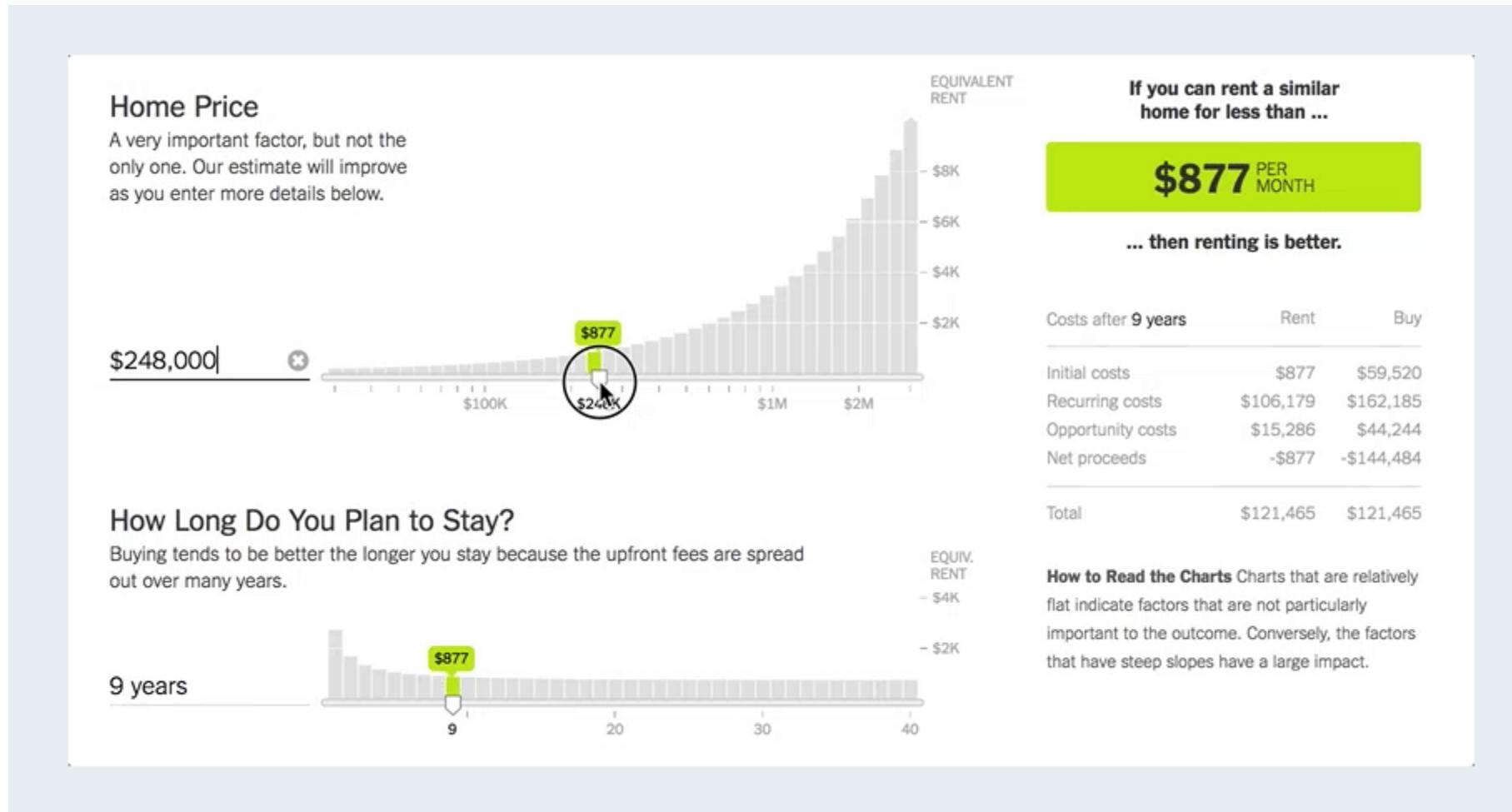


Visualization. Introduction

Pere-Pau Vázquez

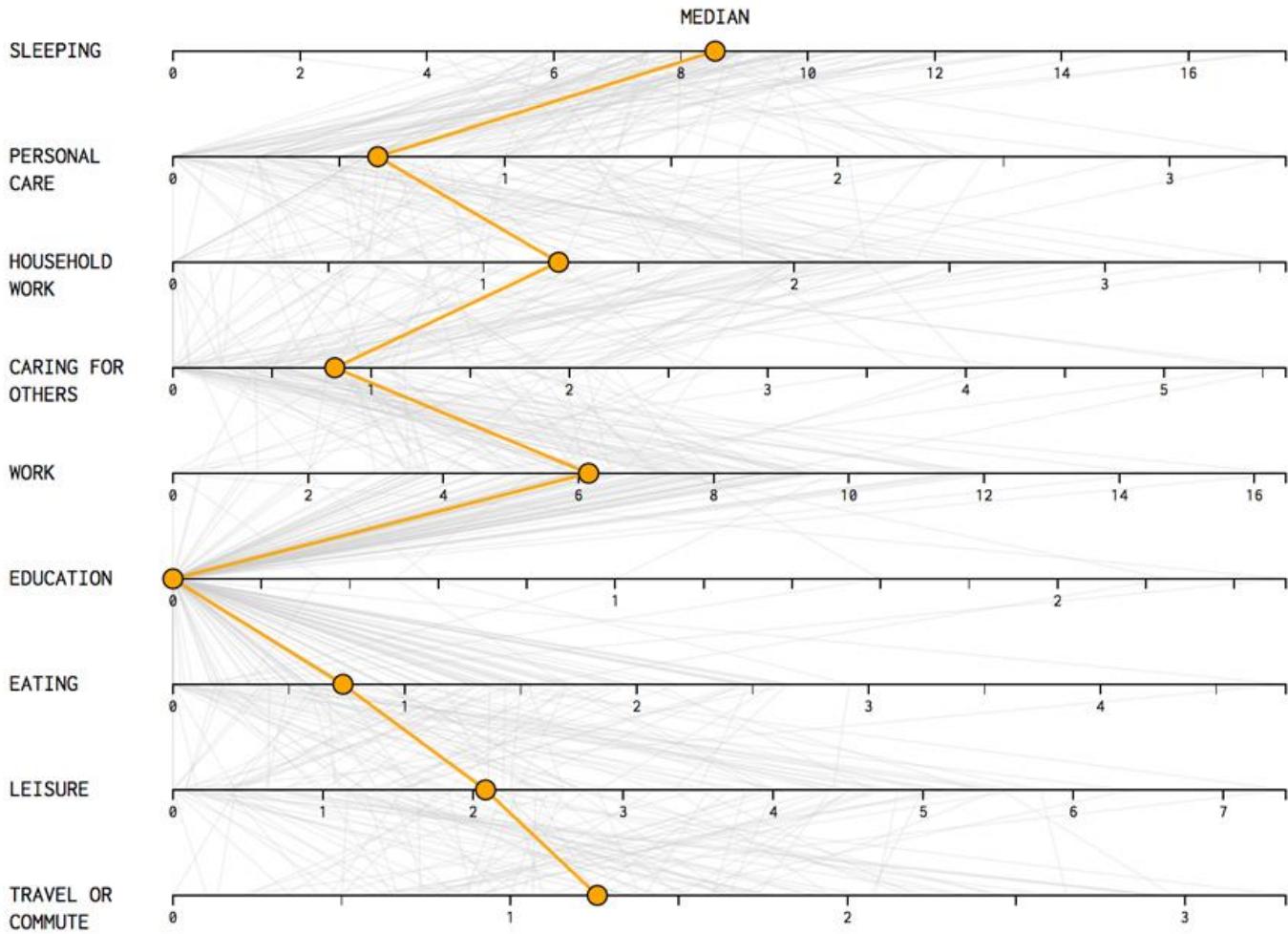
Dep. Computer Science – UPC

Visualization examples



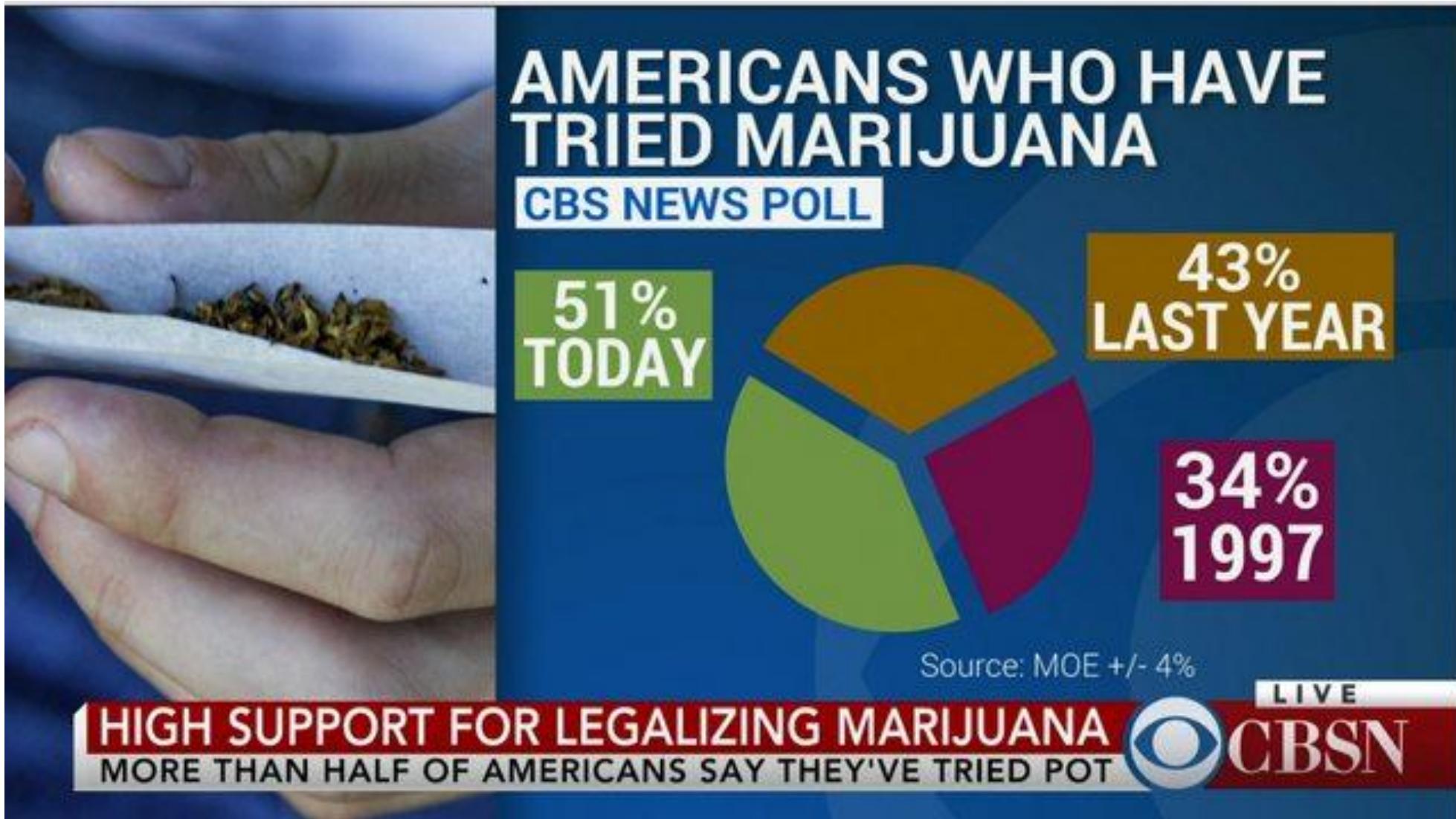
I am female 25 to 44 years old and employed

Show me the hours spent on a weekday

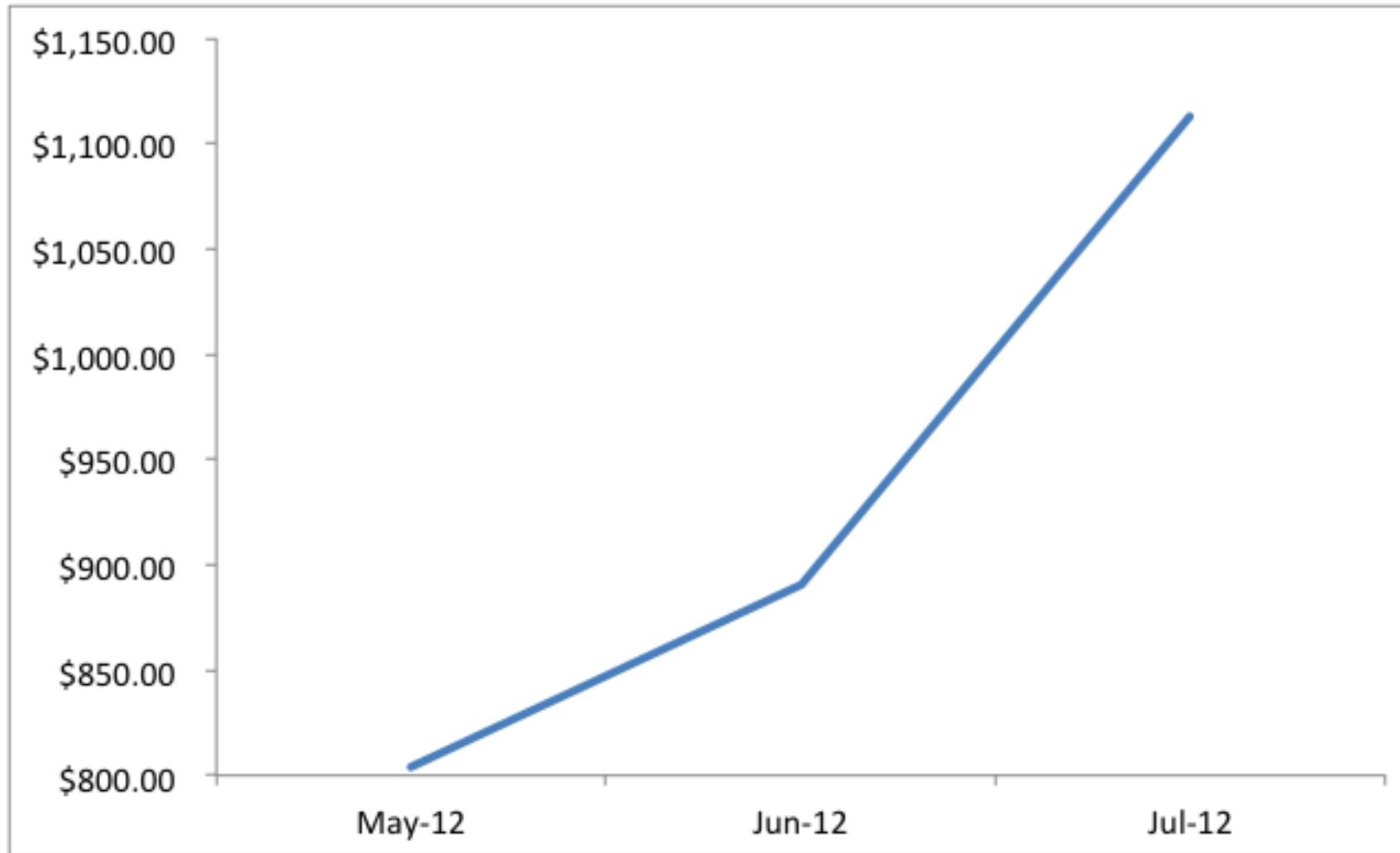


SCALE: Relative Absolute

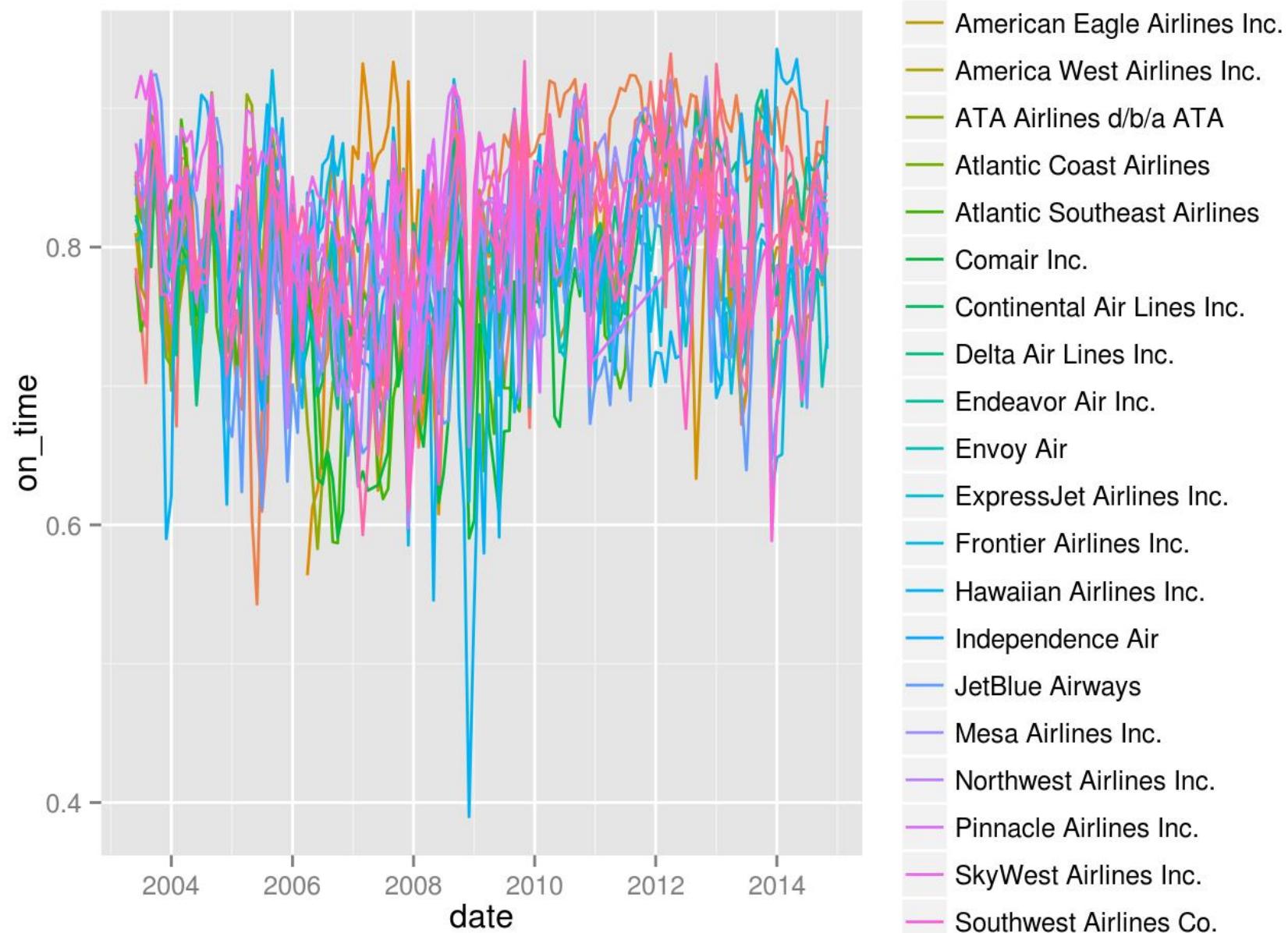
... but not everything is good Visualization



