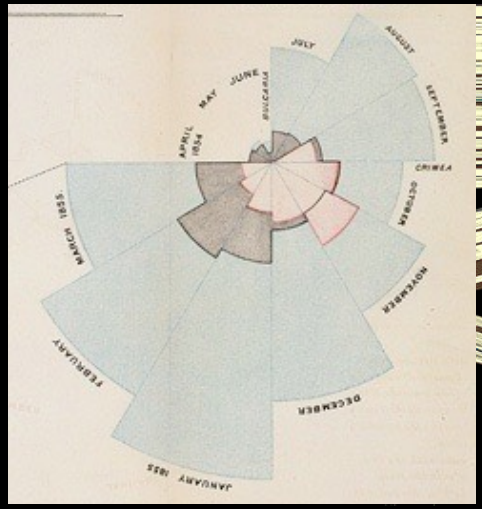
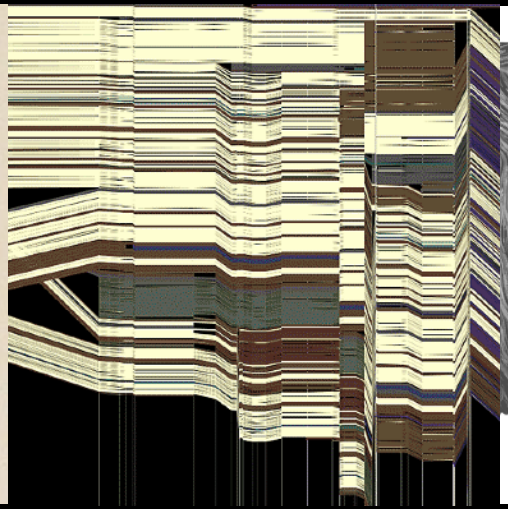
CSE 512 - Data Visualization

Mapping & Cartography





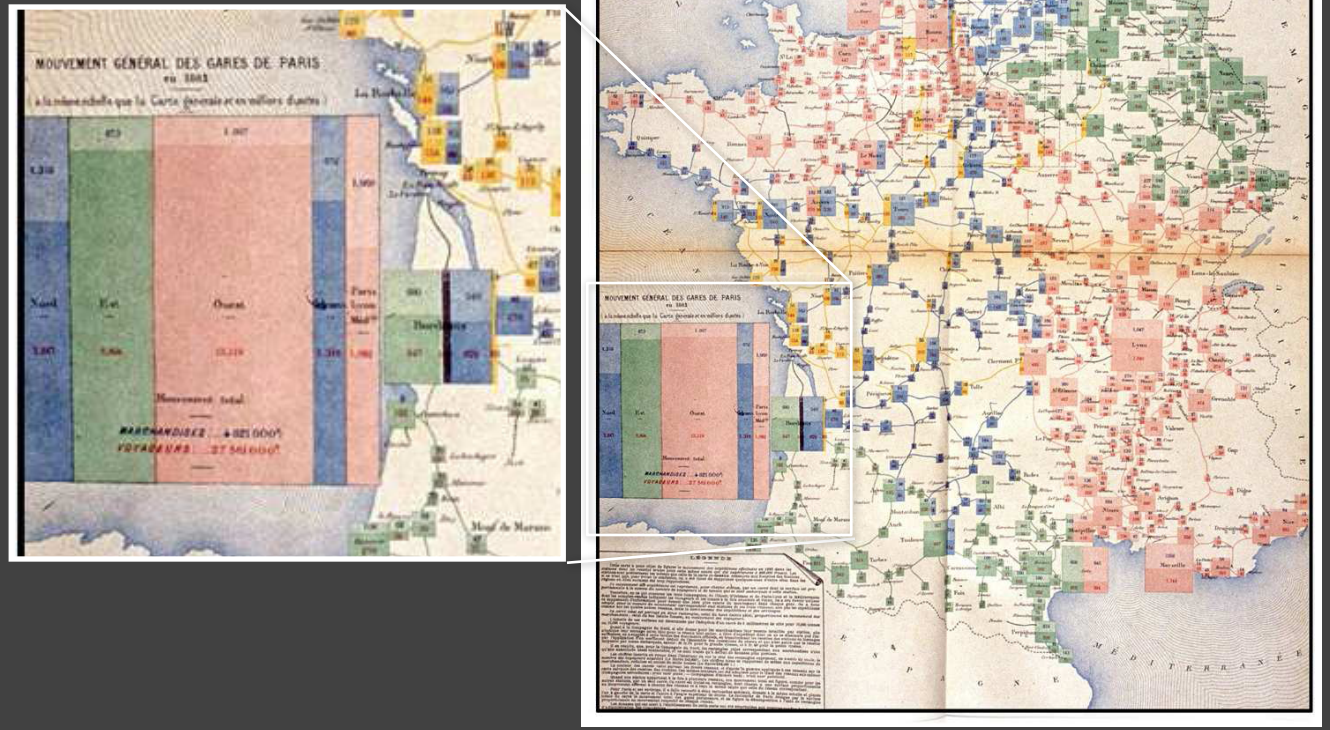
Jeffrey Heer University of Washington
(with significant material from Michal Migurski)

