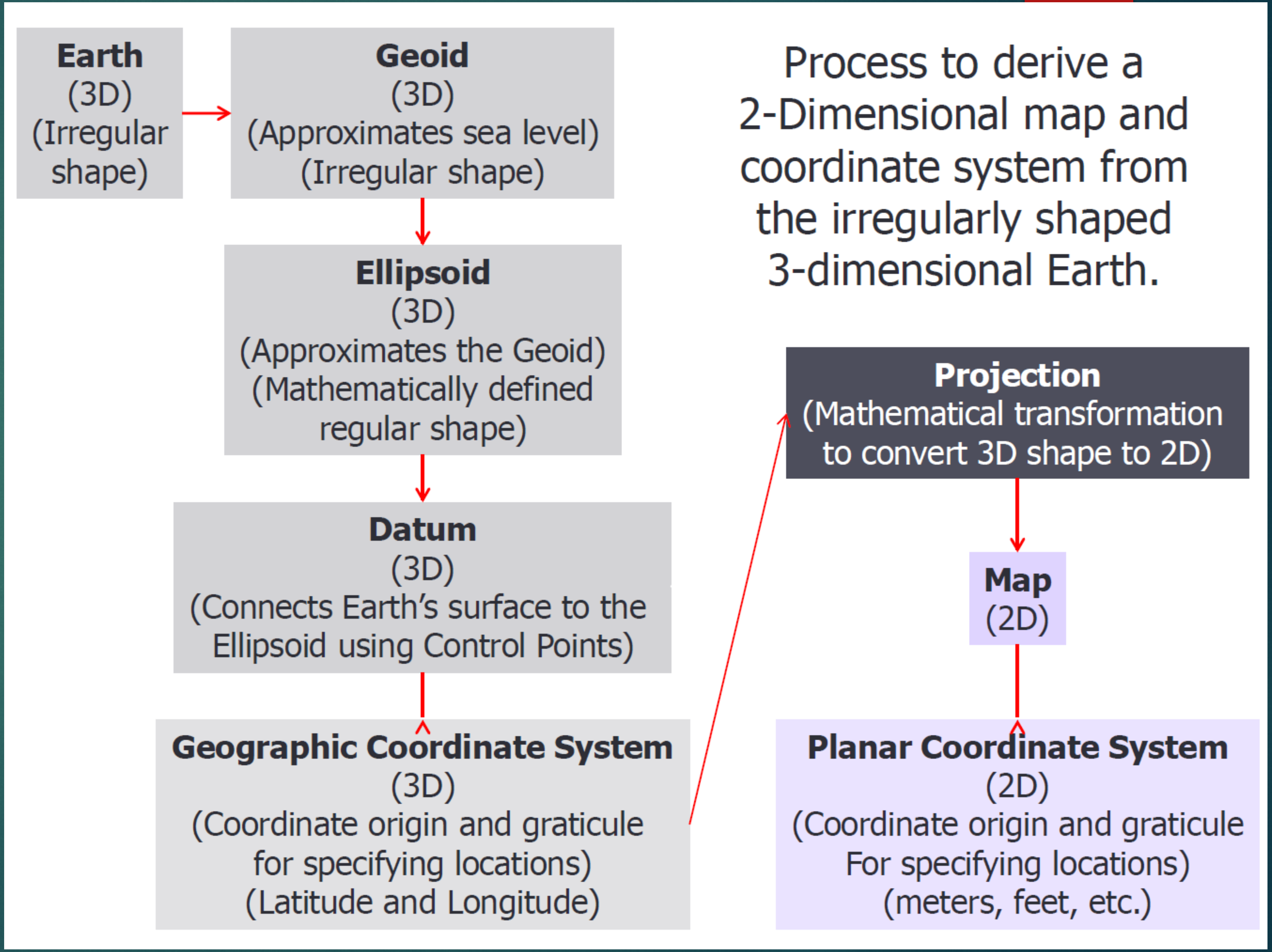
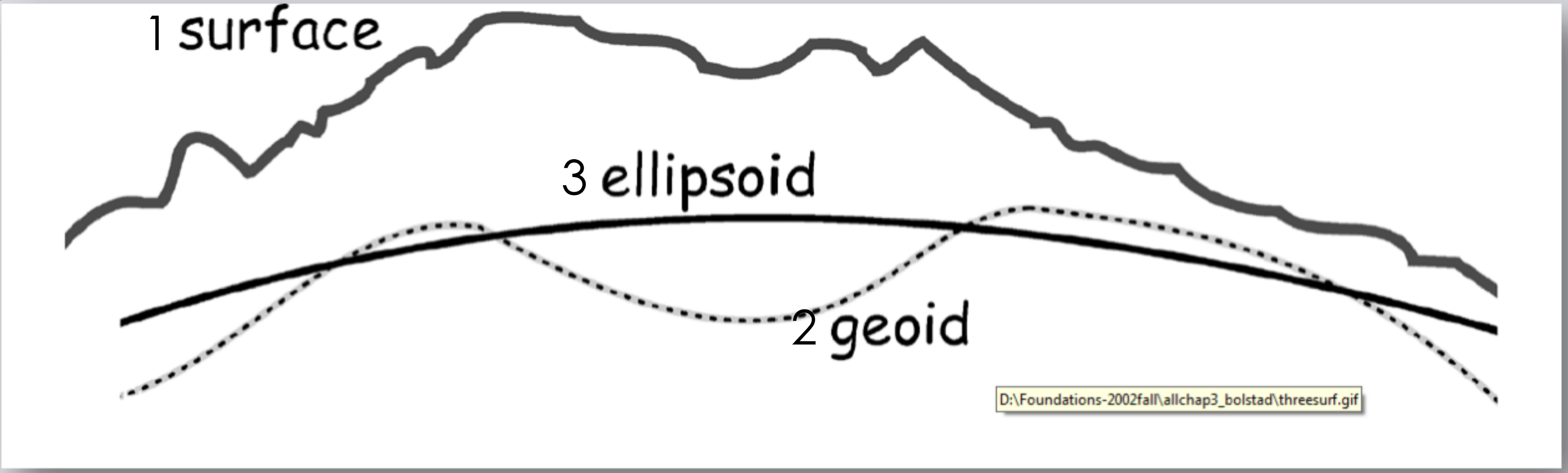
Coordinate Systems and Projections

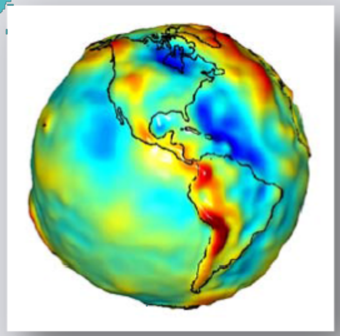
LECTURE 7: WEEK 5

Process of Mapping the Earth



An ellipsoid is selected and "best fitted" to a geoid.

