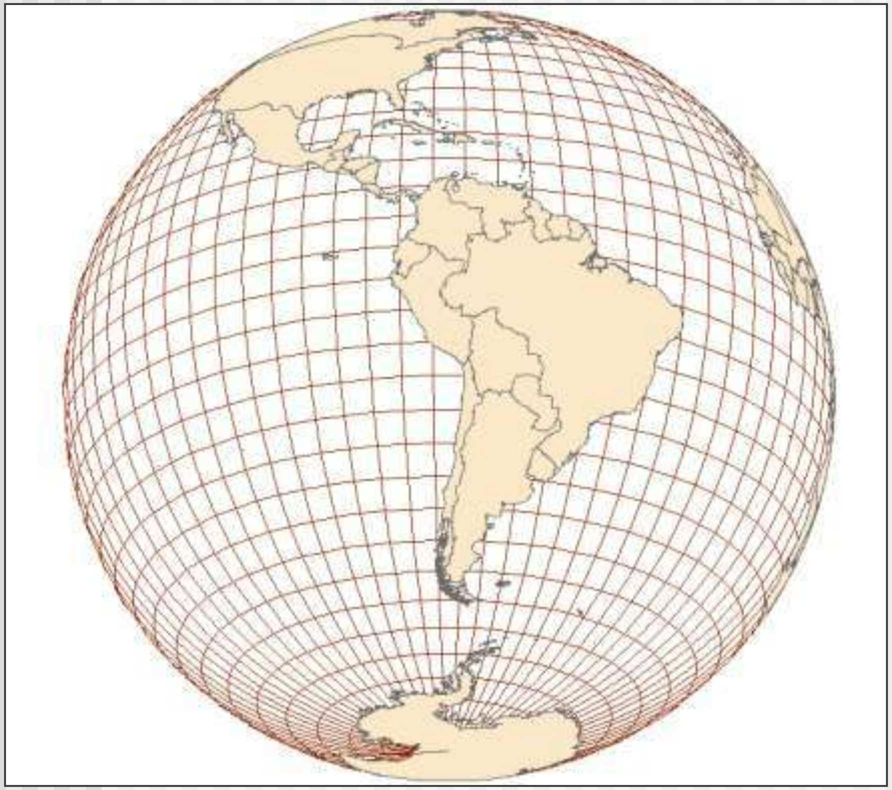
FOR SEMESTER 3 GE Students , Geography

Paper 4 (Th.)

UNIT : I ; TOPIC : 3

Map Projections

...Introduction



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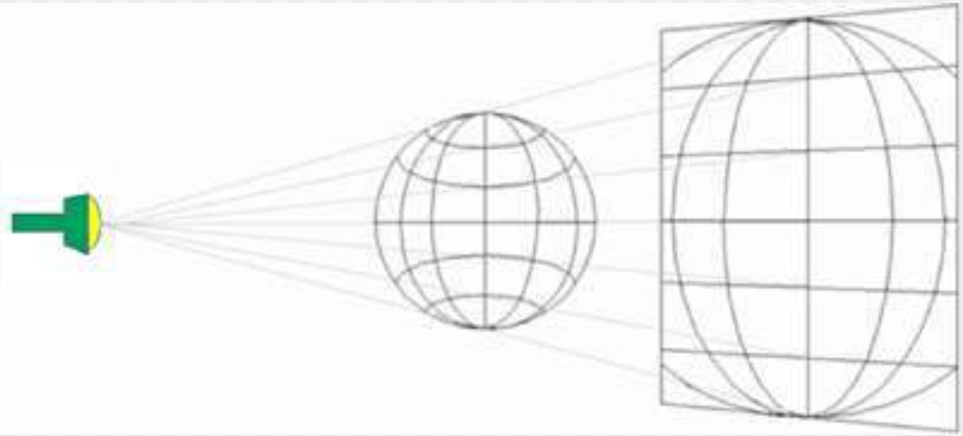
Map Projections …

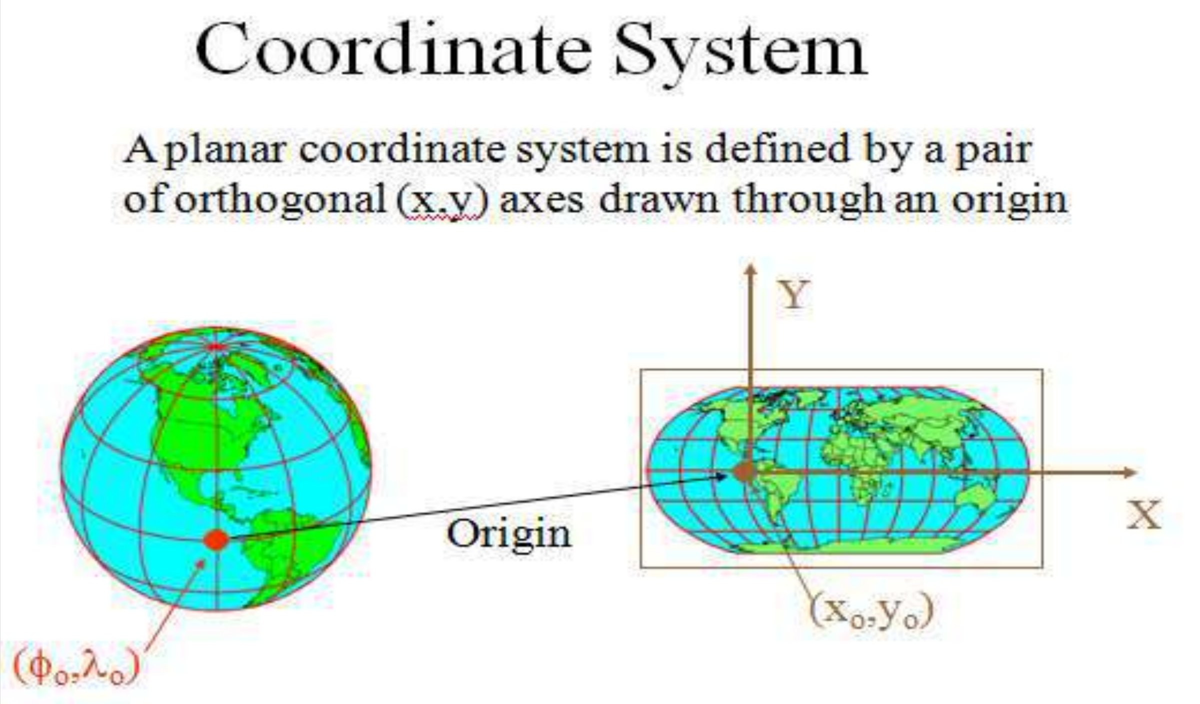
- The method by which we transform the earth's spheroid (real world) to a flat surface (abstraction), either on paper or digitally
- Define the spatial relationship between locations on earth and their relative locations on a flat map

