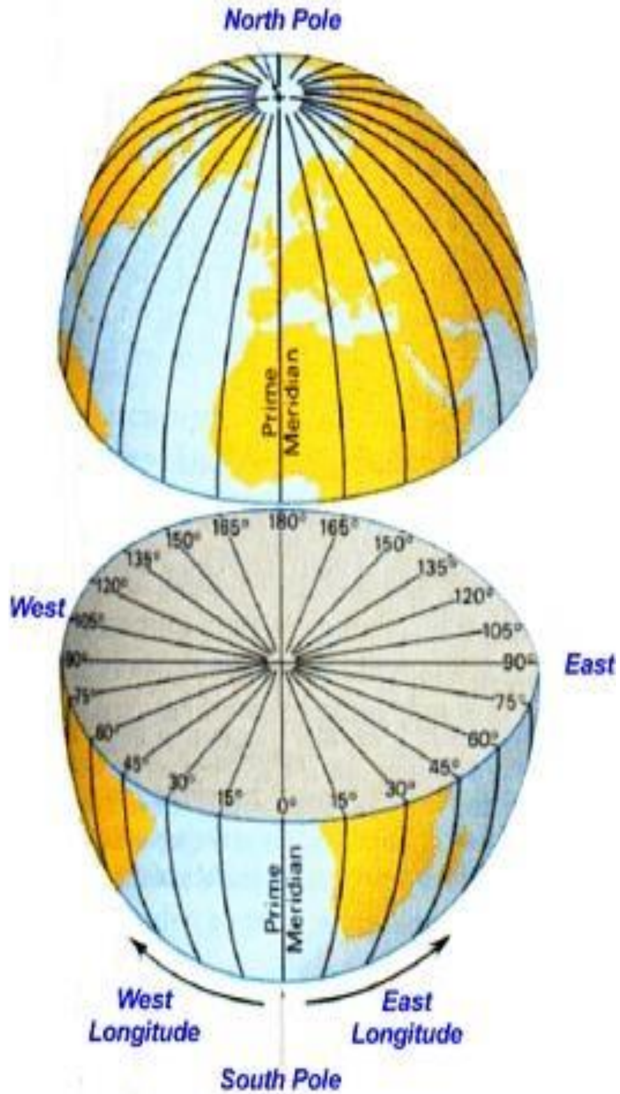
Geographic Coordinate System - Latitude



Geographic Coordinate System - Longitude

- **Meridian** is a constant line of longitude
- **Prime Meridian** is 0° longitude and separates the Eastern and Western hemispheres
- **International Date Line** is 180° longitude sitting opposite of the Prime Meridian. This is where the days start and end.

