

distortion

foundations of geospatial analysis

2026.09.07

some quick housekeeping things

group curations

lab 02 progress

coordinate systems

go to <https://thetruesize.com/>



Mercator

Eckert IV





The Mercator map exaggerates the area of North America and Eurasia while under-representing the size of much of South America and Africa. NASA's Earth O



The African Union has endorsed the #CorrectTheMap Campaign, a call for the United Nations and the wider global community to use a different kind of world map. The campaign currently has over 4,500 signatures.



Why changing the world map is difficult

Bringing about changes won't be easy.

Firstly, global map production is not governed by a single authority. Even if the United Nations were to adopt the Equal Earth projection, world maps could still be drawn in other projections. Cartographers are frequently commissioned to update world maps to reflect changes to names and borders. But the changes don't always find quick acceptance. For example, cartographers changed English-language world maps after the Czech Republic adopted the name "Czechia" as its English name in 2016. While making the change was not difficult, broader acceptance has been harder to achieve.

A person's mental image of the world is solidified at a young age. The effects of a shift to the Equal Earth projection may take years to materialise. Previous efforts to move away from Mercator projection, such as by Boston Public Schools in 2017, upset cartographers and parents alike.

Given the African Union's larger goals, supporting the Equal Earth projection is the first step in pushing the global community to see the world more fairly and reframing how the world values Africa. Mobilising social support for the new projection through workshops with educators, diplomatic advocacy, forums with textbook publishers, journalists, and Africa's corporate partners could help move the world away from the Mercator projection for everyday use.

Shifting to the Equal Earth projection alone will not undo centuries of distorted representations or guarantee more equitable global relations. But it's a step towards restoring Africa's rightful visibility on the world stage.



UN tells the world: Stop making Africa look small



UN Photo | Robert Dussey, Minister for Foreign Affairs of Togo, briefs reporters at the United Nations on the day of the vote. "A fair map does not change the geography of the world, it changes how we see the world," he said.

4 September 2026 | Culture and Education

The UN [General Assembly](#) has voted overwhelmingly to encourage governments, schools and tech companies worldwide to stop using maps that make Africa look far smaller than it really is.



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Africa

UN votes to adopt new world map that shows Africa's true scale

Eromo Egbejule in Abidjan

Fri 4 Sep 2026 12.49 EDT



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WORLD • AFRICA

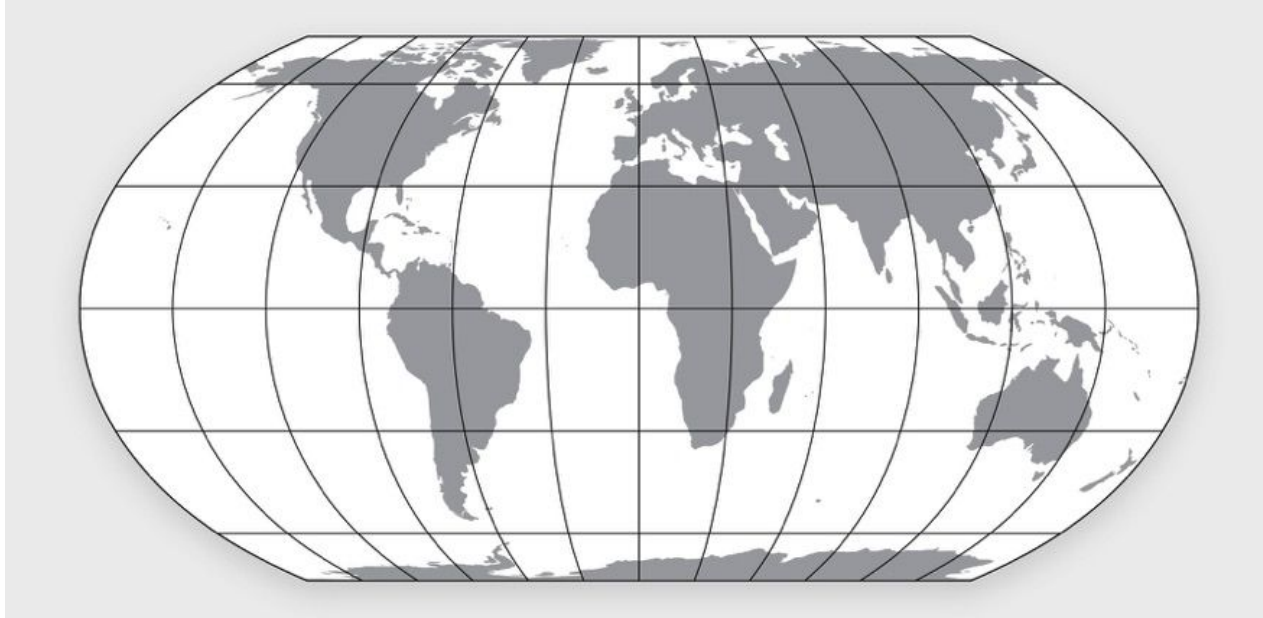
France adopts fairer world map ahead of UN vote on more balanced geography

As part of a movement led by the African Union, Paris announced on Friday that it will abandon the Mercator projection to better reflect the physical reality of the planet. France will now appear smaller on world maps.

By Christophe Châtelot

Published on September 4, 2026, at 4:02 pm (Paris) · [🕒 3 min read](#) · [Lire en français](#)

equal earth projection

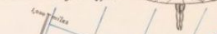


all that is to say...
map projections matter
a whole lot!

THE WORLD CENTRIFUGED

NORTH-POLAR AXONOMETRIC EQUIPUNCT PROJECTION

The principle of this projection may be illustrated by a dancer with a skirt in the shape of a globe upon which is inscribed the map of the world. When she whirls the skirt rises to a horizontal plane and the map on it will then resemble the map on this page. The projection has two important advantages: it shows little distortion of the Northern Hemisphere, and it nowhere breaks the continuity of the land or sea areas involved in the present far-flung struggle.



LONGITUDE SCALES

Each scale is two inches in length on the parallels, and together they constitute an accurate graph of the relative distortion of the map.

THE WORLD DIVIDED

The political alignments of the world are here shown, centering geographically around the North Pole but ideologically and economically around the U.S. The classification keyed below is necessarily simplified and does not of course meet all the subtleties of politics and diplomacy—for instance, the peculiar position of Vichy and its colonies. The special case of the U.S.S.R. is acknowledged by a special color.

Anti-Axis	Definitely anti-Axis	Potentially anti-Axis	Neutrally anti-Axis	Definitely pro-Axis	Axis

THE SITUATION IS AS OF JULY 7, 1941, AND IS SUBJECT TO CHANGE WITHOUT NOTICE

All distances are given in statute miles in walled miles they are by sea.

Richard E. Scammon, July 1941

THIS is a map of a world struggle that will mark a turning point in civilization. The struggle divides the world into two huge camps: those who are for us (in various degrees) and those who are against us (likewise in various degrees). Between these extremes there are the neutrals, some leaning one way, some another. All these gradations are explained in the key on the opposite page.

Several important points regarding this map should be noted. The first is that the entire conflict pivots around the U.S. This is not due merely to the placing of the U.S. in the center of the spread; it lies, rather, in the very nature of the struggle. The U.S. is the pivot (a) because of its geographical position, which is central to the oceans; (b) because of its ideological position, which makes it the hope of all free peoples; and (c) because of its policy of supplying the enemies of the Axis with the materials of war, via the lend-lease lines.

Because the U.S. is pivotal, and because the U.S. has not yet taken military action, the map is political rather than strategical. Yet there are several strategical considerations:

A. The Western Hemisphere lies between the shores of the great land mass of the Eastern Hemisphere. If those shores were controlled by the enemy, the U.S. would find itself in the grip of a gigantic pincer. At present there are two bastions preventing this—and only two. One is Britain, led by the big lend-lease line from the East Coast. The other is China, led by a thinner lend-lease line to the Burma Road. B. The enormous importance of the U.S.S.R. shows up on this map. If Hitler can crush the Russian Army and set up a puppet government, this will constitute a direct territorial threat to the U.S. The thin red line running from San Francisco around the polar cap to Archangel is quite academic as a lend-lease route, but it serves to show how close we are to that theatre of action. Air attack from this quarter is not beyond possibility. And if the Soviet Union were to fall, Hitler would be mainland to mainland, within fifty-seven miles of U.S. territory across the Bering Strait.

A result of its pivotal position the U.S. is fighting the war all over the world. It is intimately interested in the affairs of almost every nation outside the black area of the Axis. The lend-lease lines show the lines of major involvement, but there are also such problems as Iran, India, and the Union of South Africa. If Hitler won the Irish Government to his side the repercussions in the U.S. would be tremendous. The Union of South Africa is real on our side, but internally divided. And India, which Hitler may be able to reach through the U.S.S.R., wants freedom now. Finally, there is Latin America. We have sought in many ways to bind the Latin-American countries to our cause—by dollar loans, by military missions, and by education and propaganda. The results so far have been anything but satisfactory.

Such is the world we face. Largely, it is the result of our own failure to be realistic in the past. Now we have to fix it. And our first move had better be to become realistic for the future.

