GEO 309 – Intro to GIS

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Topics

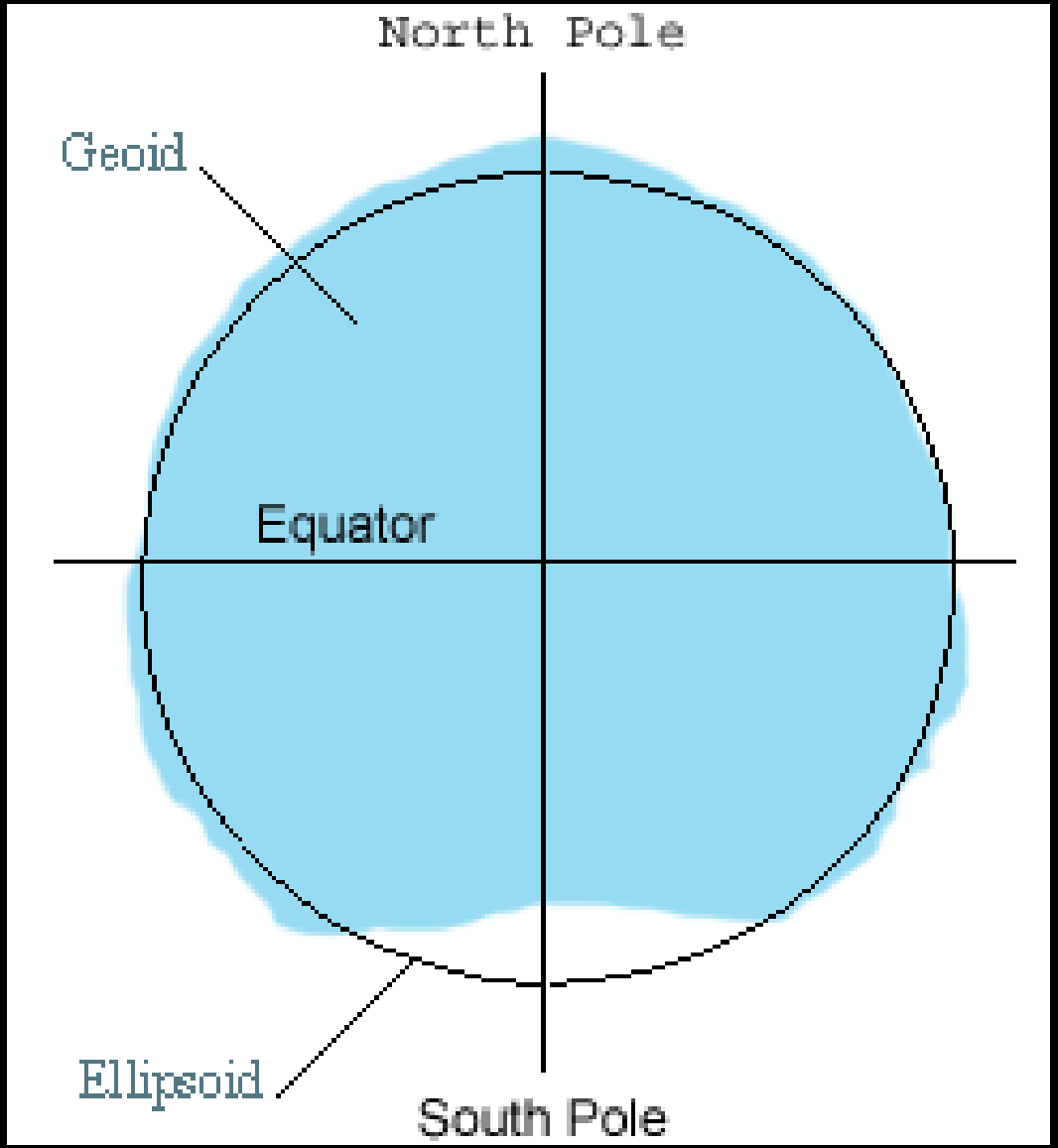
- Discussion – Kelso
- Projection
  - Distortion
  - Selecting a Projection
- Coordinate reference systems
  - Geographic and projected coordinate systems
    - Global vs Local
  - Coordinate transformations
    - Permanent vs on-the-fly

Discussion – Kelso

- Kelso, C. 1999. Ideology of mapping in apartheid South Africa. *South African Geographical Journal* 81(1): 15-21.

Projection

- From globe to map
  - Geodesy – study of size/shape of planet
  - Geometric (Euclidean) space
    - Relationships between objects
  - Geoid – actual size/shape of the planet
  - Oblate Ellipsoid – geometric shape of planet
    - Spheroidal reference surface at sea level



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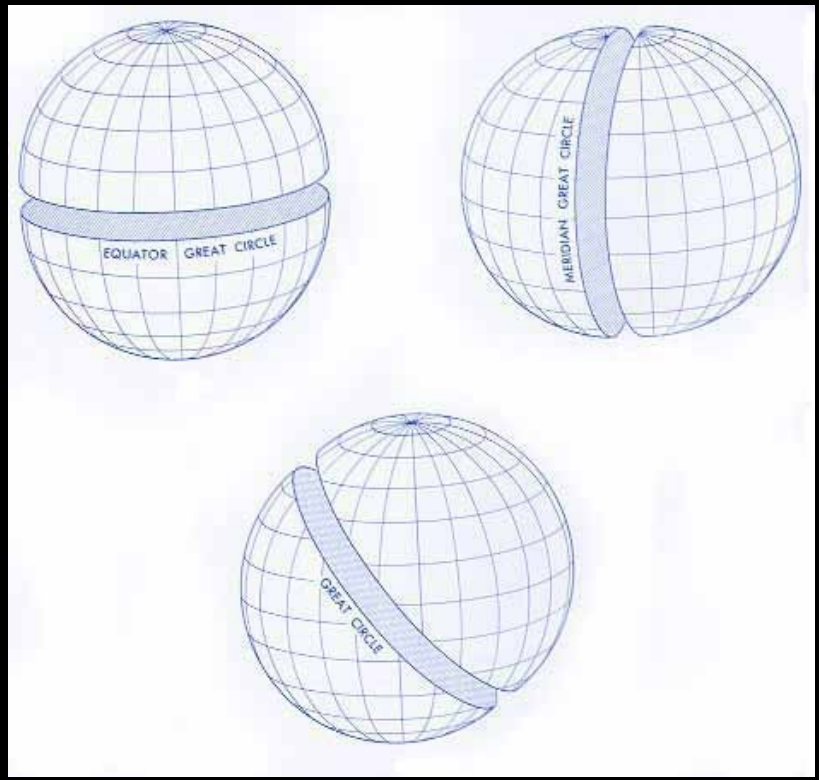
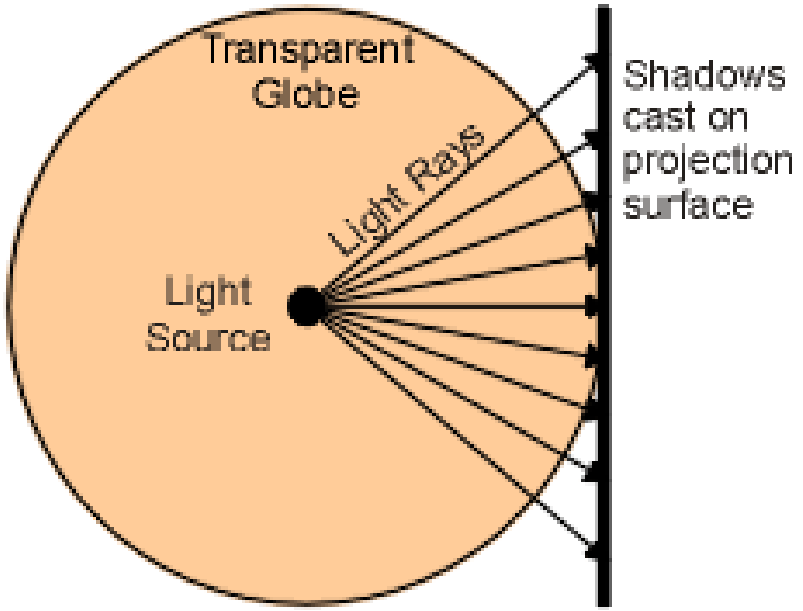
Projection

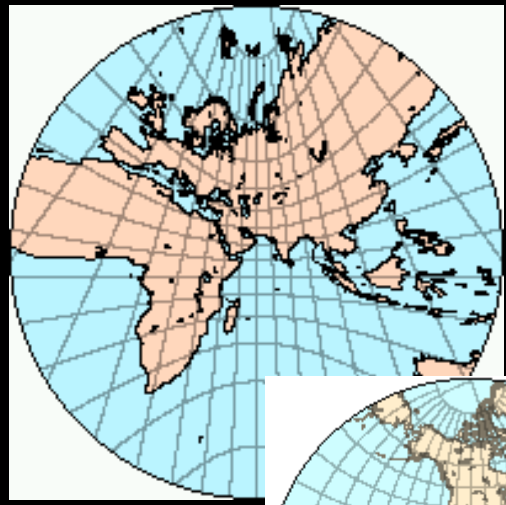
- Great Circles
  - Divide sphere in half
    - Hemispheres
  - Measuring long distances
- Small Circles
  - Less than a great circle

