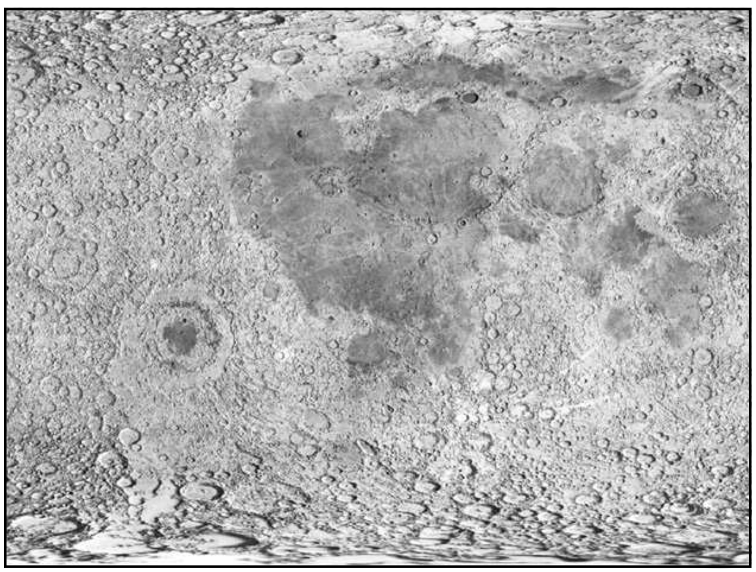
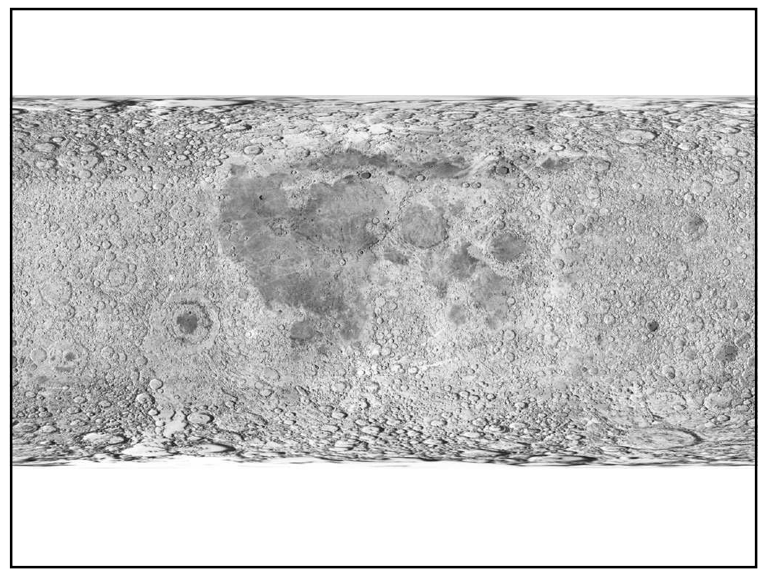
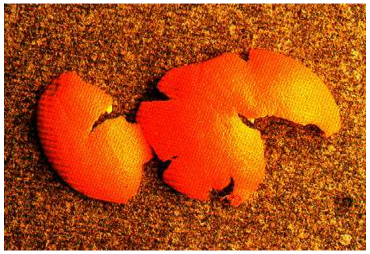




Map Projections (Part 1)

Earth is a round, maps are not.

Four projection families.



Equivalent (Equal Area) projections
Preserves relative areas
Commonly used for thematic maps
Ex: Albers

Conformal projections
Preserve angles, correct shape
… with small shapes at least
Graticule has right angles
Ex. Mercator

Equidistant
Preserves distance, equal scale along standard parallel(s), latitude of origin

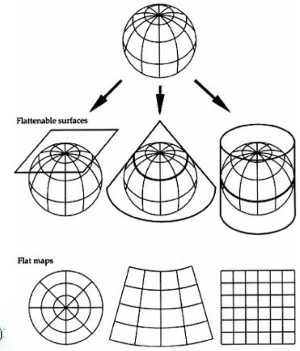
* No flat map is both equivalent and conformal – only globes have this property

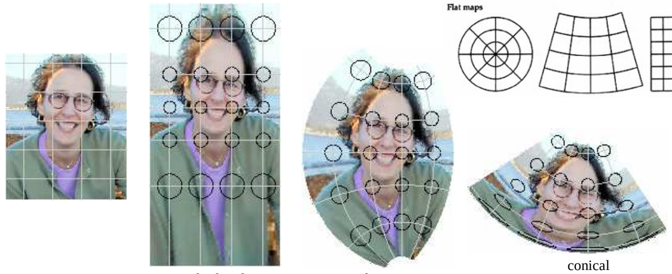
---

Three classes (families) of projections:

Developable surface as a:

- Planar (Azimuthal), project the globe onto a tangent plane.
- Conic, project the globe on to a cone
- Cylindrical, central cylindrical vs. cylindrical equal-area





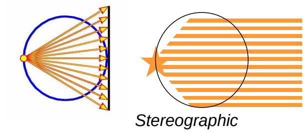
cylindrical planar conical (not comical)

Perspective ("point of projection")

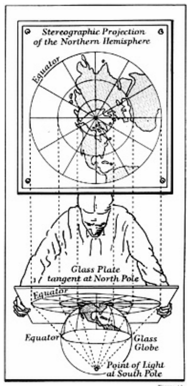
Orthographic
- light source at infinity (straight through)

Stereographic
- light source at opposite side of the sphere

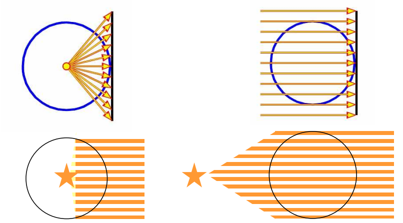
Gnomonic
- centrally located light source
- preserves great circles as straight lines
- distortions increase from standard point or line, increase outward in concentric bands



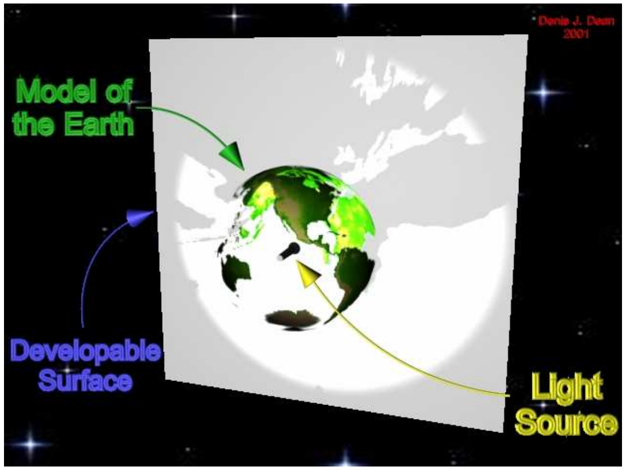
Stereographic



In the Stereographic Projection the Earth Is Shown from the Opposite Side

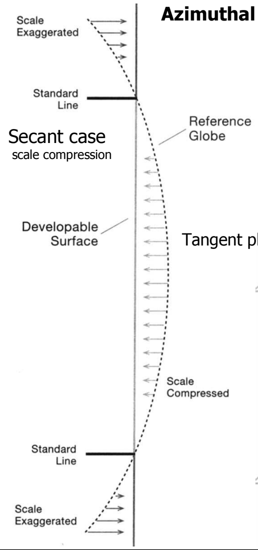


Gnomonic *Orthographic*

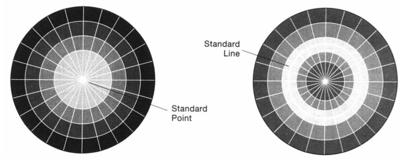


The transformation process simplified: a light source is in center of the cut out globe casts shadows from the continents of the model of the Earth onto on a plane that is tangent to it, tracing the outline leaves projected coordinate system.

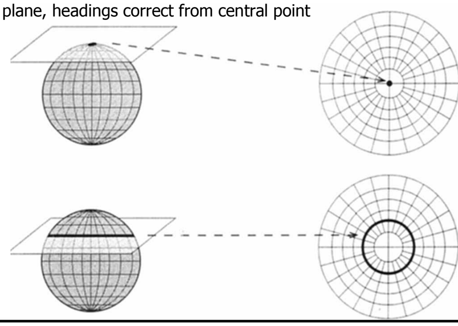
Azimuthal (planar) class – developable surface is a plane



Two cases



Tangent plane, headings correct from central point



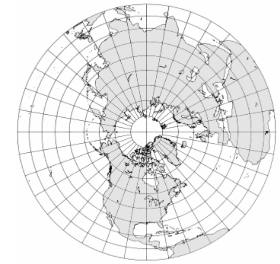
Lambert Azimuthal Equal-Area

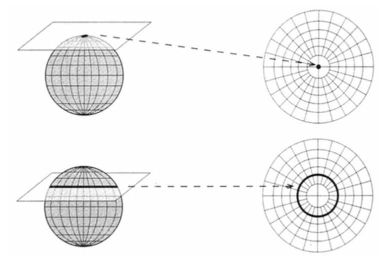
Stereographic "perspective"

