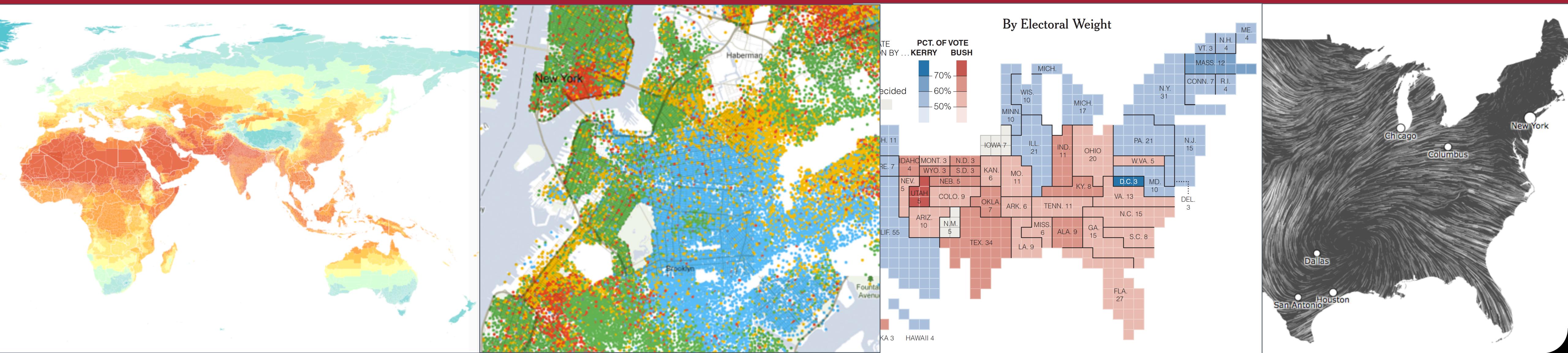


6.894: Interactive Data Visualization Mapping & Cartography

Arvind Satyanarayan



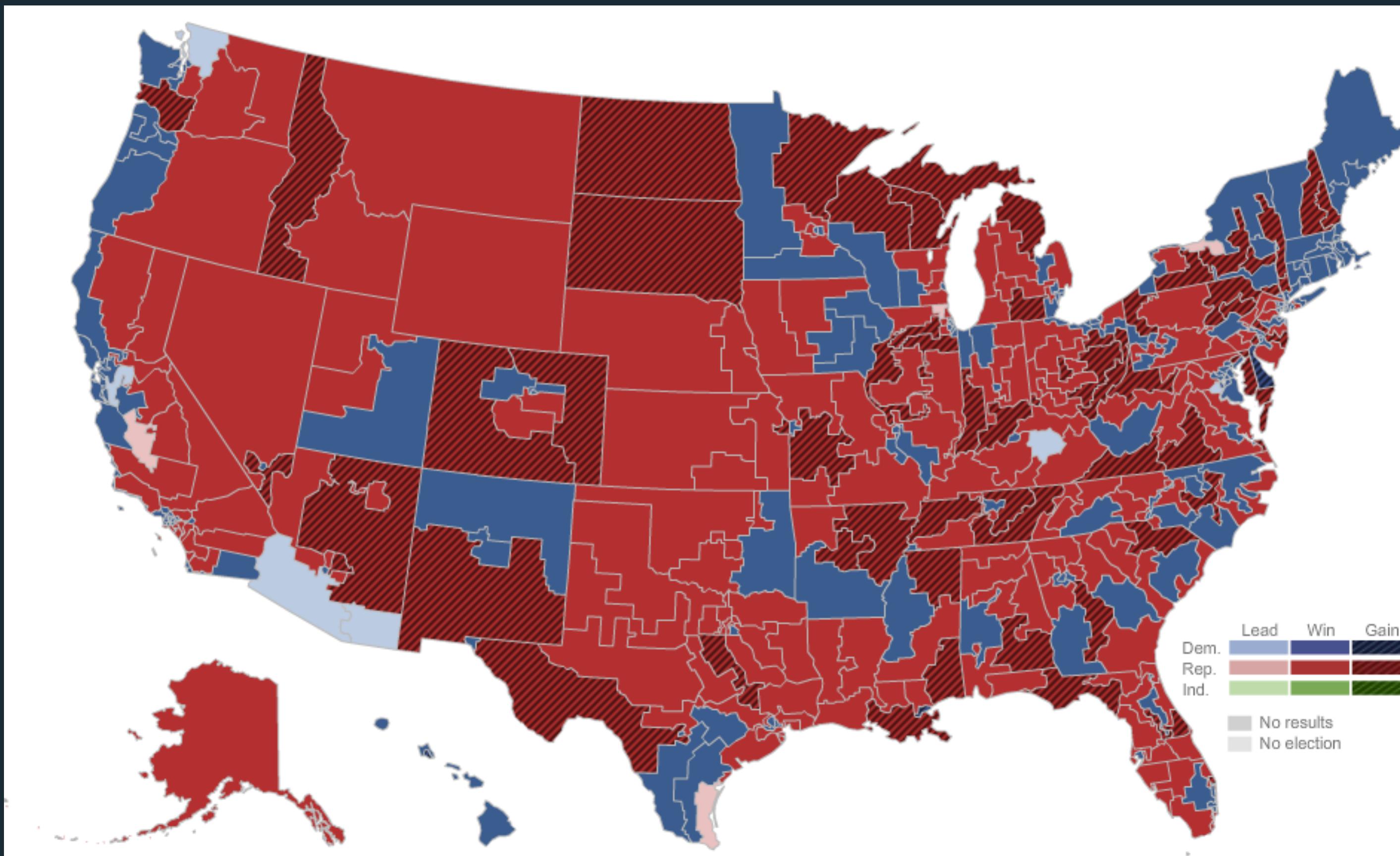
When should we use maps?

When should we use maps?

1. When our data contains geographical attributes (e.g., latitude, longitude, city, state, country, etc.).
2. When visualizing **geographic relationships** is important.

When should we use maps?

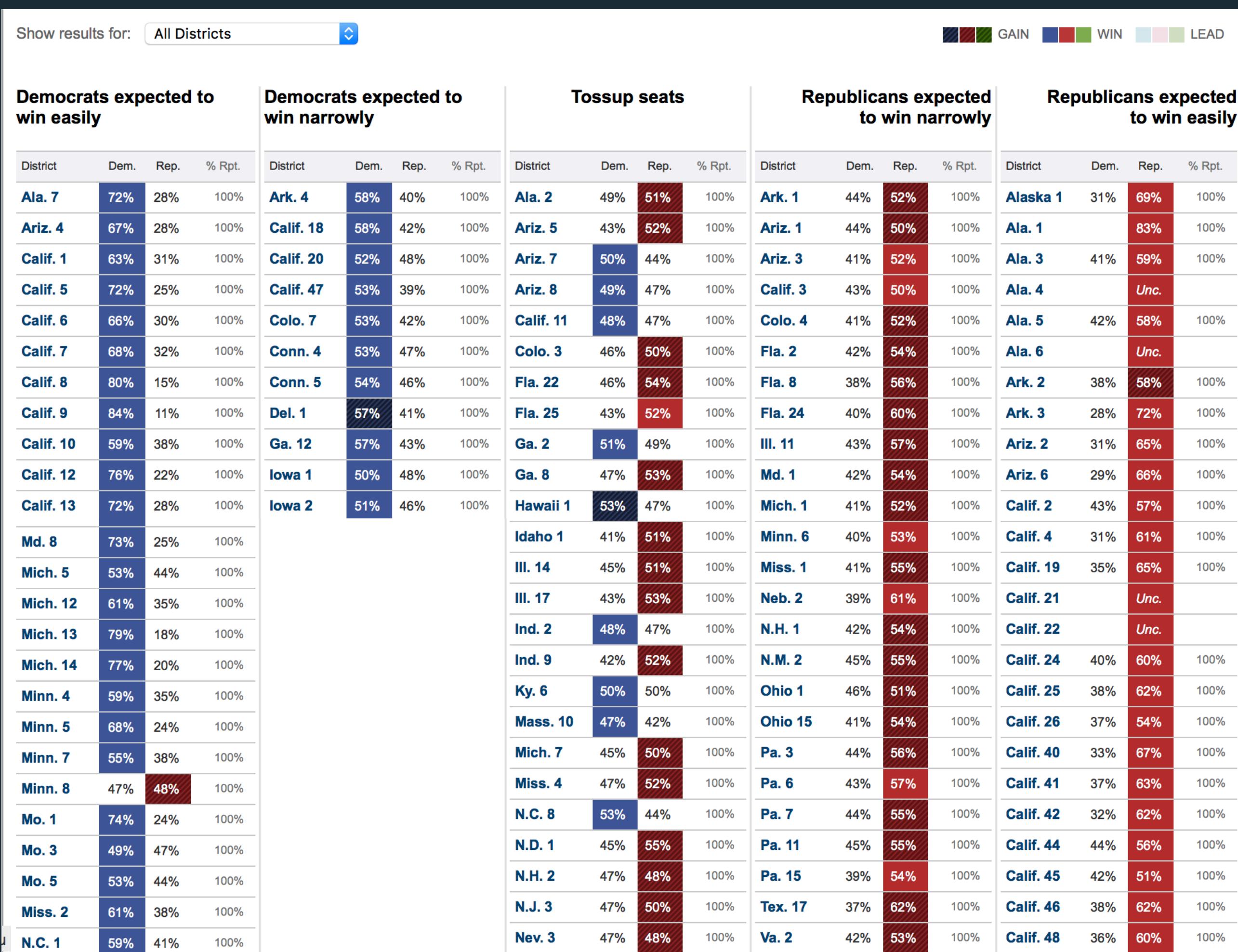
When visualizing **geographic relationships** is important.



- ✓ Who's winning my district?
- ✗ Is it a landslide?
- ✗ What are the paths to victory?

When should we use maps?

When visualizing **geographic relationships** is important.



✓ Who's winning my district?

✓ Is it a landslide?

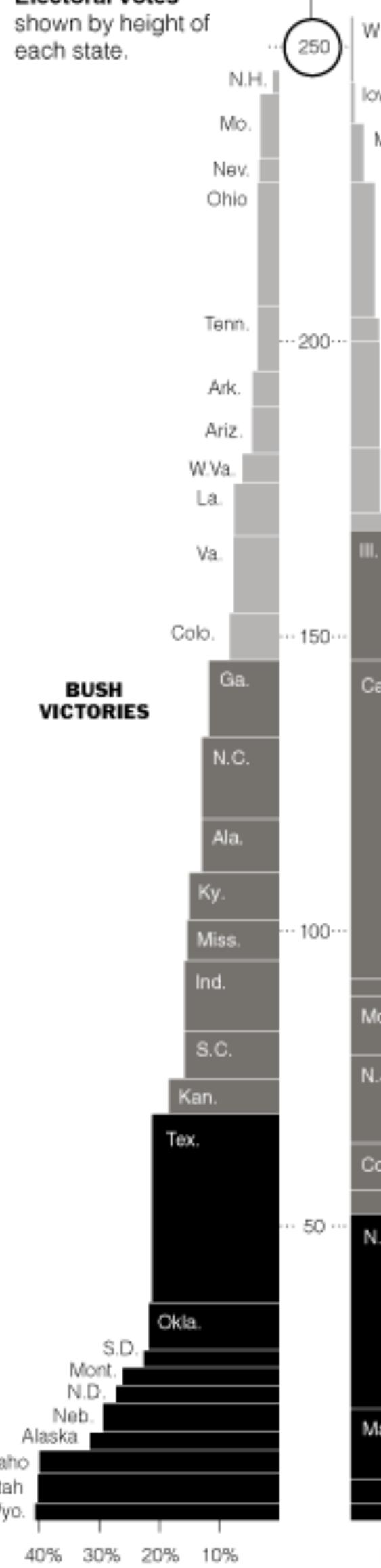
✗ What are the paths to victory?

Building An Electoral Victory

270 electoral votes are needed to win the election.

270

Electoral votes
shown by height of each state.

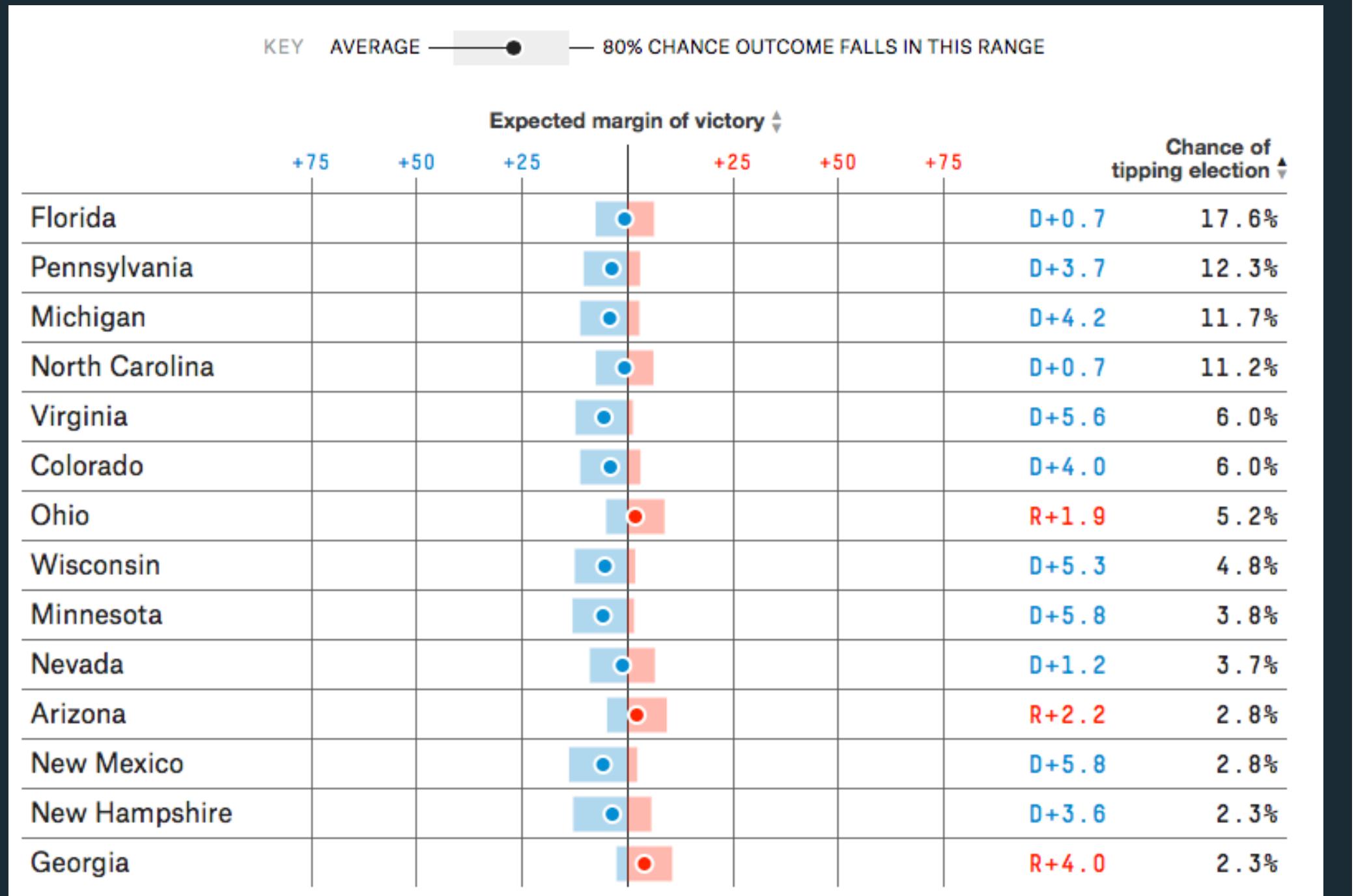
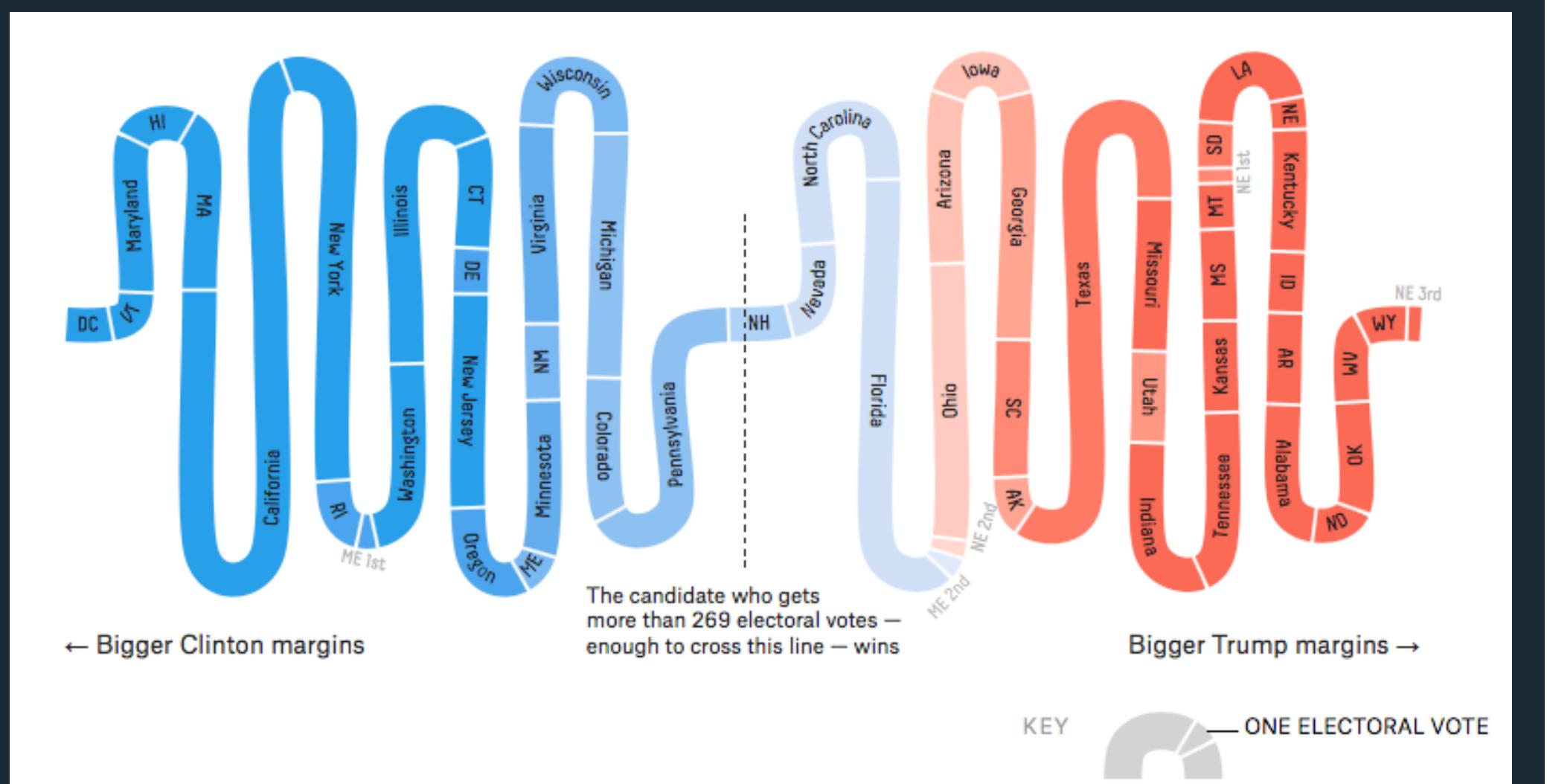
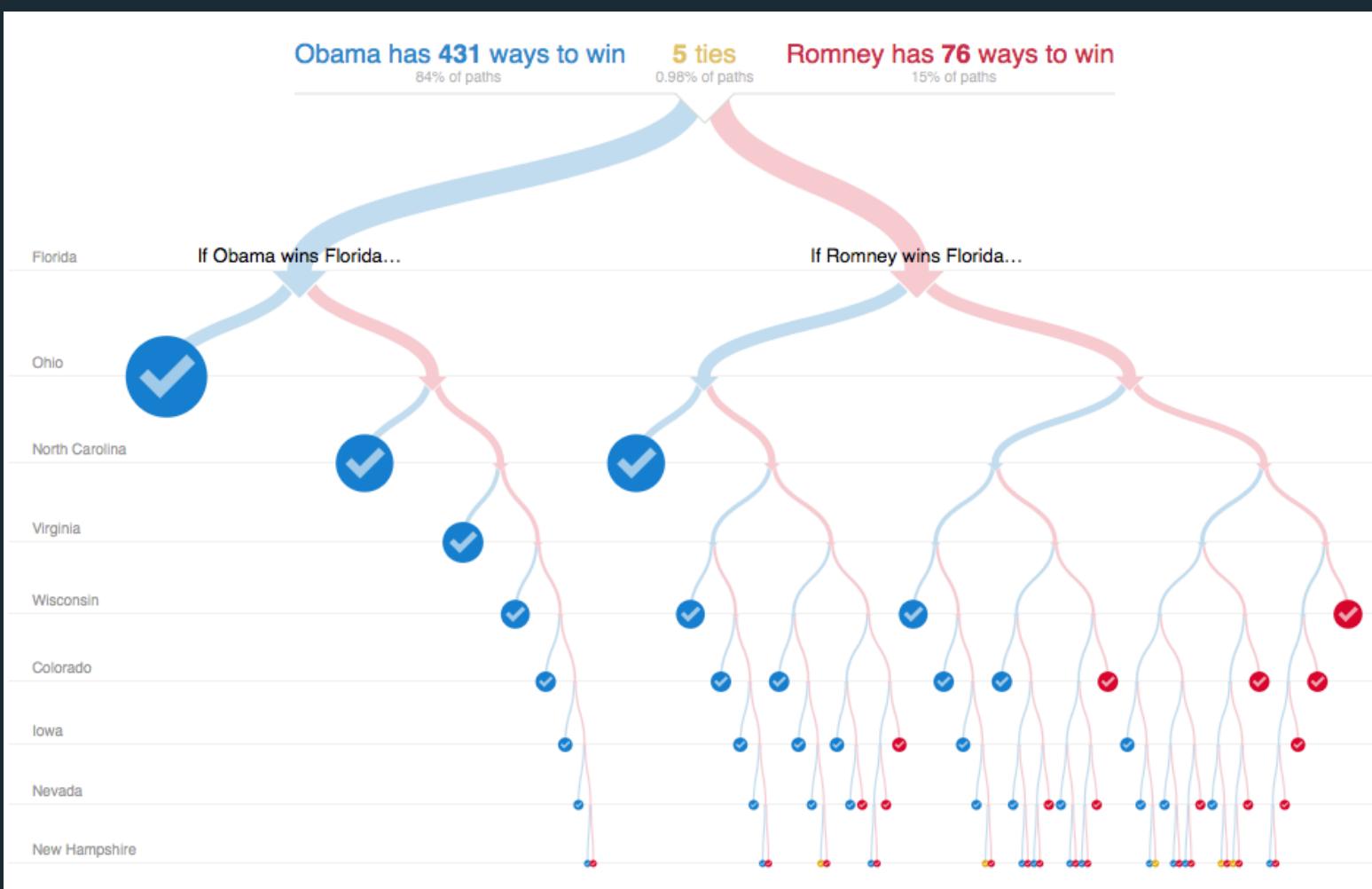


Because most states award electoral votes in a winner-take-all contest, even a slim statewide victory can catapult a candidate toward election. Electoral votes versus percentage margin of victory.

■ States won by less than 10 percent of the popular vote.

■ States won by 10 to 20 percent of the popular vote.

■ States won by more than 20 percent of the popular vote.



Margin of victory for each candidate shown by the width of each state.

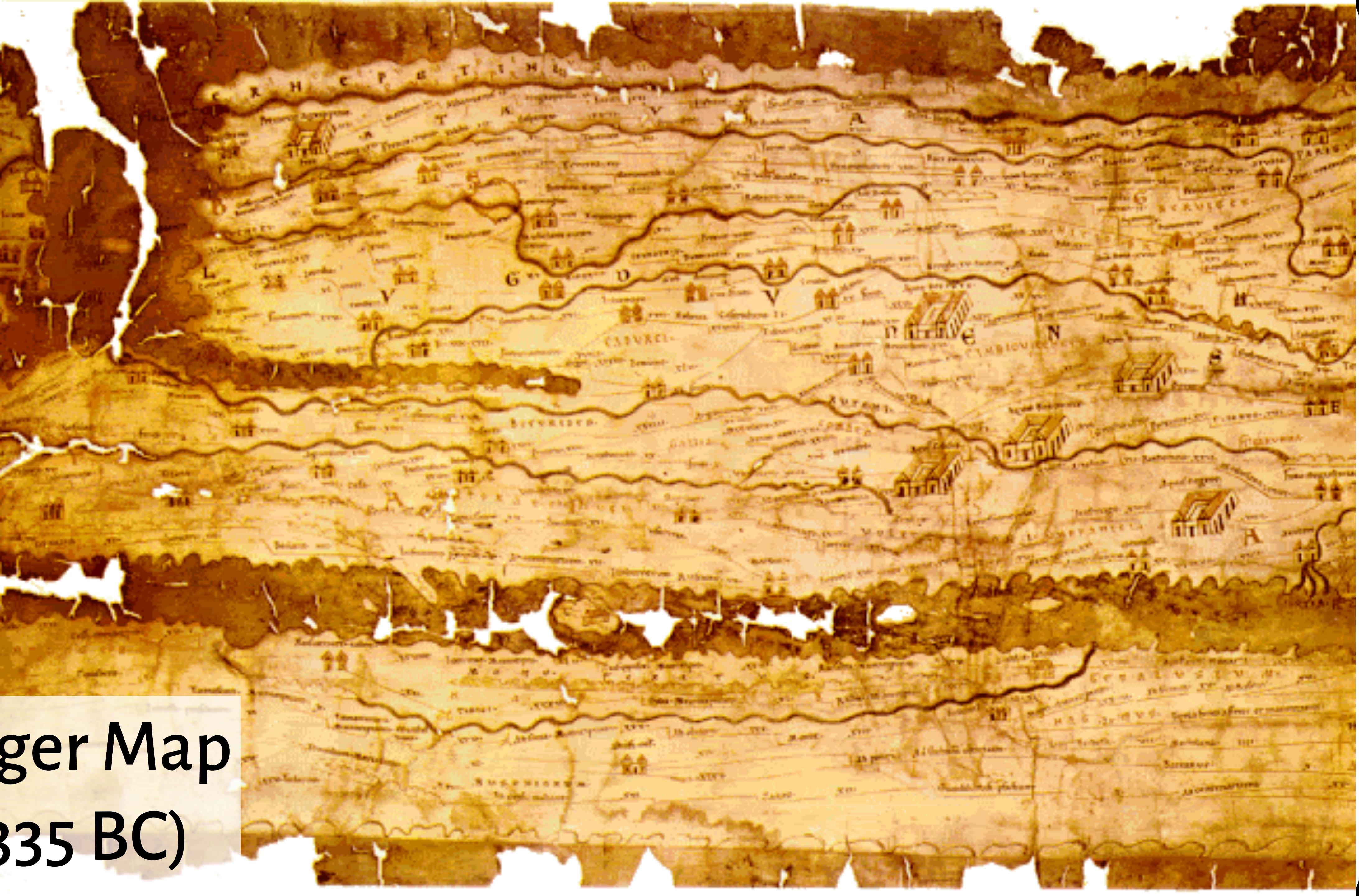
Cartography

(Map Making)

Oldest Known Map: Konya, Turkey (~6200 BC)



Peutinger Map
(366–335 BC)



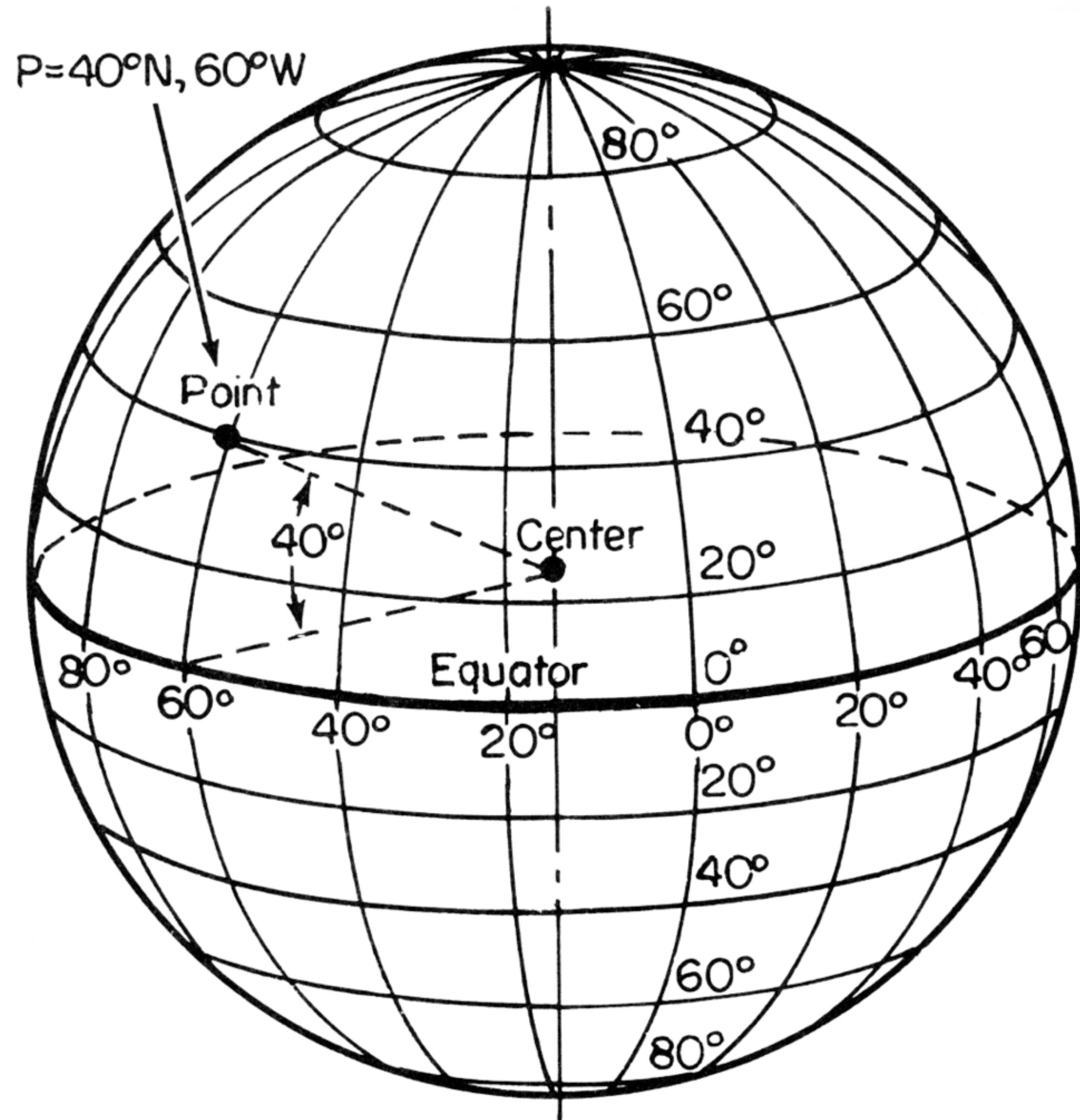


Ptolemy's World Map (~150 AD)

Latitude (ϕ): Angle north/south from the equator.

Longitude (λ): Angle east/west from the Prime Meridian.

Graticule: The grid formed by lines of latitude and longitude.



What's the right way to flatten a sphere?