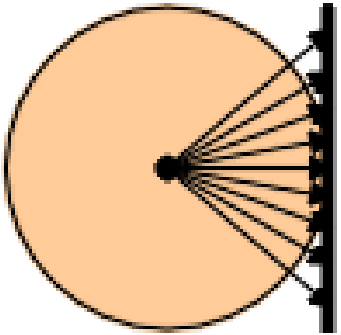


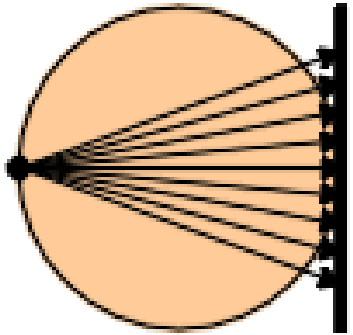
Projection

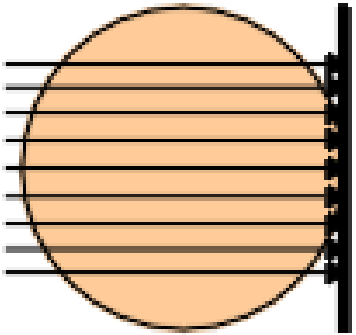
- Modeling a projection based on light source
  - Gnomonic azimuthal
    - Light at center, distorts area and shape
    - Great circle routes as straight lines
  - Stereographic azimuthal
    - Light at antipode, true shape, distorts area
  - Orthographic azimuthal
    - Light at infinite distance, distorts shape and area


Transparent Globe
Light Rays
Light Source
Shadows cast on projection surface




Gnomonic


Stereographic

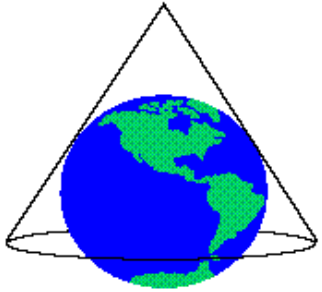

Orthographic

Projection

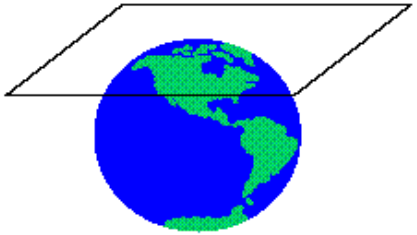
- Modeling a Projection using simple geometric shapes
  - **Classes** (Cylinder, Cone, Plane)
  - **Cases** (Tangent, Secant)
  - **Aspects** (Polar, Equatorial, Transverse, Oblique)
  - Can also use more advanced mathematical projections
  - The underlying geodetic reference system
    - Better known as a Datum (e.g., WGS 84, NAD 83)
    - Must maintain link to a coordinate reference system

