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<https://cspaul.com>



# Visualization for Data Science

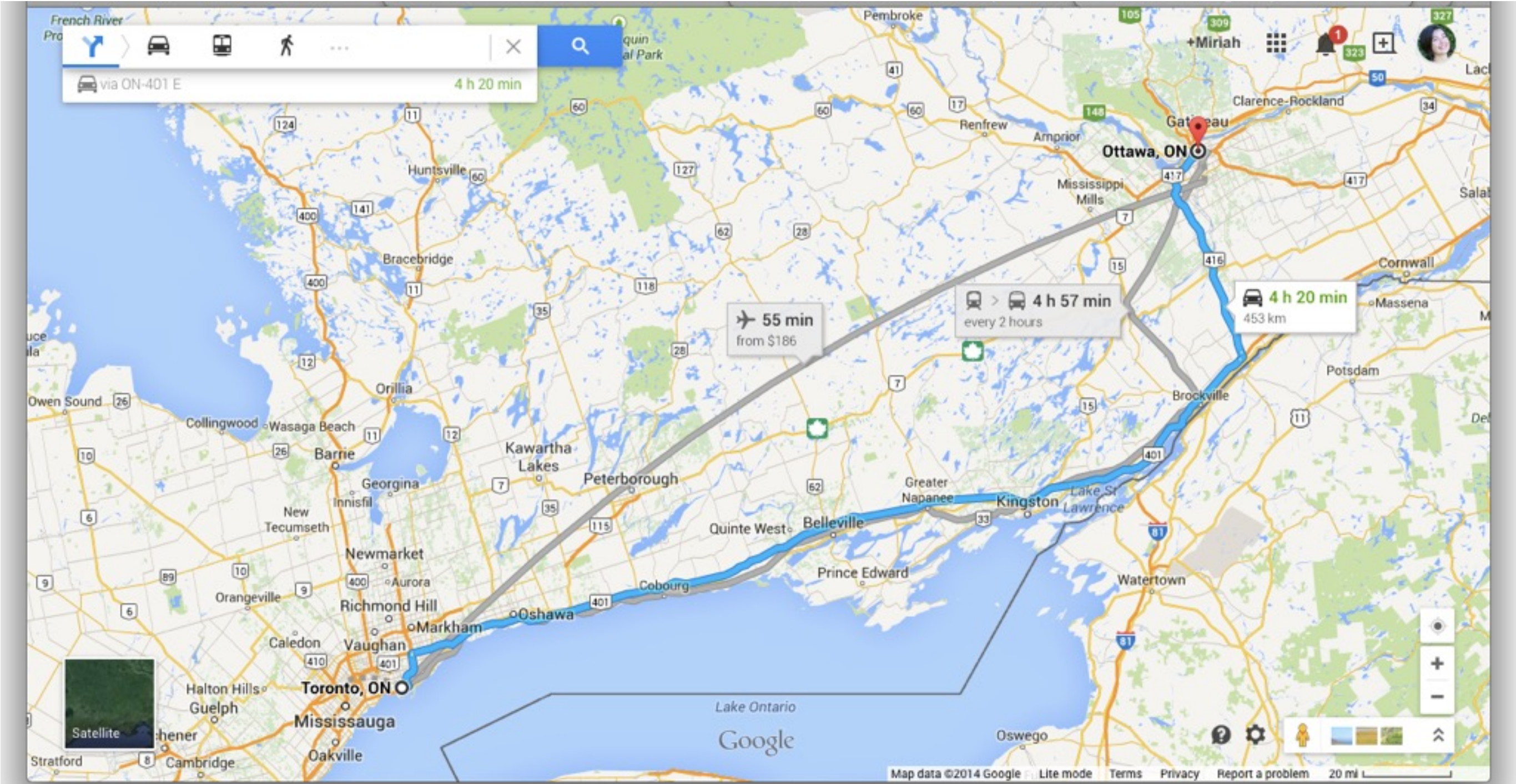
## DS-4630 / CS-5630 / CS-6630

MAPS

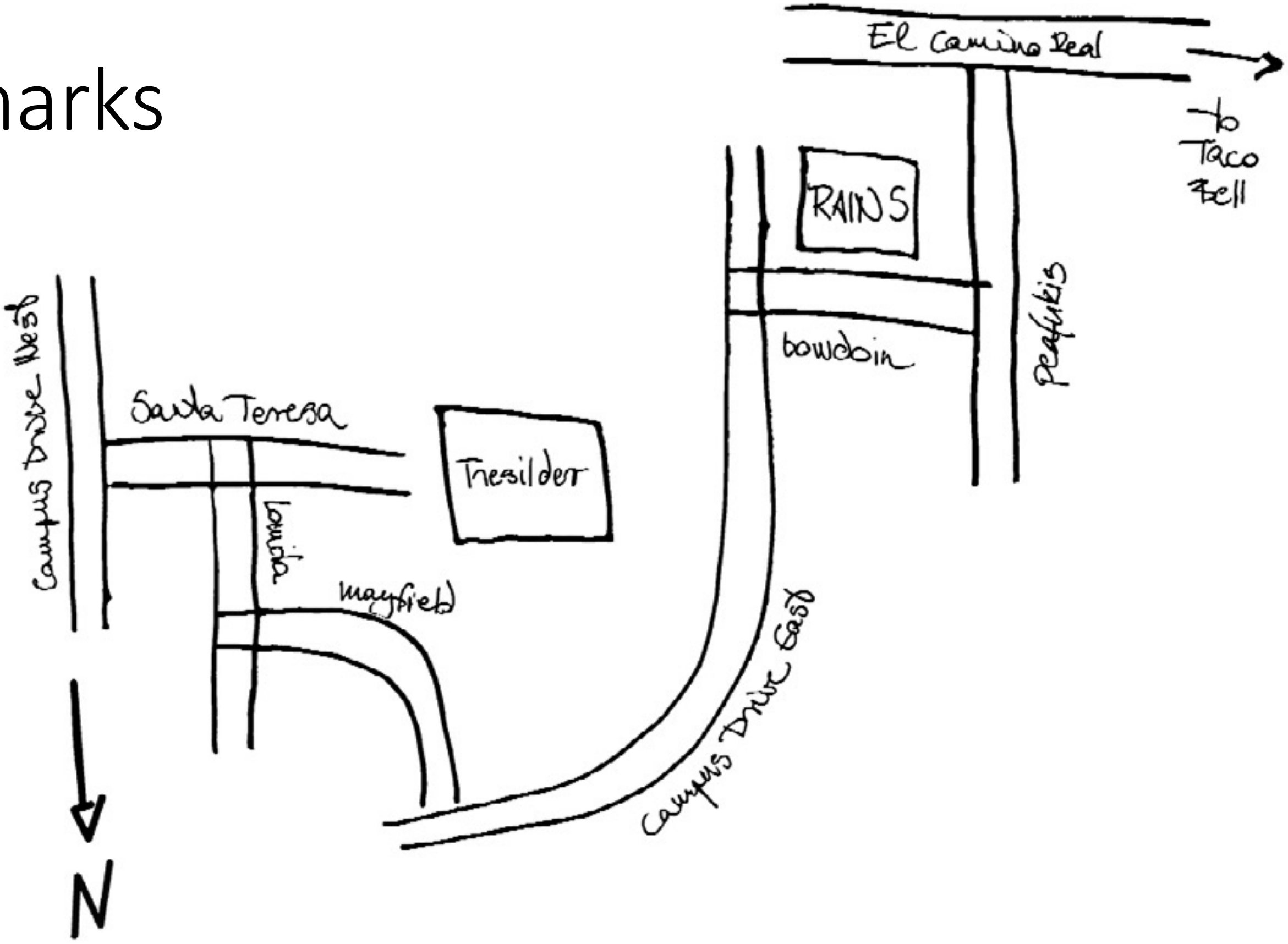
# Maps!

- Landmarks
- discrete data
- continuous data
- Choropleths
- Cartograms
- projections

# landmarks



# landmarks



# Rendering Effective Route Maps: Improving Usability Through Generalization

Maneesh Agrawala    Chris Stolte  
Stanford University\*

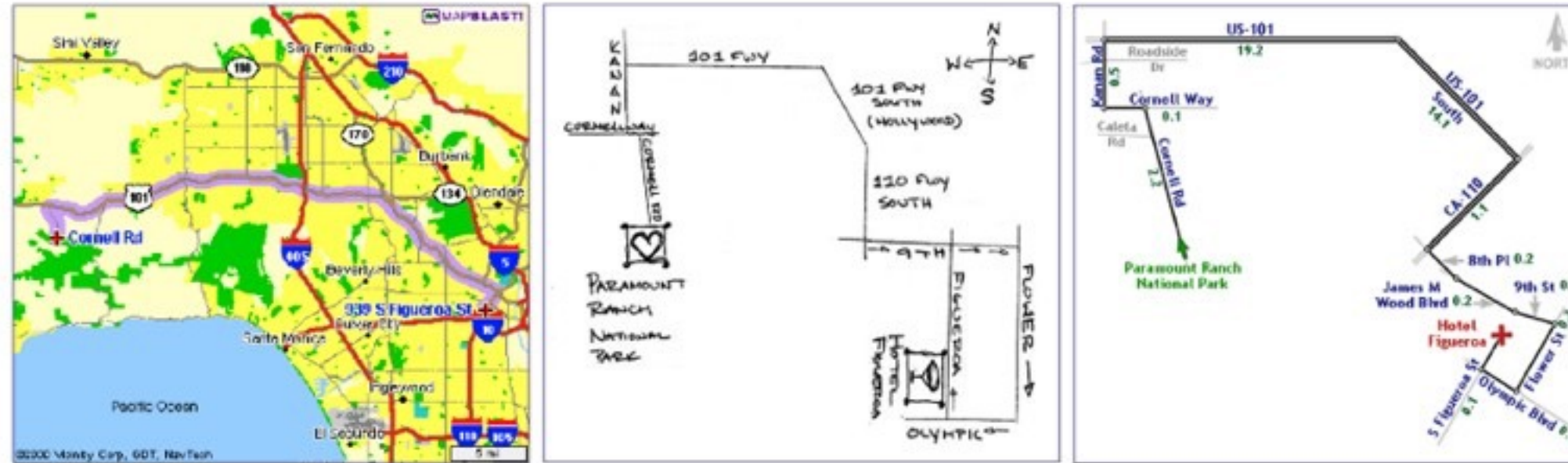


Figure 1: Three route maps for the same route rendered by (left) a standard computer-mapping system, (middle) a person, and (right) LineDrive, our route map rendering system. The standard computer-generated map is difficult to use because its large, constant scale factor causes the short roads to vanish and because it is cluttered with extraneous details such as city names, parks, and roads that are far away from the route. Both the handdrawn map and the LineDrive map exaggerate the lengths of the short roads to ensure their visibility while maintaining a simple, clean design that emphasizes the most essential information for following the route. Note that the handdrawn map was created without seeing either the standard computer-generated map or the LineDrive map. (Handdrawn map courtesy of Mia Trachinger.)

## Abstract

difficult to use. In this paper we present a set of cartographic generalization techniques specifically designed to improve the usability of route maps. Our generalization techniques are based both on cognitive psychology research studying how route maps are used and on an analysis of the generalizations commonly found in handdrawn route maps. We describe algorithmic implementations of these generalization techniques within LineDrive, a real-time system for automatically designing and rendering route maps. Feedback from over 2200 users indicates that almost all believe LineDrive maps are preferable to using standard computer-generated route maps alone.

**Keywords:** Information Visualization, Non-Realistic Rendering, WWW Applications, Human Factors

clarity of the map and to emphasize the most important information.

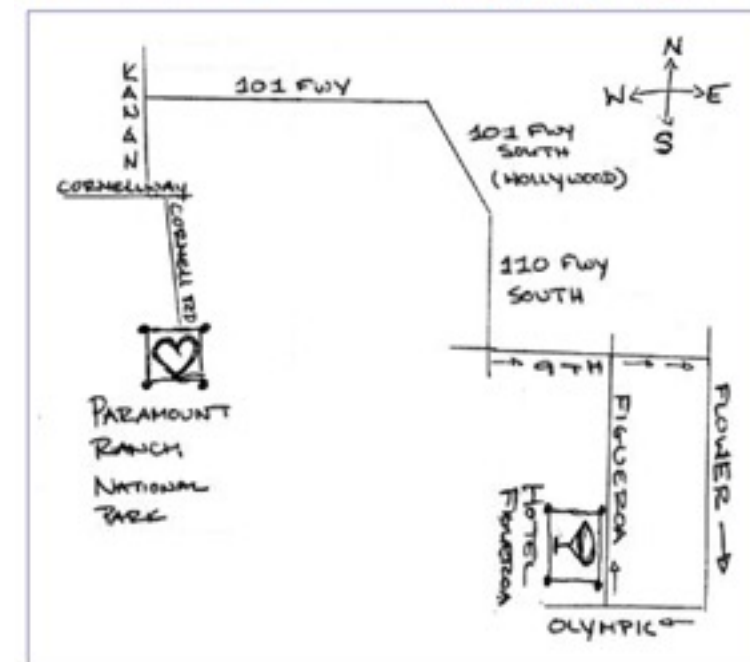
## RECOMMENDED READING

Recently, route maps in the form of driving directions have become widely available through the Web. In contrast to hand-designed route maps, these computer-generated route maps are often more precise and contain more information. Yet these maps are more difficult to use. The main shortcoming of current systems for automatically generating route maps is that they do not distinguish between essential and extraneous information, and as a result, cannot apply the generalizations used in hand-designed maps to emphasize the information needed to follow the route.

Figure 1 shows several problems arising from the lack of differentiation between necessary and unnecessary information. The primary problem is that current computer-mapping systems maintain a constant scale factor for the entire map. For many routes, the

# Recommendations

- straighten wiggly lines
- snap turns to right angles
- expand regions with turns
- contract long straight roads
- label carefully
- maintain overall orientation



# Discrete data

# Data as icons/glyphs





**TIME OF DAY**  
Show All | Hide All  
Light | Dark [nearest hour]  
Commute | Nightlife  
Day | Night | Swing Shift

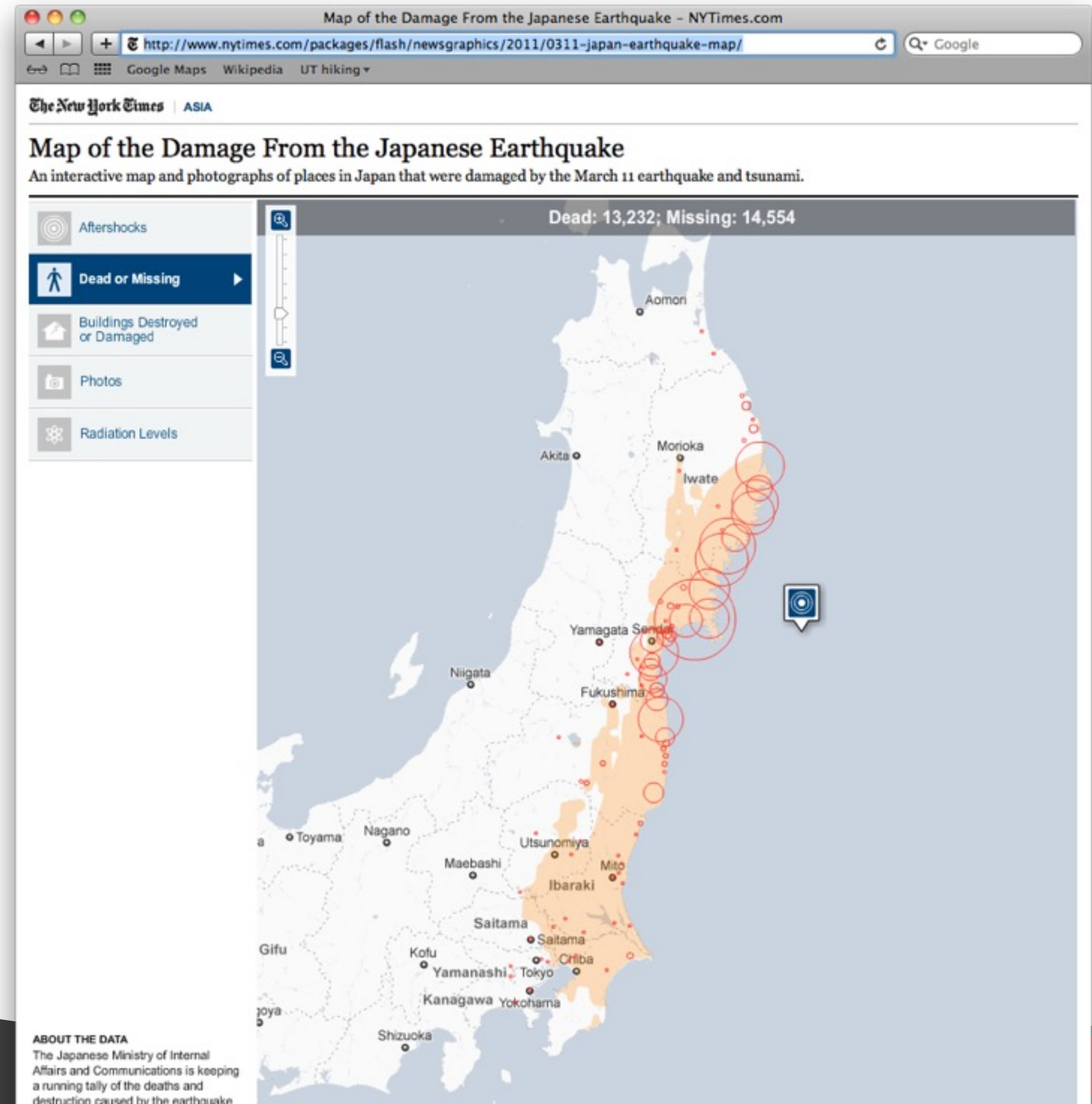
**CRIME TYPE** Show All | Hide All

- 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

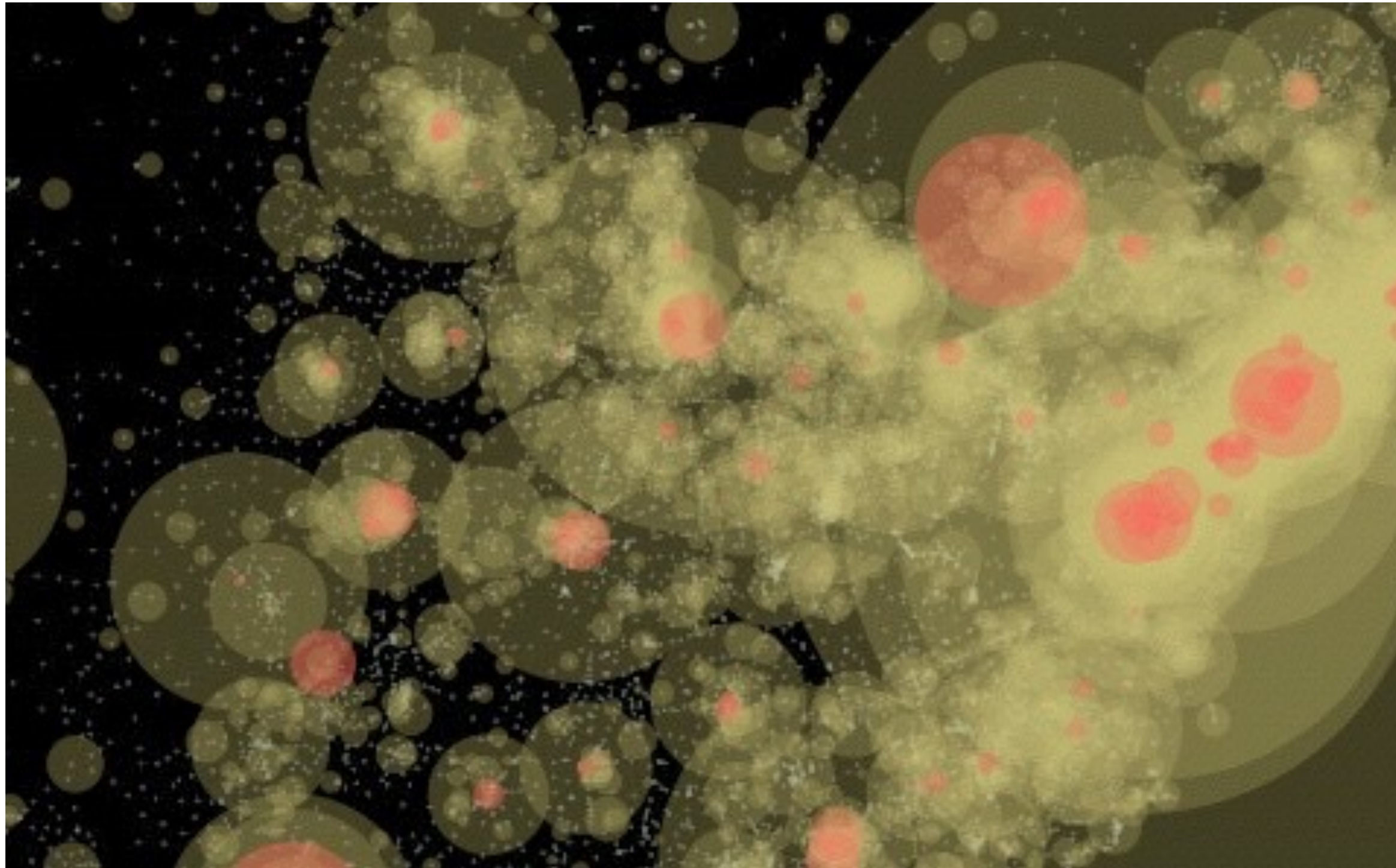
Map tiles © CloudMade. Map data © CC-BY-SA OpenStreetMap.org