Map Projections

Projection Surface

Cylindrical

Conic

Planar (Azimuthal)

Metric Preservation

Equal-Area

Equidistant

Conformal (Preserve Angle)

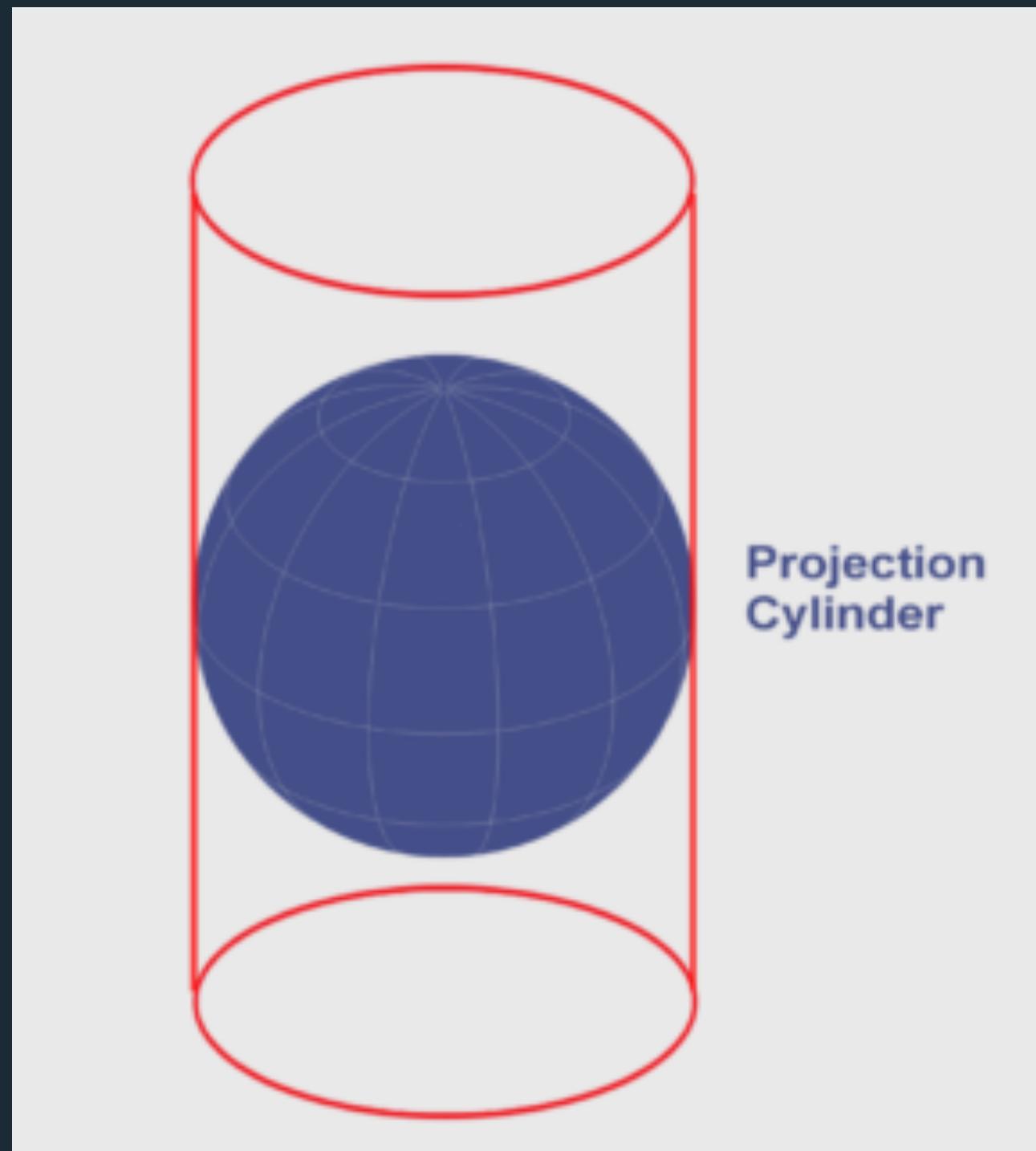
Map Projections

Projection Surface

Cylindrical

Conic

Planar (Azimuthal)



<https://gisgeography.com/cylindrical-projection/>

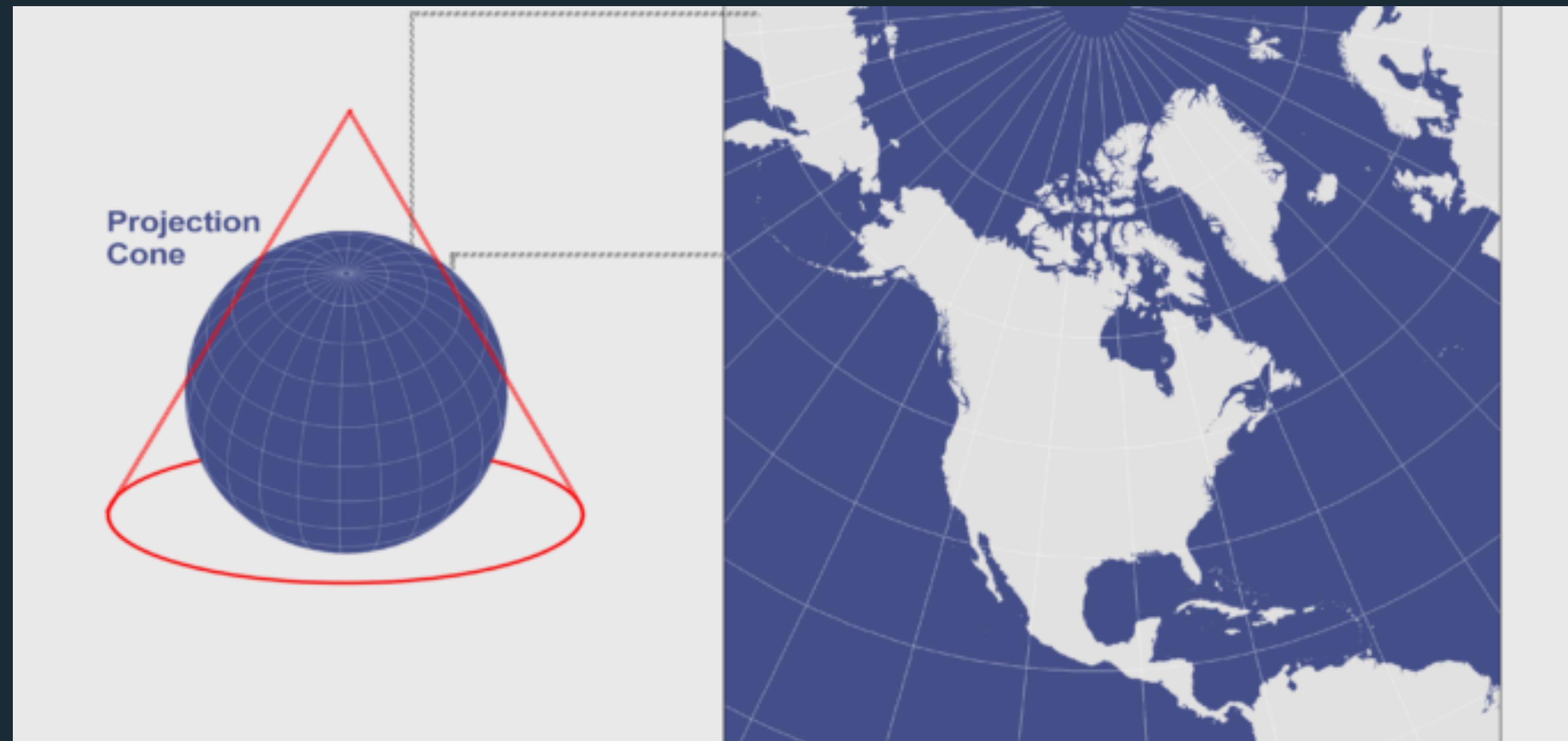
Map Projections

Projection Surface

Cylindrical

Conic

Planar (Azimuthal)



<https://gisgeography.com/conic-projection-lambert-albers-polyconic/>

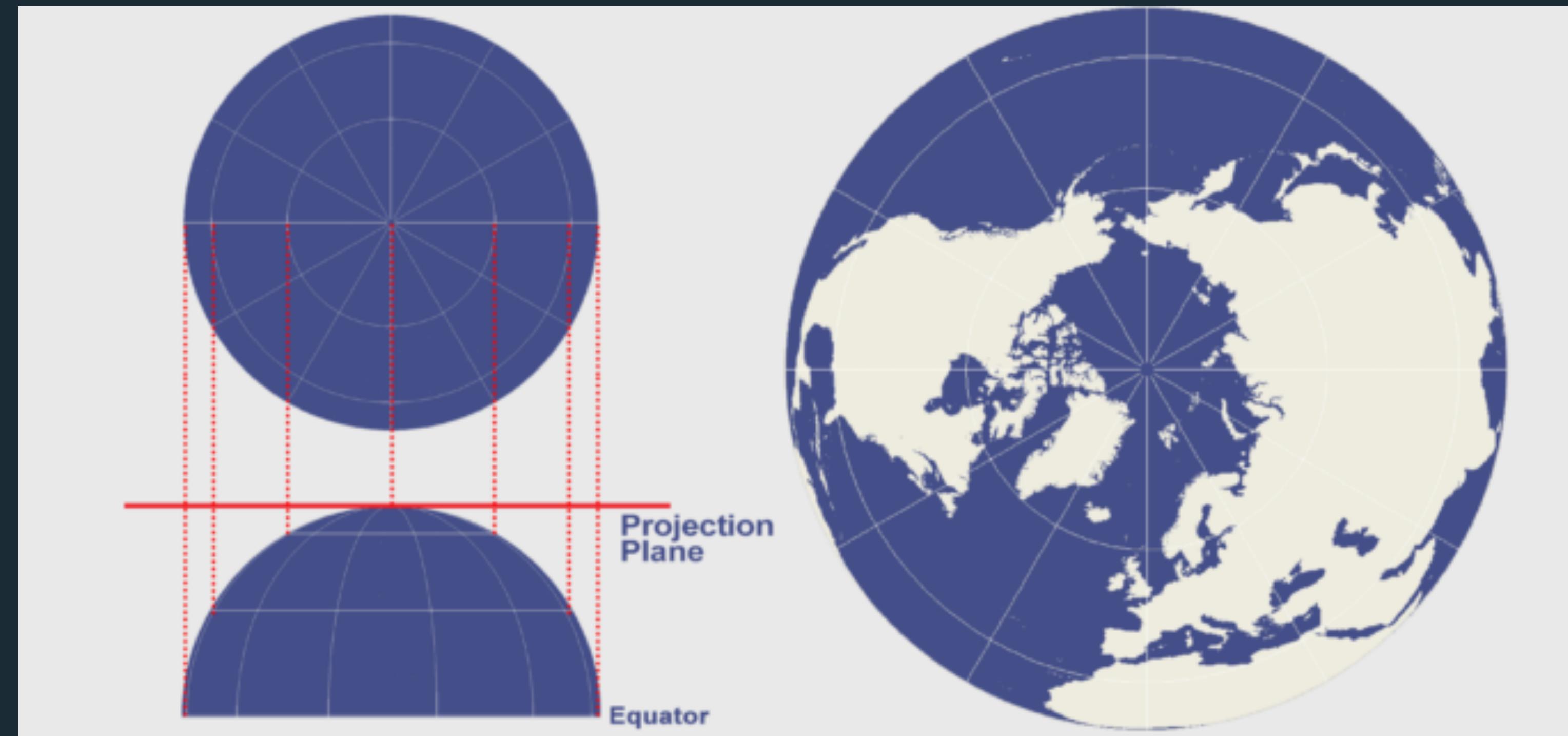
Map Projections

Projection Surface

Cylindrical

Conic

Planar (Azimuthal)



<https://gisgeography.com/azimuthal-projection-orthographic-stereographic-gnomonic/>

Map Projections

Projection Surface

Cylindrical

Conic

Planar (Azimuthal)

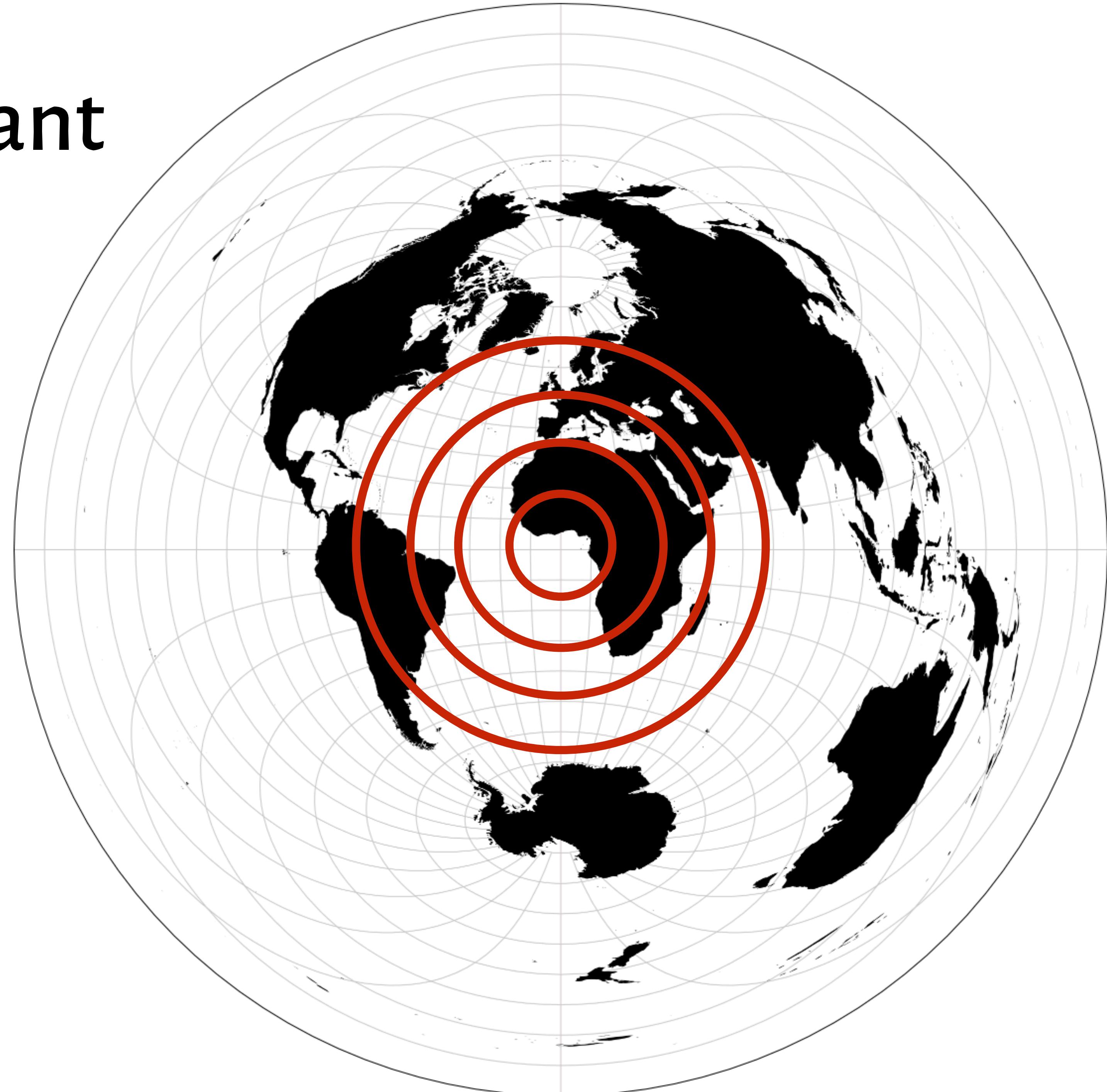
Metric Preservation

Equal-Area

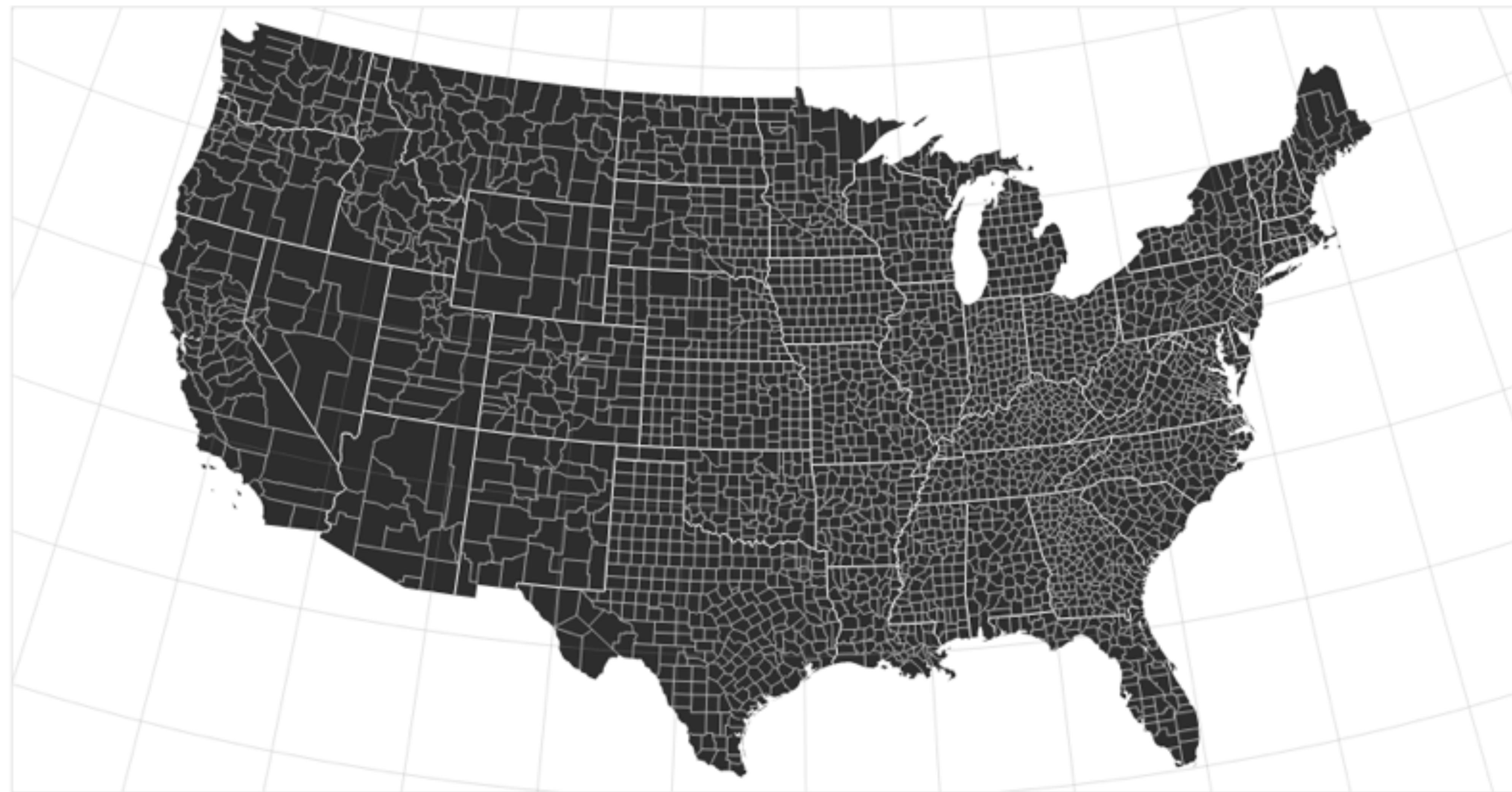
Equidistant

Conformal (Preserve Angle)

Azimuthal Equidistant



Albers Equal-Area Conic



Mercator



Rhumb Lines



Mercator

Web Mercator cuts off latitude at 85.051129° : the exact point at which the projection frames the world in a square.



Original Poster
jfricker

8/4/09

Why does Google maps use the inaccurate, ancient and distorted Mercator Projection? 1 expert reply

Dear Google Maps,

Every time I see a "Powered By Google" website display the default Google world map, I wince and wonder "why does the most sophisticated information technology company in the world use the most distorted and archaic world map known to humankind?".

The Mercator Projection distorts the world, giving the false impression that Greenland is the size of South America, Asia is ginormous and Alaska is bigger than Mexico - all inaccuracies that are being presented by Google. Google's reputation for accuracy means that these distortions are reinforced in our conscience as facts.

[... More](#)

Expert Reply

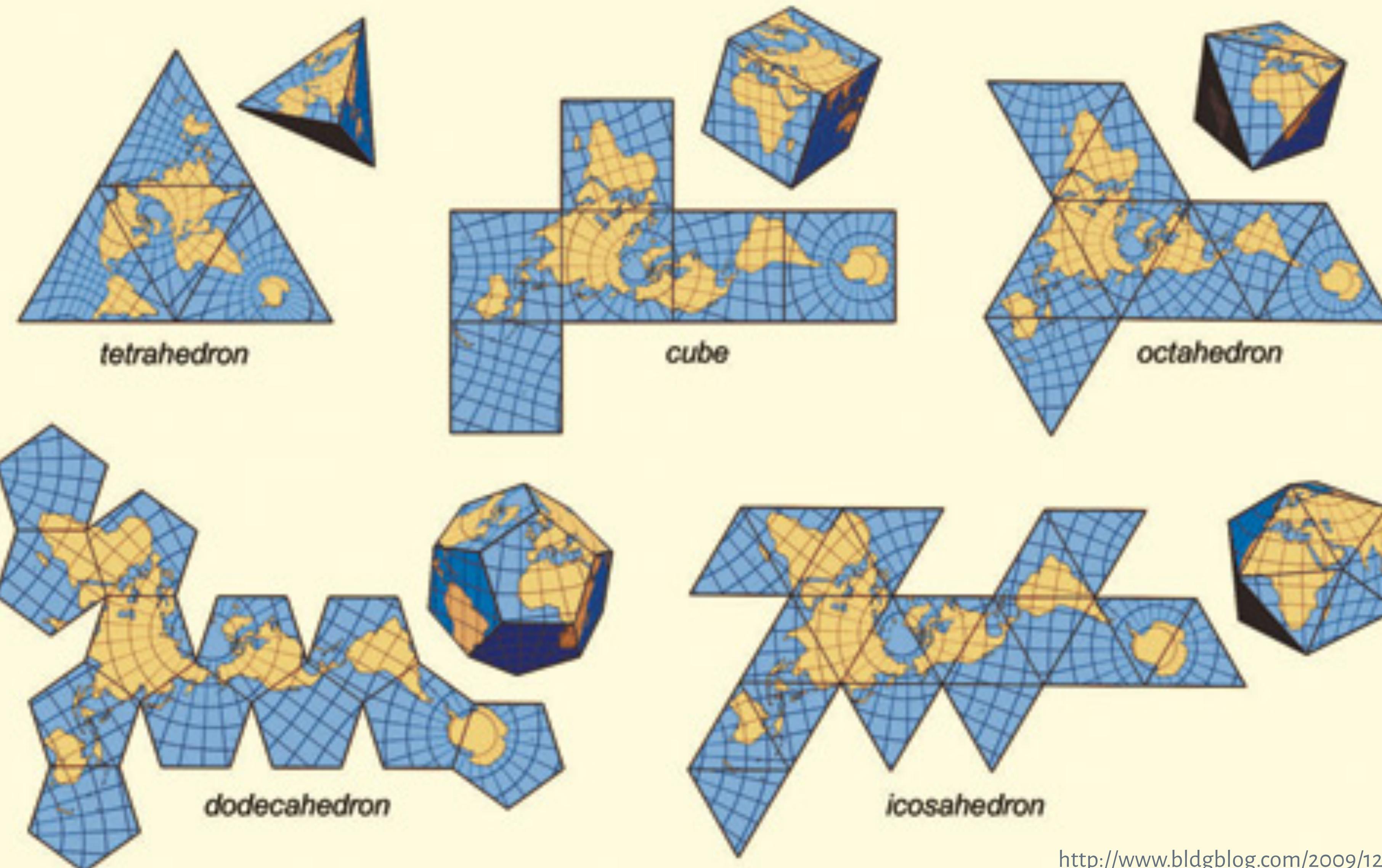


Expert - Google Employee
Joel H

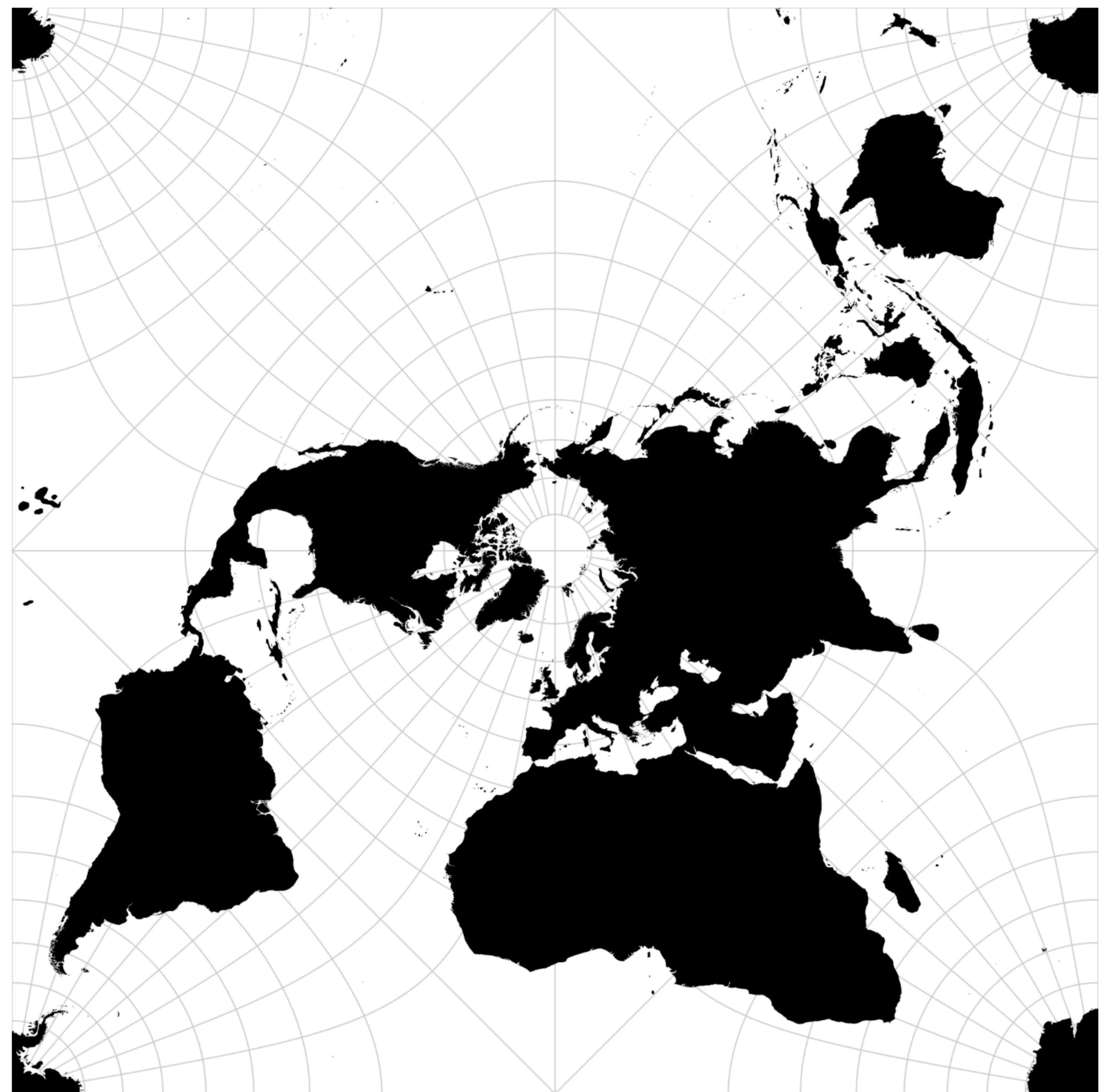
8/4/09

Hi John - Thanks for the feedback. Maps uses Mercator because it preserves angles. The first launch of Maps actually did not use Mercator, and streets in high latitude places like Stockholm did not meet at right angles on the map the way they do in reality. While this distorts a 'zoomed-out view' of the map, it allows close-ups (street level) to appear more like reality. The majority of our users are looking down at the street level for businesses, directions, etc... so we're sticking with this projection for now. In the meantime, you might want to look at our favorite 3D view of the world. [1]

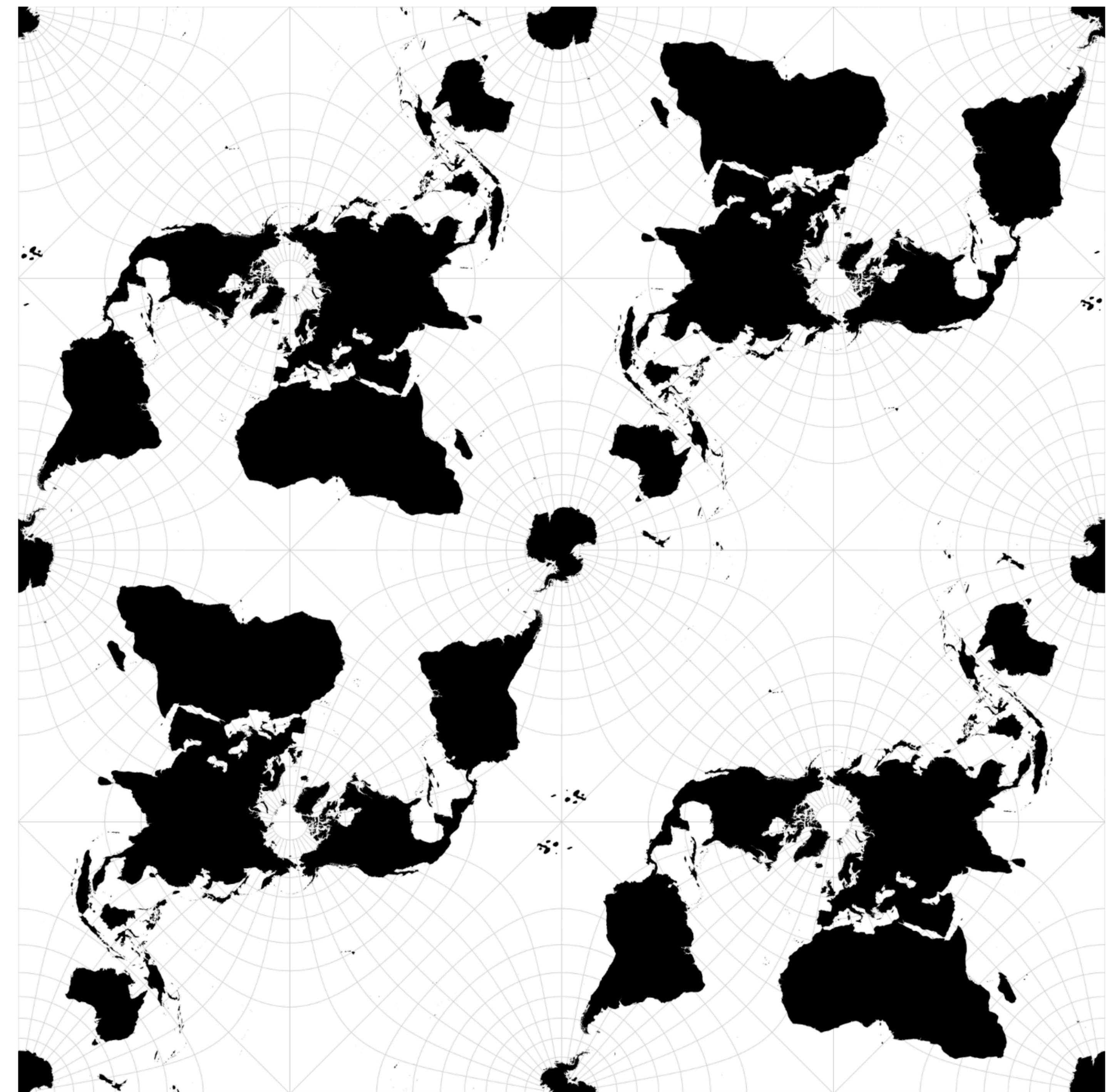
There's no right way to flatten the Earth!