Map Projection Surfaces

Cylindrical

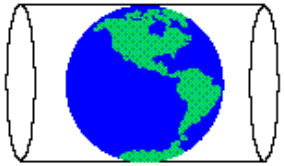


Conic

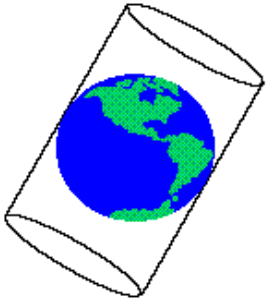


Azimuthal

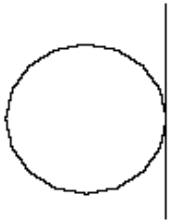
Orientation



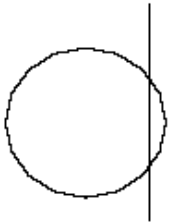
Transverse



Oblique

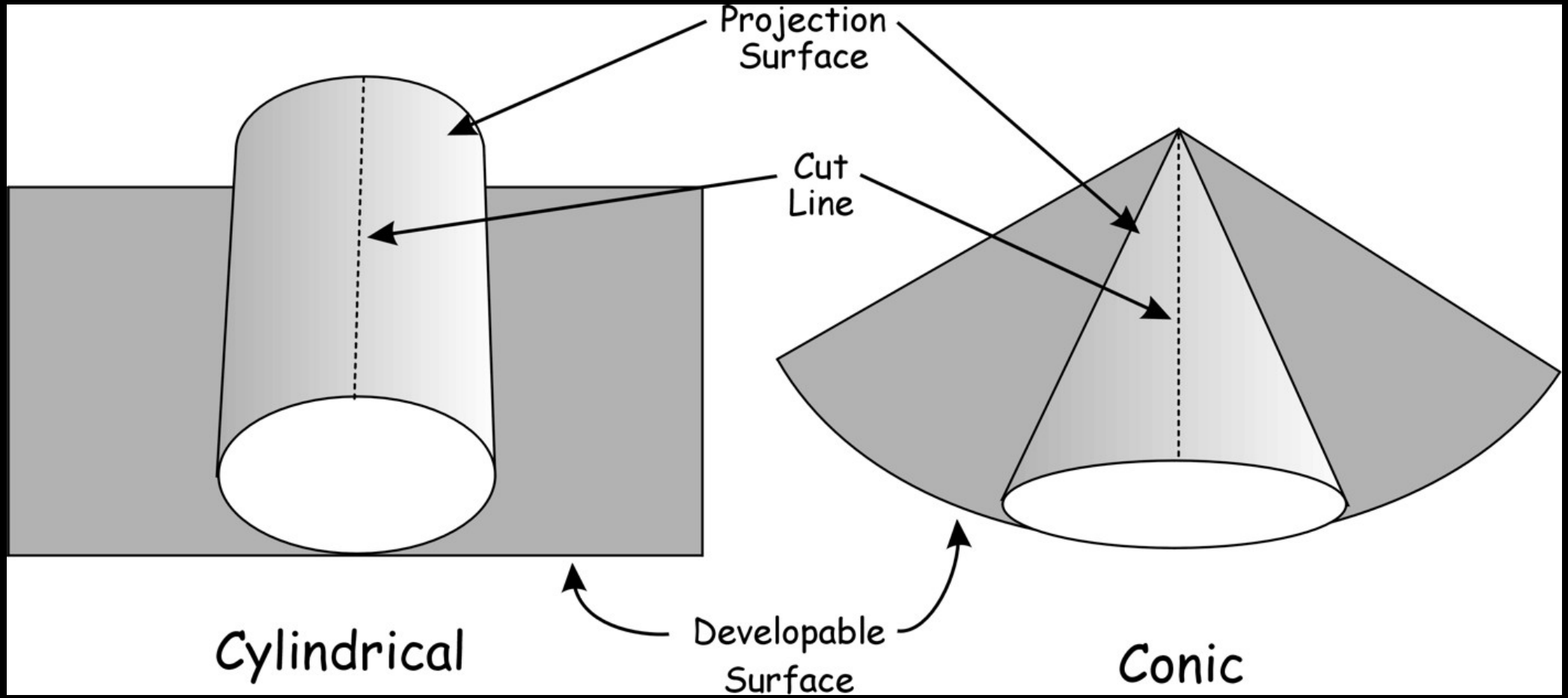


Tangent

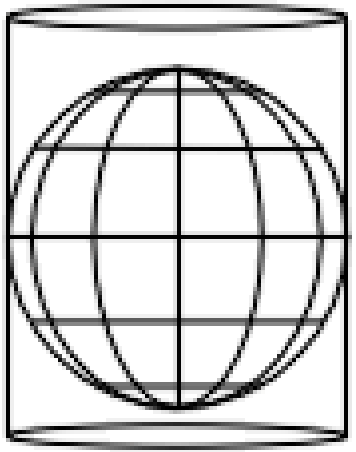


Secant

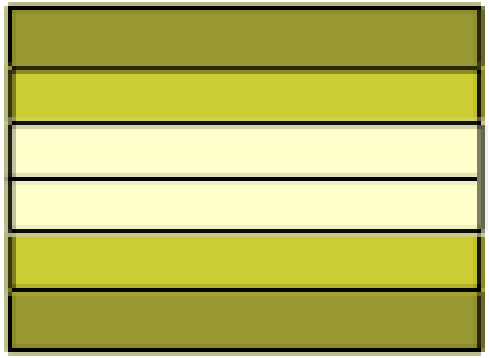
R. Dodson, 8/97


Projection Surface
Cut Line
Cylindrical
Developable Surface
Conic

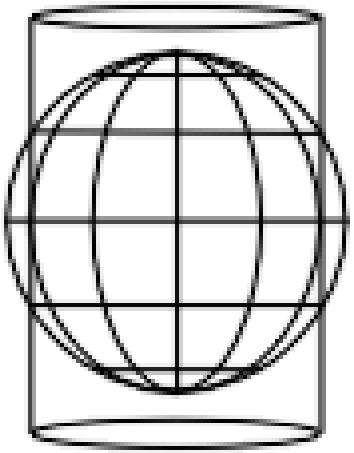
Tangent Case



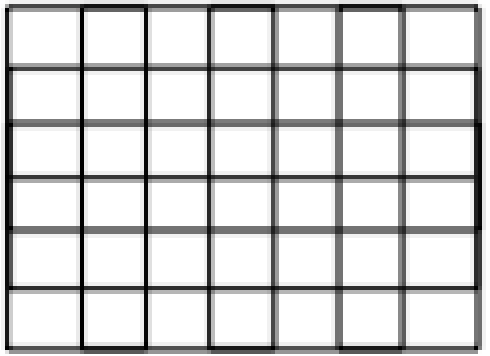
Pattern of Distortion



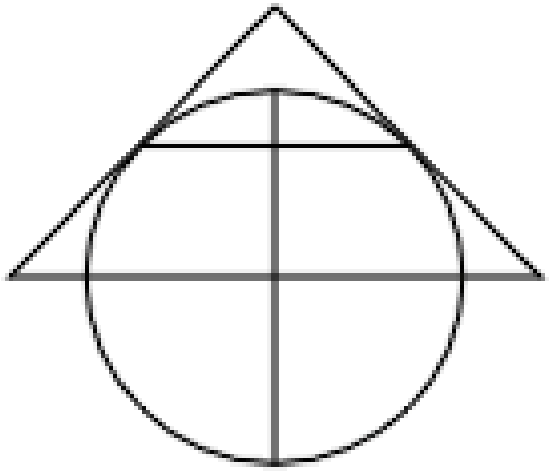
Secant Case



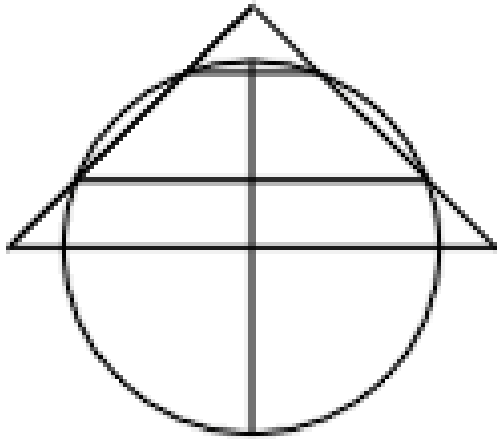
Graticule



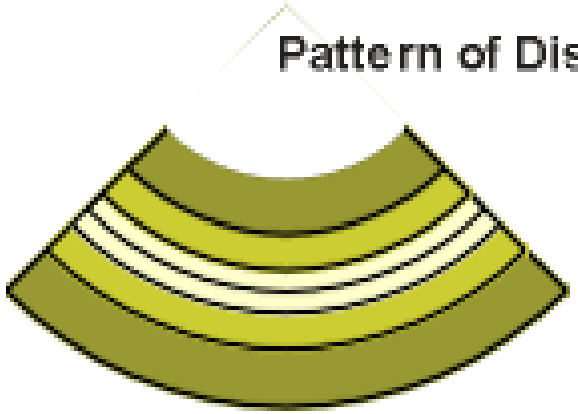
Tangent Case

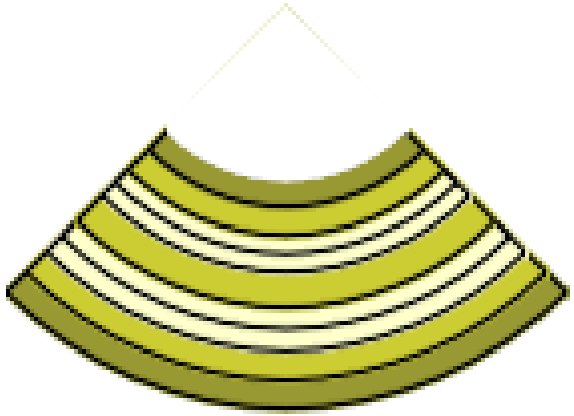


Secant Case

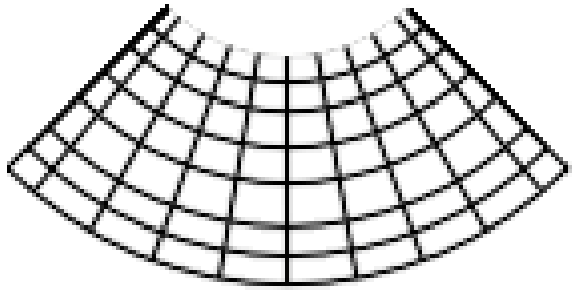