Geographic Coordinate System - Longitude

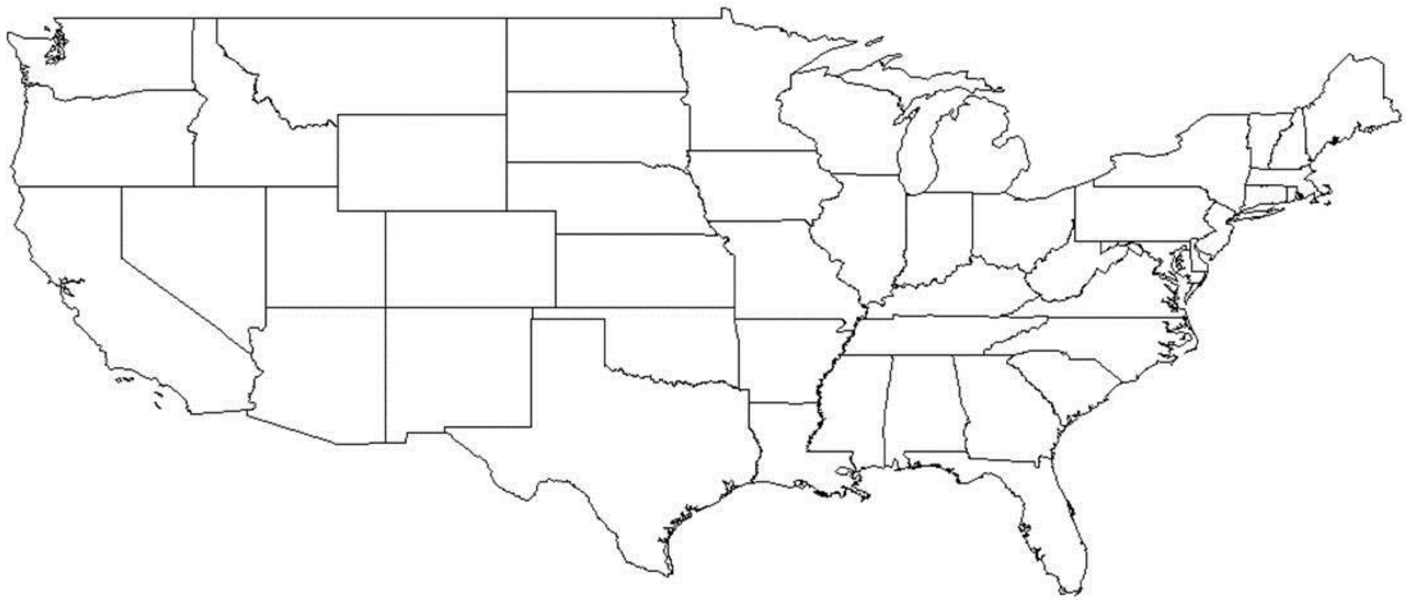


How do we display lat-long on a map?

- Anytime you translate from a 3D surface to 2D, you must 'project' the coordinate system
- Lat-long is ***not*** a projection and therefore cannot be directly shown on a flat 2D surface (paper map, computer screen)
- ArcGIS uses the "Platte Carree" cylindrical projection (the 'unprojected' projection) to represent lat-long

Plate Caree Projection

The ‘square map’



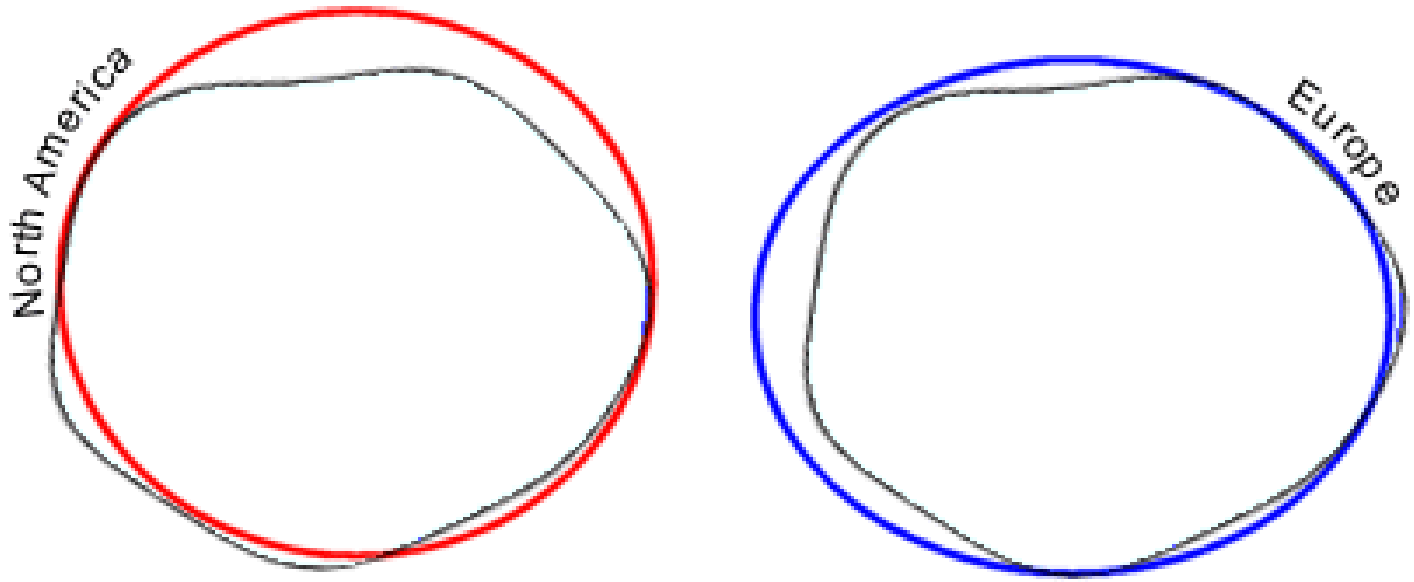
Geodetic Datums

Geodetic Datums

- Define Earth's size and shape, as well as the origin and orientation of a coordinate system
  - Based on a set or precisely surveyed points and an ellipsoid
  - "Middleman" between ellipsoid and coordinate system
  - Ellipsoid > Datum > Lat/Long
- Nations and agencies use different datums for mapping and as the basis for the different coordinate systems
- Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters

Geodetic Datum

- Defines Earth's size and shape for a particular location



The red ellipsoid fits the geoid well in North America.