It has both classes of map projection:

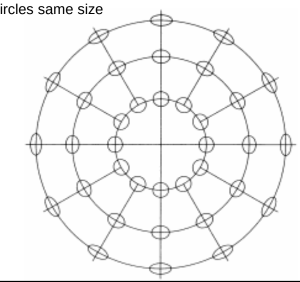
Azimuthal: preserves directions from the tangent point

Equal-area: lowest scale distortion of all azimuthal projections

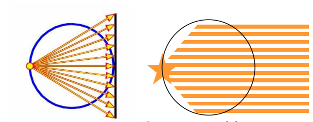




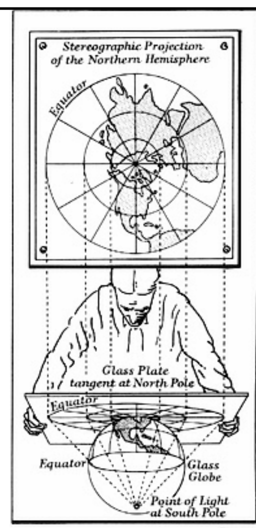
Circles same size



Stereographic "perspective"



Stereographic

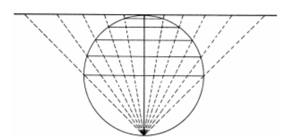


In the Stereographic Projection the Earth Is Shown from the Opposite Side

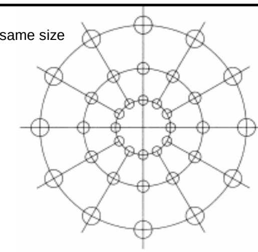
Stereographic Projection (perspective)

Azimuthal Conformal

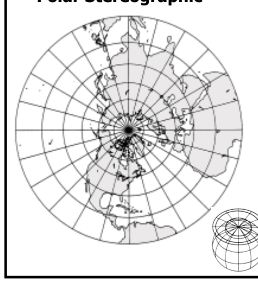
Used in geophysics and orbit trajectory solutions, simplifies for solving spherical geometric problems



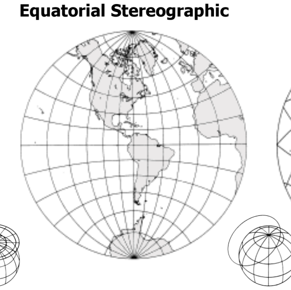
Circles same size



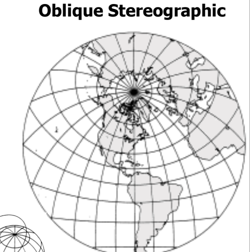
Polar Stereographic



Equatorial Stereographic



Oblique Stereographic

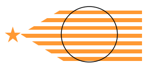


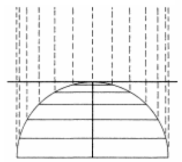
Orthographic Projection (perspective)

Azimuthal non-Conformal

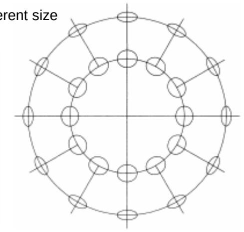
Popular visualization, the "earth from space" perspective view

Distortion is extreme

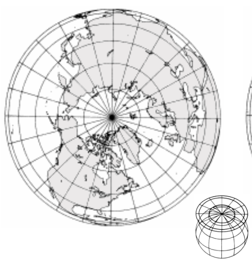




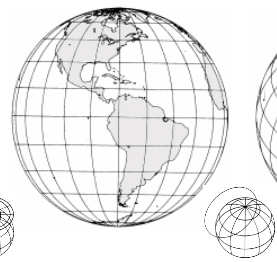
Circles different size



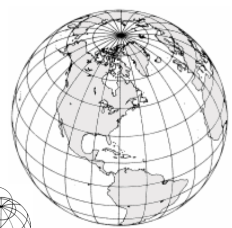
Polar Orthographic



Equatorial Orthographic



Oblique Orthographic



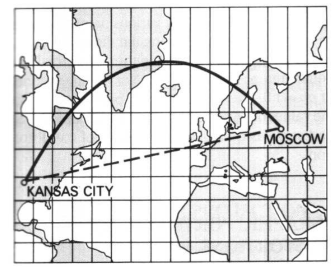
Mercator Projection

vs.