# data as points

- data : ordered/ quantitative
- encoding : size

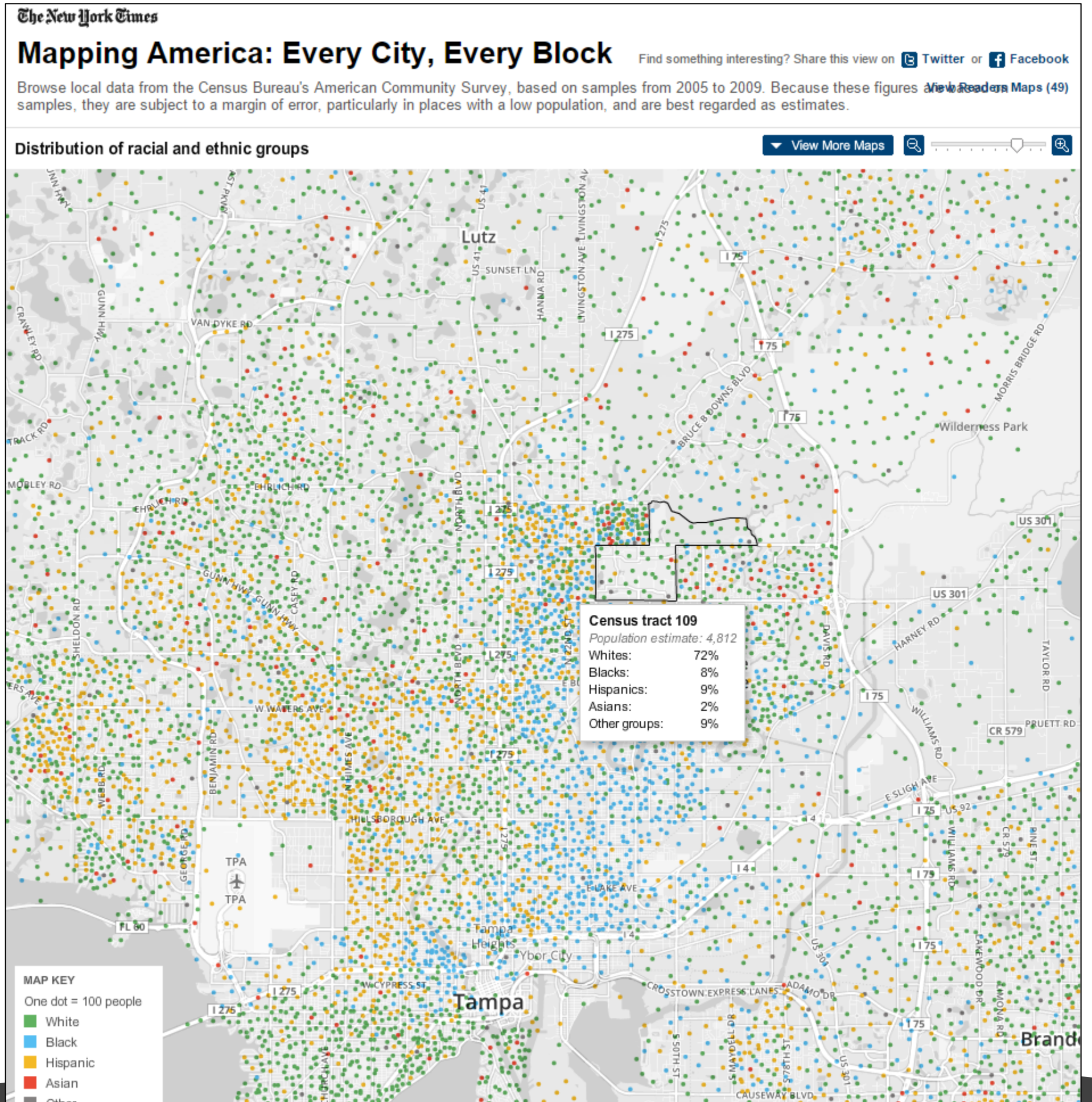


traffic



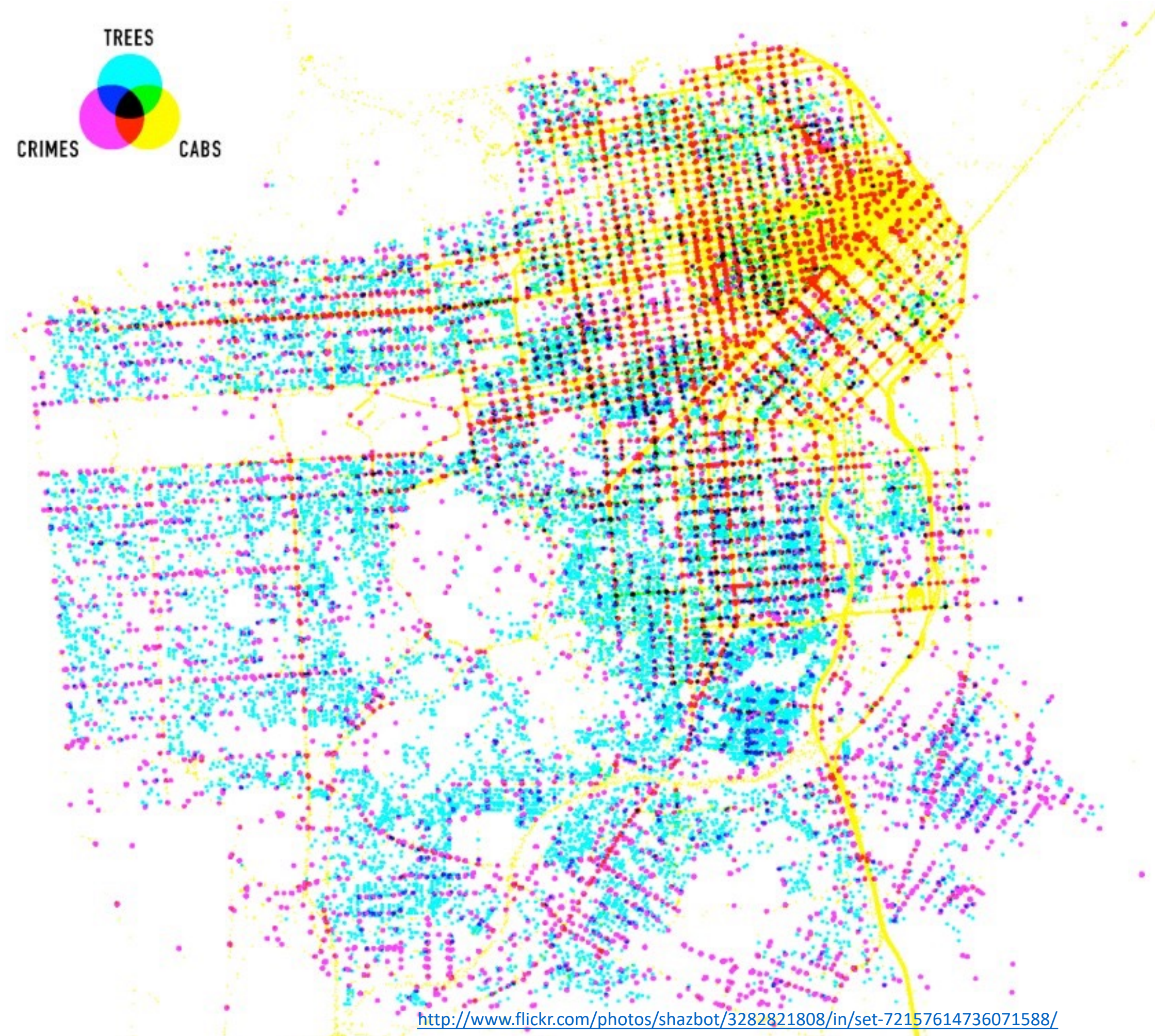
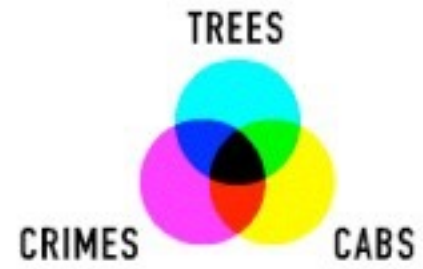
# data as points

- data : categorical
- encoding : hue



# data as points

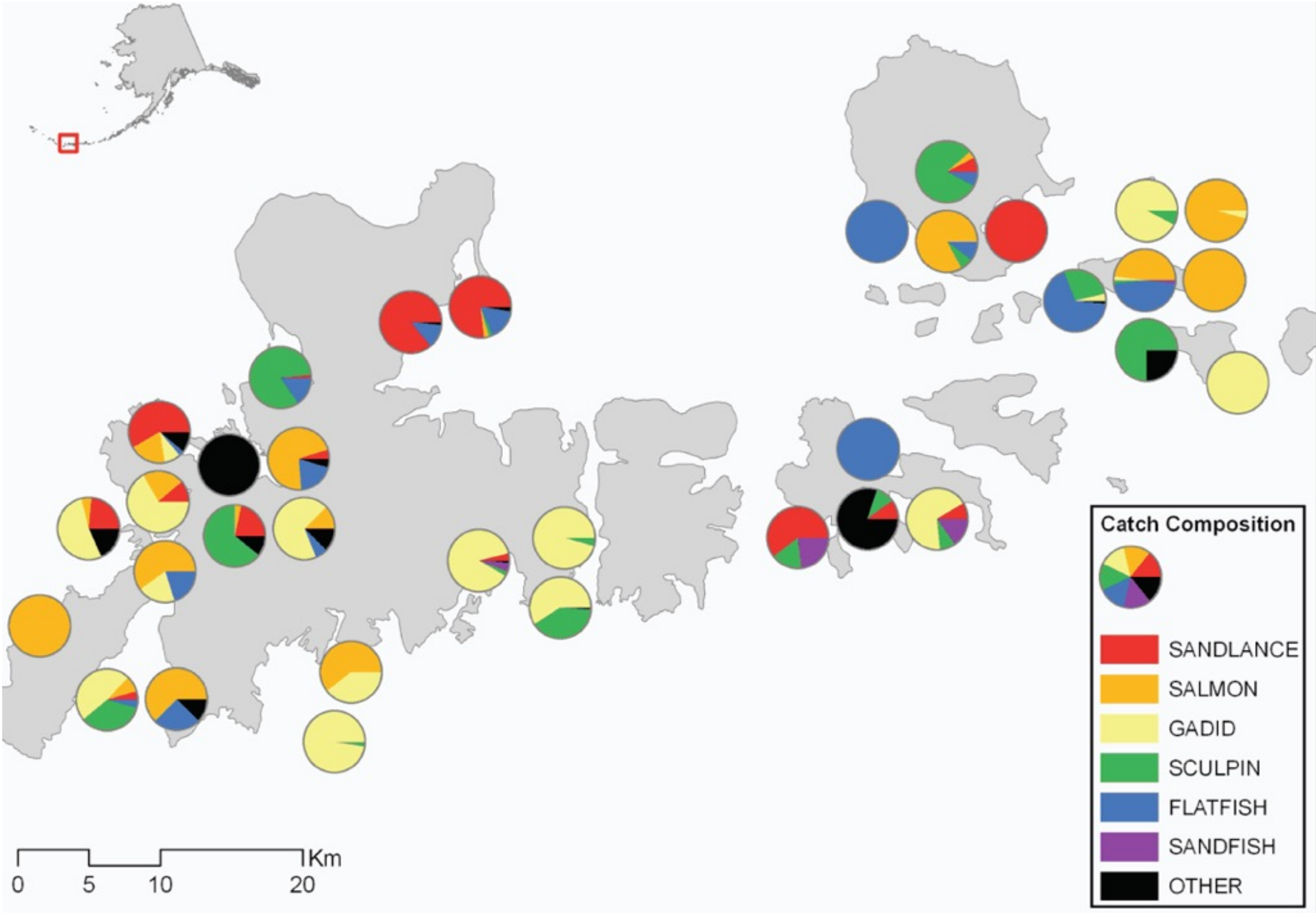
- data : categorical
- encoding : hue



# data as lines



# data as charts



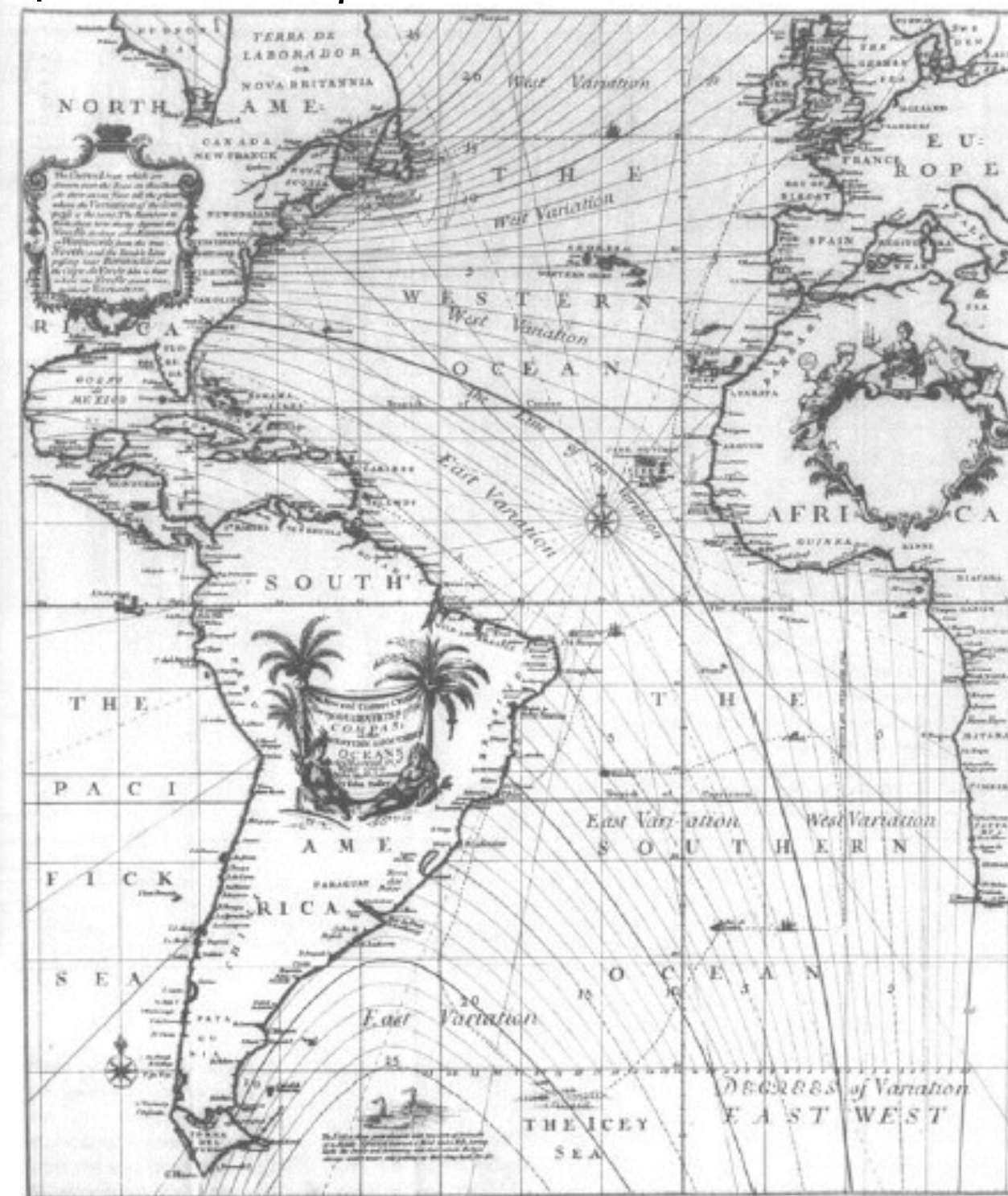
continuous data



# isopleth

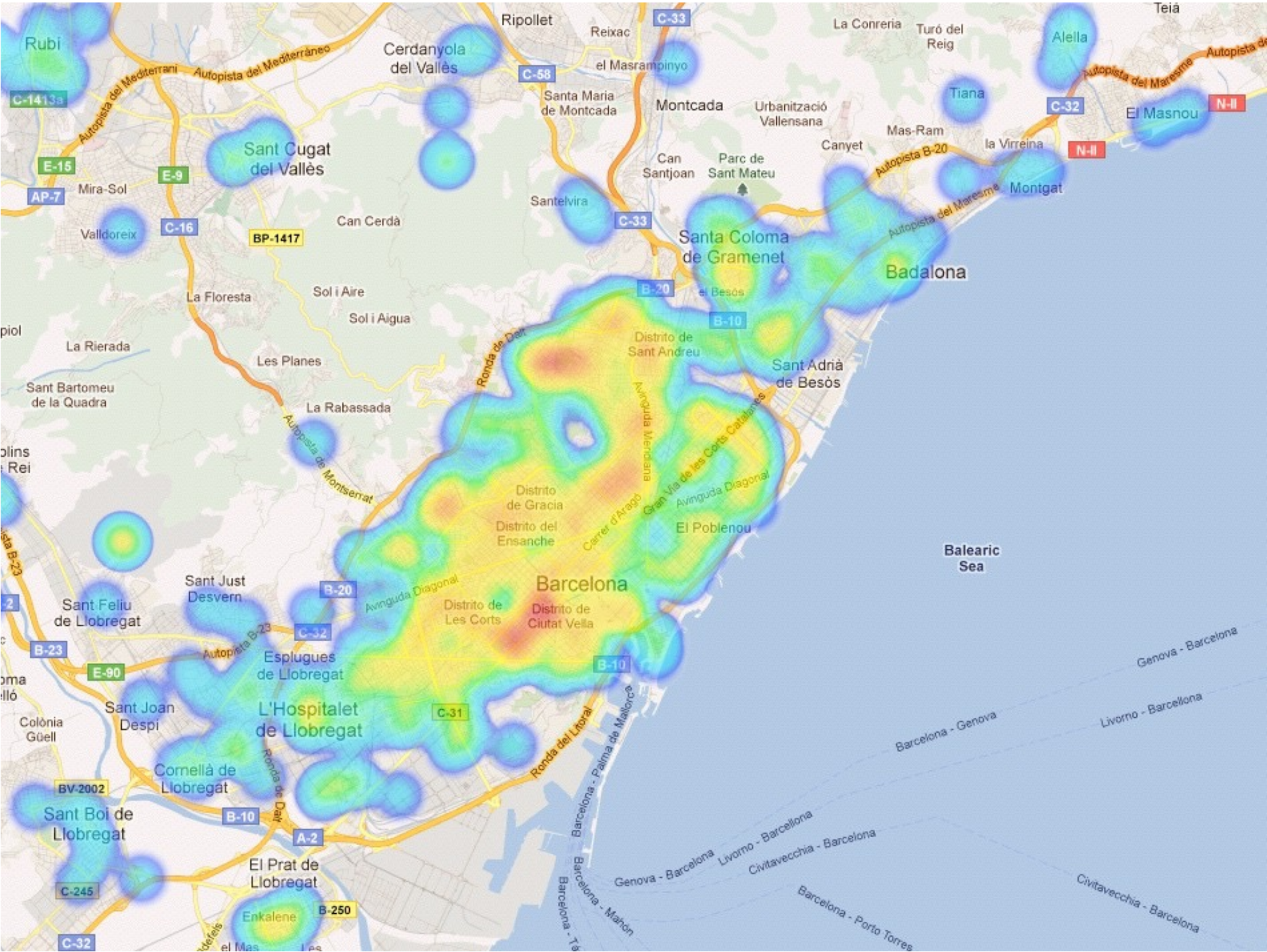
- map which overlays continuous data using a third encoding channel

