

Map Projections

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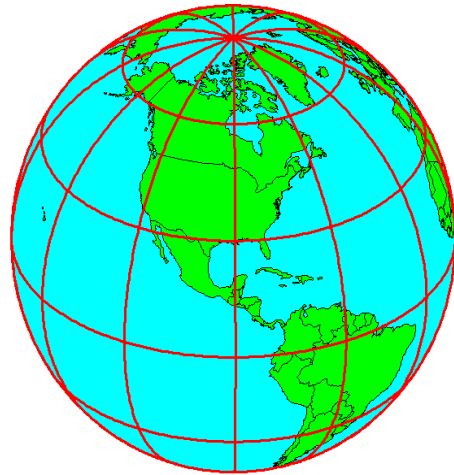
Centre for Ecological Science

Indian Institute of Science

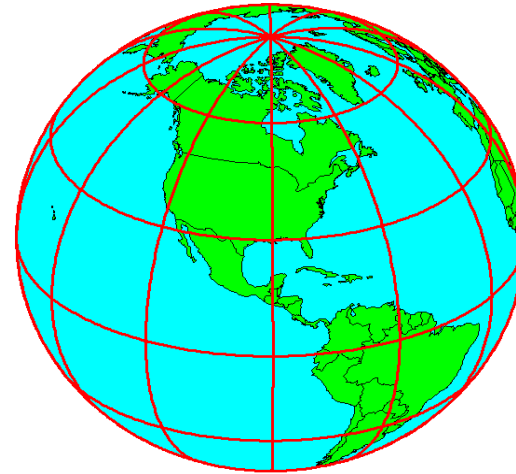
- *Geodesy and map projections*

Shape of the Earth

We think of the earth as a **sphere**



It is actually a **spheroid**, slightly larger in radius at the equator than at the poles



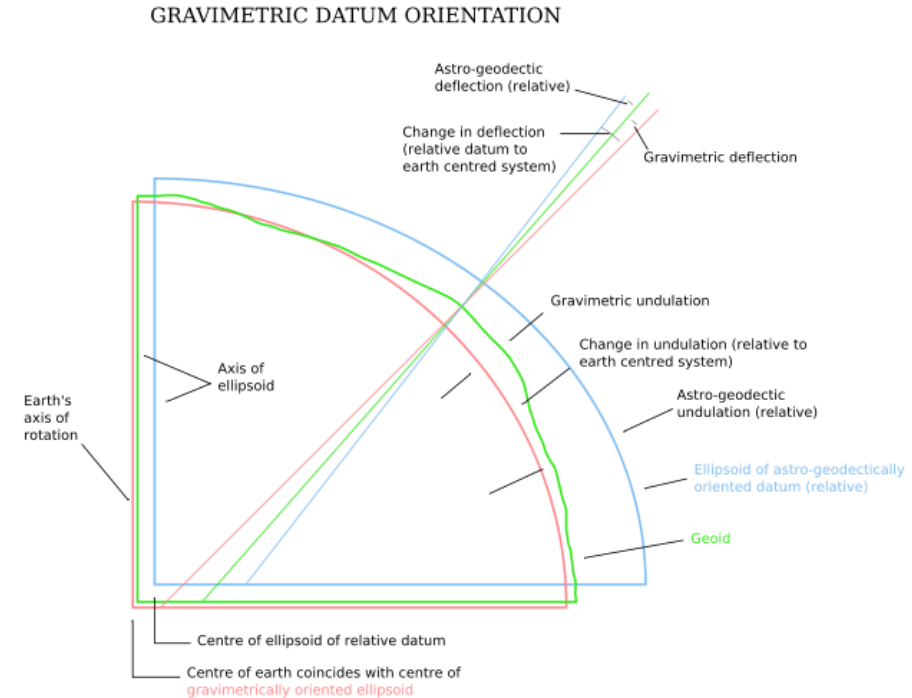
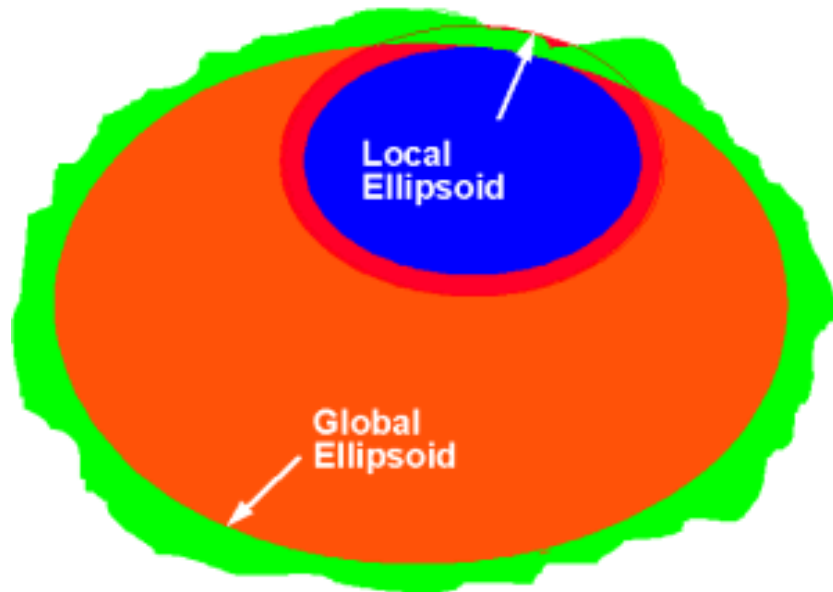
Geographic Coordinates (ϕ , λ , z)

- Latitude (ϕ) and Longitude (λ) defined using an **ellipsoid**, an ellipse rotated about an axis
- Elevation (z) defined using **geoid**, a surface of constant gravitational potential
- Earth **datums** define standard values of the ellipsoid and geoid

Datums

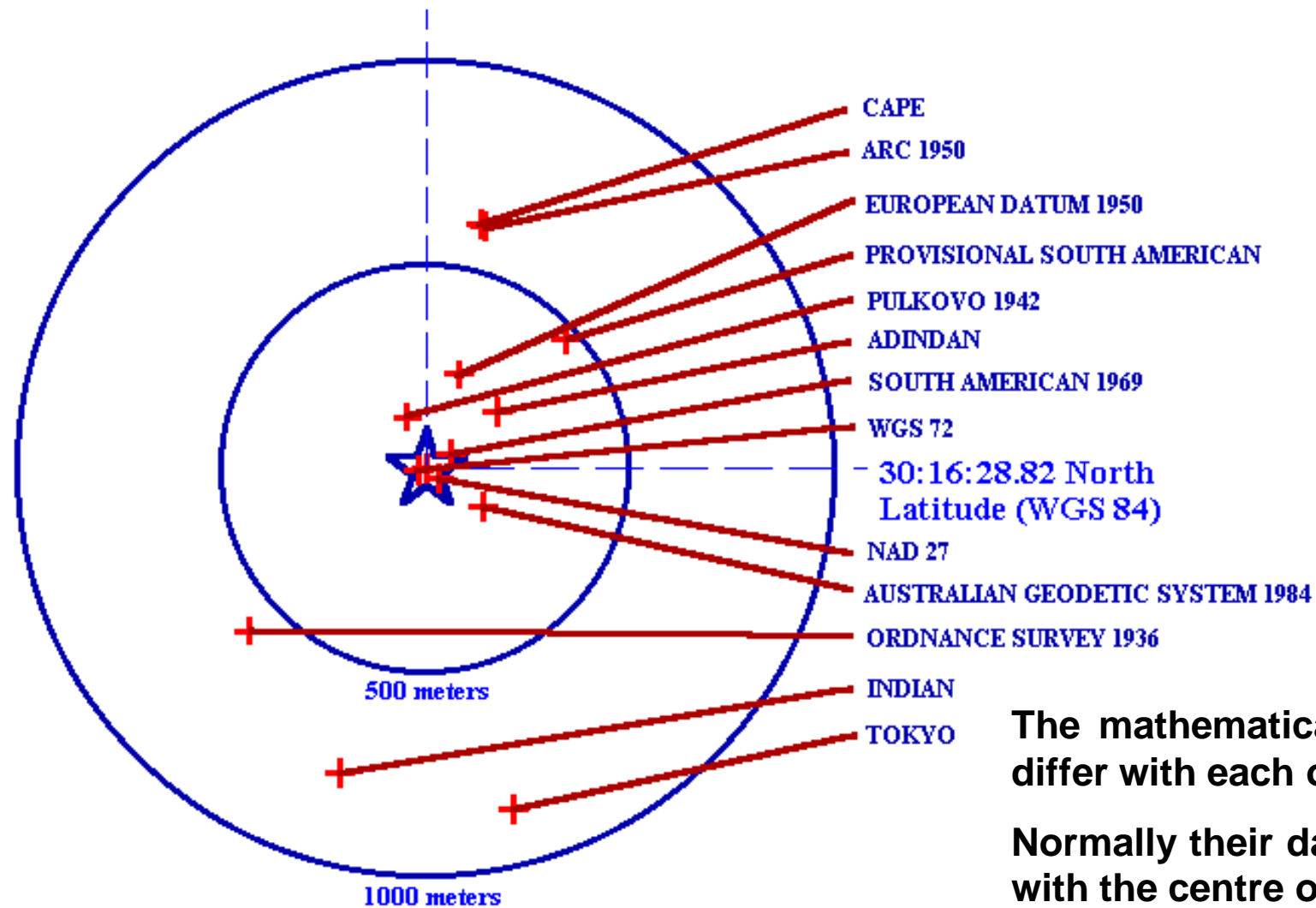
A datum is a reference from which measurements are made.

