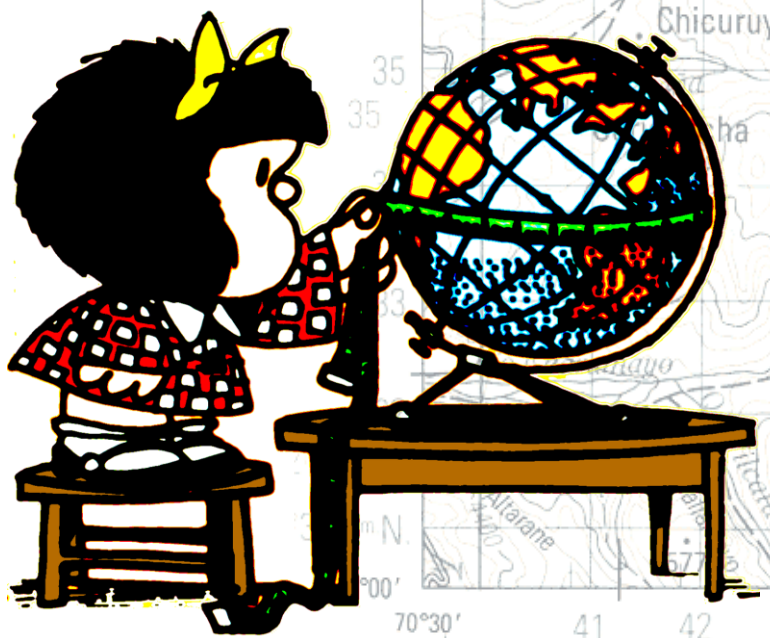
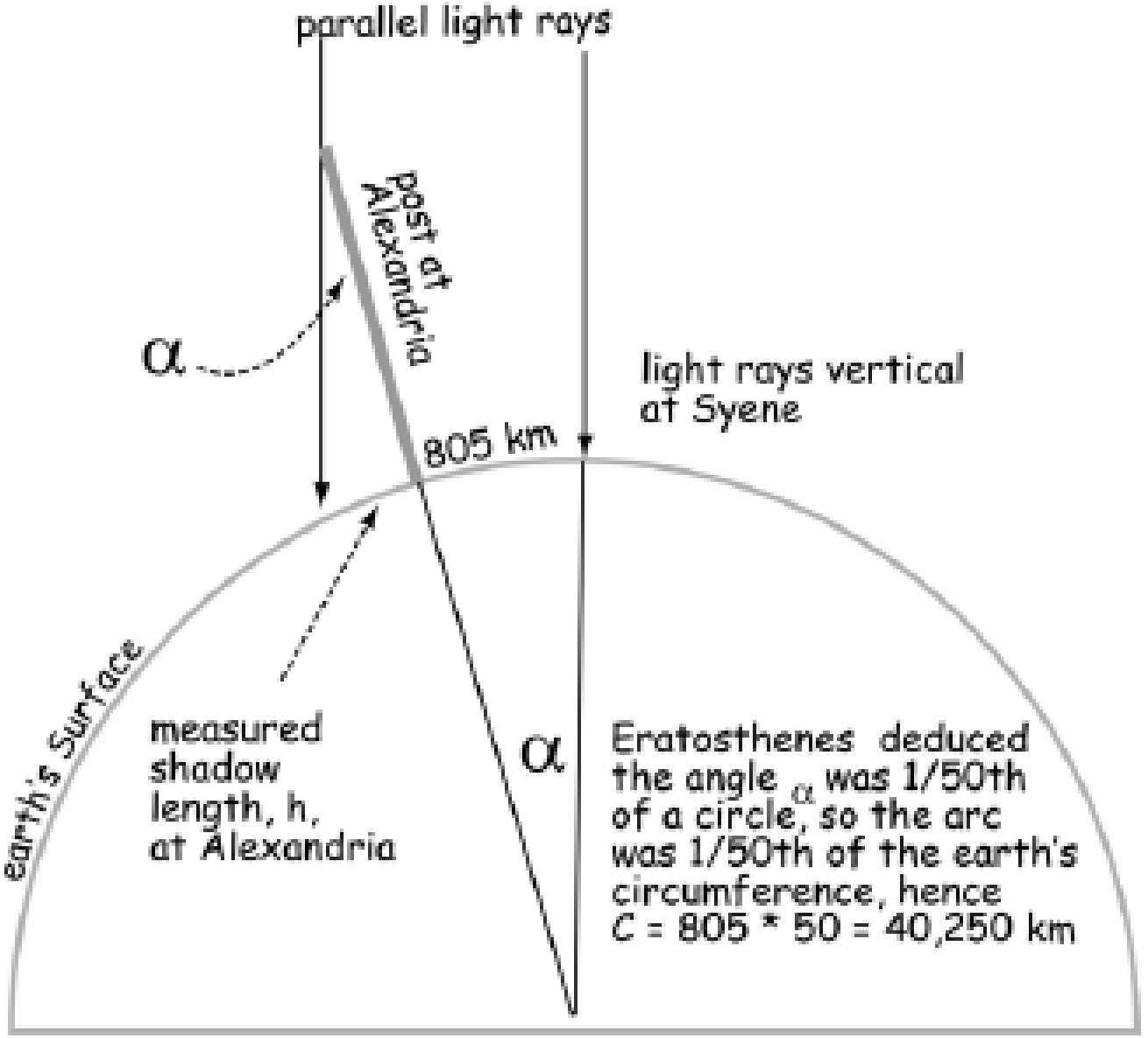
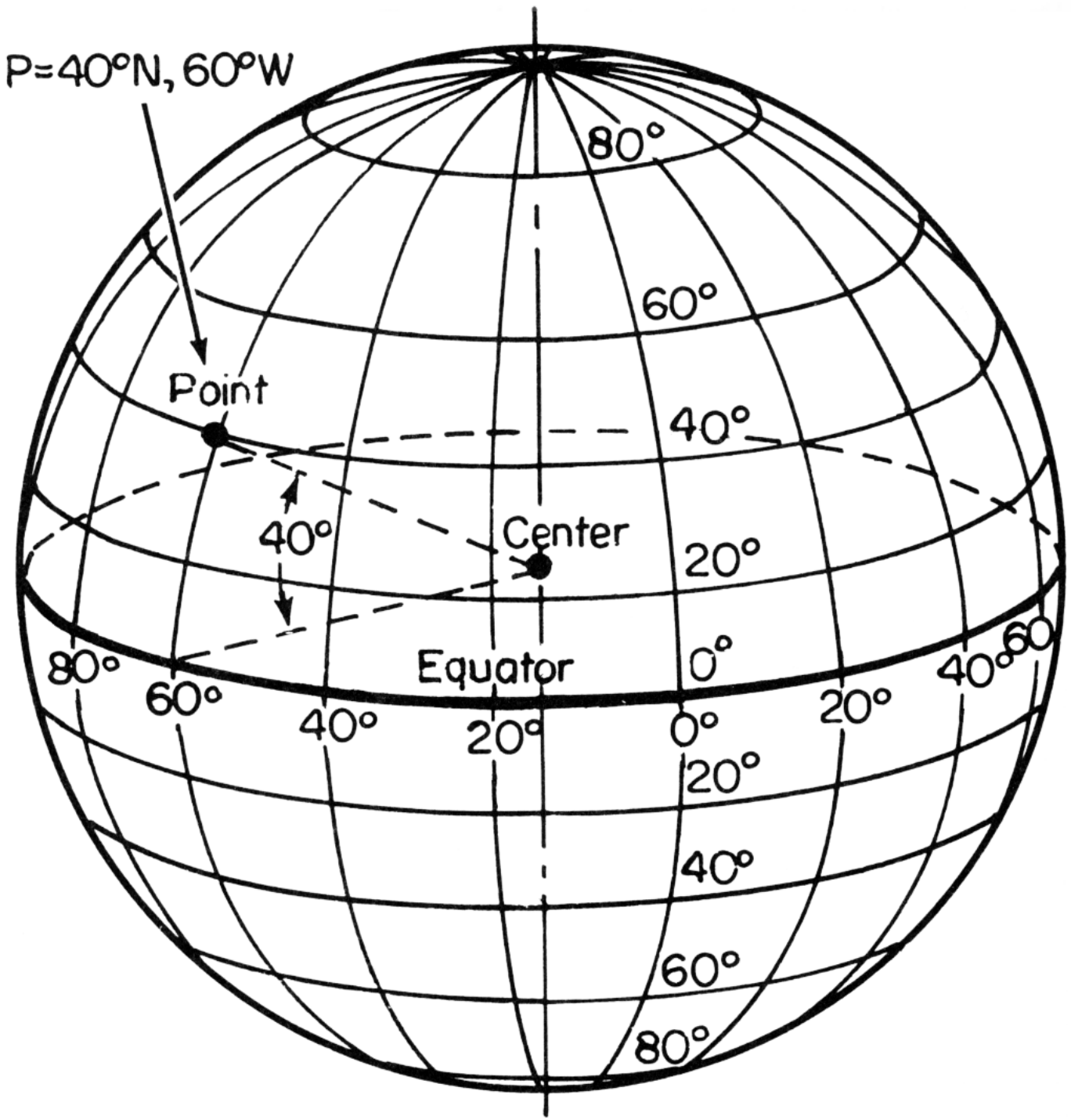
Coordinate reference systems