**Lines of Equal Magnetic Declination**  
*first contour map*

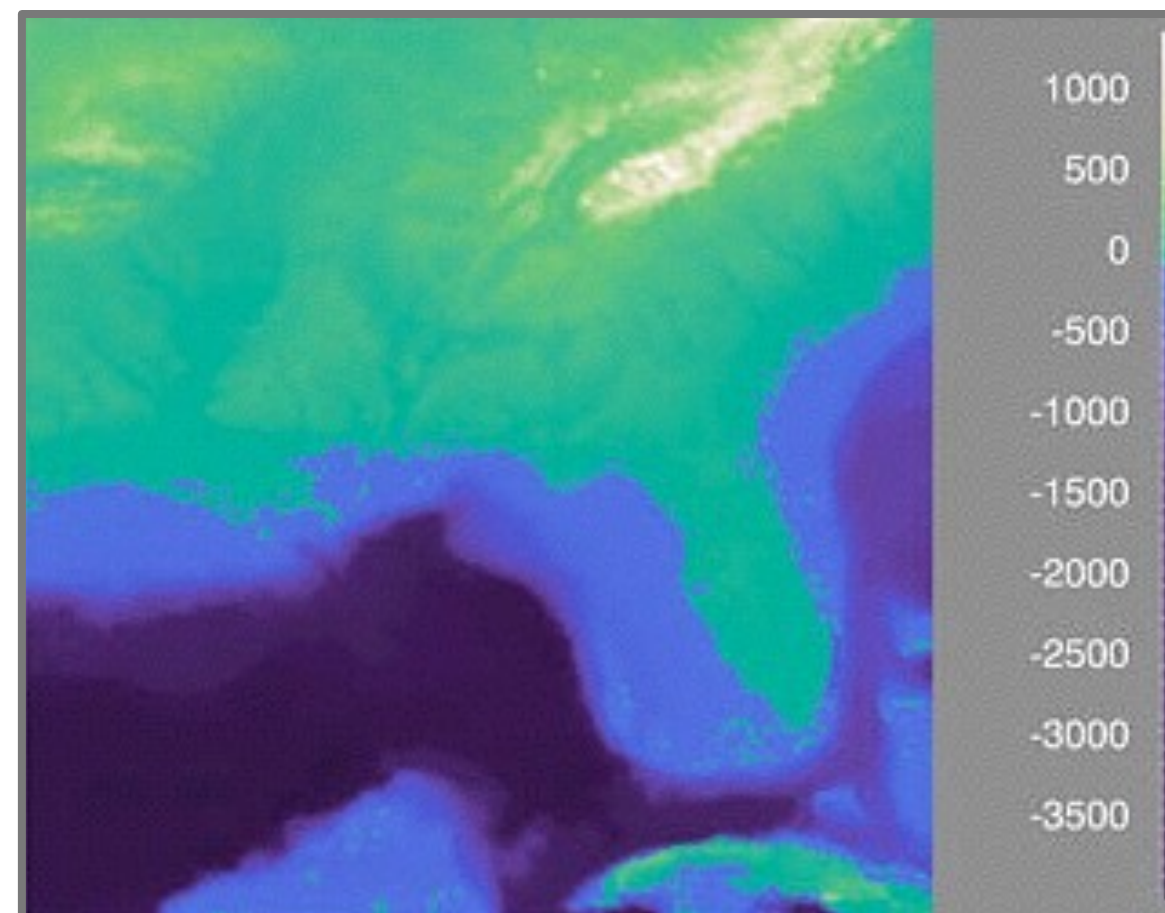
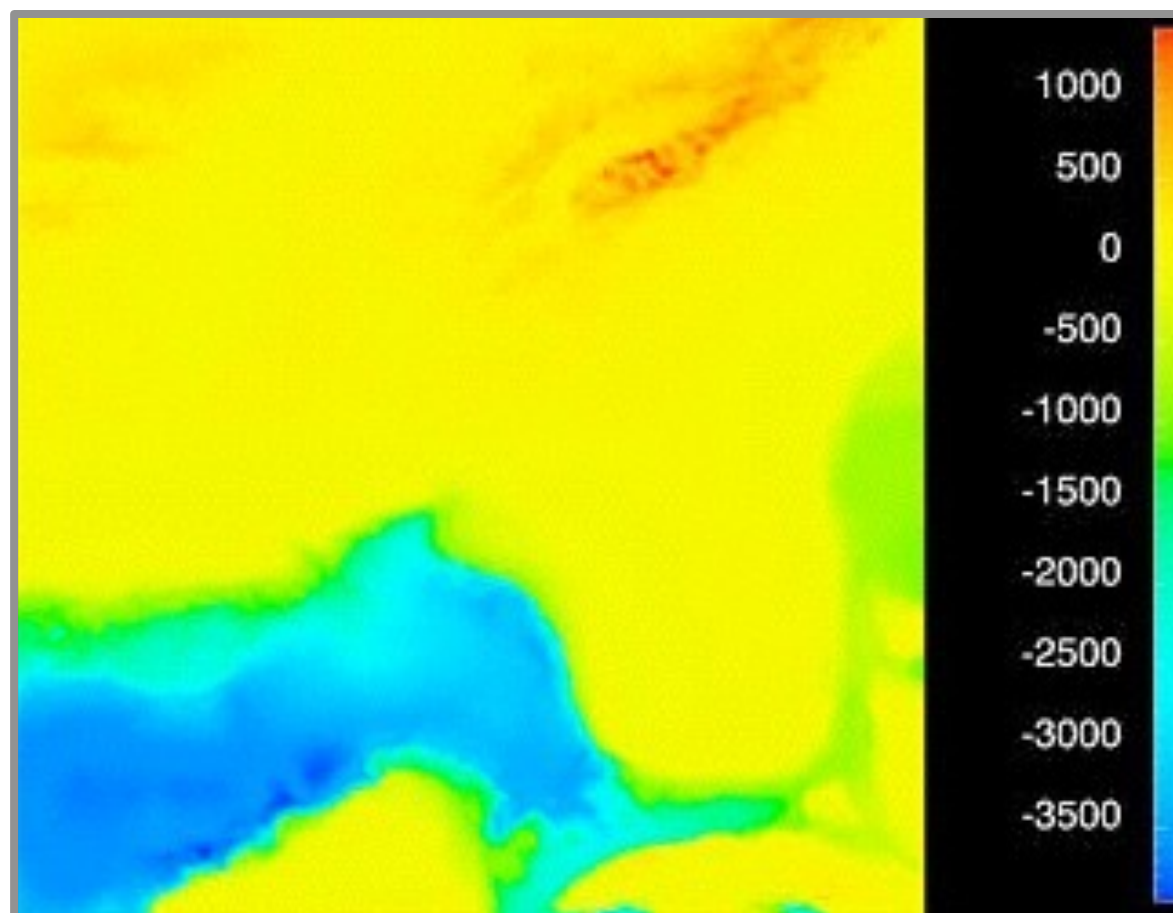


# HEATMAPS

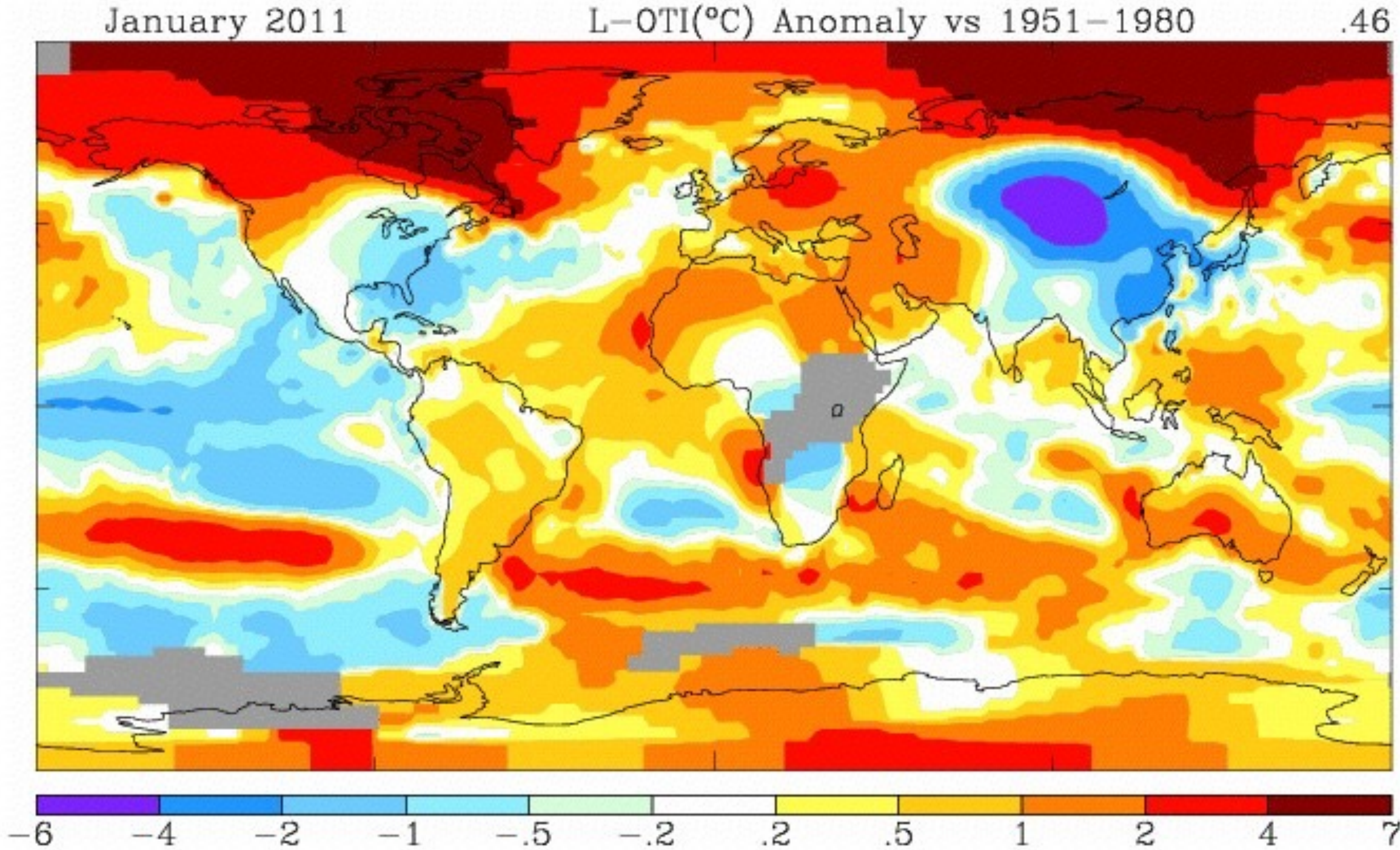
# Heatmap



choose the appropriate colormap



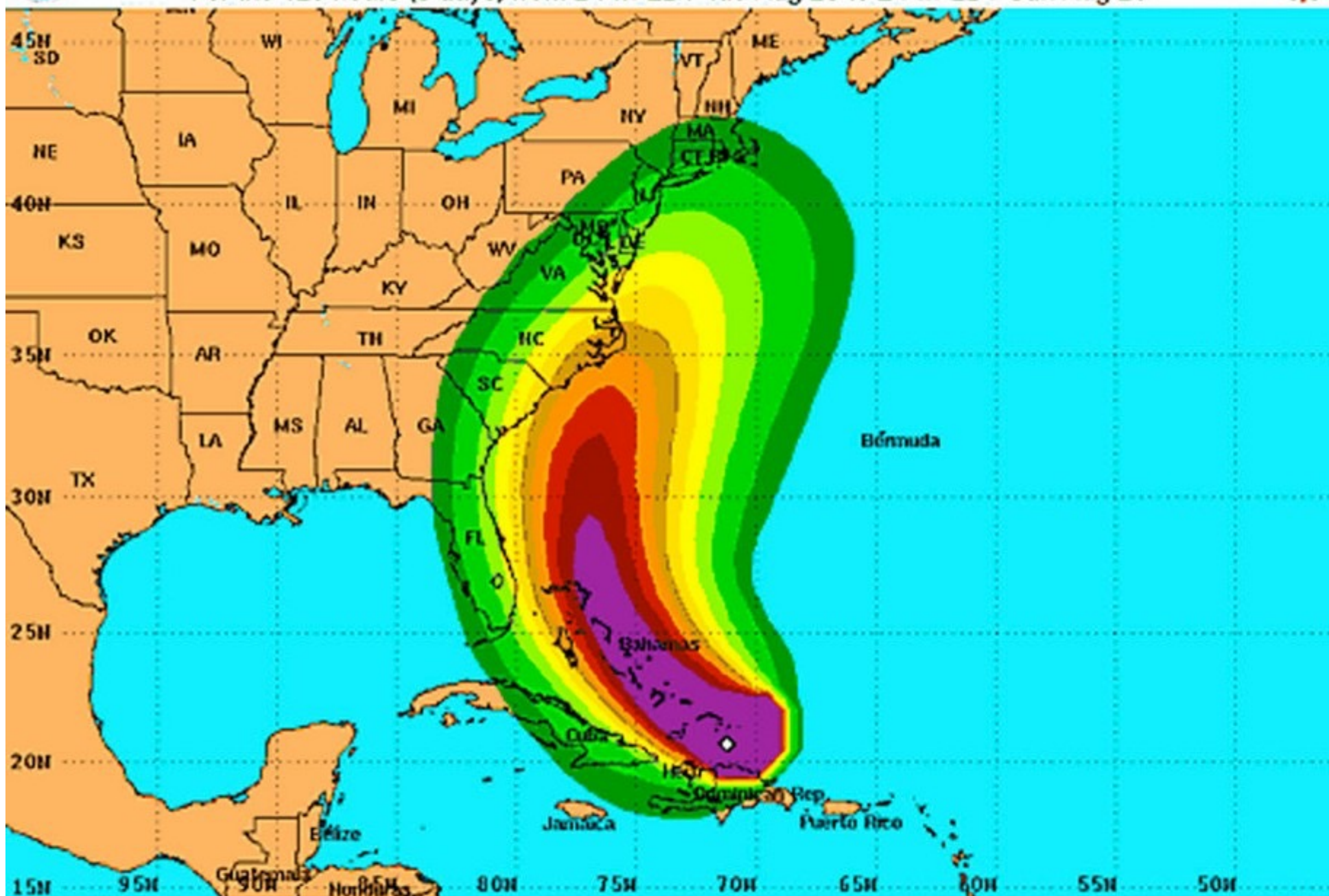
# bin the data





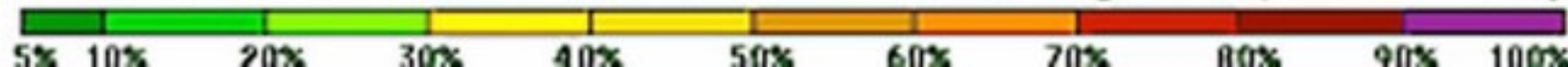
# Tropical Storm Force Wind Speed Probabilities

For the 120 hours (5 days) from 2 PM EDT Tue Aug 23 to 2 PM EDT Sun Aug 28



Probability of tropical storm force surface winds (1-minute average  $\geq 39$  mph) from all tropical cyclones

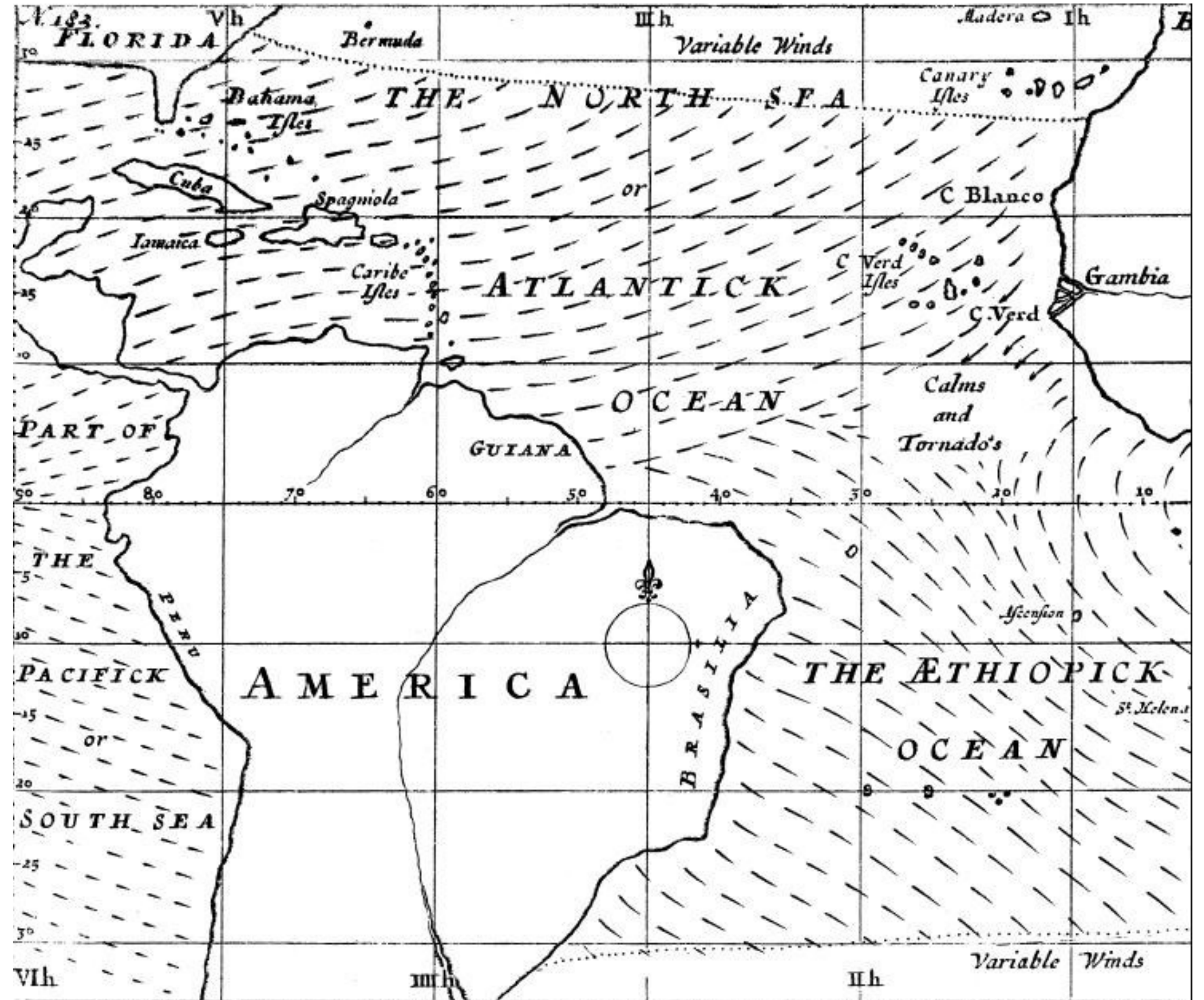
◆ indicates HURRICANE IRENE center location at 2 PM EDT Tue Aug 23 2011 (Forecast/Advisory #14)