The blue ellipsoid fits the geoid well in Europe.

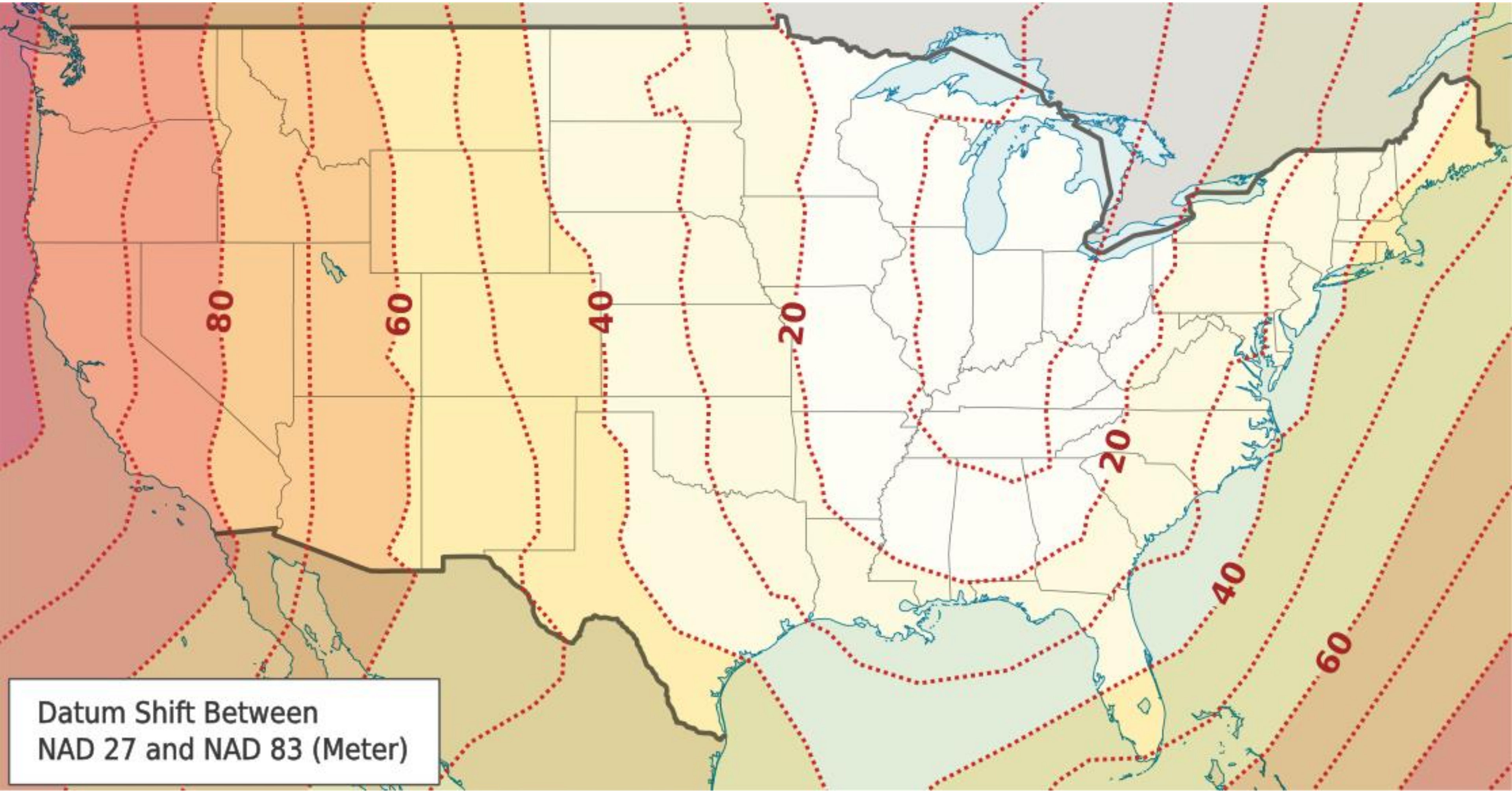
North American Datum 1927 (NAD27)