Mapping

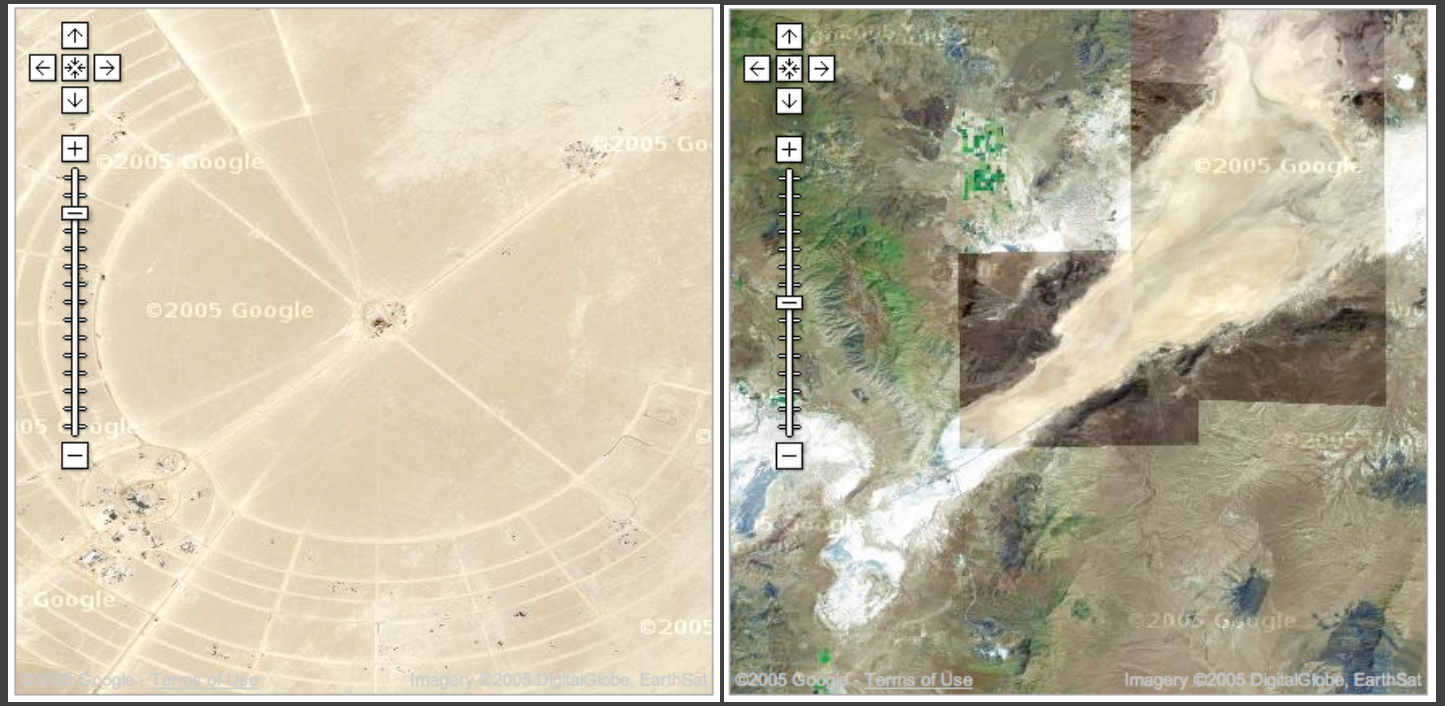
Visualizing Geospatial Data

Ptolemy's Geographica

Original ~150AD, This Map ~1300AD

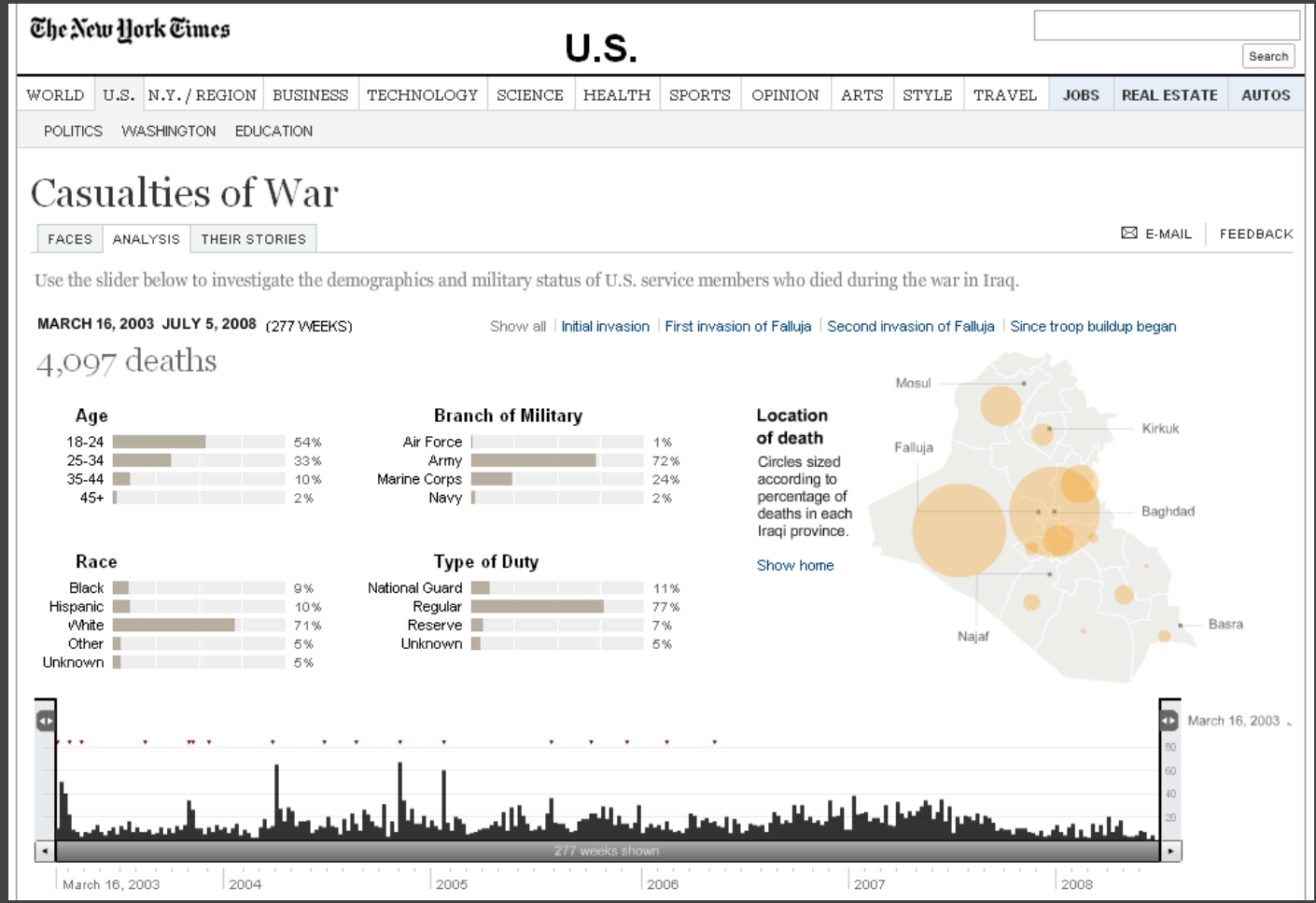


Rail Passengers and Freight from Paris 1884



Black Rock City, Nevada
(Burning Man)

Google Maps 2005



Casualties of War, New York Times 2006

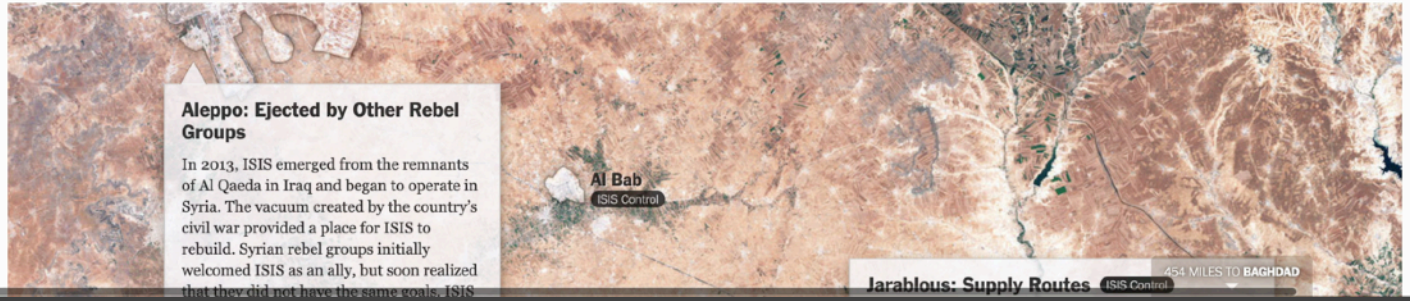
A Rogue State Along Two Rivers

How ISIS Came to Control Large Portions of Syria and Iraq

By JEREMY ASHKENAS, ARCHIE TSE, DEREK WATKINS and KAREN YOURISH July 3, 2014

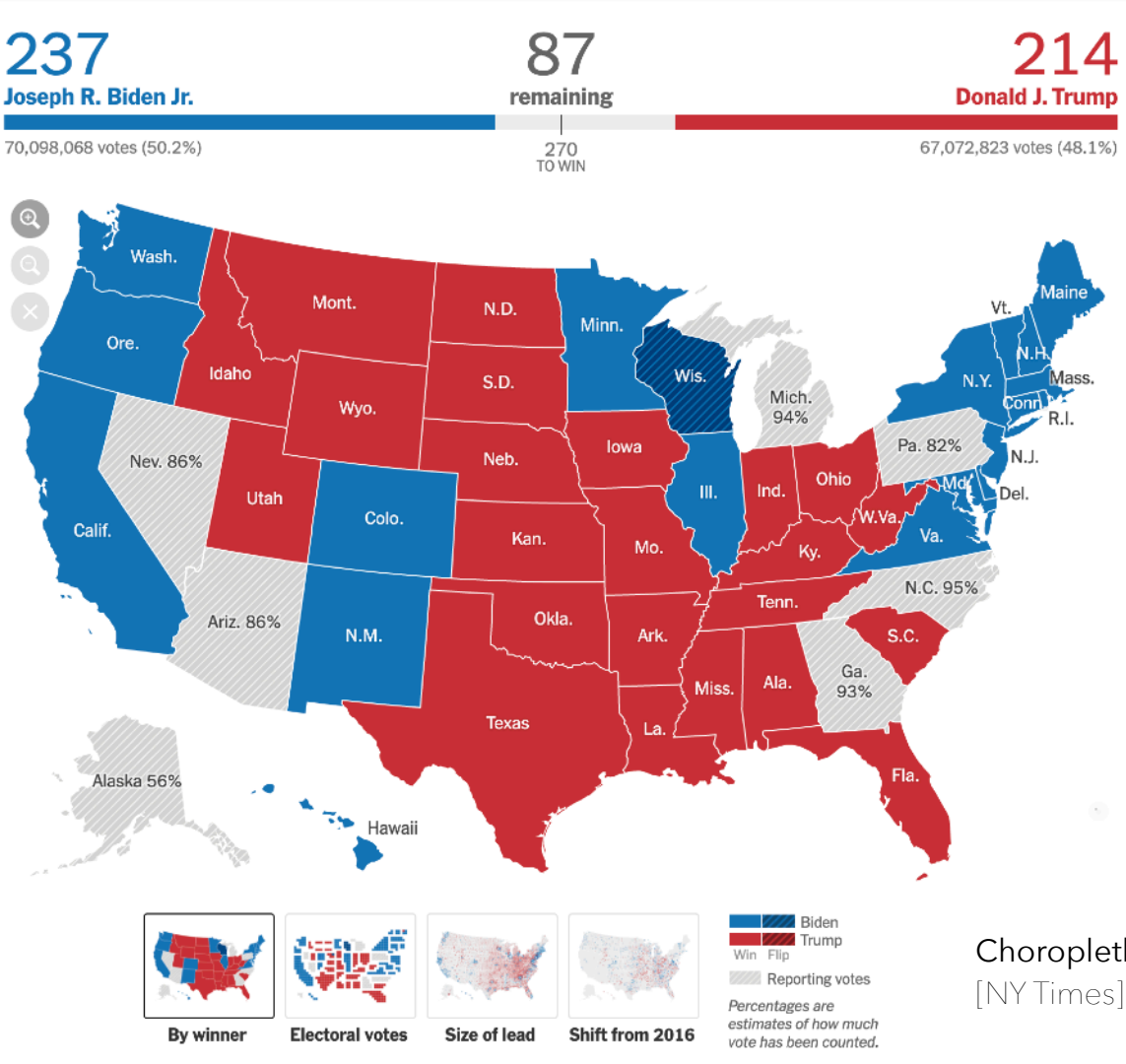
The militant group called the Islamic State in Iraq and Syria, or ISIS, seemed to surprise many American and Iraqi officials with the recent gains it made in its violent campaign to create a new religious state. But the rapid-fire victories achieved over a few weeks in June were built on months of maneuvering along the Tigris and Euphrates Rivers.