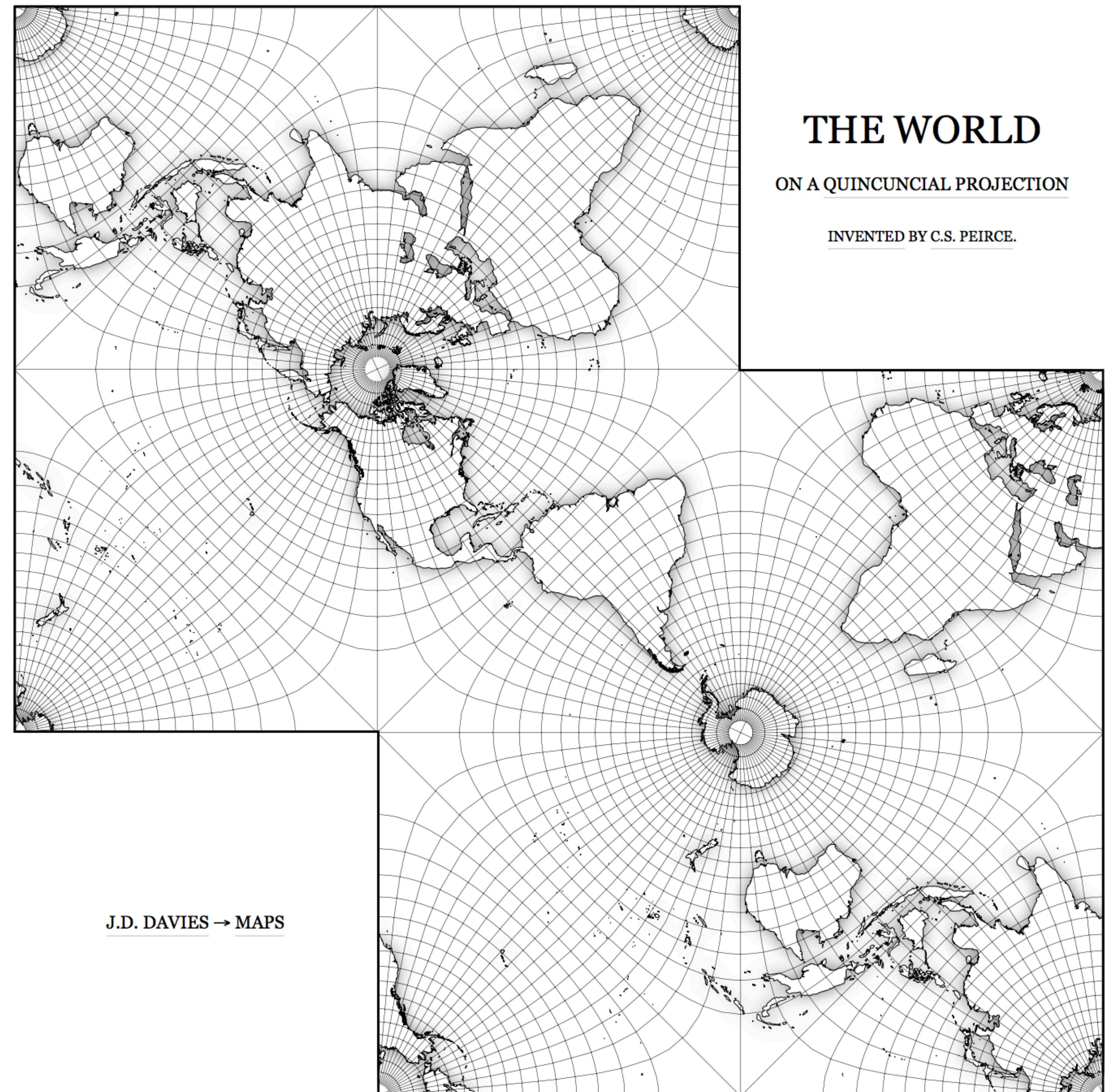
Peirce Quincuncial



Peirce Quincuncial



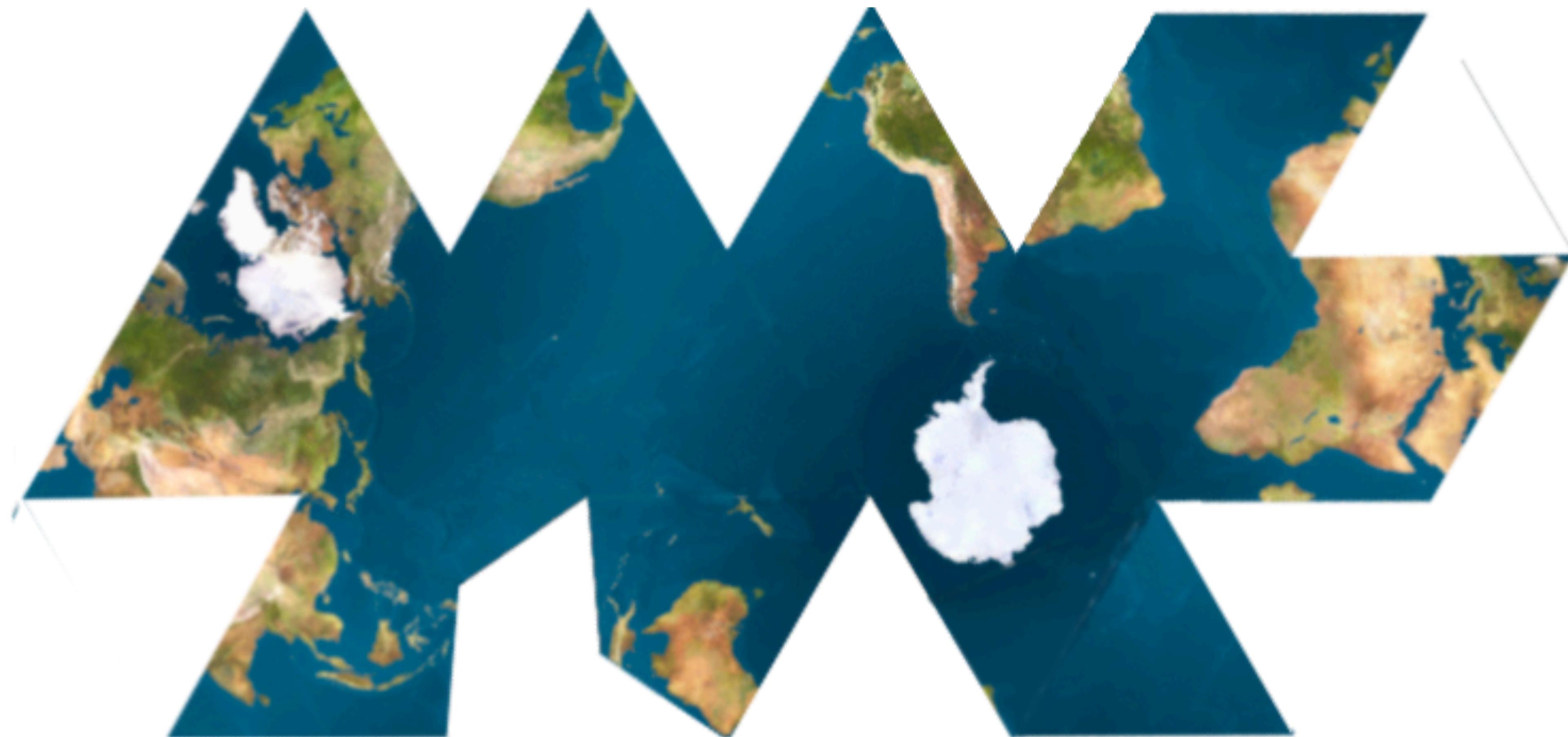
Peirce Quincuncial



Dymaxion (Fuller) Map



Dymaxion (Fuller) Map



WHAT YOUR FAVORITE
MAP PROJECTION
SAYS ABOUT YOU

<https://xkcd.com/977/>

MERCATOR



YOU'RE NOT REALLY INTO MAPS.

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!

WHAT YOUR FAVORITE

MAP PROJECTION

SAYS ABOUT YOU

<https://xkcd.com/977/>

Dymaxion



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

WHAT YOUR FAVORITE

MAP PROJECTION

SAYS ABOUT YOU

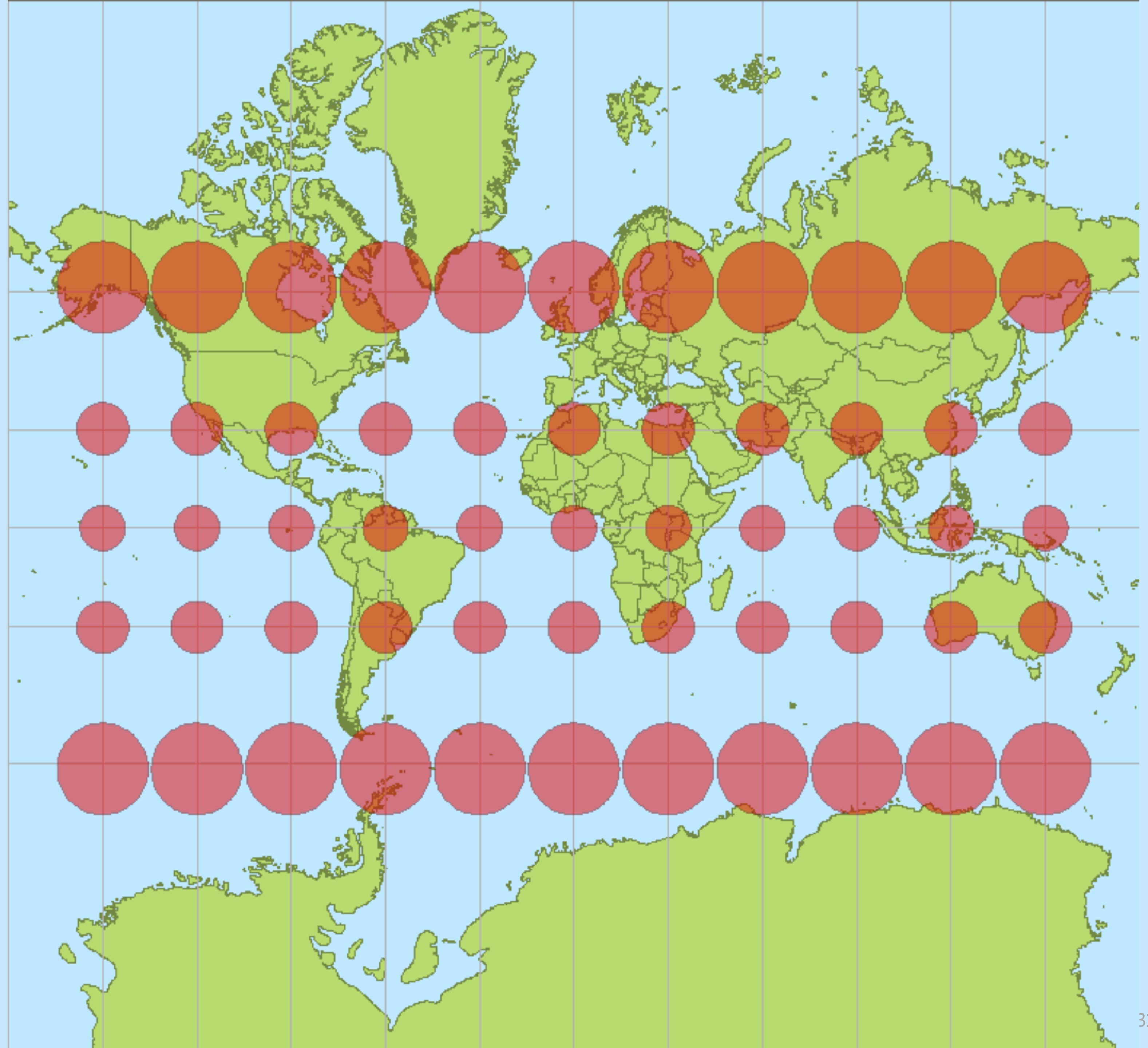
PEIRCE QUINCUNCIAL



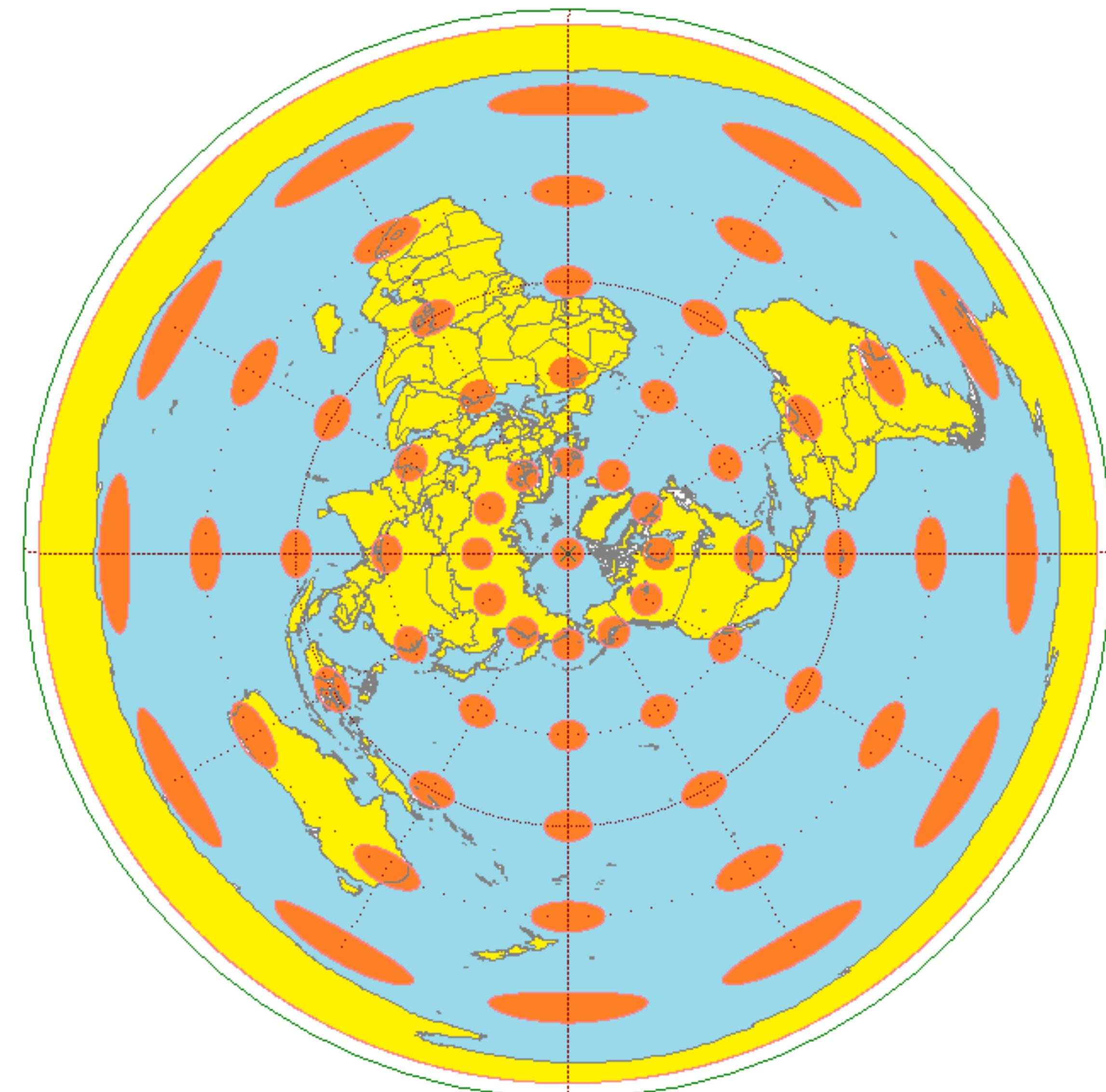
YOU THINK THAT WHEN WE LOOK AT A MAP, WHAT WE
REALLY SEE IS OURSELVES. AFTER YOU FIRST SAW
INCEPTION, YOU SAT SILENT IN THE THEATER FOR
SIX HOURS. IT FREAKS YOU OUT TO REALIZE THAT
EVERYONE AROUND YOU HAS A SKELETON INSIDE THEM.
YOU HAVE REALLY LOOKED AT YOUR HANDS.

<https://xkcd.com/977/>

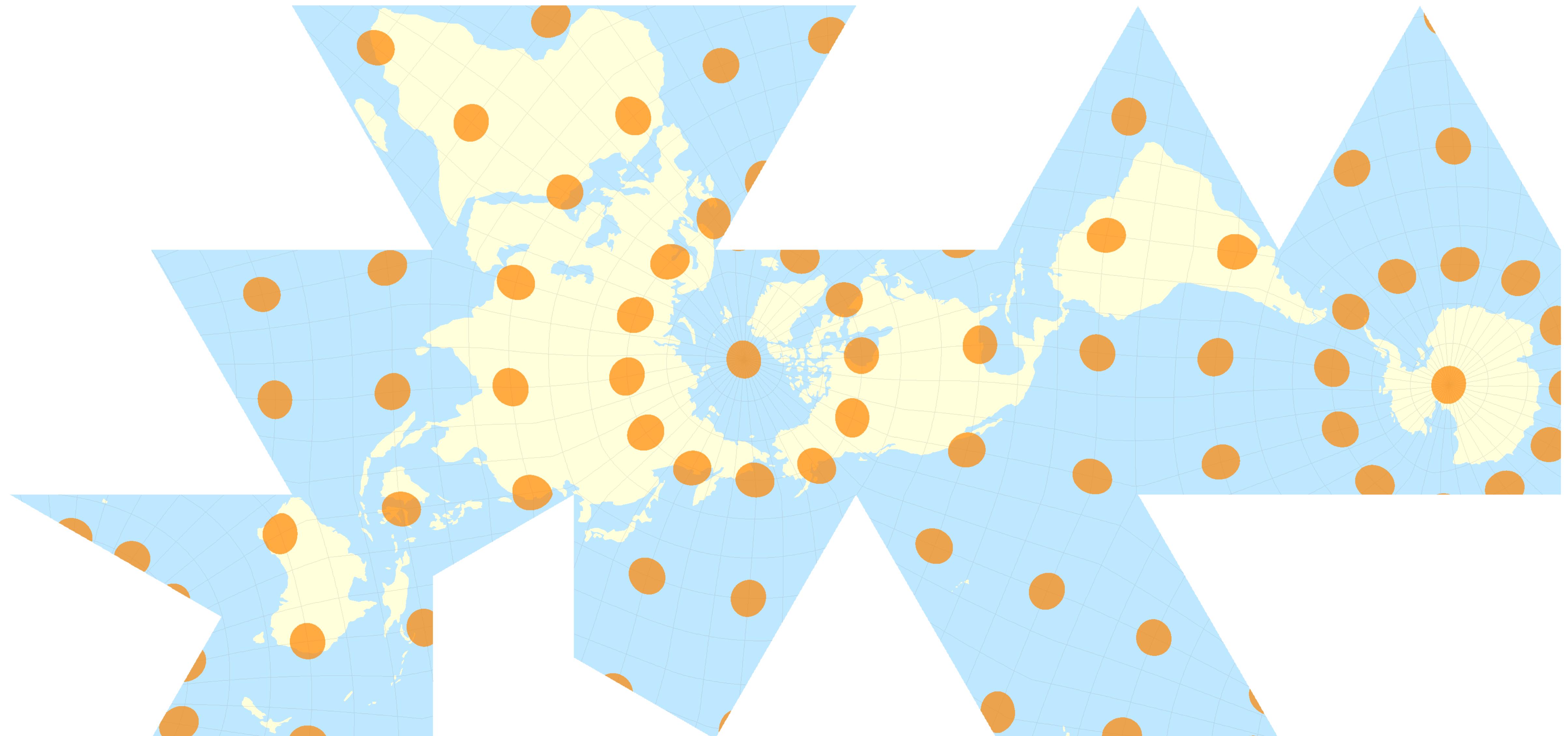
Tissot's Indicatrix



Tissot's Indicatrix (Azimuthal Equidistant)



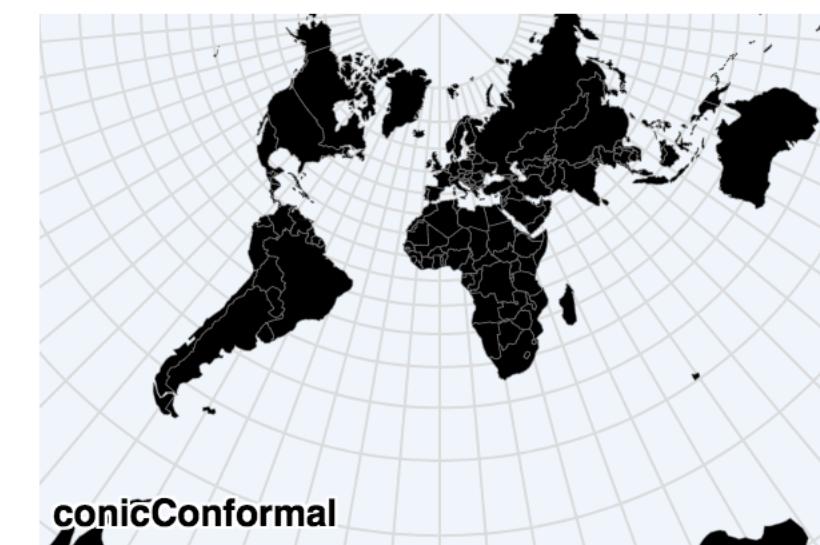
Tissot's Indicatrix (Dymaxion Map)



Projections Example



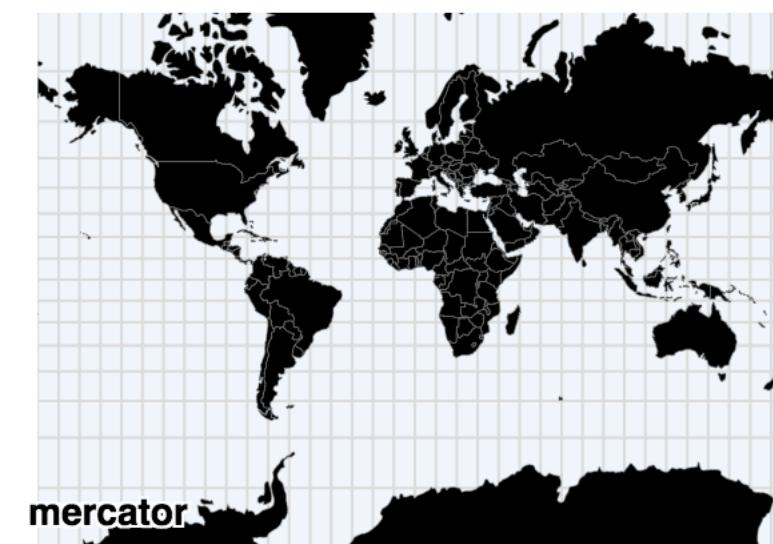
azimuthalEquidistant



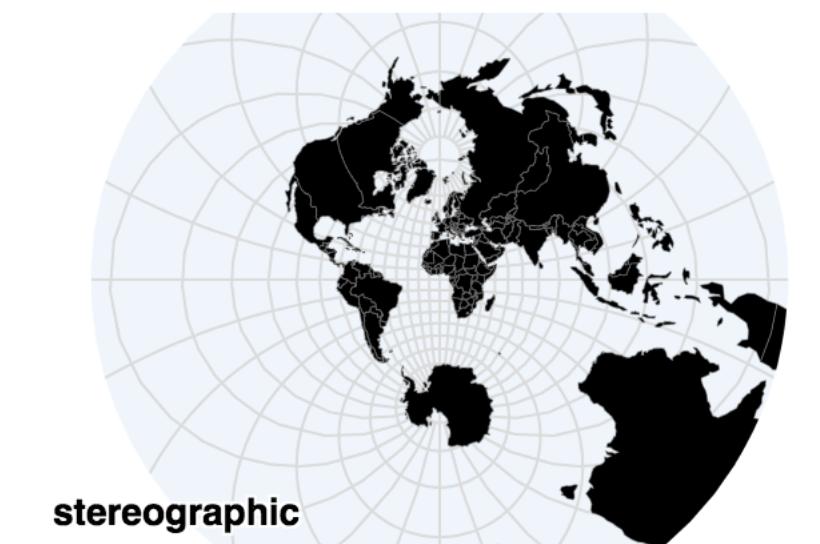
conicConformal



gnomonic



mercator



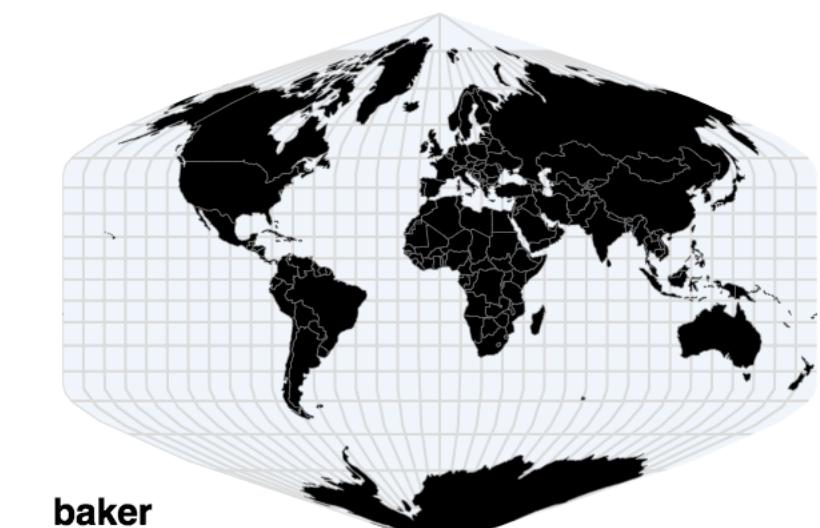
stereographic



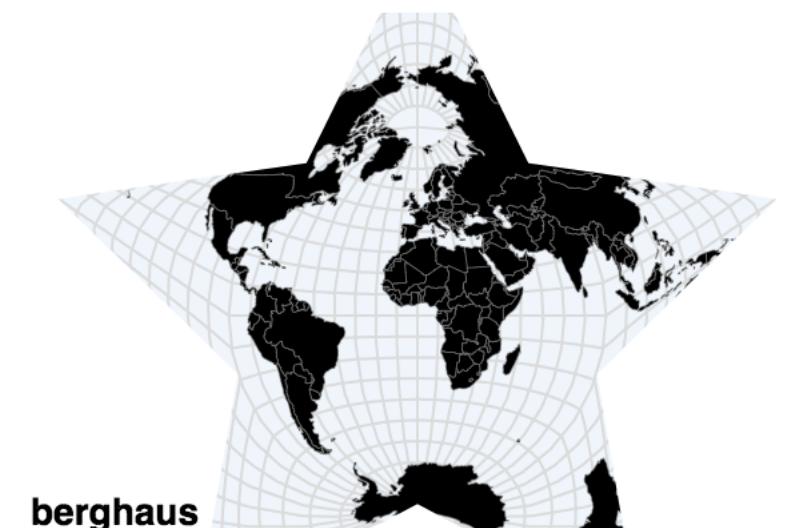
airy



armadillo

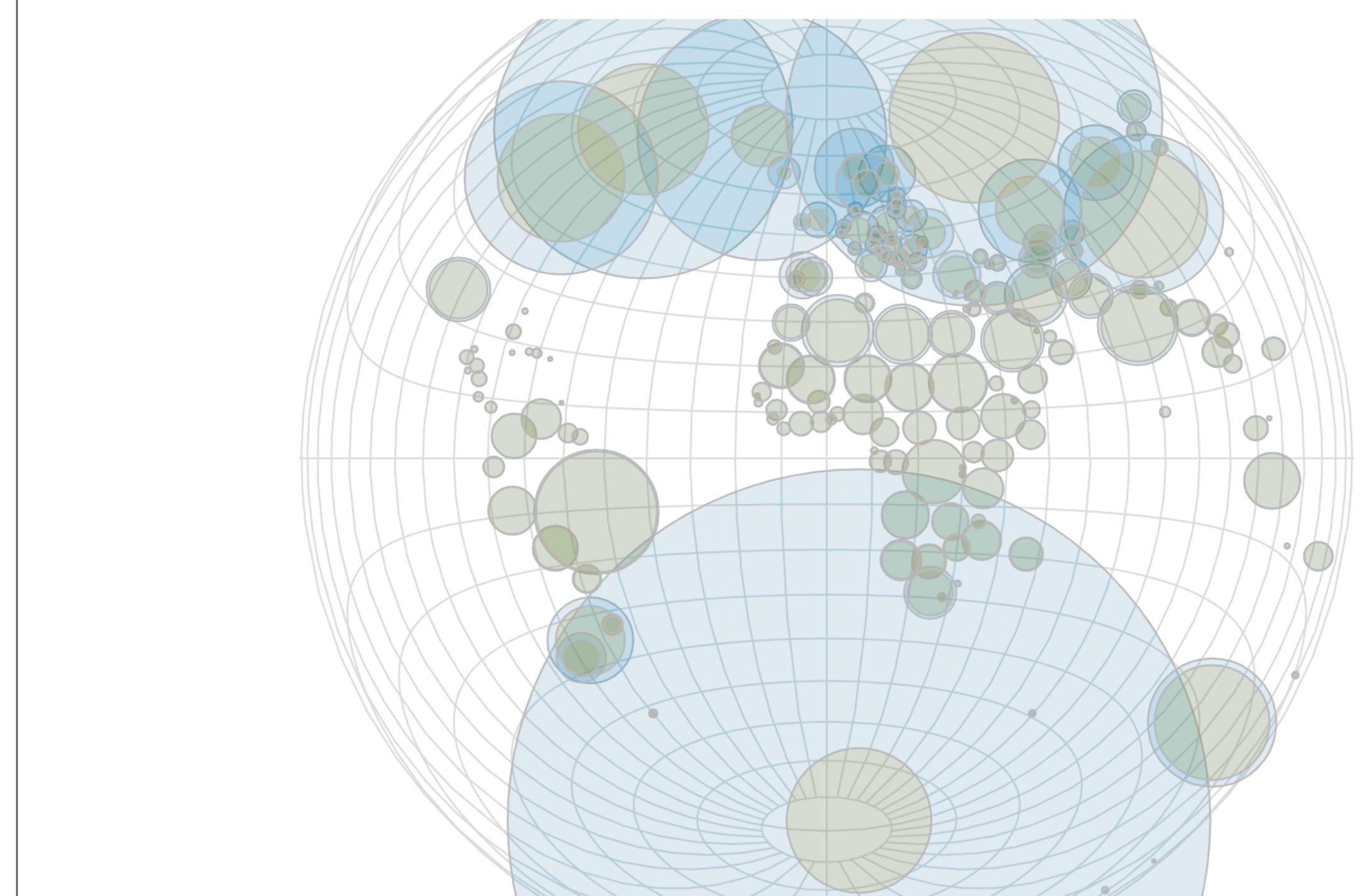


baker



berghaus

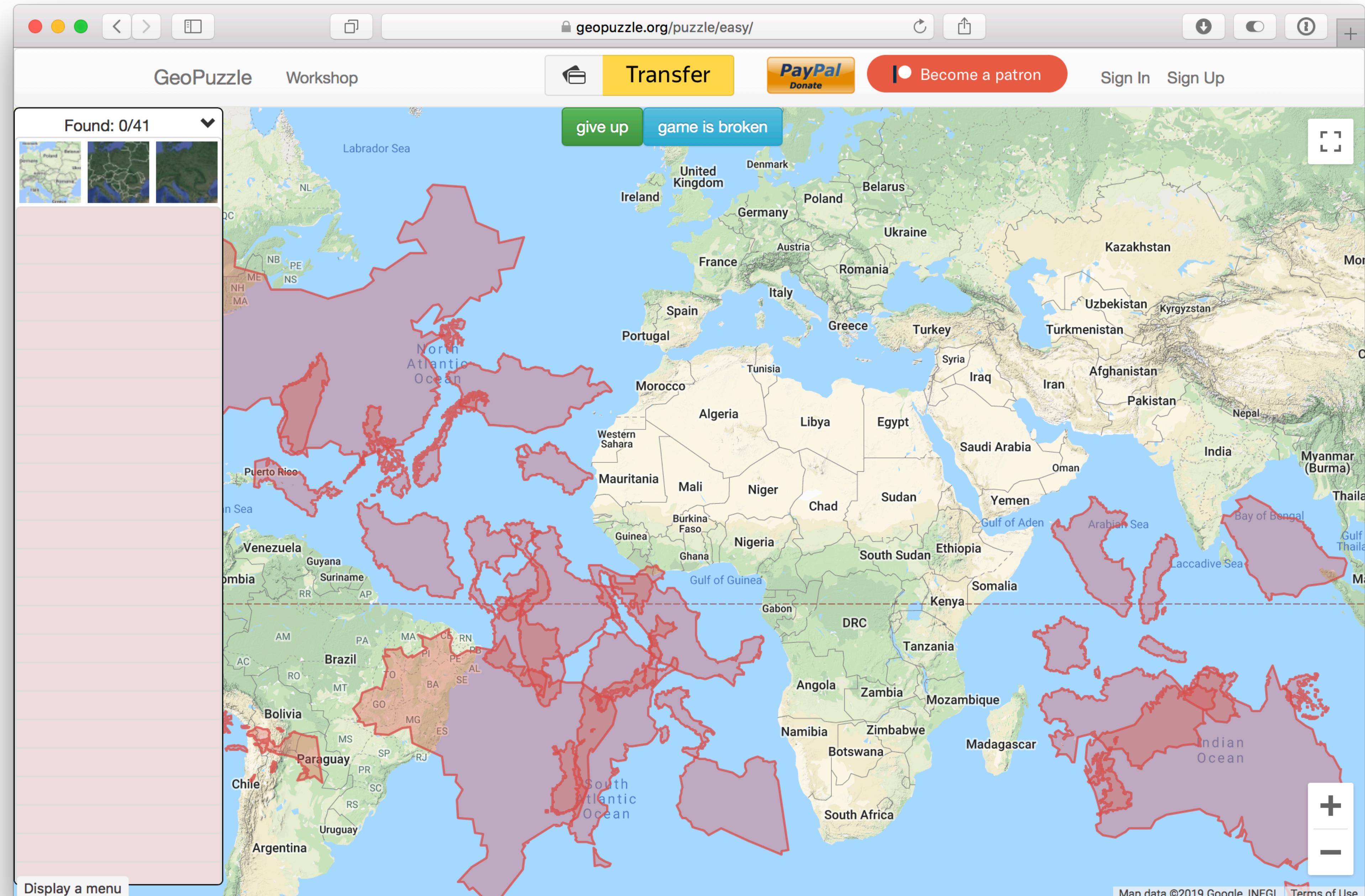
Distortion Comparison Example



baseProjection altProjection baseColor altColor

<https://vega.github.io/vega/examples/projections/>

<https://vega.github.io/vega/examples/distortion-comparison/>



Cartography

(Map Making)

Mapping

(Visualizing Geospatial Data)

How does the data change?

