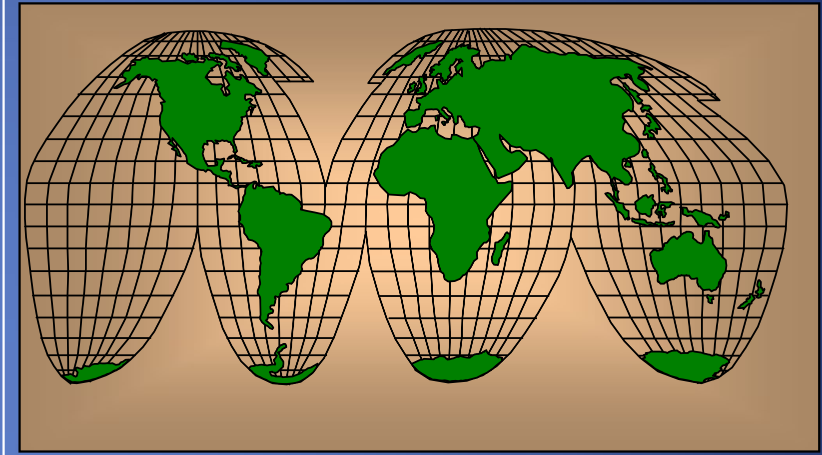
MAP PROJECTION

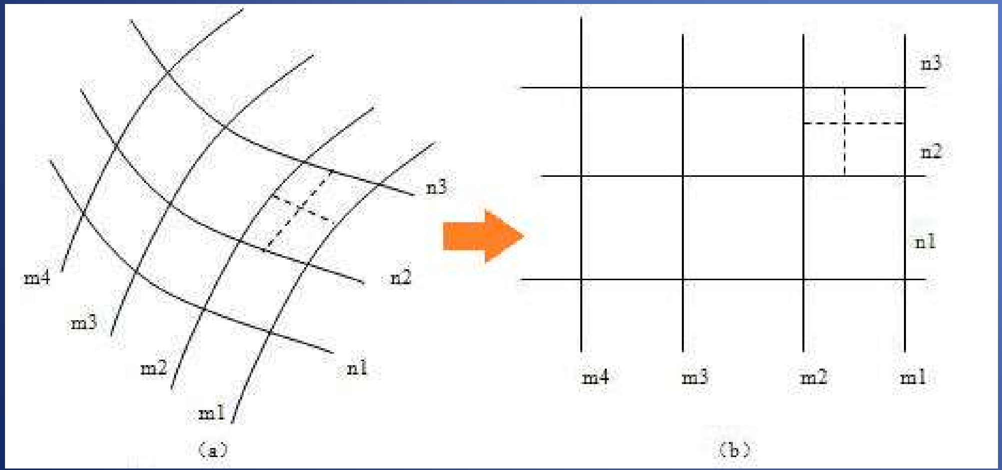
Source: ESRI

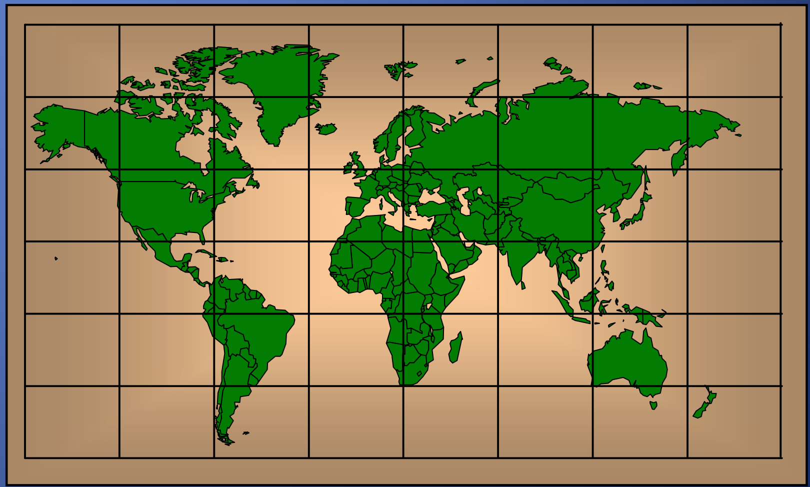
- Series of theories and methods by which the curved surface of the earth is portrayed on a flat surface
- This requires a systematic mathematical transformation of the earth's graticule of lines of latitude and longitude onto a plane

PROJECTED COORDINATE SYSTEM

- The coordinate system is used to determine the position of any point on the earth. The map uses different projection methods, and its corresponding coordinate system is also different.

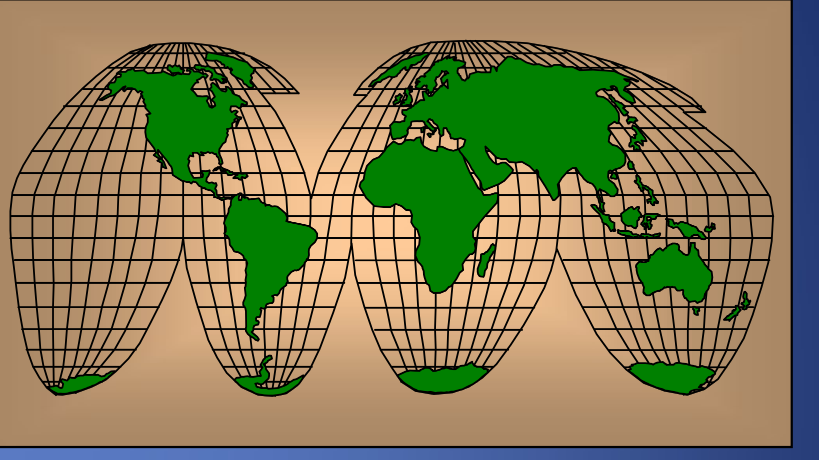


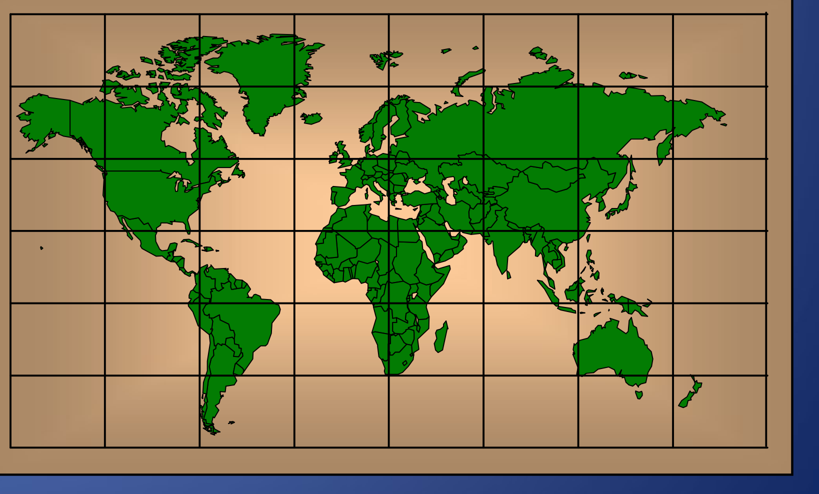




PROJECTED COORDINATE SYSTEM

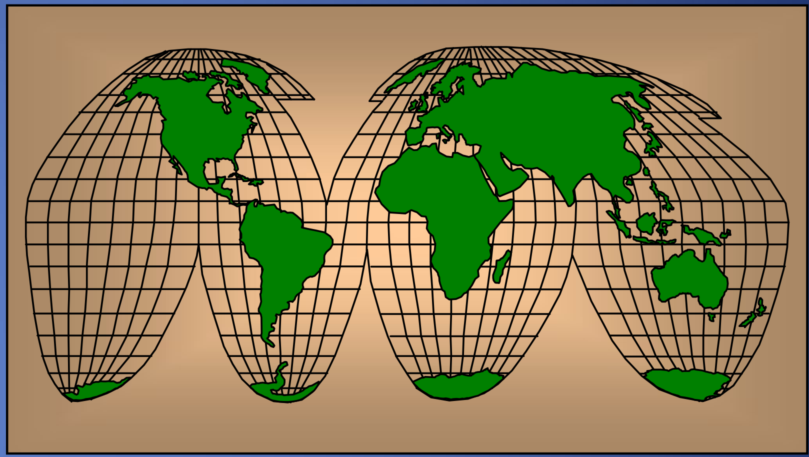
- Also c/a Plane Coordinate System
- Based on a map projection
- Relates the coordinates of points on earth's curved surface with the coordinates of the same points on a plane or flat surface
- Key consideration is accuracy in a feature's location and its position
- Defined not only by the parameters of map projection but also the parameters of the GCS it is derived from

