Meteorology

Lecture 8

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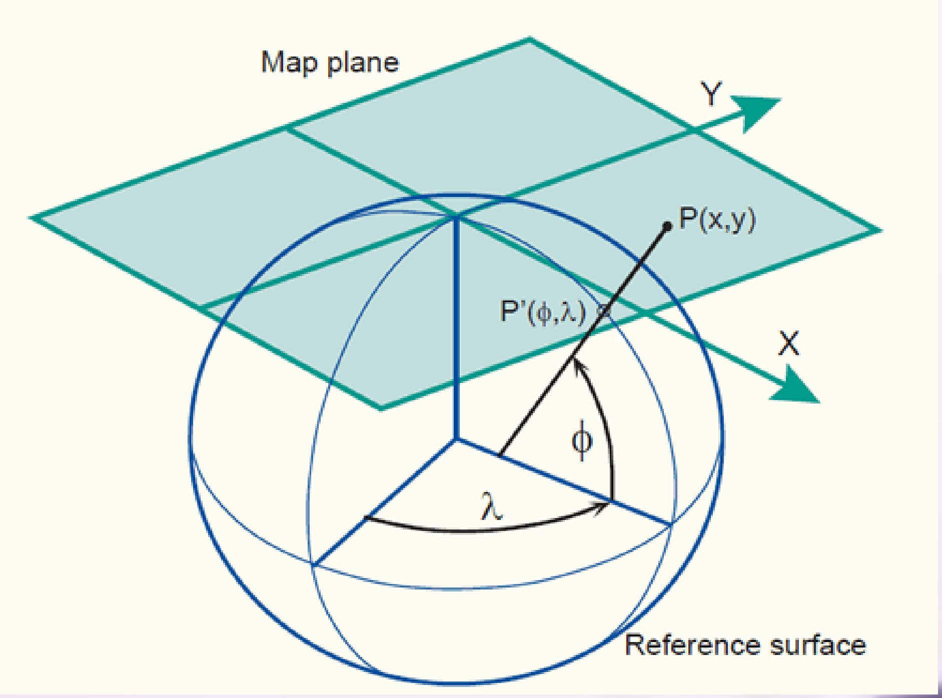
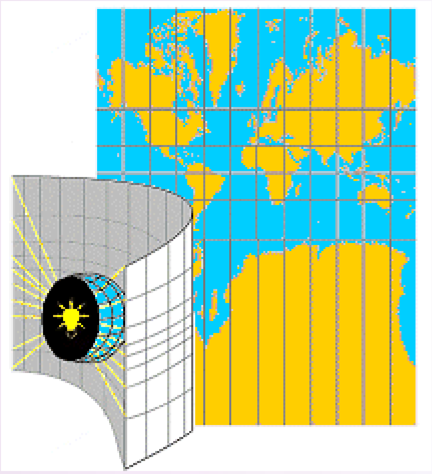
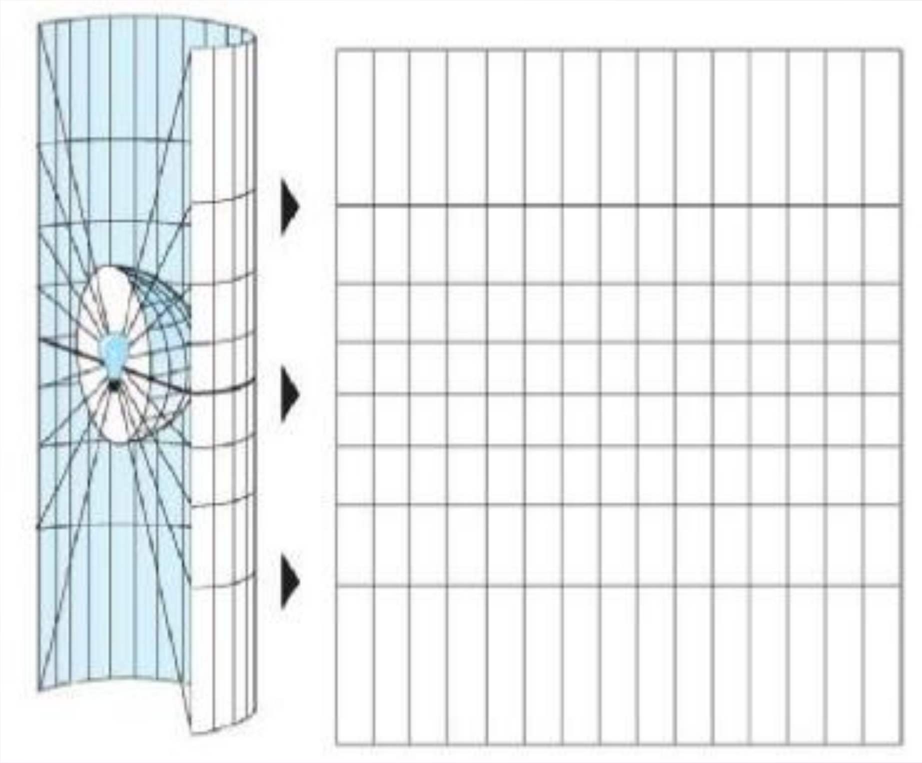
What is a map projection?

A ***map projection*** is a mathematically described technique of how to represent the Earth's curved surface on a flat map. To represent parts of the surface of the Earth on a flat paper map or on a computer screen, the curved horizontal reference surface must be mapped onto the 2D mapping plane.

The reference surface for large-scale mapping is usually an oblate ellipsoid, and for small-scale mapping, a sphere. Mapping onto a 2D mapping plane means transforming each point on the reference surface with geographic coordinates (*Φ*,*λ*) to a set of Cartesian coordinates (*x*,*y*) representing positions on the map plane (figure below).







Map Projections

transferring a curved surface (the Earth, sphere) to a flat one (the map).

Inevitable Distortions

A projection is a compromise in juggling the following distortions

Shape

Area

Distance

Direction

Map Projection-distortion

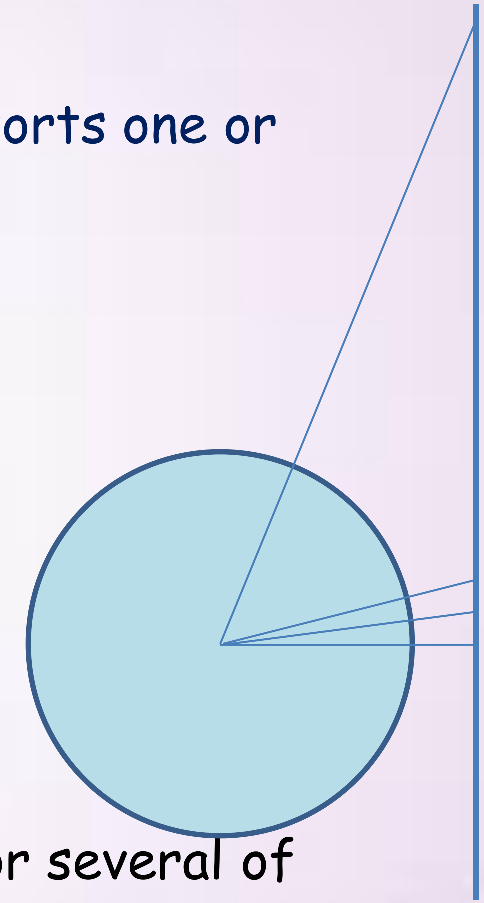
The problem with map projection is that it distorts one or several of these properties of a surface:

Shape

Area

Distance

Direction



Some projections specialize in preserving one or several of these features, but none preserve all