Where
does the
data occur?

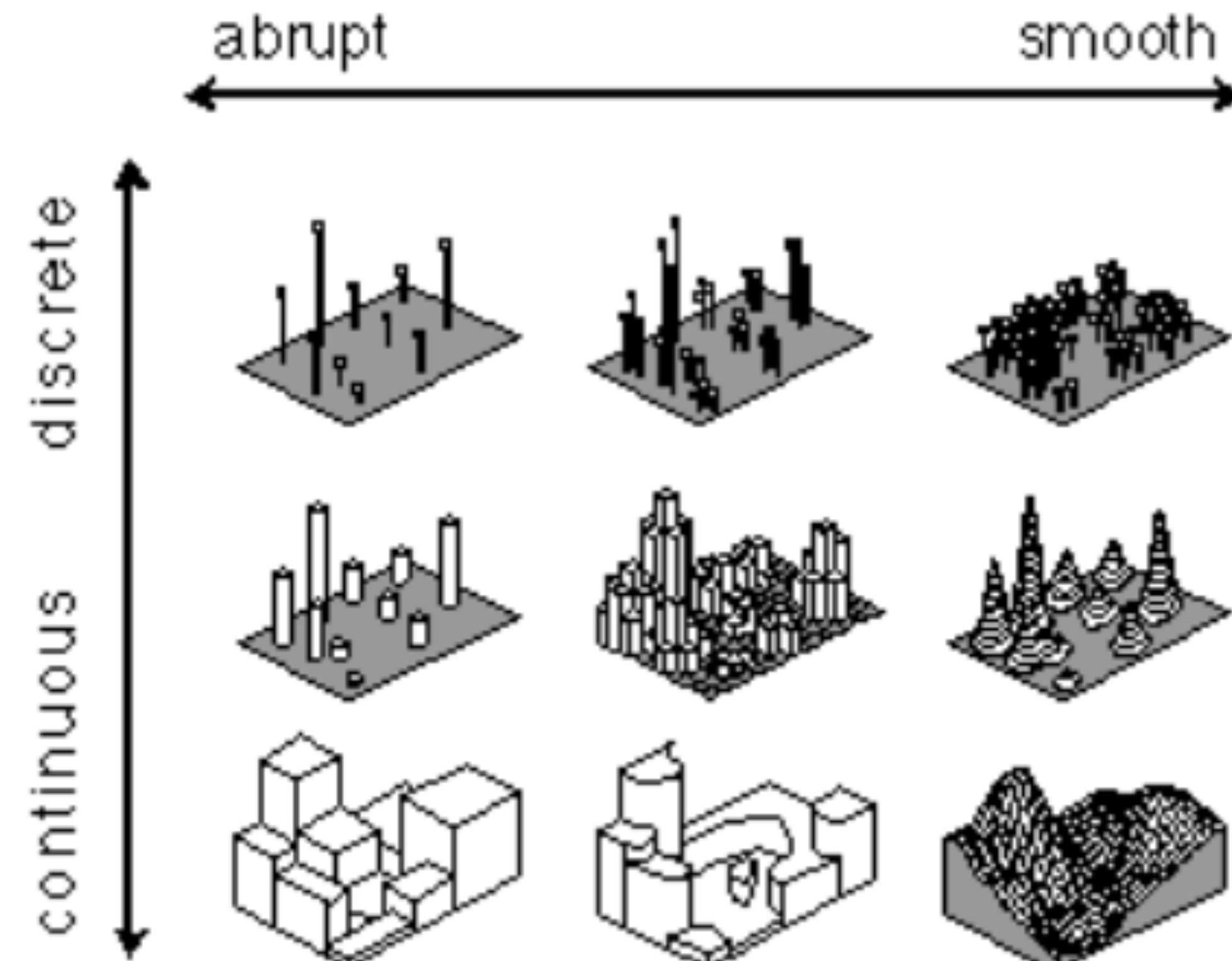


Fig. 8. Data models representing points in the continuity-abruptness phenomena space.

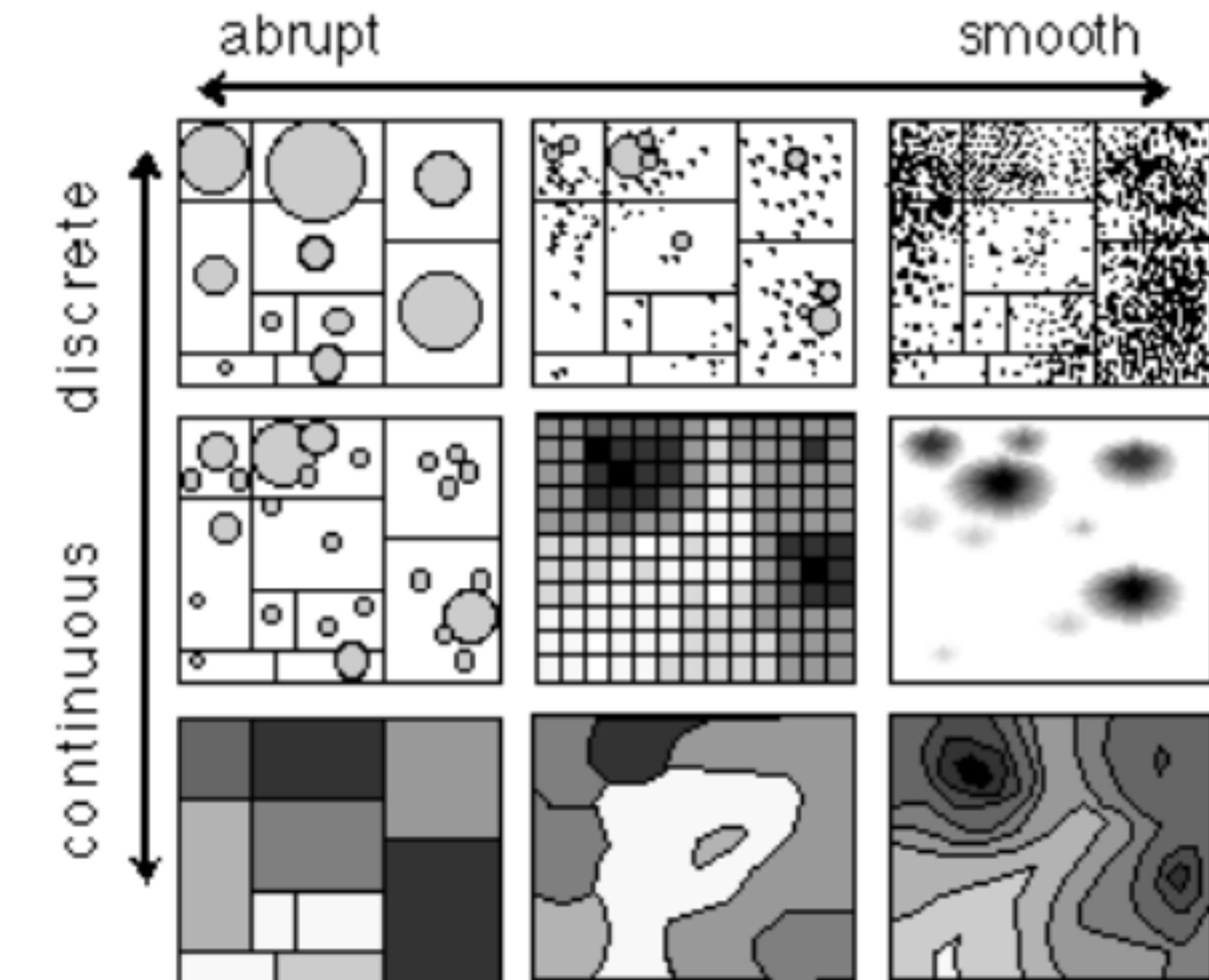


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

[MacEachren. Visualizing Uncertain Information. 1992]

Dot Distribution Map

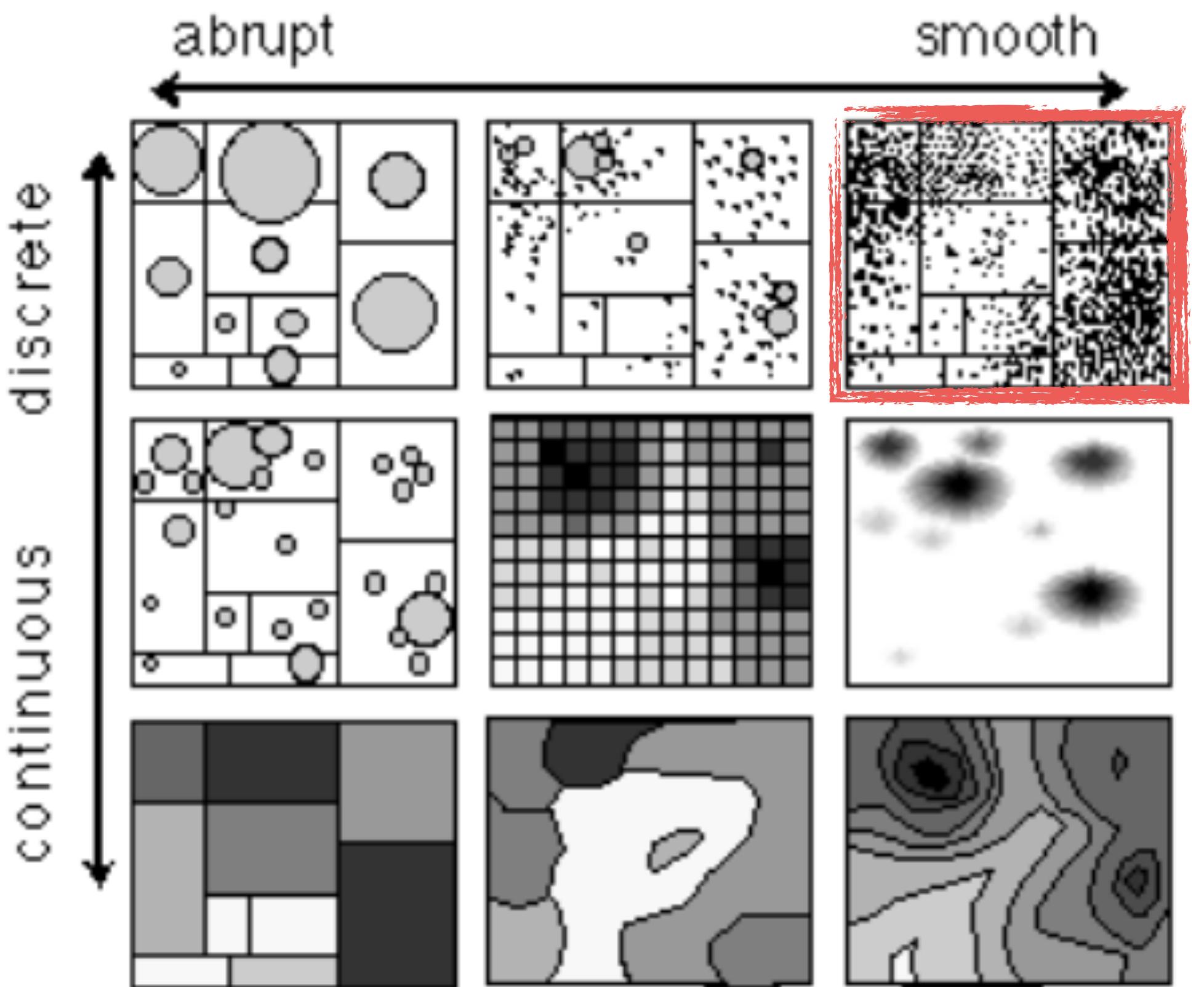


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

[MacEachren. Visualizing Uncertain Information. 1992]

A TAXONOMY OF TRANSITIONS

racial / ethnic self-identification in chicago in the year 2000

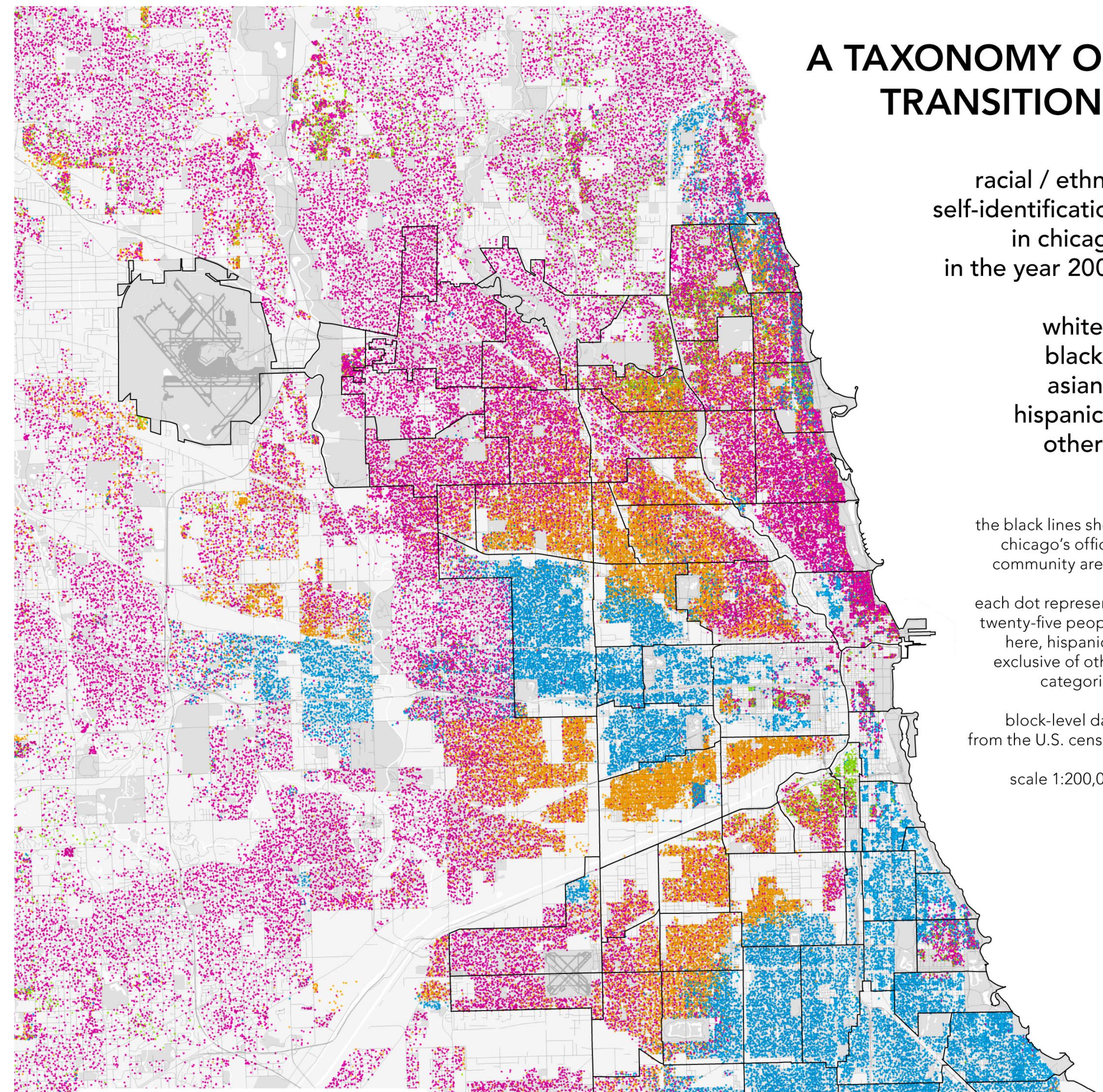
white ■
black ■
asian ■
hispanic ■
other ■

the black lines show chicago's official community areas.

each dot represents twenty-five people. here, hispanic is exclusive of other categories.

block-level data from the U.S. census.

scale 1:200,000



<http://www.radicalcartography.net/index.html?chicagodots>

Dot Distribution Map

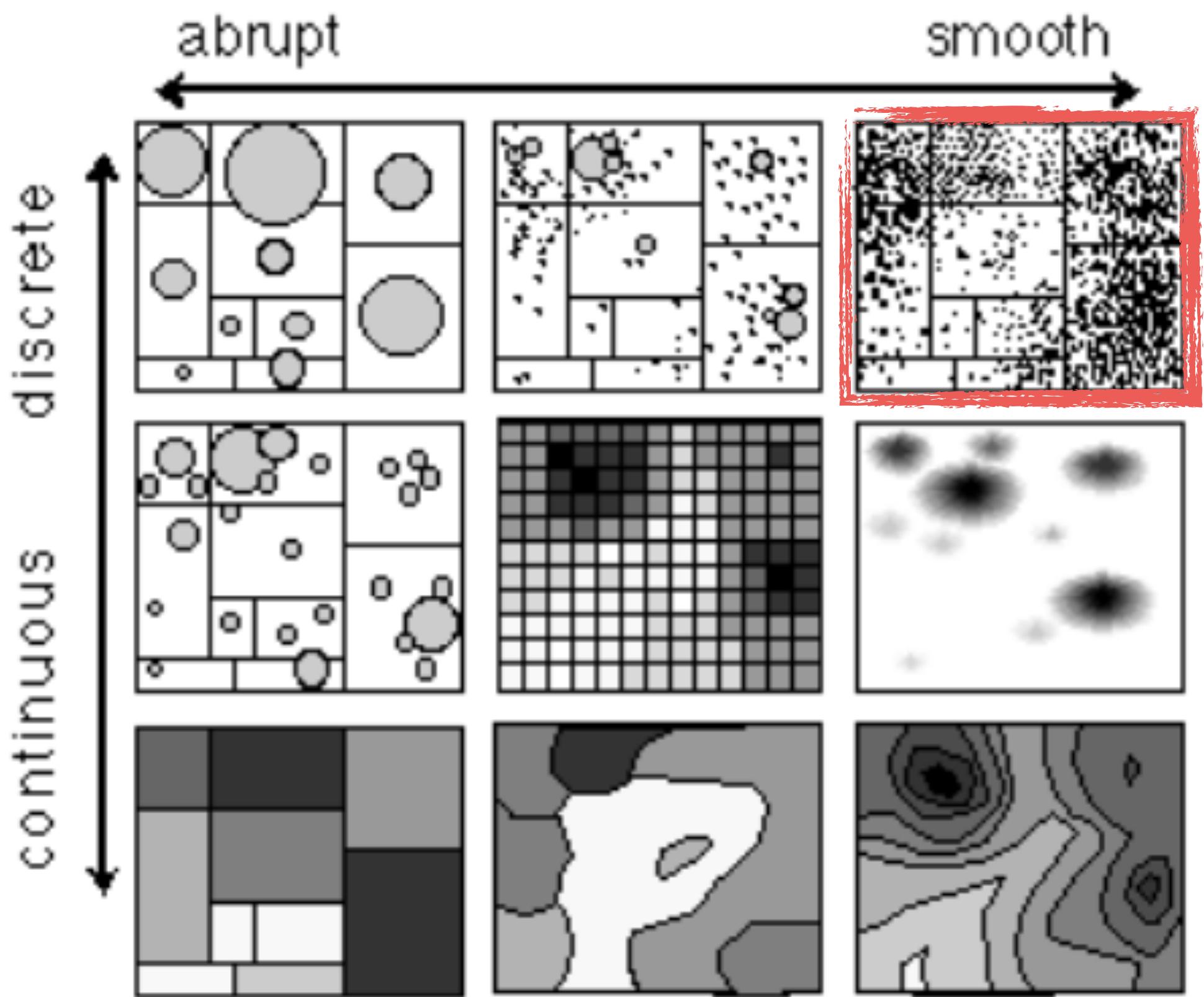
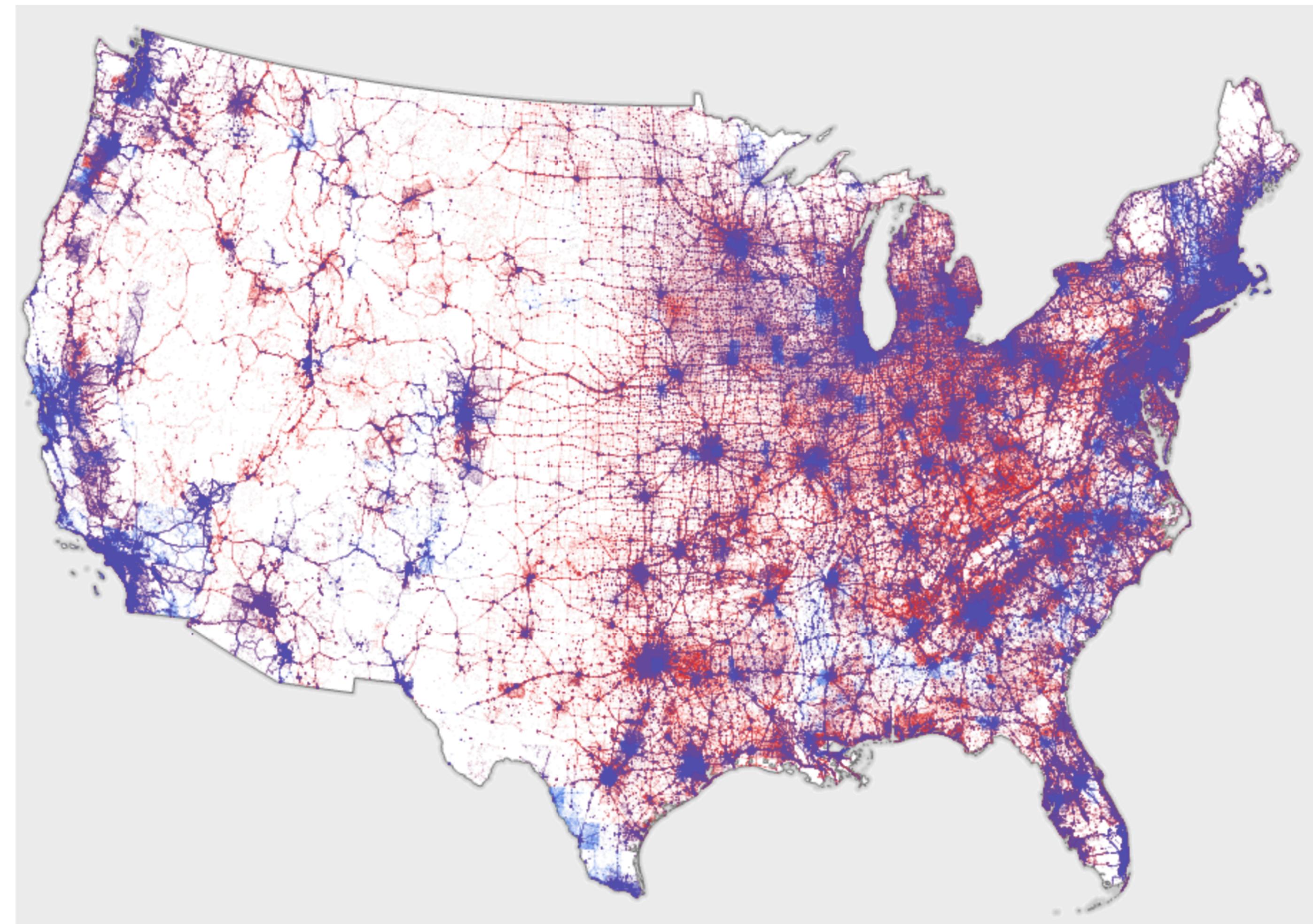


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

[MacEachren. Visualizing Uncertain Information. 1992]



Votes cast in the 2016 Presidential Election

Dot Distribution Map

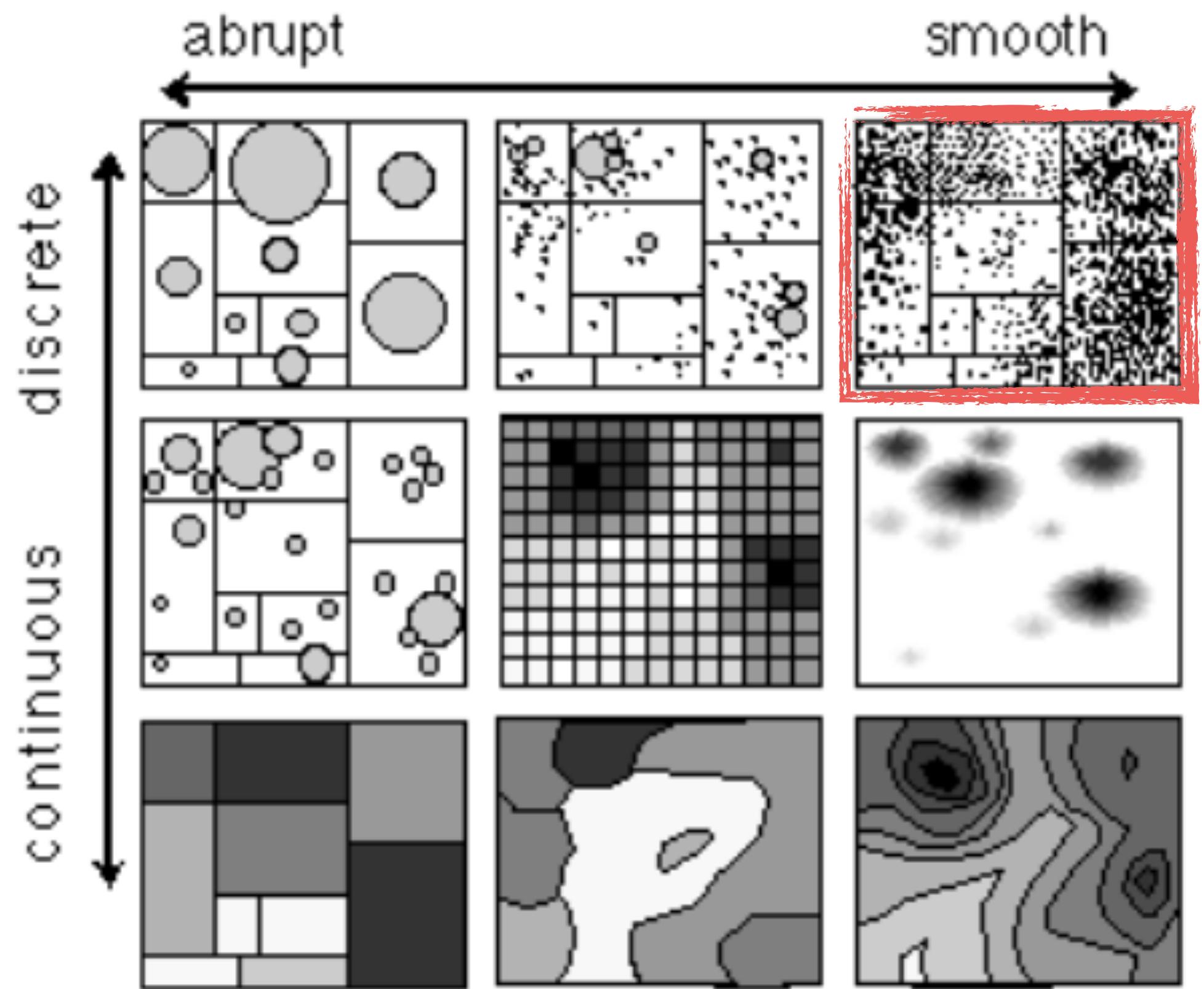
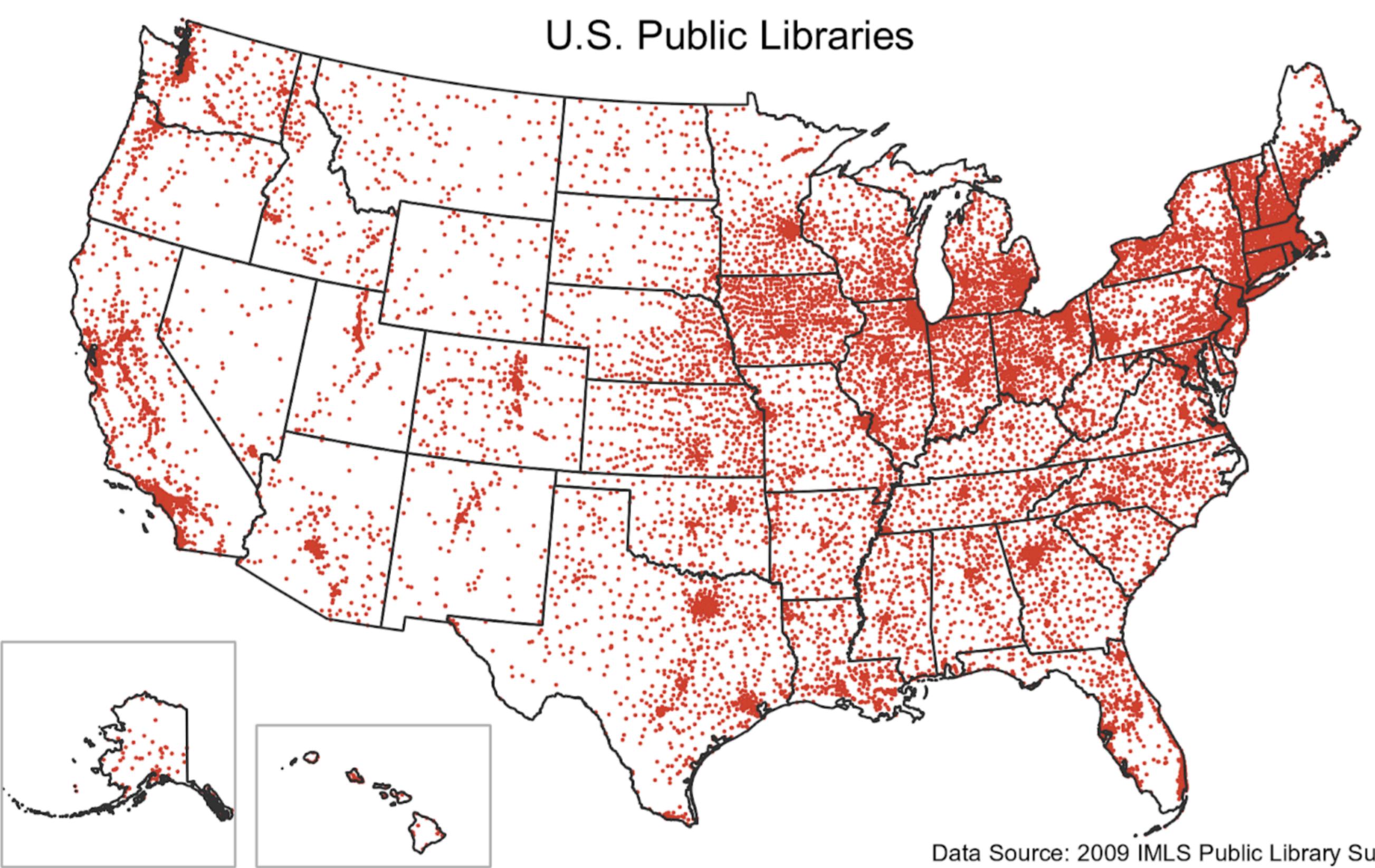


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.