Think about projecting a see-through globe onto a wall



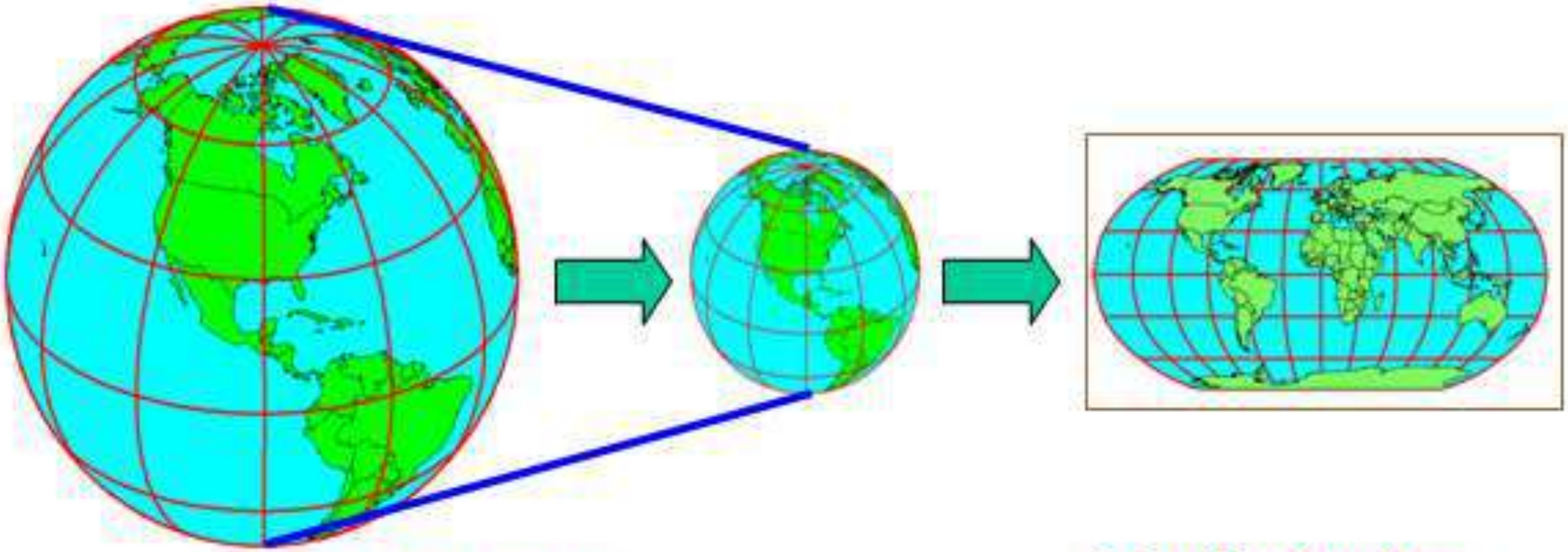
Spatial Reference = Datum + Projection + Coordinate system

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 an earth datum which gives (f, l) and distance above geoid gives (z)

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)

Classifications of Map Projections

Criteria	Parameter	Classes/ Subclasses			
Extrinsic	Datum Surface	Direct / Spheroidal	Double/ Spherical	Triple	
	Plane or surface of projection	Ist Order	2nd Order	3rd Order	
		I. Planar II. Conical III. Cylindrical	a. Tangent b. Secant c. Polysuperficial	i. Normal ii. Transverse iii. Oblique	
	Method of Projection	Perspective	Semi-perspective	Non-perspective	Conventional
Intrinsic	Properties	Azimuthal	Equidistant	Othomorphic	Homolographic
	Appearance of parallels and meridians	Both parallels and meridians straight Parallels straight, meridians curve Parallels curves, meridians straight Both parallels and meridians curves Parallels concentric circles , meridians radiating st. lines Parallels concentric circles, meridians curves			
	Geometric Shape	Rectangular	Circular	Elliptical	Parabolic

Classifications of Map Projections

On the basis of Intrinsic Properties

- Conformal – local shapes are preserved e.g. Mercator's Projection
- Equal-Area – areas are preserved. e.g. Bonne's Projection, Cylindrical Equal Area Projection
- Equidistant – distance from a single location to all other locations are preserved e.g. Simple conical projection with one standard parallel.
- Azimuthal – directions from a single location to all other locations are preserved. e.g. Zenithal Stereographic Projection

Another Classification System

On the basis of Extrinsic Property-
Plane/Surface of Projection

By the geometric surface that the sphere is projected on:

- Planar-

e.g. Zenithal Stereographic Projection

Earth intersects the plane on a small circle. All points on circle have no scale distortion.

- Cylindrical-

e.g. Simple Conical Projection with One standard Parallel, Bonne's Projection

Earth intersects the cylinder on two small circles. All points along both circles have no scale distortion.

- Conic -

e.g. Mercator's Projection, Cylindrical Equal Area Projection

Earth intersects the cone at two circles. All points along both circles have no scale distortion.