- Lend-lease water route
- Lend-lease air routes
- U.S. military missions
- U.S. financial aid

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Latitude scales

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Definitely anti-Axis
Axis neutrals
Potentially anti-Axis
Neutrals—merely waiting to pick a winner
Potentially pro-Axis
Definitely pro-Axis
Axis neutrals
Axis

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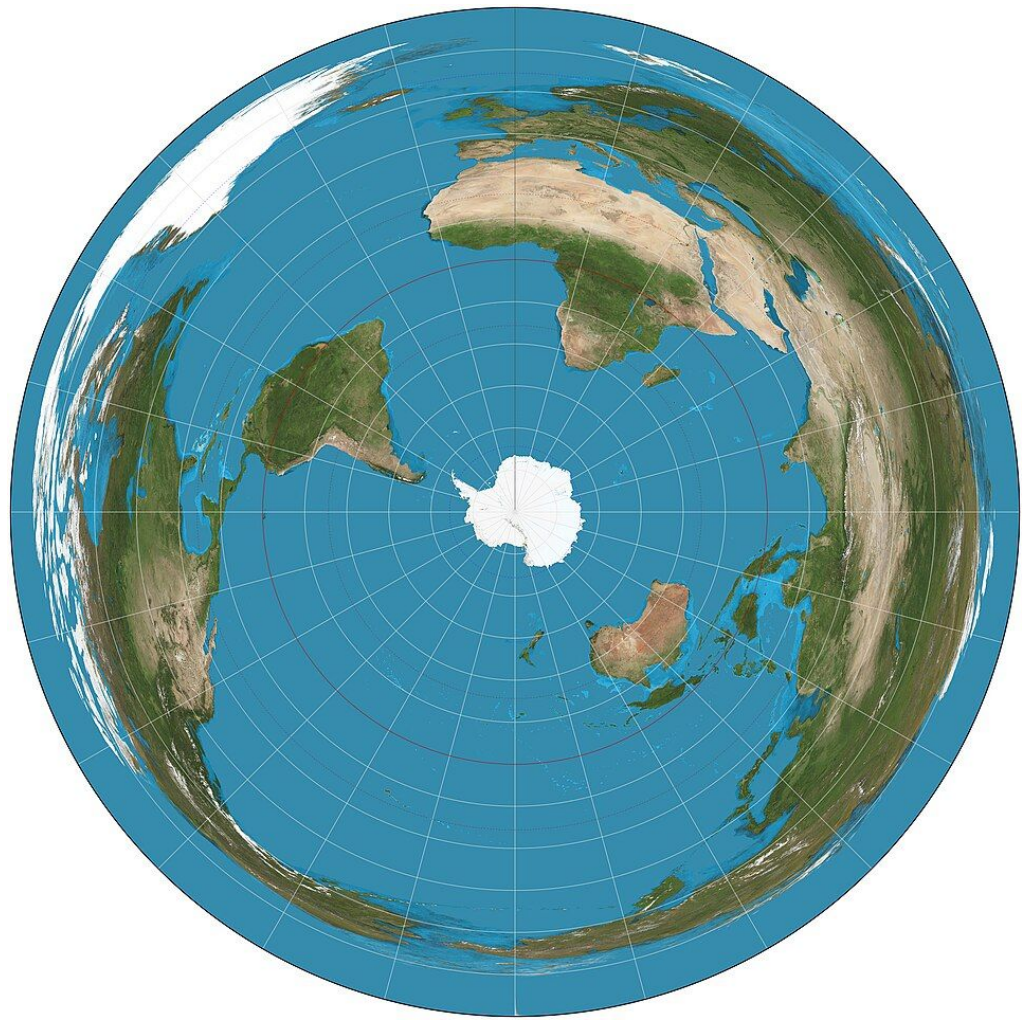
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Lend-lease air routes
U.S. military missions
U.S. financial aid

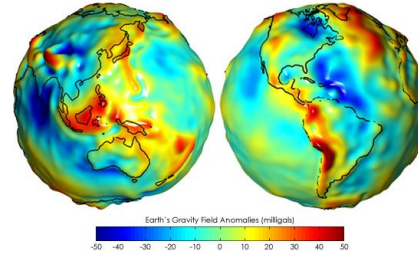


**the fundamental
challenge of
mapping?**

**how to represent a
round globe**

on a flat surface

how to represent a
~~round globe~~
lumpy geoid
on a flat surface



**two steps in the
process**

**first, measuring
the earth**

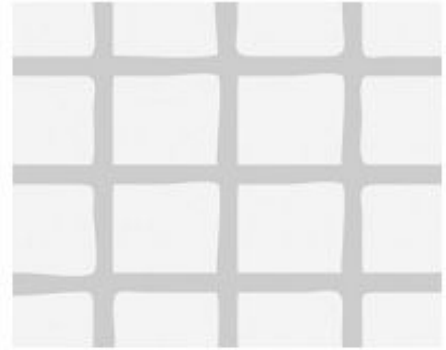
**second,
flattening it**

coordinate systems

- 1. geographic
coordinate
systems**
- 2. projected
coordinate
systems**



Geographic (3D)

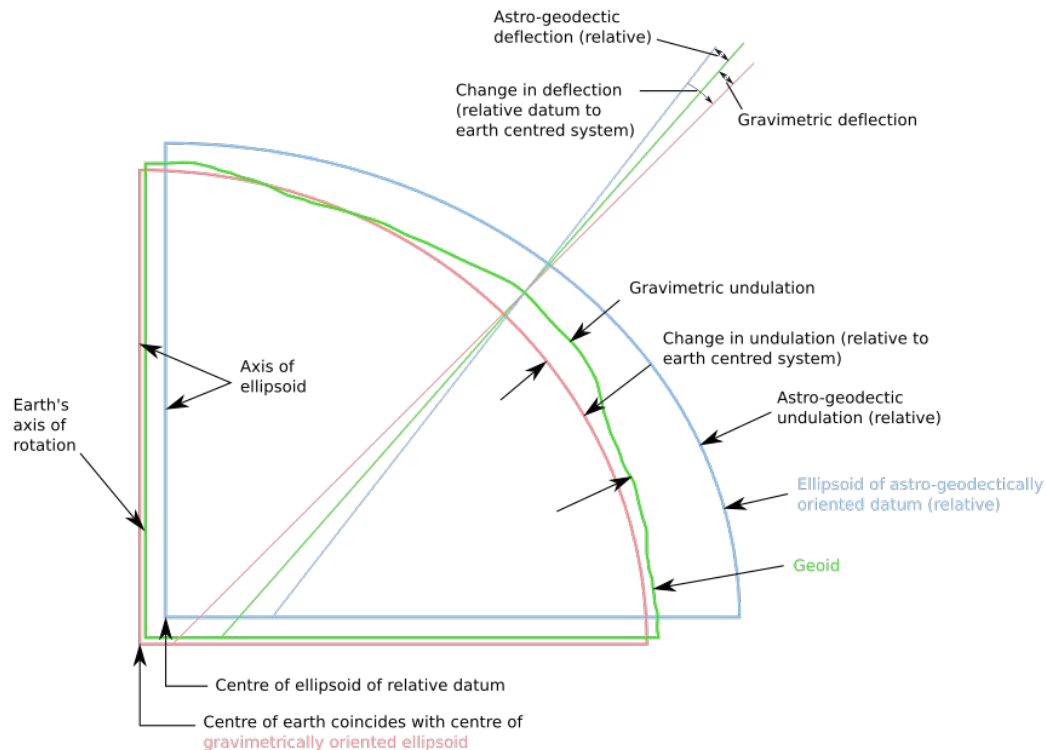


Projected (2D)

coordinate systems

1. geographic coordinate systems

2. projected coordinate systems



coordinate systems

- 1. geographic coordinate systems** a geographic coordinate system or **GCS** defines how we measure locations on the curved surface of the earth
- 2. projected coordinate systems** it depends on **measured values** that translate our **lumpy geoid** to a **round globe**

coordinate systems

1. geographic coordinate systems

lines of **latitude** or **parallels** are horizontal, separating N/S

lines of **longitude** or **meridians** are vertical, separating E/W

2. projected coordinate systems

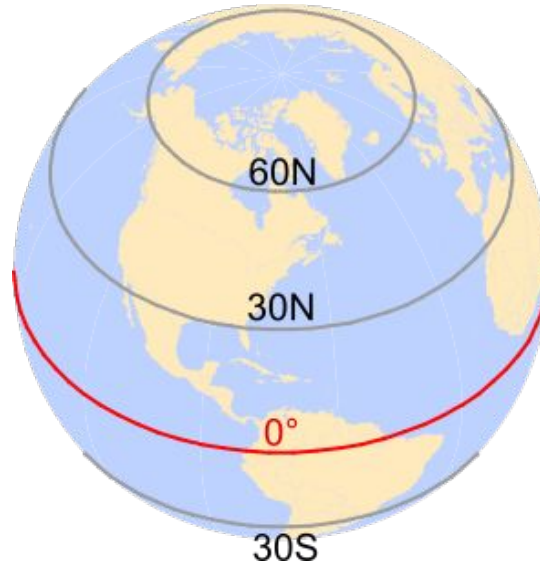
latitudes and longitudes form a graticule on an **idealized ellipsoid**

coordinate systems

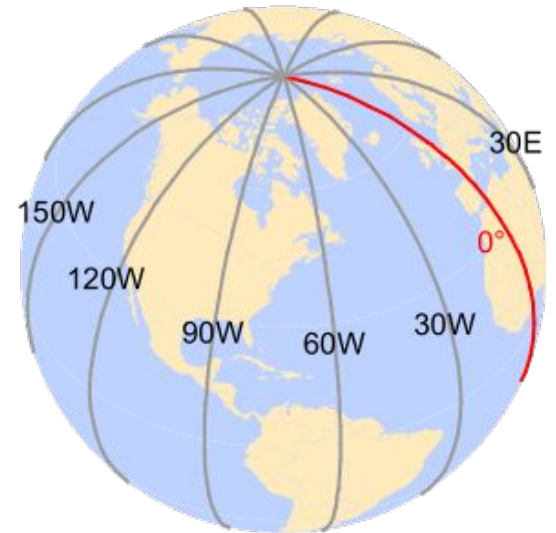
1. geographic coordinate systems

2. projected coordinate systems

latitude/parallels



longitude/meridians

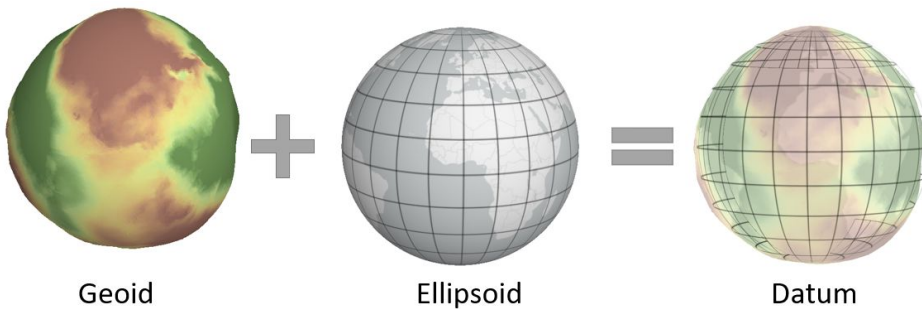


coordinate systems

1. geographic coordinate systems

in order to make maps, we need to reconcile the real world (**geoid**) with our desired model (**ellipsoid**)
– that's called a **datum**