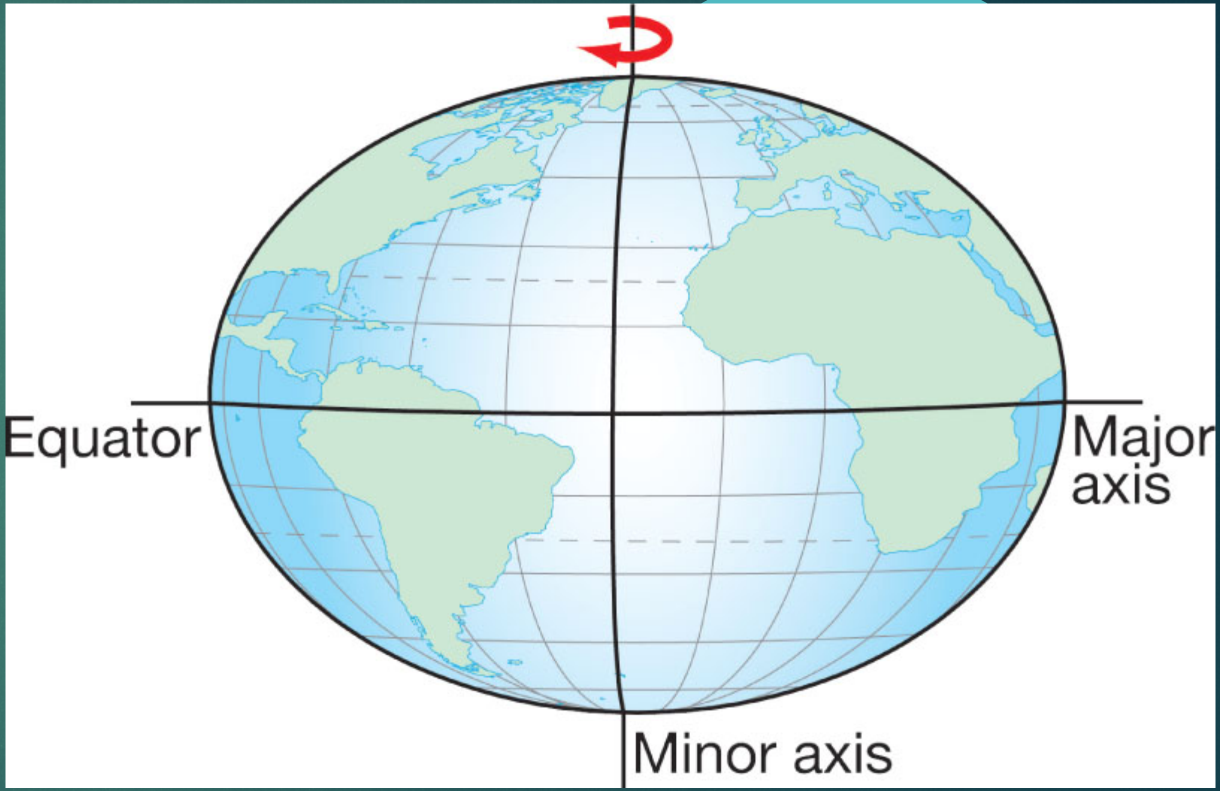




- 1. Surface of the Earth – irregular surface
- 2. Geoid – approximates sea level – irregular shape
- 3. Ellipsoid – approximates the geoid – regular shape

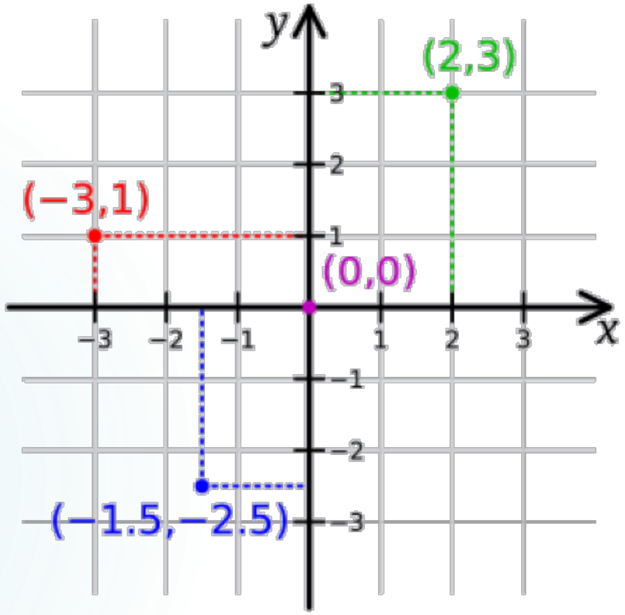
Ellipsoid, Major Axis, Minor Axis & Flattening

- Spheres are defined by a radius from their centers. **Ellipsoids** are defined by two axes: Major and Minor
- **Flattening** is a ratio showing how flat the ellipsoid is as compared to a sphere.
- WGS84 – World Geodetic System of 1984
- NAD83 – North American Datum of 1983 is almost identical but is highly accurate for North America

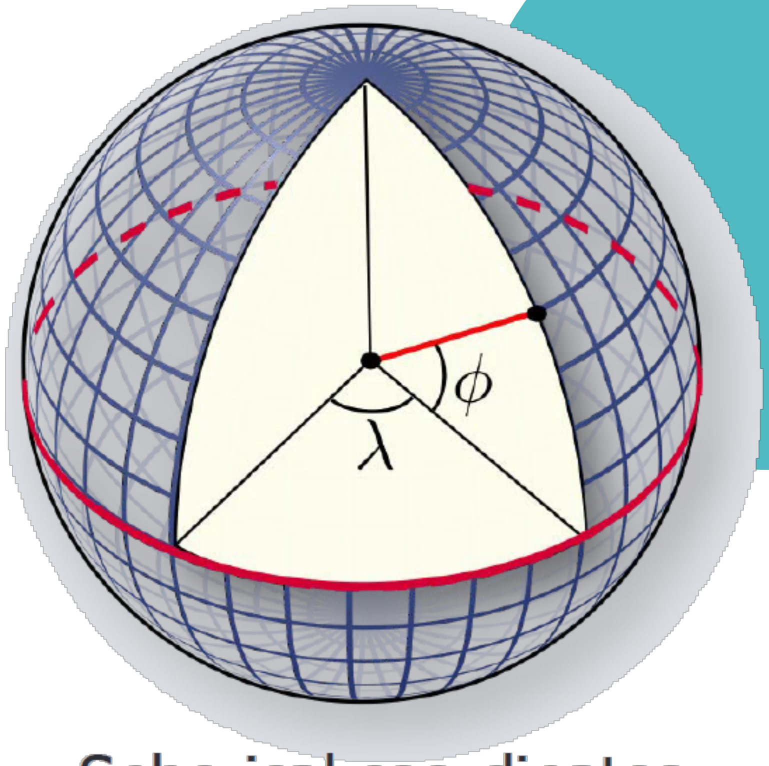


Coordinate Systems

Coordinate systems let us **locate** points in continuous space and **measure** spatial properties (e.g., distance).



Cartesian coordinates:
Distances as (x,y)



Spherical coordinates:
Angles as (φ, λ)

Geographic Coordinate System

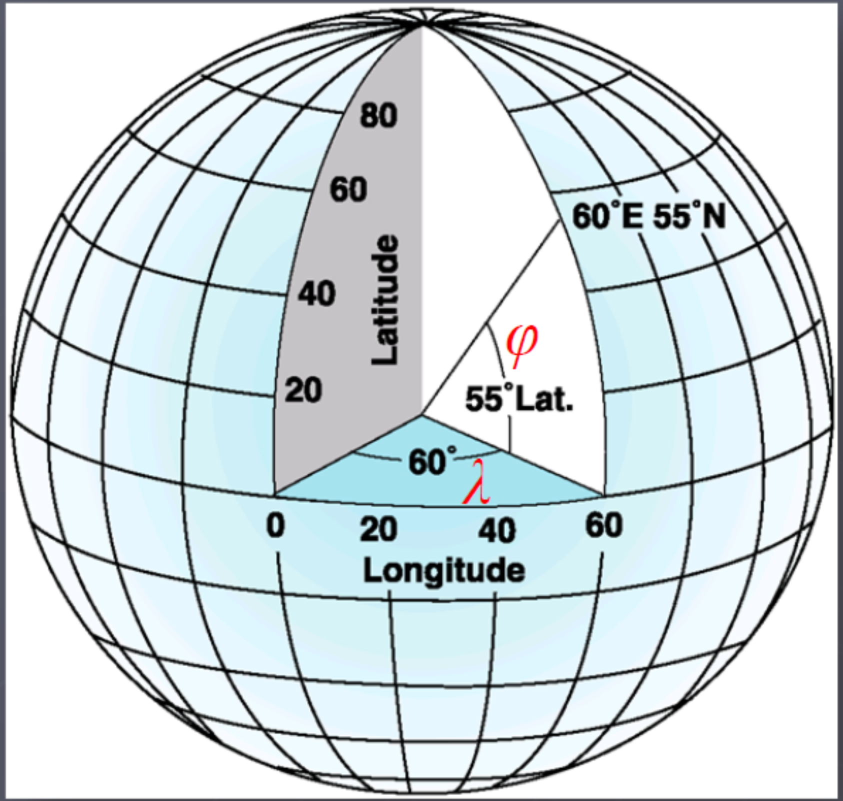
Longitude and **latitude** are **angular** measurements relative to the plane of the **Prime Meridian**, and to the plane of the **equator**, respectively.