The Euphrates

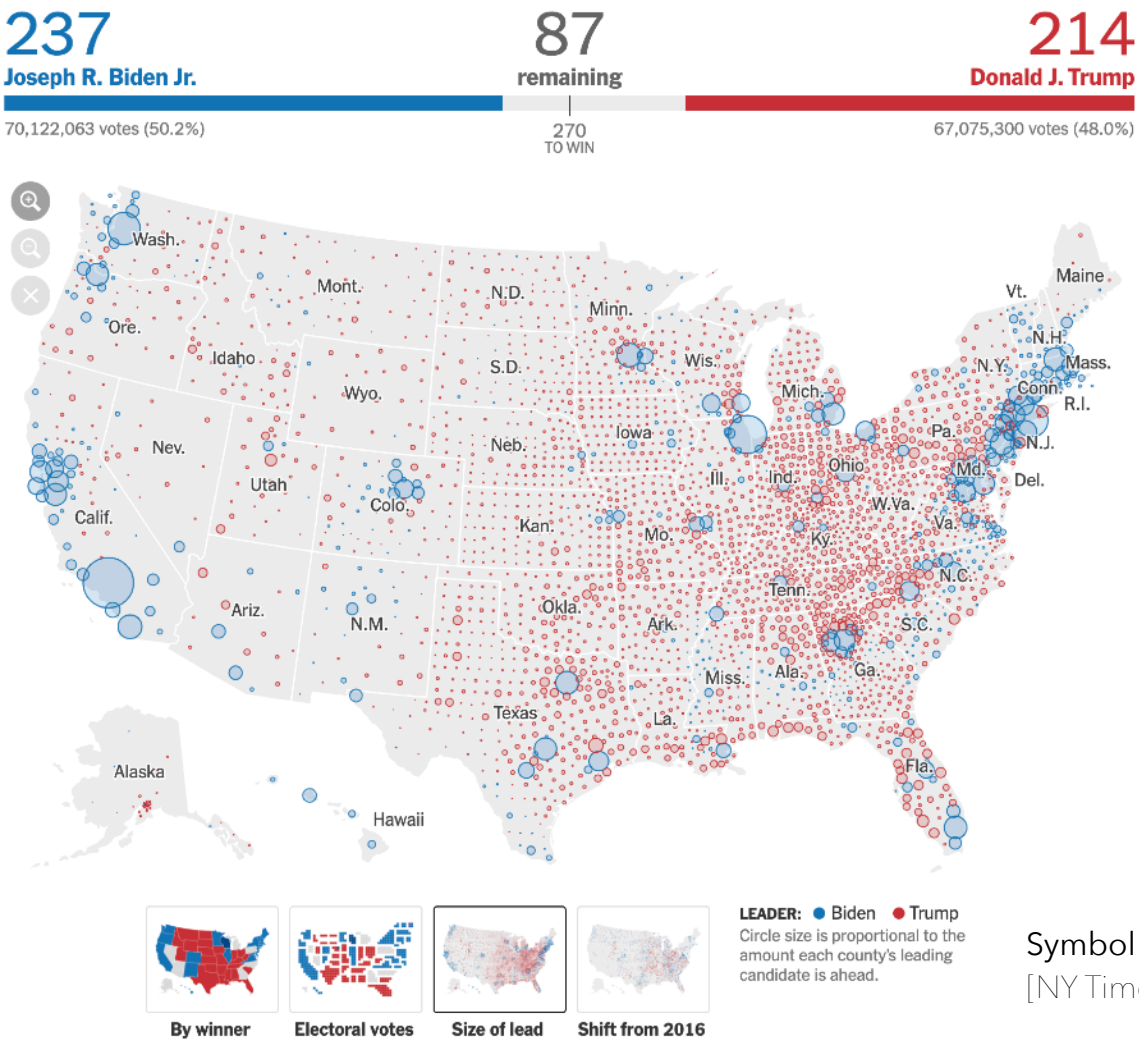


NY Times 2014

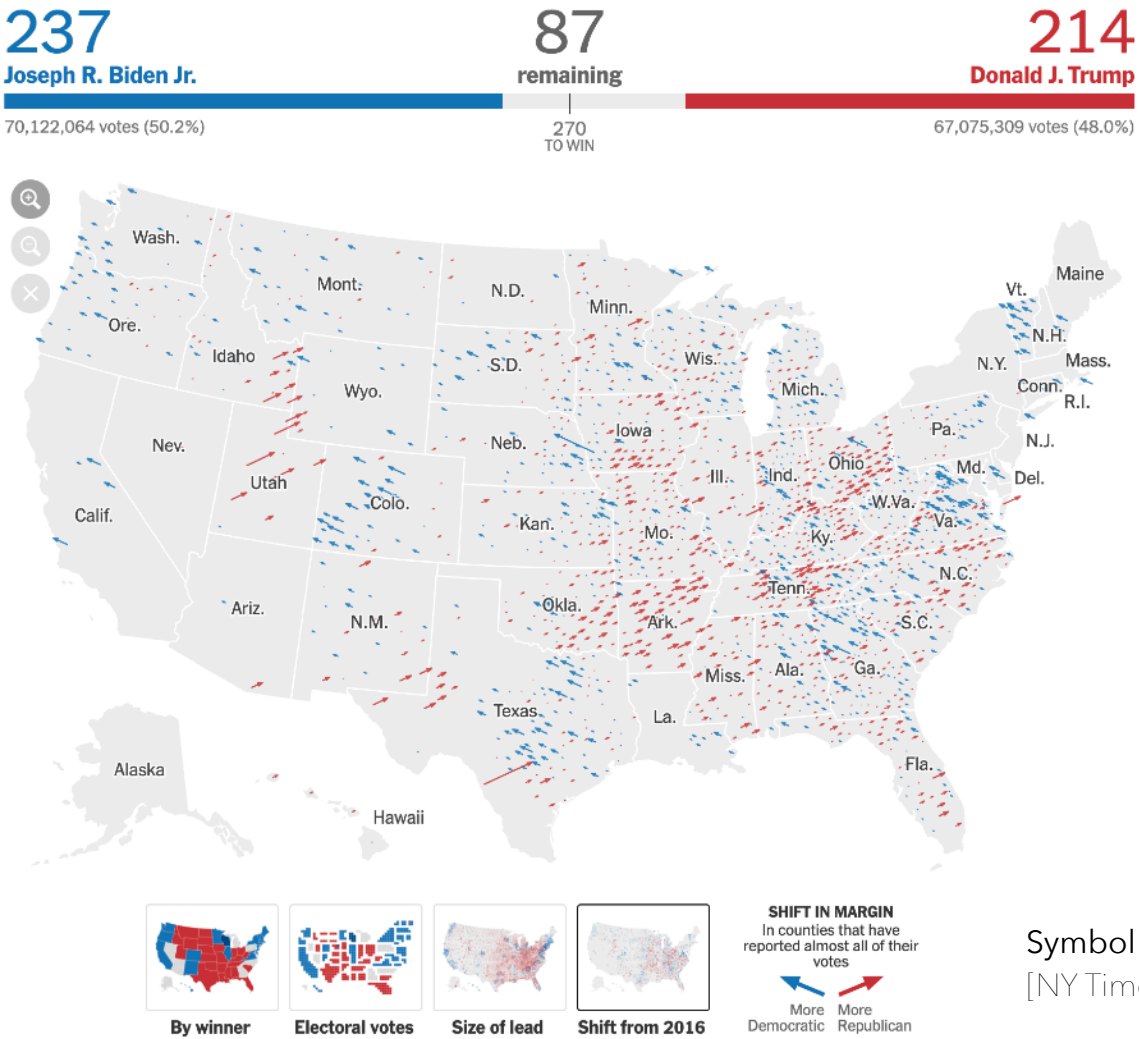
NY Times
2014



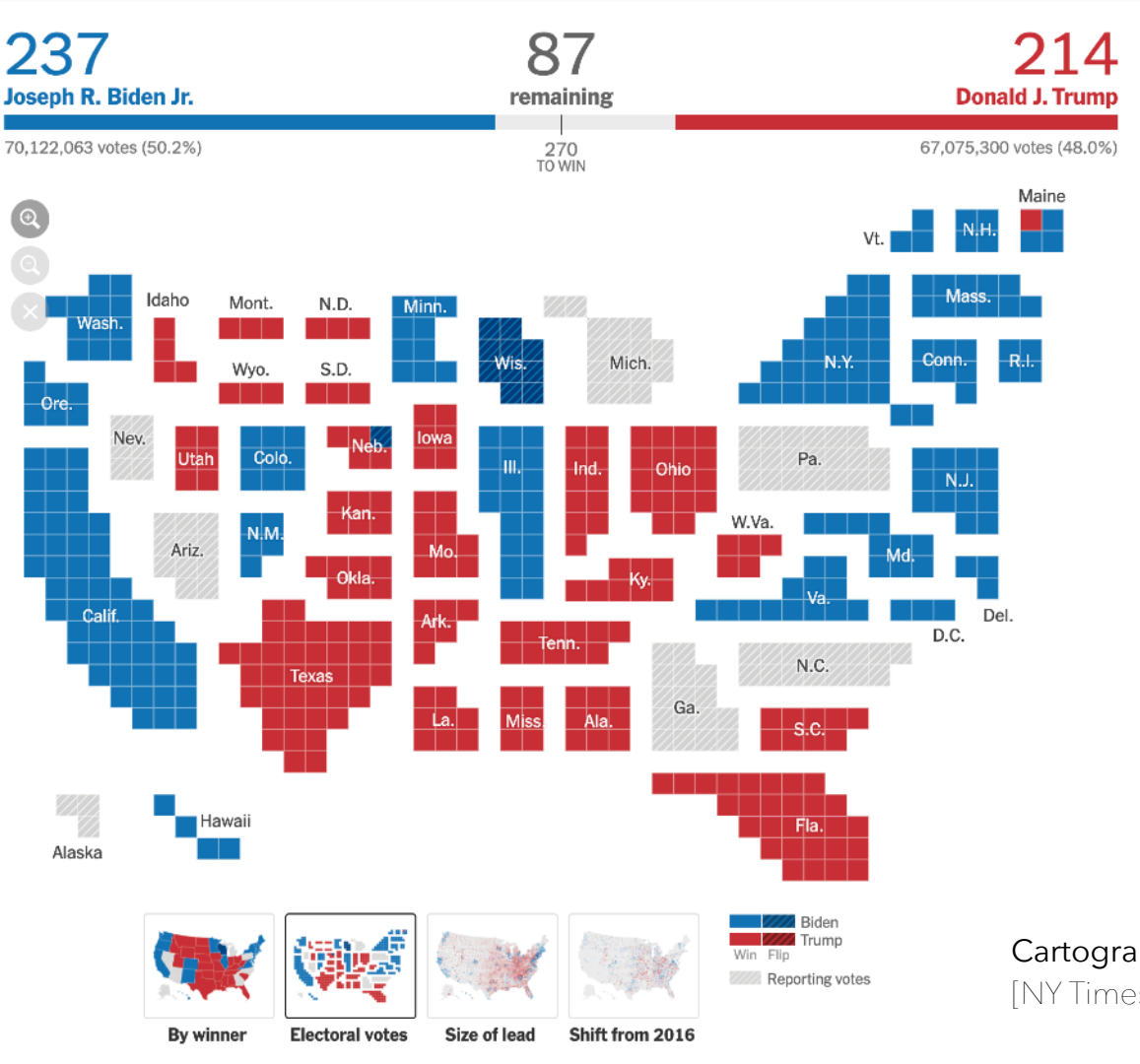
Choropleth Map
[NY Times]



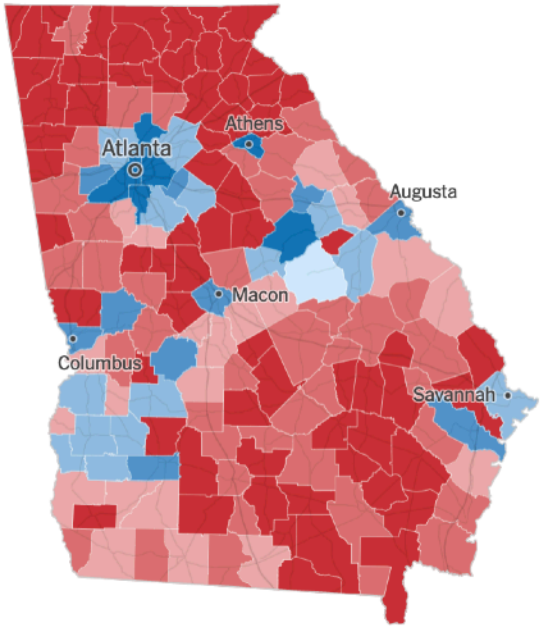
Symbol Map
[NY Times]



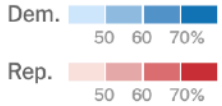
Symbol Map
[NY Times]

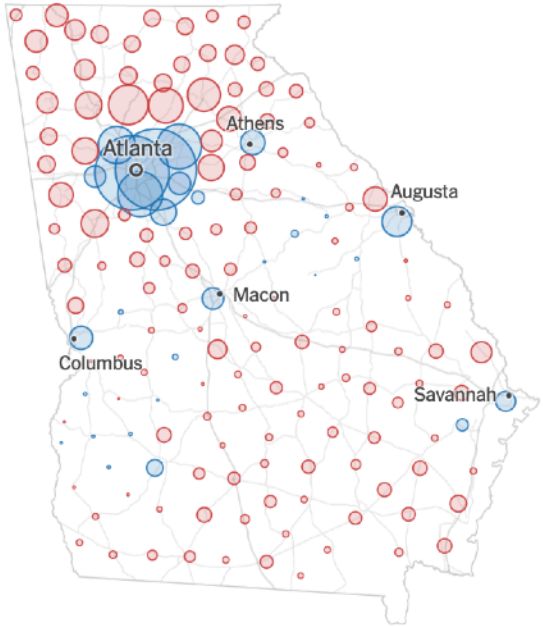


Cartogram
[NY Times]



Choropleth Map
[NY Times]





Symbol Map
[NY Times]

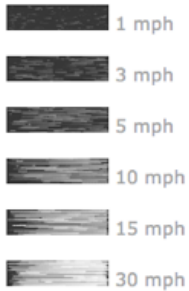
Circle size is proportional to the amount each county's leading candidate is ahead.

