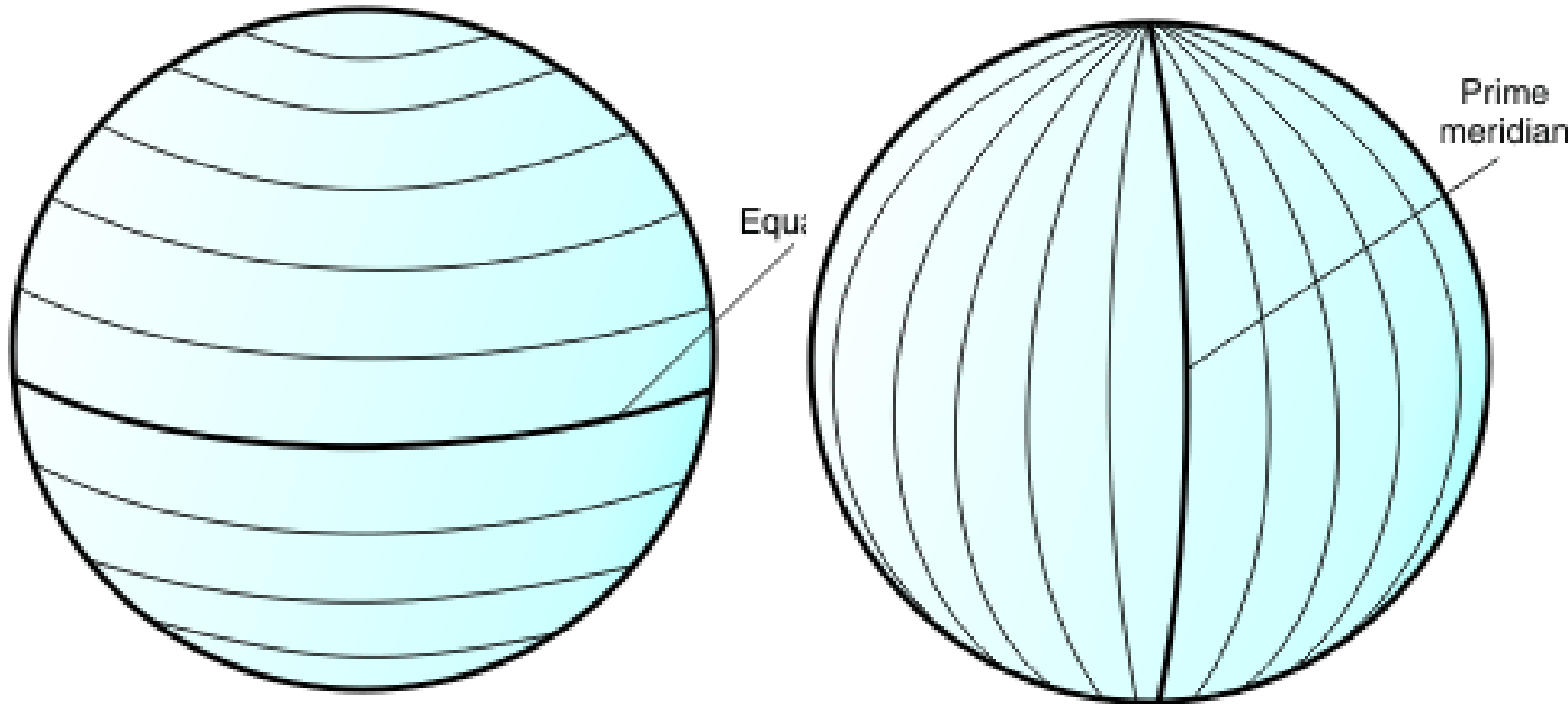


Mills College 2009

SOC128 **G**eographic **I**nformation **S**ystems *and Sociological Geography*

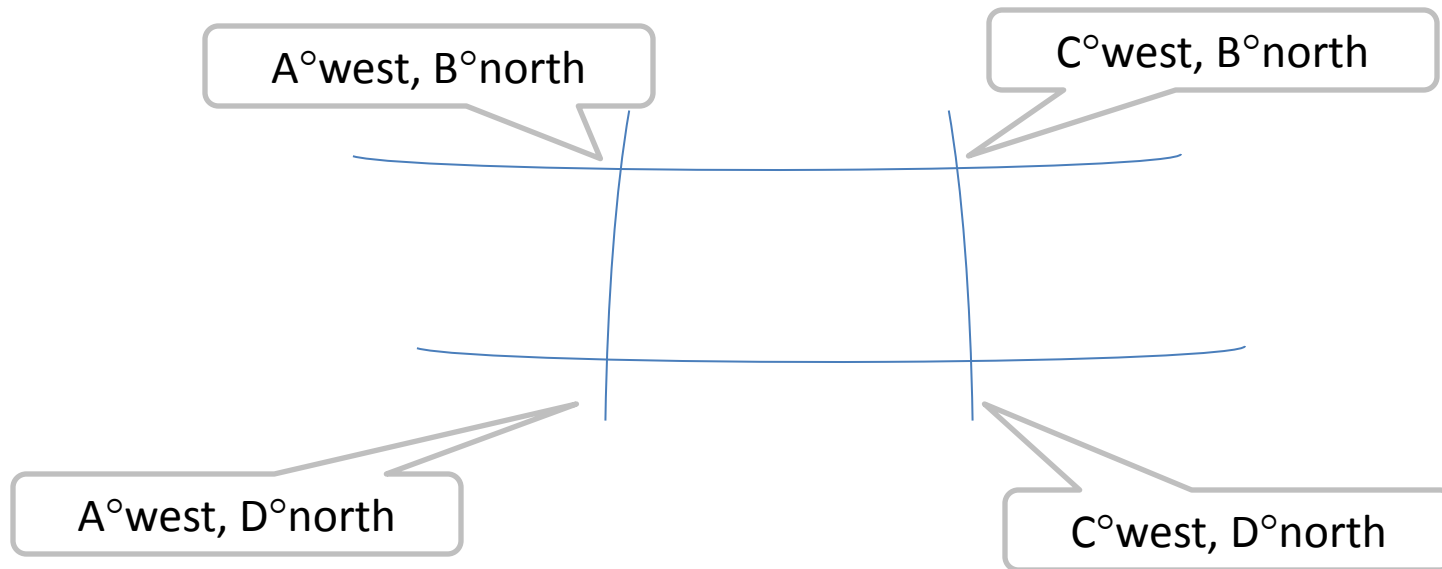
# Projections I

# The Problem

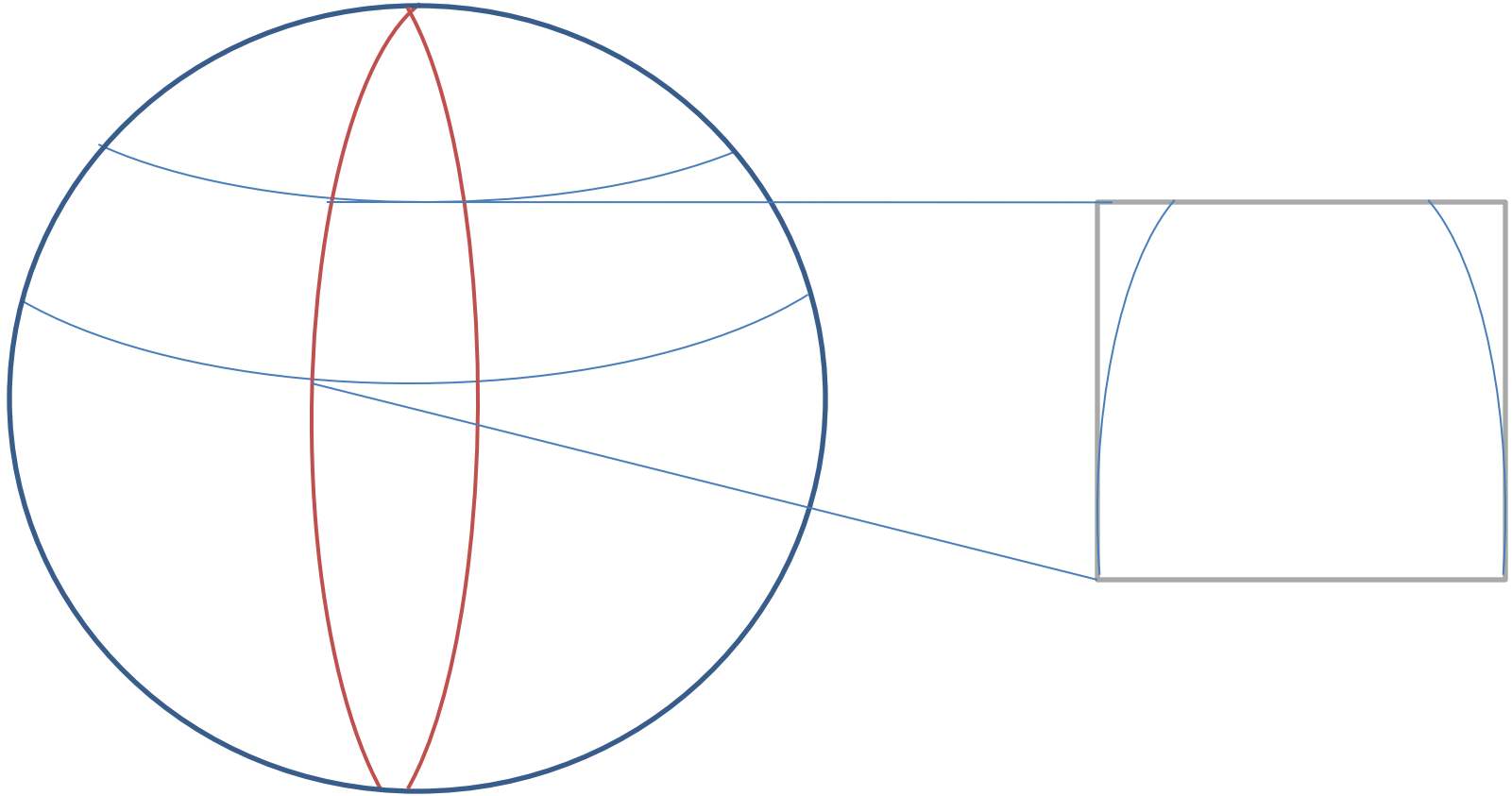


# The Problem

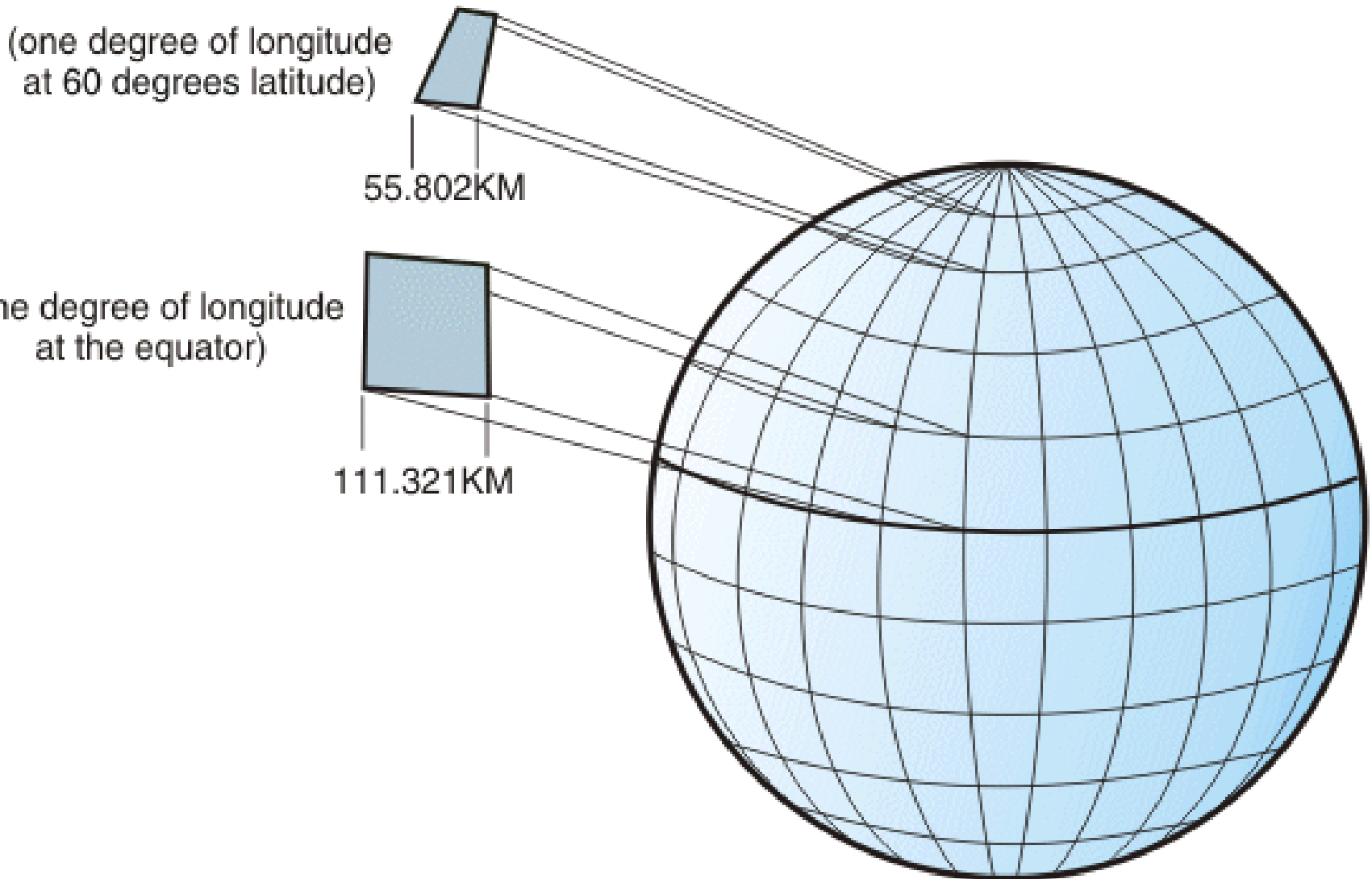
- A “rectangle” on the earth’s surface...
- ...that is, a four cornered area aligned with parallels and meridians



# The Problem, in “global” context



# A degree here, a degree there...



# A Puzzle

- Start anywhere out on the meadow.
- Face due north and walk 200 miles.
- Turn right to face due east and walk 200 miles.
- Turn right again to face due south and walk 200 miles.
- Turn right one last time and walk due west 200 miles.
- Where are you now?

# Puzzle Number 2

- Take a globe. Identify two cities, say NY and London.
- What direction should you set out from the one if you wish to sail/fly in a straight line and arrive at the other?
- What if I have a map instead of a globe?

