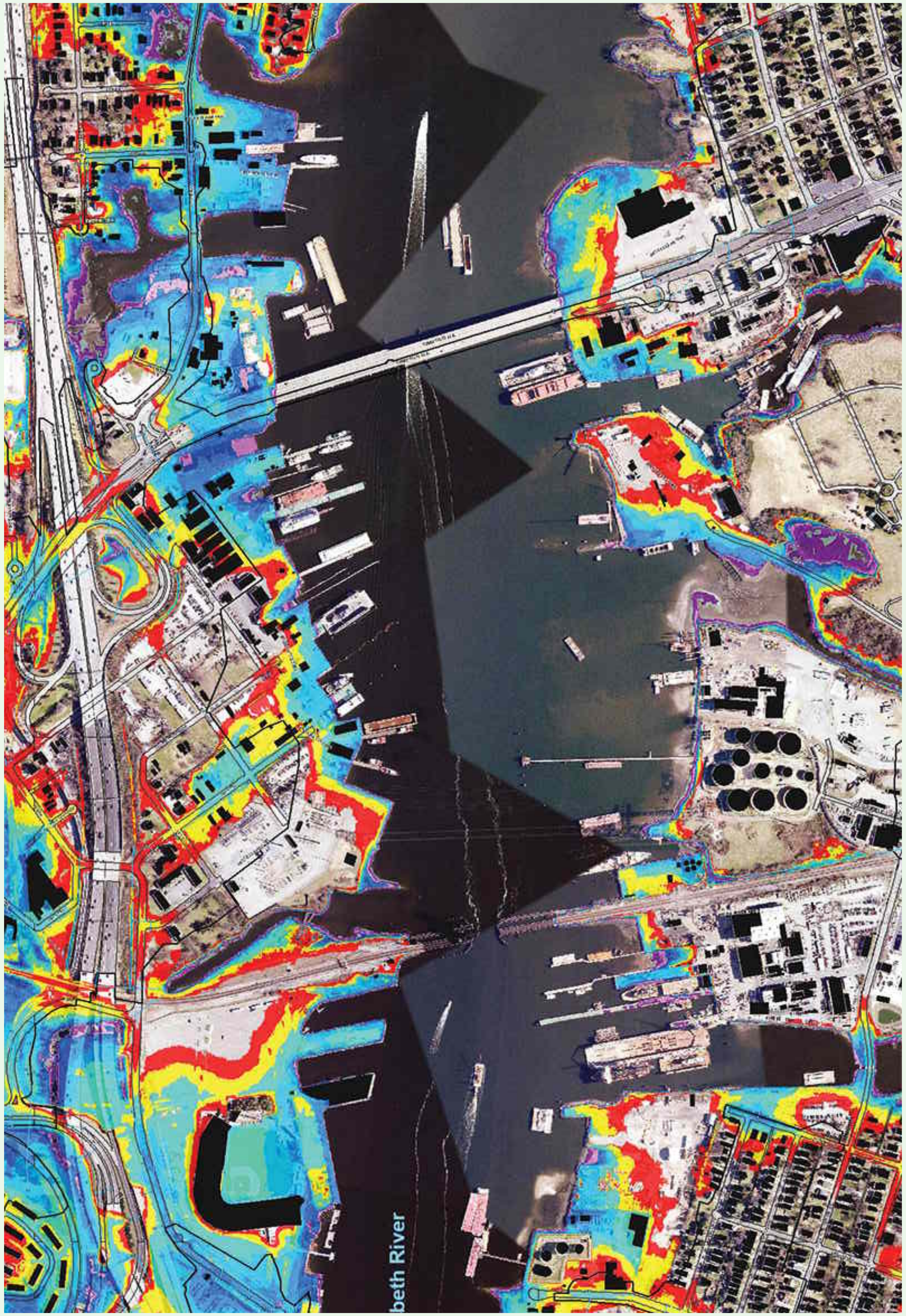
GEOG 358: Introduction to Geographic Information Systems

Measuring location on Earth's surface



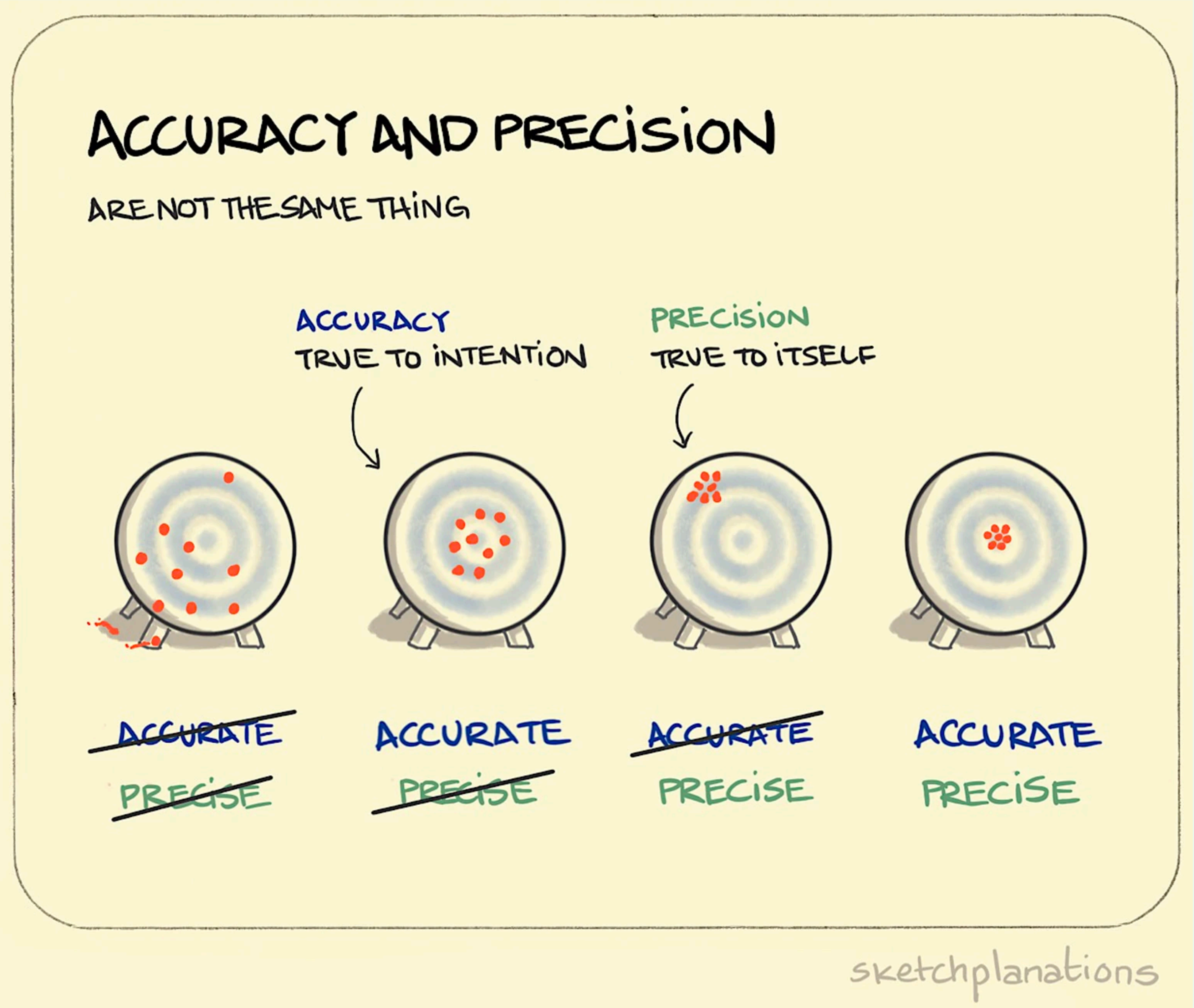
Measuring location on Earth’s surface

Topics

- Measurement
- Latitude and longitude
- Ellipsoids, geoids, & datums, oh my!
- Geographic coordinate systems
- Map projections