Eratosthenes ~200 BC

It actually is ~ 40,075 km (24,900 miles)


P=40°N, 60°W
Point
Center
Equator
80°
60°
40°
20°
0°
20°
40°
60°
80°
40°
20°
0°
20°
40°
60°
80°

Number(s) to remember

- Distance from the equator to a pole ≈ 10,000 km
- Circumference of the earth ≈ 4 * 10,000 = 40,000 km
- 1 degree at equator ≈ 40,000 / 360 = 111 km
  - 1 minute at equator ≈ 1.8 km
  - 1 second at equator ≈ 30 m
- Radius of the earth ≈ 40,000 / 2π = 6370 km
- Arusha (longitude, latitude) = (-36.68 , -3.39)

Degree – distance

- NS distance is independent of latitude
- EW distance depends on latitude

Longitude at the equator and latitude anywhere

- 1 degree = 111.11 km
- 1 minute = 1851 m
- 1 second = 30.8 m
- 30 seconds = 0.9 km (~ 1 km)
- 1 km = 0.009 deg
- 0.00001 degree ~ 1 m

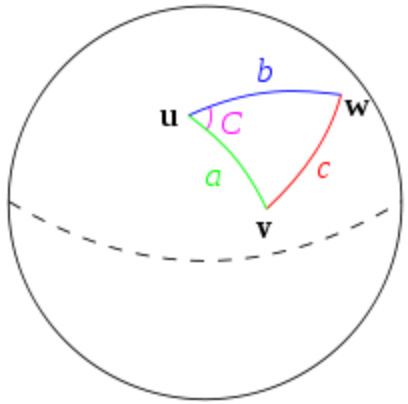
Degree - Distance computation

Spherical trigonometry

For example, distance between points *s* and *f*

$$\phi_s, \lambda_s; \;\; \phi_f, \lambda_f$$

ϕ = latitude, λ = longitude



spherical law of cosines

$$\Delta\widehat{\sigma} = \arccos\left(\sin\phi_s \sin\phi_f + \cos\phi_s \cos\phi_f \cos\Delta\lambda\right).$$