... but not everything is good Visualization

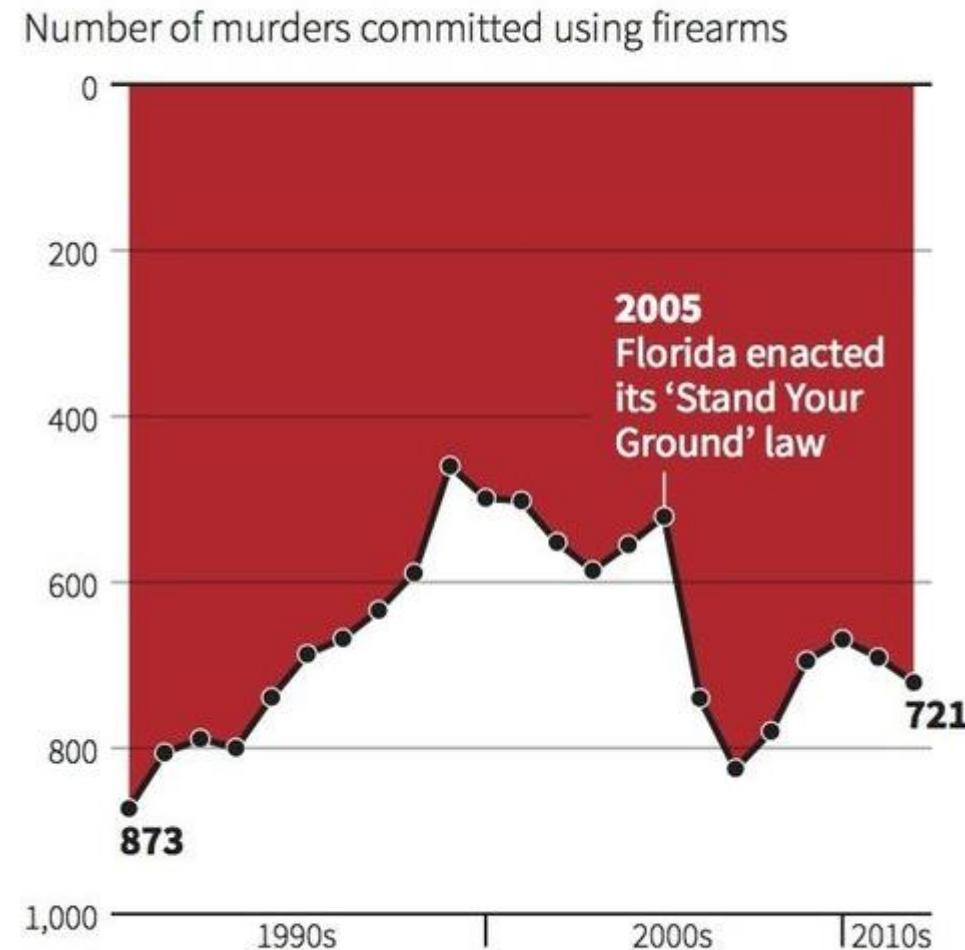


... but not everything is good Visualization



... but not everything is good Visualization

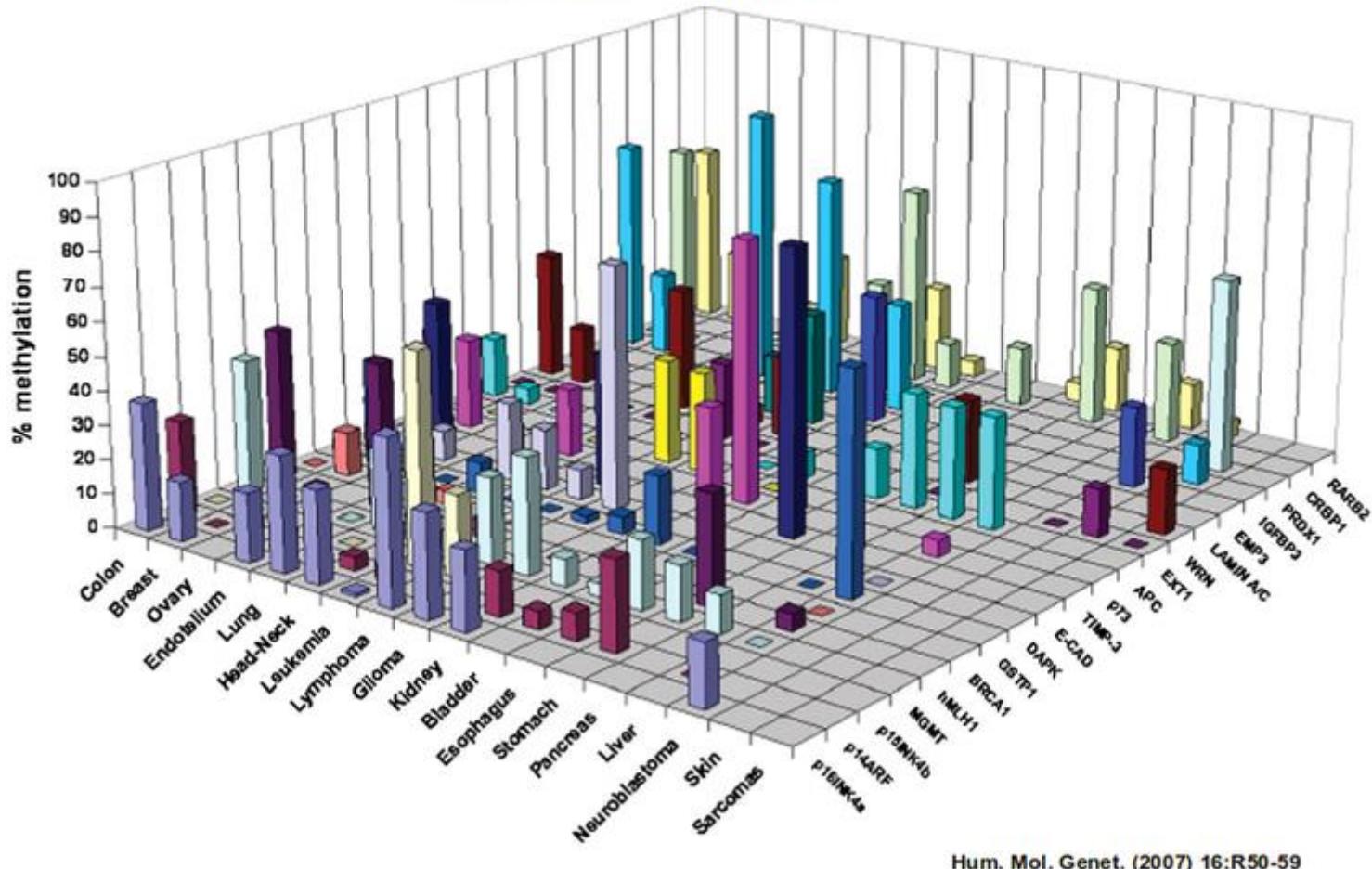
Gun deaths in Florida



Source: Florida Department of Law Enforcement

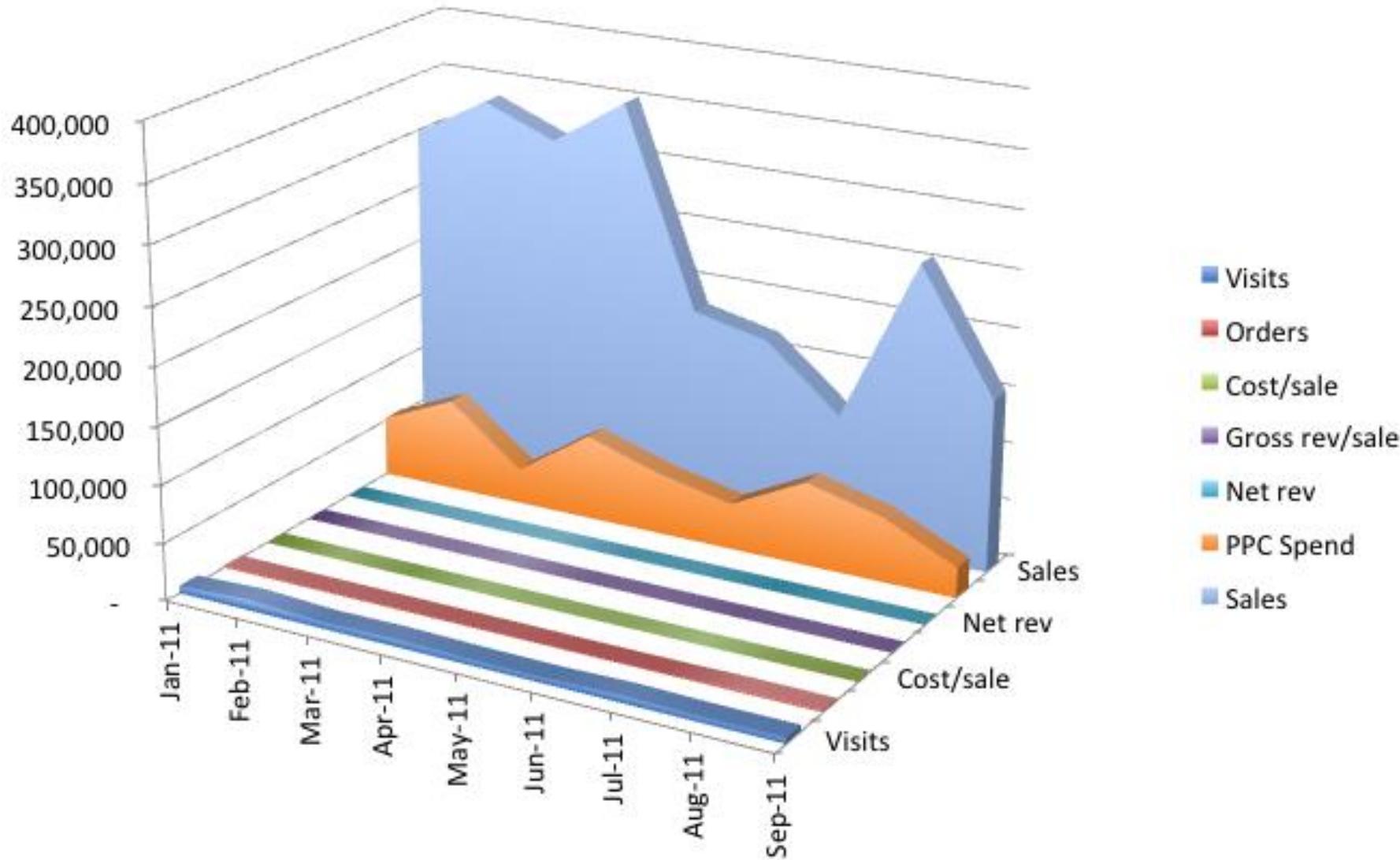
... but not everything is good Visualization

A CpG Island Hypermethylation Profile of Human Cancer

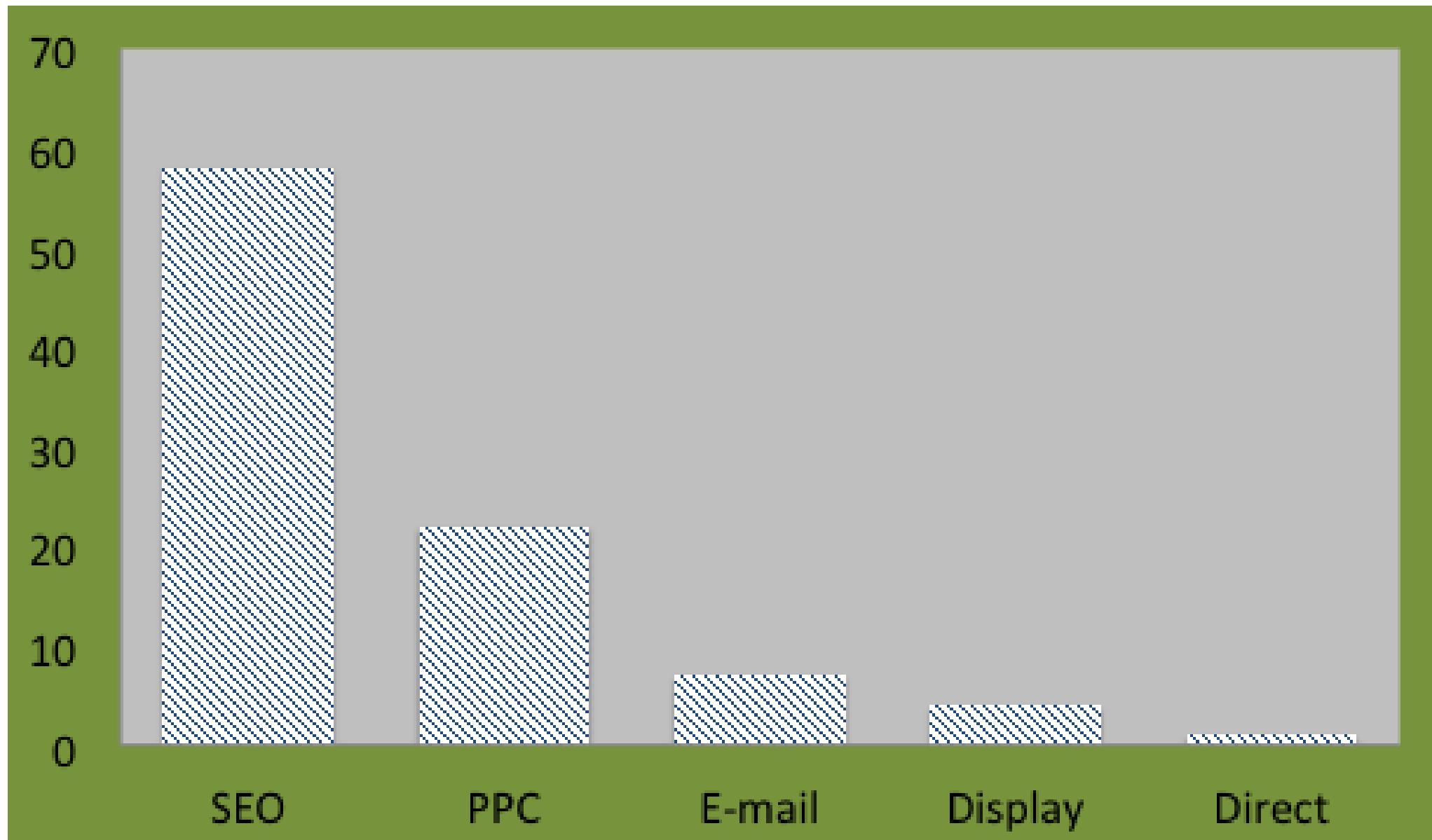


Hum. Mol. Genet. (2007) 16:R50-59

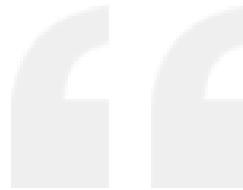
... but not everything is good Visualization



... but not everything is good Visualization

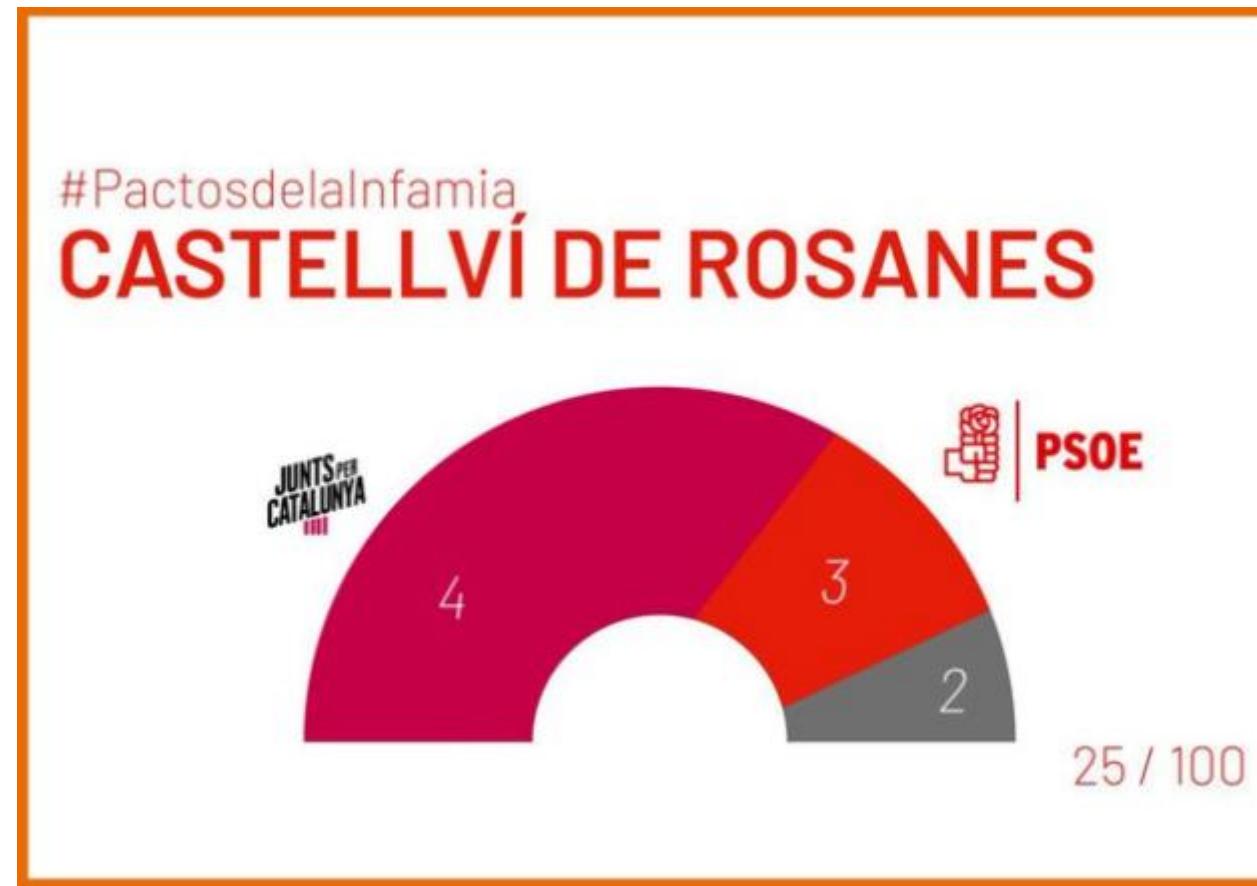


... sometimes Visualization is intended to lie



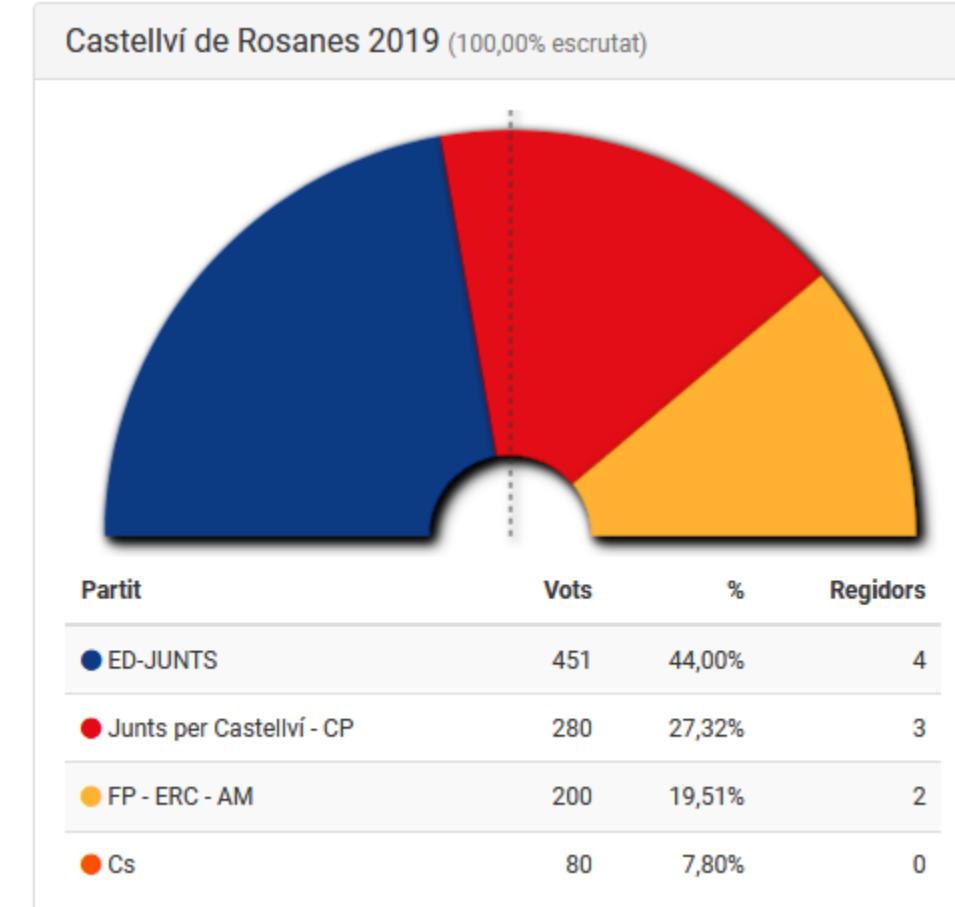
- ➡ *Siempre que puede, Sánchez pacta con nacionalistas.*
- ➡ *Nadie le obliga: en Navarra, el PSOE podría favorecer al constitucionalismo y ha preferido pactar con Geroa Bai y Bildu.*
- ➡ *No es el único caso, hay al menos 100 #PactosDeLaInfamia.*
- ➡ *;Abre hilo! <https://t.co/ra95Cx5G5p> pic.twitter.com/KGFqHyHYFd*
- *Ciudadanos ESEU (@CiudadanosCs) 23 de junio de 2019*

... sometimes Visualization is intended to lie



"No hay manera de hacer que se aparten de los independentistas"

... sometimes Visualization is intended to lie





✳️ Al PSOE le faltaba un concejal para formar gobierno en Vila-real...

❓ ¿Socio prioritario?