Measurement

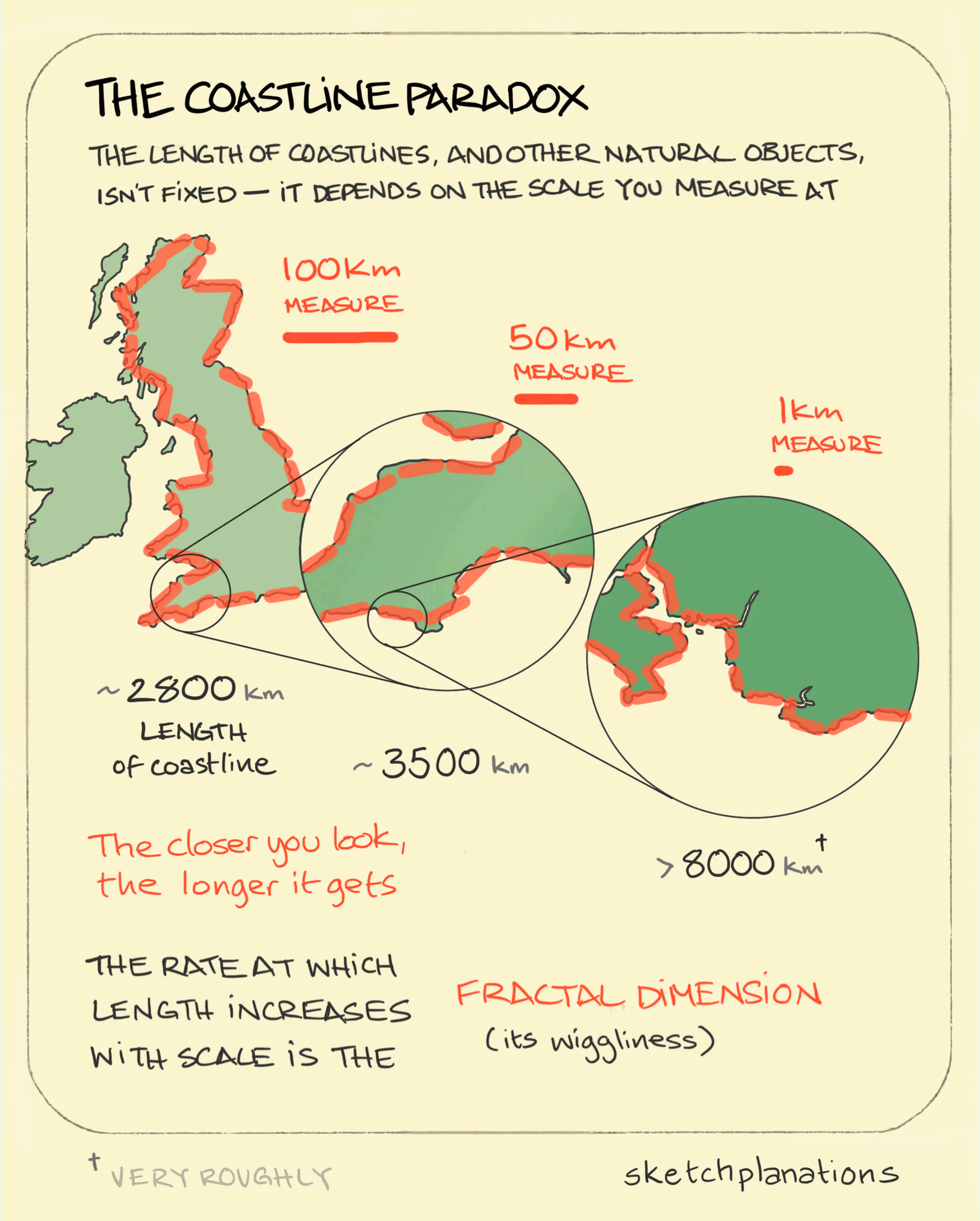
Accuracy & precision



Measurement

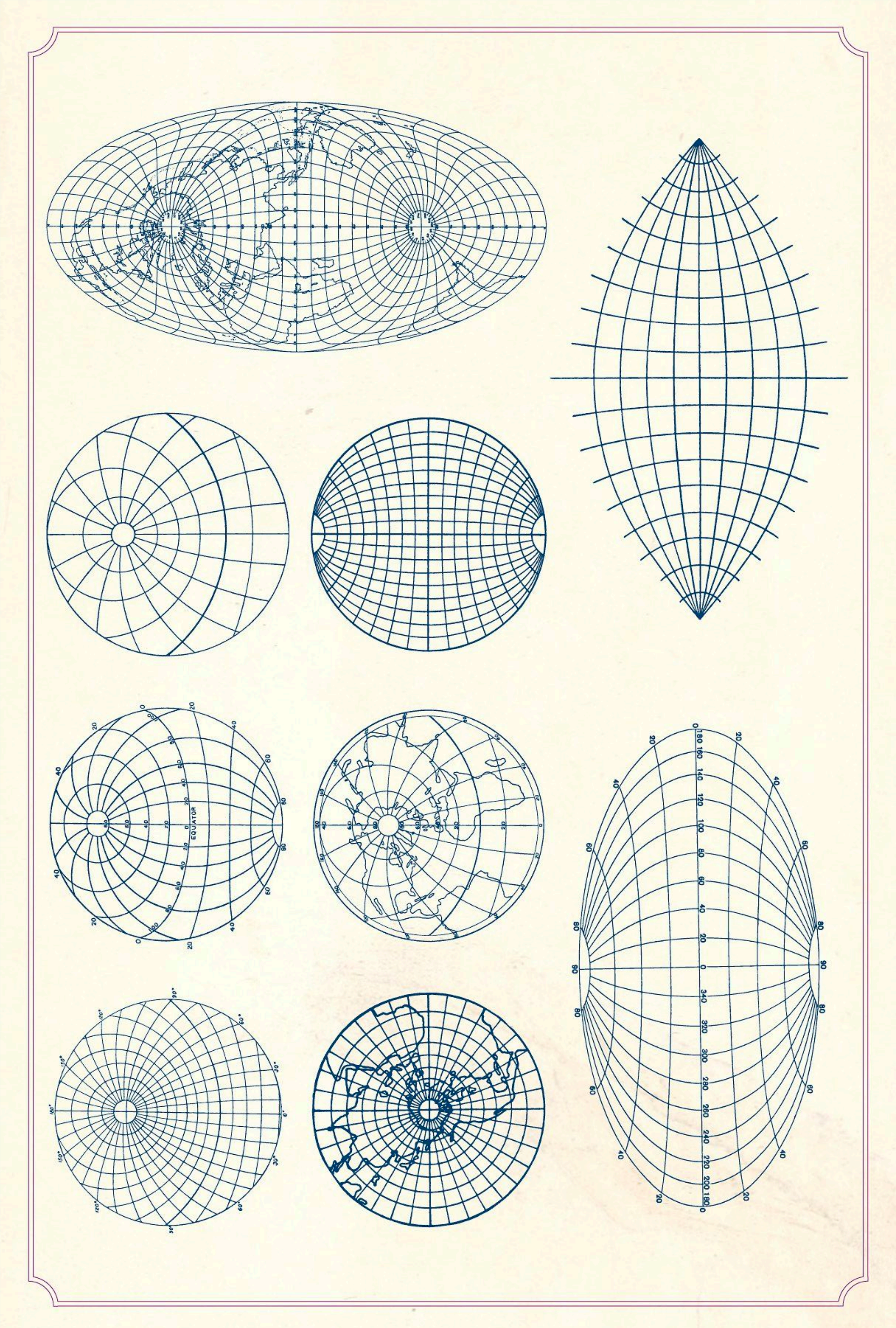
Simplification of complexity

- generalization of phenomena
- always an approximation
- need standards
- necessary level of detail



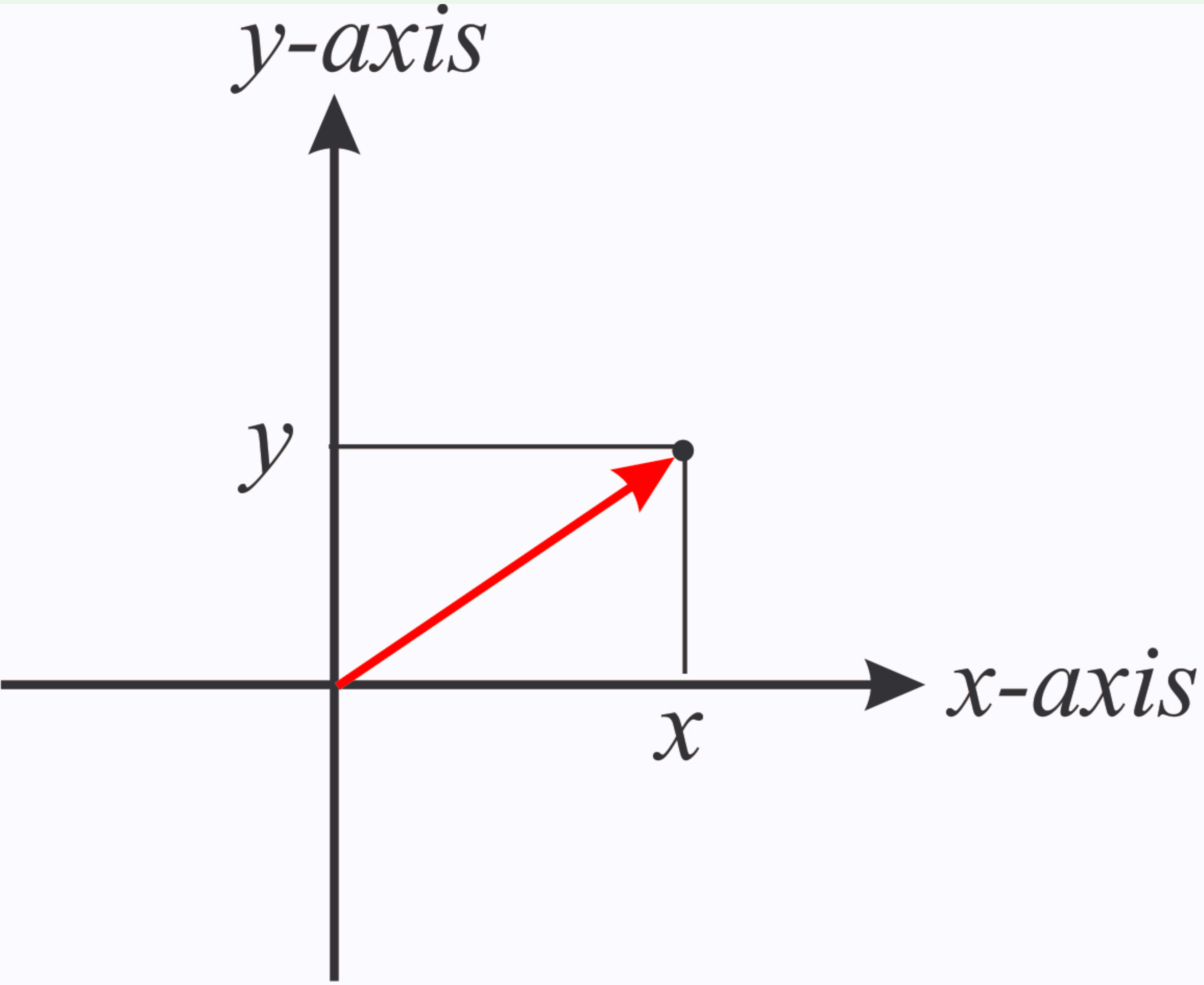
Basic Coordinate Systems

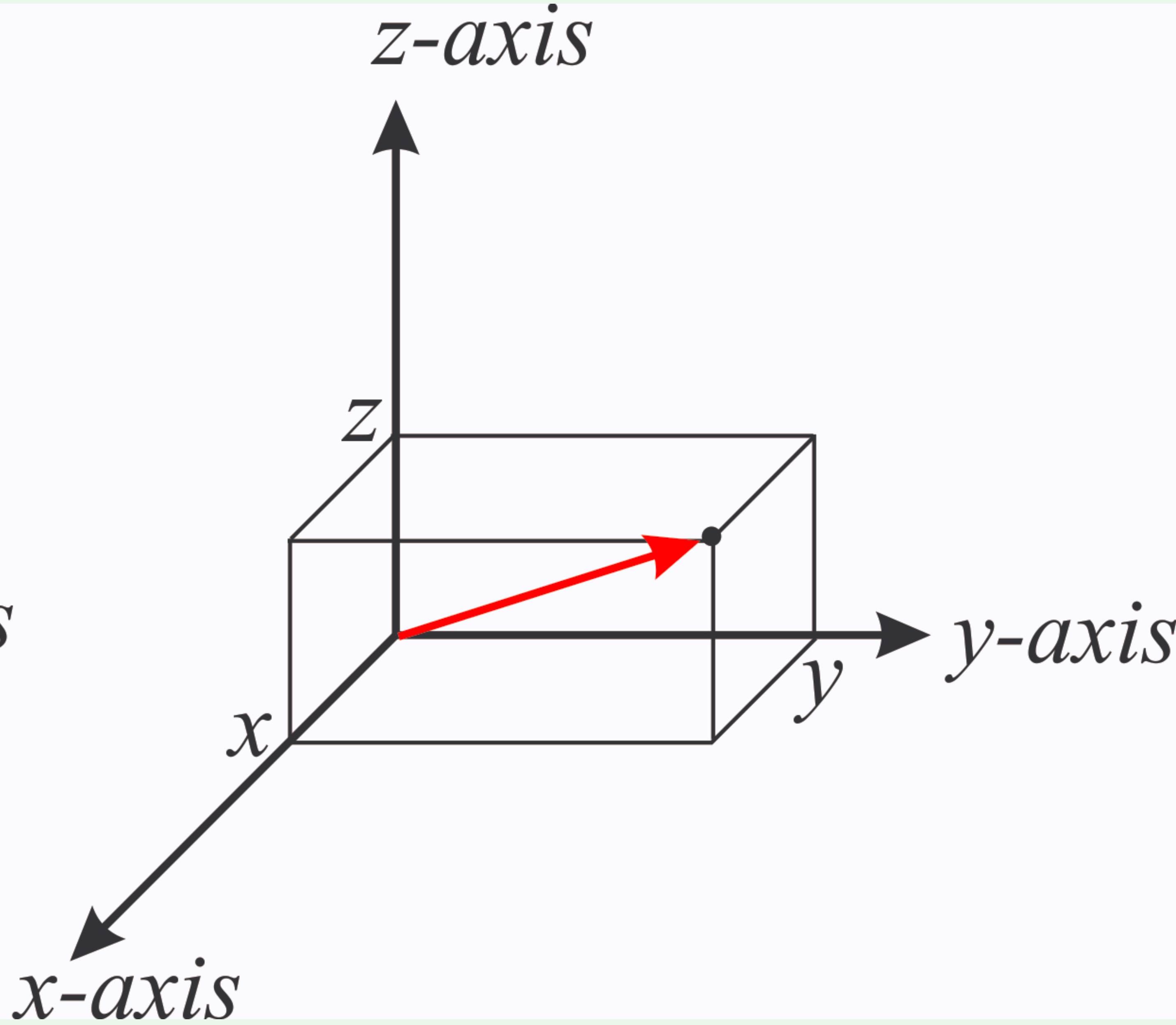
- unambiguously specify location in space
- relationships between locations can be calculated
    - distance
    - direction