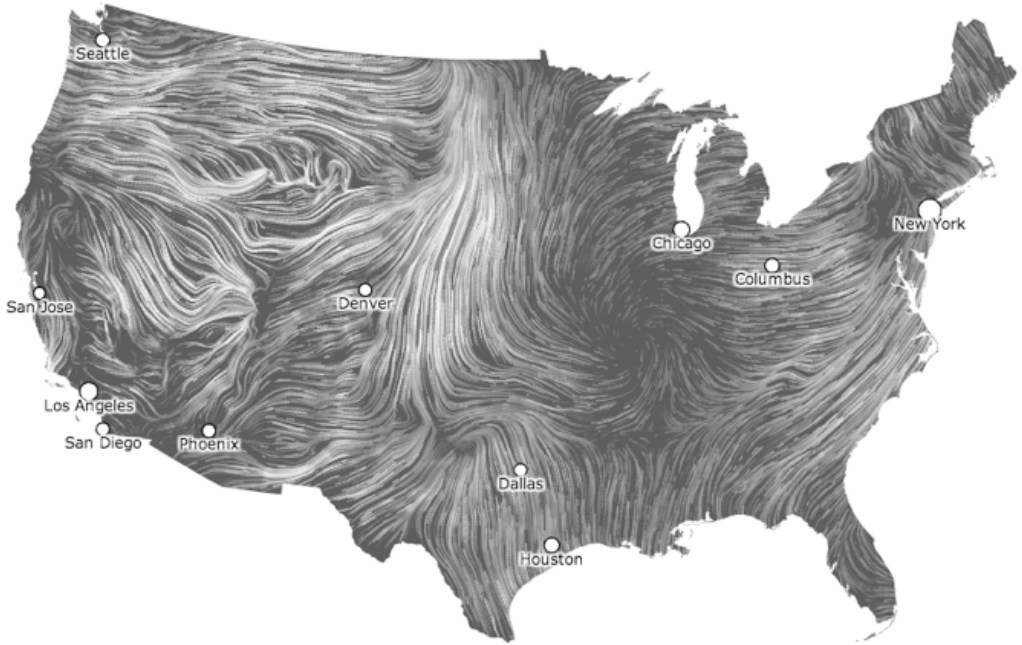
● Trump ● Biden

wind map

February 19, 201
11:55 am EST
(time of forecast download)

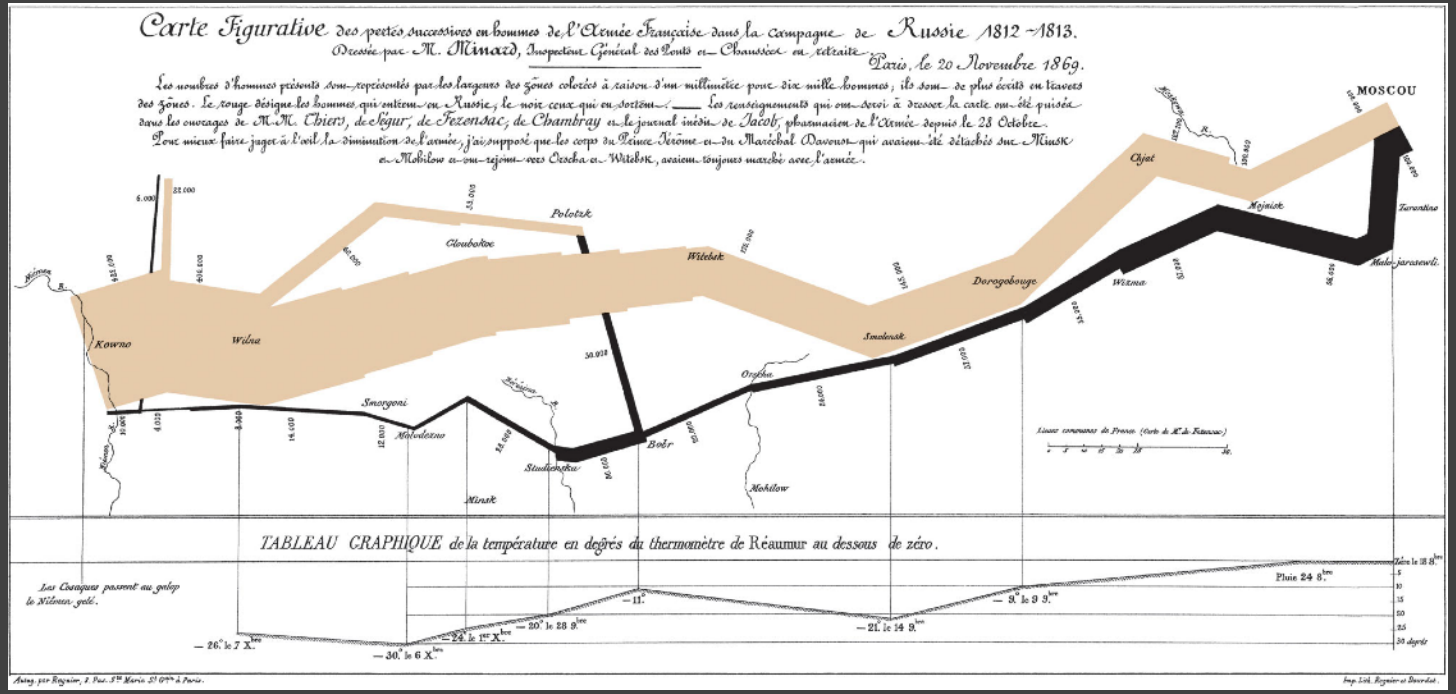
top speed: **35.3 mph**
average: **11.6 mph**

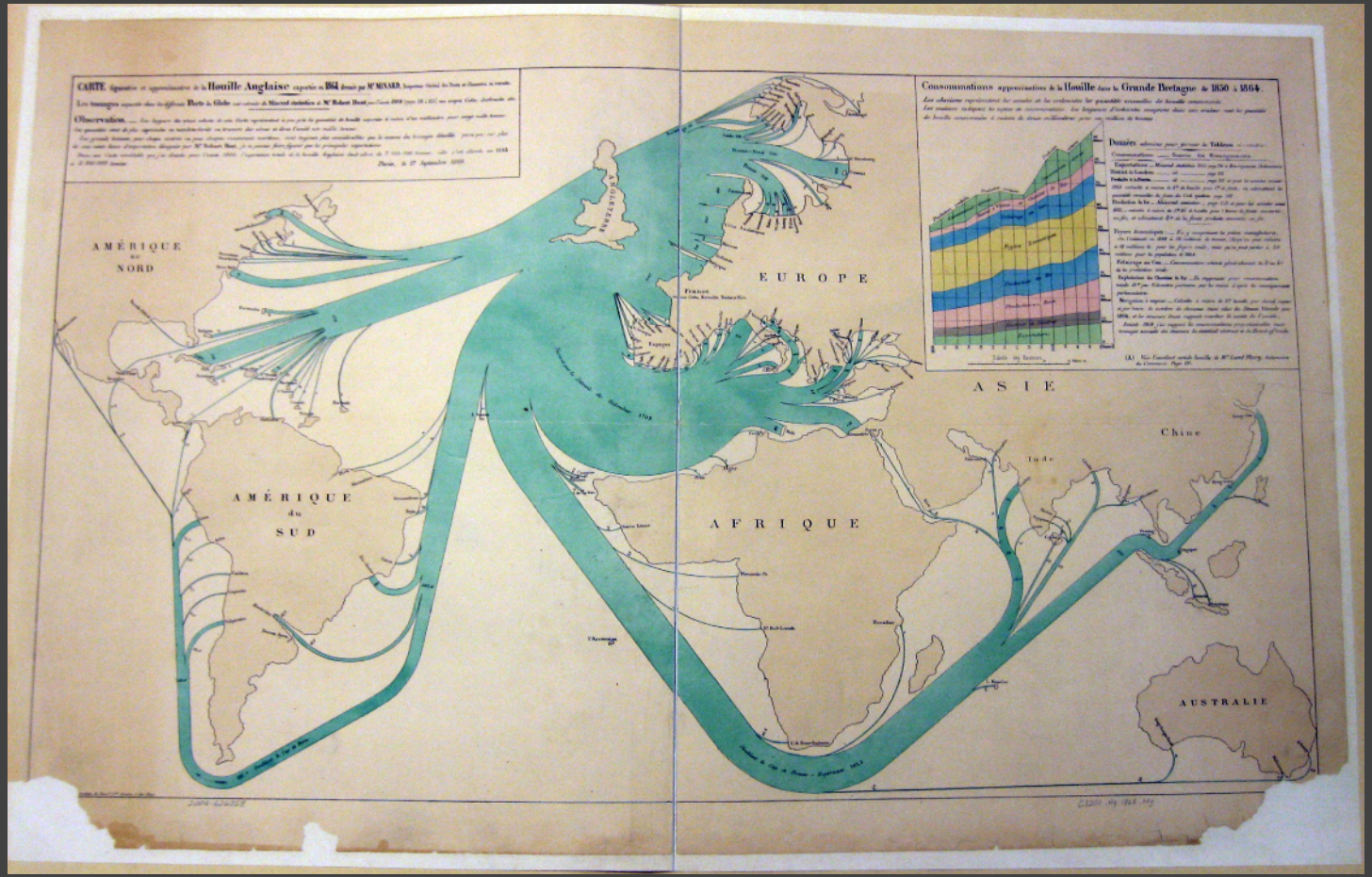




Wattenberg & Viegas

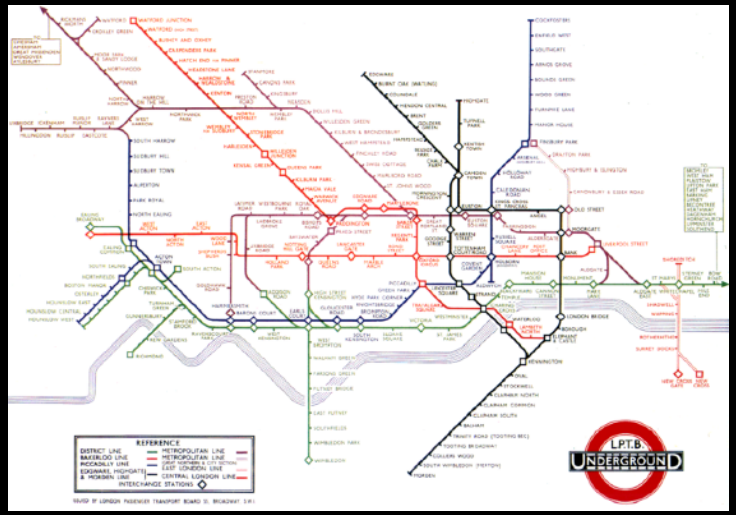
Minard 1869: Napoleon's march



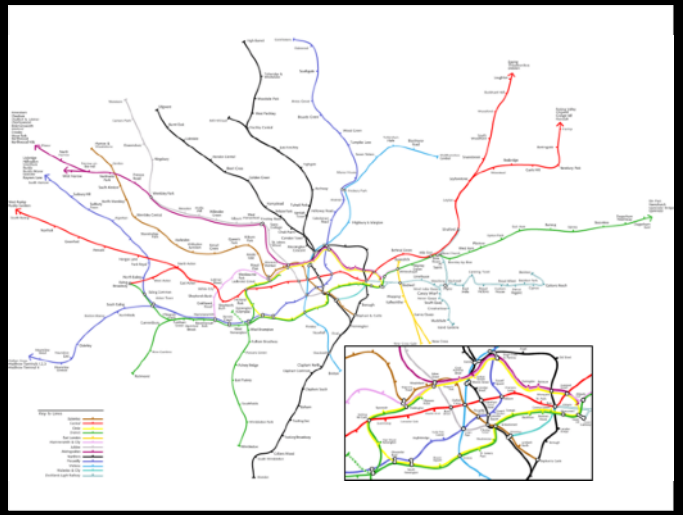


1864 British Coal Exports, Charles Minard

Beck's London tube diagram



London Underground [Beck 33]