# ISOCURVES

# Wind Map

- first weather map

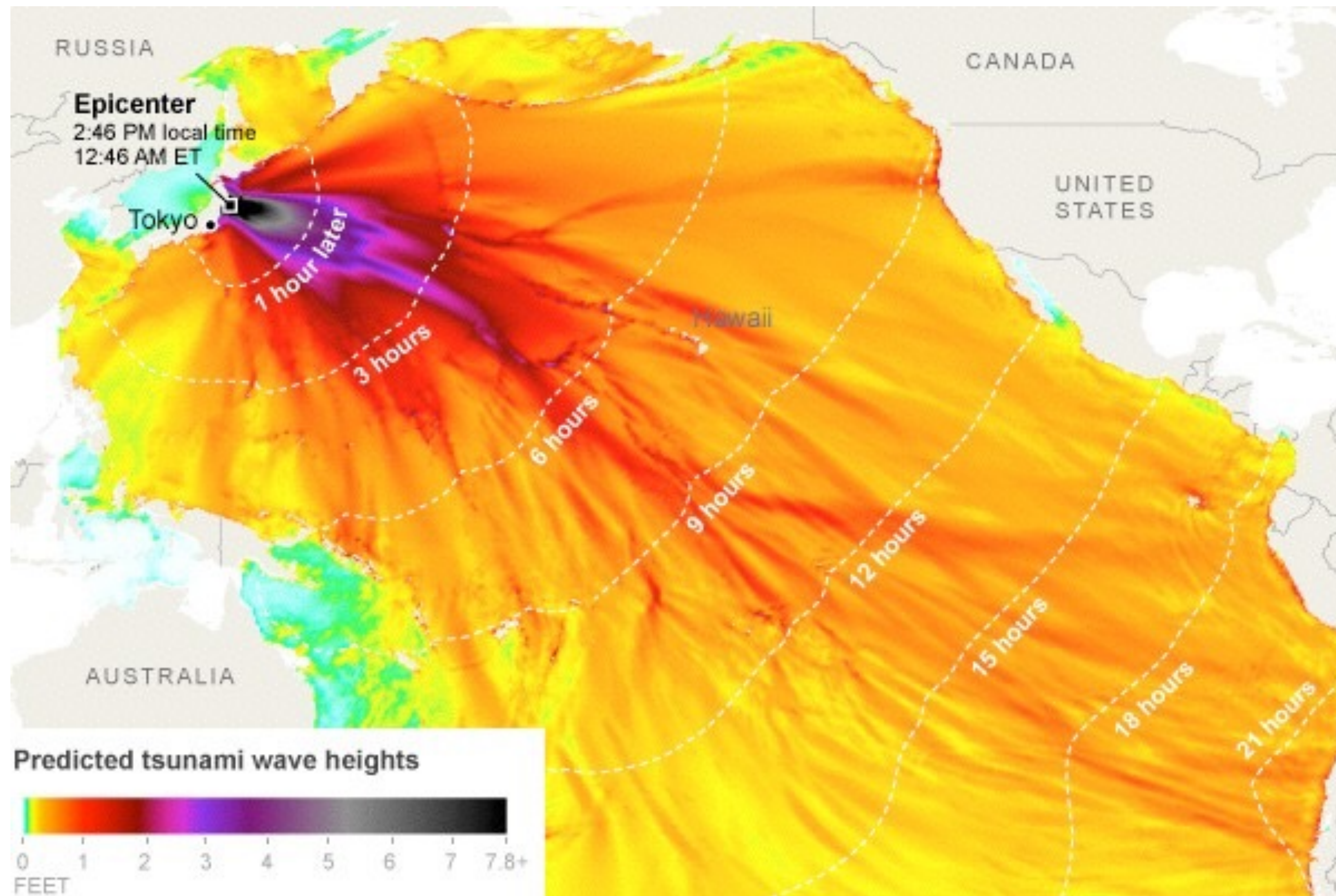




show topology



show time



choropleths

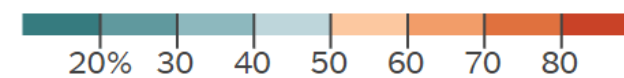
# How Americans Think About Climate Change, in Six Maps

By NADJA POPOVICH, JOHN SCHWARTZ and TATIANA SCHLOSSBERG MARCH 21, 2017

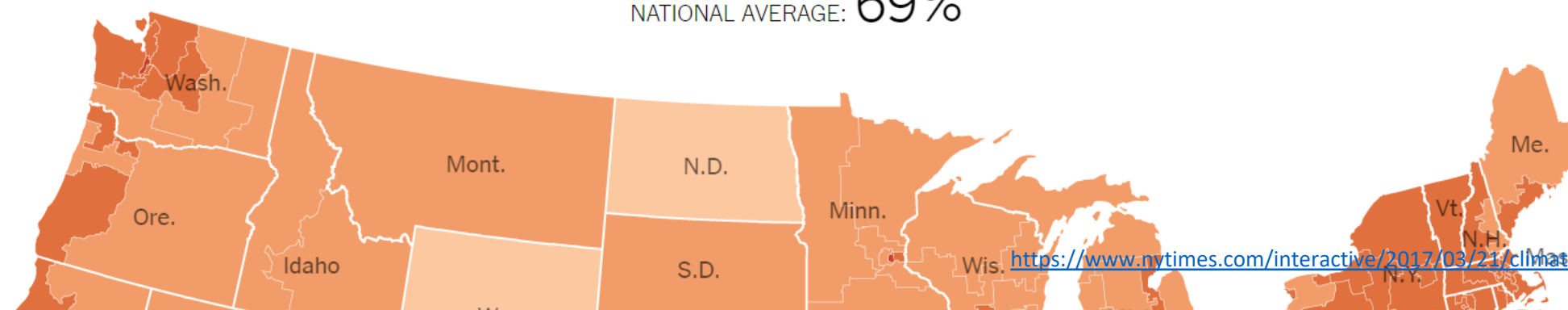
Americans overwhelmingly believe that global warming is happening, and that carbon emissions should be scaled back. But fewer are sure that the changes will harm them personally. New data released by Yale researchers gives the most detailed view yet of public opinion on global warming.

**Americans want to restrict carbon emissions from coal power plants. The White House and Congress may do the opposite.**

Percentage of adults per congressional district who support strict CO2 limits on existing coal-fired power plants



NATIONAL AVERAGE: 69%



[https://www.nytimes.com/interactive/2017/03/21/climate/how-americans-think-about-climate-change-in-six-maps.html?\\_r=0](https://www.nytimes.com/interactive/2017/03/21/climate/how-americans-think-about-climate-change-in-six-maps.html?_r=0)

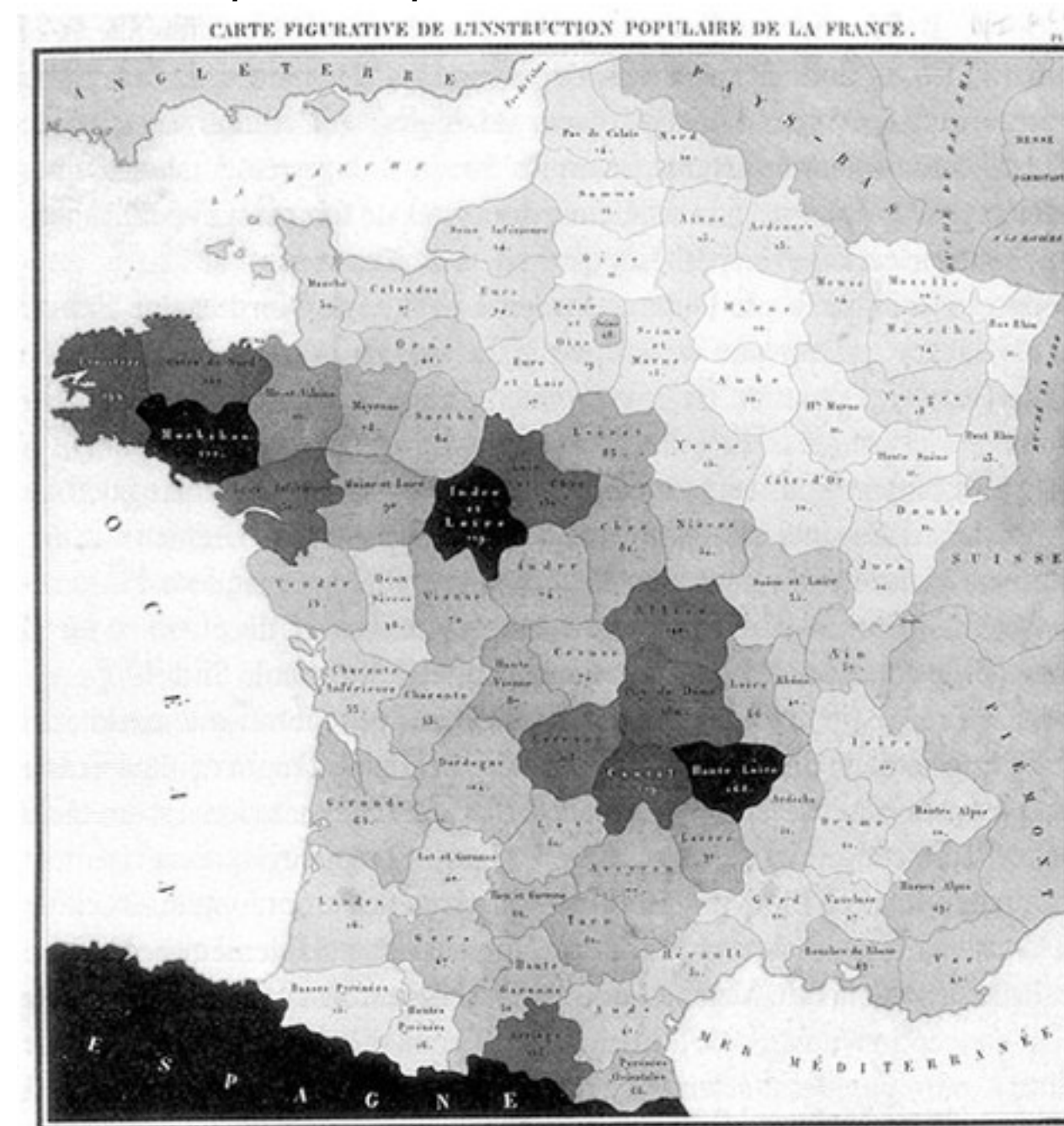


# choropleth

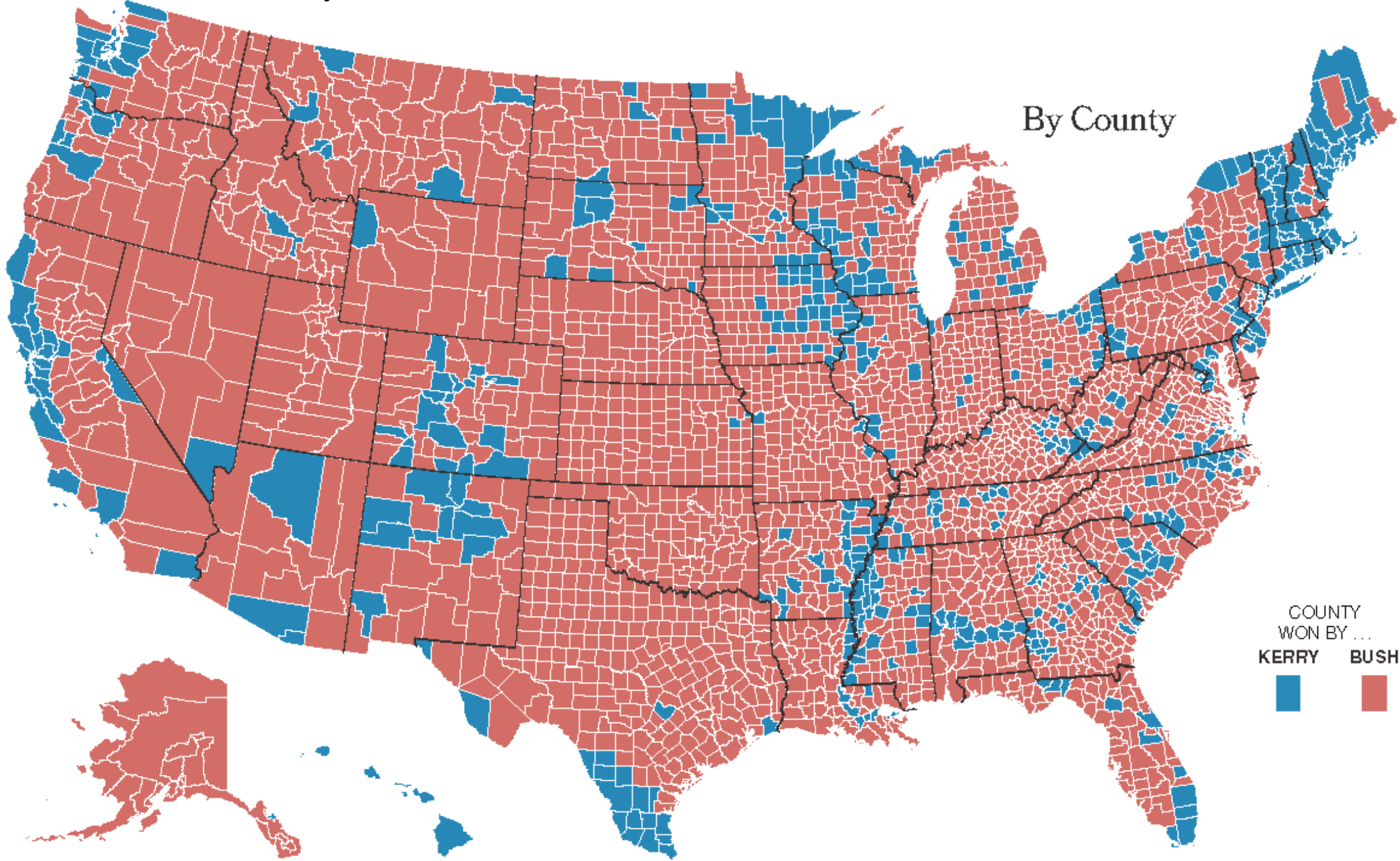
- map in which areas are shaded, colored, or patterned relative to a data attribute value

