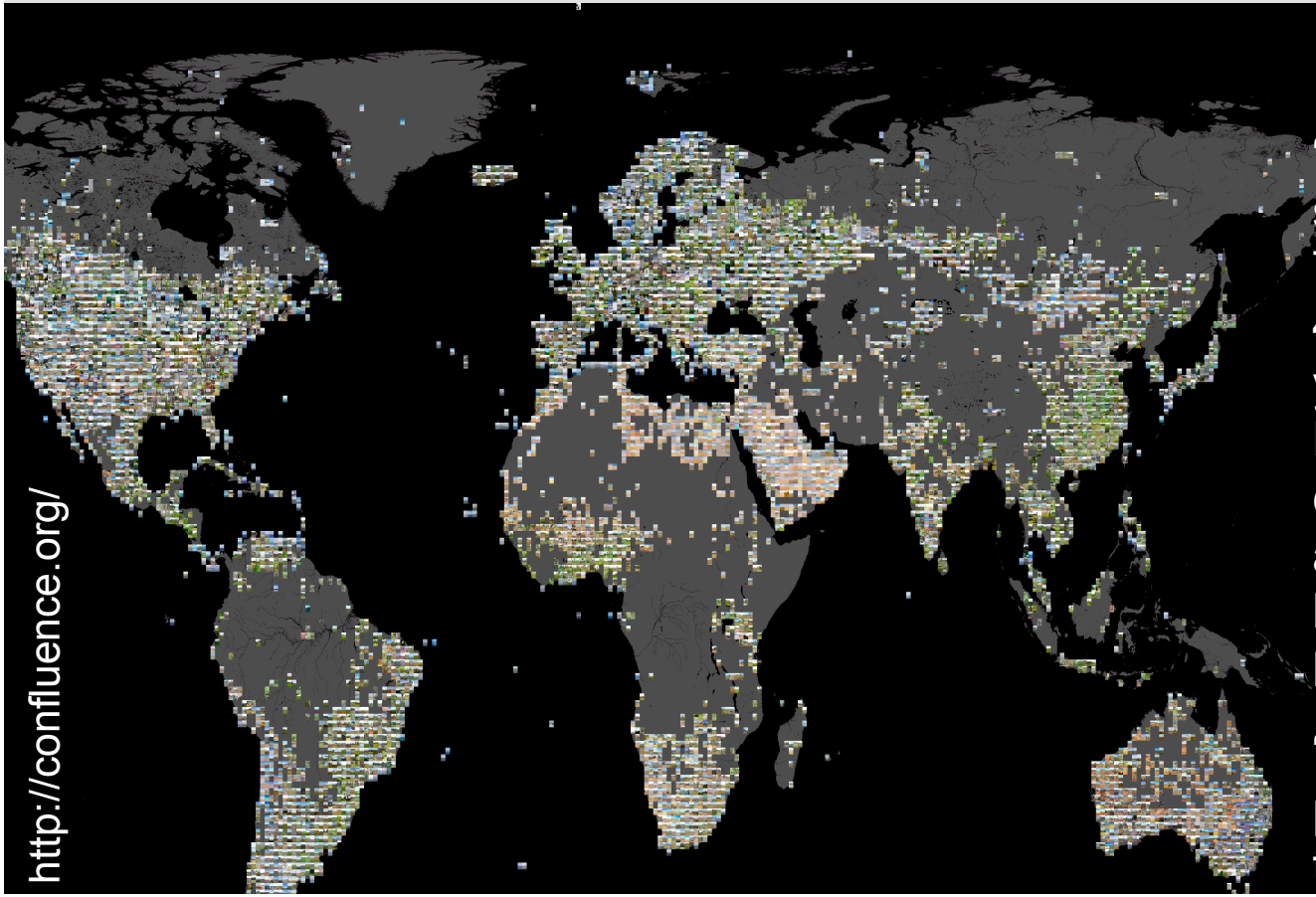
"The goal of the project is to visit each of the latitude and longitude integer degree intersections in the world, and to take pictures at each location."



"The project is an organized sampling of the world. There is a confluence within 49 miles (79 km) of you if you're on the surface of Earth. We've discounted confluences in the oceans and some near the poles, but there are still 9,911 to be found."

"You're invited to help by photographing any one of these places...."

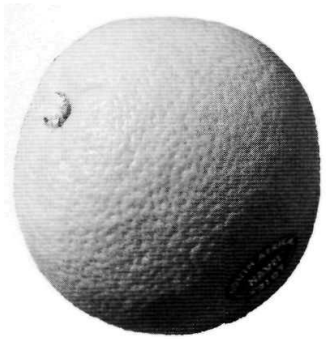
Geography 360
October 24, 2016

How GIS understands shapes on the Earth (continued.)

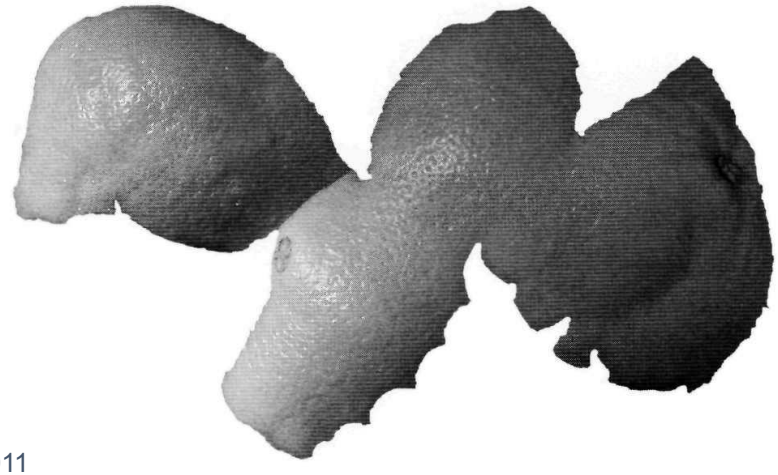
1. *Questions and Announcements*
   - Great job on your projects!
   - New tutorial up: Simply Seattle
2. *How does GIS represent and present features on the Earth? (continued.)*
   - Projections: What they are. When to use which one.
   - Datums
   - Data in well-specified spatial reference systems:
     Coordinates with a specific datum in a projection.

Map Projections.

- They go from 3D to 2D.
  - Transforming points on a curved surface to points on a flat plane.
- None are neutral or the simple truth.

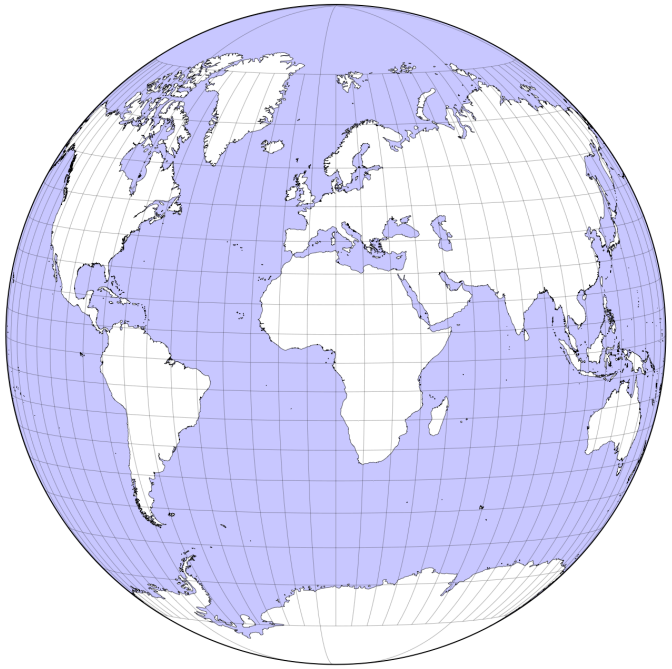


An orange peel *tears* when you peel and flatten it.

