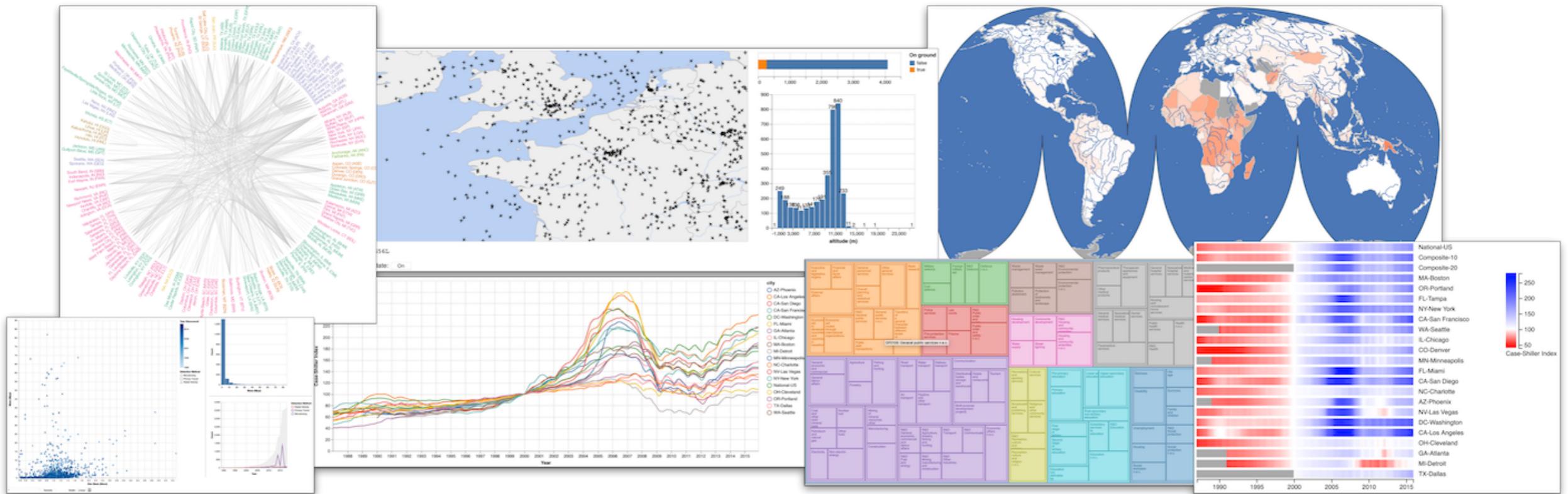


# Data Visualization

INF552 (2023-2024)

## Session 01 Introduction to Data Visualization



Make computers easier to use while augmenting peoples' capabilities, enabling them to deal with more complex problems, larger datasets, as efficiently as possible, in single-user or cooperative work contexts

HCI - an interdisciplinary design science

- Computer Science
- Experimental Psychology, Psychophysics
- and more: graphic designers, experts in human factors and ergonomics, sociologists, ...

Based on an understanding of the cognitive and perceptual abilities of users

- Visual perception, short-term memory, long-term memory, problem solving and reasoning, decision making, learning, ...

# Science... and art

Theoretical grounding (visual perception, color, Gestalt principles, etc.), informed by an increasing body of empirical studies, ... but aesthetic choices (necessarily subjective) as well.

*“Aesthetics matter: attractive things work better.”*

[Don Norman, Emotional Design, 2005]

The difficulty in creating a good visualization is sometimes technical...

... but most often it lies in making the right design choices.

# Science... and art

**art<sup>1</sup>** | a:t |

noun

1 [mass noun] the expression or application of human creative skill and imagination, typically in a visual form such as painting or sculpture, producing works to be appreciated primarily for their beauty or emotional power: *the art of the Renaissance* | *great art is concerned with moral imperfections* | *she studied art in Paris*.

- works produced by human creative skill and imagination: *his collection of modern art* | [as modifier] : *an art critic*.
- creative activity resulting in the production of paintings, drawings, or sculpture: *she's good at art*.