## Illiteracy in France

*first choropleth map*



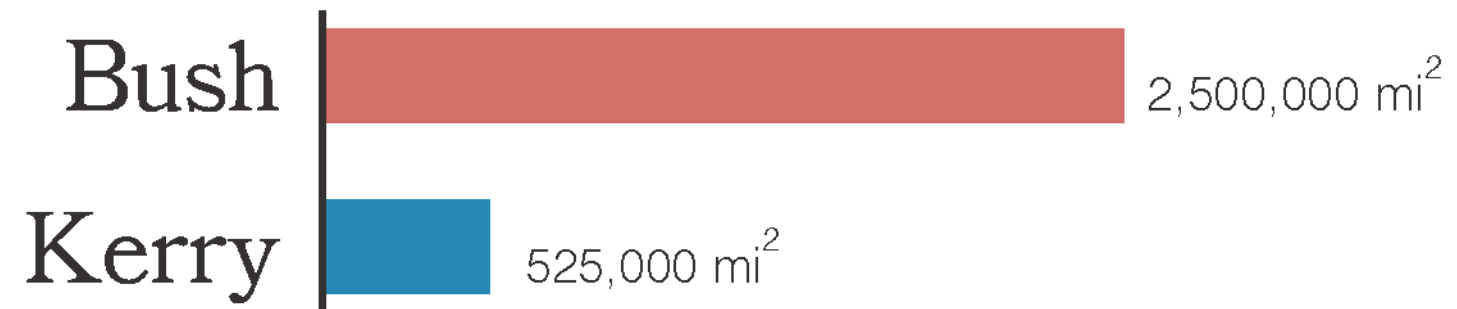
# Kerry vs Bush, 2004

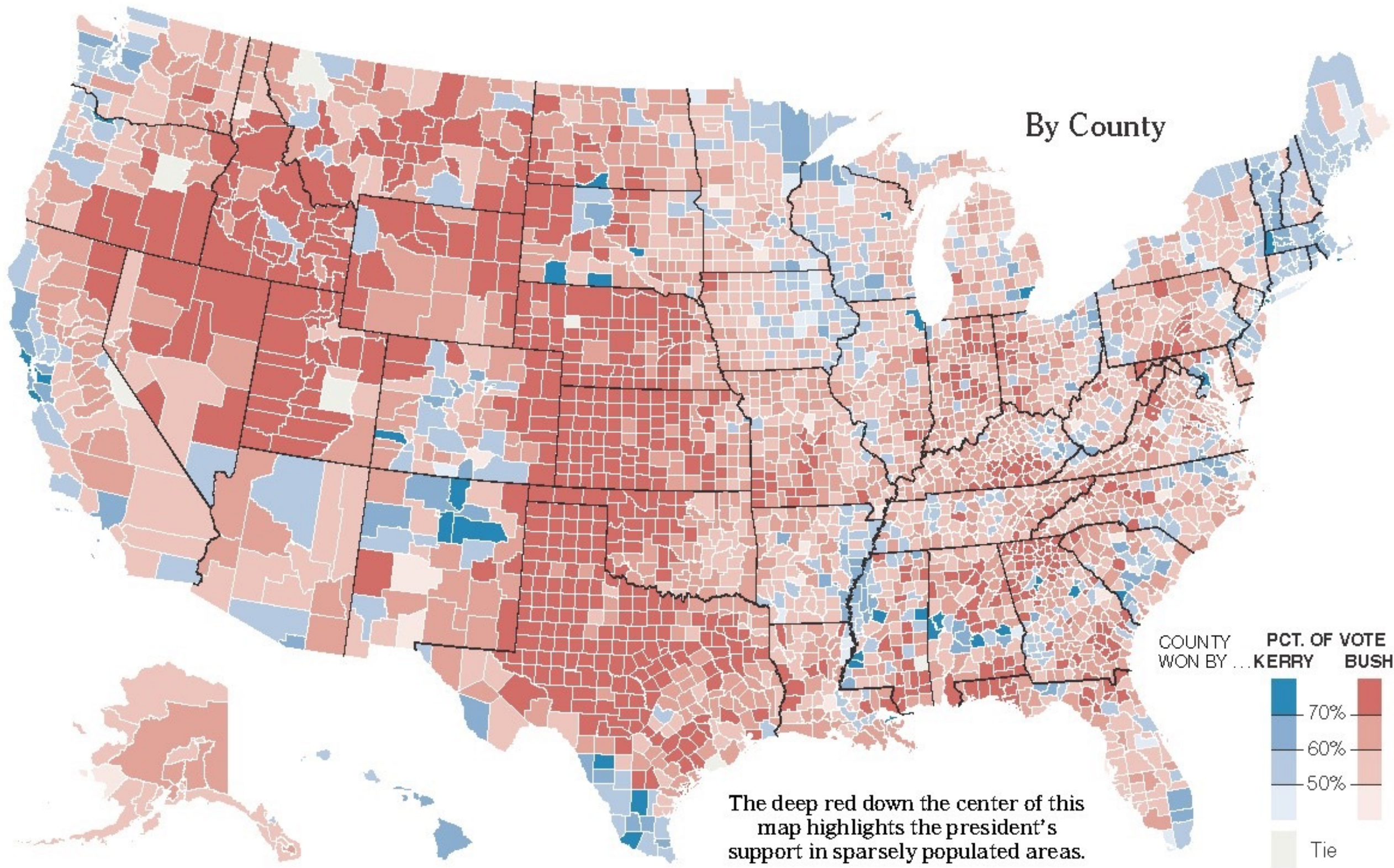


### 2004 Popular Vote

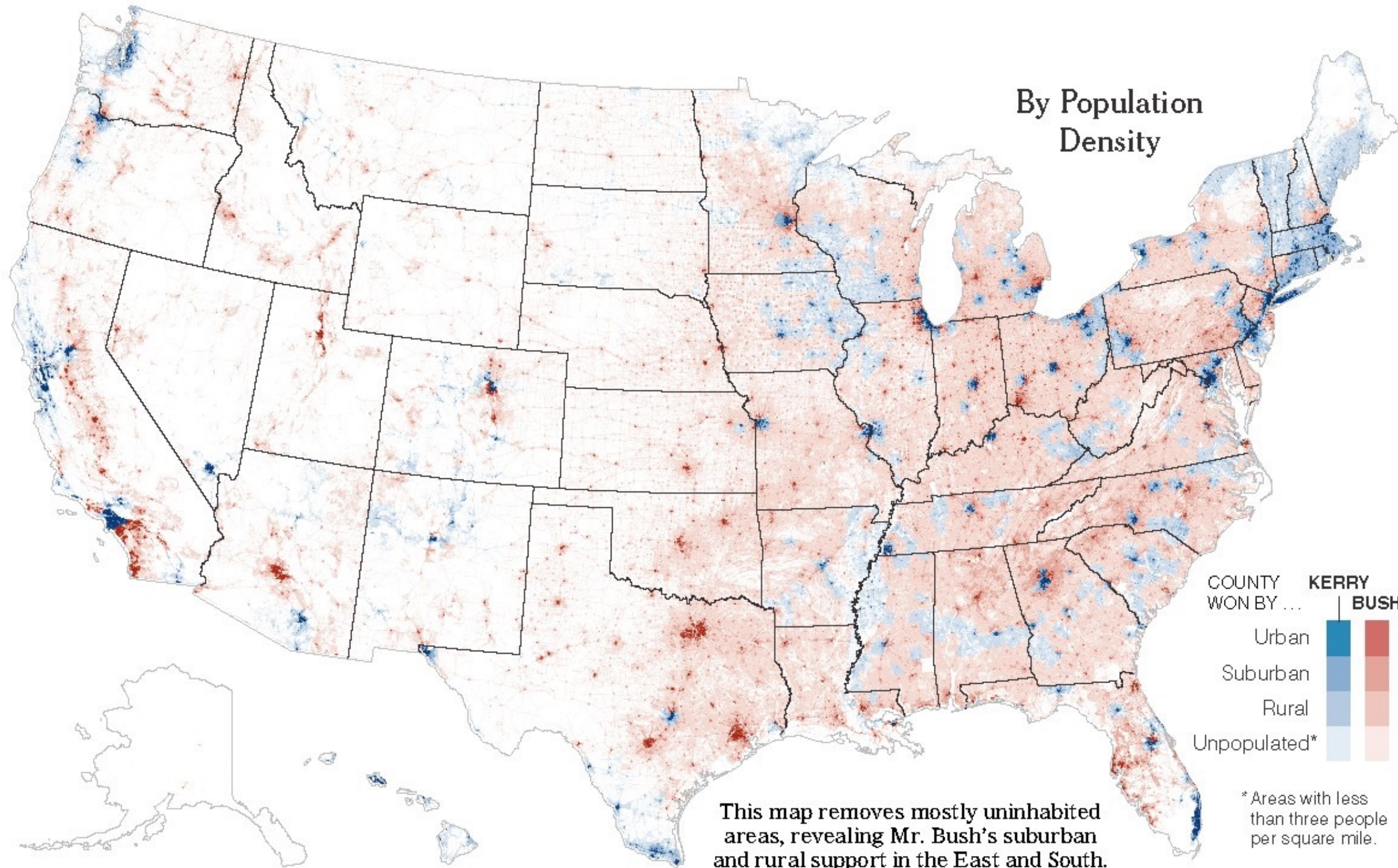


### Amount of red and blue shown on map









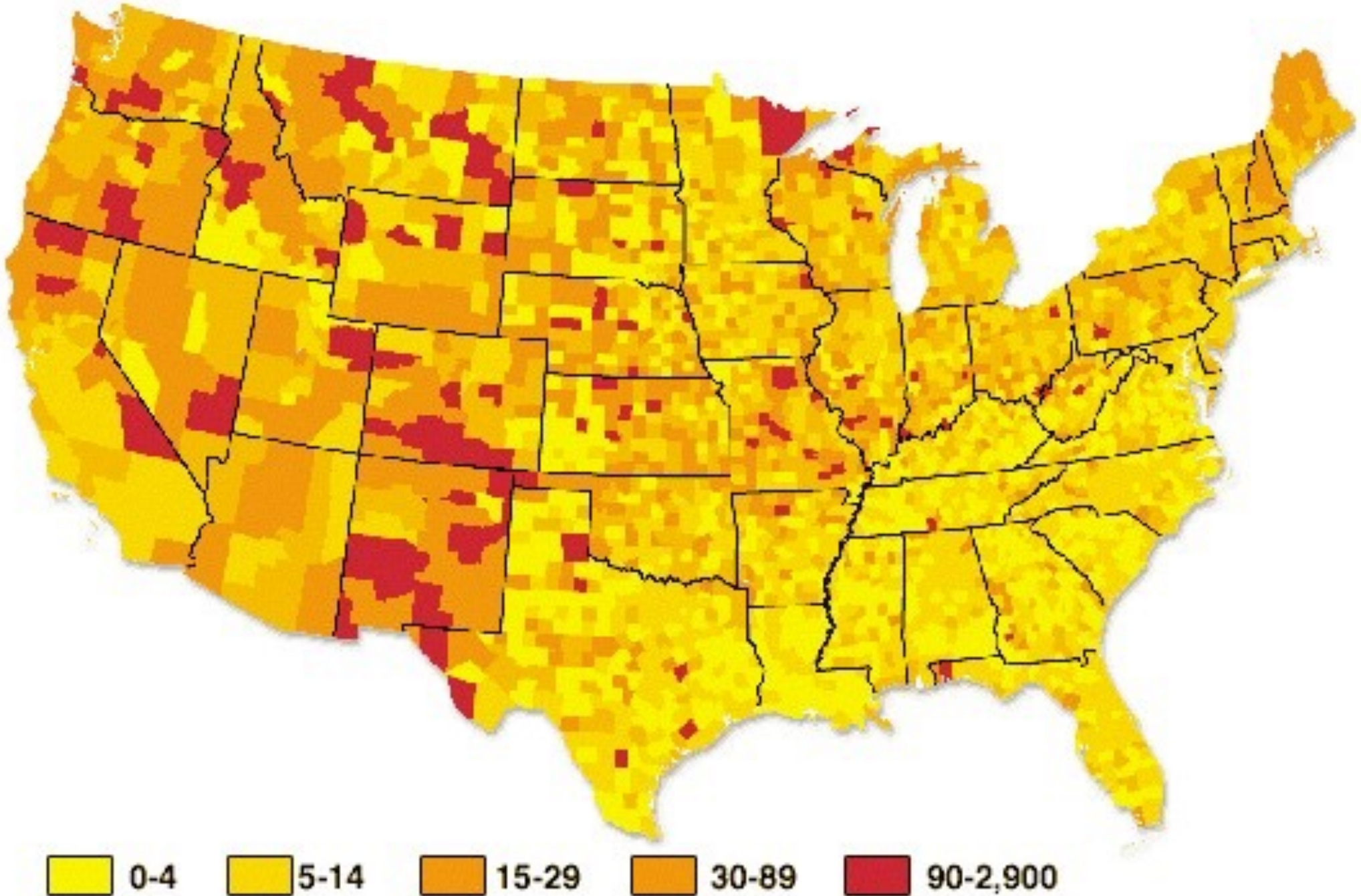
**By Population Density**

COUNTY WON BY ...	KERRY	BUSH
Urban	Dark Blue	Dark Red
Suburban	Medium Blue	Medium Red
Rural	Light Blue	Light Red
Unpopulated*	Very Light Blue	Very Light Red

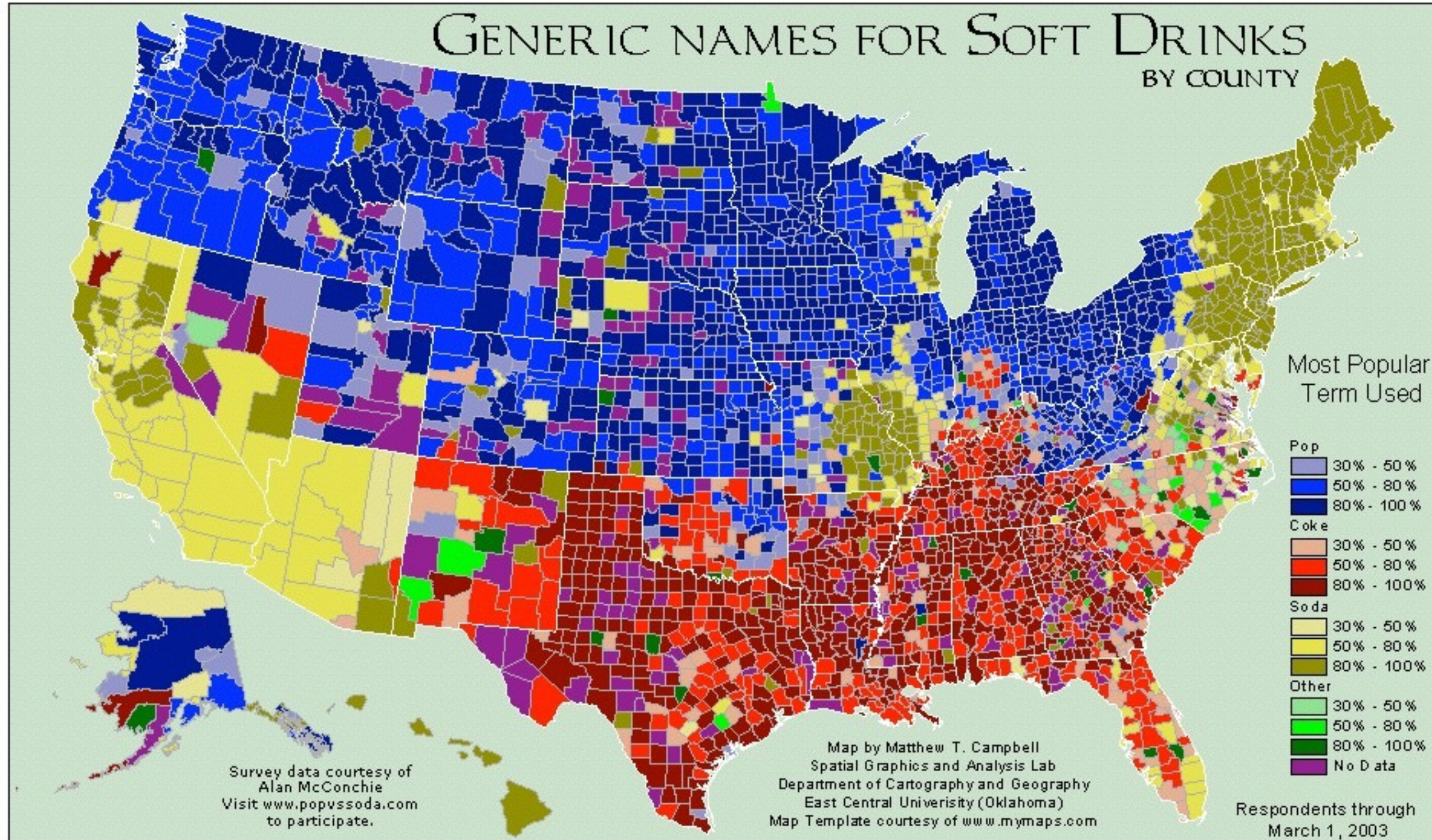
**This map removes mostly uninhabited areas, revealing Mr. Bush's suburban and rural support in the East and South.**

\* Areas with less than three people per square mile.

# UFO hotspots



# GENERIC NAMES FOR SOFT DRINKS BY COUNTY

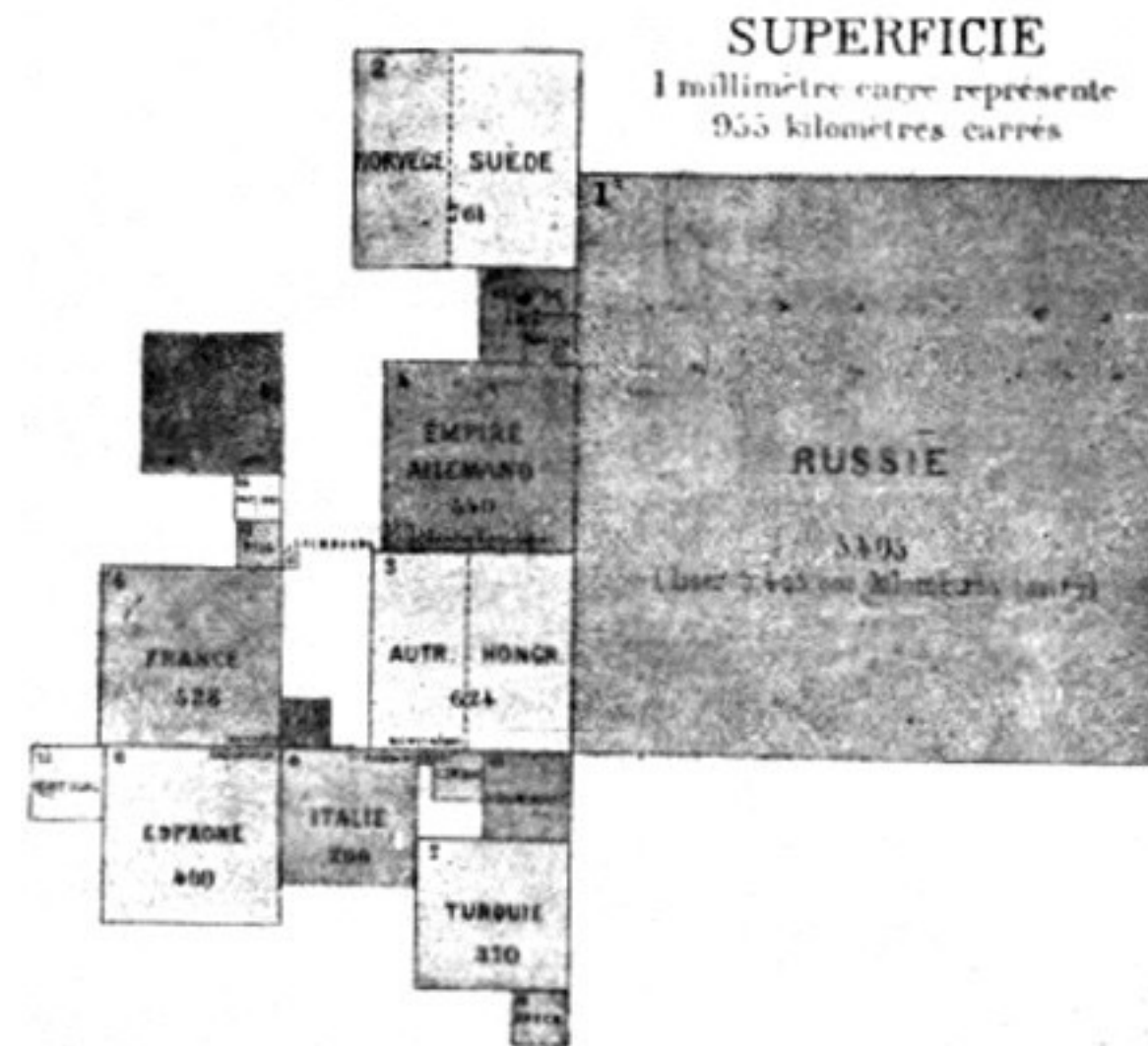


# cartogram

- map in which areas are scaled and distorted relative to a data attribute value

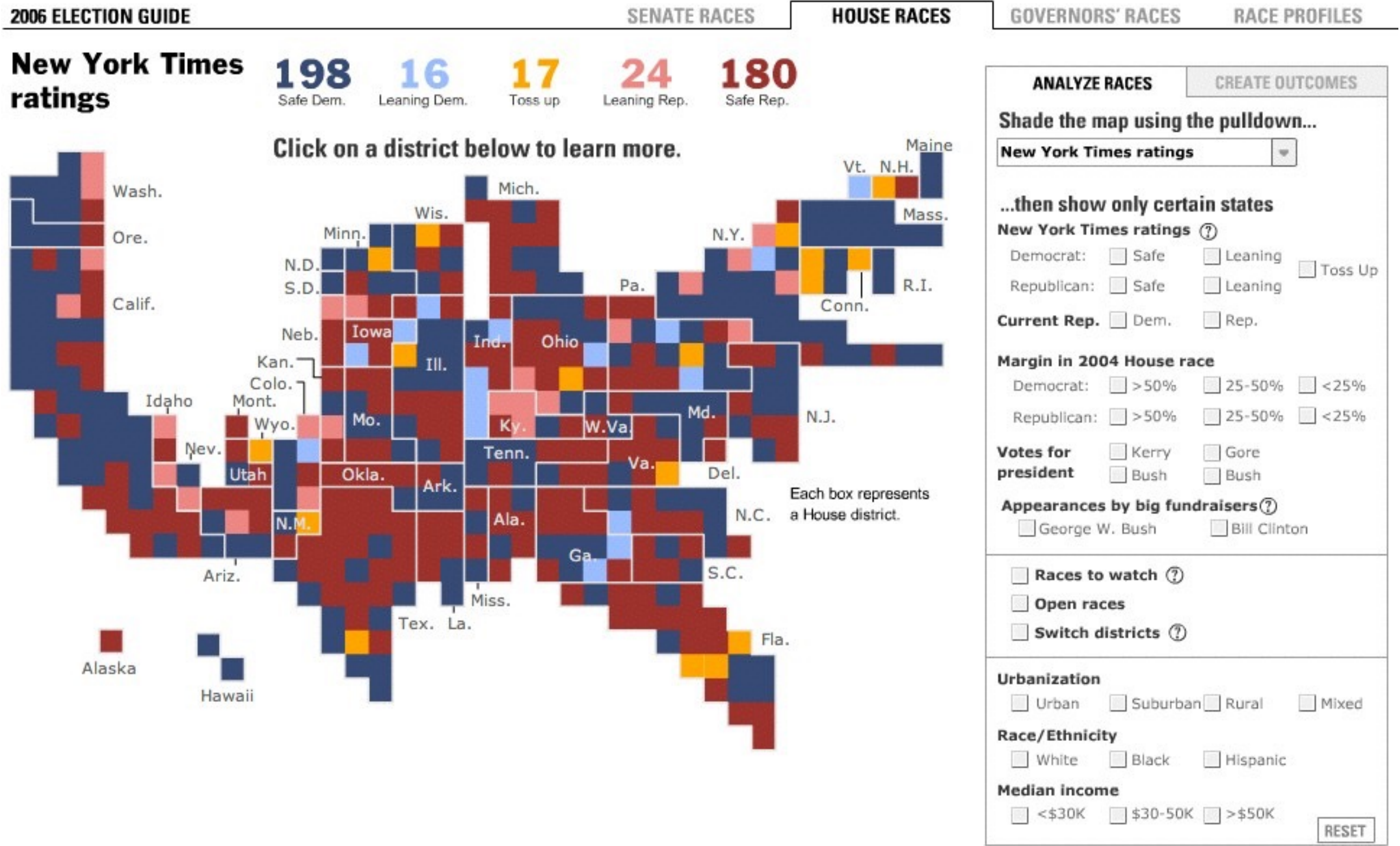
Land Area  
*first cartogram*

**STATISTIQUE FIGURATIVE**



Emile Levasseur, 1868

# rectangular cartogram



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2% SPARK BUSINESS SPARK BUSINESS DOUBLE MILES LEARN MORE >>

MORE INFO

September 4, 2008

E-MAIL | FEEDBACK

# What Your Global Neighbors Are Buying

How people spend their discretionary income – the cash that goes to clothing, electronics, recreation, household goods, alcohol – depends a lot on where they live. People in Greece spend almost 13 times more money on clothing as they do on electronics. People living in Japan spend more on recreation than they do on clothing, electronics and household goods combined. Americans spend a lot of money on everything.

[Related Article](#)

CLOTHING & FOOTWEAR ELECTRONICS ALCOHOL & TOBACCO HOUSEHOLD GOODS RECREATION

Boxes represent selected countries and are scaled according to total spending in 2007.



Roll over countries to see spending figures.