Geographic version of map

Principle: Straighten lines to emphasize stop sequence

Technique used to emphasize/de-emphasize information

Approaches to Mapping Data

Symbol Maps → plot data over a map

Choropleth Maps → colored regions

Heatmaps & Contours → show densities

Cartograms → distort to show quantities

Flow Maps → flux across regions

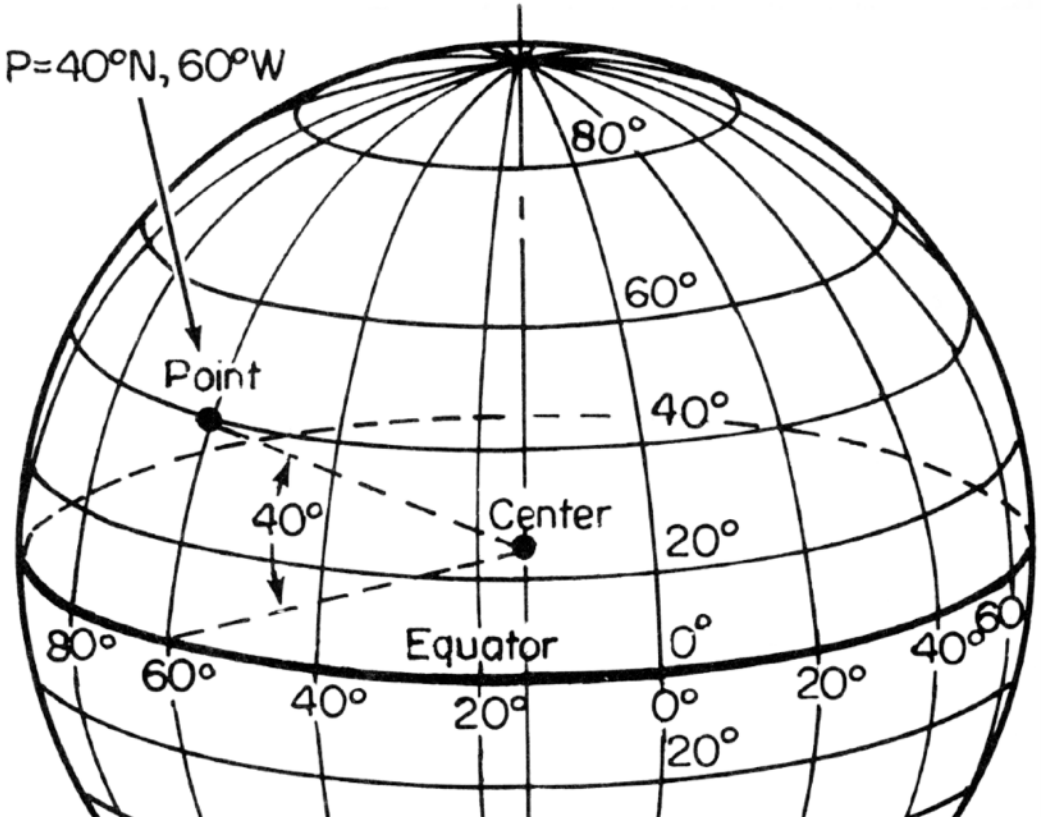
Generalization → distort/abstract to aid tasks

Cartography

The Making of Maps

Projections

Latitude, Longitude




A sphere tears
when you flatten it

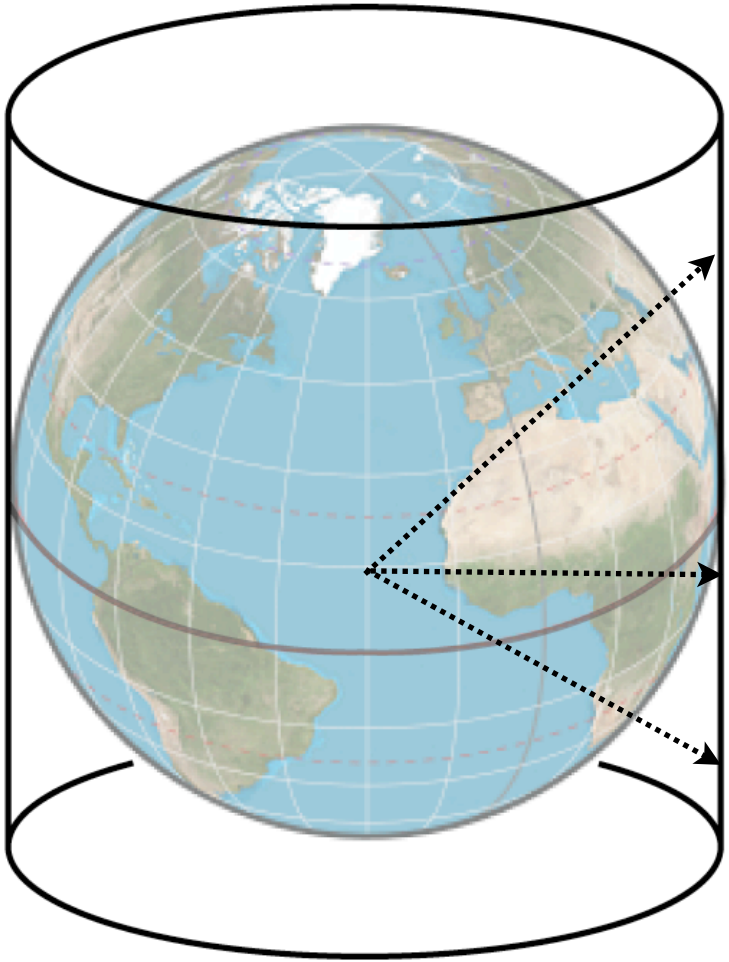
Projections

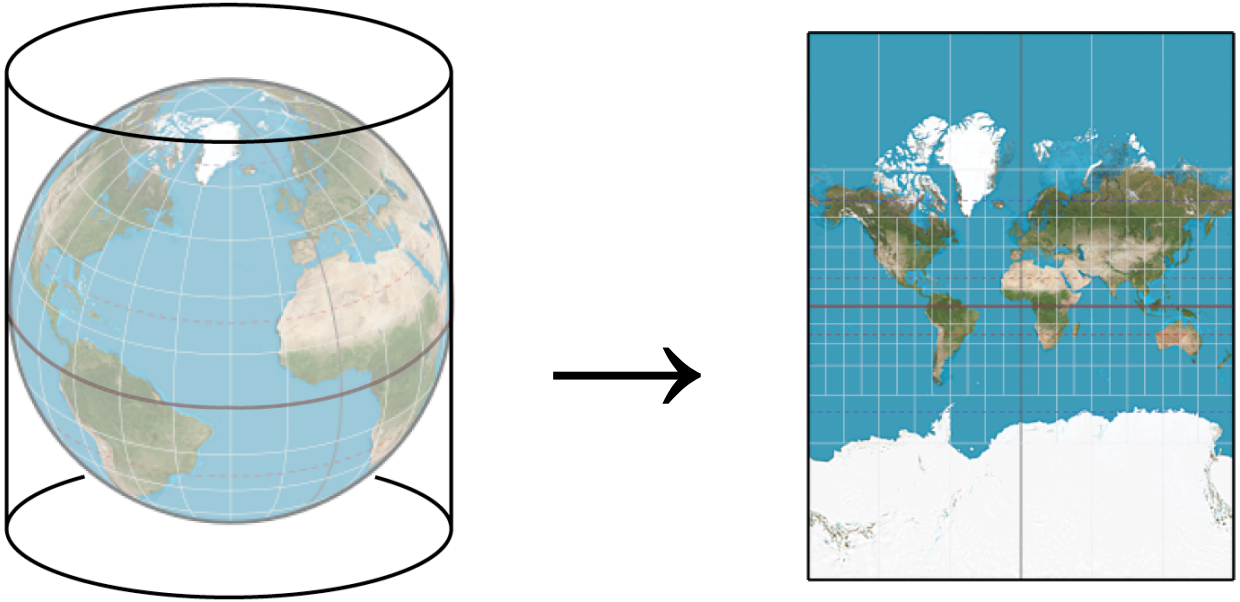
$$f(\phi, \lambda) \rightarrow (x, y)$$

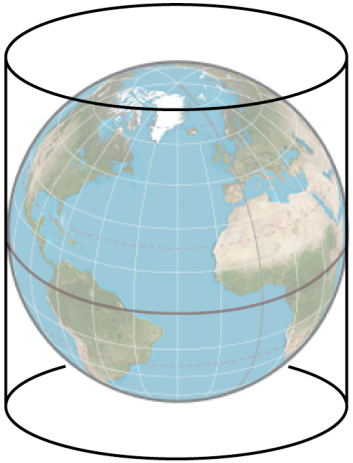
Projections

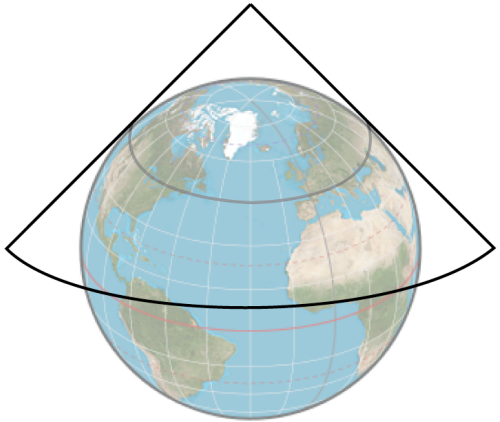
$$f(\phi, \lambda) \leftrightarrow (x, y)$$

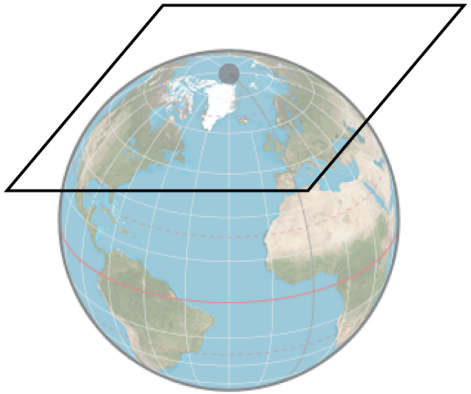
??