Map Projection-distortion

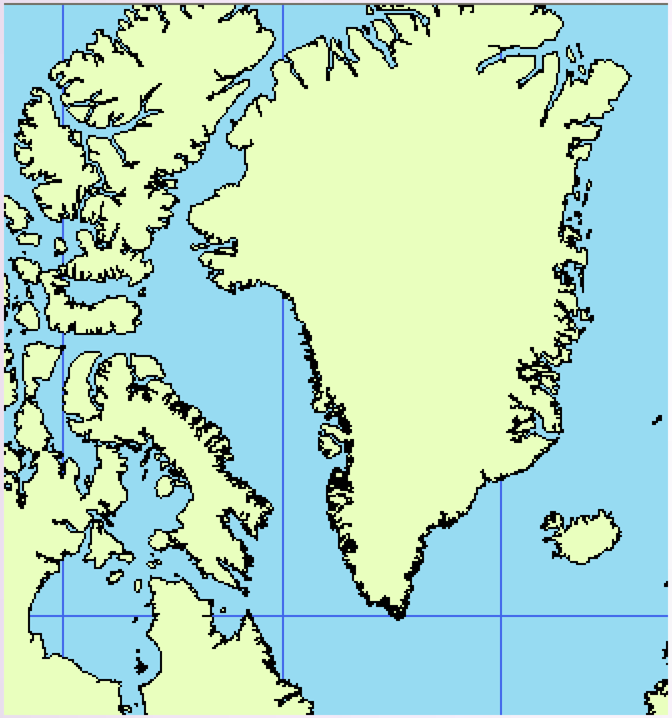
Shape: projection can distort the shape of a feature. *Conformal* maps preserve the shape of smaller, local geographic features, while general shapes of larger features are distorted.

That is, they preserve local angles; angle on map will be same as angle on globe. Conformal maps also preserve constant scale locally

Area: projection can distort *area,* meaning that features do not have the correct area relative to one another. Map projections that maintain this property are often called *equal area map projections*.

No map projection can be conformal and equal area; sacrifice shape to preserve area and vice versa.

Shape distortion



Mercator (left)

World Cylindrical Equal Area (above)

The distortion in shape above is necessary to get Greenland to have the correct area

The Mercator map looks good but Greenland is many times too big

Area Distortion

Mercator Projection

827,000 square miles

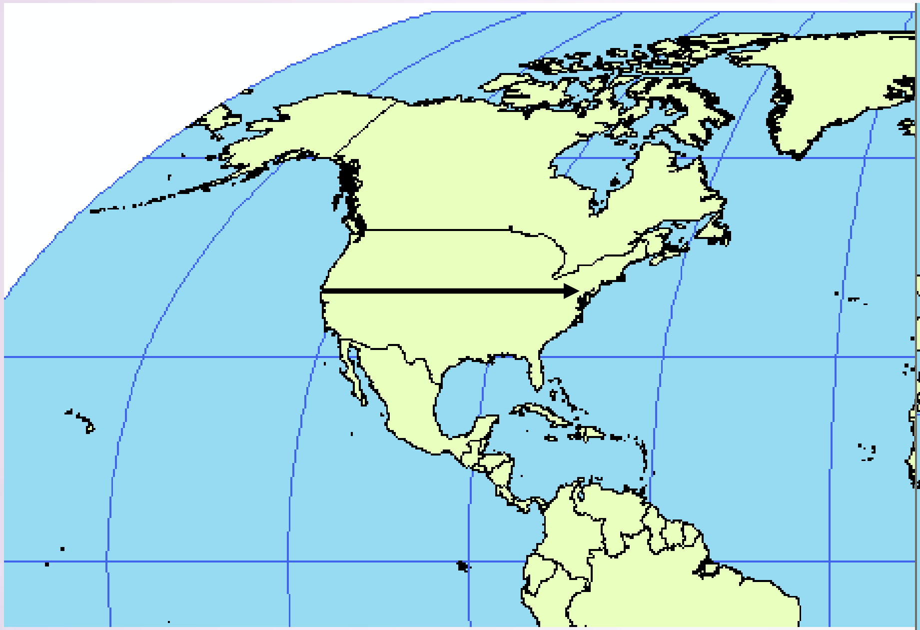
6.8 million square miles

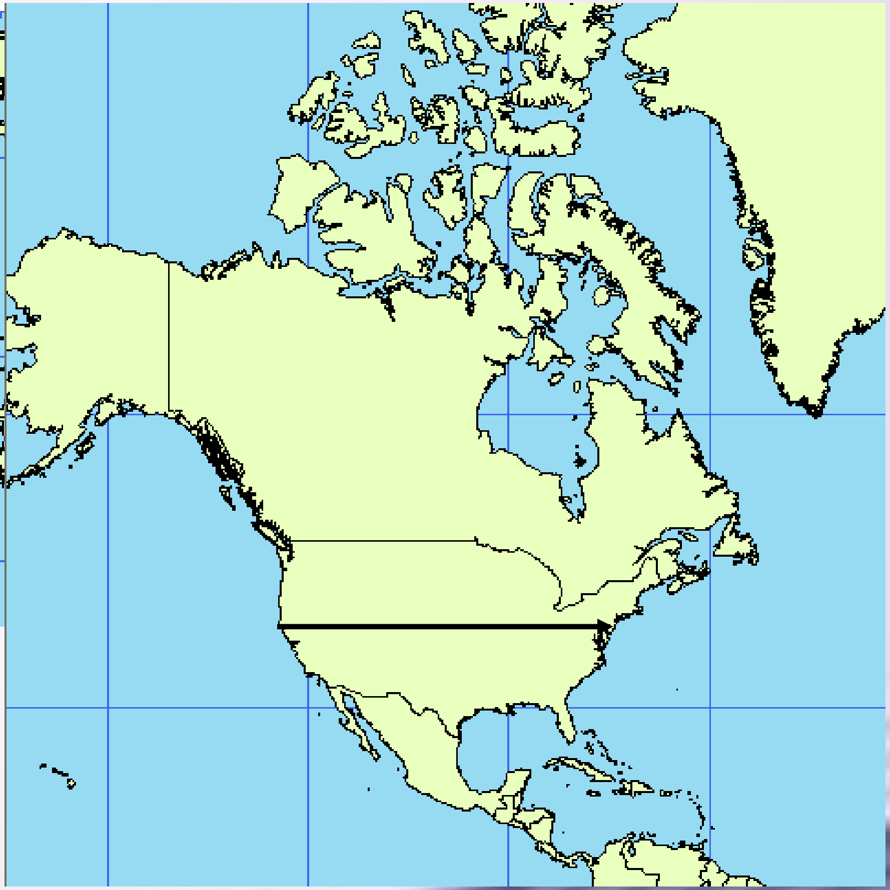
Map Projection-distortion

Distance: Projection can distort measures of true distance. Accurate distance is maintained for only certain parallels or meridians unless the map is very localized.

Maps are said to be *equidistant* if distance from the map projection's center to all points is accurate. We'll go into this more later.

Distance distortion



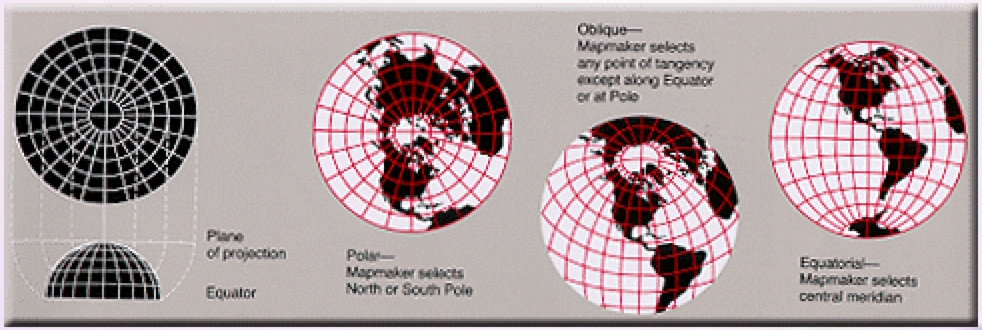


4,300 km: Robinson
5,400 km: Mercator

Map Projection-distortion

Direction: Projection can distort true directions (angle or azimuth) between locations; azimuthal projections maintain true direction with respect to the center point.