$$d = r\,\Delta\widehat{\sigma}.$$

R package geosphere

Map projections

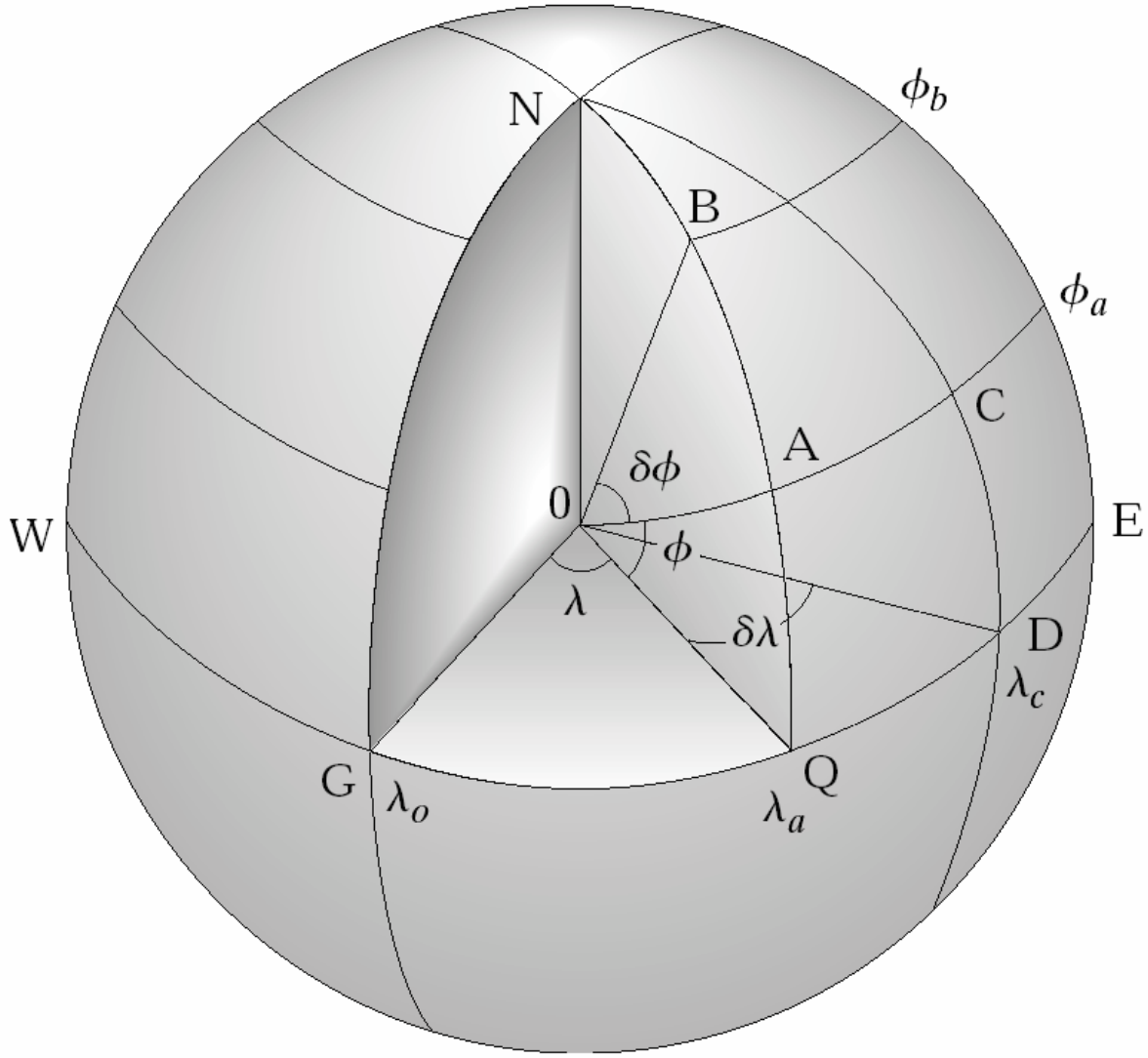
A *projection* is defined by a functional relationship between points (x, y) on the plane surface (map) and (ϕ, λ) on the globe.

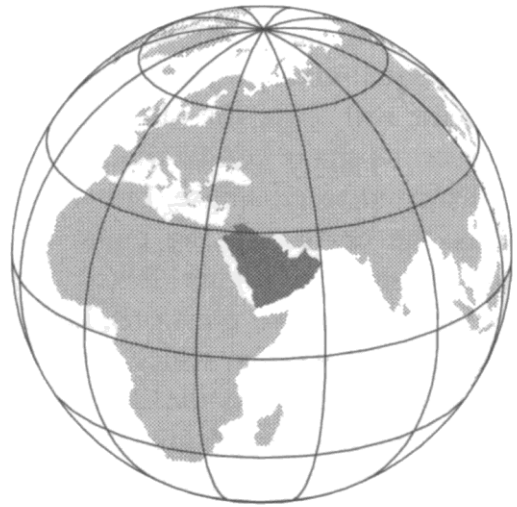
ϕ = latitude

λ = longitude

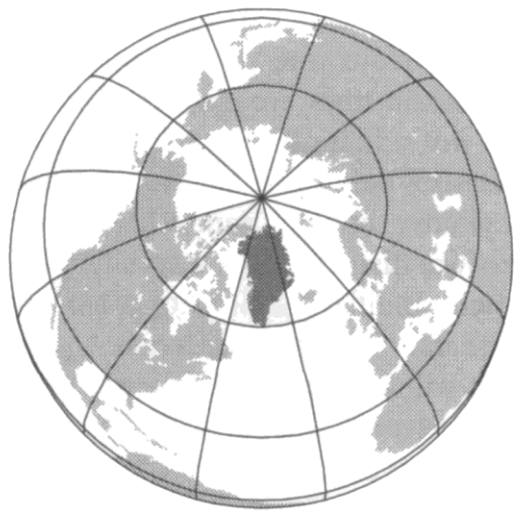
$x = f(\phi, \lambda)$

$y = g(\phi, \lambda)$

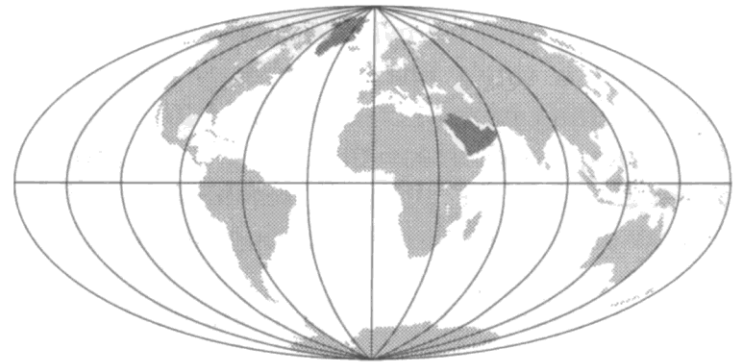




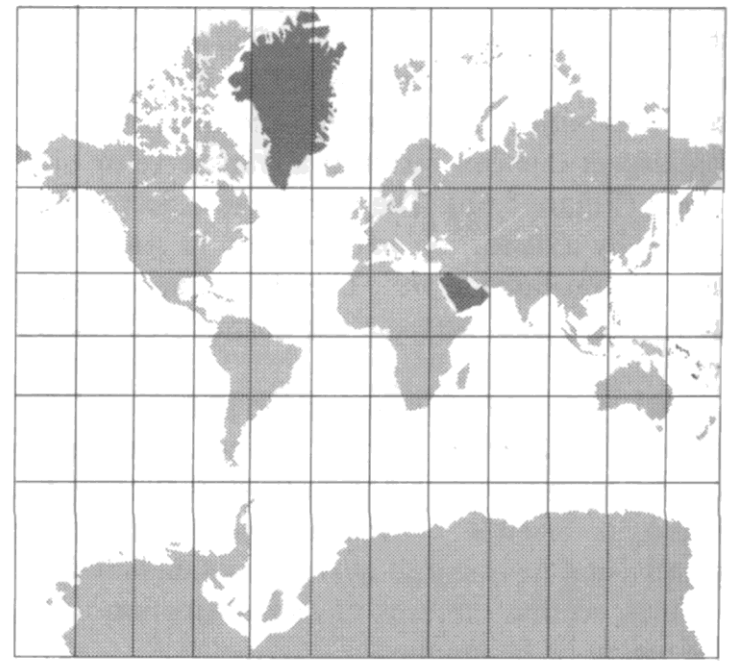
(a)