Another Classification System

On the basis of Extrinsic Property- Method of Projection

Perspective Projection: Here graticules are drawn from a transparent generating globe made of glass with the help of a light source. Rays emerging from the sources cast shadows of parallels and meridians on the projection plane.

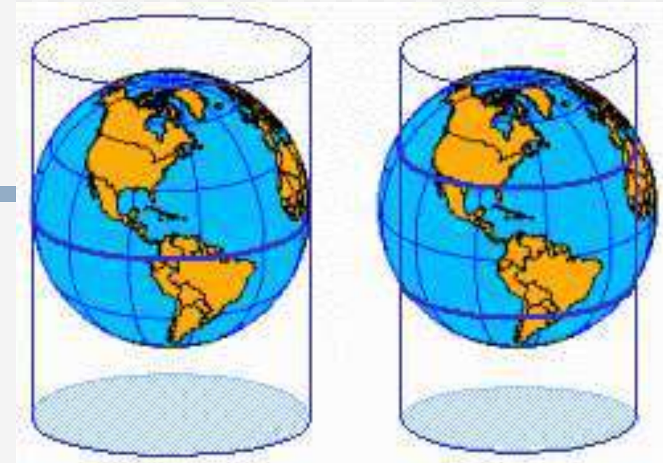
Semi-Perspective Projection: In this case, one set of intersecting lines are geometrically projected and the other set drawn purely to suit a desired property.

Non-Perspective Projection : In this case, projection is done in accordance to a consistent principle to satisfy certain objectives.

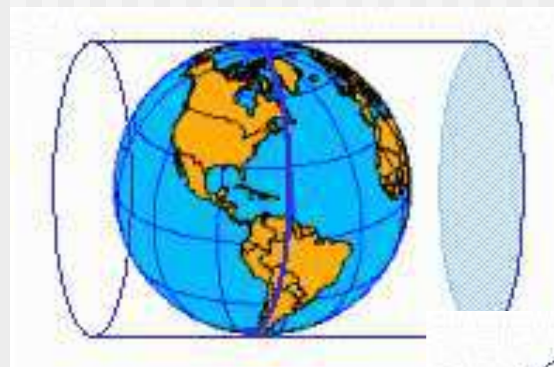
Conventional Projection : In this case projection is constructed following a set of conventions purely based on mathematical operations postulated by a cartographer.

Developable Surface

Cylindrical

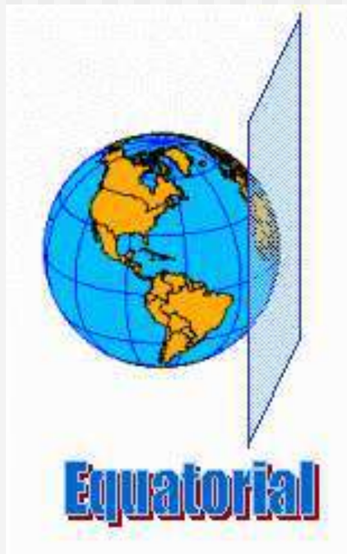


Normal

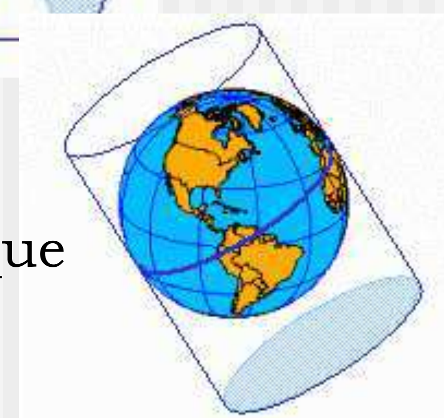


Transverse

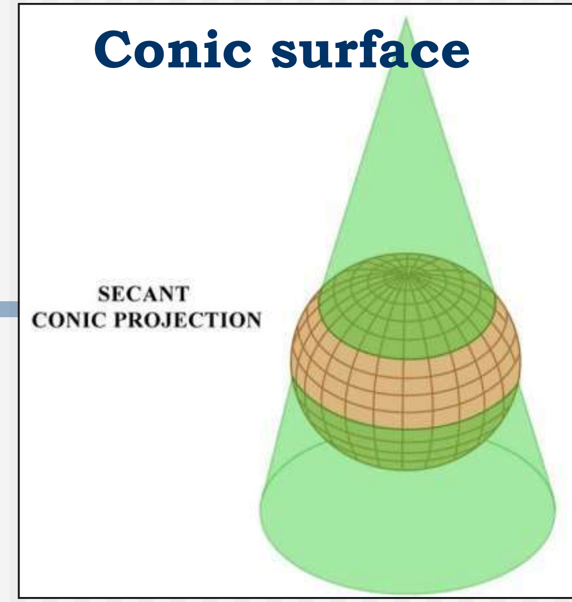
Azimuthal /Planar;