Some azimuthal map projections maintain direction between any two points, so that the angle of a line drawn between any two locations on the projection gives the correct direction with respect to true north.



Map Projection-distortion

Hence, when choosing a projection, one must take into account what it is that matters in your analysis and what properties you need to preserve

Conformal and equal area properties are mutually exclusive but some map projections can have more than one preserved property. For instance a map can be conformal and azimuthal

Conformal and equal area properties are **global** (apply to whole map) while equidistant and azimuthal properties are **local** and may be true only from or to the center of map

Conformal Map Projections

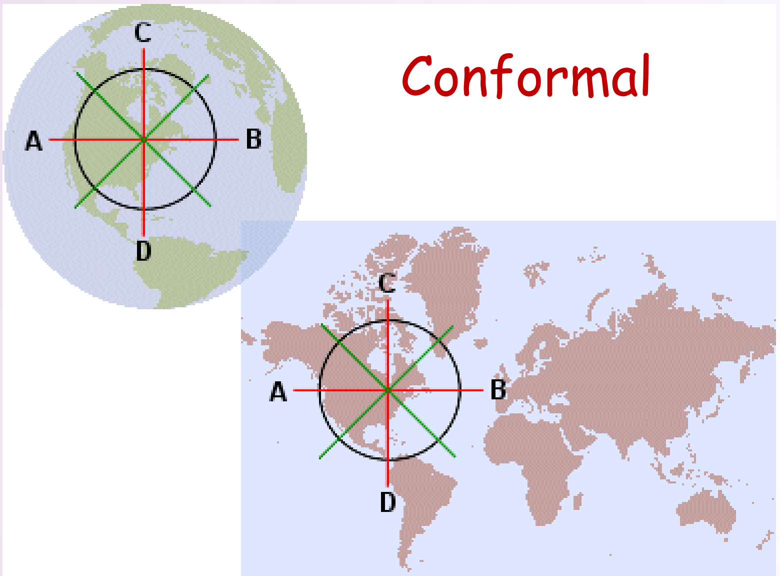
Projections that maintain local angles are called **conformal**.

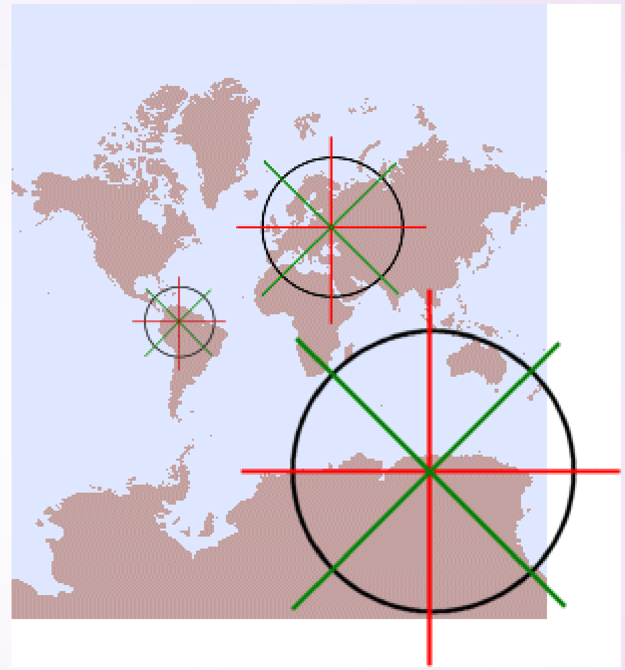
Conformal maps preserve angles

Conformal maps show small features accurately but distort the shapes and areas of large regions

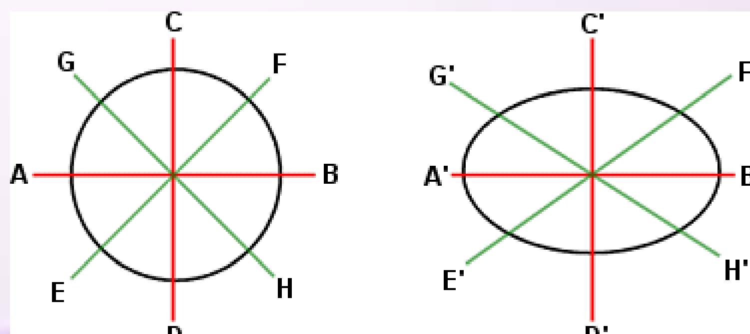
Examples: Mercator, Lambert Conformal Conic