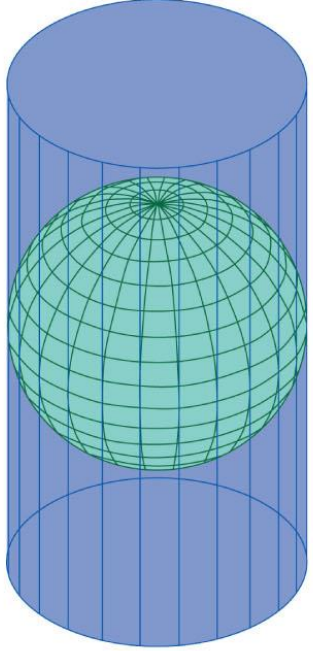


(b)



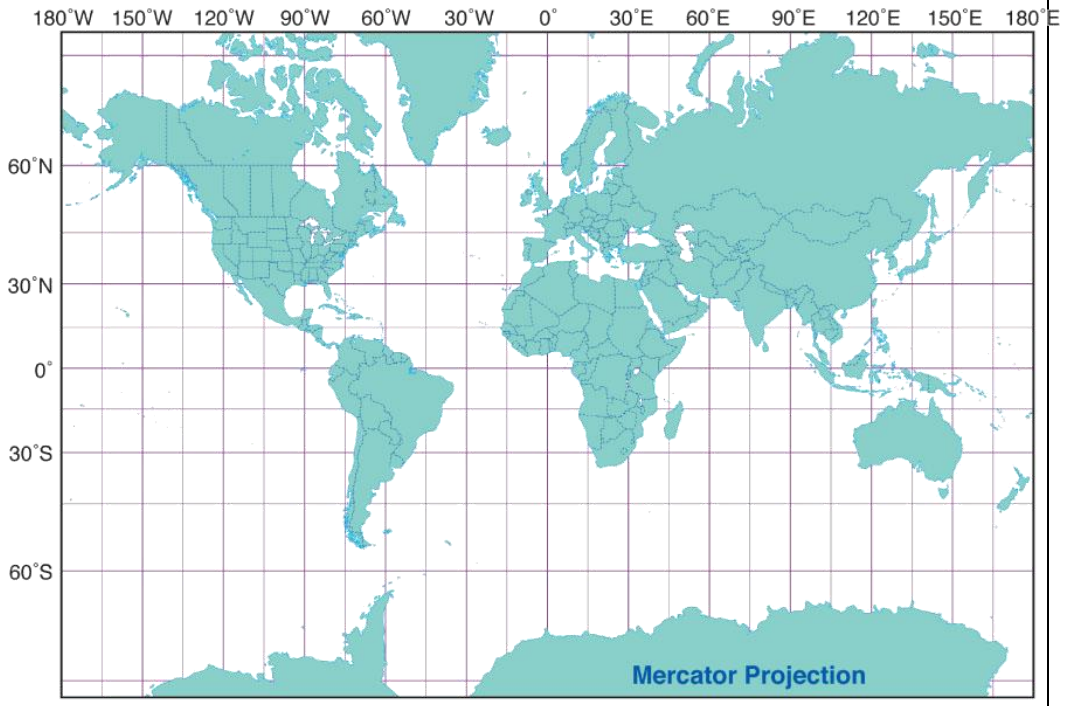
(c)

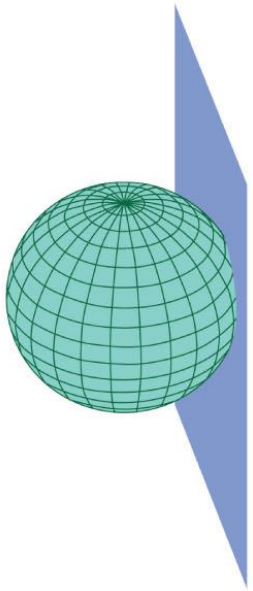




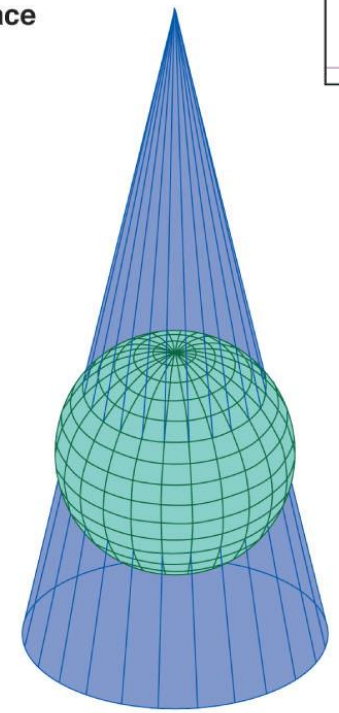
Cylindrical Projection Surface

Mercator

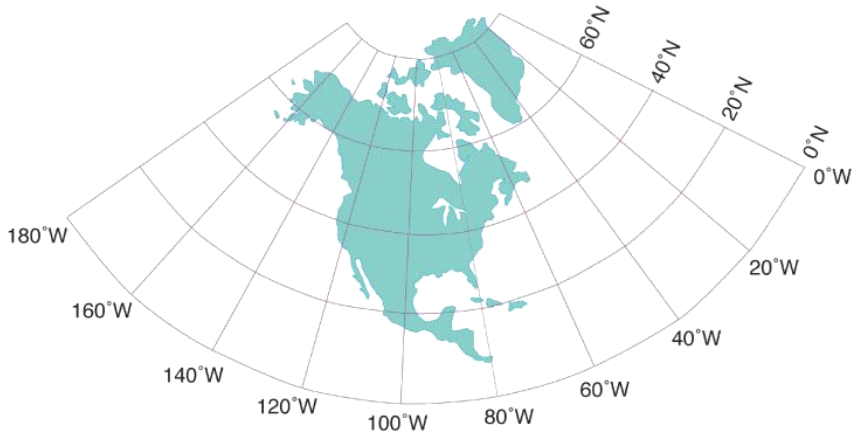




Secant Planar Projection



Secant Conic Projection



North America
Lambert Conformal Conic
Origin: 23N, 96W
Standard Parallels: 20N, 60N