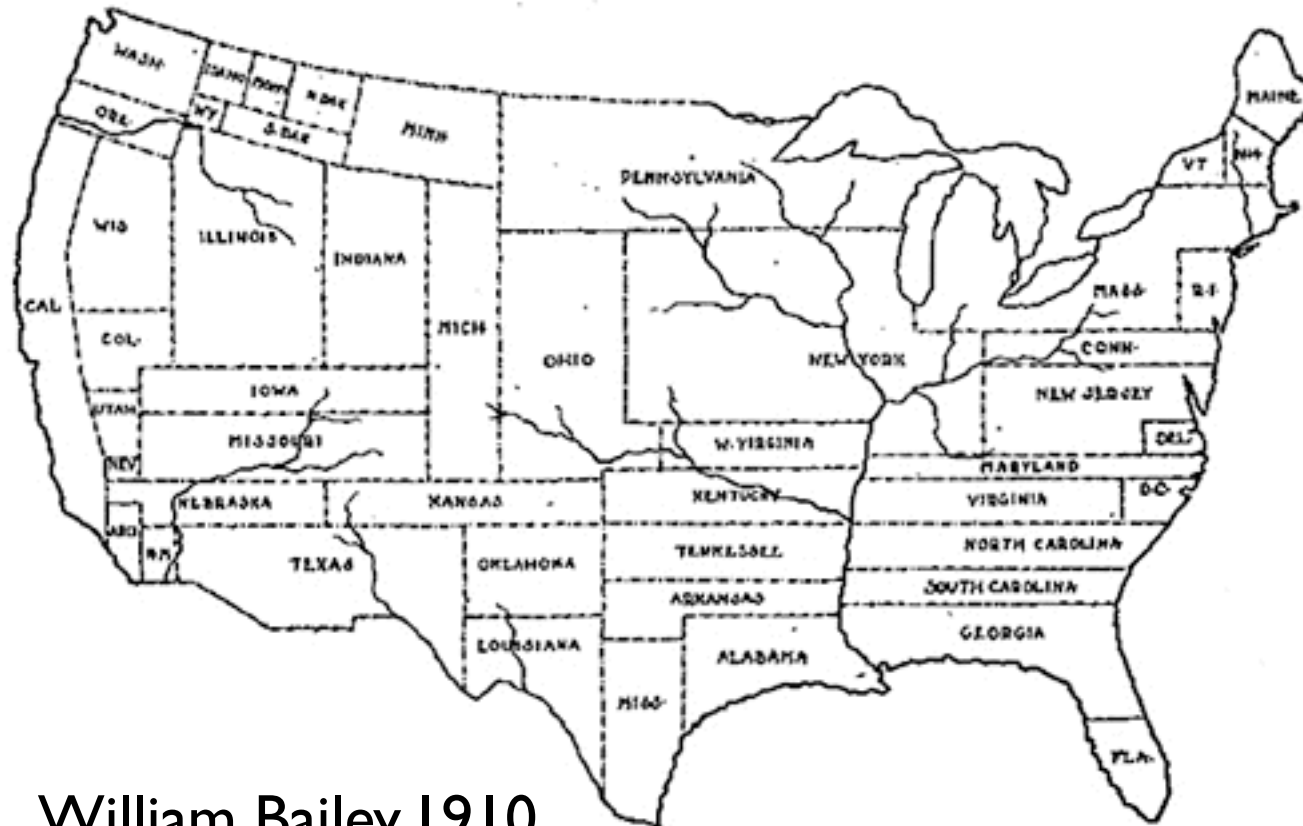
# Population

*first nonrectangular cartogram*

## Apportionment Map of the United States

BY WILLIAM B. BAILEY, Ph.D.

ASSISTANT PROFESSOR OF POLITICAL ECONOMY IN YALE UNIVERSITY.



William Bailey, 1910

## Population and Federal Taxes

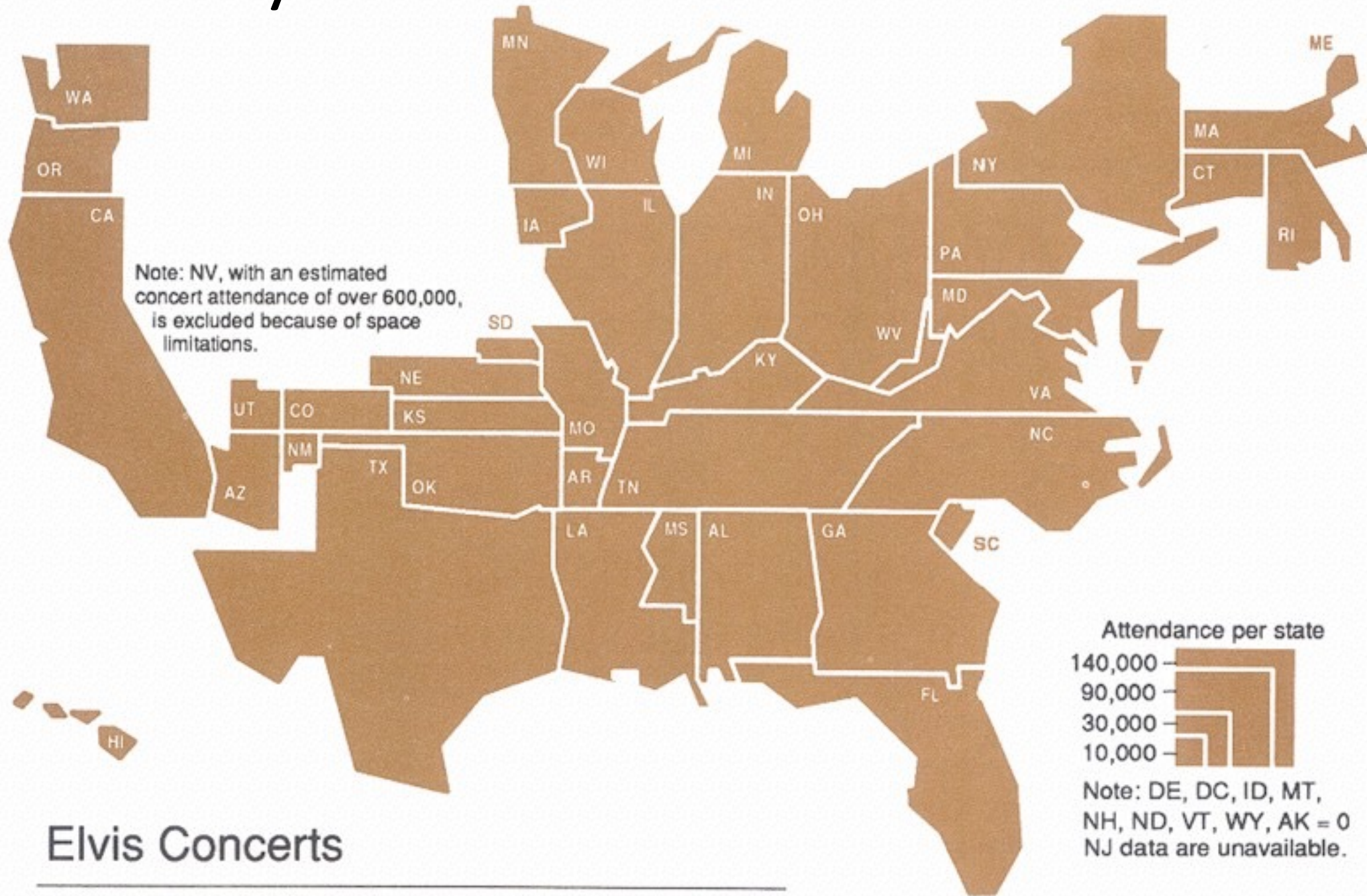
*first modern cartogram*

### GRUNDY'S MAP OF THE UNITED STATES



Joseph Grundy, 1929

# area scaled by data



Elvis Concerts  
Attendance per State, 1970 - 1977

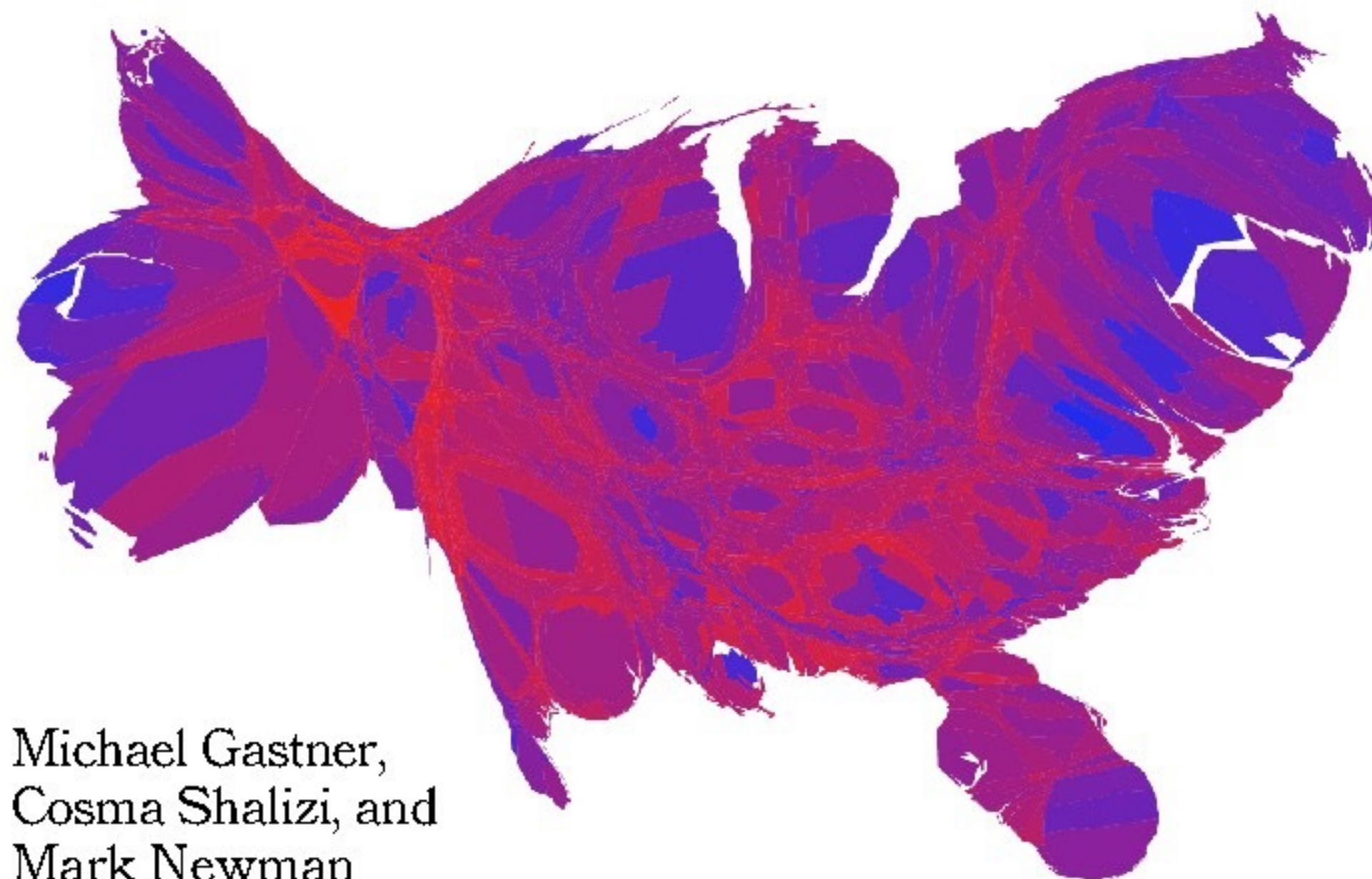
Source: Stanley, David E., with Frank Coffey. The Elvis Encyclopedia. Santa Monica, CA.: General Publishing Group, Inc , 1994.