A datum is a set of reference points on the earth's surface against which position measurements are made and an associated model of the shape of the earth to define a geographic coordinate system.



Earth's ellipsoid, geoid, and two types of vertical deflection.

97:44:25.19 West
Longitude (WGS 84)



- CAPE
- ARC 1950
- EUROPEAN DATUM 1950
- PROVISIONAL SOUTH AMERICAN
- PULKOVO 1942
- ADINDAN
- SOUTH AMERICAN 1969
- WGS 72
- 30:16:28.82 North
Latitude (WGS 84)
- NAD 27
- AUSTRALIAN GEODETIC SYSTEM 1984
- ORDNANCE SURVEY 1936
- INDIAN
- TOKYO

The mathematical parameters of these datums differ with each other.

Normally their datum centres would not coincide with the centre of earth.

Position Shifts from Datum Differences

Texas Capitol Dome Horizontal Benchmark

Ellipse

An ellipse is defined by:

Focal length = ε

Distance (F1, P, F2) is
constant for all points
on ellipse

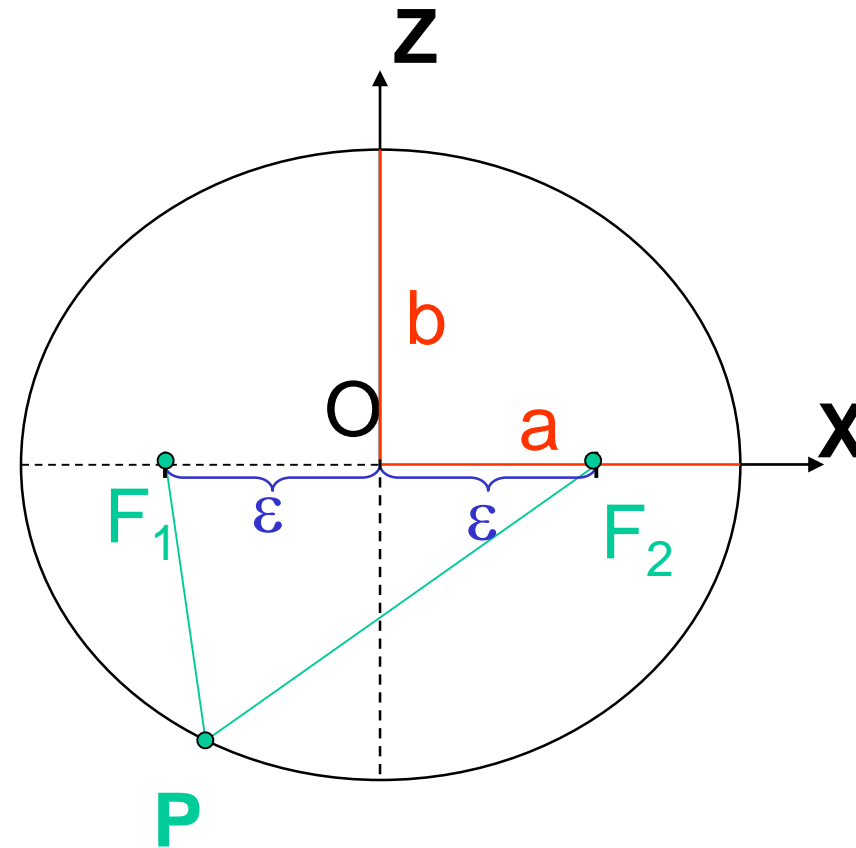
When $\varepsilon = 0$, ellipse = circle

For the earth:

Major axis, $a = 6378$ km

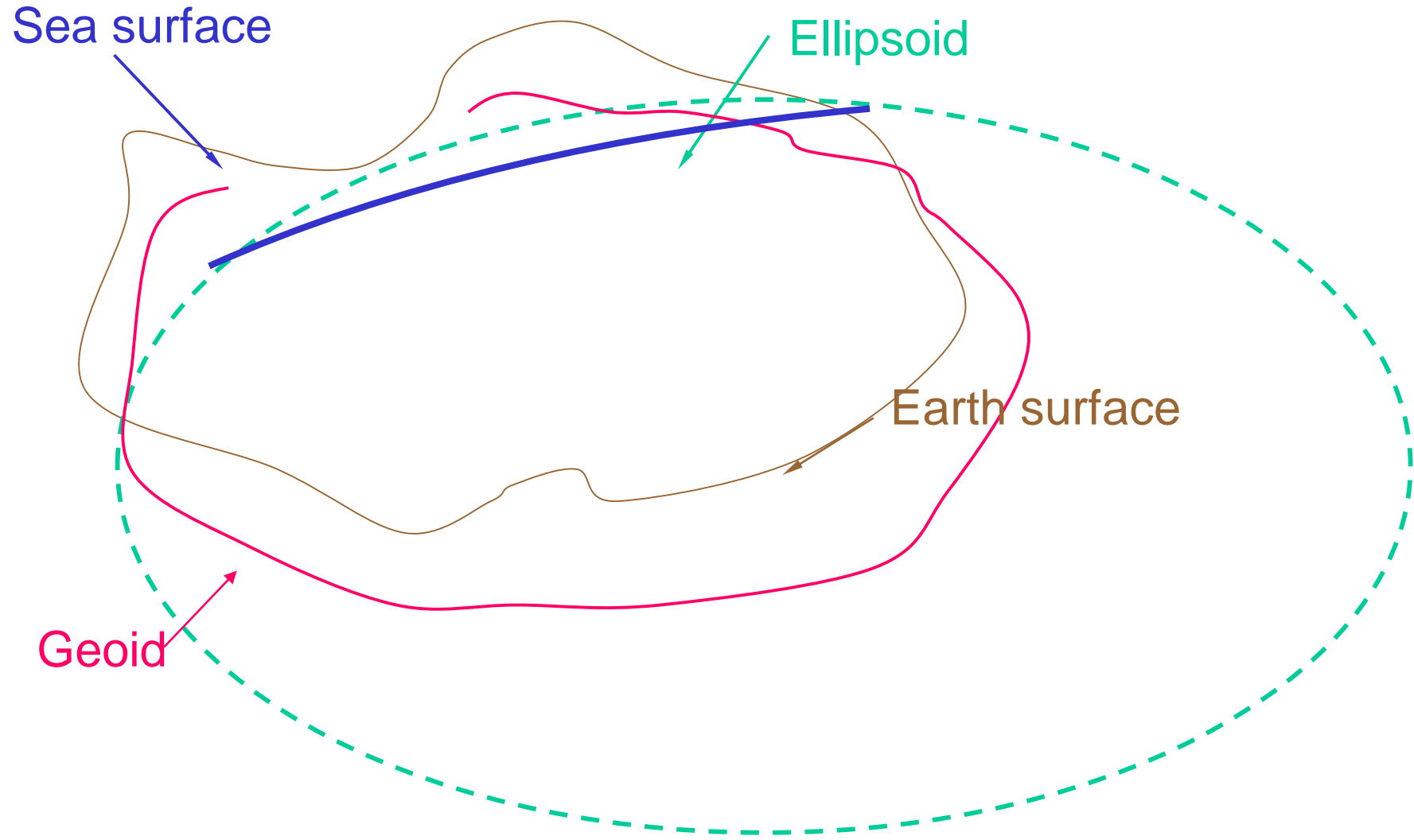
Minor axis, $b = 6357$ km

Flattening ratio, $f = (a-b)/a$
 $\sim 1/300$

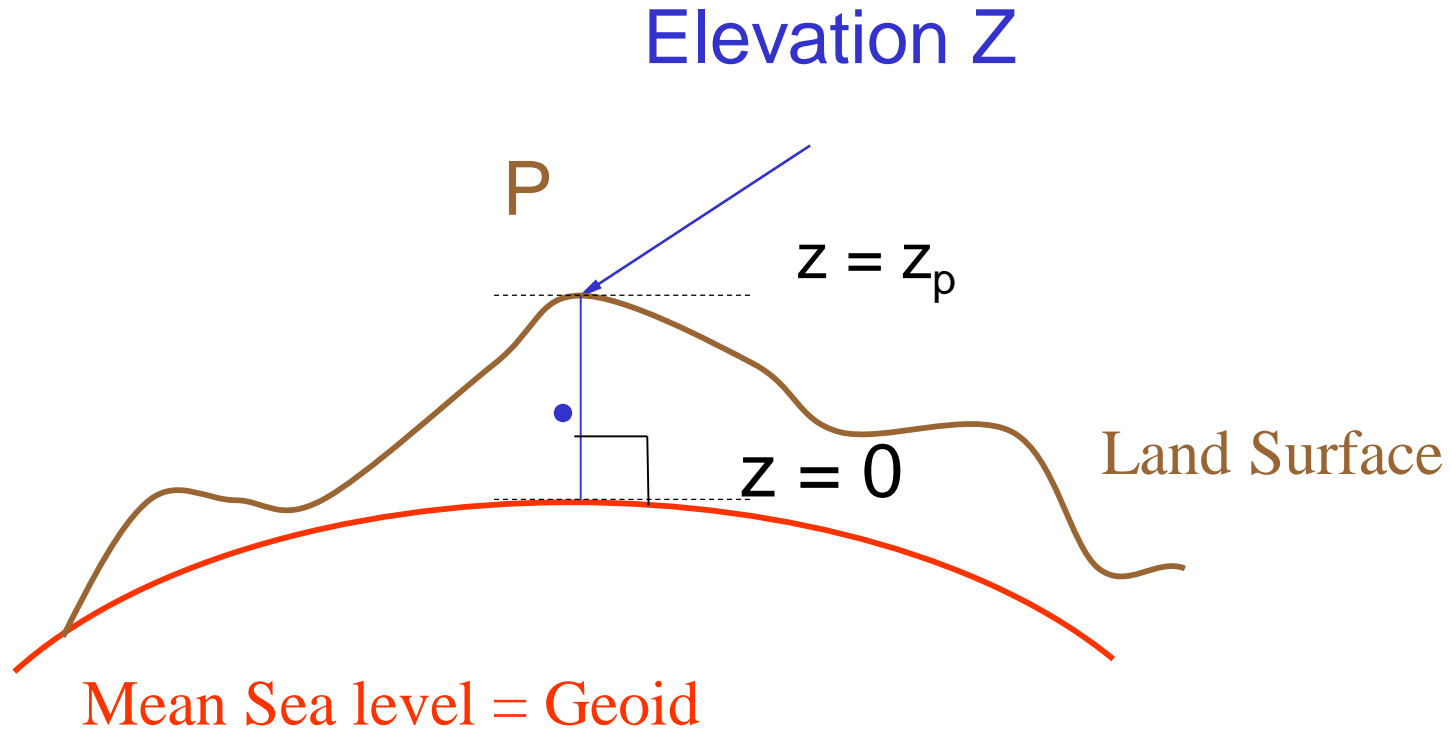


Representations of the Earth

Mean Sea Level is a surface of constant **gravitational potential** called the **Geoid**



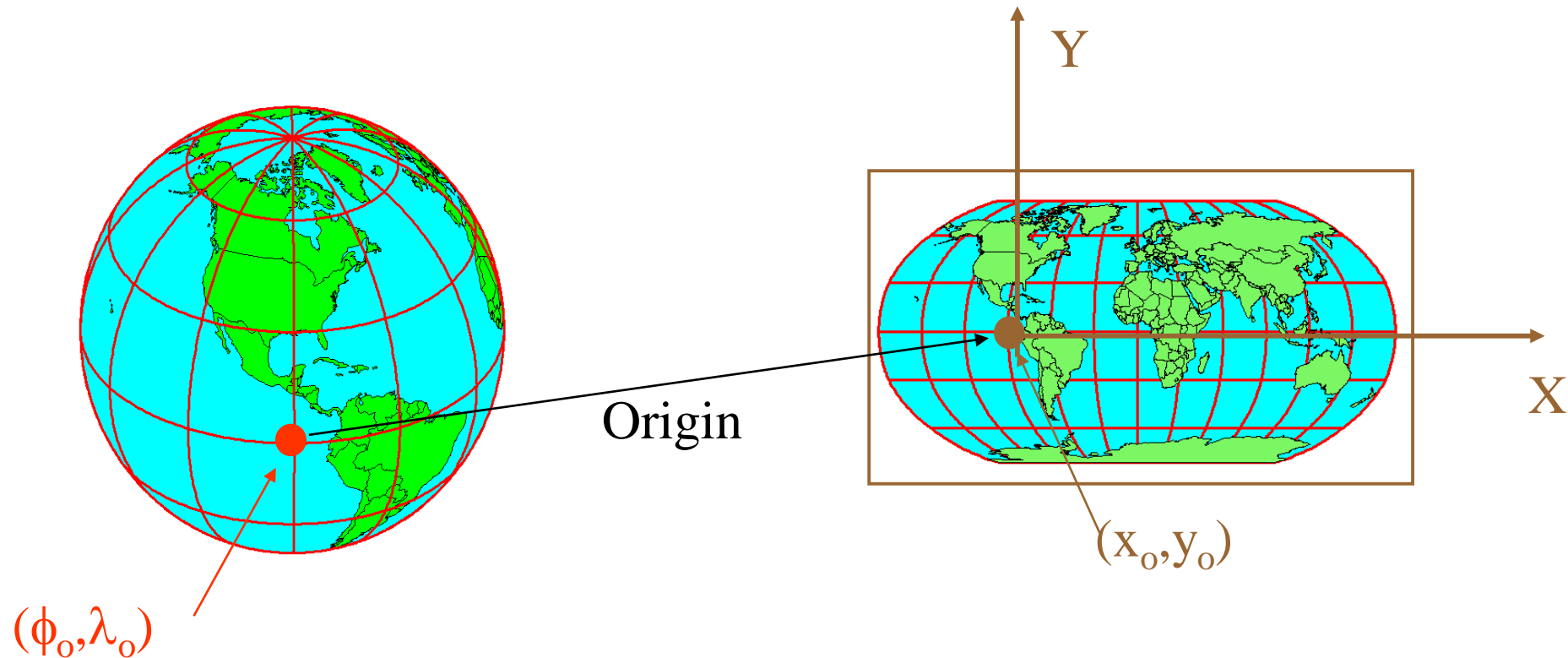
Definition of Elevation



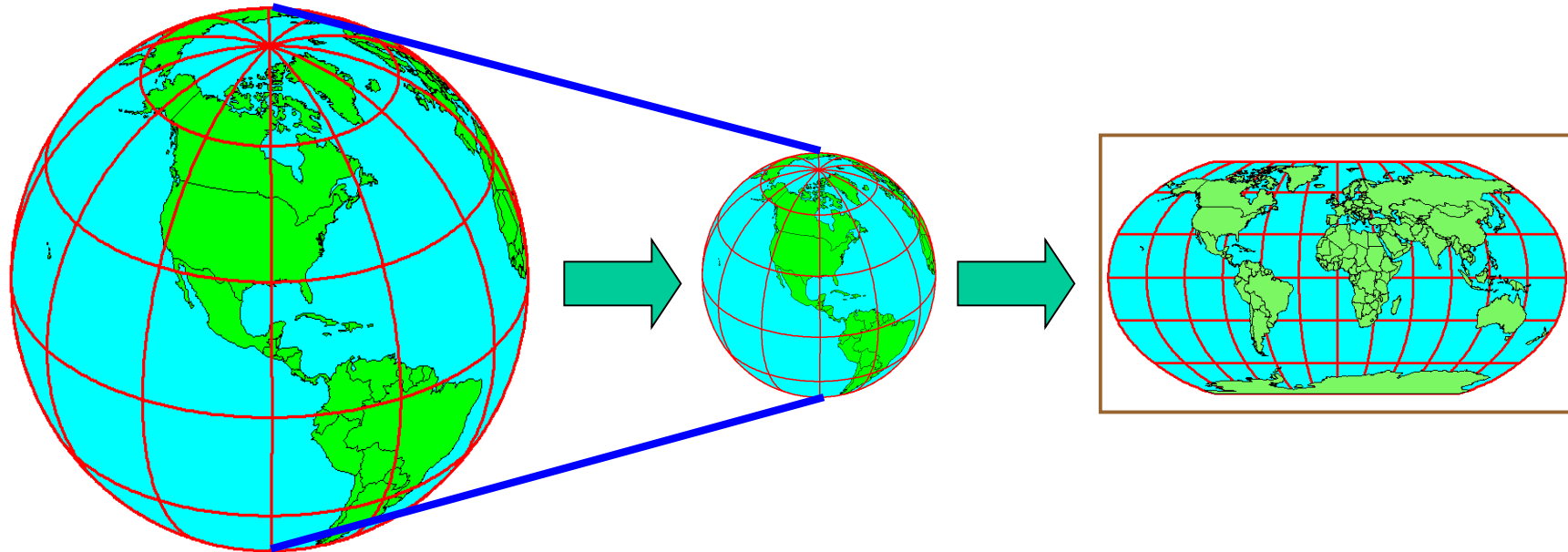
Elevation is measured from the Geoid

Coordinate System

A planar coordinate system is defined by a pair of orthogonal (x,y) axes drawn through an origin