Cylindrical equal area projection

A cylindrical equal area projection is obtained by projecting the sphere directly onto a tangent cylinder

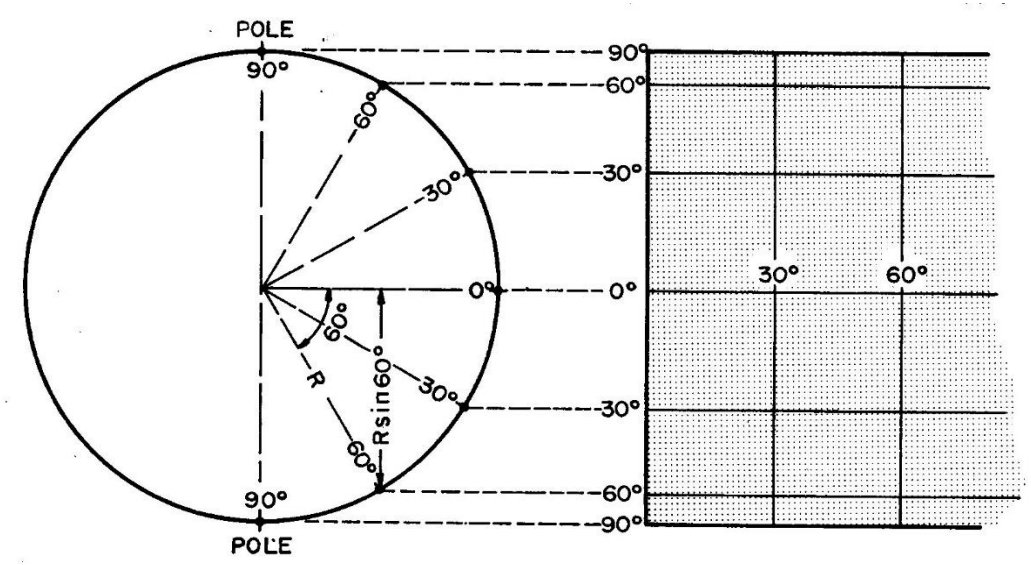
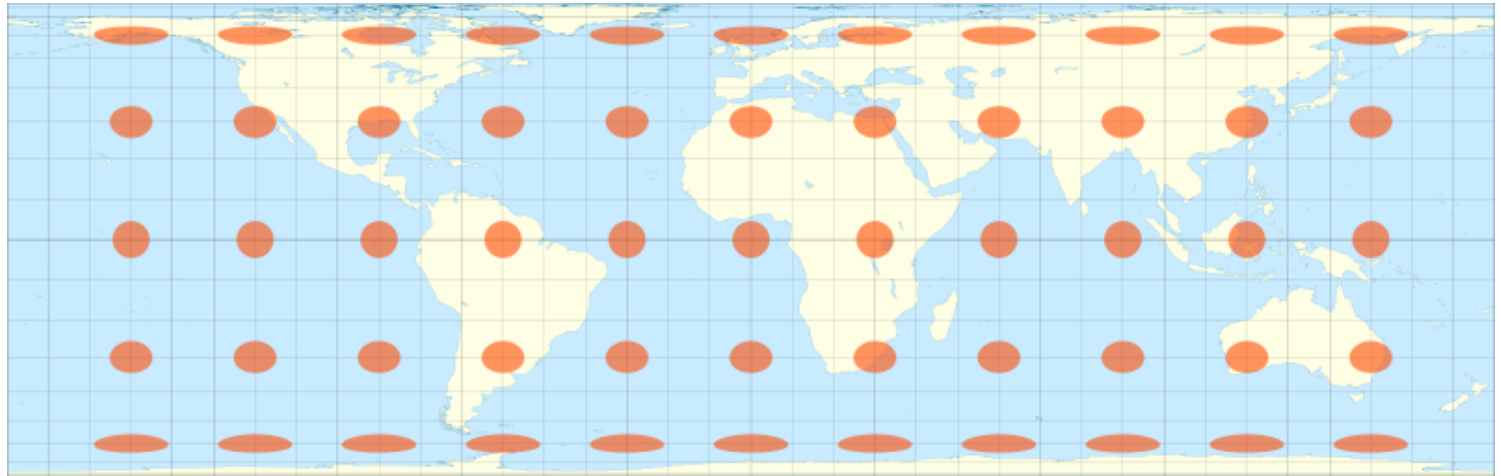
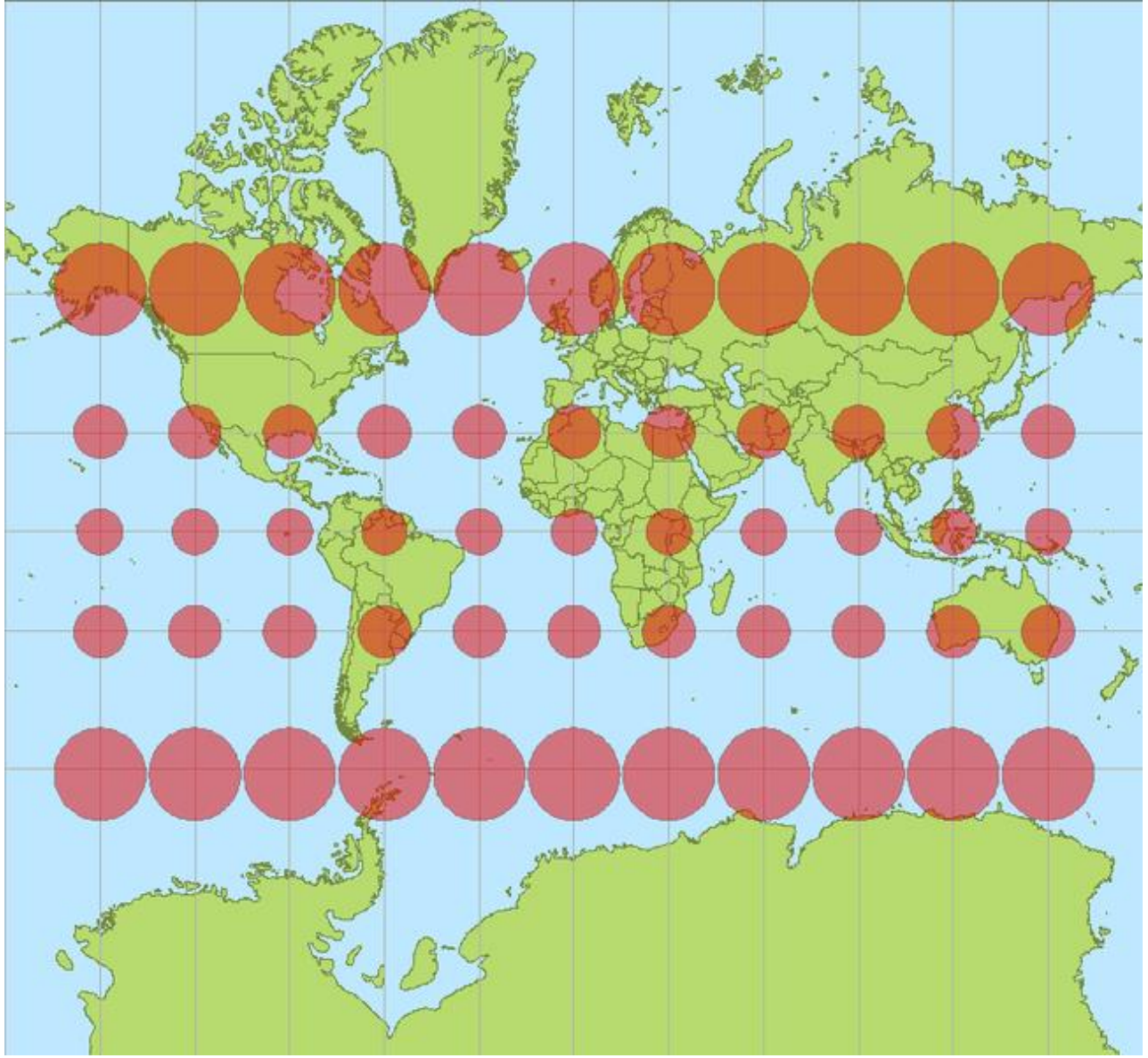