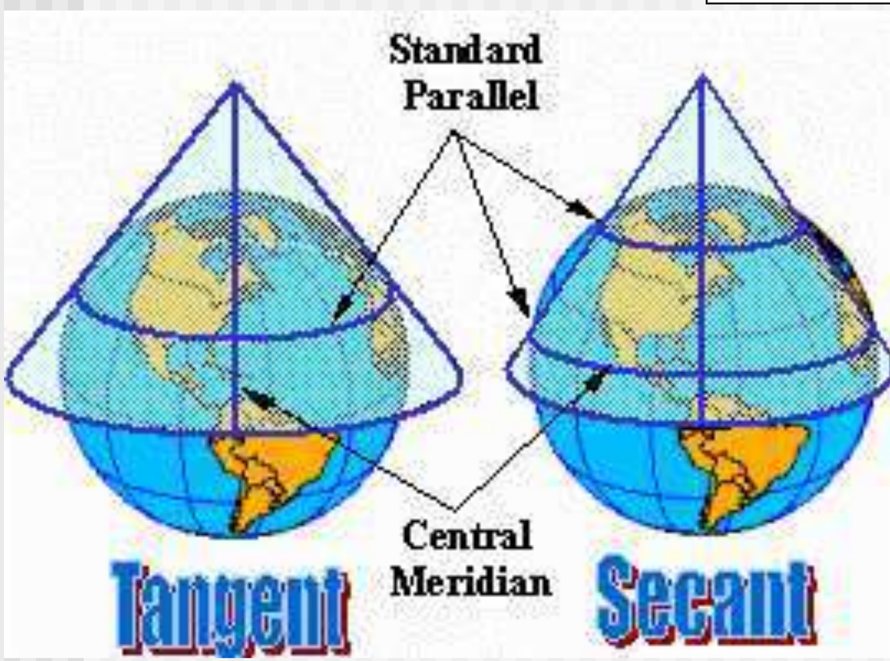


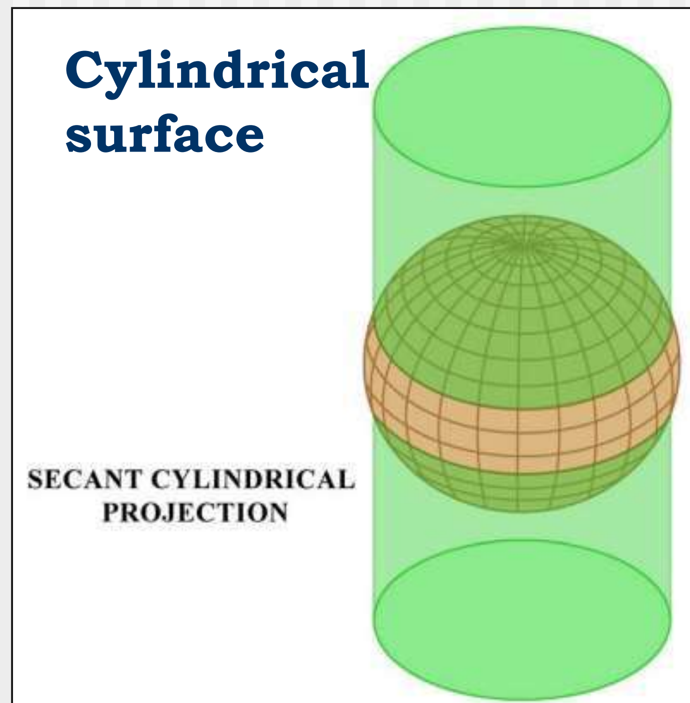
Oblique



Developable Surface







Some Projection Parameters

- Standard parallels and meridians – the place where the projected surface intersects the earth – there is no scale distortion. Along the standard parallels, tangential scales essentially 1:1.

- Central meridian –The meridian which lies exactly at the median or middle position. It has constructional importance, usually drawn as a straight line and is commonly divided true to scale for spacing the parallels along it. The net of graticules on one side of the central meridian is infact the replica of the other side.

Projection Parameters contd……

- **Graticule :** It refers to the net of mutually intersecting parallels and meridians drawn to a certain scale and based on certain principles.
- Spherical Coordinates- The position of a point on the earth's surface is usually determined with respect to an imaginary reference framework constituted by a fixed pair of mutually intersecting perpendicular lines - equator and prime meridian. The ordinate values are the latitudes while the abcissa values are longitudes.

Projection Parameters contd……

- Generating Globe: It refers to the globe from which projections are generated or developed. Normally this is a small skeleton globe made of glass or wire. The parallels and meridians are shown by black lines or wires (wire globe) placed at their true angular distances apart. Naturally the generating globe is a geometrically accurate earth reduced in size.
- Projection Plane: It is a two-dimensional geometric plane upon which the parallels and meridians are usually projected. In case of a perspective planar projection the projection plane touches the generating globe at a single point.

Projection Parameters contd……

- **Developable Surface:** In planar projections (where a flat plane always touches a curved surface at a point), only a single point is truly represented with exact one to one correspondence. From this point of tangency, distortion of map increases in all directions.

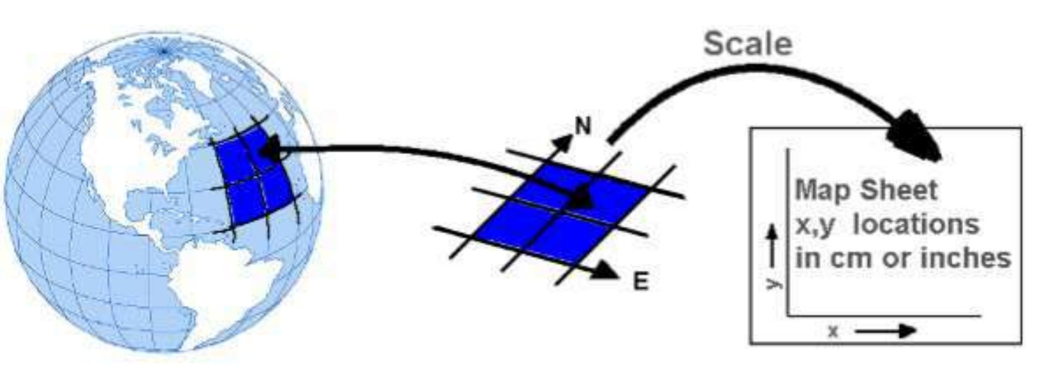
To minimise the deformation, the point of contact with the generating globe is maximised. This is usually done by using projection surfaces that can be easily developed into 2-dimensional geometrical planes. Such projection surfaces are known as developable surfaces e.g. a cone or a cylinder.

A right circular cone or a cylinder usually touches a generating globe along a parallel and may intersect it along two definite parallels in some desired situations. Along these lines of latitudes one-to -one correspondence is truly maintained involving no error and are termed ***lines of zero distortion***.

Basic Problem of Map Projection

The basic problem of map projection is the representation of a curved surface in a plane. The figure of the earth is truly represented only by an equipotential surface at the mean sea level , called the ***Geoid***, and such an equipotential surface is irregular, or undulating , impossible to express by a rigorous mathematical formula.