2. projected coordinate systems



coordinate systems

1. geographic coordinate systems
2. projected coordinate systems



coordinate systems

1. geographic coordinate systems

measurements for north american datum 1927

ellipsoid	semimajor axis	semiminor axis	inverse flattening
Clarke 1866	6,378,206.4 m	6,356,583.8 m	294.978698214

2. projected coordinate systems

[Adapted from Wikipedia](#)

coordinate systems

local vs. geocentric datums

1. geographic coordinate systems

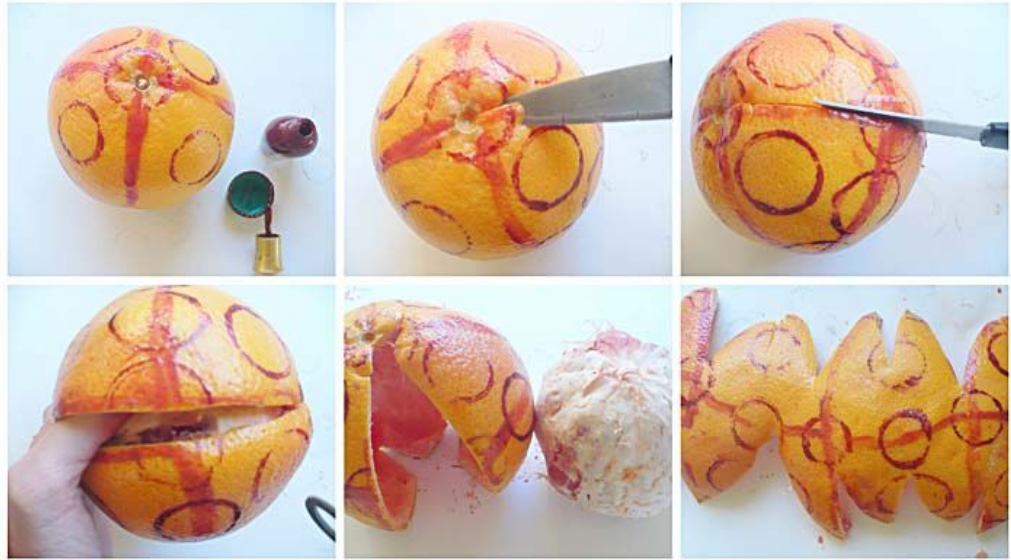
2. projected coordinate systems

	ellipsoid	earth-centered or local?	origin point of datum
NAD27	Clarke 1866	local (geodetic a.k.a. surface)	Meade's Ranch, KS (celestial measurements)
NAD83	GRS80	earth-centered (geocentric)	center of the earth (satellite measurements)
WGS84	WGS84	earth-centered (geocentric)	center of the earth (satellite measurements)