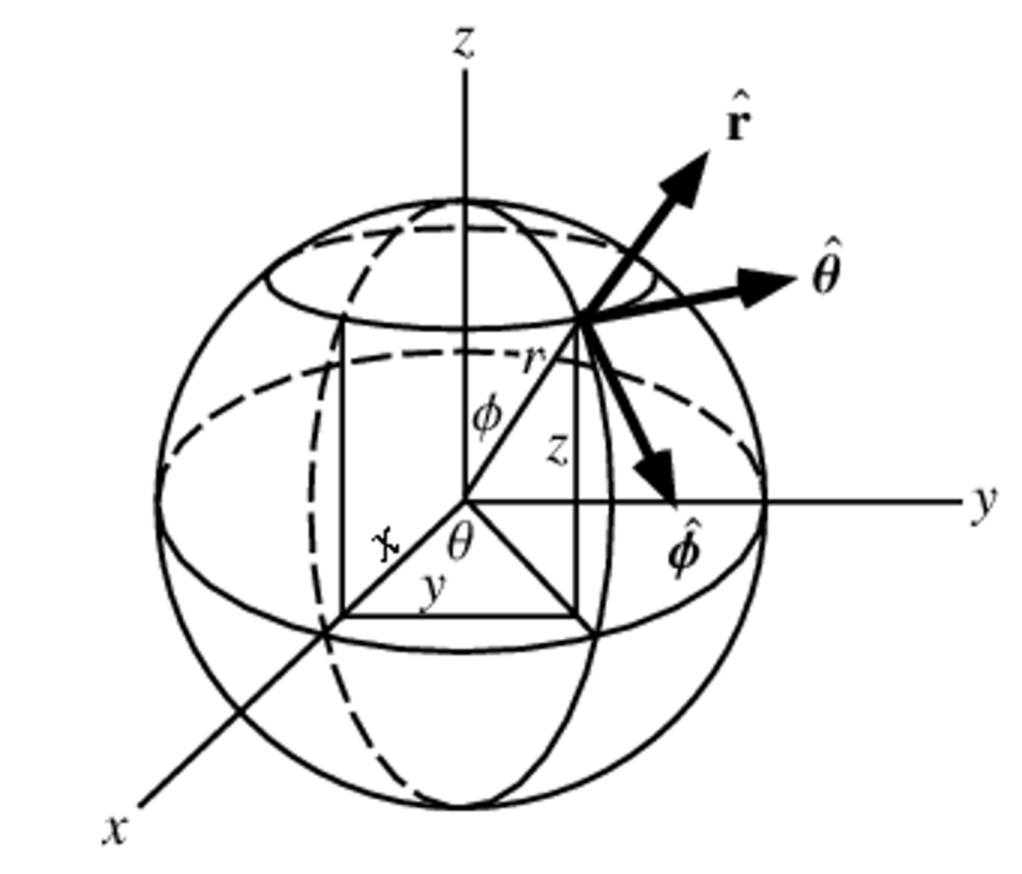
Cartesian coordinate systems

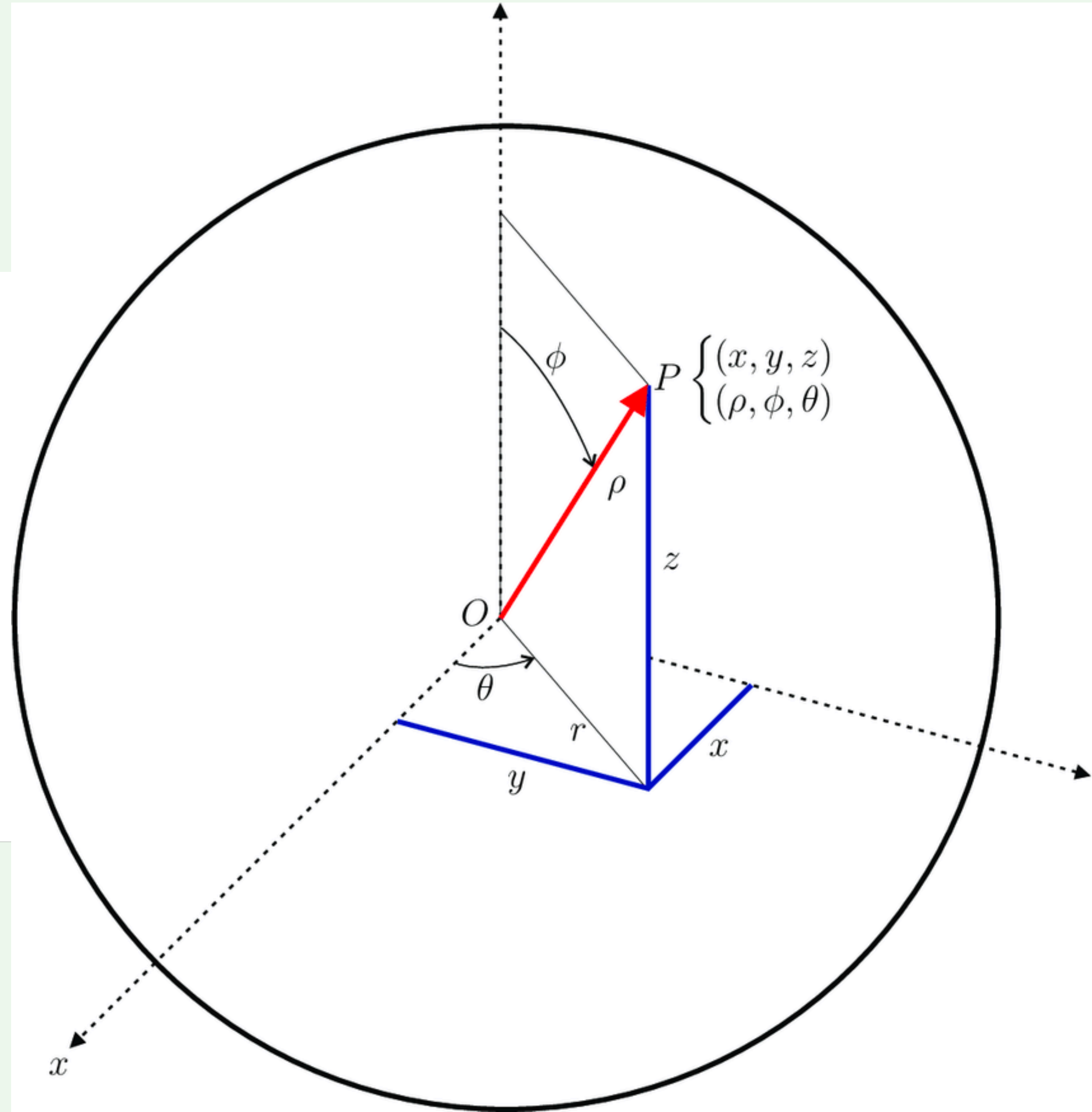
2-dimensional and 3-dimensional



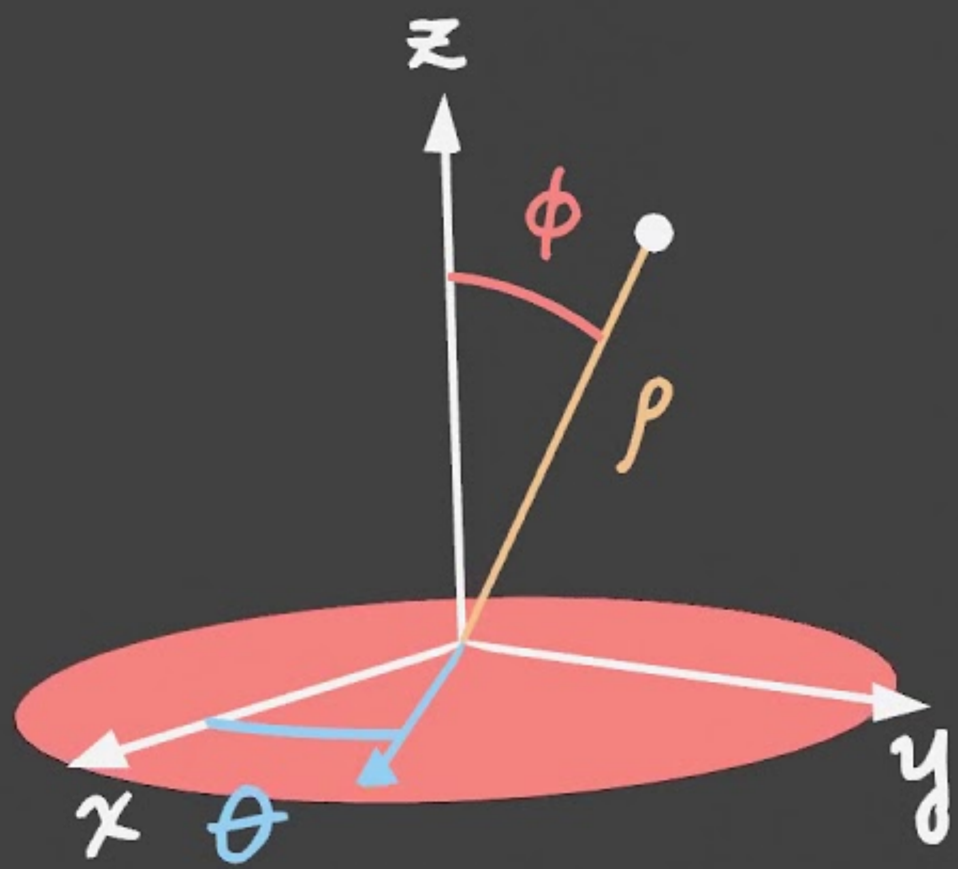


Spherical coordinate systems





Spherical Coordinates: (ρ, θ, ϕ)