Shape Property

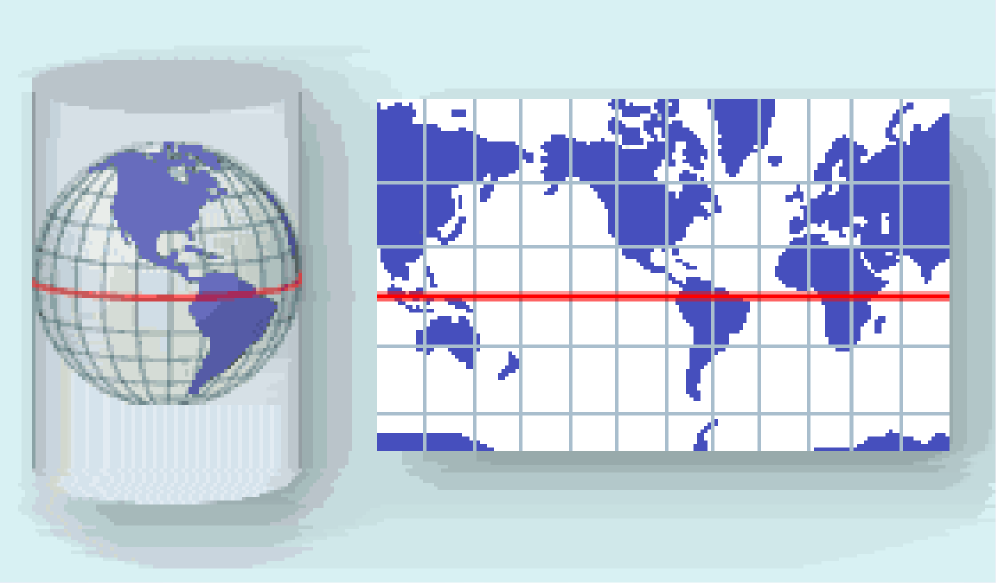




Non-conformal



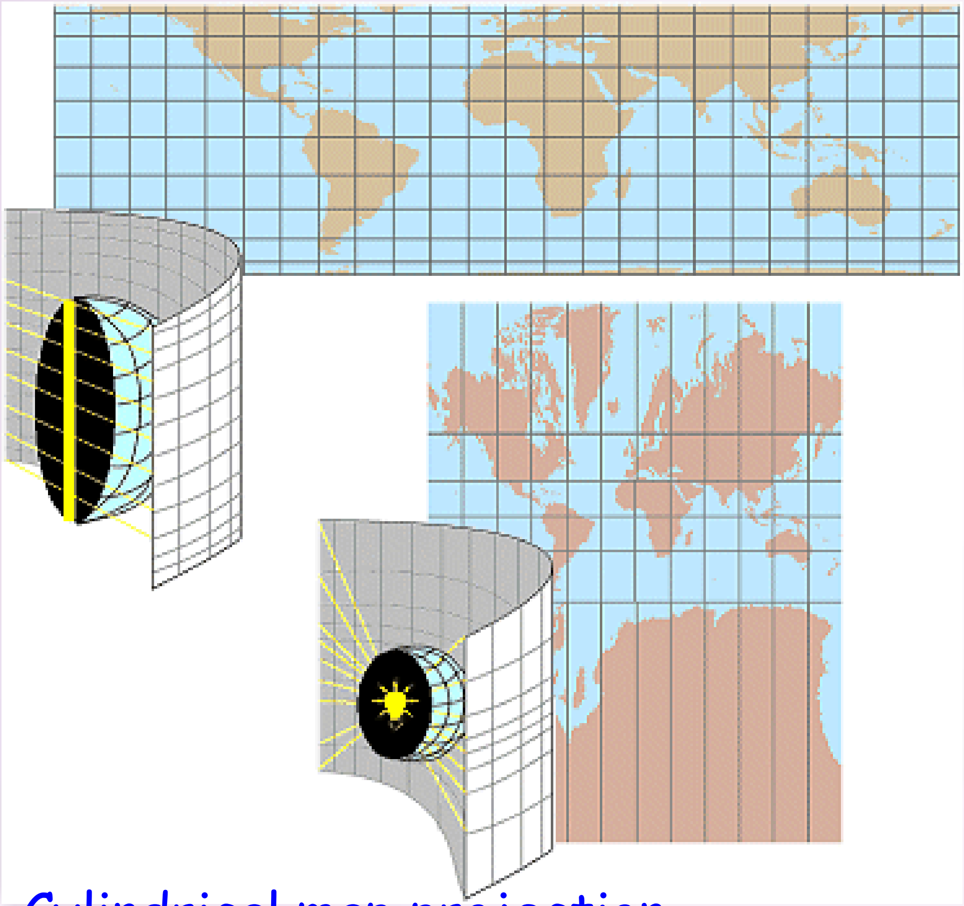
Mercator Projection Map

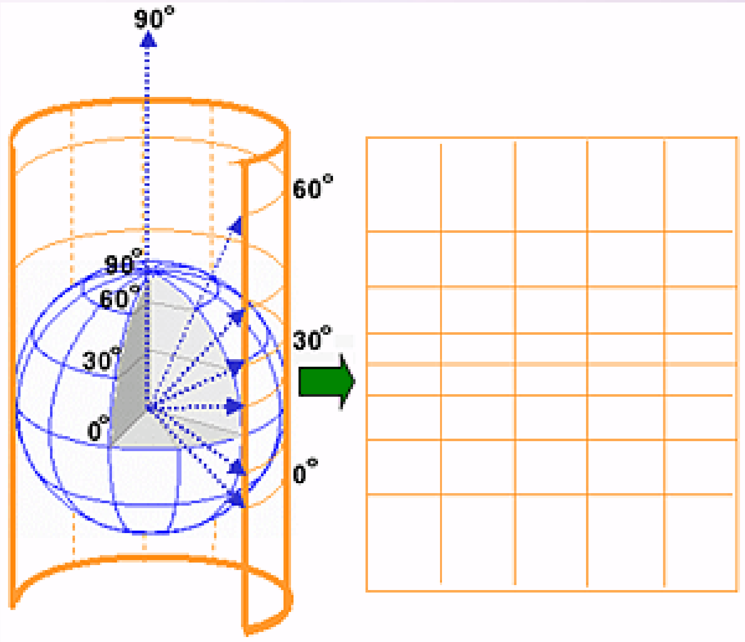


The mercator map projection shows the view of Earth as if a large cylinder of paper had been wrapped around the globe.

This is the most common type of projection

Cylindrical Projections





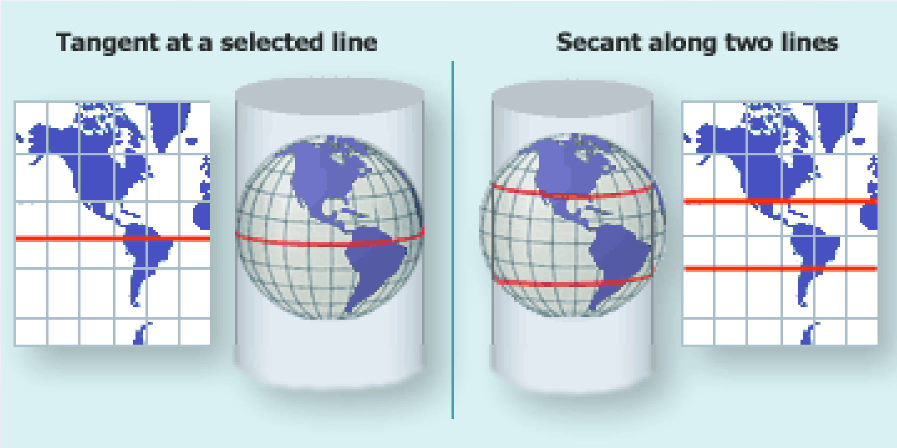
Cylindrical map projection

Useful for navigation because it maintains accurate direction

Famous for their distortion in area that makes landmasses at the poles appear oversized

Cylindrical Map Types

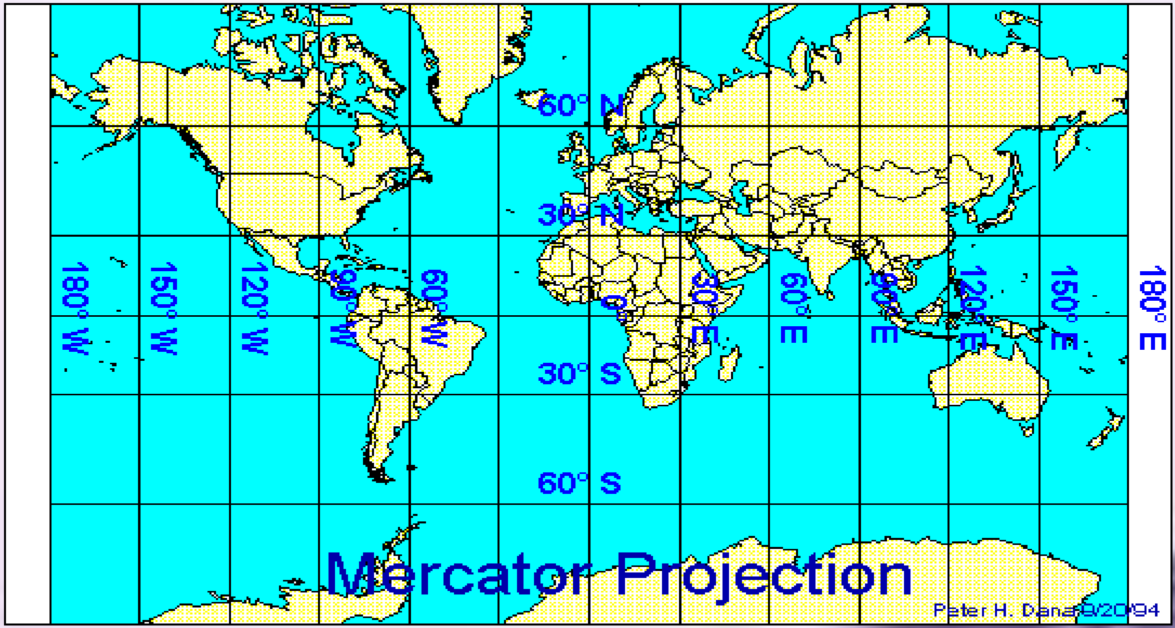
1. Tangent to great circle: in the simplest case, the cylinder is North-South, so it is tangent (touching) at the equator; this is called the *standard parallel* and represents where the projection is most accurate
2. If the cylinder is smaller than the circumference of the earth, then it intersects as a *secant* in two places