🍆 Los populistas

#PactosDeLaInfamia

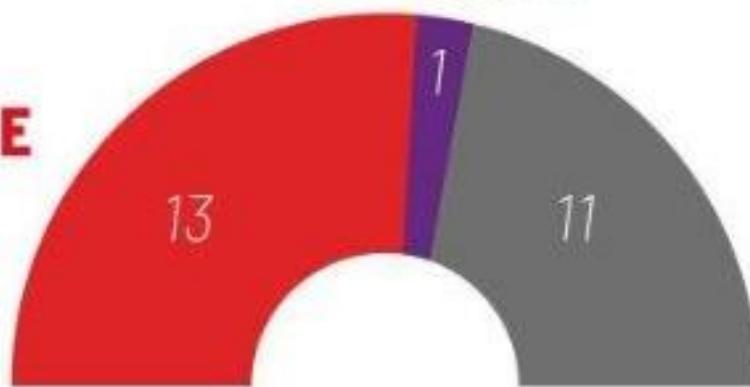
#PactosdeLaInfamia

VILA-REAL



PSOE

UNIDAS
PODEMOS



92 / 100

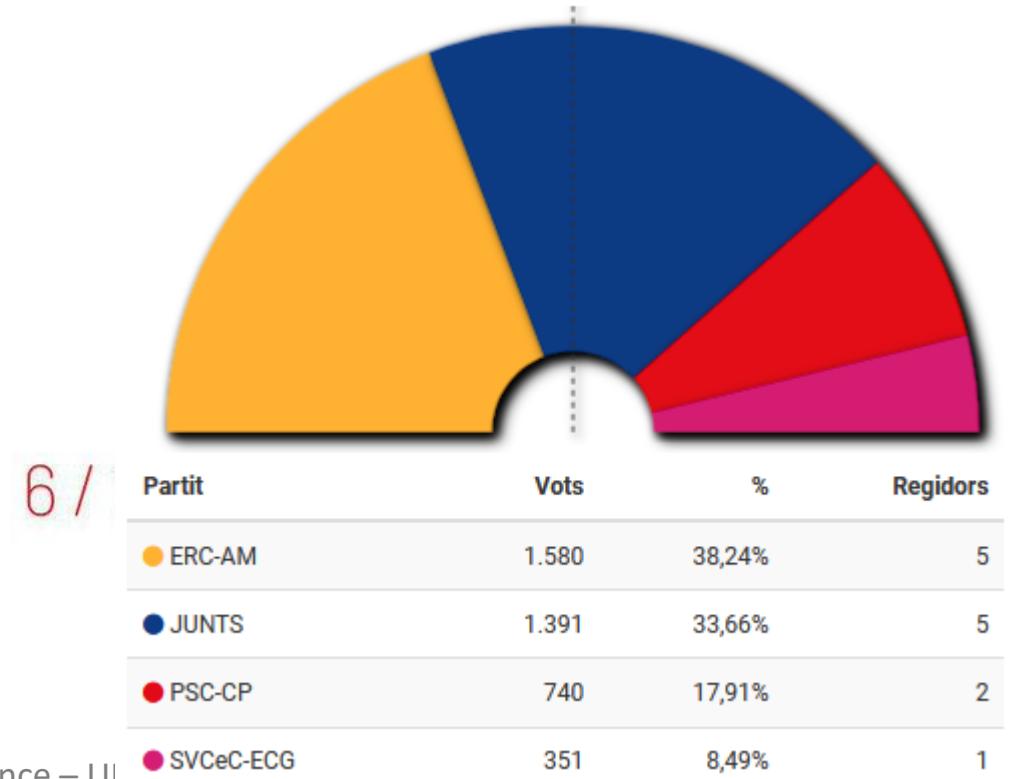
... sometimes Visualization is intended to lie

#PactosdelalInfamia

SANT VICENÇ DE CASTELLET



Sant Vicenç de Castellet 2019 (100,00% escrutat)

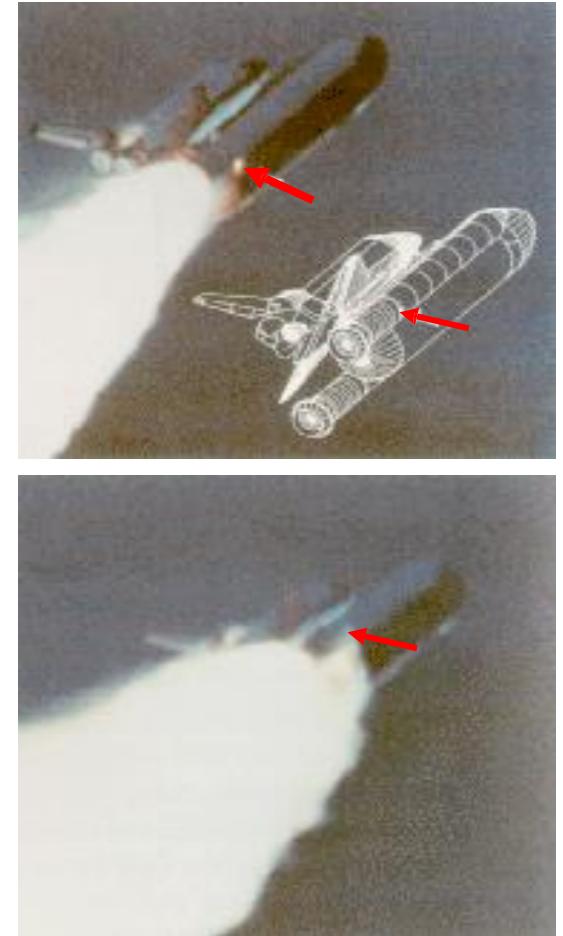


Visualization

- Visualization may have an impact
 - January 27th, 1986, the Challenger launch
 - <https://www.youtube.com/watch?v=j4JOjcDFtBE>

Visualization

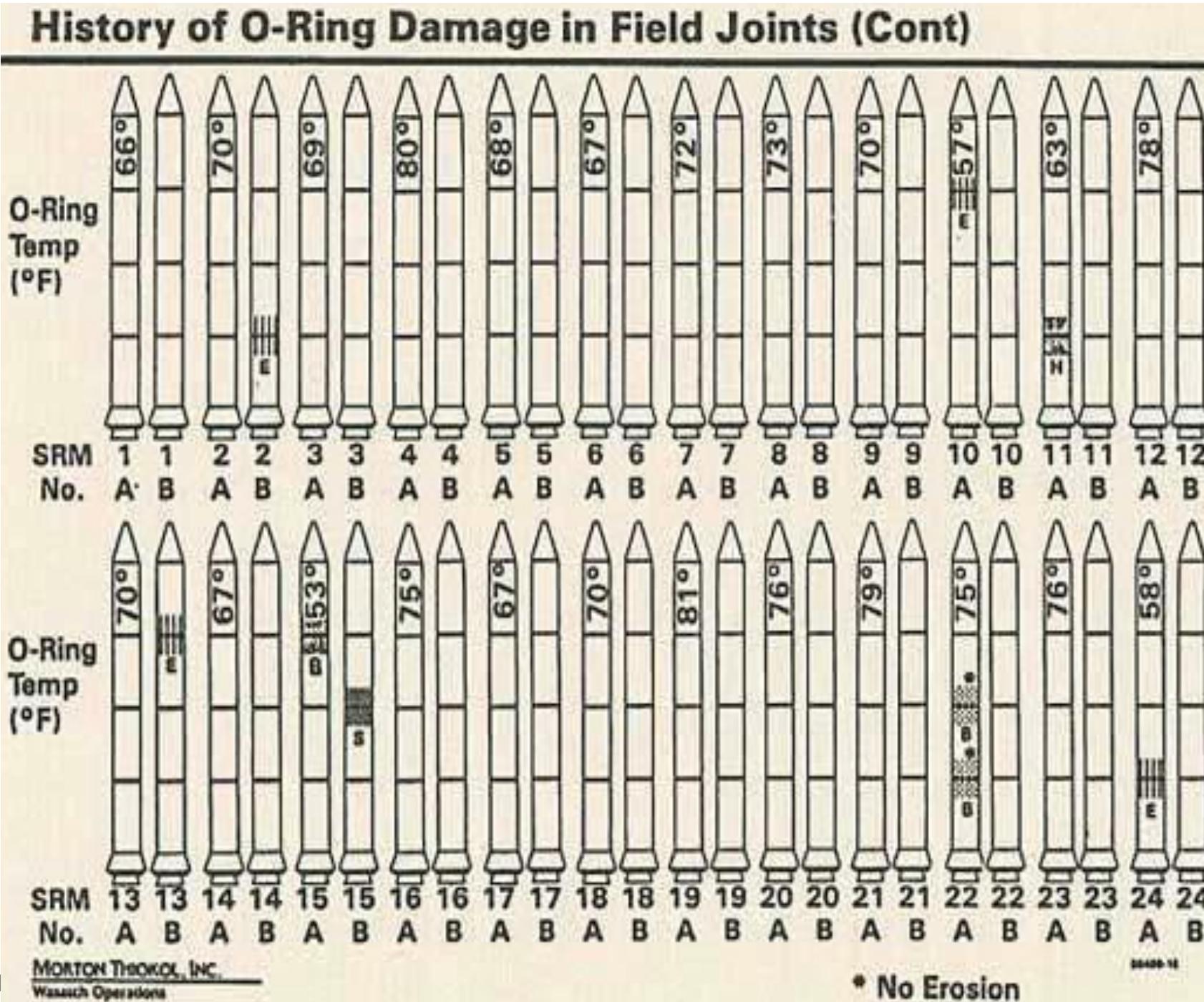
- The Challenger Disaster
 - January 27th, 1986, the Challenger explodes 72 seconds after launch
 - Reason:
 - Sealing-rings in the right booster were damaged due to weather conditions
 - Reliability-Problems of the so-called O-rings were known



Visualization

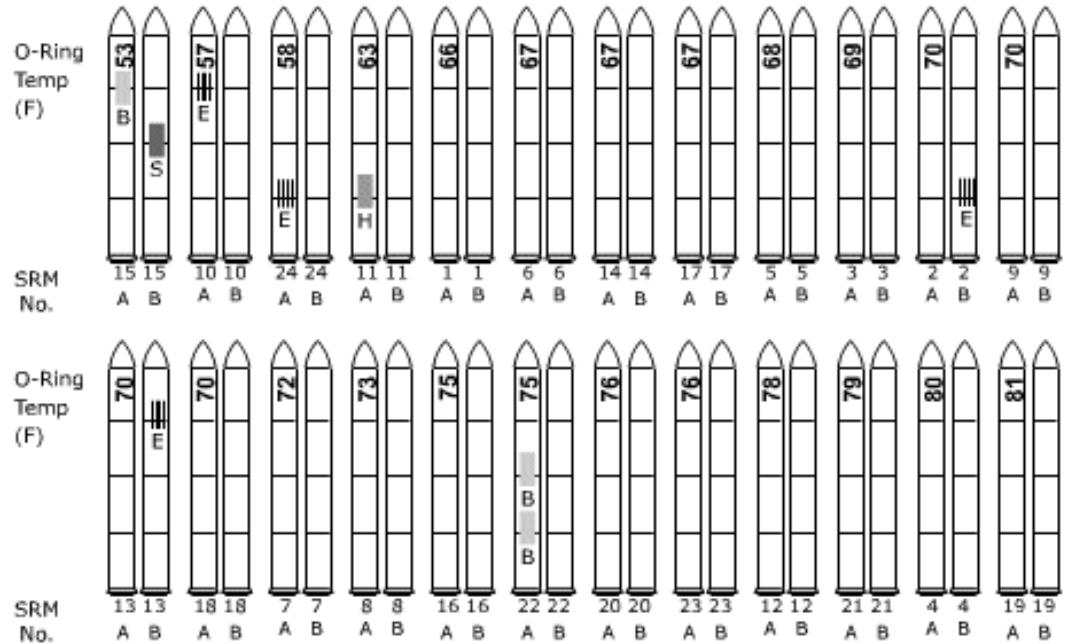
- The Challenger Disaster
 - The manufacturer of the boosters warned NASA before launch that the expected cold temperatures might be an extra risk.
 - NASA did not see any correlation between the failing of O-Rings and the temperatures.
 - This was wrong!
- Edward R. Tufte showed that the risk would have been obvious to NASA engineers if a better visualization would have been used

- The Challenger Disaster
 - Information prepared for oral discussion



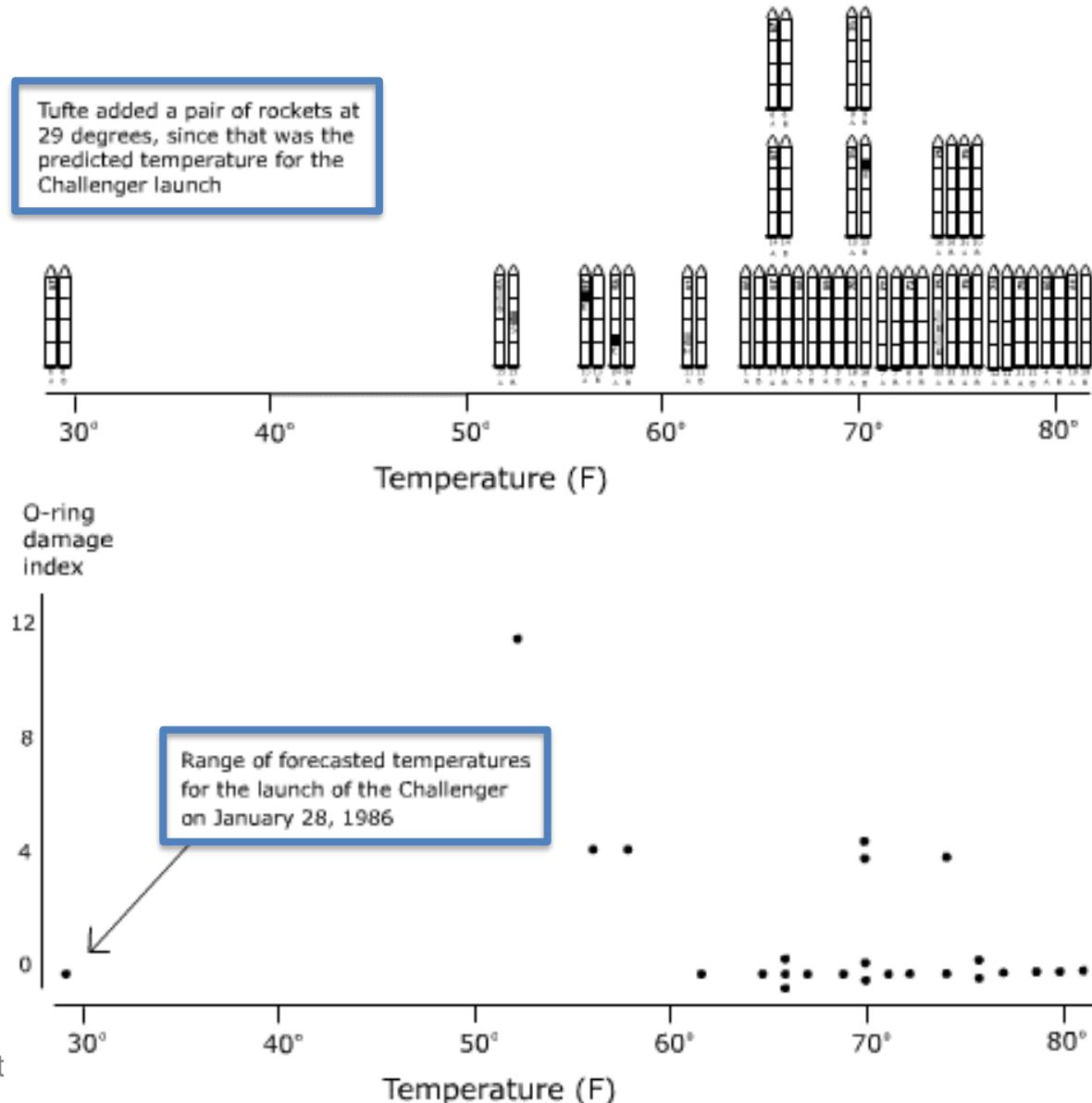
Visualization

- The Challenger Disaster
 - Added charts (by E. Tufte)



Pere-Pau Vázquez – Dep. Comput

Tufte added a pair of rockets at 29 degrees, since that was the predicted temperature for the Challenger launch



Visualization

- The Challenger Disaster. Take-away:
 - Engineers' charts were too much simplified
 - Though they had been arguing against further launches (at any temperatures) due to faults in O-rings seals
 - Tufte's criticism is also not complete
 - Temperature was only one factor
- Further information:
 - <https://eagereyes.org/criticism/tufte-and-the-truth-about-the-challenger>
 - <http://people.rit.edu/wlrgsh/FINRobison.pdf>

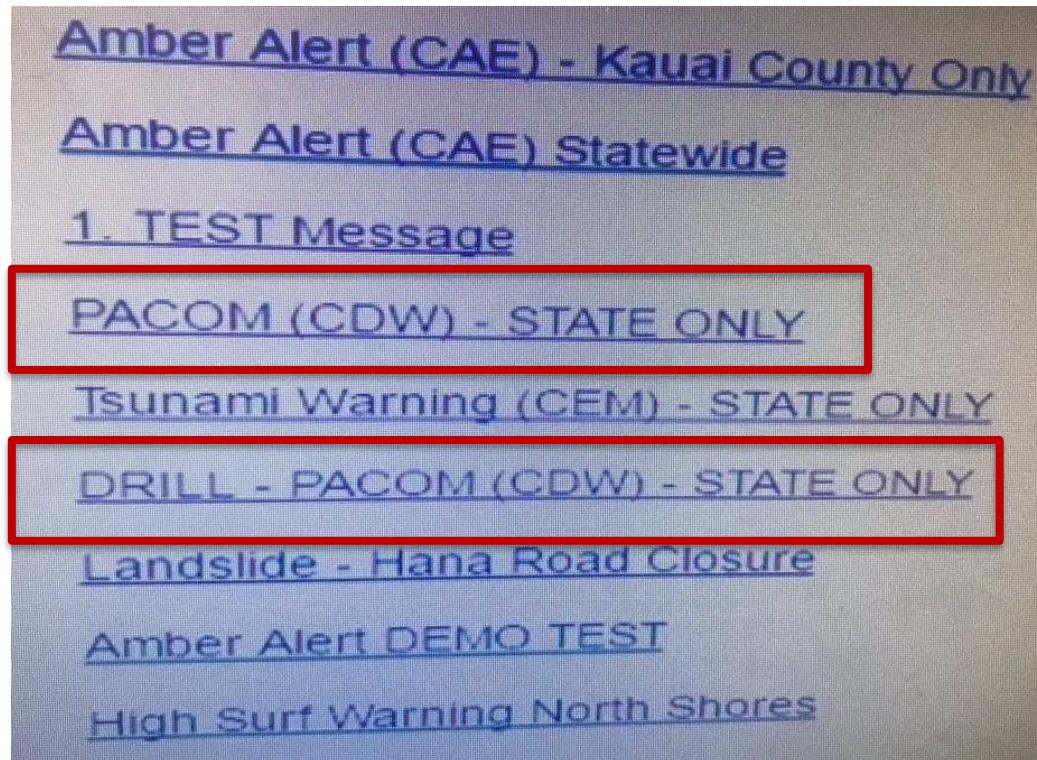
Visualization

- Modern example: Hawaii Missile Emergency
 - On January 13th, 2018, a false ballistic missile alert was issued over television, radio, and cellphones in the US state of Hawaii



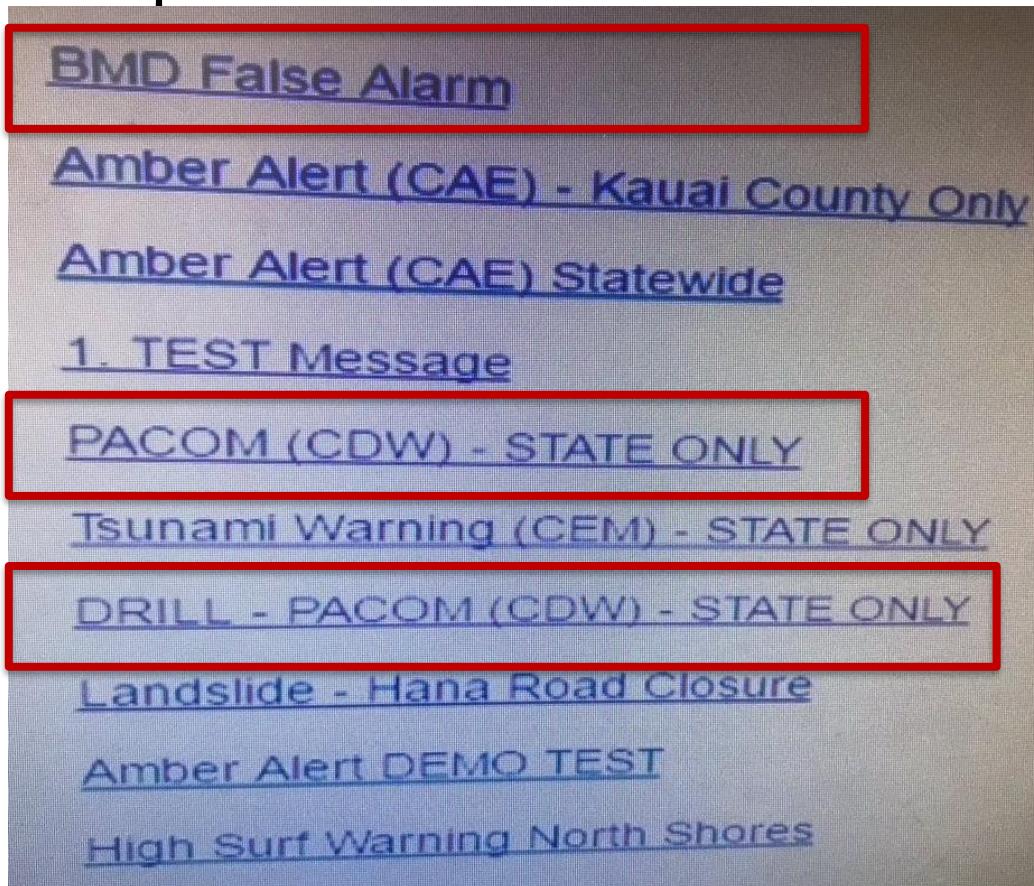
Visualization

- Modern example: Hawaii Missile Emergency
 - It was a mistake due to poorly designed UI.
 - Look at these two menu options



Visualization

- Modern example: Hawaii Missile Emergency
 - UI now has a new option



Visualization

- Modern example: Hawaii Missile Emergency
 - Great example of wrong design in critical systems in the UI of the Hawaiian Emergency Management Agency (HEMA)
 - BTW, it now has its own Wikipedia page at:
https://en.wikipedia.org/wiki/2018_Hawaii_false_misile_alert

Outline

- *Examples*
- **Visualization. The basics**
- History of Visualization
- Visualization areas

Visualization. The basics

- Visualization is related to **understanding the underlying data**
 - Cognitive process
 - Gain understanding on data
 - Helping the user (human) to understand data

Visualization. The basics

- Visualization is related to **understanding the underlying data**
 - Cognitive process
 - Gain understanding on data
 - Helping the user (human) to understand data
- Visual representations help us understand
 - How?