2 (the arts) the various branches of creative activity, such as painting, music, literature, and dance: *the visual arts* | [in singular] : *the art of photography*.

3 (arts) subjects of study primarily concerned with human creativity and social life, such as languages, literature, and history (as contrasted with scientific or technical subjects): *the belief that the arts and sciences were incompatible* | *the Faculty of Arts*.

4 a skill at doing a specified thing, typically one acquired through practice: *the art of conversation*.

# Science... and art

- Involves theory & craft
- Requires creativity & criticality
- Knowledge from many disciplines
- Abstraction
- Human-centered evaluation
- Technical skills & person skills

Theoretical grounding (visual perception, color, Gestalt principles, etc.), informed by an increasing body of empirical studies, ... but aesthetic choices (necessarily subjective) as well.

*“Aesthetics matter: attractive things work better.”*

[Don Norman, Emotional Design, 2005]

The difficulty in creating a **good** visualization is sometimes technical...

... but most often it lies in making the **right** design choices.

The design space is huge, and there is no systematic method: it is an exploratory, iterative design process.

# INF552 - Course Organization

<https://www.enseignement.polytechnique.fr/informatique/INF552/>

<https://moodle.polytechnique.fr/course/view.php?id=17085>

[#inf552-2023](https://dix-polytechnique.slack.com)

The screenshot shows the Slack application interface. On the left, there is a sidebar with a list of channels and other options like Threads, All DMs, and Slack Connect. The channel **# inf552-2021** is selected and highlighted with a red circle. The main pane shows the channel's name in large bold letters, its creation date (September 12th), and its description (INF552 Data Visualization). It also shows recent messages from users Emmanuel Pietriga and Caroline Appert.

**#inf552-2021**

You created this channel on September 12th. This is the very beginning of the **#inf552-2021** channel. Description: INF552 Data Visualization <https://www.enseignement.polytechnique.fr/informatique/INF552/> (edit)

[+ Add people](#)

Sunday, September 12th

Emmanuel Pietriga 6:03 PM joined #inf552-2021.

Emmanuel Pietriga 6:03 PM set the channel description: INF552 Data Visualization

Caroline Appert 6:04 PM was added to #inf552-2021 by Emmanuel Pietriga.

Emmanuel Pietriga 6:47 PM set the channel description: INF552 Data Visualization <https://www.enseignement.polytechnique.fr/informatique/INF552/>

# INF552 - Contents

- Introduction to Data Visualization (s#01)
- Visual Perception (s#02)
- Multi-variate Data (s#03+[s#04](#))
- Temporal Data / Time-series ([s#05](#))
- Animated Transitions ([s#05](#))
- Geovisualization / GIS, Multi-scale Navigation (s#06)
- Graph Structures / Networks, Hierarchical Structures / Trees ([s#07-08](#))
- Visualization of live data streams (s#09)

s#nn = normal classroom session

[s#nn](#) = flipped classroom session

# INF552 - Evaluation

Students will be evaluated based on:

- the results of an individual project (see next slide);
- and their achievements during petites classes s04 → s09.

# INF552 - Evaluation

Individual project (a single project can involve two students):

- Visualize a dataset of your choice.
- No hard constraint on how you do it: static, interactive, involving programming or BI tools such as Tableau.
- Choose data from anywhere based on your own interests:

*(non-exhaustive list)*

Catalogs and Search Engines

**Google Dataset Search**

<https://toolbox.google.com/datasetsearch>

**kaggle**

<https://www.kaggle.com>

**DATA HUB**

<https://datahub.io>

 **data.world**

<https://data.world>

A wide range of domain-specific data portals (totally random examples...)