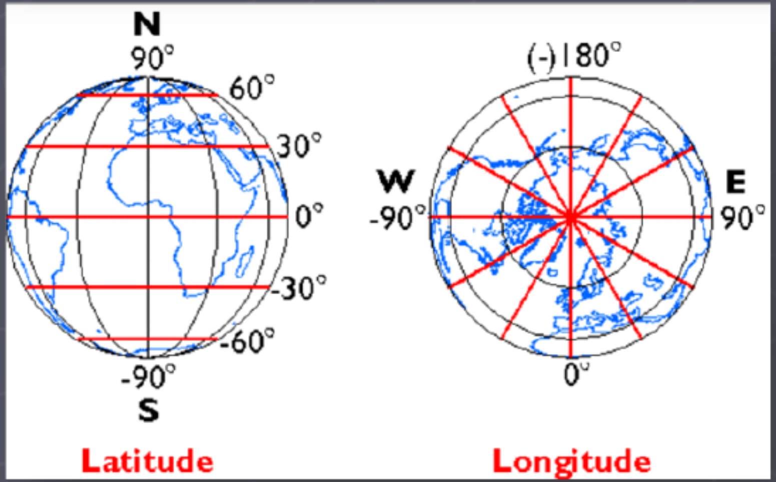
The angles are measured in **degrees** (expressed as degrees, minutes, seconds (DMS) or decimal degrees).

e.g., 9° 06’ 18.42” S or - 9.105116

The surface *expression* of lines of longitude and latitude form a **graticule** of **meridians** and **parallels**, respectively.

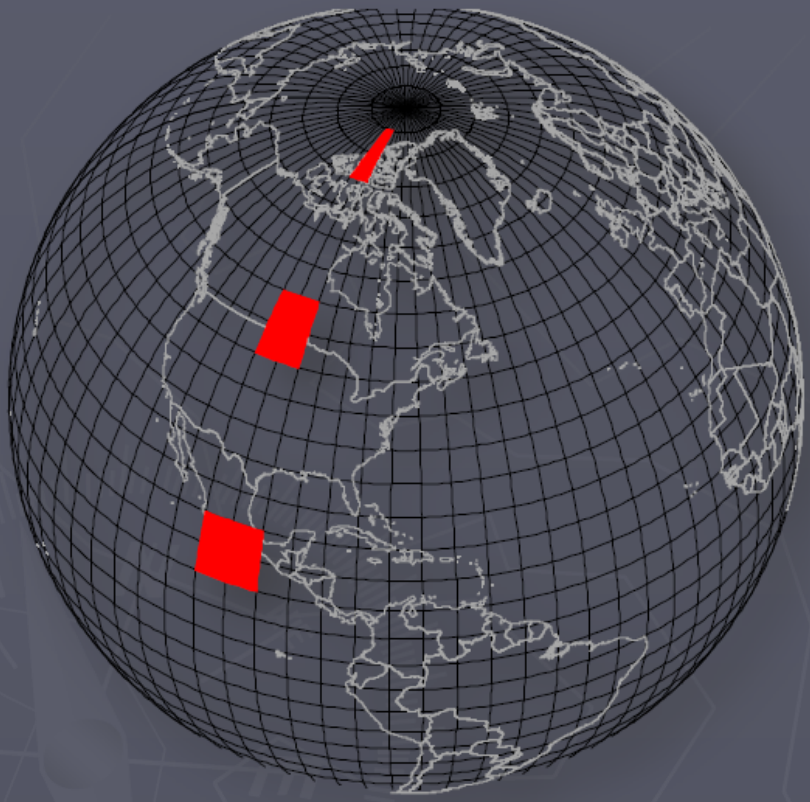
Longitude and latitude can locate exact positions on Earth’s surface.





Latitude and Longitude

- Lines of longitude converge at poles (called Meridians)
  - Which meridian have you heard of most often?
- Lines of latitude are parallel to each other. (called parallels)
  - Most famous line of latitude?
- The length of latitude lines decreases closer to the poles



All three red areas are 10 degrees on a side.

Great circles

- Shortest distance between two points on the earths surface

Let's try coordinate conversion!

- 42° 5' 10" → Decimal Degrees
  - Keep the full integer as your degree. (42)
  - Divide **!seconds!** by 60. 10/60 = 0.16 Add it to the minutes. 5 + 0.167 = 5.167
  - Divide <u>updated</u> minutes by 60. 5.167/60 = .086117
  - Add this to degrees
  - **Answer: 42.086117**

- Decimal Degrees (42.086) →Degrees, Minutes, Seconds
  - Keep the full integer as your degree. (42)
  - Multiply remainder fraction by 60. 086*60 = 5.16. Keep the full integer as your minutes (5')
  - Multiply remainder fraction by 60, for seconds 0.16 *60 = 9.6
  - **Answer: 42 Degrees, 5 Minutes, 9.6* Seconds**
    (*9.6 is smaller than 10 because we started with a rounded decimal degree value)