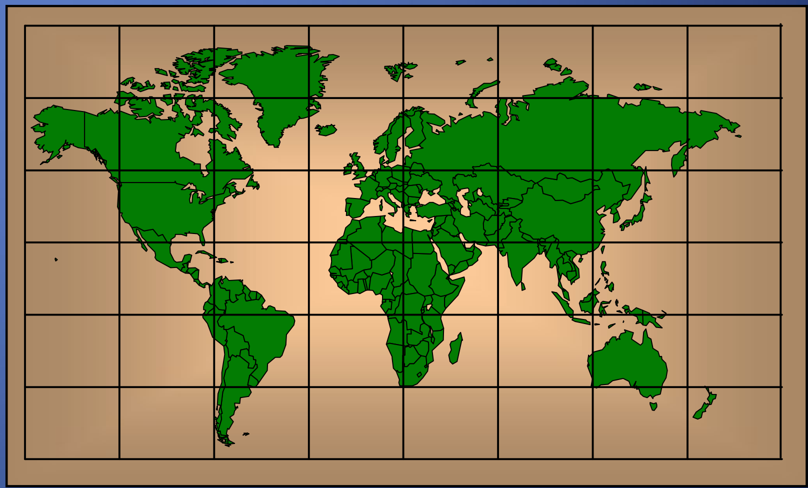




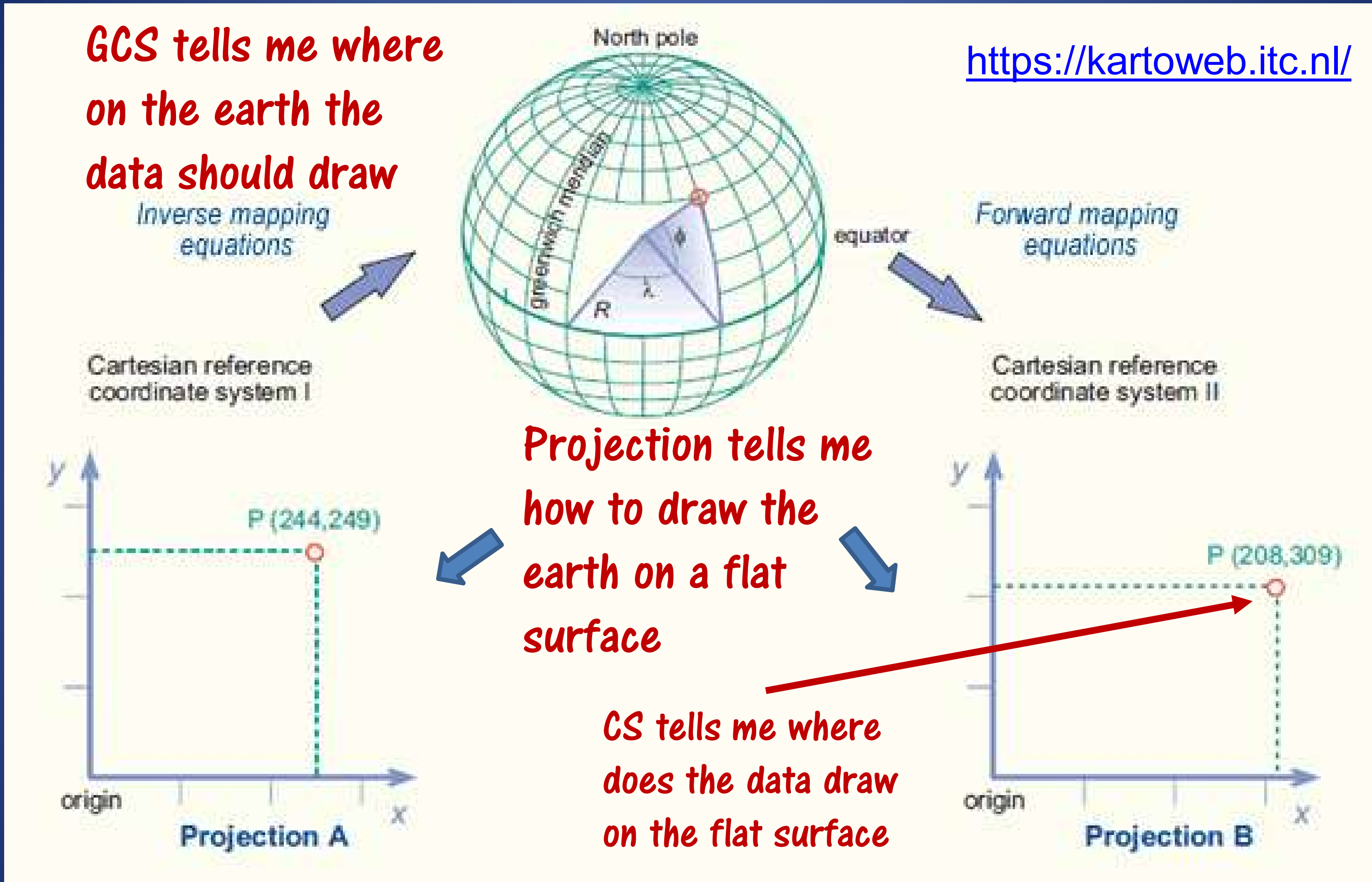
PROJECTED COORDINATE SYSTEM

- Also c/a Plane Coordinate System
- The graticule represents positions on 3D surface of the Earth that have been projected or transformed onto the 2D surface of the map
- The rectangular coordinate grid is superimposed on the graticule so that positions of mapped features can be georeferenced by means of linear measurements rather than by angular measurements