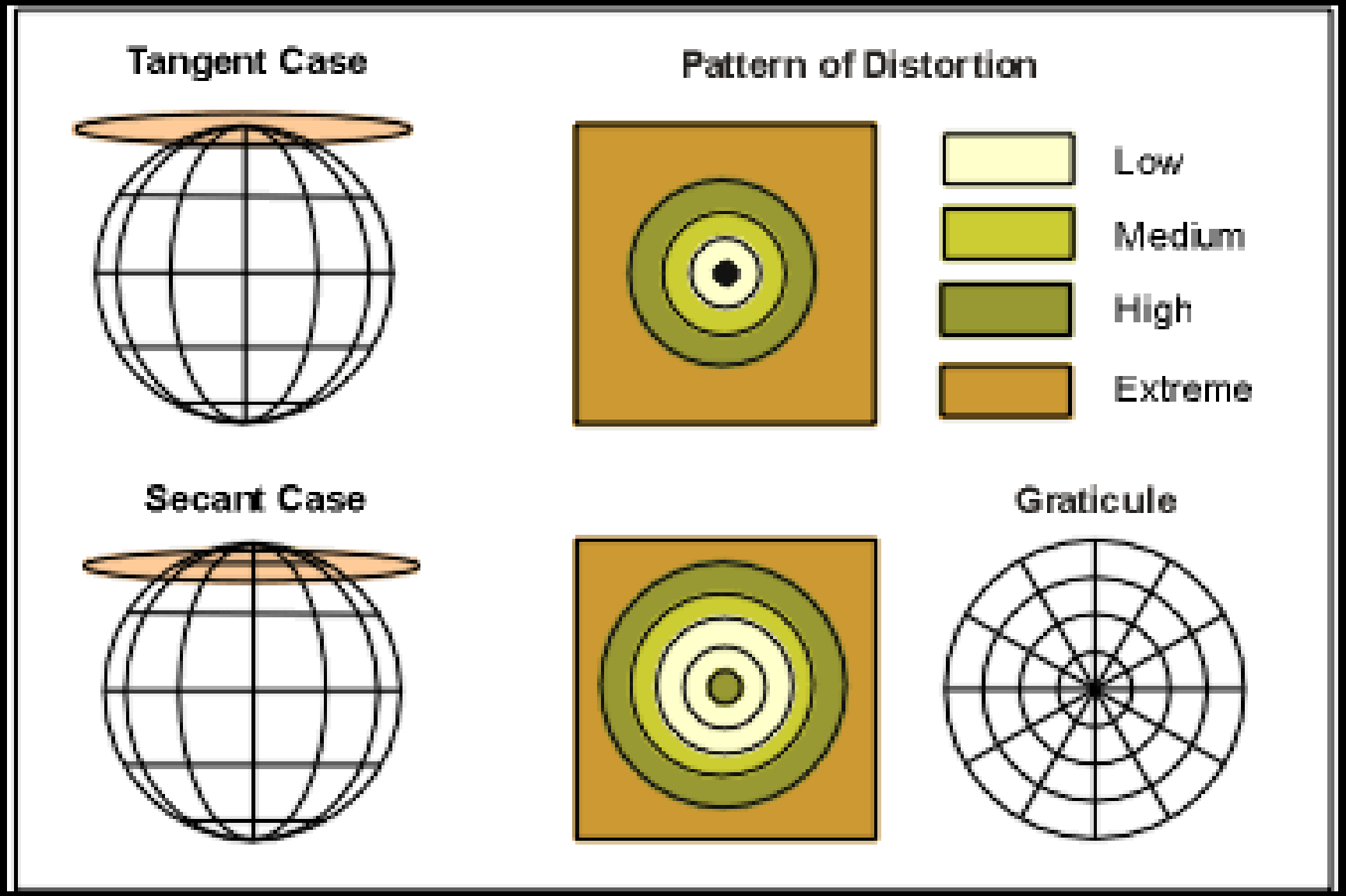
Pattern of Distortion



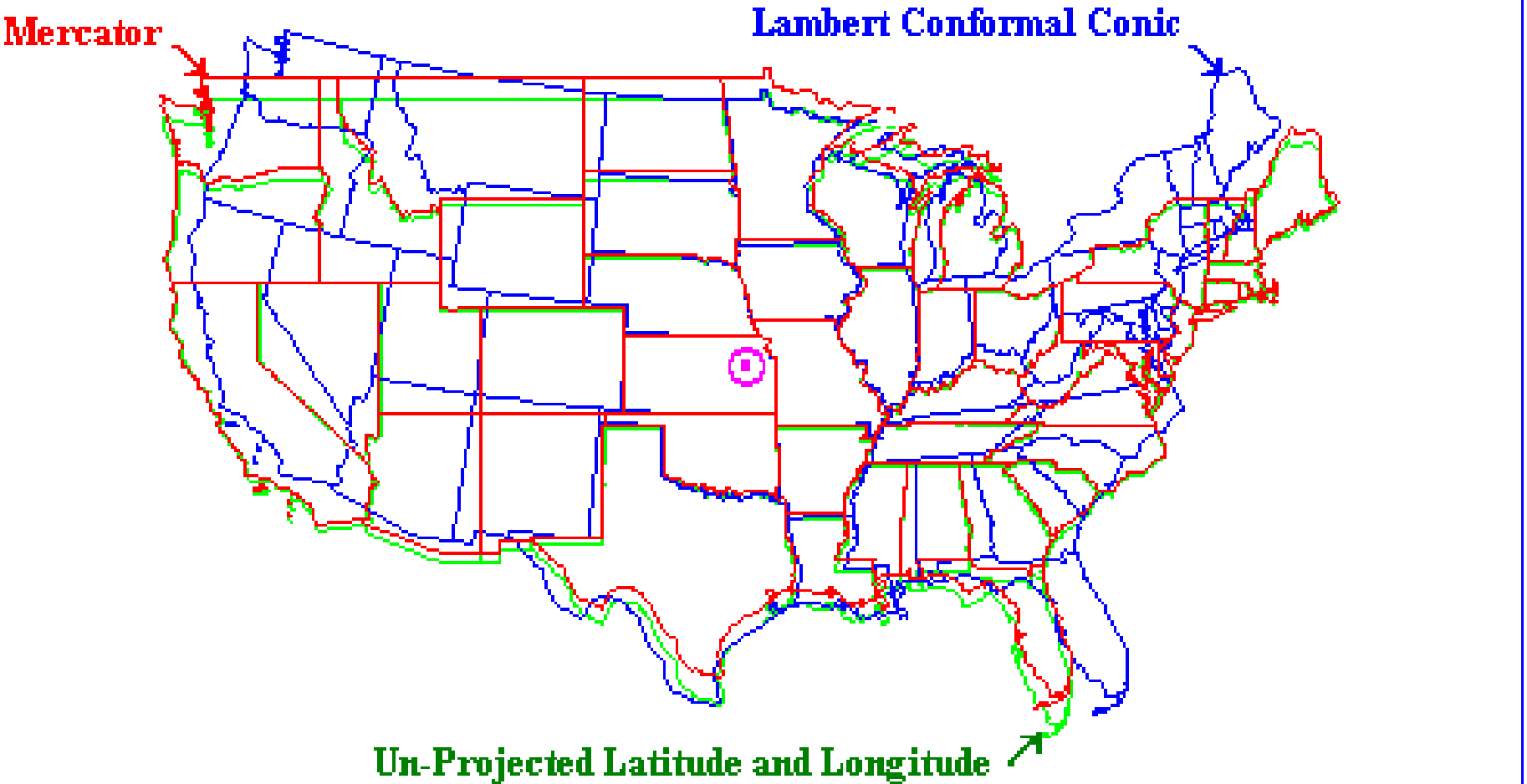


Graticule




Tangent Case
Pattern of Distortion
Low
Medium
High
Extreme
Secant Case
Graticule

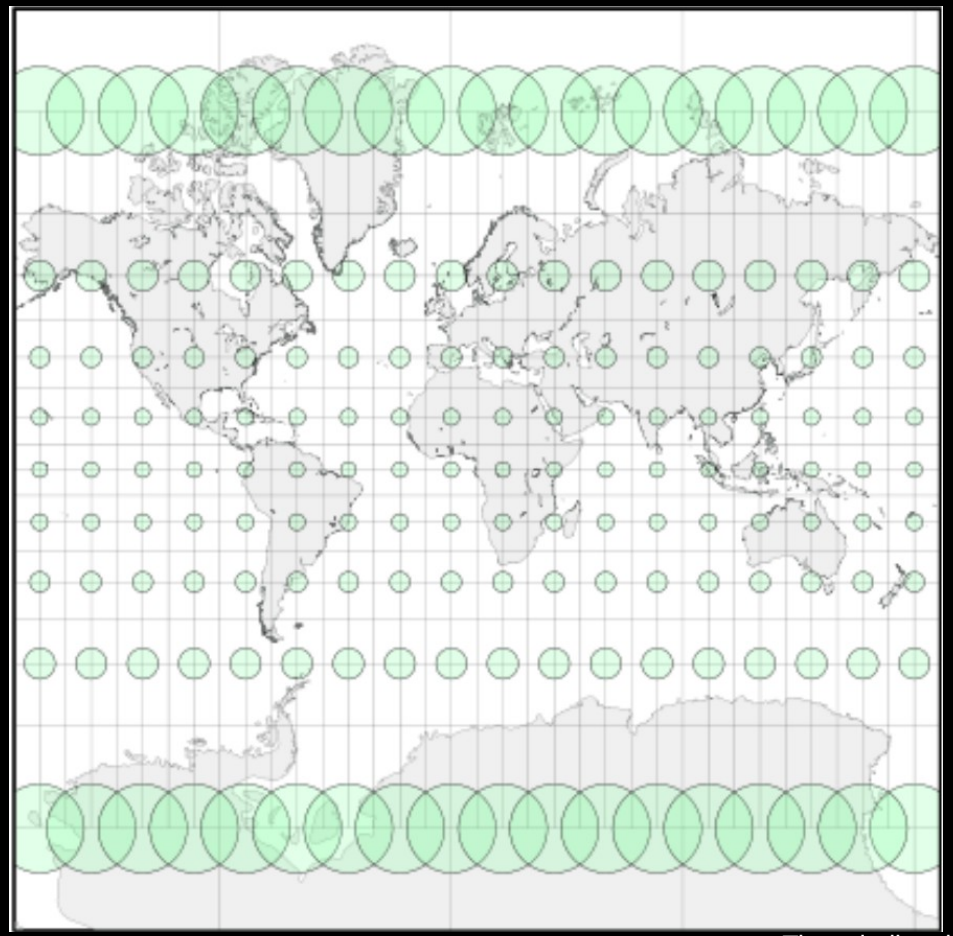
Three Map Projections Centered at 39 N and 96 W



Peter H. Dana 6/23/97

Projection

- Distortion
  - Direction
  - Distance
  - Size (Area)
  - Shape
- Levels of distortion
  - Scale of map
  - Purpose of map



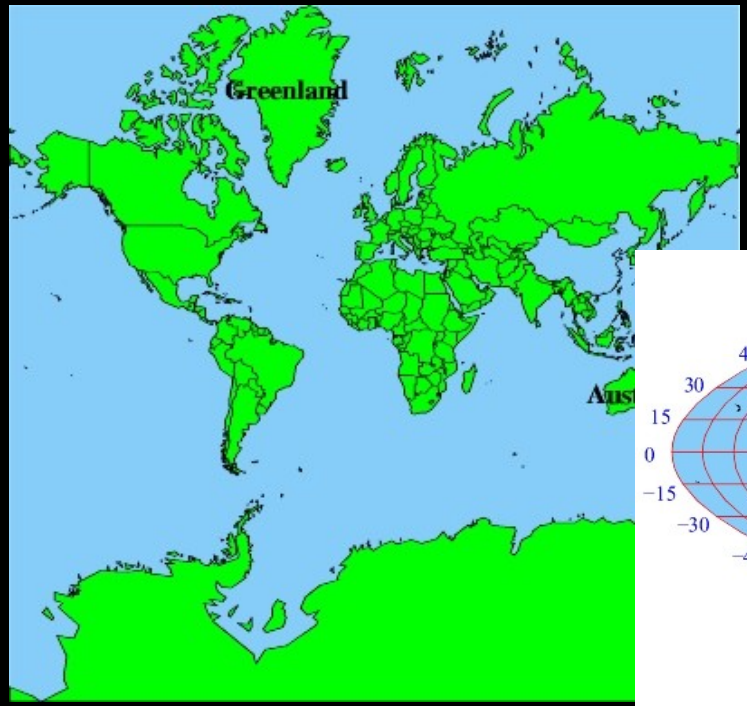
Tissot indicatrices

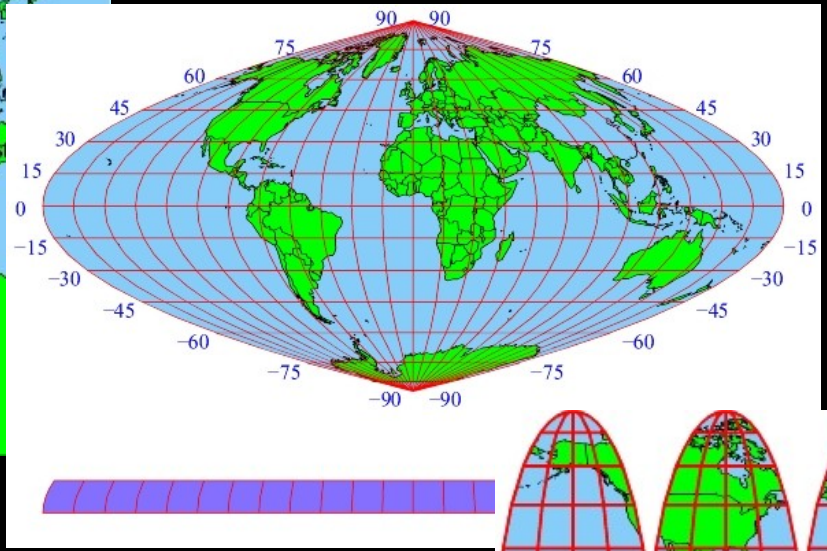
Projection

- Azimuthal (true direction)
  - Can occur in an equidistant, equivalent, or conformal map
  - Direction from point of tangency true
- Equidistant (true distance/scale)
  - Can occur in a azimuthal, equivalent, or conformal map
- Equivalent (equal area)
  - Distorts shape
- Conformal (true shape)
  - Distorts area
- Compromise

