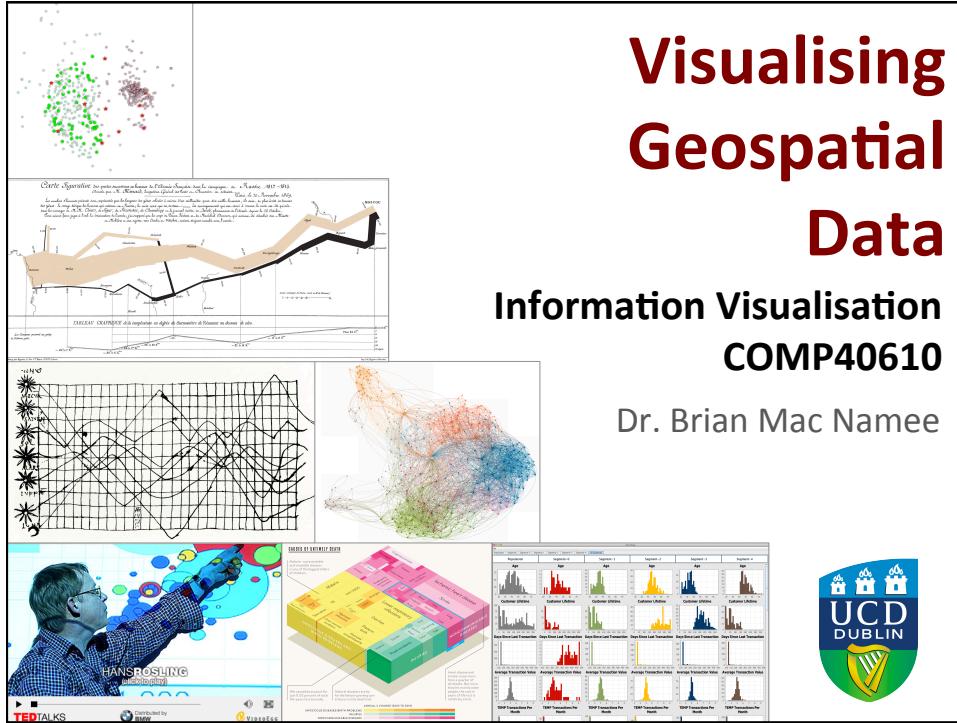


Visualising Geospatial Data

Information Visualisation
COMP40610

Dr. Brian Mac Namee



Origins

This course curates material from multiple online and published sources

When this is the case full citations will be given

Agenda

In this lecture we will cover:

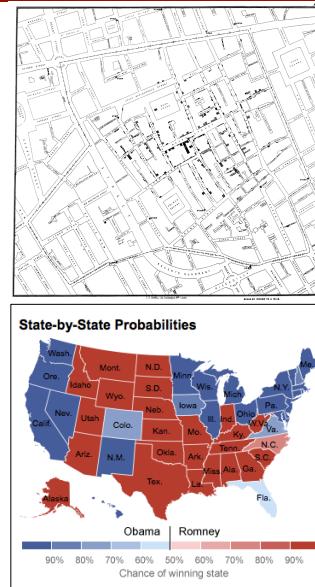
- Introduction
- Map projections
- Visual encodings for spatial dimensions
- Geospatial visualisation types
- Visualising change in geospatial data

INTRODUCTION

Introduction

Maps are a sub-category of data visualization

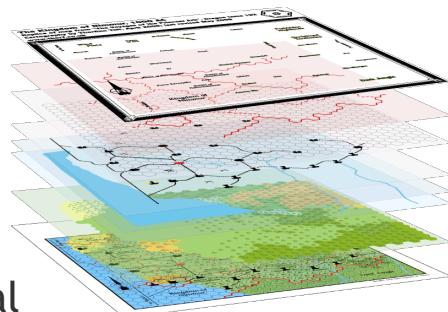
- Maps can be a great, intuitive way to understand your data
- Maps are essentially scaled down, accurate versions of the physical world
- Cartography is a large subject in its own right

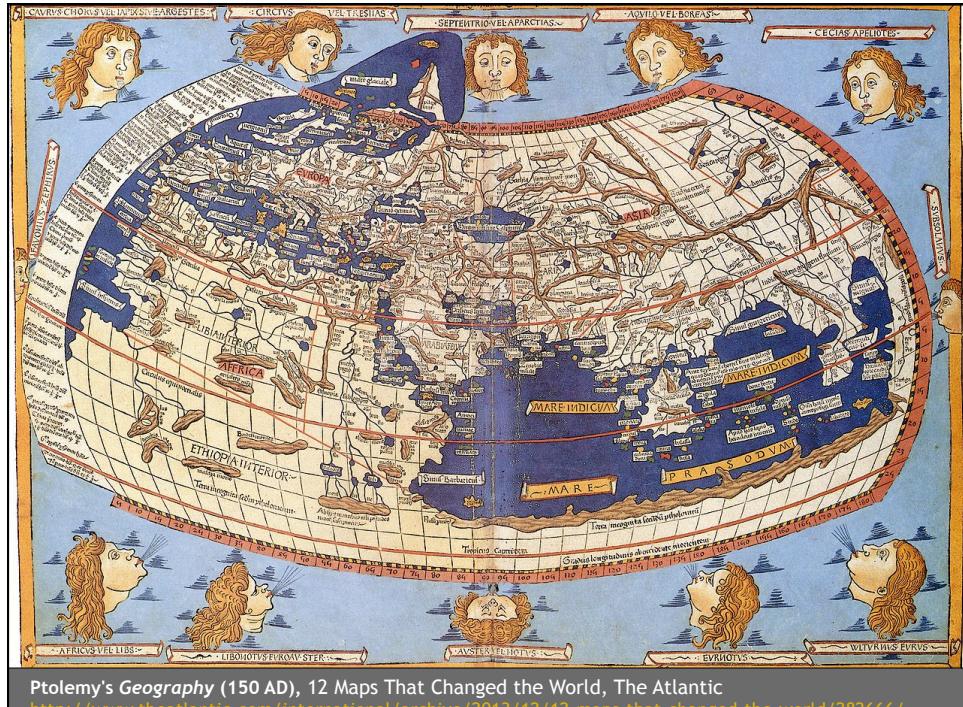


Mapping, It's Like An Onion

When you create your maps, it's useful to think of them as layers

The bottom layer is usually the base map that shows geographical boundaries, and then you place data layers on top of that.

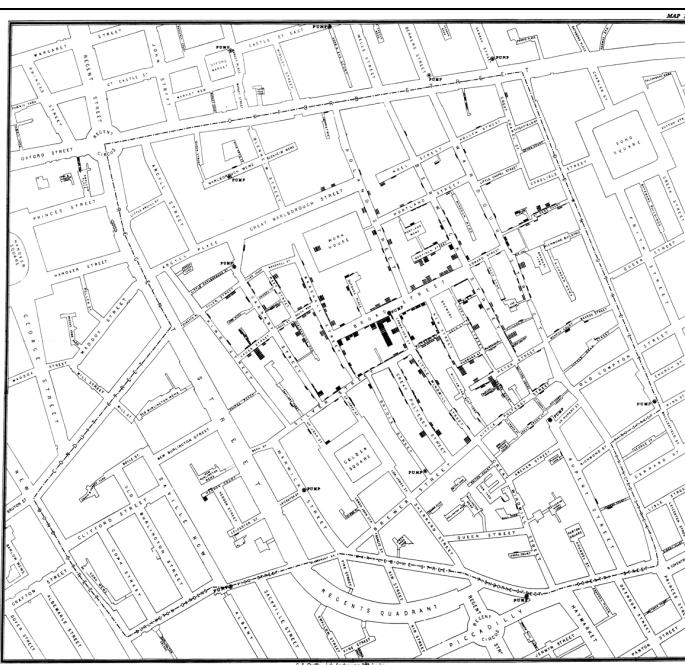






Mercator's World Map (1569), 12 Maps That Changed the World, The Atlantic

<http://www.theatlantic.com/international/archive/2013/12/12-maps-that-changed-the-world/282666/>



Adapted from "The Visual Display of Quantitative Information", Graphics Press USA, 2001

www.edwardtufte.com/tufte/books_visex

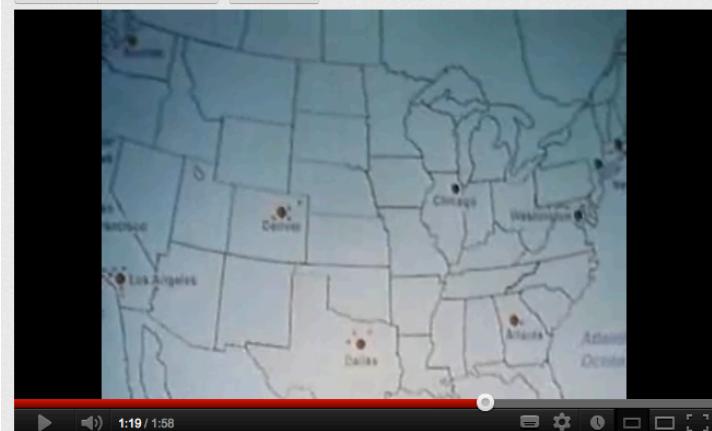
Outbreak!

Outbreak Movie Trailer (1995)

vision3001

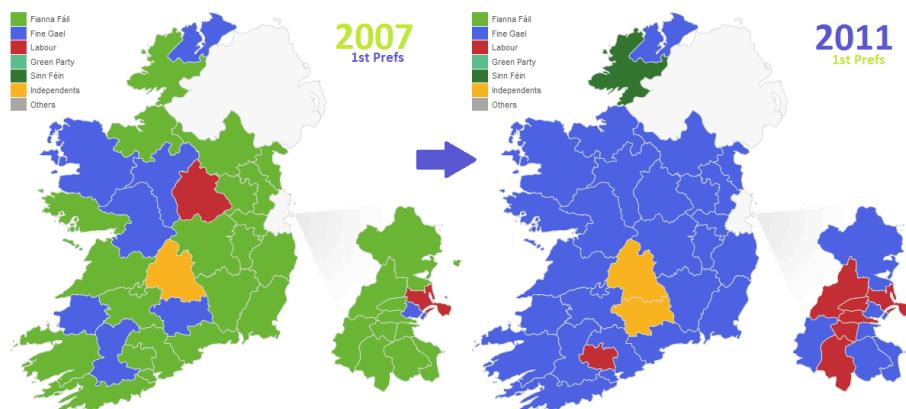
Subscribe

8 videos



Outbreak Movie Trailer (Time index 1:19) <https://www.youtube.com/watch?v=Mj9SUJdpJS4>

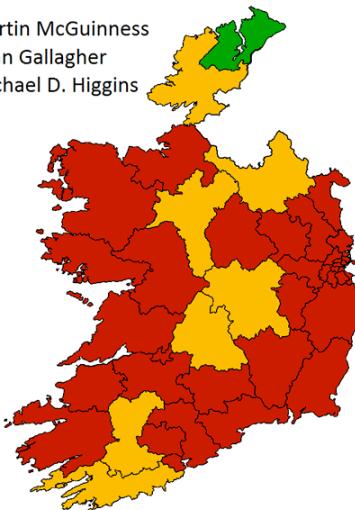
Irish Elections



<http://www.ronanlyons.com/2011/03/01/home-thoughts-to-abroad-three-things-the-irish-election-has-made-clear/>

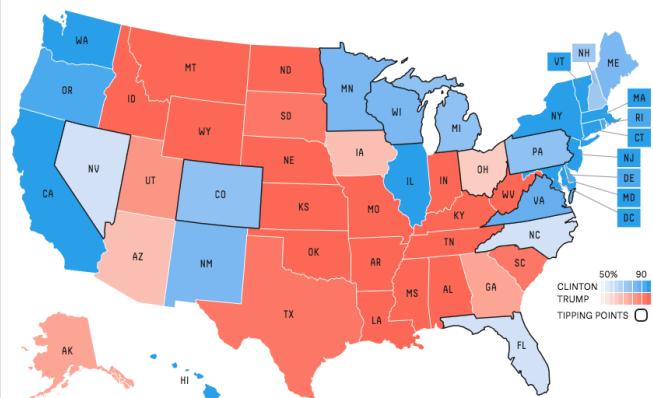
Irish Elections

■ Martin McGuinness
■ Seán Gallagher
■ Michael D. Higgins



http://www.faiocracy.com/newsblog/full_results_of_the_2011_irish_presidential_election.html

Chance of winning



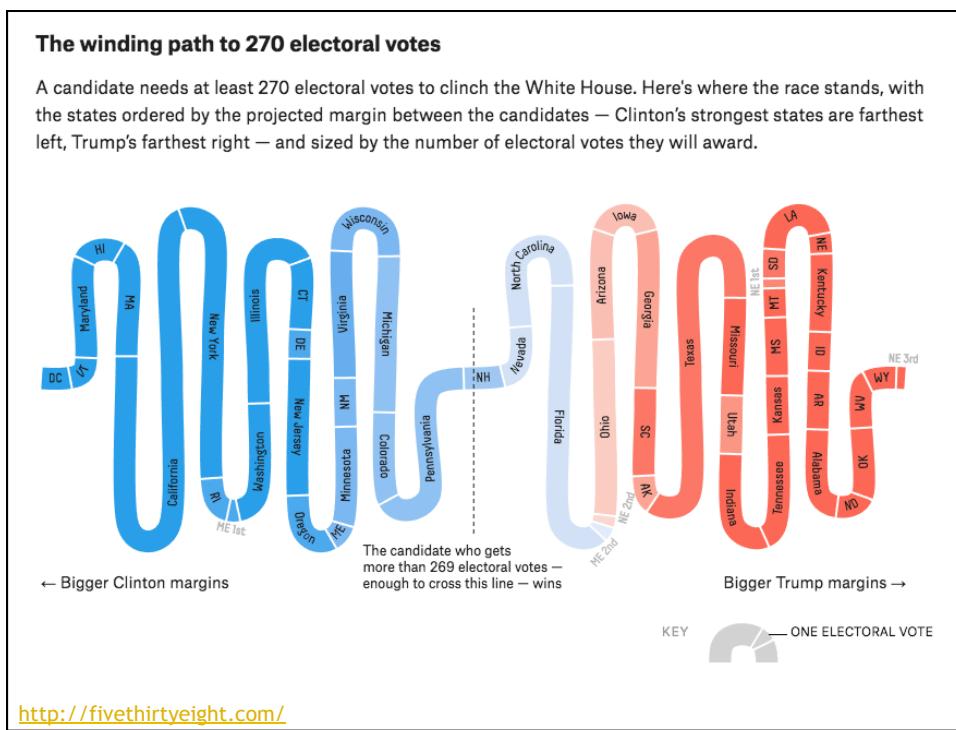
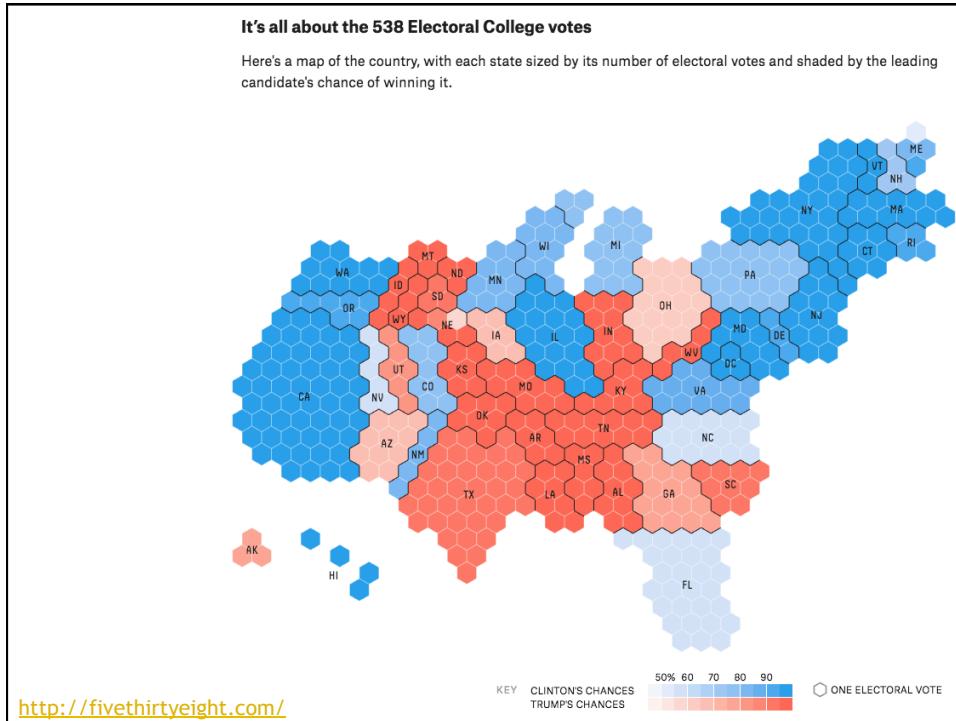
Electoral votes

| | |
|-------------------|---------|
| ■ Hillary Clinton | 302 . 4 |
| ■ Donald Trump | 234 . 7 |
| ■ Evan McMullin | 0 . 8 |
| ■ Gary Johnson | 0 . 0 |

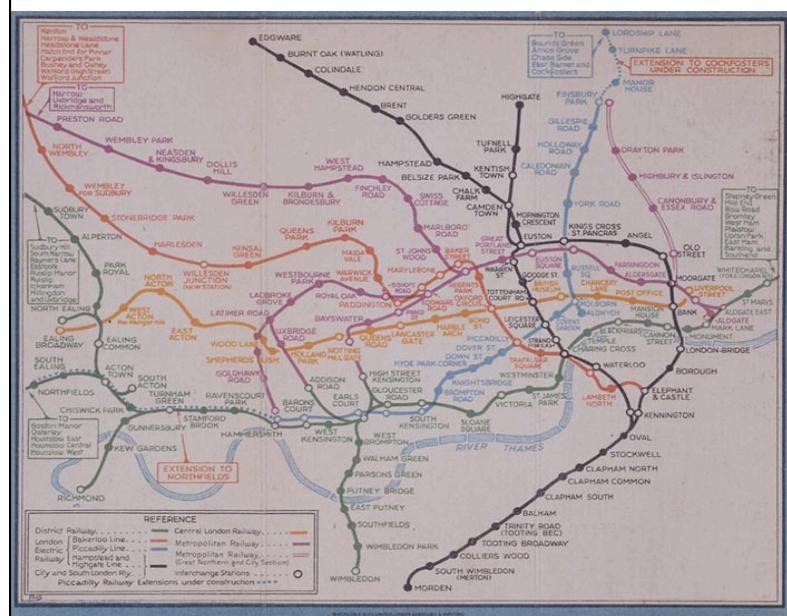
Popular vote

| | |
|-------------------|---------|
| ■ Hillary Clinton | 48 . 6% |
| ■ Donald Trump | 45 . 0% |
| ■ Gary Johnson | 4 . 8% |
| ■ Other | 1 . 6% |

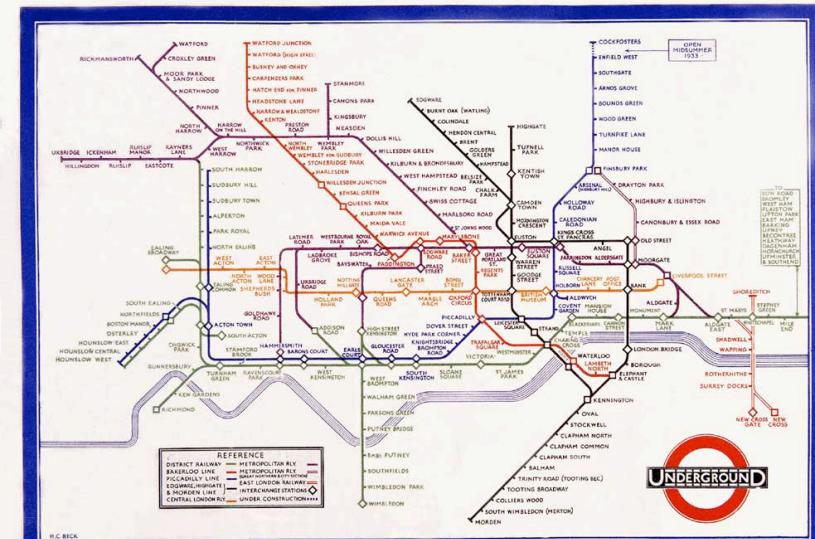
<http://fivethirtyeight.com/>



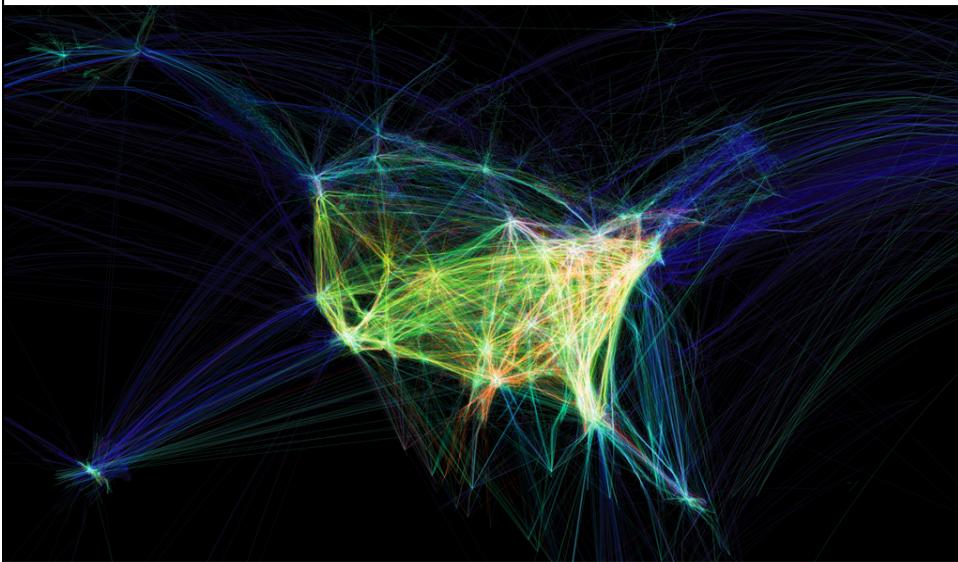
Is This A Map?