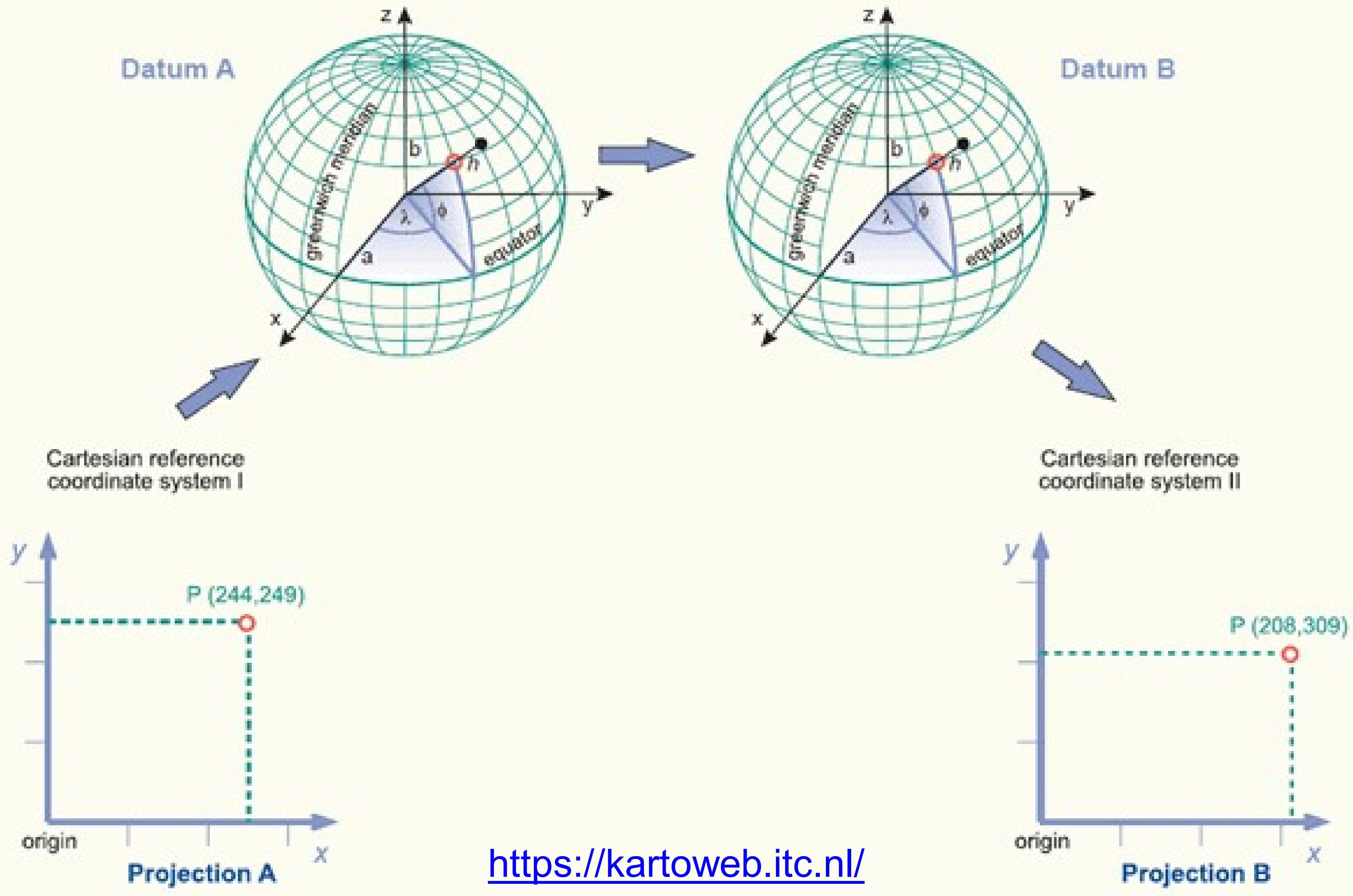


GCS, Projection and PCS



- Coordinate systems are constructed based on map projections, they are not map projections themselves

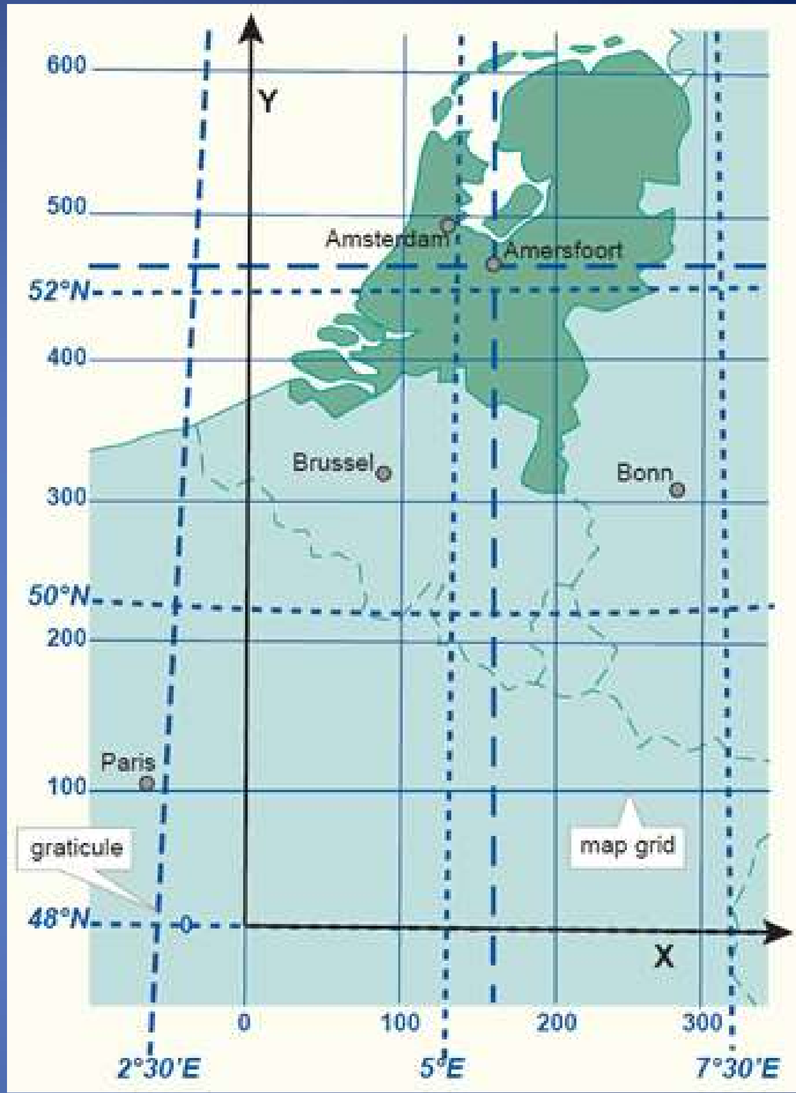
Coordinate Transformation



https://kartoweb.itc.nl/

Map projections and coordinate systems serve two different purposes in geo-referencing

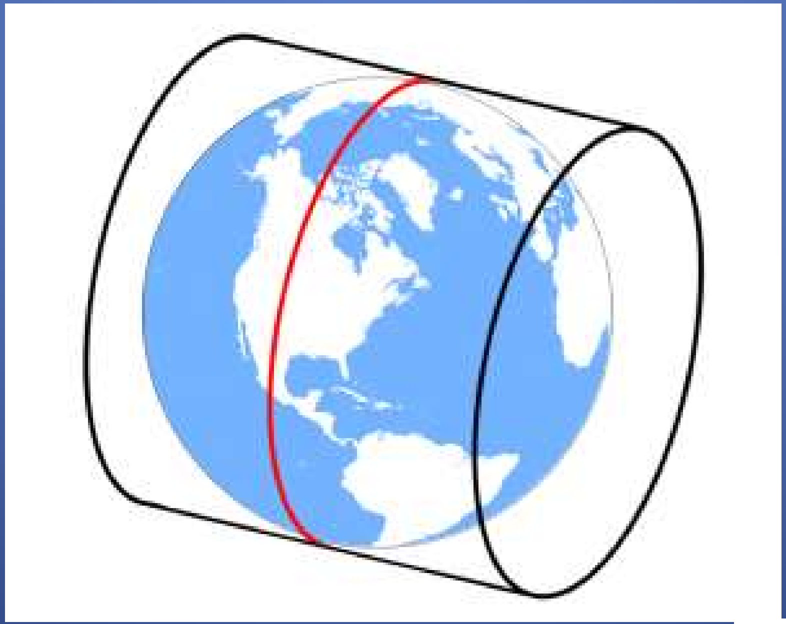
- The function of map projections is to define how positions on the Earth's curved surface are transformed onto a flat map surface
- Coordinate system is then superimposed on the surface to provide the referencing framework by which positions are measured and computed



https://kartoweb.itc.nl/geometrics/Coordinate%20systems/coordsys.html

The UNIVERSAL TRANSVERSE MERCATOR CS

- UTM is based on the Transverse Mercator projection.
- Transverse Mercator: Invented by Johann Heinrich Lambert in 1772. Modified Mercator projection
- Transverse aspect - the axis of the cylinder is rotated 90°, so the tangent line is longitudinal, rather than equatorial