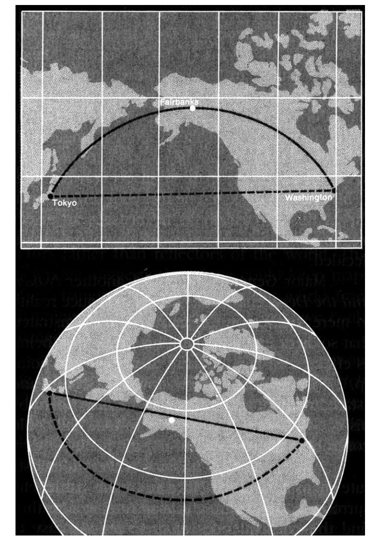
Oblique Orthographic

Right, Caption read something like:

> "The Senator is using tax payers dollars to make an out of the way illegal campaign stop to Anchorage"



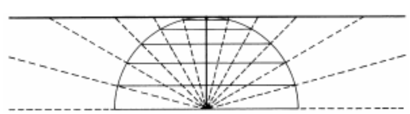
Dashed = rhumb line (constant heading)
Solid = great circle route

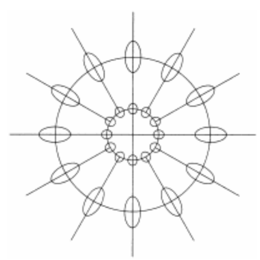


Gnomonic Projection (perspective)

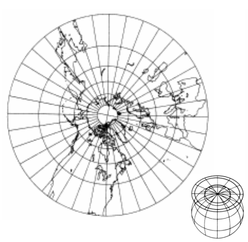
Distorts everything – but <u>straight lines are great circles</u>

Useful for finding the shortest path distance between two locations, but limited because < ½ hemisphere is visible

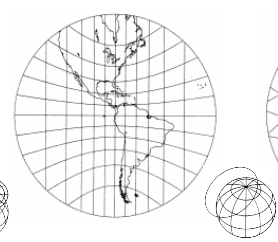




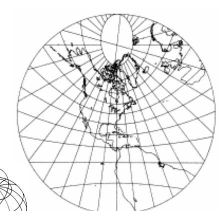
Polar Gnomonic



Equatorial Gnomonic

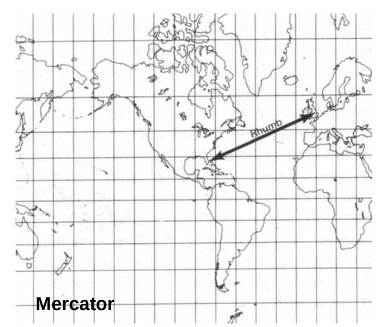


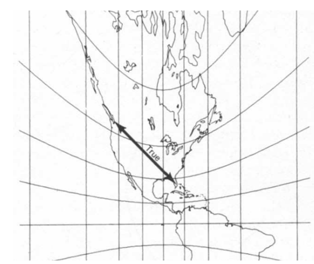
Oblique Gnomonic

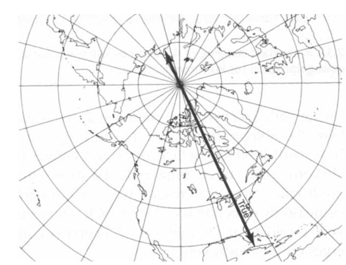


A line that crosses all meridians at the same angle is called a rhumb line, loxodrome, (or azimuth)

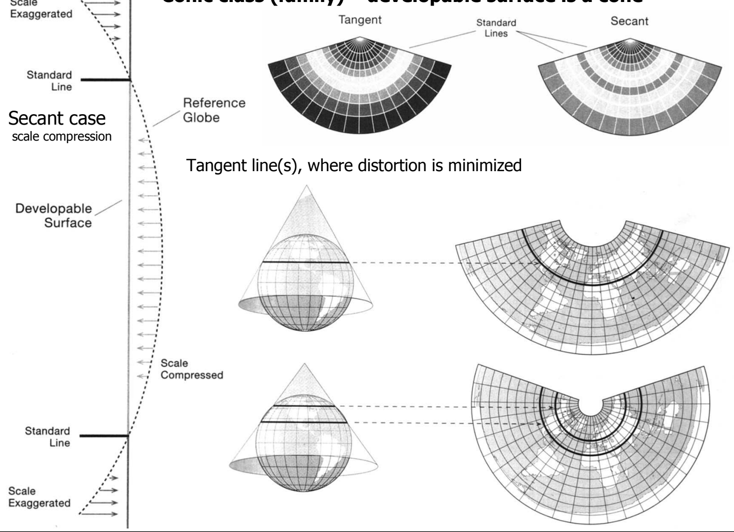
Gnomic projections are in the planar family, used in aviation because <u>great circles are straight lines</u>