Is This A Map?



Fight Patterns, Aaron Koblin



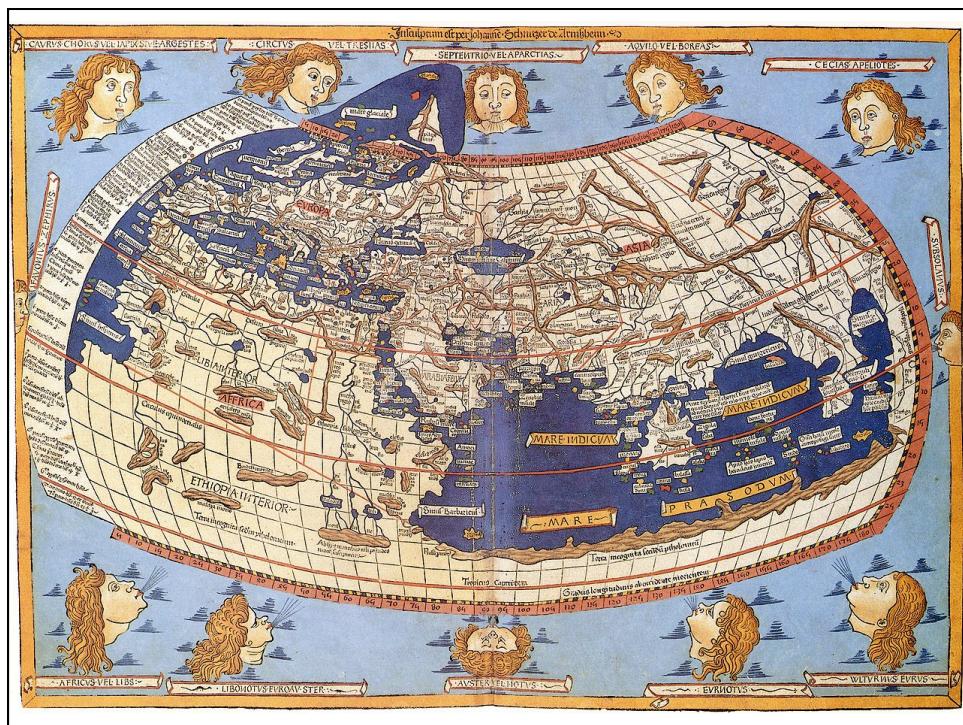
www.aaronkoblin.com/work/flightpatterns

A History Of The World



<http://www.ragtag.info/2011/feb/2/history-world-100-seconds/>

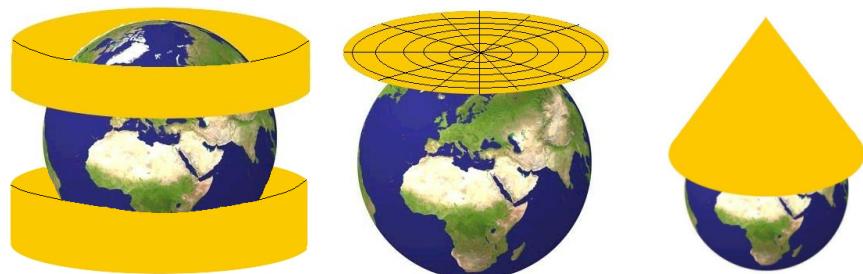
MAP PROJECTIONS



The West Wing Explains



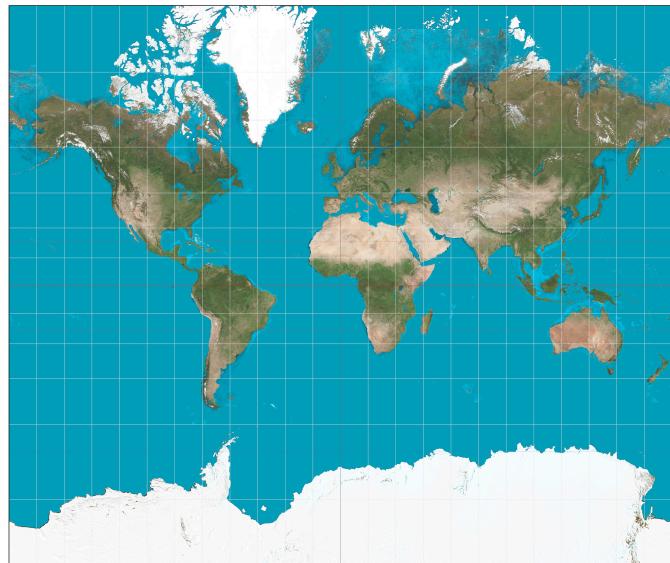
Map Projections



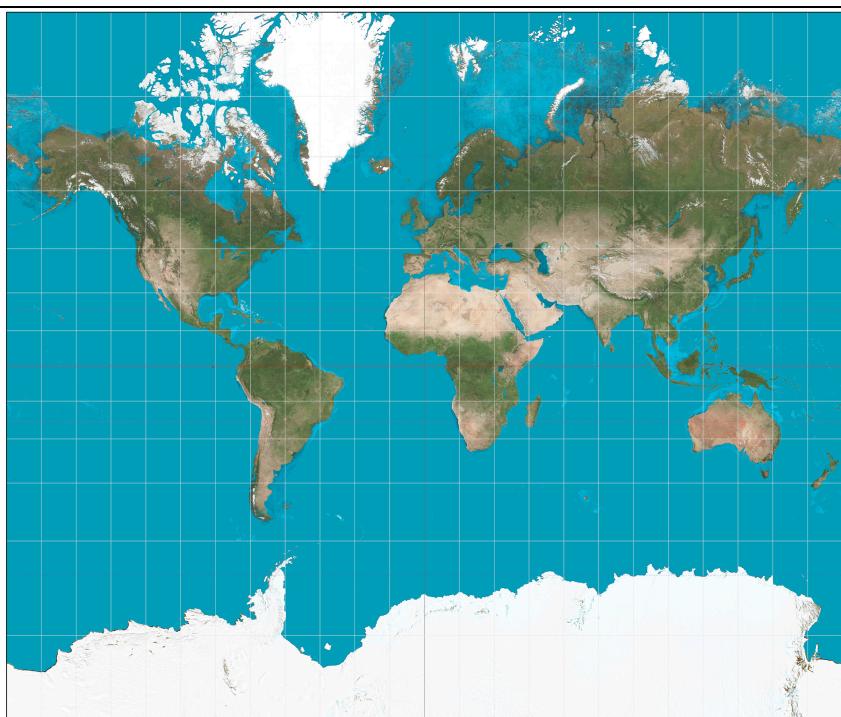
Cylinder, plane, and cone projections

"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

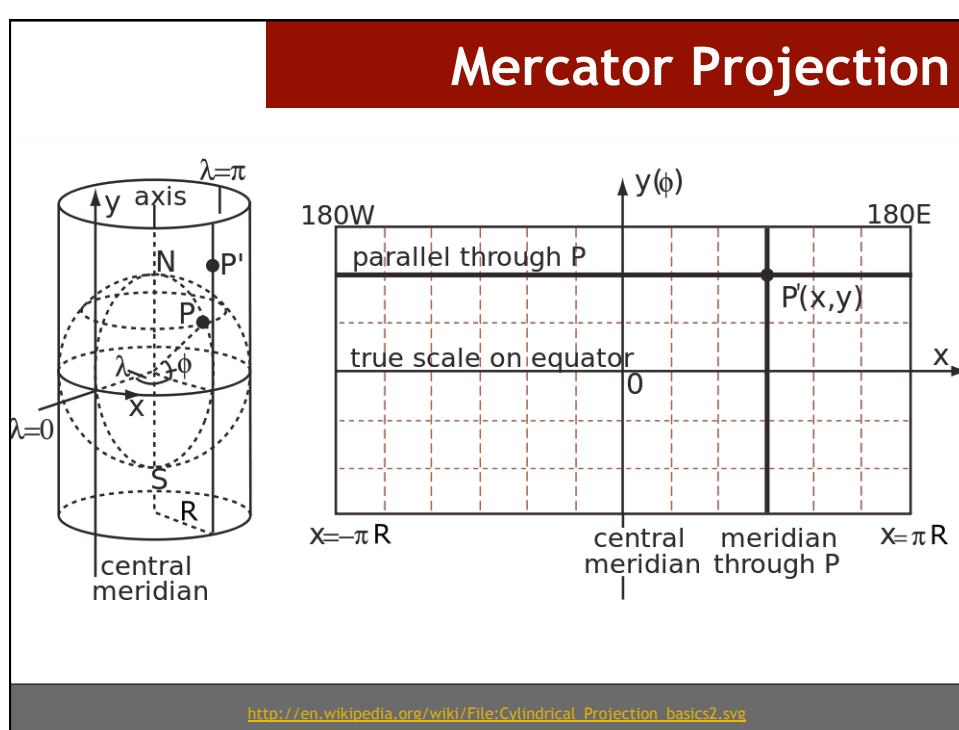
Mercator Projection



http://en.wikipedia.org/wiki/File:Mercator_projection_SW.jpg



Mercator Projection



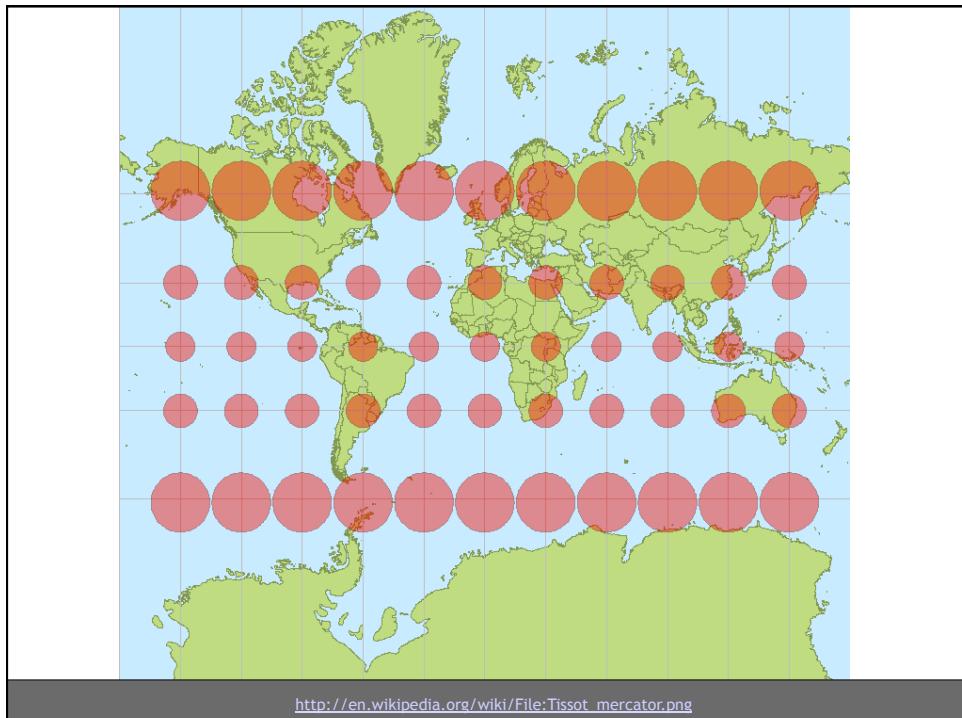
Mercator Projection

The formulae for calculating the x and y coordinates for a point in a Mercator projection are:

$$x = \frac{W}{2\pi} (\lambda - \lambda_0)$$

$$y = \frac{W}{2\pi} \ln \left[\tan \left(\frac{\pi}{4} + \frac{\phi}{2} \right) \right]$$

where λ is a longitude, ϕ is a latitude and W is the width of the map

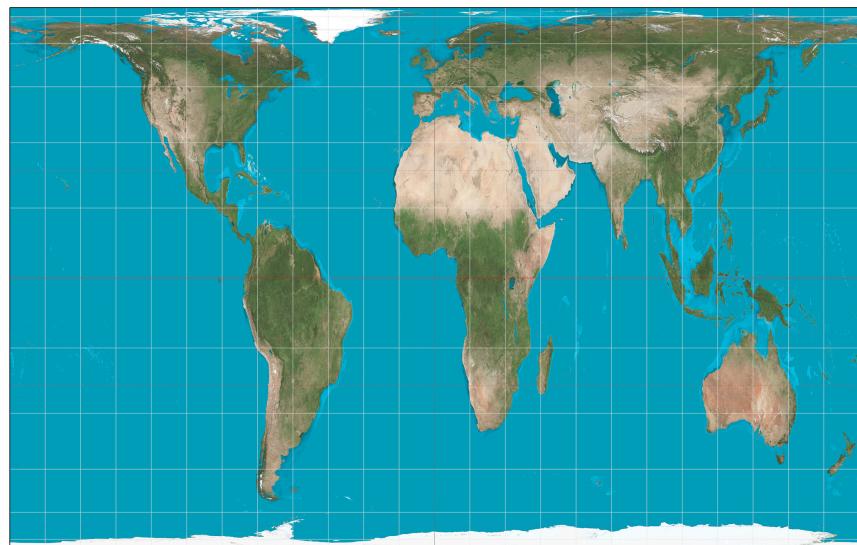


Mercator Projection

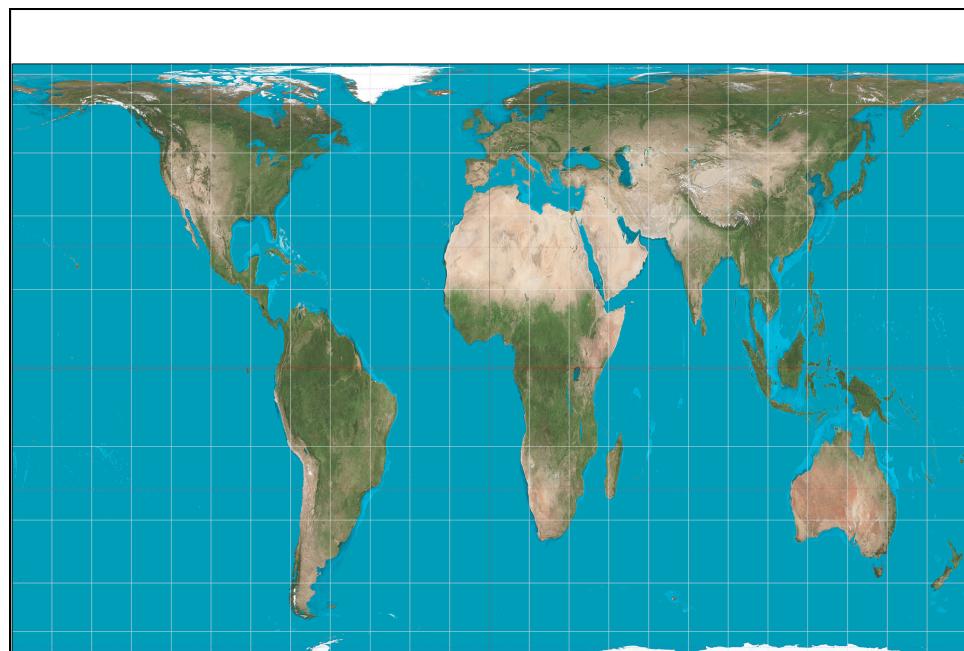
The Mercator projection exaggerates areas far from the equator, for example:

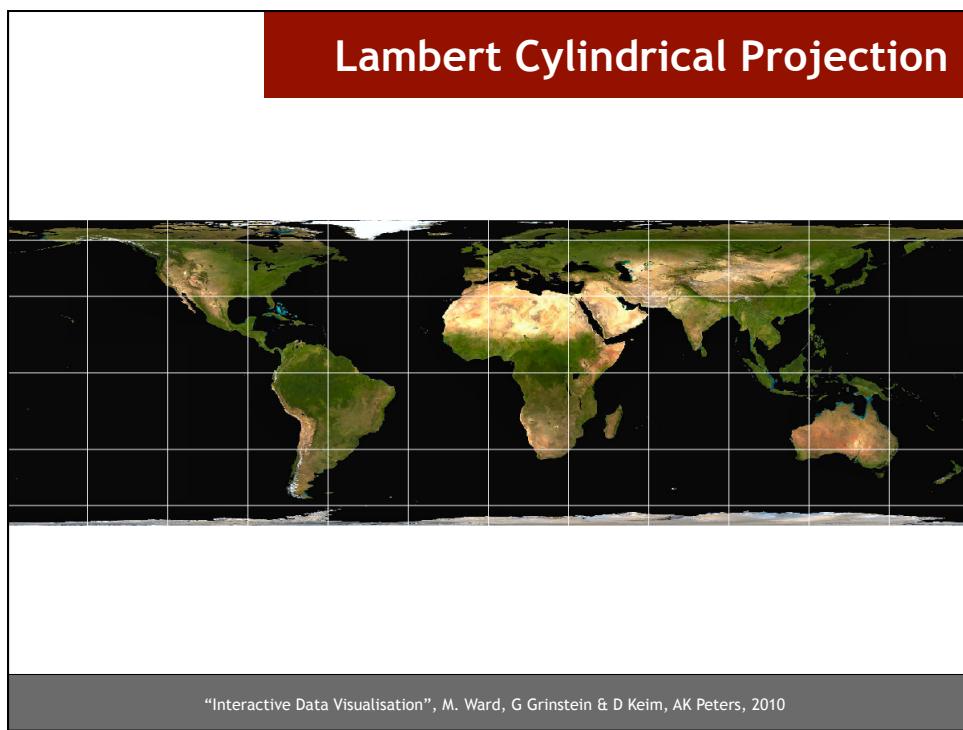
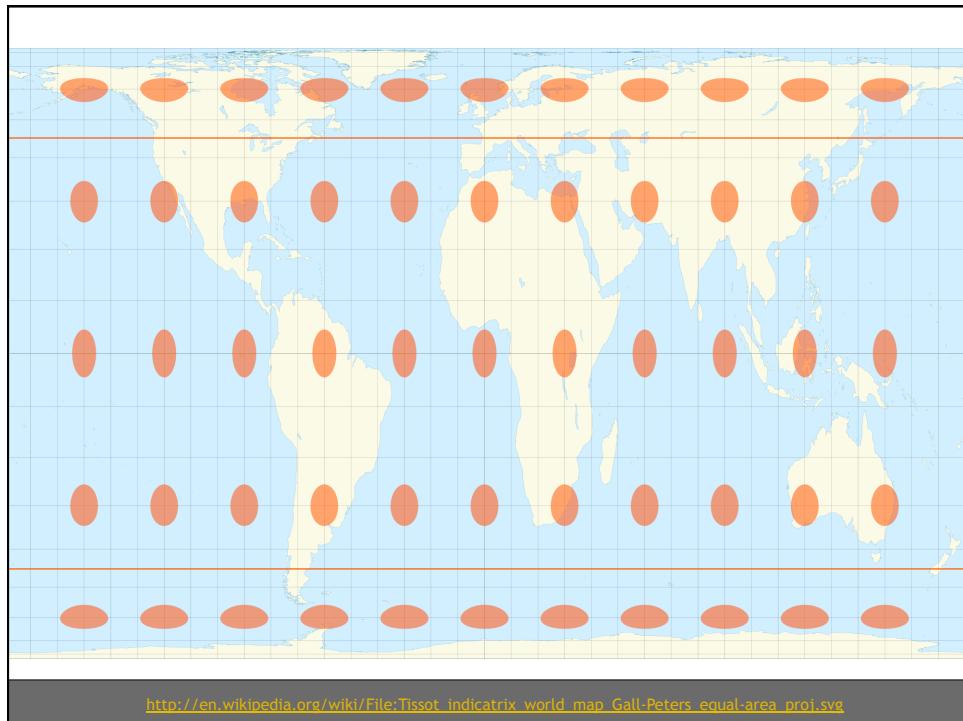
- Greenland takes as much space on the map as Africa, when in reality Africa's area is 14 times greater and Greenland's is comparable to Algeria's alone.
- Alaska takes as much area on the map as Brazil, when Brazil's area is nearly five times that of Alaska
- Finland appears with a greater north-south extent than India, although India's is greater
- Antarctica appears as the biggest continent, although it is actually the fifth in terms of area

Gall-Peters Projection

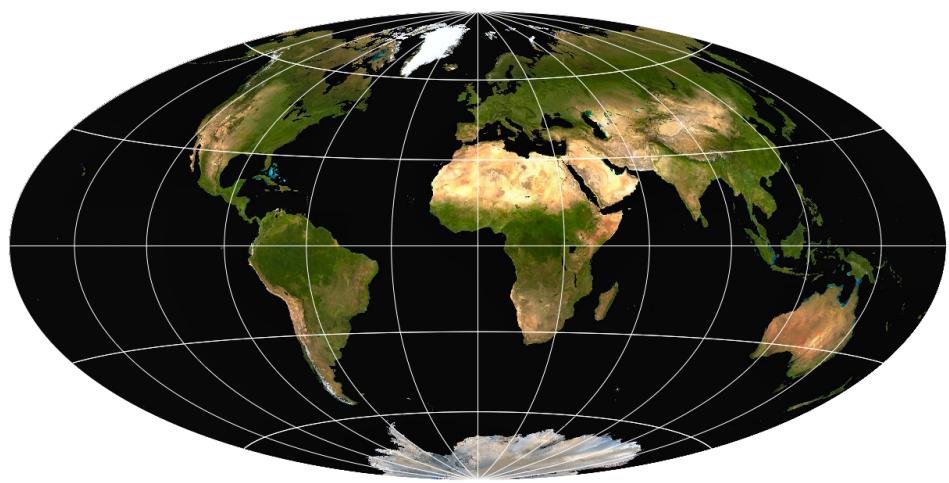


http://en.wikipedia.org/wiki/File:Gall%20Peters_projection_SW.jpg



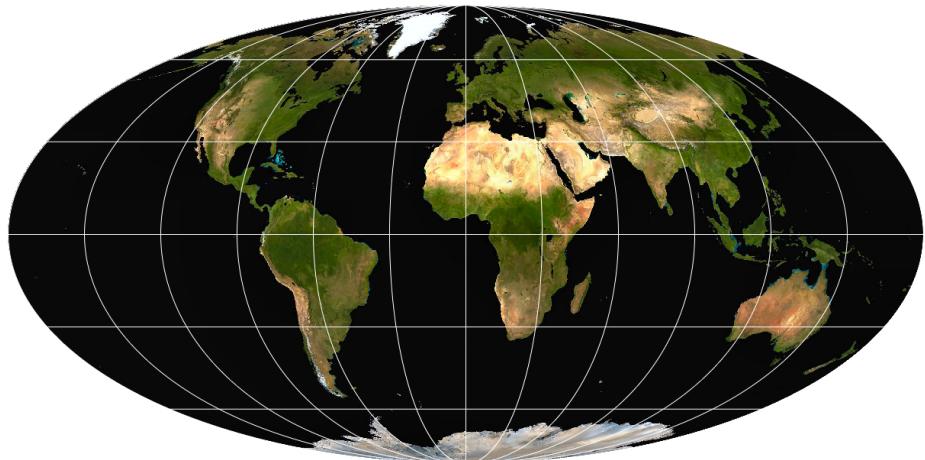


Hammer-Aitoff Projection



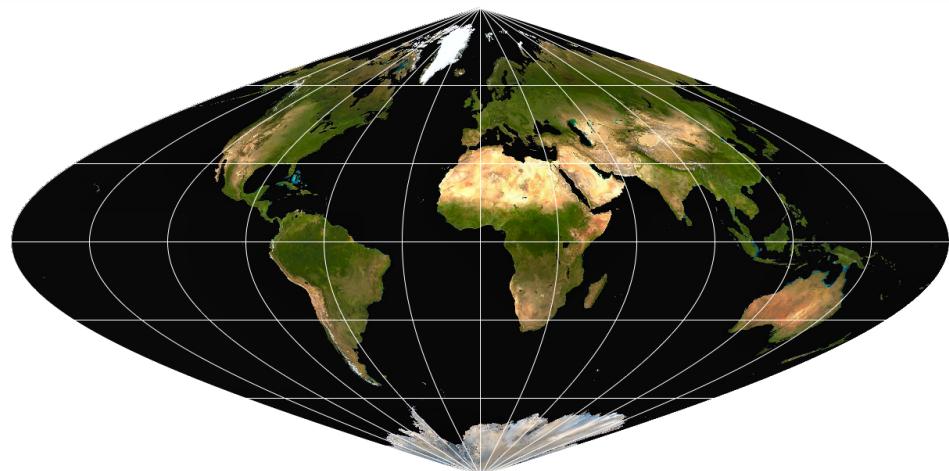
"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

Mollweide Projection



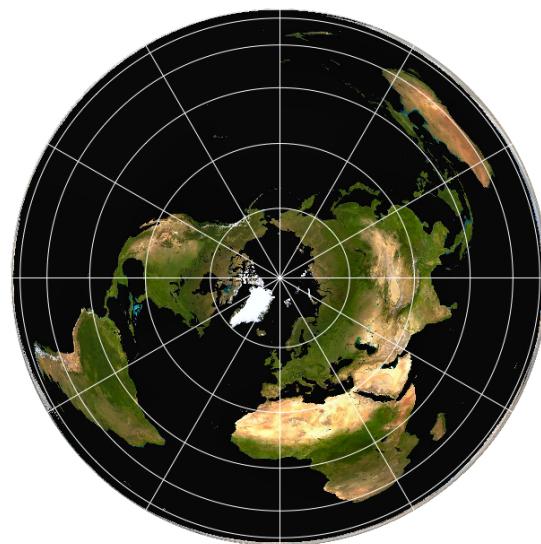
"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

Cosinuodial Projection

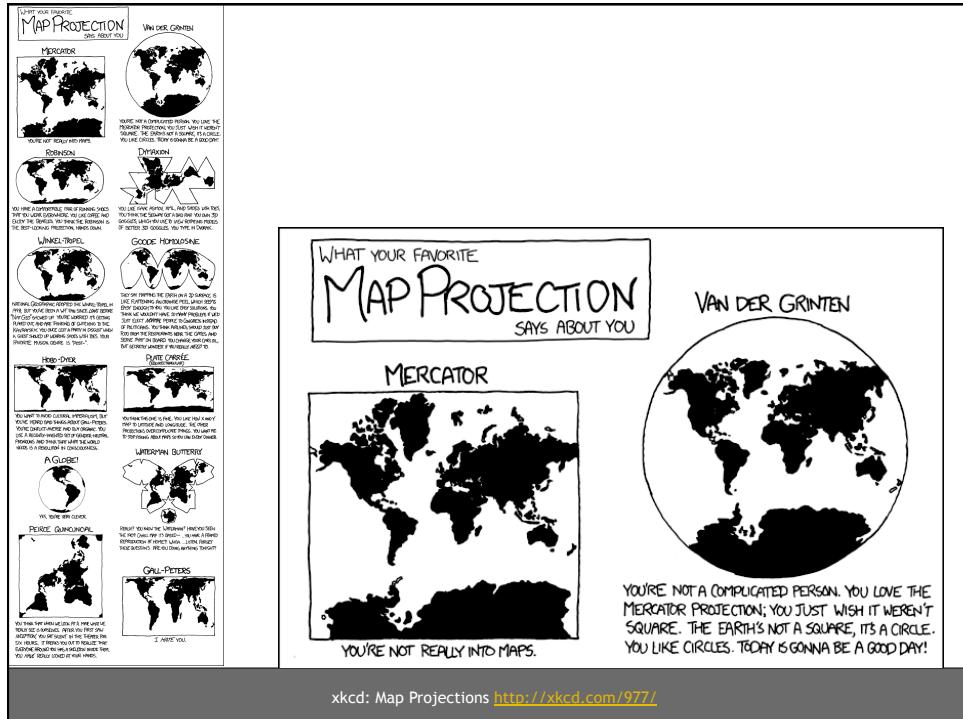


"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

Albers Equal-area Conic Projection



"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

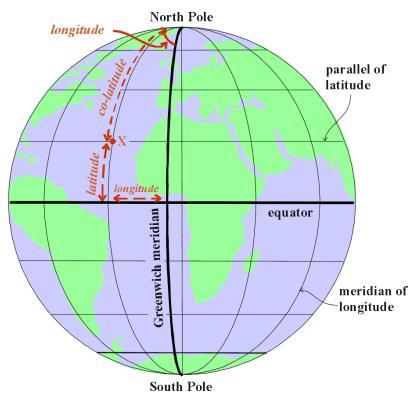


A WORD ON GEOCODING

Find Latitude & Longitude

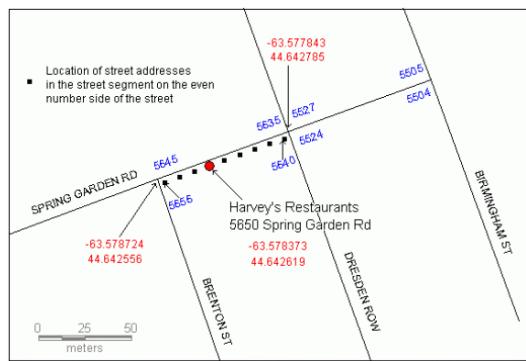
In most practical applications, you need latitude & longitude to map points

Most likely will have a list of addresses that must be converted - use **geocoding**



Geocoding Services

Take an address, give it to a service, the service queries its database for matching addresses - get latitude and longitude for where the service thinks your address is



Geocoding Services

geocoder.us find the latitude & longitude of any US address - for free

[HOME](#) [Documentation/Help](#) [FAQ](#) [Member Info](#) [Geocoder Blog](#) [About us/looking forward](#)

Look up an Address:

Enter a US address or intersection, e.g. 1600 Pennsylvania Ave, Washington, DC.

For best results please use a comma between the street and the city, and add the zip code if possible. Free lookups are throttled by your IP address to one request every 15 seconds.

[Sign up for an account](#) to use the non-throttled service, and to receive geocoder.us updates:

Or try one of these examples...

- 1600 Pennsylvania Ave, Washington DC
- West 42nd & Broadway, New York NY
- Hollywood & Vine, Los Angeles, CA
- Mission & Valencia Sts, San Francisco CA
- 1005 Gravenstein Highway North, Sebastopol CA

Recent News and Notes

Oct 15, 2012 Server load this morning was through the roof. Checking the log files it is largely because of people using the free service, but not respecting the 15 second throttle. Please, if you are going to use the free service please try to space your requests out a bit. Thank you!

geocoder.us <http://geocoder.us>

Geocoding Services

geocoder.us find the latitude & longitude of any US address - for free

[HOME](#) [Documentation/Help](#) [FAQ](#) [Member Info](#) [Geocoder Blog](#) [About us/looking forward](#)

Address

1600 Pennsylvania Ave NW
Washington DC 20502
(38.898748, -77.037684)

Latitude

38.898748 °
N 38 ° 53' 55.5"
38 ° 53.9249' (degree m.mmmm)

Longitude

-77.037684 °
W 77 ° 2' 15.7"
-77 ° 2.2610' (degree m.mmmm)

[View location in Google Maps](#) (opens in new window)

Search for another address:

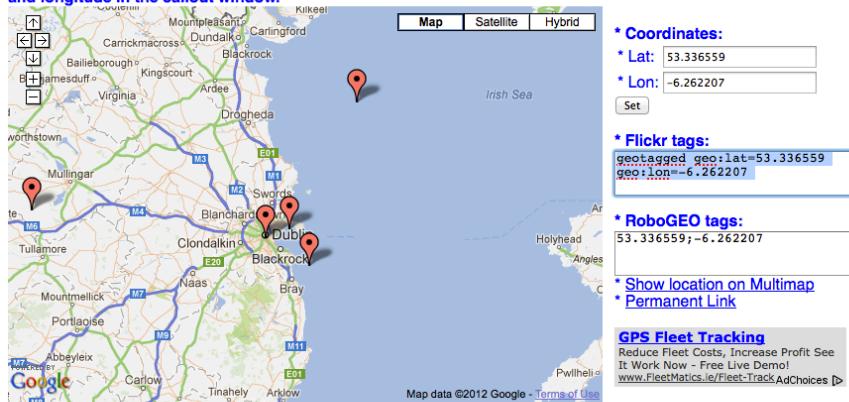


geocoder.us <http://geocoder.us>

Geocoding Services

Google Maps Latitude, Longitude Popup

Simply click on the map on a location and it will provide you with the latitude and longitude in the callout window.



Google Maps Latitude, Longitude Popup: <http://www.gorissen.info/Pierre/maps/googleMapLocationv3.php>

Geocoding Services

For a few locations:

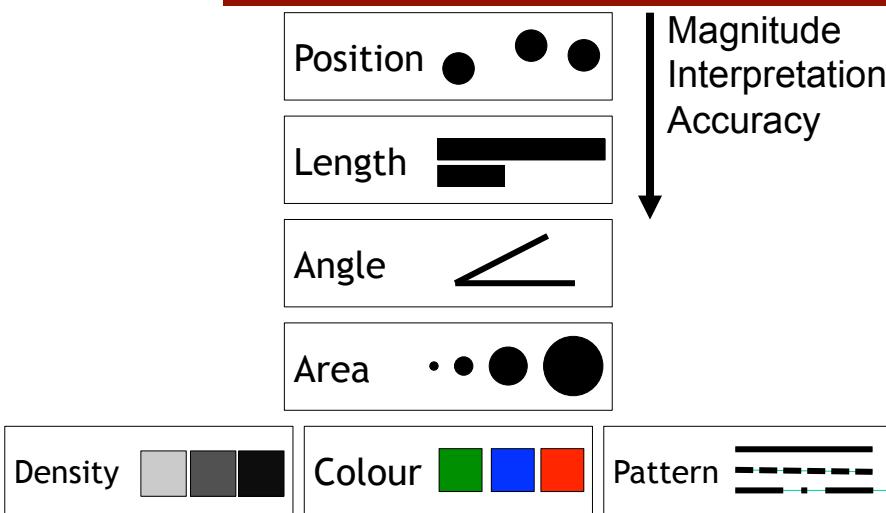
- Easy enter them manually in a website, e.g. Geocoder.us

For many locations - do it programmatically:

- Google, Yahoo!, Geocoder.us, and Mediawiki all provide APIs for geocoding

GEOSPATIAL VISUALISATION TYPES

Ease of Perception Of Encodings



Graphical perception: Theory, experimentation, and application to the development of graphical methods, W S Cleveland, R McGill, Journal of the American Statistical Association 01/1984; 79:531-554.
<https://www.researchgate.net/publication/229099907>

Graphical perception: Theory, experimentation, and application to the development of graphical methods.

Visual Encodings For Spatial Dimensions

The following visual encodings are most useful for spatial dimensions:

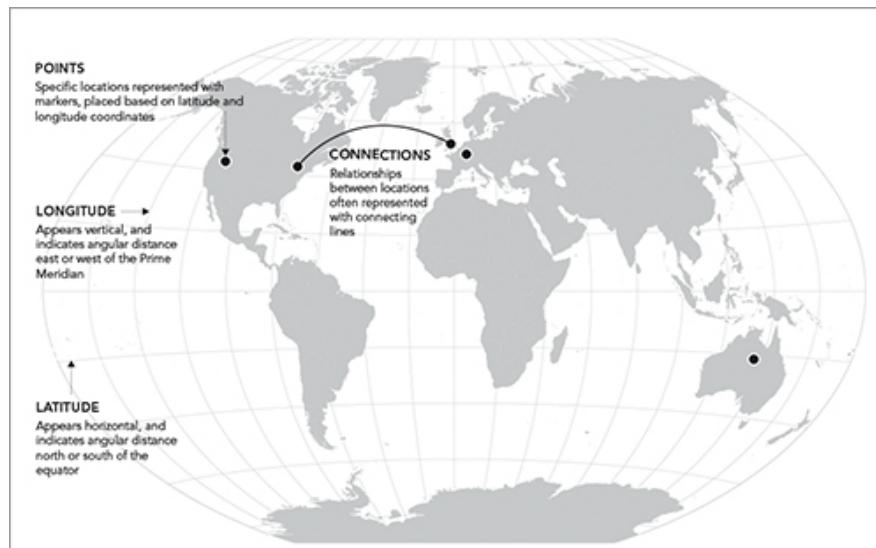
- **Size:** size of individual symbols, width of lines
- **Shape:** shape of individual symbols
- **Brightness:** brightness of symbols, lines or areas
- **Colour:** colour of symbols, lines or areas

Geospatial Visualisation Types

Some of the important geospatial visualisation types we can create are:

- Dot maps
- Line maps
- Chloropleth maps
- Cartograms

Dot Maps



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map Example

For the following examples we will use a dataset that contains the locations of stores in the American Costco Wholesale chain

| Address,City,State,Zip Code,Latitude,Longitude |
|-------------------------------------------------------------------------------|
| 1205 N. Memorial Parkway,Huntsville,Alabama 35801-5930,34.7430949,-86.6009553 |
| 3650 Galleria Circle, Hoover, Alabama, 35244-2346, 33.377649, -86.81242 |
| 8251 Eastchase Parkway,Montgomery,Alabama,36117,32.363889,-86.150884 |
| 5225 Commercial Boulevard,Juneau,Alaska,99801-7210,58.3592,-134.483 |
| 330 West Dimond Blvd,Anchorage,Alaska,99515-1950,61.143266,-149.884217 |
| 4125 DeBarr Road,Anchorage,Alaska,99508-3115,61.210815,-149.804337 |

"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

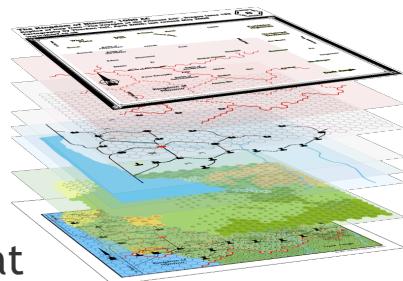


Mapping, It's Like An Onion

When you create your maps, it's useful to think of them as layers

The bottom layer is usually the base map that shows geographical boundaries, and then you place data layers on top of that.

In our case the bottom layer is a map of the United States, and the second layer is Costco locations



Map By Dots

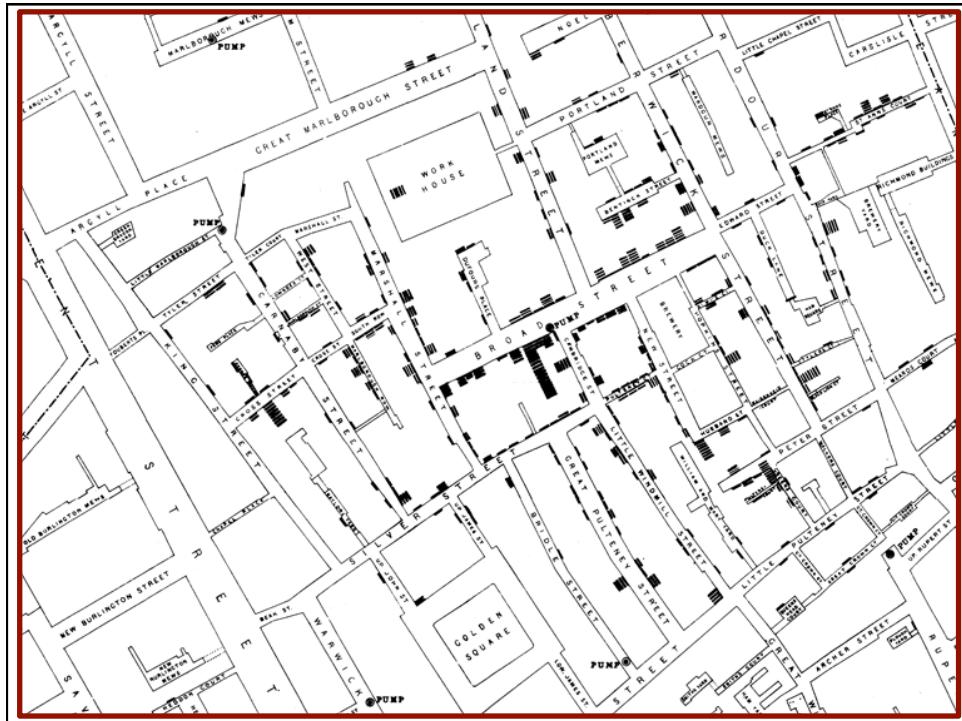


"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Dots



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>



Map By Bubbles

Like we did with scatter plots we can add bubbles to map visualizations to include an extra dimension

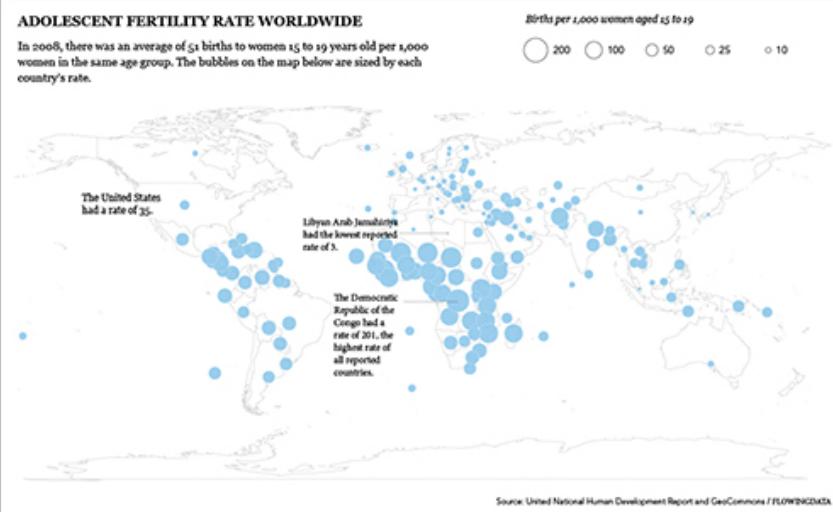
In the following example we plot worldwide adolescent fertility rates - the fertility rate is represented by the area of the bubbles

Map By Bubbles

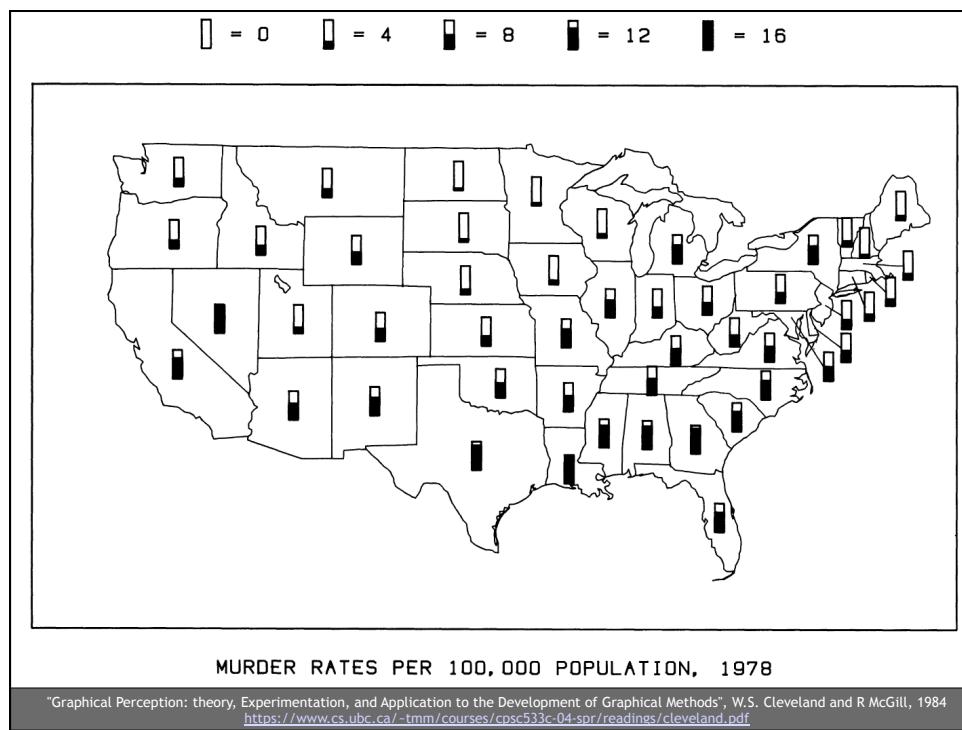
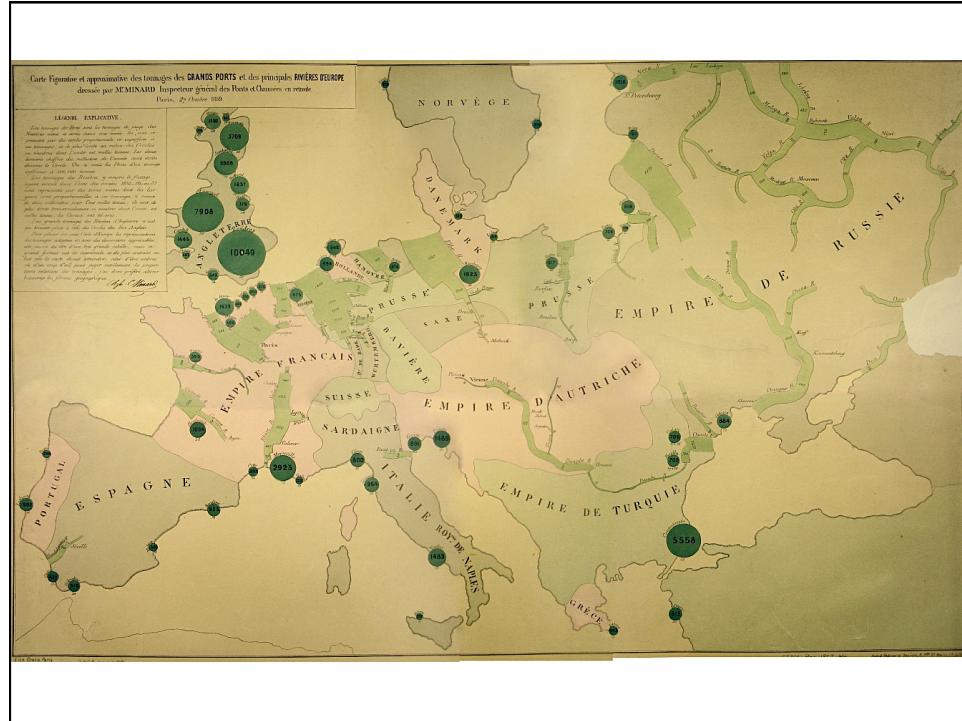


"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Bubbles

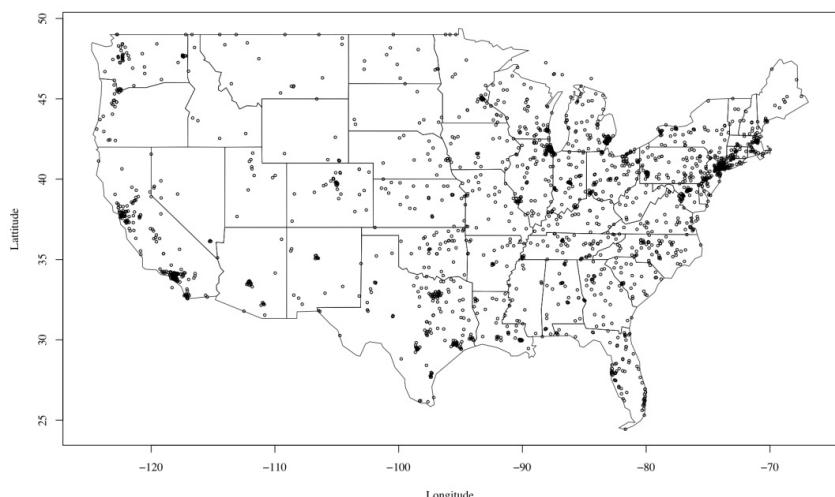


"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>



Problems With Point Maps

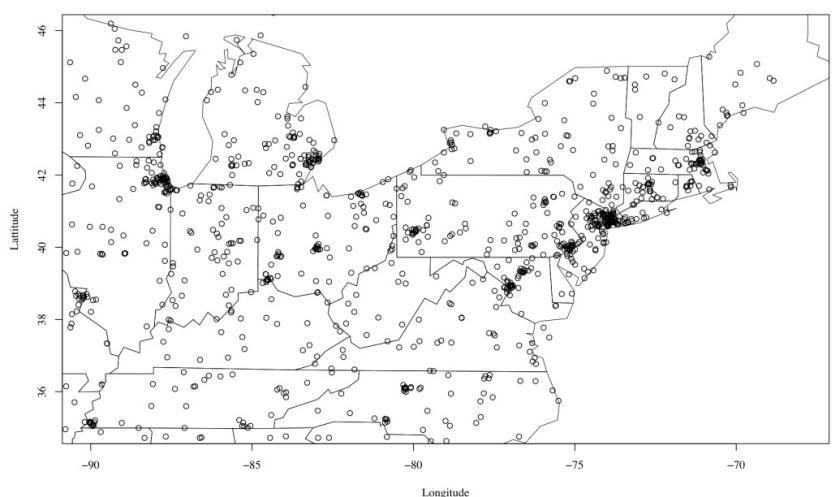
Dot Map



"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

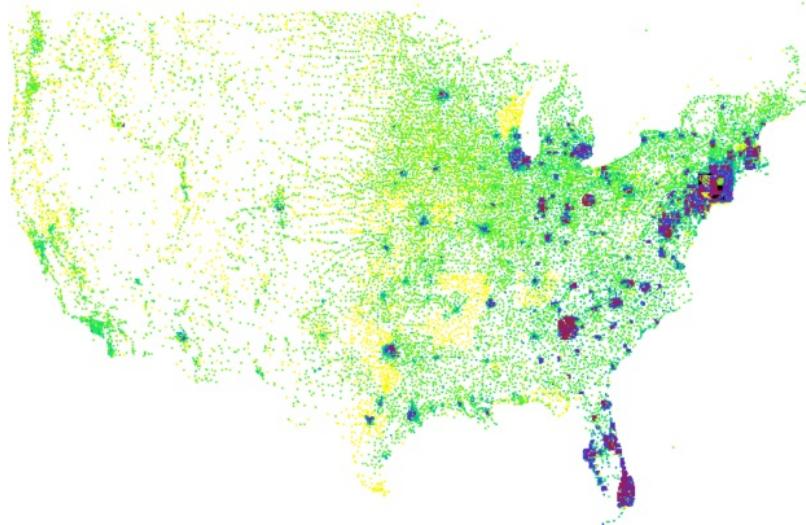
Problems With Point Maps

Dot Map



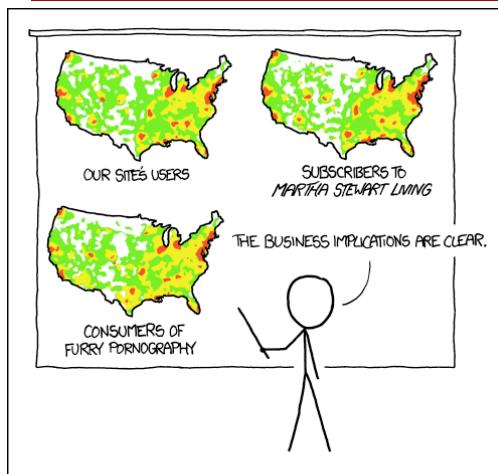
"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

Problems With Point Maps



Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

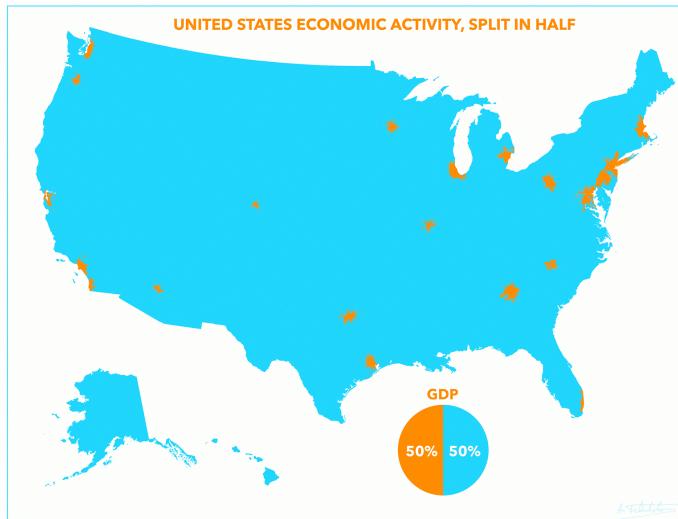
Problems With Dot Maps



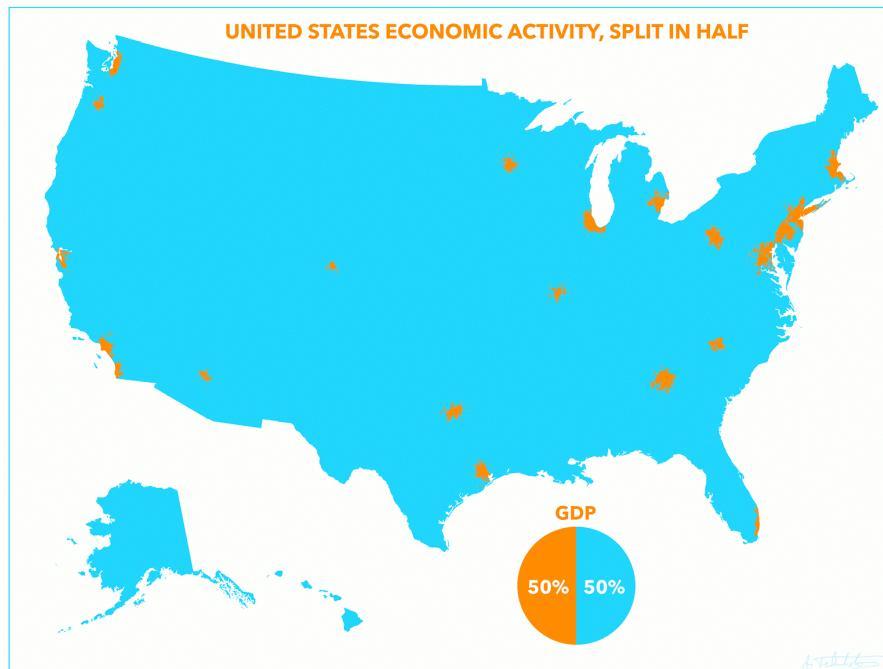
PET PEEVE #208:
GEOGRAPHIC PROFILE MAPS WHICH ARE
BASICALLY JUST POPULATION MAPS

XKCD Heatmap:
<http://xkcd.com/1138/>

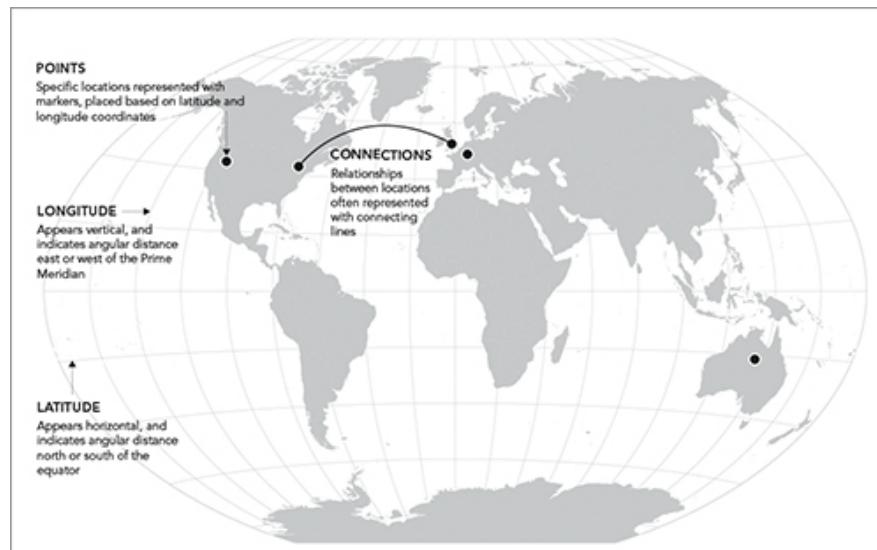
Problems With Dot Maps



<http://www.thefunctionalart.com/2014/02/the-incredible-gdp-map-that-shows-that.html>



Line Maps



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Line Maps

By connecting points together we can add an extra layer of information to our maps

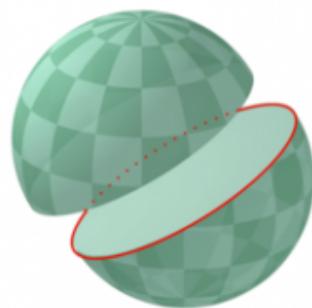
Map By Lines



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Great Circles

Great circles, or Riemannian circles, are shortest paths across the surface of the globe that appear as circles on a map projection



Drawing connections on a map as great circles rather than straight lines can lead to more appealing visualisations

Flowing Data: <http://flowingdata.com/2011/05/11/how-to-map-connections-with-great-circles/>

Great Circles



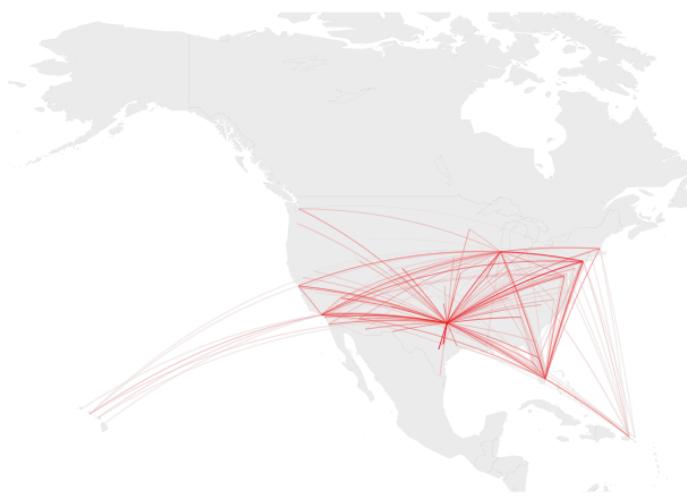
Great Circles



"Visualize This", N. Yau, Wiley, 2011

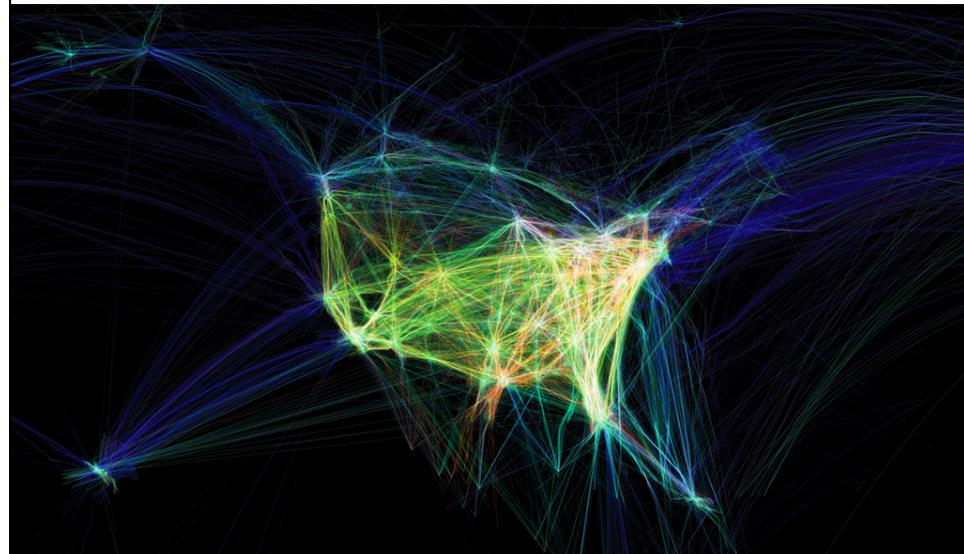
<http://shop.oreilly.com/product/0636920022060.do>

Great Circles



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Fight Patterns, Aaron Koblin



www.aaronkoblin.com/work/flightpatterns

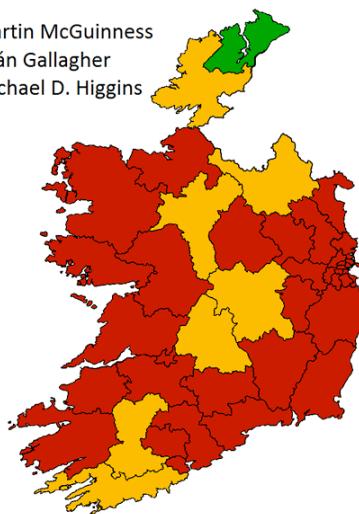
Chloropleth Maps

Points and lines are great for maps, but often we want to illustrate properties of areas in a map

Chloropleth maps are the most common approach to visualising area phenomena - colour meaningful areas in a map to illustrate the property under scrutiny

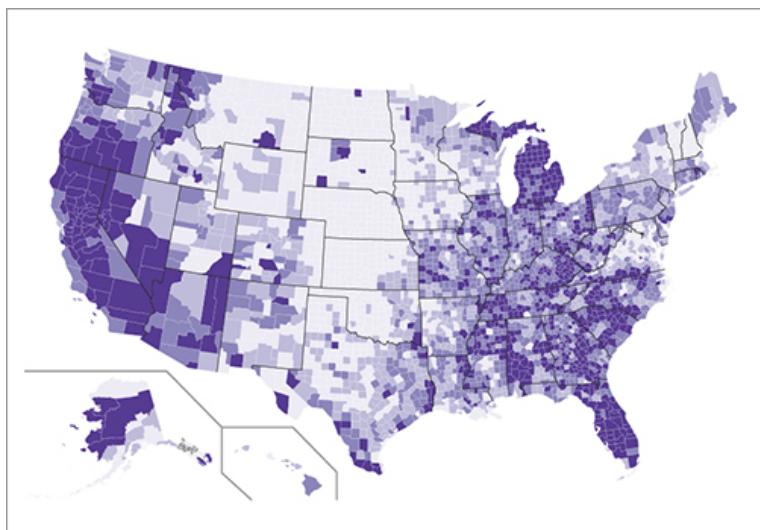
Irish Elections

- █ Martin McGuinness
- █ Seán Gallagher
- █ Michael D. Higgins



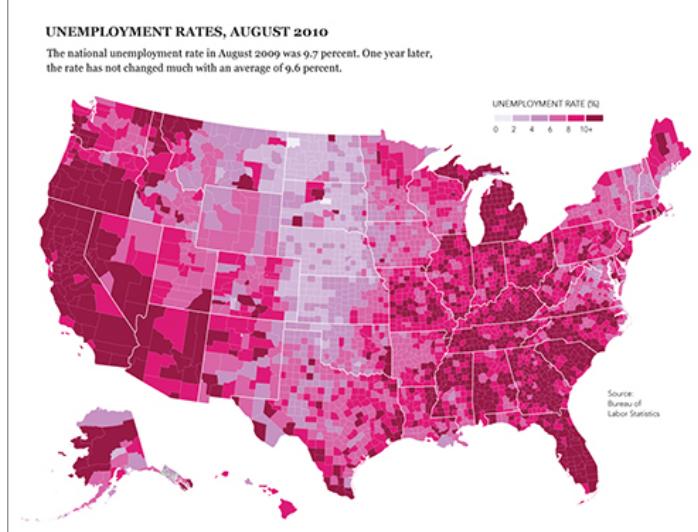
<http://www.fairocracy.com/newsblog/full-results-of-the-2011-irish-presidential-election.html>

US Unemployment



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

US Unemployment By County

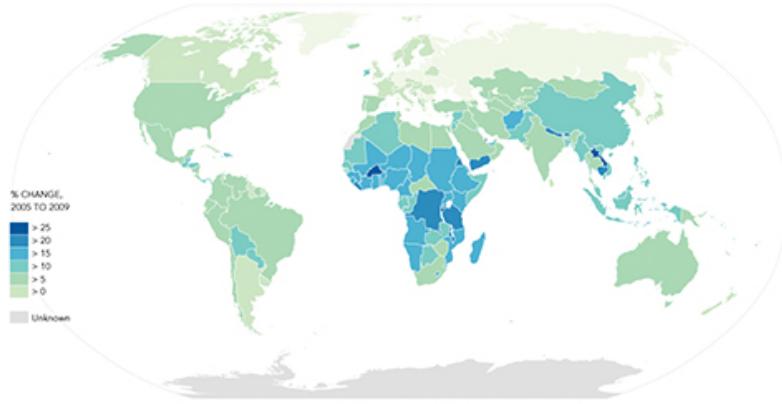


"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Region

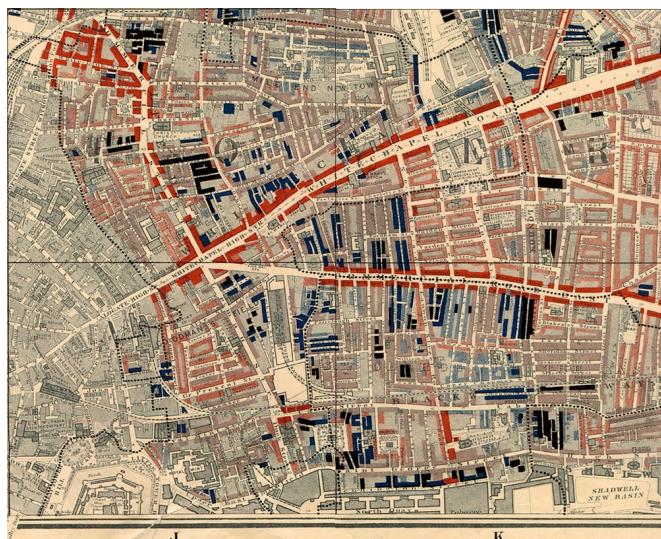
CHANGES IN URBAN POPULATION

Although there are still many countries where people primarily live in rural areas, there have been increases over the last few years in percent of people who live urban areas.

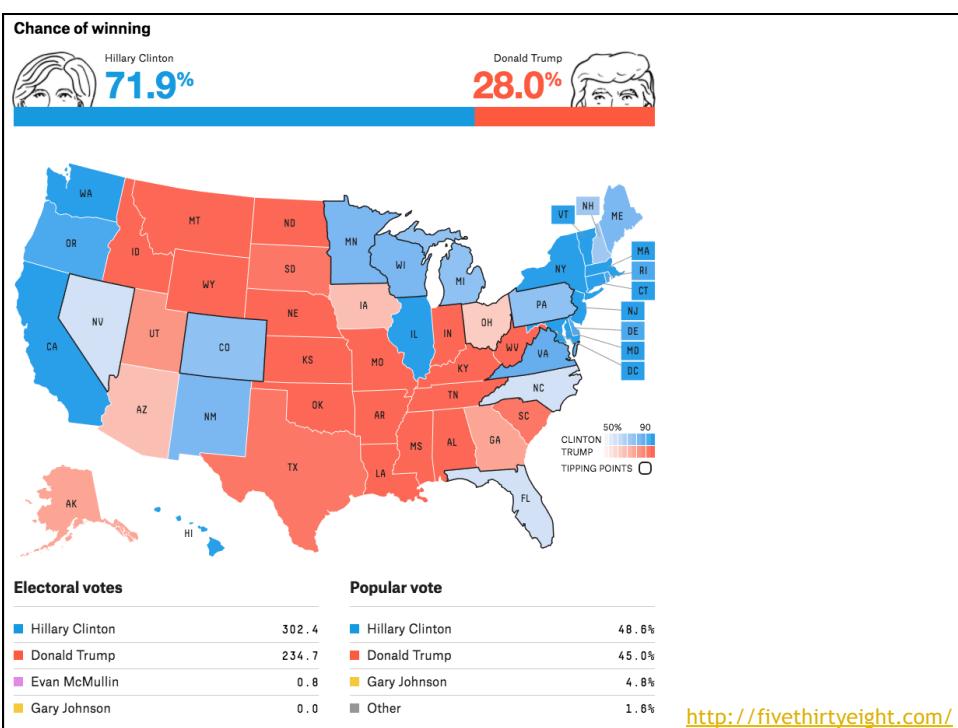
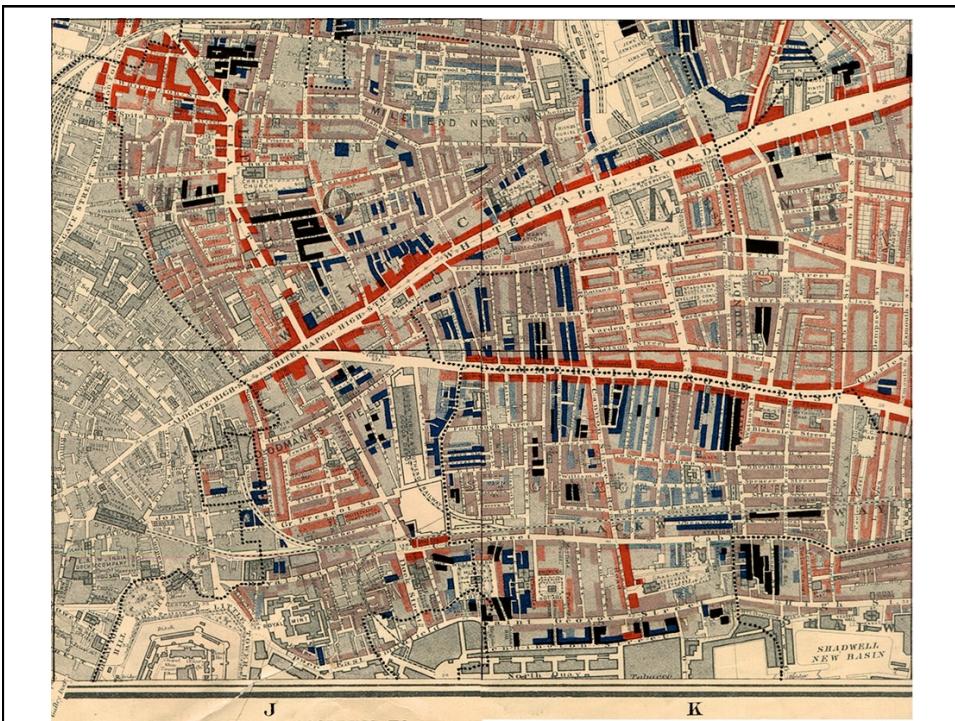


"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

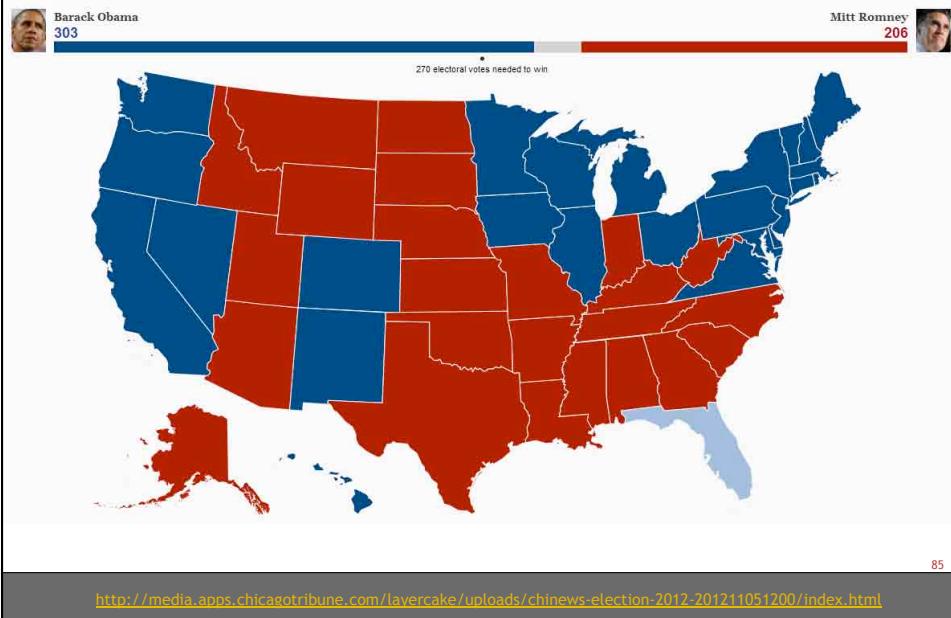
Charles Booth's London Poverty Maps



Charles Booth Online Archive <http://booth.lse.ac.uk/>



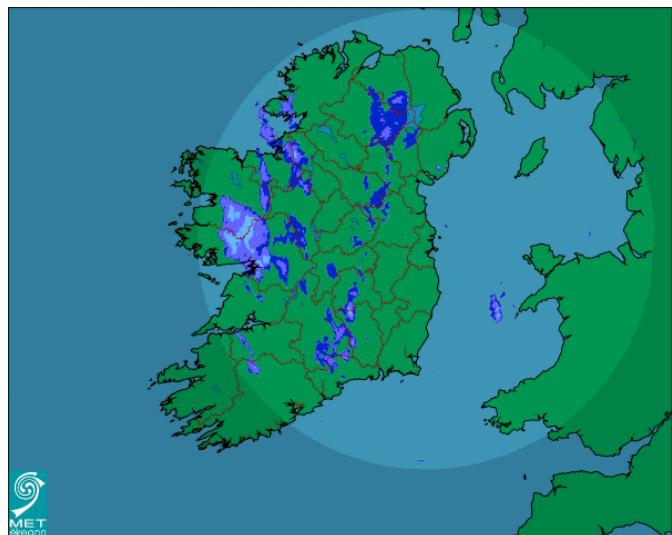
Problems With Chloropleth Maps



Isarithmic Maps

Isarithmic maps are an alternative to chloropleth maps in which the contours of some continuous phenomenon are shown over a map with semantic boundaries

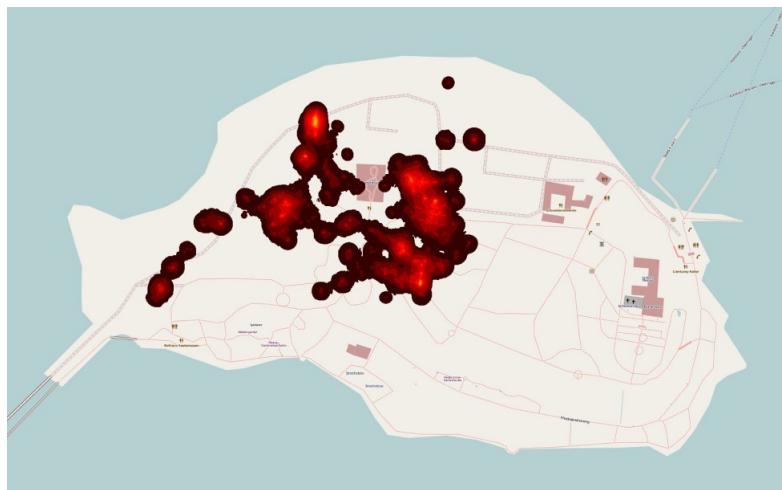
Met Eireann Rainfall Radar



87

Met Eireann Rainfall Radar: http://www.met.ie/latest/rainfall_radar.asp

Isarithmic Maps



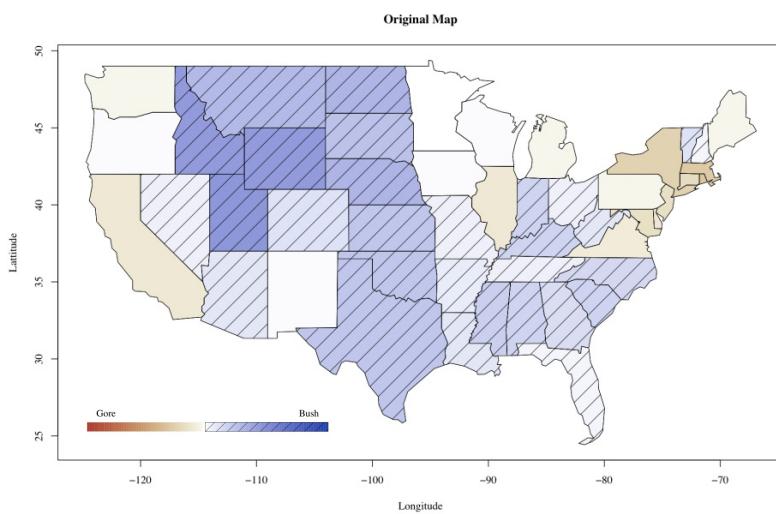
An isarithmic map showing the number of pictures taken on Mainau Island, where the colors range from black (least) to red to yellow (most)

"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010

Cartograms

Cartograms are map-based visualisations that distort the geography of the map to display some phenomenon (typically an area phenomenon)

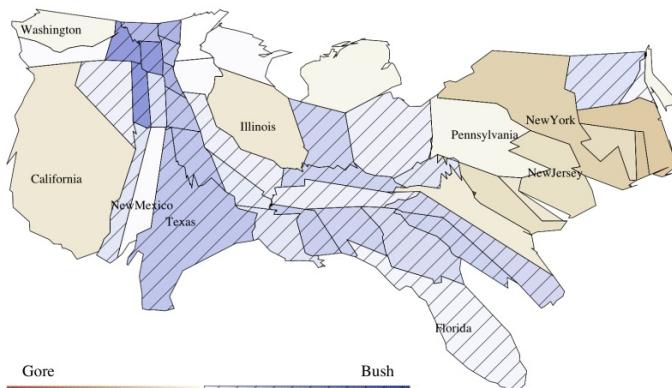
US Election 2000 Cartograms



Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

US Election 2000 Cartograms

Population-Cartogram



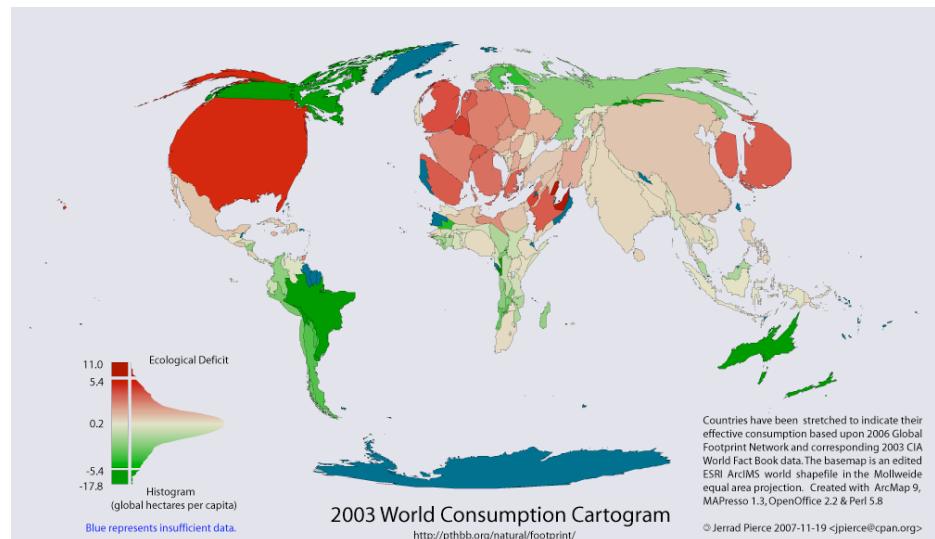
Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

Cartograms

World Population

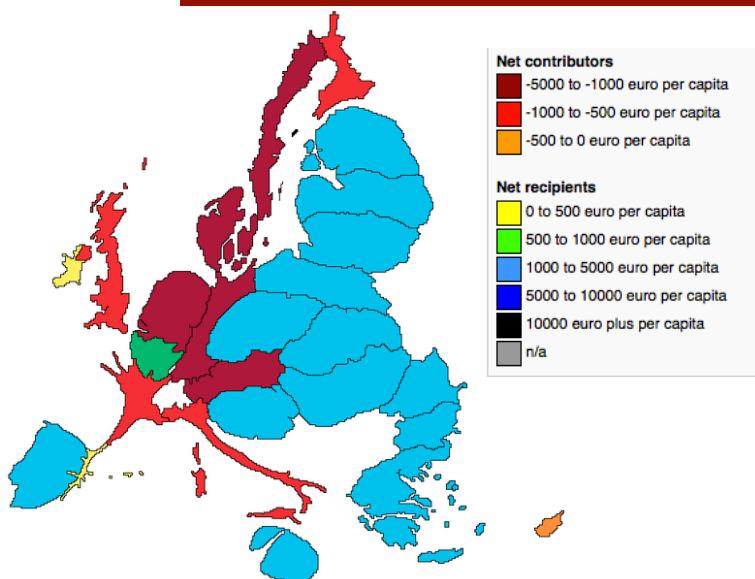
<http://www.sasi.group.shef.ac.uk/worldmapper/display.php?selected=2>

Cartograms



<http://www.geois.de/?p=794>

Cartograms

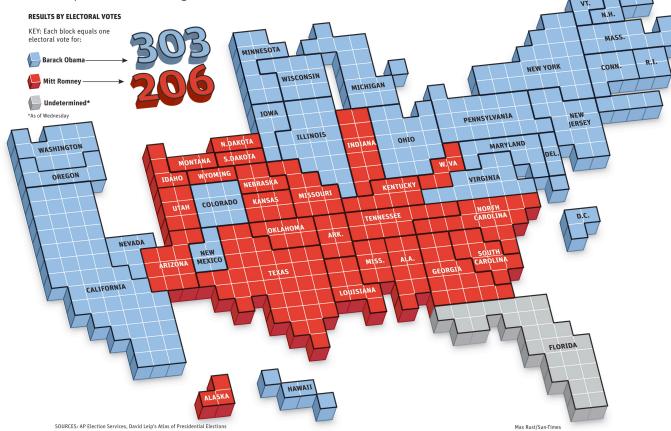


<http://en.wikipedia.org/wiki/Cartogram>

Cartograms

Piecing together a win

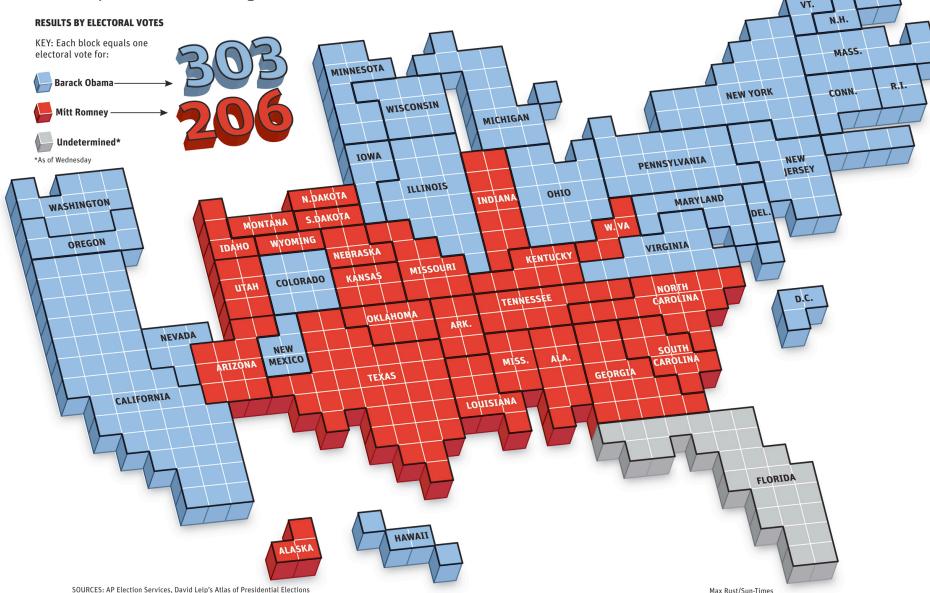
As with other recent presidential elections, Democratic electoral votes came from northeastern, midwestern and west coast states while Republican votes were won in southern, mountain and plains states. The swing state of Ohio proved to be a deciding factor in President Obama's win.

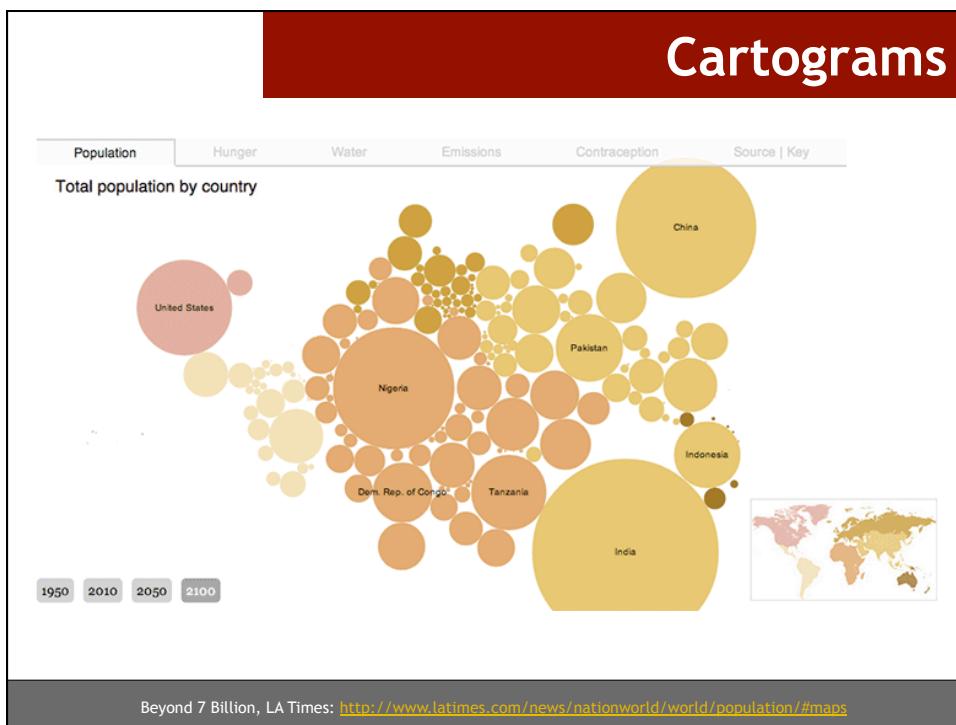
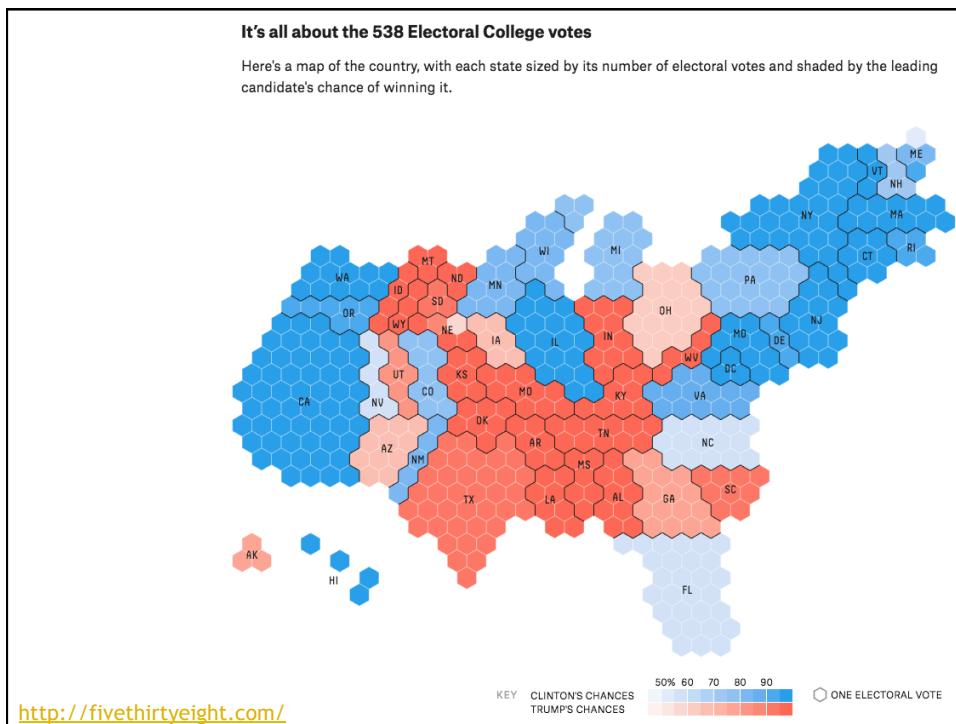


<http://chicago.suntimes.com/news/7/71/793213/graphics-breaking-down-the-presidential-vote>

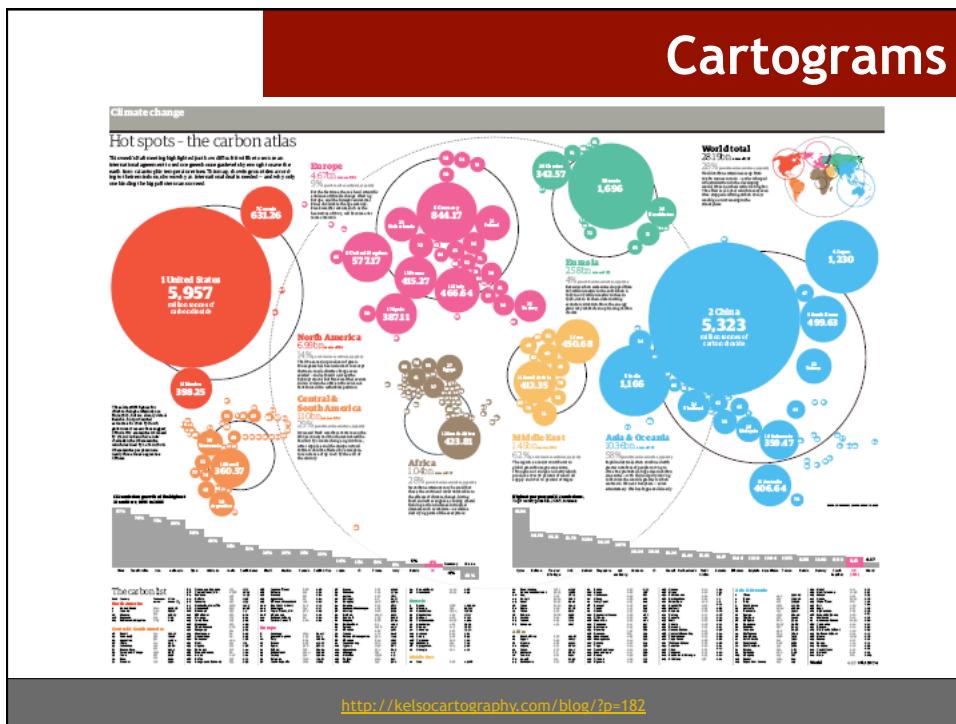
Piecing together a win

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Cartograms

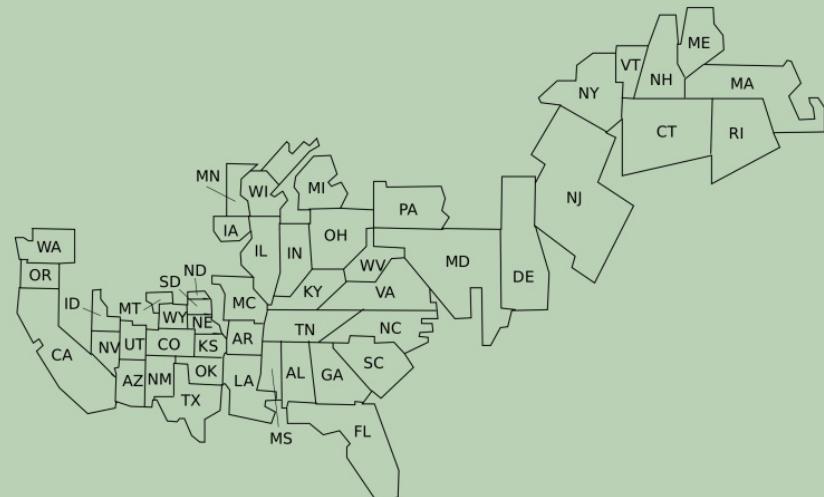


Cartograms

There are a number of different kinds of commonly used cartograms:

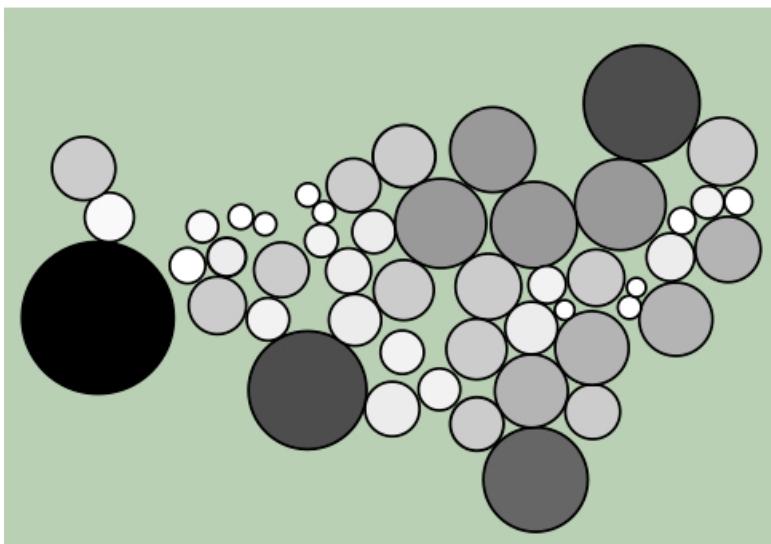
- **Non-continuous:** Scale polygons to their target sizes to maintain shape but relax topology and adjacency relationships
- **Circular/rectangular:** Completely ignore original polygon shape and attempt to maintain topology and adjacency with some relaxation
- **Continuous:** Retain adjacency and topology but relax area and shape constraints

Non-continuous Cartograms



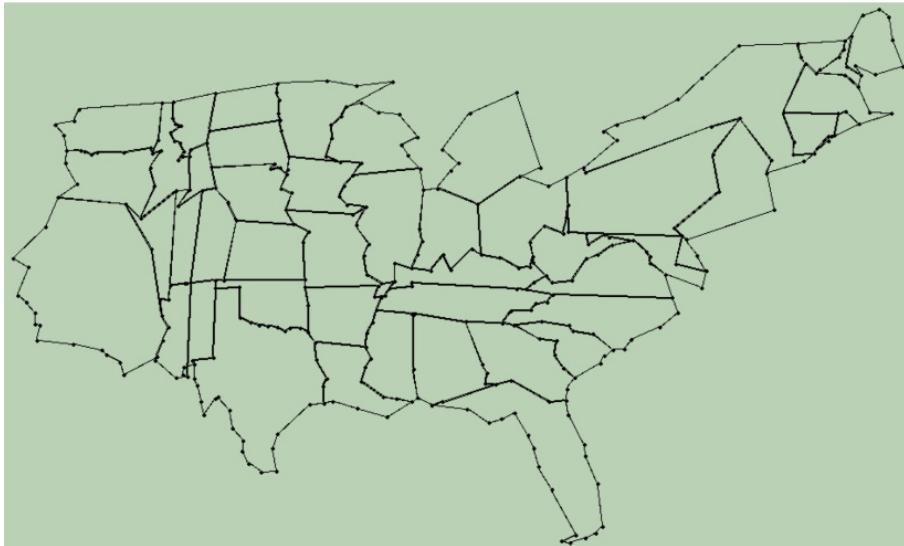
"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010
Daniel A. Keim, Christian Panse, and Stephen C. North. "Medial-Axis-Based Cartograms." IEEE Comput. Graph. Appl. 25:3 (2005), 60-68.

Circular Cartograms



"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010
Daniel A. Keim, Christian Panse, and Stephen C. North. "Medial-Axis-Based Cartograms." IEEE Comput. Graph. Appl. 25:3 (2005), 60-68.

Continuous Cartograms



"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010
Daniel A. Keim, Christian Panse, and Stephen C. North. "Medial-Axis-Based Cartograms." IEEE Comput. Graph. Appl. 25:3 (2005), 60-68.

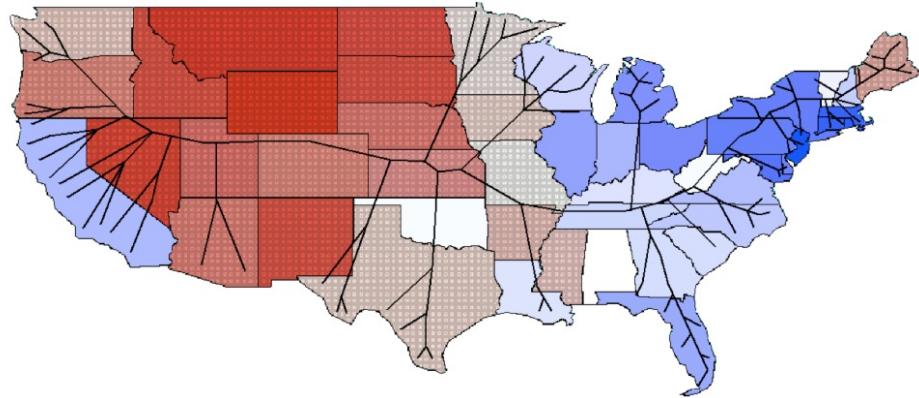
Drawing Cartograms

Drawing cartograms is extremely tricky - basically an optimization problem that balances the trade-offs that must be made

- Shape
- Topology
- Area
- Adjacency

So we are searching for a **pseudo-dual** of the original map that minimises shape, area, topology and adjancency errors - this is typically an NP-complete problem

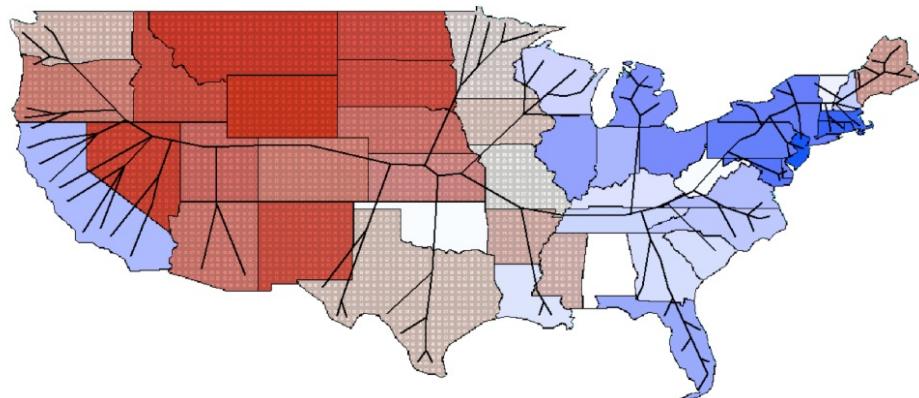
US Telephone Call Volume Cartogram By CartoMap Algorithm



Regular US map with scanlines shown and polygons that have to become large colored blue and polygons that have to become smaller colored red

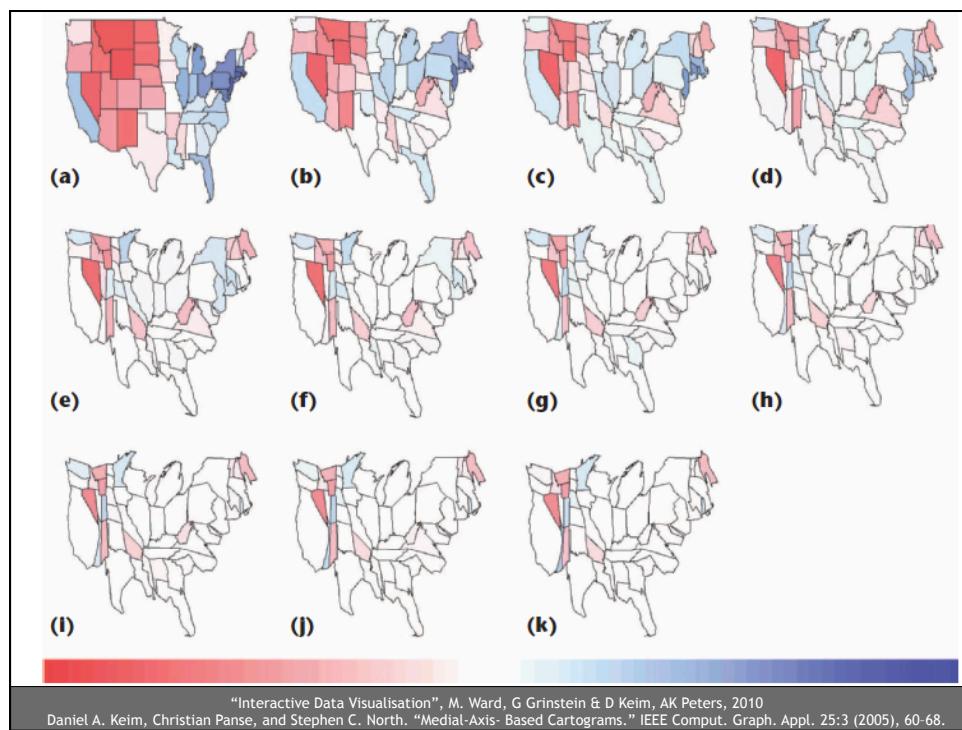
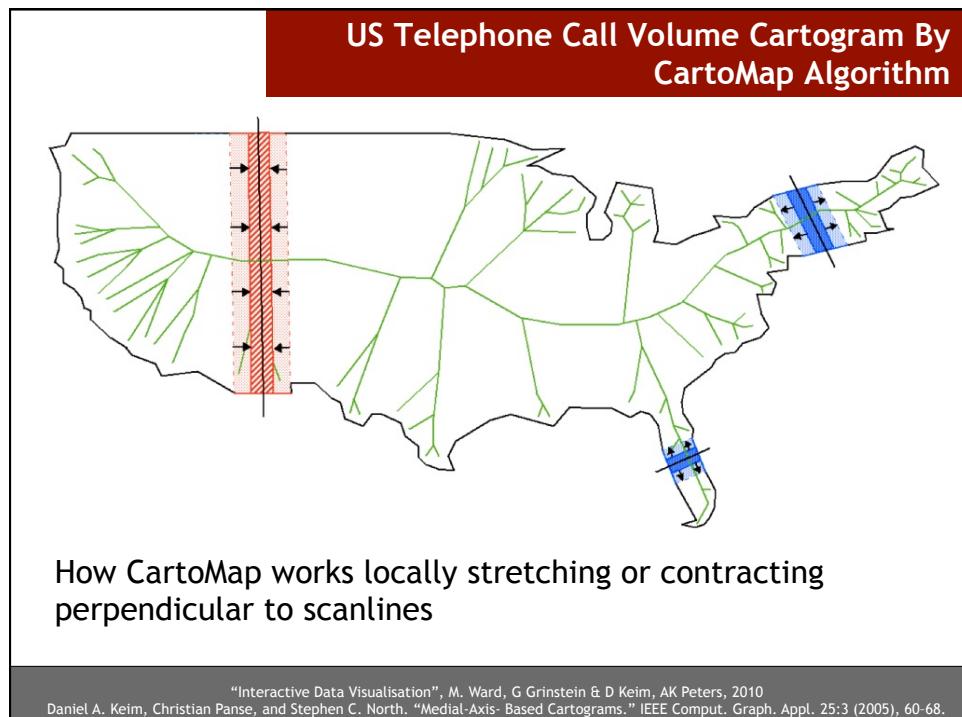
"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010
Daniel A. Keim, Christian Panse, and Stephen C. North. "Medial-Axis- Based Cartograms." IEEE Comput. Graph. Appl. 25:3 (2005), 60-68.

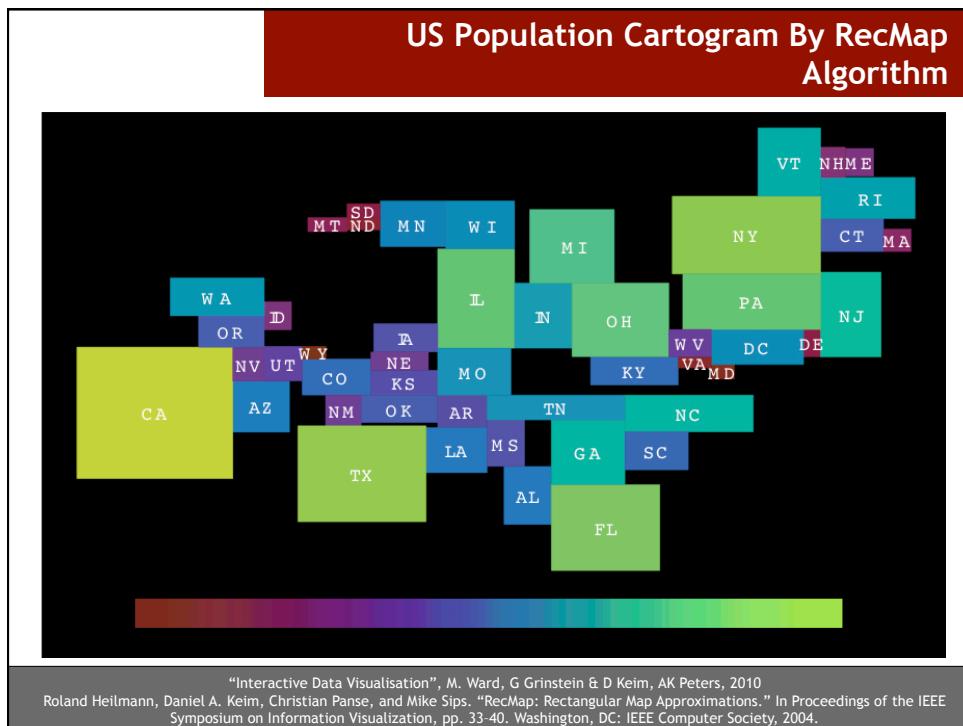
US Telephone Call Volume Cartogram By CartoMap Algorithm



Iteratively stretch and contract polygons perpendicular to the scanlines checking how many constraints are broken

"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010
Daniel A. Keim, Christian Panse, and Stephen C. North. "Medial-Axis- Based Cartograms." IEEE Comput. Graph. Appl. 25:3 (2005), 60-68.





**VISUALISING CHANGE IN
GEOSPATIAL DATA**

Small Multiple Mapping

MULTIPLE MAPS

Placing smaller maps together can help show patterns.



"Visualize This", N. Yau, Wiley, 2011

<http://shop.oreilly.com/product/0636920022060.do>

Small Multiple Mapping

UNEMPLOYMENT, 2004 to 2009



Source: Bureau of Labor Statistics / Created by: FlawingData, http://flawingdata.com

"Visualize This", N. Yau, Wiley, 2011

<http://shop.oreilly.com/product/0636920022060.do>

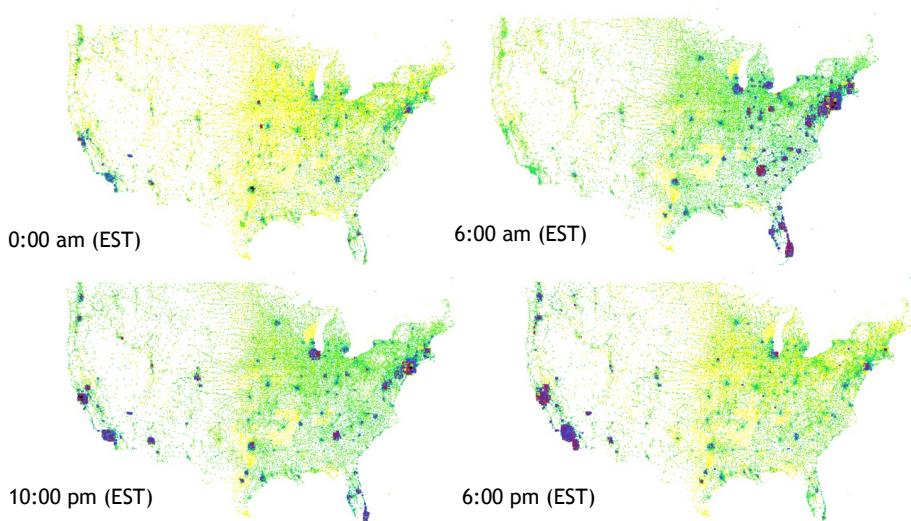
Small Multiple Mapping



"Visualize This", N. Yau, Wiley, 2011

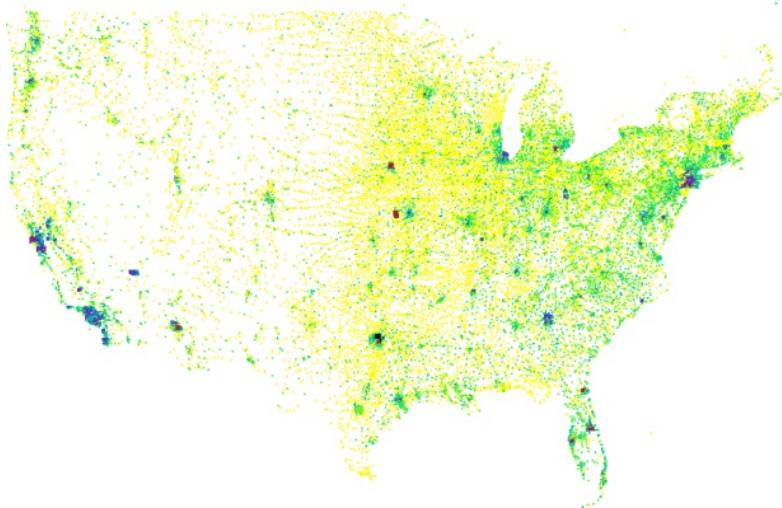
<http://shop.oreilly.com/product/0636920022060.do>

US Call Volume Over Time



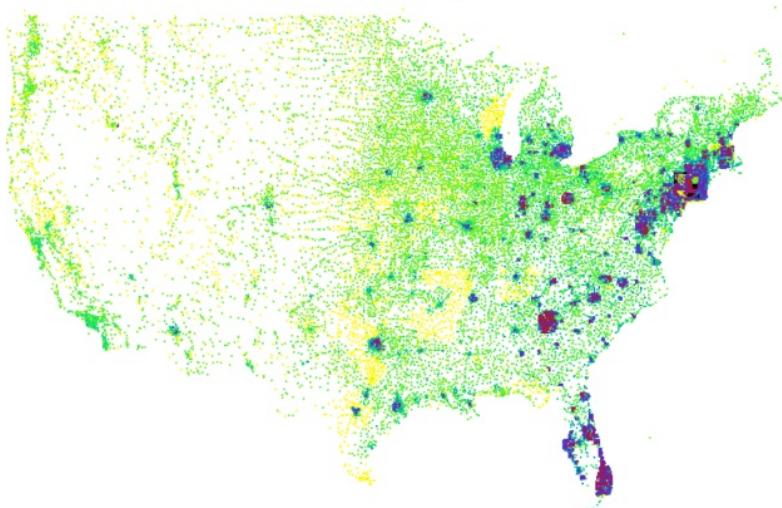
Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

US Call Volume Over Time



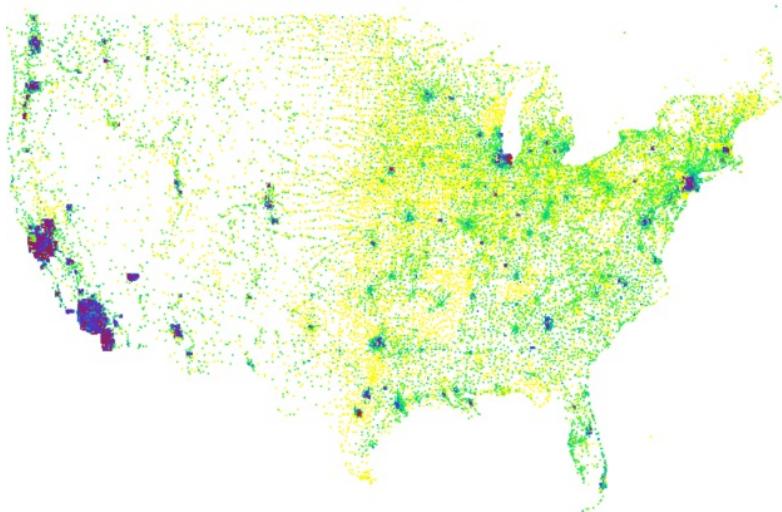
Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

US Call Volume Over Time



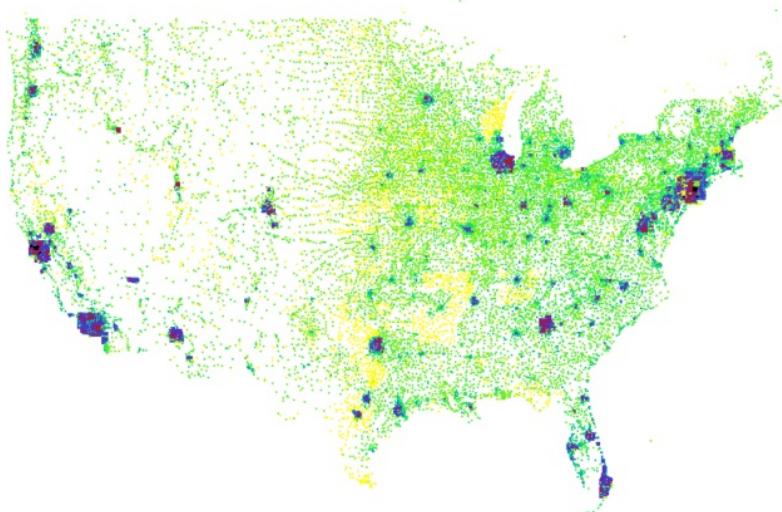
Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

US Call Volume Over Time



Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

US Call Volume Over Time

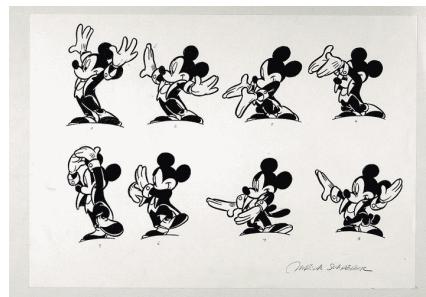


Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, pp. 201-215. Berlin: Springer, 2003.
<http://www.sciencedirect.com/science/article/pii/S0097849304000263>

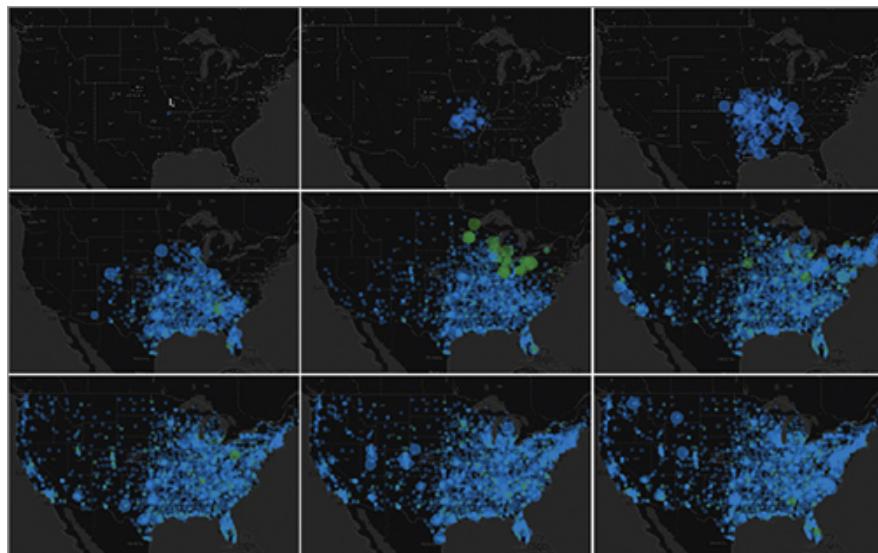
Animation

One obvious way to visualize changes over space and time is to animate your data

This keeps the intuitiveness of the map, while allowing readers to explore the data on their own



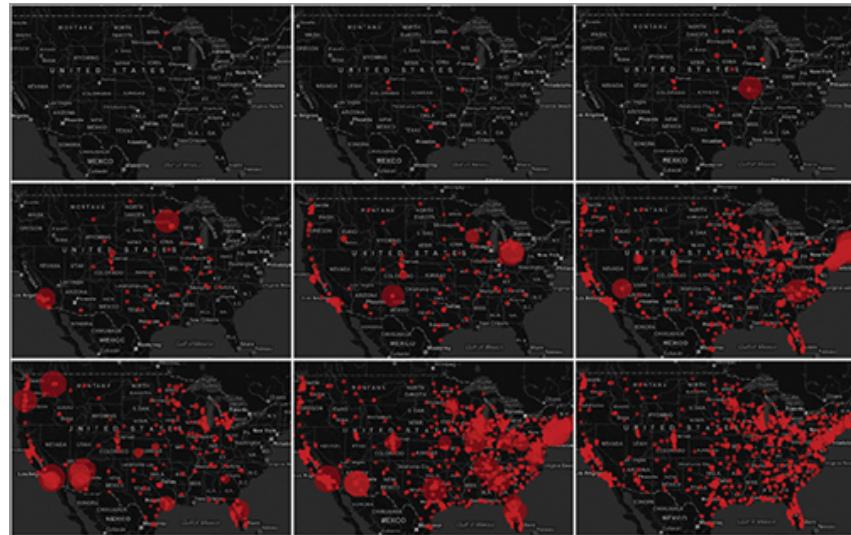
Animating the Growth of Walmart Stores



"Visualize This", N. Yau, Wiley, 2011

<http://projects.flowingdata.com/walmart/>

Animating the Growth of Target Stores



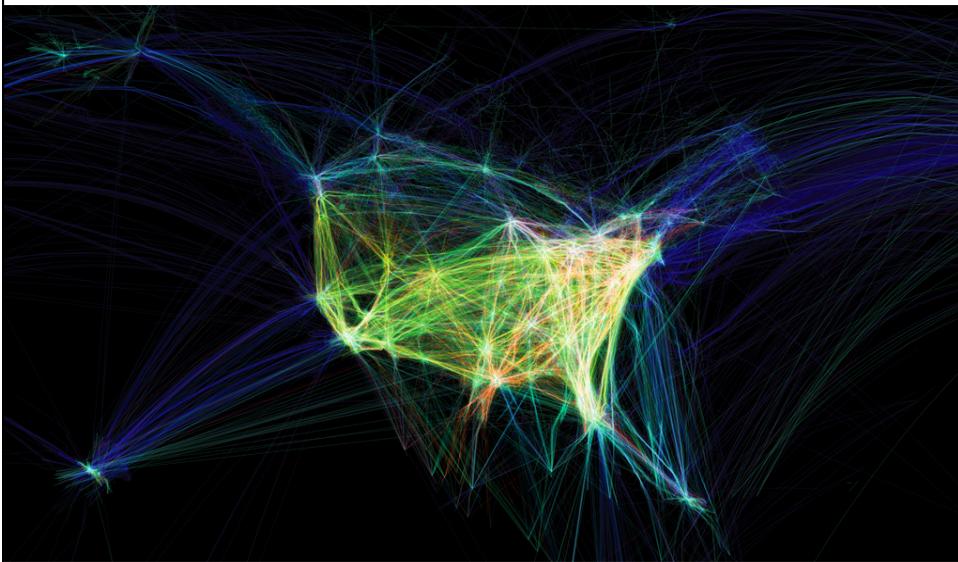
"Visualize This", N. Yau, Wiley, 2011
<http://projects.flowingdata.com/target/>

Why So Popular?

People are interested in using animated visualisations for two main reasons:

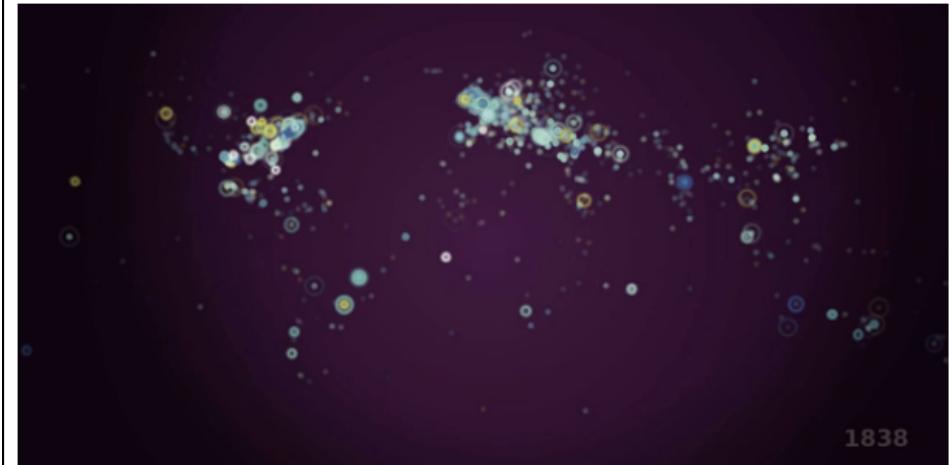
- The animated map enables you to see patterns that you wouldn't see with a time series plot
 - For example in the Walmart visualisation a regular plot would show only the number of store openings per year, but the animated maps show growth that's more organic
- The map is immediately understandable to a general audience
 - When the animation starts, you know what you're seeing.
 - Particularly suitable for the low time threshold for the web

Fight Patterns, Aaron Koblin



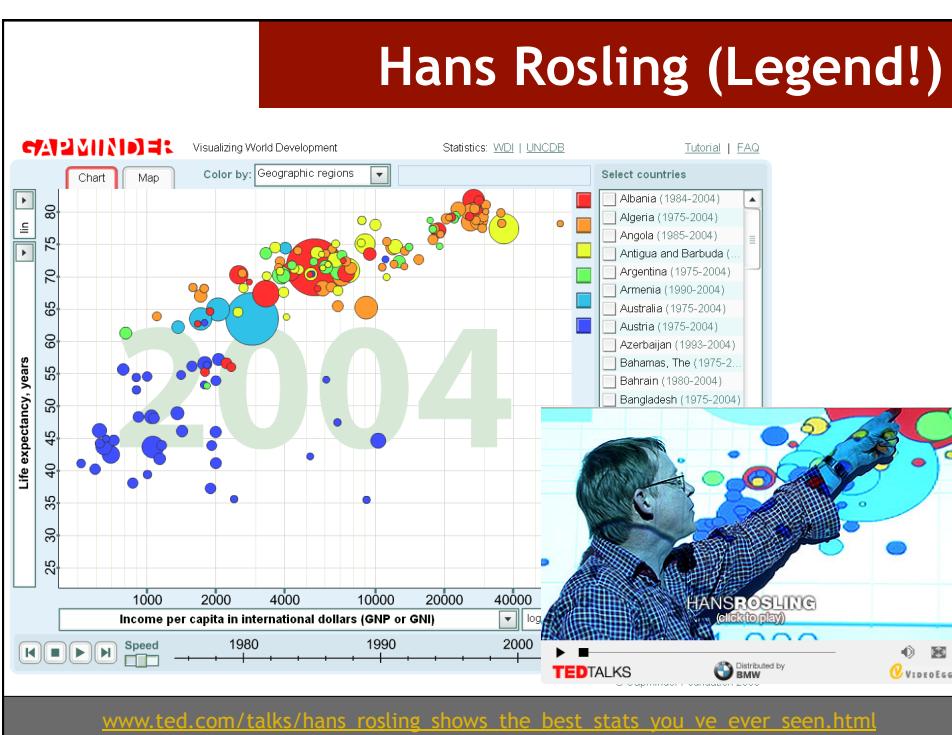
www.aaronkoblin.com/work/flightpatterns

A History Of The World



<http://www.ragtag.info/2011/feb/2/history-world-100-seconds/>

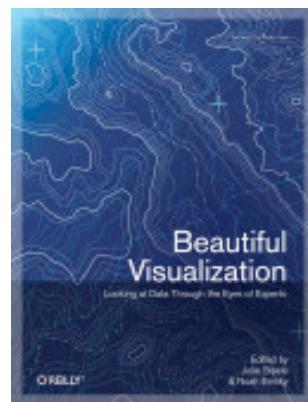
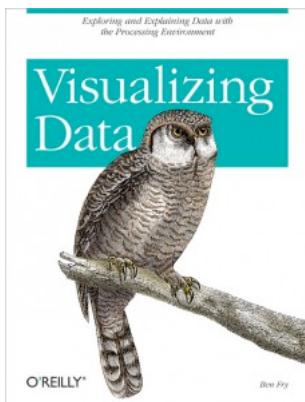
Hans Rosling (Legend!)



CONCLUSIONS

Deep Dives

Two chapters from these nice books give good deep dives on spatial visualisation



Conclusions

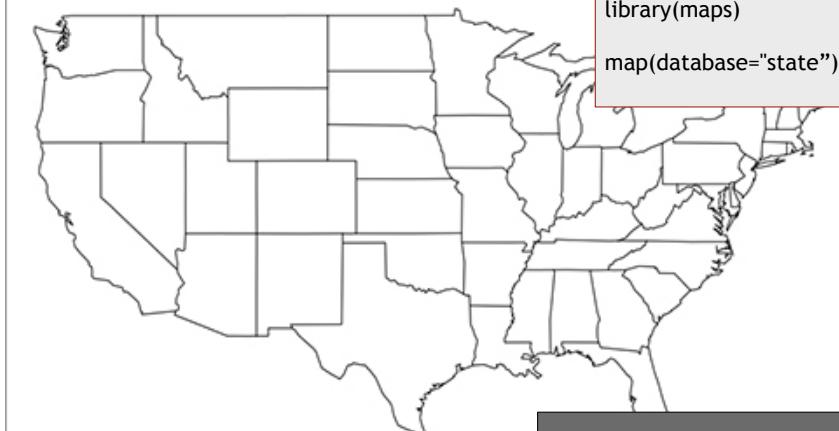
Maps offer us an opportunity to visualise data with a direct reference to geospatial parameters

Cartography has been around for a long time and is a very advanced field that goes way beyond data visualisation

- Thematic Cartography and Geovisualisation, Terry Slocum, Robert McMaster, Fritz Kessler & Hugh Howard
- Cartography - Visualization of Geospatial Data, Menno-Jan Kraak & Ferjan Ormel

MAP EXAMPLES IN R (EXTRA OPTIONAL MATERIAL)

Map By Dots

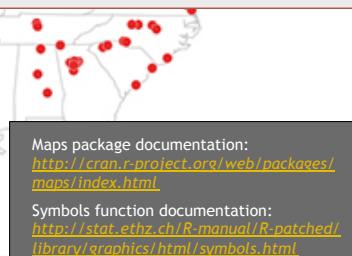


“Visualize This”, N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Dots



```
library(maps)  
  
costcos <- read.csv("costcos-geocoded.csv", sep=",")  
  
map(database="state", col="#cccccc")  
symbols( costcos$Longitude, costcos$Latitude,  
        bg="#e2373f", fg="#ffffff", lwd=0.5,  
        circles=rep(1, length(costcos$Longitude)),  
        inches=0.05, add=TRUE)
```



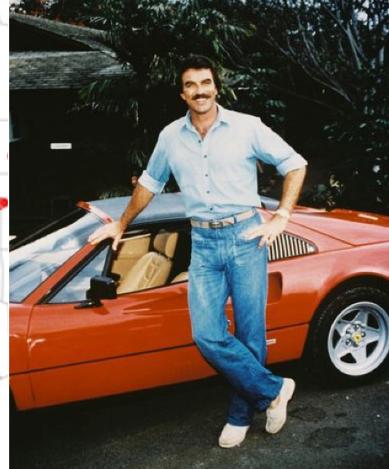
"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Anything Missing? (US Geography Question)



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Anything Missing? (US Geography Question)



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Alaska & Hawaii

Double-click to add graphics



► Click to add text



Aside



Alaska was purchased from Russia on March 30, 1867, for \$7.2 million (\$120 million in today's dollars). Became the 49th state of the U.S. on January 3, 1959

Aside



1778 British explorer James Cook was Hawaii's first documented contact with Europeans. Annexed by United States in 1898 as a territory. Became 50th state on August 21, 1959.

Map By Dots



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Dots

library(maps)

```
map(database="world", col="#cccccc")
symbols( costcos$Longitude, costcos$Latitude,
         bg="#e2373f", fg="#ffffff", lwd=0.3,
         circles=rep(1, length(costcos$Longitude)),
         inches=0.03, add=TRUE)
```

Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>

Symbols function documentation:
<http://stat.ethz.ch/R-manual/R-patched/library/graphics/html/symbols.html>

"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Ireland & UK



"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Ireland & UK

```
library(maps)  
  
map( database="world",  
      region=c("UK", "Ireland"),  
      xlim = range(c(3, -12)),  
      ylim = range(c(49, 61)))
```



Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>

"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Bubbles

```
library(maps)
fertility <- read.csv("adol-fertility.csv")
map('world', fill = FALSE, col = "#cccccc")
symbols(fertility$longitude, fertility$latitude,
        circles=sqrt(fertility$ad_fert_rate),
        add=TRUE, inches=0.15, bg="#93ceef",
        fg="#ffffff")
```

Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>
Symbols function documentation:
<http://stat.ethz.ch/R-manual/R-patched/library/graphics/html/symbols.html>

"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Lines

```
faketrace <- read.csv("fake-trace.txt", sep="\t")
map(database="world", col="#cccccc")
lines(faketrace$longitude, faketrace$latitude,
      col="#bb4cd4", lwd=2)
symbols(faketrace$longitude, faketrace$latitude,
        lwd=1, bg="#bb4cd4", fg="#ffffff",
        circles=rep(1, length(faketrace$longitude)),
        inches=0.05, add=TRUE)
```

Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>
Symbols function documentation:
<http://stat.ethz.ch/R-manual/R-patched/library/graphics/html/symbols.html>

"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Lines

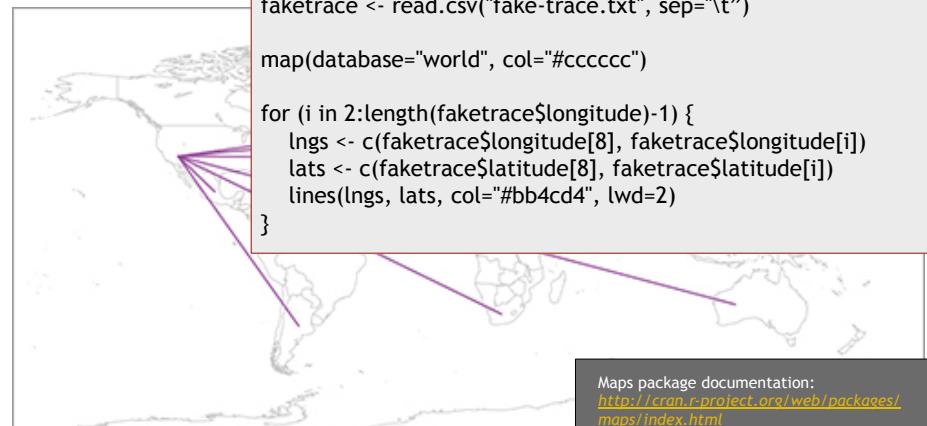


"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Map By Lines

```
faketrace <- read.csv("fake-trace.txt", sep="\t")
map(database="world", col="#cccccc")

for (i in 2:length(faketrace$longitude)-1) {
  lngs <- c(faketrace$longitude[8], faketrace$longitude[i])
  lats <- c(faketrace$latitude[8], faketrace$latitude[i])
  lines(lngs, lats, col="#bb4cd4", lwd=2)
}
```



Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>

Symbols function documentation:
<http://stat.ethz.ch/R-manual/R-patched/library/graphics/html/symbols.html>

"Visualize This", N. Yau, Wiley, 2011
<http://shop.oreilly.com/product/0636920022060.do>

Great Circles

```
library(maps)
library(geosphere)

lat_dub <- 53.29          lon_dub <- -6.24
lat_lon <- 51.5           lon_lon <- -0.09
lat_cork <- 51.87         lon_cork <- -8.47
inter <- gcIntermediate(c(lon_dub, lat_dub),
                        c(lon_lon, lat_lon),
                        n=50, addStartEnd=TRUE)
inter2 <- gcIntermediate(c(lon_dub, lat_dub),
                        c(lon_cork, lat_cork),
                        n=50, addStartEnd=TRUE)
lines(inter)
lines(inter2, col="red")
```

Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>

Geosphere package documentation:
<http://cran.r-project.org/web/packages/geosphere/geosphere.pdf>

A Very Simple Map



A Very Simple Map



Maps package documentation:
<http://cran.r-project.org/web/packages/maps/index.html>

Symbols function documentation:
<http://stat.ethz.ch/R-manual/R-patched/library/graphics/html/symbols.html>

```
library(maps)

mapData <- map(database="world", region=c("UK", "Ireland"), plot=FALSE)

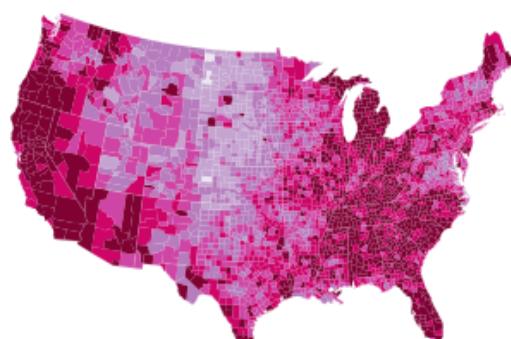
cols <- 1:length(mapData$names)
for(i in 1:length(mapData$names)){
  if(substr(mapData$names[i], 1, 2) == "UK"){
    cols[i] <- "#0000ff"
  }else{
    cols[i] <- "#00ff00"
  }
}

mapData <- map(database="world", region=c("UK", "Ireland"),
               plot=TRUE, col = cols, fill=TRUE, bg="white",
               lwd=0.05, xlim = c(-12, 3), ylim = c(49, 61))
```

A Better Example

US Unemployment By County, 2009

4-6% ■ 6-8% ■ 8-10% ■ >10%



This is the Green Room, Choropleths in R (yes, "choropleths")
<http://www.thisisthegreenroom.com/2009/choropleths-in-r/>

A Better Example

```
library(maps)

data(unemp)
data(county.fips)

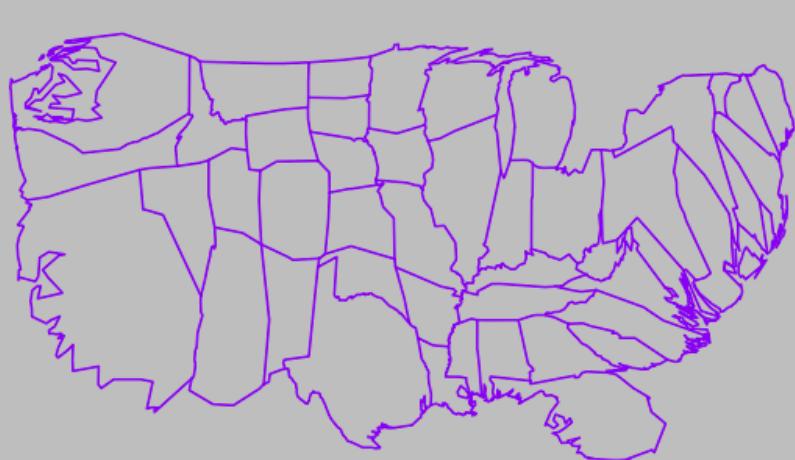
# define color buckets
colors = c("#F1EEF6", "#D4B9DA", "#C994C7", "#DF65B0", "#DD1C77", "#980043")
unemp$colorBuckets <- as.numeric(cut(unemp$unemp, c(0, 2, 4, 6, 8, 10, 100)))
leg.txt <- c("<2%", "2-4%", "4-6%", "6-8%", "8-10%", ">10%")

# align data with map definitions by matching FIPS codes
colorsmatched <- unemp$colorBuckets [match(county.fips$fips, unemp$fips)]

# draw map
map("county", col = colors[colorsmatched], fill = TRUE, resolution = 0,
     lty = 0, projection = "polyconic")
map("state", col = "white", fill = FALSE, add = TRUE, lty = 1, lwd = 0.2,
     projection="polyconic")
title("US Unemployment By County, 2009")
legend("topright", leg.txt, horiz = TRUE, fill = colors)
```

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Cartograms in R



"Interactive Data Visualisation", M. Ward, G Grinstein & D Keim, AK Peters, 2010
Roland Heilmann, Daniel A. Keim, Christian Panse, and Mike Sips. "RecMap: Rectangular Map Approximations." In Proceedings of the IEEE Symposium on Information Visualization, pp. 33-40. Washington, DC: IEEE Computer Society, 2004.