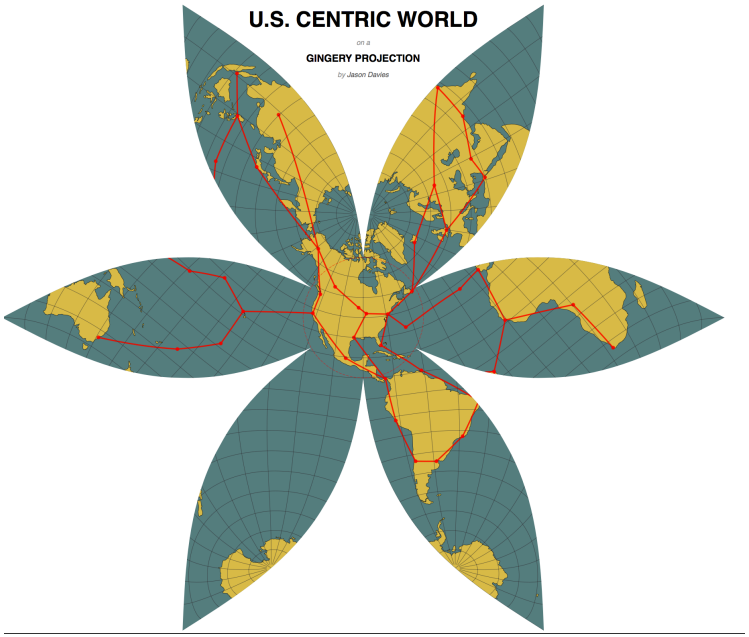


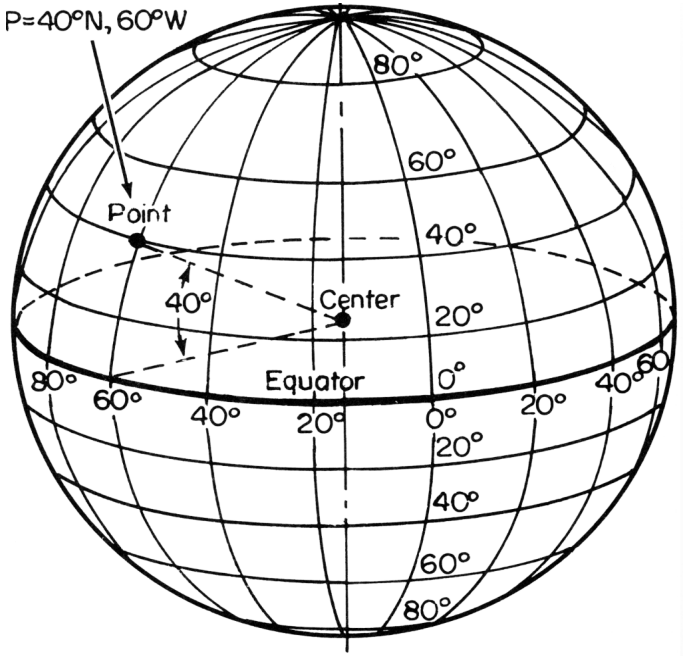
Krygier and Wood 2011

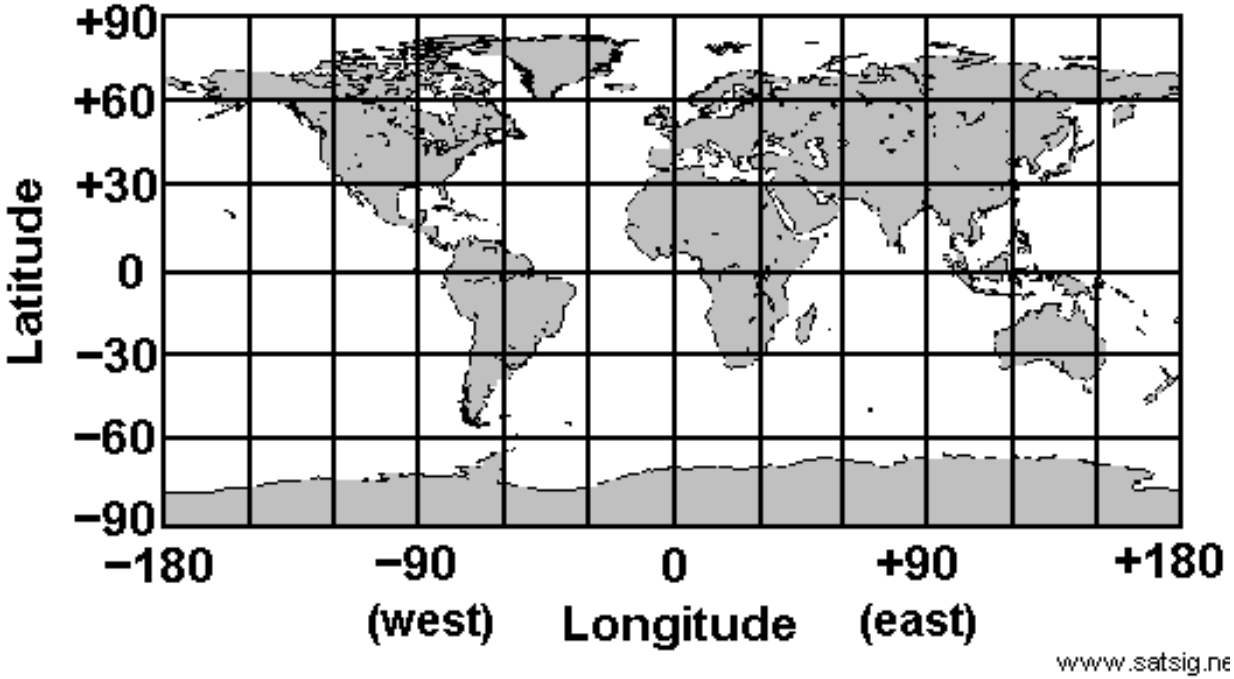
Gilbert's Two-World Perspective



Gilbert's Two-World Perspective Projection, centred at 5°N, 5°E.







Peeling the sphere and stretching it into the *plate carrée* or 'geographical' (!?) projection:

Latitude & Longitude

Also called an 'unprojected' (!?) coordinate system.

Latitude

- Lines of equal latitude are *parallels*
- Equator = 0°
- Extends to 90°N and S

Longitude

- Lines of equal longitude are *meridians*
- Prime Meridian = 0°;
- Extends to 180°E and W.