- Designed for use in…..North America!
- Based on the Clarke 1866 ellipsoid
- Created by manually surveying the entire continent based off of a single survey point in Meade Ranch, Kansas
- Not as accurate as newer datums, which use more precise ellipsoids and more survey points
- Still used on most USGS topographic map (DRGs & DLGs)

North American Datum 1983 (NAD83)

- Updated datum for….North America!
- Based on the Geodetic Reference System of 1980 (GRS80), a higher precision ellipsoid
- Compatible with modern survey techniques using the Earth as a whole not a single point or direction
- Official datum of the Federal gov't and most states
- Current version is NAD 83(2011/MA11/PA11) that used highly accurate GPS technology

NAD27 v NAD 83



World Geodetic Survey 1984 (WGS84)

- Datum for the whole world
- Based on the WGS84 Ellipsoid
- World reference system first developed by the Department of Defense in the 1950s
- Official datum of inter-continental ballistic missiles (and Google Earth)
- Used by the US Global Positioning System (NAVSTAR)

Geodetic Datums

- Locations can have different coordinates depending on the datum

Bellingham, WA Coordinates (in decimal degrees)

Datum	**Longitude**	**Latitude**
NAD 1927	-122.46690368652	48.7440490722656
NAD 1983	-122.46818353793	48.7438798543649
WGS 1984	-122.46818353793	48.7438798534299

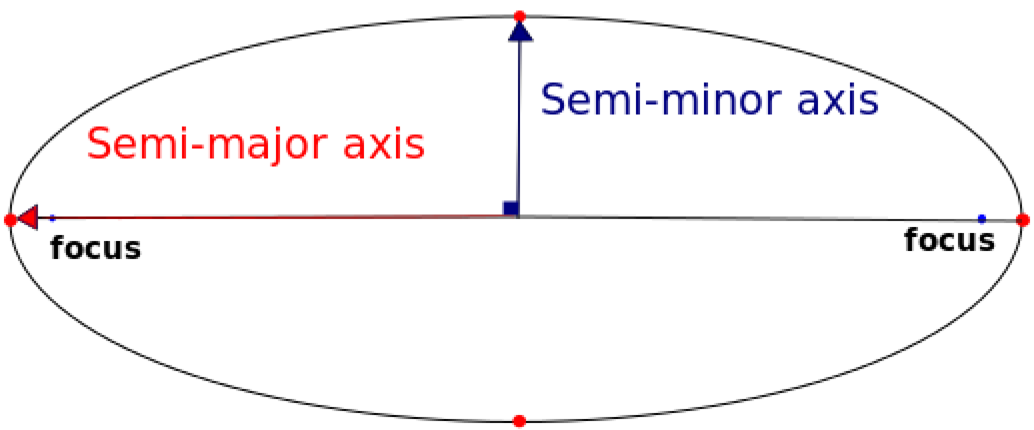
Components of a GCS

Components of GCS

- Spheroid or Ellipsoid
- Geodetic Datum
- Prime Meridian
- Units of measure

Spheroid / Ellipsoid

- Mathematical representation of the Earth
- Used to find the average surface of the earth—accounts for Mt. Everest (29,000 feet) and depths of oceans
- Measured in terms of semimajor and semiminor axis



Spheroid flattening and axis measurements

Selected Reference Ellipsoids

Ellipse	Semi-Major Axis (meters)	1/Flattening
Airy 1830	6377563.396	299.3249646
Bessel 1841	6377397.155	299.1528128
Clarke 1866	6378206.4	294.9786982
Clarke 1880	6378249.145	293.465
Everest 1830	6377276.345	300.8017
Fischer 1960 (Mercury)	6378166.0	298.3
Fischer 1968	6378150.0	298.3
G R S 1967	6378160.0	298.247167427
G R S 1975	6378140.0	298.257
G R S 1980	6378137.0	298.257222101
Hough 1956	6378270.0	297.0
International	6378388.0	297.0
Krassovsky 1940	6378245.0	298.3
South American 1969	6378160.0	298.25
WGS 60	6378165.0	298.3
WGS 66	6378145.0	298.25
WGS 72	6378135.0	298.26
WGS 84	6378137.0	298.257223563