Visualization. The basics

- Visual representations help us understand. How?
 - By augmenting human capabilities
 - Instead of replacing people with computational decision-making methods
 - Computer-based visualization systems provide visual representations of datasets designed to help **people** carry out tasks more effectively
 - Putting **human in the loop** is fundamental

Visualization. The basics

- Human in the loop needs the details [& no trusted automatic solution exists]
 - Doesn't know exactly what questions to ask in advance
 - Exploratory data analysis
 - speed up through human-in-the-loop visual data analysis
 - Present known results to others
 - Stepping stone towards automation
 - Before model creation to provide understanding
 - During algorithm creation to refine, debug, set parameters
 - Before or during deployment to build trust and monitor

Visualization. The basics

- If the result is a calculation, then you should probably not be using visualization at all.
 - If you know what you are looking for, you probably do not need the vis
 - Vis has human in the loop
- “*The purpose of computing is insight, not numbers*”

Richard Hamming, 1971

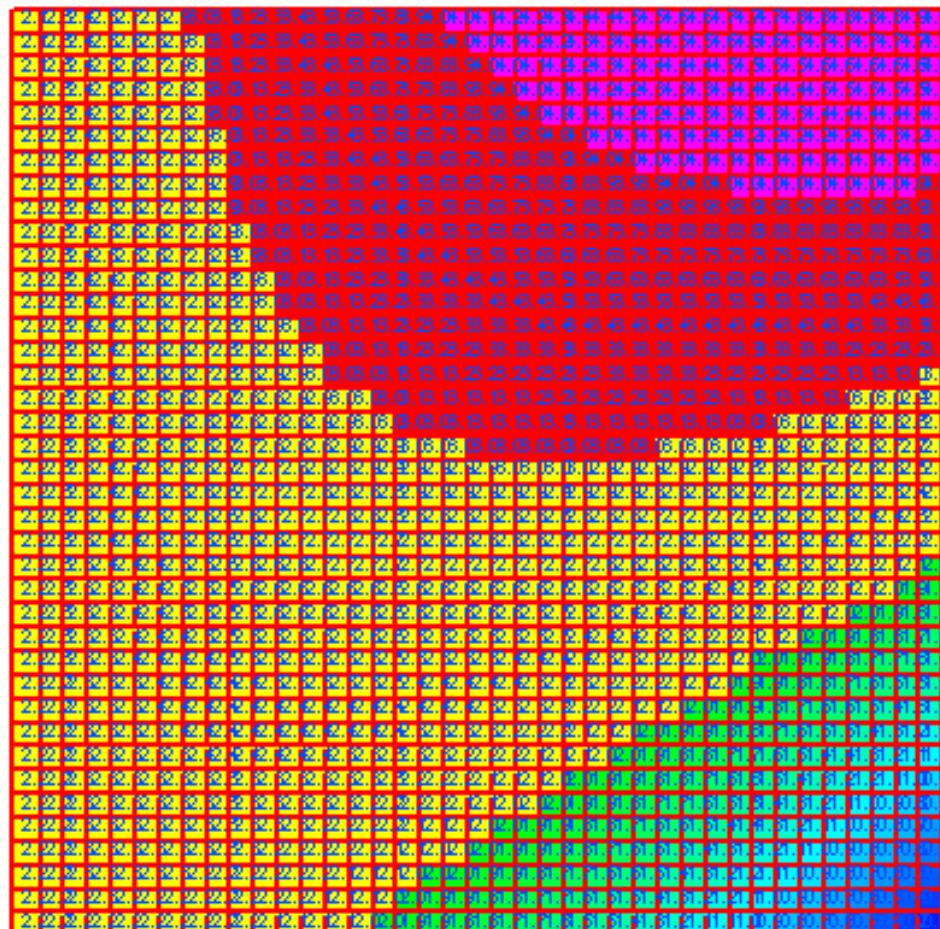
Visualization. The basics

- Try to get the domain from this:

1.3	1.8	2.2	2.6	3.0	3.3	3.6	3.9	4.1	4.3	4.4	4.5
1.3	1.8	2.2	2.5	2.9	3.2	3.4	3.6	3.8	4.0	4.1	4.1
1.4	1.8	2.1	2.5	2.7	3.0	3.2	3.4	3.5	3.7	3.7	3.8
1.4	1.7	2.1	2.4	2.6	2.8	3.0	3.2	3.3	3.3	3.4	3.4
1.4	1.7	2.0	2.3	2.5	2.7	2.8	2.9	3.0	3.0	3.0	3.0
1.4	1.7	2.0	2.2	2.4	2.5	2.6	2.7	2.7	2.7	2.7	2.6
1.5	1.7	1.9	2.1	2.3	2.4	2.4	2.5	2.5	2.4	2.3	2.2
1.5	1.7	1.9	2.0	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.9
1.5	1.7	1.8	1.9	2.0	2.1	2.0	2.0	1.9	1.8	1.7	1.5
1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.8	1.7	1.5	1.3	1.1
1.6	1.7	1.7	1.8	1.8	1.7	1.7	1.5	1.4	1.2	1.0	0.7
1.6	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.1	0.9	0.6

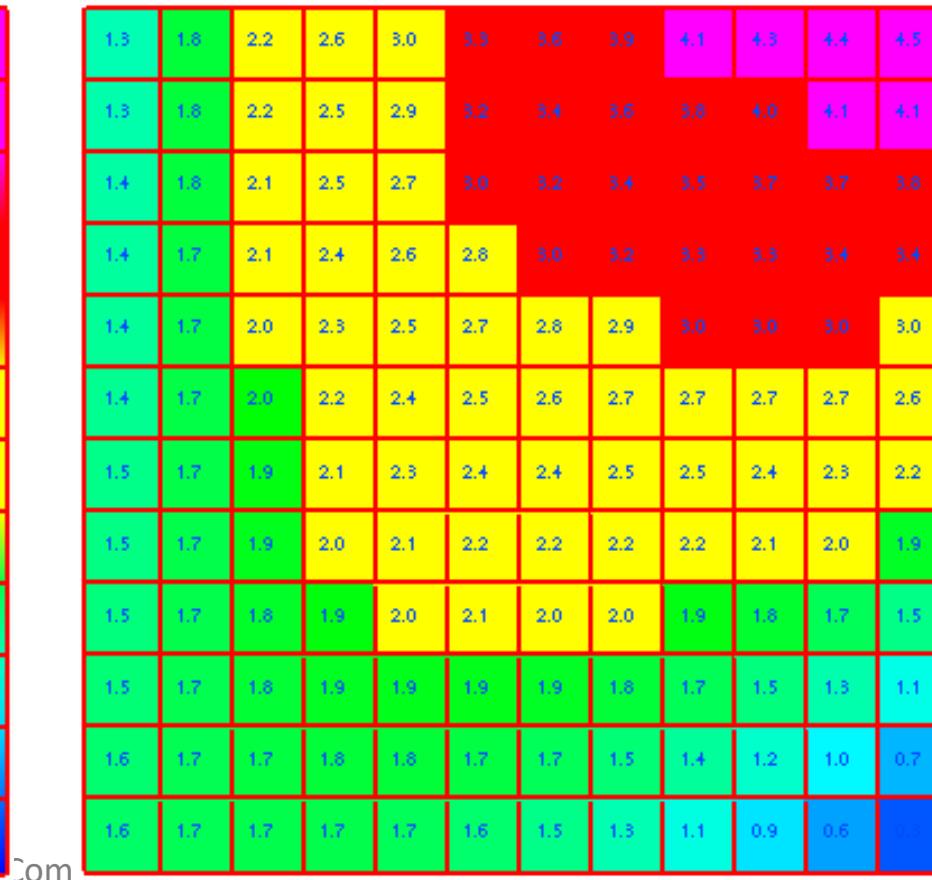
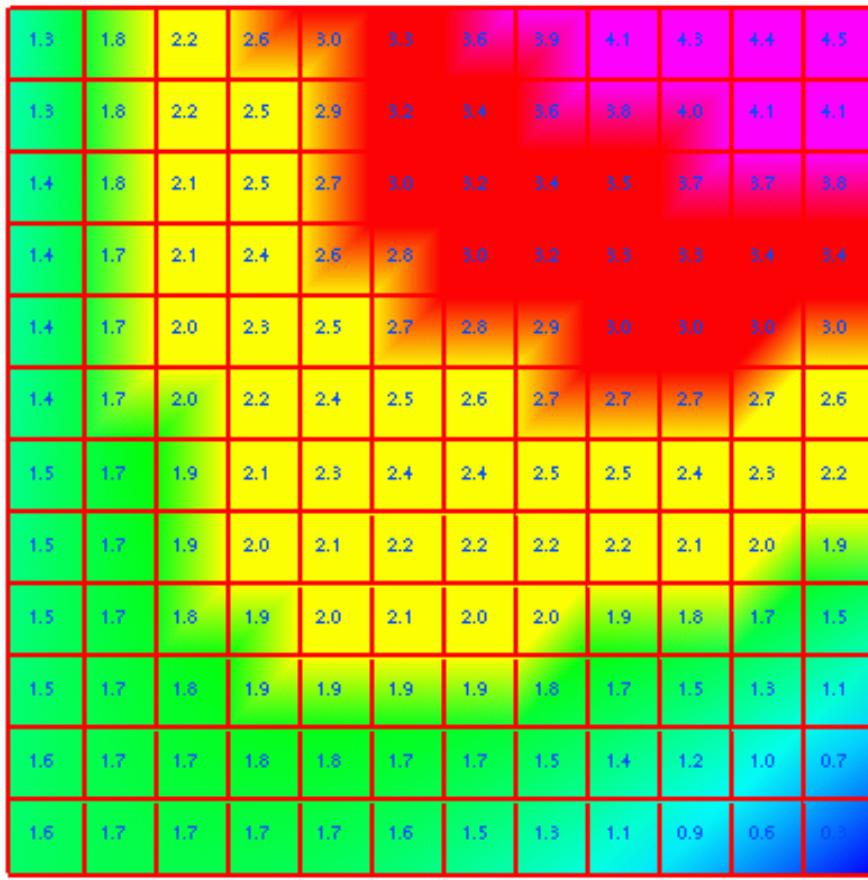
Visualization. The basics

- What if we use images?



Visualization. The basics

- And even simplify?

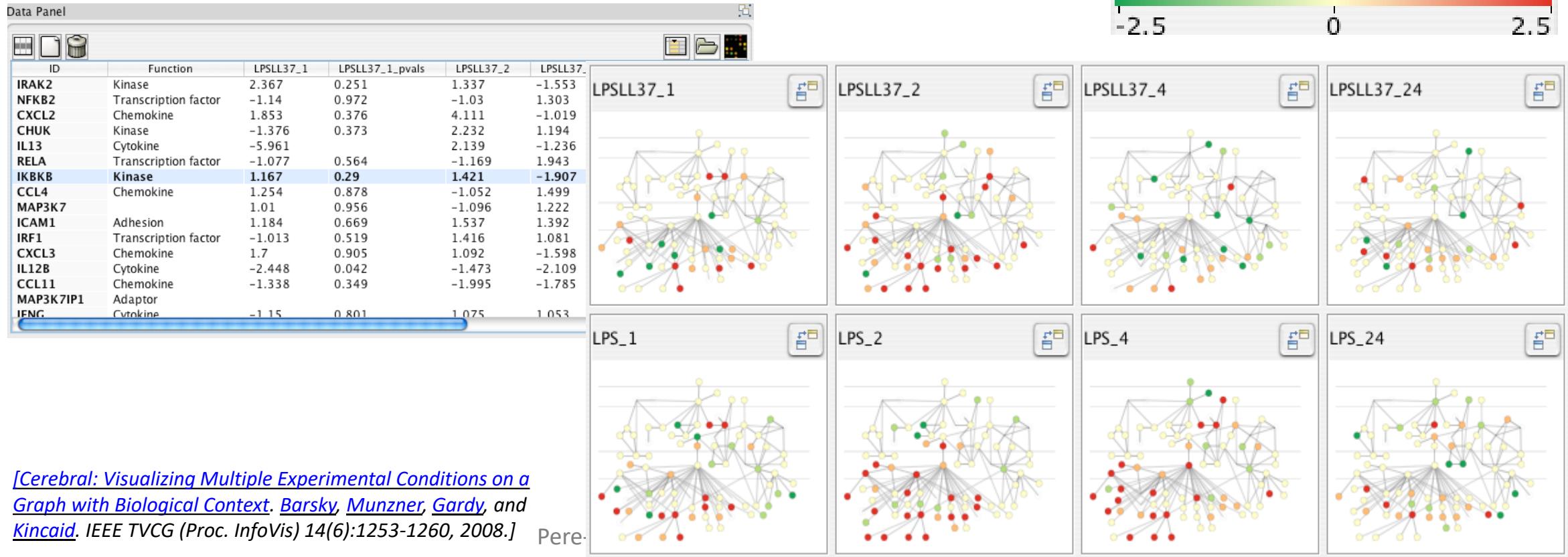


Visualization. The basics

- Computer-based visualization systems provide **visual representations of datasets** designed to **help people carry out tasks more effectively**
 - Visual representations → human visual system
 - Datasets
 - People
 - Effective

Visualization. The basics

- Visual [external] representations. Why depending on vision?
 - Replace cognition with perception



Visualization. The basics

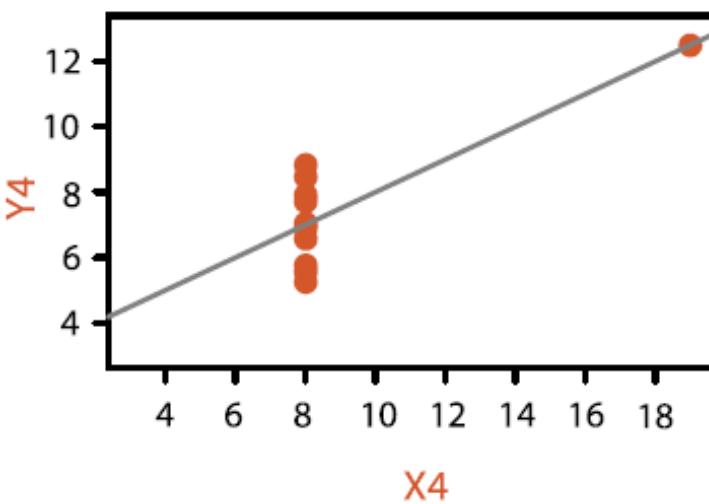
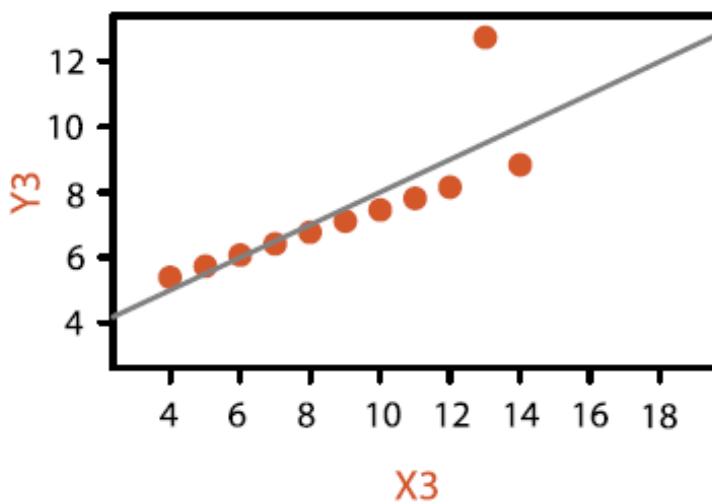
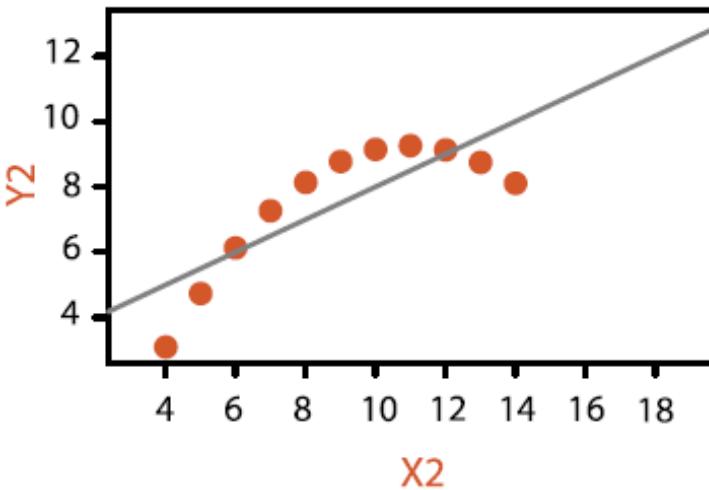
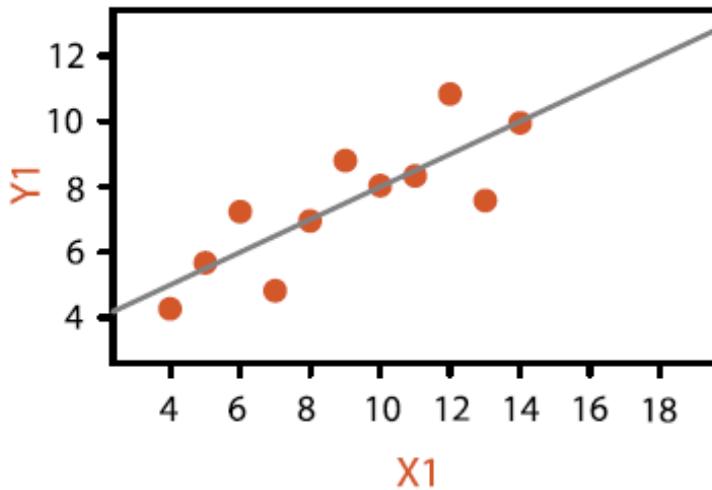
Anscombe's Quartet: Raw Data

	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
	6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
	4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
	12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
	7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
	5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89
Mean	9.0	7.5	9.0	7.5	9.0	7.5	9.0	7.5
Variance	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75
Correlation	0.816		0.816		0.816		0.816	

Visualization. The basics

- Same statistical properties:
 - Number of observations (n): 11
 - Mean x: 9.0
 - Mean y: 7.5
 - Equation of regression line: $y = 3 + 0.5x$
 - Sums of squares of $x - \text{mean}_x$: 110.0
 - Regression sums of squares: 27.50 (1 d.f.)
 - Residual sums of squares of y: 13.75 (9 d.f.)
 - Multiple R^2 : 0.667

Visualization. The basics



Visualization. The basics

- **Representations of datasets**
 - We can go even further
 - <https://www.youtube.com/watch?v=DbJyPELmhJc>

Visualization. Motivation

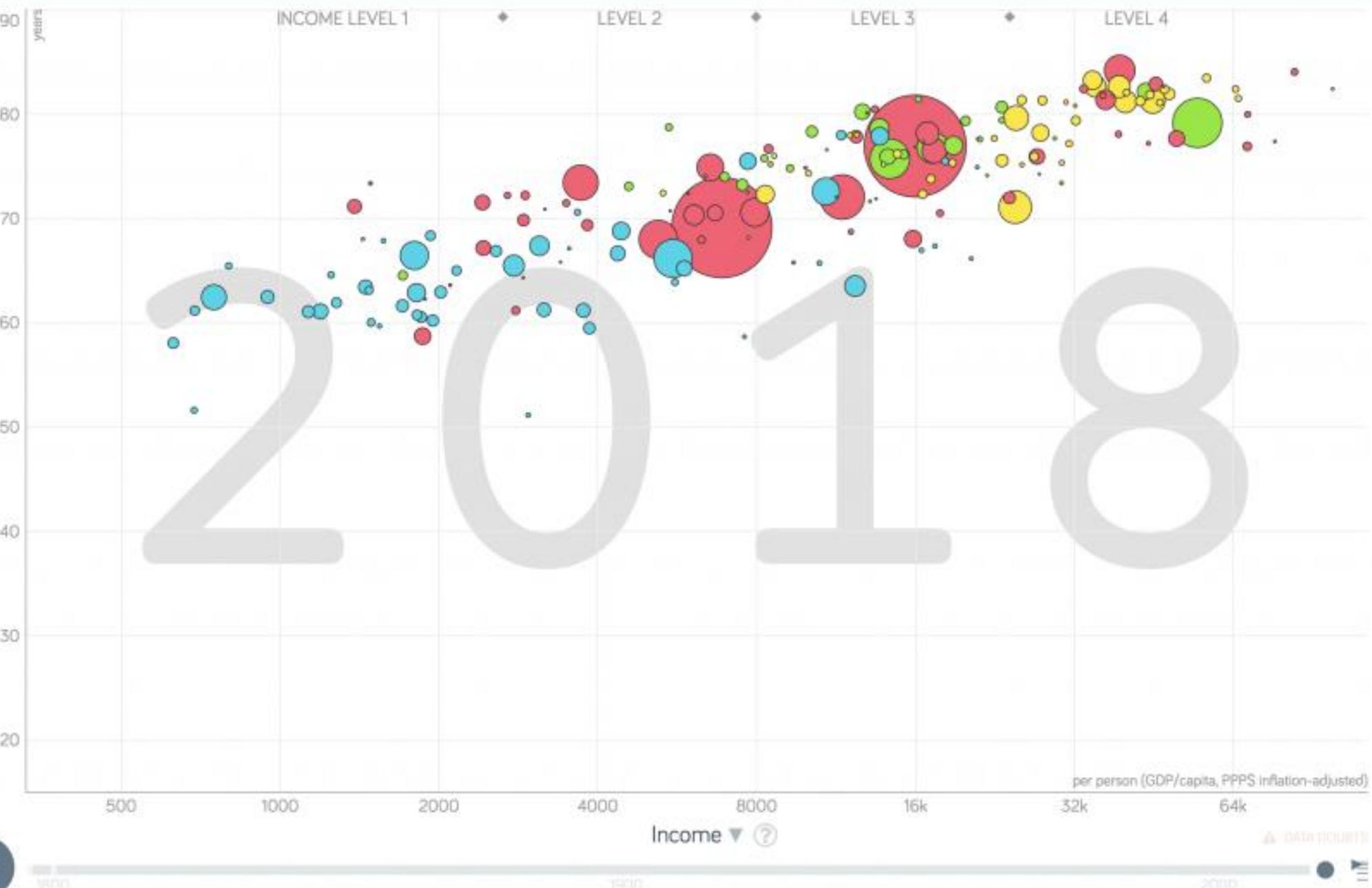
- Carry out tasks more **effectively**
 - Effectiveness requires match between data/task and representation
 - Set of representations is huge
 - Many are ineffective mismatch for specific data/task combo
 - Increases chance of finding good solutions if you understand full space of possibilities
 - What counts as effective?
 - Novel: enable entirely new kinds of analysis
 - Faster: speed up existing workflows
 - How to validate effectiveness
 - Many methods, must pick appropriate one for your context

Visualization. Motivation

- Purpose: Better understanding of mortality rate, life expectancy, growth ... using publicly available data
 - Hans Rosling, TED Talk 2006



Life expectancy ▶ ?