Note: 1 degree = 60 minutes
1 minute = 60 seconds

Much classic geometrical terminology naming projections uses words that imply we are shining light onto paper...

Imagine we had a light source…

Shining light through a *reference globe…*

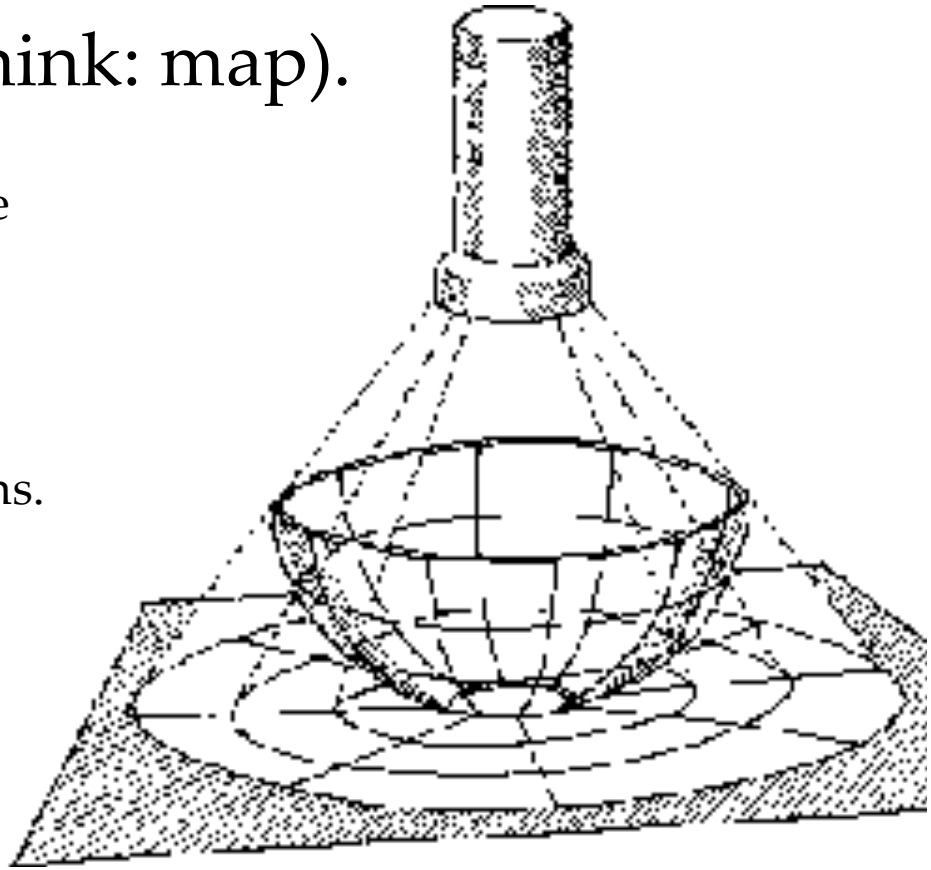
Onto a *developable surface* (think: map).

There are a lot of ways you can configure those items with respect to each other.

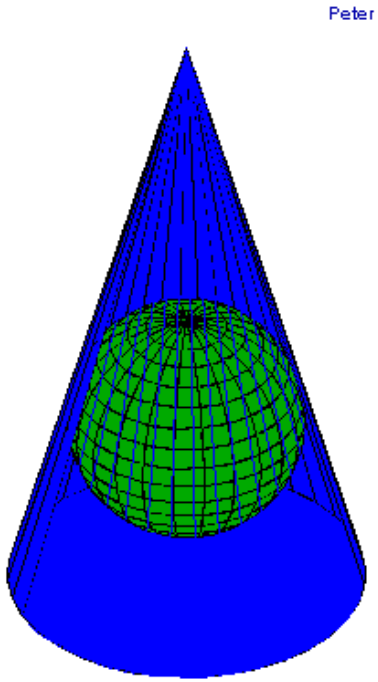
Geometry is a rich subject.

And thus, there are a lot of different terms. Sorry!

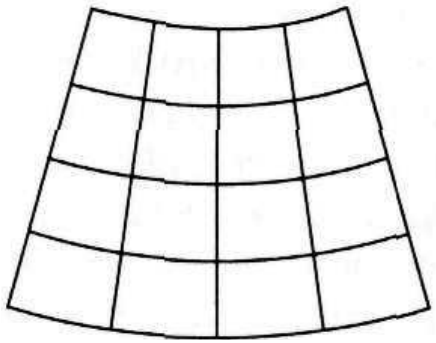
But knowing the terms helps you understand and evaluate projections at a glance.



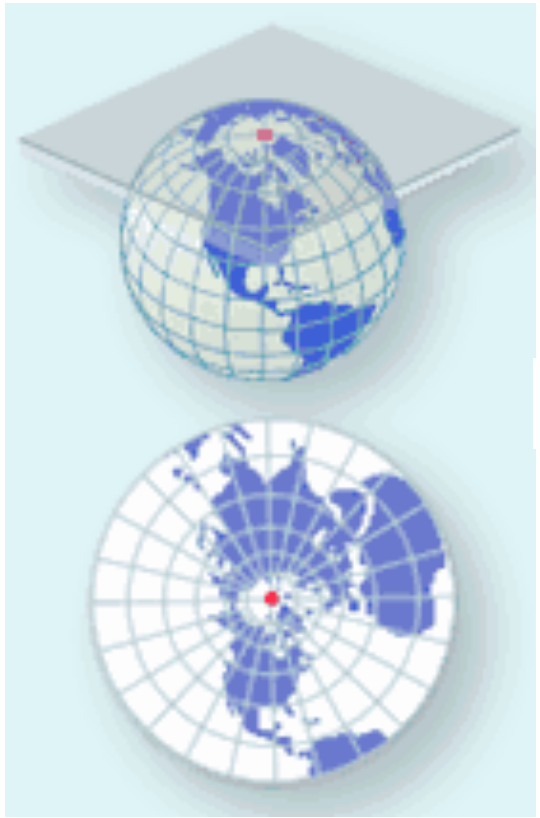
Three different ways of placing the developable surface lead to three ‘classes’ of projections