Projection

- Overcoming distortion
  - Mathematically-combined projections
  - Compression
    - Warps area without changing shape
  - Shearing
    - Warp features without changing area
  - Tearing
    - Cut down on shearing and compression


Greenland


90
90
75
75
60
60
45
45
30
30
15
15
0
0
−15
−15
−30
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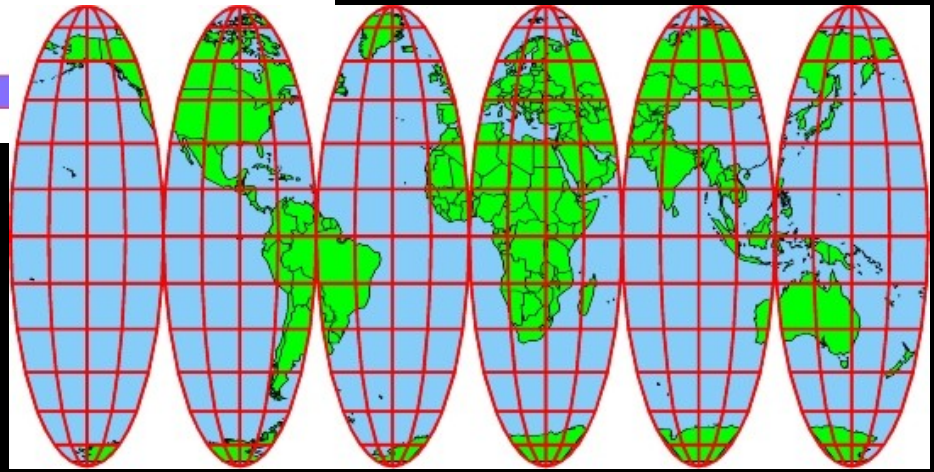
−45
−60
−60
−75
−75
−90
−90



Projection

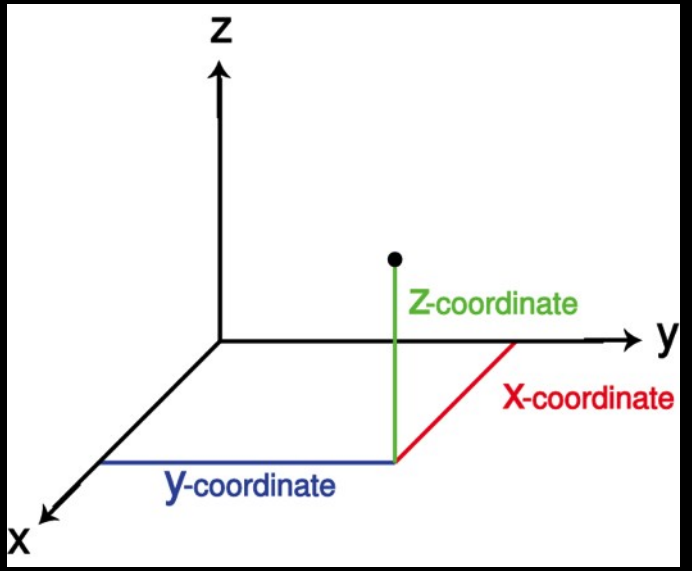
- Selecting projections
  - What aspect(s) of a spatial phenomena do you want to analyze?
    - Accuracy of location, size, or shape?
  - Large scale or small scale?
  - Where is the center of the map?
- Snyder’s Hierarchical Selection Guideline

Projection

- Selecting projections
  - General guidelines
    - Cylindrical for equatorial regions
    - Conical for temperate zones
    - Planar/azimuthal for polar regions
  - You will never be able to get rid of 100% distortion
    - Projections just minimize aspects of distortion
      - From center of map outward

Coordinate Reference Systems

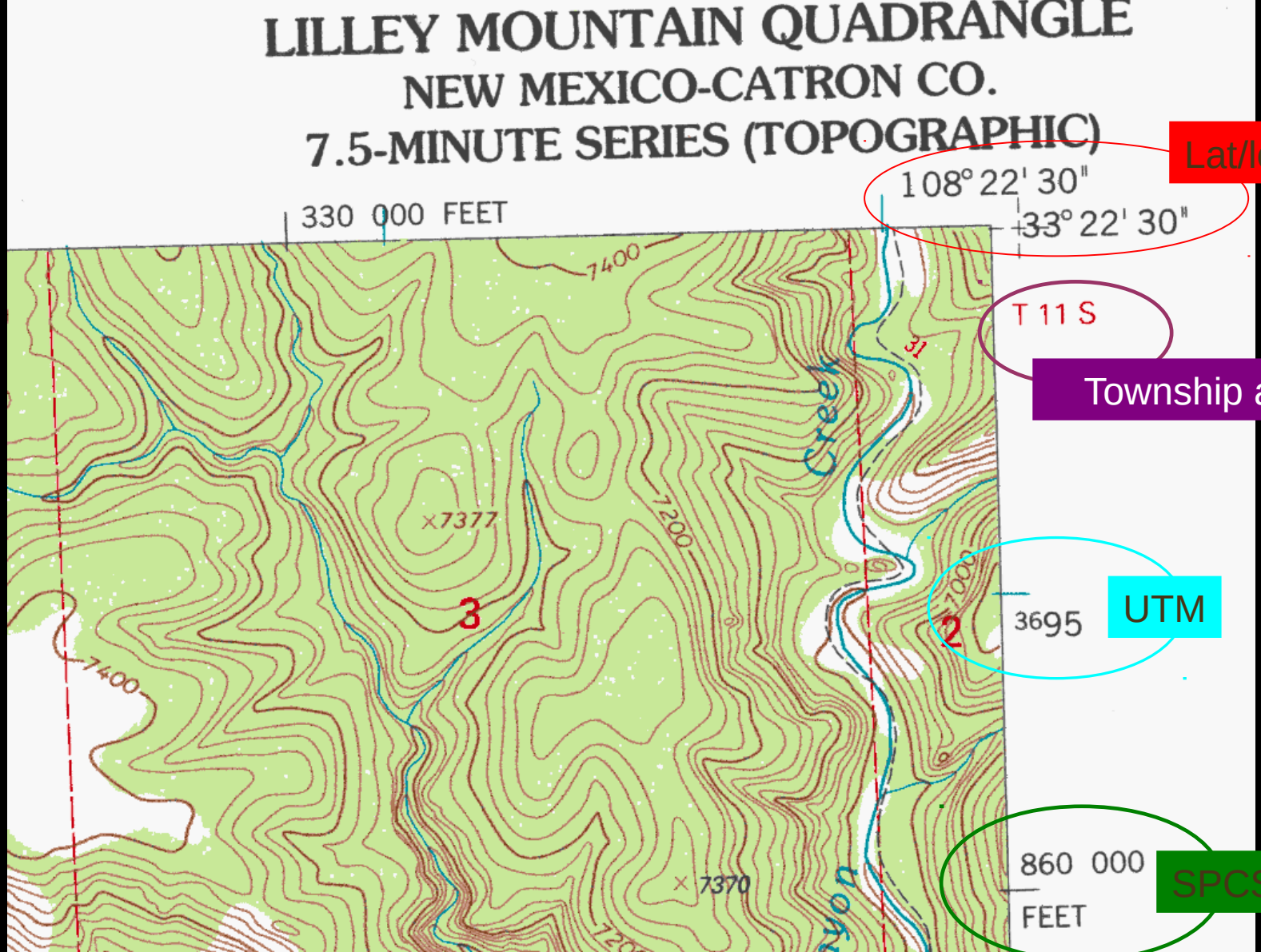
- Reference system (Cartesian) consisting of a point of origin and units of measurement
  - Latitude & Longitude
    - Geographic coordinate system
      - Related to geodetic datum
    - Projected coordinate system
      - Easting (generally x) and Northing (generally y)
        - But there are exceptions
  - UTM
  - State Plane
  - Township and Range