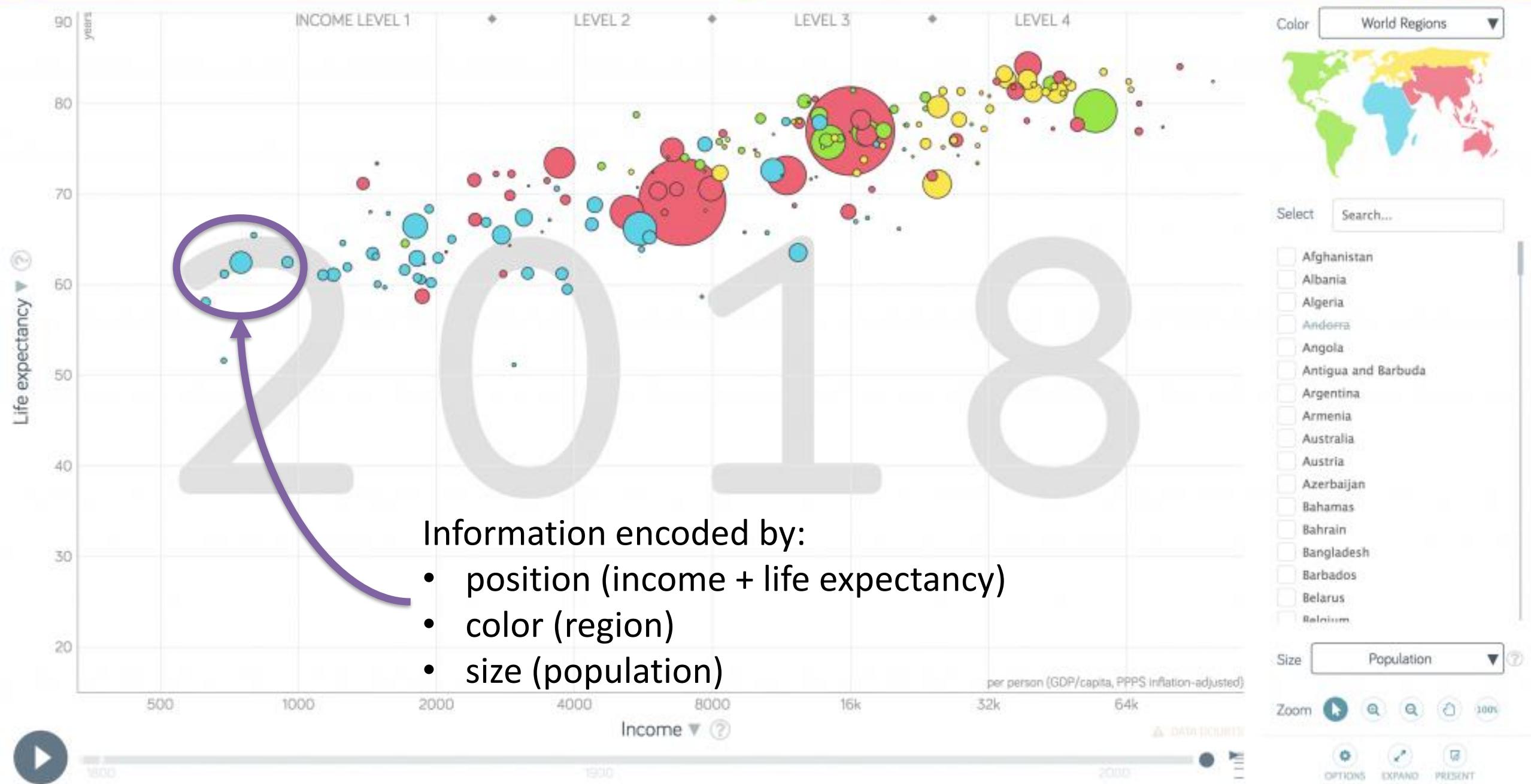
Color World Regions ▾Select Search...

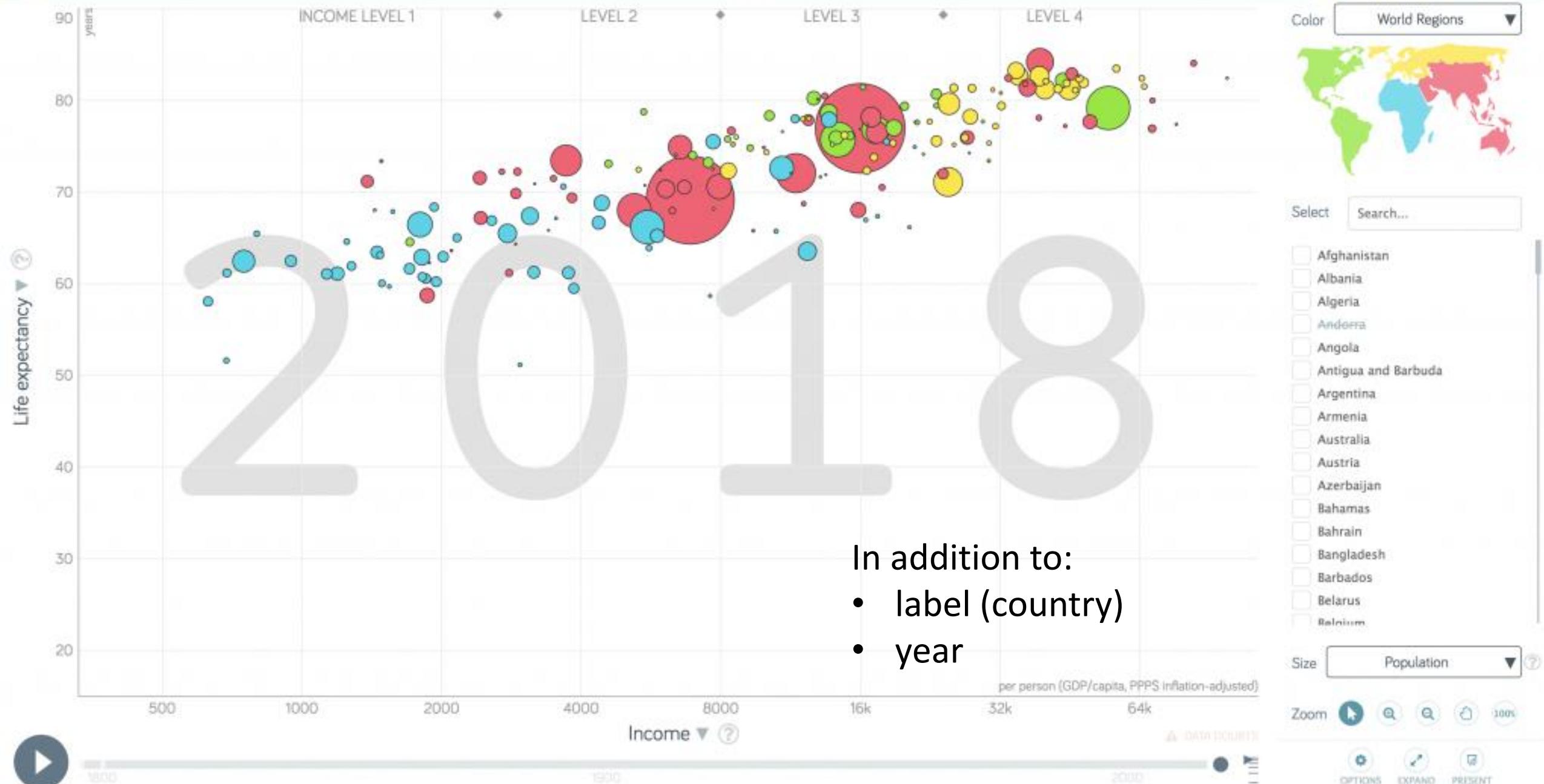
- Afghanistan
- Albania
- Algeria
- Andorra
- Angola
- Antigua and Barbuda
- Argentina
- Armenia
- Australia
- Austria
- Azerbaijan
- Bahamas
- Bahrain
- Bangladesh
- Barbados
- Belarus
- Belgium

Size Population ▾

Zoom 100%

OPTIONS EXPAND PRESENT



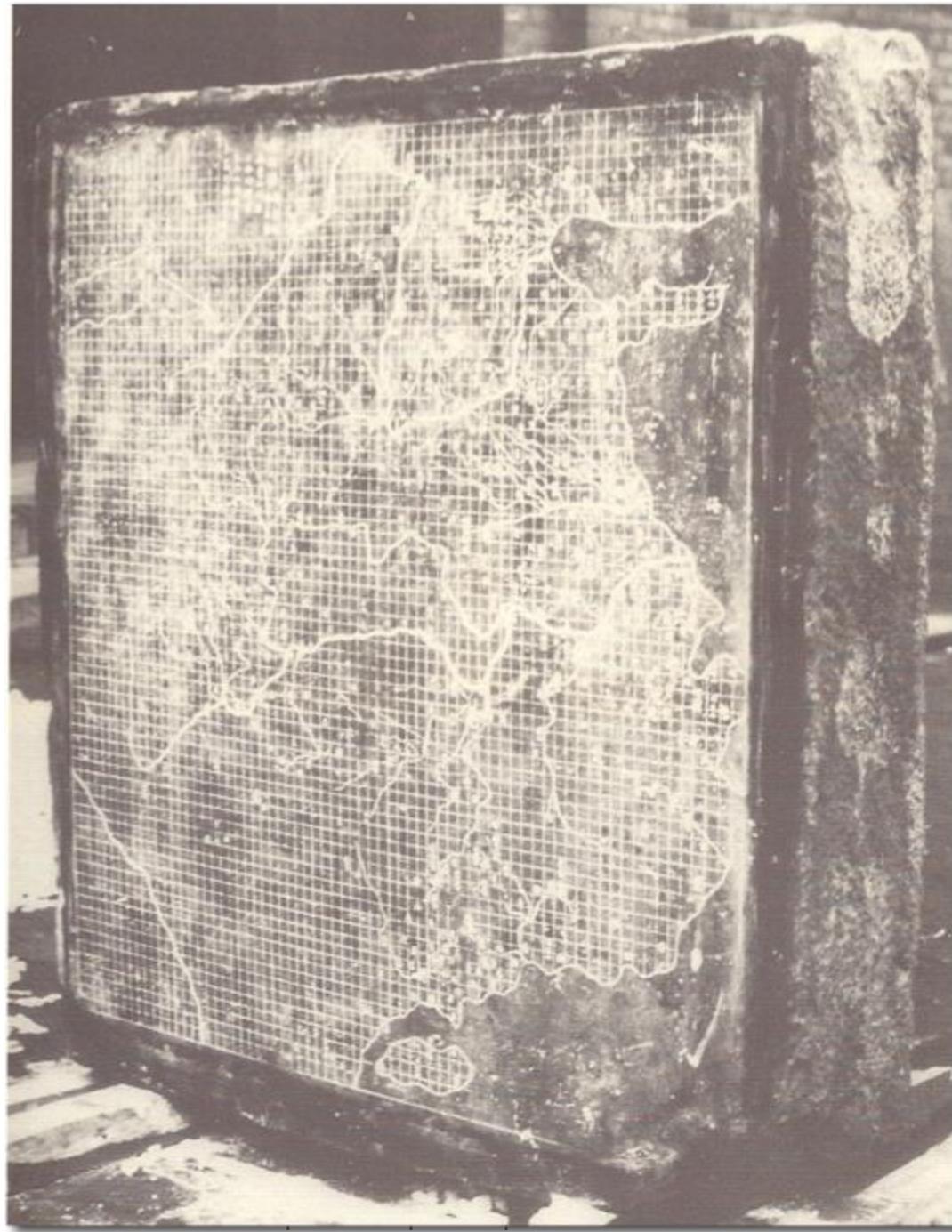


Outline

- *Examples*
- *Visualization. The basics*
- **History of Visualization**
- *Visualization areas*

History of Visualization

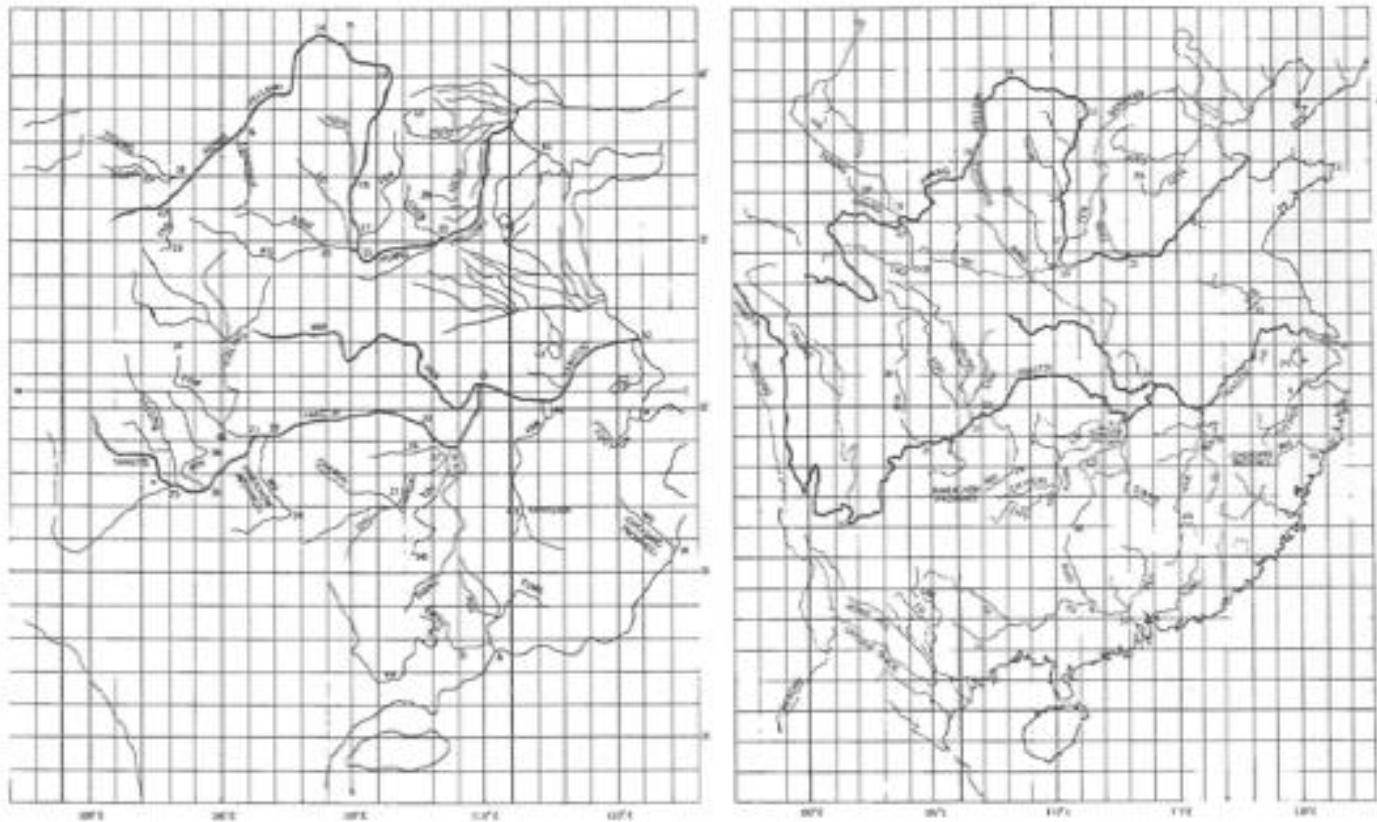
- But when did this start?
 - Quite long ago...
 - E. g. we may track cartographic examples for thousands of years
 - E.g.: The Yu Ji Tu (Map of the Tracks of Yu the Great), a map carved into stone in the year 1137 during the Song Dynasty
 - Uses Cartesian coordinates
 - » Grid with longitudinal and latitudinal lines





Pere-Pau Vázquez – Dep. Computer Science – UPC

History of Visualization

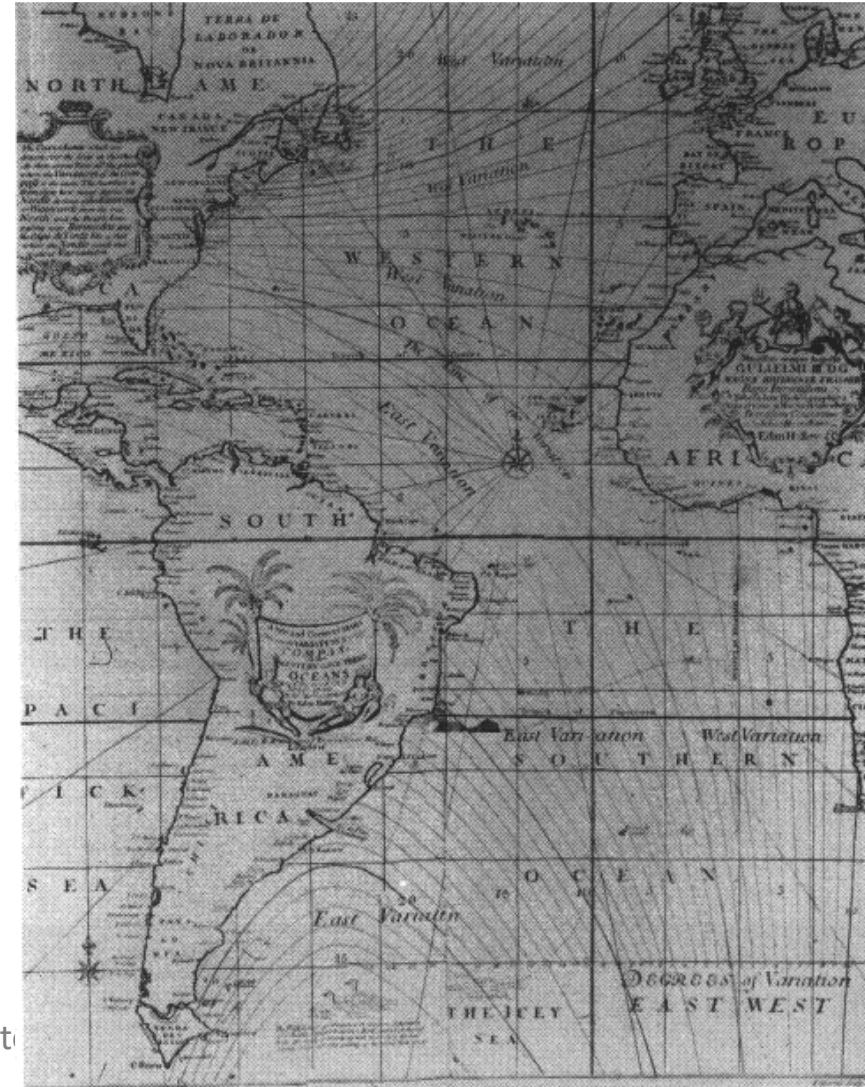


A redrawing of the Yü-chi T'u with an oblong grid constructed empirically from the geography, the numbers refer to the accompanying table.
(from Flapgood)

A modern map of China, on a comparable scale to the Yü-chi T'u and corresponding numbers