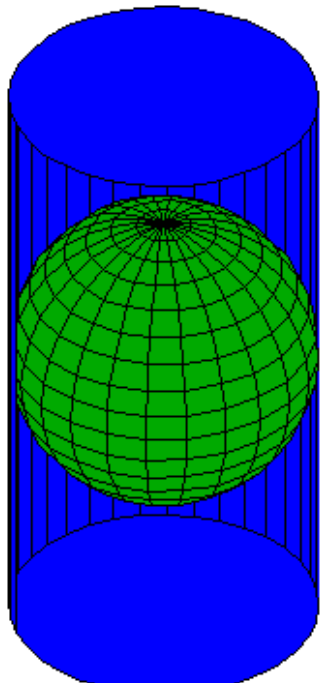


‘Conical’ Projection

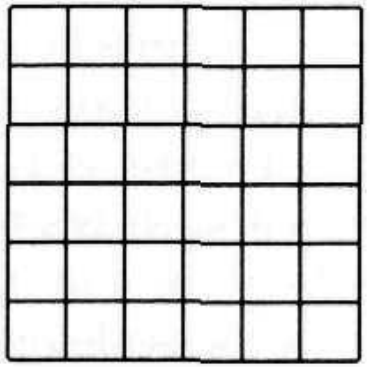


‘Planar’ Projection

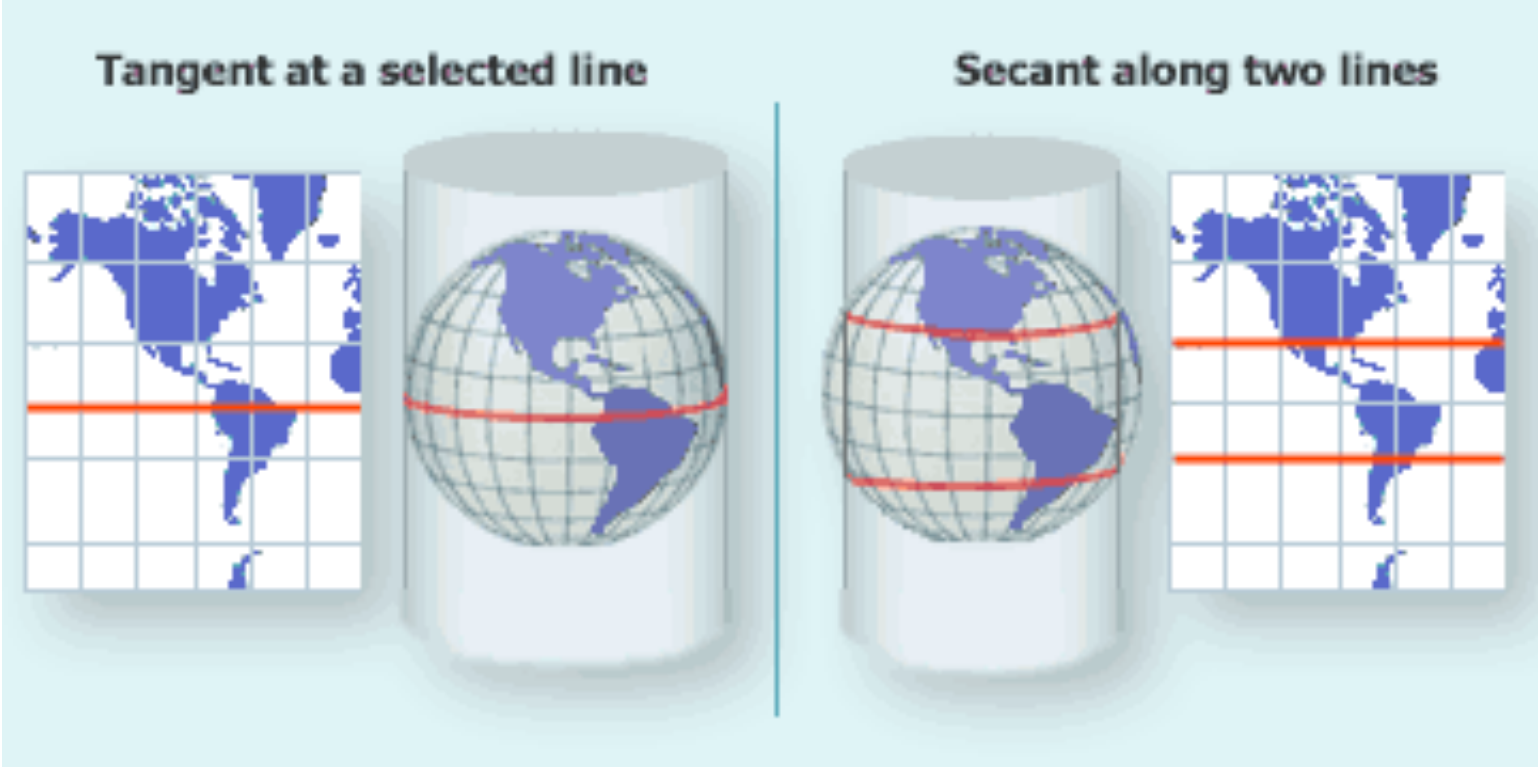




‘Cylindrical’ Projection



Projection “Case”: Secant vs. Tangent

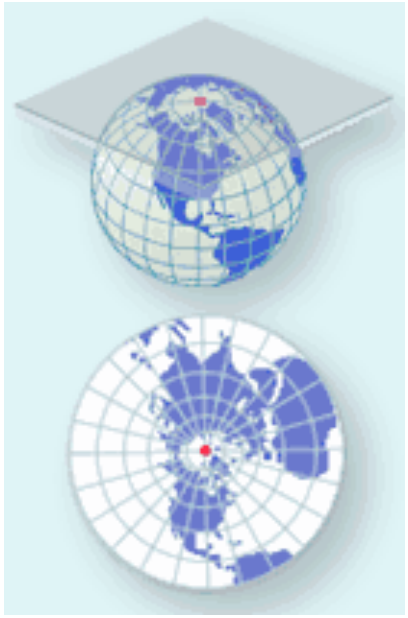


Where do you think the distortions of surface features are going to be least in the projected spaces above?

“Aspect”:

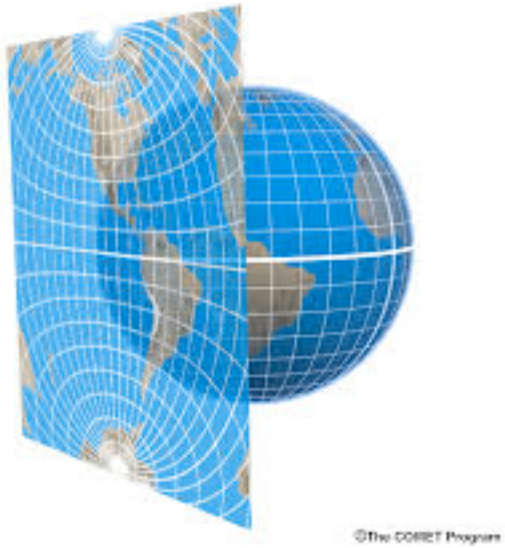
the direction of the light in the projection.