Data Source: 2009 IMLS Public Library Survey

Dot Distribution Map

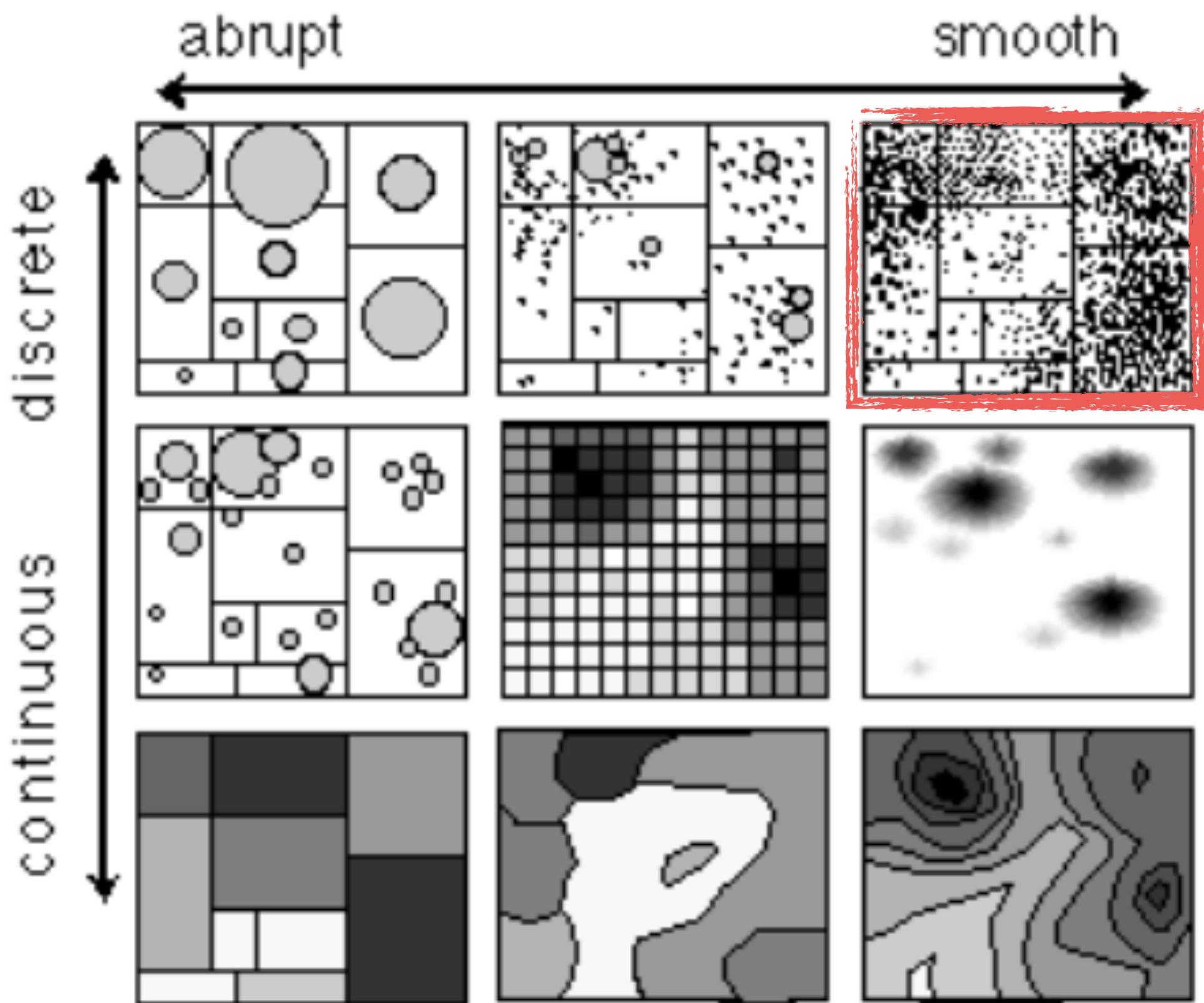
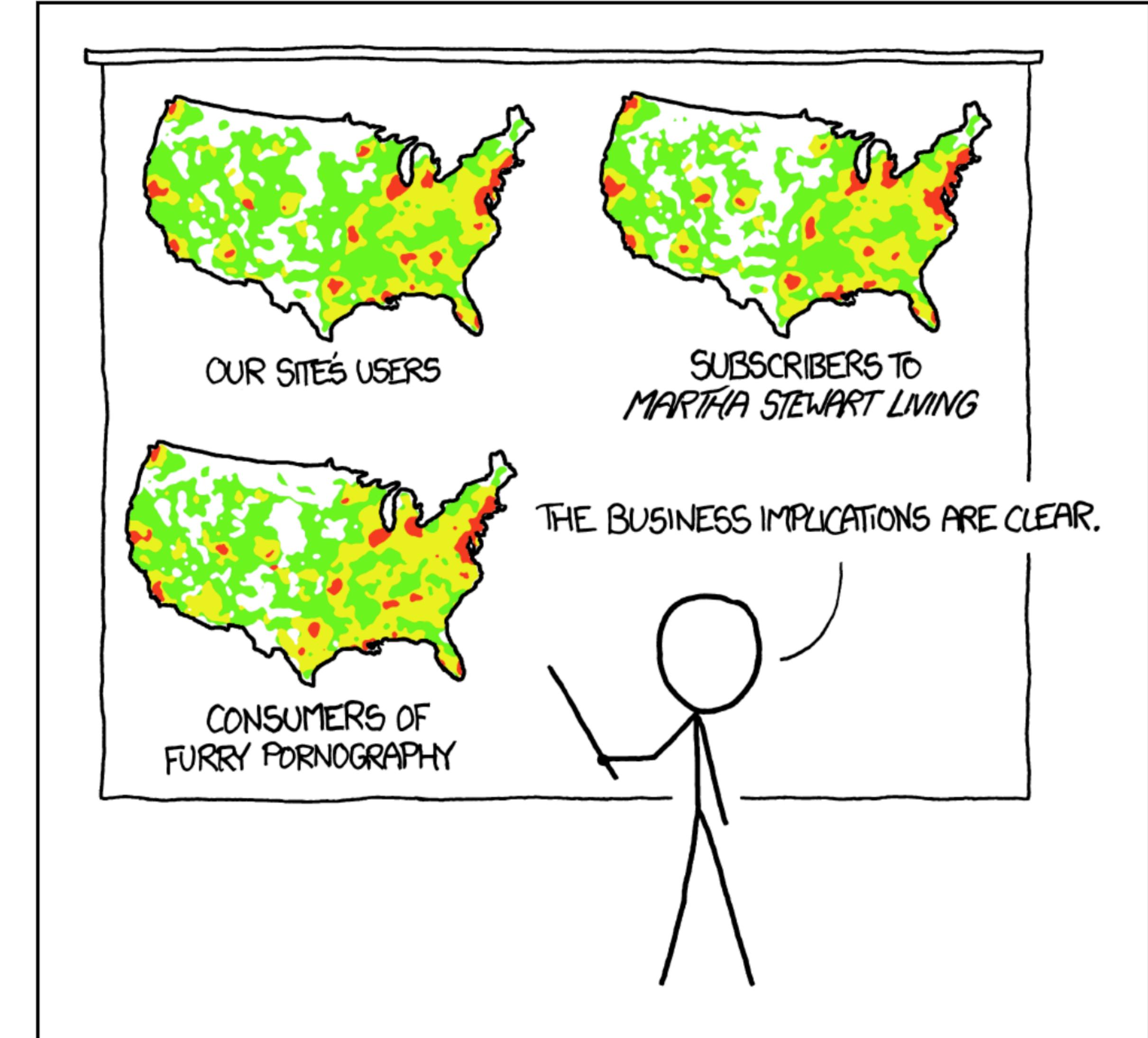


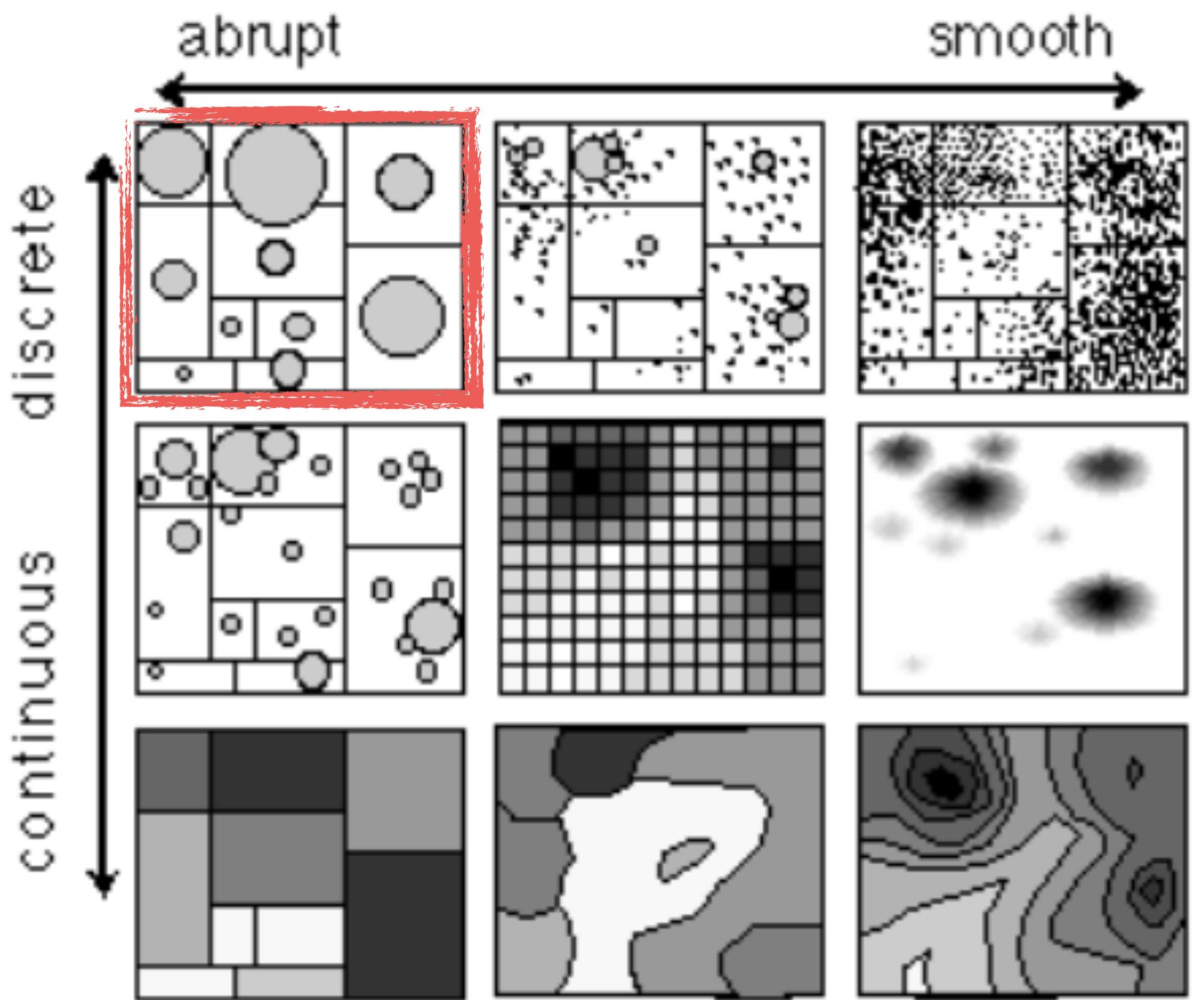
Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

[MacEachren. Visualizing Uncertain Information. 1992]



<https://xkcd.com/1138/>

Proportional Symbol Map



Craters

The earth is marked with about 180 named craters that are scars from previous run-ins with asteroids like the one that exploded over Russia on Friday.

Crater diameter



99 miles
20 miles

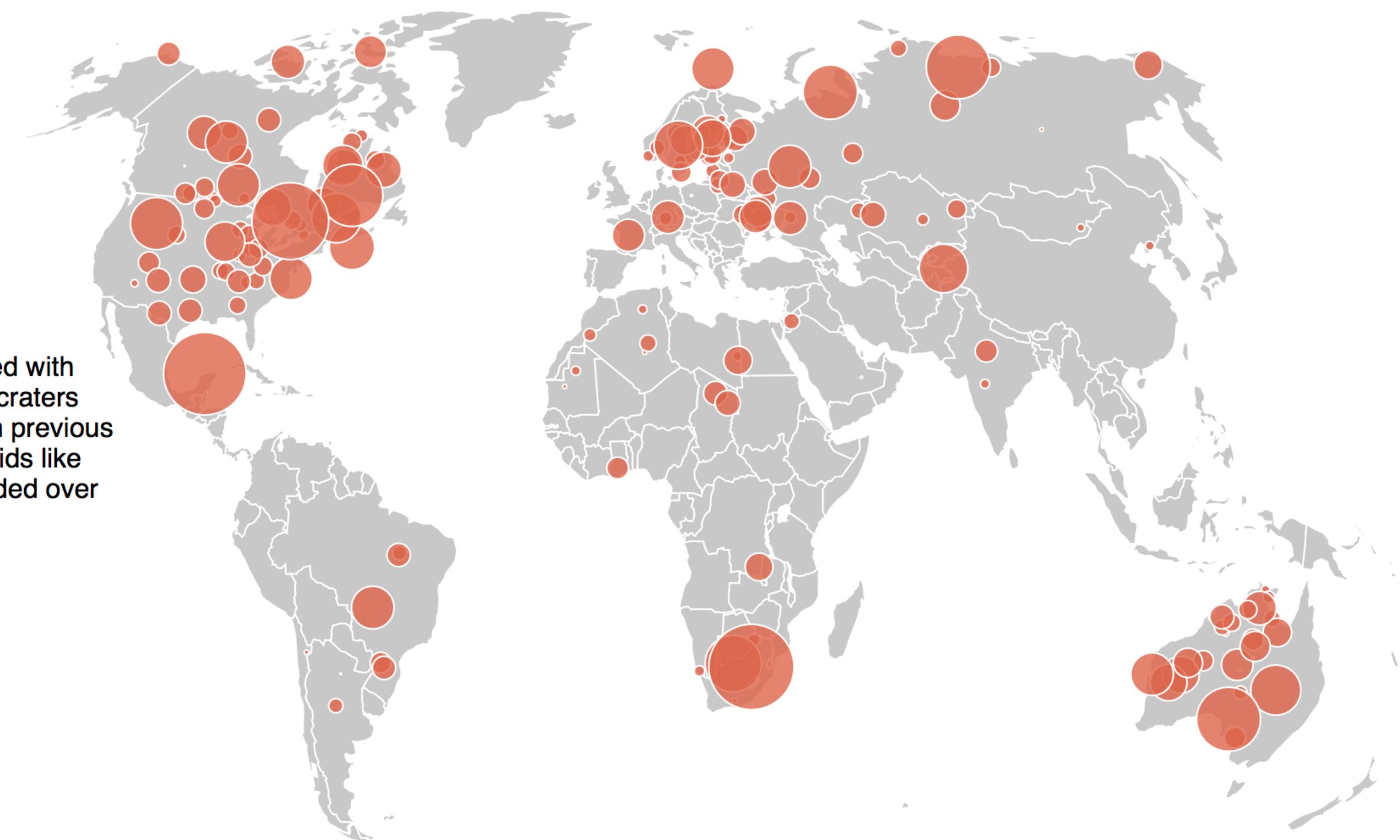


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

<http://www.washingtonpost.com/wp-srv/special/world/russia-meteor/index.html>

Proportional Symbol Map

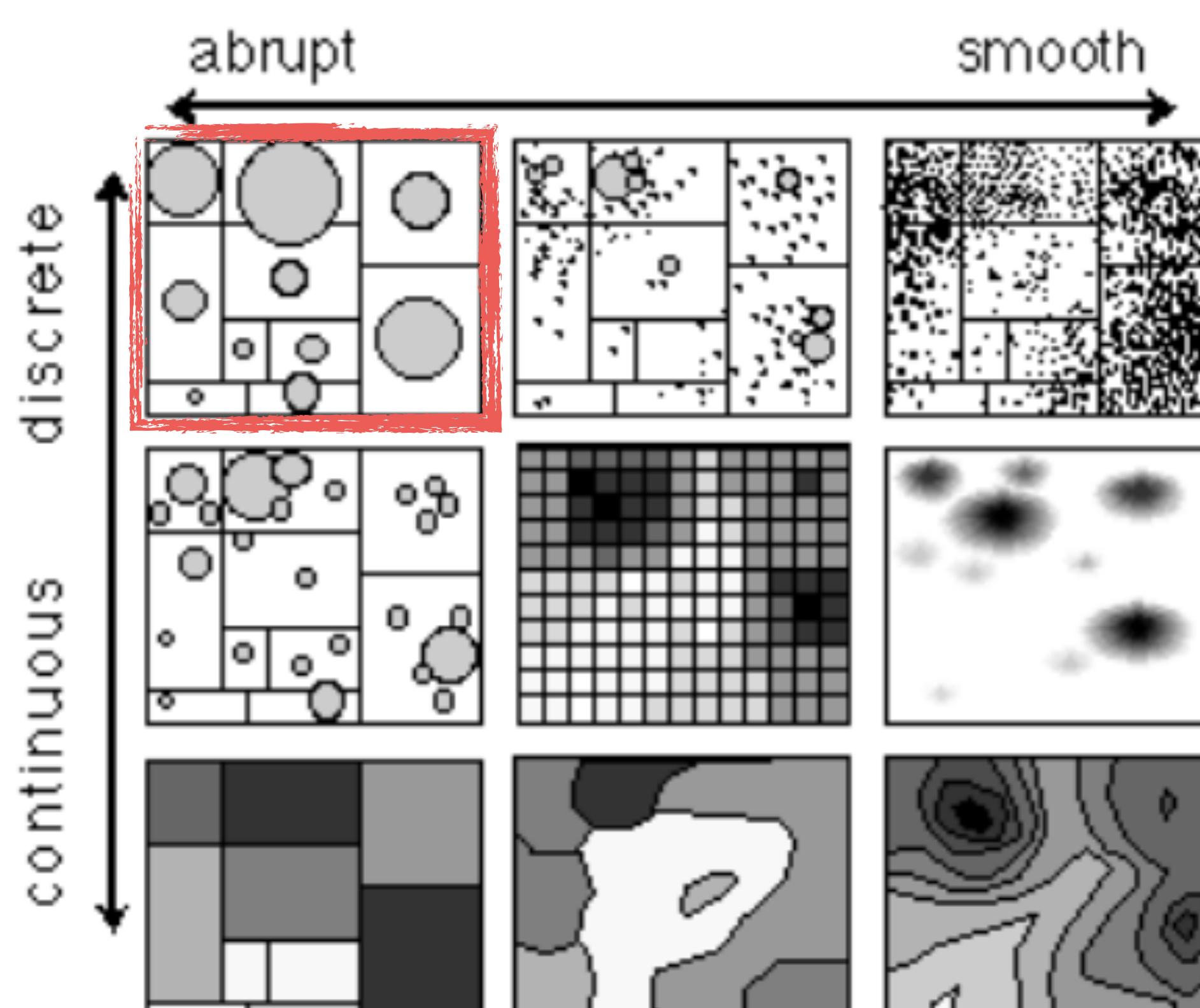
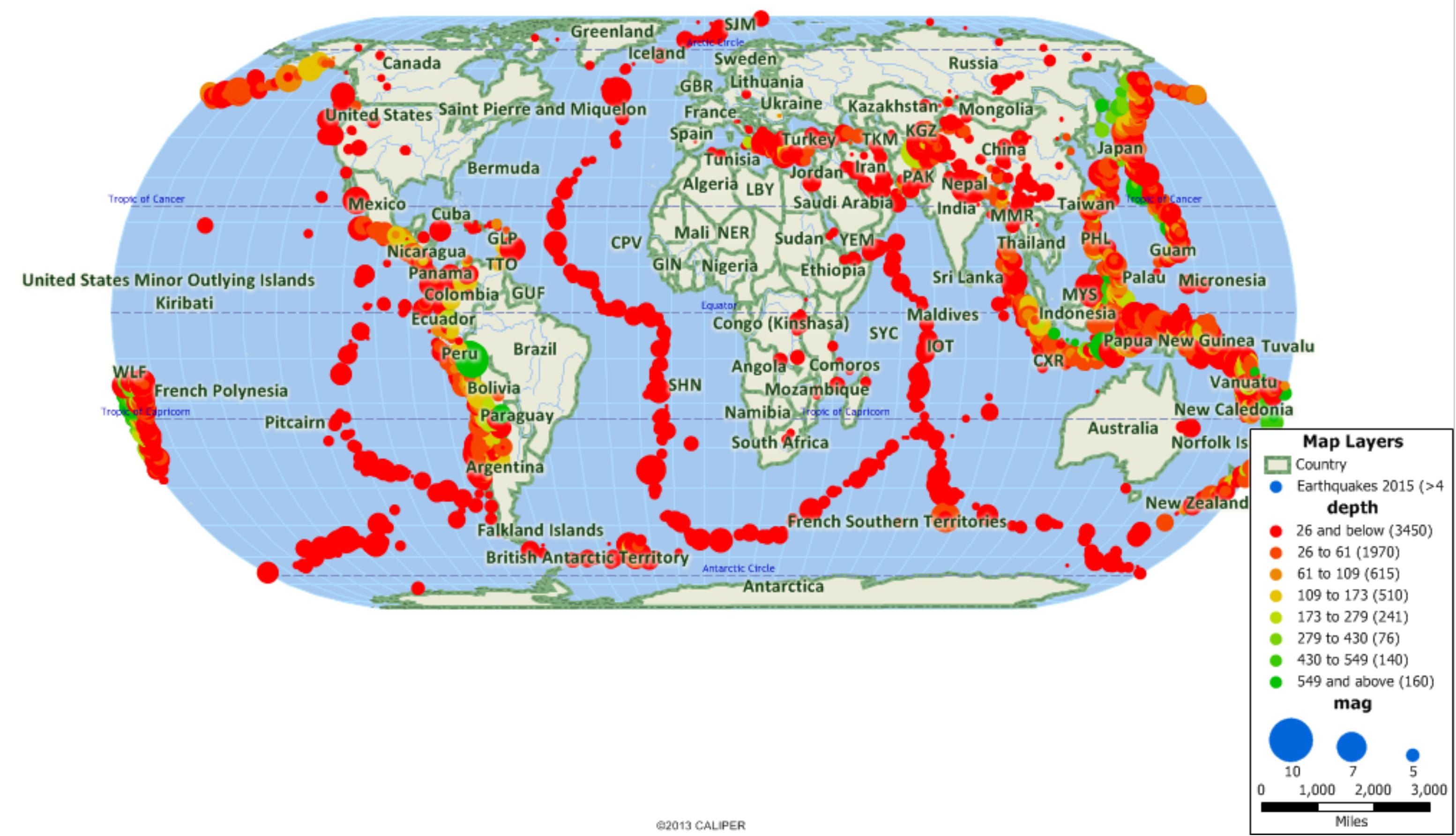


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.



Graduated Symbol Map

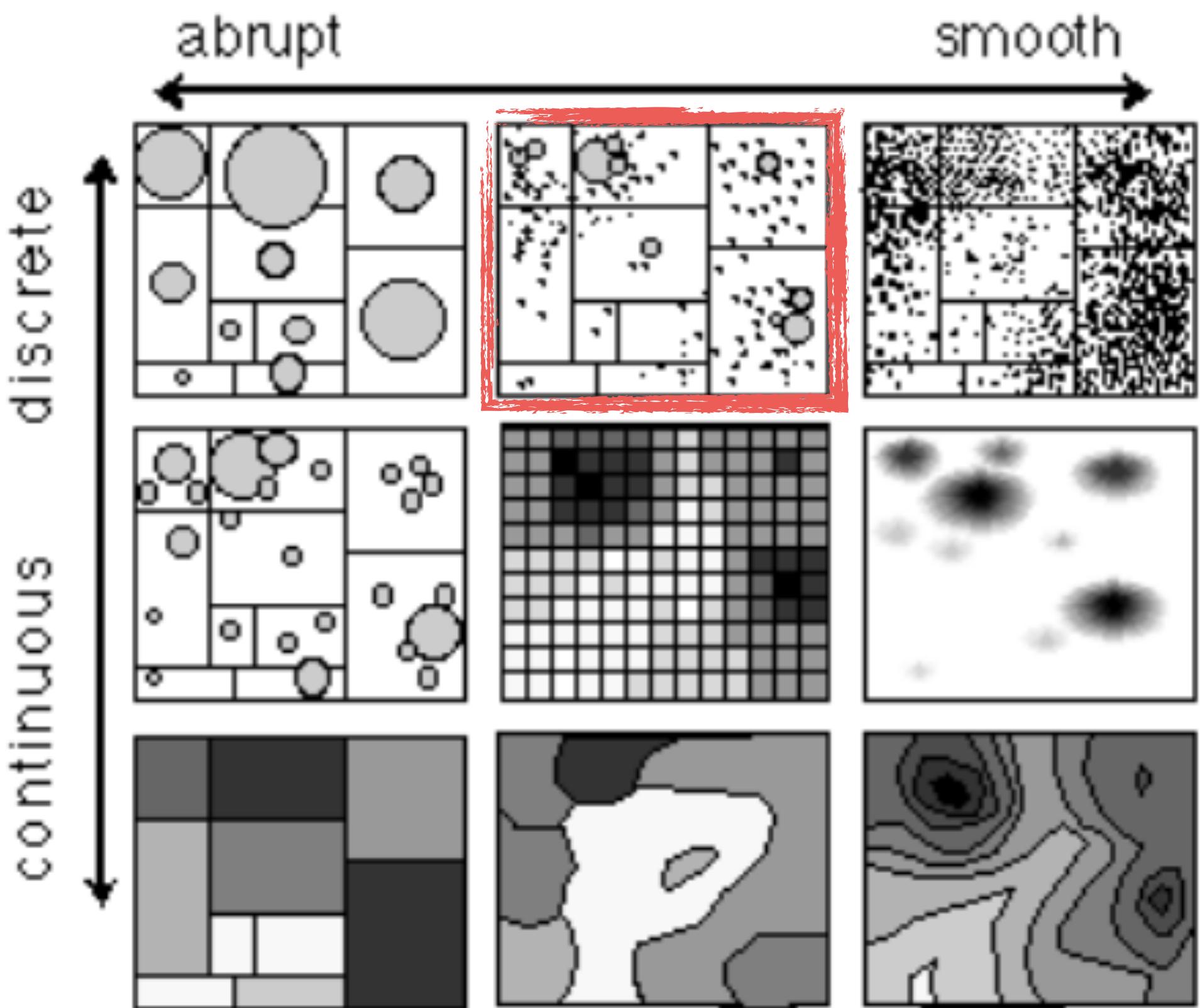
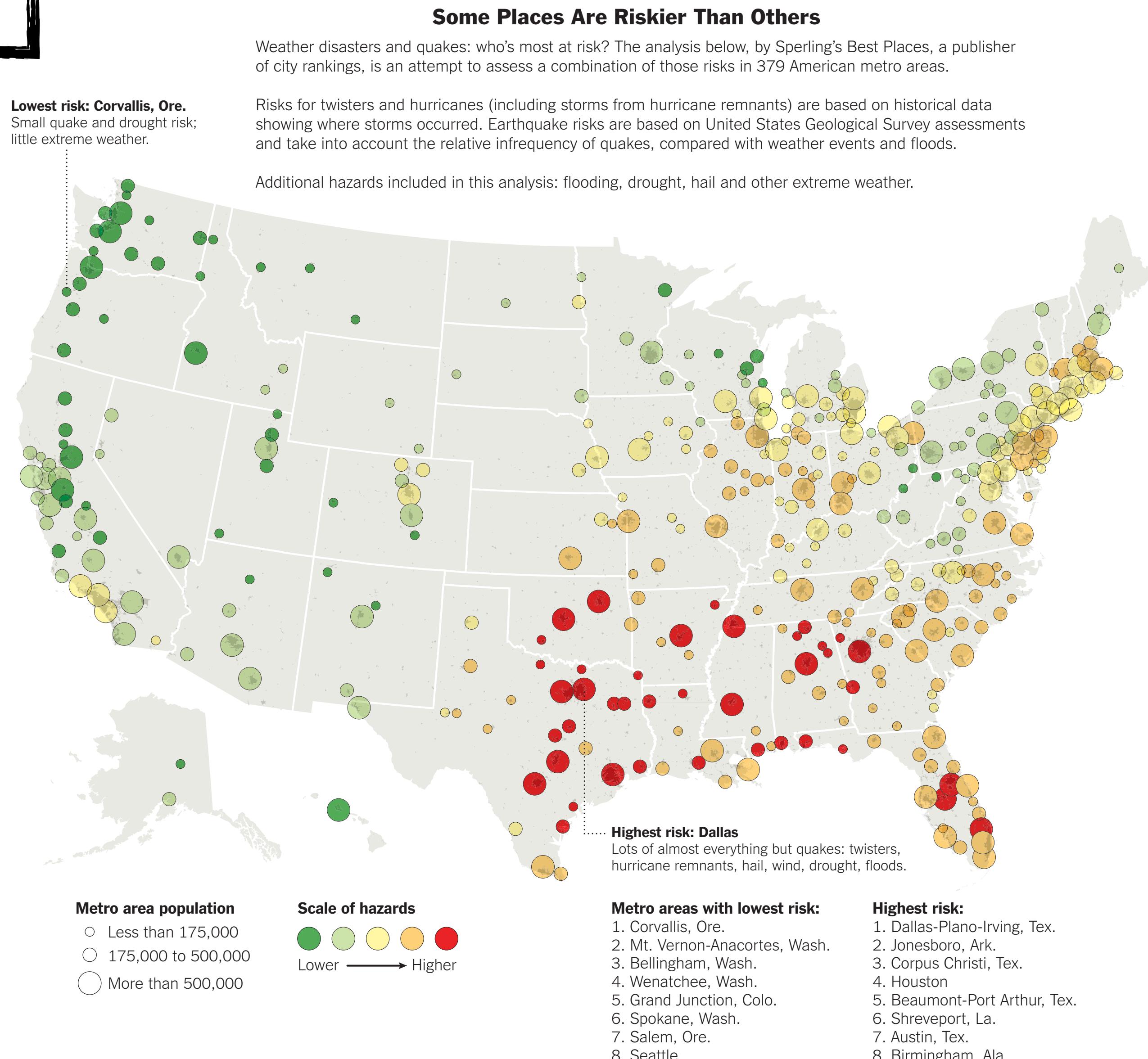


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

[MacEachren. Visualizing Uncertain Information. 1992]