ρ is the distance from the origin.
You can think of this as a 3D radius

θ is measured from the positive x axis,
in the direction of the positive y axis

ϕ is measured from the positive z axis

Defining coordinate systems

Four main issues

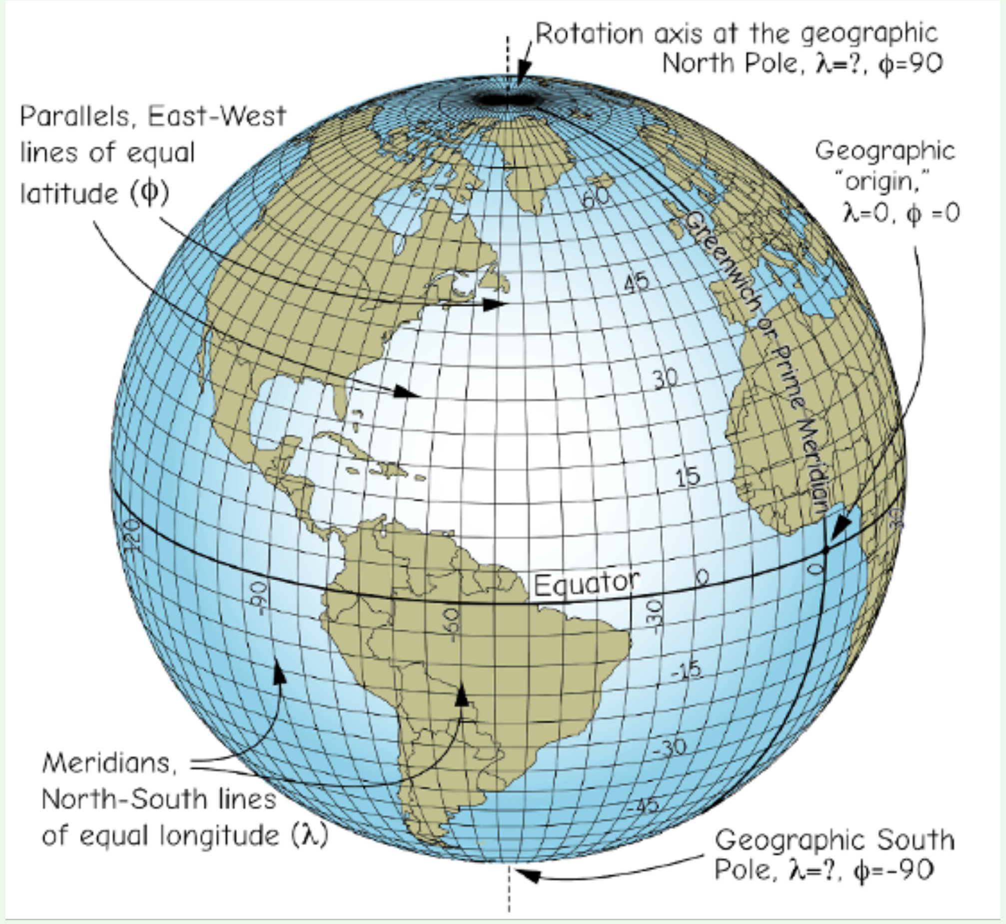
- Translating a 3-d surface onto a 2-d map
- Earth has an irregular surface
- Uncertainty in measurement
- Earth's surface is dynamic

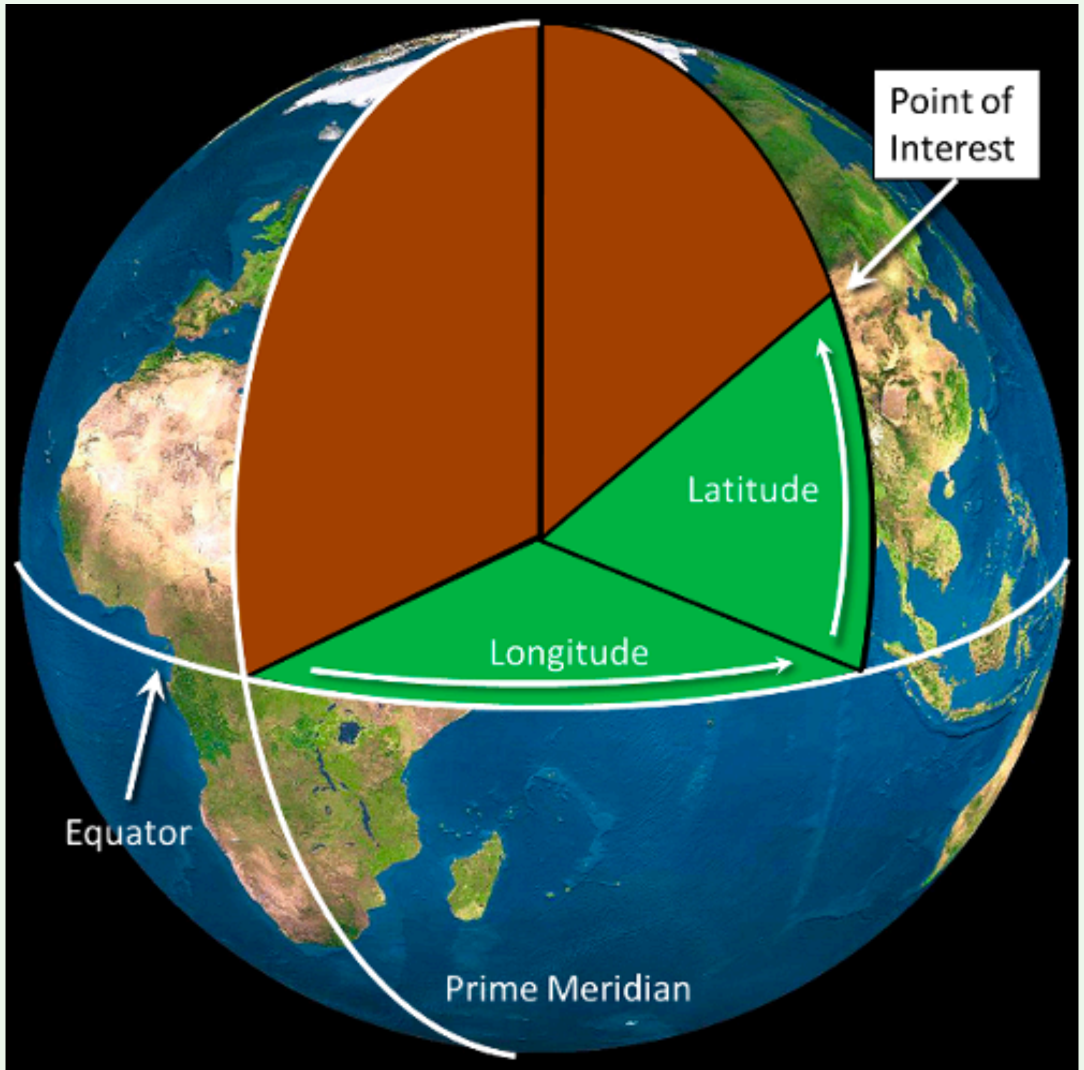
Geospatial coordinate systems

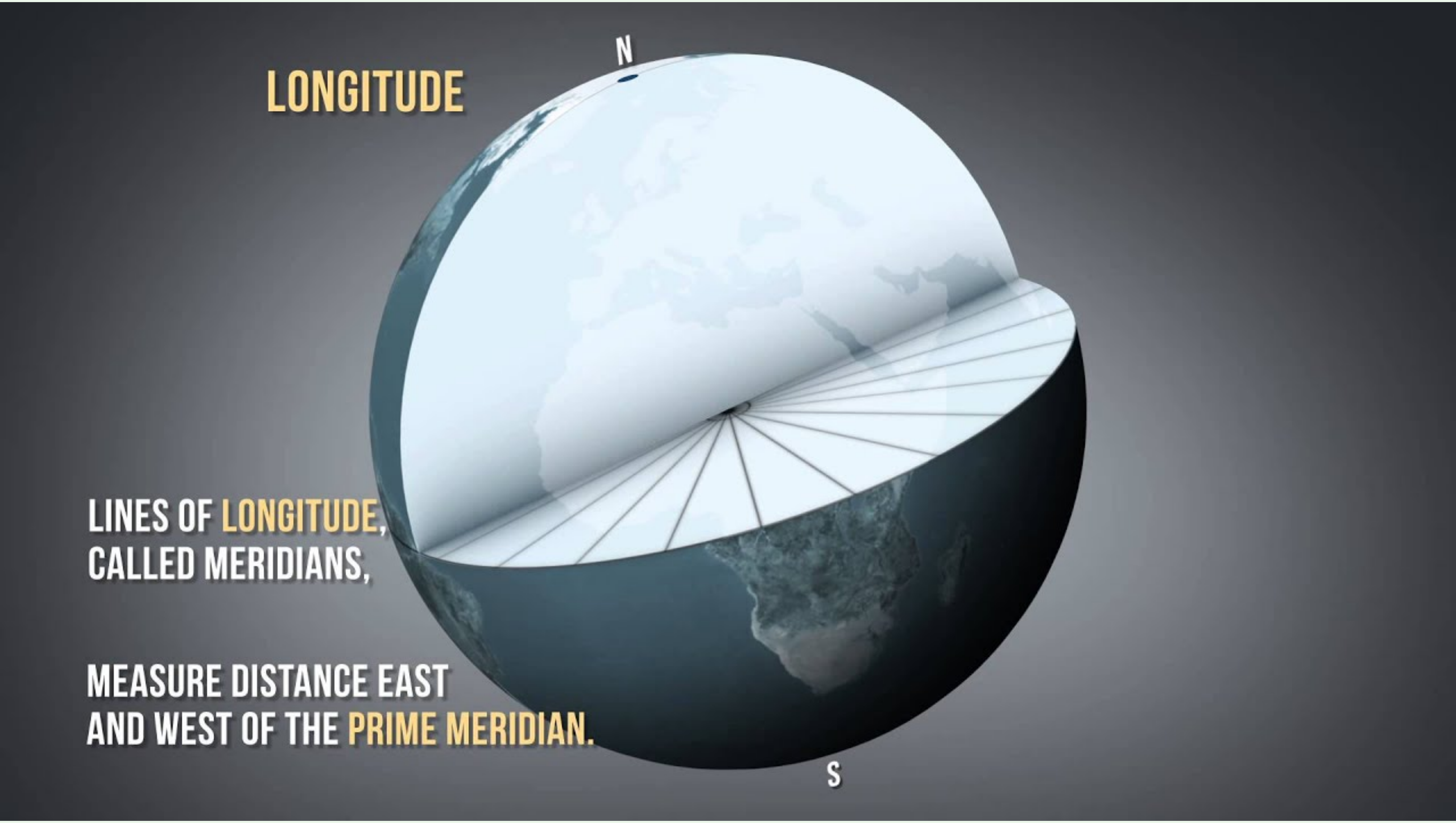
- Location on or close to Earth's surface
- Geometric model to approximate size and shape of Earth
    - sphere
    - ellipsoid