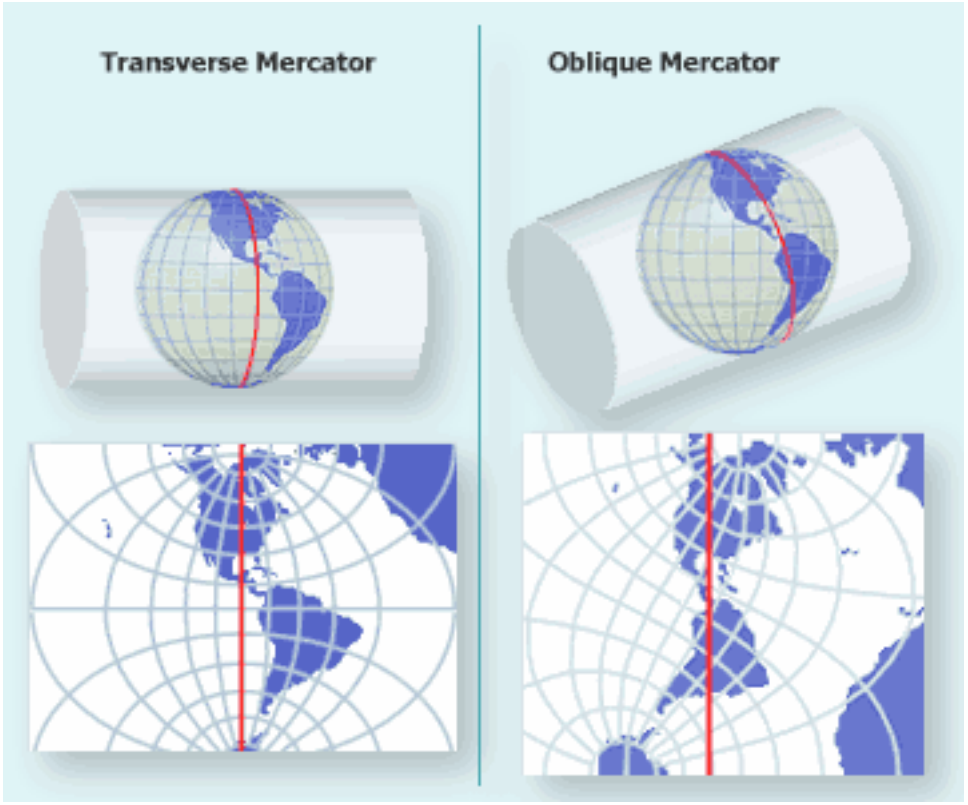
- Equatorial
- Polar & Transverse
- Oblique



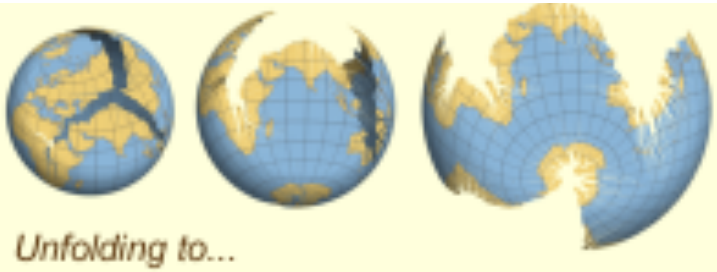
Polar

Equatorial





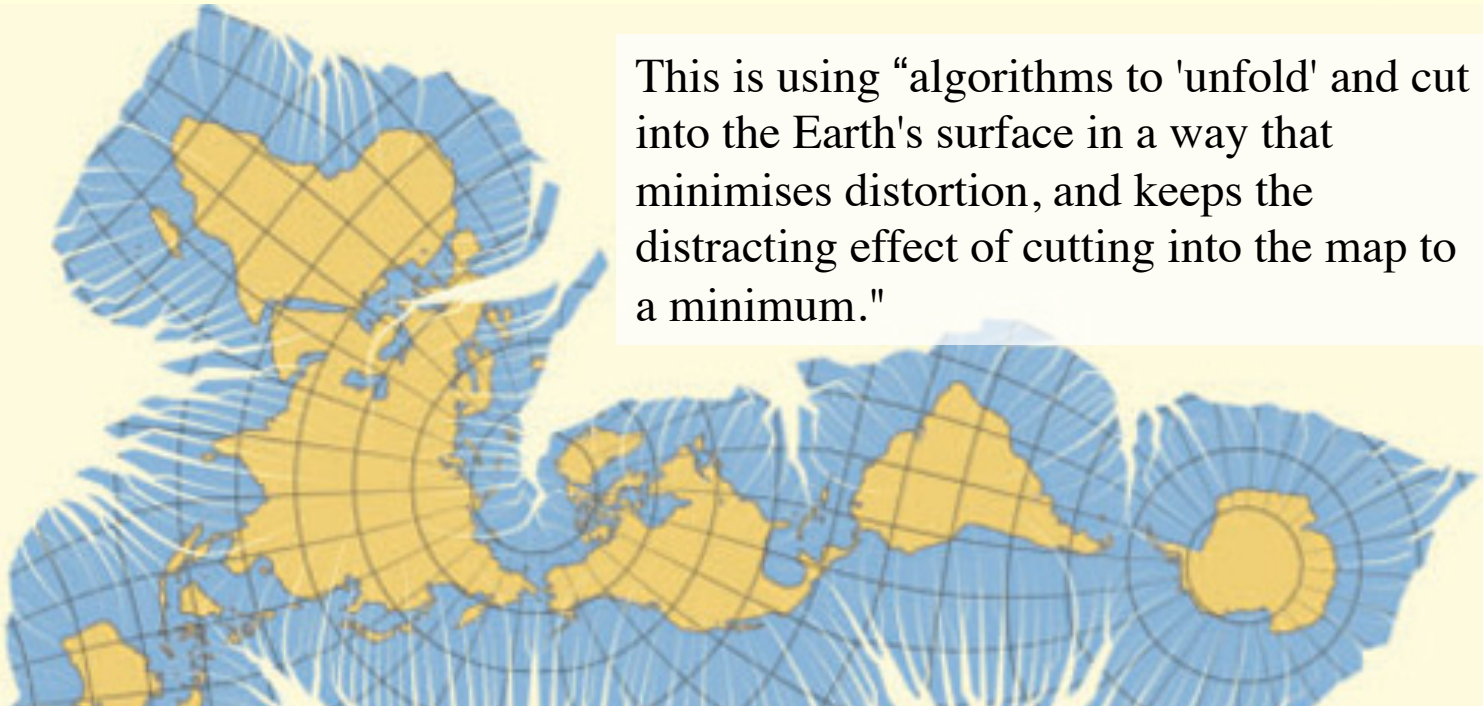
But not all projections are classical geometric ones…



Unfolding to...

...the coastline of the earth.

This is using “algorithms to 'unfold' and cut into the Earth's surface in a way that minimises distortion, and keeps the distracting effect of cutting into the map to a minimum."

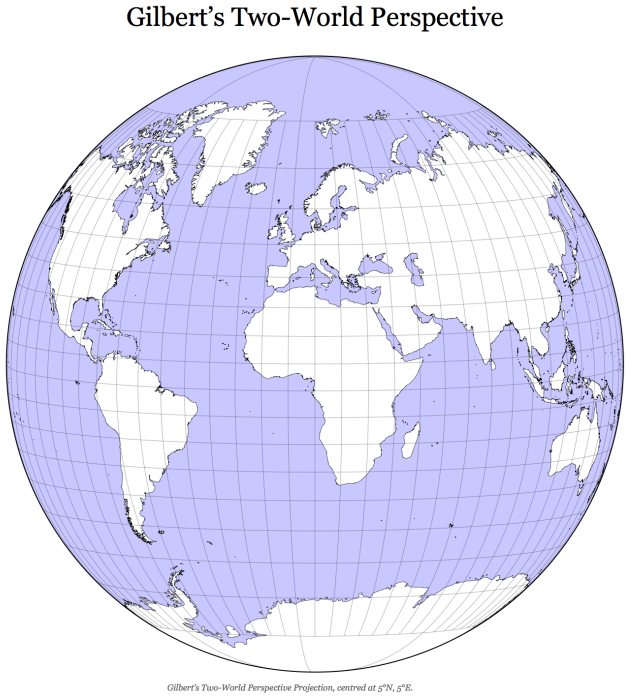


http://www.newscientist.com/gallery/unfolding-the-earth
http://www.win.tue.nl/~vanwijk/myriahedral/

Map Projections?