 **THE WORLD BANK**  
IBRD • IDA

<https://data.worldbank.org>

  
**Exoplanet.eu**

<http://exoplanet.eu>

  
Liberté • Égalité • Fraternité  
RÉPUBLIQUE FRANÇAISE

**data.gouv.fr**

<https://www.data.gouv.fr>

 **BnF** Bibliothèque  
nationale de France

<http://data.bnf.fr>

**data.bnf.fr**

<http://data.bnf.fr>

 **DATA.GOV**

<https://www.data.gov>

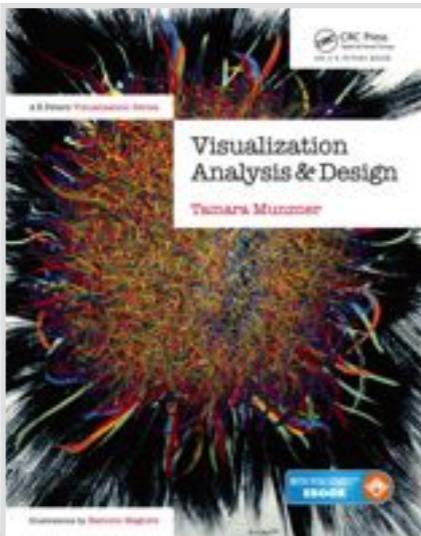
- More information, as well as sample student projects from previous years, on INF552's landing page on Moodle:

<https://moodle.polytechnique.fr/course/view.php?id=17085>

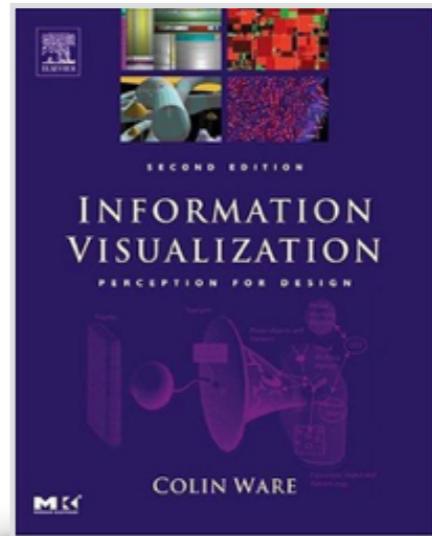
# Practical Considerations

- **Letters of recommendation** (4A @ MIT, Stanford, Columbia, ETH, Imperial College, Oxford, etc.)
  - Many ask not only for a letter but for an assessment of the student's performance (top X%, on a scale, ...).
  - Difficult to make such assessments if you do not attend PC, or if the submission deadline is too early in 3A/P1.
  - Limiting the number of letters (sent to the same program).
  - *Anticipate such requests.*
  - Required: transcripts, SoP (even a draft), CV.

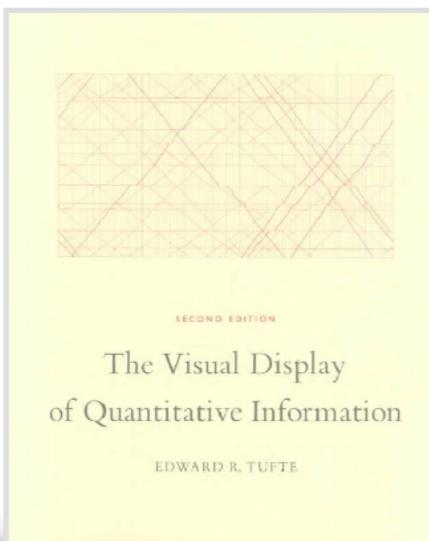
# Books



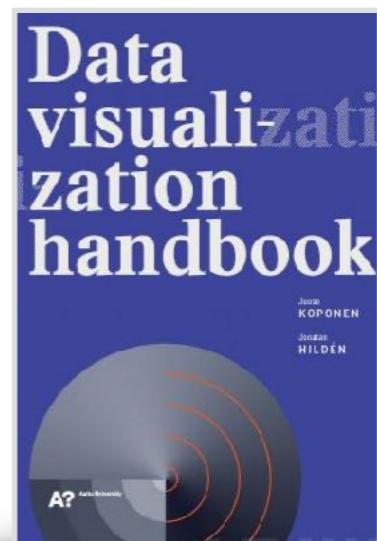
Tamara Munzner. *Visualization Analysis and Design*.  
A K Peters/CRC Press, 2014.