Hence for representation of curved surfaces on a plane, stretching or shrinking is involved resulting in distortions.



Mapping Round Earth
On Flat Paper Leads to Distortion

All flat maps have some distortion in their representation of: Distance, Shape, Area, Or Direction.

CHOICE OF PROJECTIONS :

The correct use of projections involves their right selection for the purpose in view. There is no projection which can display all the characteristics of a globe. Some of them show areas of correct bearings, while some others give correct shapes. Some projections are meant to show only small areas, others are means to represent larger areas like continents while still others can show up the whole world. There are few other characteristics which individual projections possess. But there is none which possesses all the characteristics simultaneously. A judicious choice of projections, therefore forms an important step in cartographic processes.

Sl. No.	Regions	Suitable Map Projections
1	World in one sheet	➢ Cylindrical Equal Area Projection, ➢ Mercators Projection, ➢ Mollweids Projection, ➢ Sinusoidal Projection
2	World in Hemispheres	➢ Polar Zenithal Equal Area Projection ➢ Polar Zenithal Equidistant Projection ➢ Polar Zenithal Stereographic Projection
3	Region north or south of the equator Asia	➢ Polar Zenithal Equidistant Projection ➢ Bonne's Projection
	North America	➢ Bonne's Projection ➢ Conical with two standard parallels ➢ Polyconic Projection
	Europe	➢ Polyconic Projection ➢ Conic with two standard parallels
	Australia	➢ Bonne's Projection ➢ Simple Conic with two standard parallels
4	Polar Regions	Zenithal Projections
5	Large Scale Topographical Maps	➢ Modified Polyconic Projection ➢ Bonne's Projection

Polar Zenithal Stereographic Projection

Principle : The plane of projection is tangent at either of the poles. The parallels of latitude are projected as concentric circles- closer towards the centre and farther apart towards the edges. The meridians are radiating straight lines at true angular distances apart.

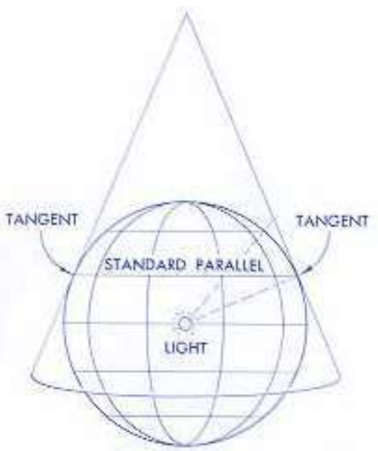
Properties :

- The property of correct azimuths or true bearings from the centre of the map or projection is retained.
- Those great circles which pass through the source of light and the point of tangency of the plane of projection are projected as straight lines.
- The exaggeration of scales-both tangential and radial away from the centre is nevertheless appreciable.

Limitations:

The antipode of the point of tangency of the plane of projection with the generating globe cannot be represented .

Simple Conical Projection with One Standard Parallel



Principle : In this projection, a right circular cone is supposed to touch the generating along a selected parallel passing through the centre of the area to be projected and known as the standard parallel.

Properties :

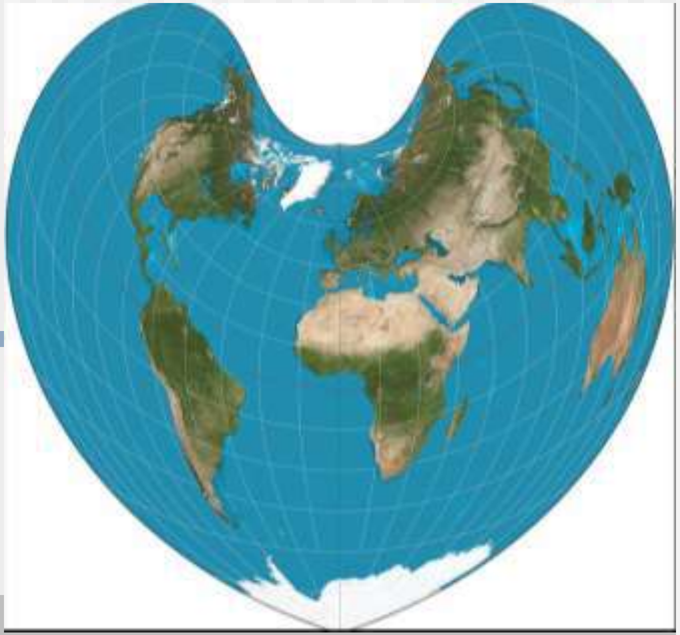
- The scale along the standard parallel is everywhere correct; elsewhere the scale along the parallel is exaggerated.
- The radial scale is correct only at the standard parallel.
- This is neither equal –area nor orthomorphic.

Limitations :

- Away from the standard parallel both the tangential and radial scales become greatly exaggerated , resulting in distortion of shape. Hence, the projection is of little economic value.

Bonne's Projection

Principle : In this projection, each parallel is divided truly- a modification from the previous projection introduced to make the scale along the parallels correct and therefore to make the projection an equal-area one.