FIG 4-1a Cylindrical equal-area projection and its generating globe.

$$x = C\,\lambda$$
$$y = C \sin\phi$$



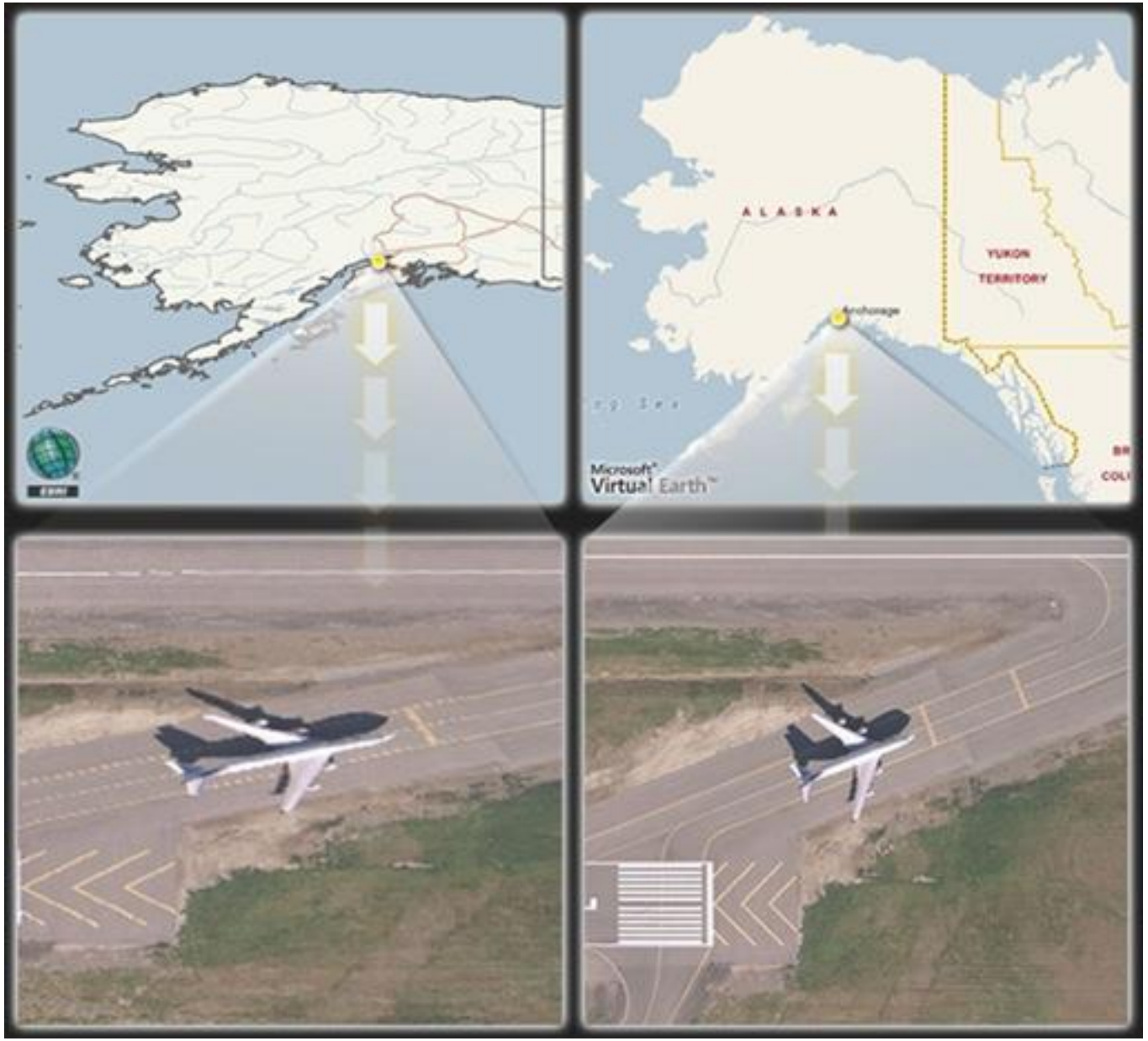
Tissot's Indicatrix (1859)