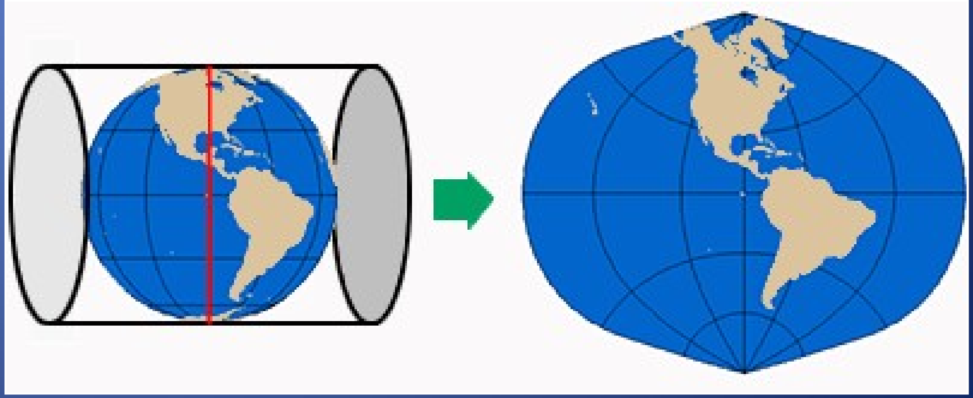


https://gisgeography.com/

TRANSVERSE MERCATOR PROJECTION

- In this case, only the central longitudinal meridian and the equator are straight lines. Distances are true along the central meridian
- It is a conformal projection
- All distances, directions, shapes and areas are reasonably close to the Central Meridian
- Shapes and angles within any small area are essentially true
- However, meridians and parallels are no longer straight lines as in case of the regular Mercator Projection

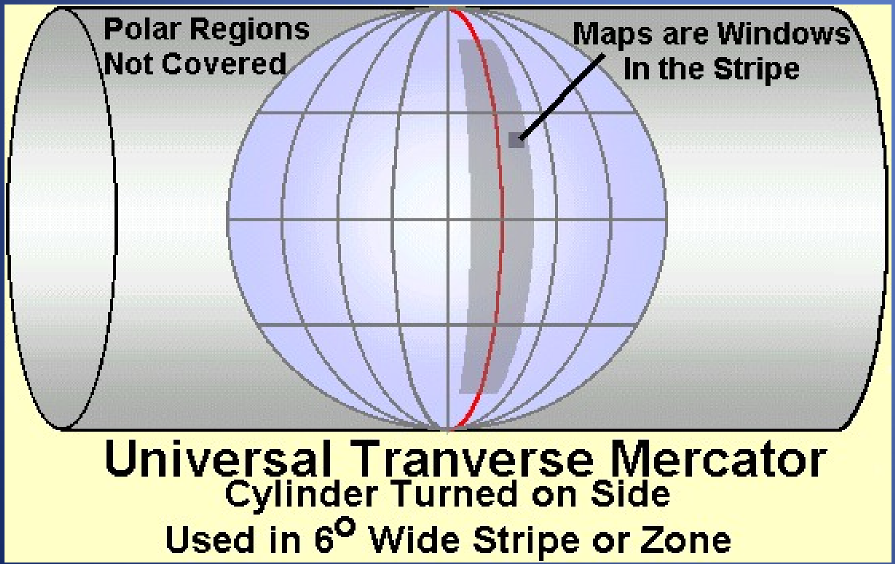
All other lines are represented by complex curves: that is they can't be represented by single section of a circle



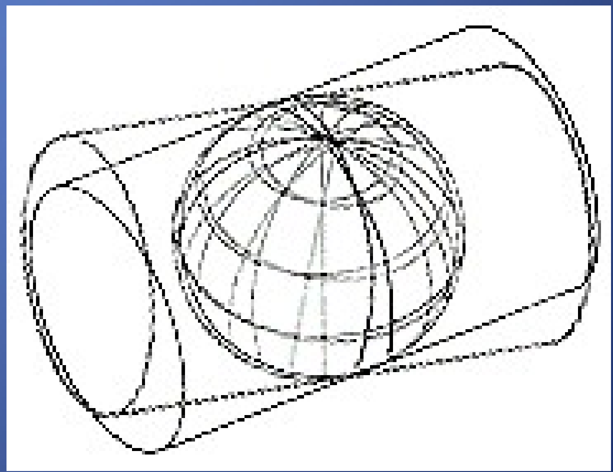
Source: ESRI

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

- TM projection modified to minimize the distortions so that it can be used for georeferencing (by US Army post World War II)
- The projection is applied repeatedly by using multiple cylinders that touch the globe at 6 degree intervals, resulting in 60 projection zones each of 6 degree longitude. Each UTM zone is projected separately .
- To avoid extreme distortions that occur in polar areas, the projection zones are limited to 84 deg North to 80 deg South



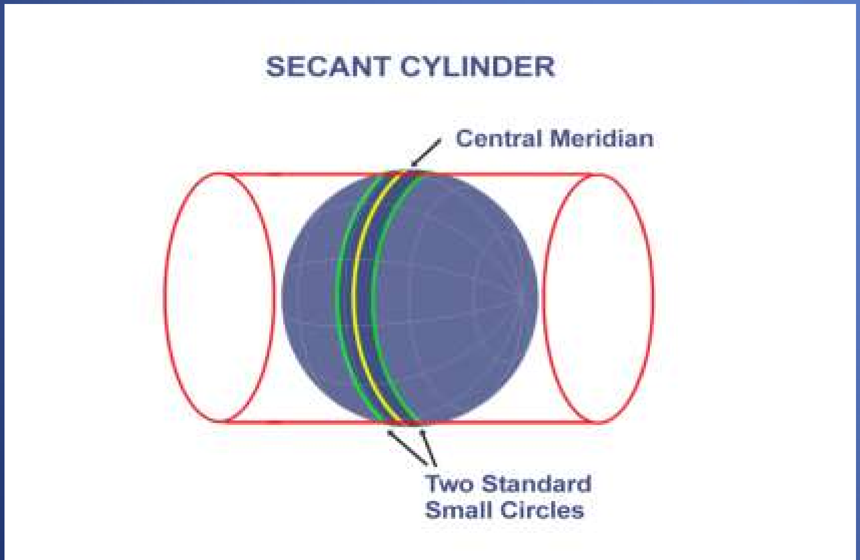
https://www.quora.com



http://www.georeference.org/

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

- To improve the overall accuracy of measurements within a projection zone, the cylinder is made to intersect the globe at two standard meridians that are 180 km east and west of the central meridian (i.e. a secant cylinder)
- This gives true scale along two standard meridians of longitude instead of one along the central meridian