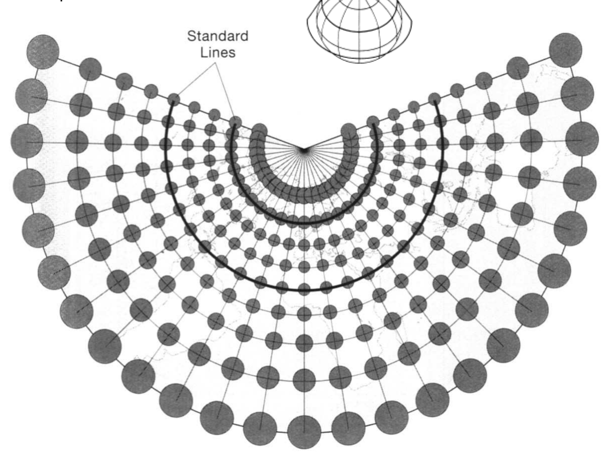


Conic class (family) – developable surface is a cone



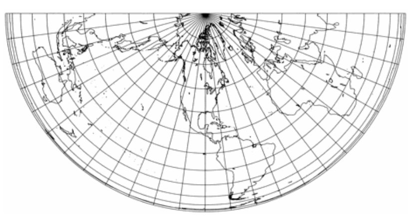
Lambert Conic Conformal

Secant case (two tangent lines)
Standard parallels 30n 45n

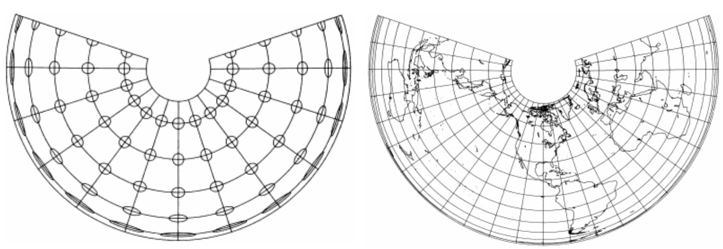


Conic Equal-Area

Lambert (tangent)



Albers (secant)



Cylindrical class (family) – developable surface is a tube

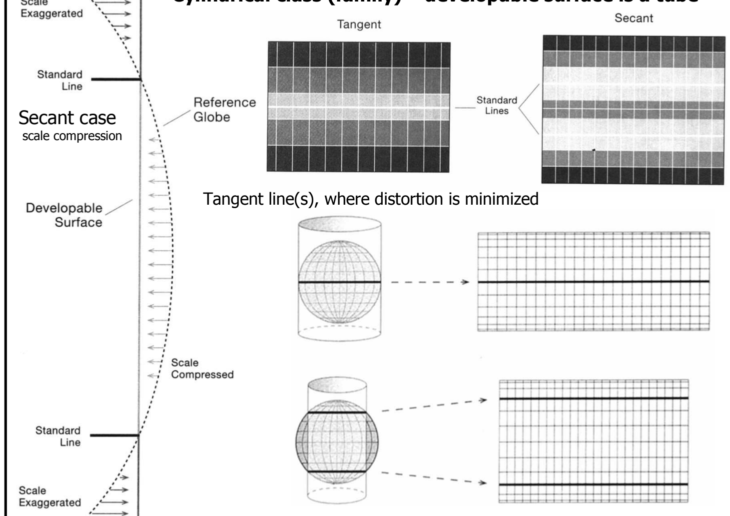


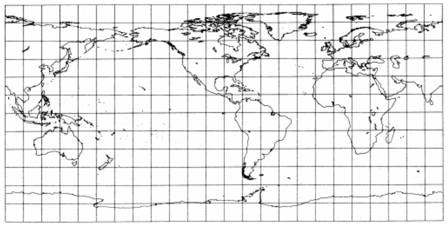
Plate Carree = Geographic

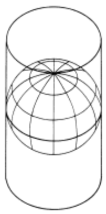
Equidistant Cylindrical

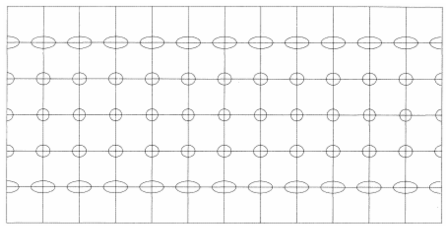
Based on Earth as a sphere, tangent along Eq.

