What is a Map Projection?

2-Dimensional Representation of a 3-Dimensional World

--- Flattening the Earth ---

Because the Earth is spherical in shape, its surface cannot be shown precisely on a flat surface...

Only a globe can accurately represent shapes, areas, sizes, and directions on the Earth's surface.
Cartography is the practice, study, science and art of making maps.

- Measuring Earth’s shape and features
- Collecting and storing information about terrain, places, people, etc.
- Representing the three-dimensional planet
- Designing conventions for graphical representation of data
- Printing and publishing information

From Greek
Khartēs, = Map
Graphein = Write
Early Tools of Cartography

The Age of Exploration

Sextant
Compass
Telescope
Quadrant
Vernier
The Cartographic Challenge

A wide variety of map “projections” are used by cartographers and map makers...

“Projections” involve compromises in which some curved aspects are distorted while others are shown accurately.
Types of Projections

**Cylindrical**
Regularly-spaced meridians to equally spaced vertical lines, and parallels to horizontal lines.

**Pseudo-cylindrical**
Central meridian and parallels as straight lines. Other meridians are curves (or possibly straight from pole to equator), regularly spaced along parallels.

**Conic**
Maps meridians as straight lines, and parallels as arcs of circles.

**Pseudo-conical**
Represents the central meridian as a straight line, other meridians as complex curves, and parallels as circular arcs.

**Azimuthal**
Maps meridians as straight lines and parallels as complete, concentric circles. They are radially symmetrical and preserve directions from the center point (i.e., great circles through the central point are represented by straight lines on the map).

**Pseudo-azimuthal**
Maps the equator and central meridian to perpendicular, intersecting straight lines. They map parallels to complex curves bowing away from the equator, and meridians to complex curves bowing in toward the central meridian. (Generally similar pseudocylindrical in shape and purpose).

**Polyhedral**
Maps which can be folded up into a polyhedral approximation to the sphere, using particular projection to map each face with low distortion.

**Retroazimuthal**
Direction to a fixed location B (by the shortest route) corresponds to the direction on the map from A to B.

**Others...**
Typically calculated from formula, and not based on a particular projection.

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Properties

**Conformal**
Preserves angles locally, implying that locally shapes are not distorted.

**Equal Area**
Areas are conserved.

**Compromise**
Neither conformal or equal-area, but a balance intended to reduce overall distortion.

**Equidistant**
All distances from one (or two) points are correct; while other equidistant properties are mentioned in the notes.

**Gnomonic**
All great circles are straight lines.
There are many types of projections!

- Adams hemisphere-in-a-square
- Aitoff
- Albers conic
- American polyconic
- Azimuthal equidistant
- B.J.S. Cahill's Butterfly Map
- Behrmann
- Bonne
- Bottomley
- Cahill-Keyes
- Craig retroazimuthal
- Dymaxion map
- Eckert
- Equidistant conic projection
- Equirectangular
- Gall stereographic
- Gall–Peters
- Gauss–Krüger
- Gnomonic
- Goode
- Hammer
- Hammer retroazimuthal
- HEALPix
- Quartic authalic
- Hobo-Dyer
- Homolosine
- Kavrayskiy
- Lambert
- Lambert conformal conic
- Lambert cylindrical equal-area
- Littrow
- Loximuthal
- Mercator
- Miller
- Mollweide
- Myriahedral projections
- Orthographic
- Peirce quincuncial
- Guyou hemisphere-in-a-square
- Quadrilateralized spherical cube
- Robinson
- Tobler hyperelliptical
- Sinusoidal
- Stereographic
- Two-point equidistant
- Van der Grinten
- Vertical perspective
- Wagner
- Collignon
- Waterman butterfly
- Werner
- Winkel tripel
Let’s Review

6 Well-known Map Projections

• Cylindrical
  – **Mercator** Projection (Gerardus Mercator, 1569)
  – **Mollweide** Projection (Karl Brandan Mollweide, 1800)
  – **Robinson** Projection (Arthur Robinson, 1963)

• Conical (conic) Projection

• **Planar** (plane or polar) Projection

• **Interrupted** (broken area) Projection
The Mercator Projection was invented in 1569 by a Flemish map maker.
Mercator Projections are mathematically accurate.
Mercator Projection
(a mathematically-derived cylindrical projection)

Preserves local angles
East-west scale is identical to the north-south scale at every point on the map
Note the exaggerated size of high latitude areas.