History of Visualization

- Other examples
 - Isolines to visualize compass deviations



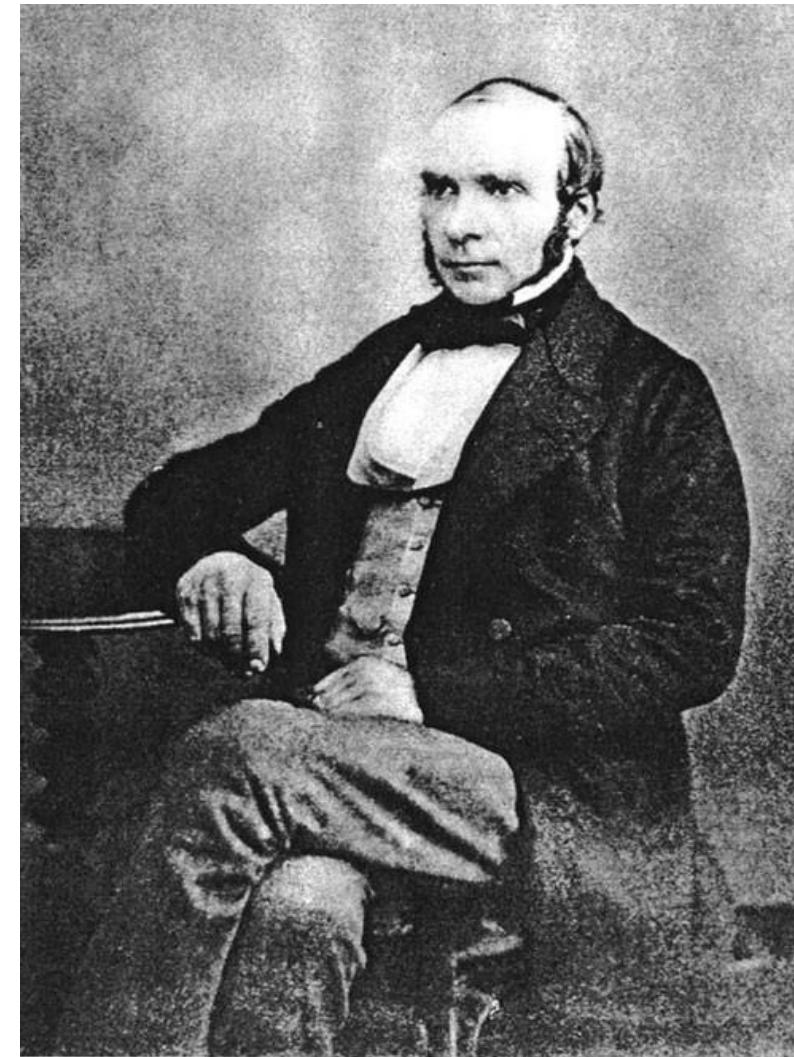
History of Visualization

- Cholera epidemic in London 1854



History of Visualization

- Cholera epidemic in London 1854
 - Dr. John Snow was able to trace the source of the cholera outbreak in Soho
 - His findings inspired fundamental changes in the water and waste systems in London
 - He is considered one of the fathers of modern epidemiology

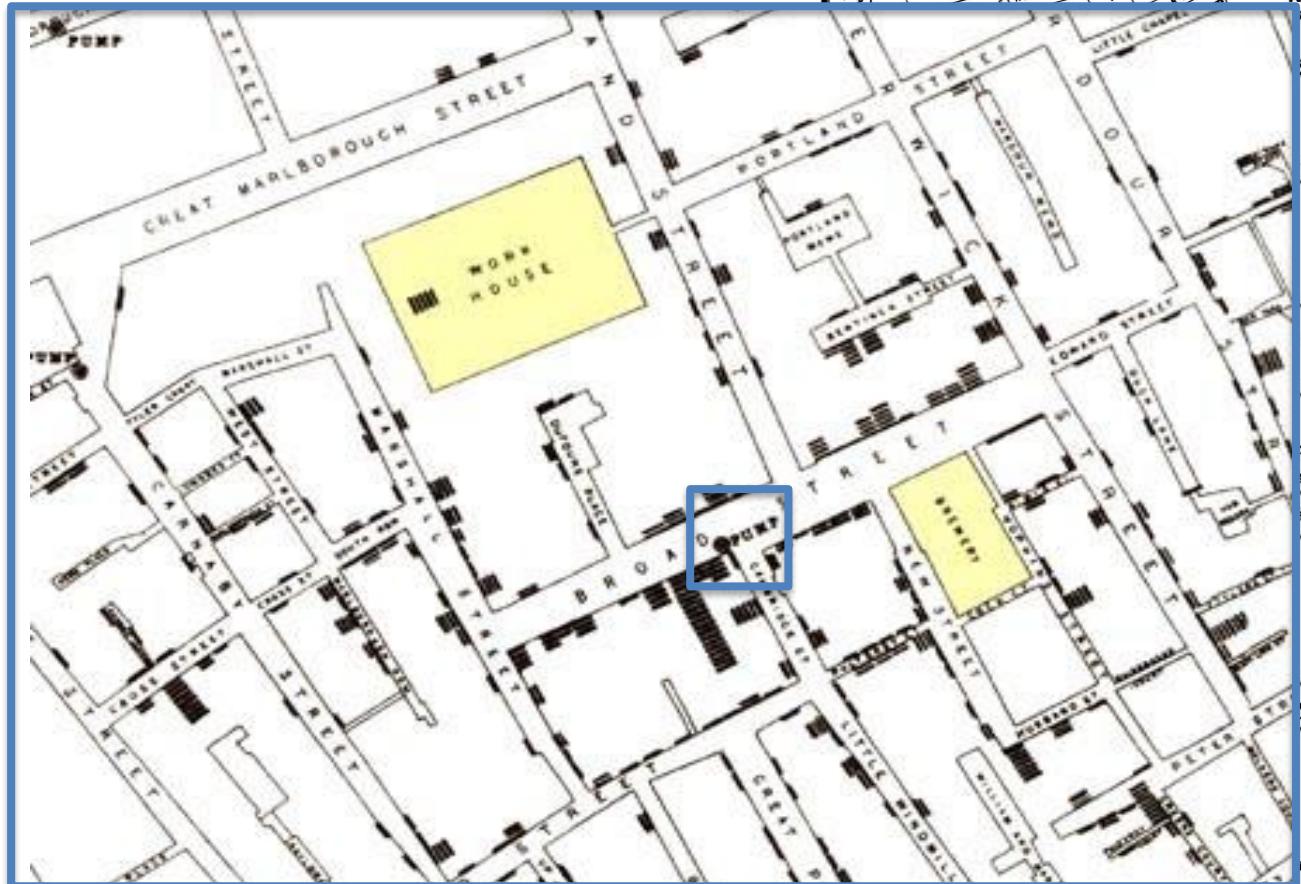


John Snow

History of Visualization

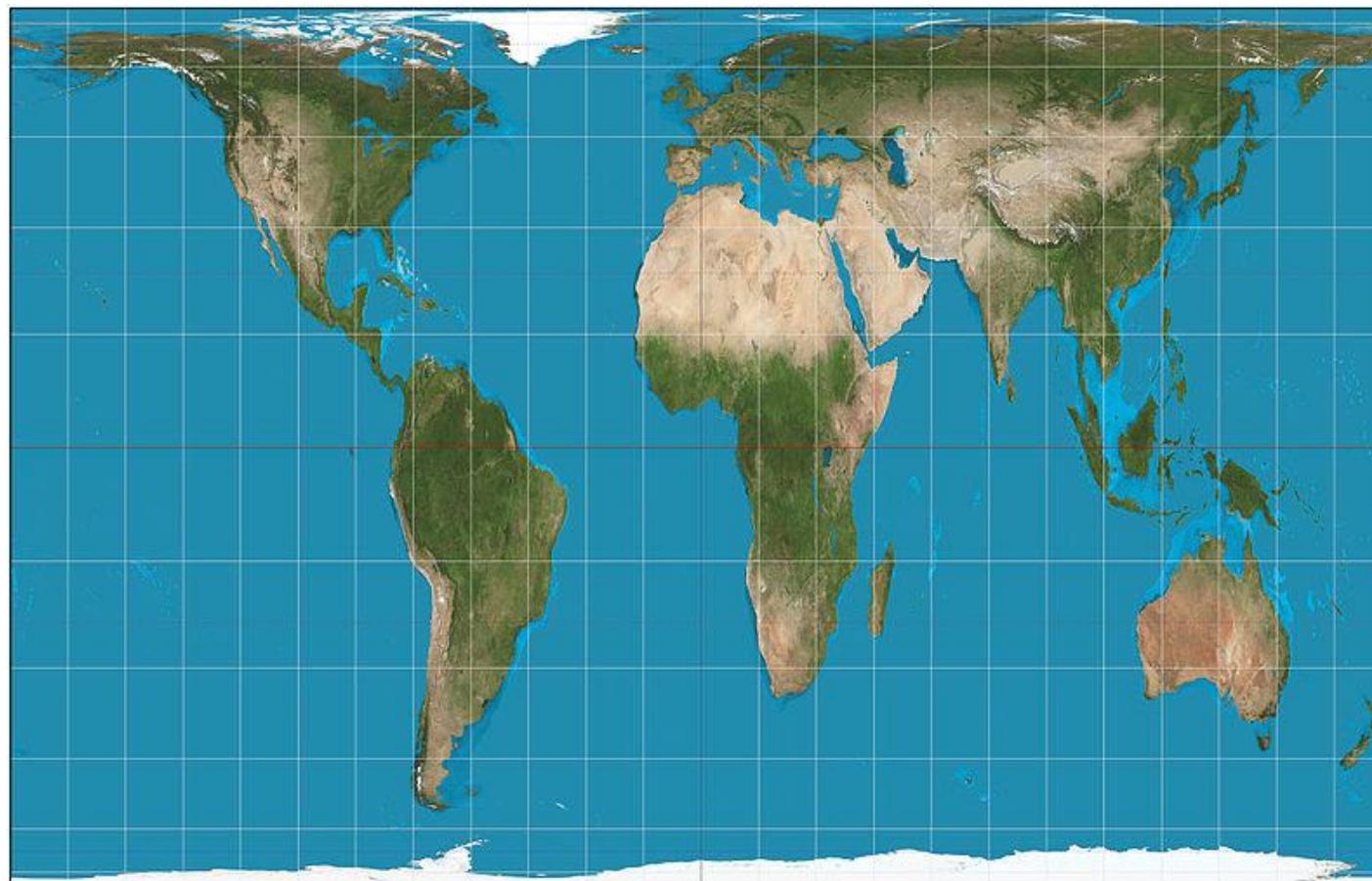
- Cholera epidemic in London 1854
 - “On proceeding to the spot, I found that **nearly all the deaths had taken place within a short distance of the [Broad Street] pump.** There were only ten deaths in houses situated decidedly nearer to another street-pump. In five of these cases the families of the deceased persons informed me that they always sent to the pump in Broad Street, as they preferred the water to that of the pumps which were nearer. In three other cases, the deceased were children who went to school near the pump in Broad Street...”

- Drawing by John Snow



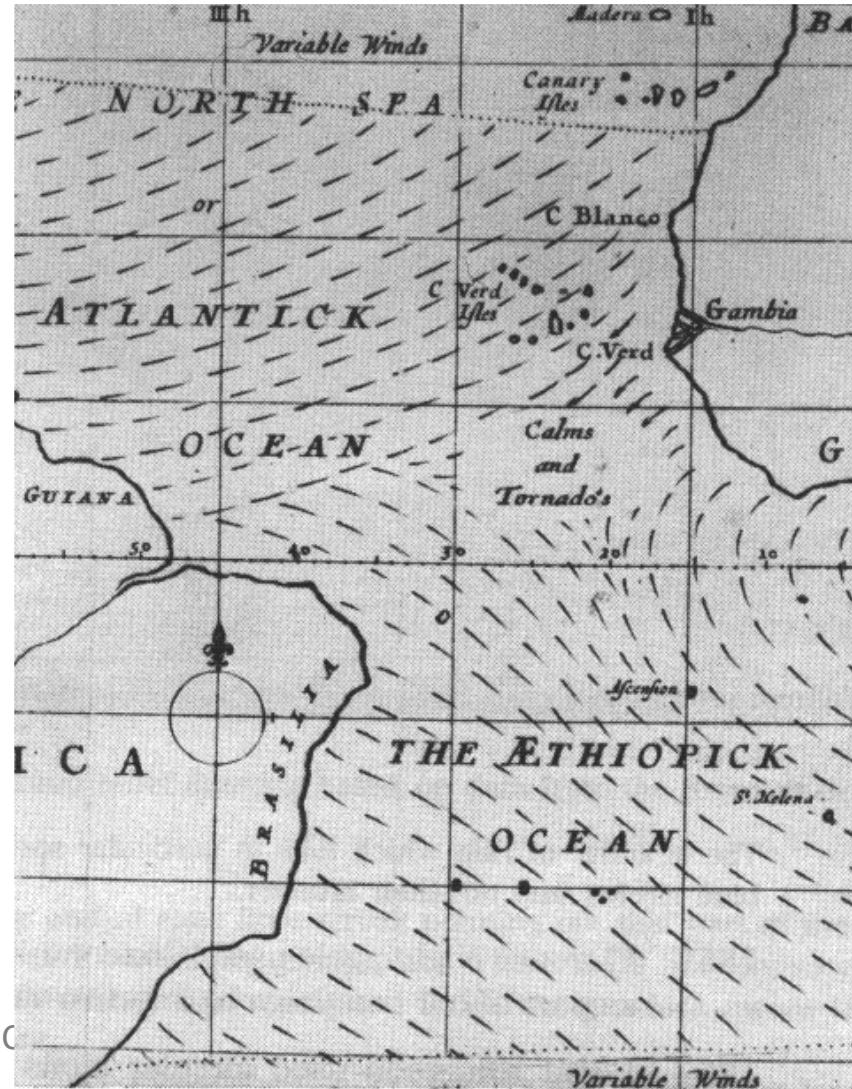
History of Visualization

- Mercator vs Gall-Peters projection



History of Visualization

- Other examples
 - Wind flow visualization

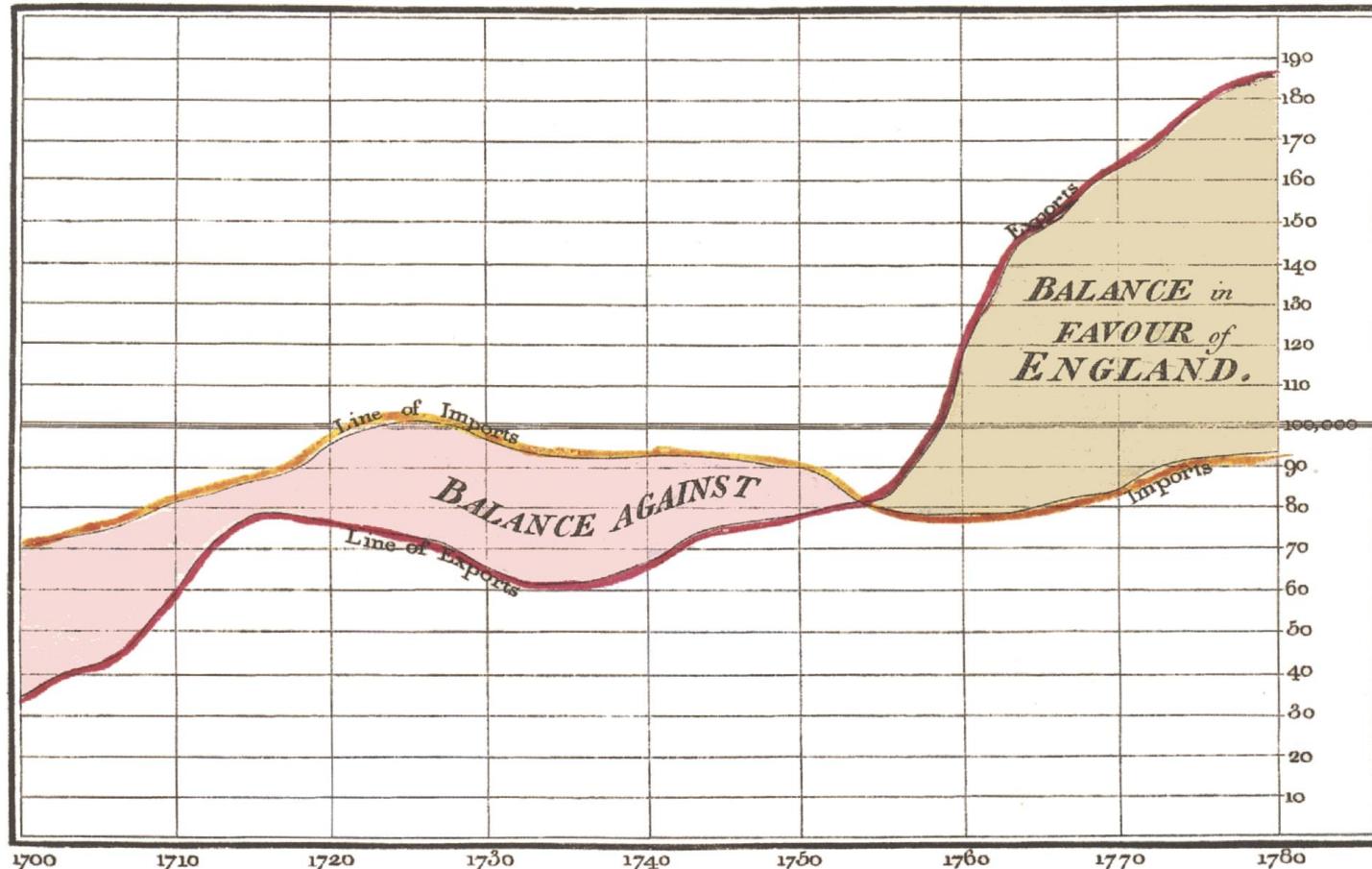


History of Visualization

- The first visual representations of abstract, nonspatial datasets were created in the 18th century by William Playfair.

History of Visualization

Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.



The Bottom line is divided into Years, the Right hand line into £10,000 each.

Published as the Act directs, 1st May 1786, by W^m. Playfair
Neale sculpt 352, Strand, London.

History of Visualization

- Other examples... the Russian campaign by Napoleon

History of Visualization

Carte Figurative des pertes successives en hommes de l'Armée Française dans la Campagne de Russie 1812-1813.

Dressée 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. M. Chiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avaient été détachés sur Minsk en Mohilow et qui rejoignirent vers Orscha et Witebsk, avaient toujours marché avec l'armée.

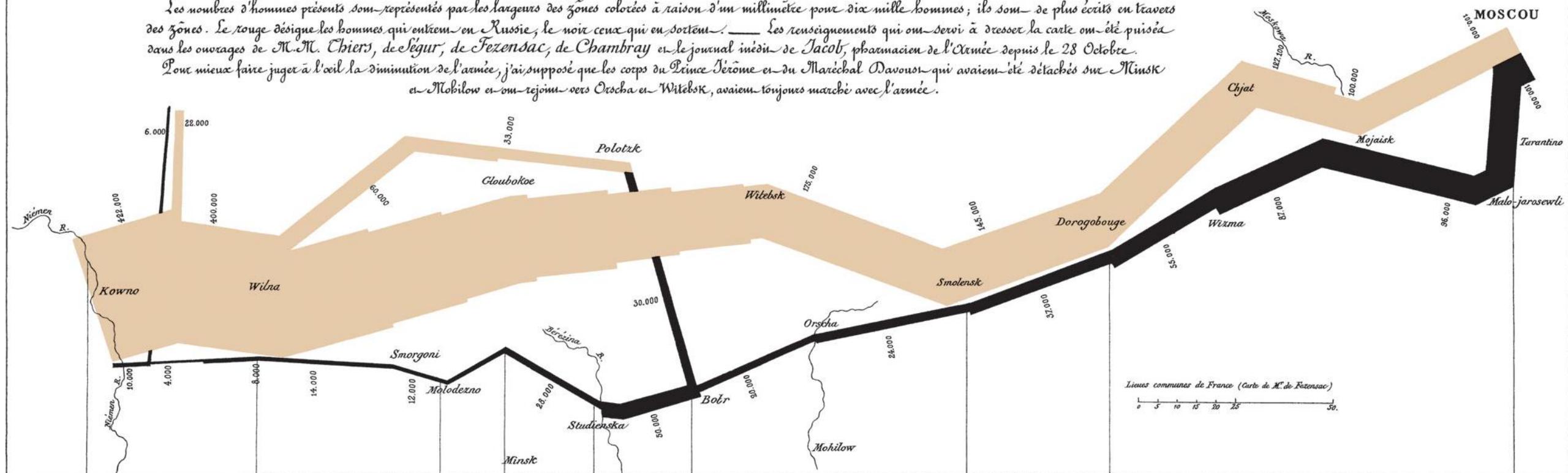
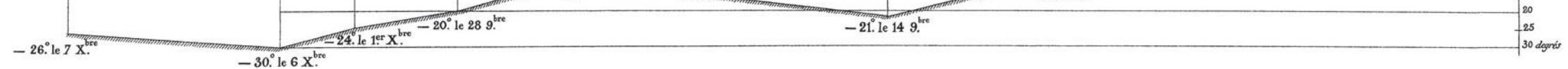


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les cosaques passent au galop
le Niemen gelé.



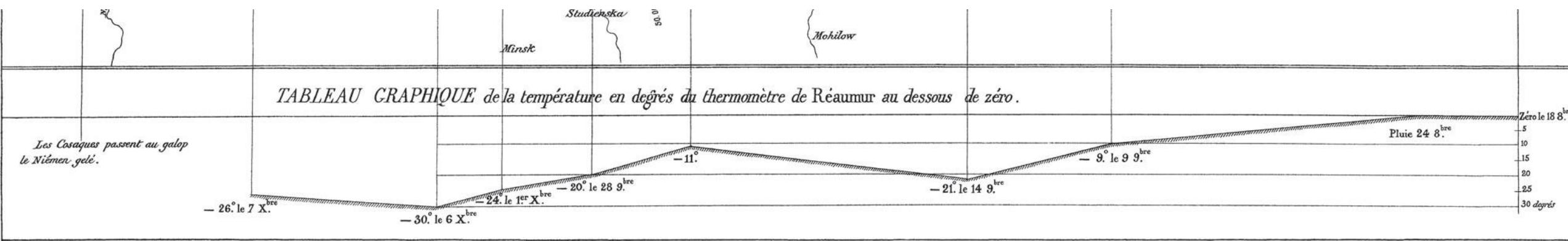
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General rules (will talk on them later...)