Distorts shape and area, but preserves distance

*non-existent Figure 8.5 in Slocum





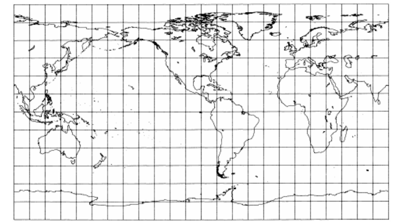


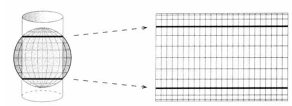
Equirectangular ("Rectangular")

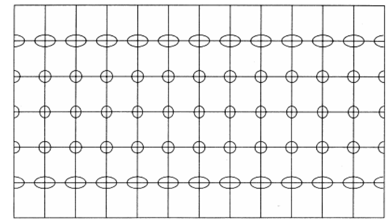
Equidistant Cylindrical

A form of the Geographic projection; the difference is that there are two standard parallels, 30 N and 30 S (secant)

Parallels lines have wider spacing than meridians (compresses the map in the east-west direction)

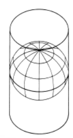


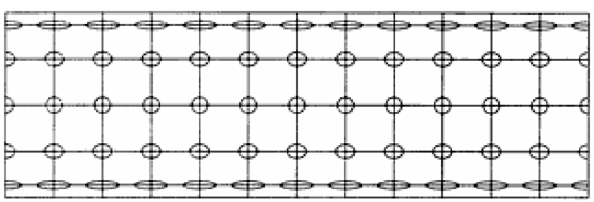




Lambert Cylindrical Equal-Area

Preserves area but distorts shape (tangent at Eq., shape distortion minimized there)



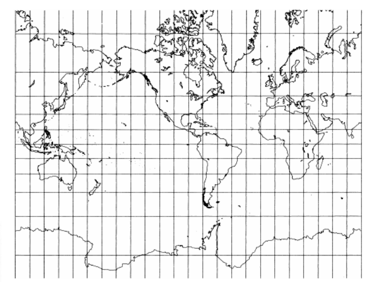


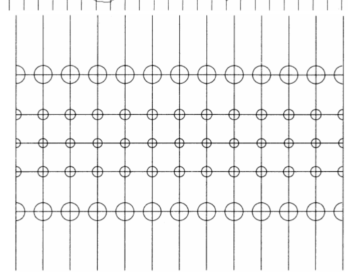
Mercator

Cylindrical Conformal

The only projection that preserves bearings, rhumb lines (loxodromes) are straight lines
- intersect meridians at the same angle

Area/Shape are distorted, goes to infinity at the poles





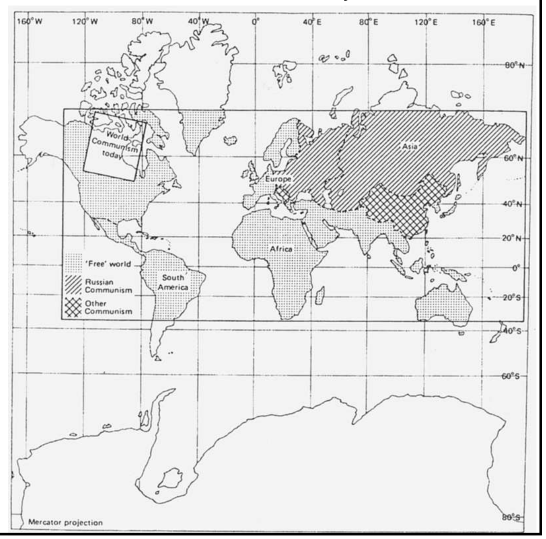
Propaganda Map

Mercator projection
distorts area

"Maps and Perceptions of Scale"

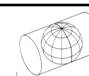
Lanegram and Palm eds. 1973

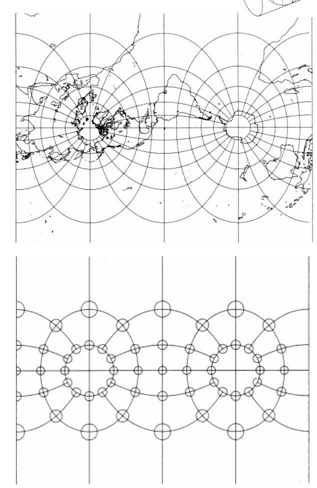
World Communism Today



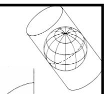
From Map Misuse
Campbell Ch 16

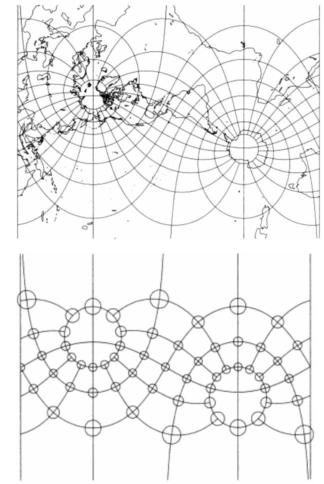
Transverse Mercator
Cylindrical Equal-Area