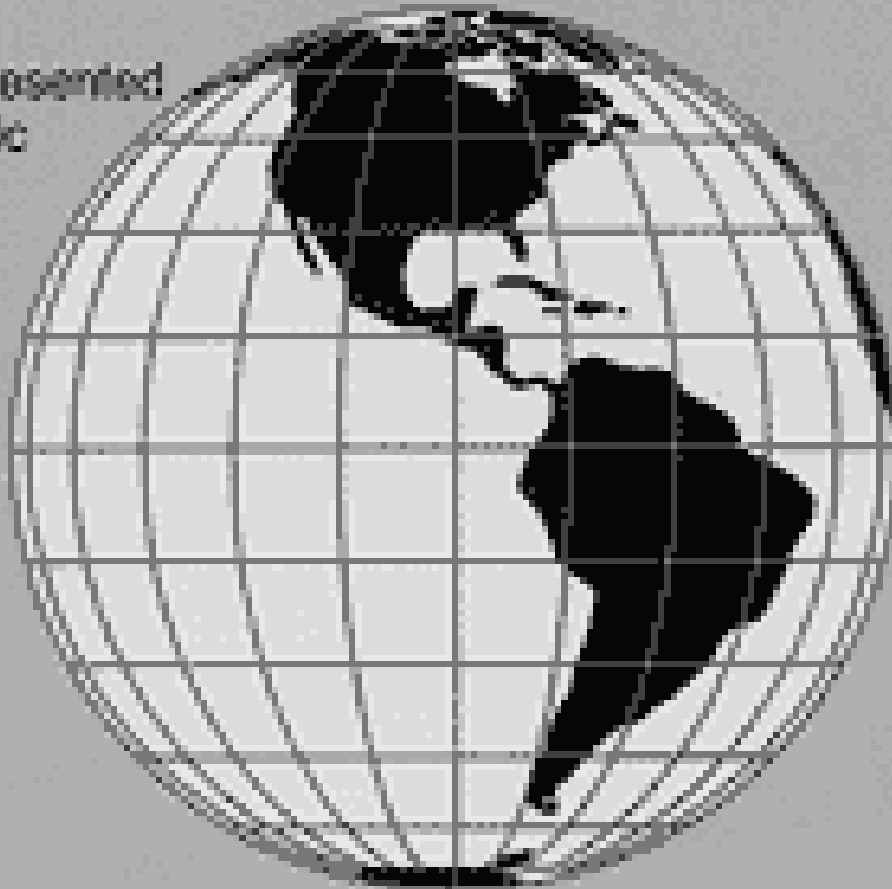
# The Globe

- **Directions**—True
- **Distances**—True
- **Shapes**—True
- **Areas**—True
- **Great circles**—The shortest distance between any two points on the surface of the Earth can be found quickly and easily along a great circle.
- **Disadvantages:**
  - Even the largest globe has a very small scale and shows relatively little detail.
  - Costly to reproduce and update.
  - Difficult to carry around.
  - Bulky to store.
- **On the globe:**
  - Parallels are parallel and spaced equally on meridians. Meridians and other arcs of great circles are straight lines (if looked at perpendicularly to the Earth's surface). Meridians converge toward the poles and diverge toward the Equator.
  - Meridians are equally spaced on the parallels, but their distances apart decreases from the Equator to the poles. At the Equator, meridians are spaced the same as parallels. Meridians at 60° are half as far apart as parallels. Parallels and meridians cross at right angles. The area of the surface bounded by any two parallels and any two meridians (a given distance apart) is the same anywhere between the same two parallels.
  - The scale factor at each point is the same in any direction.



# The Globe

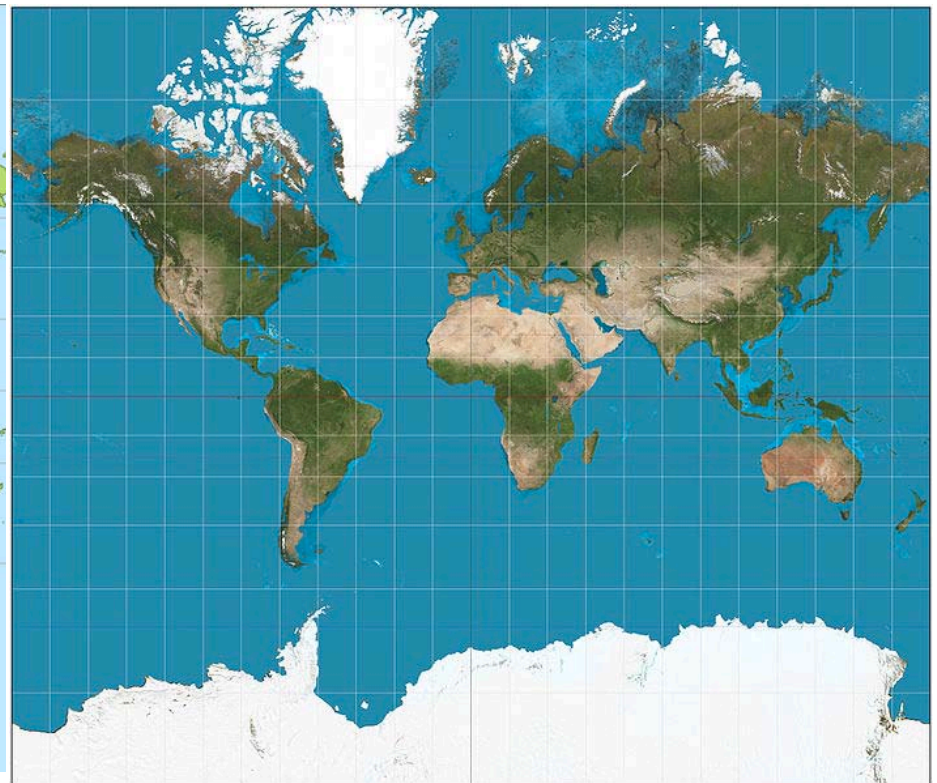
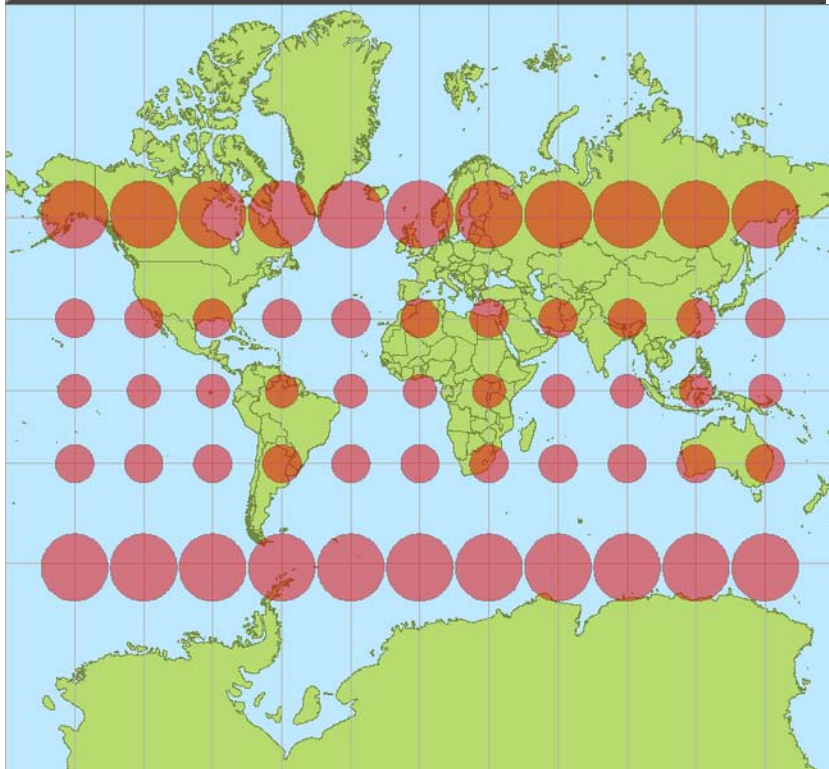
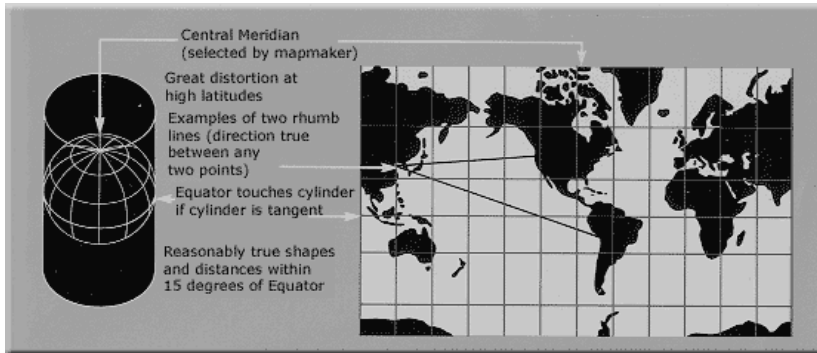
Globe, as represented  
by Orthographic  
projection -  
equatorial  
aspect