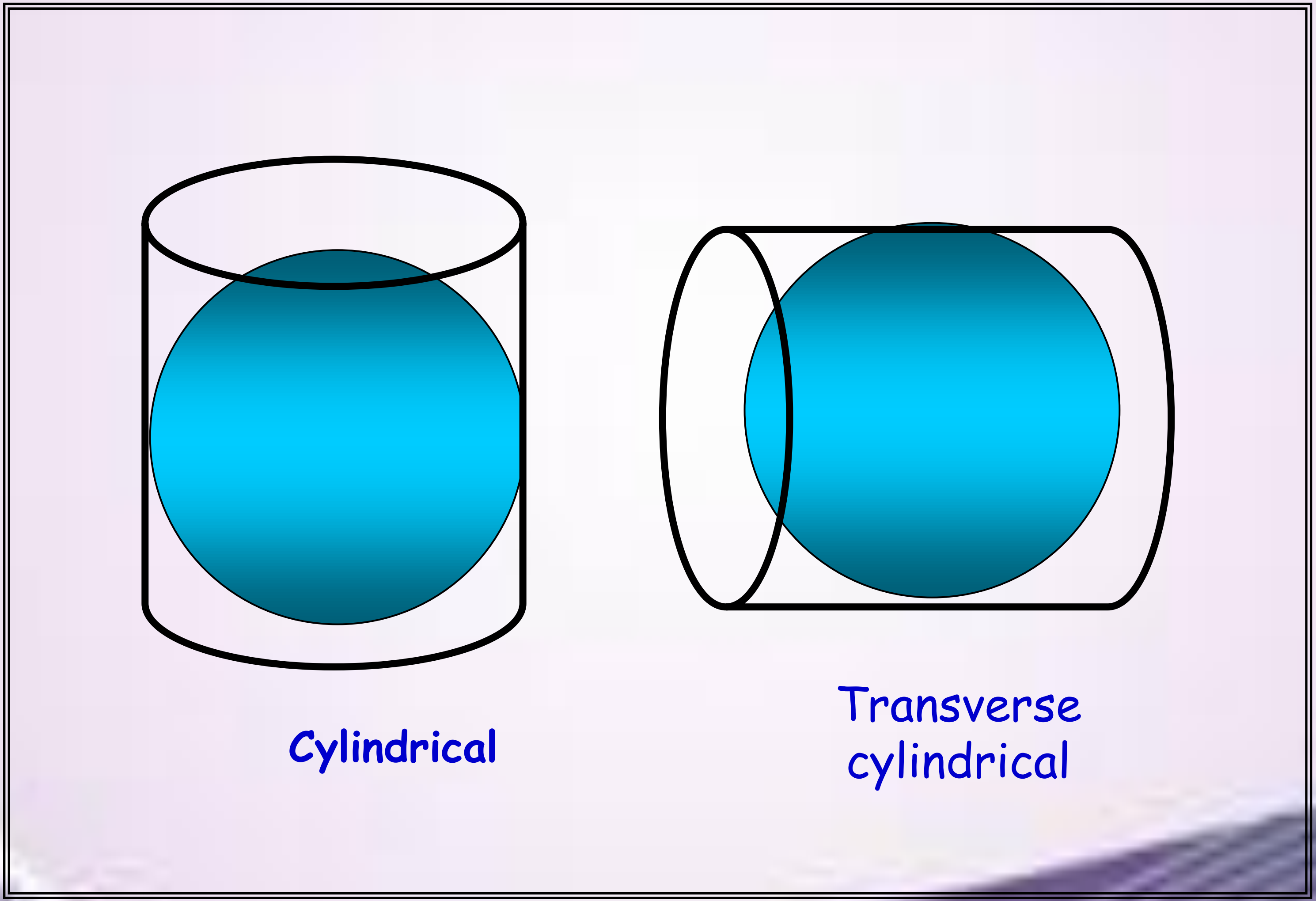
Mercator Projection Map

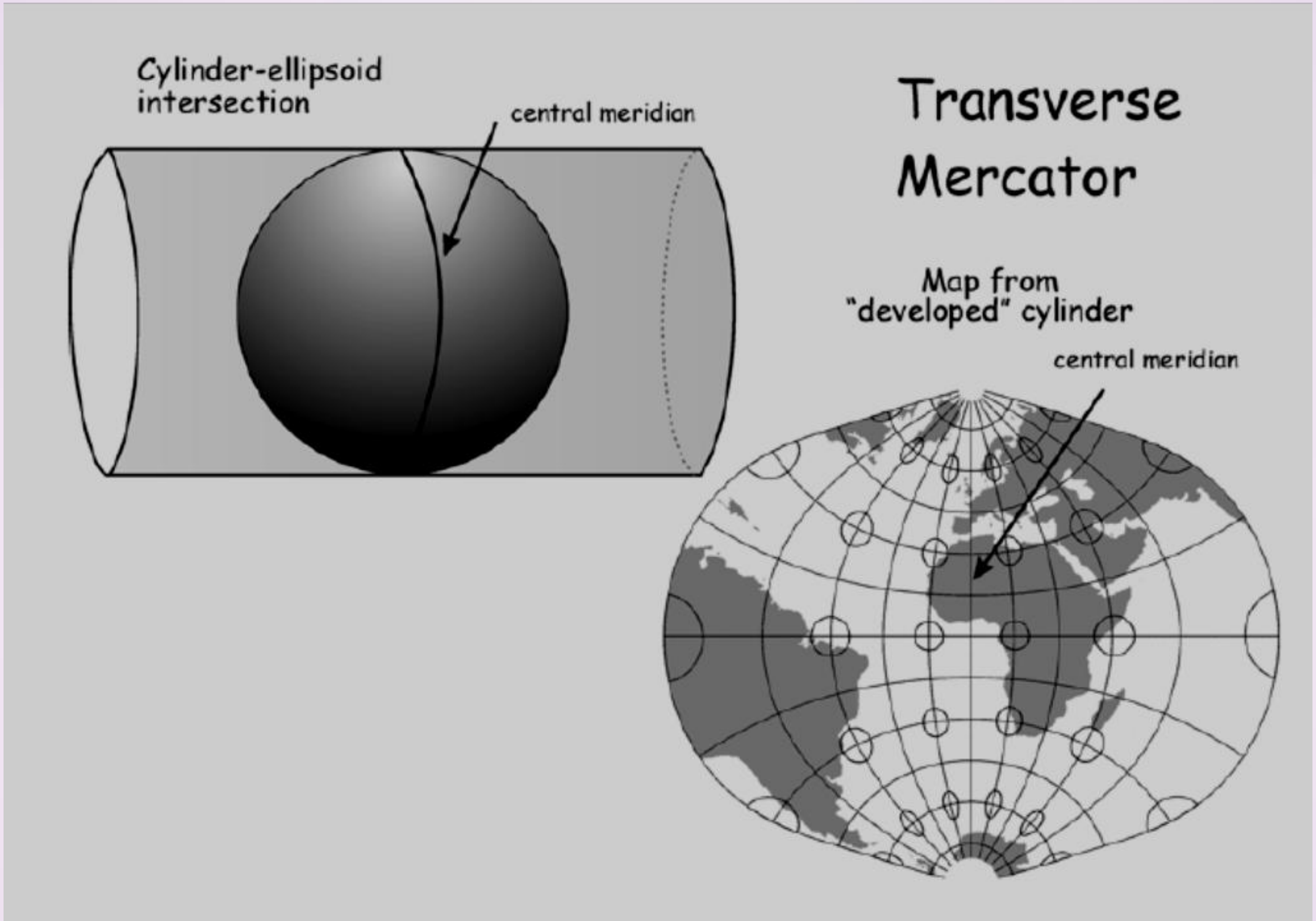
-Disadvantage → Major distortion effects near the poles (land looks larger than what it really is)

+Advantage → Indicates true directions as straight lines of latitude and longitude, makes a rectangular grid pattern