Latitude & longitude

- Latitude is measured location in the North-South direction
  - ϕ
  - parallels
- Longitude is measured in the East-West direction
  - λ
  - meridians

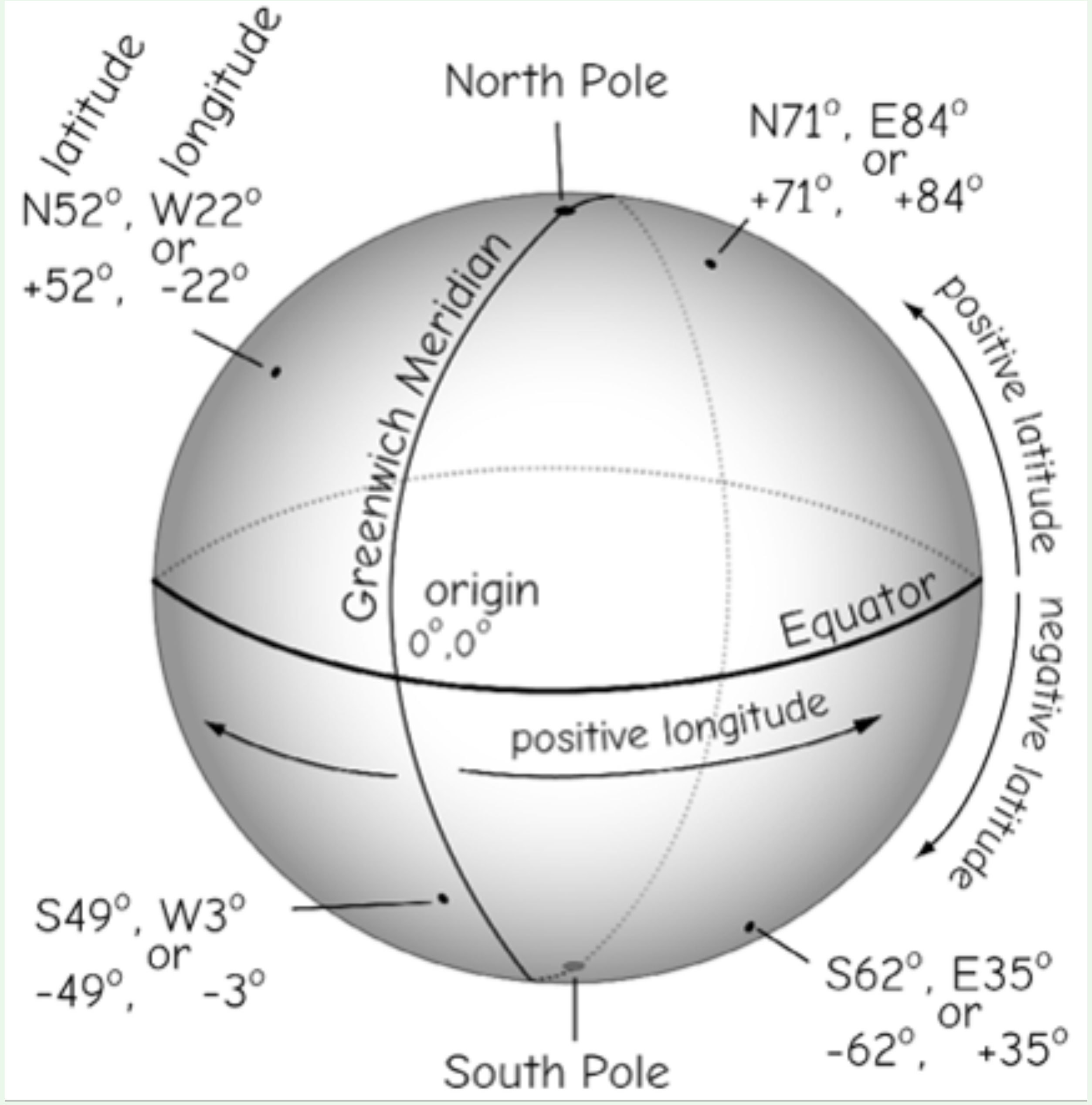





N
LONGITUDE
LINES OF LONGITUDE,
CALLED MERIDIANS,
MEASURE DISTANCE EAST
AND WEST OF THE PRIME MERIDIAN.
S

Signs & units

- Signs
  - N (+), S (-) for latitudes
  - E (+), W (-) for longitudes
- Degrees
  - a circle has 360 degrees
- Degrees, Minutes, and Seconds (DMS)
  - 35° 46’ 20”
- Decimal Degrees (DD)
  - 35.7722°
- Conversion
  - Decimal Degrees = **Degrees** + **Minutes**/60 + **Seconds**/3600
  - 35 + 46/60 + 20/3600 = 35.7722°



Latitude & longitude

Practice

- N 45° 45′ 45″
- longitude -127.34795°
- S 96° 12′ 33″
- E 66° 15′ 60″
- W -12° 23′ 55″
- N 56.9999°

Latitude & longitude

Practice

DMS to DD

$$36° \; 45' \; 12'' \quad = 36 + 45/60 + 12/3600$$

$$= 36 + 0.75 + 0.0033$$

$$= 36.7533$$

Latitude & longitude

Practice

DD to DMS

36.7533° **D** = 36

M = 0.7533 x 60

= integer of 45.198

= 45

S = 0.198 x 60

= 11.88

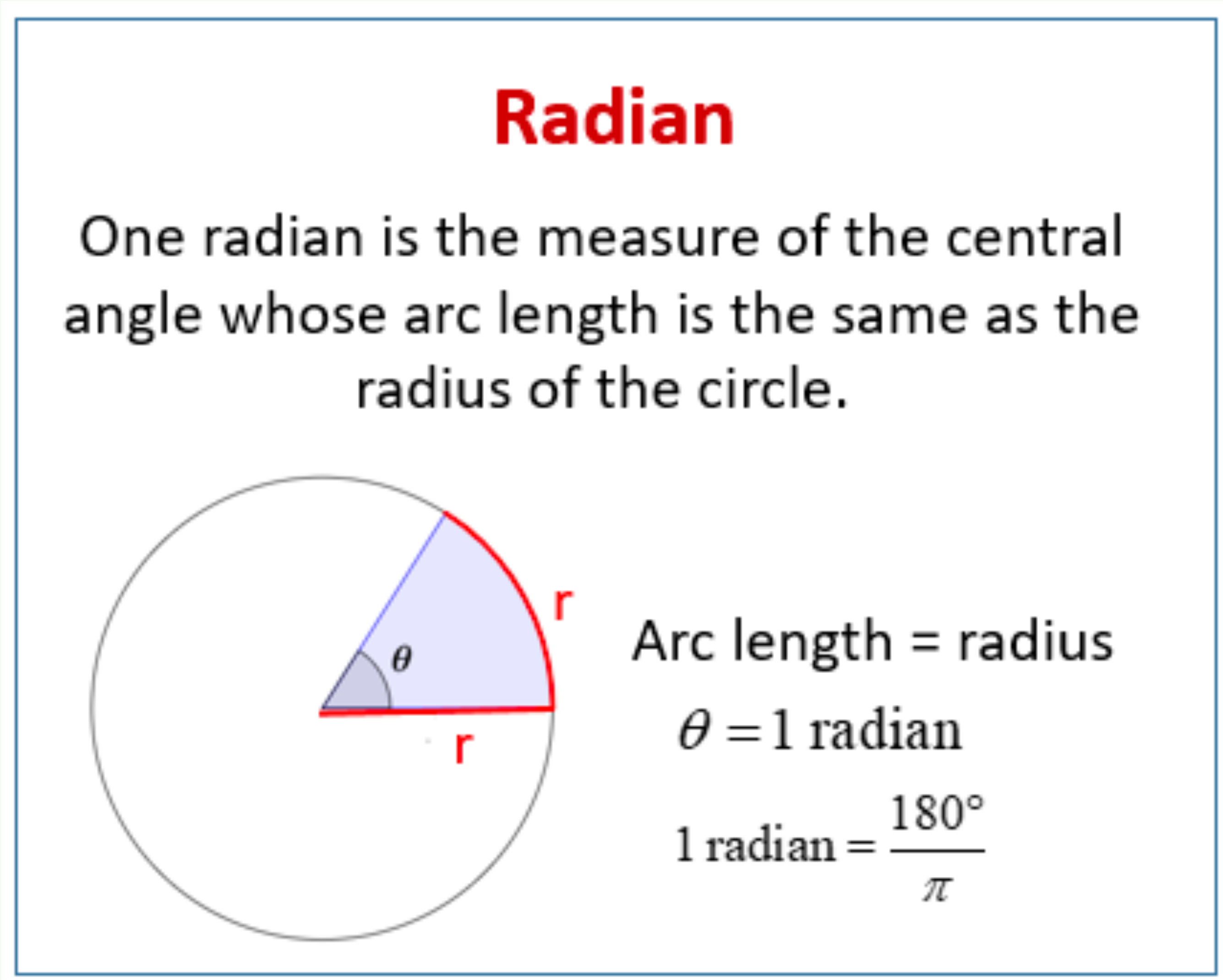
DMS = 36° 45′ 12″

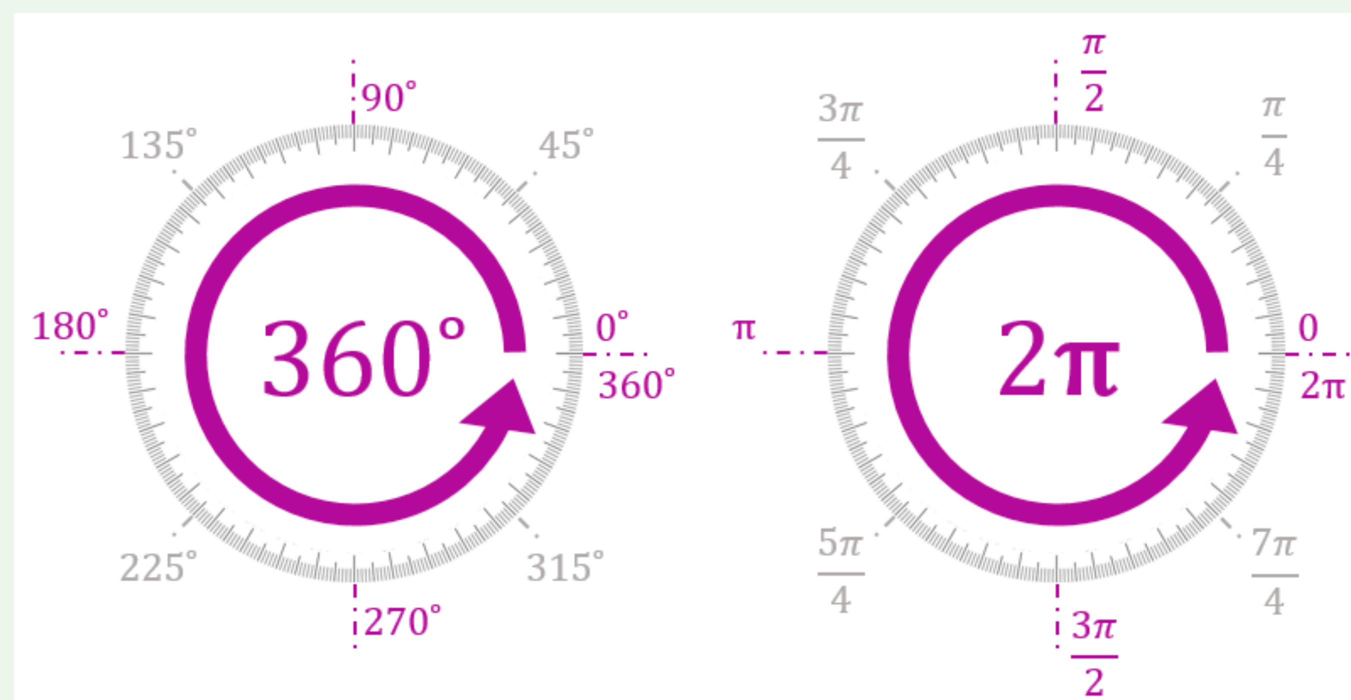
Radians

- Radian is the angle where the arc length is equal to the radius of a circle
- 1 radian = $180/\pi$