Why not just use a globe?

- It doesn't avoid most of the issues projections seek to solve.
- You still can't see the whole surface of the earth at the same time!
- Almost all of what you do see on a globe *from a given point of view* is still distorted.



- Viewing the globe from a distance is actually just one of a whole family of projections itself (an 'orthographic projection').

- More fundamentally, projections are not just some failed attempt to achieve a singularly accurate representation of [phenomena on] the Earth's surface.
- *Projections are tools for transforming geographic data in order to interpret and analyze geographic phenomena.*
- This is a principle of analytical cartography.

The best and worst part of 2D projections:

Different projections are better at 'preserving' different 'properties'

- Projections distort in different ways
- Projections can *preserve* various ***properties***.

  A map that preserves a property is one that has that property appear the same way across the map.

  - ***Property preserved:*** What we call this sort of projection
  - ***Area:*** "Equal Area" or "Equivalent" projections
  - ***Angle / (small) Shapes:*** "Conformal" projections
  - ***Distance from a line or point or two:*** "Equidistant" projections
  - ***Direction from the center:*** "Azimuthal" projections
- But no map preserves all properties, perfectly, at once!
- This is simultaneously a representational lack and an analytical opportunity.

So what difference does a particular projection make?

- Affects the map's appearance.
- Affects the map's possible uses.
- Affects the map's absolute-spatial accuracy corresponding to the landscape.
- Helps reinforce or create particular assumptions about 'the way our world is.'
- Helps us visualize and understand phenomena.

WHAT YOUR FAVORITE MAP PROJECTION SAYS ABOUT YOU

MERCATOR

YOU'RE NOT REALLY INTO MAPS.

VAN DER GRINTEN

YOU'RE NOT A COMPLICATED PERSON. YOU LOVE THE MERCATOR PROJECTION; YOU JUST WISH IT WEREN'T SQUARE. THE EARTH'S NOT A SQUARE, IT'S A CIRCLE. YOU LIKE CIRCLES. TODAY IS GONNA BE A GOOD DAY!

ROBINSON

YOU HAVE A COMFORTABLE PAIR OF RUNNING SHOES THAT YOU WEAR EVERYWHERE. YOU LIKE COFFEE AND ENJOY THE BEATLES. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION, HANDS DOWN.

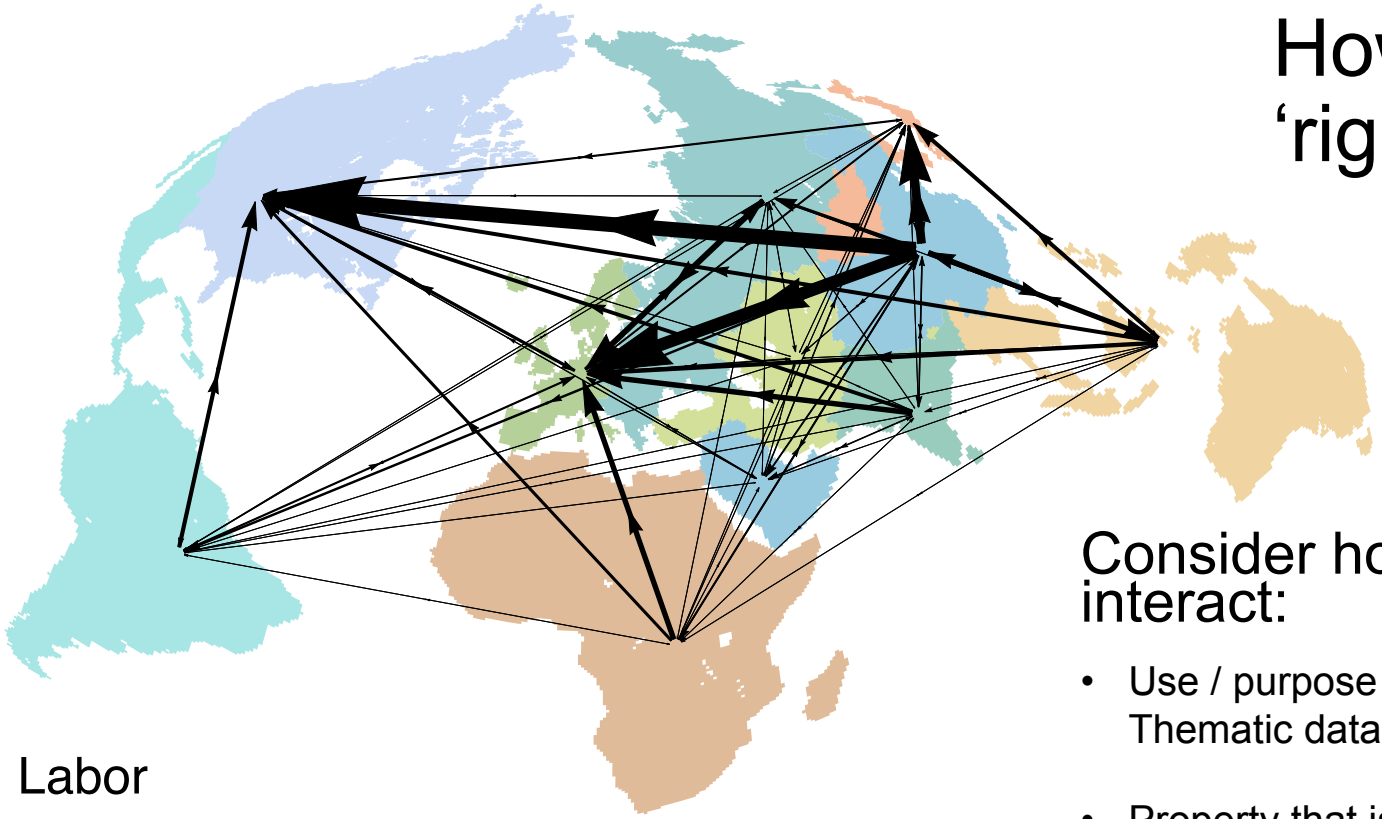
DYMAXION

YOU LIKE ISAAC ASIMOV, XML, AND SHOES WITH TOES. YOU THINK THE SEGWAY GOT A BAD RAP. YOU OWN 3D GOGGLES, WHICH YOU USE TO VIEW ROTATING MODELS OF BETTER 3D GOGGLES. YOU TYPE IN DVORAK.

?!

XKCD 2011

How do I pick the ‘right’ projection?



Labor

Figure drawn from Bergmann 2017. **An interpretation of global trade in terms of the years of human labor it took to produce commodities and services.** Arrows flow from exporters to importers; widths represent the relative numbers of years required. Color merely differentiates 11 (mostly contiguous) macroregions, territories to and from which all flows have been aggregated for the purposes of visualization.