Earth to Globe to Map



Map Scale:

Representative Fraction

$$= \frac{\text{Globe distance}}{\text{Earth distance}}$$

(e.g. 1:24,000)

Map Projection:

Scale Factor

$$= \frac{\text{Map distance}}{\text{Globe distance}}$$

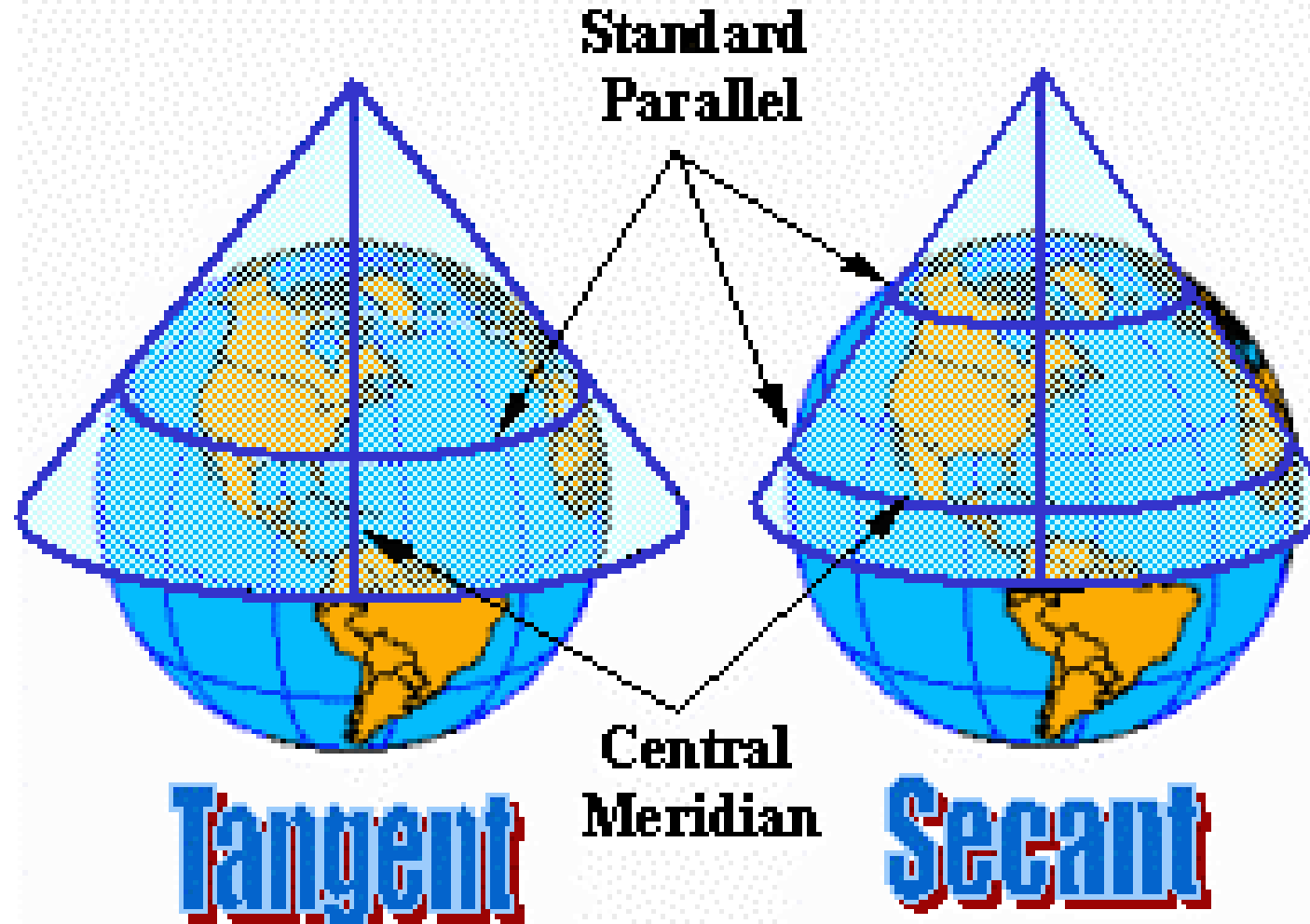
(e.g. 0.9996)

Map Projections

- A transformation of the spherical or ellipsoidal earth onto a flat map is called a map projection.
- The map projection can be onto a flat surface or a surface that can be made flat by cutting, such as a cylinder or a cone.
- If the globe, after scaling, cuts the surface, the projection is called secant. Lines where the cuts take place or where the surface touches the globe have no projection distortion.

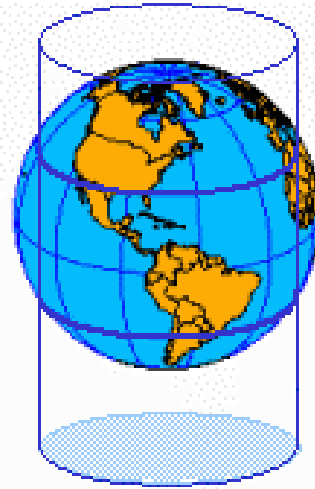
Conic Projections

(Albers Equal Area, Lambert Conformal Conic)

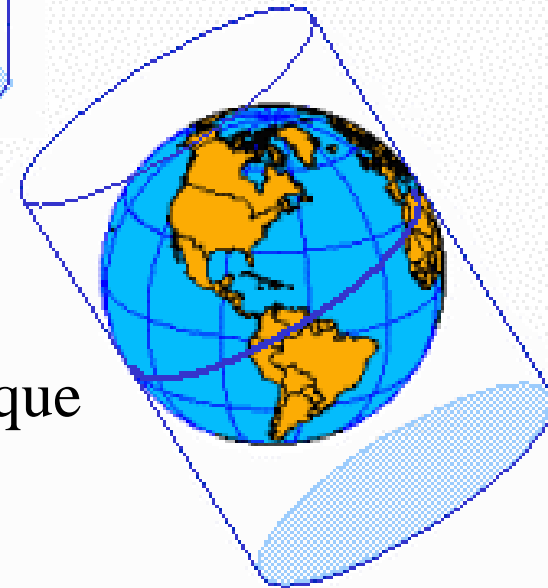
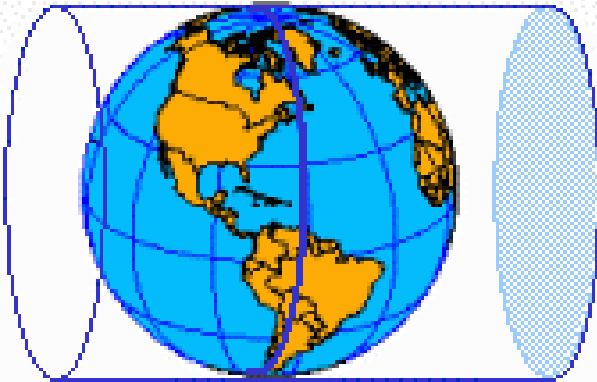


Cylindrical Projections

(Universal Transverse Mercator)



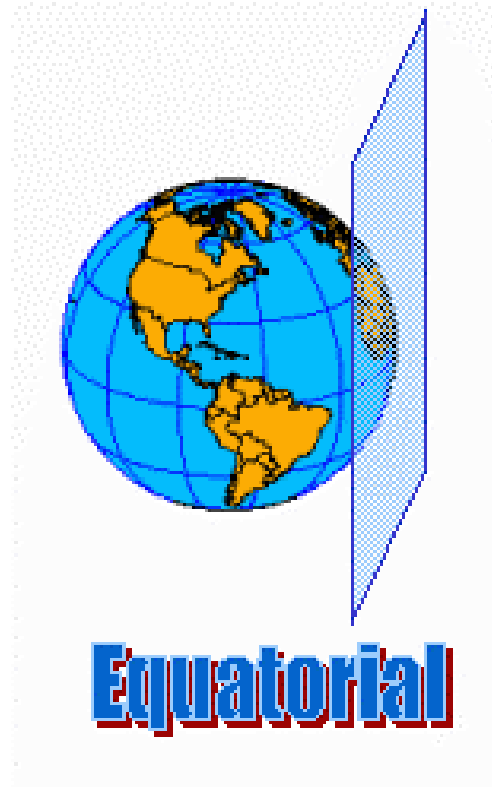
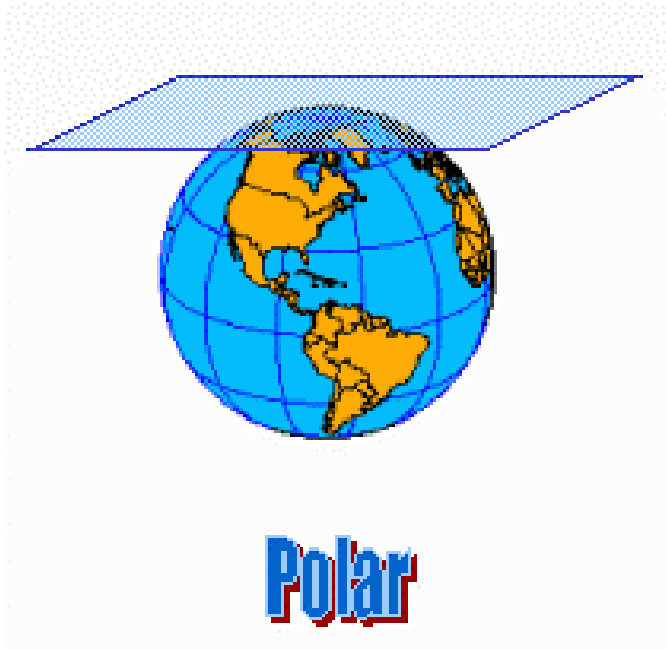
Transverse