Adapted from Humboldt State

coordinate systems

1. geographic coordinate systems

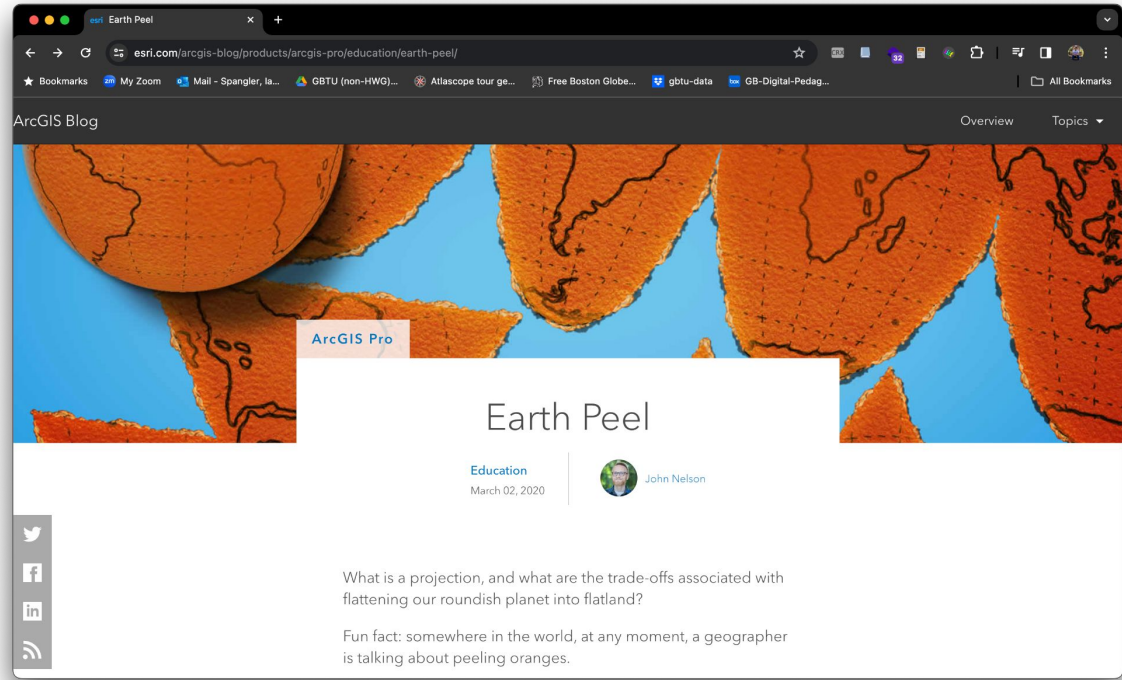


2. projected coordinate systems

coordinate systems

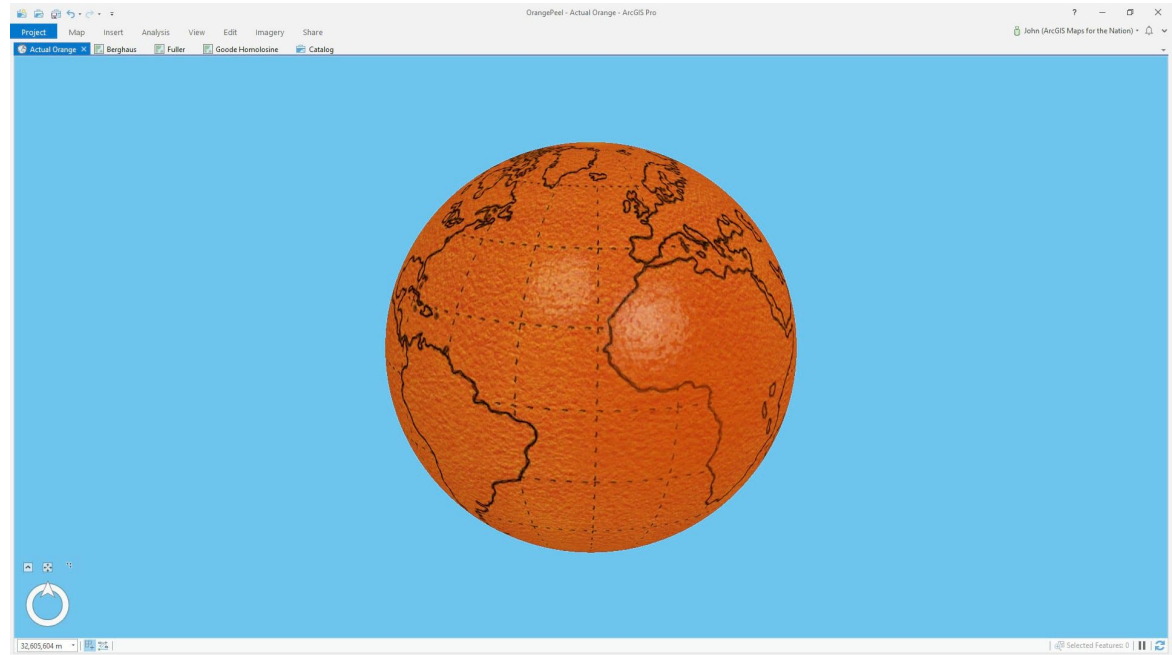
1. geographic coordinate systems

2. projected coordinate systems



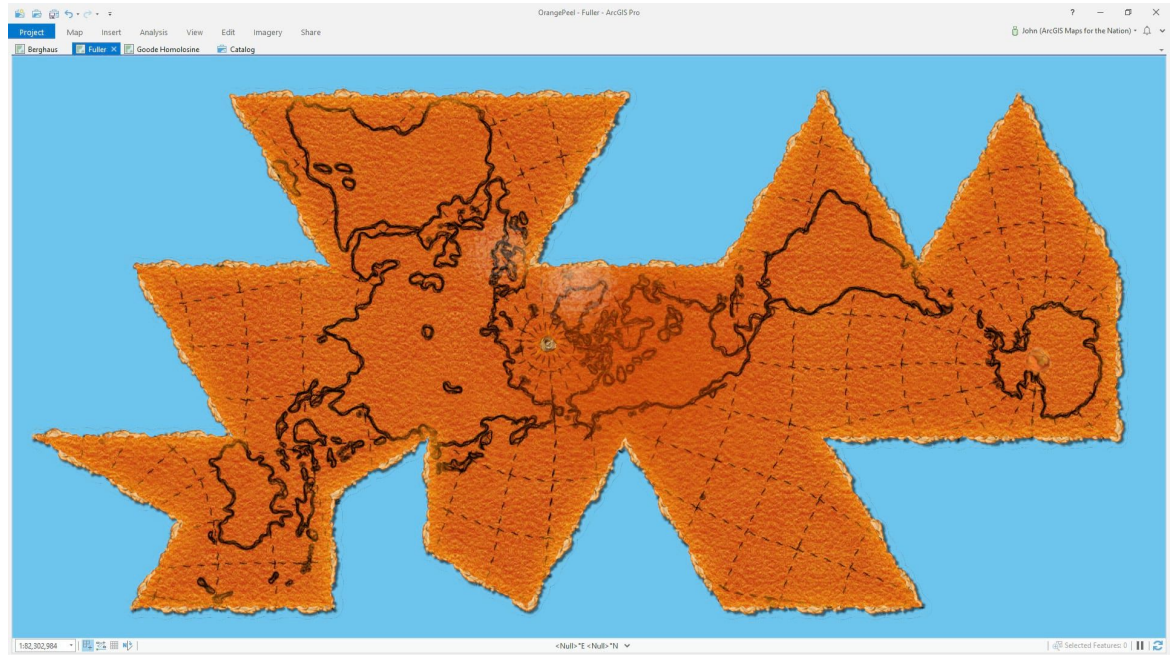
coordinate systems

1. geographic coordinate systems
2. projected coordinate systems



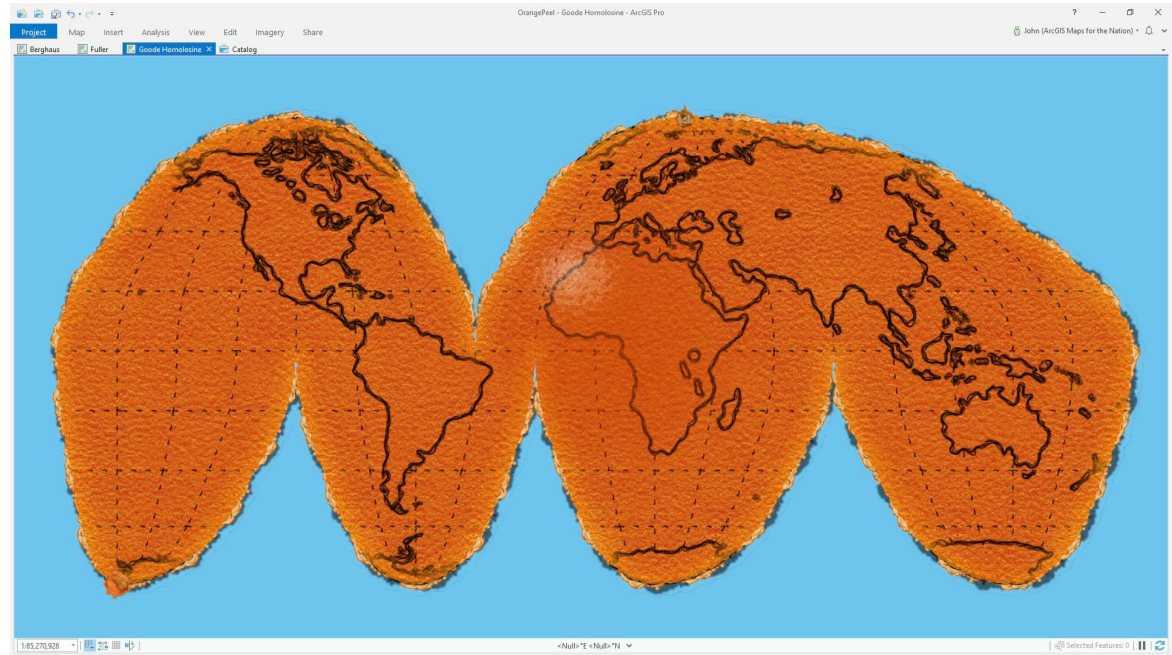
coordinate systems

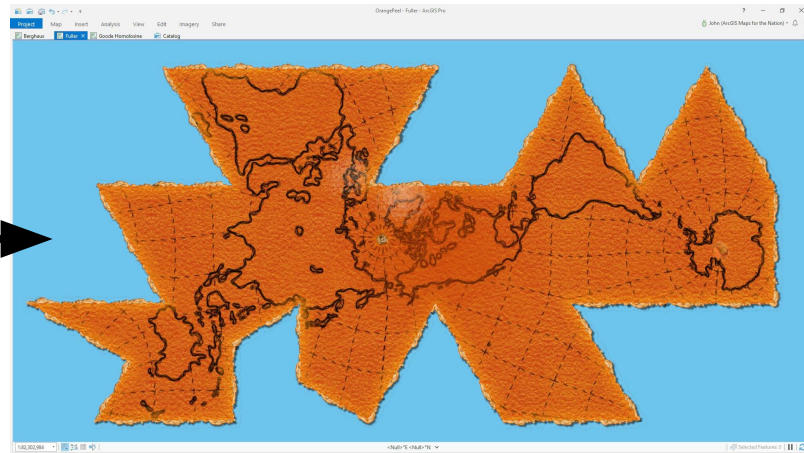
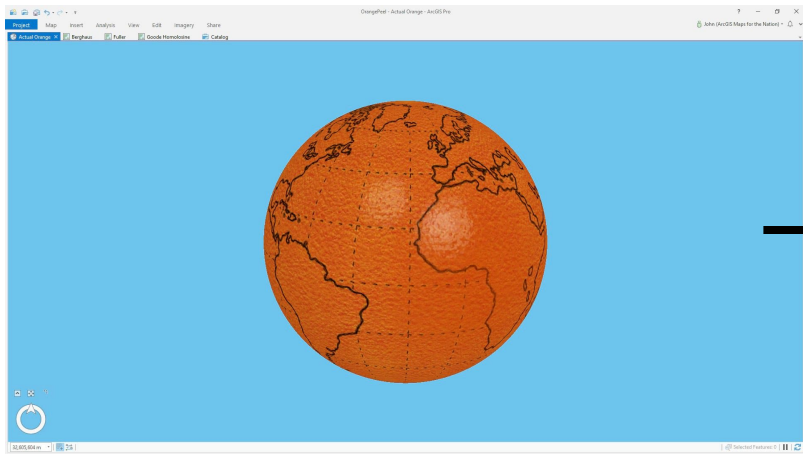
1. geographic coordinate systems
2. projected coordinate systems



coordinate systems

1. geographic coordinate systems
2. projected coordinate systems





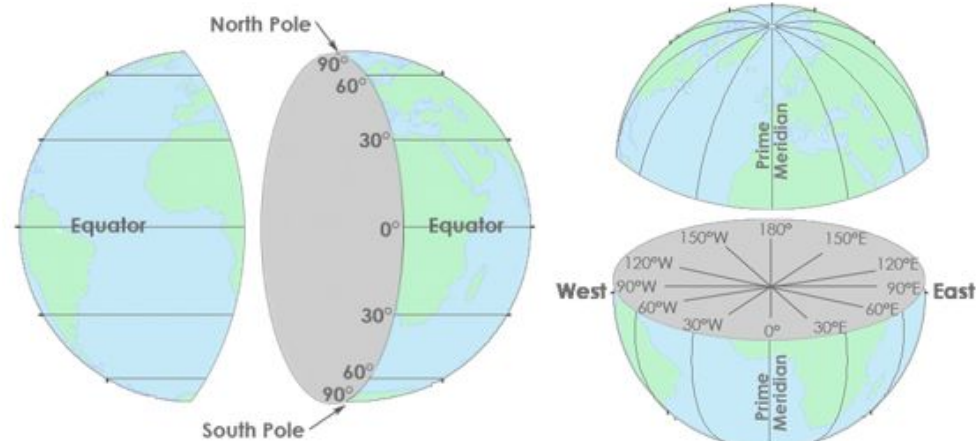
???

coordinate systems

1. geographic
coordinate
systems

ellipsoid

2. projected
coordinate
systems

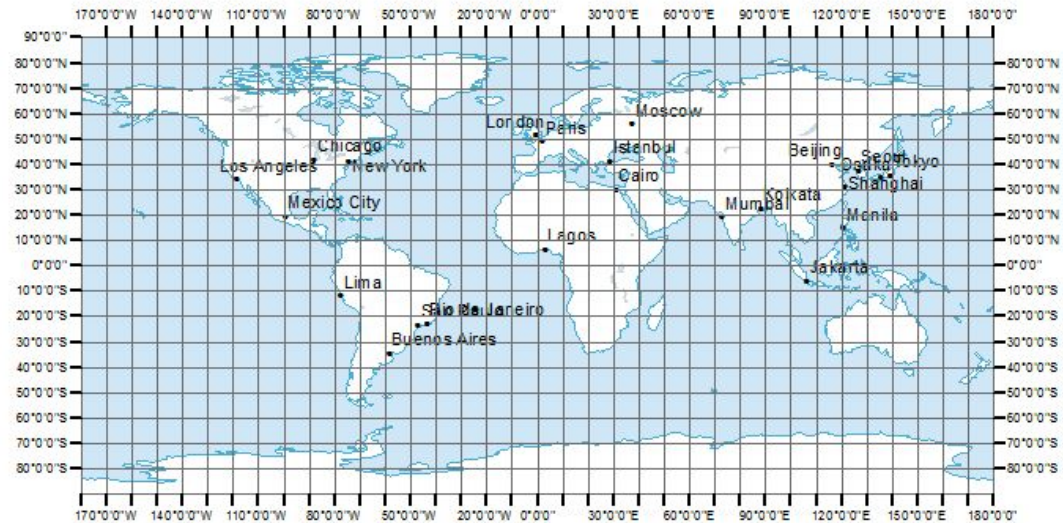


coordinate systems

1. geographic coordinate systems

2. projected coordinate systems

cartesian grid



coordinate systems

1. geographic coordinate systems a projected coordinate system or **PCS** translates geographic data as a flat map
2. **projected coordinate systems** every projection derives from *abstract formulas* that refer to a *cartesian grid*

coordinate systems

1. **geographic coordinate systems** the projected coordinate system speaks in **planar** or **linear** units of measurement (e.g., feet or meters)
2. **projected coordinate systems** whereas a GCS uses **angular** units of measurement (e.g., degrees)

coordinate systems

1. geographic coordinate systems

two geometric terms of great importance:

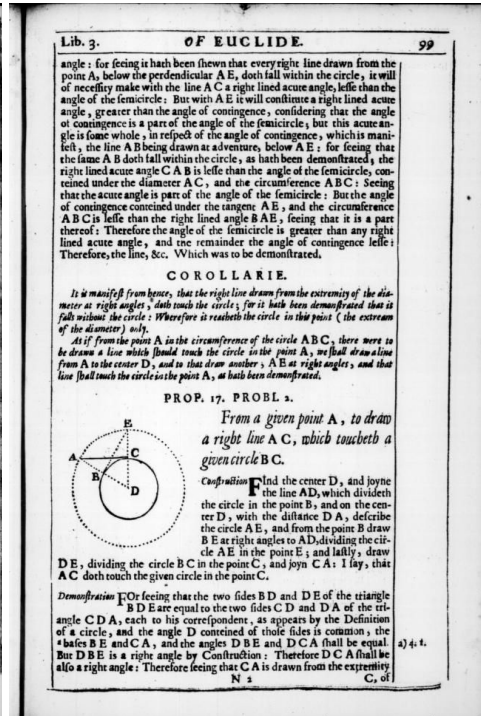
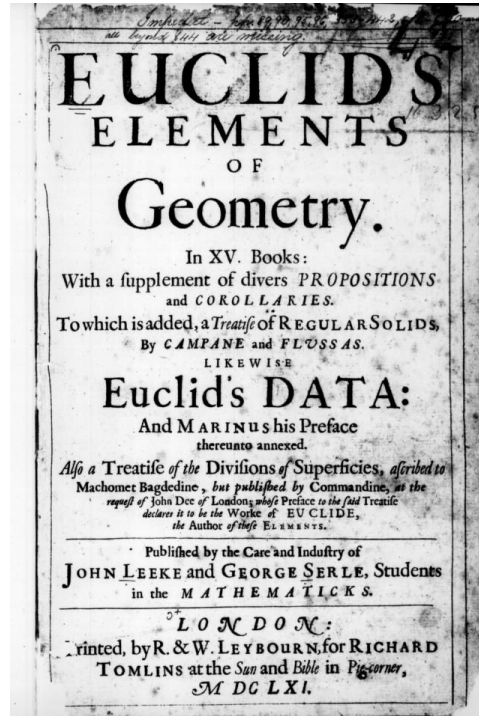
2. projected coordinate systems

- **tangent** = a line that intersects a circle at exactly one point
- **secant** = a line that intersects a circle at two points

coordinate systems

1. geographic
coordinate
systems

2. projected
coordinate
systems



coordinate systems

1. geographic coordinate systems

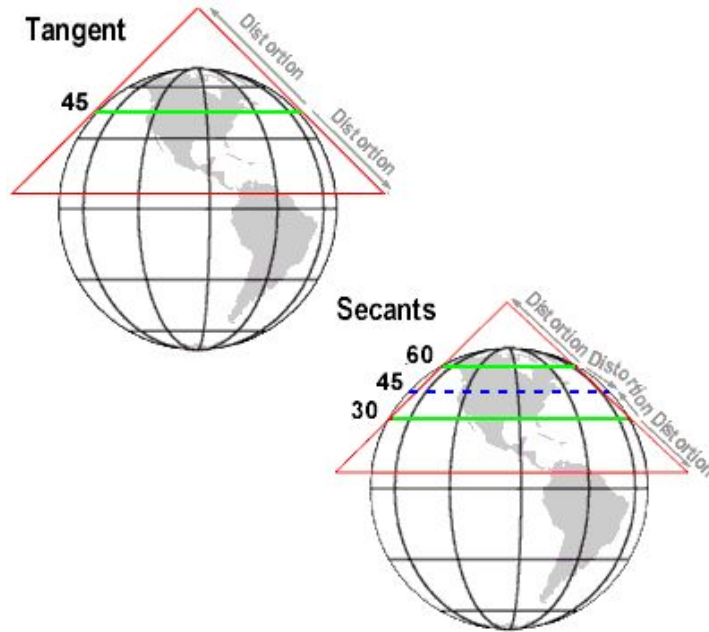
distortion is minimized at **standard parallel(s)**, either:

2. projected coordinate systems

- the *one point* at which the globe is touched by a **tangent**
- or the *two points* at which the globe is intersected by a **secant**

coordinate systems

1. geographic coordinate systems
2. projected coordinate systems

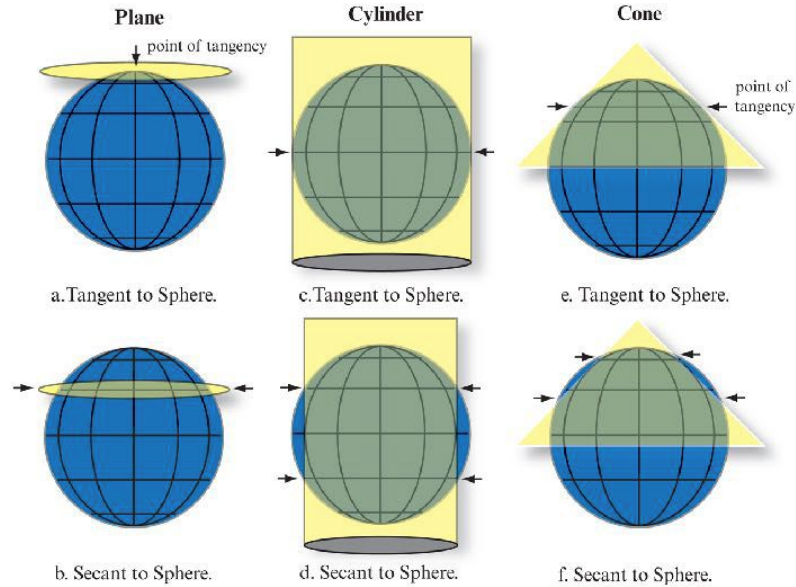


coordinate systems

1. geographic
coordinate
systems

2. projected
coordinate
systems

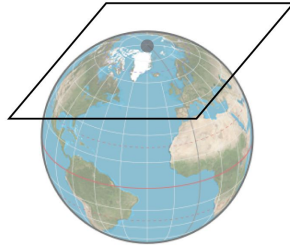
developable surfaces



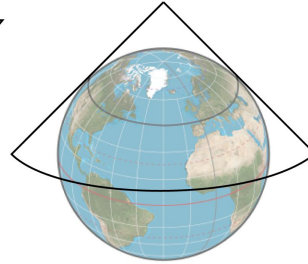
coordinate systems

1. geographic
coordinate
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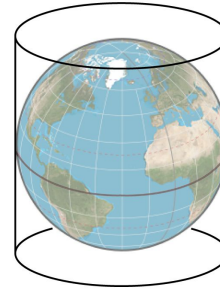
plane or
azimuth



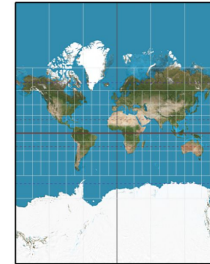
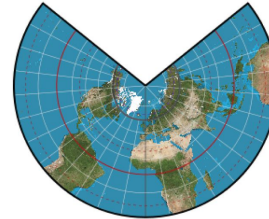
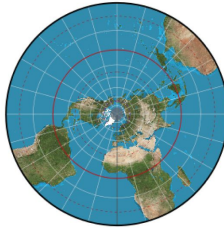
conic



cylindrical

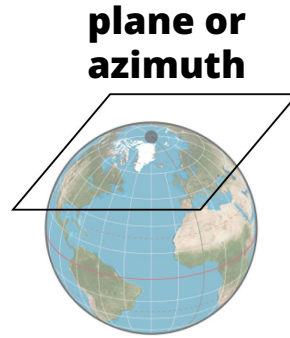


2. projected
coordinate
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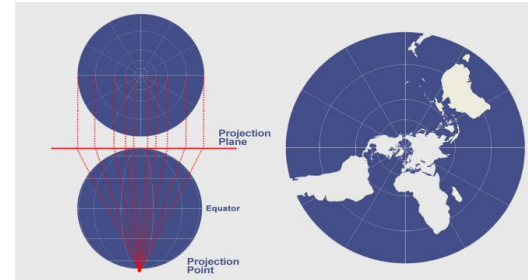
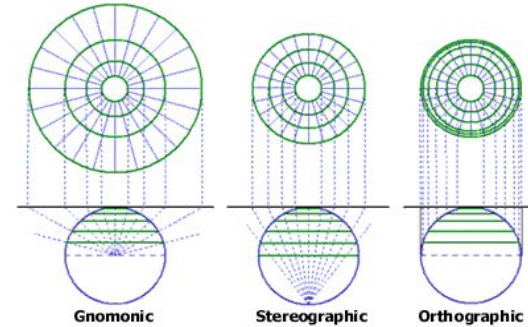
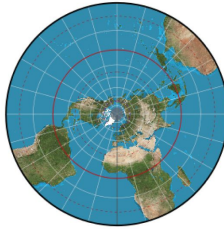


coordinate systems

1. geographic coordinate systems



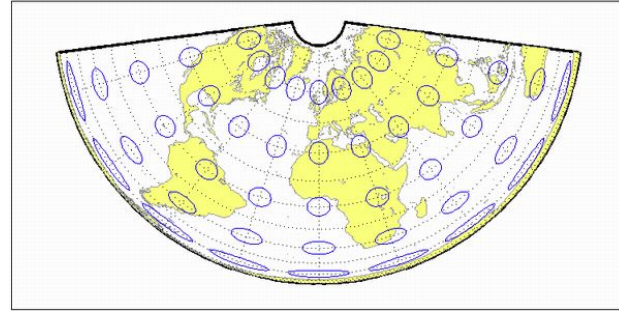
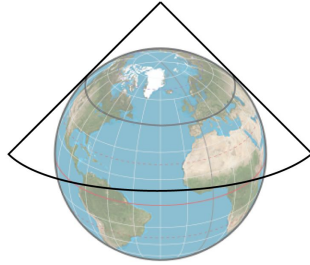
2. projected coordinate systems