Colin Ware. *Information Visualization - Perception for Design* (2nd edition). Morgan Kaufmann/Elsevier, 2004.



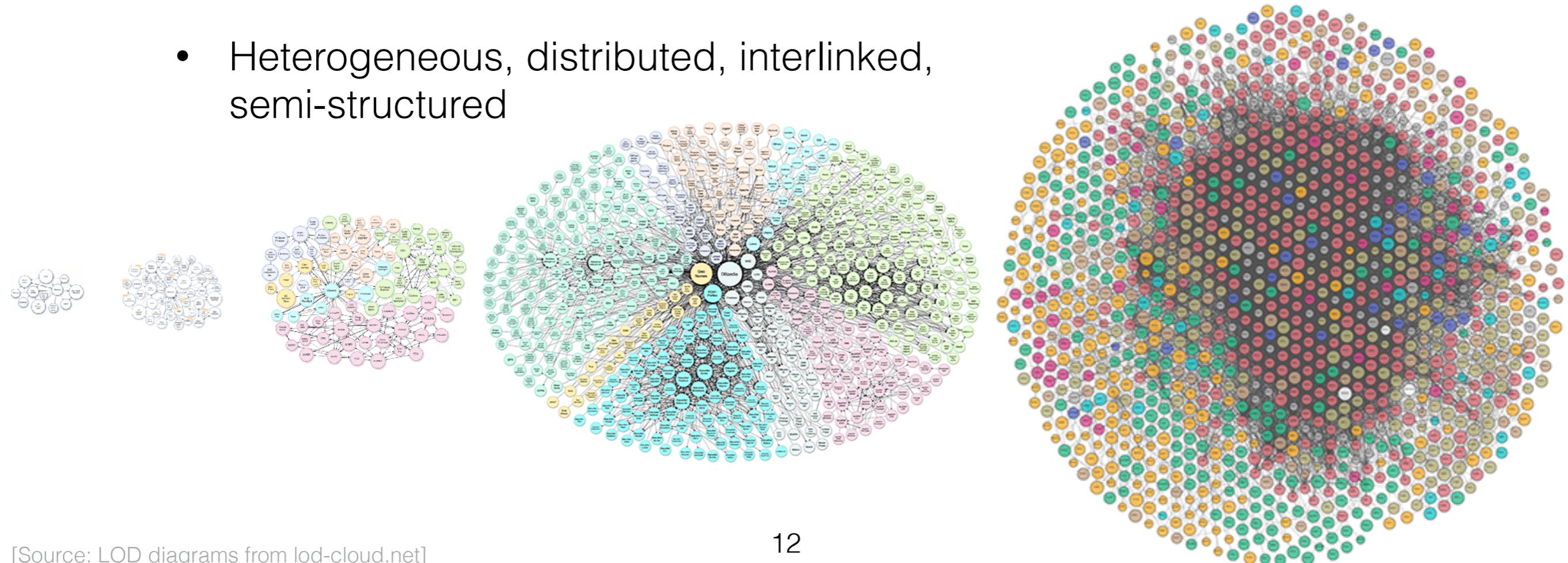
Edward Tufte. *The Visual Display of Quantitative Information* (2nd edition). Graphics Press, 2001.



Juuso Koponen & Jonatan Hildén. *Data Visualization Handbook*. Aalto University, 2019.

# Why visualization?

- Increasingly *large* datasets
  - In many areas: science, government & open data, personal data, + ICT has become pervasive in many sectors
- Increasingly *complex* datasets
  - Heterogeneous, distributed, interlinked, semi-structured



# Why visualization?

- Vision is a very powerful input channel; it is our most dominant sense.
- Visual representations help communication findings
- Humans are very good at recognizing visual patterns.
- Visual representations help understand and reason about the data, and eventually make decisions.