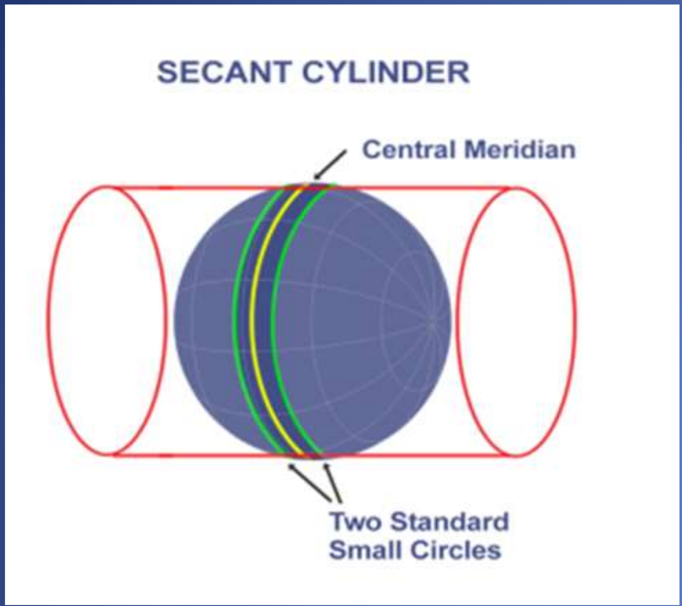


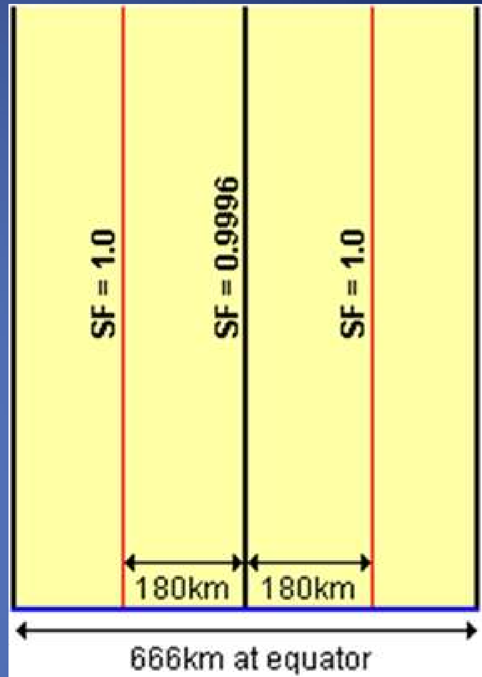
Each zone uses a custom Transverse Mercator projection with its own central meridian

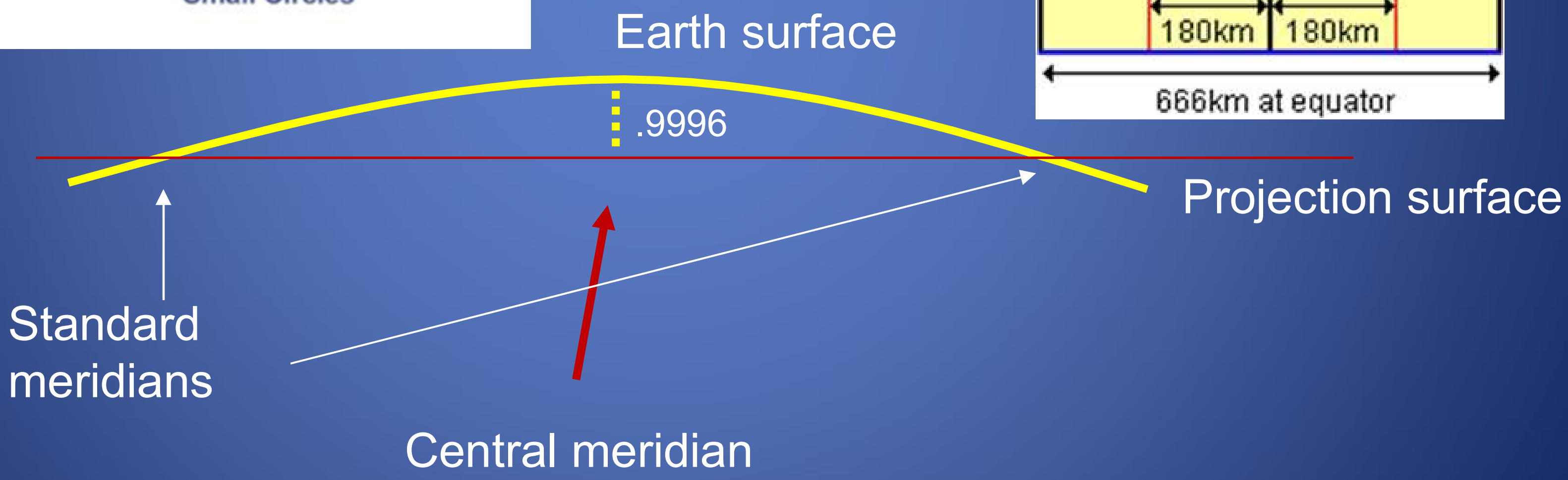
There is a false origin (zero point) in each zone

https://gisgeography.com/

- **Scale factors are .9996 in the middle and 1 at the secants**

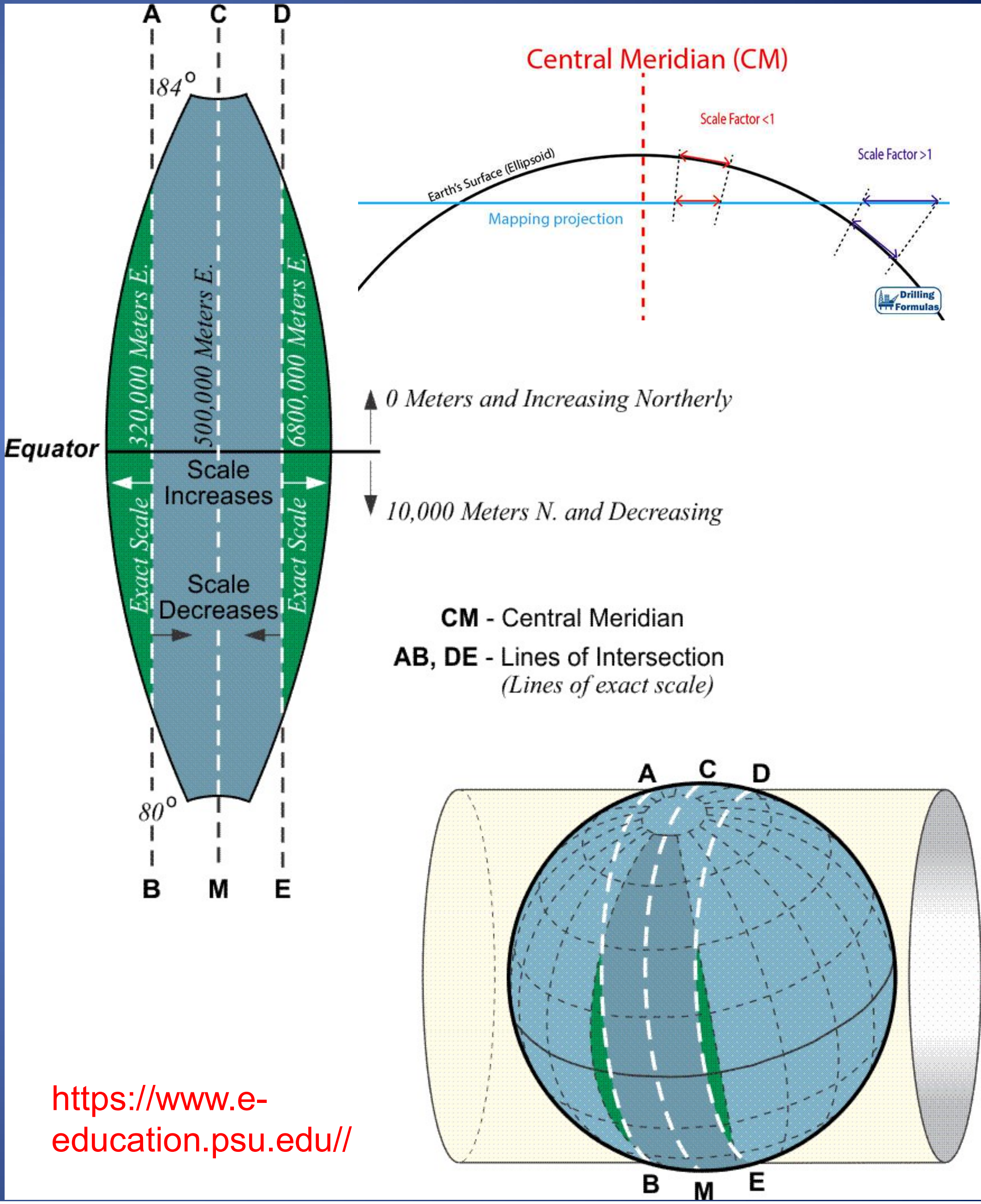






UNIVERSAL TRANSVERSE MERCATOR PROJECTION

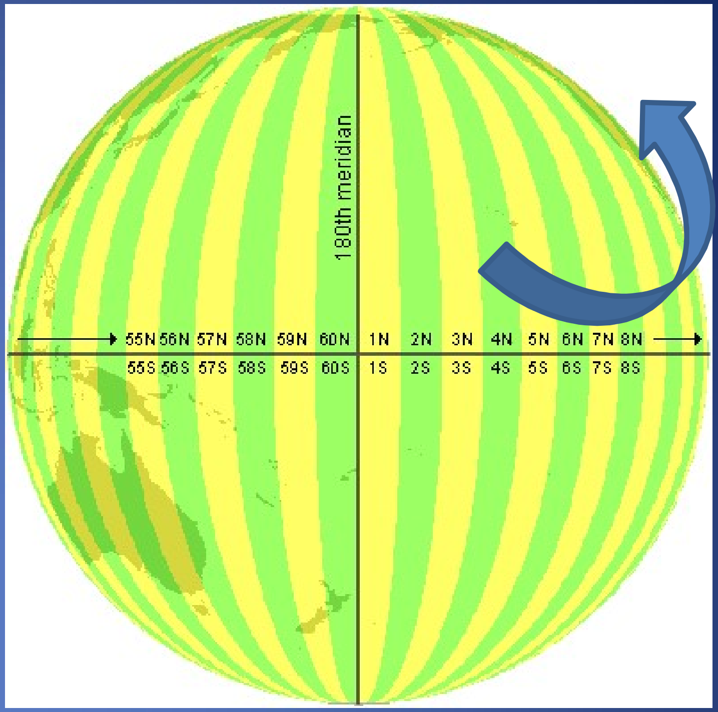
- To compensate for scale distortion that is introduced along the central meridian, a scale factor slightly less than unity (@ 0.9996) is applied to all distance measurements.
- Similarly, a scale factor slightly greater than unity (@ 1.0004) is also applied to compensate for distortions in all distance measurements near the zone boundaries



https://www.e-education.psu.edu//

UTM COORDINATE SYSTEM

- The UTM coordinate system is formed by superimposing a regular square grid on each UTM projection zone of 6 deg longitude width
- The grid is aligned so that the vertical lines are parallel to the central meridian
- There are 60 longitudinal projection zones – each 6 deg wide. They are numbered 1 to 60 starting at 180° W - International date line also c/a the antemeridian – proceeding towards east

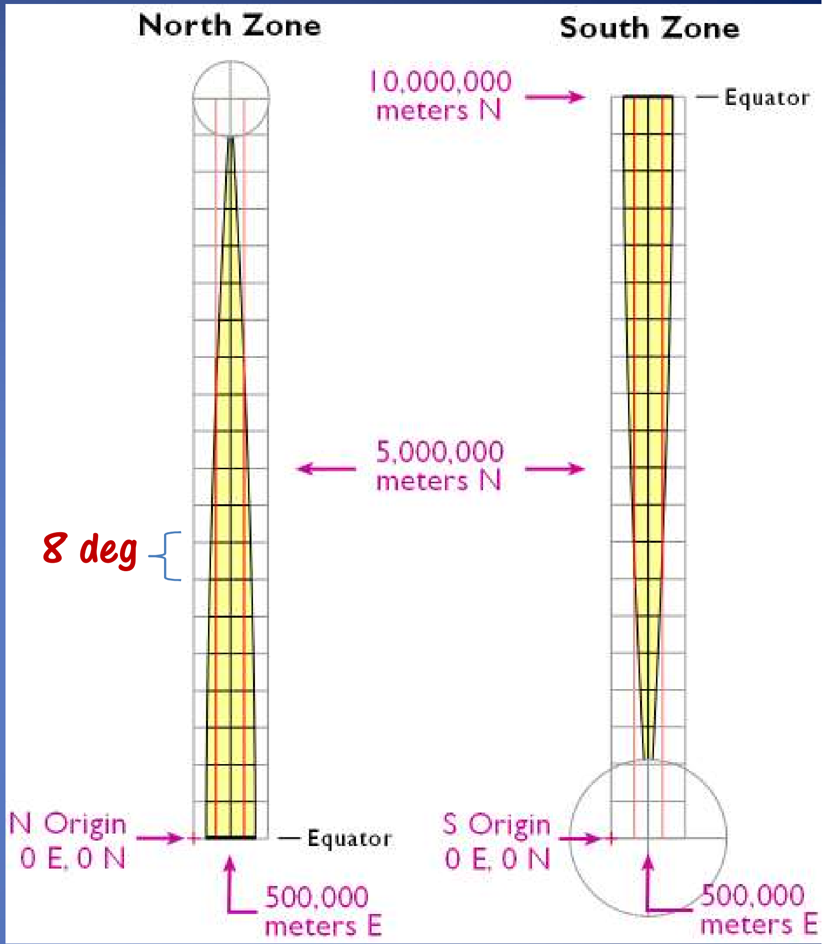


The longitudinal extension of ZONE 1 will be???

Central meridian of Zone 1 will be?