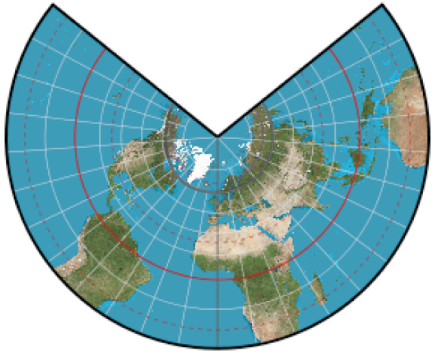


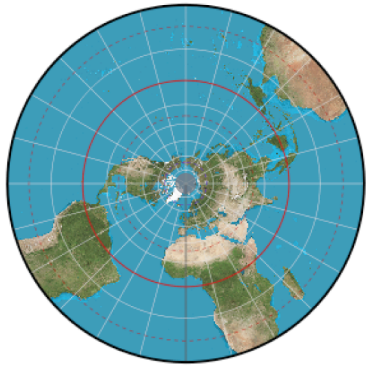












Cylindrical

Conical

Azimuthal

Exploring Projections…

Type mercator

Scale 140

Yaw 0

Pitch 0

Roll 0

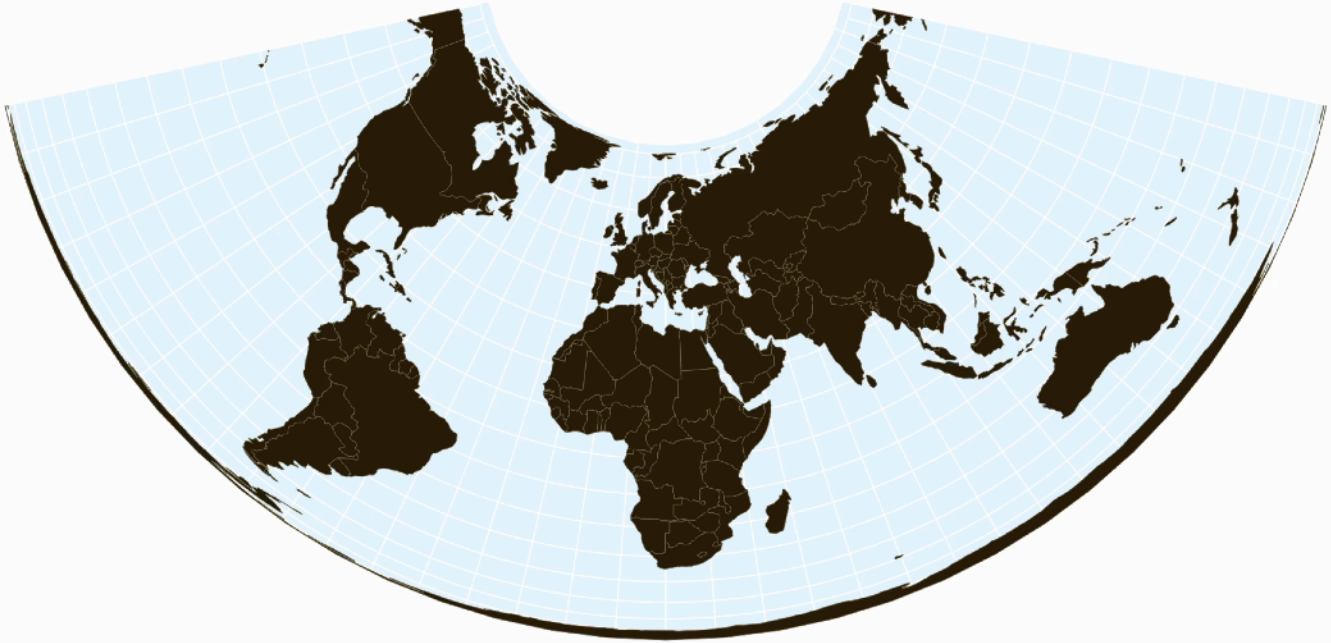
Type mercator

Scale 140

Yaw 0

Pitch 0

Roll 0



Type	conicEqualArea	
Scale		140
Yaw		-20
Pitch		0
Roll		0

Type orthographic

Scale 140

Yaw 0

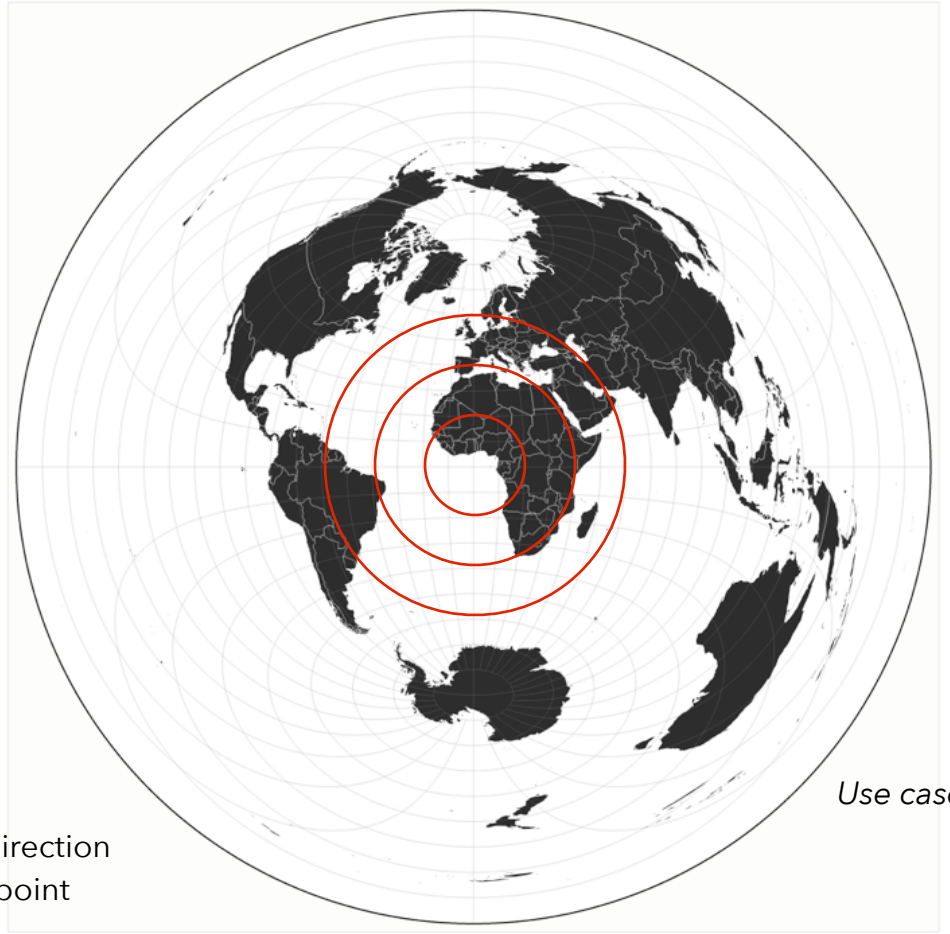
Pitch 0

Roll 0

We can categorize projections by what they preserve…


Distance
Preserve distance / direction from center

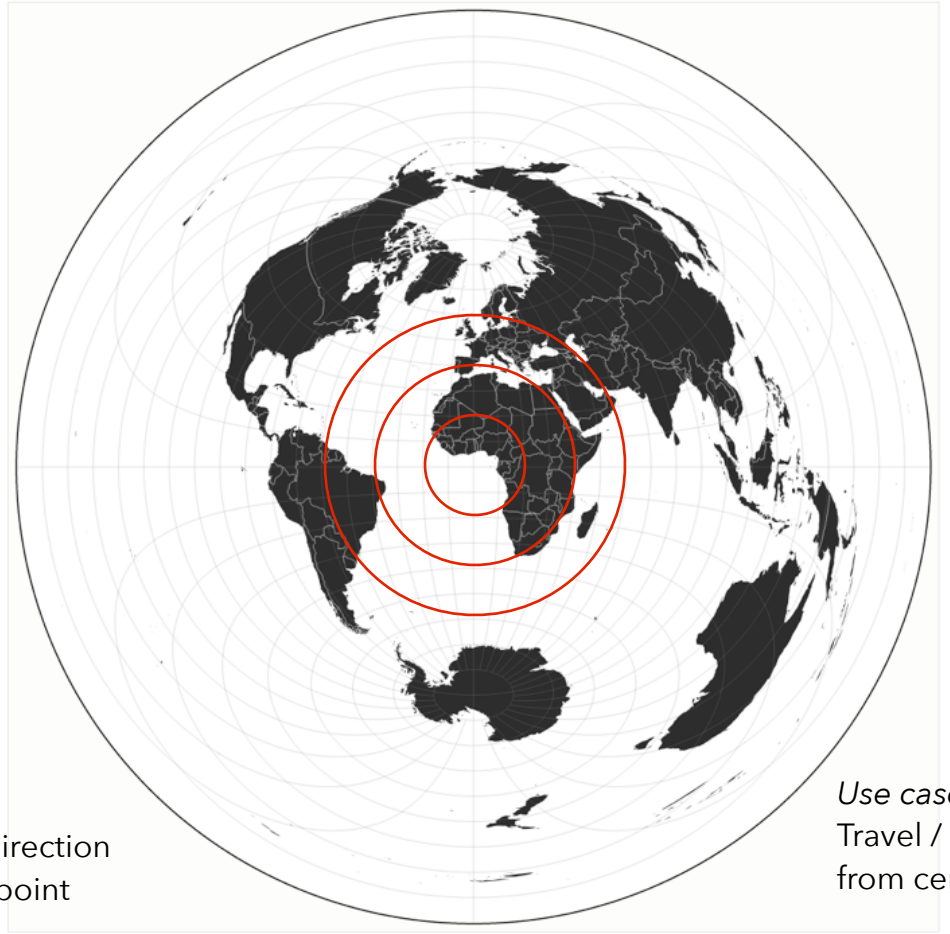
Azimuthal Equidistant



Preserves:
Distance & direction
from center point

Use cases?