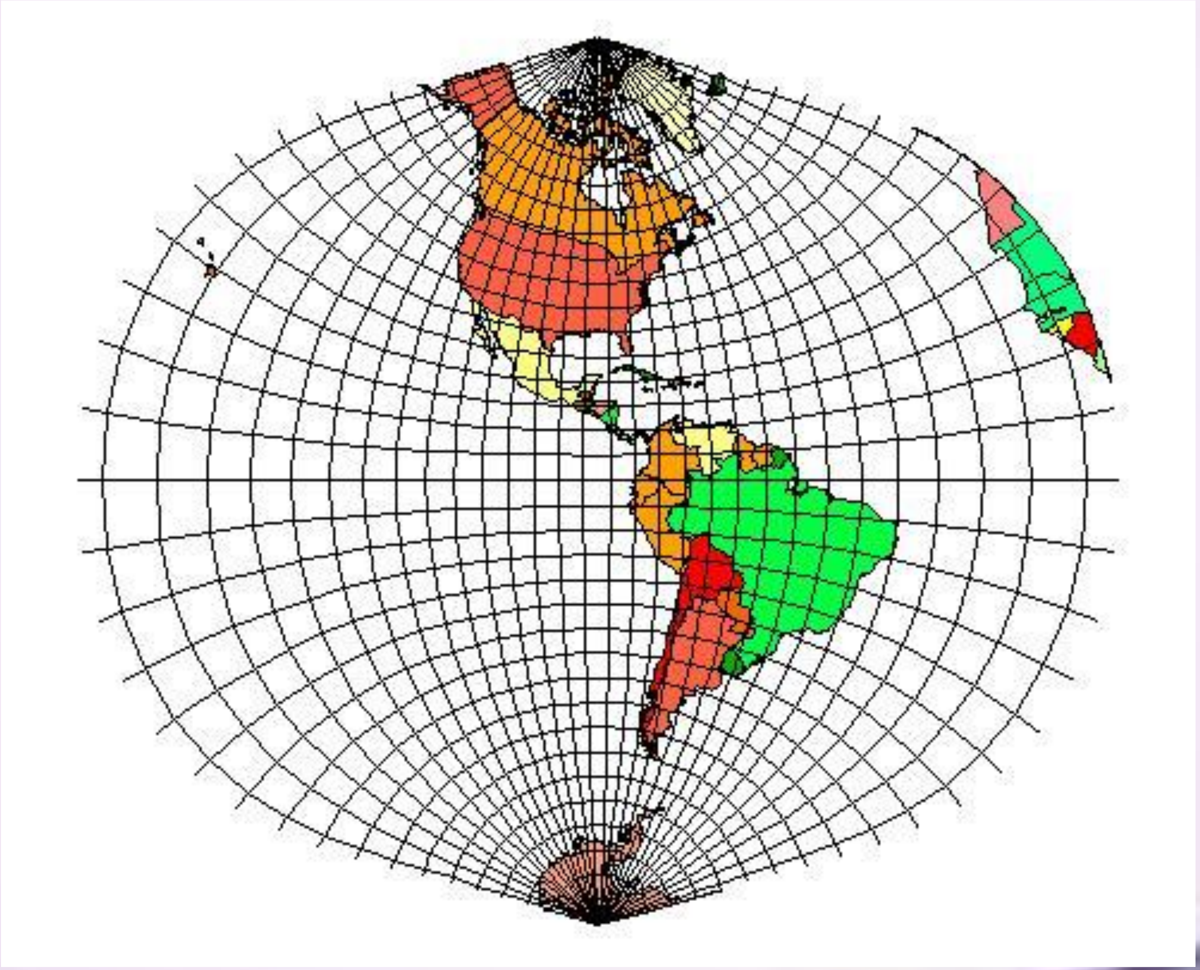


Cylindrical projections

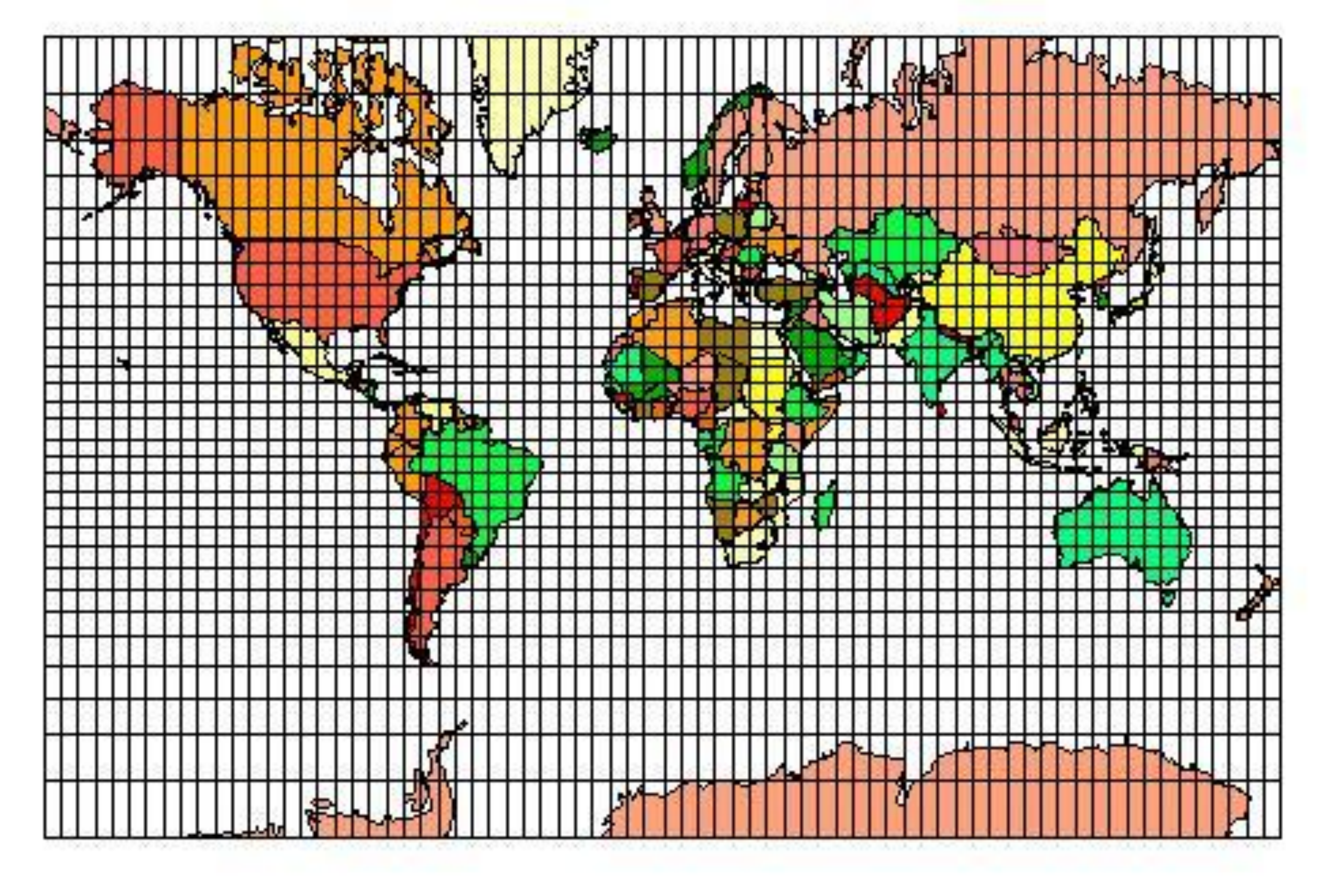


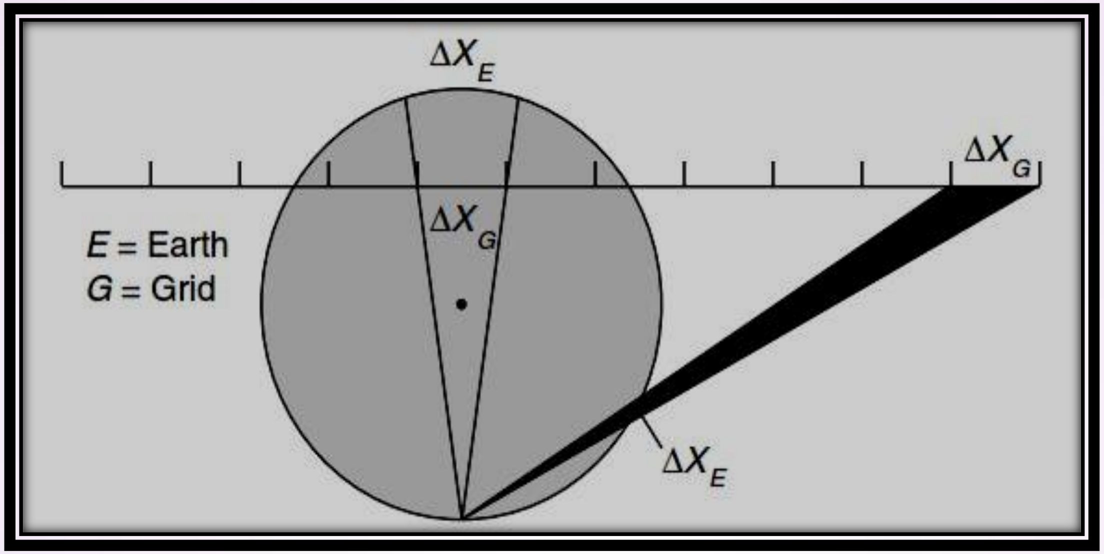

Cylinder-ellipsoid intersection
central meridian
Transverse Mercator
Map from "developed" cylinder
central meridian