Wilson, GEO109, 2018

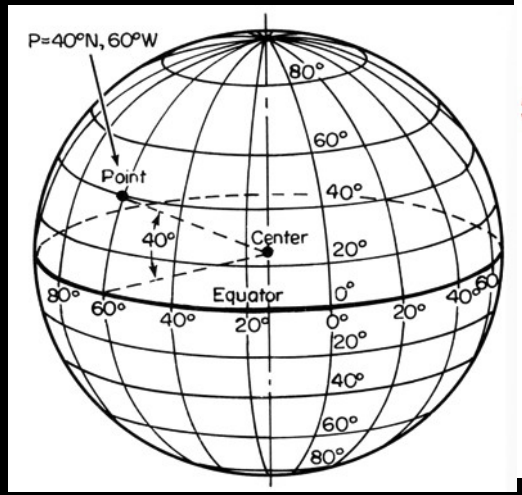
Coordinate Reference Systems

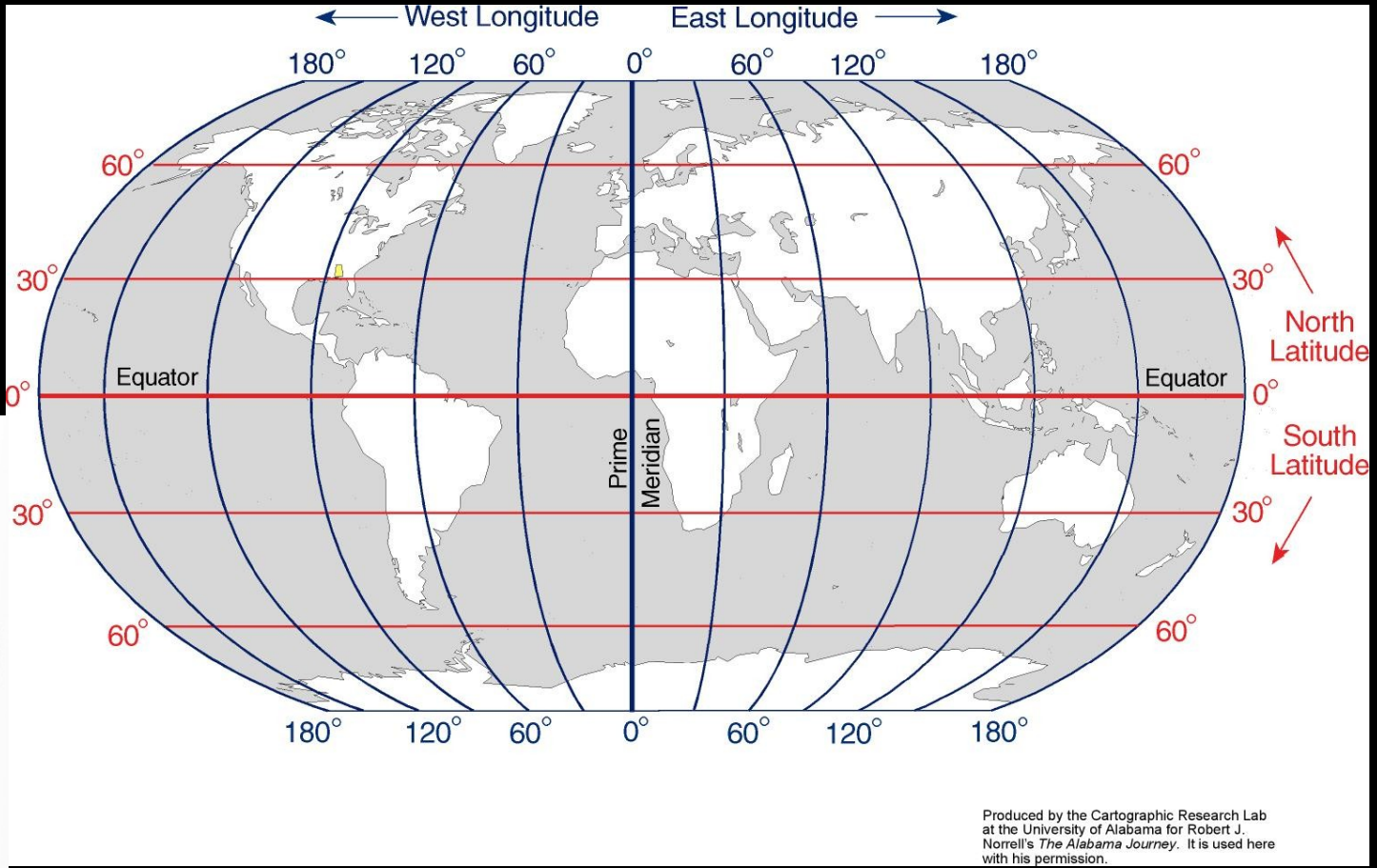
- Relationship between Projection and CRS
  - Projections convert globes to planes
  - Coordinate systems reference locations
- Which CRS to use?
  - Level of accuracy and precision
  - Limits of software
  - Coordinate system of original & existing data


LILLEY MOUNTAIN QUADRANGLE
NEW MEXICO-CATRON CO.
7.5-MINUTE SERIES (TOPOGRAPHIC)
Lat/lon
108° 22' 30"
33° 22' 30"
330 000 FEET
T 11 S
Township and Range
UTM
3695
SPCS
860 000
FEET
7400
7200
7377
7370
3
2
31

Coordinate Reference Systems

- Graticules





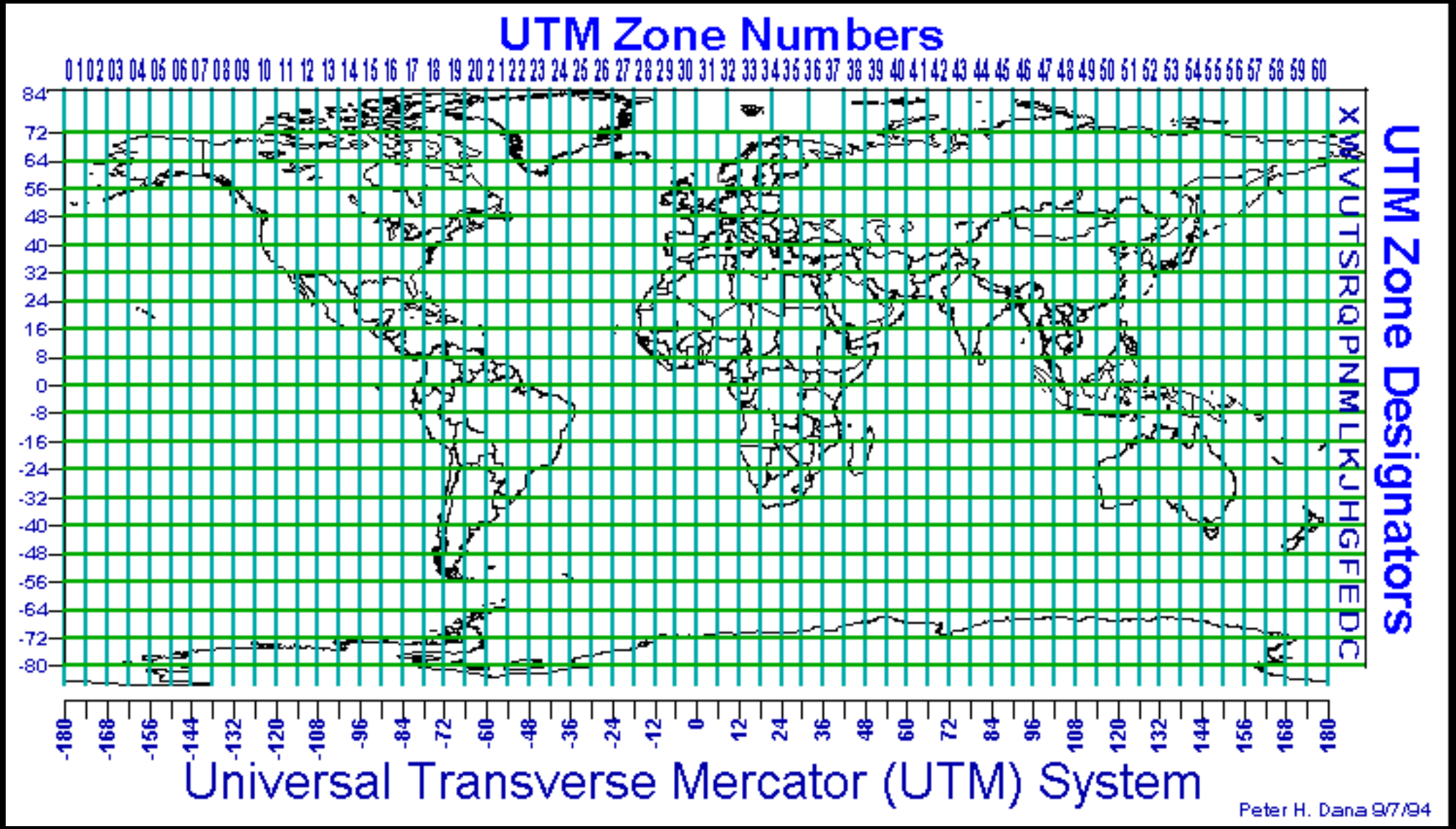
Coordinate Reference Systems

- Latitude
  - Parallels or Y-axis
  - Equator at 0° (° = degrees)
    - To 90° North and South
- Longitude
  - Meridians of X-axis
  - Prime Meridian at 0°
    - To 180° East and West

- 1 degree = 60 minutes (‘)
  - 1 minute = 60 seconds (“)
- dd°mm'ss”
- dd.mmss.xx

Coordinate Reference Systems

- Universal Transverse Mercator (UTM)
  - Projected coordinate system
  - 60 North/South zones
    - Number increases west to east
    - Each zone is a 6 degree longitudinal strip
    - With a North and South half – each with their own origin
    - Measurements in meters (Easting and Northing)