# Mercator

- **Used** for navigation or maps of equatorial regions. Any straight line on the map is a **rhumb line** (line of constant direction). **Directions** along a rhumb line are true between *any* two points on map, but a rhumb line is usually *not* the shortest distance between points. (Sometimes used with Gnomonic map on which any straight line is on a great circle and shows shortest path between two points).
- **Distances** are true *only* along Equator, but are reasonably correct within 15° of Equator; special scales can be used to measure distances along other parallels. Two particular parallels can be made correct in scale instead of the Equator.
- **Areas and shapes** of large areas are distorted. **Distortion** increases away from Equator and is extreme in polar regions. Map, however, is **conformal** in that angles and shapes within any small area (such as that shown by USGS topographic map) is essentially true.
- The map is **not** perspective, equal area, or equidistant.
- Equator and other parallels are straight lines (spacing increases toward poles) and meet meridians (equally spaced straight lines) at right angles. Poles are not shown.
- Presented by Mercator in 1569.
- **Cylindrical**— Mathematically projected on a cylinder tangent to the Equator. (Cylinder may also be secant.)

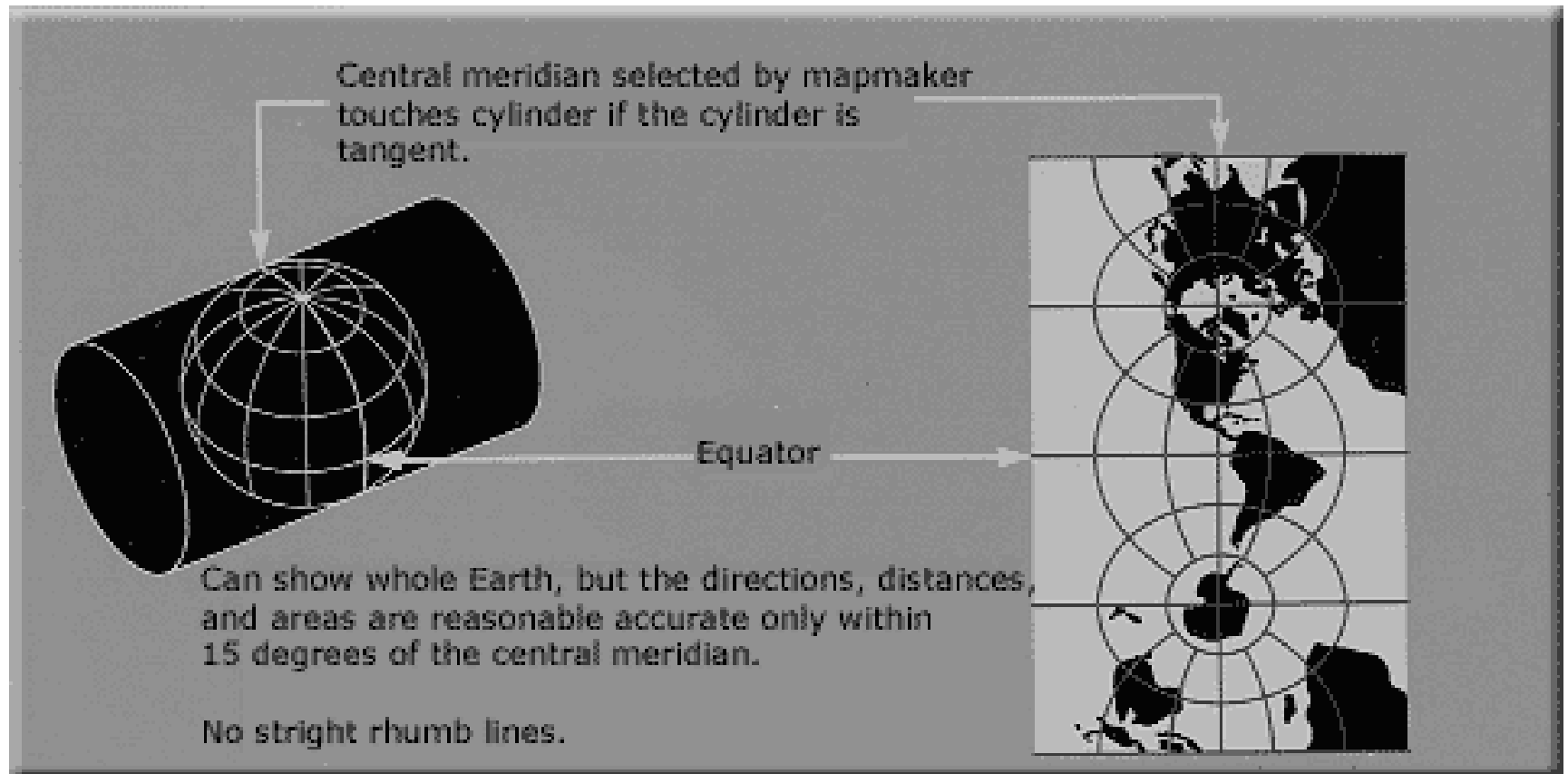
# Mercator



# Transverse Mercator

- **Used** by USGS for many quadrangle maps at scales from 1:24,000 to 1:250,000; such maps can be joined at their edges only if they are in the same zone with one central meridian. Also used for mapping large areas that are mainly north–south in extent.
- **Distances** are true *only* along the central meridian selected by the mapmaker or else along two lines parallel to it, but all distances, directions, shapes, and areas are reasonably accurate within 15° of the central meridian. **Distortion** of distances, directions, and size of areas increases rapidly outside the 15° band. Because the map is **conformal**, however, shapes and angles within any small area (such as that shown by a USGS topographic map) are essentially true.
- **Graticule spacing** increases away from central meridian. Equator is straight. Other parallels are complex curves concave toward nearest pole.
- Central meridian and each meridian 90° from it are straight. Other meridians are complex curves concave toward central meridian.
- Presented by Lambert in 1772.
- **Cylindrical**—Mathematically projected on cylinder tangent to a meridian. (Cylinder may also be secant.)

# Transverse Mercator



# Miller Cylindrical

- **Used** to represent the entire Earth in a rectangular frame. Popular for world maps. Looks like Mercator but is not useful for navigation. Shows poles as straight lines.
- **Avoids** some of the scale exaggerations of the Mercator but shows neither shapes nor areas without distortion.
- **Directions** are true only along the Equator. **Distances** are true only along the Equator. **Distortion** of distances, areas, and shapes is extreme in high latitudes.
- Map is **not** equal area, equidistant, conformal or perspective.
- Presented by O. M. Miller in 1942.
- **Cylindrical**—Mathematically projected onto a cylinder tangent at the Equator.