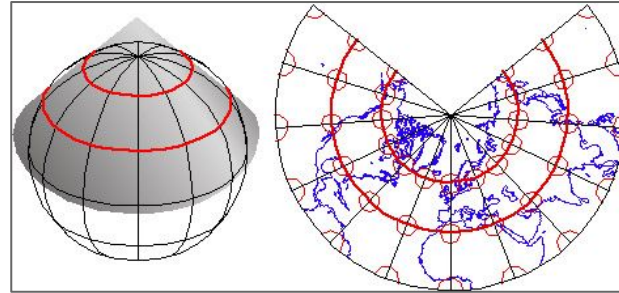
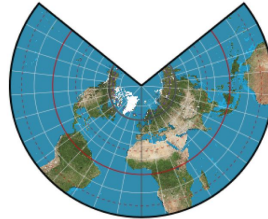
coordinate systems

1. geographic
coordinate
systems

conic



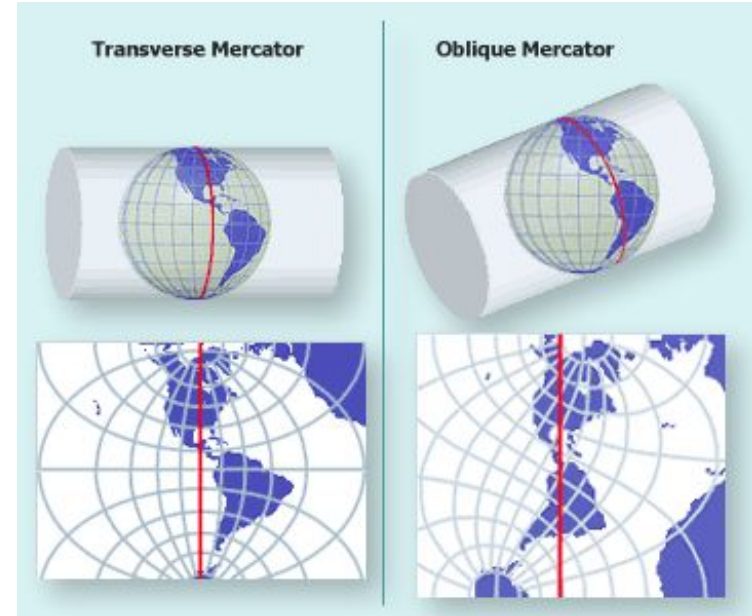
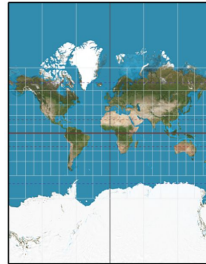
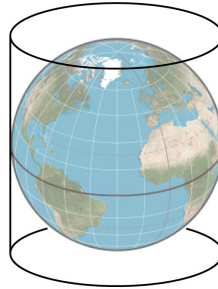
2. projected
coordinate
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coordinate systems

1. geographic coordinate systems
2. projected coordinate systems

cylindrical

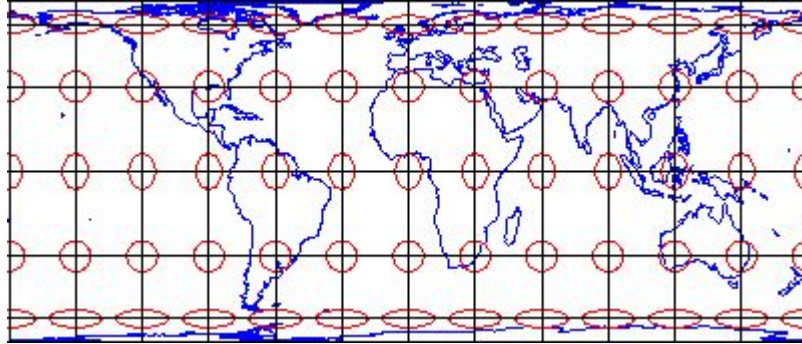


coordinate systems

- 1. area
 - 2. shape
 - 3. distance
 - 4. direction
- 
- you can preserve some.....
but never all*

coordinate systems

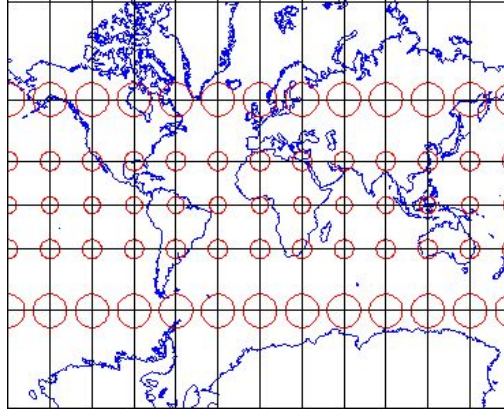
1. area
2. shape
3. distance
4. direction



*in the **equal-area projection** above, total area is preserved while shape is distorted*

coordinate systems

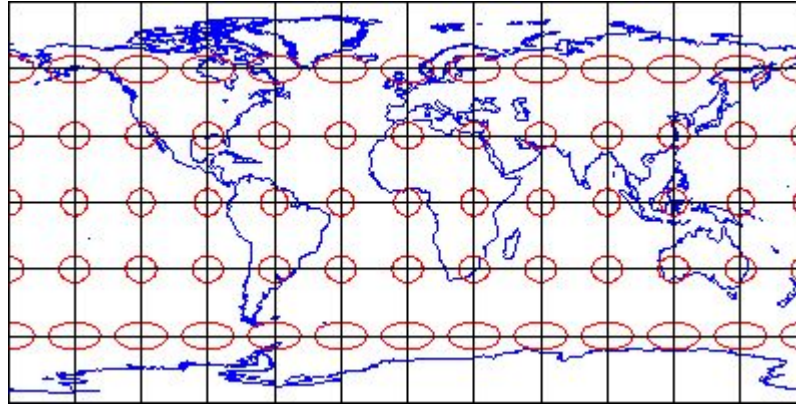
1. area
2. shape
3. distance
4. direction



*in the **conformal projection** above, shape is preserved while area is distorted*

coordinate systems

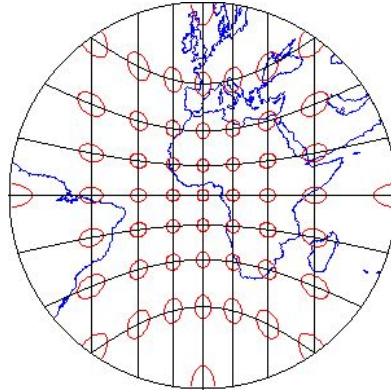
1. area
2. shape
3. distance
4. direction



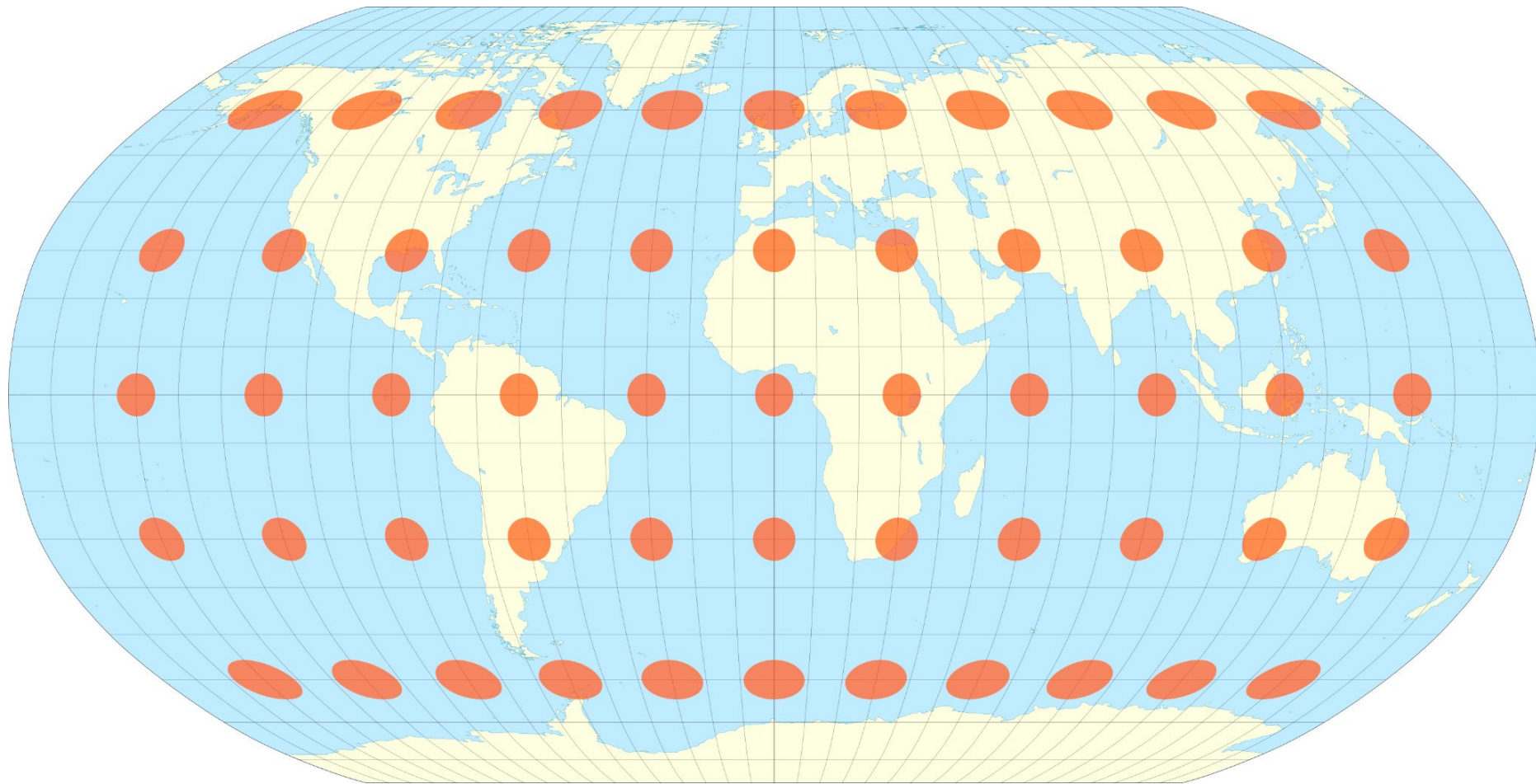
*in the **equidistant projection** above, distance is preserved while size is distorted*