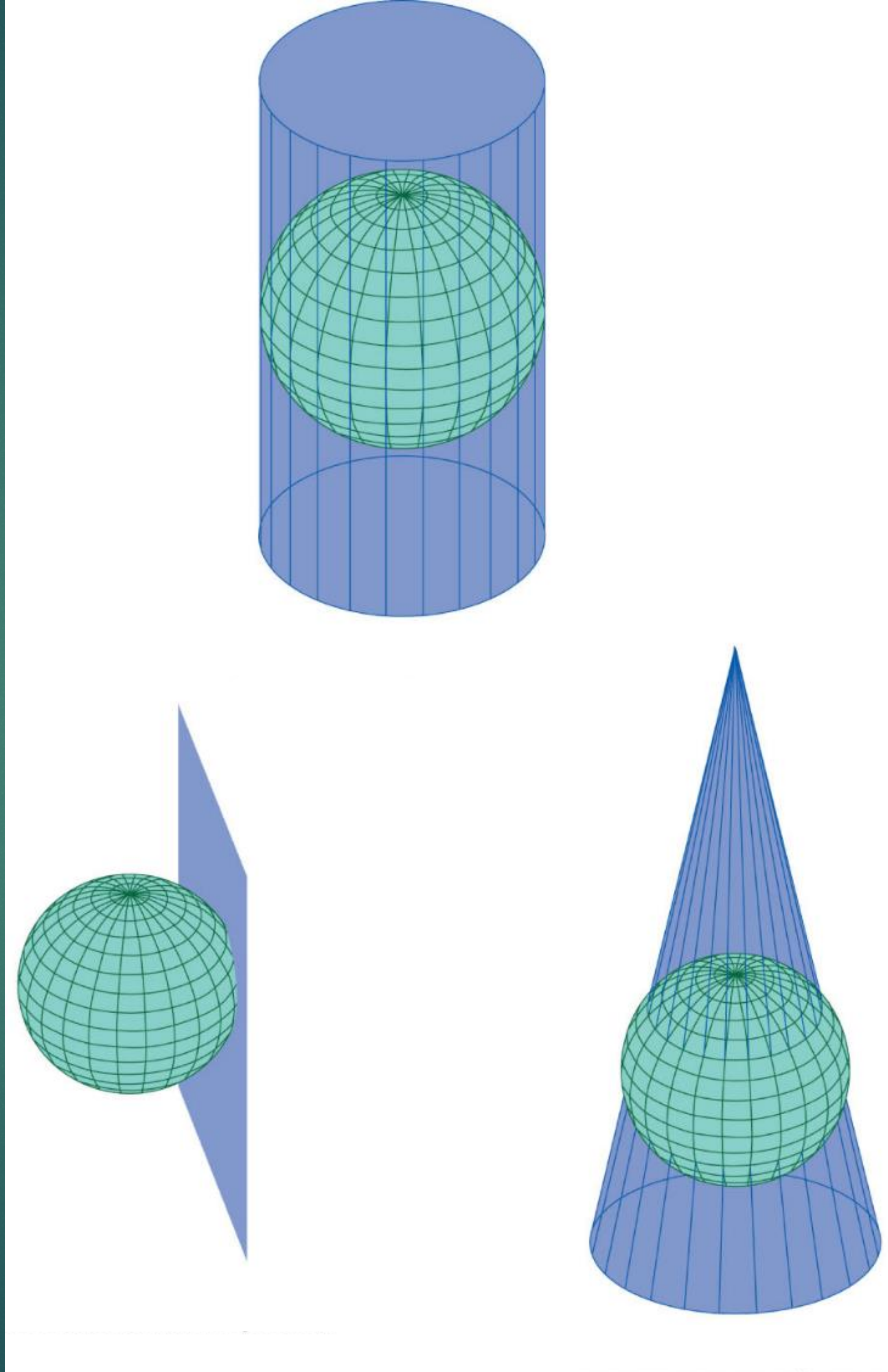
Projections

Taxonomy of Projections

- **class:**
  - Cylindrical
  - Conic
  - Planar (azimuthal)
- **aspect:**
  - Equatorial
  - Transverse
  - Oblique
- **case:**
  - tangent
  - secant
- **line/point of tangency**:
  - standard line or 1 standard point (tangent cases)
  - 2 standard lines or one standard circle (secant)
- **distortion properties**:
  - equal area
  - equidistant
  - conformal (preserves angles)
  - neither (compromise)

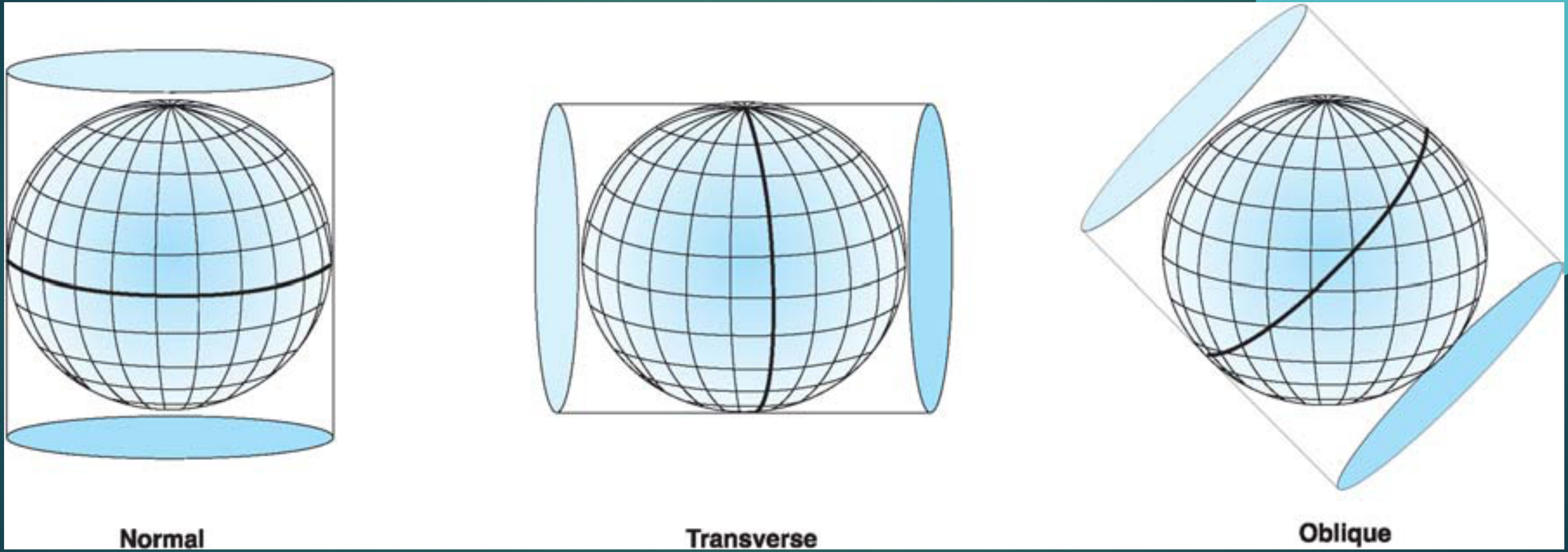
Class

- Cylinder
  - Often good for whole earth projections
- Cone
  - Good for mid-latitudes
- Plane – called azimuthal
  - Good for local areas