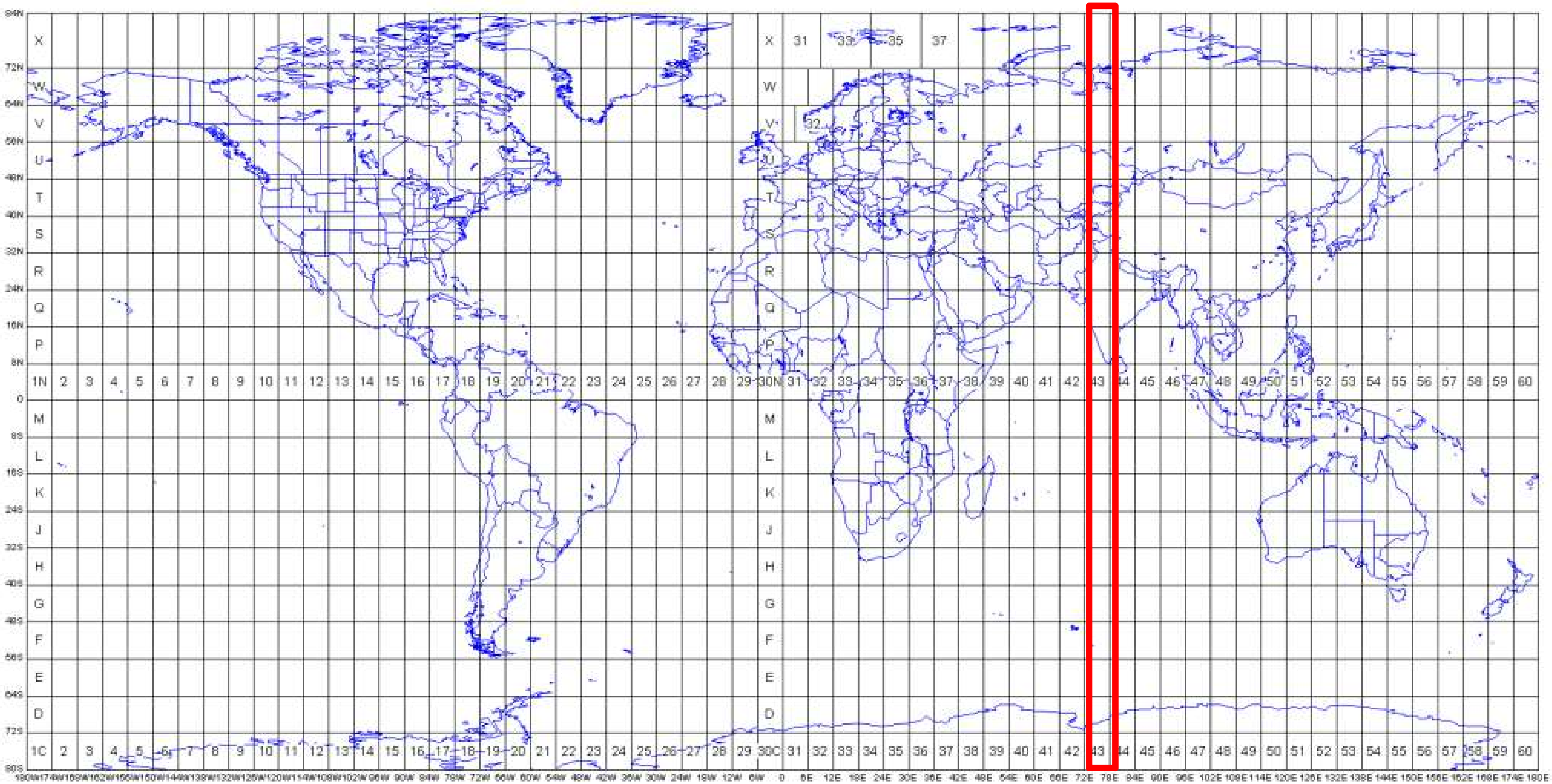
UTM COORDINATE SYSTEM

- Each UTM Zone (84 ° N to 80 ° S) is divided into horizontal bands spanning 8 ° of latitude
- There are 20 latitudinal zones
- They are identified by letters south to north beginning at 80 ° S from ‘C’ and ending at 84 °N at ‘X’, Omitting letter ‘I and O’ to avoid confusion with numbers 1 and 0.
- Only zone ‘X’ is 12 degrees N-S
- Areas are referenced by longitudinal zone number, followed by the latitudinal zone letter.



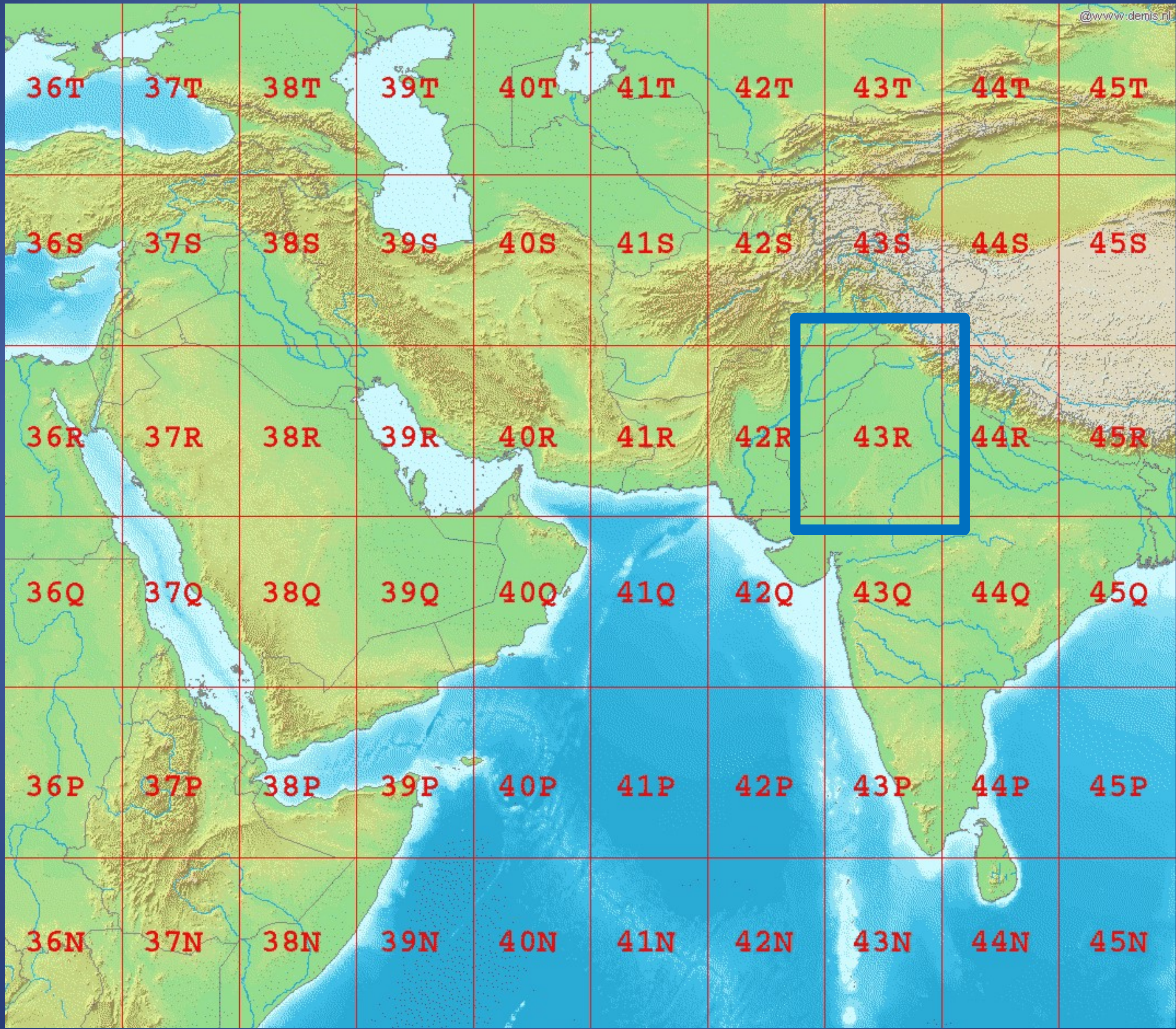
- UTM divisions of the earth between 84°N and 80°S (60 zones, each of which covers 6 degrees of longitude)

- Zone 1 begins at 180 ° W longitude.