Transverse Mercator

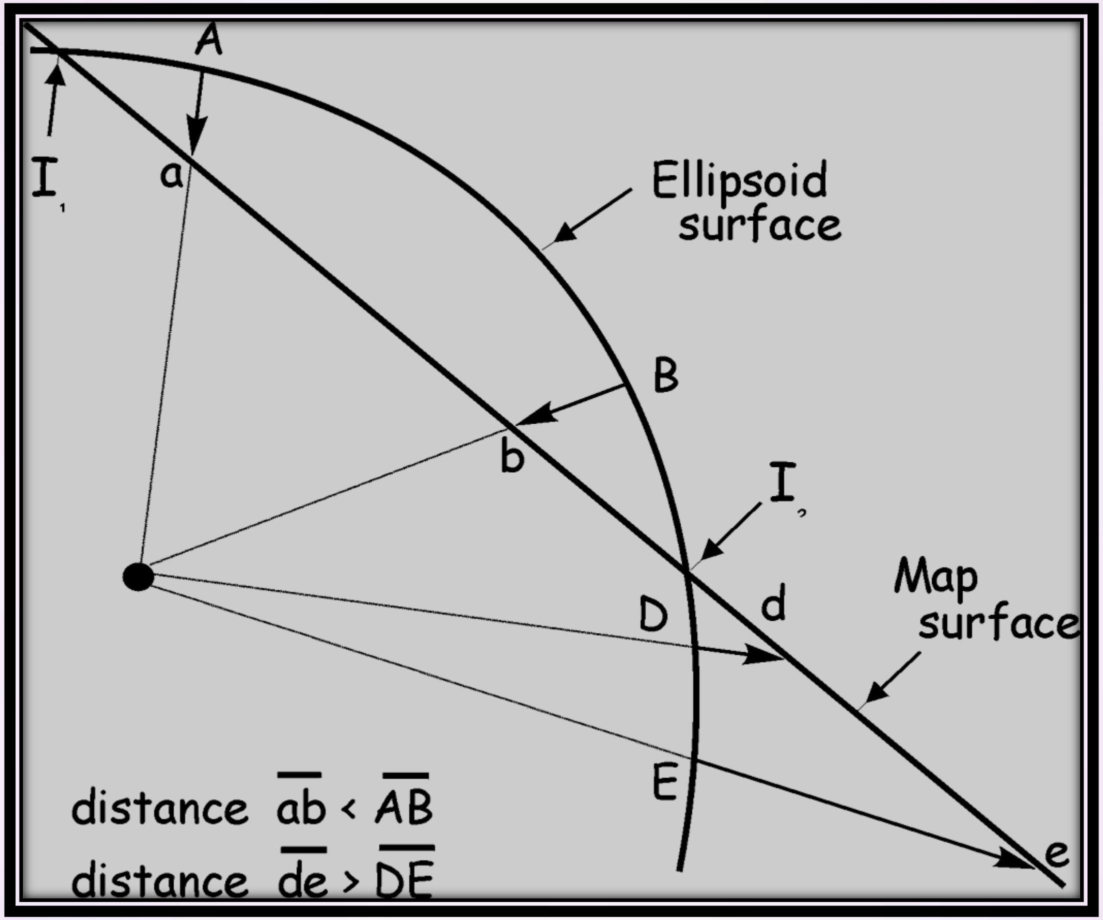


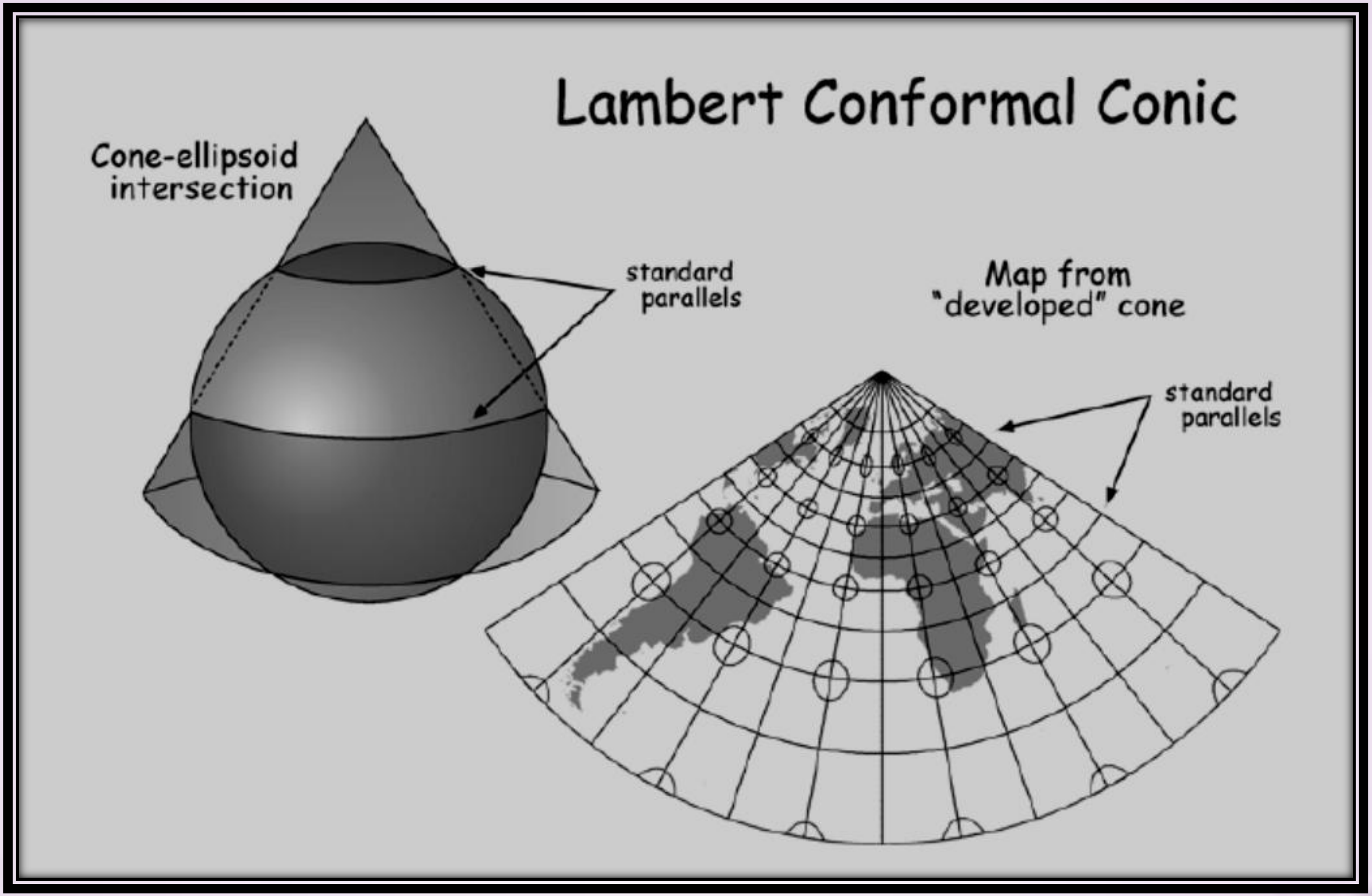
Mercator Projection



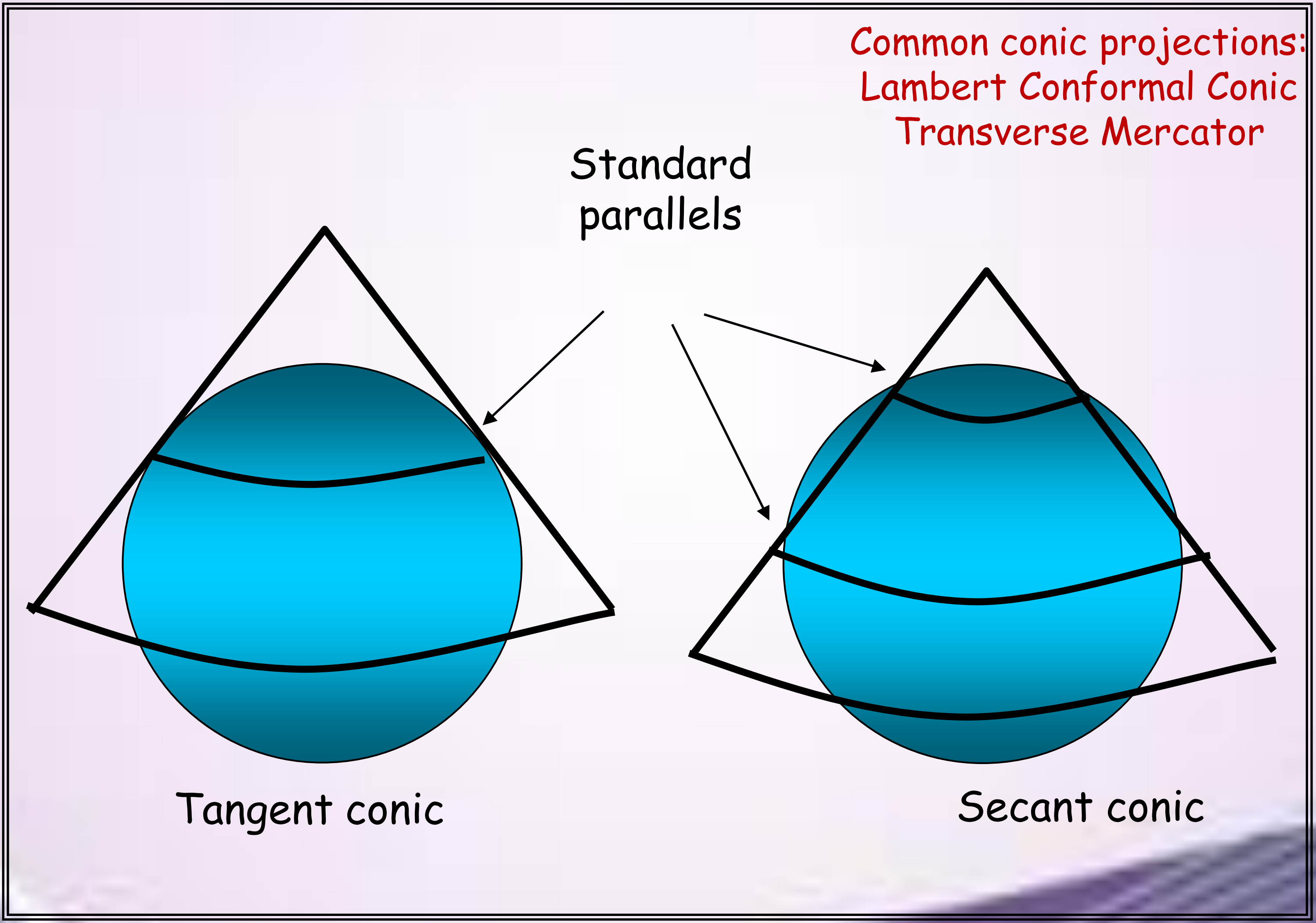


$$m = \frac{\Delta x_G}{\Delta x_E}$$

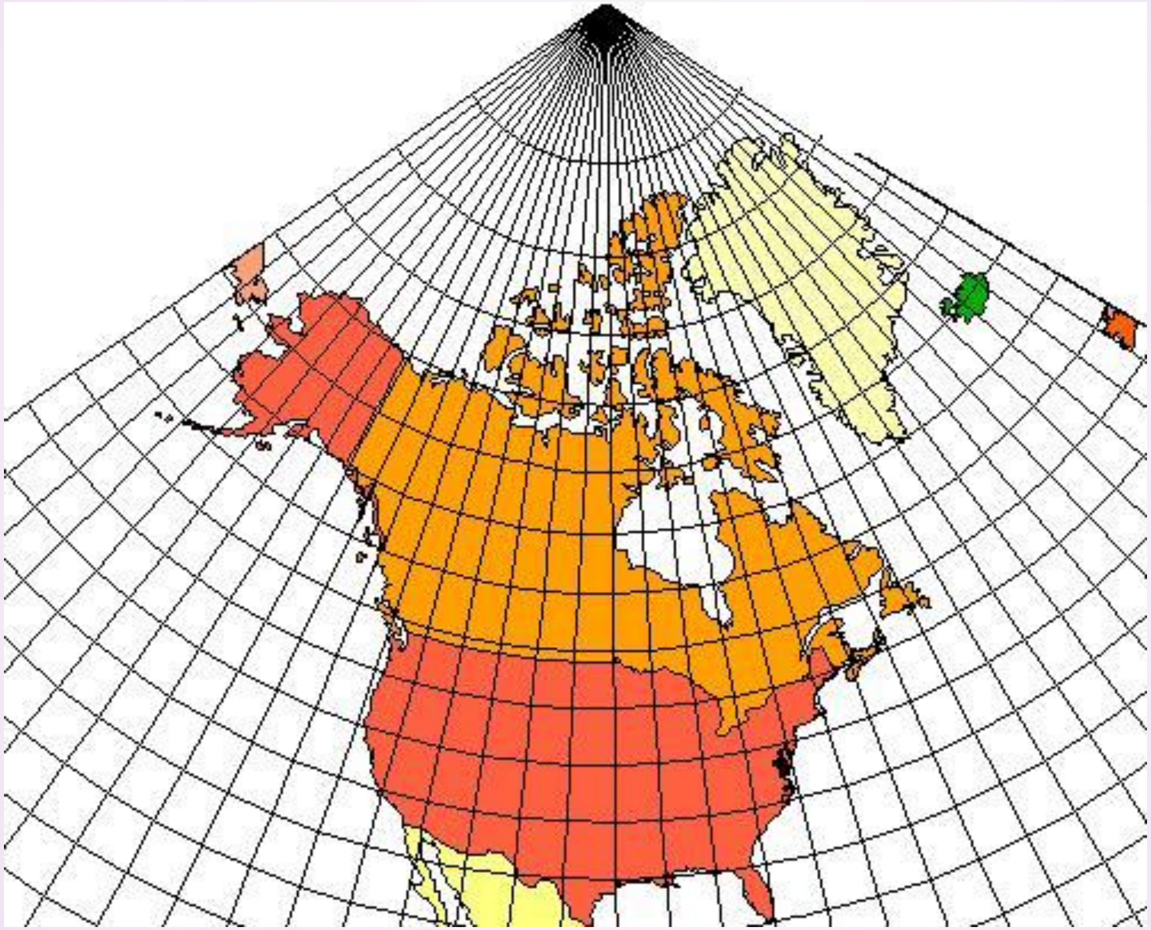

A
I1
a
Ellipsoid surface
B
b
I2
Map surface
d
D
E
e
distance ab < AB
distance de > DE


Lambert Conformal Conic
Cone-ellipsoid intersection
standard parallels
Map from "developed" cone
standard parallels

Conic projections



Lambert Conformal Conic



Developable Surfaces