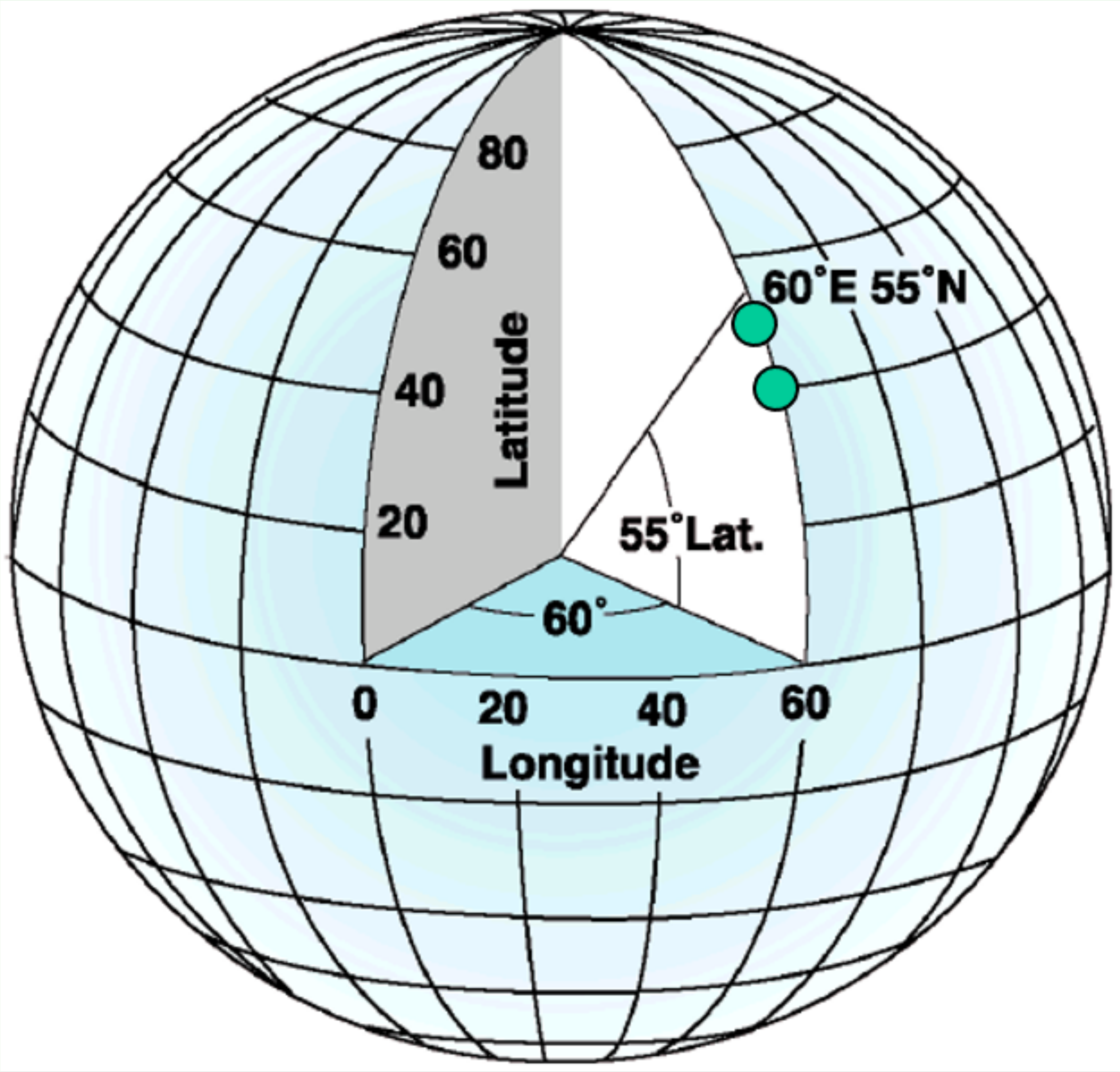
  $\approx 57.2957795°$

- radians to DD
  - r x 57.2957795°
- DD to radians
  - DD / 57.2957795°



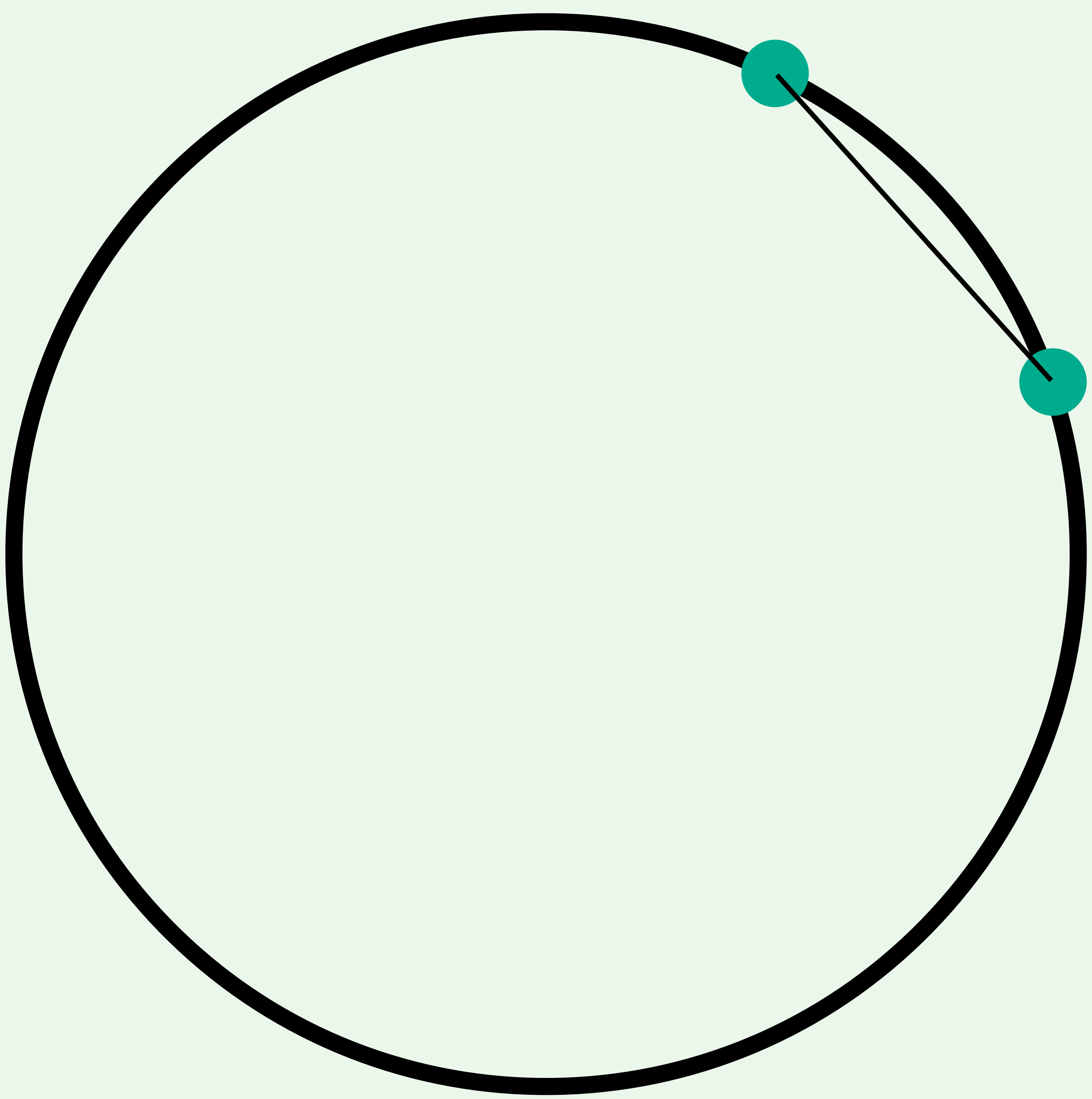


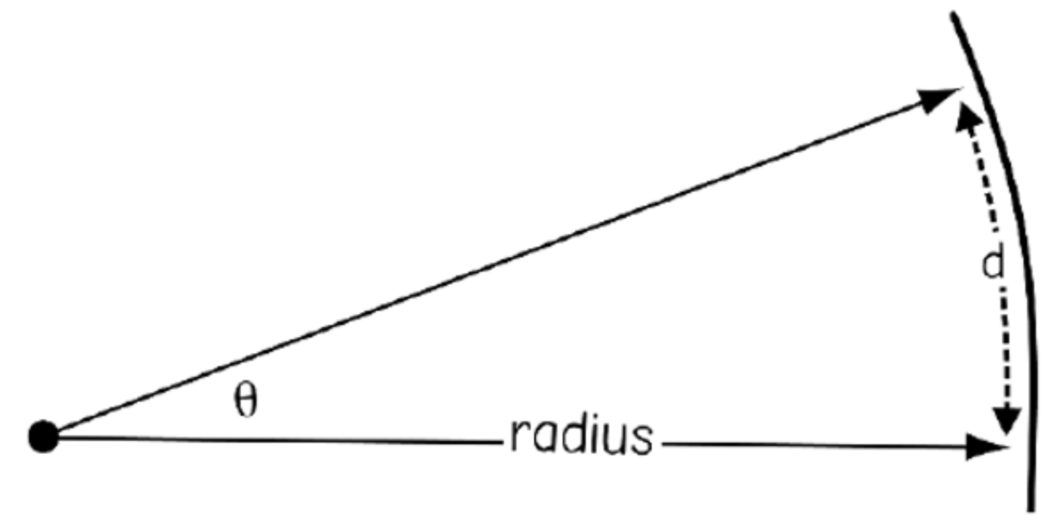
Surface distance calculation



- Assume we are using a spherical model with an equatorial radius of 6378 km
- What is the distance between the two points separated by 1° latitude?
  - (60° E, 40° N)
  - (60° E, 41° N)

Arc length





d = radius • θ

where θ is measured in radians,
with
1 radian = 57.2957°

Given an Earth radius of 6,378,137 m, how much distance is spanned by 10" of arc?