Properties :

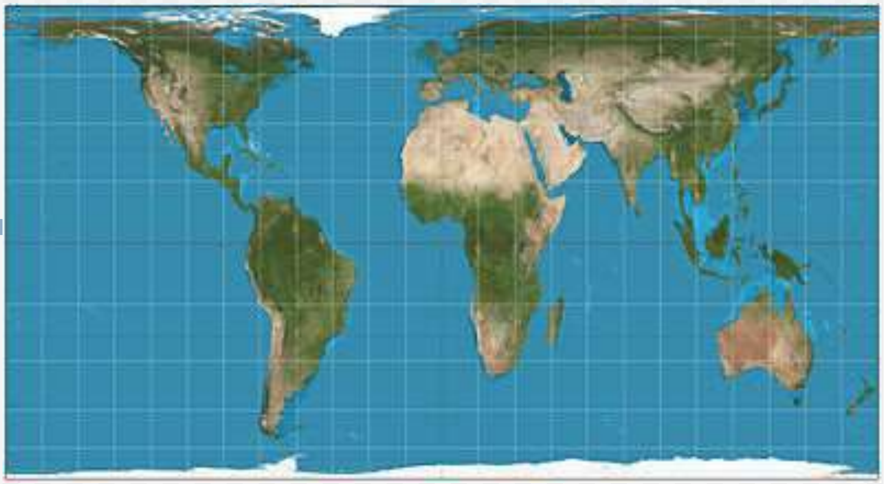
- The scale is correct along each parallel and as the parallels are arcs of concentric circles and the central meridian is truly divided the scale is correct in directions perpendicular to the parallels at all points .
- The scale along the central meridian is true; along other meridians there is exaggeration which increases away from the central meridian.
- The projection is an equal-area one.

Limitations :

- Its defects are accentuated if the range of longitude s increased.

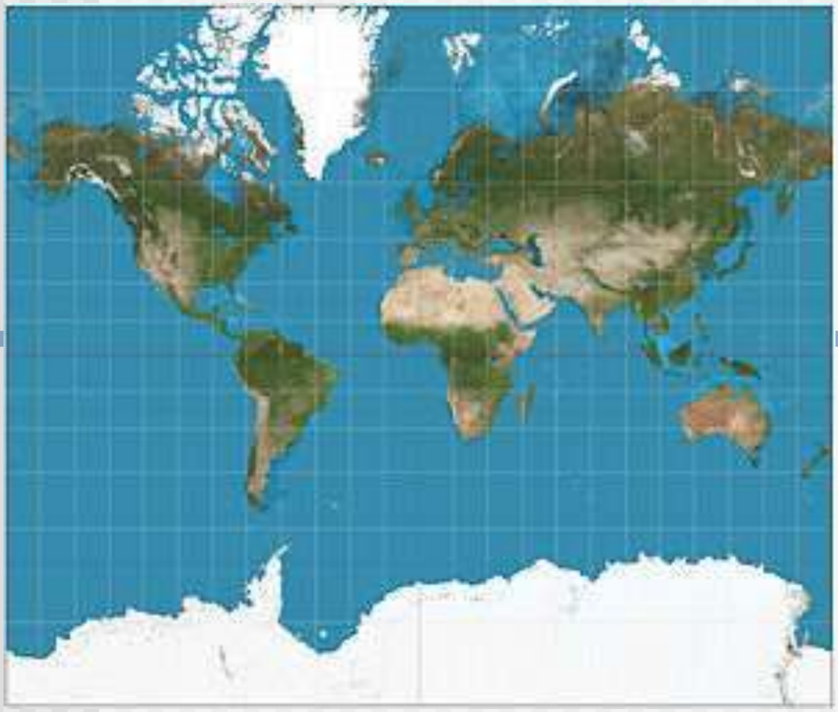
Cylindrical Equal Area Projection

The term "normal cylindrical projection" is used to refer to any projection in which meridians are mapped to equally spaced vertical lines and circles of latitude (parallels) are mapped to horizontal lines (or, mutatis mutandis, more generally, radial lines from a fixed point are mapped to equally spaced parallel lines and concentric circles around it are mapped to perpendicular lines).



Cylindrical equal-area projection of the world; standard parallel at 40°N.

The only cylindrical projection that preserve area have a north-south compression precisely the reciprocal of east-west stretching (cosine φ): equal-area cylindrical (with many named specializations such as Gall–Peters or Gall orthographic, Behrmann, and Lambert cylindrical equal-area). This divides north-south distances by a factor equal to the secant of the latitude, preserving area but heavily distorting shapes.



Mercator projection of the world between 82°S and 82°N.

As the linear scale of a Mercator map increases with latitude, it distorts the size of geographical objects far from the equator. At latitudes greater than 70° north or south the Mercator projection is practically unusable, since the linear scale becomes infinitely high at the poles. A Mercator map can therefore never fully show the polar areas

Mercator Projection

The **Mercator projection** is a cylindrical map projection presented by the Flemish geographer and cartographer Gerardus Mercator in 1569. It became the standard map projection for nautical purposes for its ability to represent lines of constant course, known as rhumb lines or loxodromes, as straight segments that conserve the angles with the meridians.

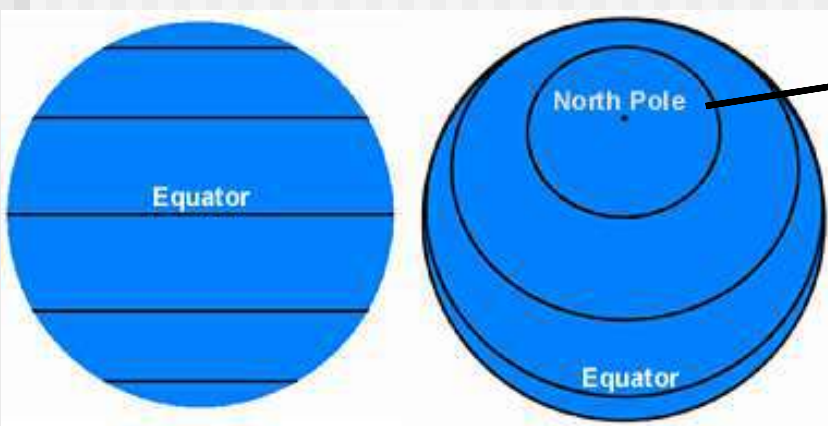
While the linear scale is equal in all directions around any point, thus preserving the angles and the shapes of small objects (which makes the projection conformal), the Mercator projection distorts the size of objects as the latitude increases from the Equator to the poles, where the scale becomes infinite. So, Greenland and Antarctica appear much larger relative to land masses near the equator than they actually are.