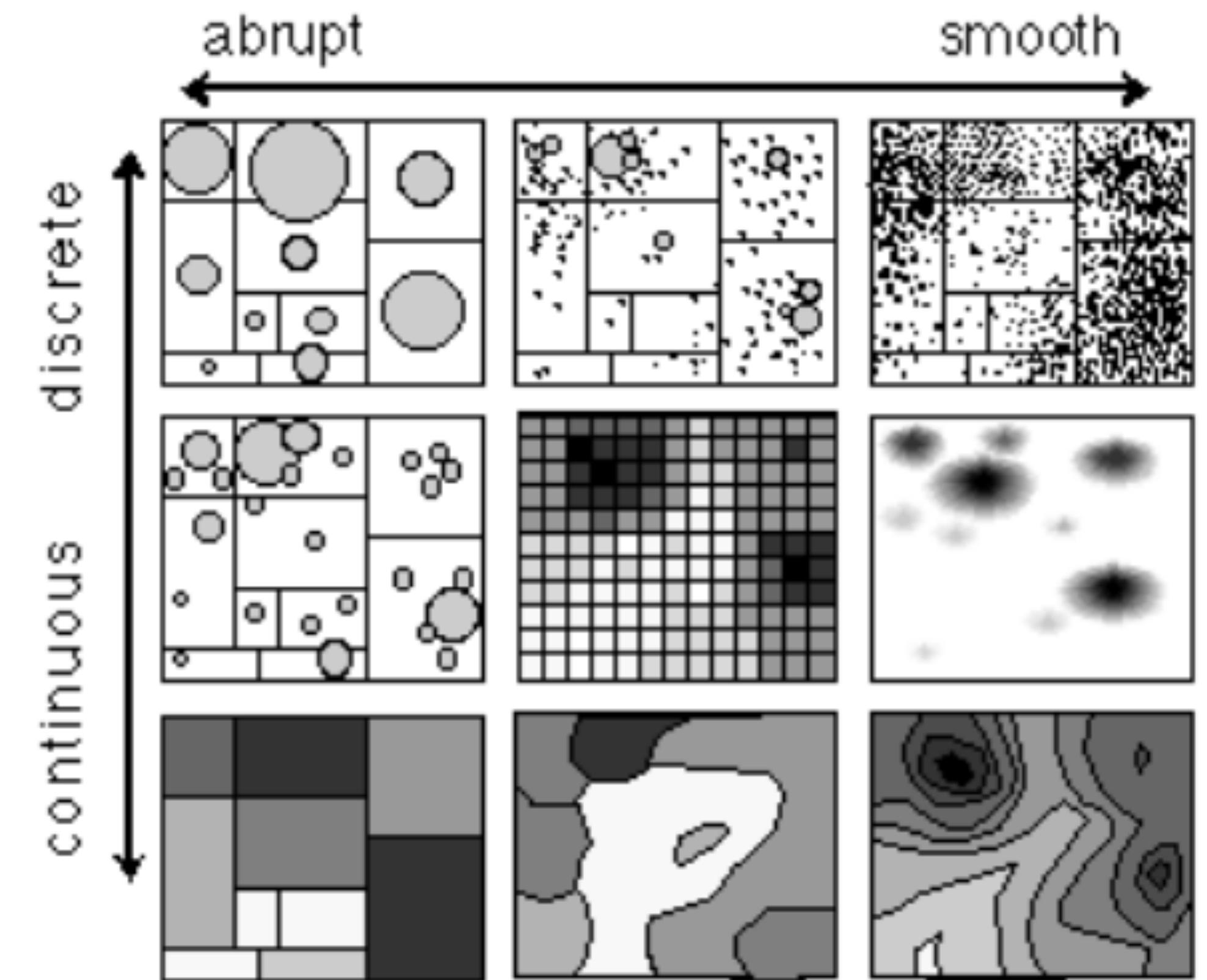
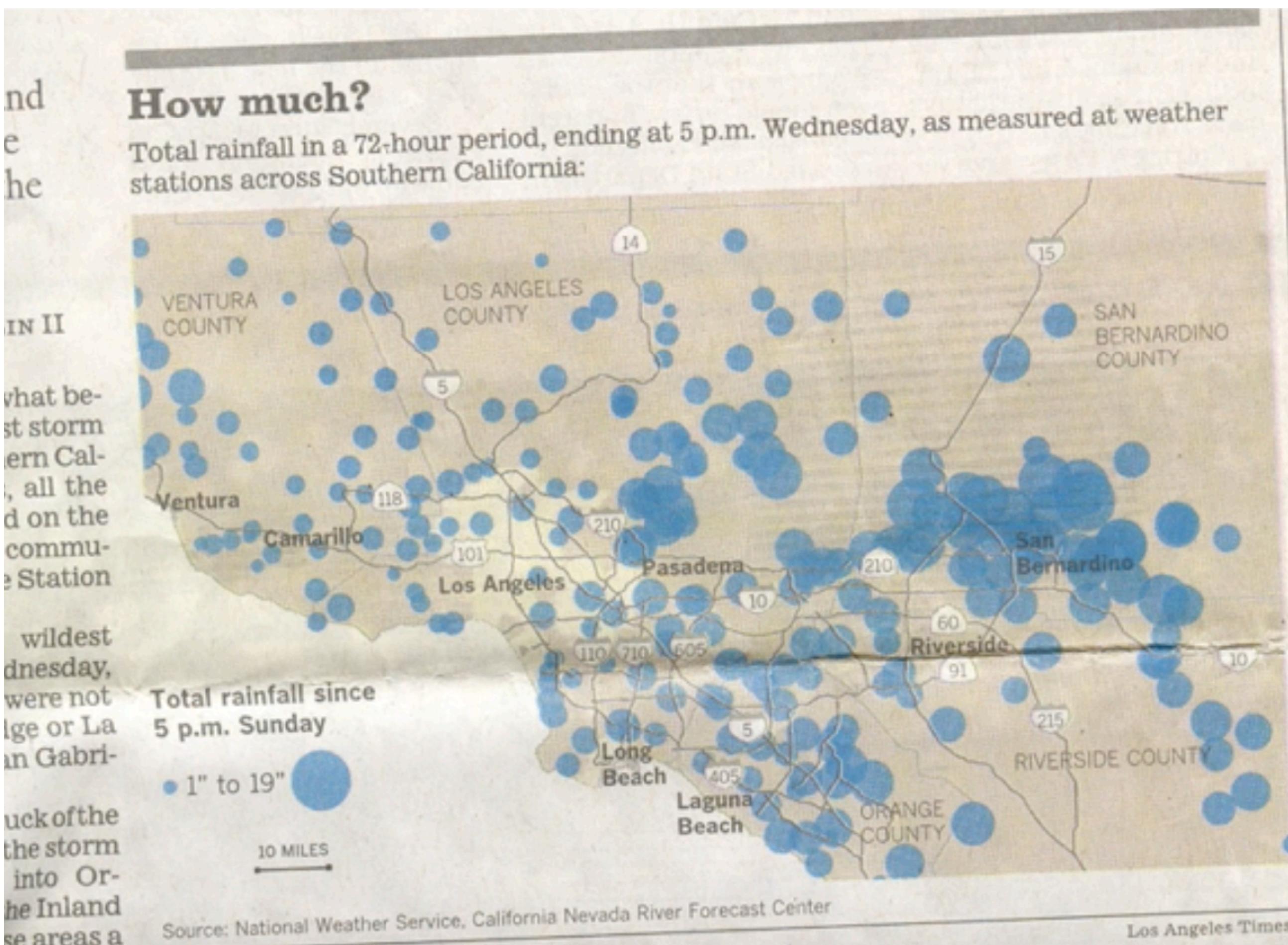


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.



ney
"They ha
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Toohe
what they
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ond-degr
and other
from the
that killed
friends C
20, and I
Jon Wilhi
crash bu
injuries.
On th
pitched
nings, G
ing with
Just pas
reled th
Fullerto
rammed
vehicle
friends.
Gallo
capture
scene.
content

Isopleth / Heat Map

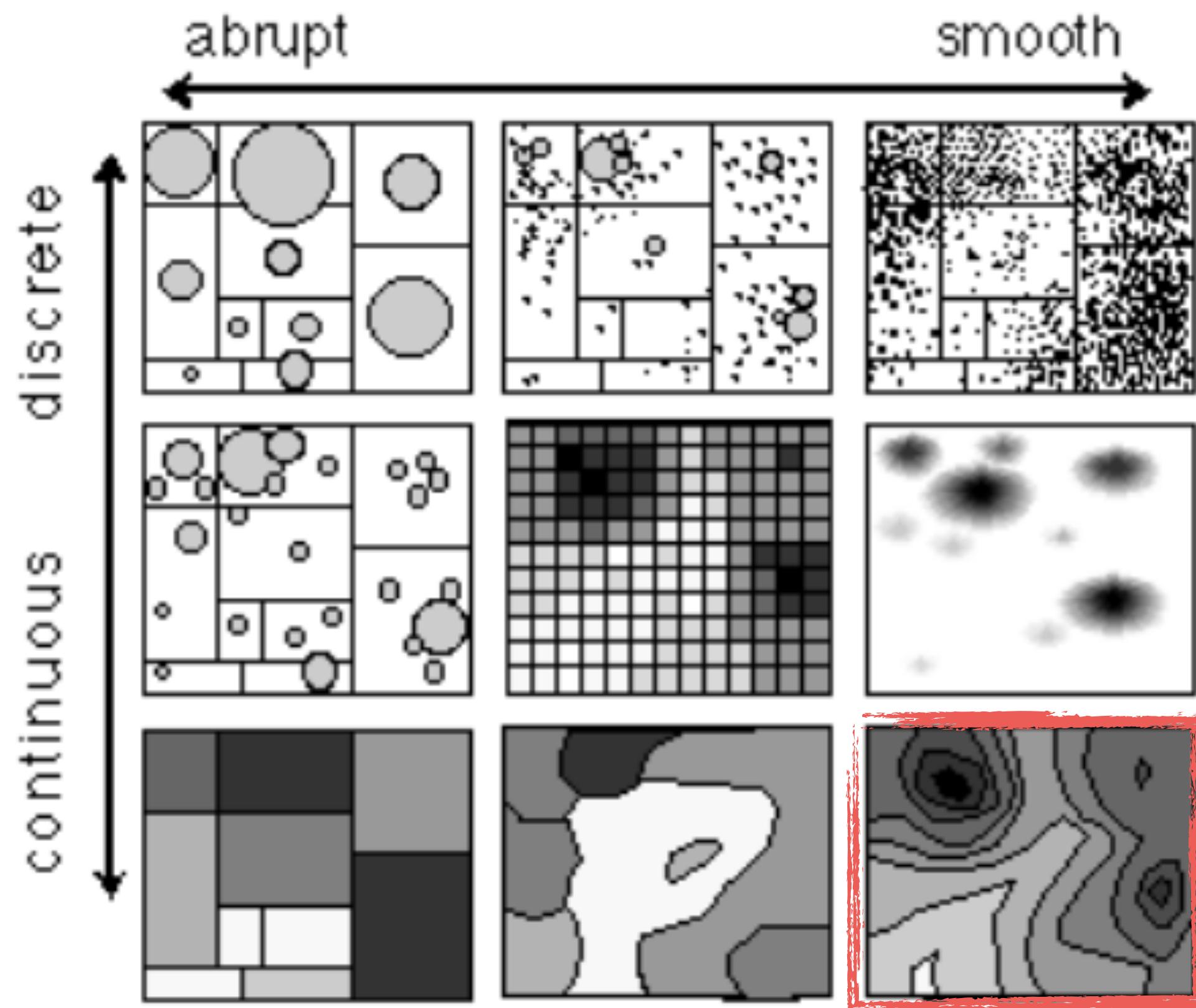
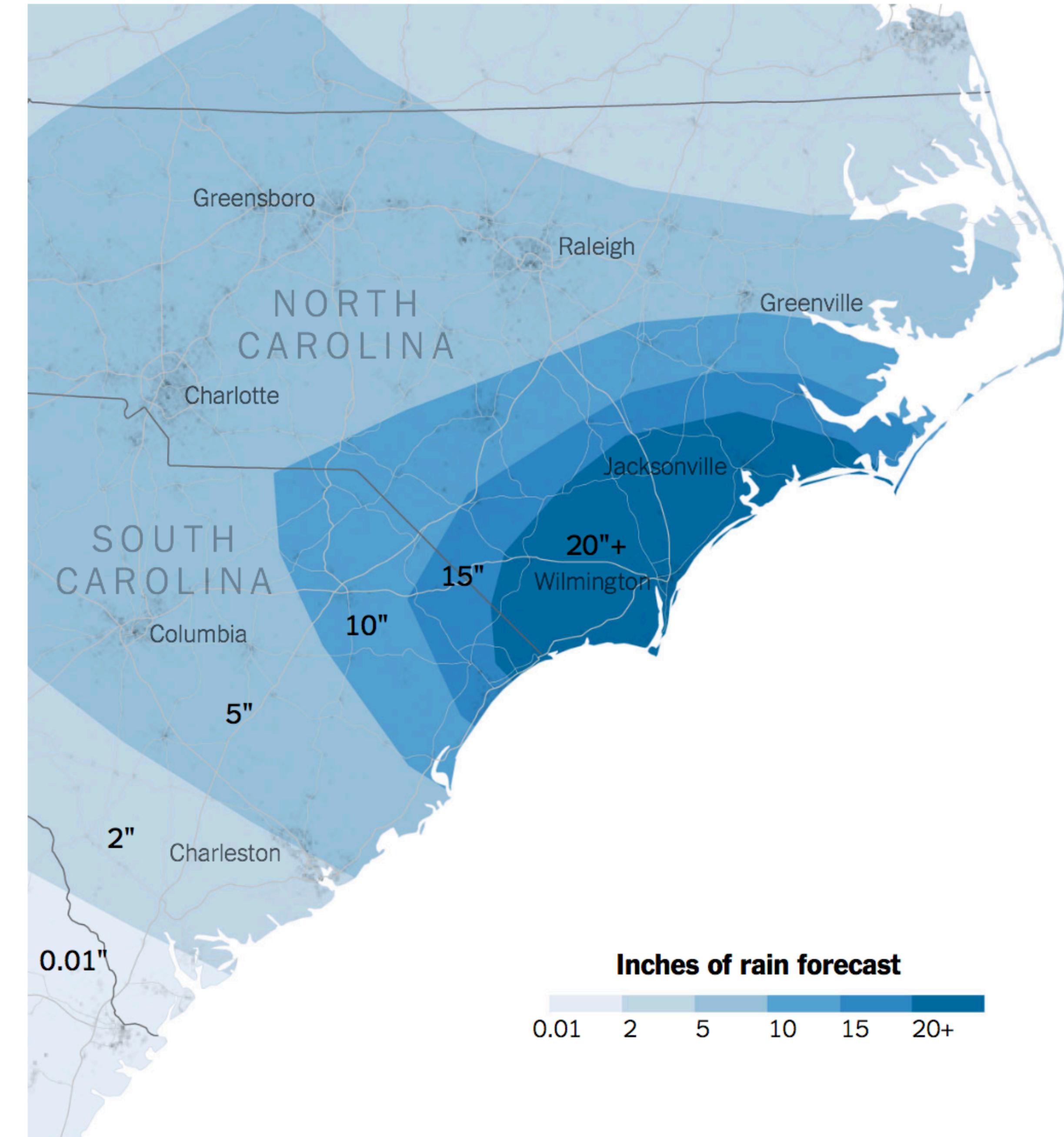


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

[MacEachren. Visualizing Uncertain Information. 1992]



Source: National Weather Service

Isopleth / Heat Map

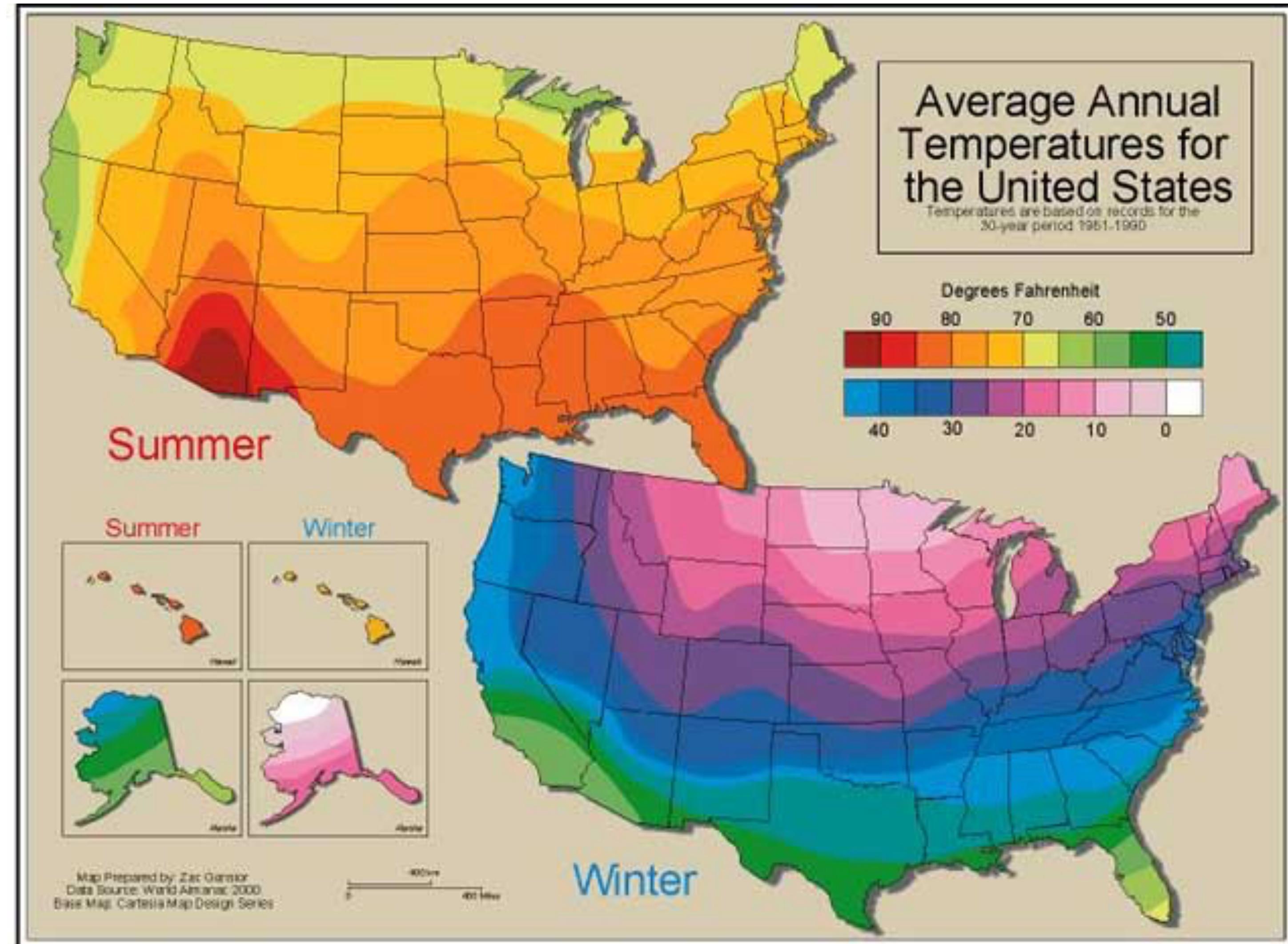
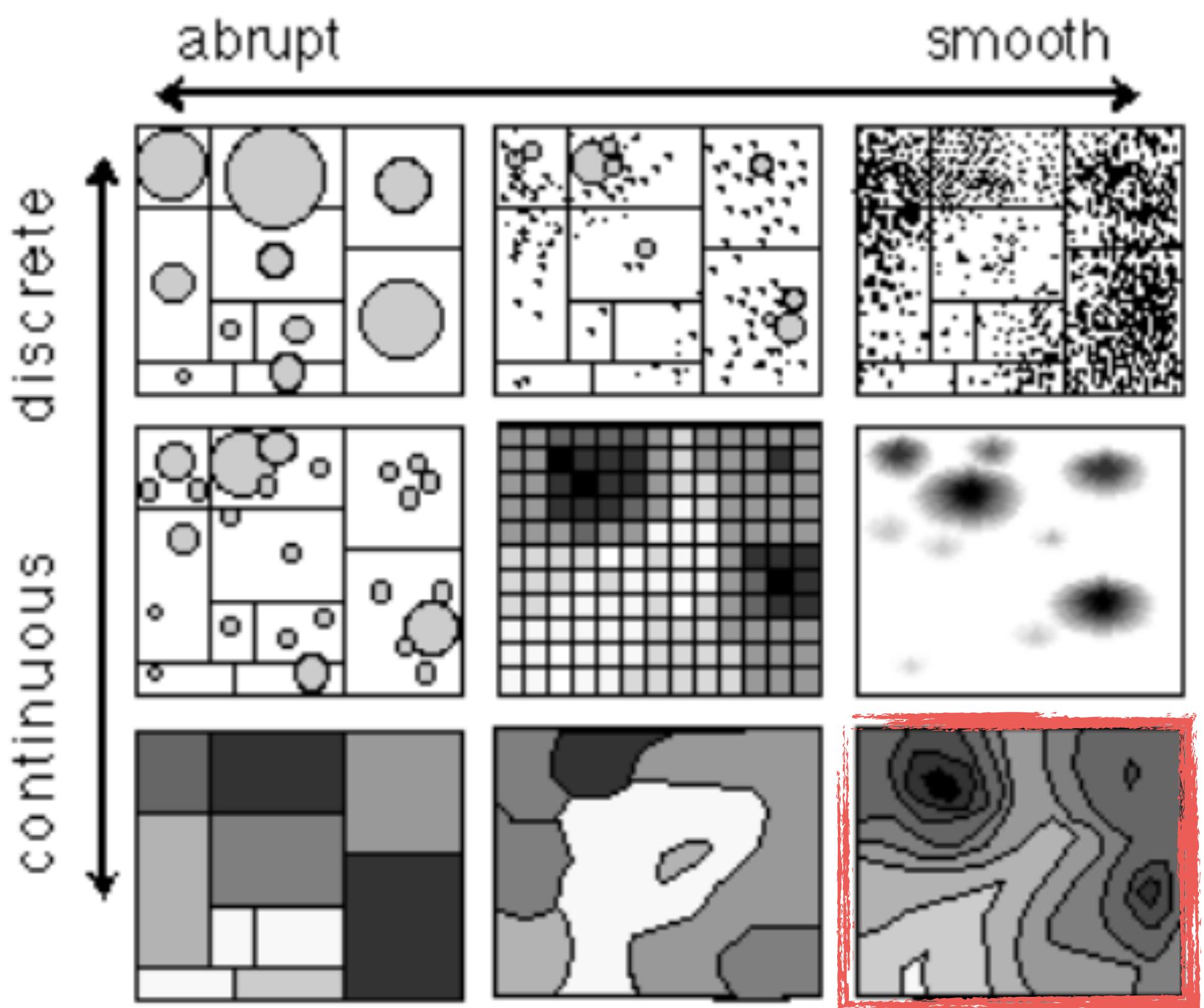
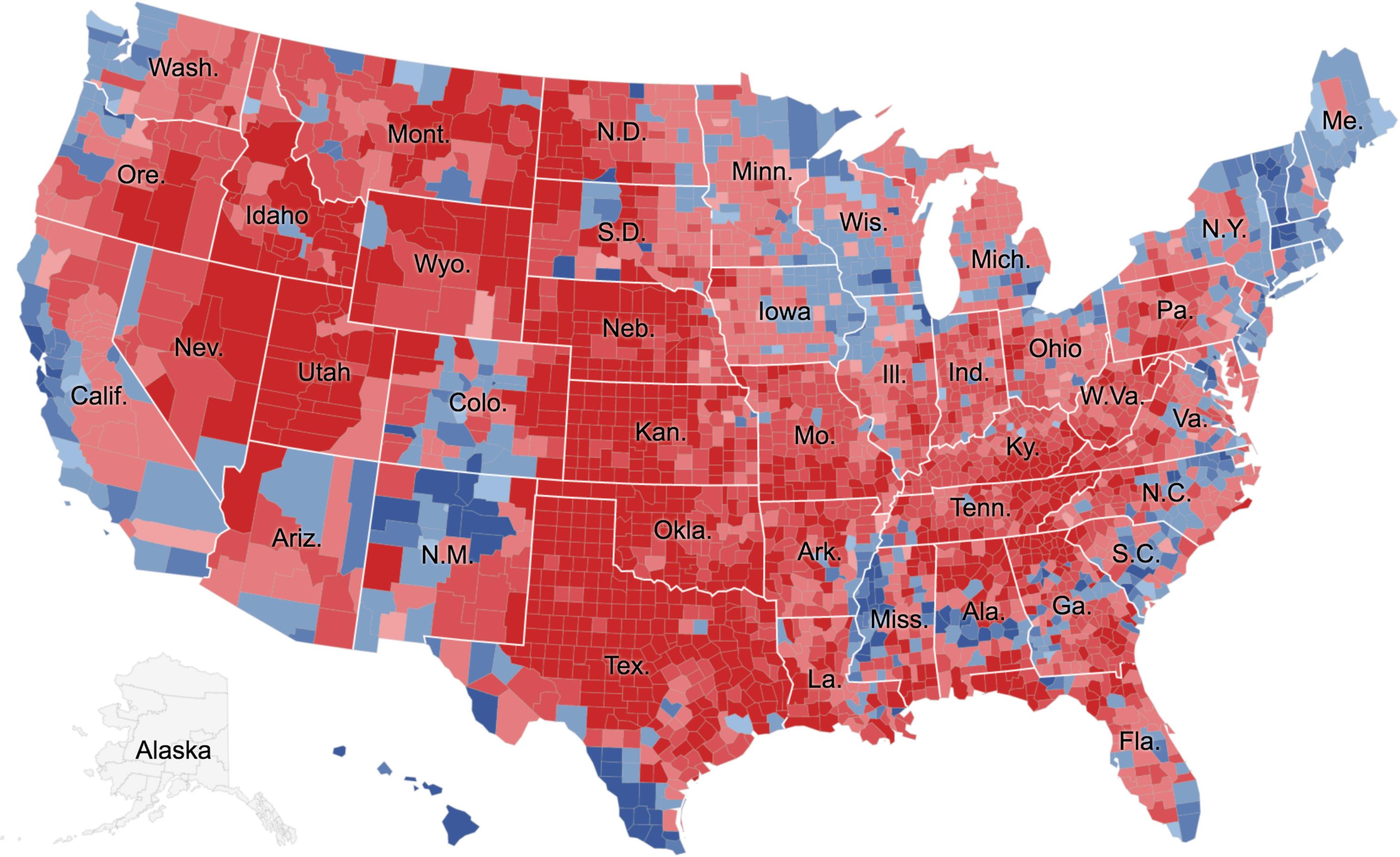
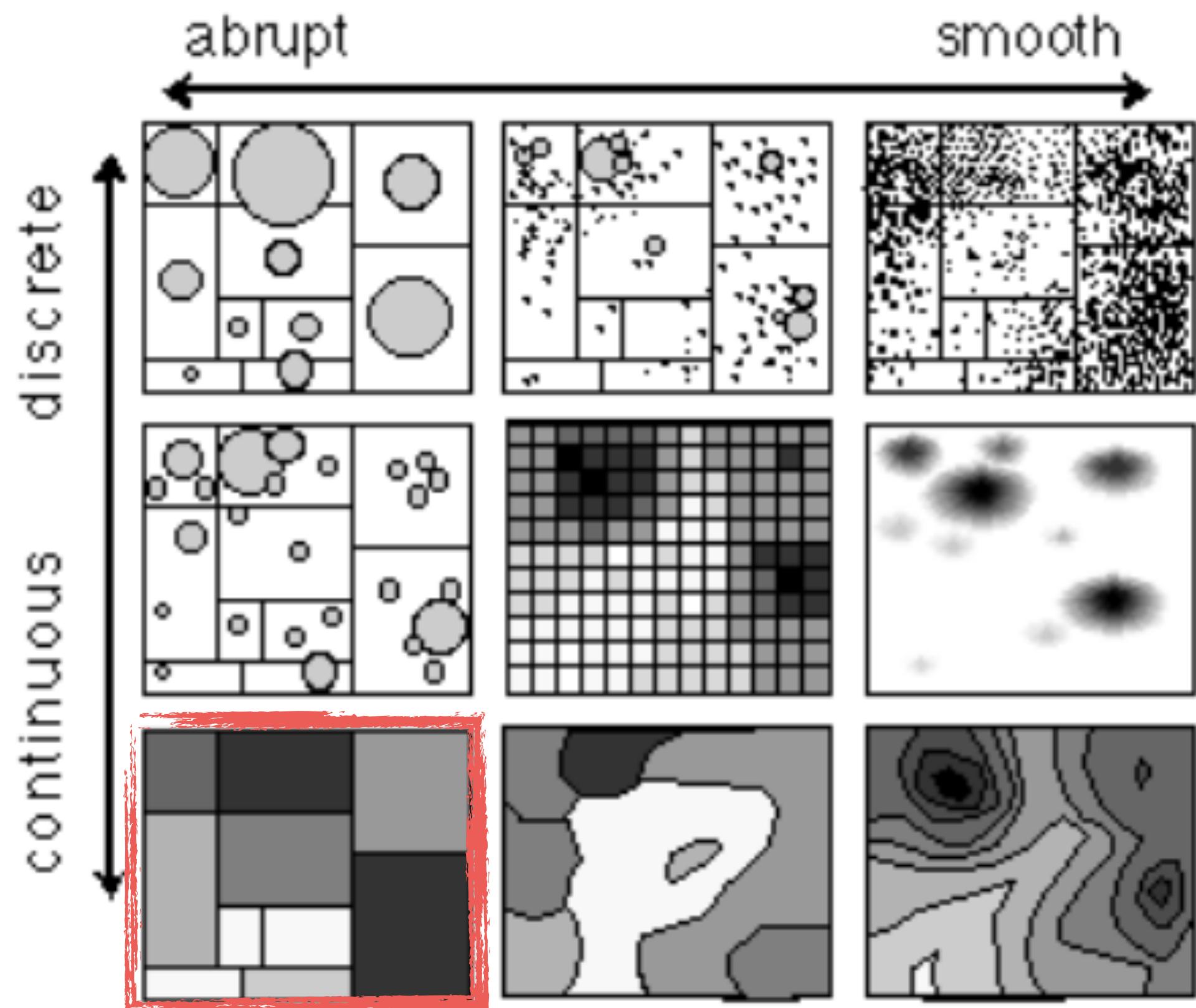


Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

Choropleth



<https://www.nytimes.com/interactive/2016/11/01/upshot/many-ways-to-map-election-results.html>

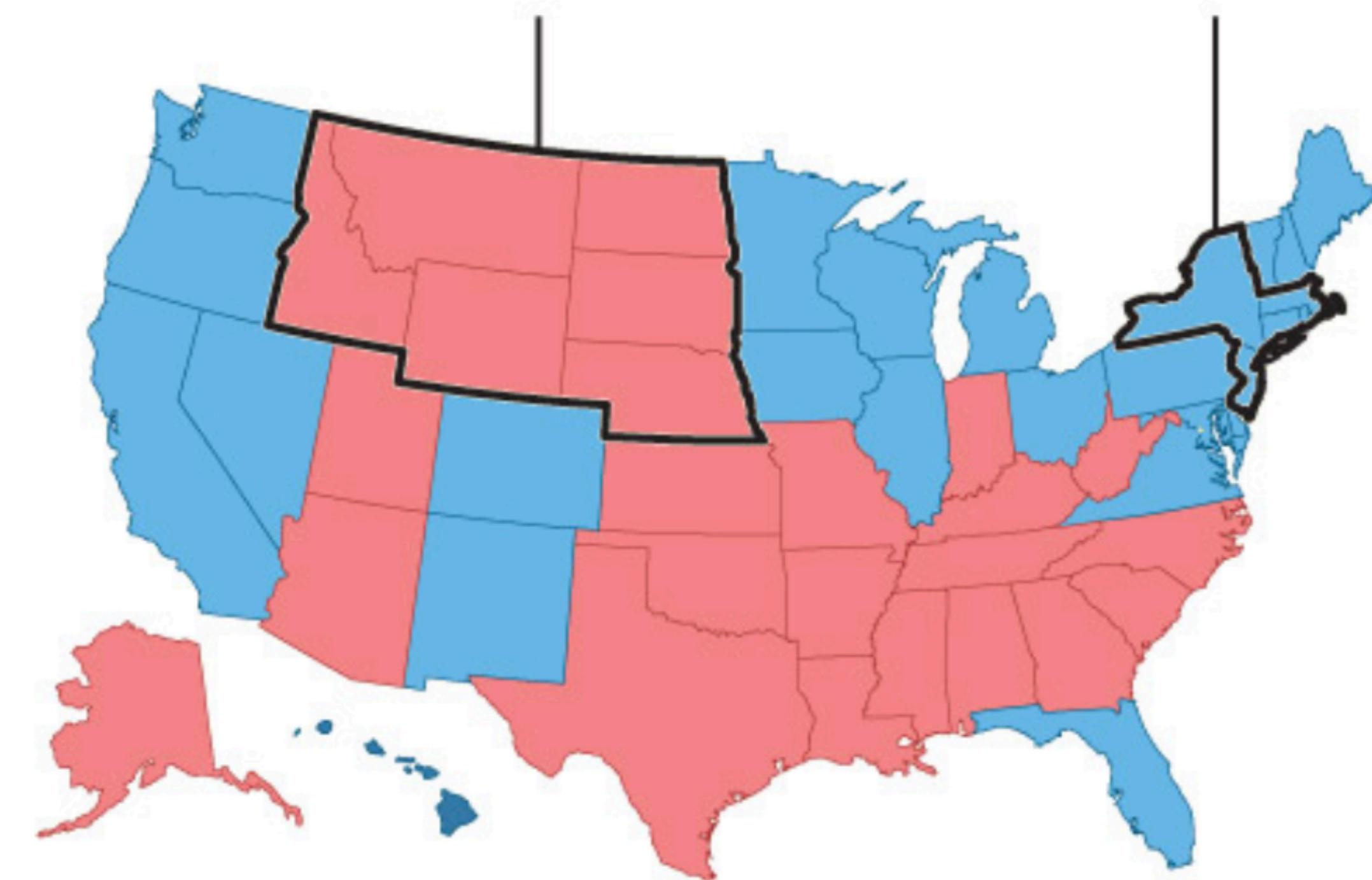
Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.