Oblique Mercator
Cylindrical Equal-Area

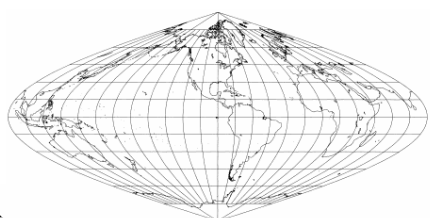


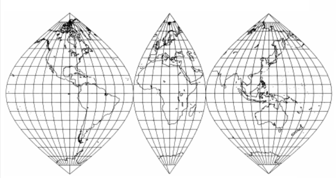


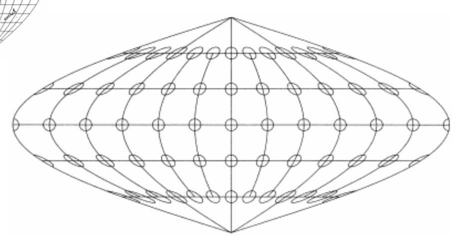
Sinusoidal

Pseudo-cylindrical Equal-area

Equally spaced parallels



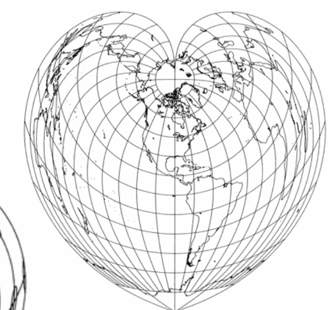


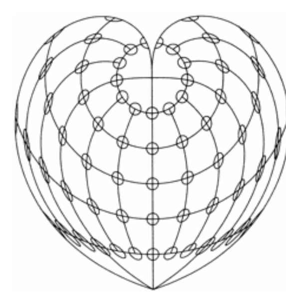


Werner

Pseudoconic, Equal-area

Cordiform (heart shaped)





Projections:
http://www.3dsoftware.com/Cartography/USGS/MapProjections/

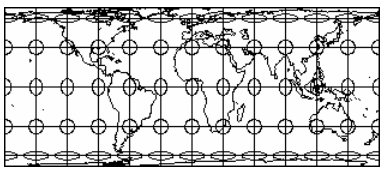
Equal-area conic (Albers Lambert Conic, popular projections)

Projection onto a cone, secant means there are two standard parallels

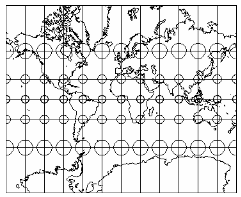
Distortions increase away from standard parallels which can be varied to preserve area, angle, distance, or direction

Equal-area = equivalent, preserves area relationships, best for thematic mapping where accurate area statistics are of importance

* Distance distortion = give up shape (conformality) to preserve area (equivalence)



equivalent



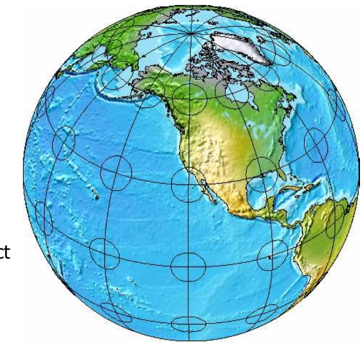
not equivalent

Equidistant projections

From <u>a point</u>, distance is correct to all other points.

Useful for plotting the distance for surface routes from a point, distortion increases outward

* Distance and area are distorted



Azimuthal projections

Tangent at one point, directions are correct from that center-point to other points

Distances are correct along parallels

* Shape and area are distorted

Conformal maps

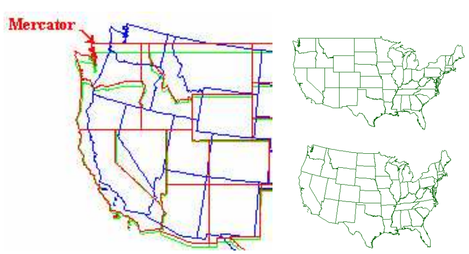
Angular relationships preserved between points (shape preserved for small areas), scale change uniformly with direction

If the scale of a map at any point is the same in any direction, the projection is conformal.

Meridians and parallels intersect at right angles.