Cylindrical map distortion

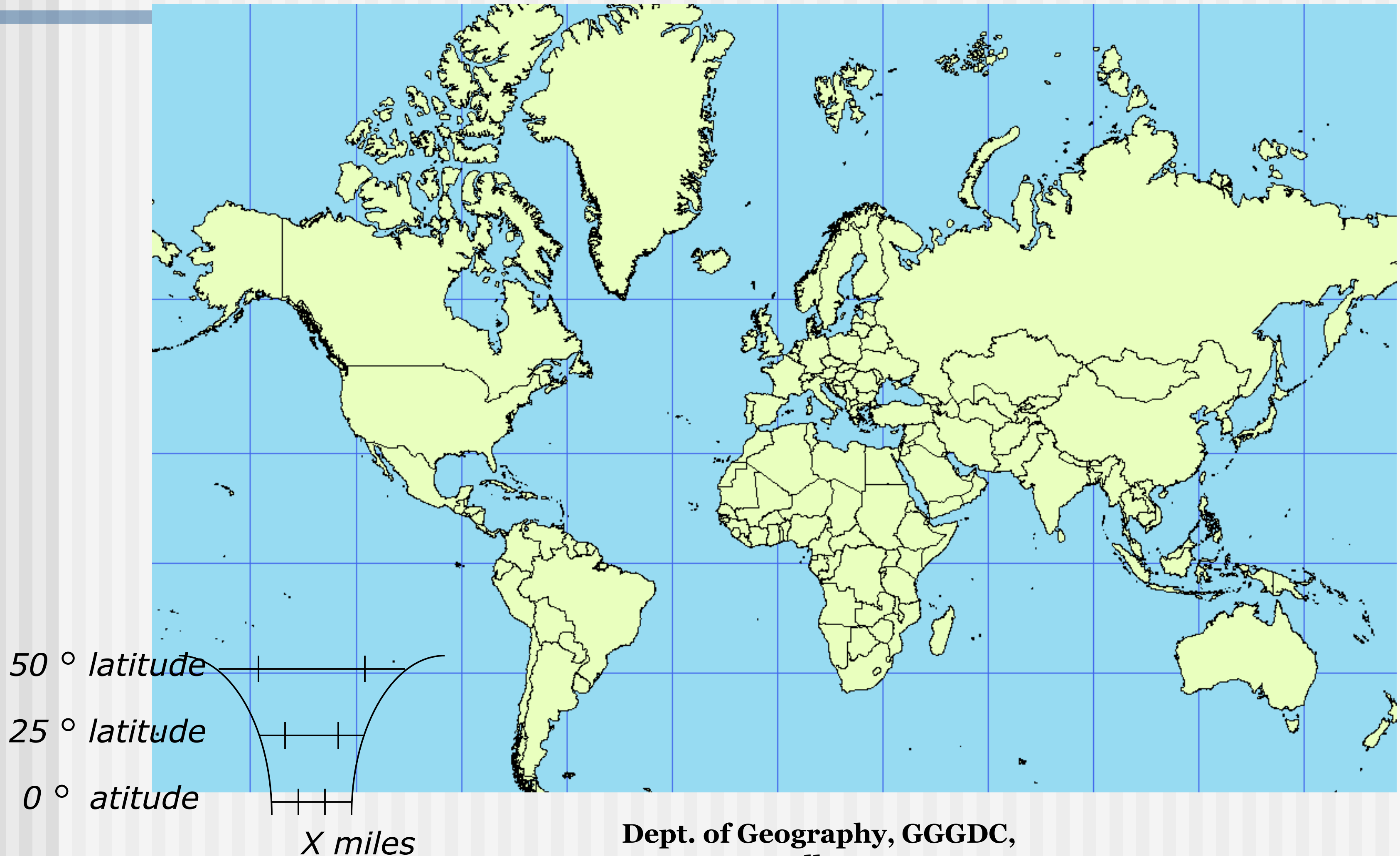
•Why is this? Because meridians are all the same length, but parallels are not.

•This sort of projection forces parallels to be same length so it distorts them

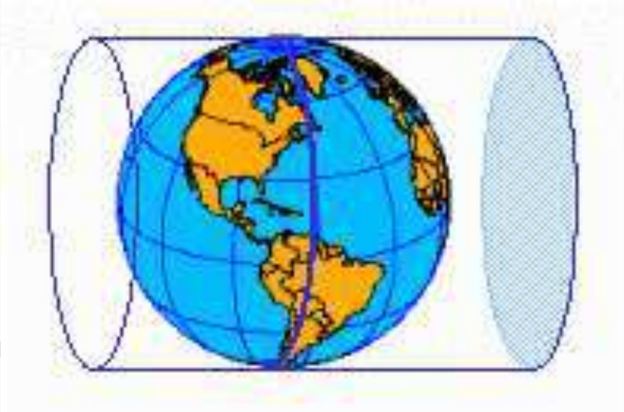
•As move to higher latitudes, east-west scale increases (2 x equatorial scale at 60° N or S latitude) until reaches infinity at the poles; N-S scale is constant