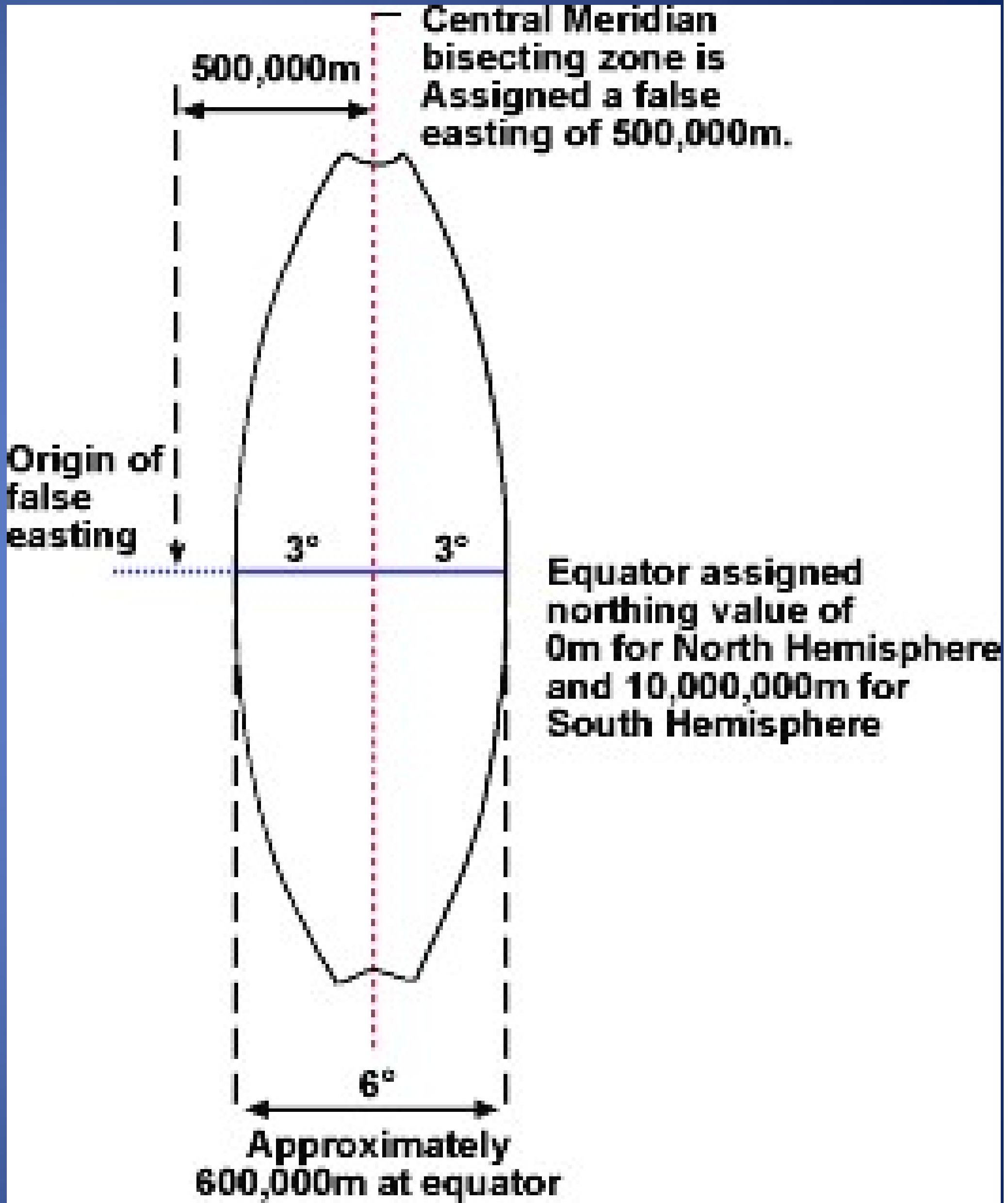
World UTM zones

UTM GRID – INDIA



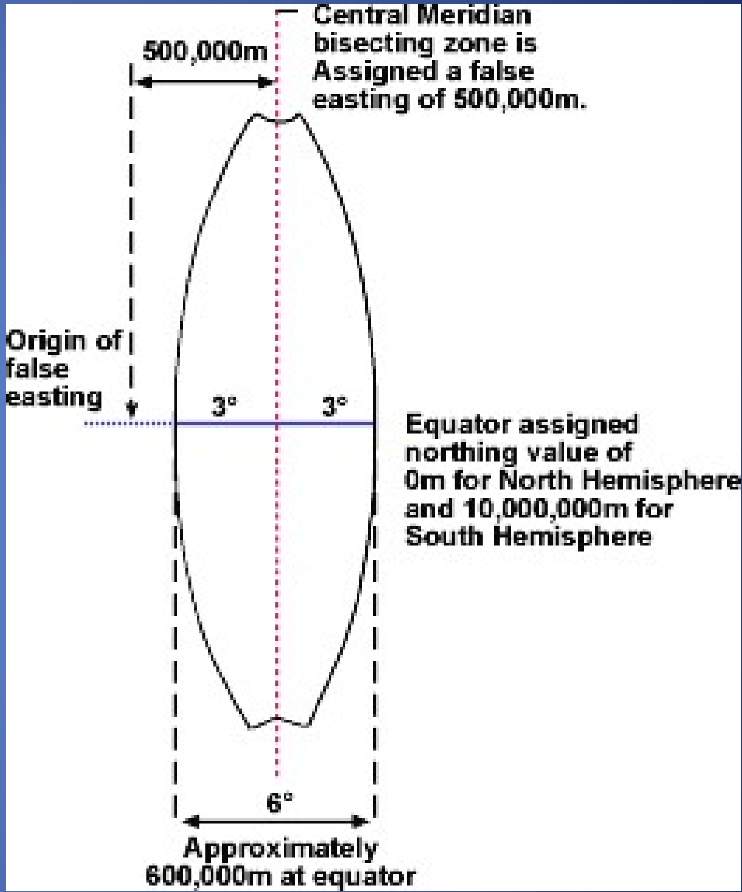
UTM COORDINATES

- UTM coordinates are expressed as a distance in meters to the east, referred to as 'easting' and a distance in meters to the north, referred to as 'northing'
- Eastings are referenced to the central meridian, which is assigned a value of 500,000. This gives the zone a false origin that is 500,000 m west of the central meridian. This eliminates the use of negative values for western half of the zone



UTM COORDINATES

- Northings are referenced to the Equator. For fixing position in the northern hemisphere, the Equator is assigned a northing value of 0 (zero) m N.
- To avoid negative numbers for locations south of Equator, in southern hemisphere position fixing is done with equator assigned a value of 10,000,000 m S.
- Thus for the northings in the southern hemisphere, the origin is defined as a point 10000000 meters south of equator



Locating a point in UTM Coordinate System

- The coordinates thus derived define a location within a UTM projection zone either North or South of Equator.
- But since the same coordinate system is repeated for each zone and hemisphere, it is necessary to additionally state the UTM longitudinal zone and either the hemisphere or the latitudinal zone to define the location uniquely world wide.
- Thus UTM Coordinate definition shall comprise (1) Easting Coordinate value (2) Northing coordinate value (3) Zone Number and (4) Hemisphere (N or S of Equator)

Coordinate Information of Udaipur

Udaipur Latitude:	24.58
Udaipur Longitude:	73.68
Latitude DMS:	24°34'48"N
Longitude DMS:	73°40'48"E
UTM Easting:	366,342.17
UTM Northing:	2,719,083.56
UTM Zone:	43R
Position from Earth's Center:	ENE
Elevation:	598.8 Meters (1964.55 Feet)

REMEMBER!!!!

- Coordinates on same projection may be referenced on different DATUMS .

  Such coordinates will have different coordinate values.

- Coordinate data may be unprojected but CANNOT be without a datum.

- Change of projection may result in change of Datum.

- It is possible to convert data from one Datum to another without projecting it.

SUMMARY CONCEPTS

- ✓ Two basic locational systems: geometric or Cartesian (x, y, z) and geographic or gravitational (f, l, z)

- ✓ Mean sea level surface or geoid is approximated by an ellipsoid to define a horizontal earth datum which gives (f, l) and a vertical datum which gives distance above the geoid (z)

SUMMARY CONCEPTS (CONT.)

- To prepare a map, the earth is first reduced to a globe and then projected onto a flat surface
- Three basic types of map projections:
  - conic
  - cylindrical
  - Planar/azimuthal
- A particular projection is defined by a datum, a projection type and a set of projection parameters

SUMMARY CONCEPTS (CONT.)

- ✓ Standard coordinate systems use particular projections over zones of the earth's surface
- ✓ Types of standard coordinate systems:
  - ✓ UTM
  - ✓ State Plane
  - ✓ Others too numerous to mention
- ✓ Do not confuse the coordinate system of a set of datum for its projection
  - ✓ Example: A shapefile that uses the Texas State Plane Coordinate System is in the Lambert Conformal Conic Projection

WHAT DOES ALL THIS MEAN???

- Careful attention must be paid to the projection, datum and coordinate system for every piece of GIS data used.
- Failure to use data from the same system OR change the data (re-project) it to the desired system will result in overlay errors
  - Can range some small to SIGNIFICANT
  - Real danger is when the errors are small (possibly unnoticed)
- Shapefiles, images, grids all have this data inherent in their very creation.
  - Usually included in a system of files known as "metadata" or xxxxxx.PRJ file.