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Geodetic Datum

- Collection of known and accurate points
- Both a horizontal and vertical
- Datum + spheroid change our estimates of where locations are (coordinates)
- E.g.: NAD 1927, NAD 1983, WGS 1984, JGD 2000, SAD 1969

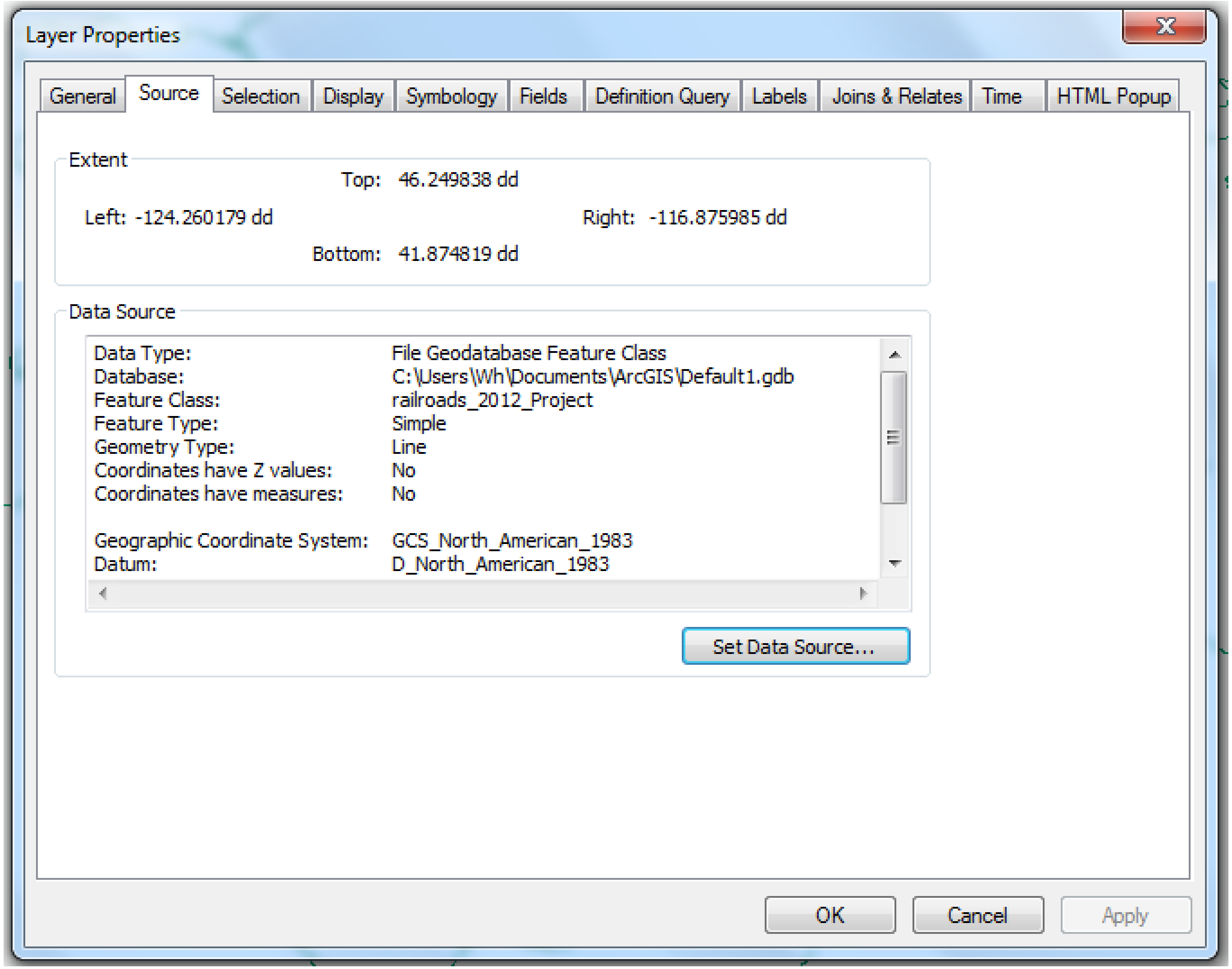
Prime Meridian

- Line of longitude (North Pole to South Pole)
- Where X-Coordinate is zero
- East of PM is positive; west of PM is negative

Units of Measure

- For a GCS, typically decimal degrees or degrees, minutes, seconds

Extent in a GCS using DD



Extent in a PCS using feet