Azimuthal Equidistant

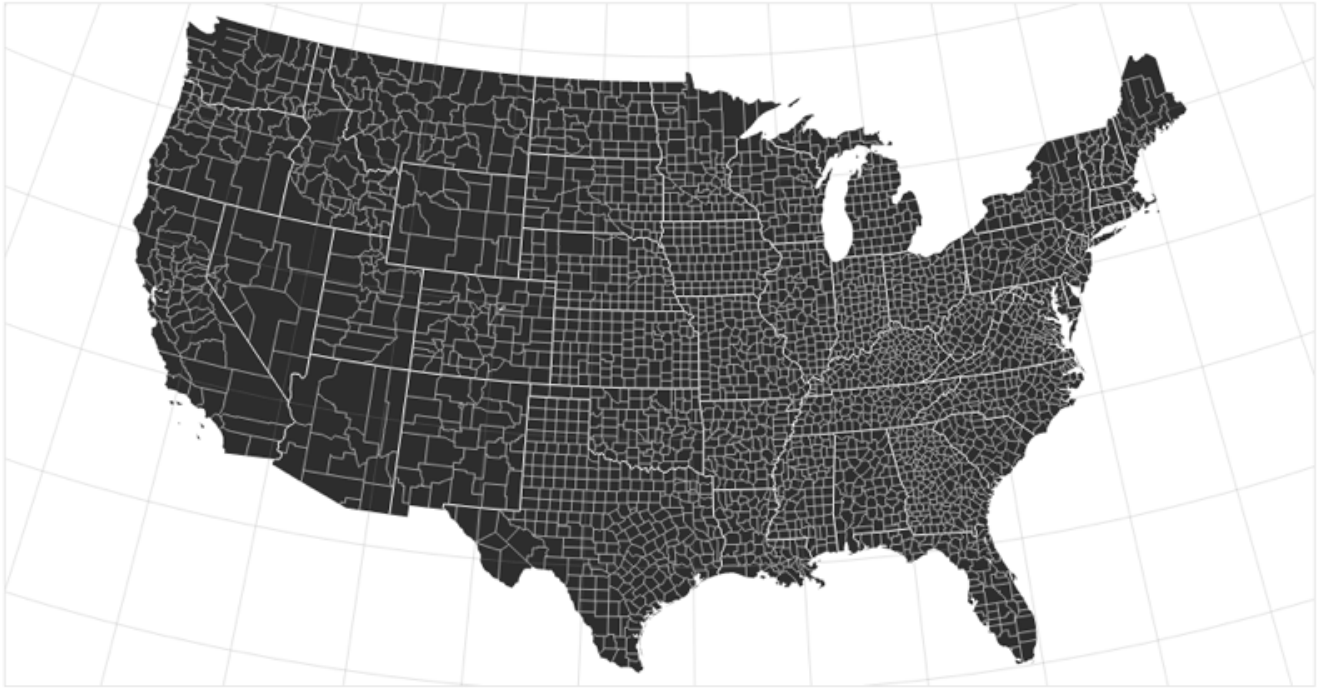


Preserves:
Distance & direction
from center point

Use cases:
Travel / propagation
from center point


Equal-Area
Preserve proportional areas

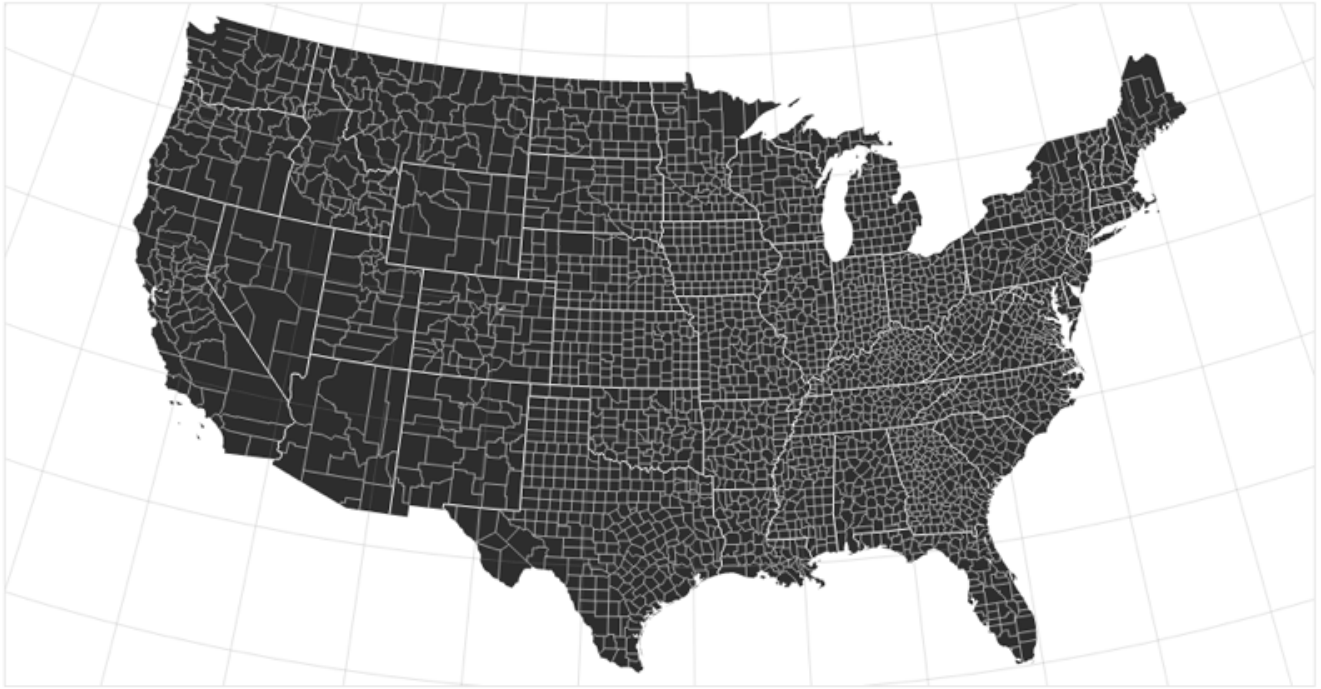
Albers Equal-Area Conic



Preserves: Proportional area of geographic regions

Use cases?

Albers Equal-Area Conic



Preserves: Proportional area of geographic regions

Use cases: Land surveys, choropleth (shaded) maps


Conformal
Preserve local angles (“shape”)

Spherical Mercator

Preserves:
Compass bearing
as a straight line

Use cases?