# Miller Cylindrical



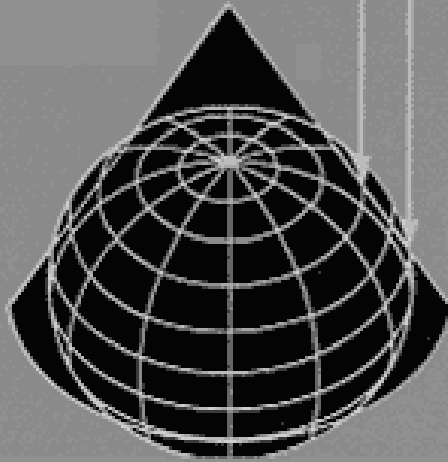
# Albers Equal Area Conic

- **Used** by USGS for maps showing the conterminous United States (48 states) or large areas of the United States. Well suited for large countries or other areas that are mainly east-west in extent and that require equal-area representation. Used for many thematic maps.
- Maps showing adjacent areas can be joined at their edges only if they have the same standard parallels (parallels of no distortion) and the same scale.
- **All areas** on the map are proportional to the same areas on the Earth. **Directions** are reasonably accurate in limited regions. **Distances** are true on both standard parallels. Maximum scale error is 1 ¼% on map of conterminous States with standard parallels of 29 ½°N and 45 ½°N. **Scale** true only along standard parallels.
- USGS maps of the conterminous 48 States, if based on this projection have standard parallels 29 ½°N and 45 ½°N. Such maps of Alaska use standard parallels 55°N and 65°N, and maps of Hawaii use standard parallels 8°N and 18°N.
- Map is **not** conformal, perspective, or equidistant.
- Presented by H. C. Albers in 1805.
- **Conic**—Mathematically projected on a cone conceptually secant at two standard parallels



# Albers Equal Area Conic

Two standard parallels  
(selected by mapmaker)



Equal areas. Deformation of shapes  
increases away from standard parallels.

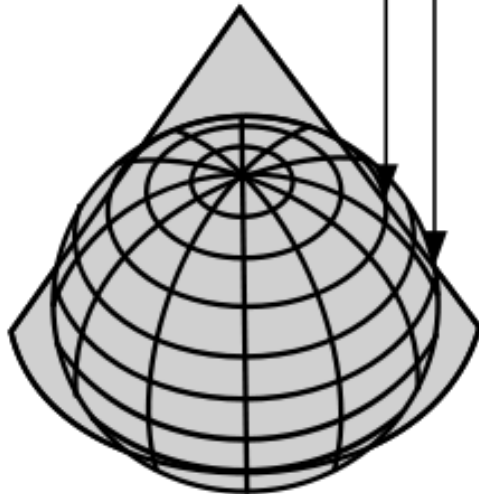


# Lambert Conformal Conic

- **Used** by USGS for many 7.5- and 15-minute topographic maps and for the State Base Map series. Also used to show a country or region that is mainly east-west in extent.
- One of the most widely used map projections in the United States today. Looks like the Albers Equal Area Conic, but graticule spacings differ.
- Retains conformality. **Distances** true *only* along standard parallels; reasonably accurate elsewhere in limited regions. **Directions** reasonably accurate. **Distortion** of shapes and areas minimal at, but increases away from standard parallels. **Shapes** on large-scale maps of small areas essentially true.
- Map is **conformal** but **not** perspective, equal area, or equidistant.
- For USGS Base Map series for the 48 conterminous States, standard parallels are 33°N and 45°N (maximum scale error for map of 48 States is 2 ½%). For USGS Topographic Map series (7.5- and 15-minute), standard parallels vary. For aeronautical charts of Alaska, they are 55°N and 65°N; for the *National Atlas of Canada*, they are 49°N and 77°N.
- Presented by Lambert in 1772.
- **Conic**—Mathematically projected on a cone conceptually secant at two standard parallels.

# Lambert Conformal Conic

Two standard parallels  
(selected by mapmaker)



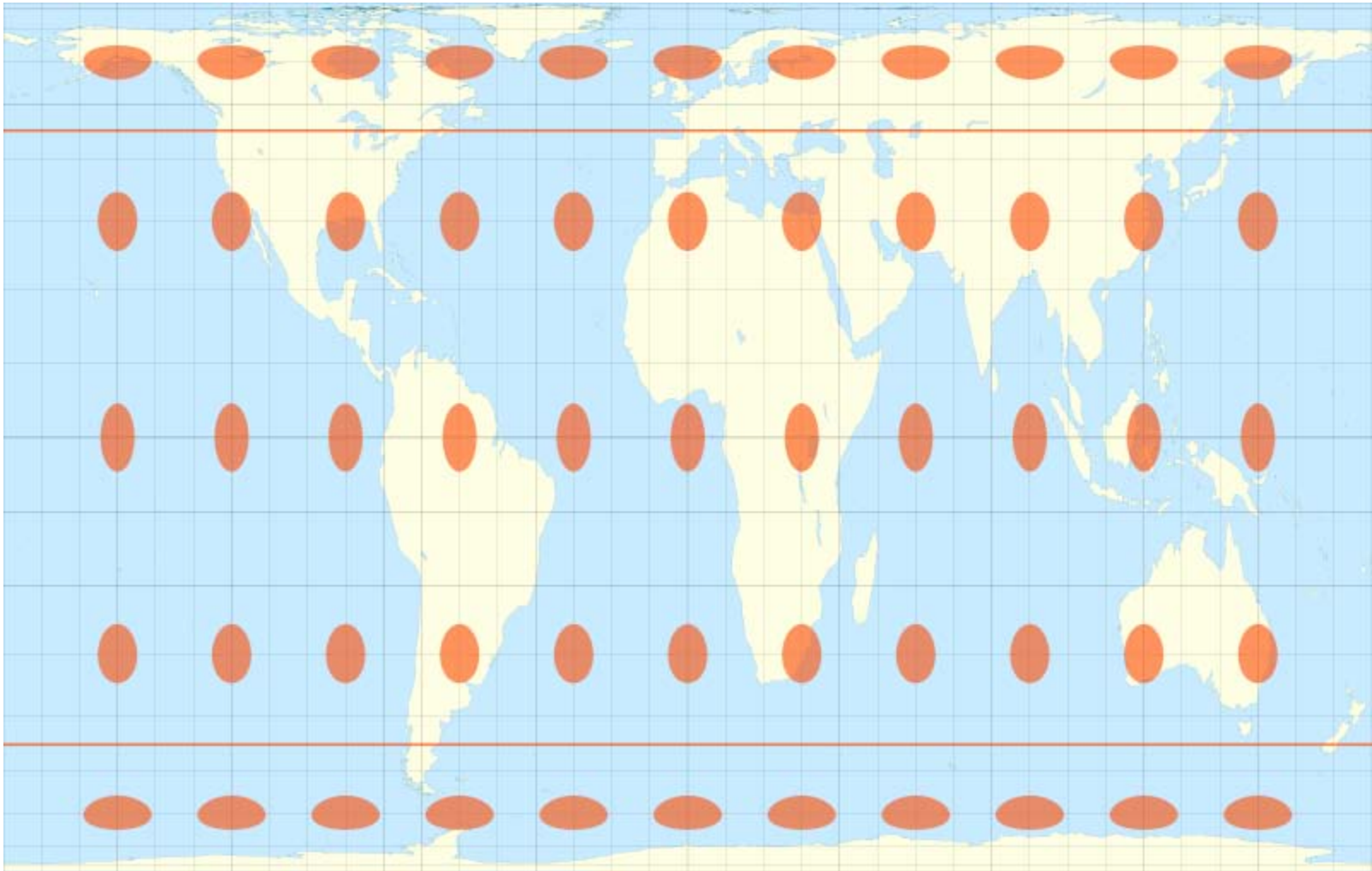
Large-scale map sheets can be joined at edges if they have the same standard parallels and scales