Briesemeister projection (an oblique Hammer projection) chosen:

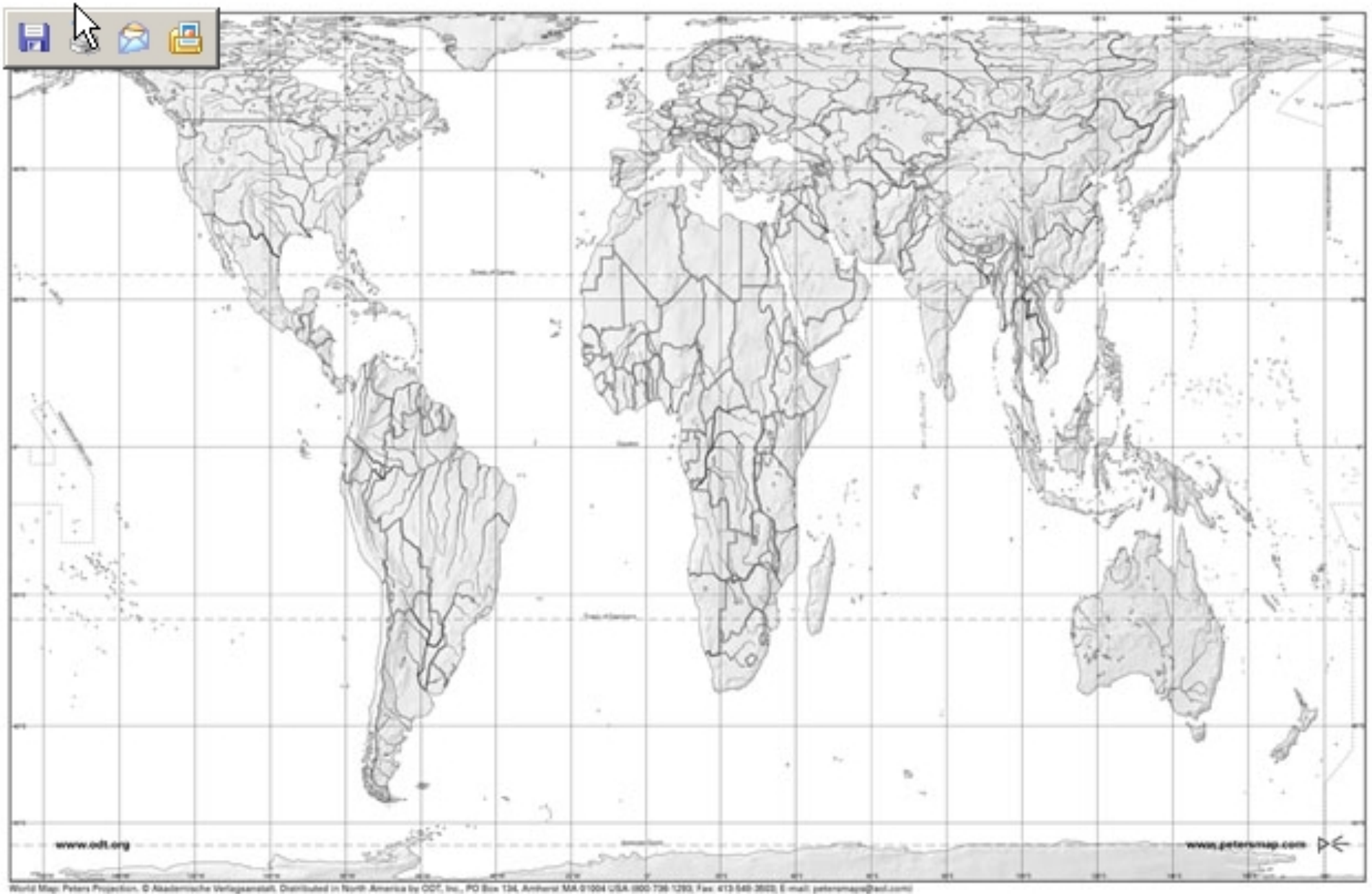
- to preserve areas (because other thematic maps in the article to which this is compared need that property),
- to not distort shape too much,
- to mostly conform to the convention of keeping the North pole toward the top,
- and to allow for the dominant flow arrows among regions around the same Northern latitudes to be distinct, not overlapping.

Consider how the following interact:

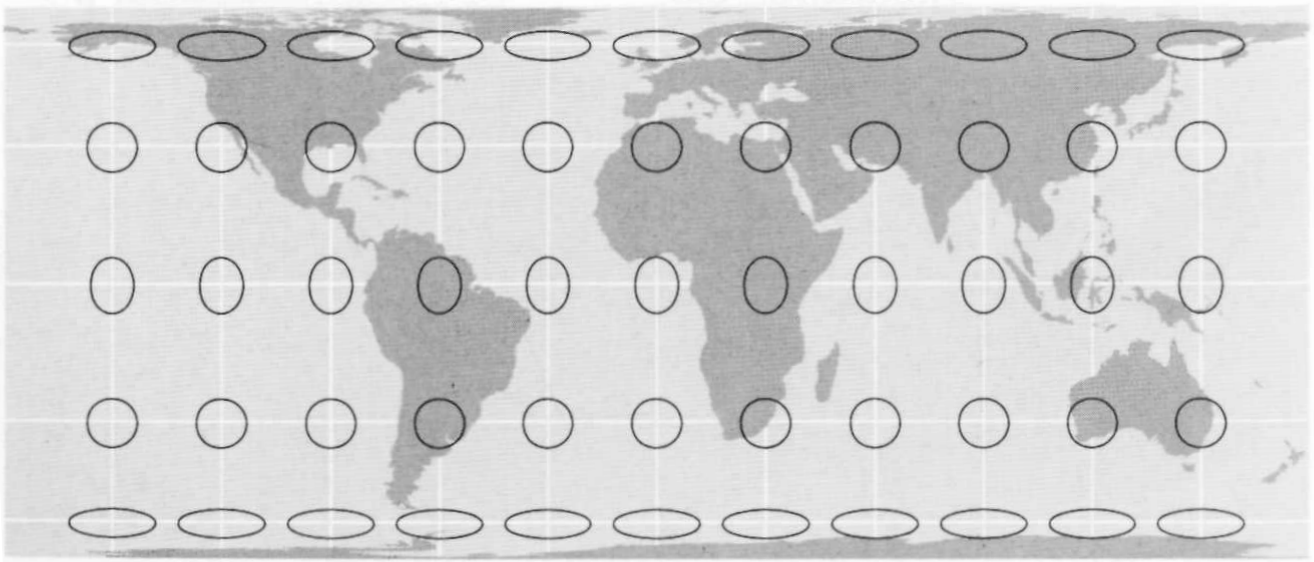
- Use / purpose of map?
  Thematic data you are going to display?
- Property that is critical to preserve?
- Extent and orientation of area to be shown?
  (World? Country? Ocean? City?
  Primarily N-S or E-W or oblique?)
- Choice of projection.

There will often be several reasonable candidates for projections.

Check your readings and links for more detail.