Mercator

$$x = C\,\lambda$$

$$y = C\,ln\,\tan(\phi) + \sec(\phi)$$

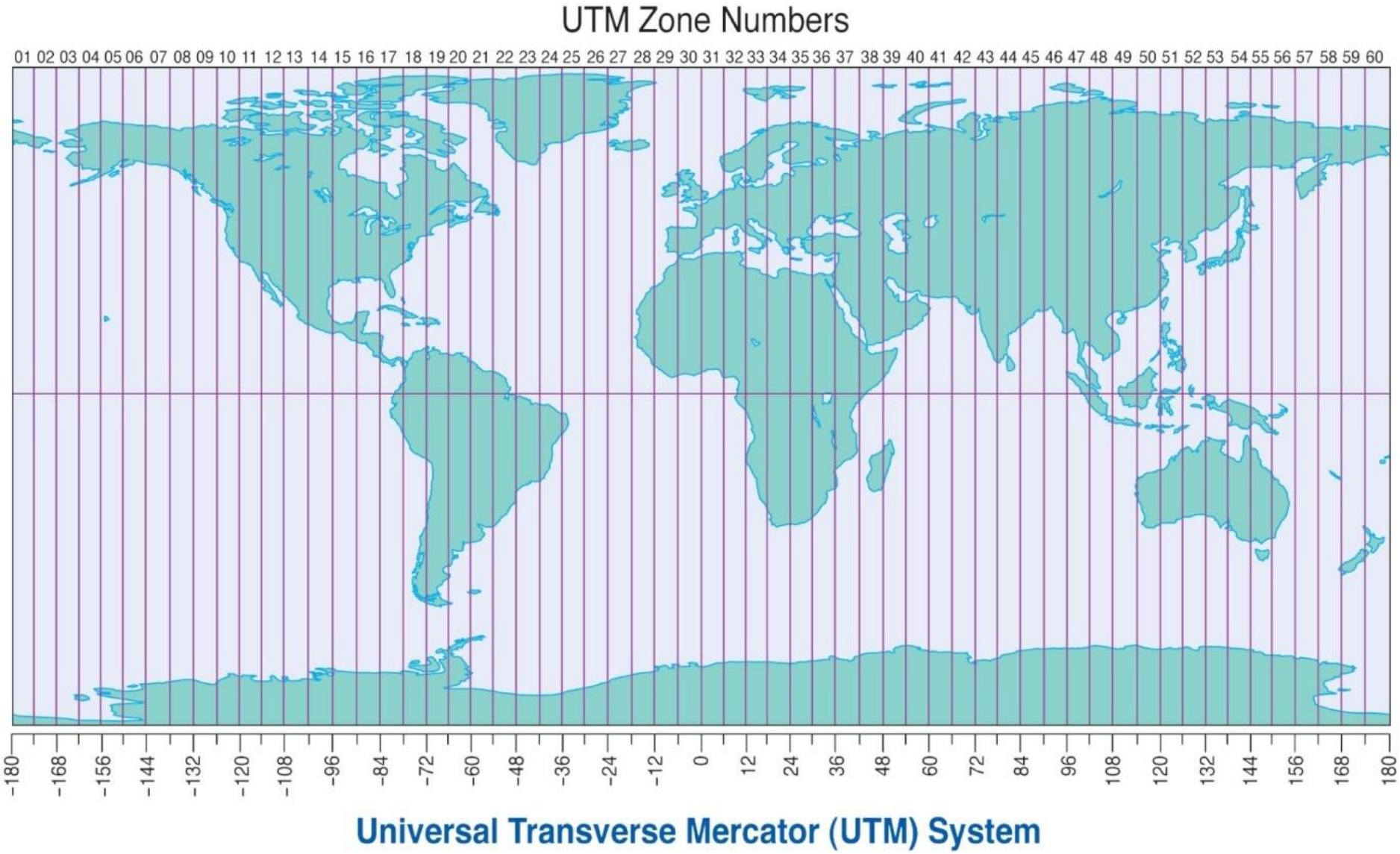


http://idvux.spaces.live.com/blog/cns!2EB6AAF6C3AC1EBE!259.entry

http://idvux.spaces.live.com/blog/cns!2EB6AAF6C3AC1EBE!259.entry

Universal Transverse Mercator

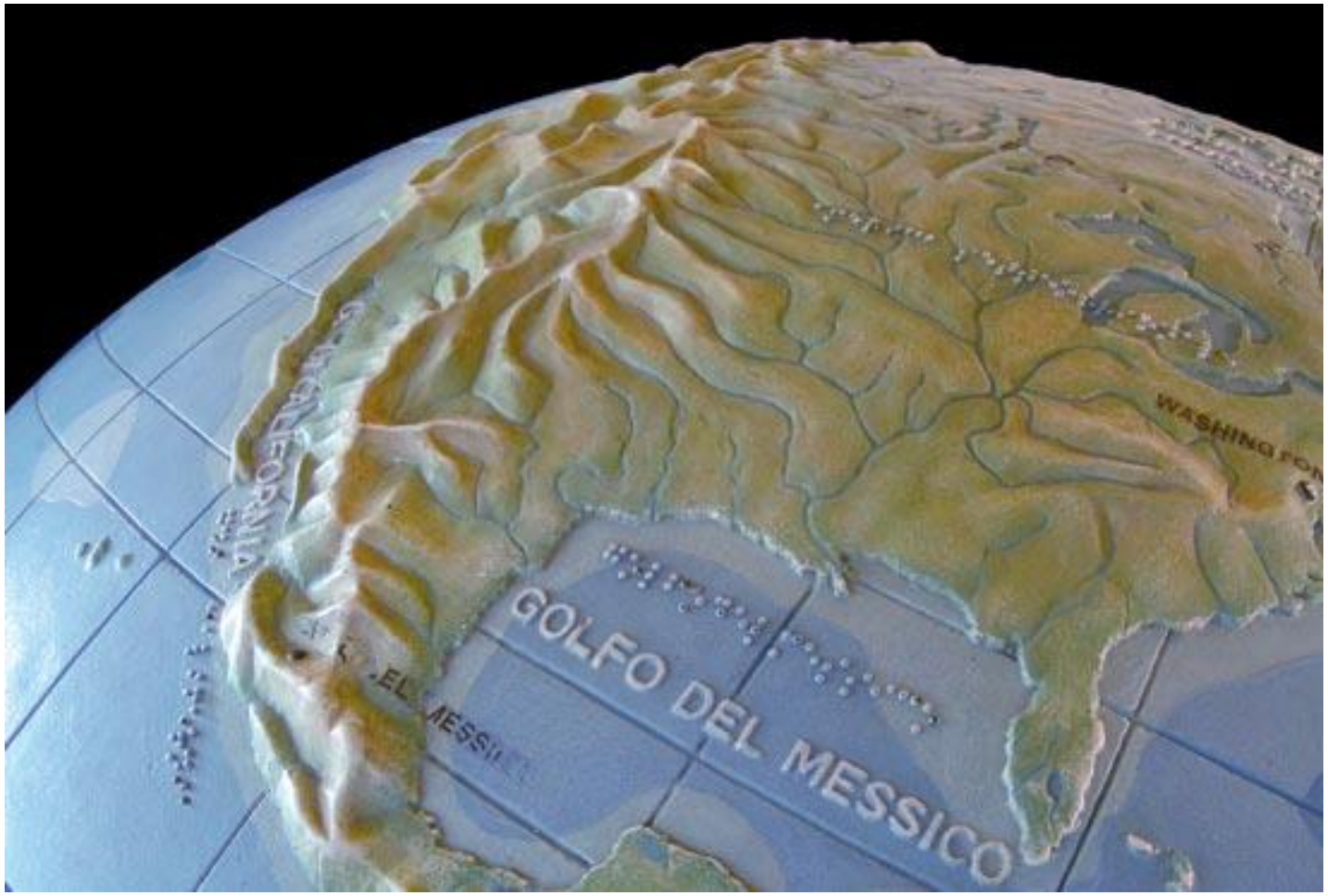
- 60 zones across the earth
- Each zone is 6° wide (≈ 660,000 m)