Arc= 10"/3600"/1° = 0.00277778°

=0.00277778°/57.2957 degrees per radian
= 0.000048481435 radians

d = 6378137m • 0.000048481435
= 309.2 meters

Figure 2-12: Example calculation of the approximate surface distance spanned by an arc.

(Surface) Length of One Degree of Latitude

- What's the length of 1° of latitude on the sphere?

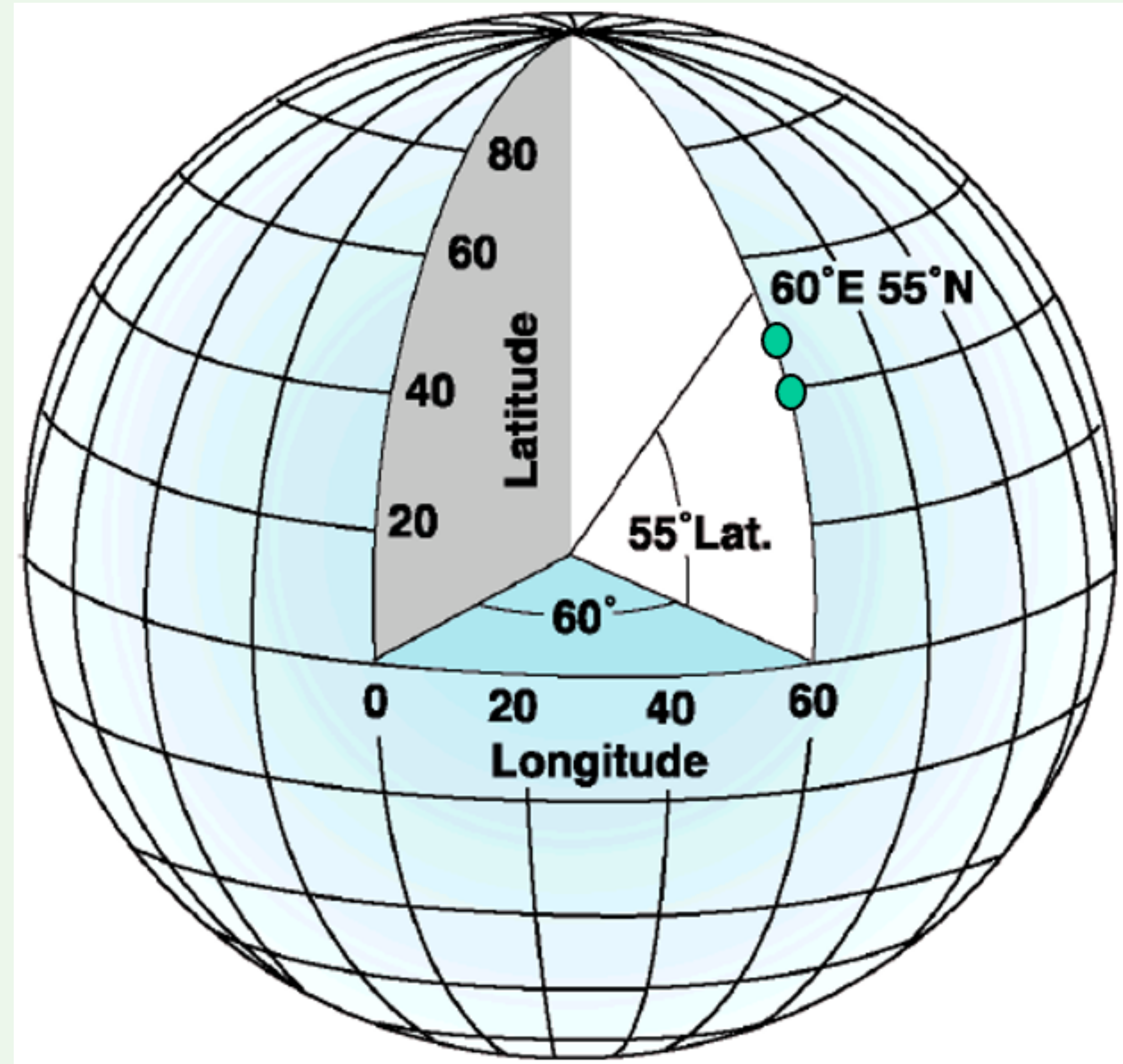
$d = R \times \phi$

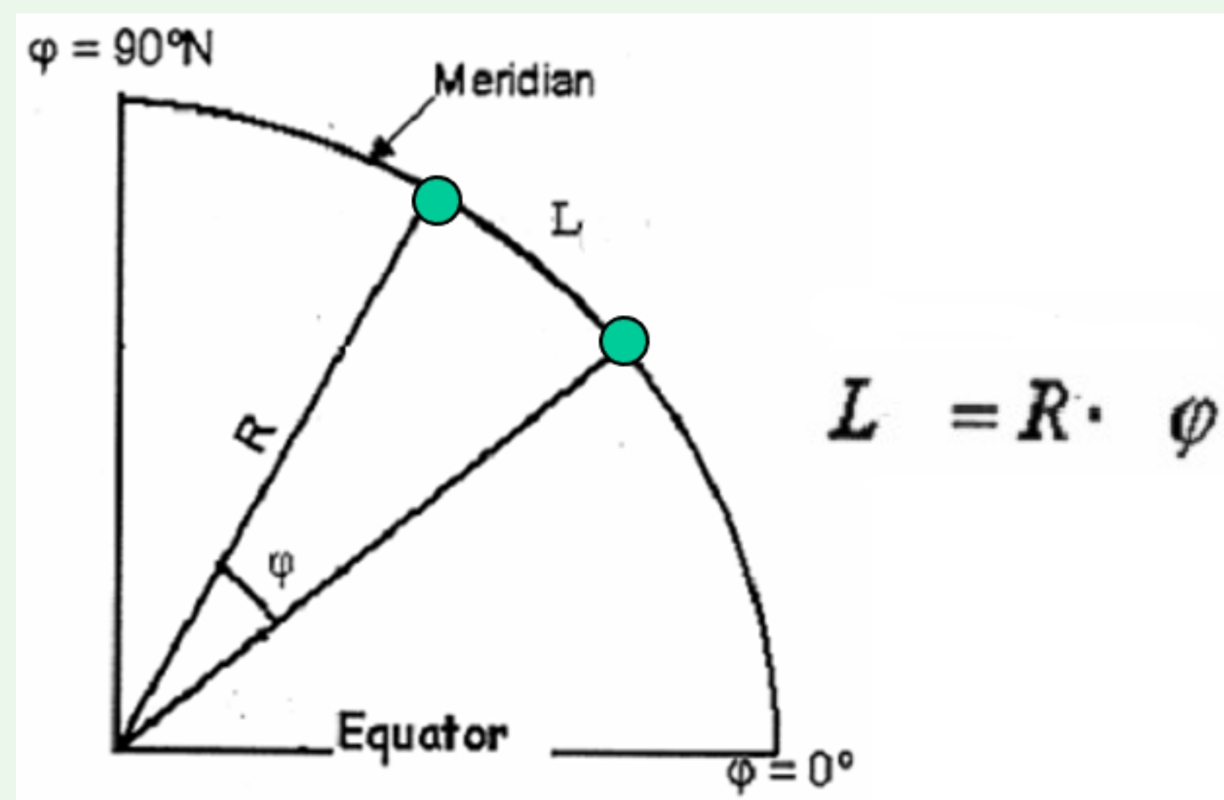
$R = 6378$ km

$\phi = 1° = \pi/180$

$L = 6378 \text{ km} \times \pi/180$

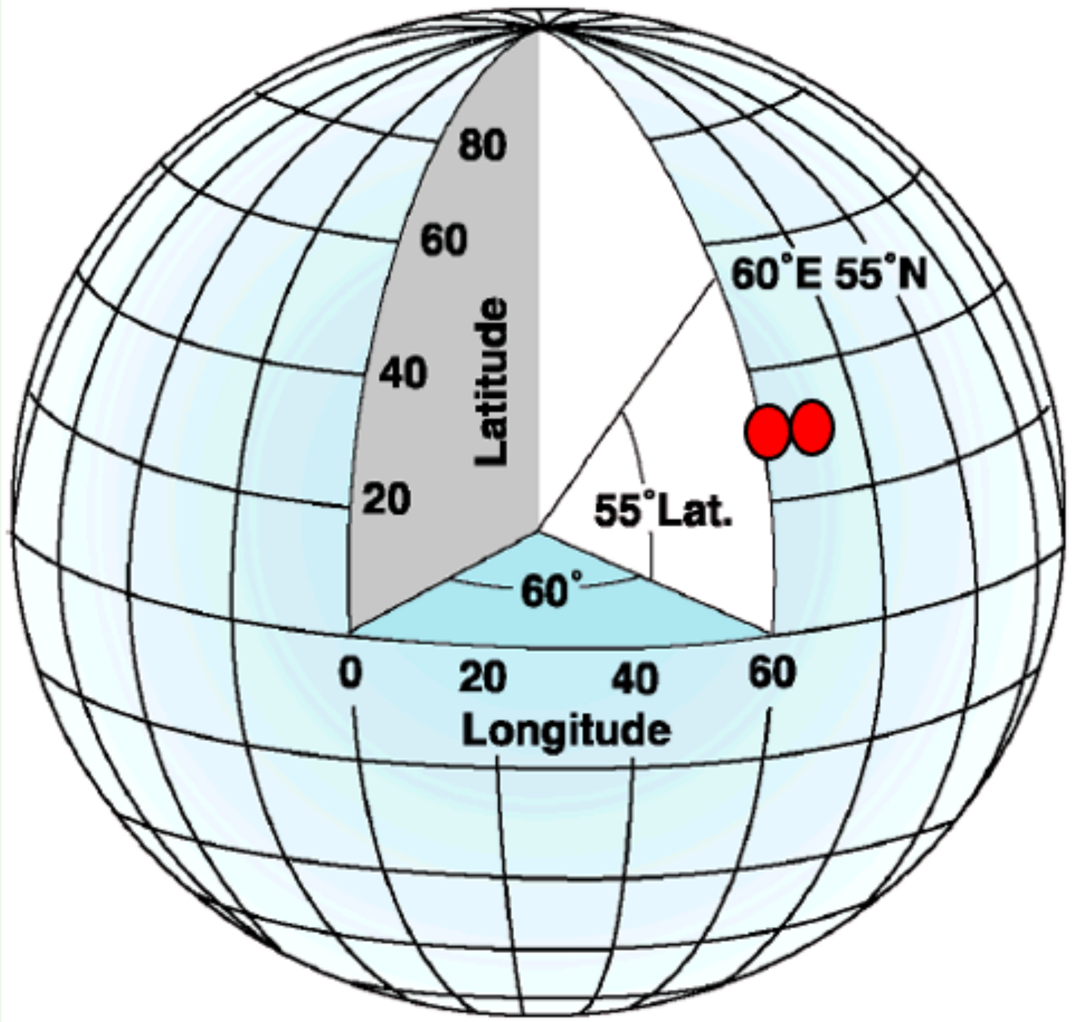
$= 111.3171$ km

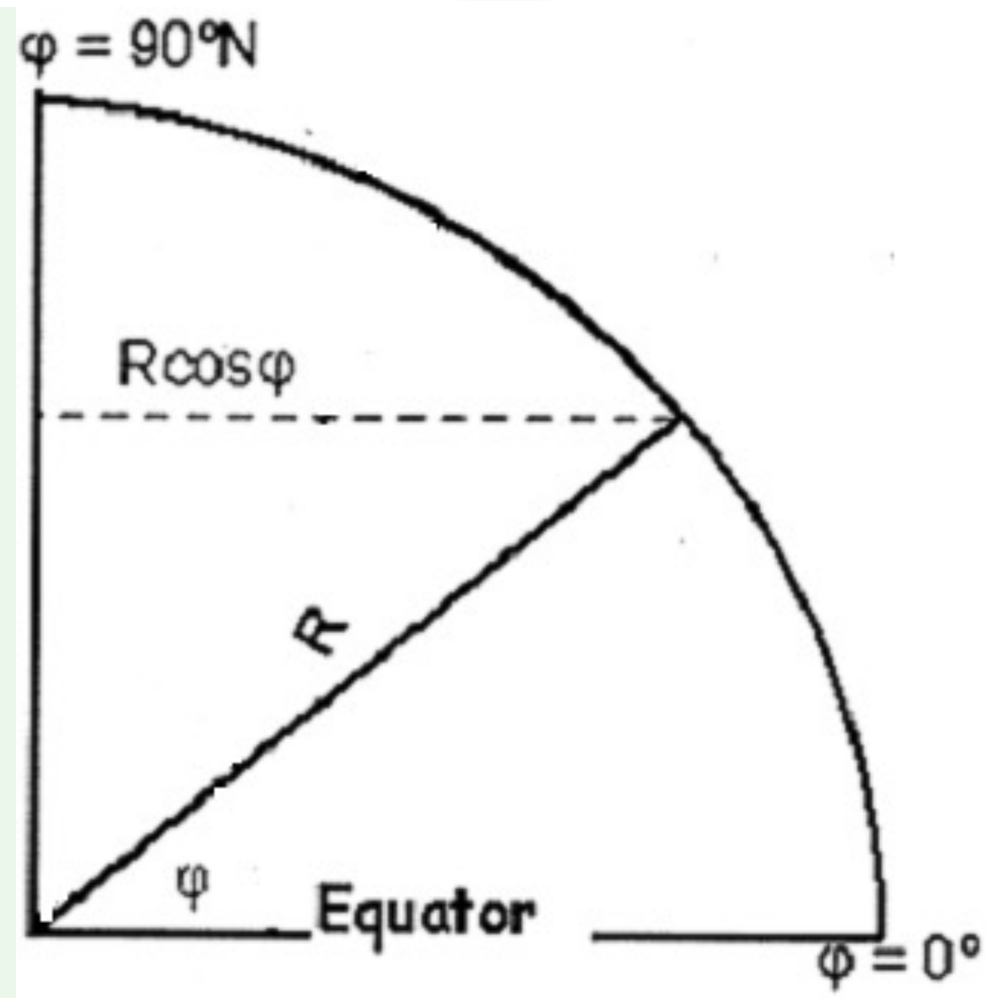




(Surface) Length of One Degree of Longitude

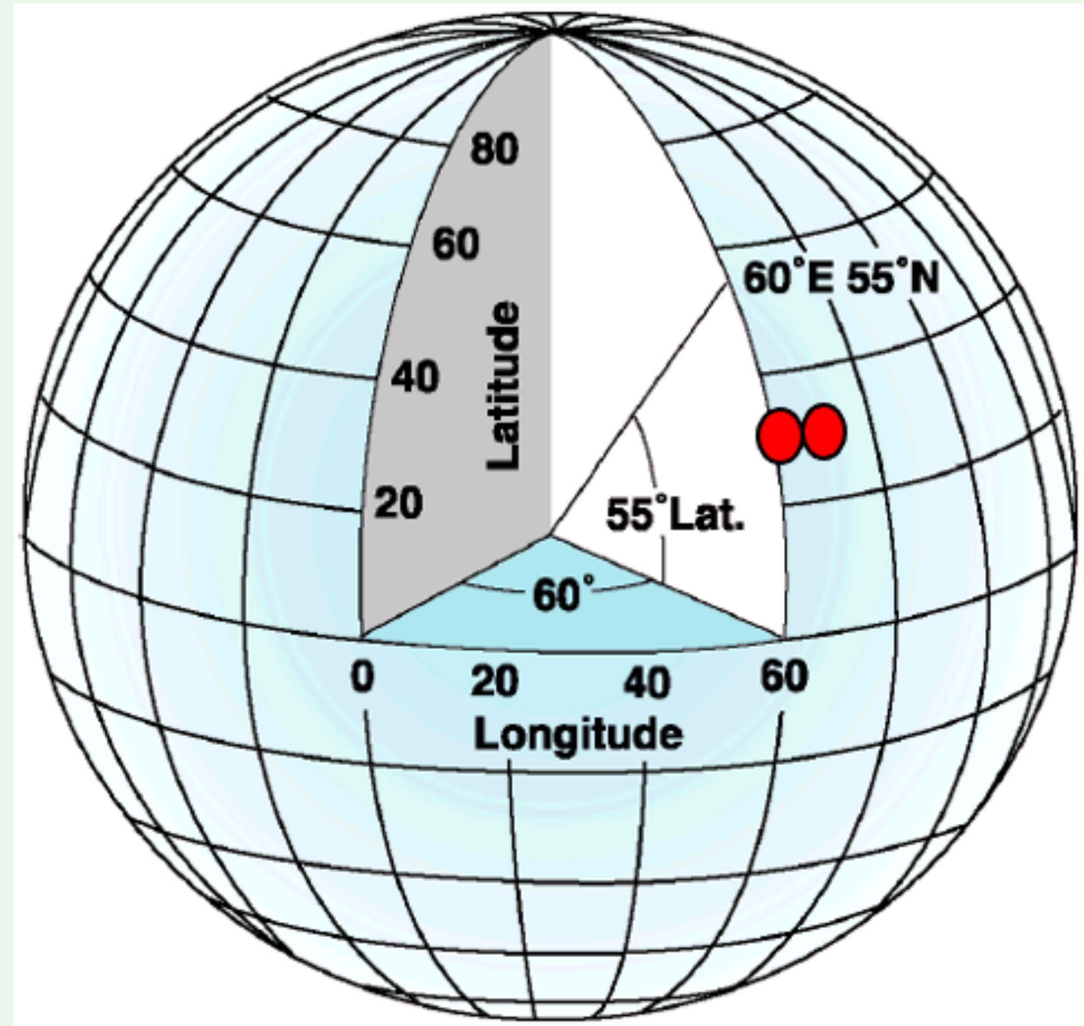