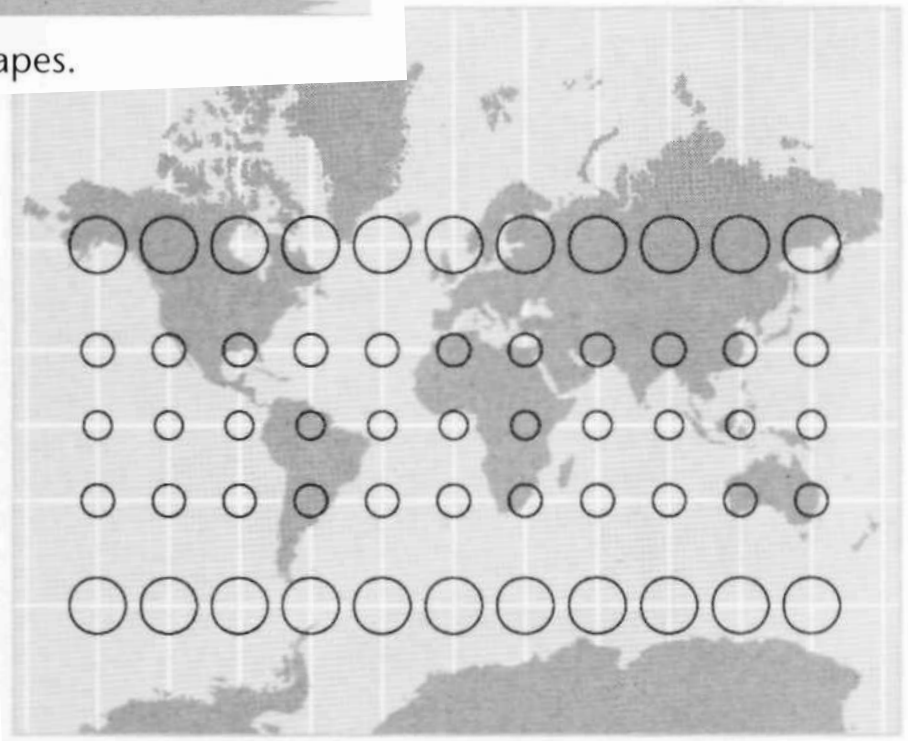


Peters: equal area, poor shape, politically significant historically.



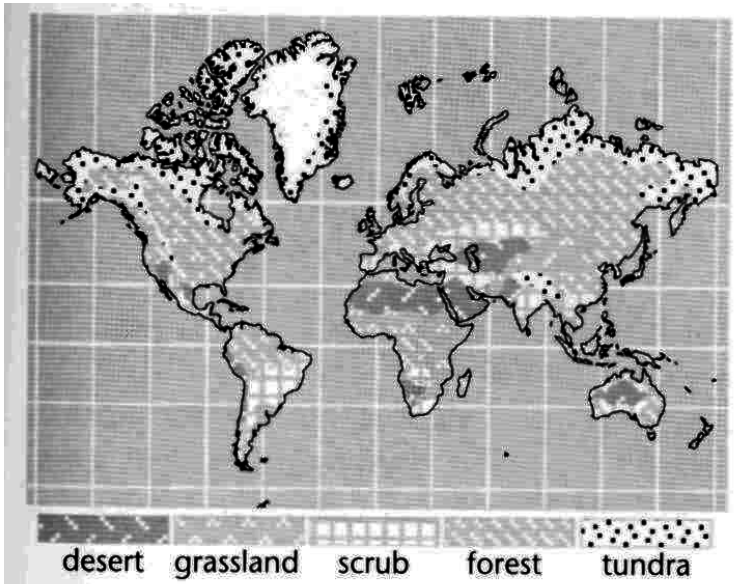
Equal-area map projection: Preserves areas, distorts shapes.

Actually a Peters projection,
though **not** all equal area projections are Peters.
Generally, choose a different one.



Mercator map projection:
Preserves shapes, distorts areas.

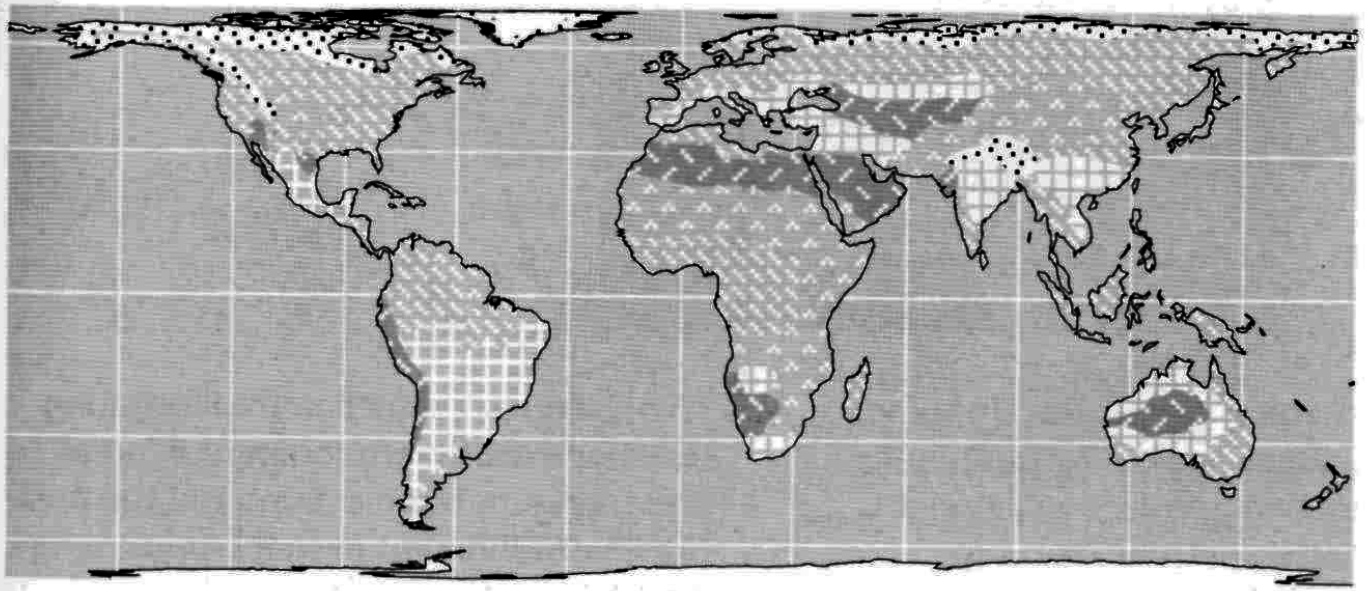
Krygier and Wood 2011



Mercator map projection:
Preserves shapes, distorts areas.

A map of vegetation on a Mercator (left) distorts the data. Northern types are greatly expanded in area compared to those near the equator. This suggests the global dominance of northern vegetation types, which is wrong.

The same data on a map projection (below) that doesn't distort areas. But now shape is distorted! You must be smart with projections and understand tradeoffs. In this case, with area vegetation data, you are better to distort shapes and not areas.



Equal-area map projection: Preserves areas, distorts shapes.

(So, what kind of projections do you use to map spatial distributions when relative areas of phenomena are important to convey?)

Krygier and Wood 2011