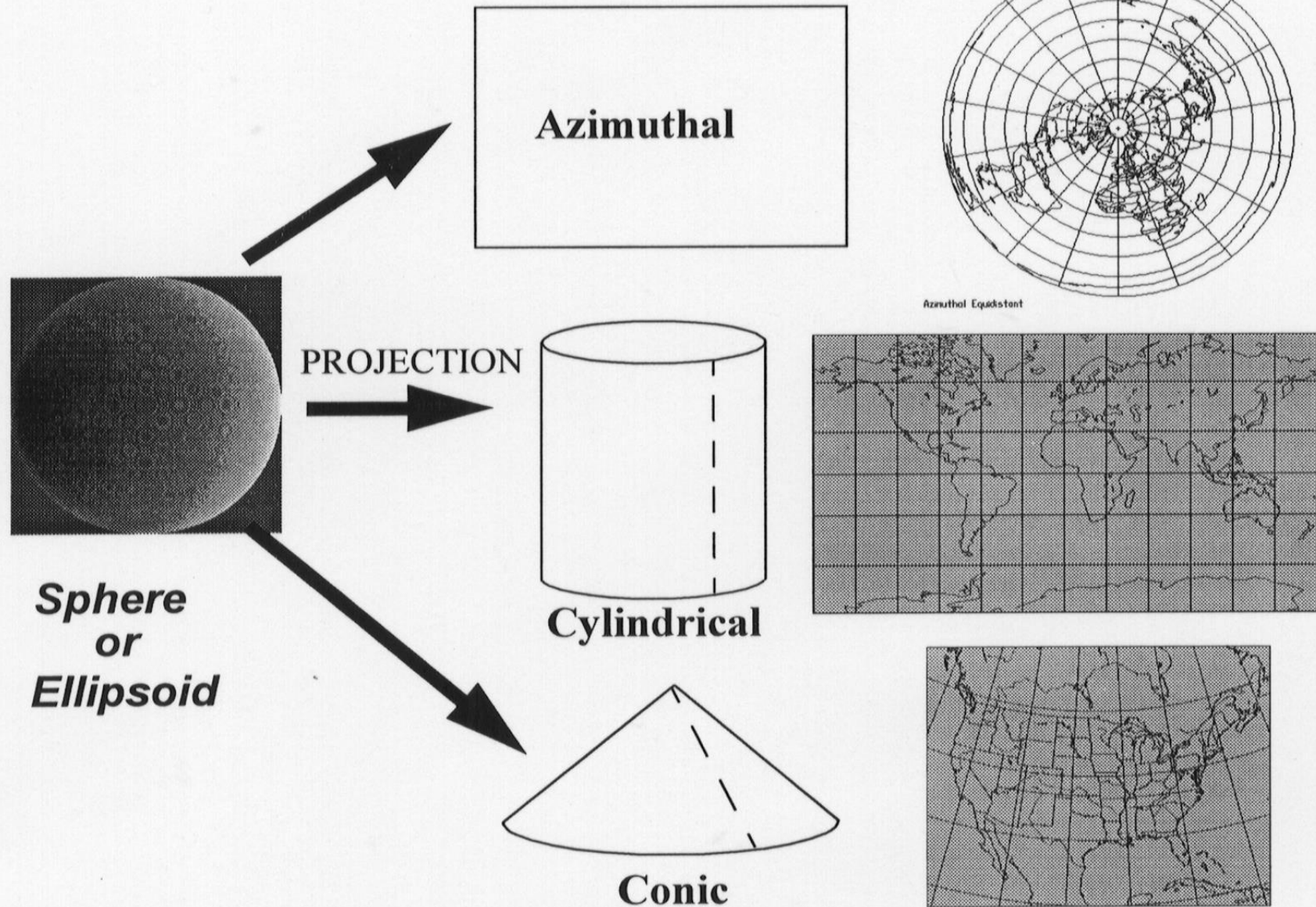
Oblique

Azimuthal

(Lambert Azimuthal Equal Area)



Map projections



Map Projections

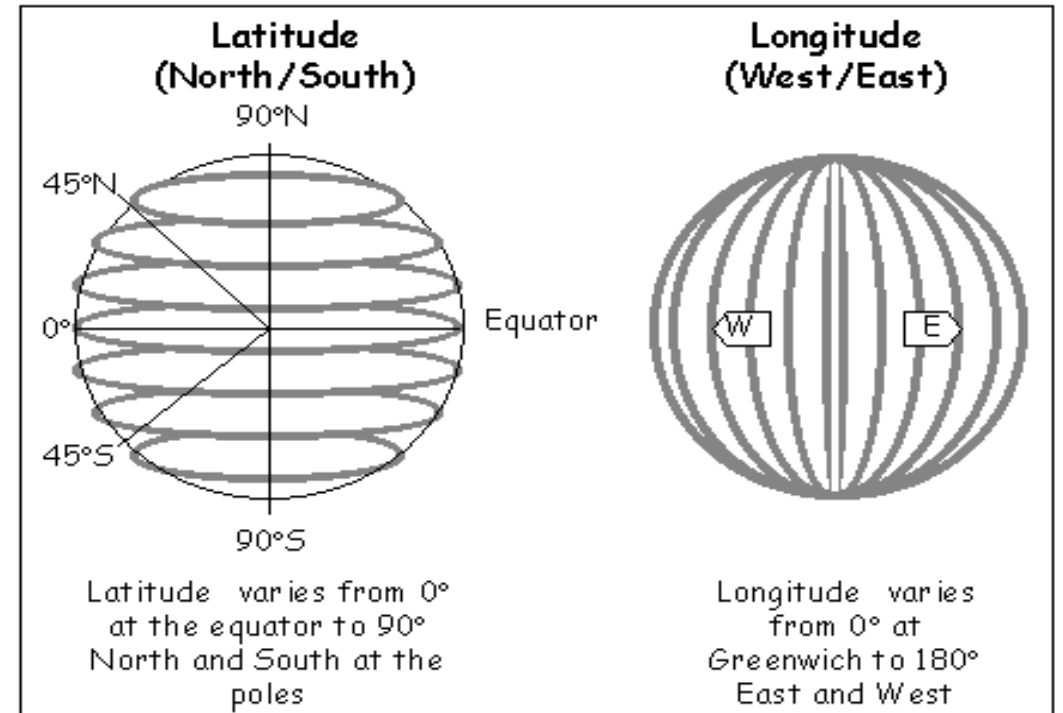
- Projections can be based on axes parallel to the earth's rotation axis (equatorial), at 90 degrees to it (transverse), or at any other angle (oblique).
- A projection that preserves the shape of features across the map is called conformal.
- A projection that preserves the area of a feature across the map is called equal area or equivalent.
- No flat map can be both equivalent and conformal. Most fall between the two as compromises.
- To compare or edge-match maps in a GIS, both maps **MUST** be in the same projection.

Coordinate Systems

- A coordinate system is a standardized method for assigning codes to locations so that locations can be found using the codes alone.
- Standardized coordinate systems use absolute locations.
- A map captured in the units of the paper sheet on which it is printed is based on relative locations or map millimeters.
- In a coordinate system, the x-direction value is the easting and the y-direction value is the northing. Most systems make both values positive.