- Be honest (check & verify the data)
- Above all, show the data
- Explain encodings
- Label your axes
- Make the geometry change as the data
- Take into account your audience

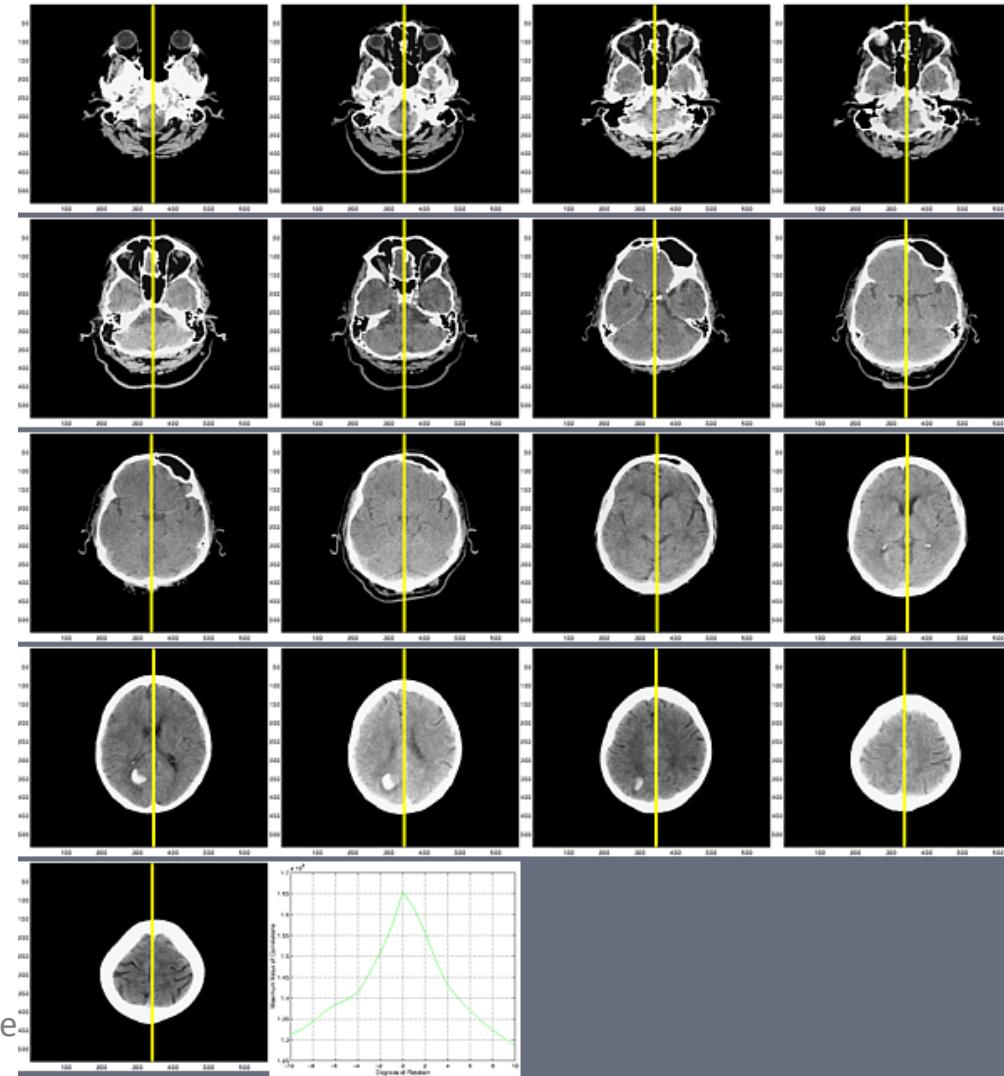
Outline

- *Examples*
- *Visualization. Motivation*
- *History of Visualization*
- **Visualization areas**

Visualization areas

- Medical data: MedVis-VolVis!
- Flow data: FlowVis!
- Abstract data: InfoVis!
- Visual Analytics
- GIS data
- Historical data (archeologist)
- Microscopic data (molecular physics)
- Macroscopic data (astronomy)
- Extreme large data sets
- ...

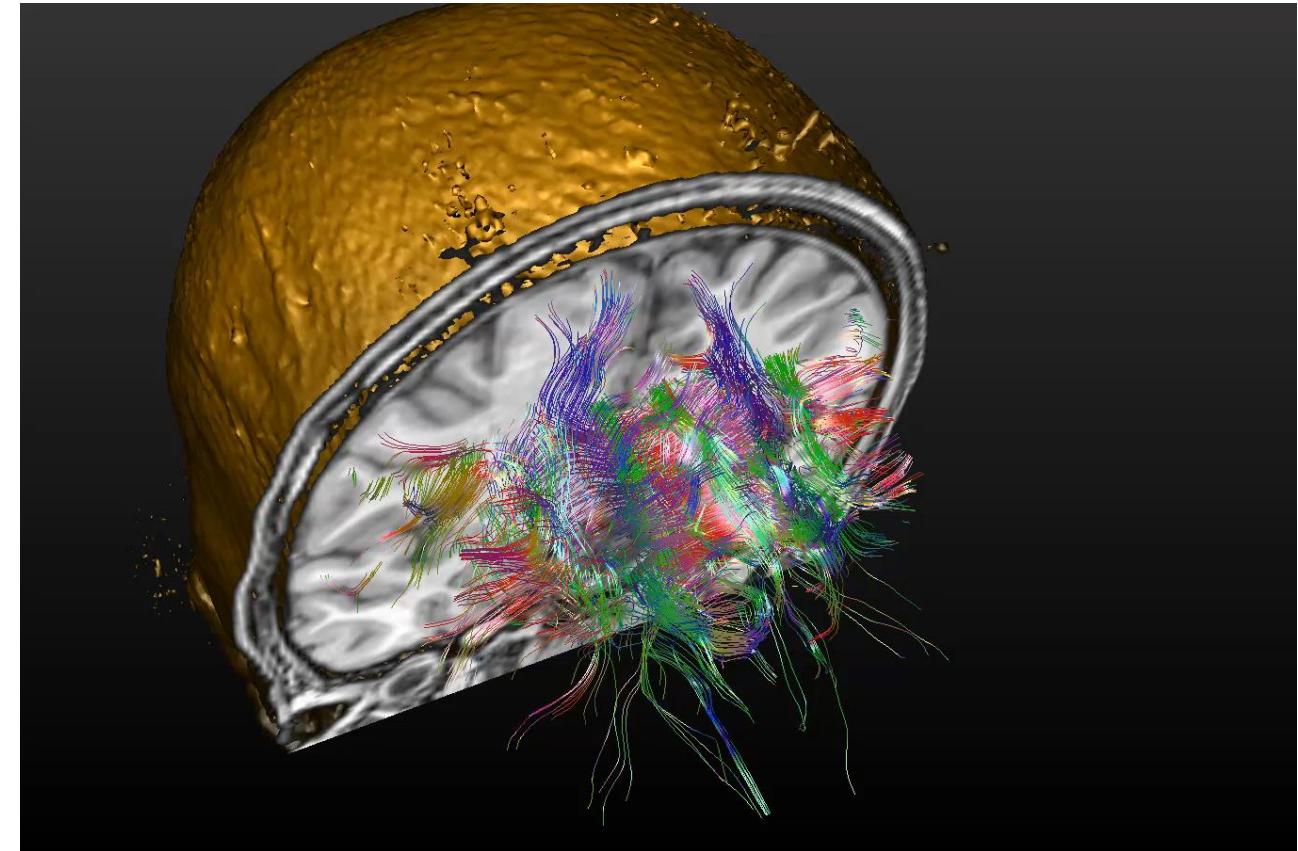
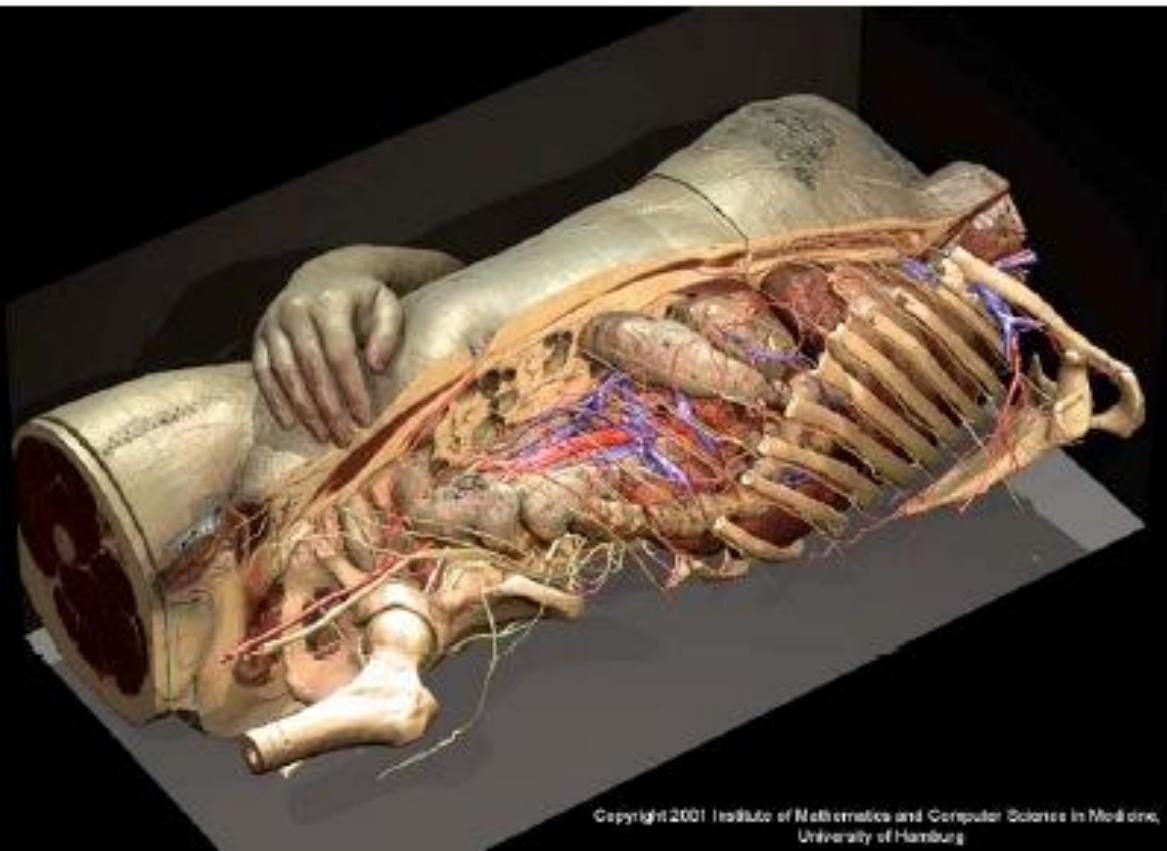
Visualization areas. MedVis



Visualization areas. MedVis

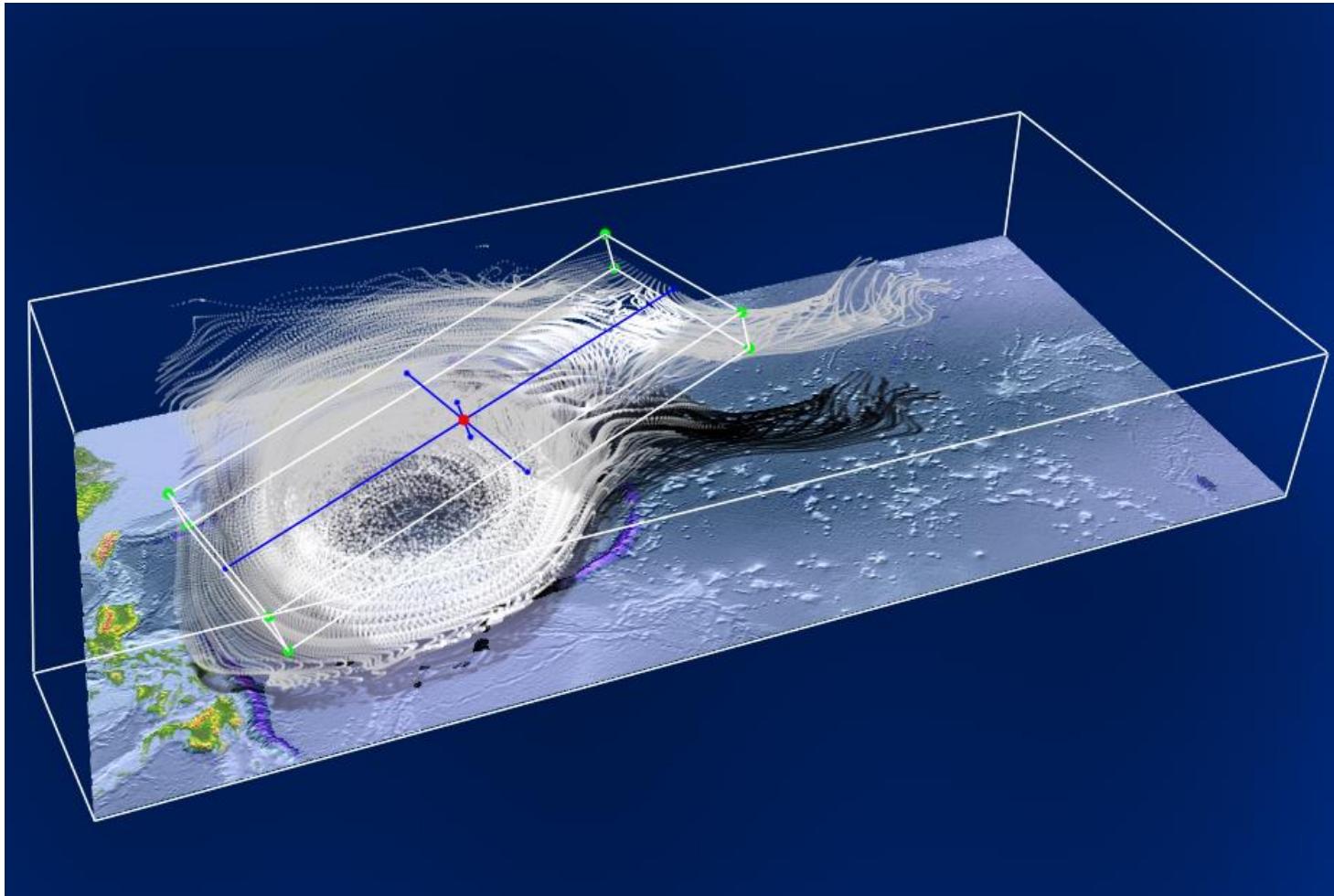


Visualization areas. MedVis



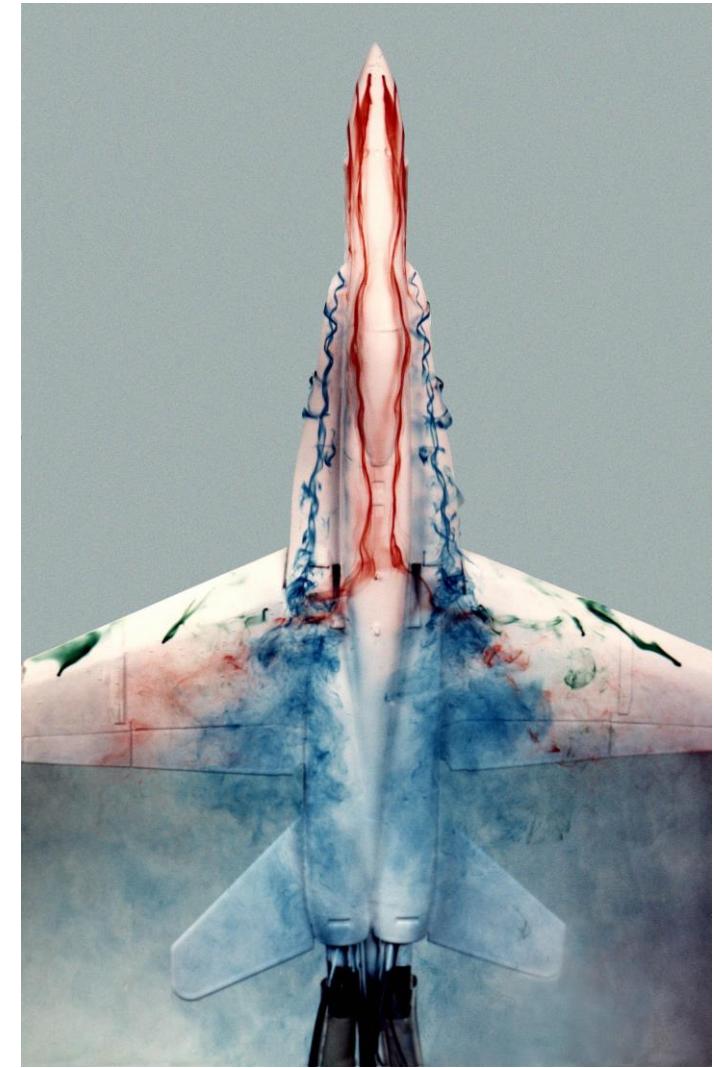
Brain white matter visualization

Visualization areas. FlowVis



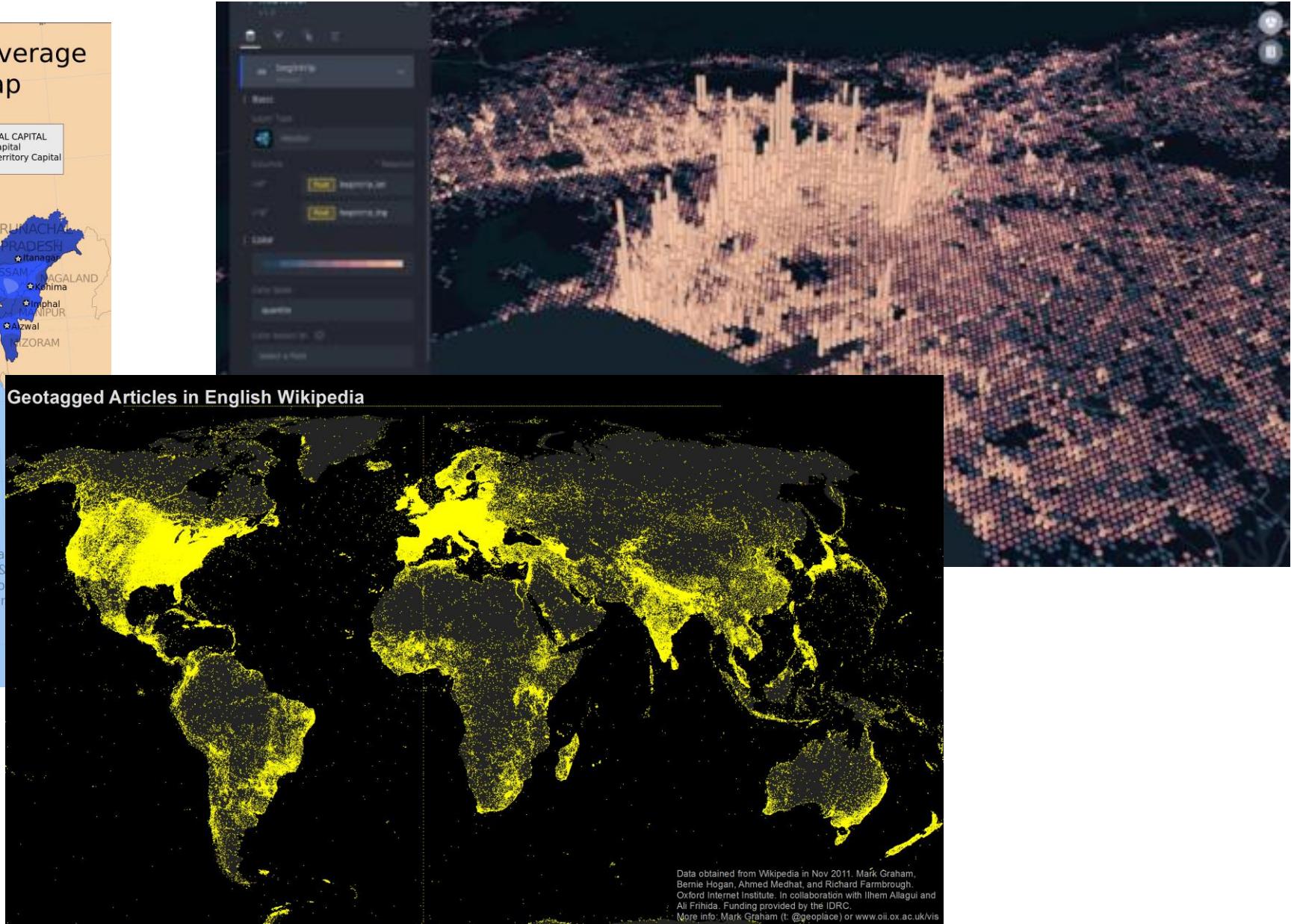
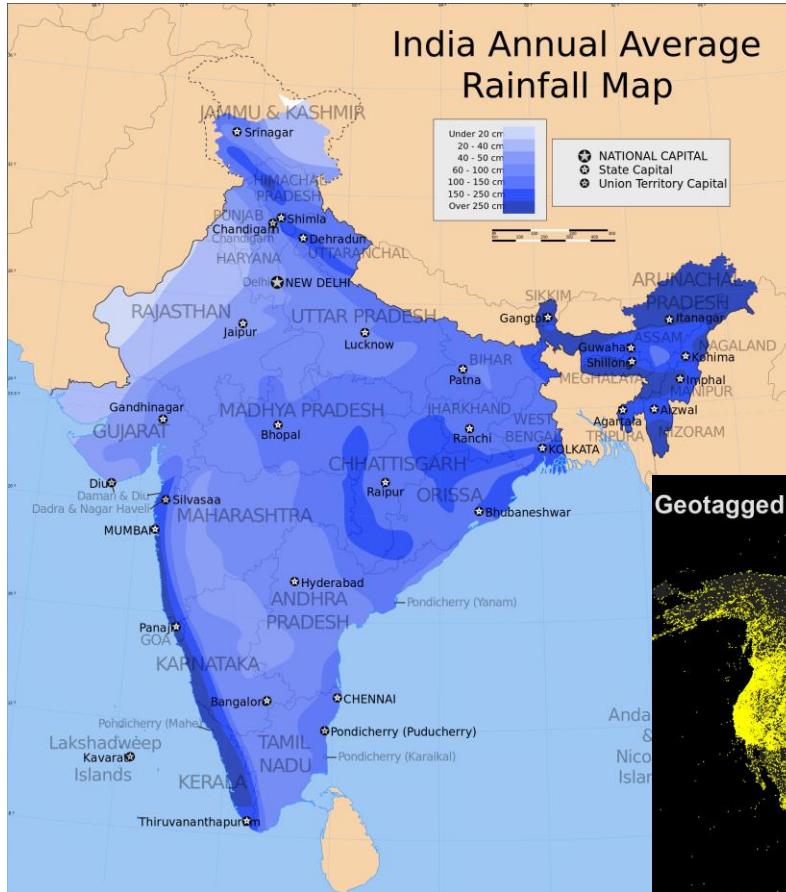
atmospheric physics,
meteorology