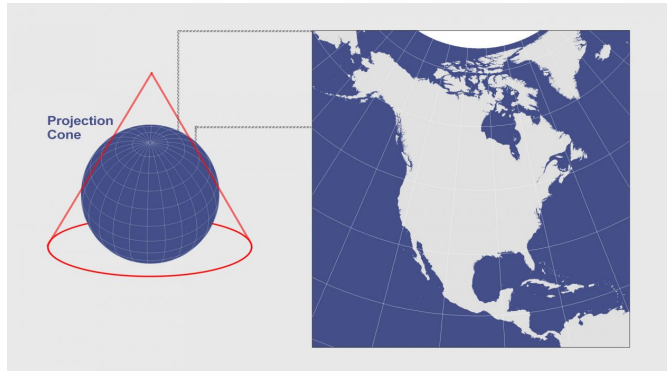
coordinate systems

1. area
2. shape
3. distance
4. direction



*in the **azimuthal projection** above, direction is preserved while shape and size are distorted*





Albers equal area projection

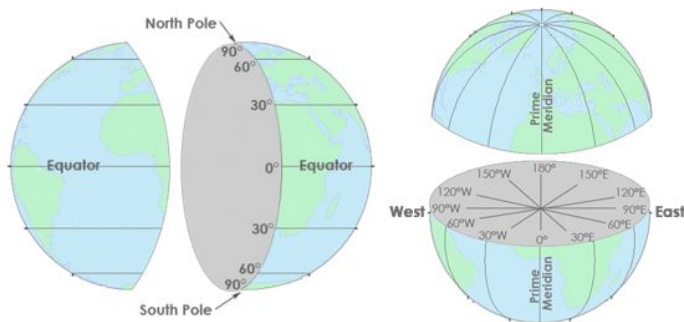
table adapted from [gisgeography](https://gisgeography.com/albers-equal-area-projection/)

distortion	description
<i>distance</i>	true only on both standard parallels.
<i>scale</i>	distortion increases away from the standard parallels.
<i>direction</i>	true direction is preserved along the standard parallels. Distortion in direction increases away from standard parallels.
<i>area</i>	accurate for areas near the standard parallels. Equal to the same areas on Earth, though it's not conformal, perspective, or equidistant.

recap and compare

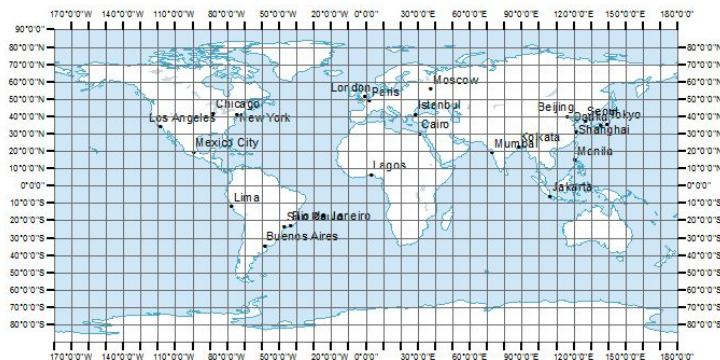
geographic coordinate systems

- ellipsoid + geoid = datum
- latitude/longitude
- angular units (e.g., degrees)



projected coordinate systems

- cartesian grid
- x/y
- linear units (e.g., meters)



recap and compare

geographic coordinate systems

- measured values
- north american datum (NAD) 1927:

ellipsoid	semimajor axis	semiminor axis	inverse flattening
Clarke 1866	6,378,206.4 m	6,356,583.8 m	294.978698214

projected coordinate systems

- formulas/algorithms
- equal earth formula:

$$\sin \theta = \frac{\sqrt{3}}{2} \cdot \sin \varphi$$

$$x = \frac{2 \cdot \sqrt{3} \cdot \lambda \cdot \cos \theta}{3 \cdot (A_1 + 3 \cdot A_2 \cdot \theta^2 + \theta^6 \cdot (7 \cdot A_3 + 9 \cdot A_4 \cdot \theta^2))}$$

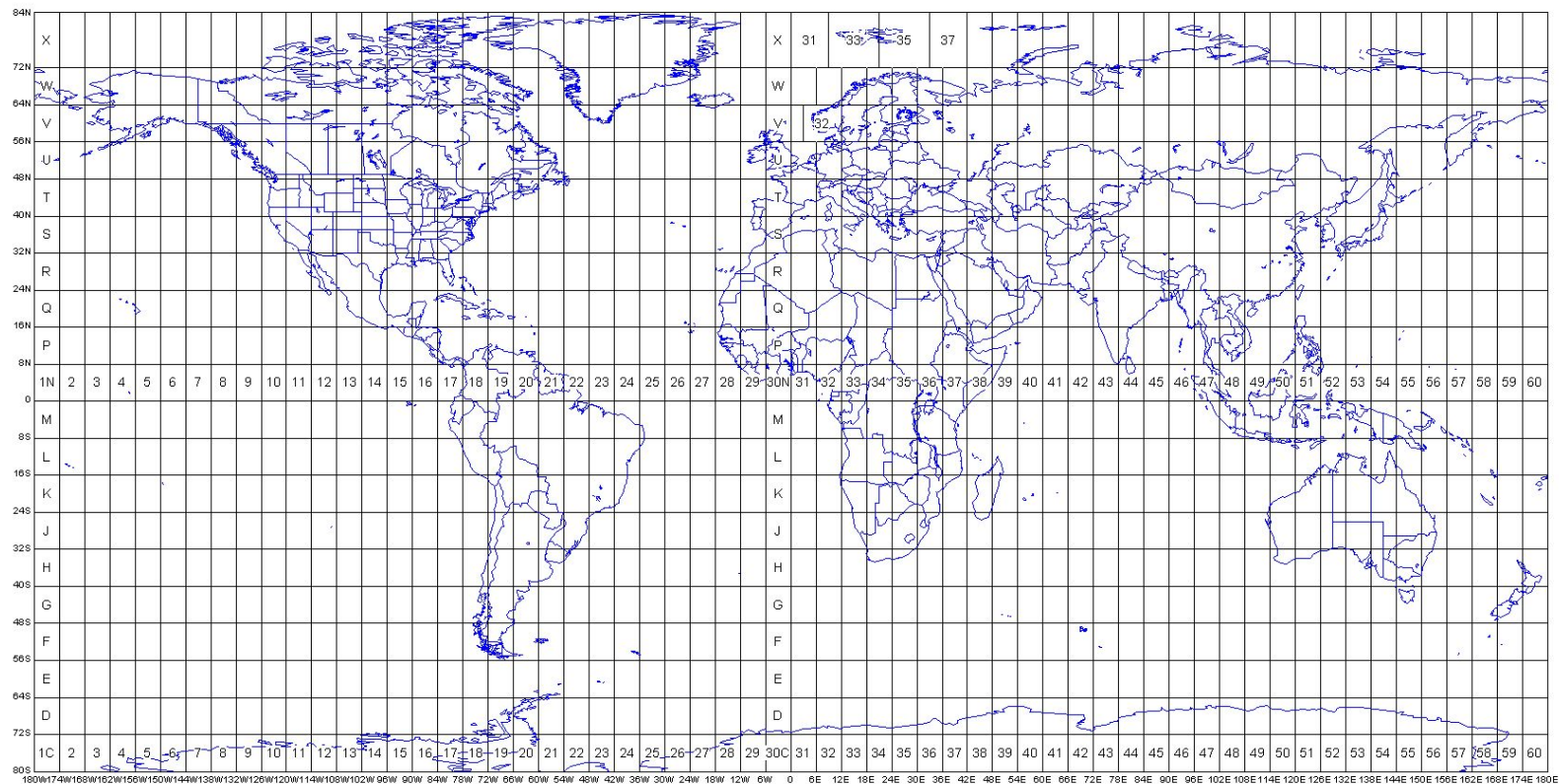
$$y = \theta \cdot (A_1 + A_2 \cdot \theta^2 + \theta^6 \cdot (A_3 + A_4 \cdot \theta^2))$$

$$A_1=1.340264, A_2=0.081106, A_3=0.000893, A_4=0.003796$$

**also, you should be
aware of “universal”
projections**

**universal transverse
mercator divides the
earth into 60 zones, each
of which covers 6
degrees of longitude**

UTM zones



What UTM Zone am I in ? - In

← → ↺

mangomap.com/robertyoung/maps/69585/what-utm-zone-am-i-in-#

🗖️ ☆ 📄 16 🌐 📁 📄 📄 📄 📄

★ Bookmarks

📄 My Zoom

📧 Mail - Spangler, Ia...

🌐 GBTU (non-HWG)...

🌐 Atlascope tour ge...

🌐 Free Boston Globe...

📄 gbtu-data

📄 GB-Digital-Pedag...

📁 All Bookmarks

What UTM Zone am I in ?

Click on the map or use the Geolocate button to find out which UTM zone you are in.

⬆️ 🌐 Maps 📄 Data

5000 km
3000 mi

Lat: -85.580440
Lon: 44.416437

🔖

🔗

🔍

🔍

Address Search 🔍

➡️

19

Multiple Features Selected (1/2) < >

UTM Zone: 19

Start Longitude: -72
Start Latitude: 0
Hemisphere: n
Central Meridian: -69

Add bookmark

Share Feature

CREATED WITH MANGO

1

Like what you see?