# Gall-Peters projection

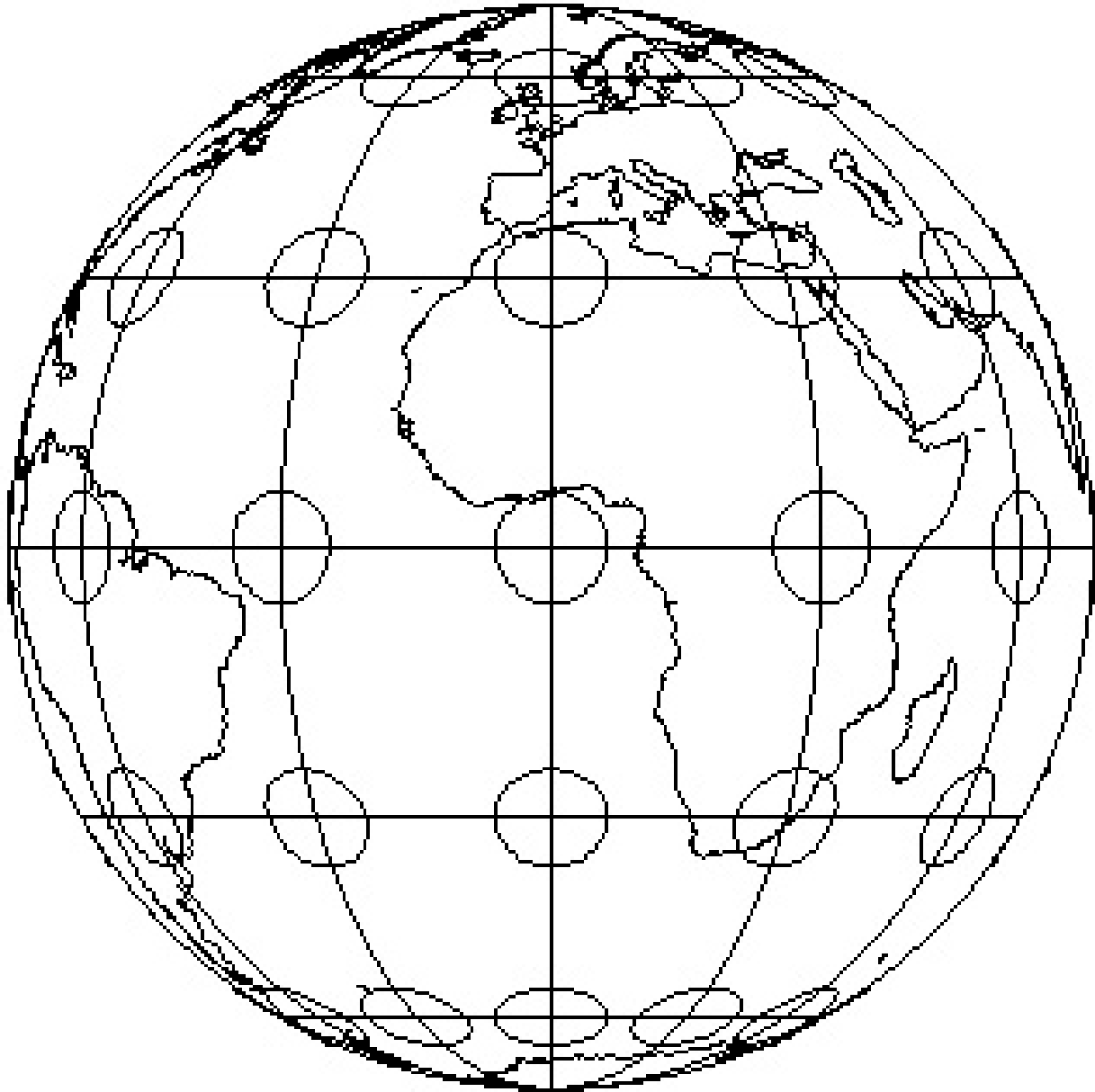


# Peters Projection Indicatrix



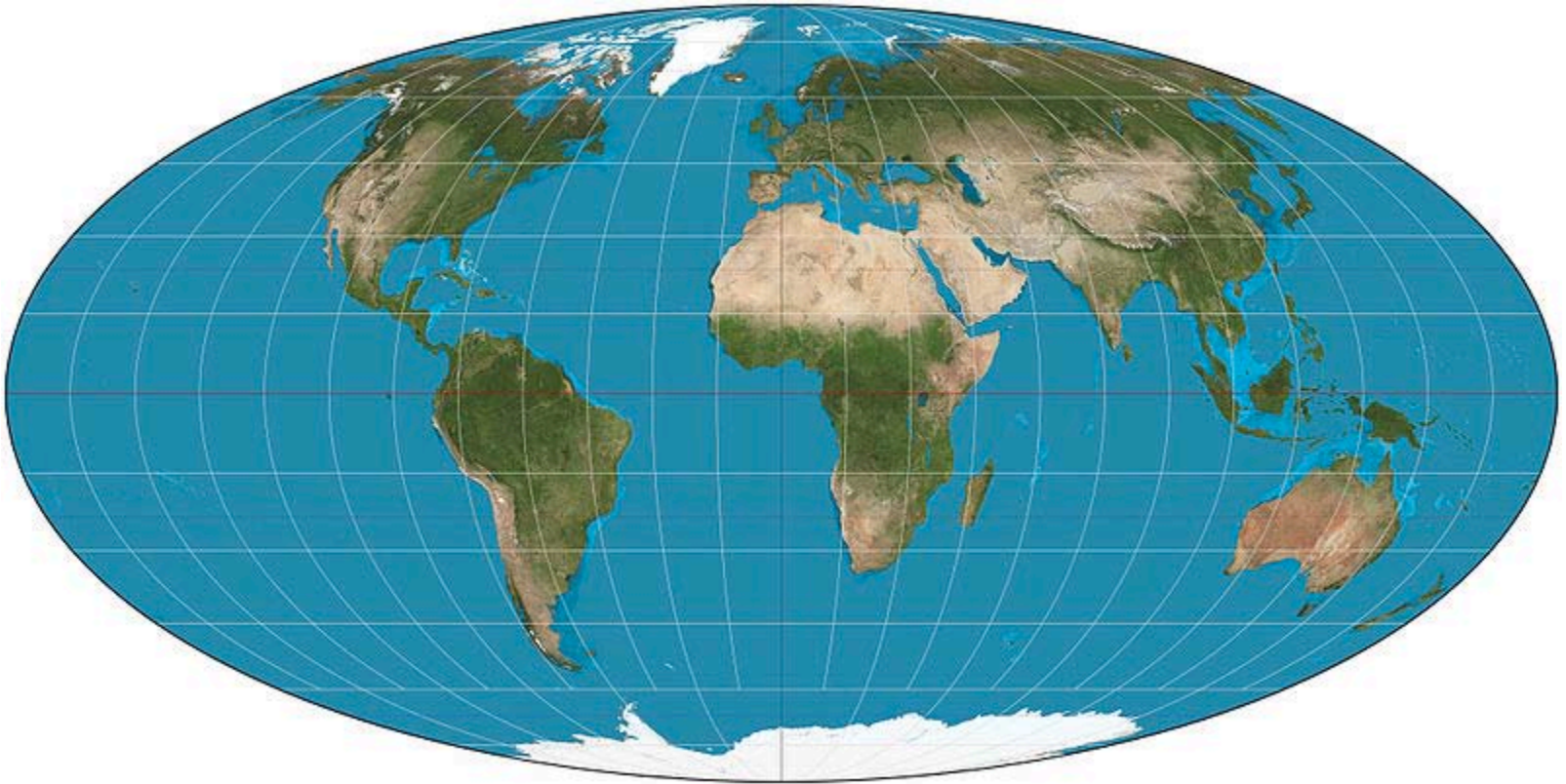
# Peters Projection

- Claimed in 60s to be “all new,” only equal area, better than dominant Mercator, equi-everything
- In fact, not new and doesn’t really solve all the problems of distortion and lots of options were (are) out there.
- Peters’ campaign and “unscholarly” activity motivated a renewed attempt to educate public about projections
- So, he does get credit for raising awareness of political implications of projections.