> Arizona, New Mexico, Colorado and Utah on a globe meet at 90˚ angles, on a conformal projection map these angles are 90˚ angles

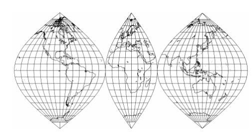
* Area will be distorted

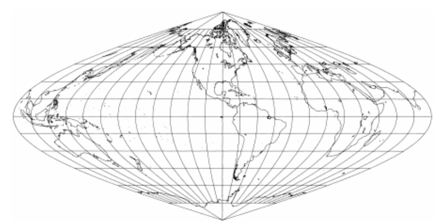


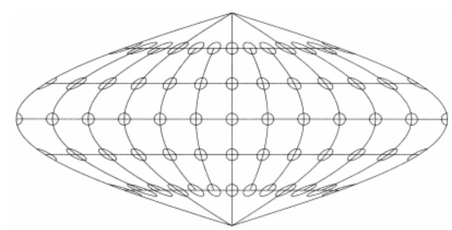
Sinusoidal

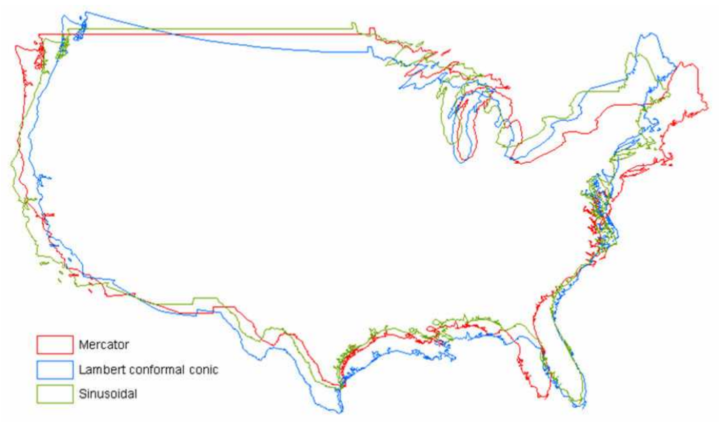
Classification: Pseudocylindrical, Equal-area (equivalent)

Equally spaced parallels





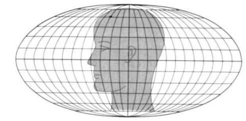




All projections distort

Preserving area: equivalent, preserving angles/shape: *conformal*

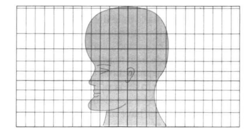
* cannot preserve both area & shape



Preserving distance: *equidistant*

* cannot preserve area & distance

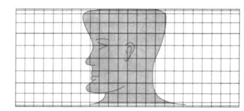
Preserving direction: *azimuthal* (plane)



* can preserve direction and area, OR shape, OR distance

Compromise projection don't preserve area, shape, distance, or direction but minimize distortion overall (good for world maps for general use)

Robinson, Miller, Gall-Peters etc.



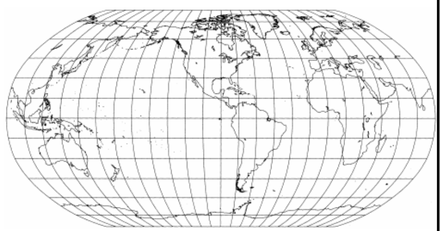
Robinson

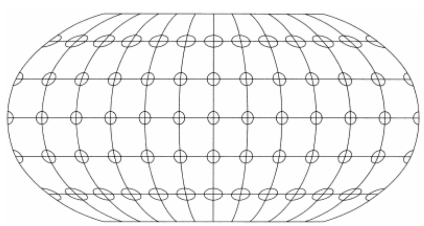
Pseudocylindrical

Compromise: neither conformal nor equal area

Created at the request of Rand McNally, the National Geographic Society, and others for numerous world maps.

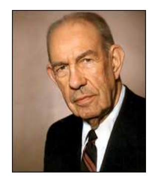
Uses tabular coordinates rather than mathematical formulas to make the world map "look" right.





Arthur H. Robinson (Jan. 5, 1915 - Oct. 10, 2004)

University of Wisconsin emeritus professor of geography and cartography.



Robinson devised his own map projection after he became dissatisfied with existing projections is his experience as director of the map division of the Office of Strategic Services in World War II.

"I started with a kind of artistic approach," Dr. Robinson said in a 1988 interview in The New York Times. "I visualized the best-looking shapes and sizes. I worked with the variables until it got to the point where, if I changed one of them, it didn't get any better."

Only then, he said, did he "figure out the mathematical formula to produce that effect." For his projection, Dr. Robinson chose 38 degrees north and 38 degrees south as the standard parallels. This established the two places on the map where both size and shape are most accurate in the middle of the temperate zone, where most of the land and people are.

The Robinson projection was eventually adopted by the National Geographic Society, some federal agencies and the world atlases of Rand McNally.

http://www.nytimes.com/2004/11/15/obituaries/15robinson.html

Gall-Peters cylindrical equal-area projection (orthographic light source, perspective)

De-emphasizes the exaggeration of areas (shape distortion) at high latitudes by shifting the standard to 45 degrees north