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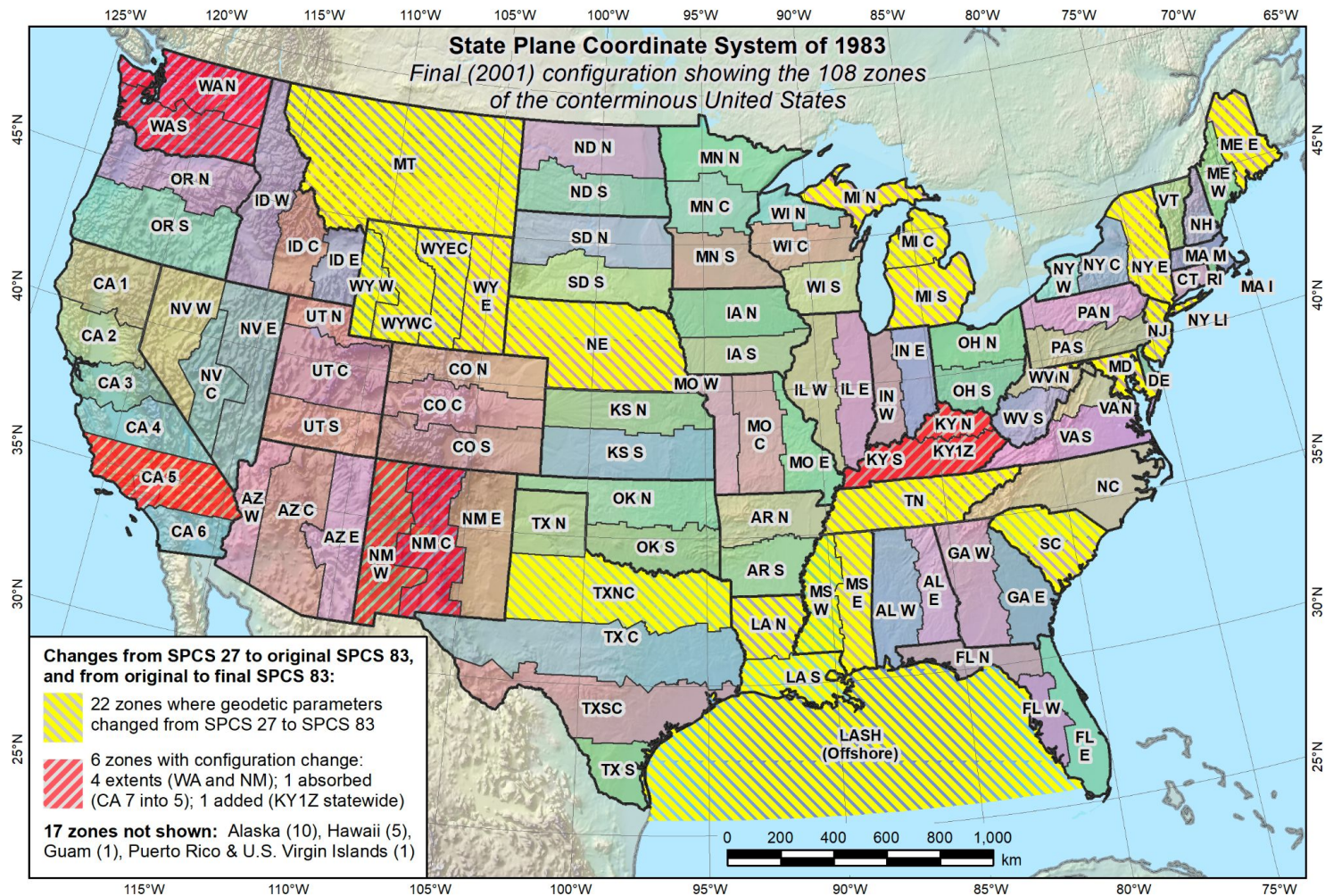
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**“state plane” projections
are locally optimized for
the US state boundaries**



**so how do you
choose?**

- cylindrical for low-latitude areas
- conical for middle-latitude areas
- azimuthal for polar regions (or propaganda maps??)
- pay attention to scale - e.g., don't use a US state plane for South Africa

here are some resources!

wikipedia is great for comparing projections in general:

en.wikipedia.org/wiki/List_of_map_projections

List of map projections

From Wikipedia, the free encyclopedia

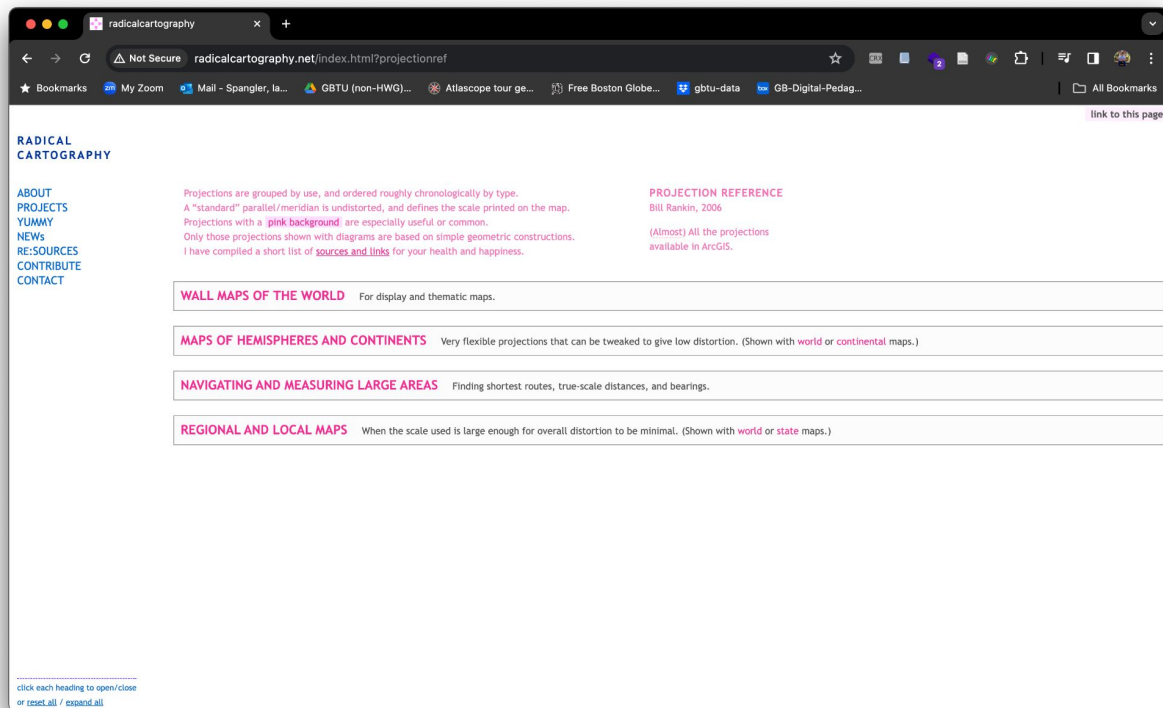
This is a *dynamic list* and may never be able to satisfy particular standards for completeness. You can help by [adding missing items](#) with *reliable sources*.

This is a summary of [map projections](#) that have articles of their own on Wikipedia or that are otherwise *notable*. Because there is no limit to the number of possible map projections,^[1] there can be no comprehensive list.

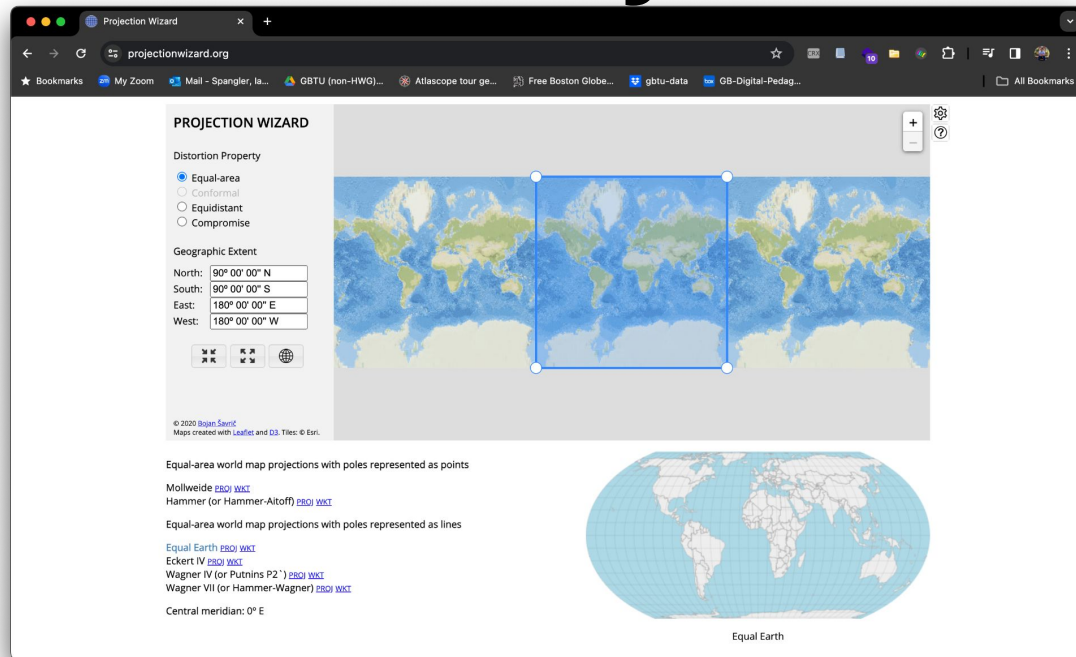
Table of projections

Year	Projection	Image	Type	Properties	Creator	Notes
c. 120	Equirectangular = equidistant cylindrical = rectangular = la carte parallélogrammatique		Cylindrical	Equidistant	Marinus of Tyre	Simplest geometry; distances along meridians are conserved. Plate carrée : special case having the equator as the standard parallel.
1745	Cassini = Cassini-Soldner		Cylindrical	Equidistant	César-François Cassini de Thury	Transverse of equidistant projection; distances along central meridian are conserved. Distances perpendicular to central meridian are preserved.

bill rankin also has a great website for that:



projection wizard is handy:



and epsg.io provides a crisp spatial search interface:

