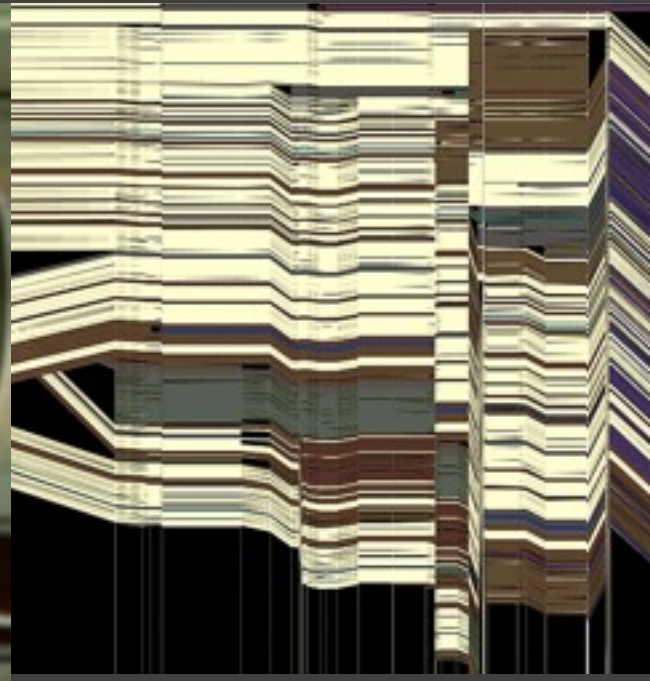
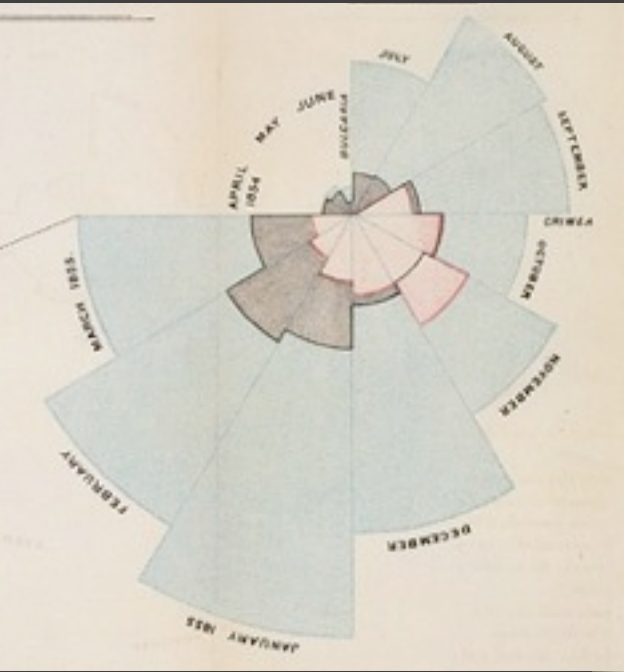


CSE512 :: 20 Feb 2014

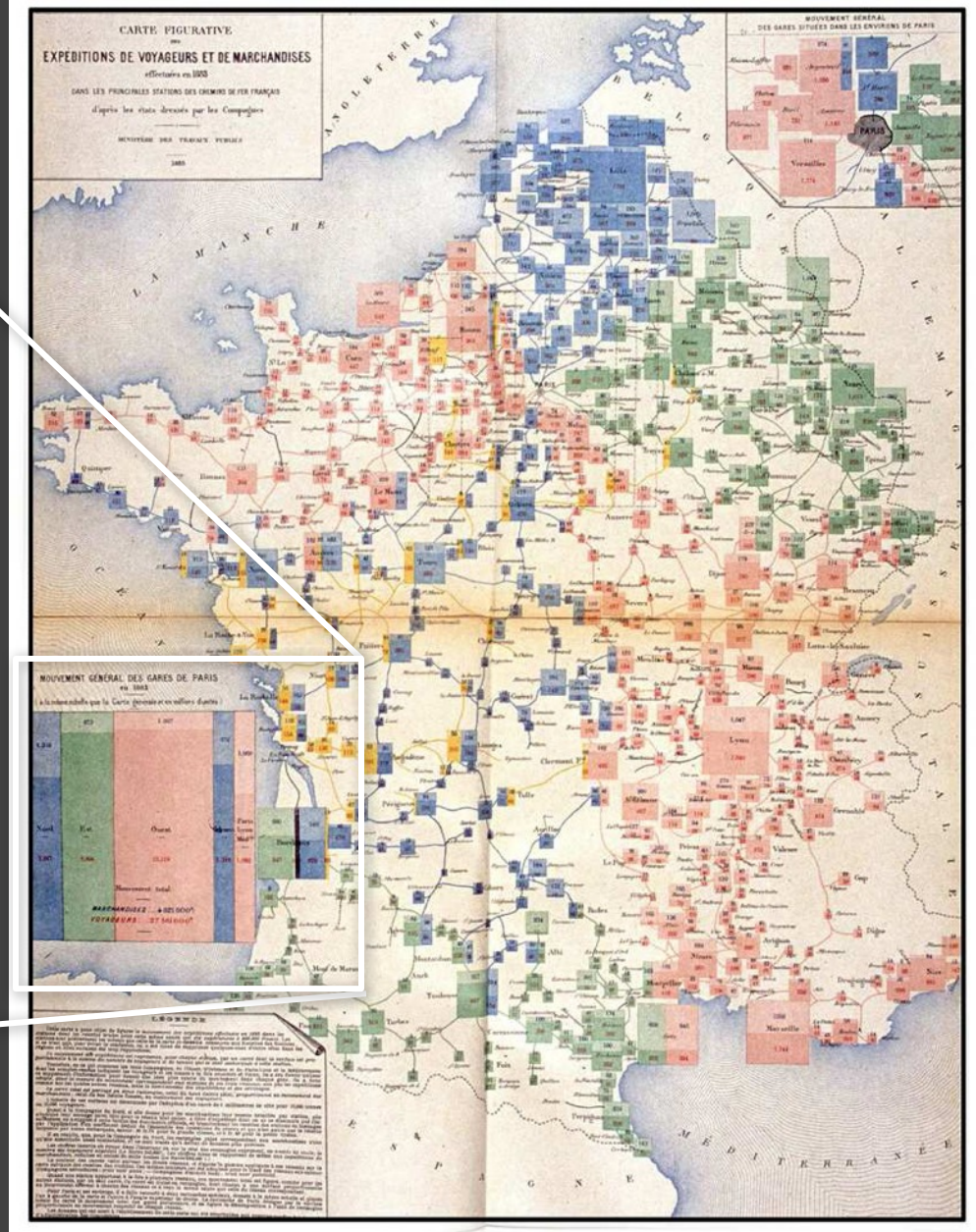
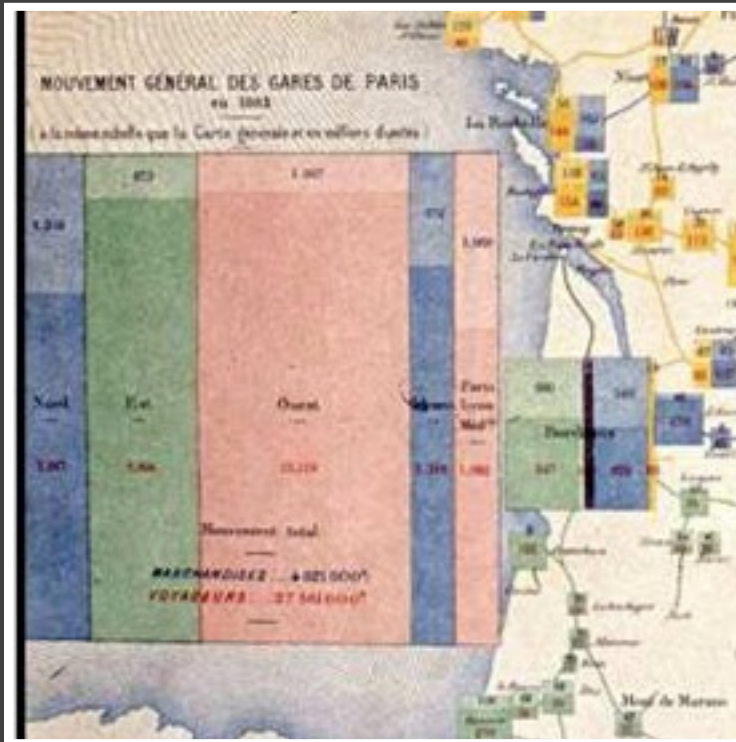
Mapping & Cartography



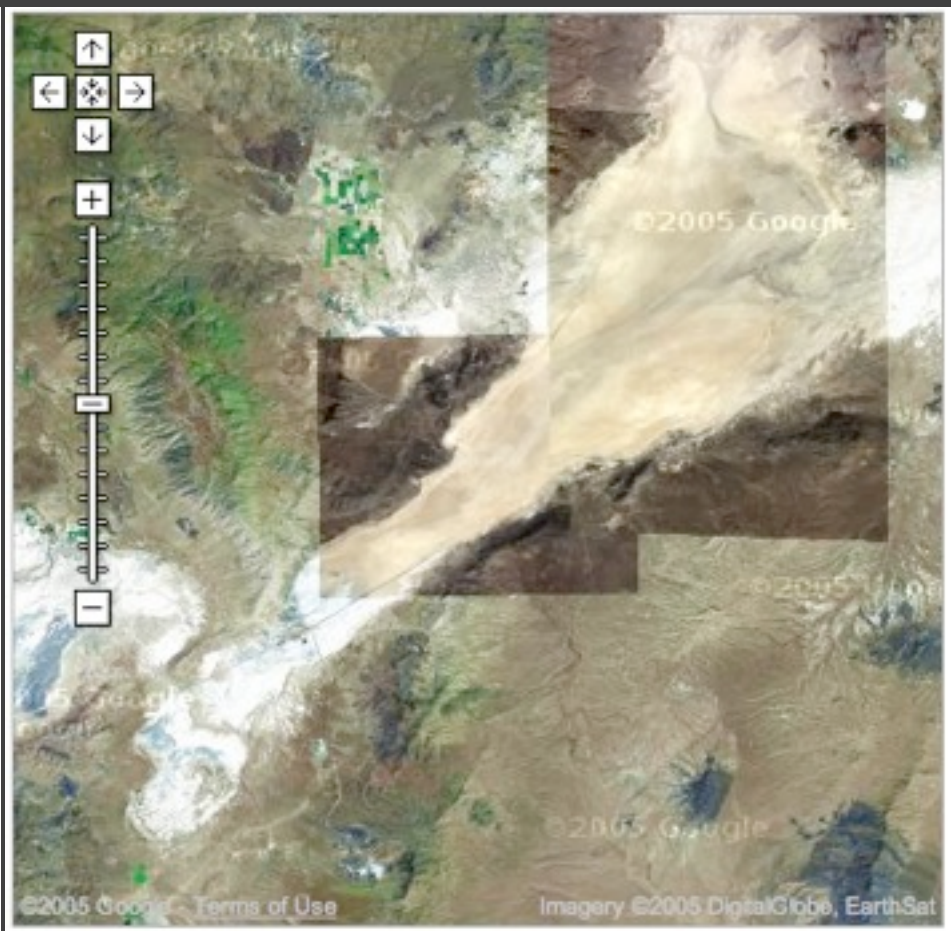
Jeffrey Heer University of Washington
(with significant material from Michal Migurski)



Ptolemy's Geographica
Original ~150AD, This Map ~1300AD



Rail Passengers and Freight from Paris 1884



Google Maps 2005

WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION ARTS STYLE TRAVEL JOBS REAL ESTATE AUTOS

POLITICS WASHINGTON EDUCATION

Casualties of War

FACES ANALYSIS THEIR STORIES

Texas oil boom is visible from space

Lighting and natural gas flares from drilling on the 400-mile-long Eagle Ford shale formation can be seen from space in this image.



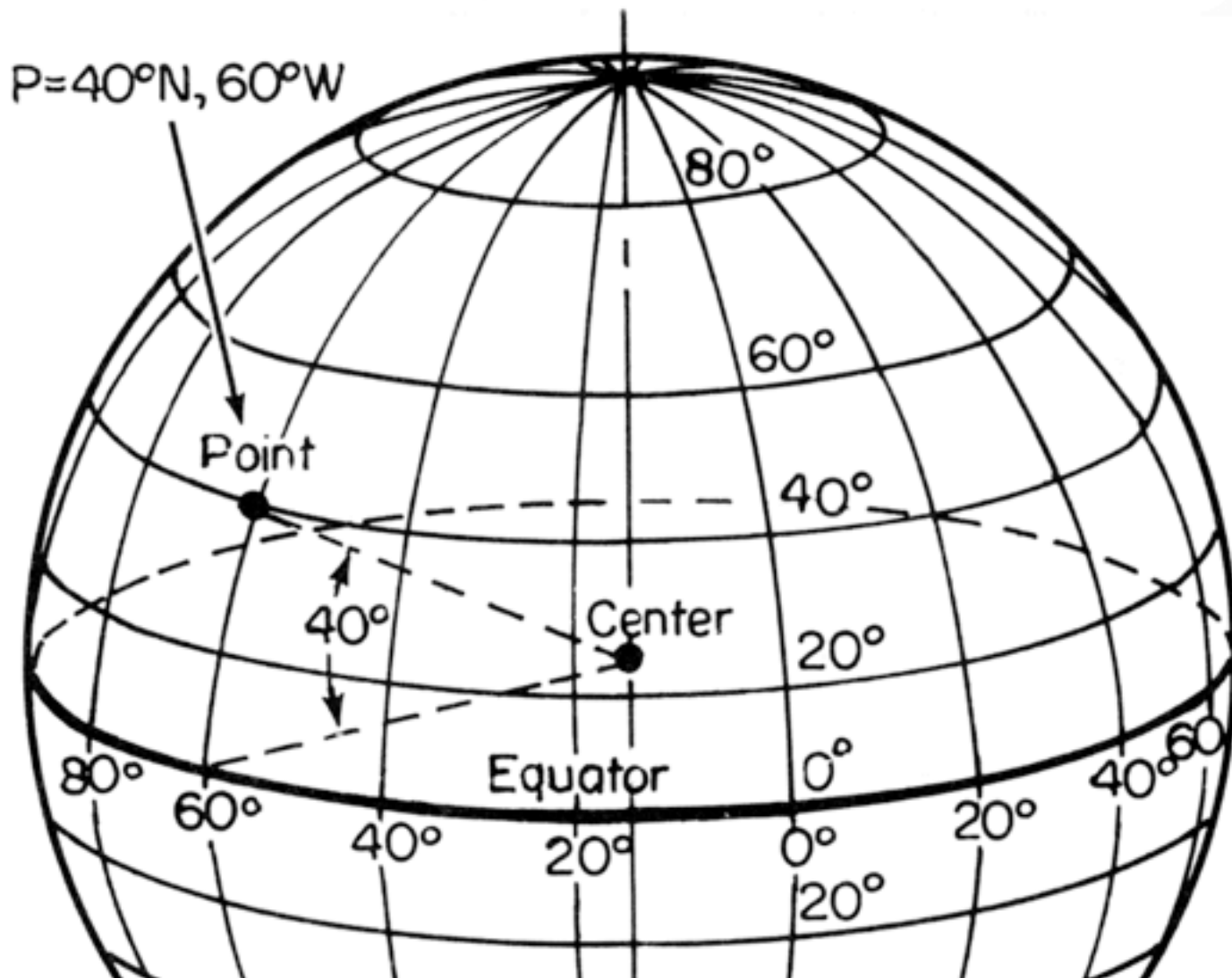
NASA

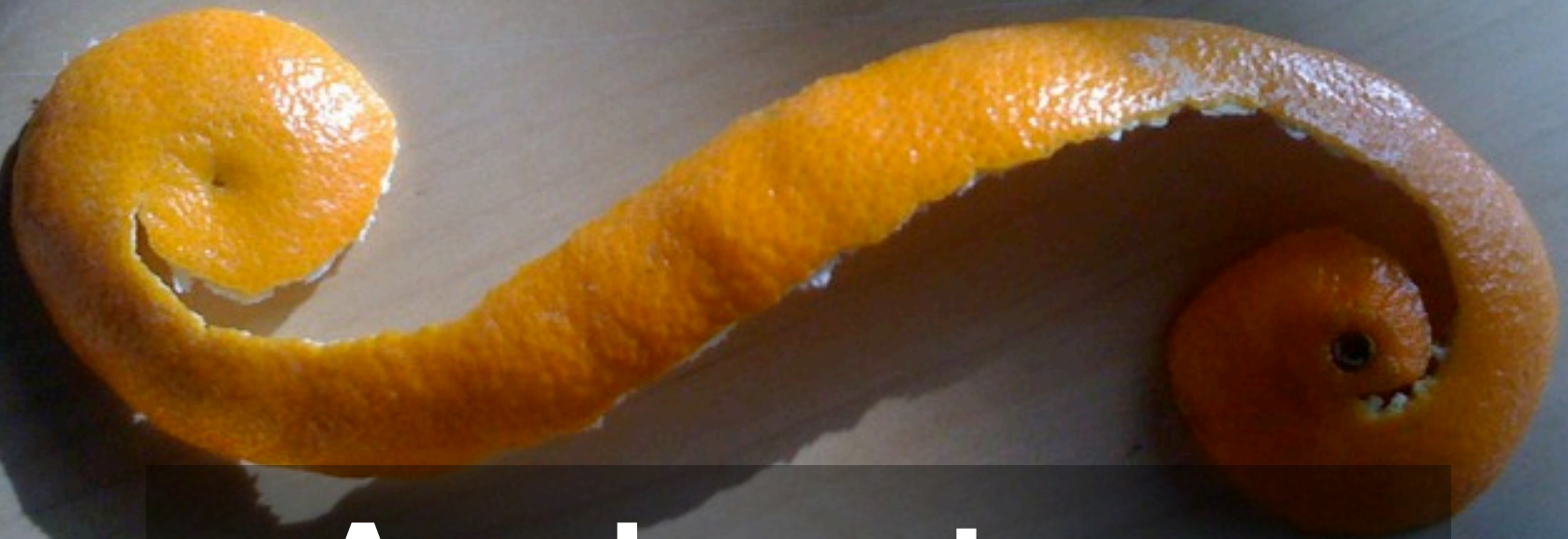
Cartography

(the creation of maps)

Projections

Latitude, Longitude





**A sphere tears
when you flatten it**

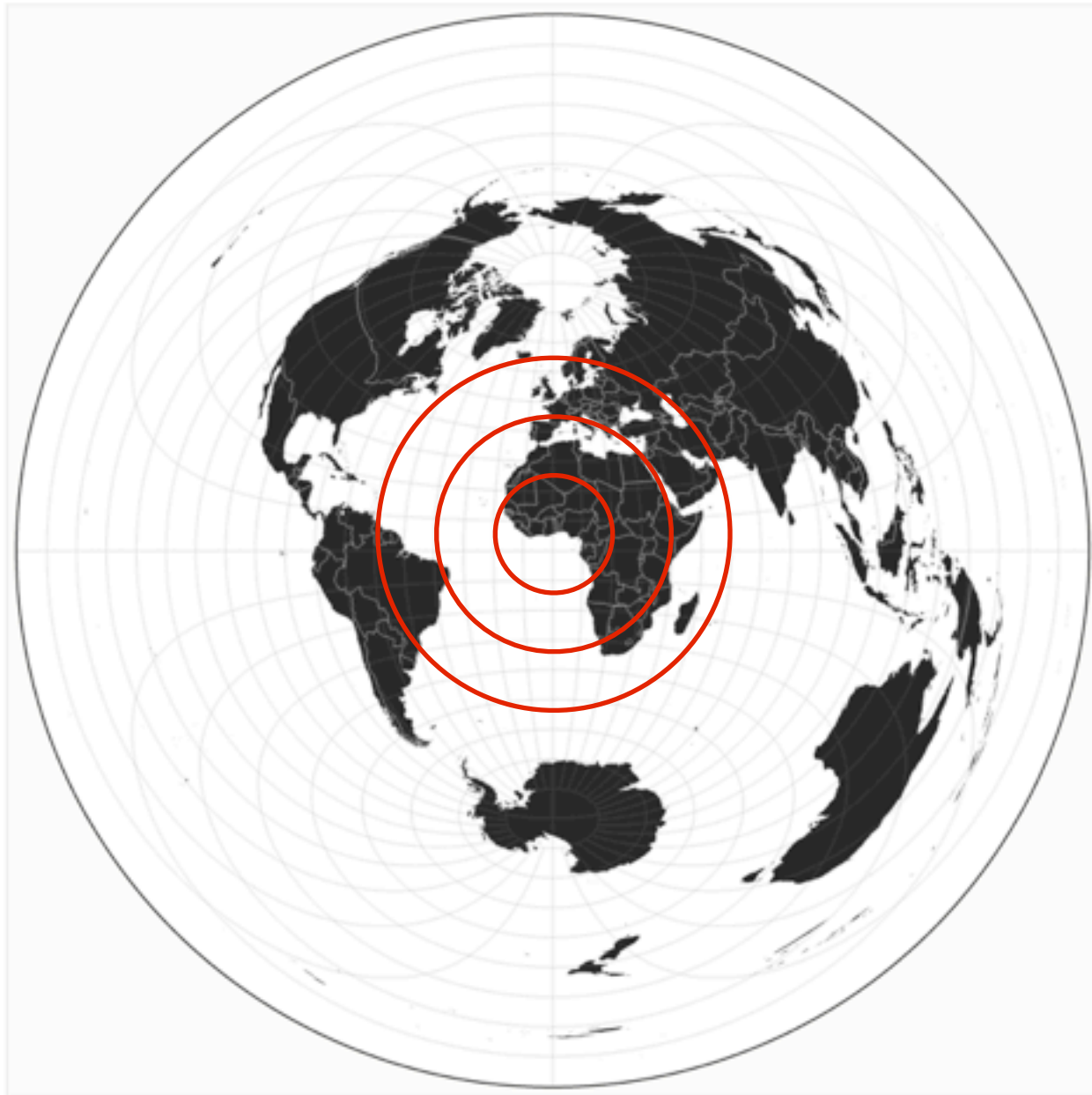
Three example ways to categorize projections...



Azimuthal

Preserves direction / distance

Azimuthal Equidistant



The azimuthal equidistant projection is available as [d3.geo.azimuthalEquidistant](#).

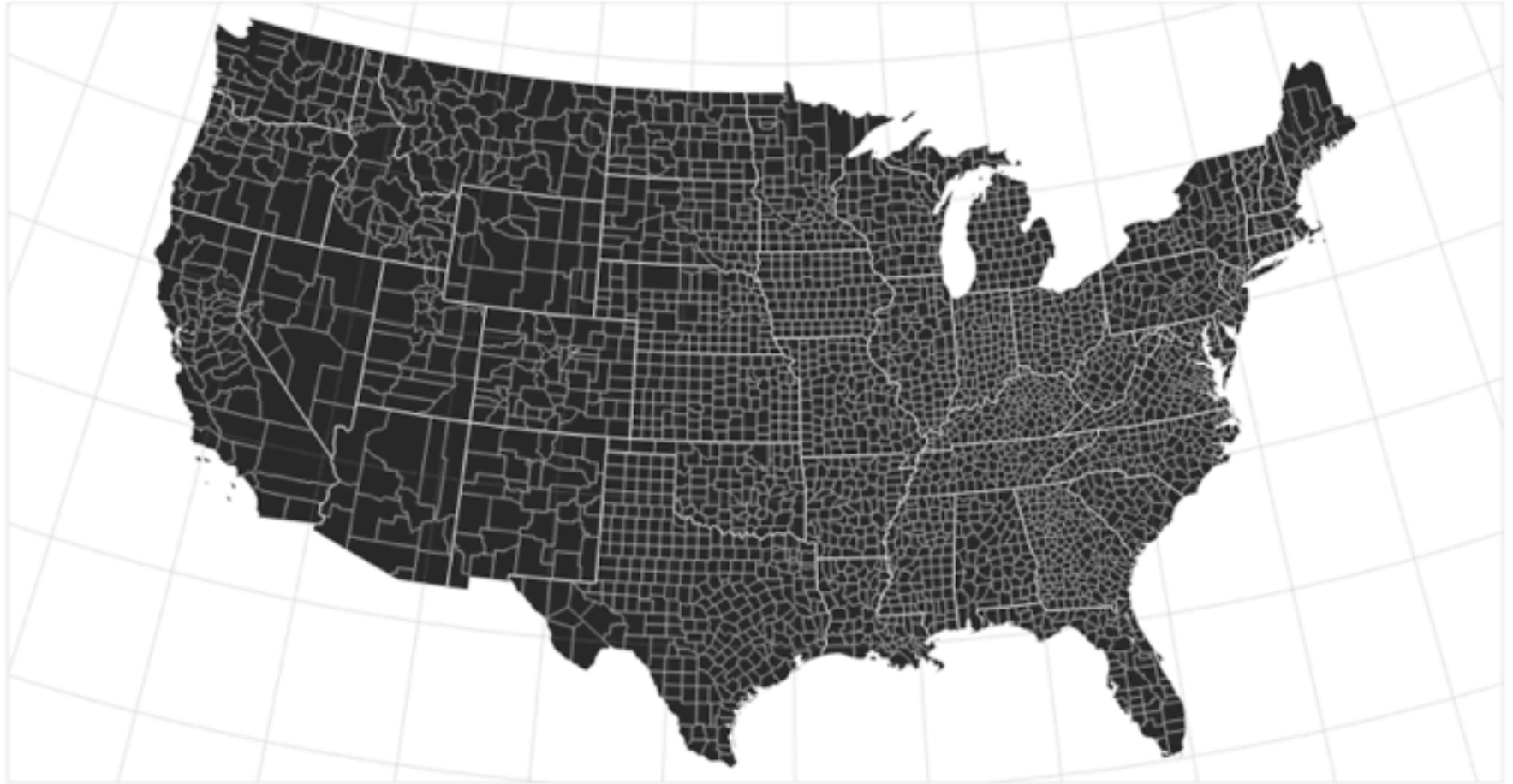
[Open in a new window.](#)

A map of the Pacific Ocean region, showing the western coast of North America, the Hawaiian Islands, and the eastern coast of Asia. A semi-transparent dark gray rectangular box is overlaid on the map, covering the area from approximately 150°W to 130°W and 30°N to 50°N. Inside this box, the text "Equal-Area" is written in large white font, and "Preserves area" is written in smaller white font below it. The landmasses are colored yellow, and the ocean is dark gray.

Equal-Area

Preserves area

Albers Equal-Area Conic



The [Albers equal-area conic projection](#) is available as [d3.geo.albers](#). See also the [interactive version](#).

[Open in a new window.](#)

A world map with yellow landmasses and dark grey oceans. A semi-transparent dark grey rectangular box is centered over the Atlantic Ocean, containing the text 'Conformal' and 'Preserves local angles'.

Conformal

Preserves local angles

Spherical Mercator



The [Mercator projection](#) is available as [d3.geo.mercator](#).

[Open in a new window.](#)



**Spherical Mercator
is ubiquitous on
the web — why?**

The Earth as a Square

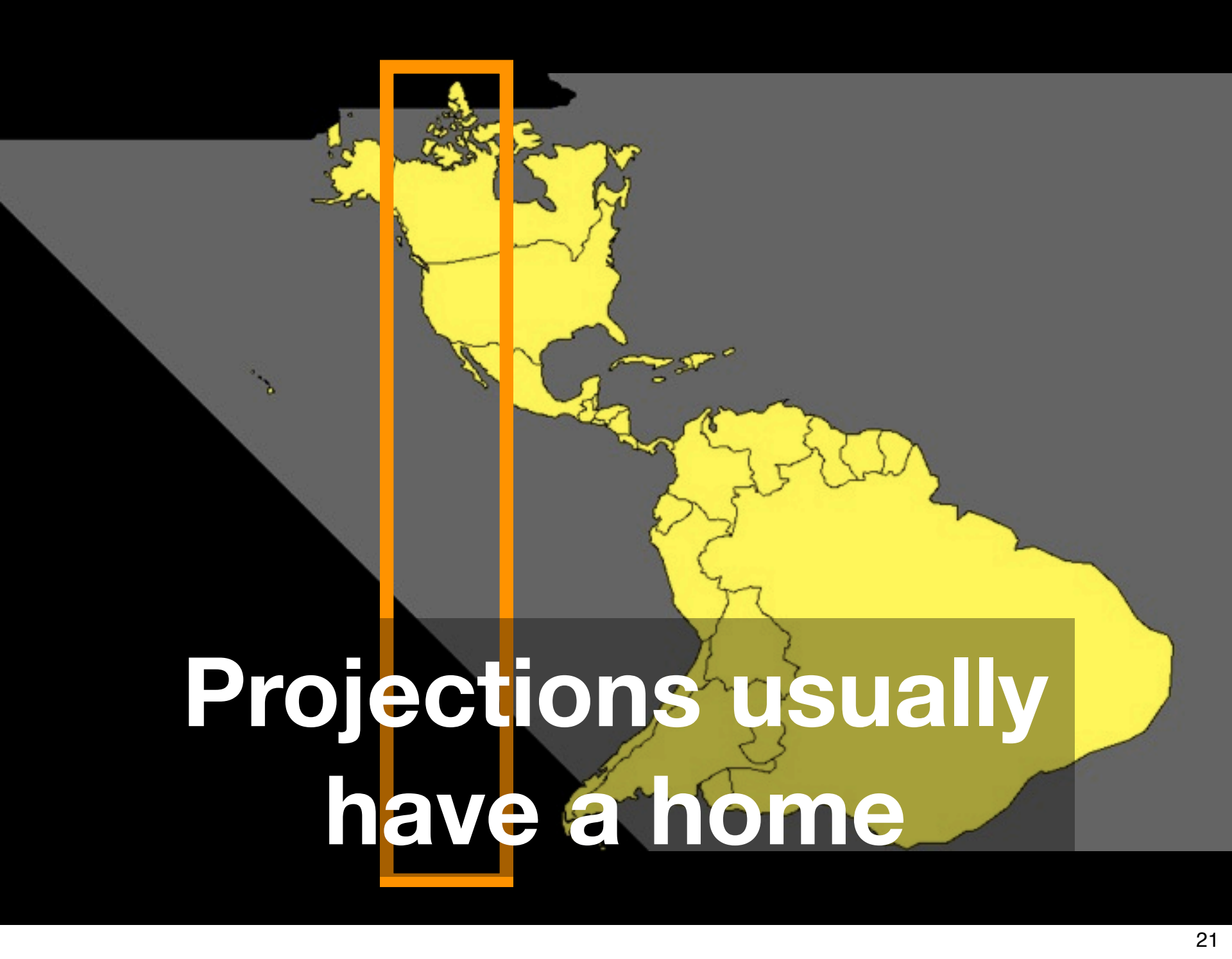


Peirce Quincuncial



The [Peirce quincuncial projection](#) is implemented as `d3.geo.peirceQuincuncial` in the [geo.projection D3 plugin](#). It is derived from the [Guyou projection](#).

[Open in a new window.](#)

A map of North and South America is shown in yellow against a dark gray background. A vertical orange rectangle highlights a central longitudinal strip, spanning from the Canadian Arctic down to the southern tip of South America. The text "Projections usually have a home" is overlaid in white, with the orange rectangle passing through the word "usually".

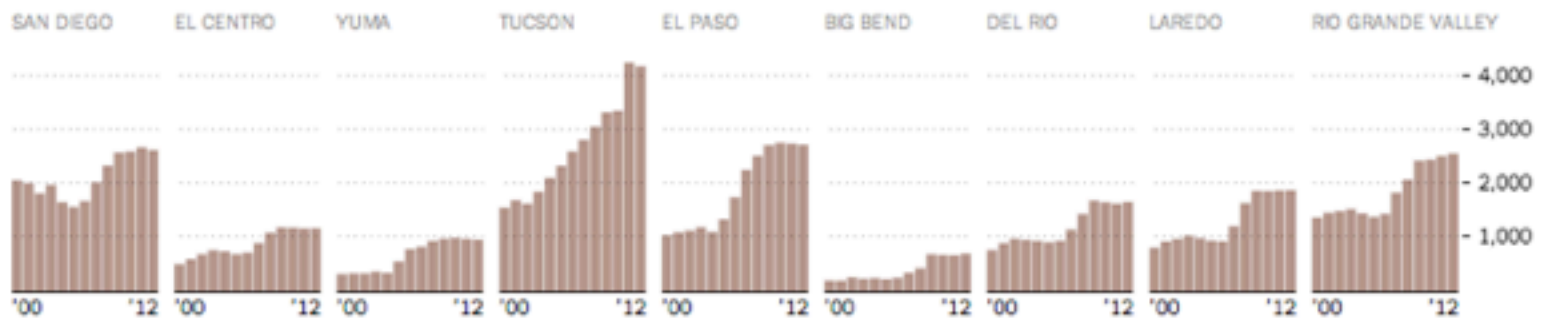
**Projections usually
have a home**

Increased Border Enforcement, With Varying Results



There are now more agents along the 1,954 mile-long border than ever before...

Border agents per sector.



Satellite Projection, NY Times



ADAPTIVE COMPOSITE MAP PROJECTIONS

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!

PEIRCE QUINCUNCIAL



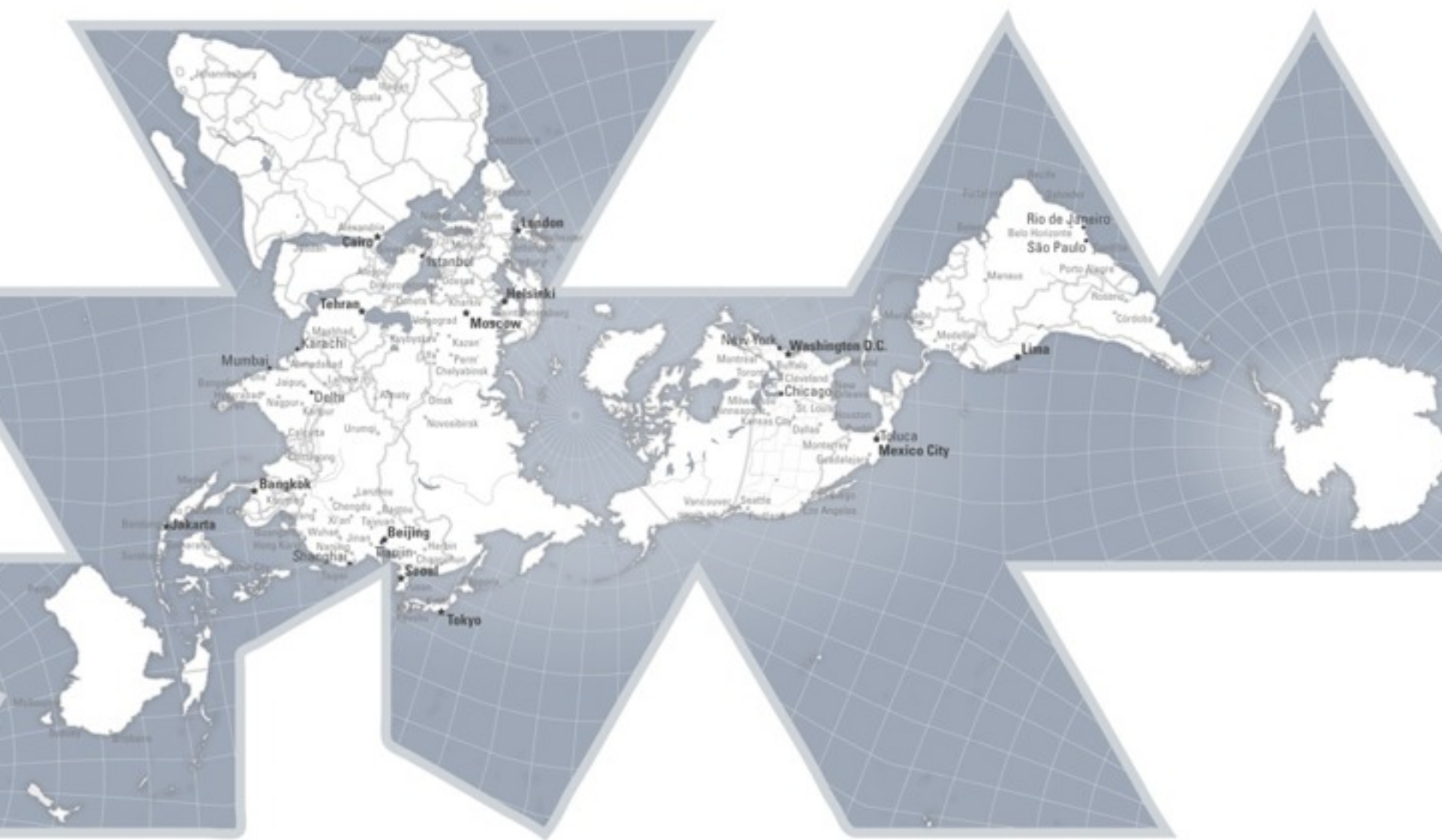
YOU THINK THAT WHEN WE LOOK AT A MAP, WHAT WE REALLY SEE IS OURSELVES. AFTER YOU FIRST SAW *INCEPTION*, YOU SAT SILENT IN THE THEATER FOR SIX HOURS. IT FREAKS YOU OUT TO REALIZE THAT EVERYONE AROUND YOU HAS A SKELETON INSIDE THEM. YOU *HAVE* REALLY LOOKED AT YOUR HANDS.

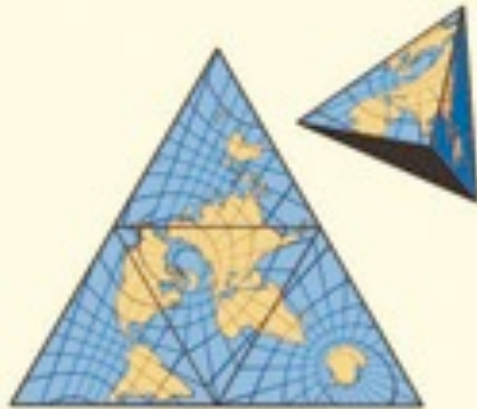


**There are interesting
ways to tear spheres**

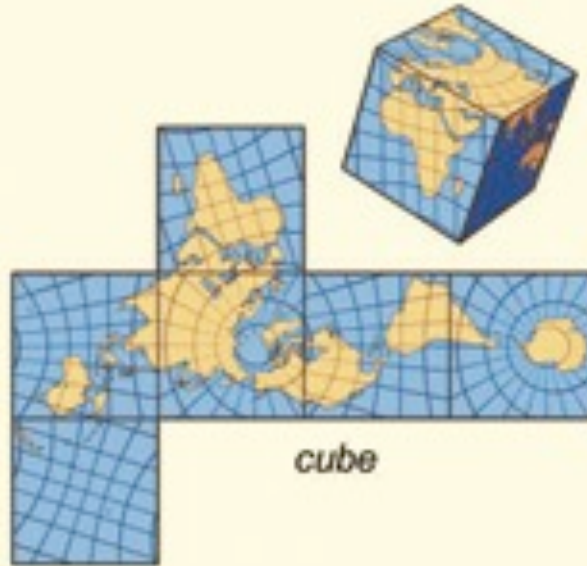
One notable interesting way to tear a sphere



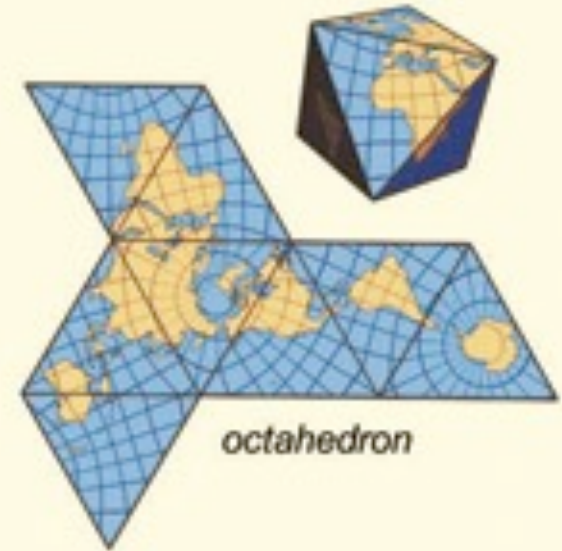




tetrahedron



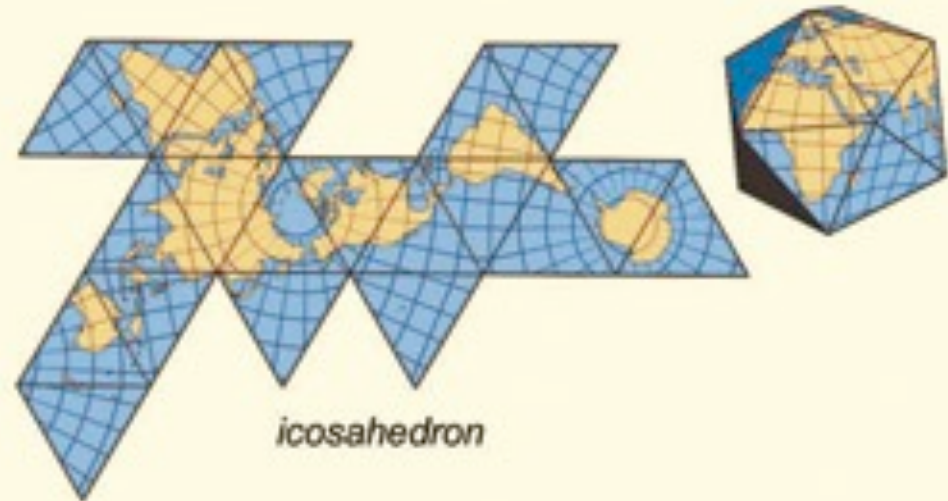
cube



octahedron

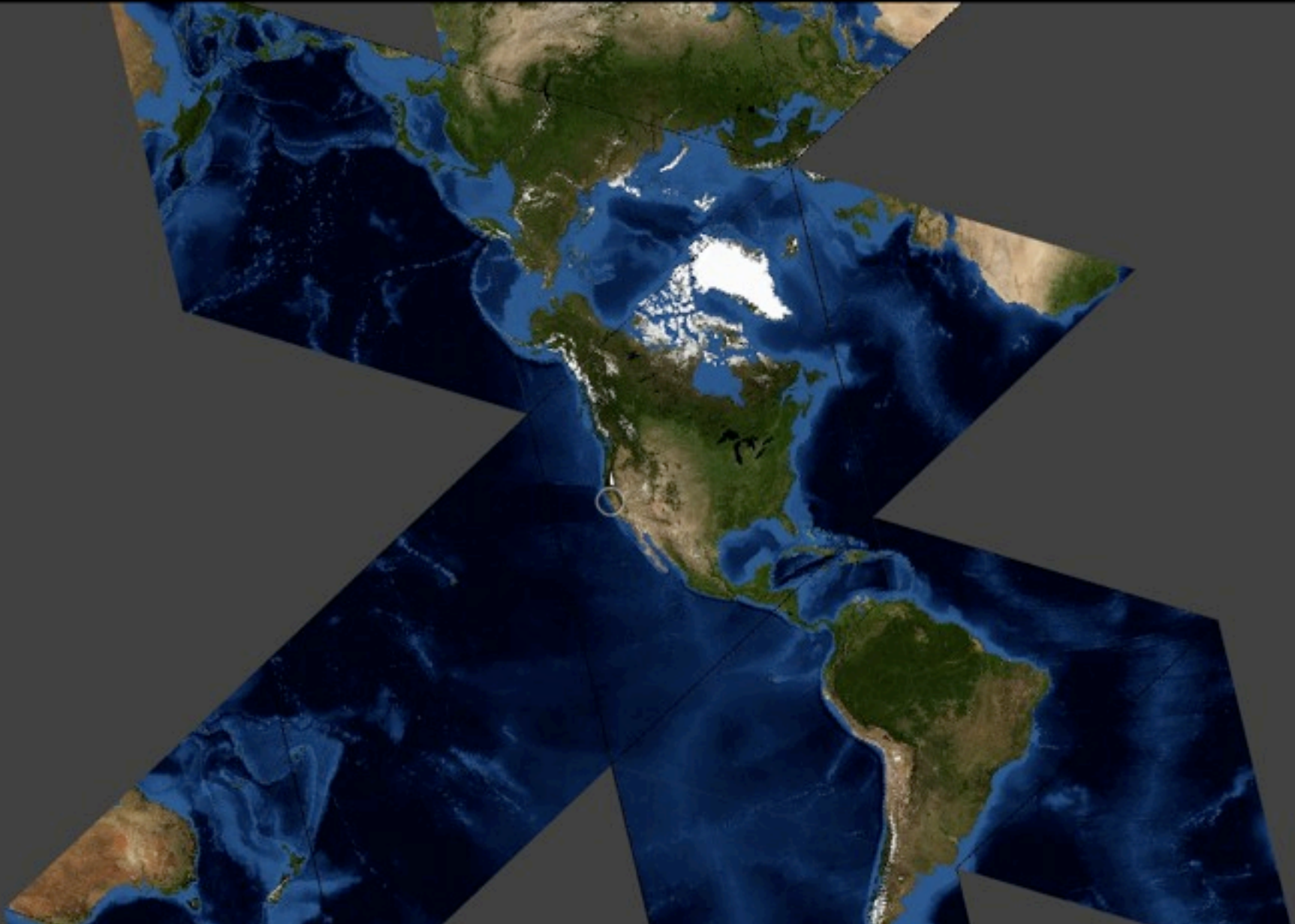


dodecahedron



icosahedron

You can drag the map with your mouse, and use the +/- buttons to zoom. The circle in the center will always indicate North for that point, and when you stop dragging the map will re-orient itself automatically. [Read more about this on my blog.](#)



Scale

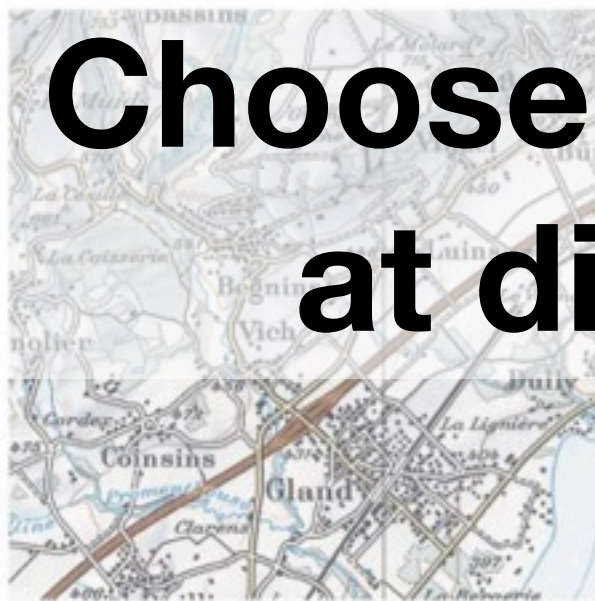


Scale is an idea imported from print





**Choose the right content
at different scales**



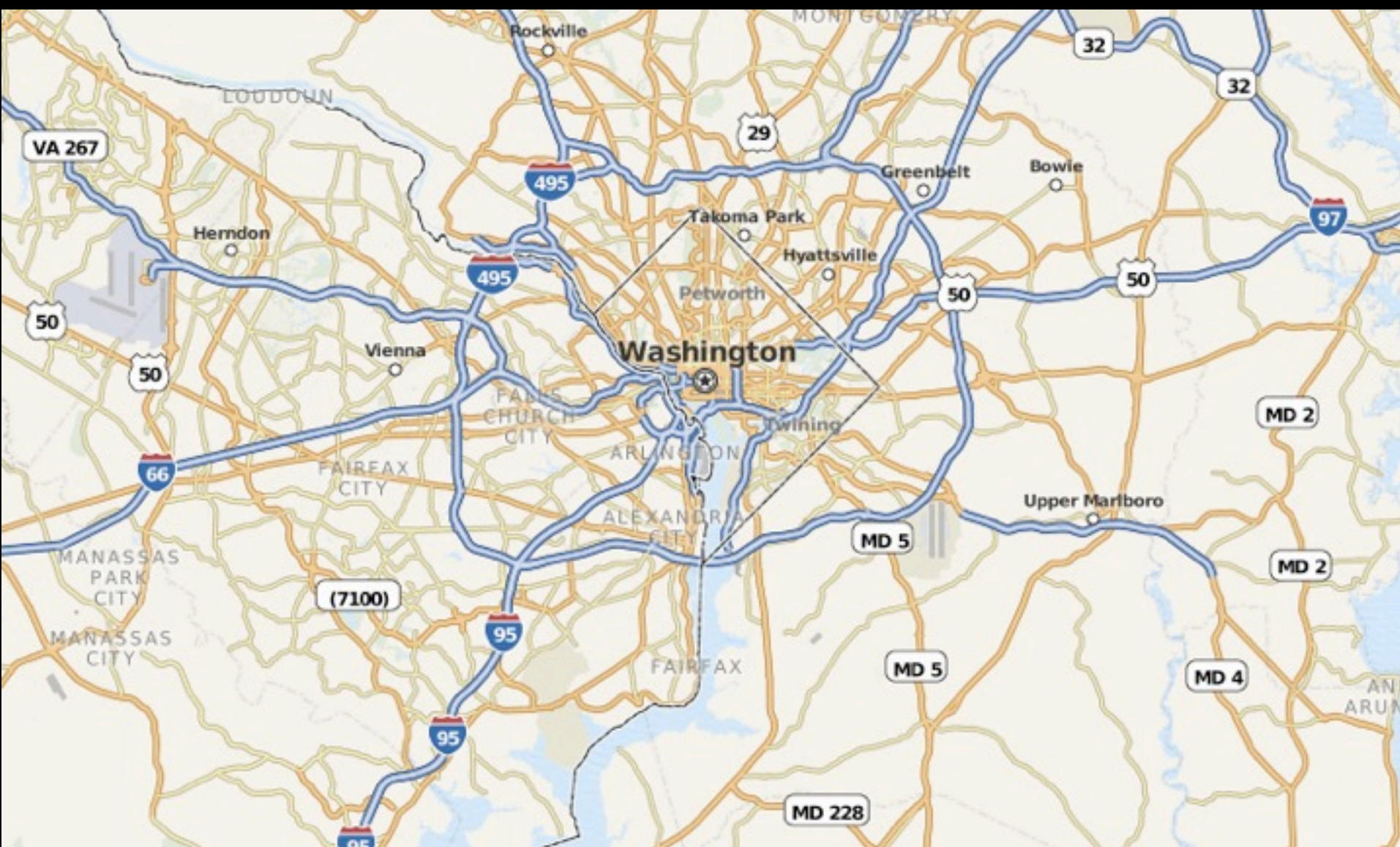
Four maps, same area

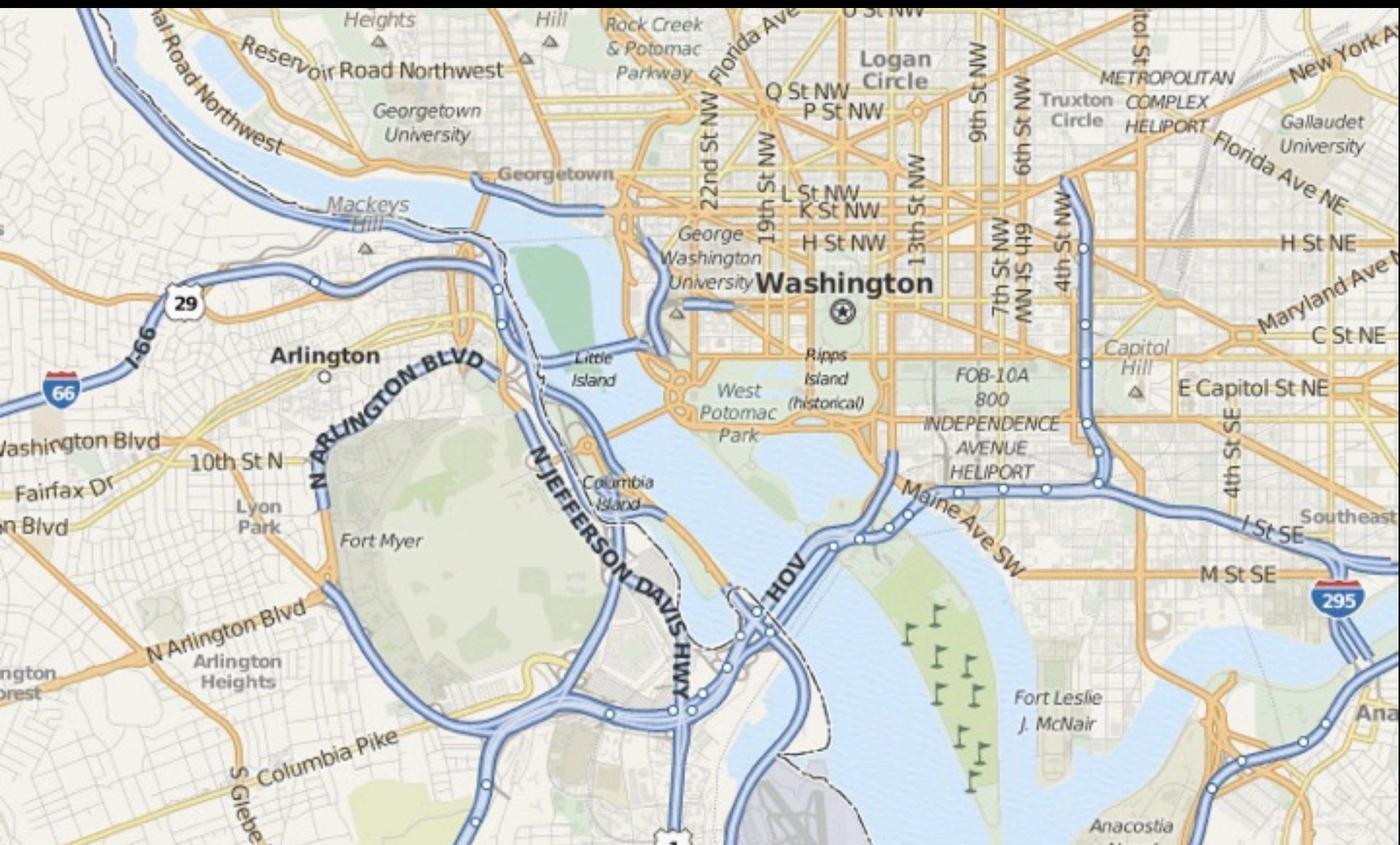


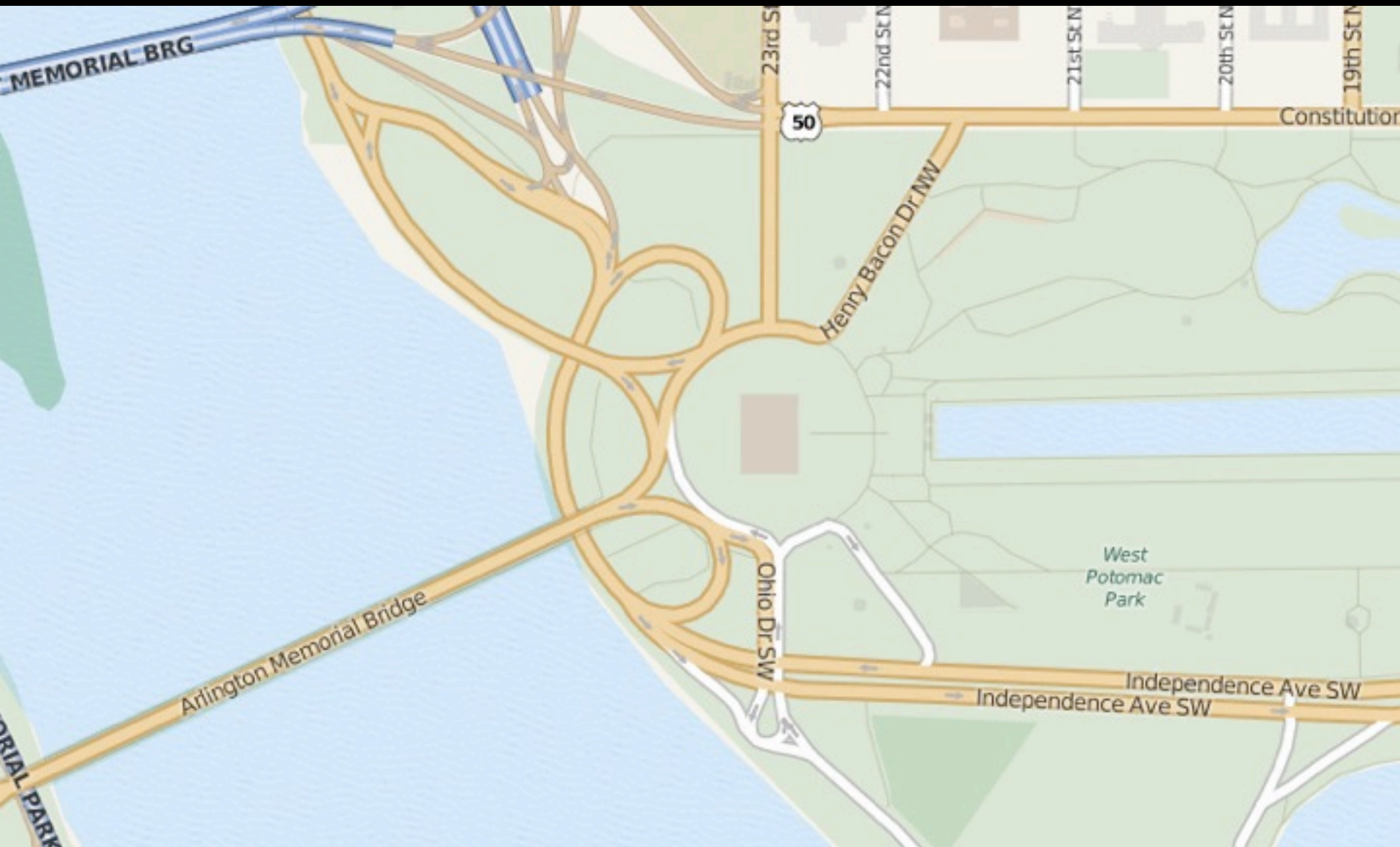
What shows at different scales?











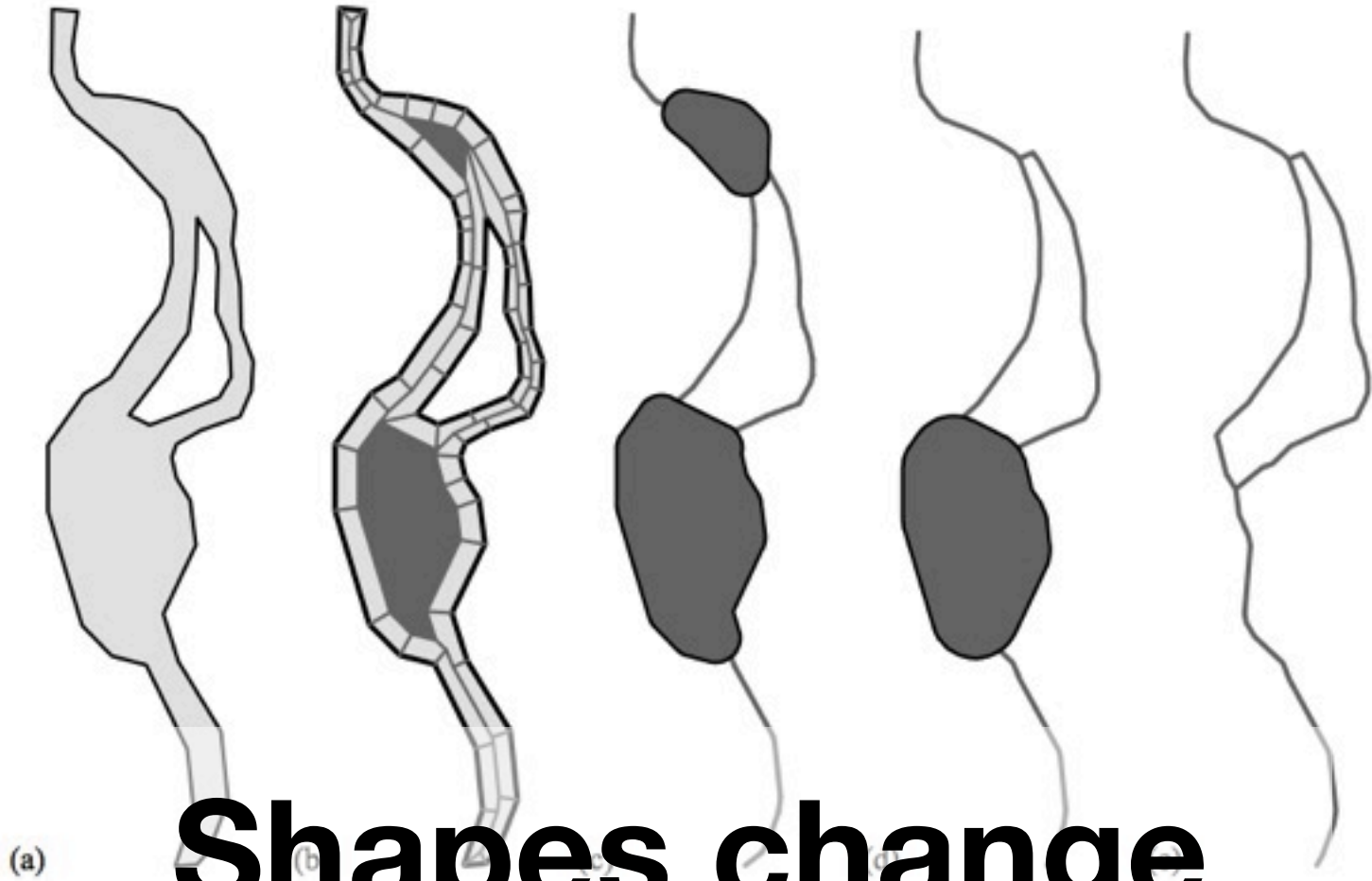


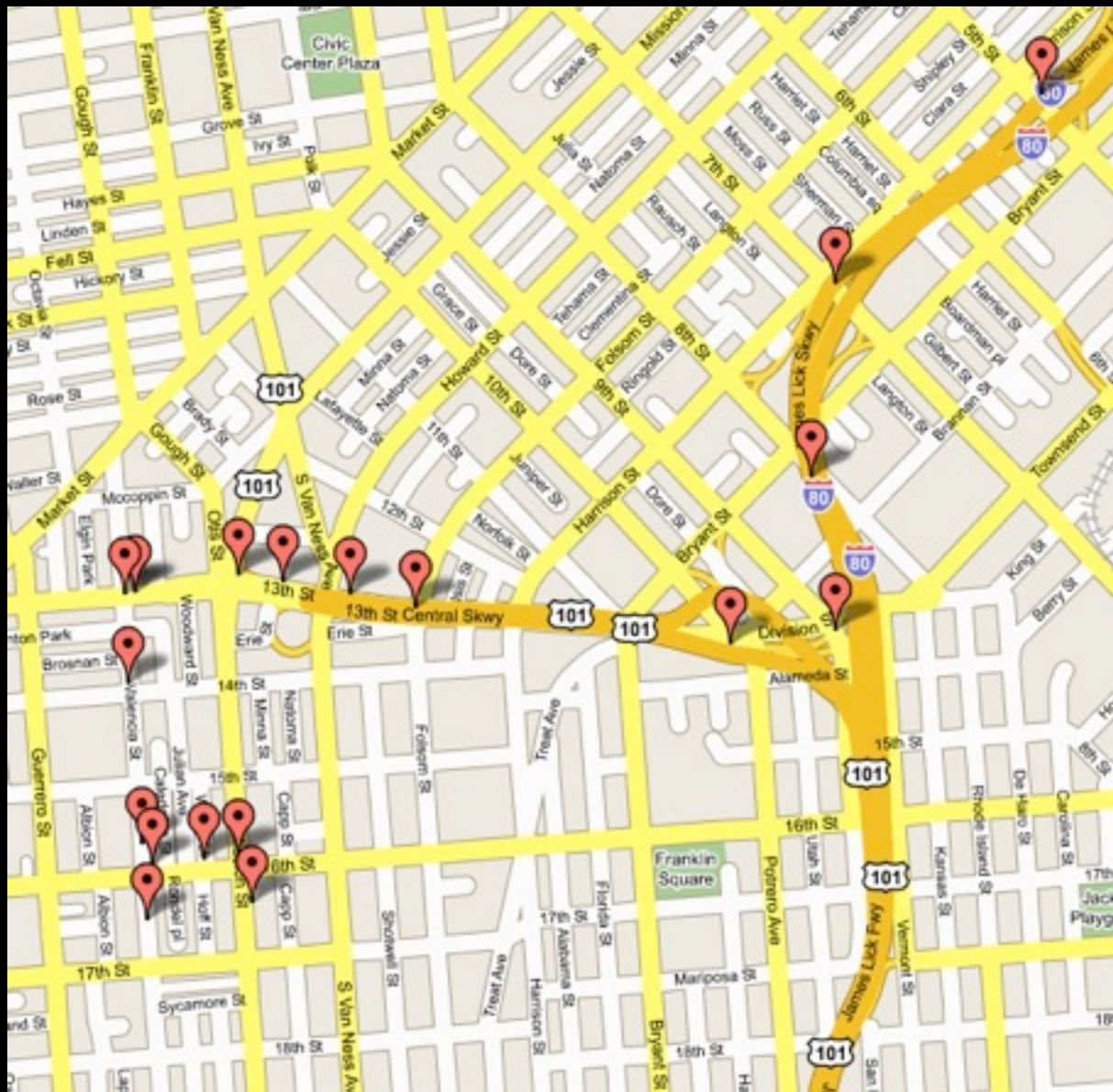
Figure 11. Fragmentation of a river into polygons and lines with different thresholds leading to different results (c, d, e)

**Shapes change
at different scales**

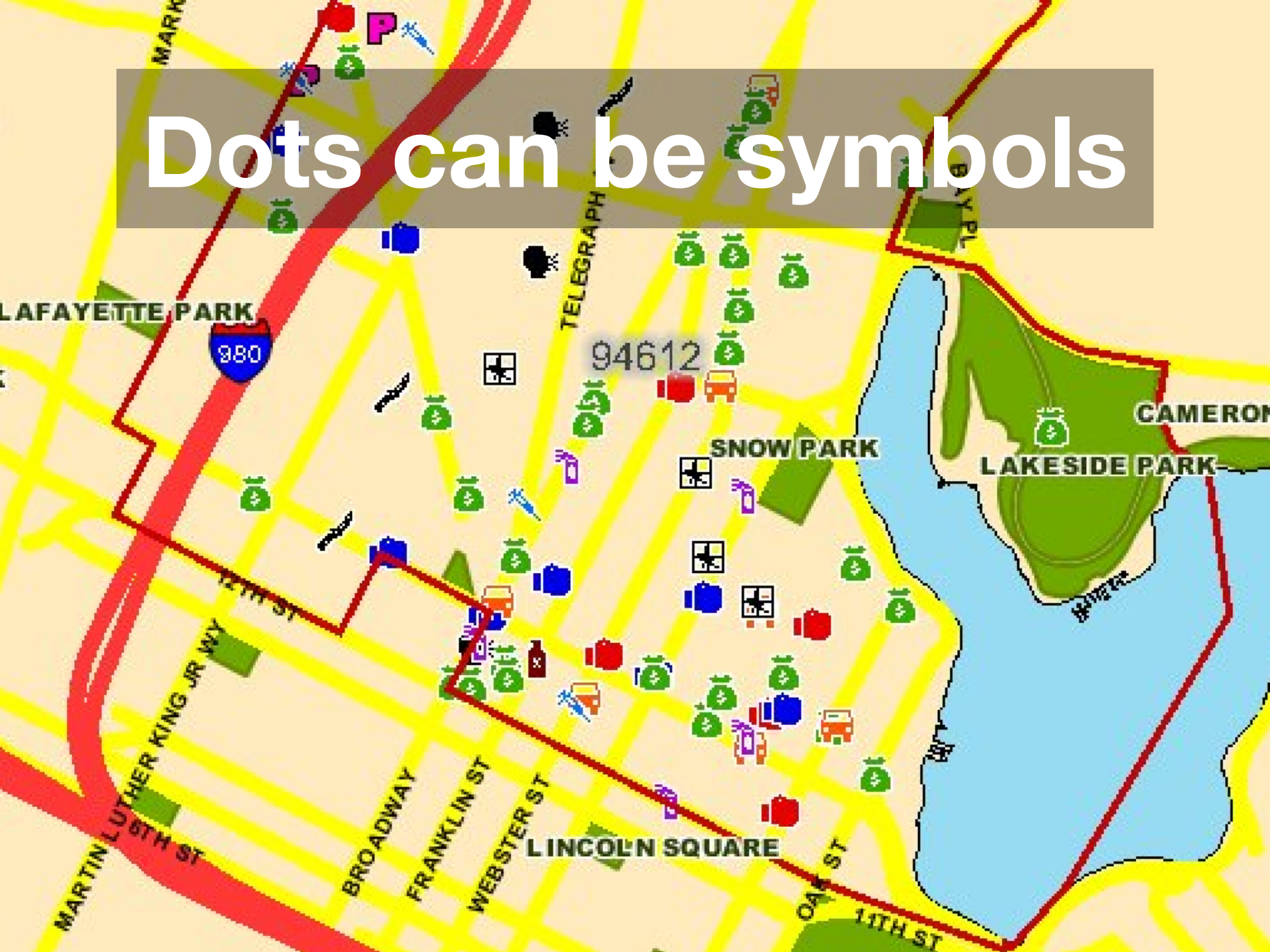
Mapping

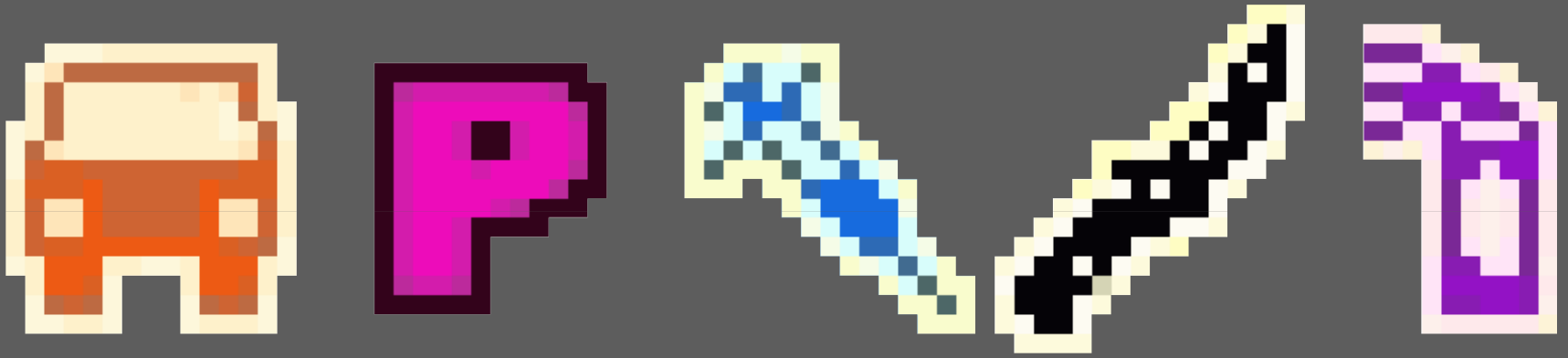
(putting data on maps)

Symbol Maps



Dots can be symbols





Guess the crime

Dots can can be good symbols

TIME OF DAY

Show All | Hide All

Light | Dark [nearest hour]

Commute | Nightlife

Day | Night | Swing Shift

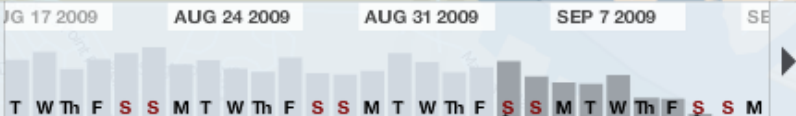


DATE

Past Week

Sep

2009



CRIME TYPE

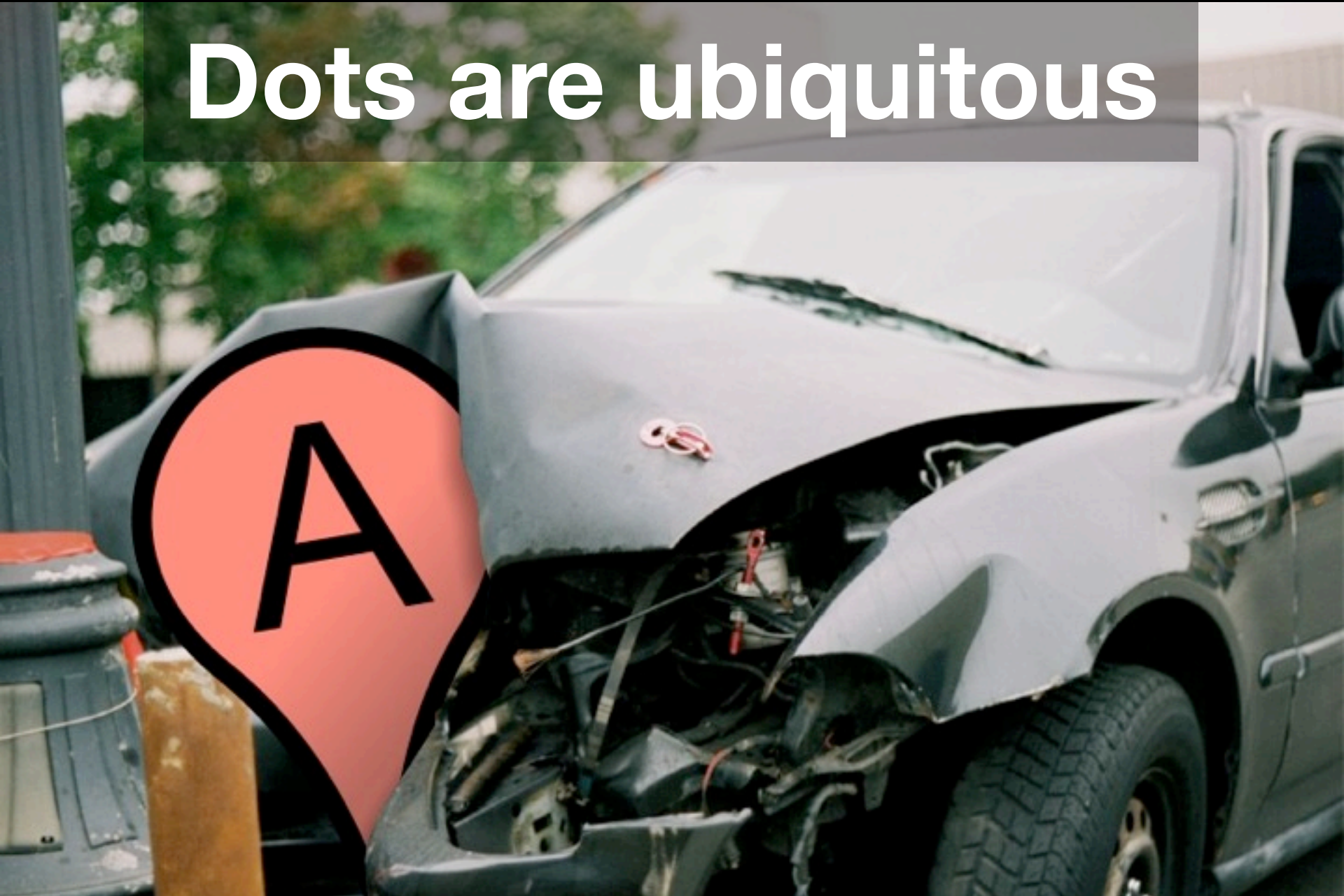
Show All | Hide All

- AA Aggravated Assault
- Mu Murder
- Ro Robbery
- SA Simple Assault
- DP Disturbing the Peace
- Na Narcotics
- Al Alcohol
- Pr Prostitution
- Th Theft
- VT Vehicle Theft
- Va Vandalism
- Bu Burglary
- Ar Arson



Dots can include data

Dots are ubiquitous



“Red Dot Fever”



The New York Times

Mapping America: Every City, Every Block

Find something interesting? Share this view on [Twitter](#) or [Facebook](#)

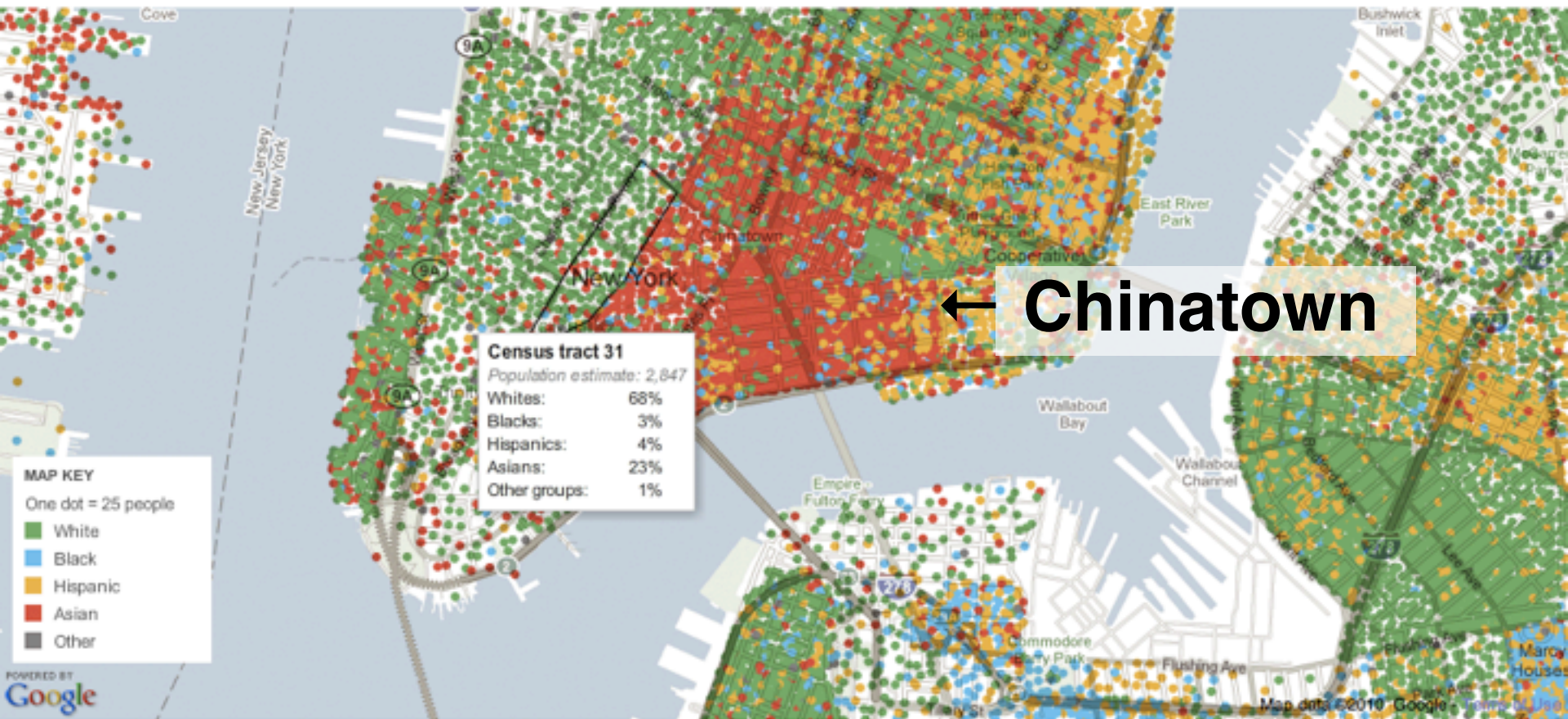
Browse local data from the Census Bureau's American Community Survey, based on samples from 2005 to 2009. Because these figures are based on [View Readers Maps \(49\)](#) samples, they are subject to a margin of error, particularly in places with a low population, and are best regarded as estimates.

Distribution of racial and ethnic groups

[View More Maps](#)

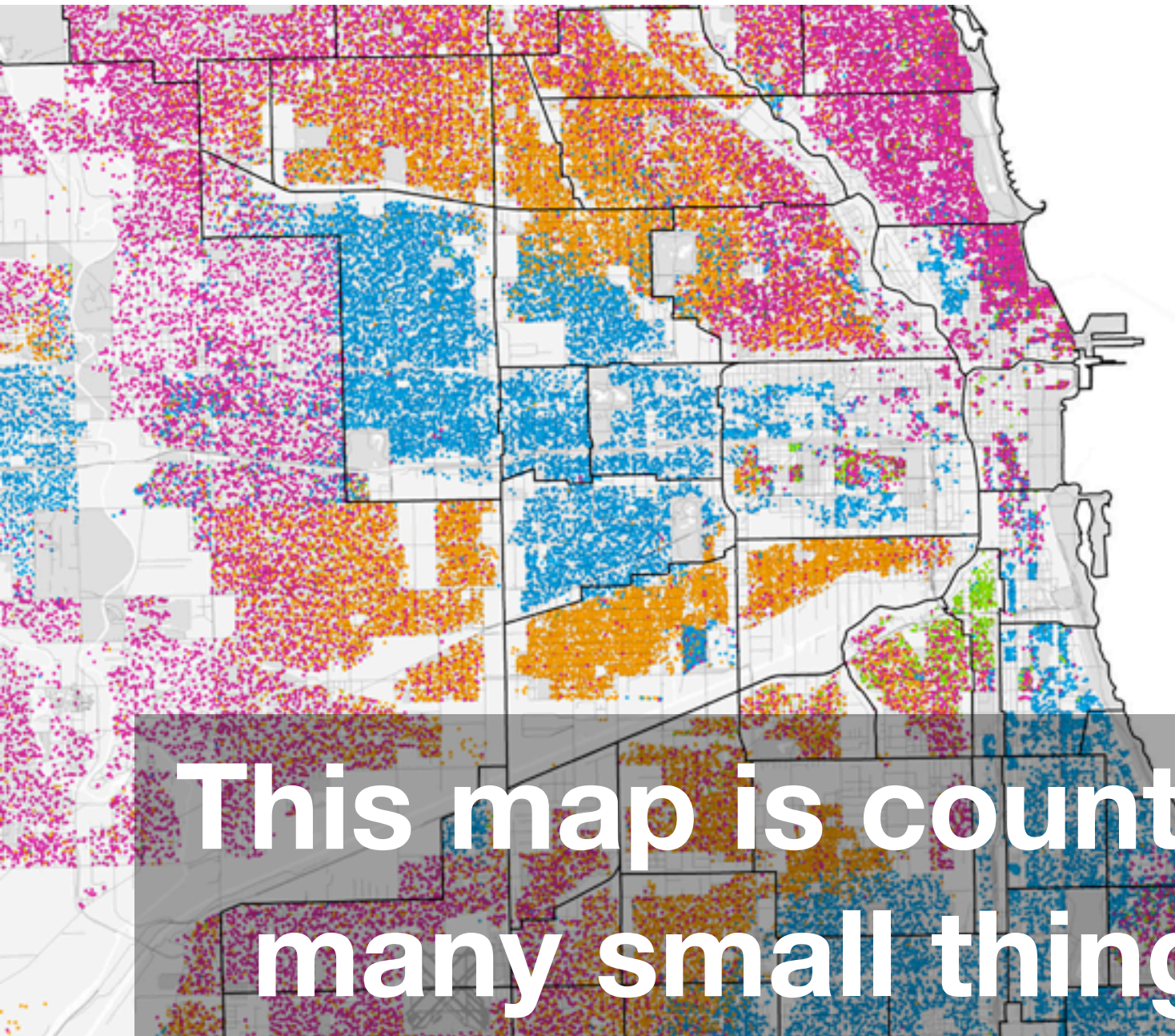
Address, ZIP code or city

Go



By MATTHEW BLOCH, SHAN CARTER and ALAN McLEAN | Source: 2005-9 American Community Survey, Census Bureau; [socialexplorer.com](#)

Note: Dots are evenly distributed across each Census tract or county. Dollar amounts are adjusted for inflation.



the black lines show
chicago's official
community areas.

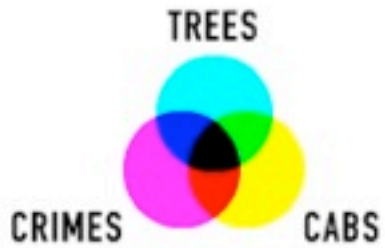
each dot represents
twenty-five people.
here, hispanic is
exclusive of other
categories.

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

scale 1:200,000

**This map is counting
many small things**

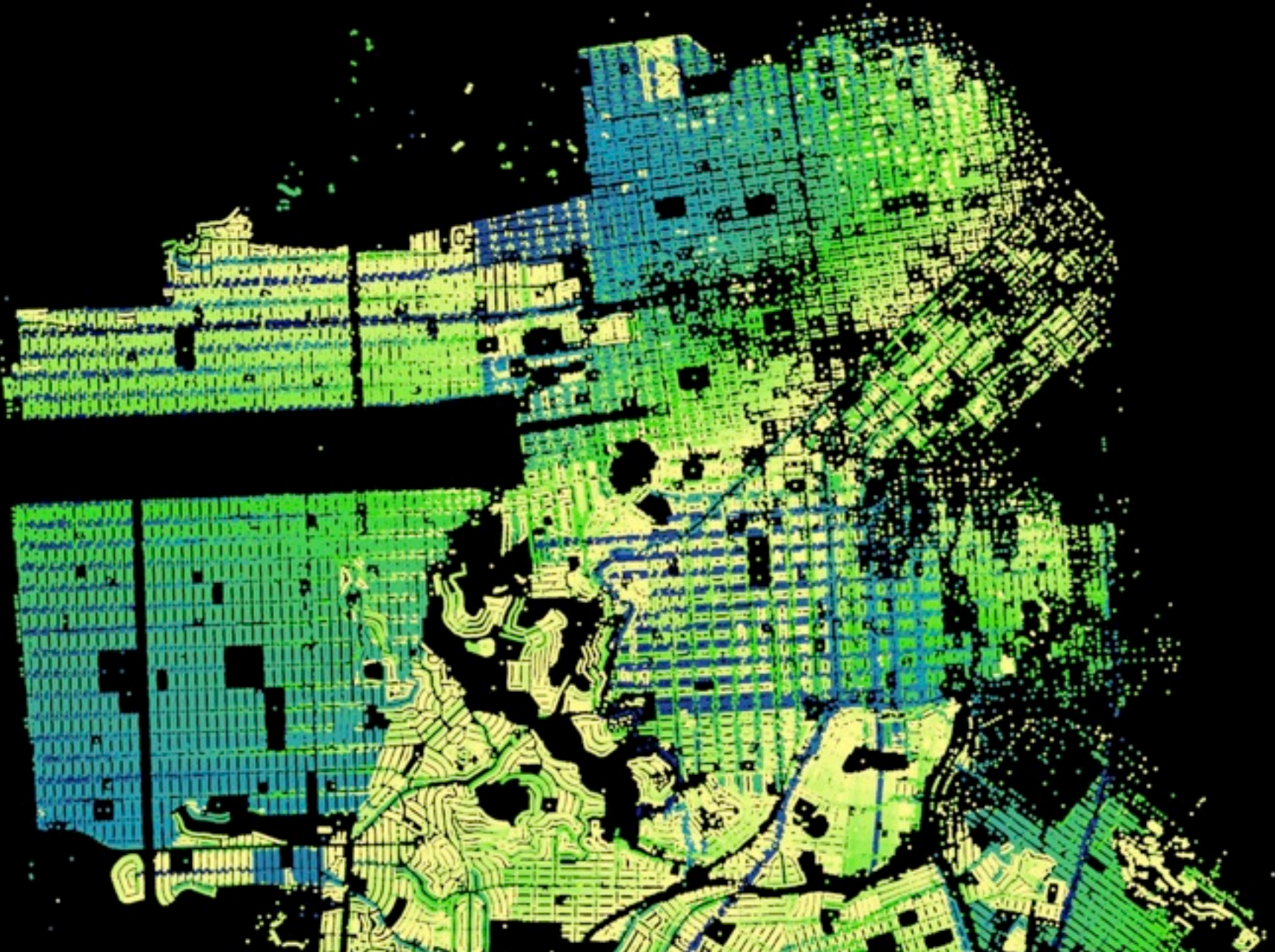


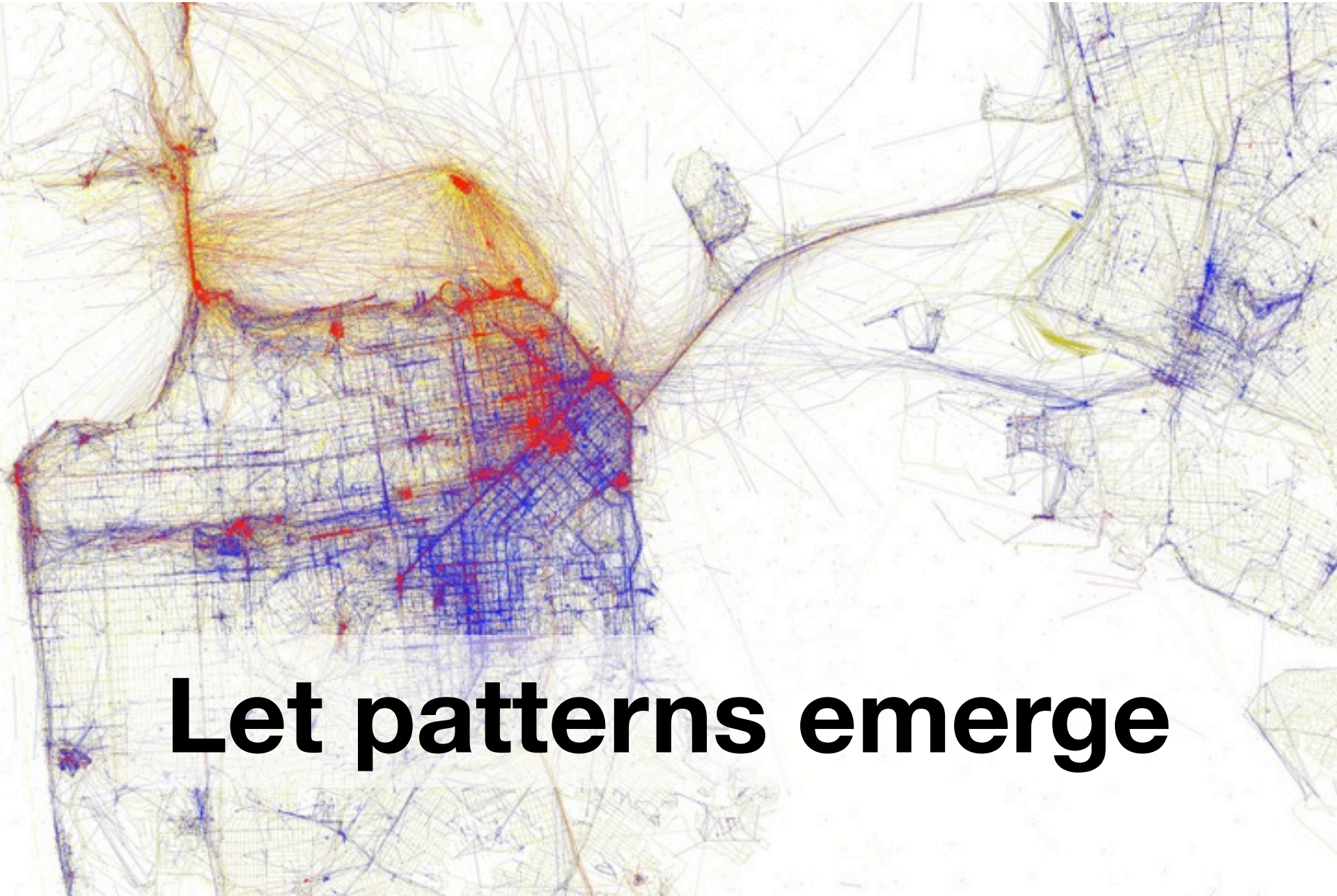


**Three dimensions
shown by color**

One dimension, shown by hue

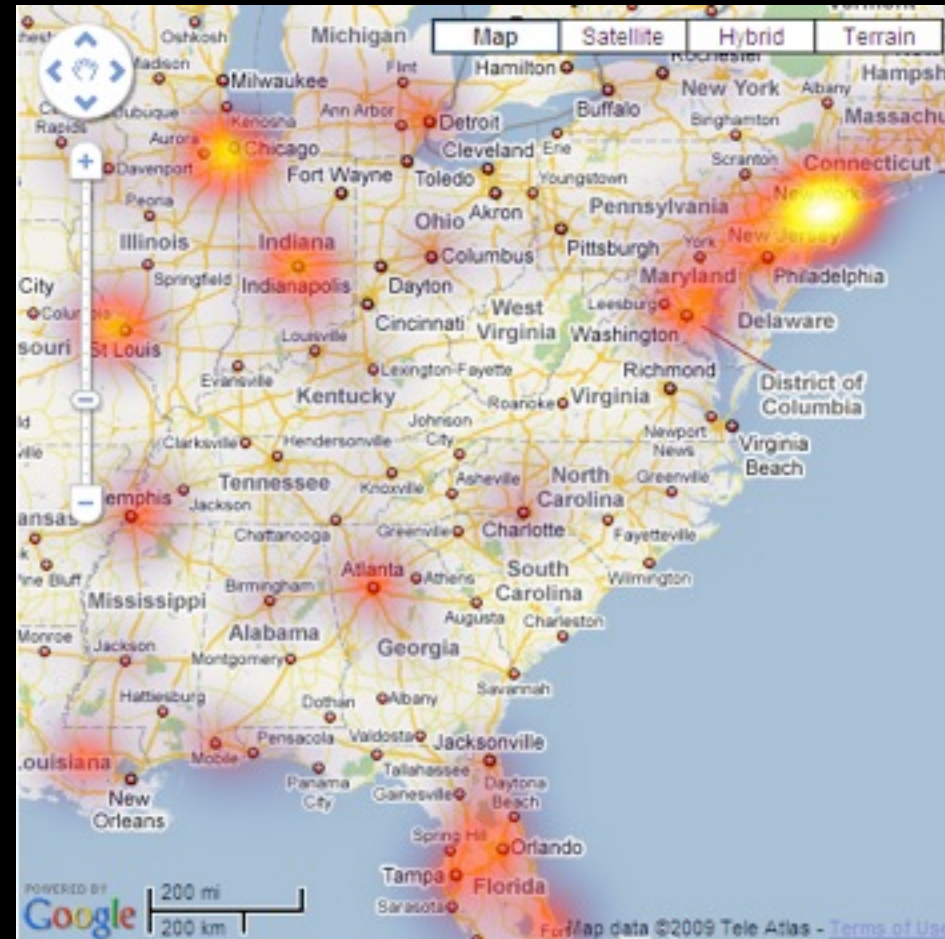
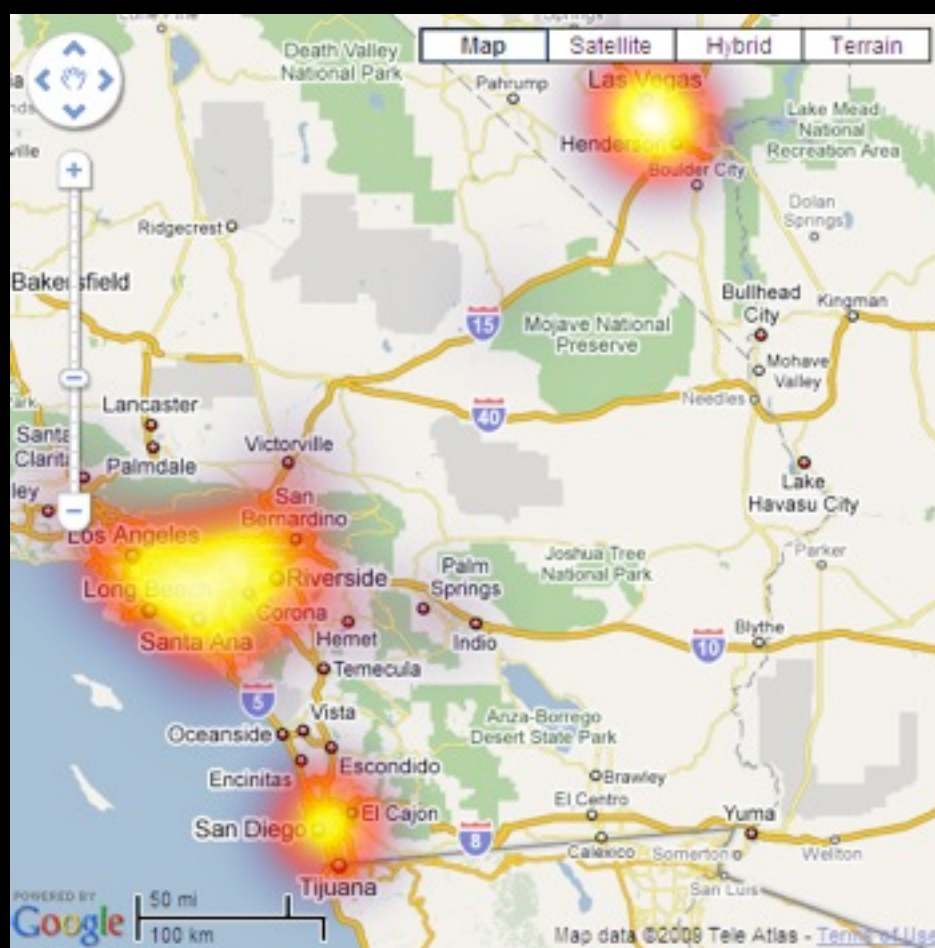
<http://sta.mn/hn9>





Let patterns emerge

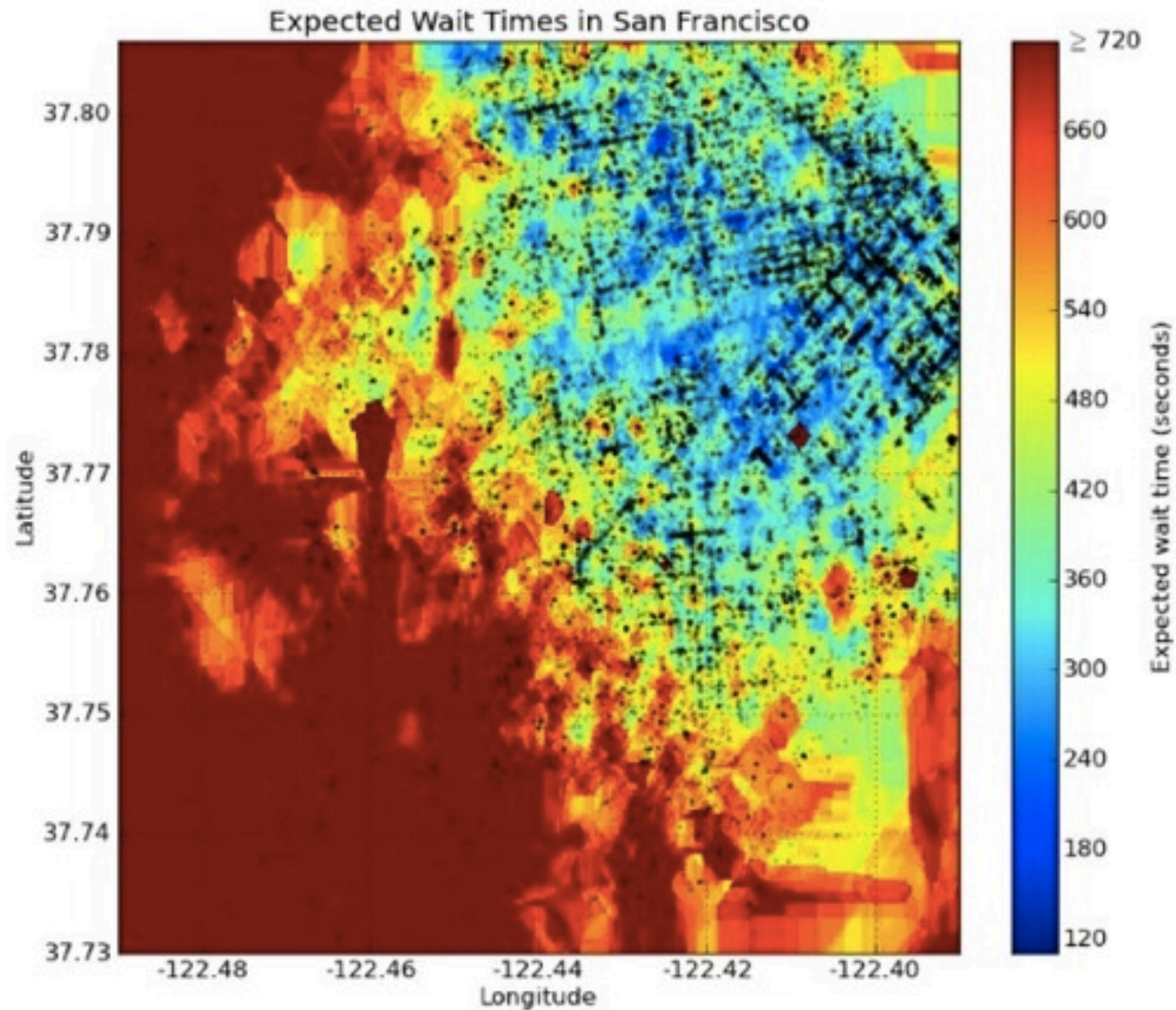
Continuous Data



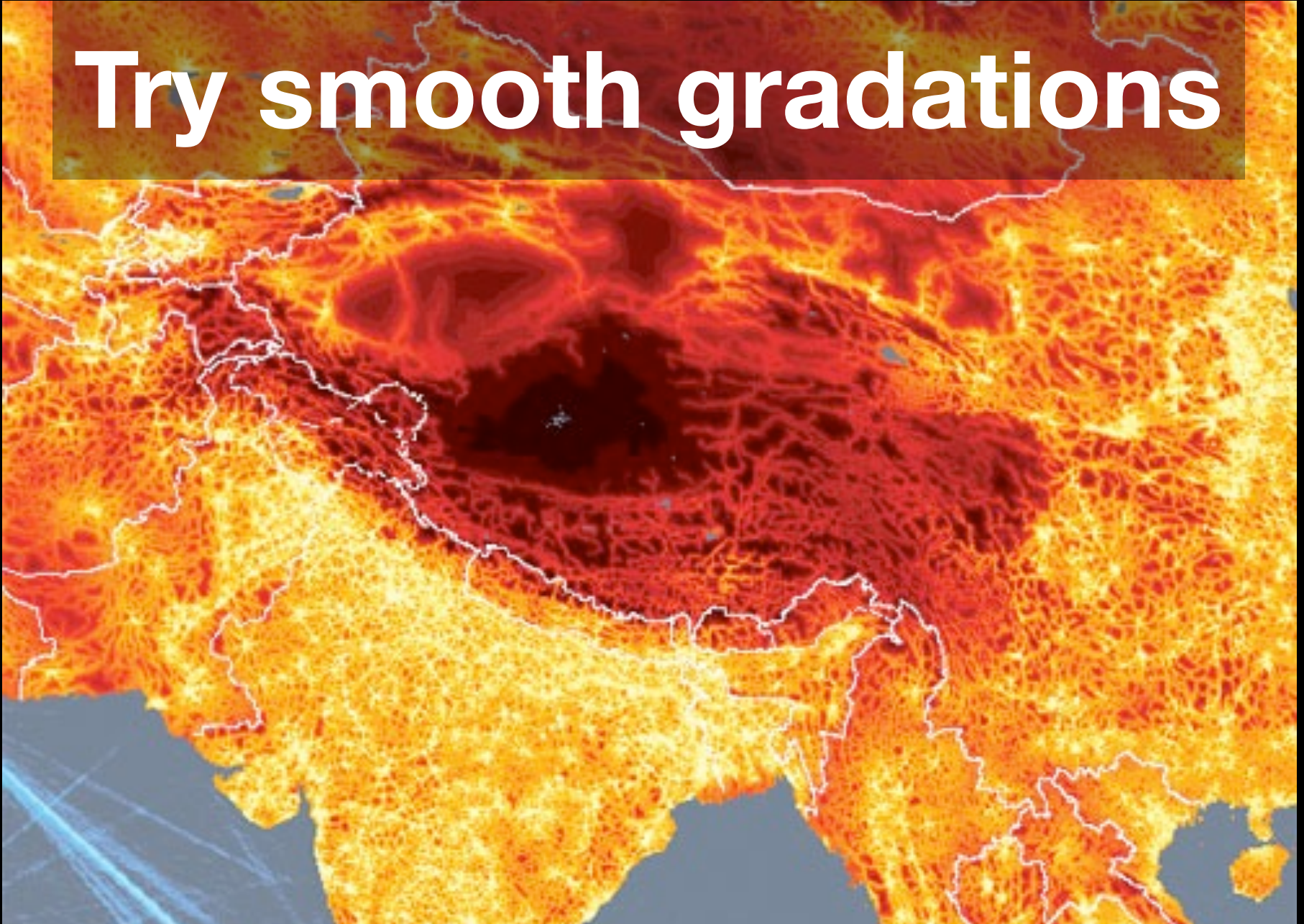
Don't hide the context

Uber Wait Times, 2011

<http://sta.mn/6x27>



Try smooth gradations



Break data into buckets

CRIMESPOTTING

The brazen 2007 murder of journalist Chauncey Bailey in Oakland, California, led Stamen partner Mike Migurski to

make the city's crime data more accessible. This heat map of downtown uses data from CrimeWatch, a community website,

to show the gaps between crimes at a given intersection: white is high-crime; darker areas are safe. stamen.com

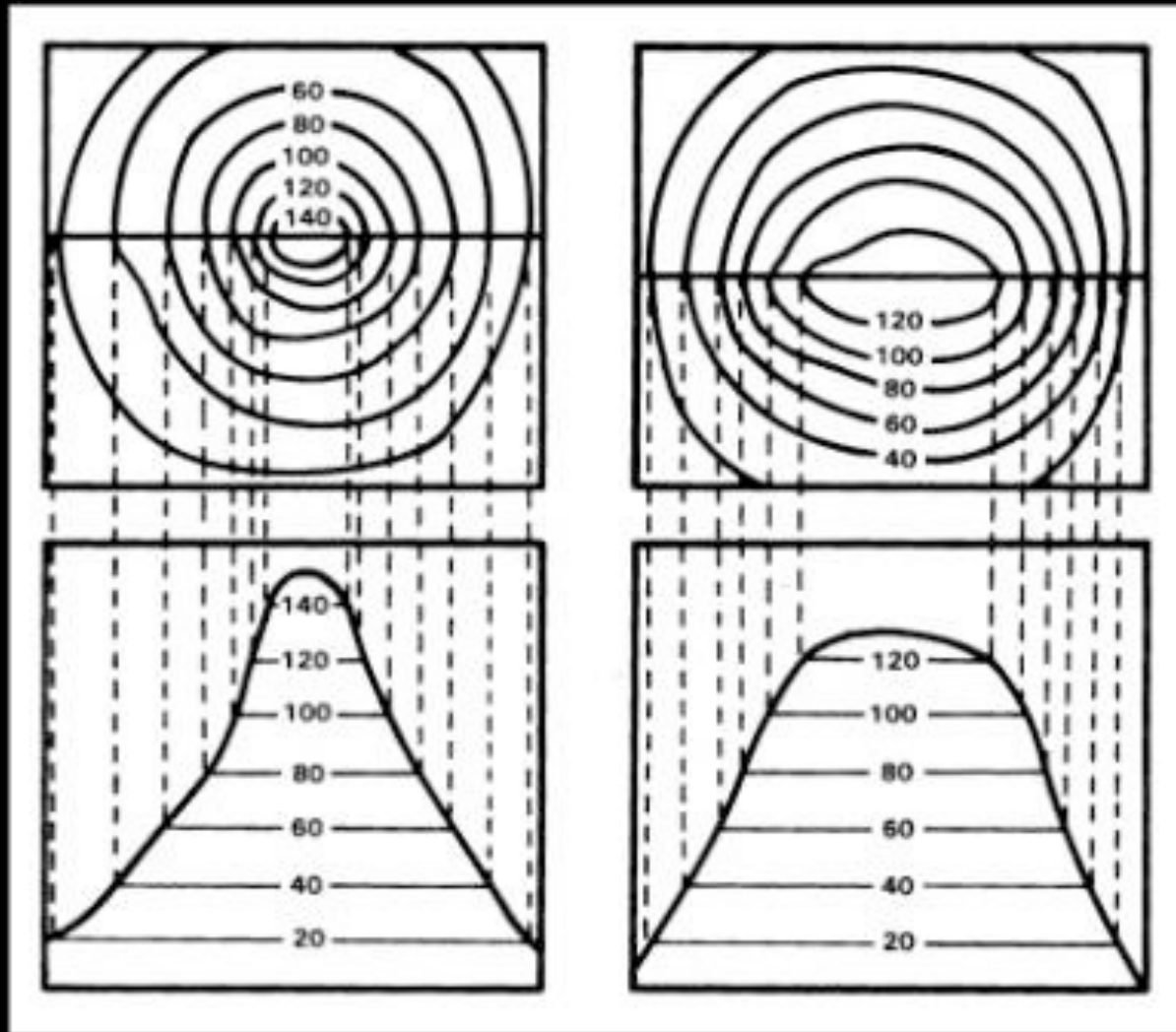
KEY

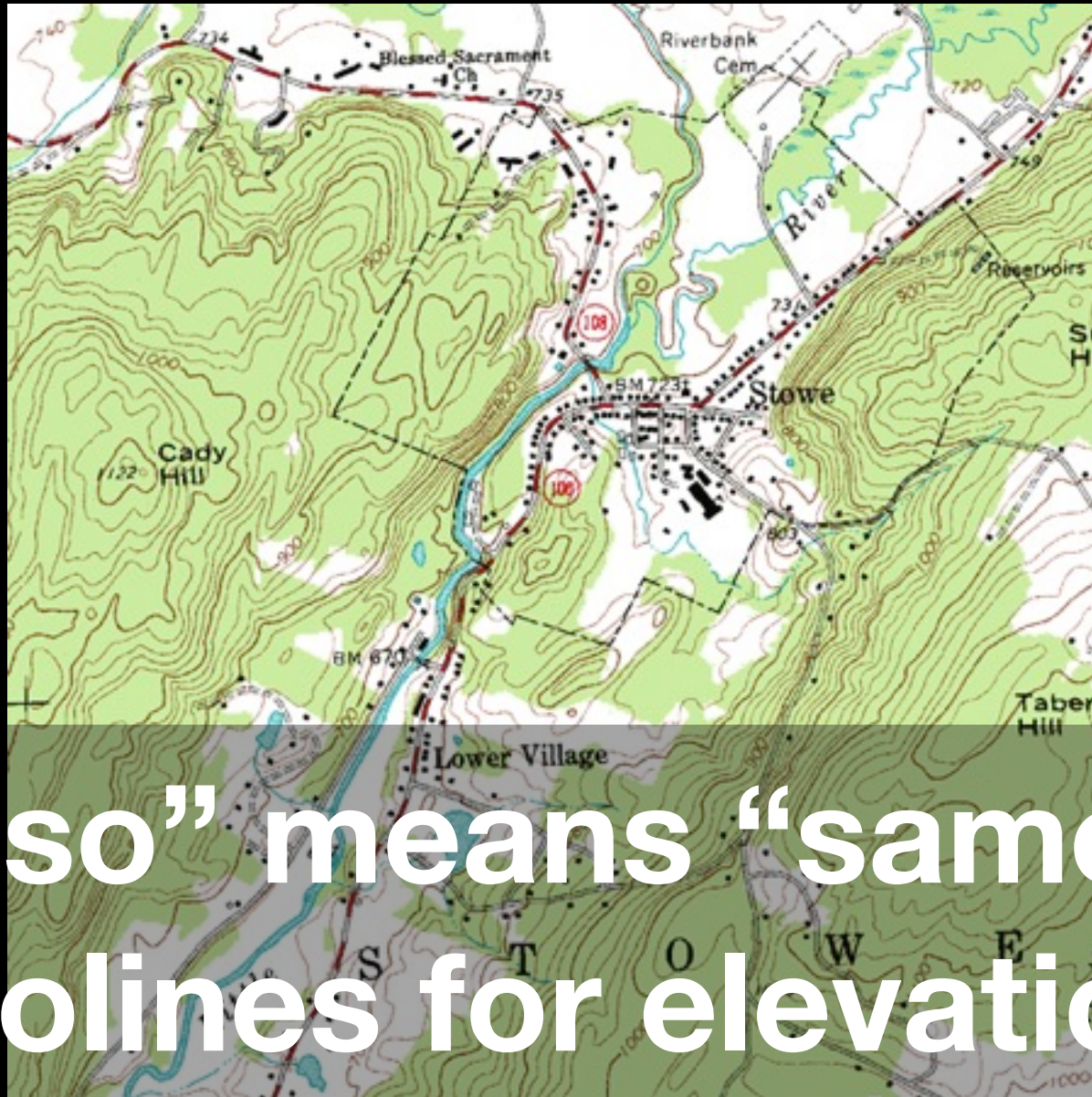
Colours show how recently a crime was reported in a given part of Oakland

- A week ago
- Two weeks ago
- A month ago
- Two months ago
- Three months ago
- Four months ago
- Five months ago

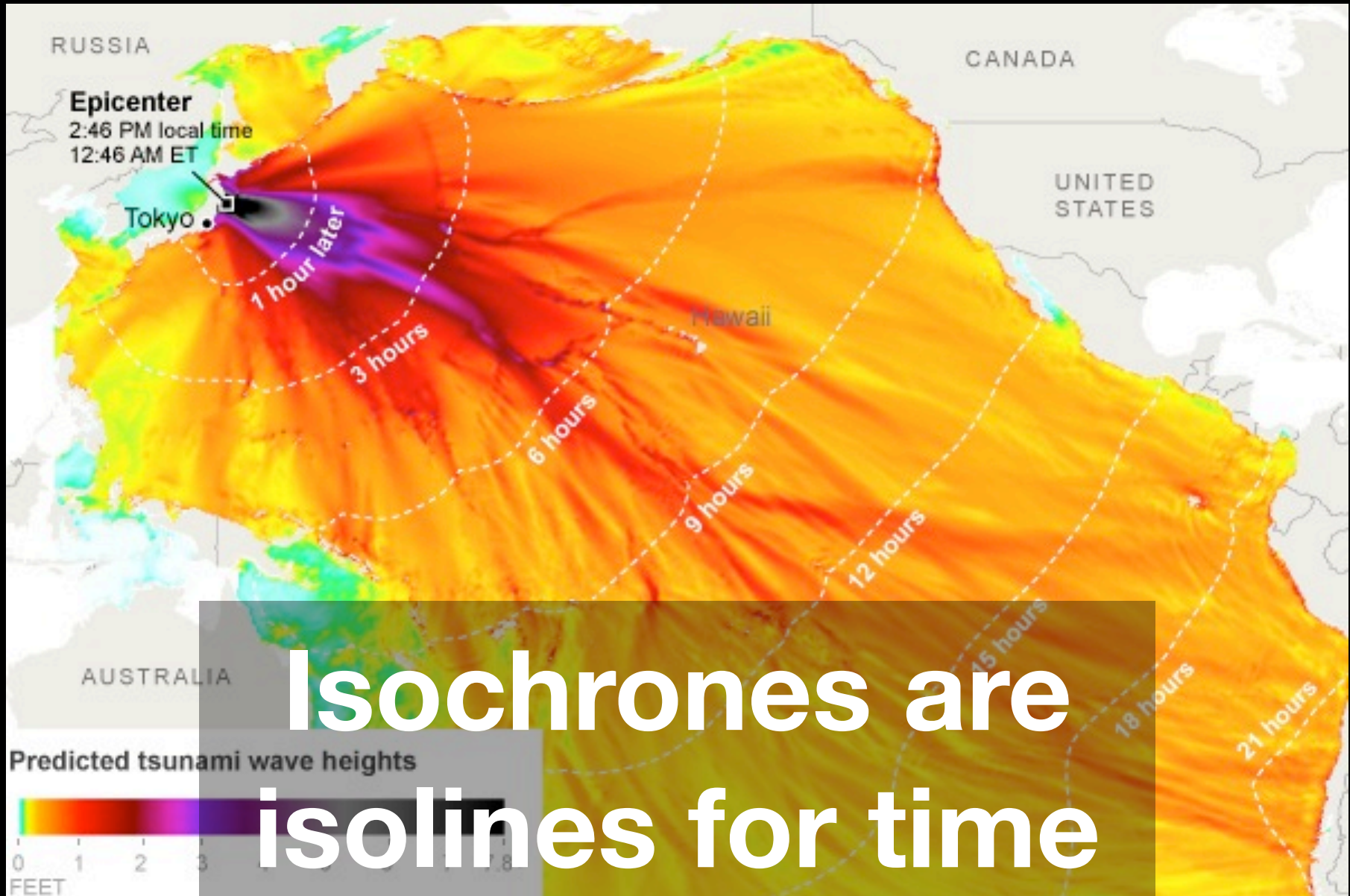
Meaningful buckets

<http://sta.mn/b6>

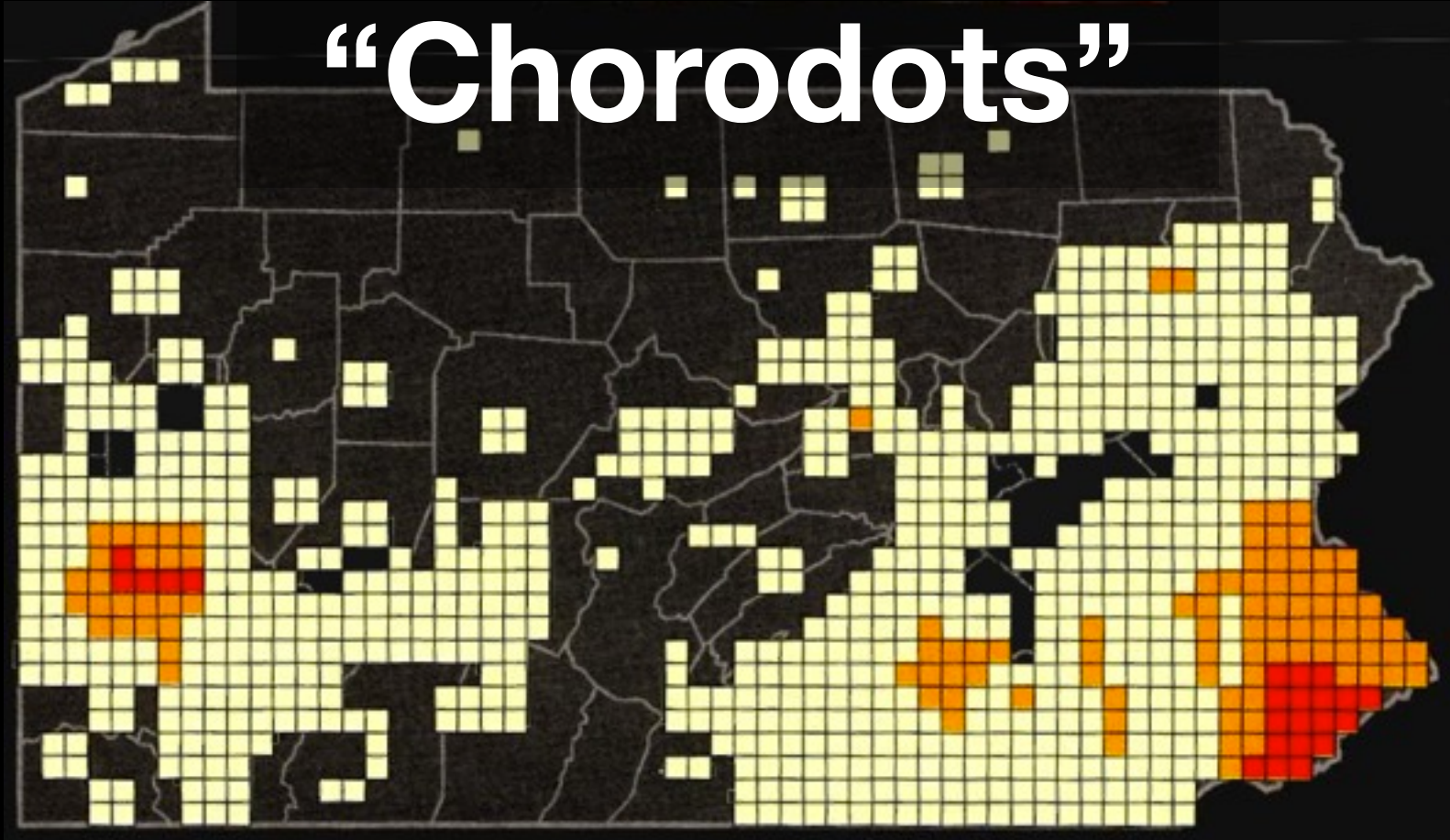




“Iso” means “same”
Isolines for elevation



“Chorodots”



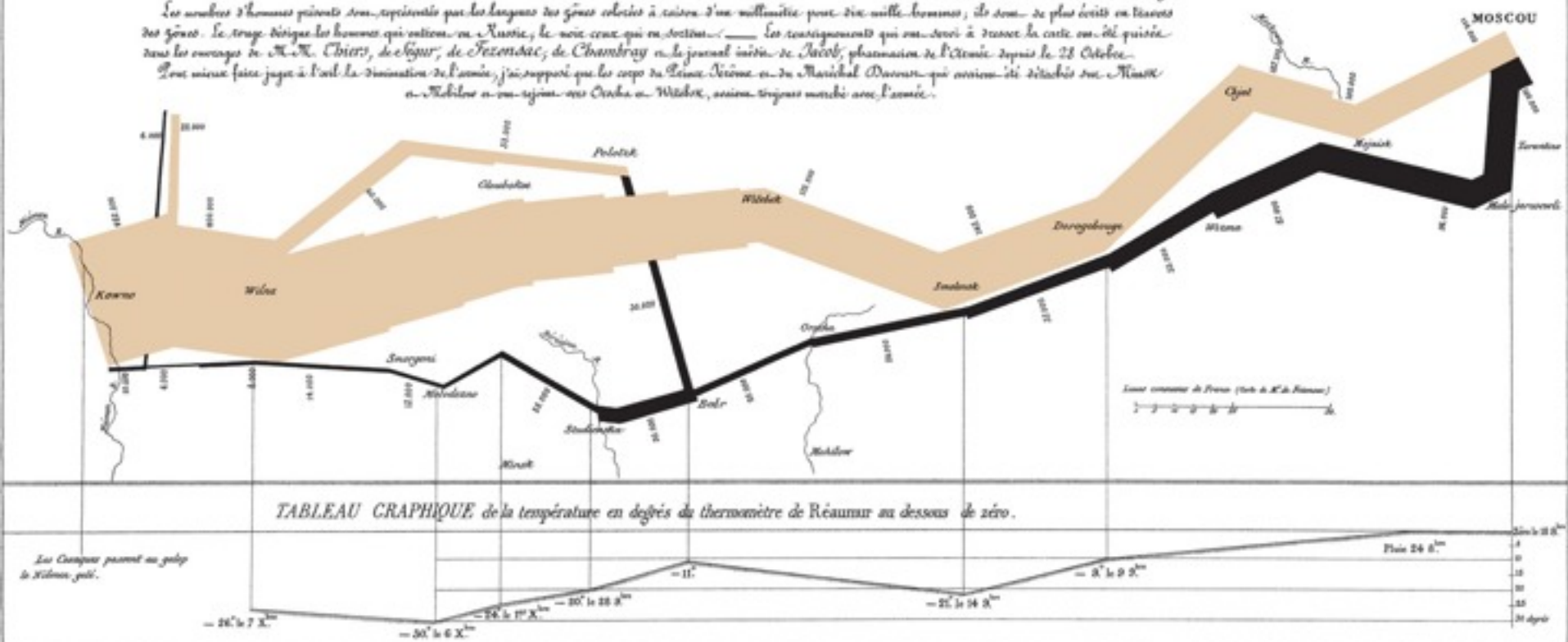
Flow Maps

Minard 1869: Napoleon's march

Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

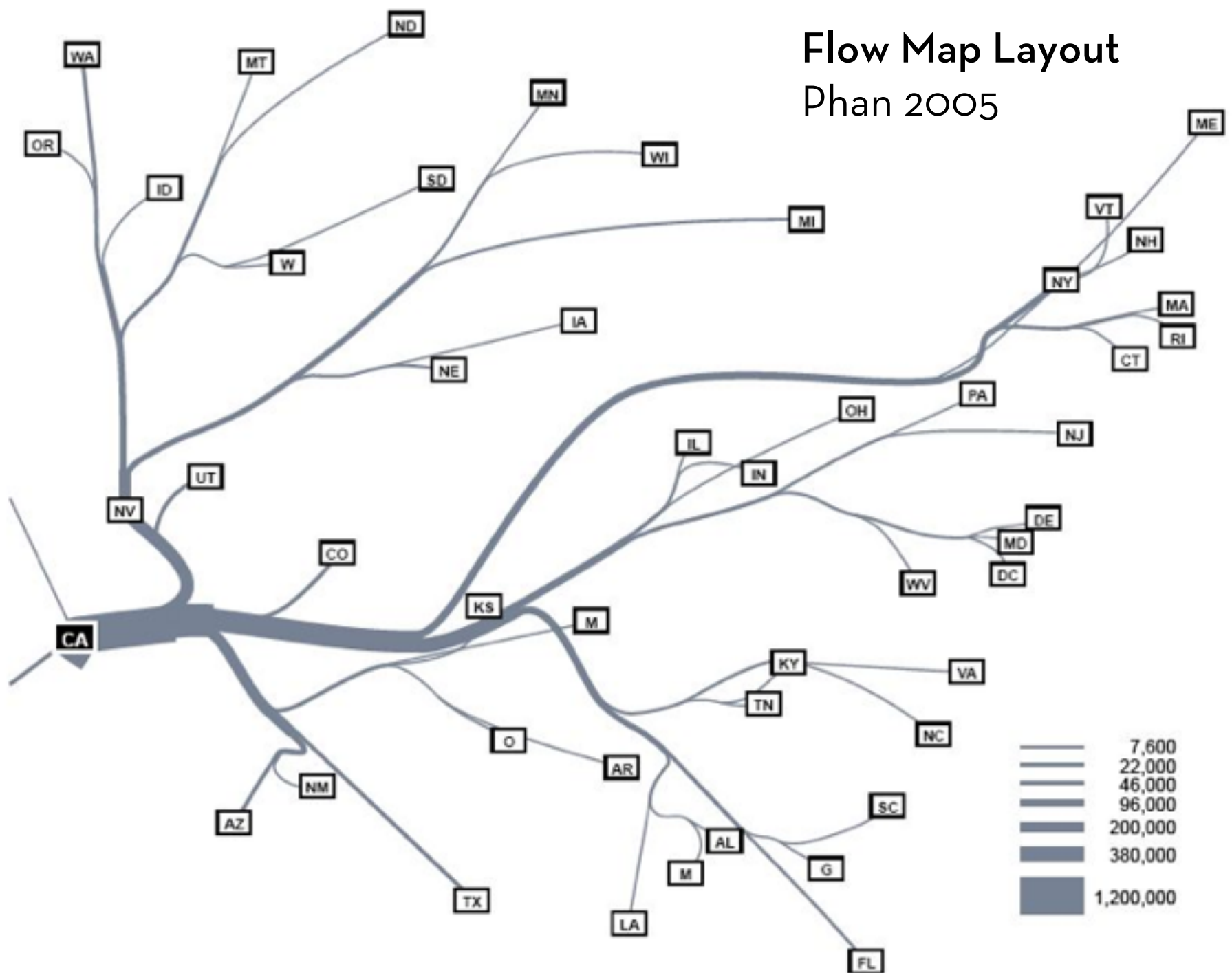
Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie; le noir ceux qui en sortent. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. Thiers, de Ségur, de Fezensac, de Chambray et du journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger de l'effet de la diminution de l'armée, j'ai supposé que les corps du Grand Armée en de Monsieur Davout qui avaient été détachés sur la Moskova n'avaient rejoint les Cossaks et Wladimir, comme toujours marchés avec l'armée.



Flow Map Layout

Phan 2005



Migration from California, 1995-2000

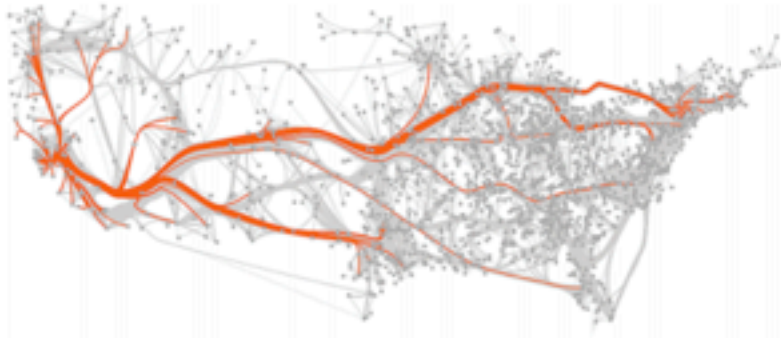
Tobler 1987



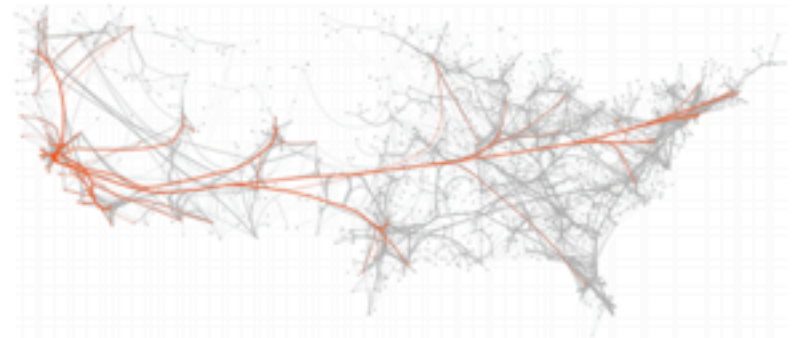
Phan et al. 2005



Verbeek et al. 2011



Cui et al. 2008



Holten & van Wijk 2009

wind map

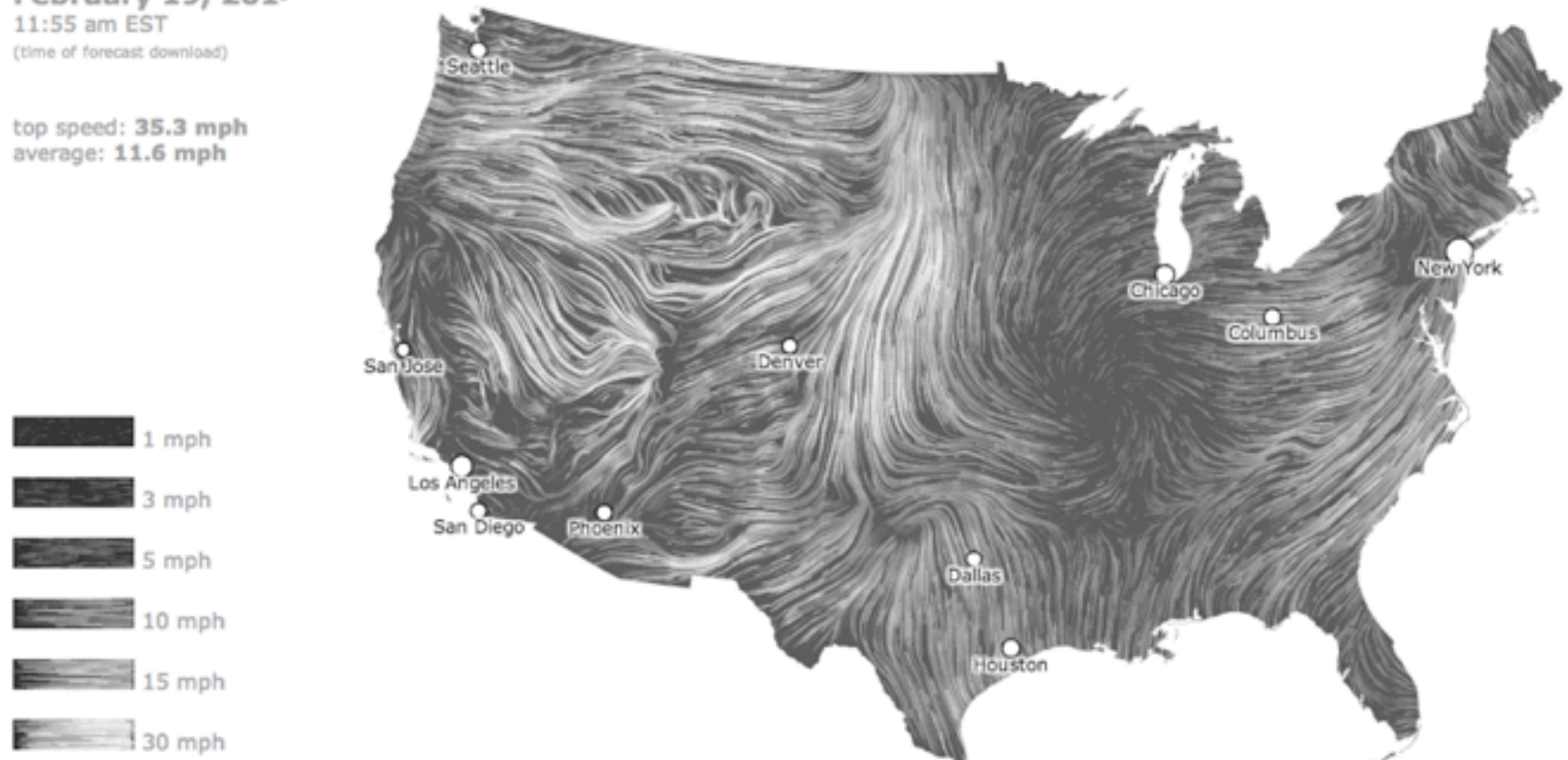
February 19, 2014

11:55 am EST

(time of forecast download)

top speed: 35.3 mph

average: 11.6 mph



How Obama Won Re-election

Whites Were Outvoted

Women

Hispanics

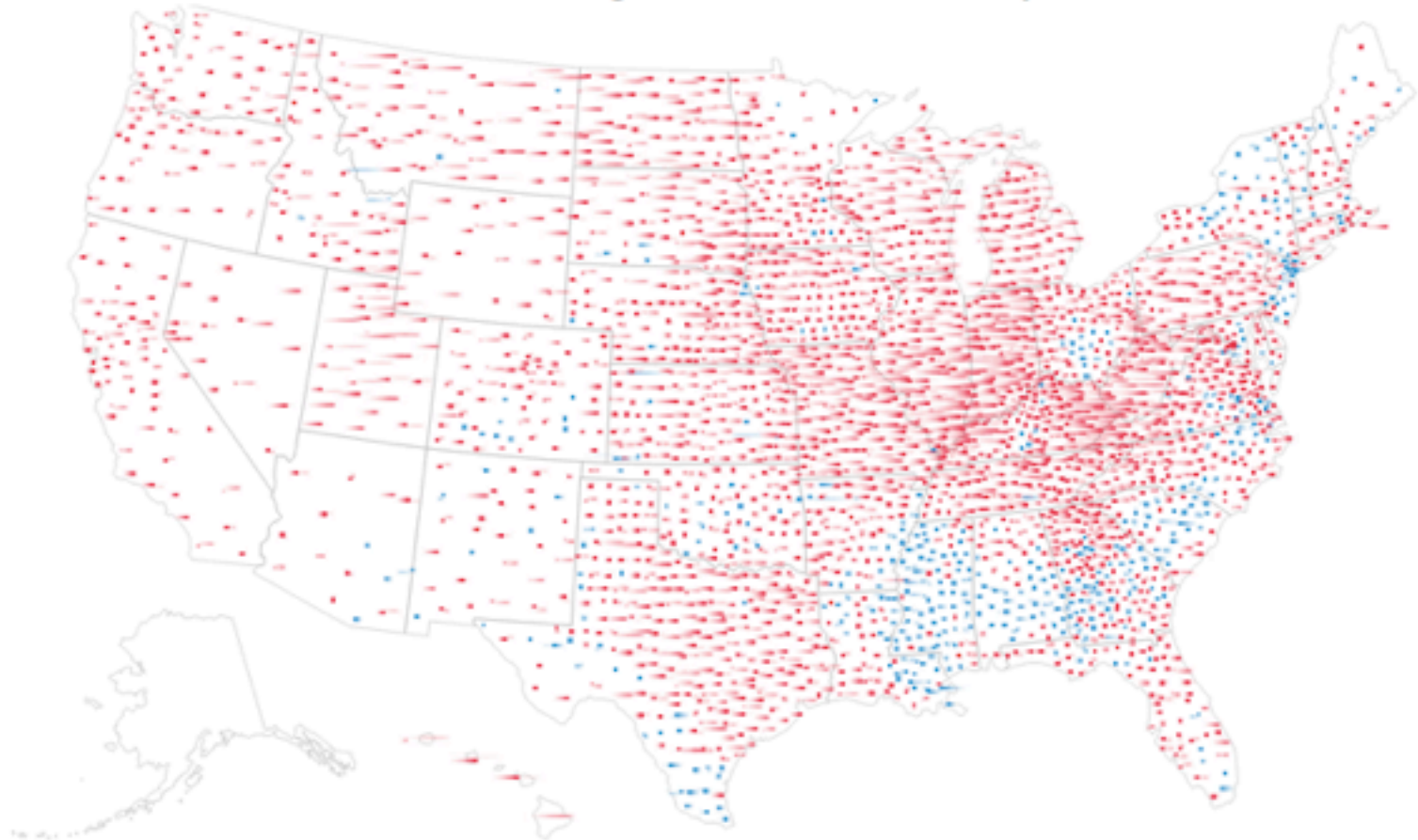
Youth

Romney's Shift Wasn't Enough

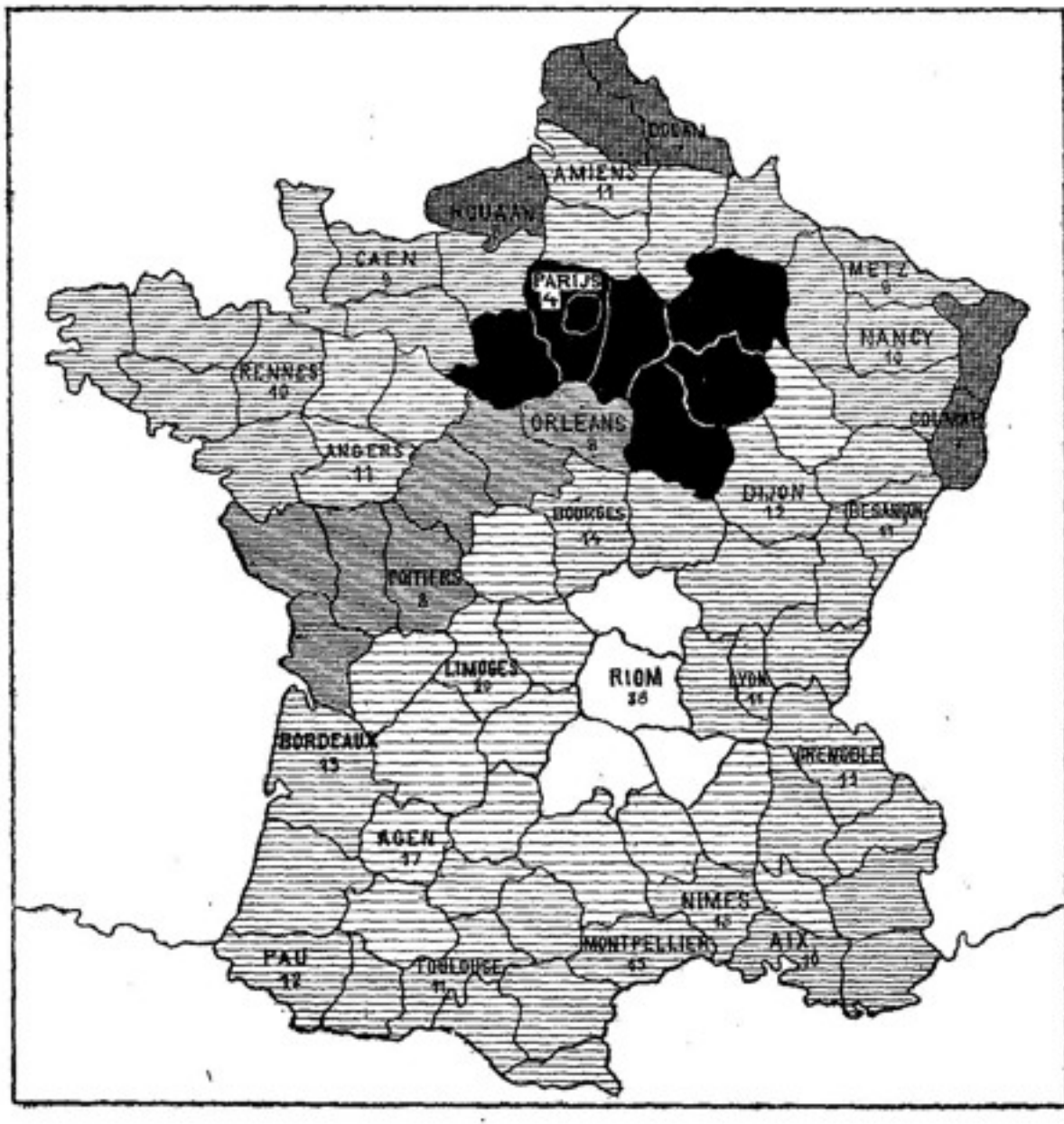
2008

2012

Most of the nation shifted to the right in Tuesday's vote, but not far enough to secure a win for Mitt Romney.



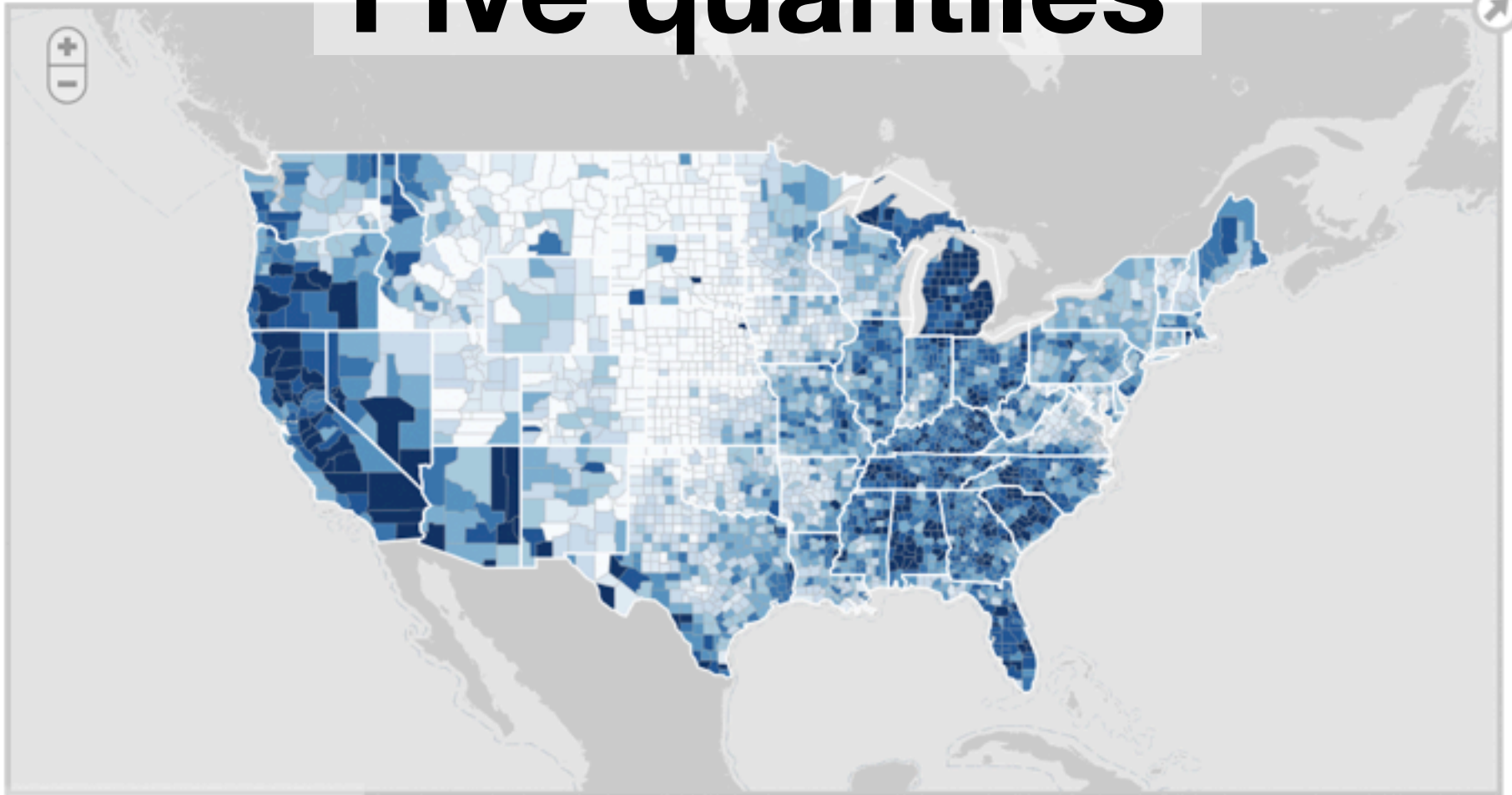
Choropleths



1826(?) Illiteracy in France, Pierre Charles Dupin

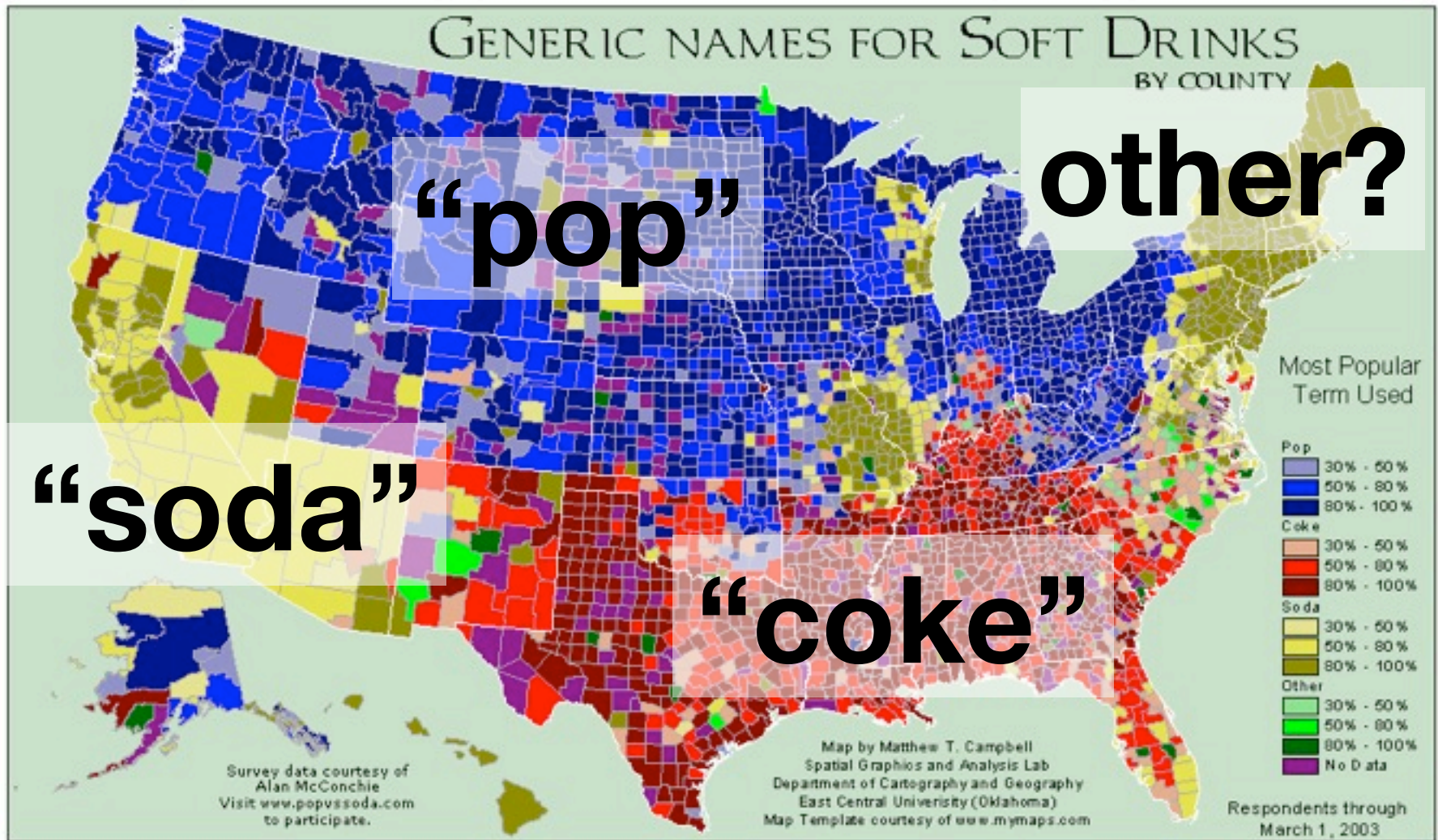
Polymaps

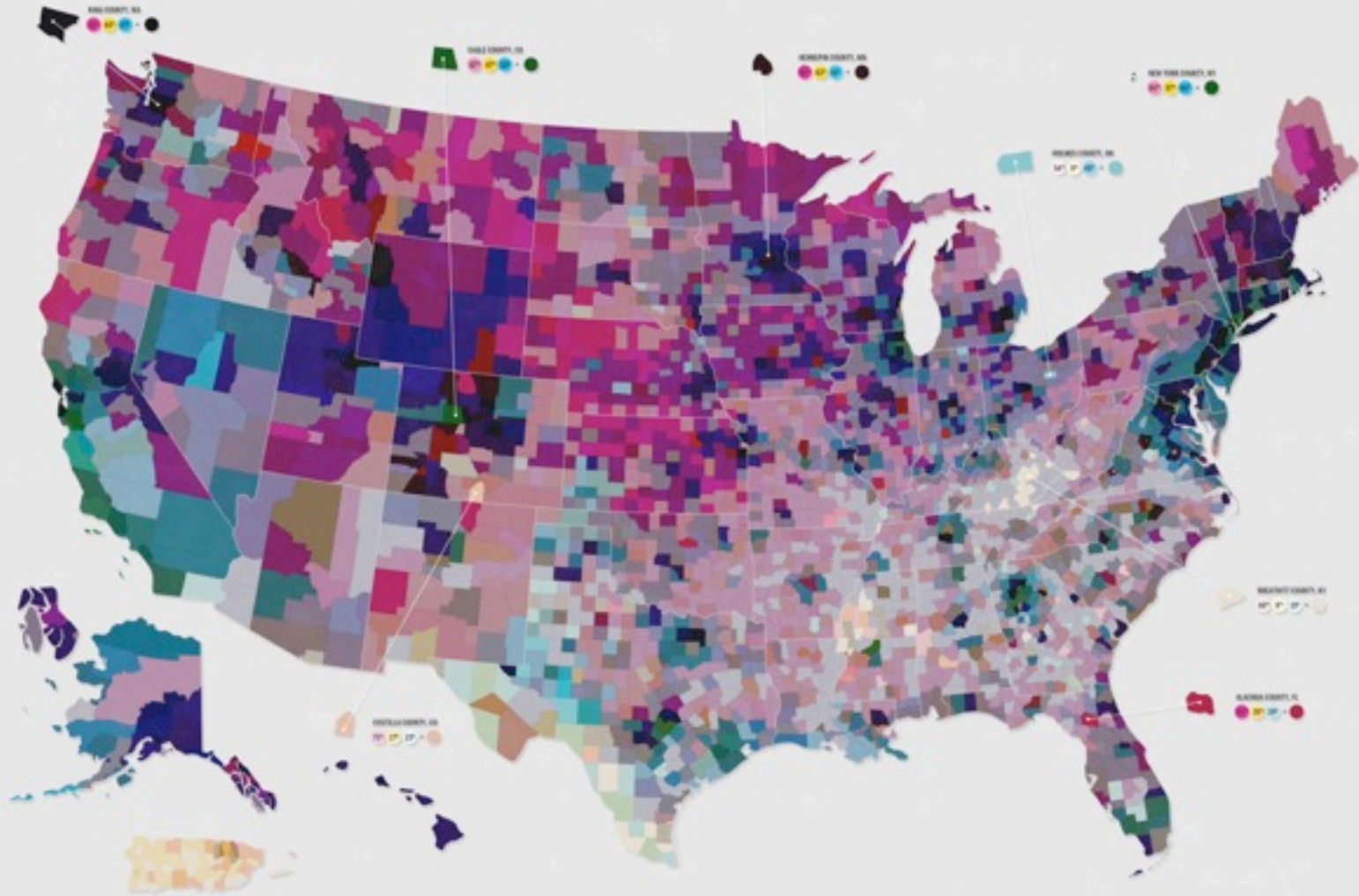
Five quantiles



Polymaps is a project from
[SimpleGeo](#) and [Stamen](#).

Unemployment





Choose colors well



Focus on the foreground

Cartograms

2006 ELECTION GUIDE

SENATE RACES

HOUSE RACES

GOVERNORS' RACES

RACE PROFILES

New York Times ratings

198

Safe Dem.

16

Leaning Dem.

17

Toss up

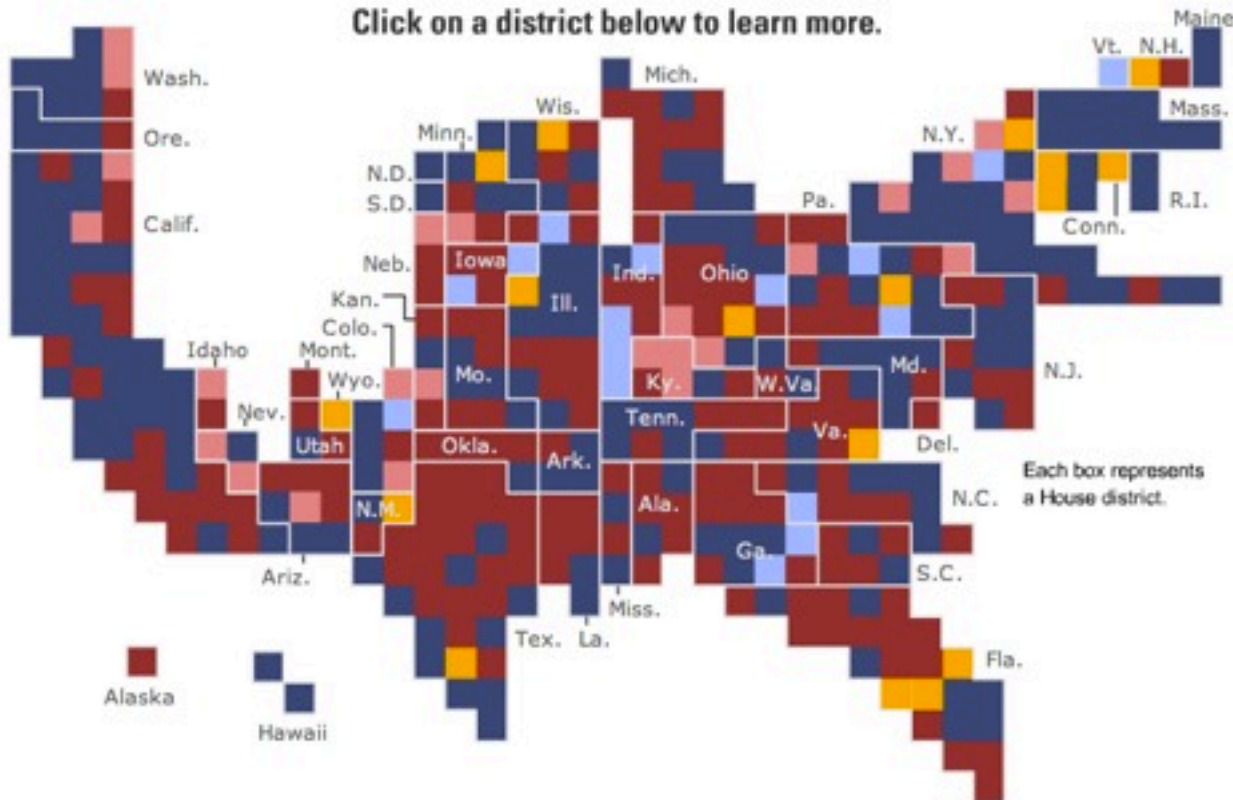
24

Leaning Rep.

180

Safe Rep.

Click on a district below to learn more.



SOURCES, CREDITS AND FEEDBACK

GOVERNORS' RACES

RACE PROFILES

ANALYZE RACES

CREATE OUTCOMES

Shade the map using the pulldown...

New York Times ratings

...then show only certain states

New York Times ratings ?

Democrat: ☐ Safe ☐ Leaning ☐ Toss Up

Republican: ☐ Safe ☐ Leaning

Current Rep. ☐ Dem. ☐ Rep.

Margin in 2004 House race

Democrat: ☐ >50% ☐ 25-50% ☐ <25%

Republican: ☐ >50% ☐ 25-50% ☐ <25%

Votes for president ☐ Kerry ☐ Gore ☐ Bush ☐ Bush

Appearances by big fundraisers ?

☐ George W. Bush ☐ Bill Clinton

☐ Races to watch ?

☐ Open races

☐ Switch districts ?

Urbanization

☐ Urban ☐ Suburban ☐ Rural ☐ Mixed

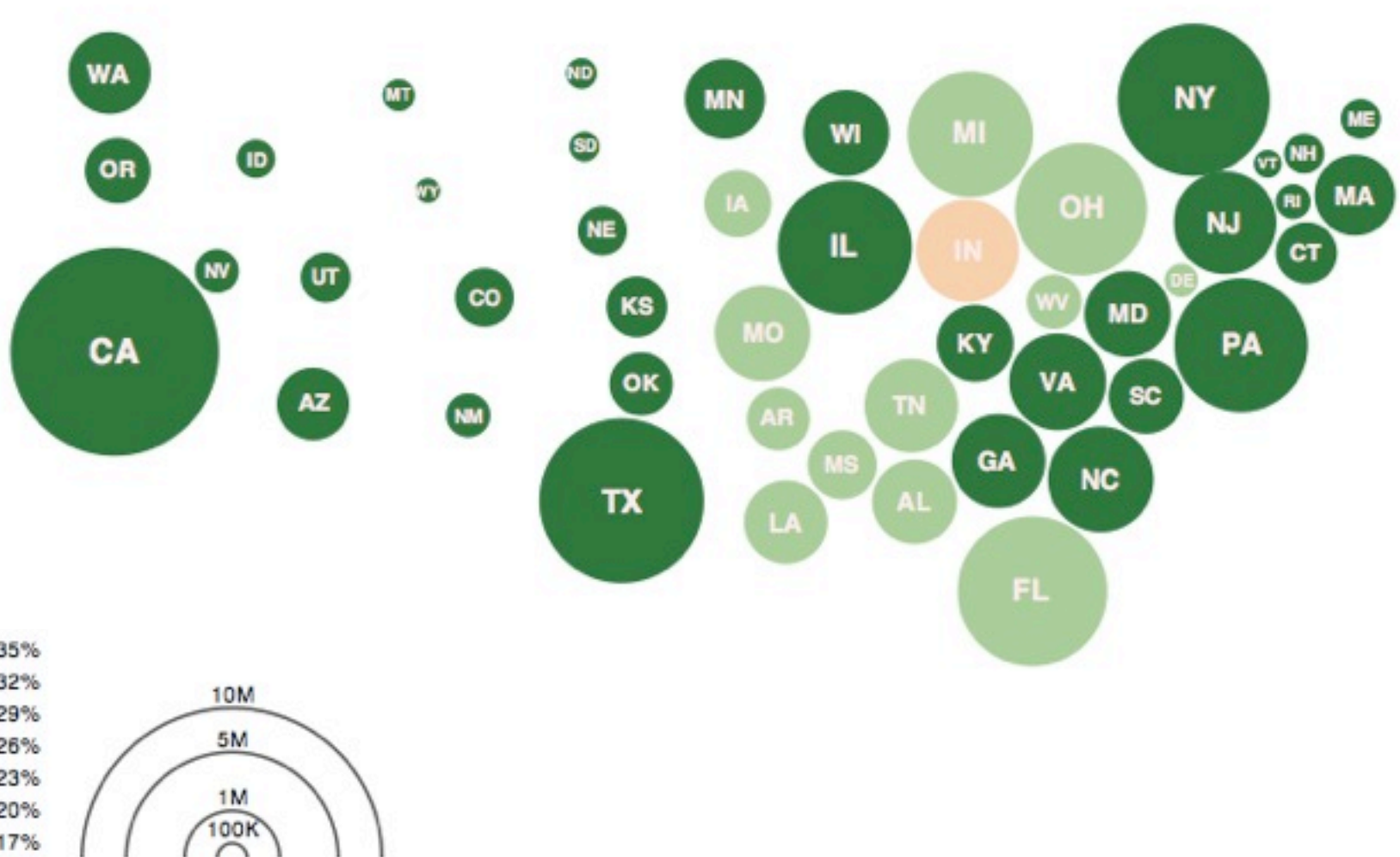
Race/Ethnicity

☐ White ☐ Black ☐ Hispanic

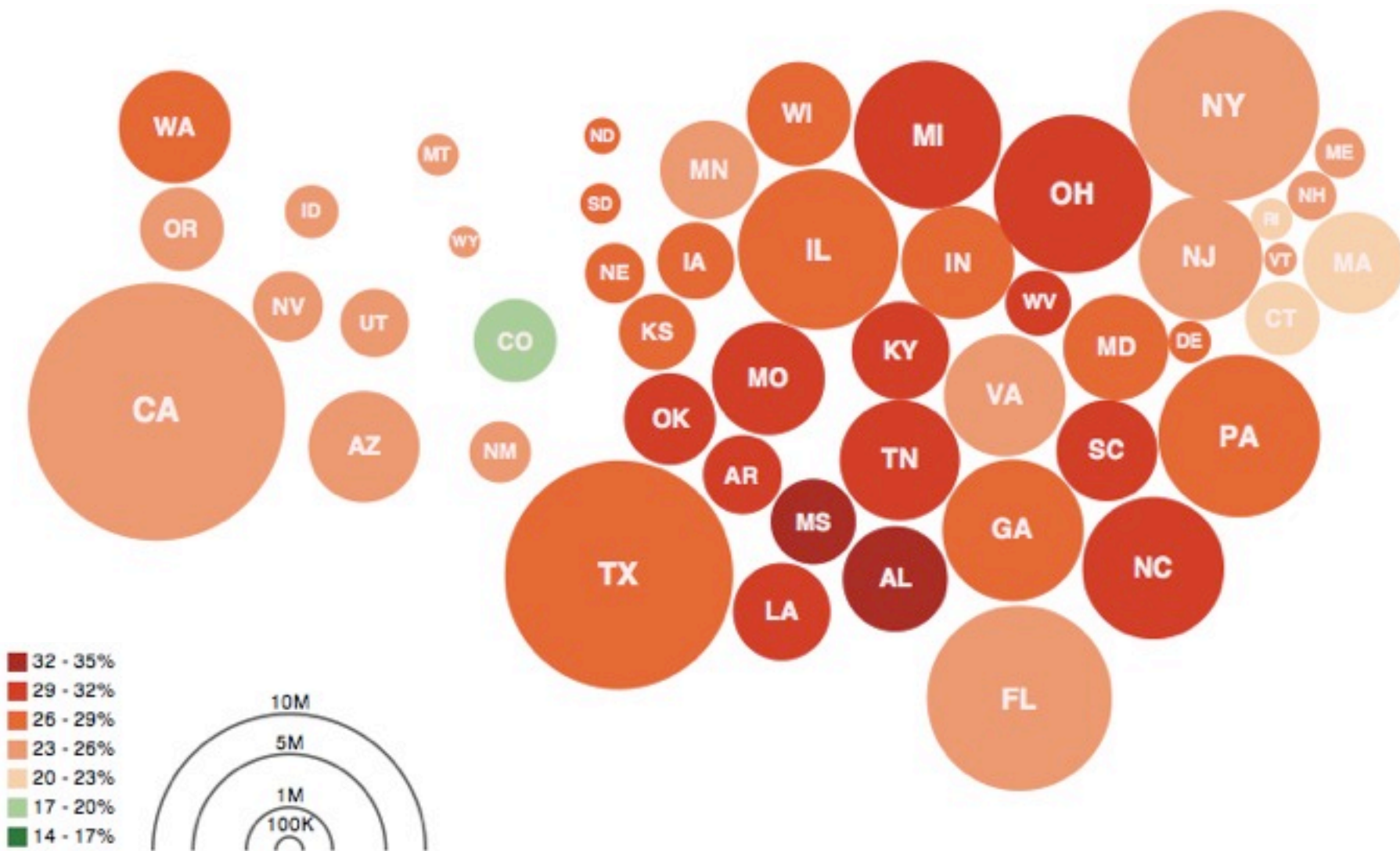
Median income

☐ <\$30K ☐ \$30-50K ☐ >\$50K

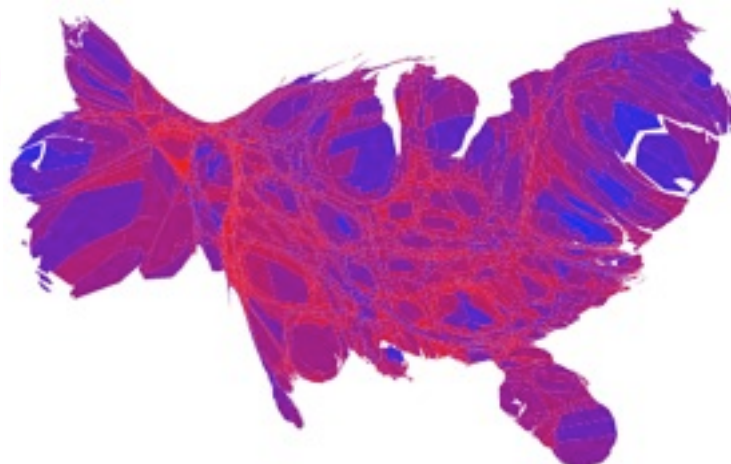
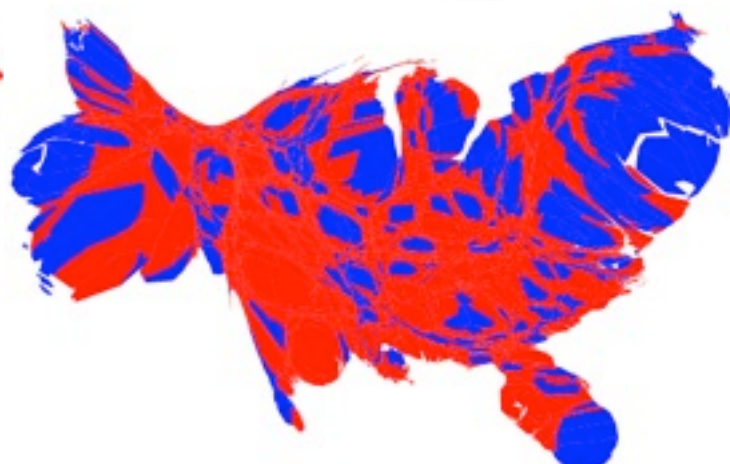
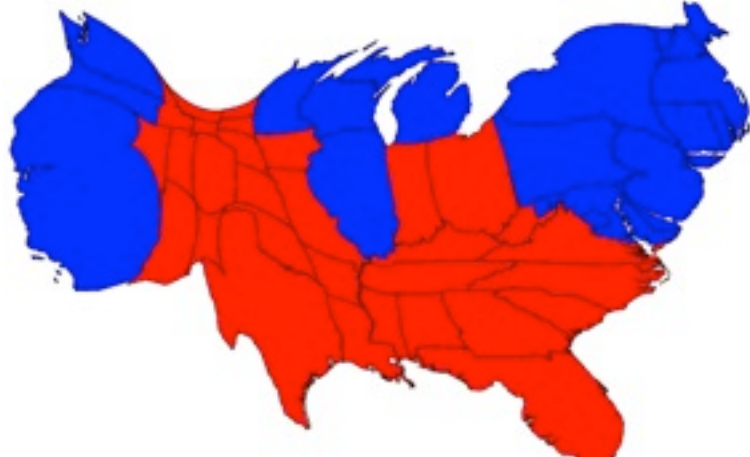
RESET



Obesity Map (Dorling Cartogram) Vadim Ogievetsky



Obesity Map (Dorling Cartogram) Vadim Ogievetsky



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

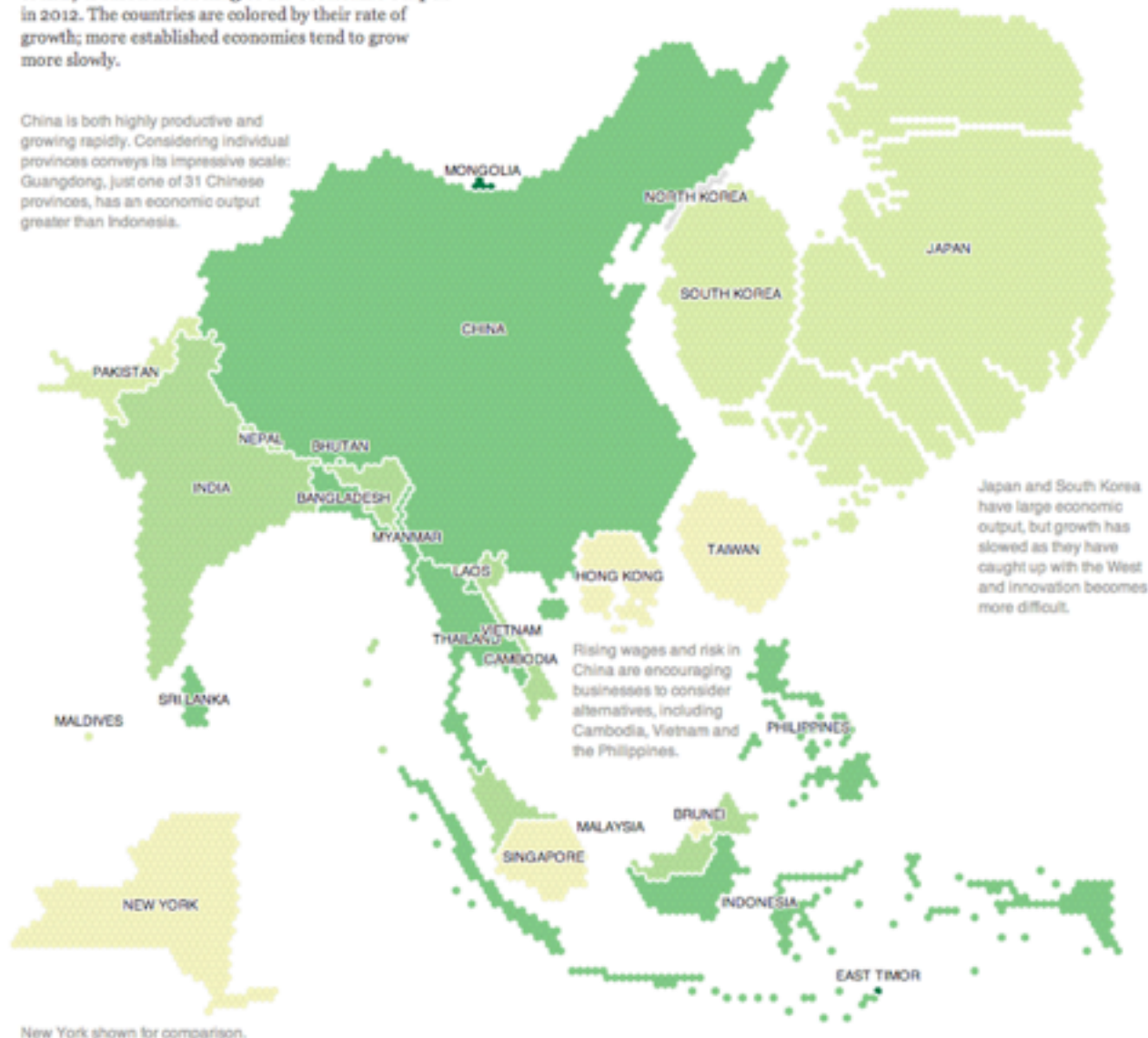
In this map, geography is distorted so that each country is **sized according to its economic output** in 2012. The countries are colored by their rate of growth; more established economies tend to grow more slowly.