Greenland and Mexico are actually about the same size.

Antarctica is greatly distorted and appears to be of enormous size.
Widely used for nautical maps and navigation charts

Preserves angles making it useful to navigators

Compass headings form straight lines (called rhumb lines by sailors)
An Original 1569 Mercator Map
1855 Colton Map – Mercator Projection
Mollweide Projections

First published by Karl Mollweide in 1805, the German astronomer and mathematician.

Mollweide maps are "Equal Area Maps" (Pseudo-cylindrical projections).

Designed to improve upon the Mercator projection.

An Elliptical Projection.
Sacrifices accurate angles and shapes in favor of accurate area representations.

Distortion-free along the parallels 40.7 degrees North and South.

Mollweide
Representation of area takes precedence over shape

Mollweide
Preserves straight lines of latitude

Pseudo-cylindrical
Homolographic
Elliptical
The Robinson Projection

Designed by Arthur H. Robinson in 1963

Published in “Elements of Cartography”
Robinson Projection

- First published in 1974
- Adopted for world maps by the *National Geographic Society* in 1988
  - Later abandoned in favor of the *Winkel Tripel* projection in 1998.

A pseudo-cylindrical projection designed for *Rand McNally*
Robinson Projection

Lengths of parallels, pole lines, and the central meridian are designed for best visual appearance.

The shape and size of the continents are shown accurately.

Water areas are expanded to fill the extra space.
Conical Projections

- Lines of latitude and longitude are intersecting at 90 degrees
- Meridians are straight lines
- Parallels are concentric circular arcs
- Scale along the standard parallel(s) is true
- Can have the properties of equidistance, conformality or equal area
- The pole is represented as an arc or a point
Conical Projections

Lambert's azimuthal equal-area, standard parallel 90°N, cone constant 1

Albers equal-area conic, standard parallels 90°N and 30°N, cone constant 0.75

Albers conic, standard parallel 48°35'25"N, cone constant 0.75

Albers conic, standard parallels 90°N and 0°, cone constant 0.5

Albers conic, standard parallel 14°28'39"N, cone constant 0.25

Albers conic, standard parallels 90°N and 30°S, cone constant 0.25

Lambert's cylindrical equal-area, standard parallel 0°, cone constant 0
Interrupted Projections
(Broken Area Map)

Reduces distortion when in representing the surface of a sphere on a flat piece of paper.
Interrupted maps cut the terrestrial surface along some arbitrarily chosen lines and project each section (called a lobe)
Interrupted Sinusoidal Map (emphasizing land areas)

Interrupted Sinusoidal Map with 3 full lobes per hemisphere (emphasizing oceanic areas)
Systematically Interrupted *Sinusoidal* Map

Example

The world split into 12 gores*

- Each segment is 30 degrees of longitude in width
- Suitable for applying onto the surface of a physical globe

* Gores are systematic interruptions which repeat periodically along related lines
Planar Projections

Example...
Polar Maps
Planar Projections

Great circles through the central point are represented by straight lines on the map.

Radial symmetry in scale and distortion.

Azimuthal projections onto a plane.
Peter Apian, in his Cosmographicus Liber of 1524 introduced one of the first circular maps of the world

1524
Single Polar Projection

1648

Louis de Mayerne Turquet
• **Mercator** Projection  (Geradus Mercator, 1569)

• **Mollweide** Projection  (Karl Brandan Mollweide, c.1800)

• **Robinson** Projection  (Arthur Robinson, 1963)

• **Conical** (conic) Projection

• **Interrupted** (broken area) Projection

• **Planar** (plane or polar) Projection
Map Projections provide us with a 2-Dimensional Representation of a 3-Dimensional World.

"Flatten the Earth" Map Projections
THANKS for Your Attention!

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The End...
Basic terms from our presentation...

- English Review
- geography
- cartography
- compass
- telescope
- sphere
- angle
- longitude
- latitude
- projection
- conic (conical)
- cylindrical
- planar
- polar
- pseudo
- distortion
- nautical
- navigation