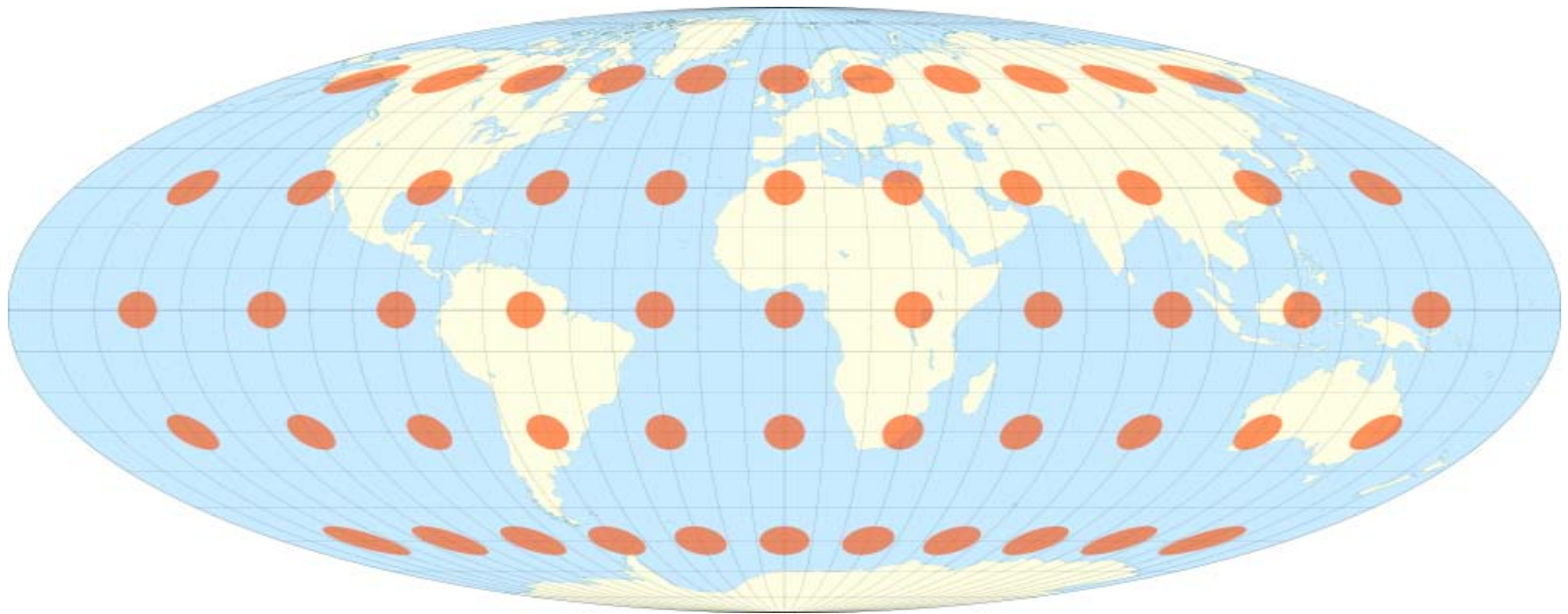
# Mollweide



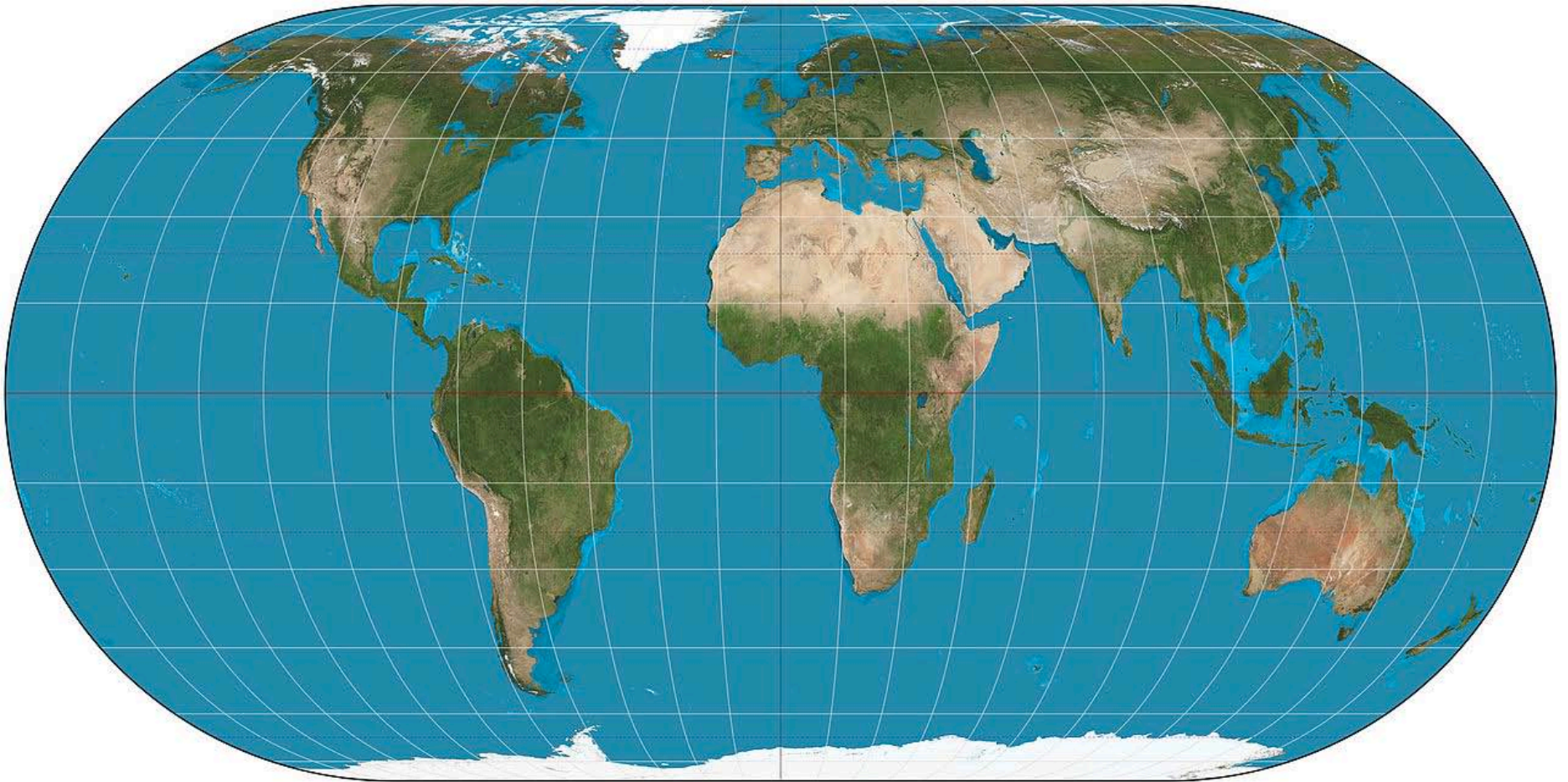


# Mollweide Equal Area Projection

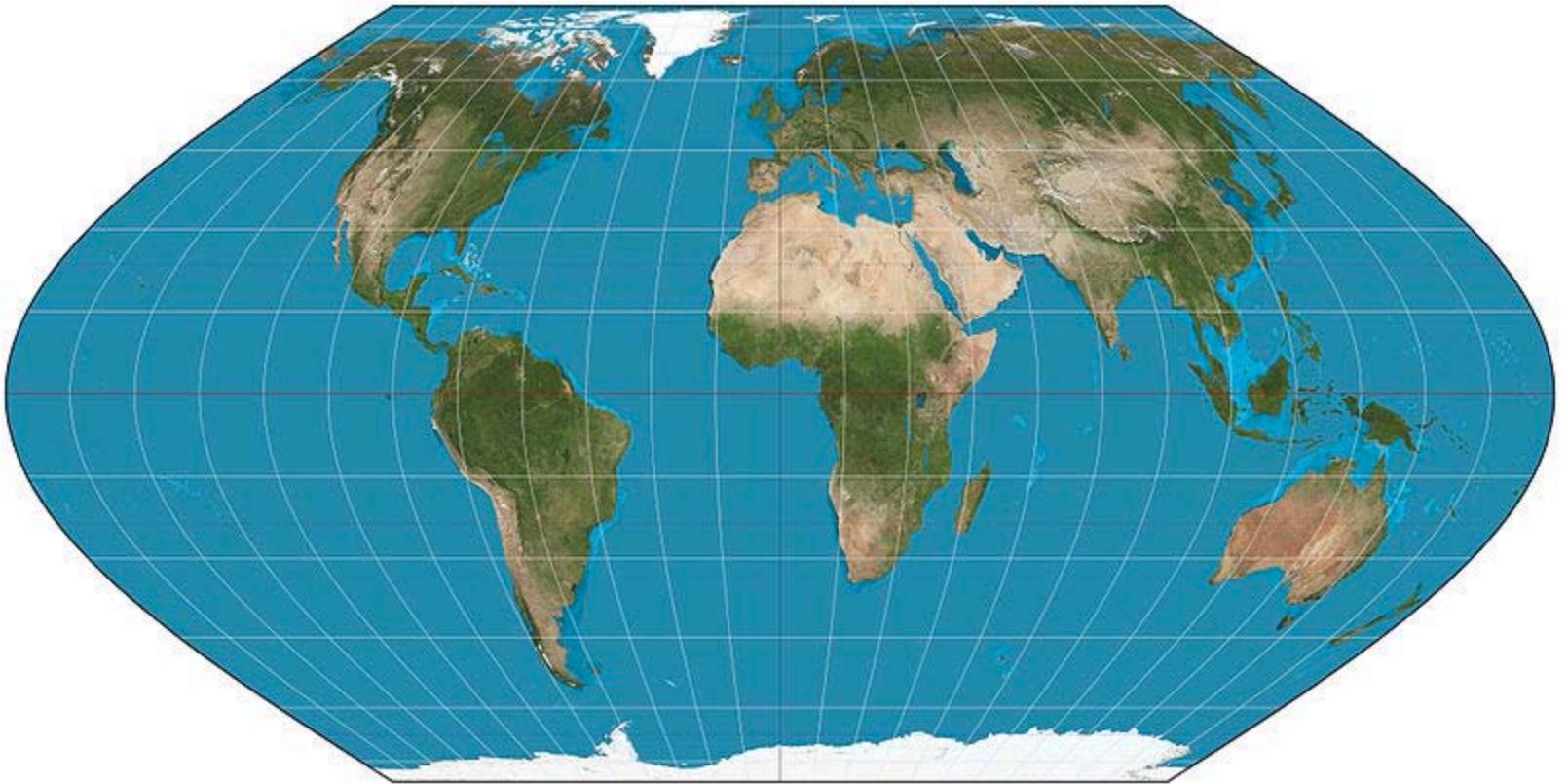
- Sacrifices fidelity to angle and shape in favor of accurate depiction of area.



# Eckert IV



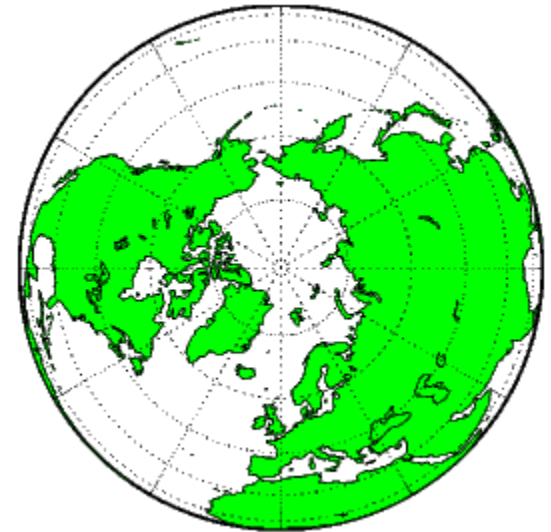
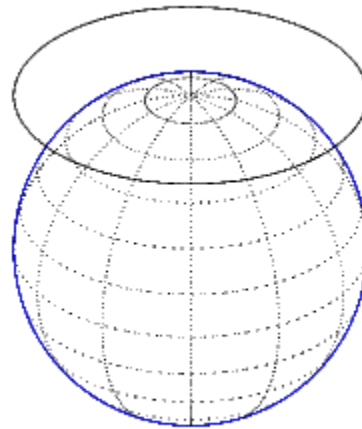