Aspect

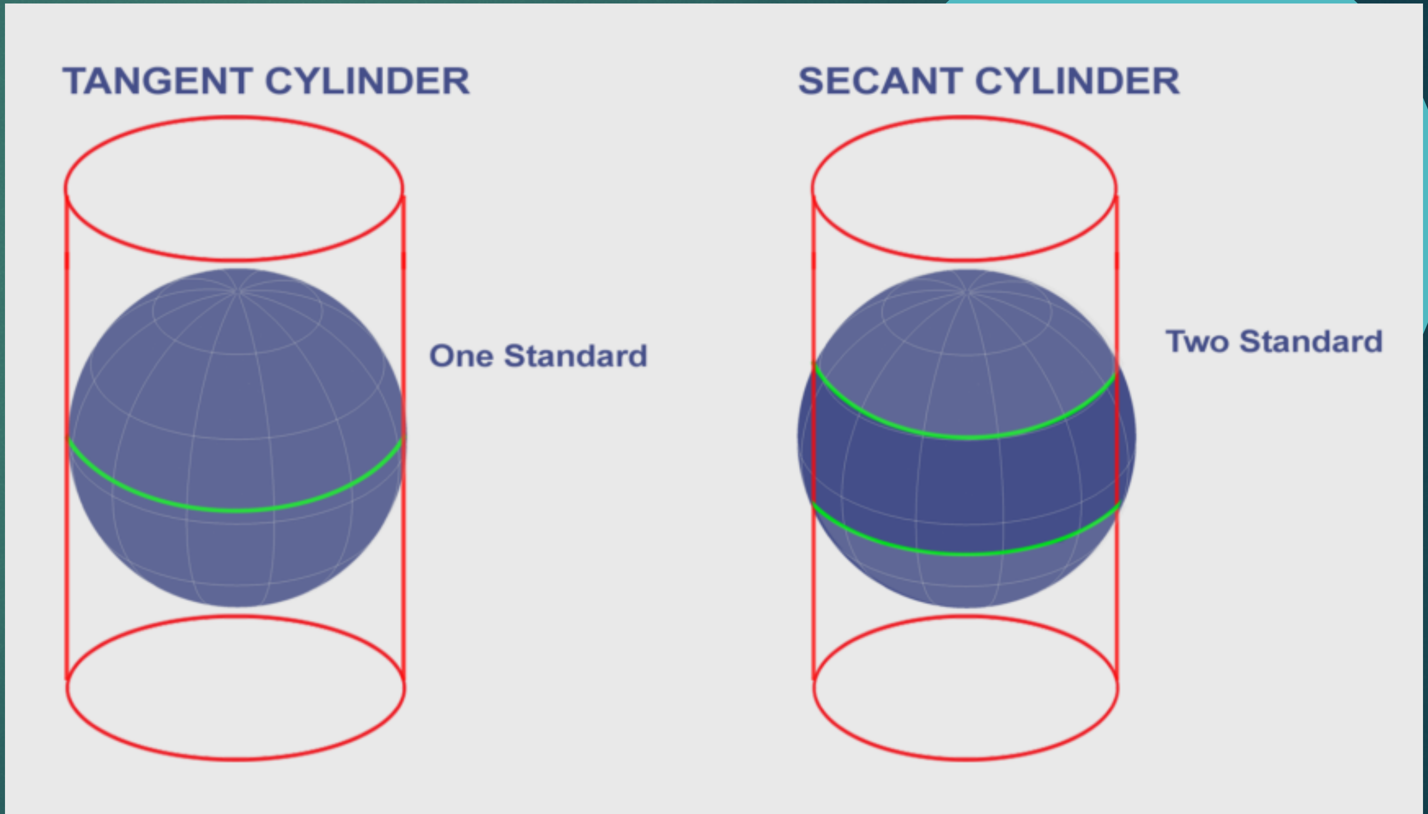
- Equatorial
- Transverse
- Oblique



Case

- Tangent
- Secant

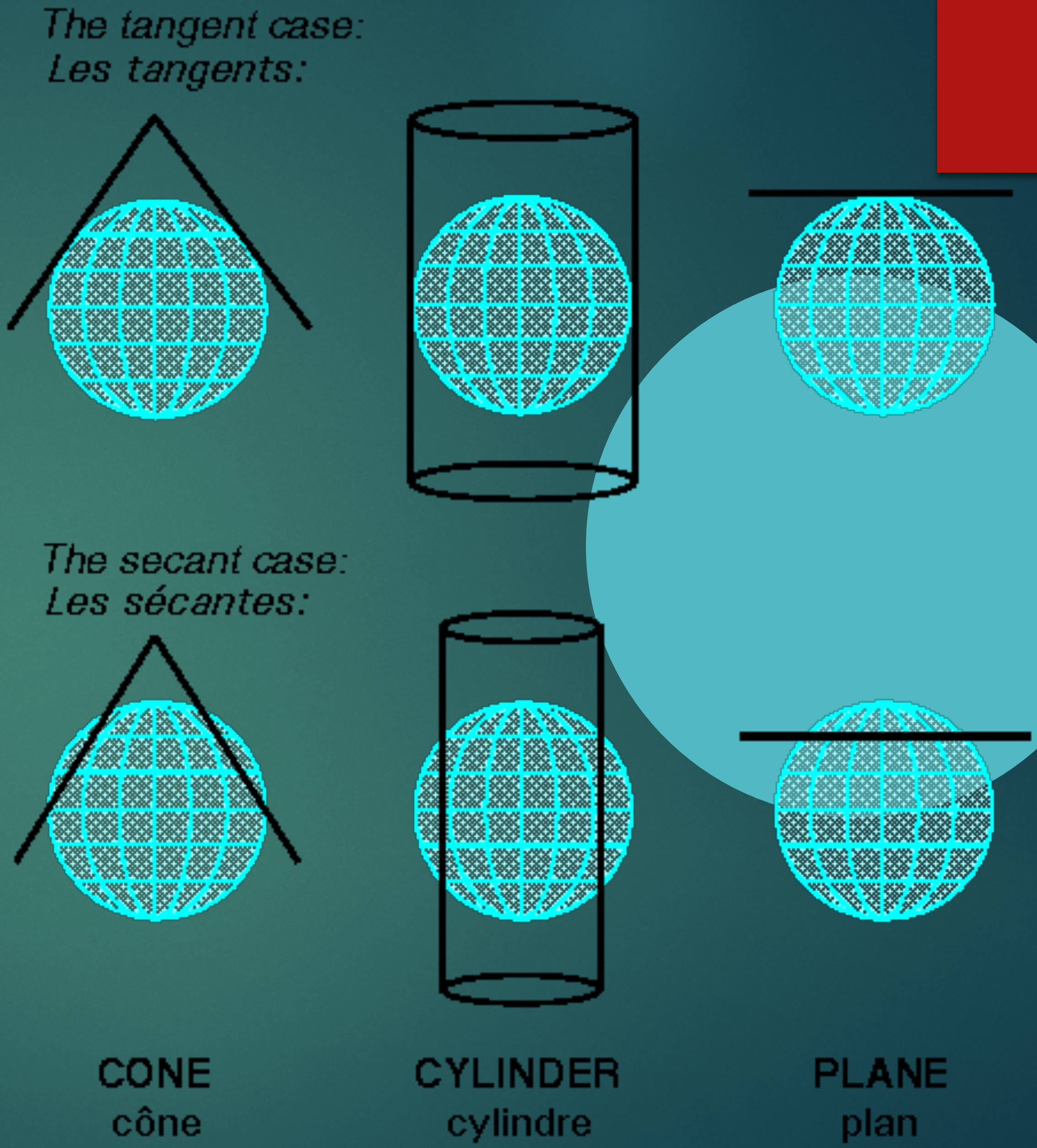
- The standard line is where the projection is correct. As you move away from the standard line, you get distortion.
- Secant projections have two standard lines, which means there are two places where the projection has no distortion.



- https://gisgeography.com/cylindrical-projection/

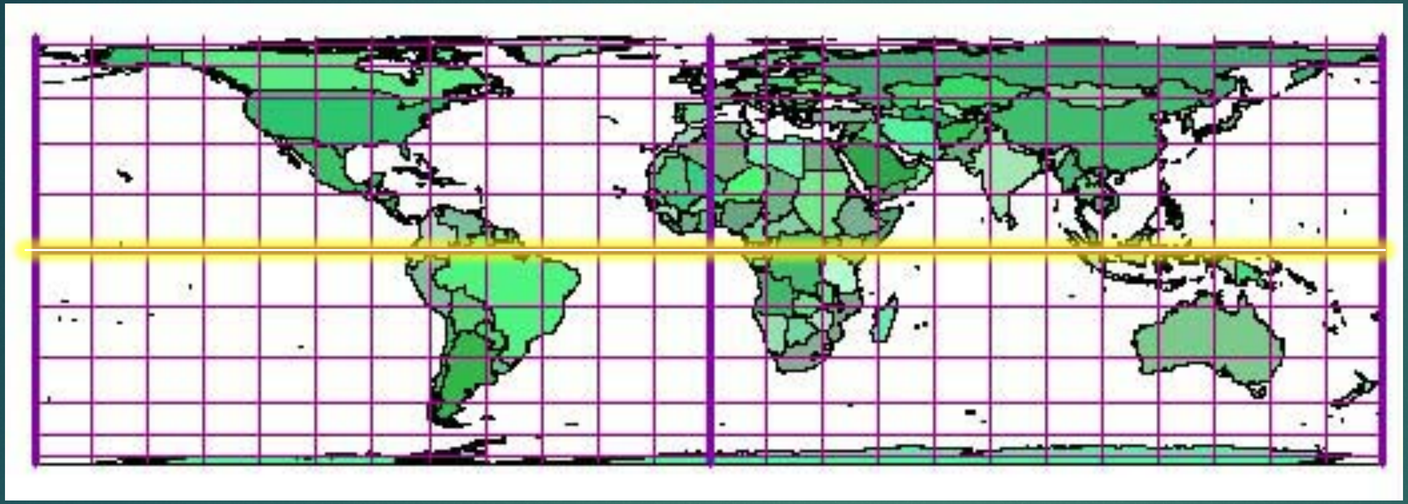
Case

- Tangent and Secant cases apply to all of the developable surfaces (cone, cylinder, and plane)

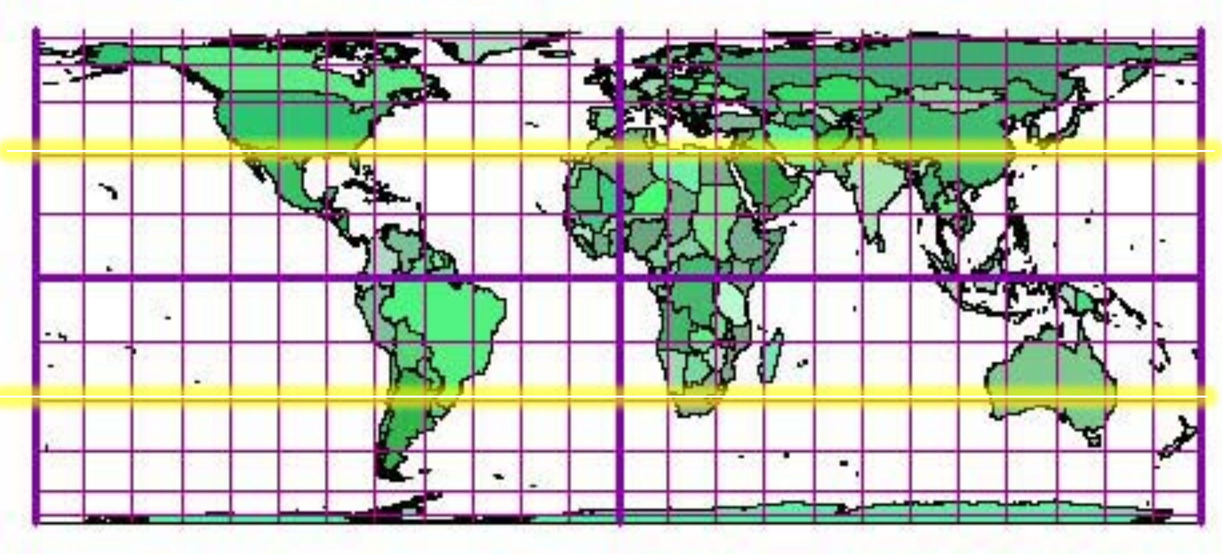


https://blogs.ubc.ca/advancedgis/schedule/slides/georeferencing/map-projections/

Cone and Cylinder Projections:



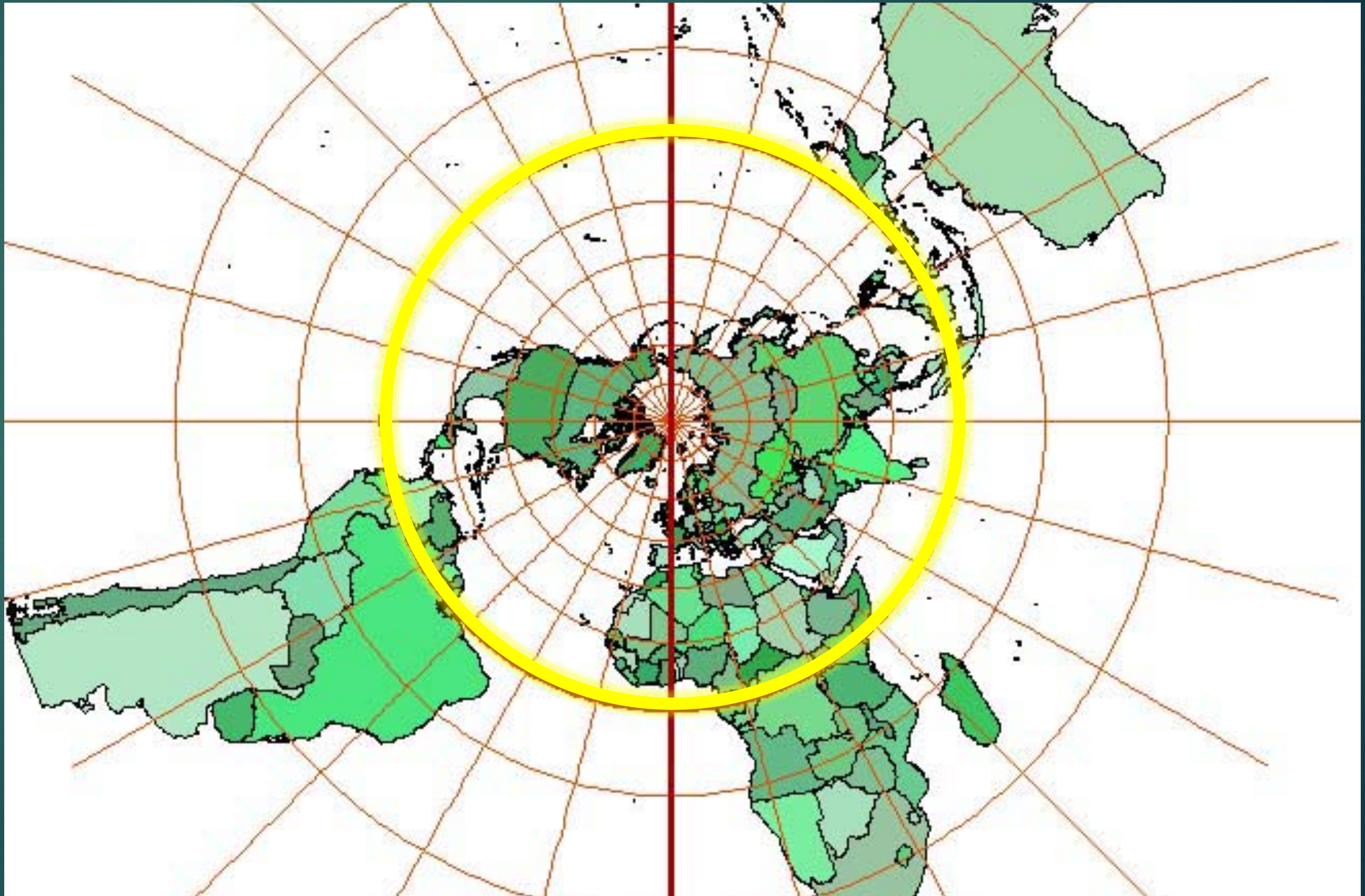
Tangent
1 standard line
at Equator



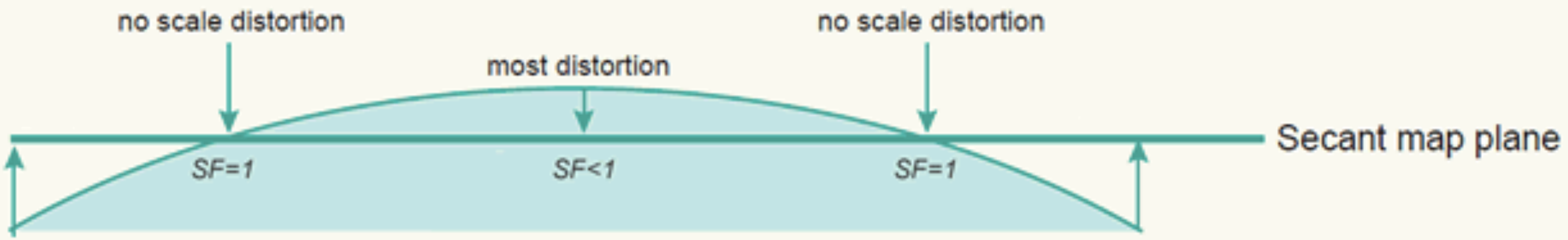
Secant
2 standard lines
at 30° N and S

Azimuthal (Planer) Projections

- Secant projections have a standard circle (pictured)
- Tangent projections have a standard point



Scale distortions on a tangent map surface. The central point is not distorted on the map.