GEOGRAPHIC MAP

CARTOGRAM OF ELECTORAL VOTES

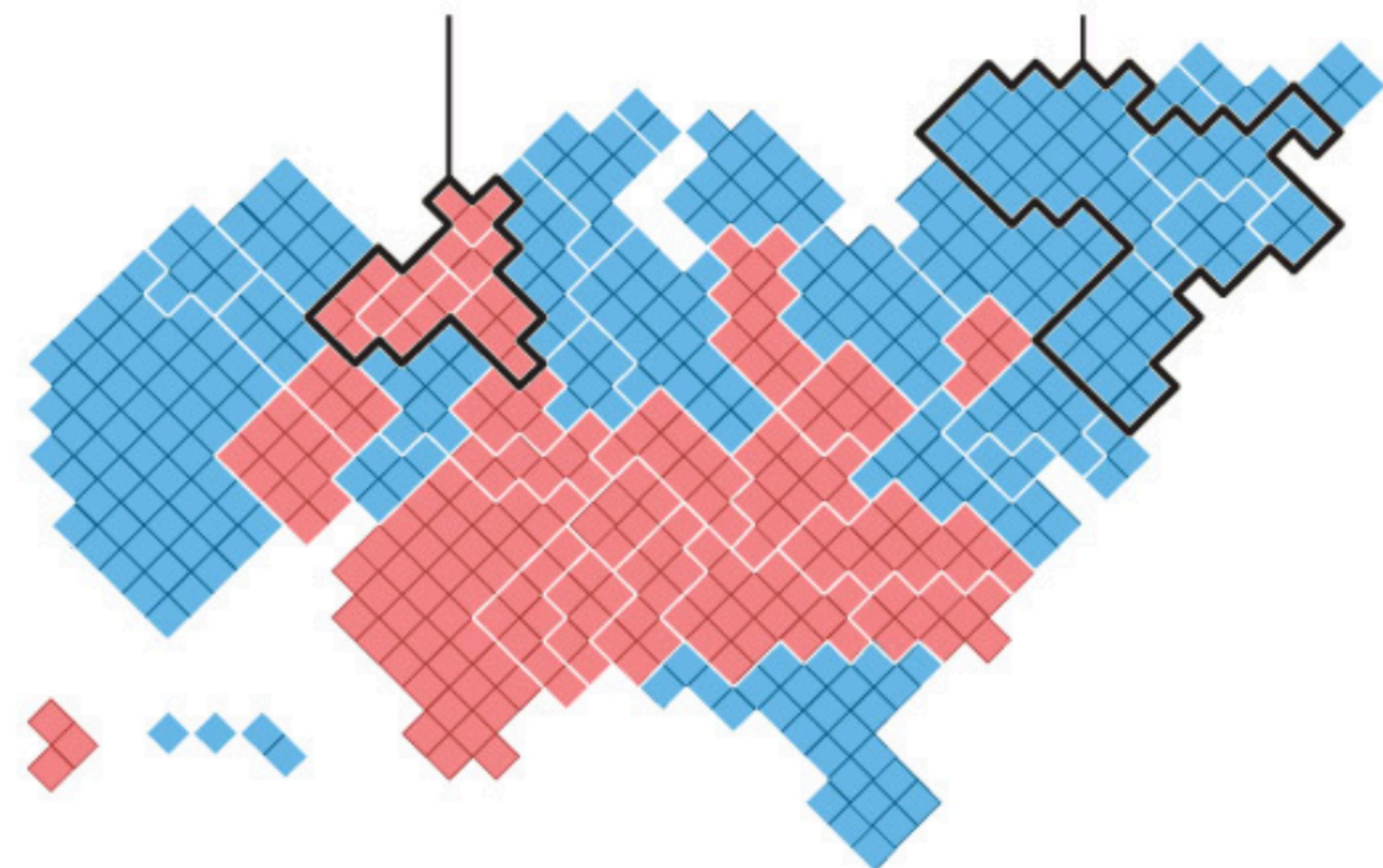
Six Western states

Five Northeastern states

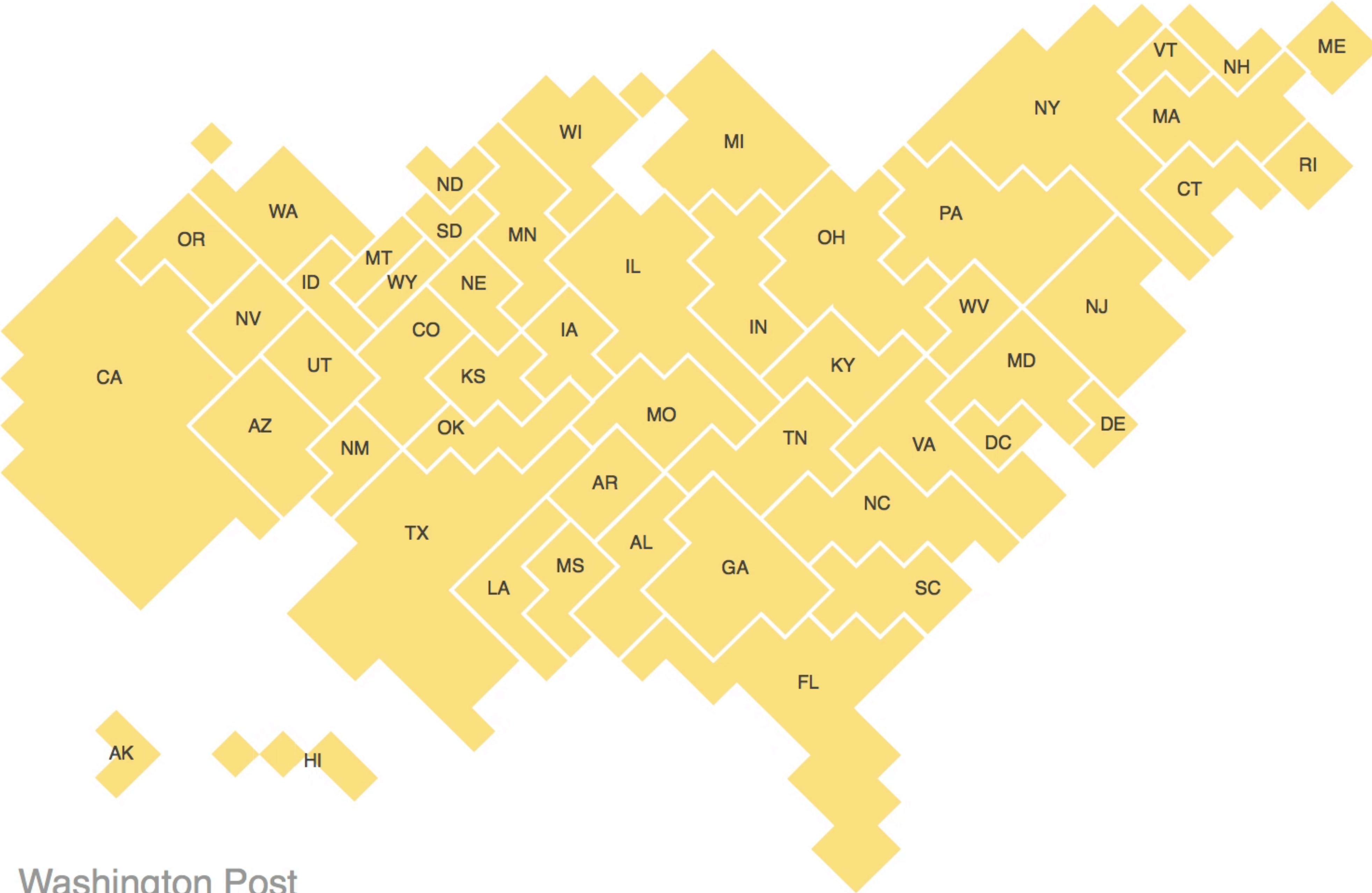


Six Western states

Five Northeastern states



[Noah Veltman. December 2018]



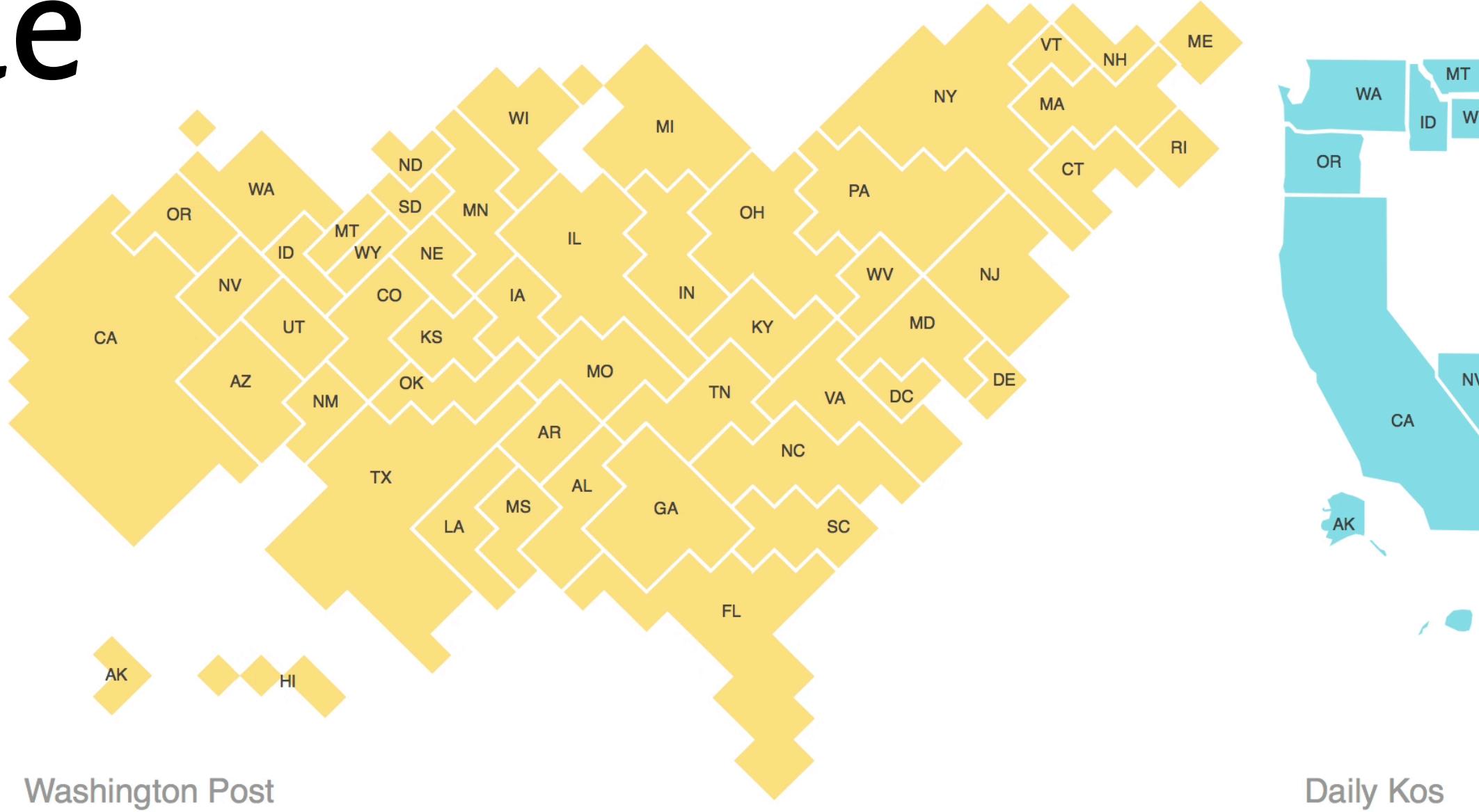
Washington Post

Design Critique

Think (~2 mins).

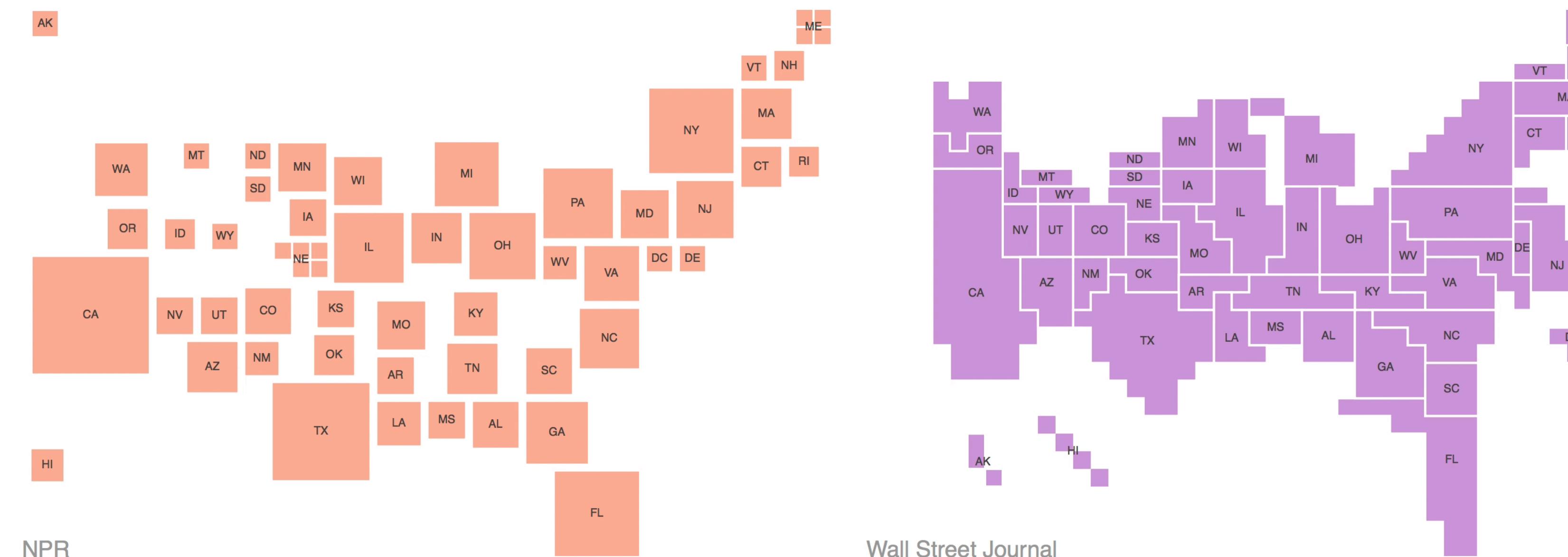
Pair (~5 mins).

Share.



Washington Post

Daily Kos



Wall Street Journal

FiveThirtyEight

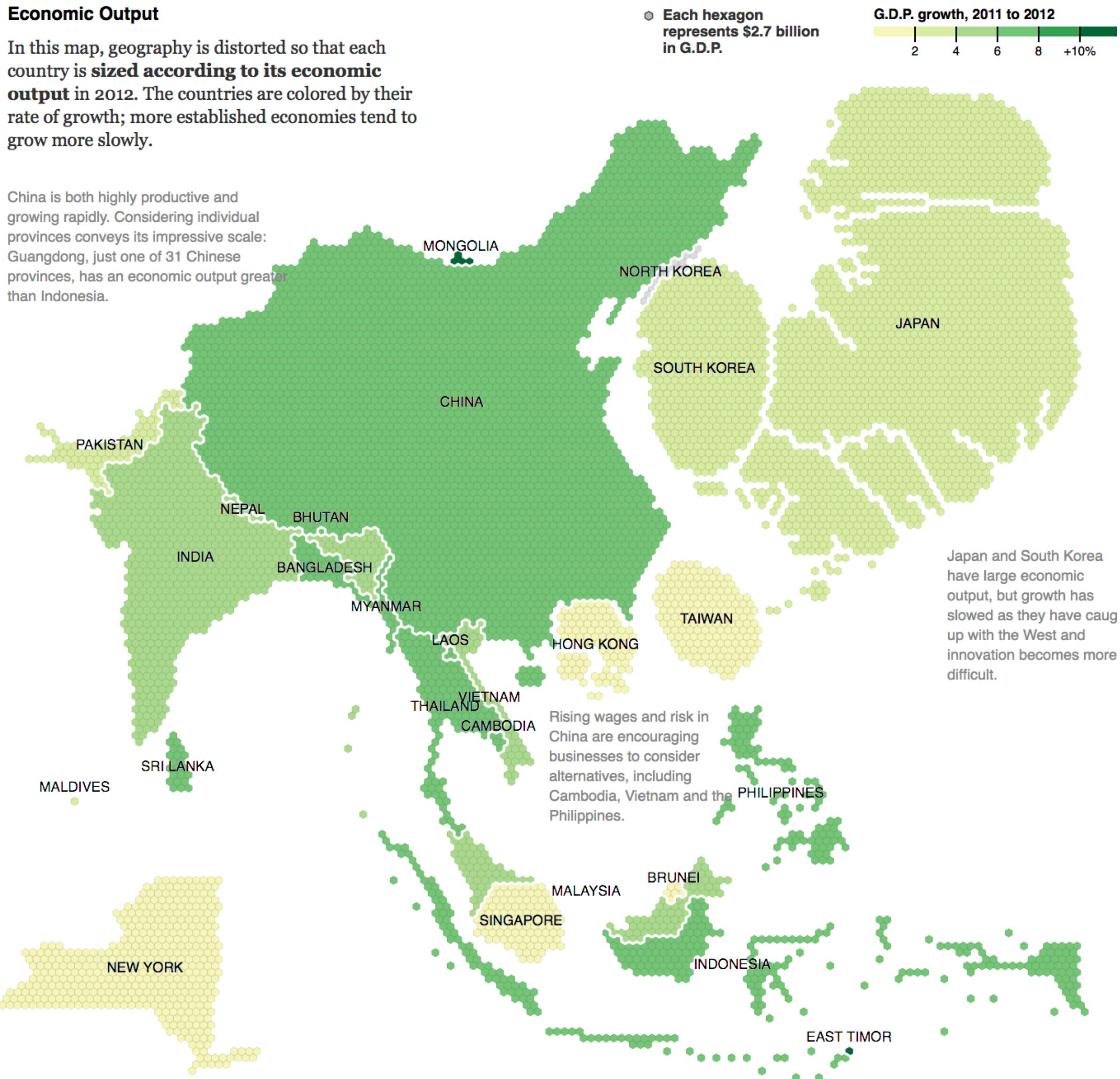
China Still Dominates, but Some Manufacturers Look Elsewhere

While China maintains its overwhelming dominance in manufacturing, multinational companies are looking for ways to limit their reliance on factories there. [Related Article »](#)

Economic Output

In this map, geography is distorted so that each country is **sized according to its economic output** in 2012. The countries are colored by their rate of growth; more established economies tend to grow more slowly.

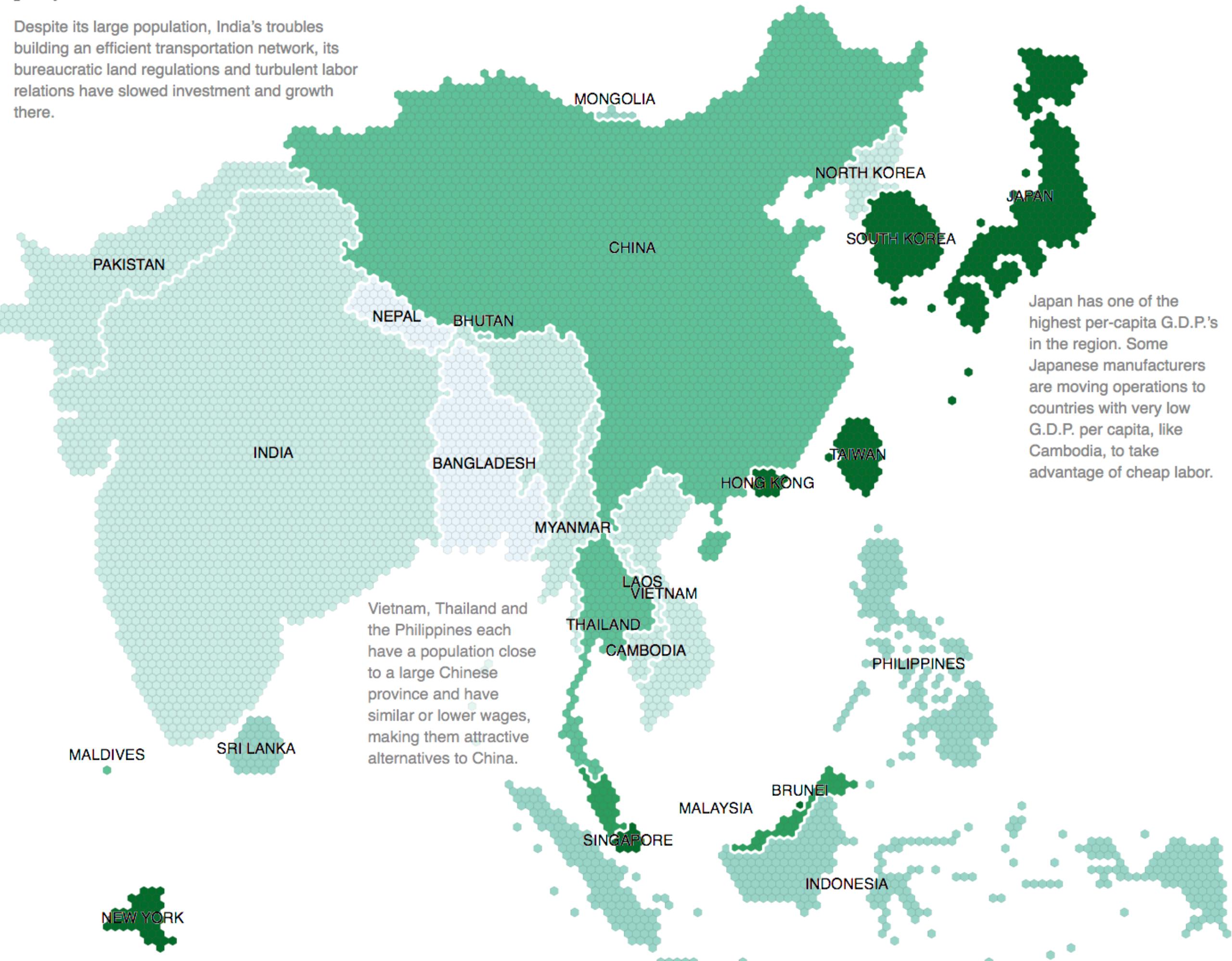
China is both highly productive and growing rapidly. Considering individual provinces conveys its impressive scale: Guangdong, just one of 31 Chinese provinces, has an economic output greater than Indonesia.



Population

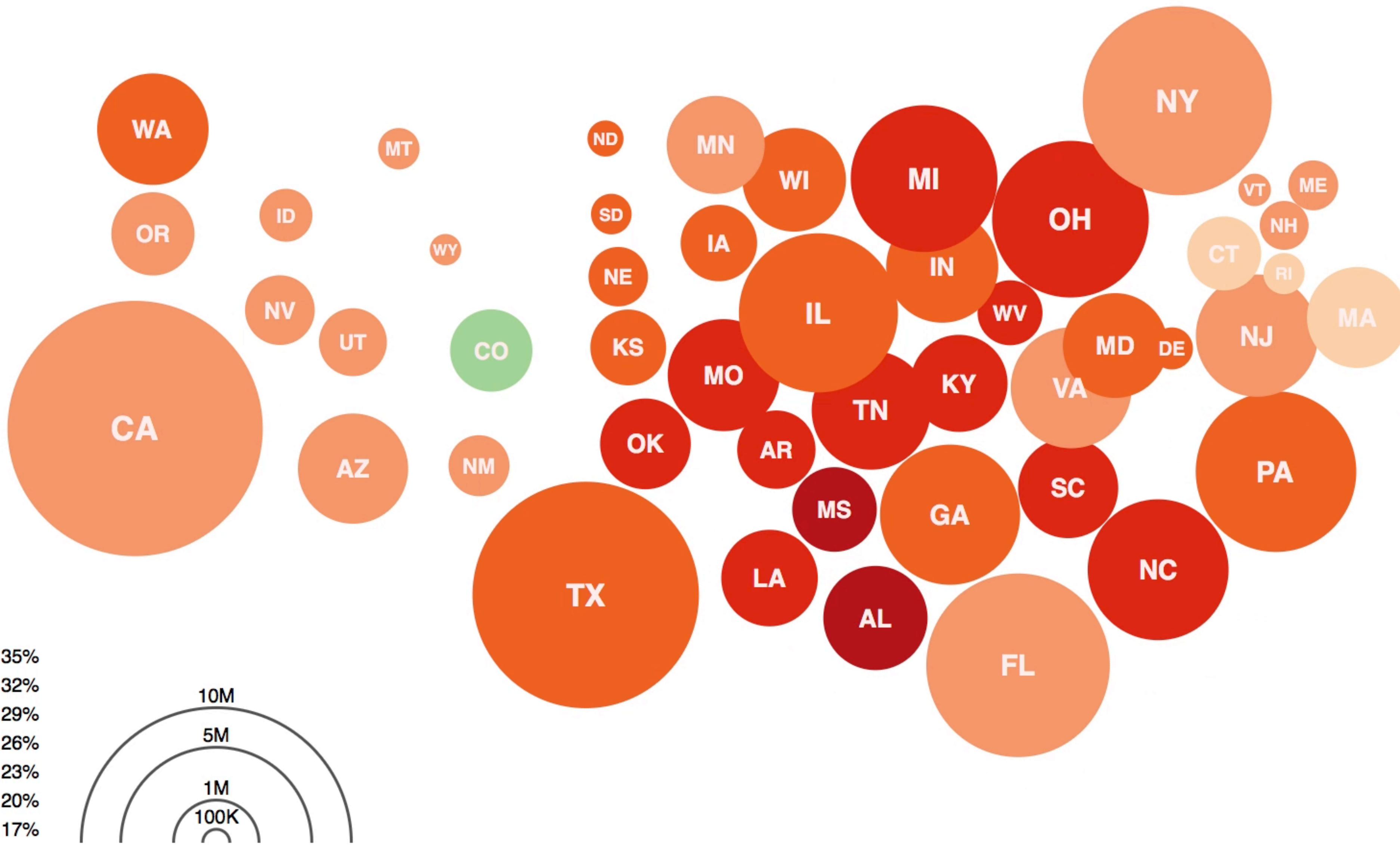
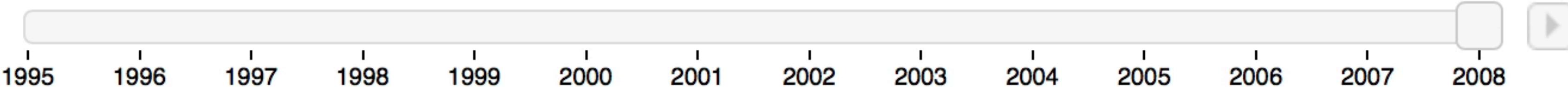
Sizing by population instead gives an estimate of a country's economic potential, at least for labor-based manufacturing. The color here shows the economic output per capita: a measure of how effectively that potential has been realized, and a proxy for labor cost.

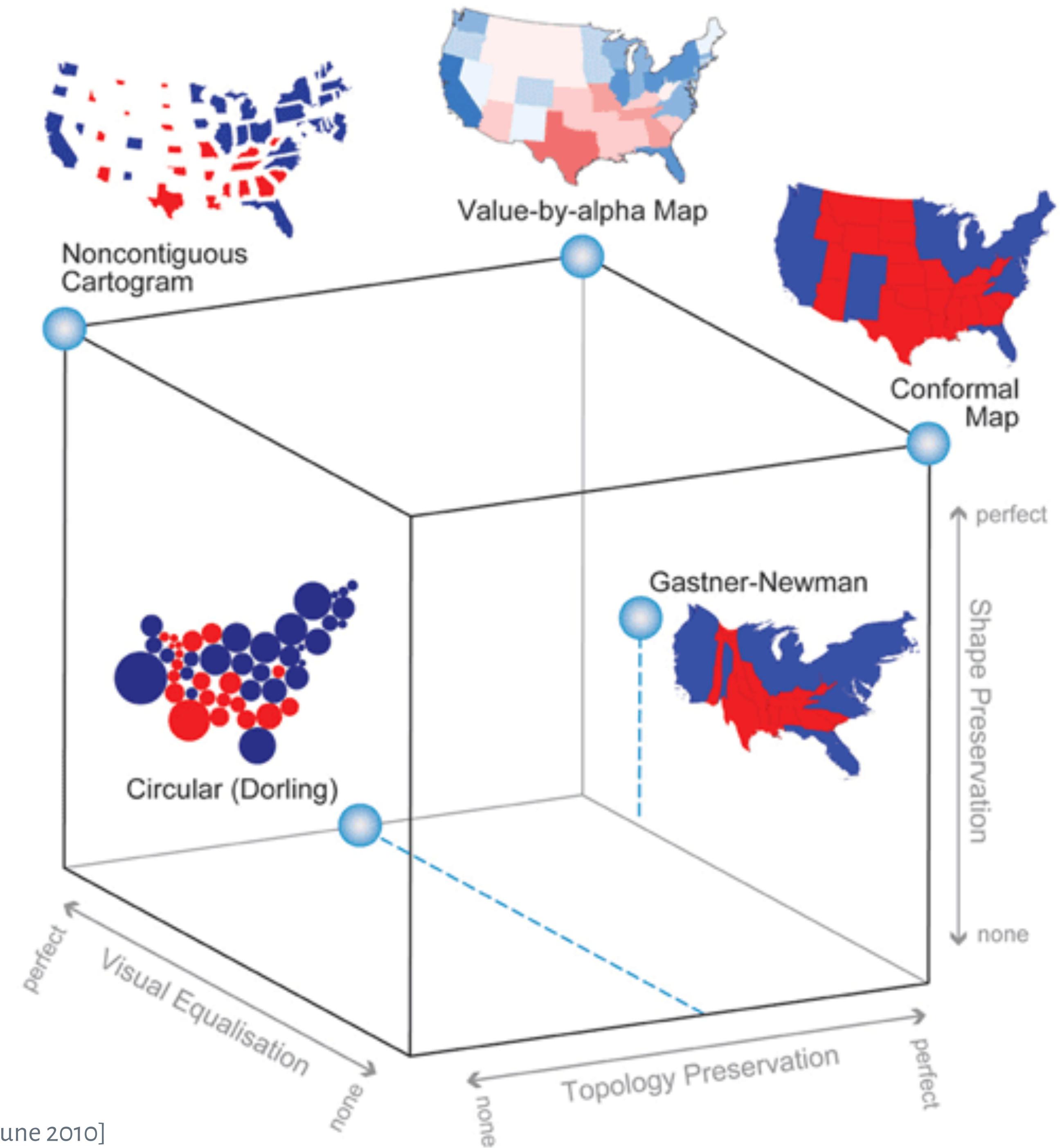
Despite its large population, India's troubles building an efficient transportation network, its bureaucratic land regulations and turbulent labor relations have slowed investment and growth there.