© 1995 Andrew Dent and Linda Turnbull





# Kerry vs. Bush, 2004

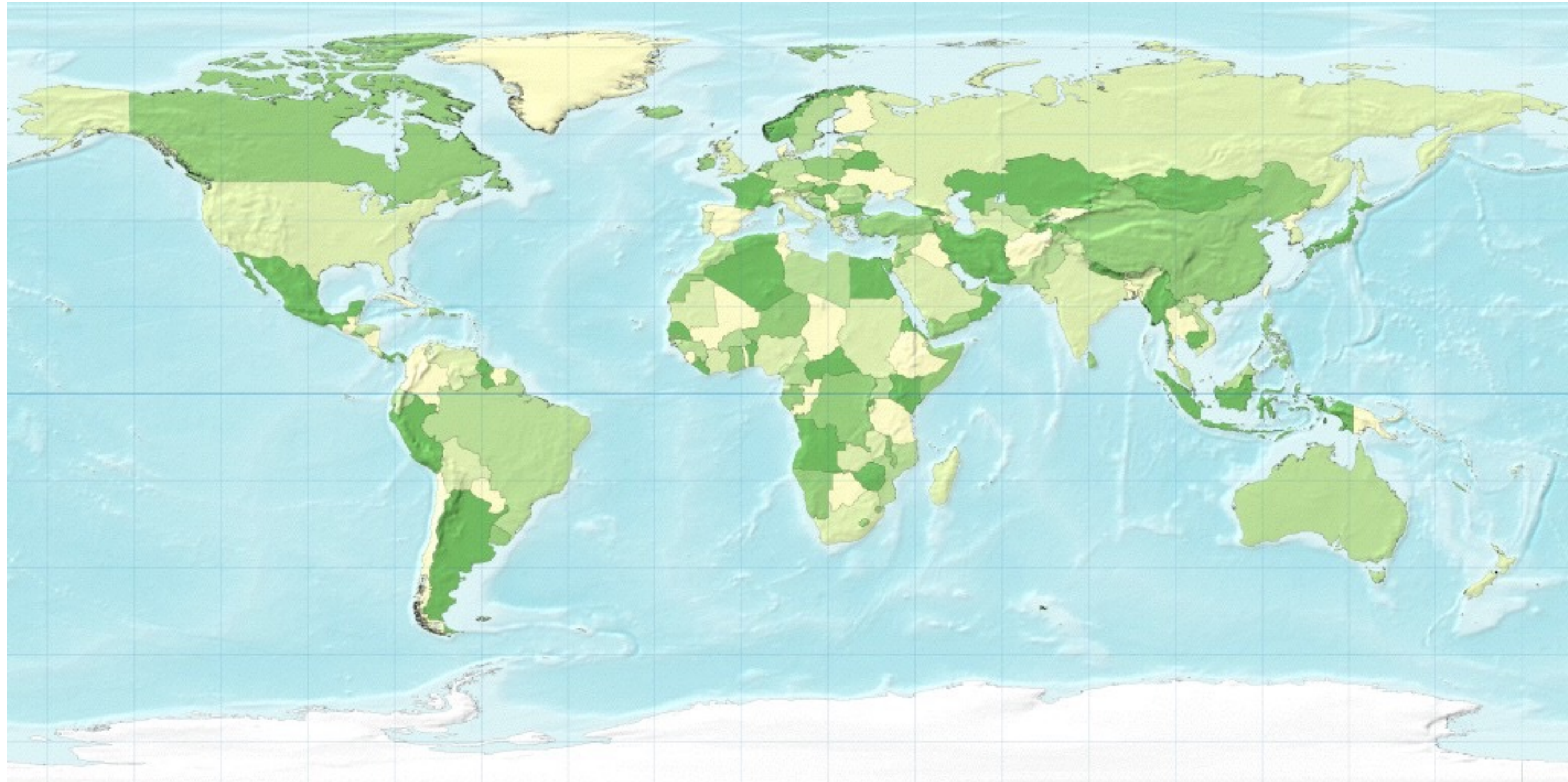


Michael Gastner,  
Cosma Shalizi, and  
Mark Newman

*University of Michigan*

**distortion via diffusion**

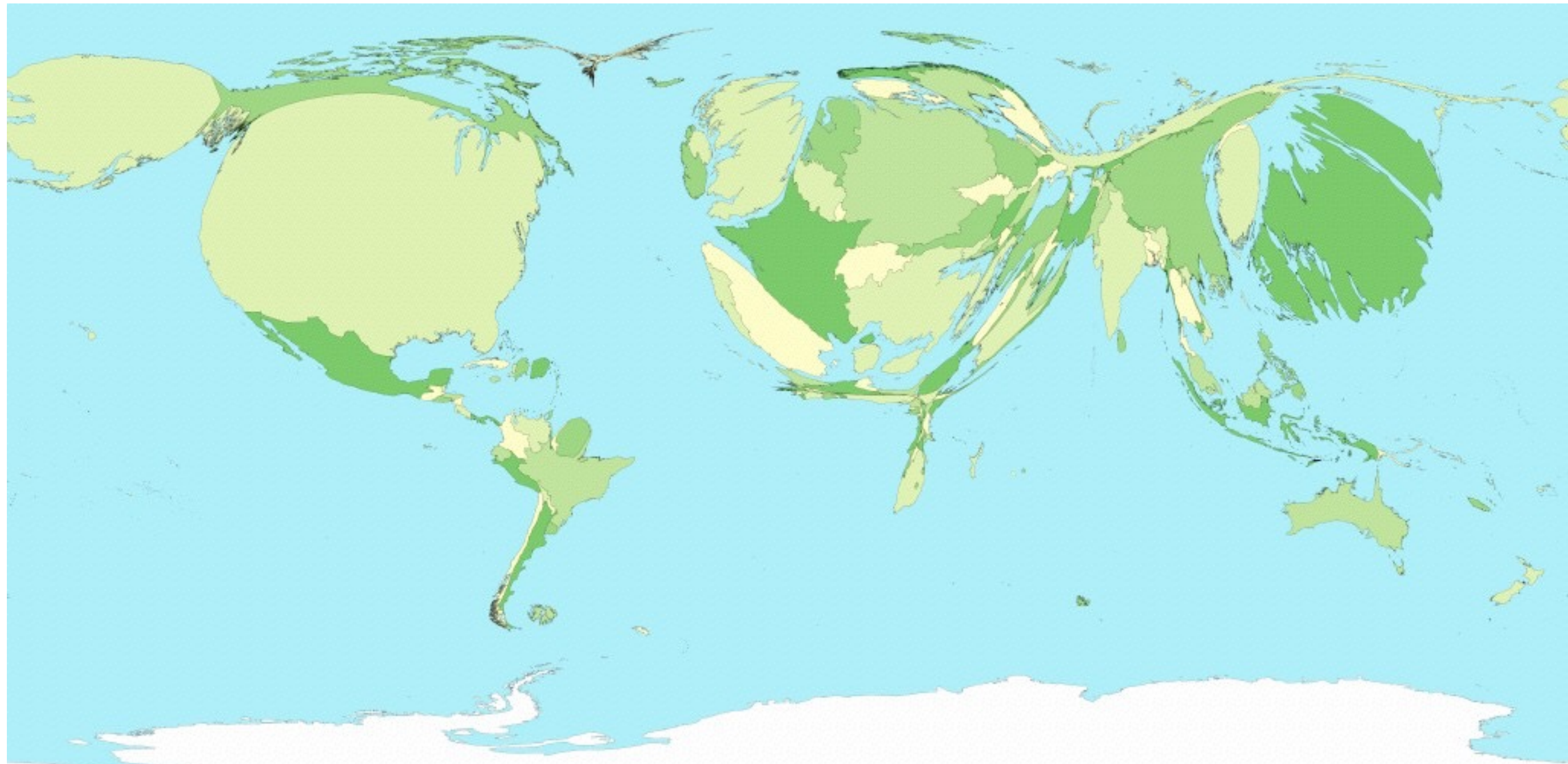
# the world



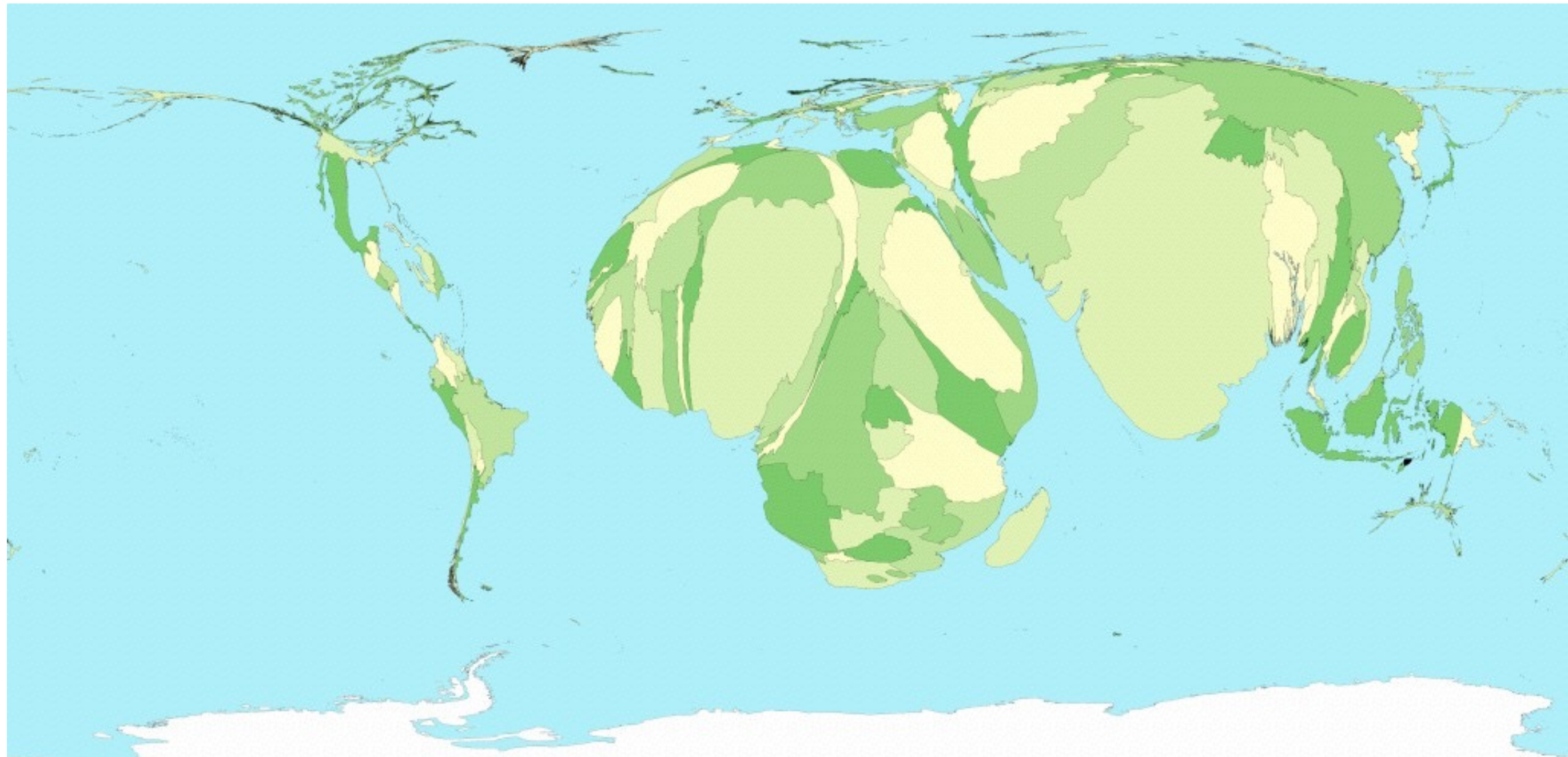
# population



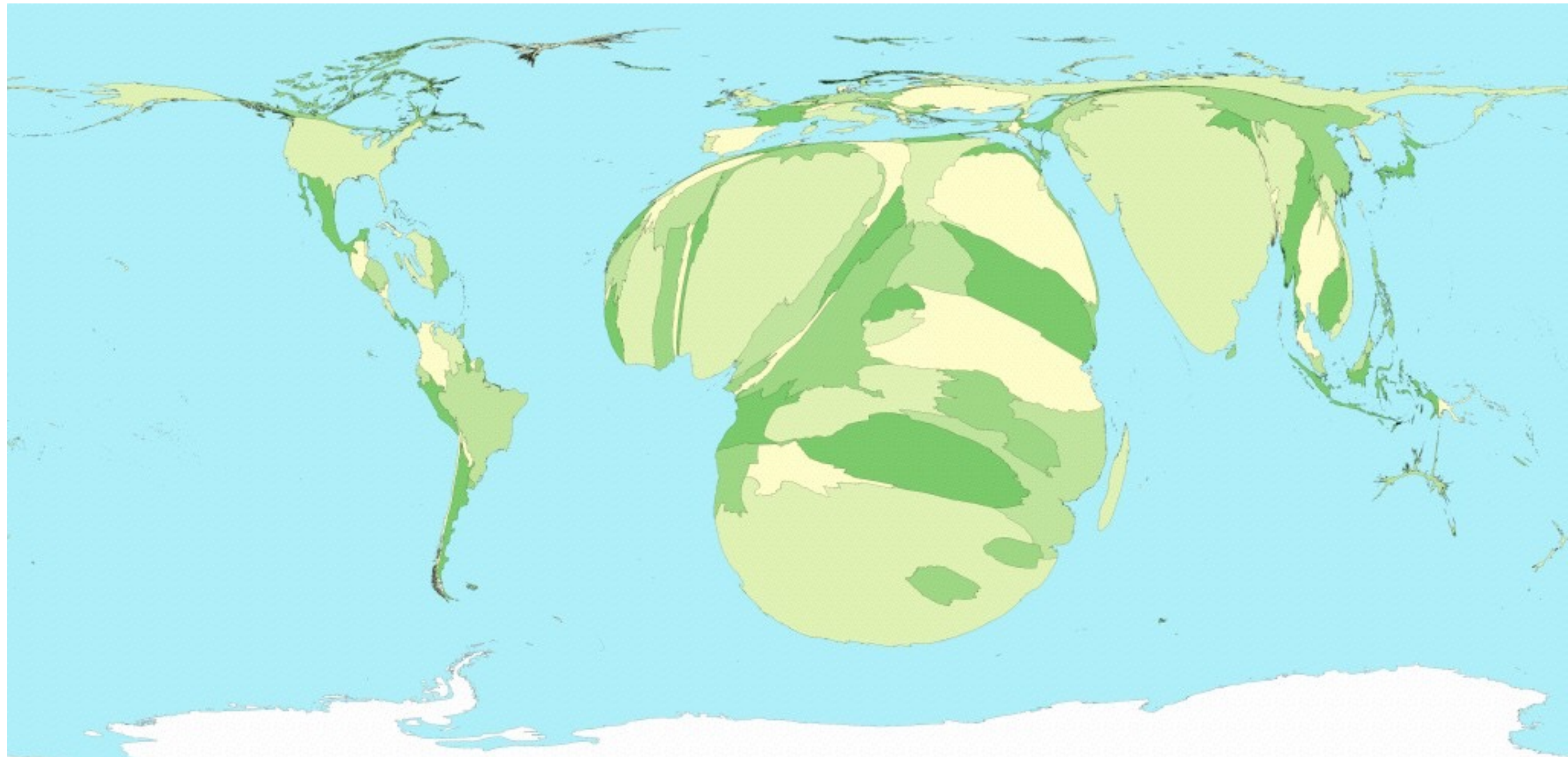
# GDP



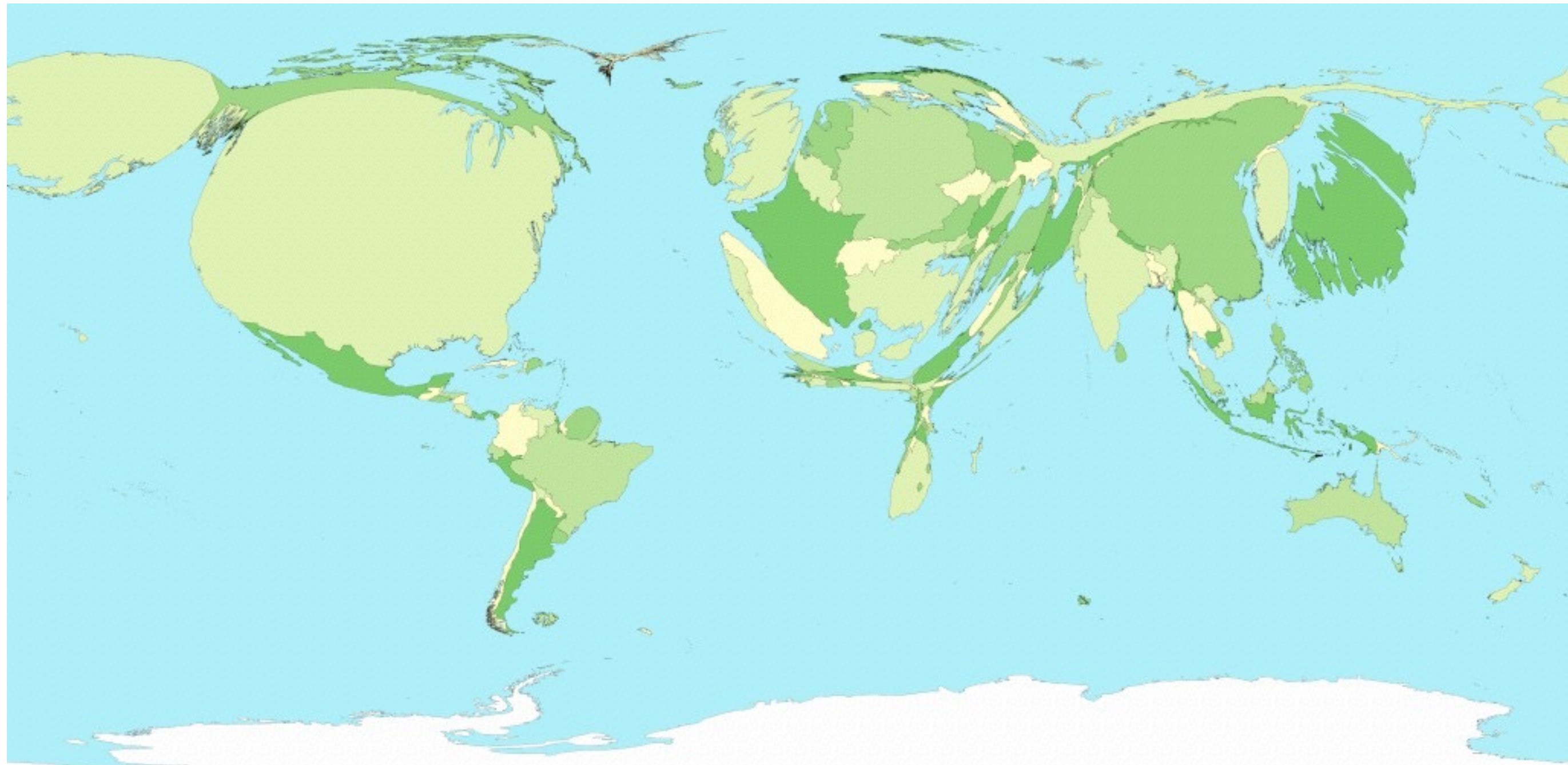
# child mortality



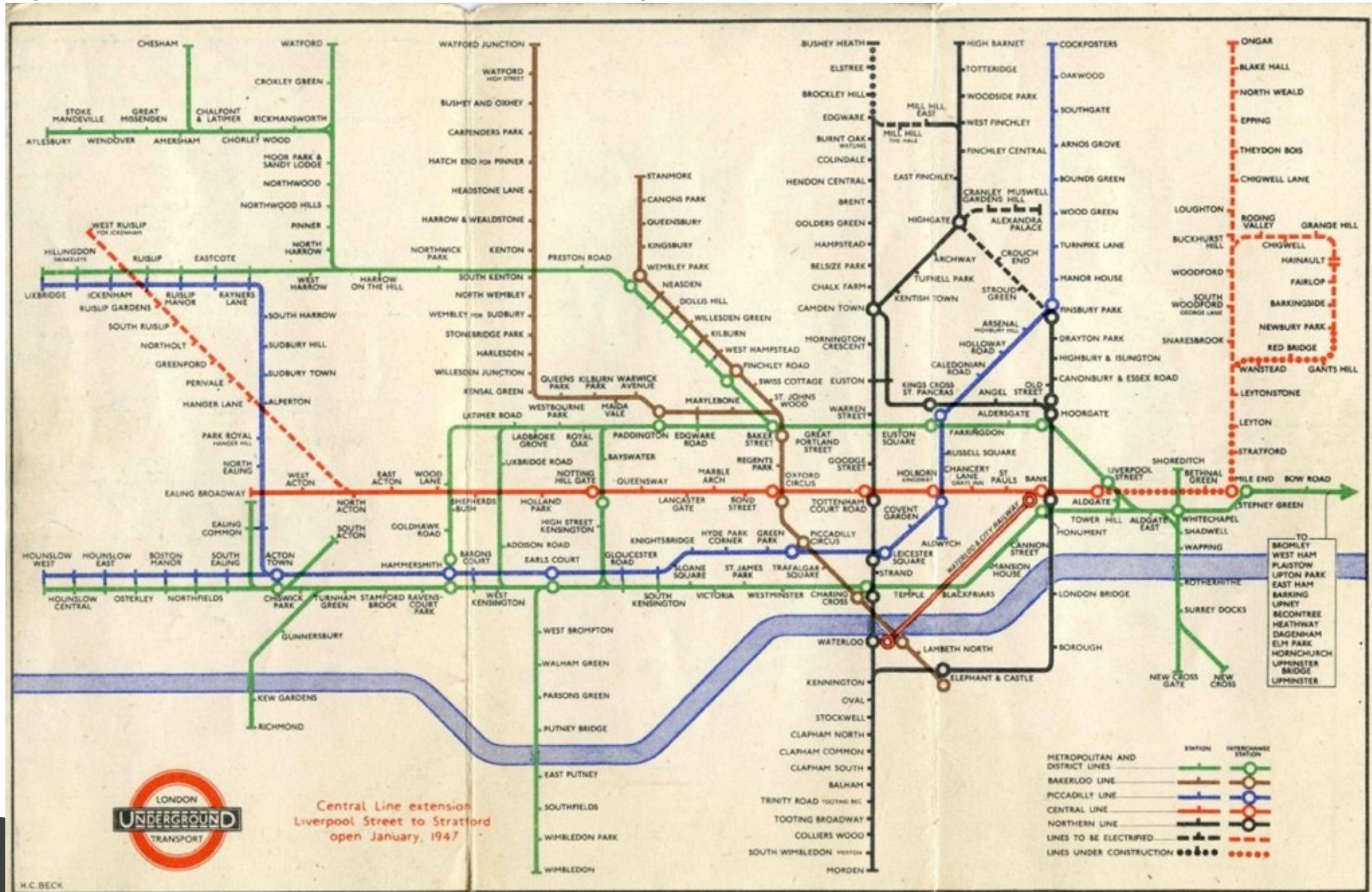
# people living with HIV/AIDS



# total spending on healthcare

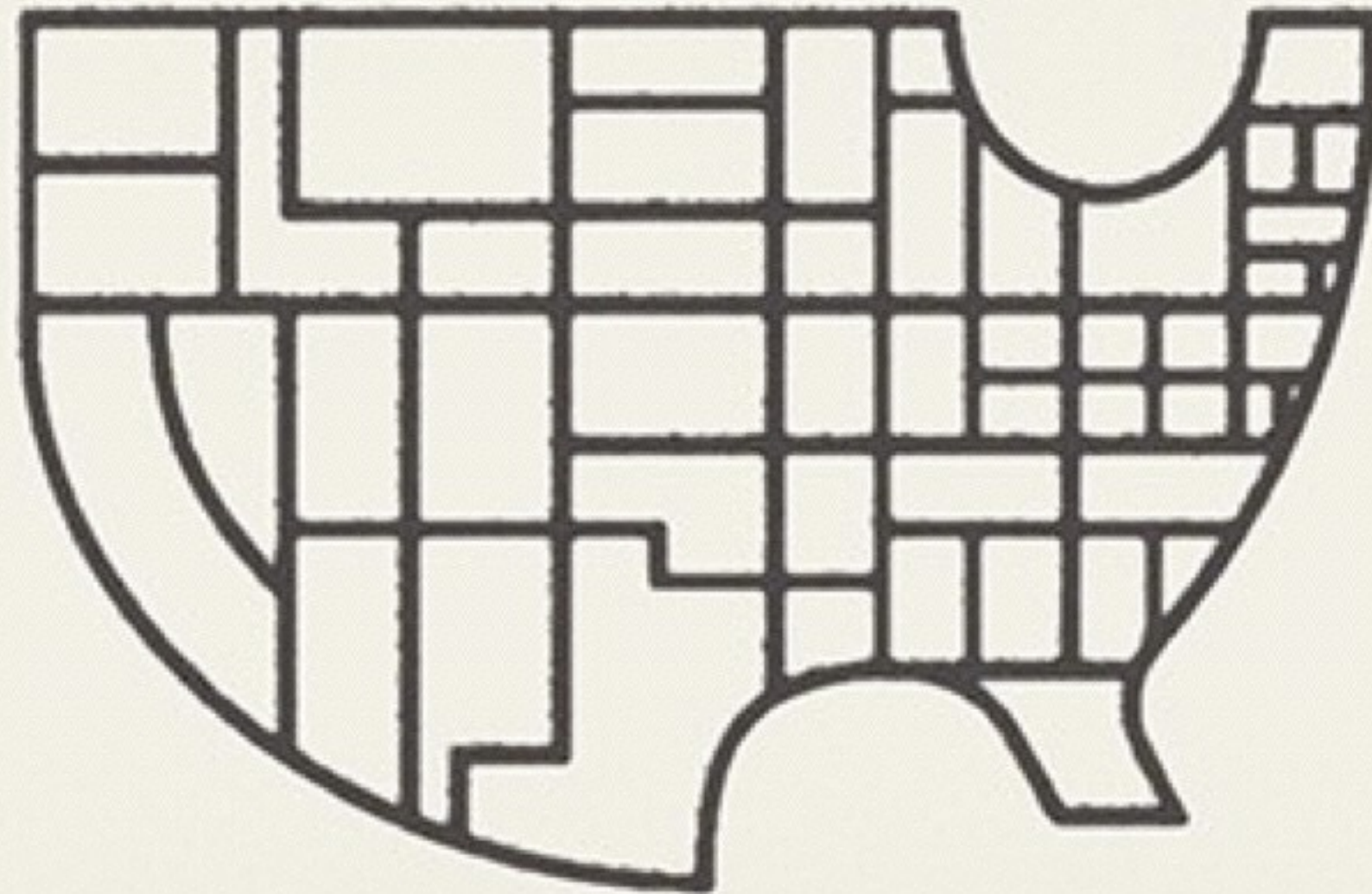


# Harry Beck's Tube Map



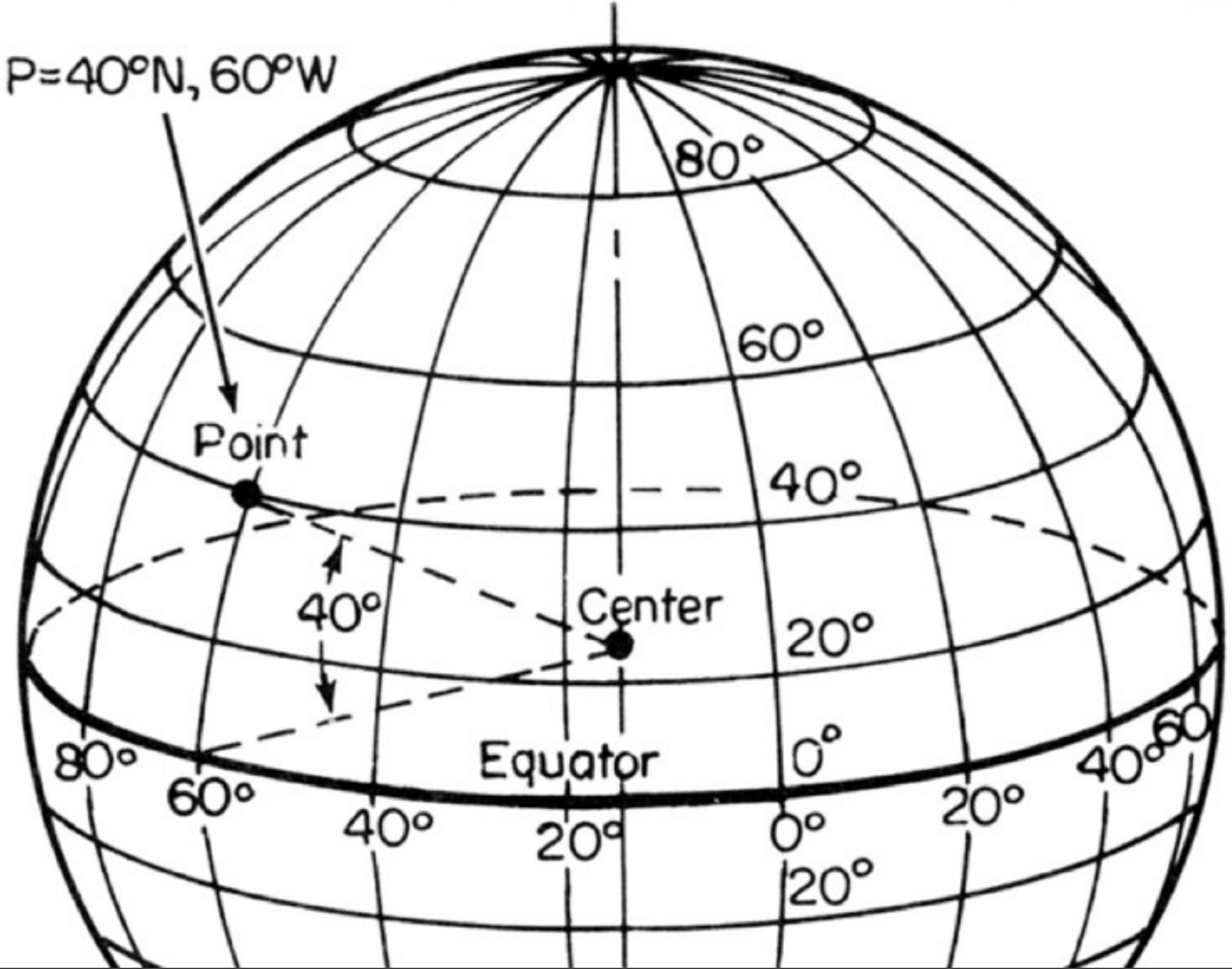


do they work?