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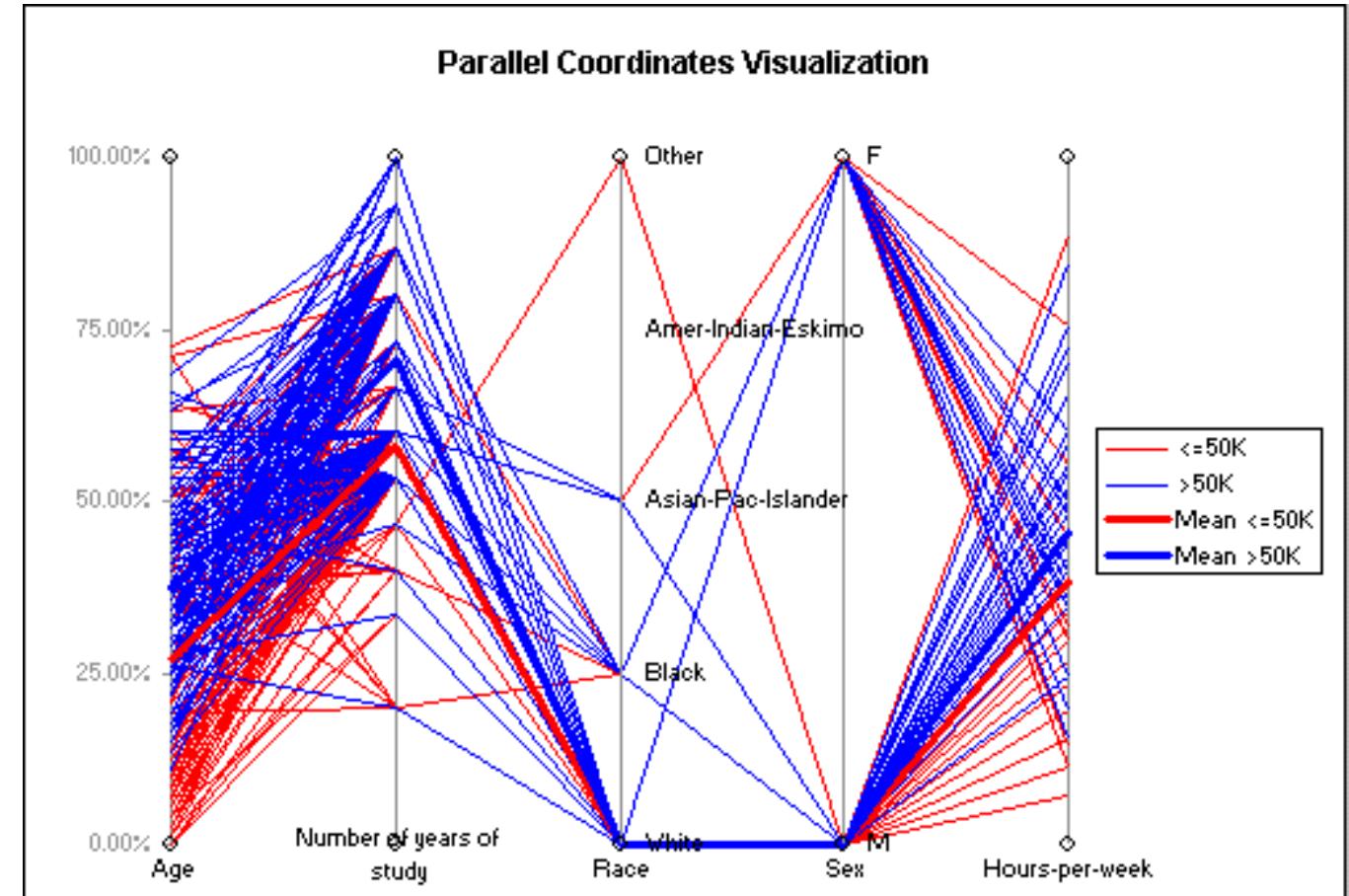
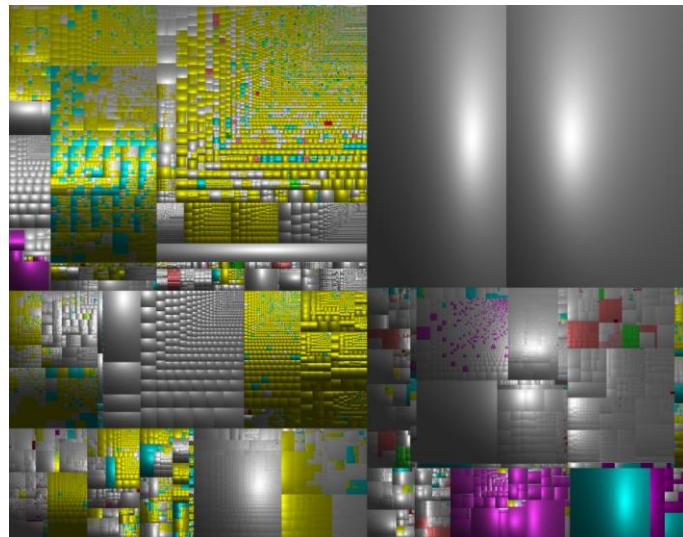
Aircraft design

Visualization areas. Geodata

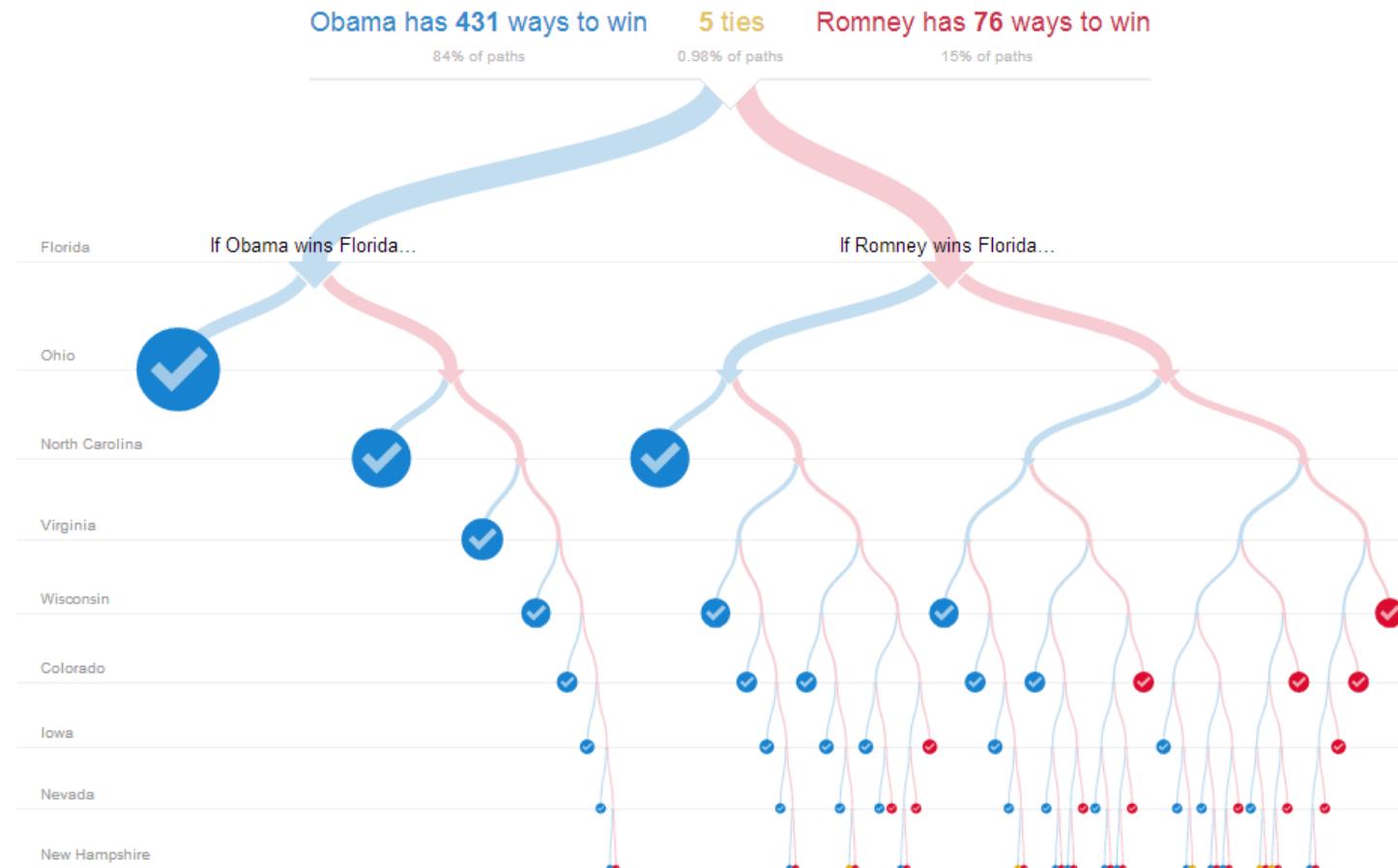
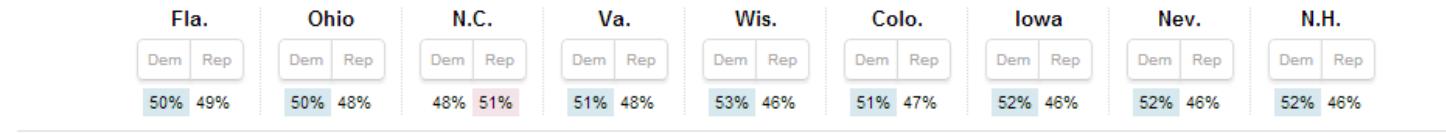


Data obtained from Wikipedia in Nov 2011. Mark Graham, Bernie Hogan, Ahmed Medhat, and Richard Farnborough. Oxford Internet Institute. In collaboration with Ilhem Allagui and Ali Frihida. Funding provided by the IDRC.
More info: [@geoplace](http://Mark.Graham.t) or www.oii.ox.ac.uk/vis

Visualization areas. InfoVis

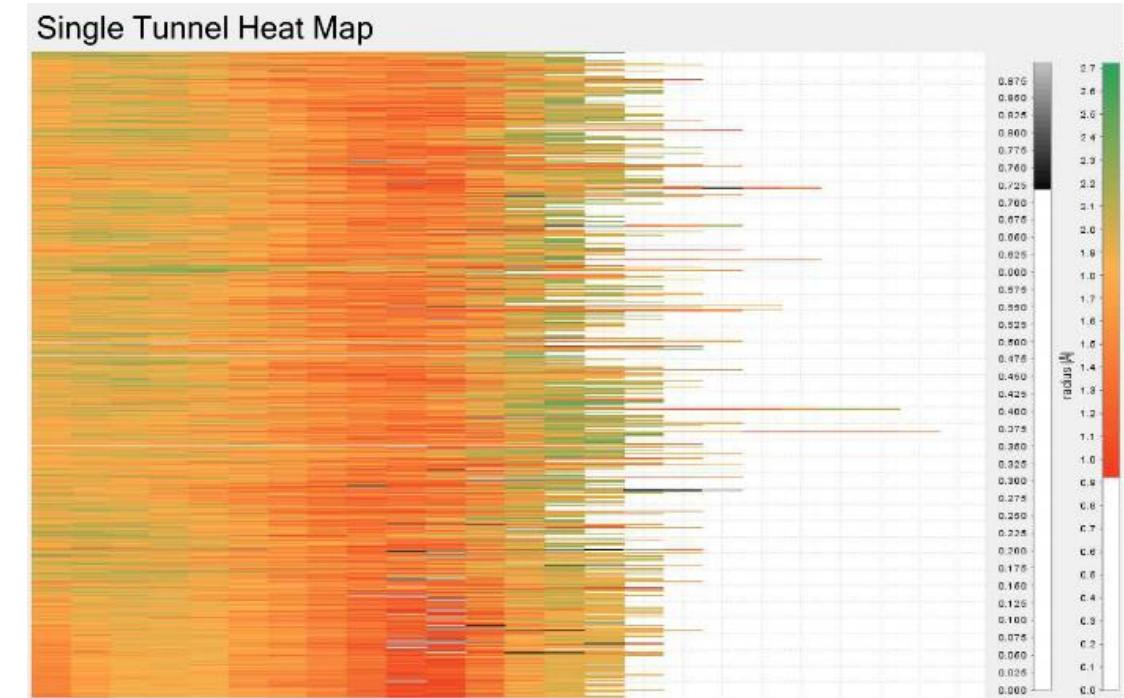
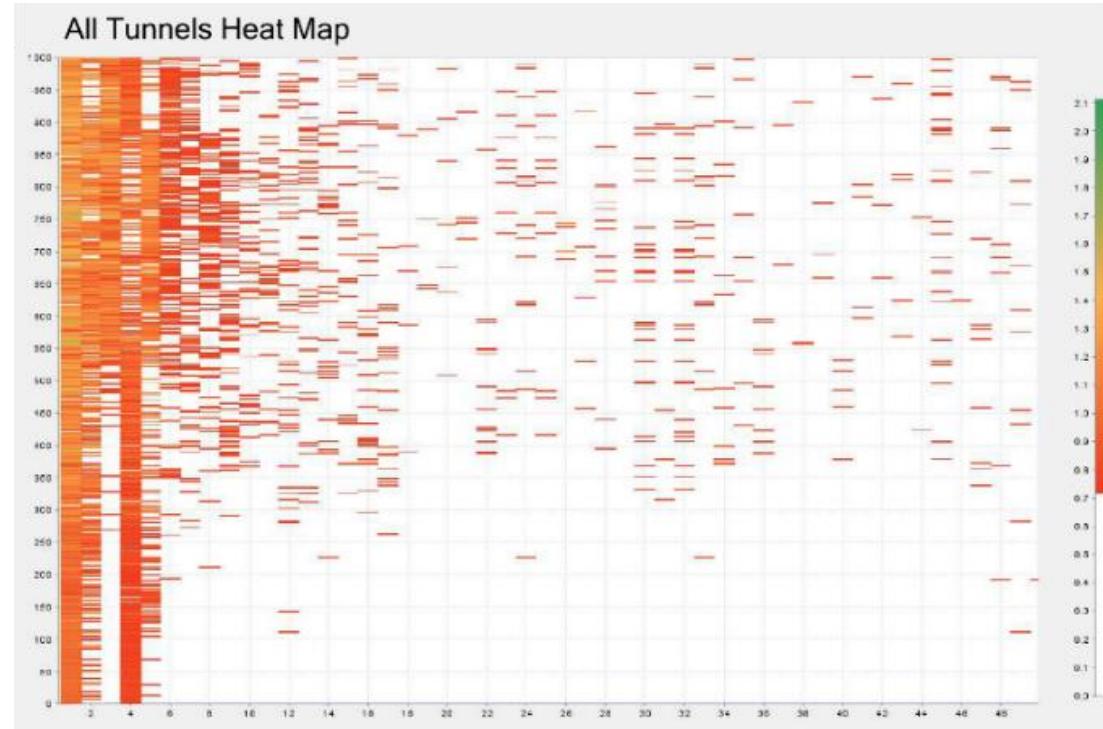


Visualization areas. InfoVis

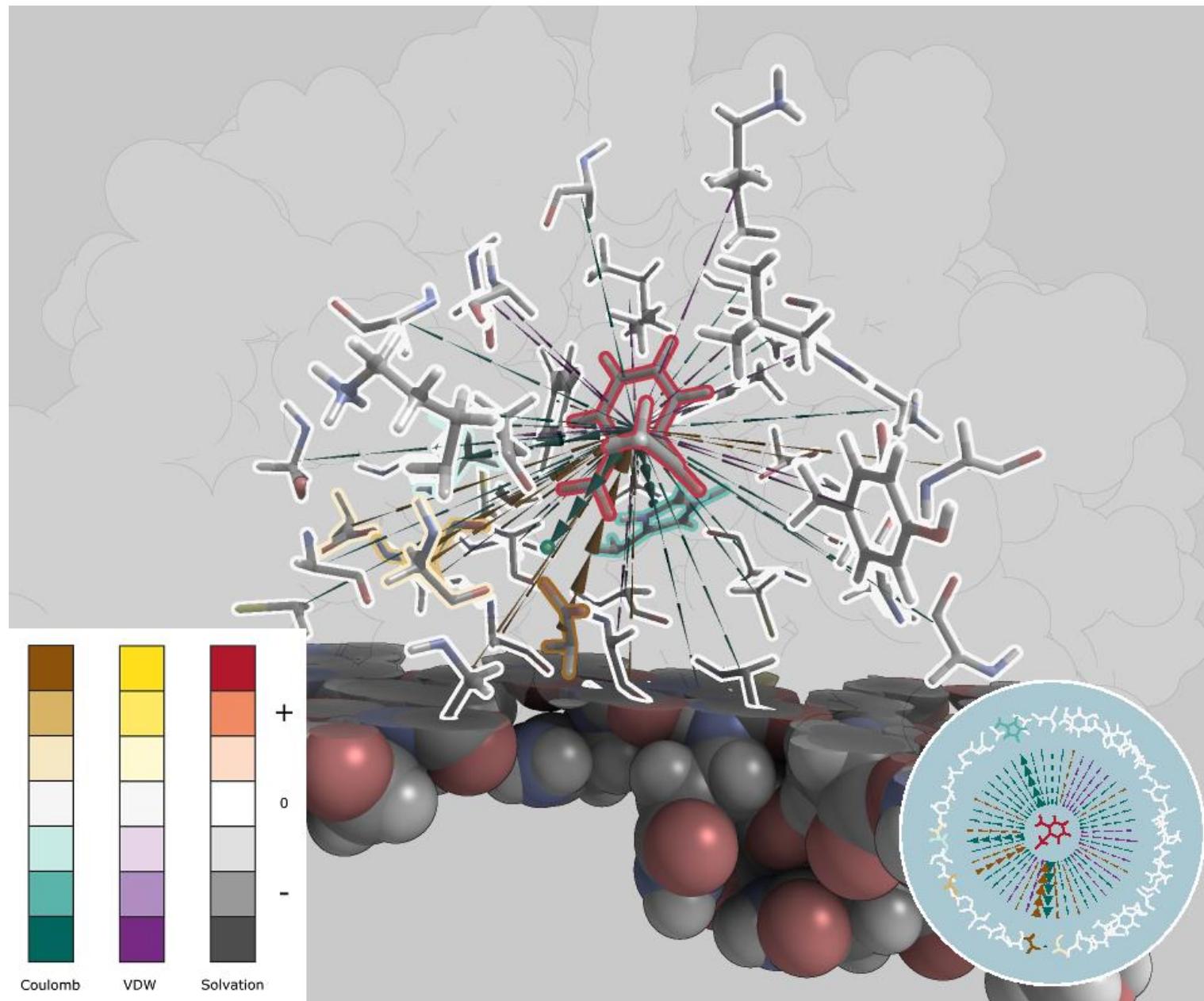


<http://elections.nytimes.com/2012/results/president/scenarios>

Visualization areas. Molecular Visualization



Visualization areas. Molecular Visualization



Visualization areas. Biology

Jorik Blaas / TU Delft 2009



Visualization Areas.

SciVis vs InfoVis vs VA

InfoVis	SciVis (VolVis/MedVis/FlowVis...)
Abstract Data No spatial reference.	Spatial Data Spatial reference.
N-dimensional. Heterogeneous.	Mostly 2 or 3-dimensional
Numerical, text, images, multimedia.	Scientific, engineering, biomedical.

Visual Analytics
Spatial and no spatial data.
N-dimensional space – heterogeneous
Combination with pattern recognition, statistical data analysis machine learning...

Thanks

- The information and some of the images come from different presentations/papers/course notes/books from:
 - A. Vilanova, T. Munzer, M. E. Groeller, M. Hadwiger, D. Weiskopf, T. Möller, R. Peikert, P. Muigg, J. Stasko, S. Oeltze-Jafra, J. Bertin, E. Tufte... and/or other papers
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Visualization. Basics

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Death & Taxes

A Visual Guide to Where Your Federal Tax Dollars Go

United States 2014
Federal Budget