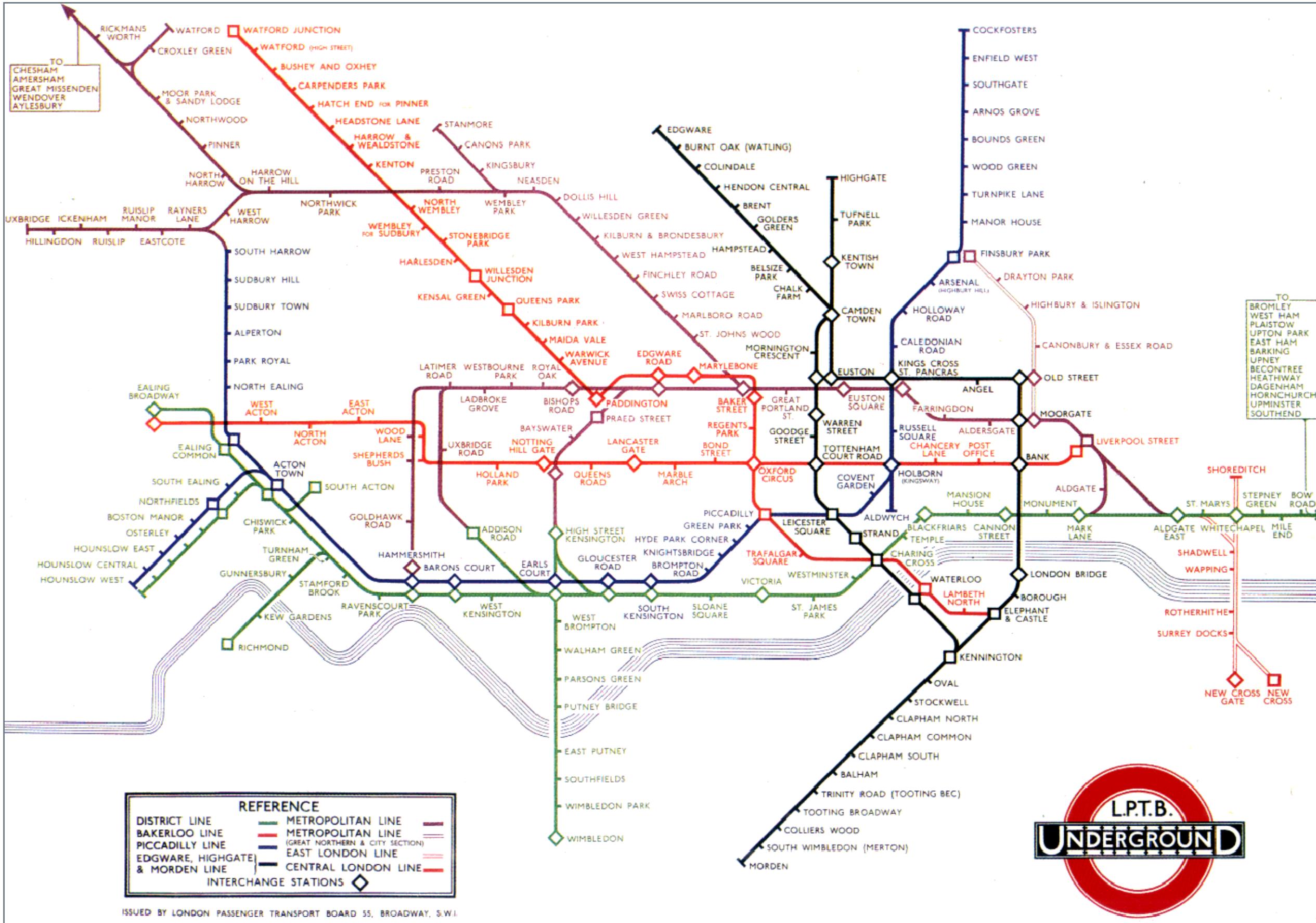
Dorling Cartograms

Year:

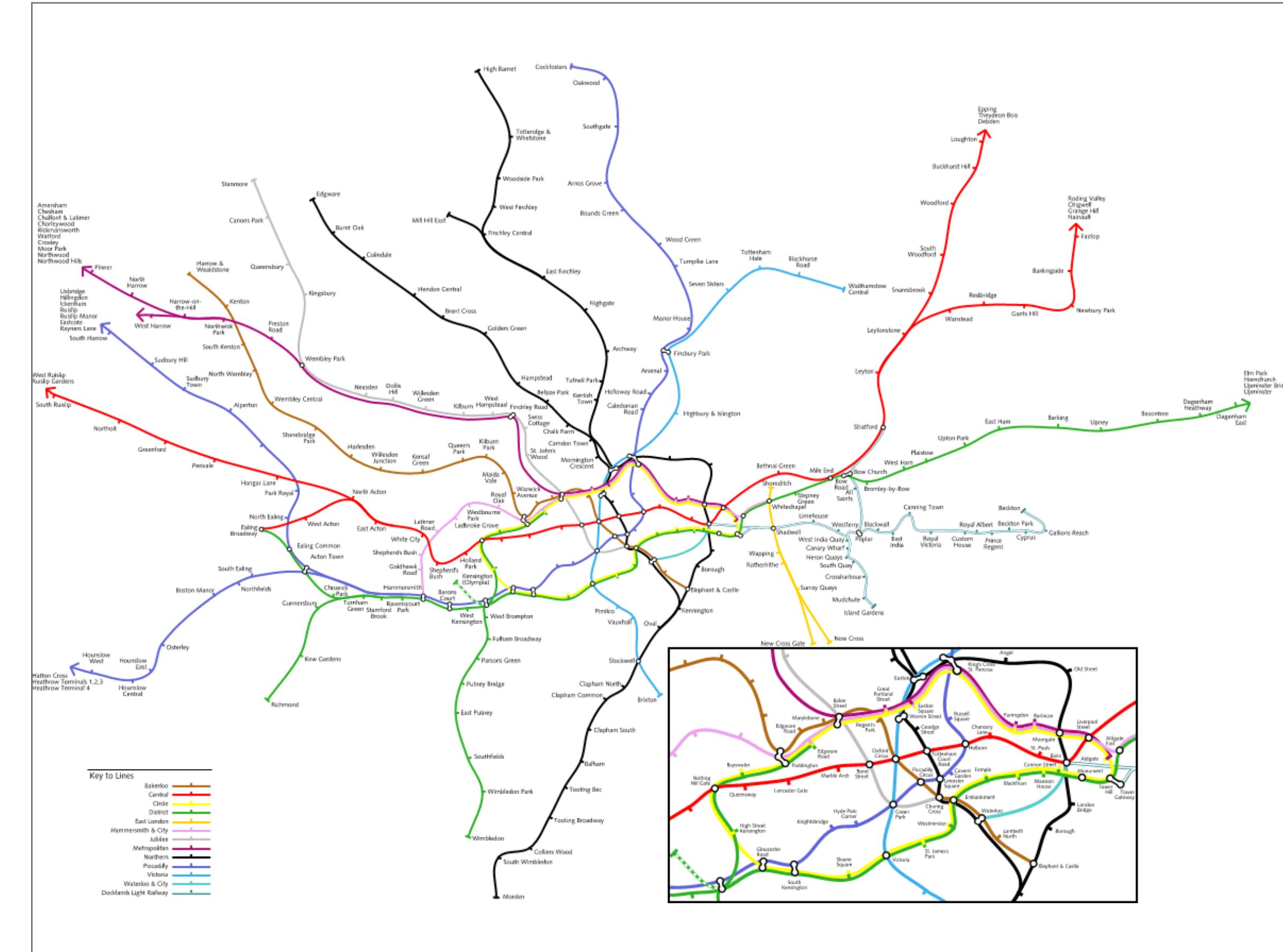




Route Maps

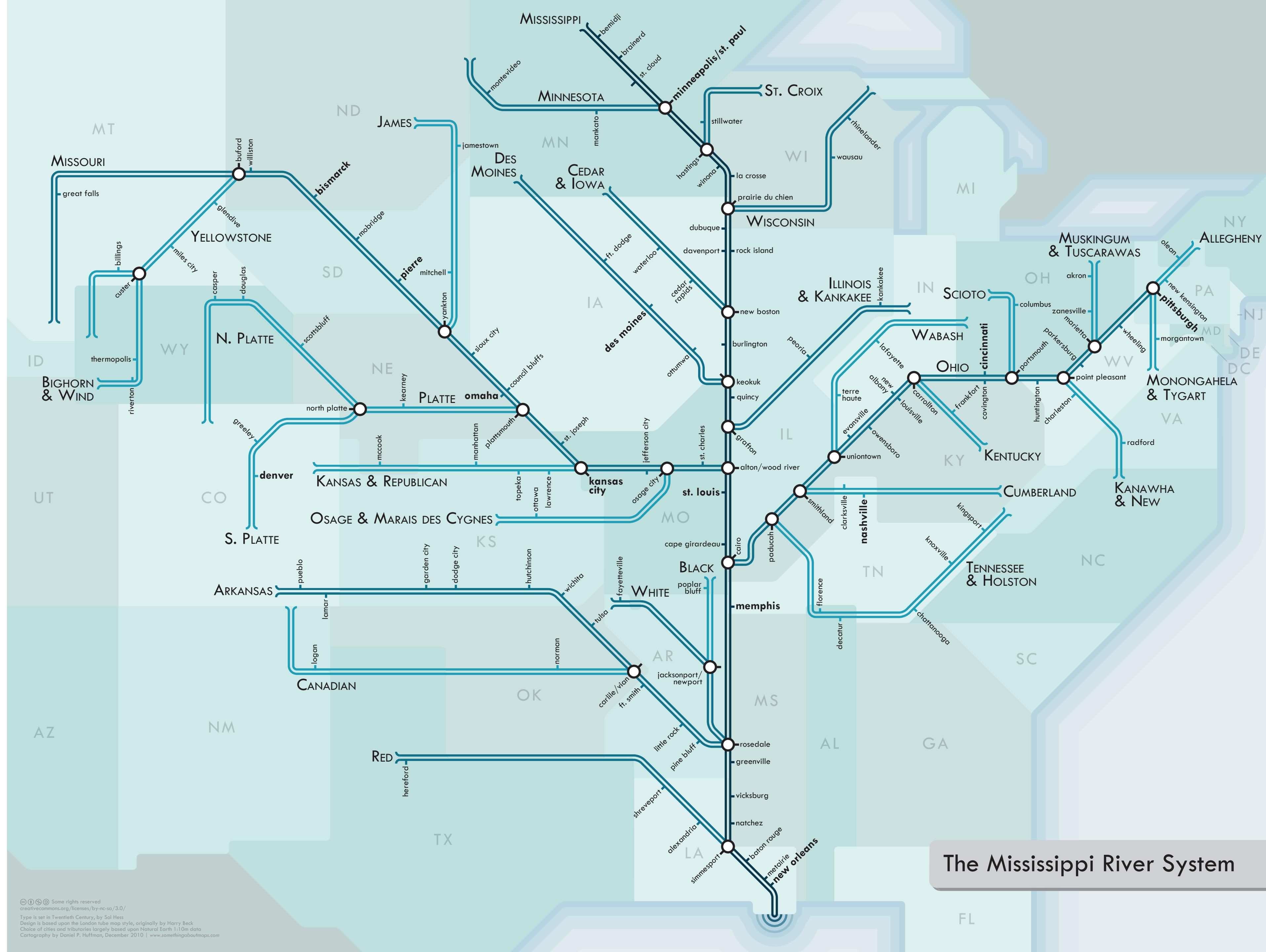


London Underground [Beck 33]



Geographic version of map

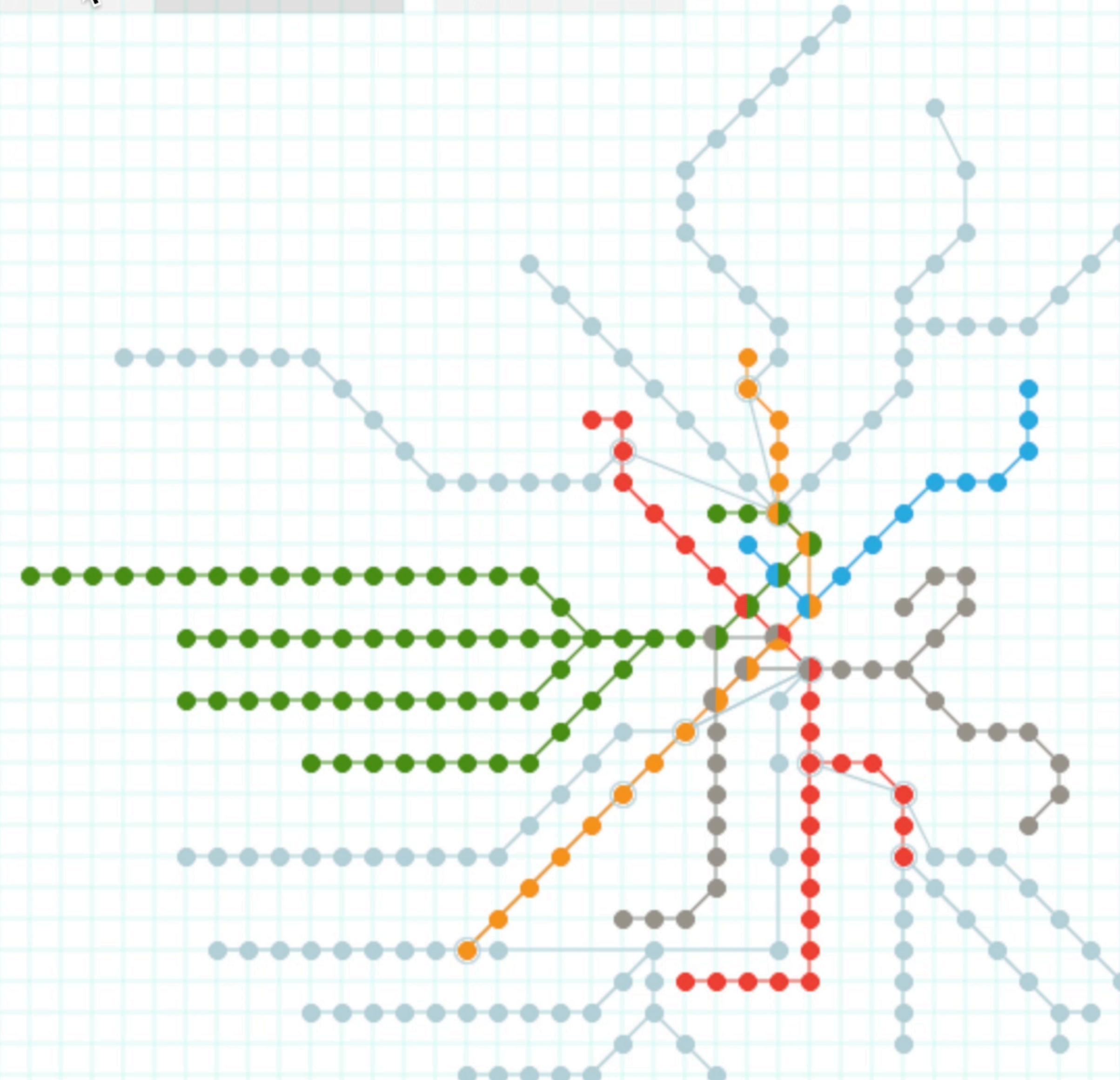
[Daniel Huffman. River Maps]



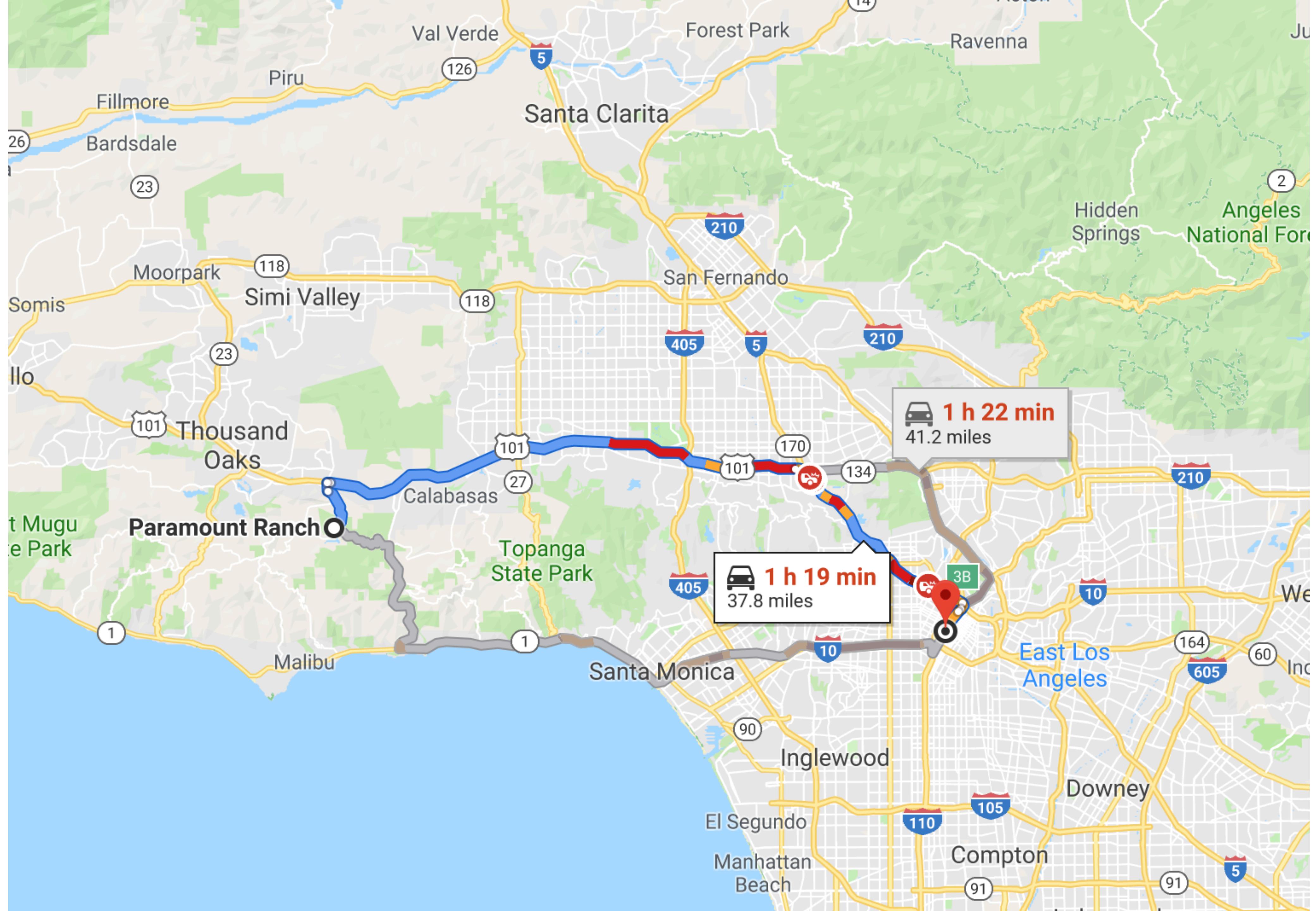
Geographic

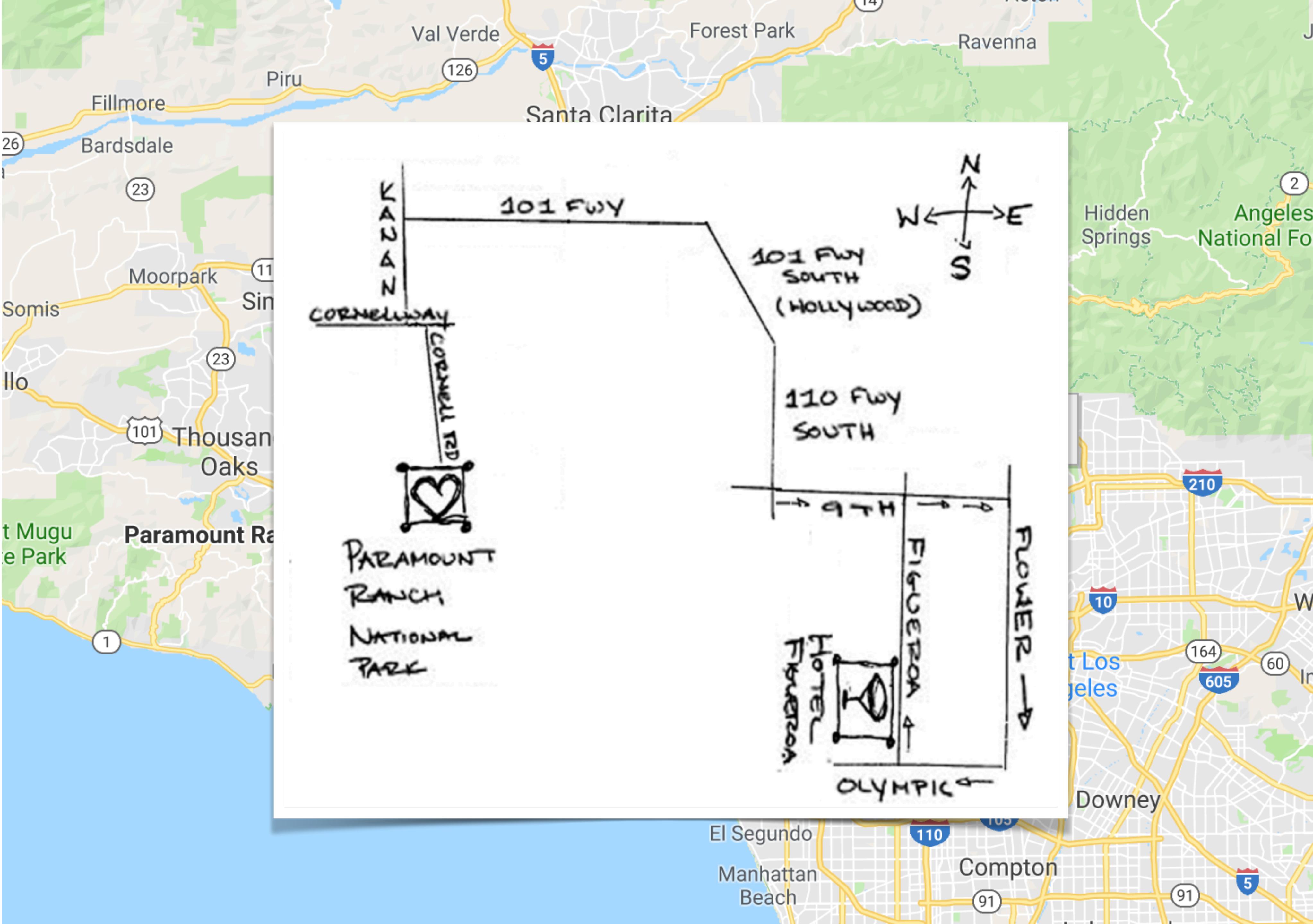
Grid

Commuter Rail On

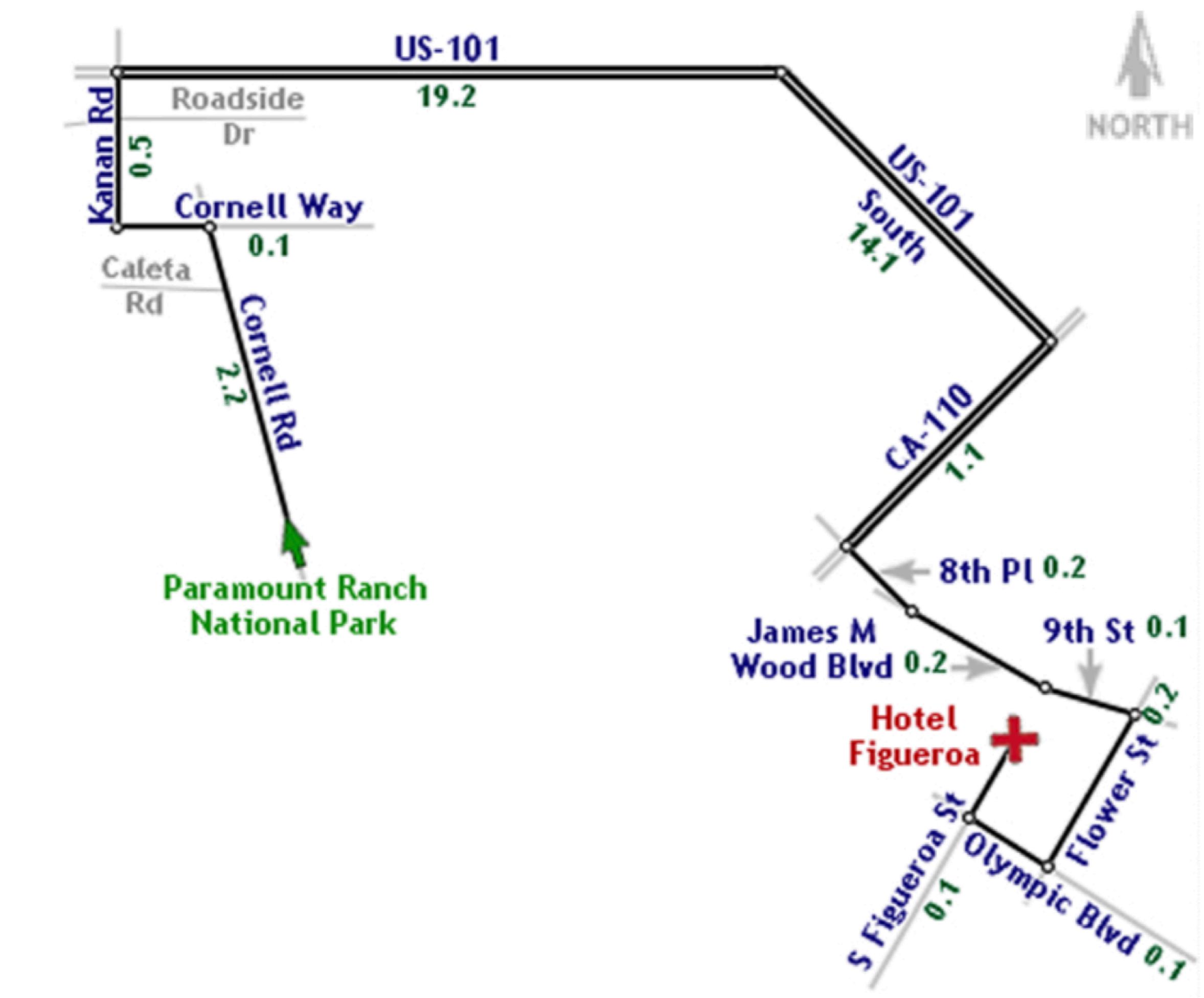
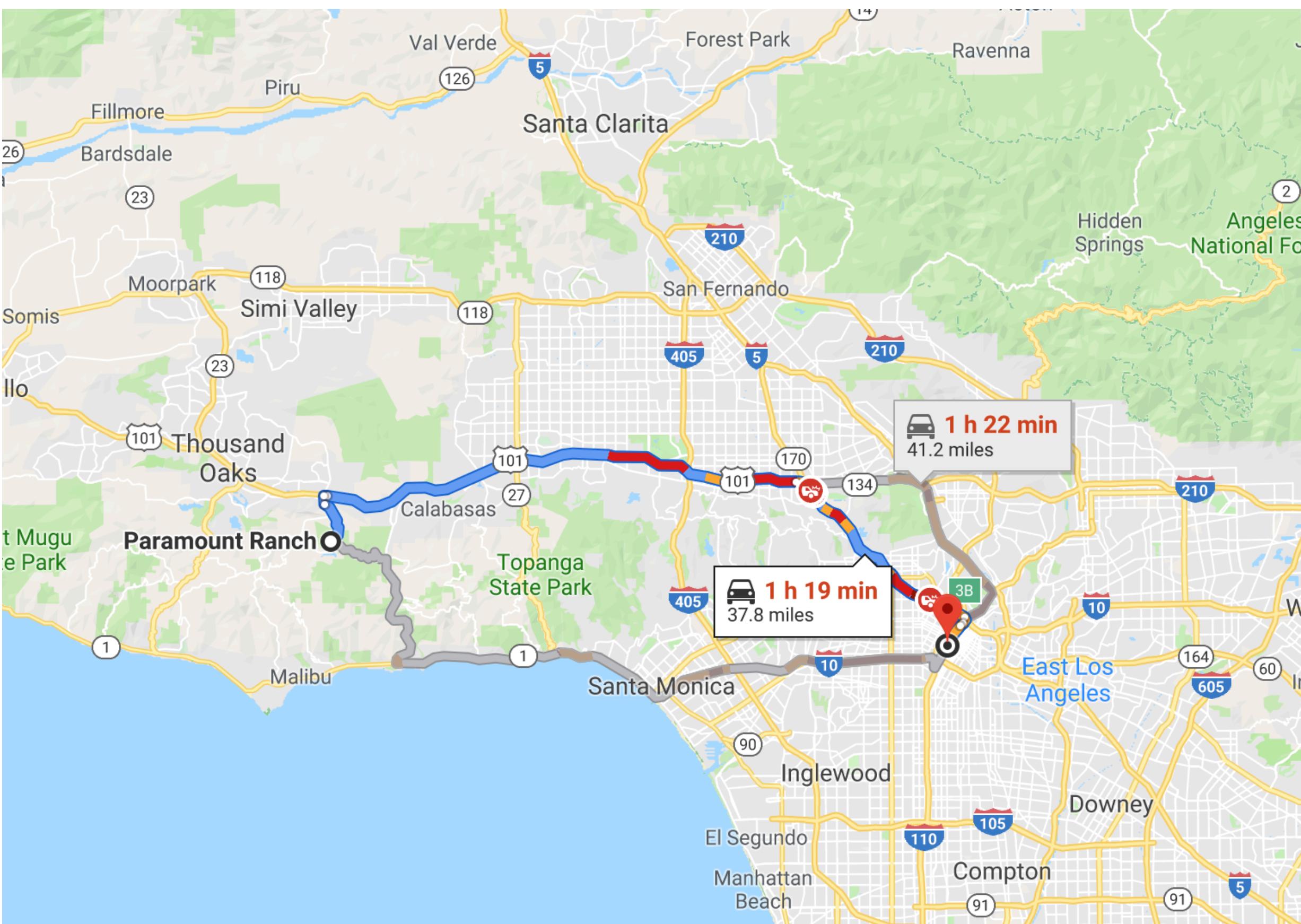


[Ben Fry. 2012]





Line Drive



Tooling

Web Tools

D3/Vega/Vega-Lite: Projections, paths, graticules, etc.

GeoJSON: JSON format for geo data.

TopoJSON: Topology → compressed GeoJSON.

Leaflet: open-source, customizable map tile system.

Data Resources

Natural Earth Data: naturalearthdata.com

OpenStreetMap: openstreetmap.org

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

Tutorials

Command Line Cartography, by Mike Bostock

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



Mike Bostock
Jan 23, 2017 · 5 min read

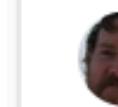
Command-Line Cartography, Part 4

A tour of d3-geo's new command-line interface.

[This is Part 4 of a tutorial on making thematic maps from the command line using d3-geo, TopoJSON and ndjson-cli. Read Part 3 here.]

450

5 responses



Mike Bostock
Dec 12, 2016 · 5 min read

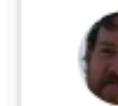
Command-Line Cartography, Part 3

A tour of d3-geo's new command-line interface.

[This is Part 3 of a tutorial on making thematic maps from the command line using d3-geo, TopoJSON and ndjson-cli. Read Part 2 and Part 4 here.]

359

10 responses



Mike Bostock
Dec 10, 2016 · 6 min read

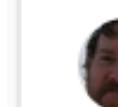
Command-Line Cartography, Part 2

A tour of d3-geo's new command-line interface.

[This is Part 2 of a tutorial on making thematic maps from the command line using d3-geo, TopoJSON and ndjson-cli. Read Part 1 or Part 3 here.]

365

15 responses



Mike Bostock
Dec 9, 2016 · 5 min read

Command-Line Cartography, Part 1

A tour of d3-geo's new command-line interface.

[This is Part 1 of a tutorial on making thematic maps. Read Part 2 here.]

1.5K

30 responses