- Assume we are using a spherical model with an equatorial radius of 6378 km
- What is the distance between the two points separated by 1° longitude?
  - (60° E, 34° N)
  - (61° E, 34° N)





(Surface) Length of One Degree of Longitude

- What is the distance between (60° N, 34° E) and (61° N, 34° E)?



$L = R \cos(\phi) * \lambda$

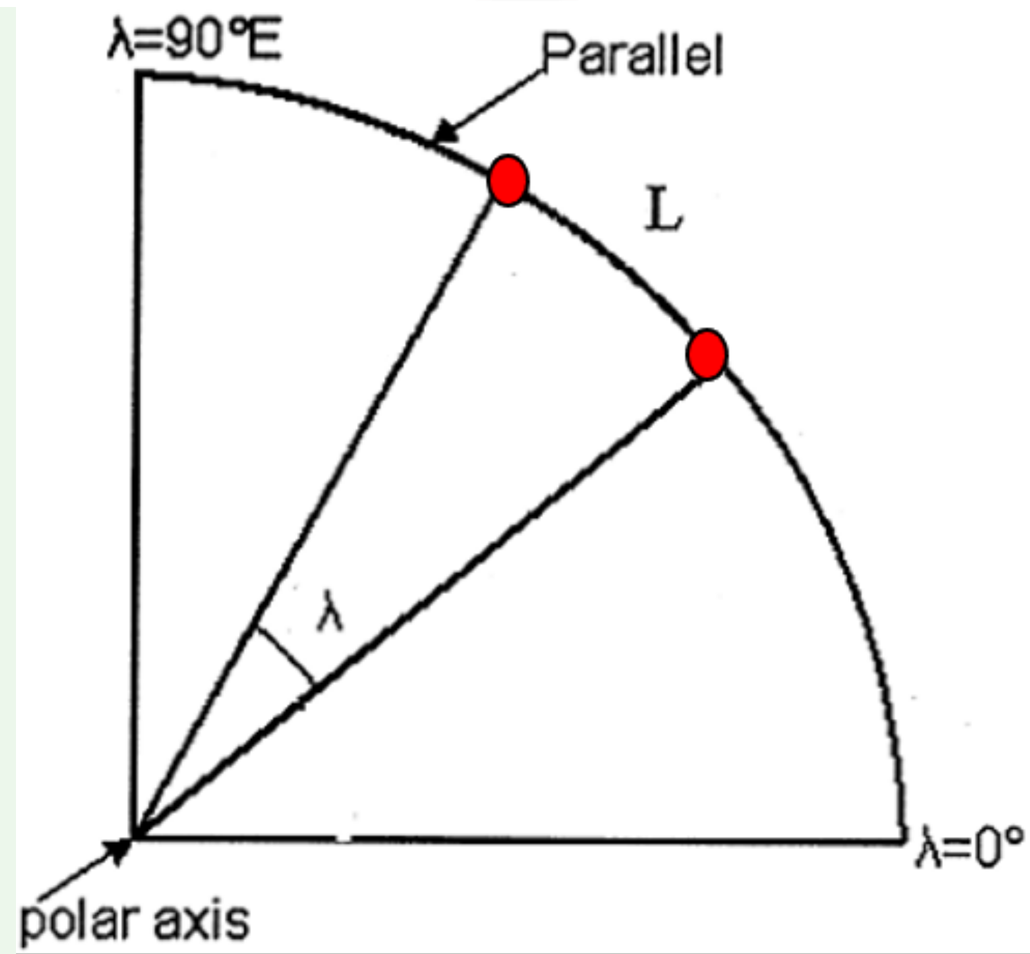
$R = 6378$ km

$\phi = 34°$

$\lambda = 1° = \pi/180$

$L = 6378 \text{ km} * \cos(34°) * \pi/180$

$= 92.2861$ km



(Surface) Length of One Degree of Longitude

Latitudinal	Latitude Degree	Longitude Degree
Position	Length (km/mi)	Length (km/mi)
90°	111.7/69.4	0/0
60°	111.4/69.2	55.8/34.7
30°	110.9/68.9	96.5/60.0
0°	110.60/68.7	111.32/69.2