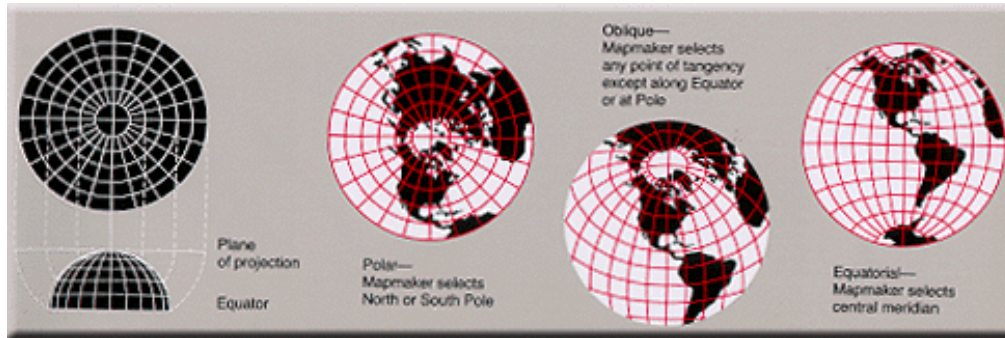
# Eckert VI





# Azimuthal Projection

[http://commons.wikimedia.org/wiki/File:Usgs\\_map\\_azimuthal\\_equidistant.PNG](http://commons.wikimedia.org/wiki/File:Usgs_map_azimuthal_equidistant.PNG)



<http://www.mathworks.com/help/toolbox/map/projec3a.gif>

# Credits

- <http://egsc.usgs.gov/isb/pubs/MapProjections/projections.html>
- Wikipedia