- Location is measured in meters away from the center of the zone
- Coordinates are called *northings* and *easting*



The system of zones of the Universal Transverse Mercator system. The zones are identified at the top. Each zone is six degrees of longitude in width

(Map by Peter H. Dana)

The earth is not a sphere!



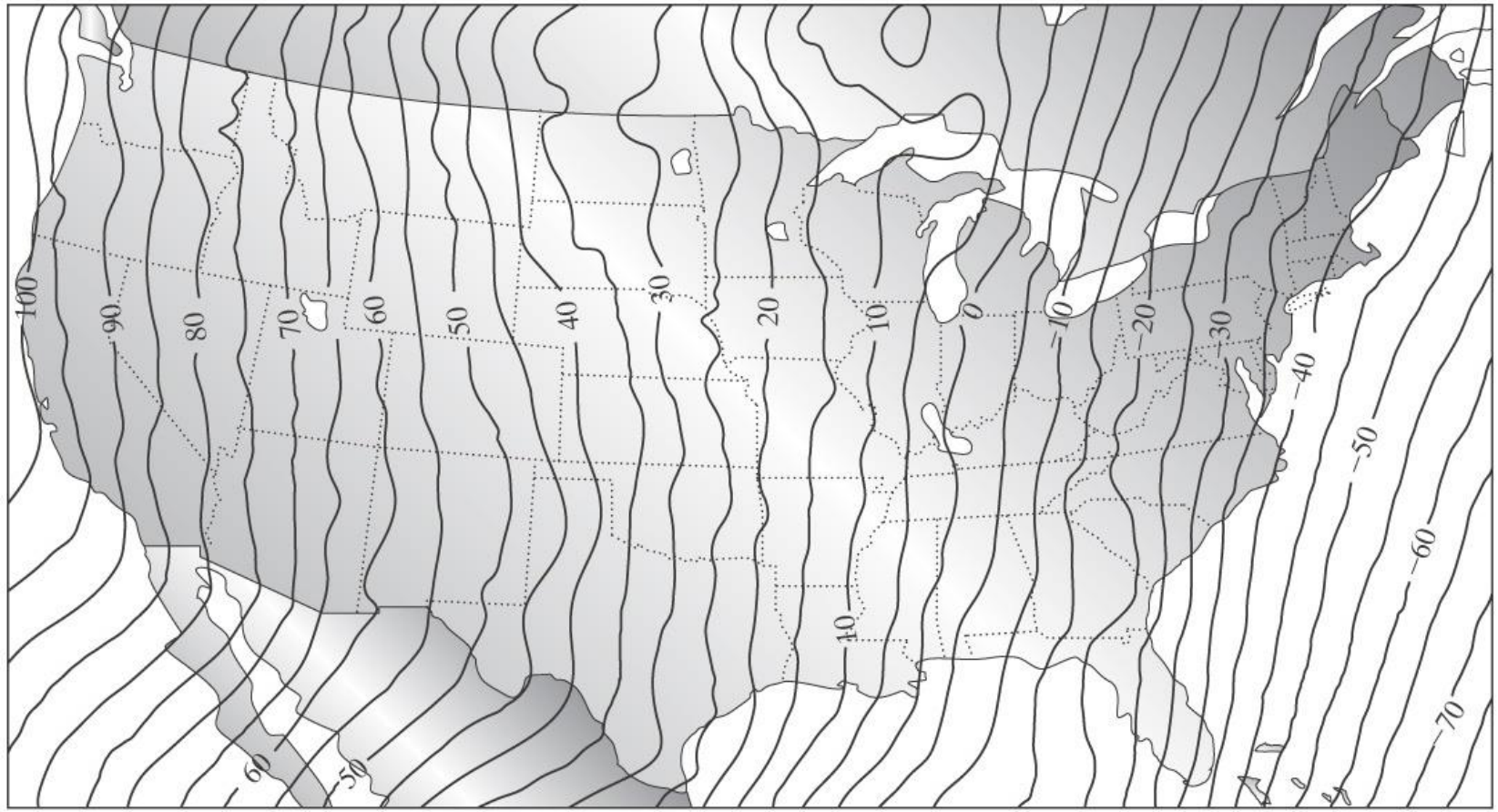


Figure 2.19(b) Longitude datum shift NAD83 – NAD27