### Anscombe's Quartet: Raw Data

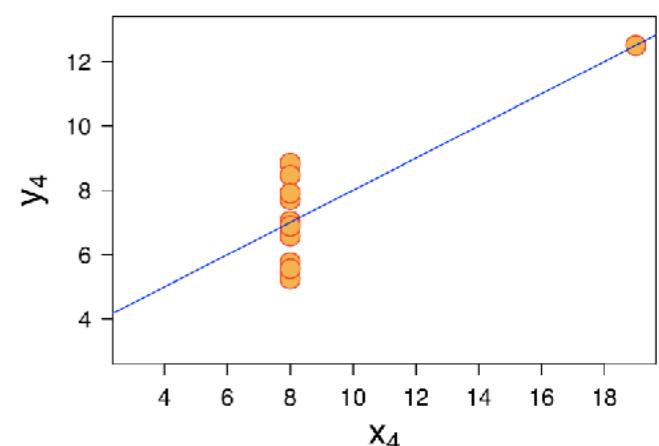
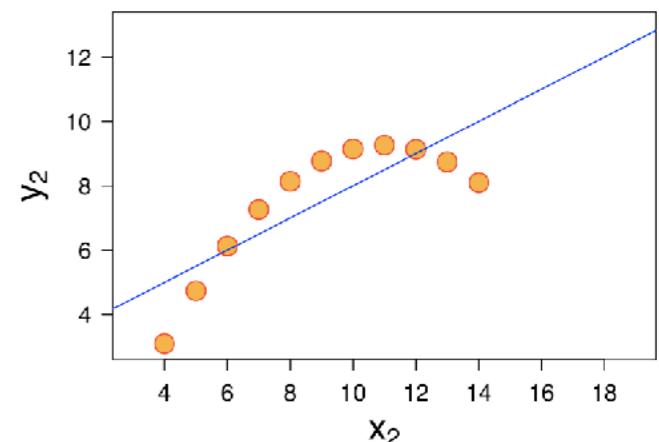
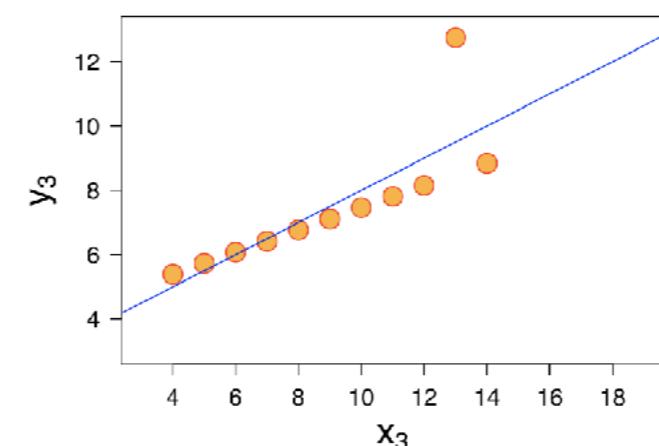
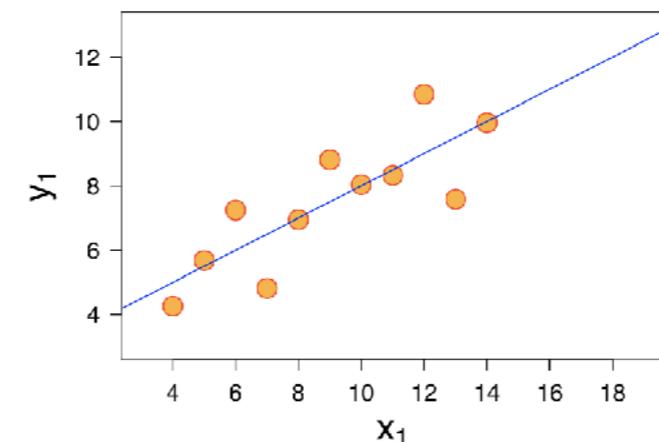
	1		2		3		4		
	X	Y	X	Y	X	Y	X	Y	
Data Points	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58	
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76	
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71	
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84	
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47	
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04	
	6.0	7.24	6.0	6.13	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	
Summary Statistics	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		