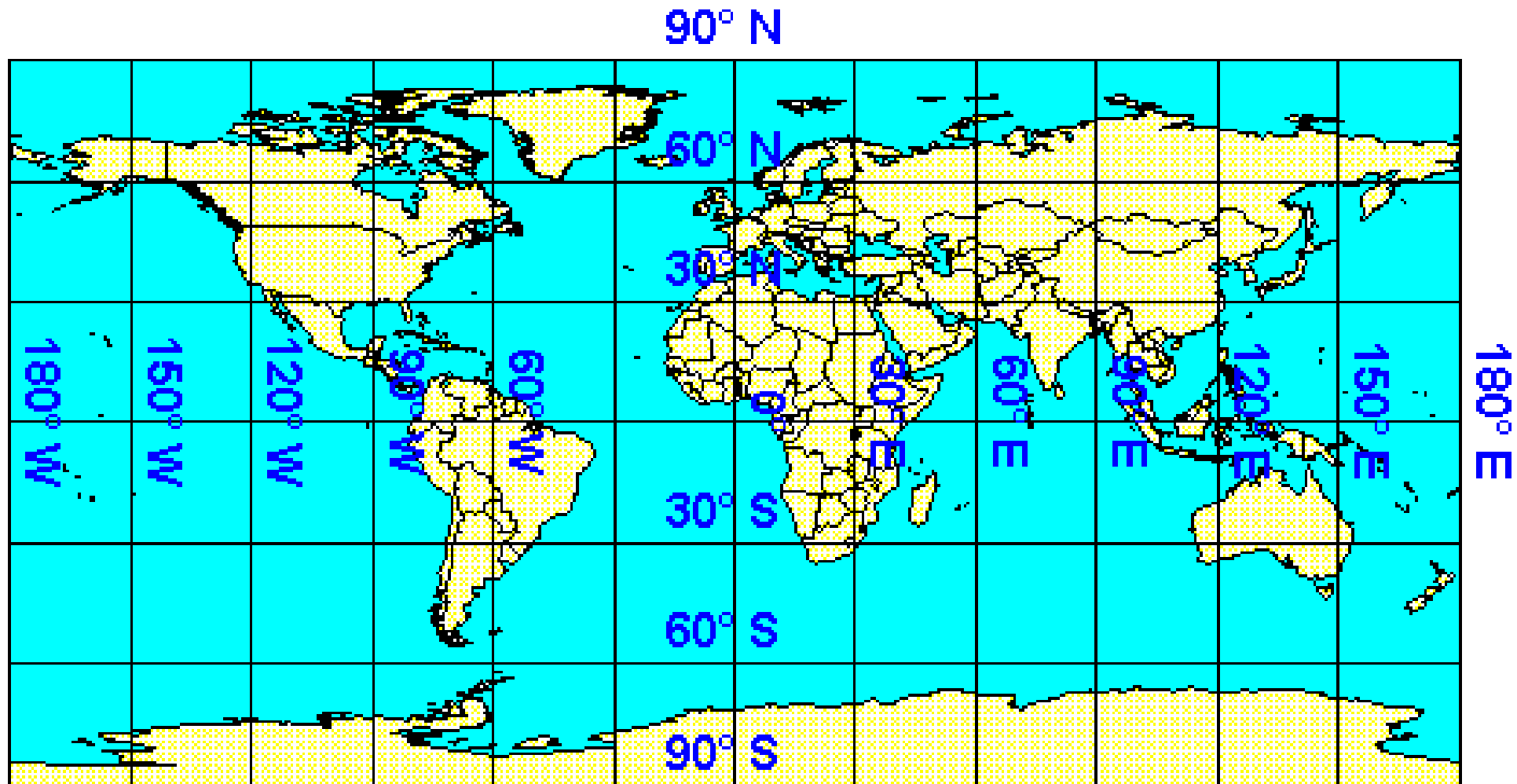
Latitude: specifies the north-south position of a point on surface of Earth. Latitude is an angle which ranges from 0° at the Equator to 90° (North or South) at the poles. Reference being equator.

Longitude: specifies the east-west position of a point on surface of Earth, measured as the angle east or west from the Greenwich Prime Meridian, ranging from 0° at the Prime Meridian to $+180^\circ$ eastward and -180° westward.