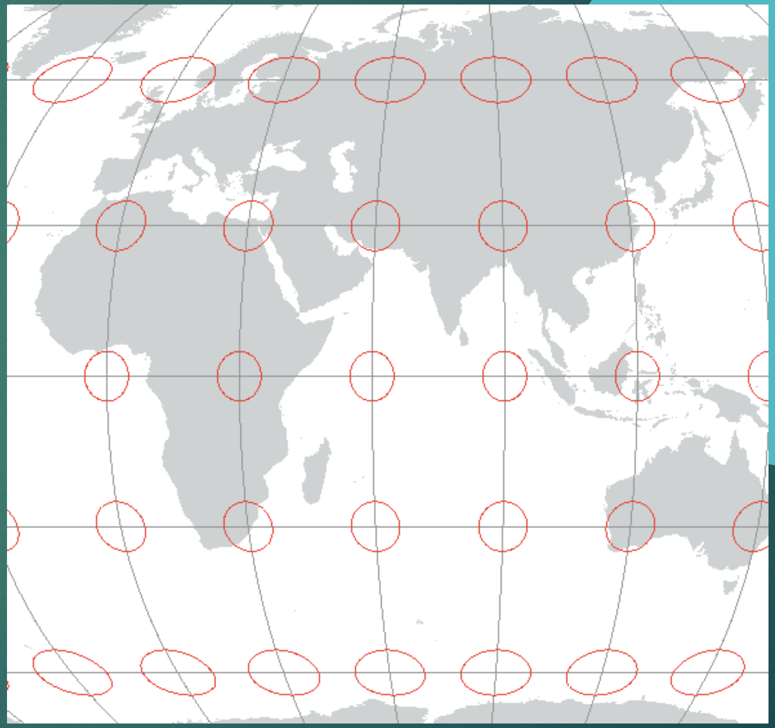


Scale distortions on a secant map surface. Line(s) of intersection are not distorted on the map.

Preservation Properties

- Equal area
- Conformal (preserves angles)
- Neither (compromise)

- Tissots Indicatrix – distortion ellipses to help identify what aspect of a projection is preserved and how distortion happens



Some helpful websites

- http://projections.mgis.psu.edu/
- https://www.jasondavies.com/maps/transition/
- http://www.gis.osu.edu/misc/map-projections/
- https://bramus.github.io/mercator-puzzle-redux/

Let's go back… Taxonomy of Projections

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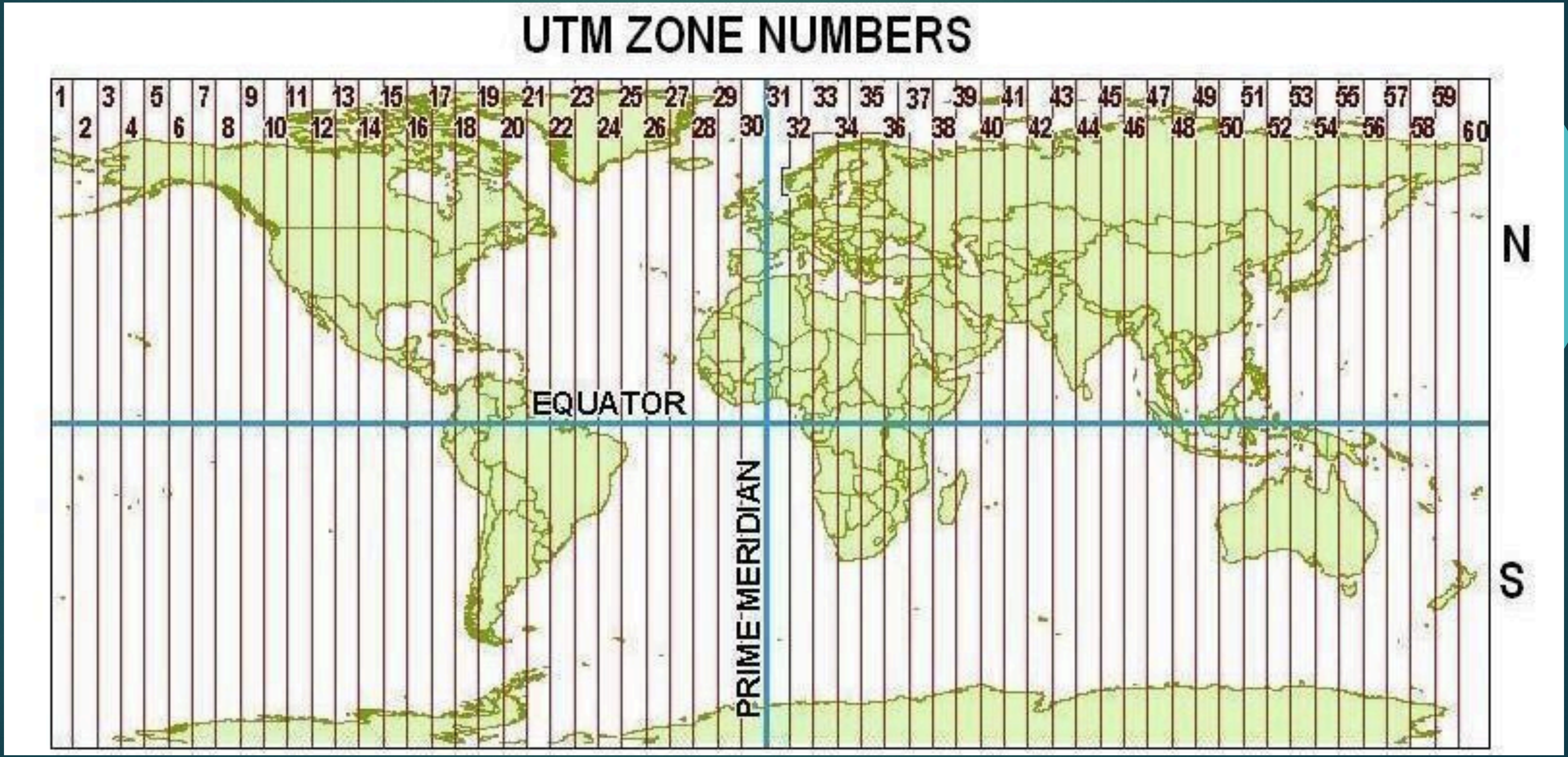
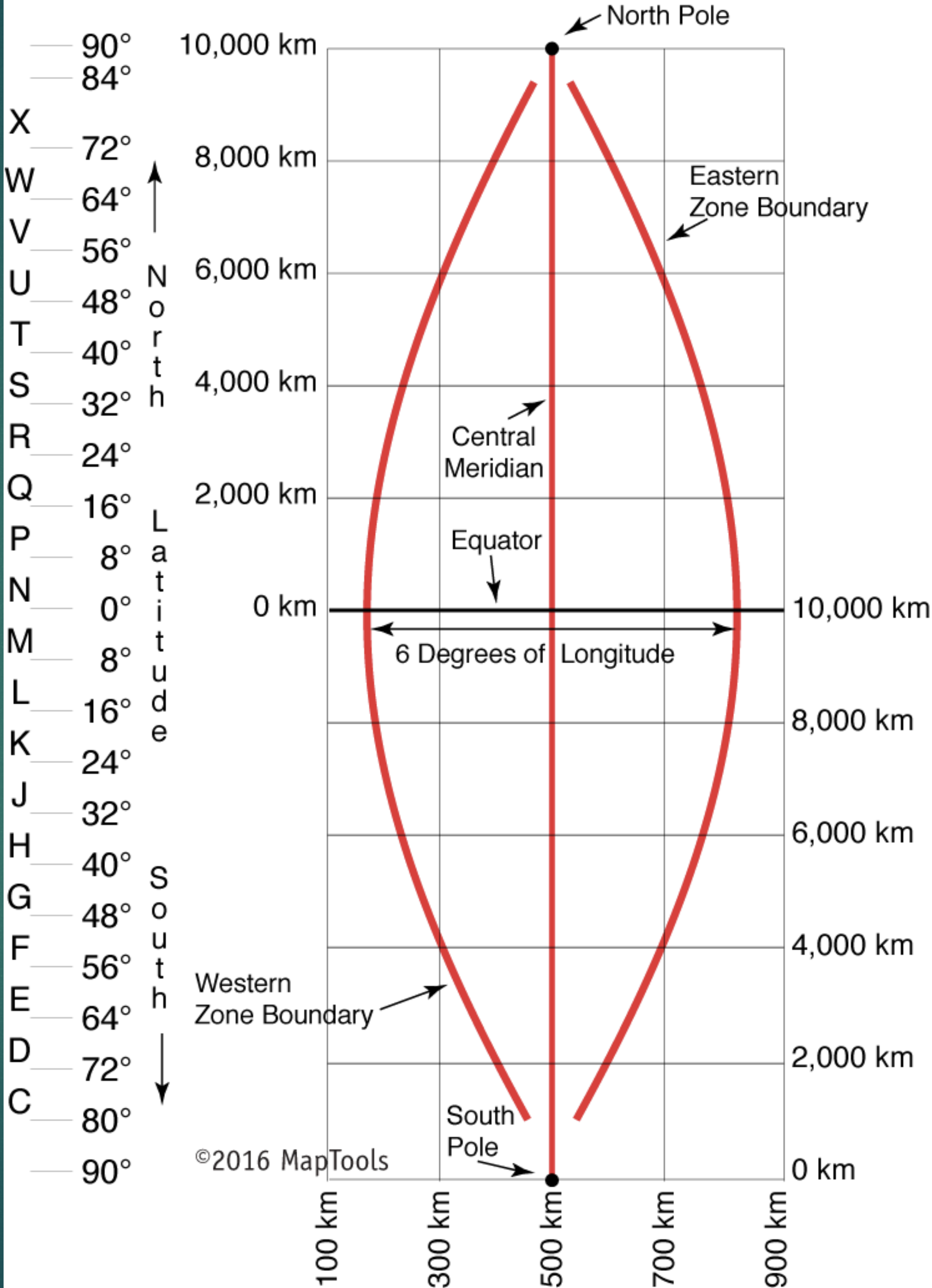
Universal Transverse Mercator