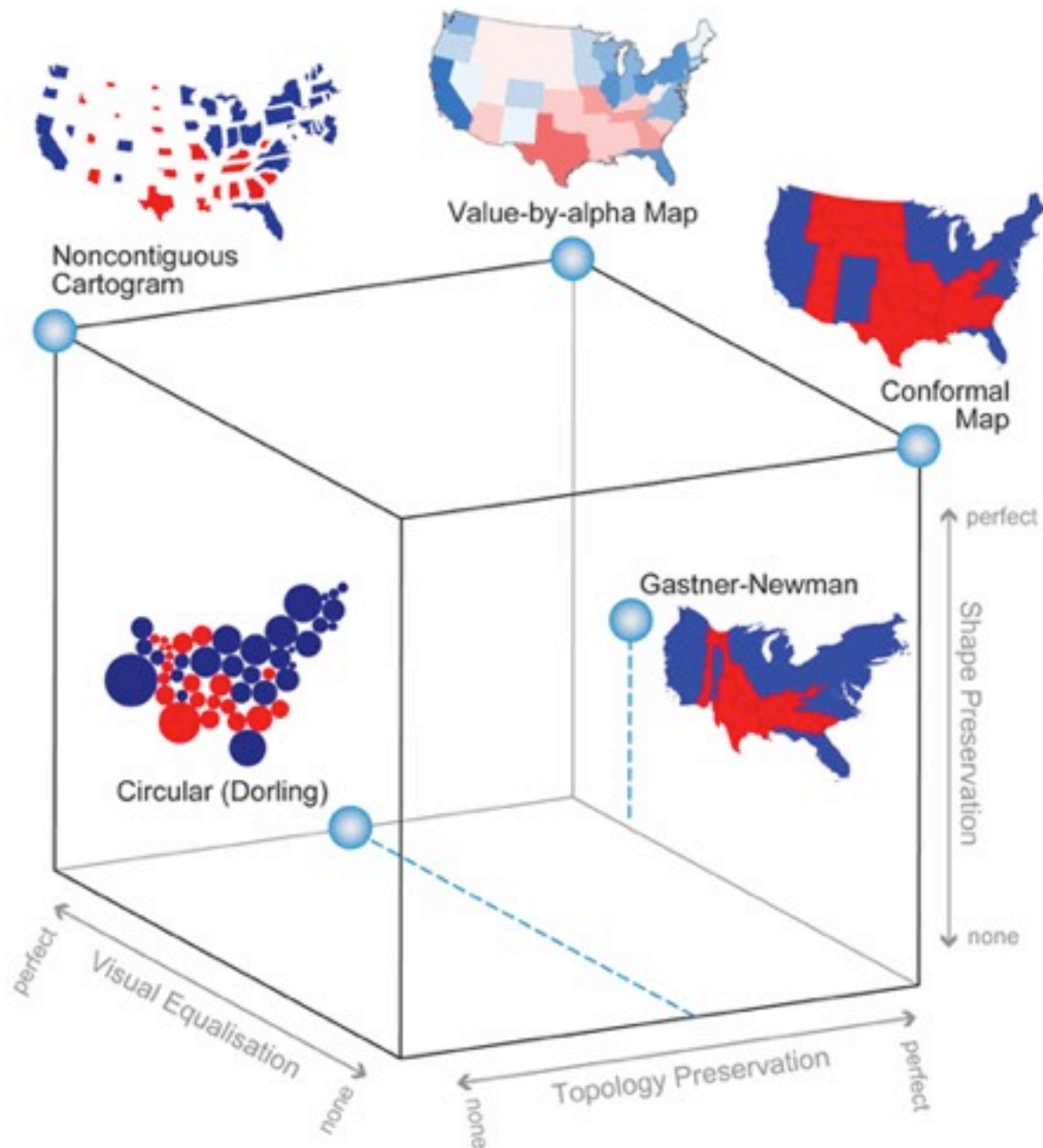
China is both highly productive and growing rapidly. Considering individual provinces conveys its impressive scale: Guangdong, just one of 31 Chinese provinces, has an economic output greater than Indonesia.

Each hexagon represents \$2.7 billion in G.D.P.

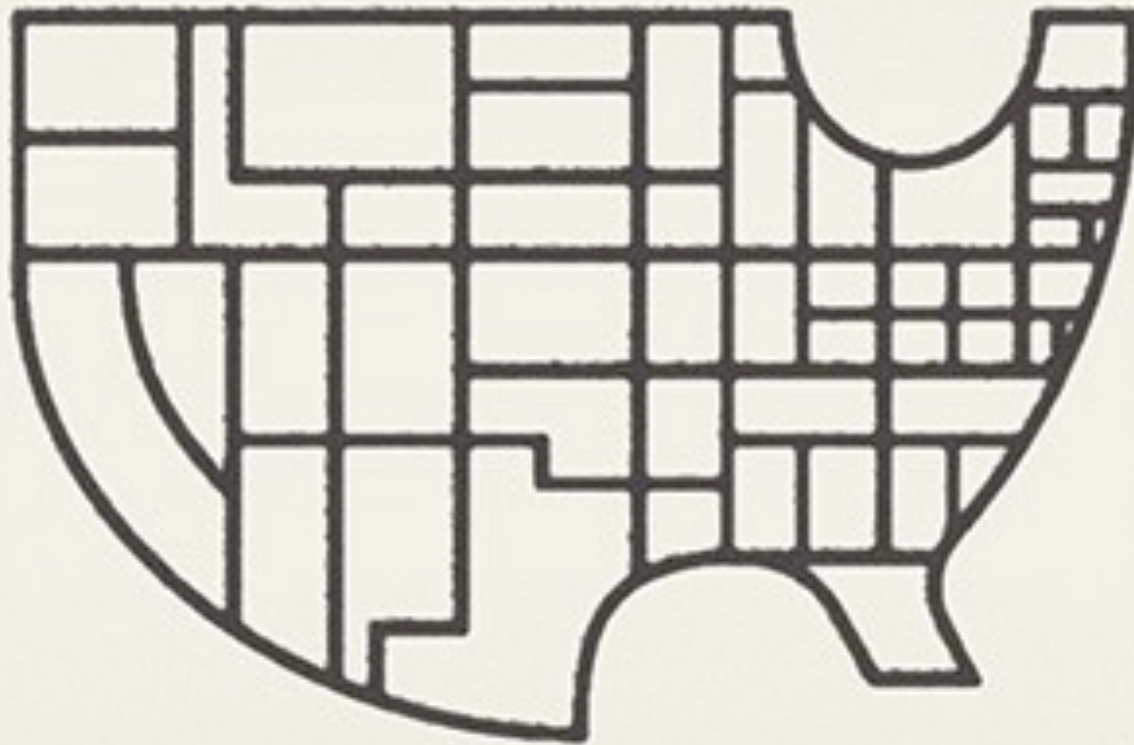
G.D.P. growth, 2011 to 2012

2 4 6 8 +10%

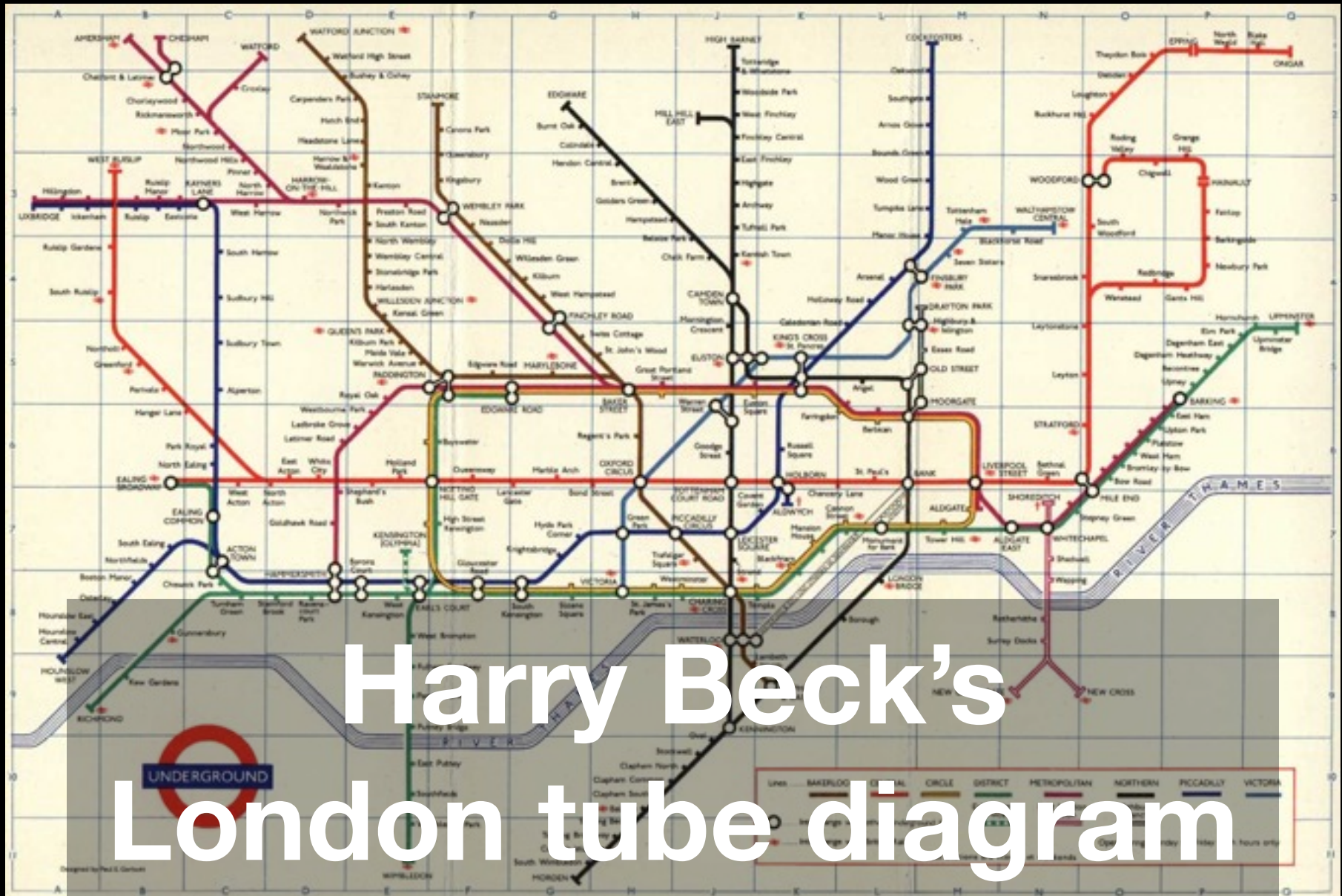




Major distortions can stay recognizable

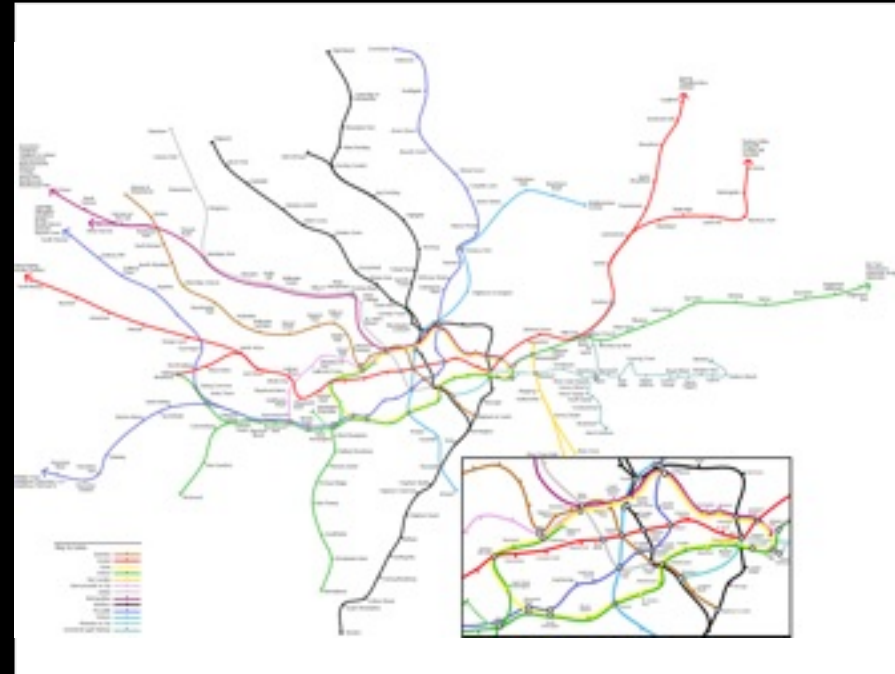


Generalization





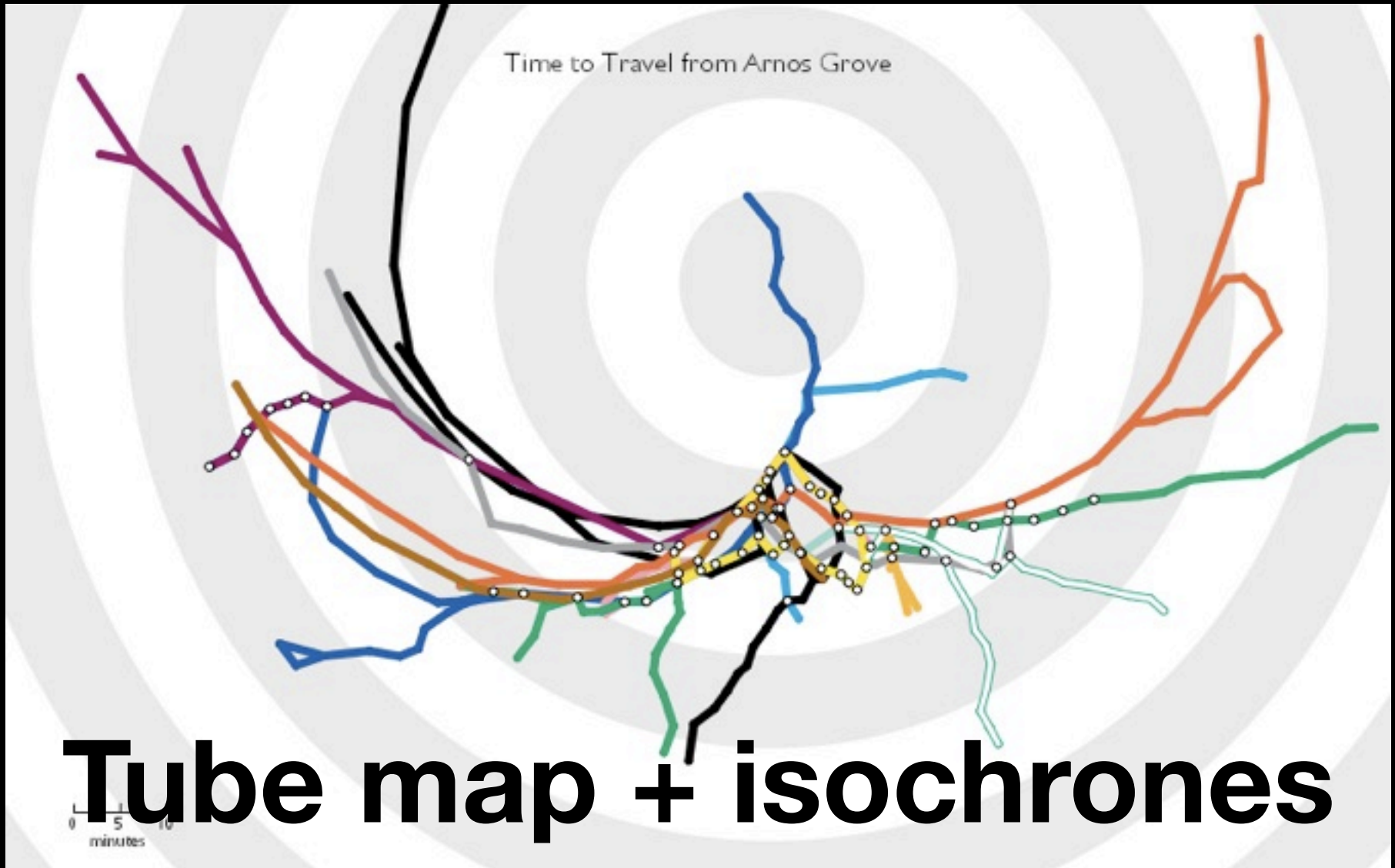
London Underground [Beck 33]



Geographic version of map

Principle: Straigten lines to emphasize stop sequence
 Technique used to emphasize/de-emphasize information





Route Maps: Bellevue to Seattle



Map Design via Optimization [Agrawala '01]

Set of graphic elements

Roads, labels, cross-streets, ...

Choose visual attributes

Position, orientation, size, ...

Distortions increase flexibility

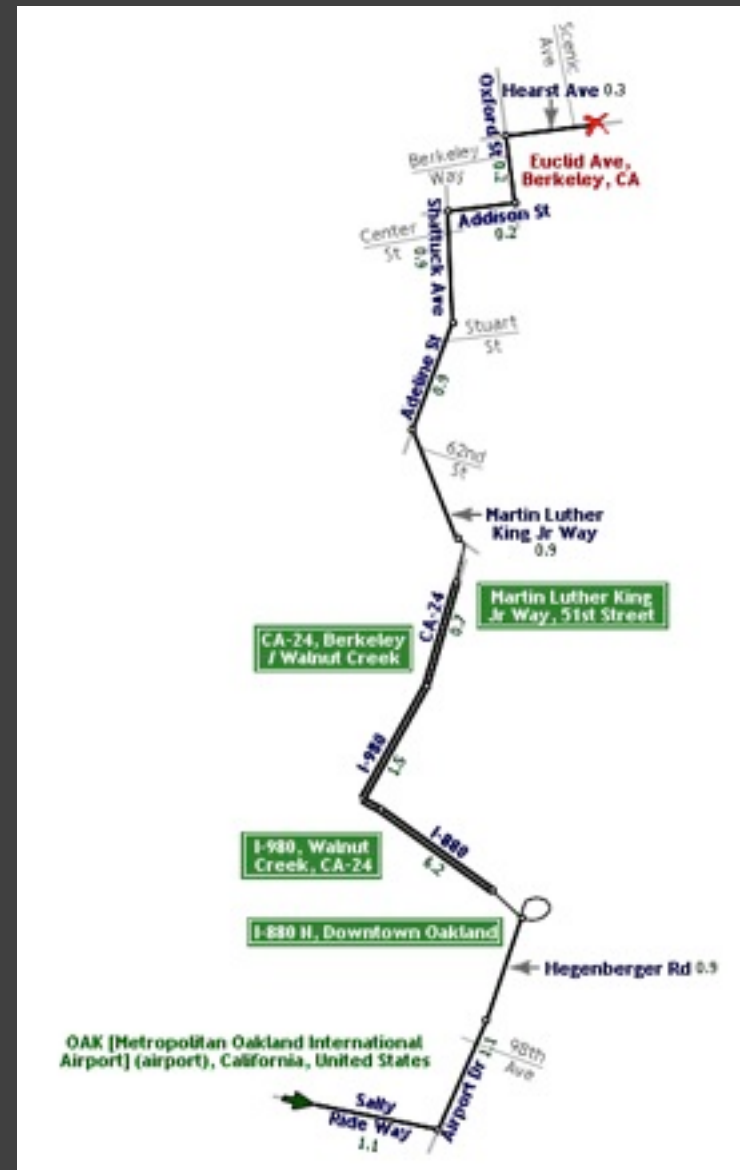
Develop constraints based on design principles

Simulated annealing

Perturb: Form a layout

Score: Evaluate quality

Minimize score



Road Layout Constraints [Agrawala '01]

Length

Ensure all roads visible

$$((L_{\min} - l(r_i)) / L_{\min})^2 * W_{\text{small}}$$

Maintain ordering by length

$$W_{\text{shuffle}}$$

Orientation

Maintain original orientation

$$|\alpha_{\text{curr}}(r_i) - \alpha_{\text{orig}}(r_i)| * W_{\text{orient}}$$

Topological errors

Prevent false

$$\min(d_{\text{origin}}, d_{\text{dest}}) * W_{\text{false}}$$

Prevent missing

$$d * W_{\text{missing}}$$

Ensure separation

$$\min(d_{\text{ext}}, E) * W_{\text{ext}}$$

Overall route shape

Maintain endpoint direction

$$|\alpha_{\text{curr}}(v) - \alpha_{\text{orig}}(v)| * W_{\text{enddir}}$$

Maintain endpoint distance

$$|d_{\text{curr}}(v) - d_{\text{orig}}(v)| * W_{\text{enddist}}$$

Tools

Software Tools

Web Tools

d3.geo: projections, paths and more

GeoJSON: JSON format for geo data

TopoJSON: topology -> compressed GeoJSON

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

Let's Make a Map!

<http://bost.ocks.org/mike/map/>

How to Infer Topology

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