Lat/Long -planar form

Peter H. Dana 9/20/94

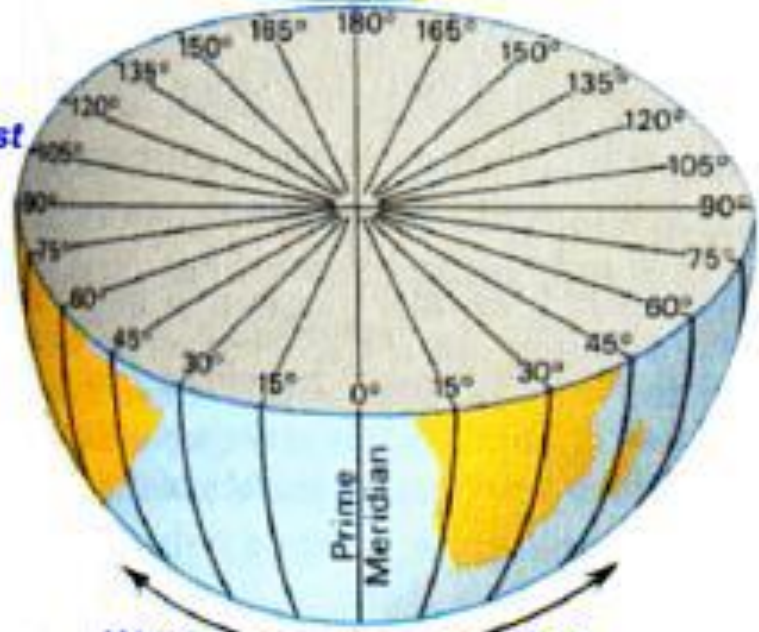


Unprojected Latitude and Longitude

North Pole



West



East

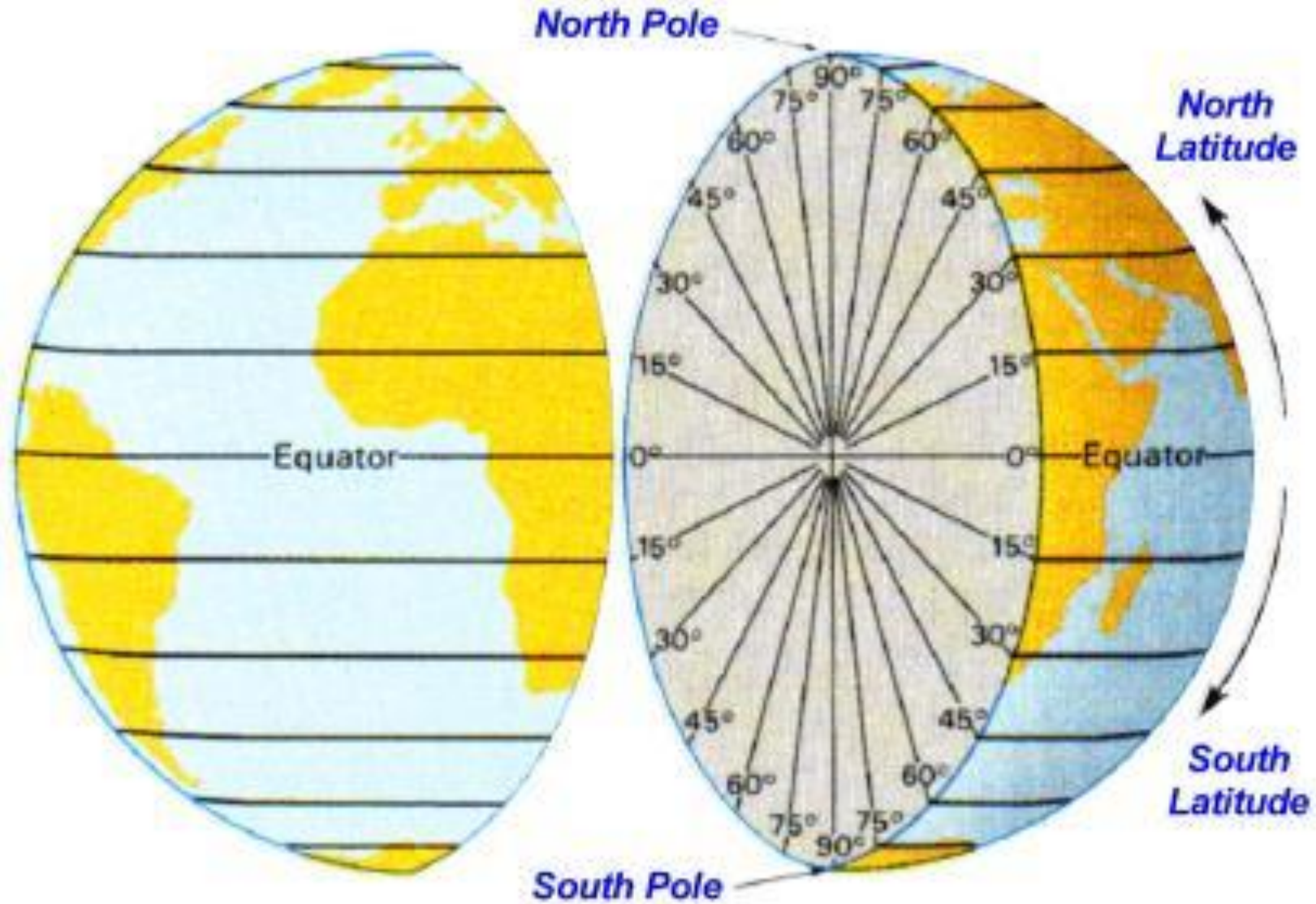
West
Longitude

East
Longitude

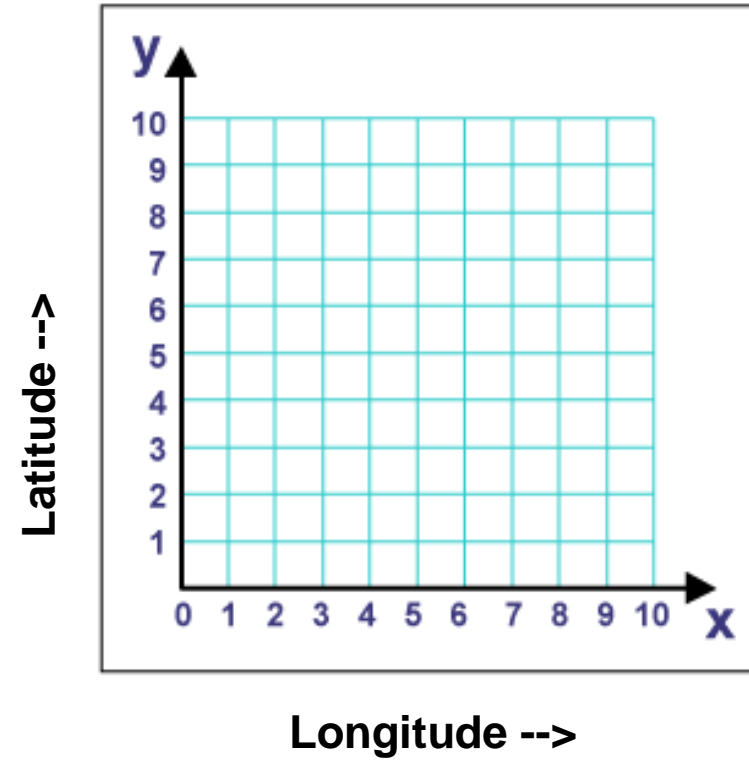
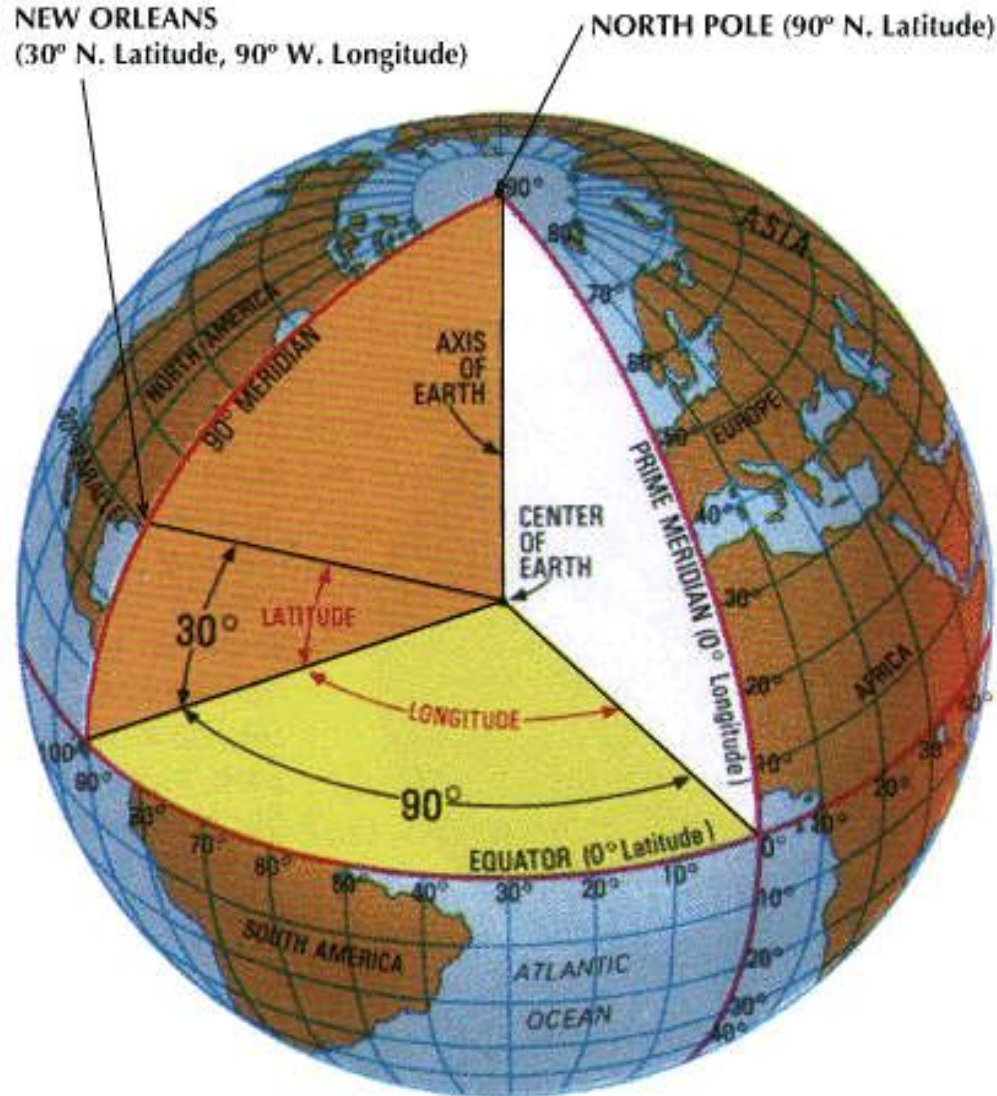
South Pole