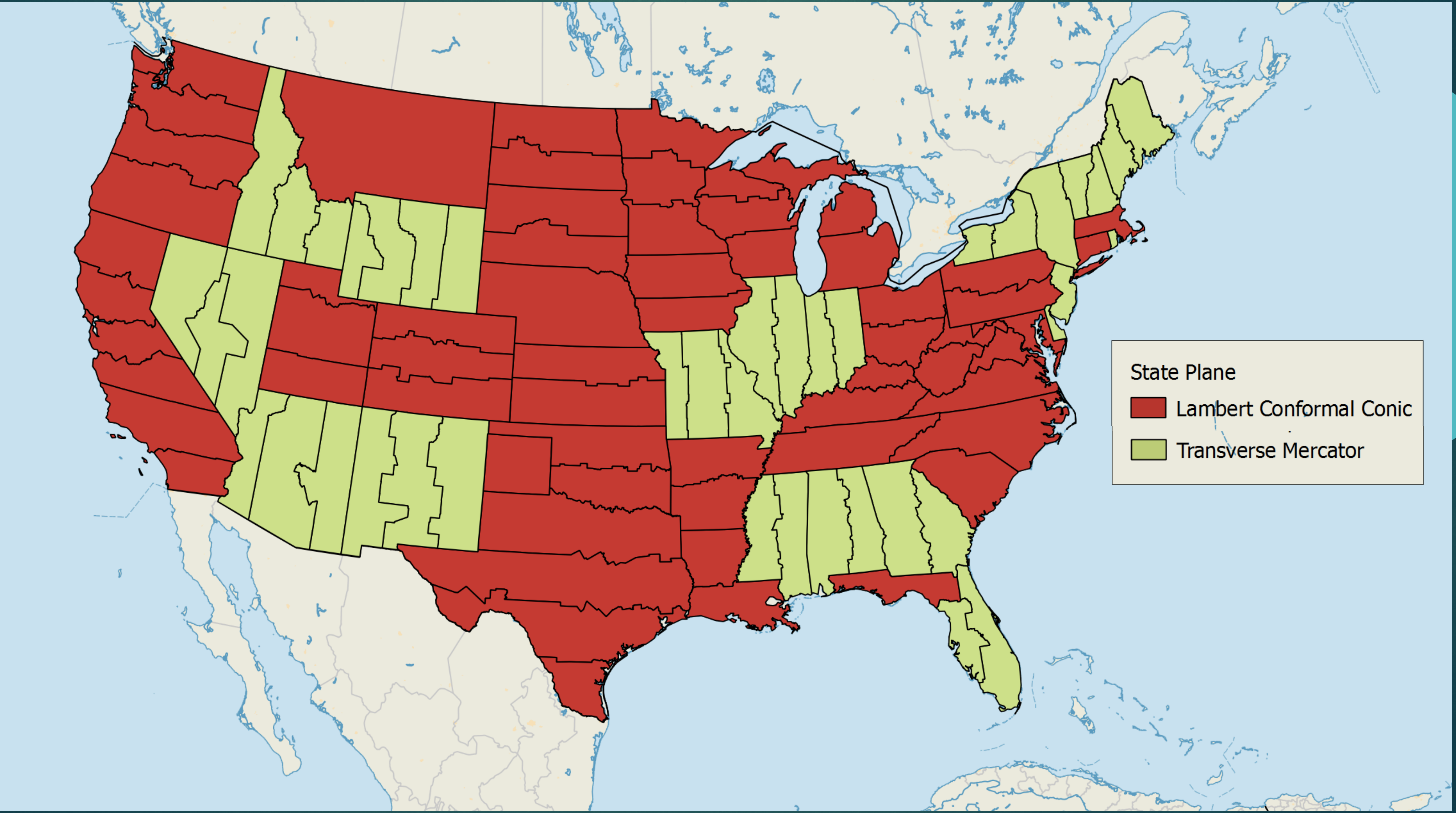


UTM

- Each zone is 6 degrees of longitude in width
- Transverse
- Secant
- Conformal – correct shape, scale is nearly the same in each zone
- Measurements are in meters which allows for easy measurement



State Plane Systems



Web Mercator

- Definitely not a perfect map projection, but it has these advantages:
  1. Accurate enough that it can support calculation, e.g. routing vehicles
  2. Fast response on calculations
  3. Conformal so it preserves local scale
  4. Little distortion in areas of high population