UTM Zone Numbers
0 1 0 2 0 3 0 4 0 5 0 6 0 7 0 8 0 9 10 11 12 13 14 15 16 17 18 19 20 2 1 22 23 24 25 26 27 28 29 30 31 32 33 3 4 35 36 37 38 39 40 4 1 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
84
72
64
56
48
40
32
24
16
8
0
-8
-16
-24
-32
-40
-48
-56
-64
-72
-80
X W V U T S R Q P N M L K J H G F E D C
UTM Zone Designators
-180 -168 -156 -144 -132 -120 -108 -96 -84 -72 -60 -48 -36 -24 -12 0 12 24 36 48 60 72 84 96 108 120 132 144 156 168 180
Universal Transverse Mercator (UTM) System
Peter H. Dana 9/7/94

Coordinate Reference Systems

- Universal Transverse Mercator (UTM)
  - Based on Mercator
  - Popular with US DoD
  - Meant to minimize distortion between
    - 84N and 80S
  - Example
    - 14 R 621160.98 3349893.53
    - Zone 14 R, Easting in meters, Northing in meters

Coordinate Reference Systems

- State Plane Coordinate System (SPCS)
  - Tailored for a small portion of an ellipsoid covering all or part of a state
    - Originally based on North American Datum 1927
      - NAD 27
    - SPCS 83 was later based on NAD 83
  - Developed to provide
    - Local reference systems tied to a national datum
  - Managed by US National Geodetic Survey

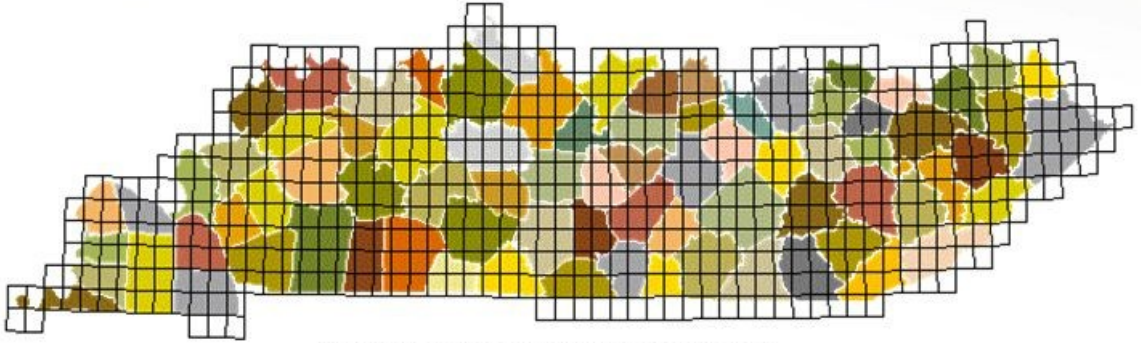
Coordinate Reference Systems

- State Plane Coordinate System (SPCS)
  - Simple Cartesian coordinate system
  - 124 geographic zones
    - Each state has more than one zone
    - At county lines
  - Used for “plane surveying” methods
    - Each zones coordinate system is highly accurate

Projected Coordinate Systems

KENTUCKY PROJECTIONS
North and South State Plane
Lambert Conformal Conic (Secant Cone)

State Plane
North Zone



State Plane South Zone

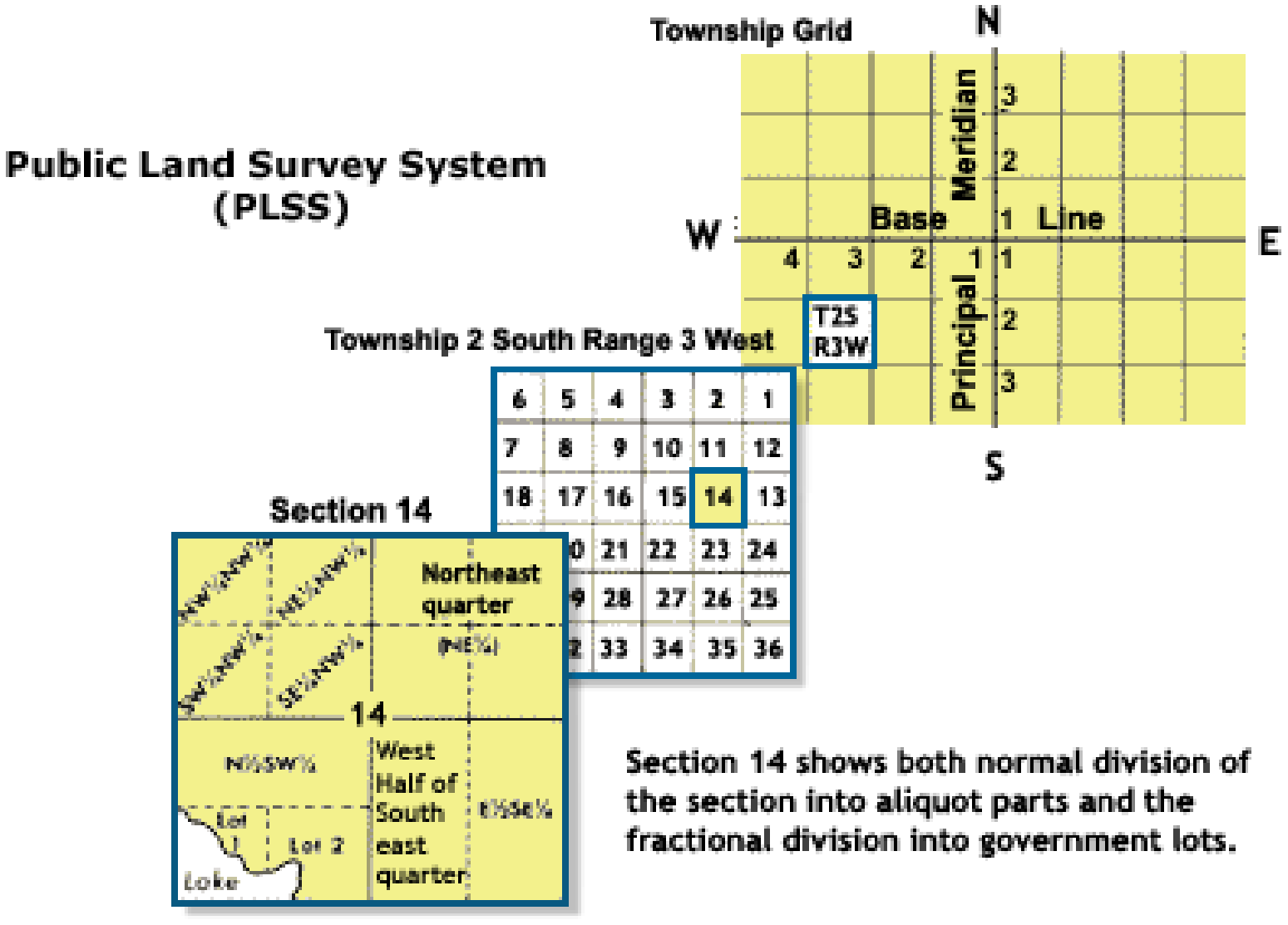
Coordinate Reference Systems

- Township and Range
  - A means of surveying for a PLSS
    - Public Land Survey System
    - Also known as Rectangular Survey System
  - Surveying, sale, settlement of new lands
    - Established in 1785 in what is now Ohio
    - Managed by US Bureau of Land Management
  - Not used in all parts of US

Coordinate Reference Systems

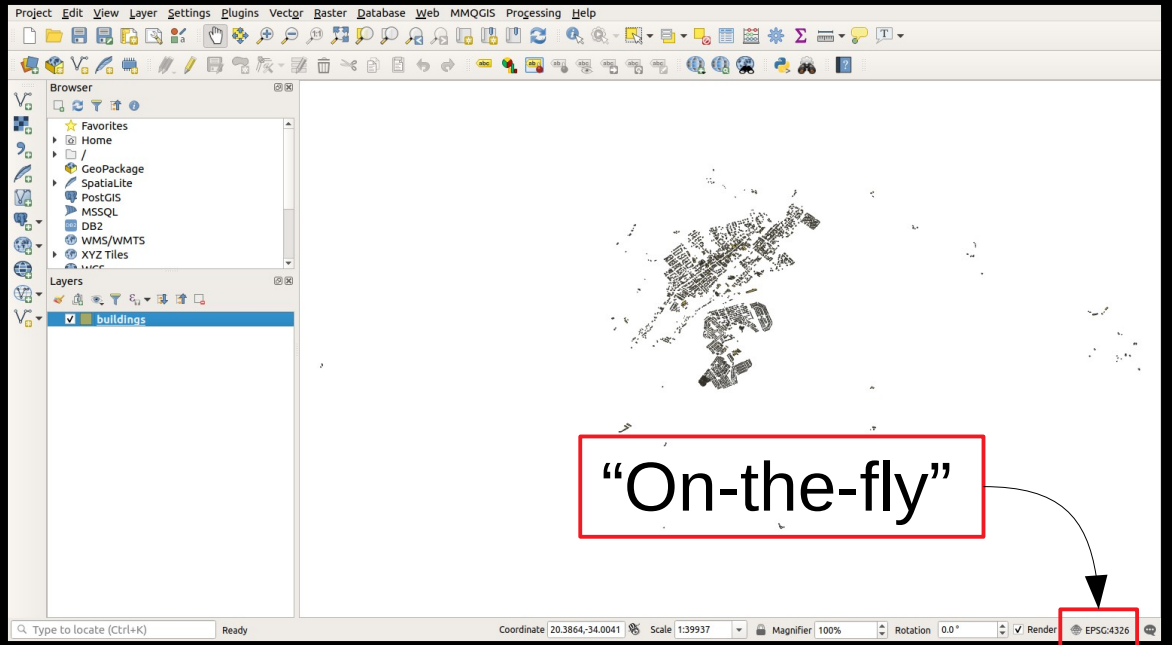
- Township and Range
  - Township
    - A 6 mile square parcel containing 36 sections
    - A measure North or South of 6 miles
  - Range
    - A measure East or West of 6 miles
  - Baseline
    - Latitude on initial point of survey
  - Principal Meridian
    - Longitude on initial point of survey