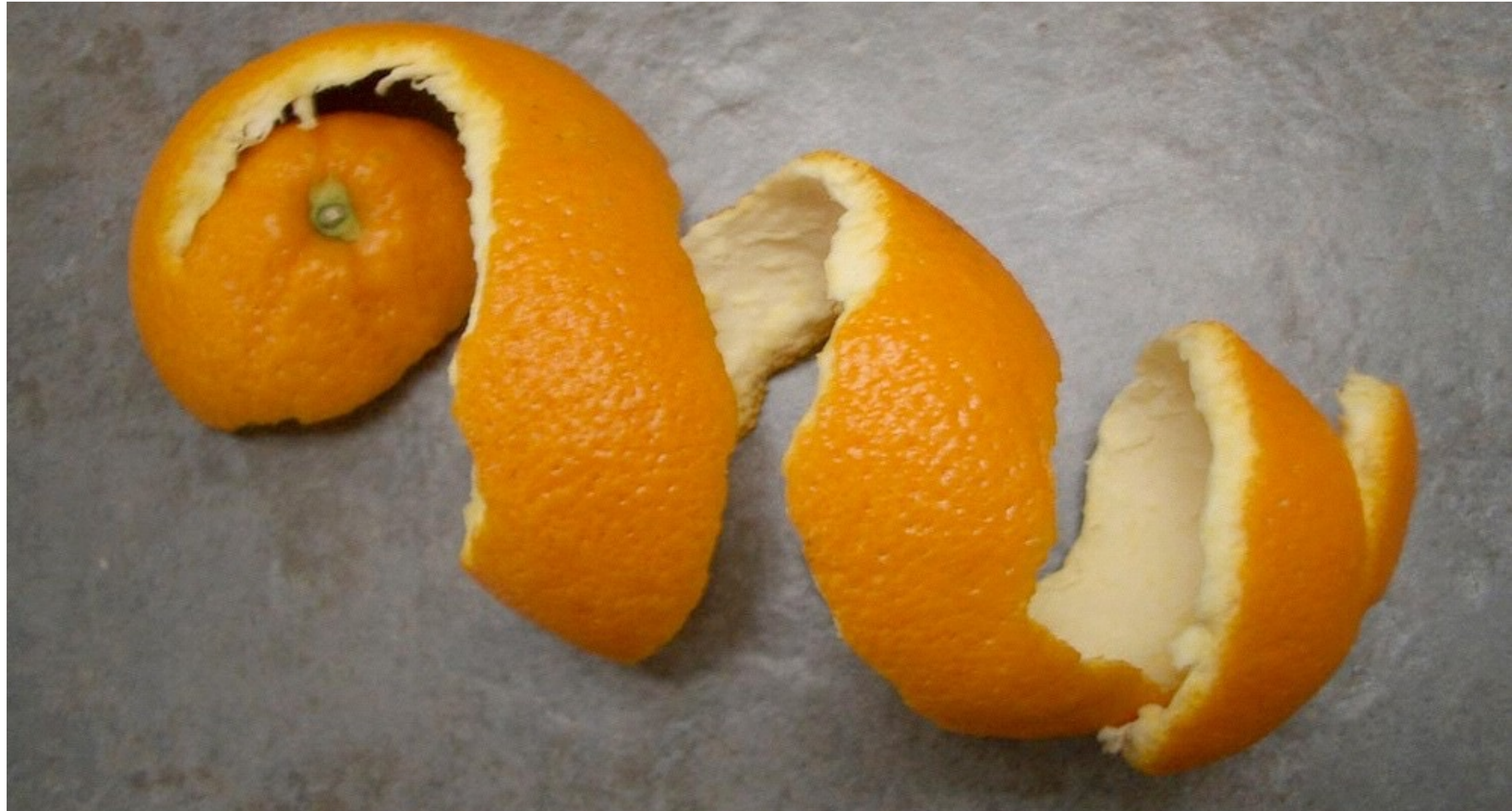


# Projections flattening the globe

# latitude, longitude

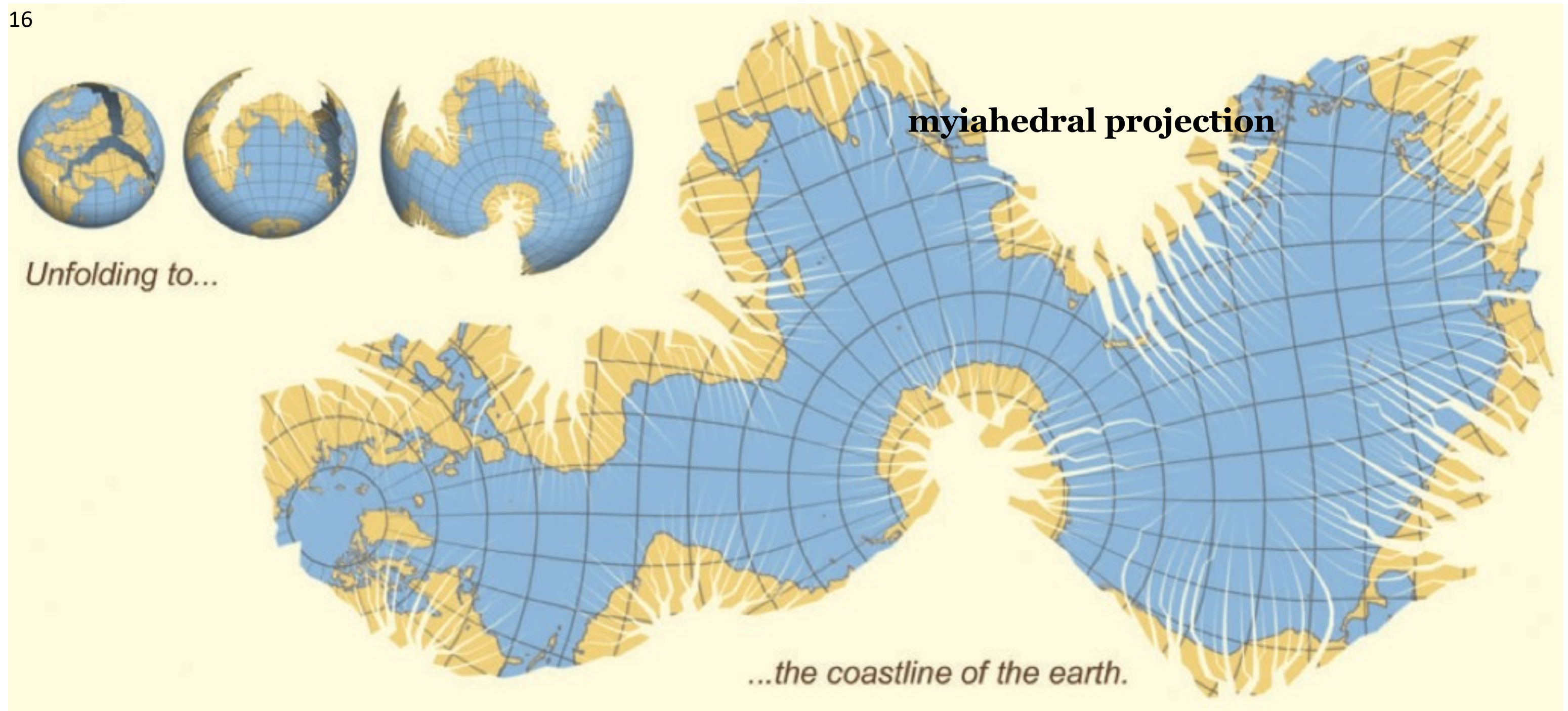


a sphere tears when you flatten it



# many ways to tear...

16



WHAT YOUR FAVORITE  
**MAP PROJECTION**  
SAYS ABOUT YOU

MERCATOR



YOU'RE NOT REALLY INTO MAPS.

ROBINSON



YOU HAVE A COMFORTABLE PAIR OF RUNNING SHOES THAT YOU WEAR EVERYWHERE. YOU LIKE COFFEE AND ENJOY THE BEATLES. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION, HANDS DOWN.

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!

DYMAXION



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

## WINKEL-TRIPPEL



NATIONAL GEOGRAPHIC ADOPTED THE WINKEL-TRIPPEL IN 1998, BUT YOU'VE BEEN A WT FAN SINCE LONG BEFORE "NAT GEO" SHOWED UP. YOU'RE WORRIED IT'S GETTING PLAYED OUT, AND ARE THINKING OF SWITCHING TO THE KAVRAYSKIY. YOU ONCE LEFT A PARTY IN DISGUST WHEN A GUEST SHOWED UP WEARING SHOES WITH TOES. YOUR FAVORITE MUSICAL GENRE IS "POST-".

## GOODE HOMOLOGINE



THEY SAY MAPPING THE EARTH ON A 2D SURFACE IS LIKE FLATTENING AN ORANGE PEEL, WHICH SEEMS EASY ENOUGH TO YOU. YOU LIKE EASY SOLUTIONS. YOU THINK WE WOULDN'T HAVE SO MANY PROBLEMS IF WE'D JUST ELECT *NORMAL* PEOPLE TO CONGRESS INSTEAD OF POLITICIANS. YOU THINK AIRLINES SHOULD JUST BUY FOOD FROM THE RESTAURANTS NEAR THE GATES AND SERVE *THAT* ON BOARD. YOU CHANGE YOUR CAR'S OIL, BUT SECRETLY WONDER IF YOU REALLY *NEED* TO.

## HOBO-DYER



YOU WANT TO AVOID CULTURAL IMPERIALISM, BUT YOU'VE HEARD BAD THINGS ABOUT GALL-PETERS. YOU'RE CONFLICT-AVERSE AND BUY ORGANIC. YOU USE A RECENTLY-INVENTED SET OF GENDER-NEUTRAL PRONOUNS AND THINK THAT WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

## PLATE CARRÉE (EQUIRECTANGULAR)



YOU THINK THIS ONE IS FINE. YOU LIKE HOW X AND Y MAP TO LATITUDE AND LONGITUDE. THE OTHER PROJECTIONS OVERCOMPLICATE THINGS. YOU WANT ME TO STOP ASKING ABOUT MAPS SO YOU CAN ENJOY DINNER.

## WATERMAN BUTTERFLY



## A GLOBE!

NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

### A GLOBE!



YES, YOU'RE VERY CLEVER.

### 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.

### WATERMAN BUTTERFLY



REALLY? YOU KNOW THE WATERMAN? HAVE YOU SEEN THE 1909 CAHILL MAP IT'S BASED— ... YOU HAVE A FRAMED REPRODUCTION AT HOME?! WHOA. ...LISTEN, FORGET THESE QUESTIONS. ARE YOU DOING ANYTHING TONIGHT?

### GALL-PETERS



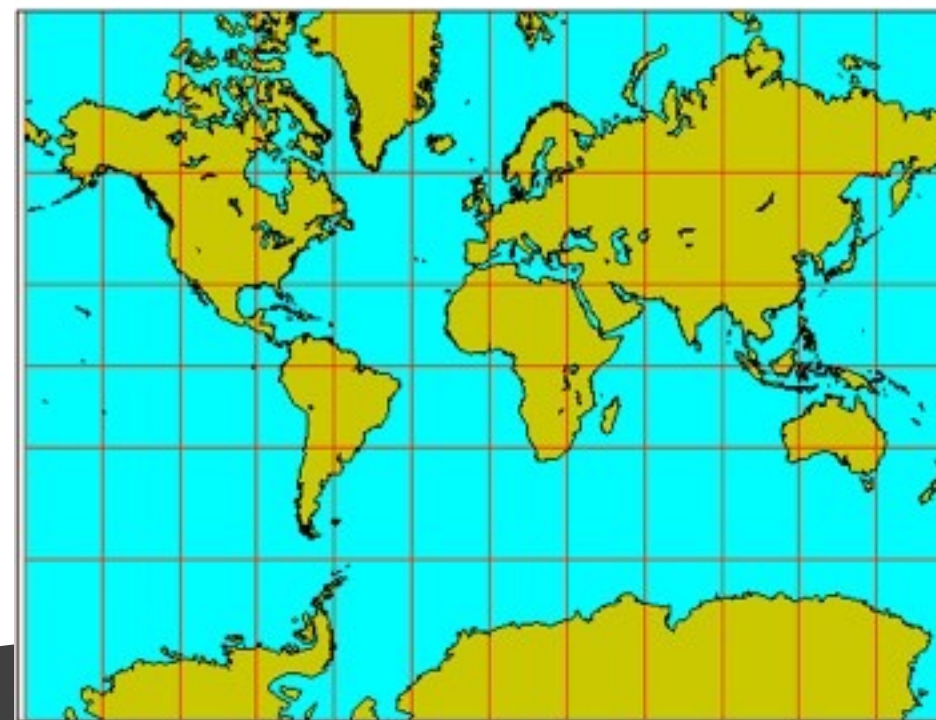
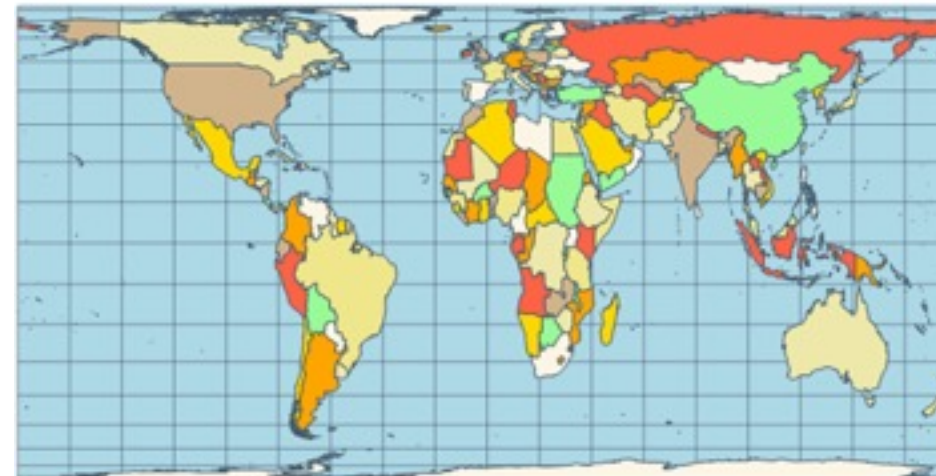
I HATE YOU.



# CLASSES OF PROJECTION

What map features would you like to maintain?

- azimuthal
  - preserves direction
- equal-area
  - preserves area
- conformal
  - preserves local shapes

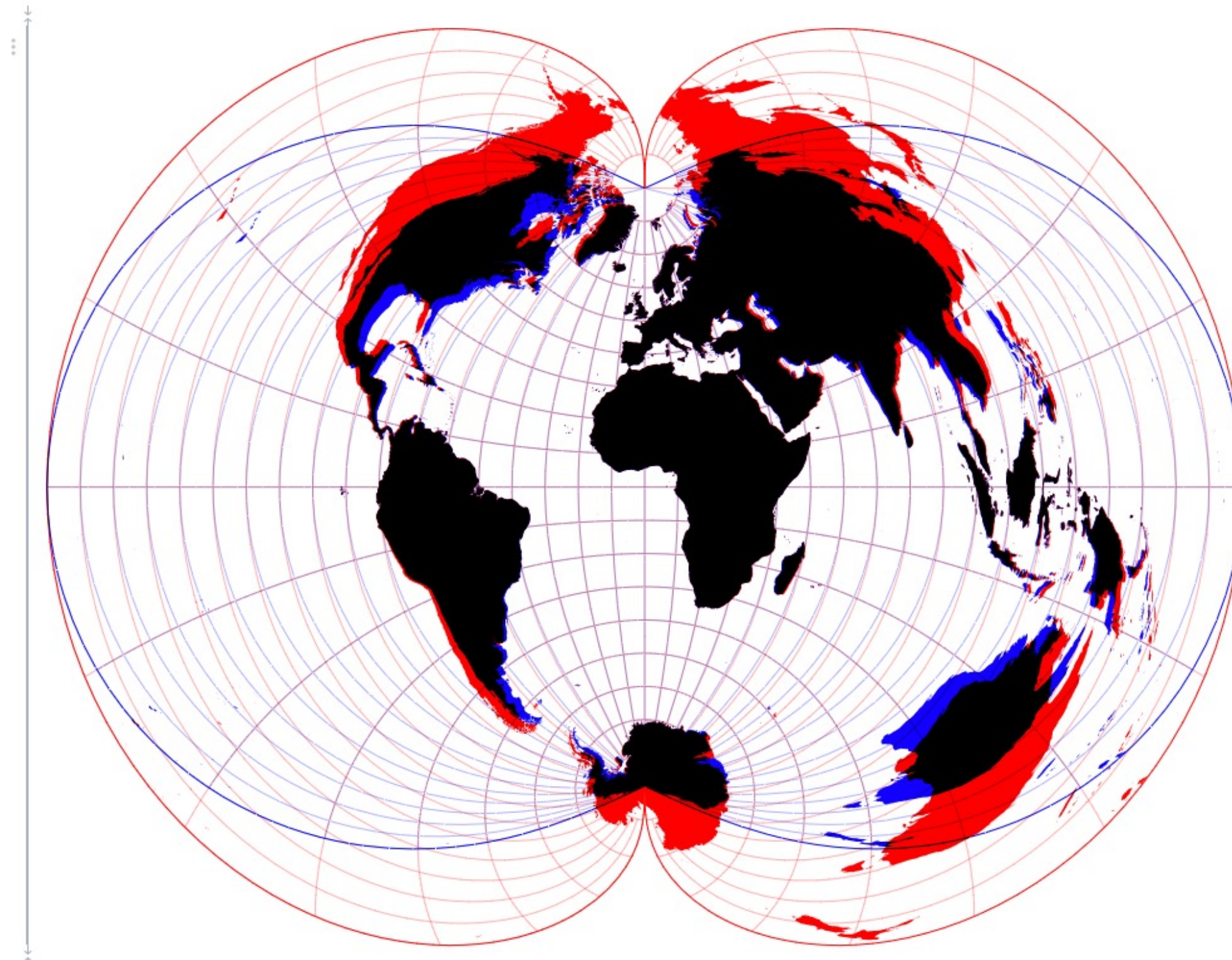


# Projection Comparison

Choose two projections below to compare.

American polyconic  red

rectangular polyconic  blue



# Mercator

- Circle of 5000km radius is centered around Paris