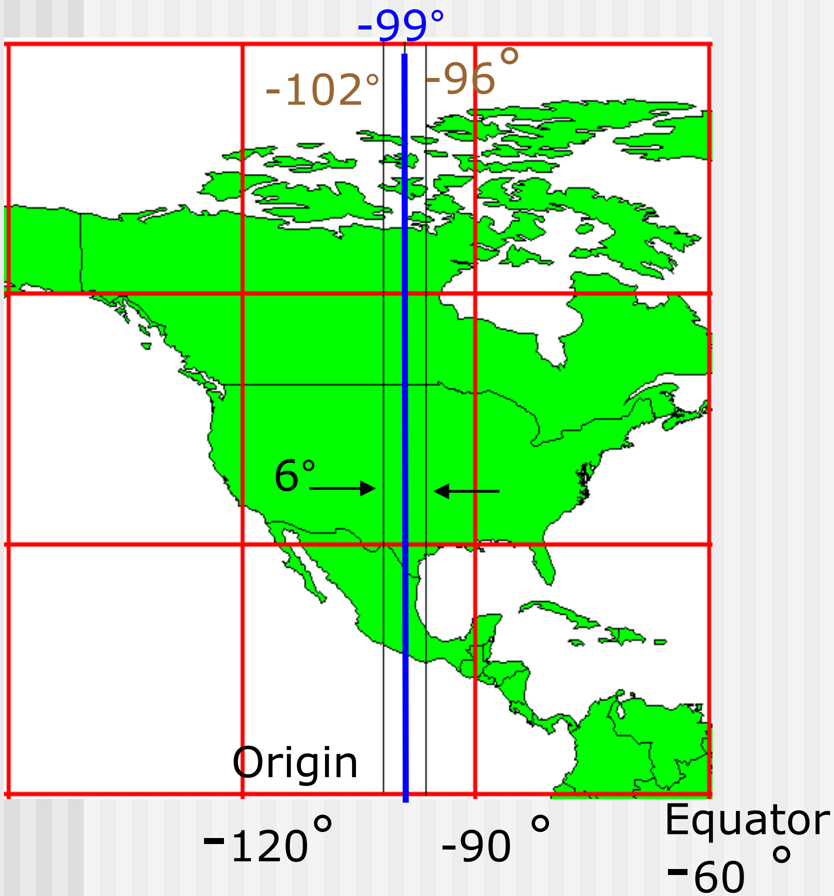
Cylindrical Map Distortion



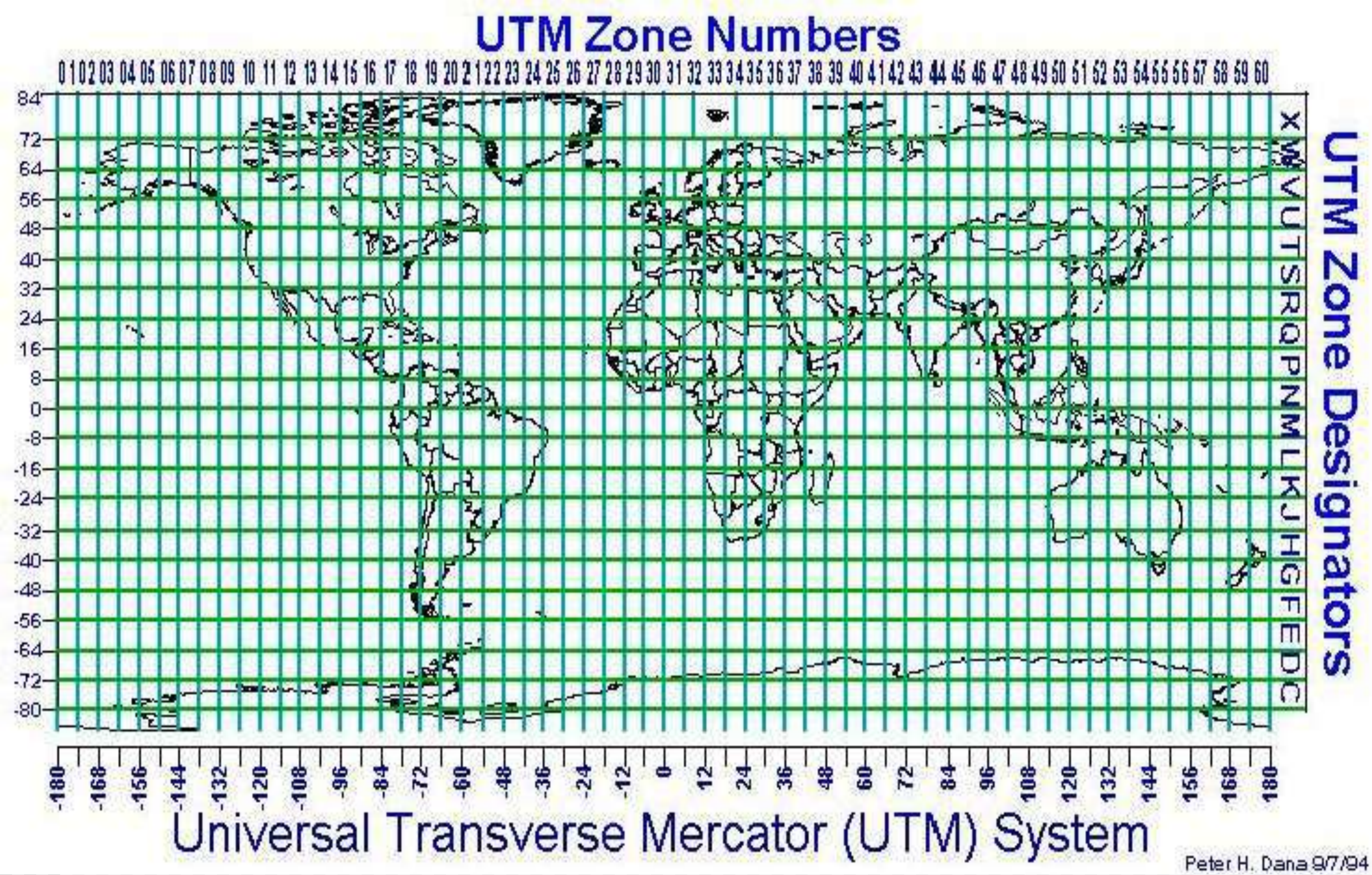
UTM Projection



UTM Zone 14



- Universal Transverse Mercator
- Conformal projection (shapes are preserved)
- Cylindrical surface
- Two standard meridians
- Zones are 6 degrees of longitude wide
- Scale distortion is 0.9996 along the central meridian of a zone
- There is no scale distortion along the standard meridians
- Scale is no more than 0.1% in the zone
- Scale distortion gets to unacceptable levels beyond the edges of the zones



UTM Zone Numbers
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 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

THANK YOU