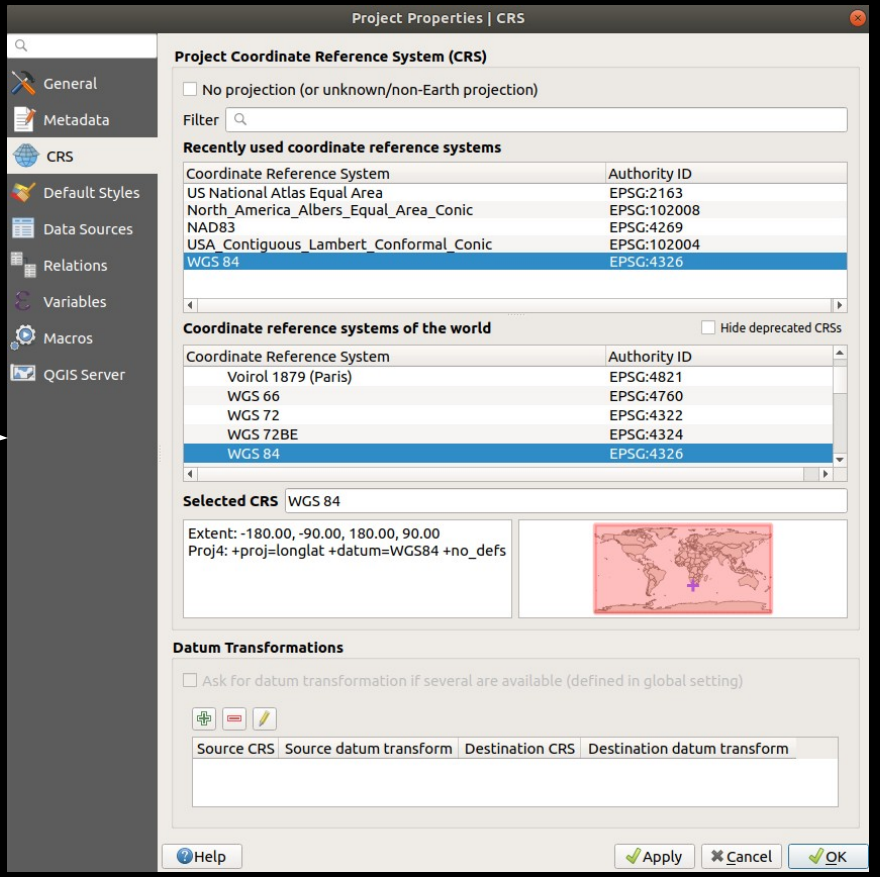
Public Land Survey System (PLSS)



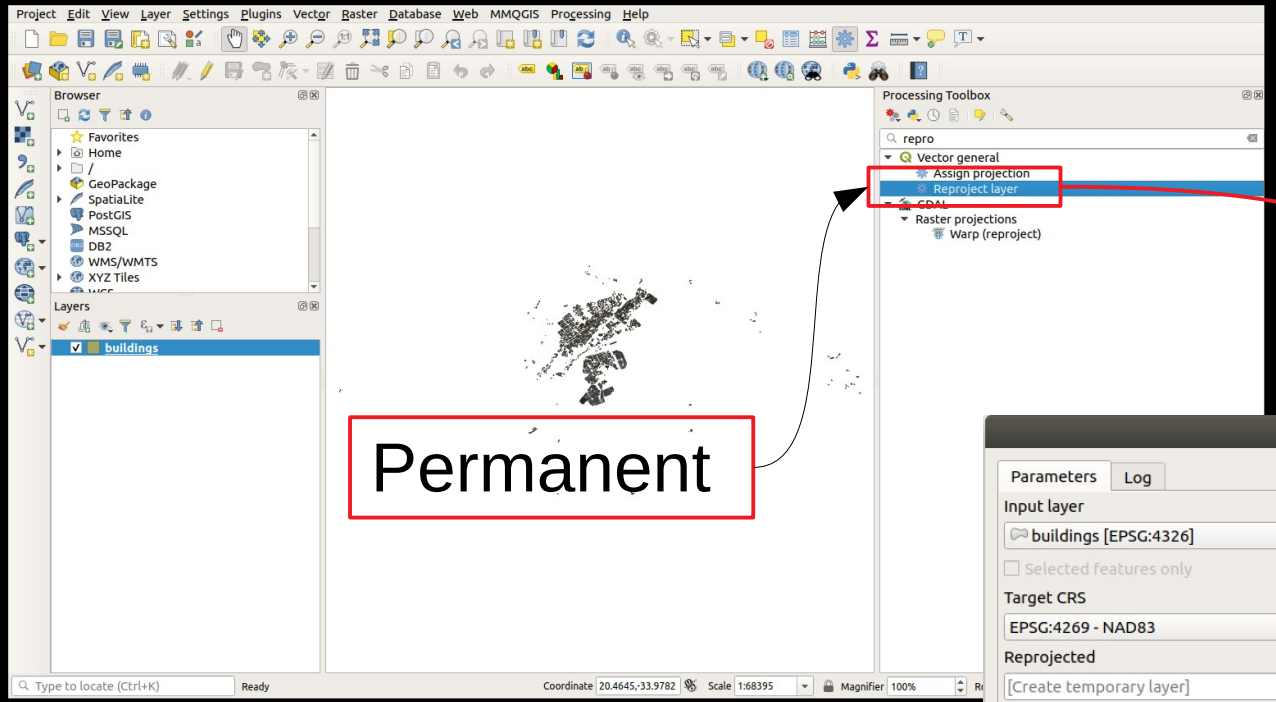
Coordinate Reference Systems

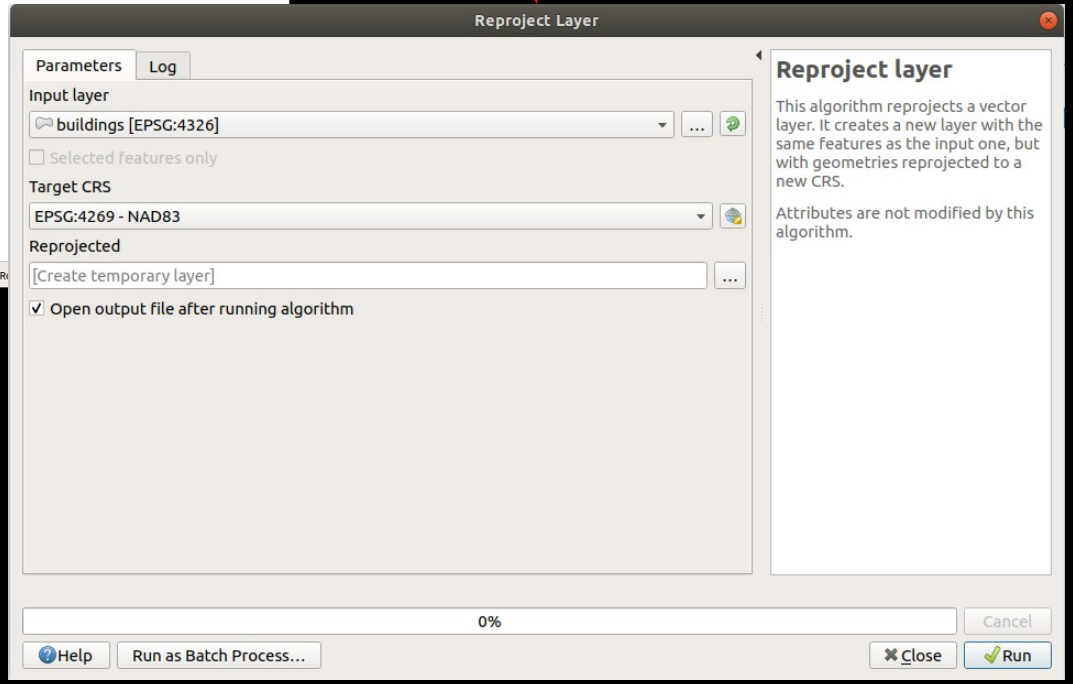
- Transformations
  - GIS software will allow you to change
    - Projections
    - Coordinate Systems
  - It can do this:
    - Permanently
      - Creation of a new layer with target projection
    - “On-the-fly”
      - GIS software alters layer in memory





This is fine for data exploration or testing elements of map design





This is needed if you intend to pursue a particular form of analysis or need to store the data for a particular use case.