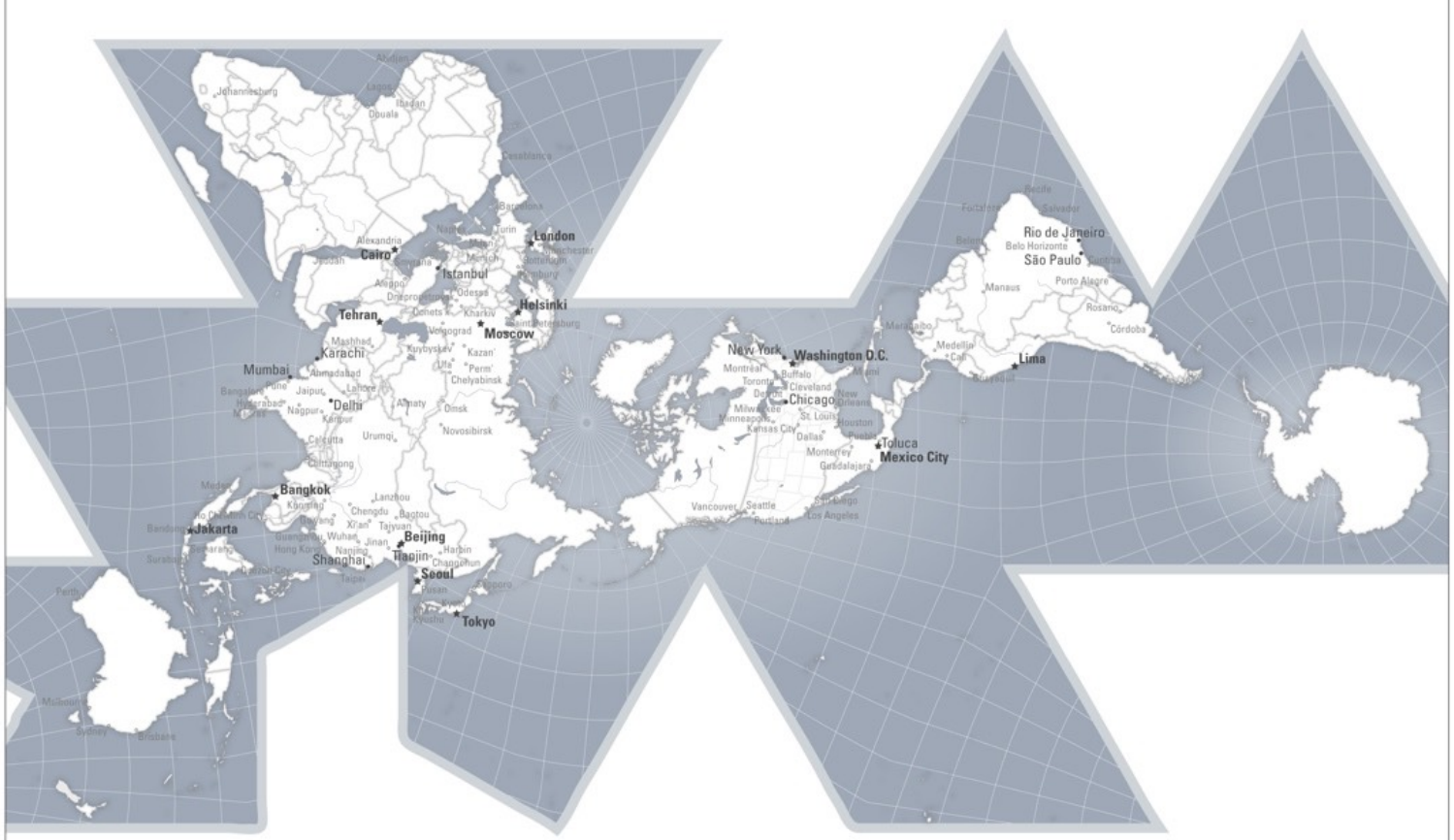
Spherical Mercator

Preserves:
Compass bearing
as a straight line

Use cases:
Navigation

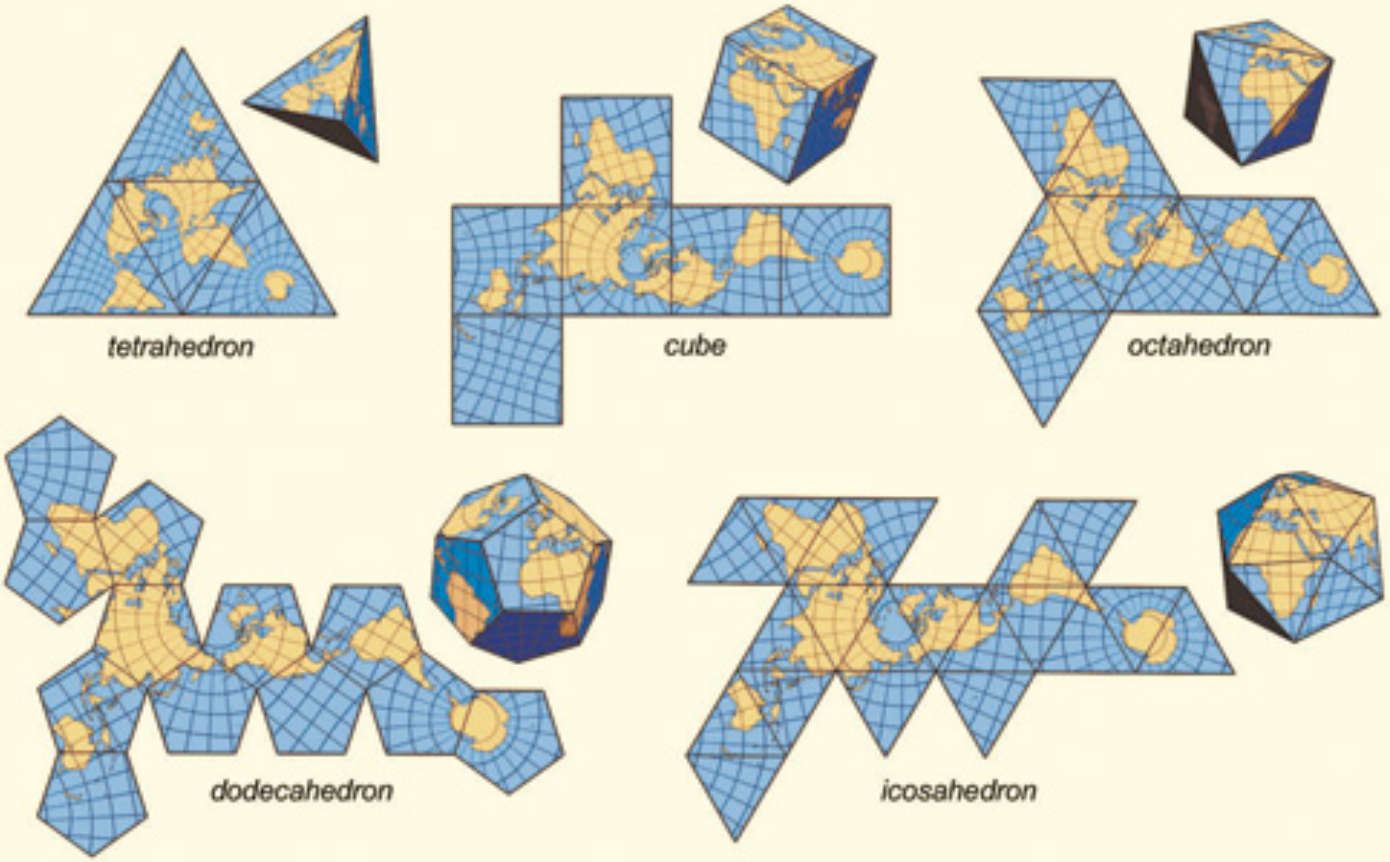
There are interesting ways to tear spheres

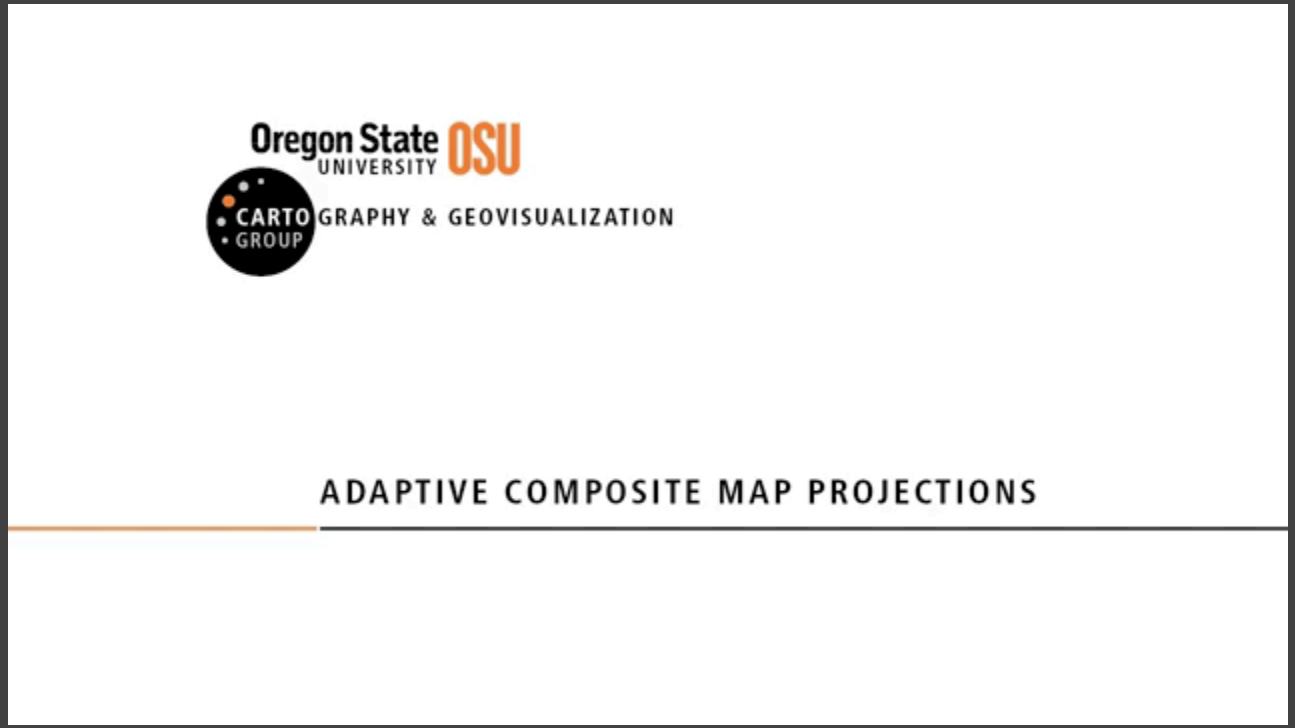
One notable interesting way to tear a sphere



Balances preservation of area and shape.

Provides different ways of thinking about the world!


tetrahedron
cube
octahedron
dodecahedron
icosahedron



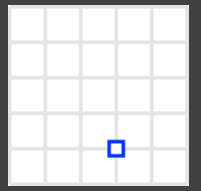
Idea: switch *between* projections by location and zoom level

Geographic Data Formats

From Tables to Geometry: Basic Shapes

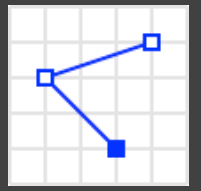
Point: An array containing 2D or 3D coords (e.g., `[lon, lat]`)

```
[125.6, 10.1]
```



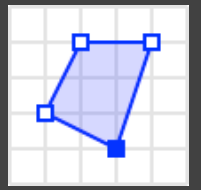
LineString: An array of points

```
[[30, 10], [10, 30], [40, 40]]
```



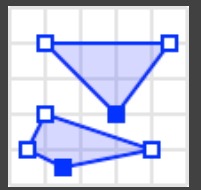
Polygon: One or more arrays of points

```
[ [[30, 10], [40, 40], [20, 40], [10, 20], [30, 10]] ]
```



MultiPolygon: An array of polygons

```
[
  [ [[30, 20], [45, 40], [10, 40], [30, 20]] ],
  [ [[15, 5], [40, 10], [10, 20], [5, 10], [15, 5]] ]
]
```



GeoJSON Format

GeoJSON is a standardized JSON format for geometric data.

Geometry: An object with a type and a coordinates array

```
{“type”: “Point”, “coordinates”: [125.6, 10.1]}
```

```
{“type”: “Polygon”, “coordinates”: [[[30.0, 20.0], [45.0, 40.0],
[10.0, 40.0], [30.0, 20.0]]]}
```

Feature: An object with a geometry and optional named attributes

```
{
  “type”: “Feature”,
  “id”: “optional_id_string”,
  “geometry”: { “type”: “MultiPolygon”, …},
  “properties”: { “attr1”: “foo”, “attr2”: 12863 }
}
```

GeoJSON Format, Continued

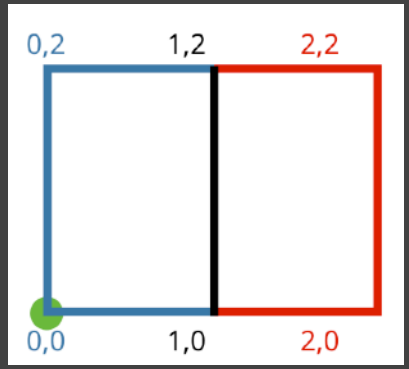
FeatureCollection: Top-level GeoJSON file object

```
{
  “type”: “FeatureCollection”,
  “features”: [
    { “type: “Feature”, “geometry”: … },
    { “type: “Feature”, “geometry”: … }
  ]
}
```

Tools like D3, Vega-Lite, and Observable Plot all use GeoJSON as the primary means of representing geographic data. Points values often use `[longitude, latitude]`, but are not required to. For example, pre-projected planar geometries are also supported.

TopoJSON Format

TopoJSON is a compressed form of GeoJSON that stores *topologies* rather than raw geometries. For example, the border between Colorado and Arizona can be stored only once, then be extracted into separate borders for each state.



Prior to use in visualization, TopoJSON data must be parsed and extracted to geometry data - typically GeoJSON. Vega-Lite includes support to perform this extraction internally.

Otherwise, one can use the topojson-client library:

```
topojson.feature(data, “states") // get feature collection
topojson.mesh(data) // get boundary mesh
```

Resources

Software Tools

Web Tools

d3-geo: projections, paths and more
GeoJSON: JSON format for geo data
TopoJSON: topology -> compressed GeoJSON
MapShaper: online editor for map data
Leaflet: open-source, customizable map tile system

Other

PostGIS: Postgres DB extensions for geo data
Mapnik: Render your own map tiles!

Data Resources

Natural Earth Data
naturalearthdata.com

OpenStreetMap
openstreetmap.org

U.S. Government
nationalatlas.gov, census.gov, usgs.gov

Tutorials

Cartographic Visualization in Vega-Lite

https://observablehq.com/@uwdata/cartographic-visualization

Command-Line Cartography

https://medium.com/@mbostock/command-line-cartography-part-1-897aa8f8ca2c

How to Infer Topology

http://bost.ocks.org/mike/topology/

Questions?