Longitude

Latitude



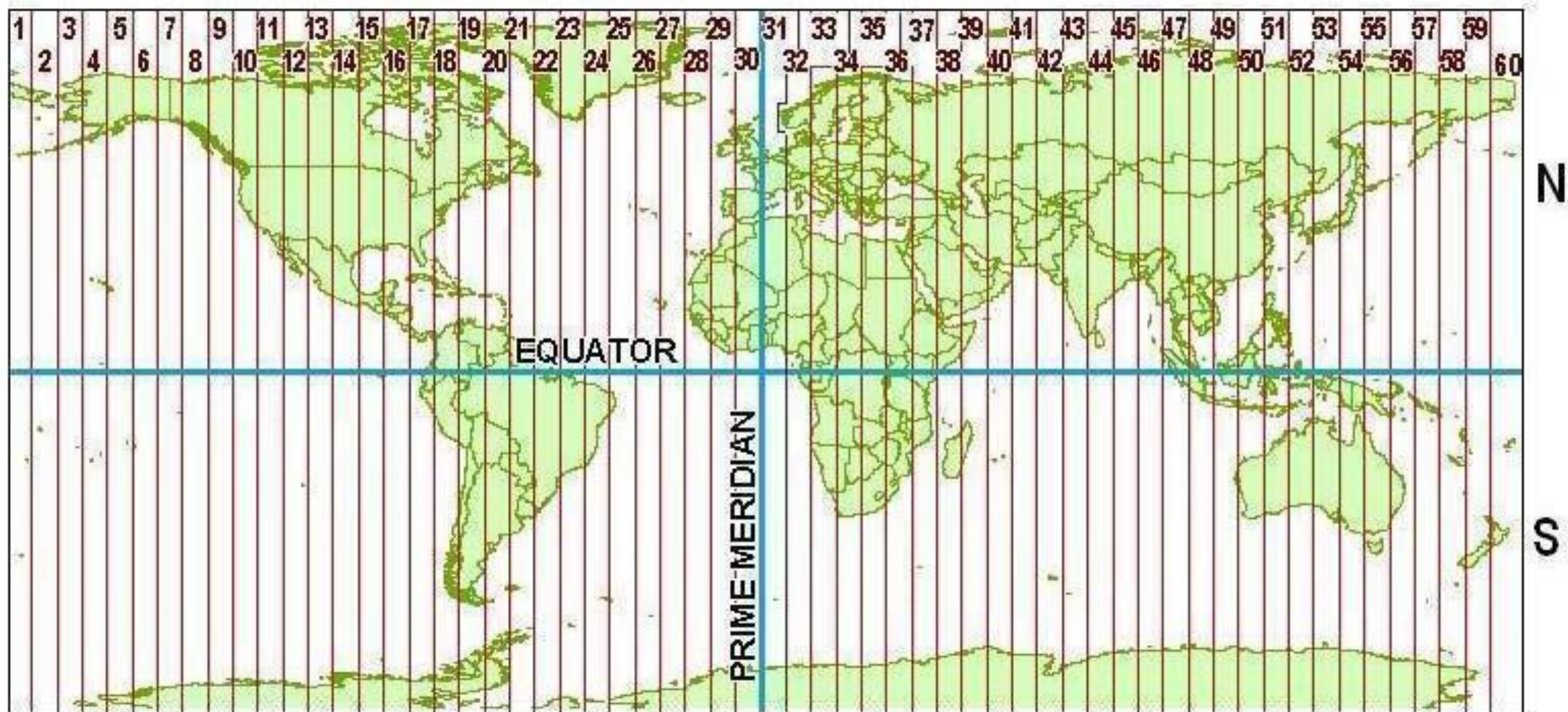
Longitude and Latitude : x and y



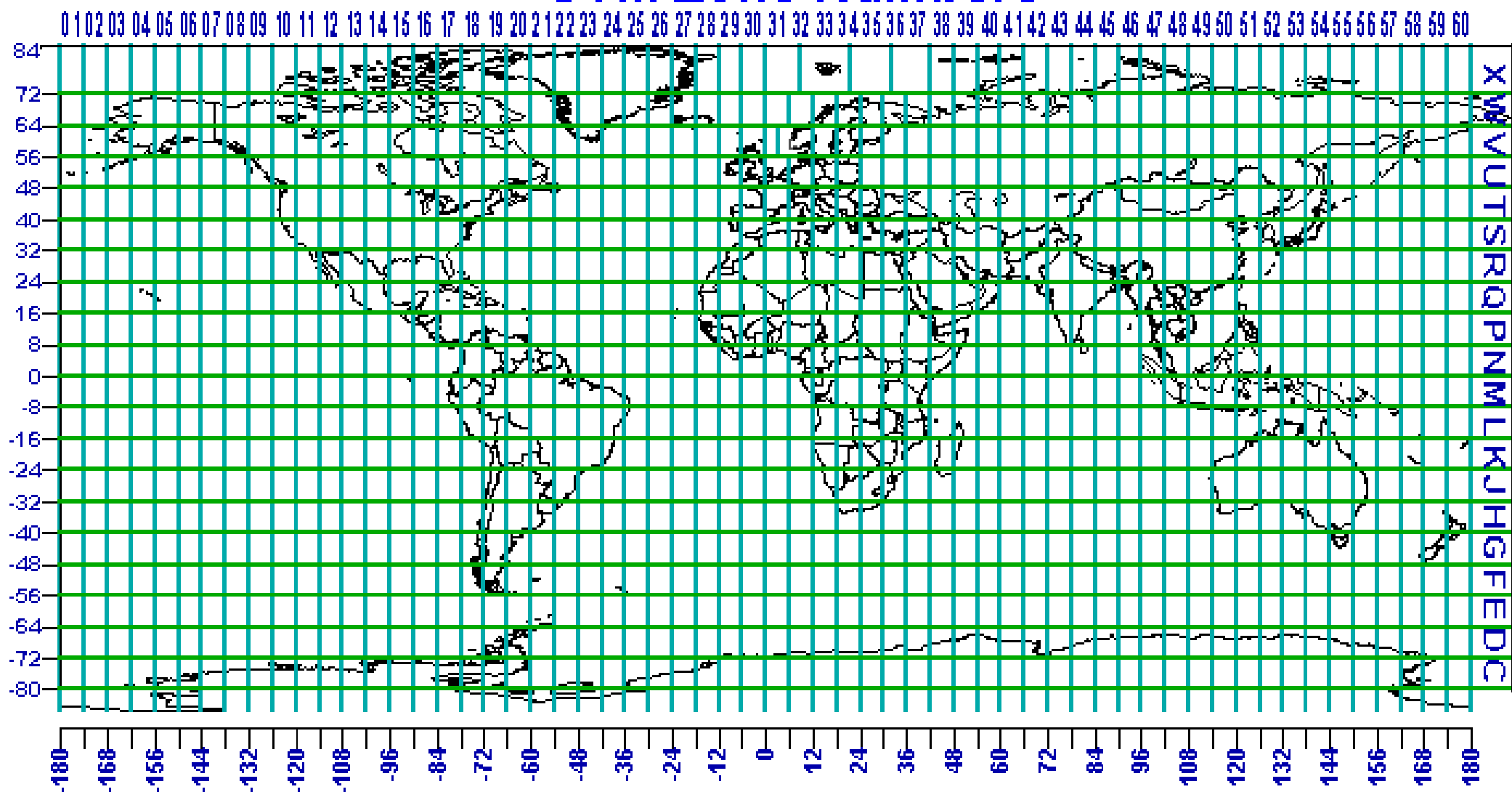
UTM Zones

- The Universal Transverse Mercator (UTM) projected coordinate system uses a 2-dimensional Cartesian coordinate system to give locations on the surface of the Earth.
- It is a horizontal position representation, i.e. it is used to identify locations on the Earth independently of vertical position,
- The UTM system divides the Earth between 80°S and 84°N latitude into 60 zones.
- Each 6° of longitude in width. EX. Zone 1 covers longitude 180° to 174° W.
- zone numbering increases eastward to zone 60 that covers longitude 174 to 180 East.
- The point of origin of each UTM zone is the intersection of the equator and the zone's central meridian, but to avoid dealing with negative numbers the central meridian of each zone is set at 500,000 meters East.

UTM ZONE NUMBERS



UTM Zone Numbers



UTM Zone Designators

Universal Transverse Mercator (UTM) System

The world is divided into 60 UTM zones.

The first number in UTM coordinates is called the easting.

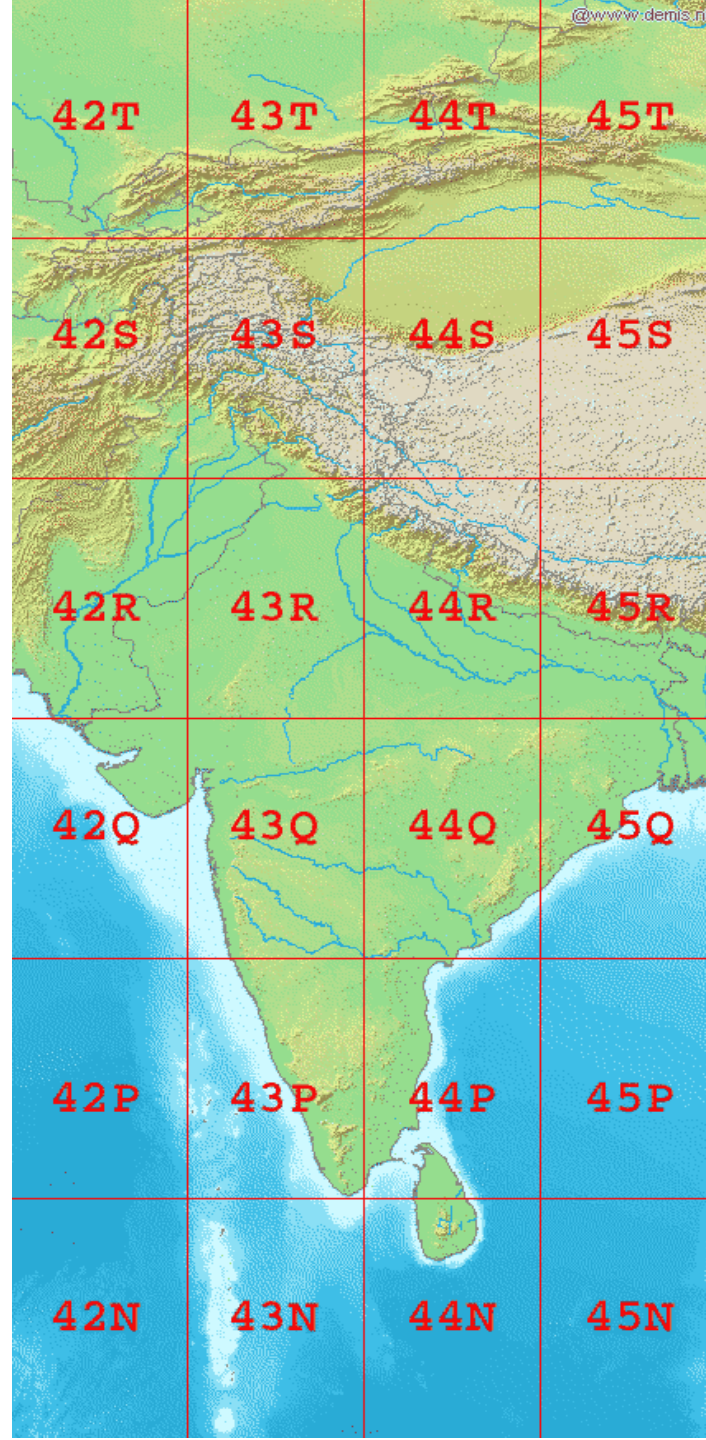
The easting refers to how far east you are.

The easting coordinates will be found along the top and bottom EDGE of the map

The second number in UTM coordinates is called the northing.

The northing refers to how far north you are.

The northing coordinates will be found along the right and left EDGE of the map.



UTM zones of India

Questions??

Thank You

Reference Material

- Dr. T.V. Ramachandra, Principles of remote sensing in environmental Management, IISc
- Dr. Nagesh Kumar, Notes of Principles of remote sensing in water resources, IISc
- Landsat.org
- Tutorials, CCRS, Canada
- ITC, netherlands