+ same linear regression formula

Anscombe, Francis J. (1973) Graphs in statistical analysis. American Statistician, 27, 17–21

**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	



Anscombe, Francis J. (1973) Graphs in statistical analysis. American Statistician, 27, 17–21

March on Moscow, by Charles Minard, 1869

<https://upload.wikimedia.org/wikipedia/commons/2/29/Minard.png>

*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 Léger, 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 et Mohilow et qui rejoignirent Orsha et Witebsk, avaient toujours marché avec l'armée.

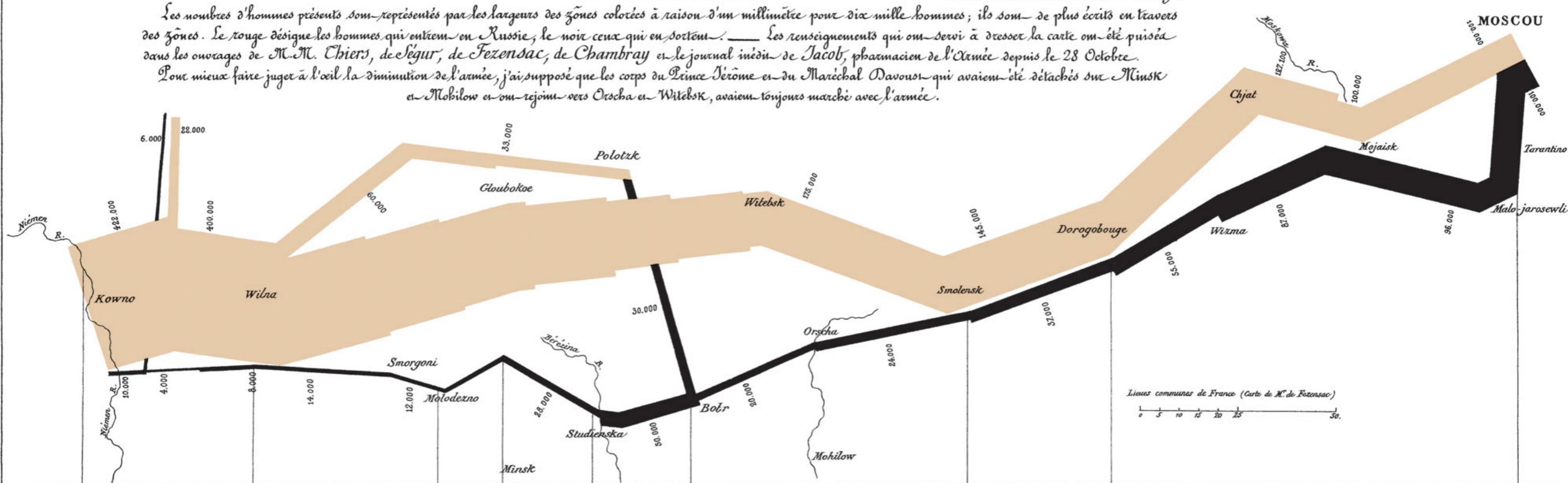
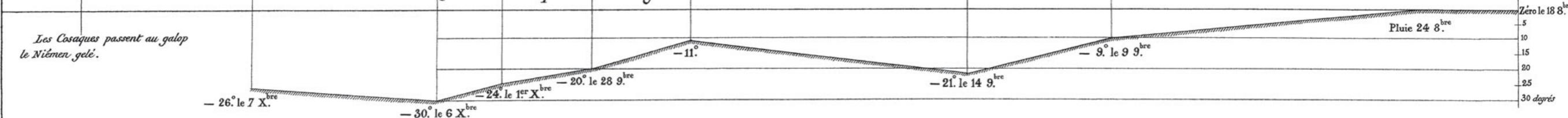


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



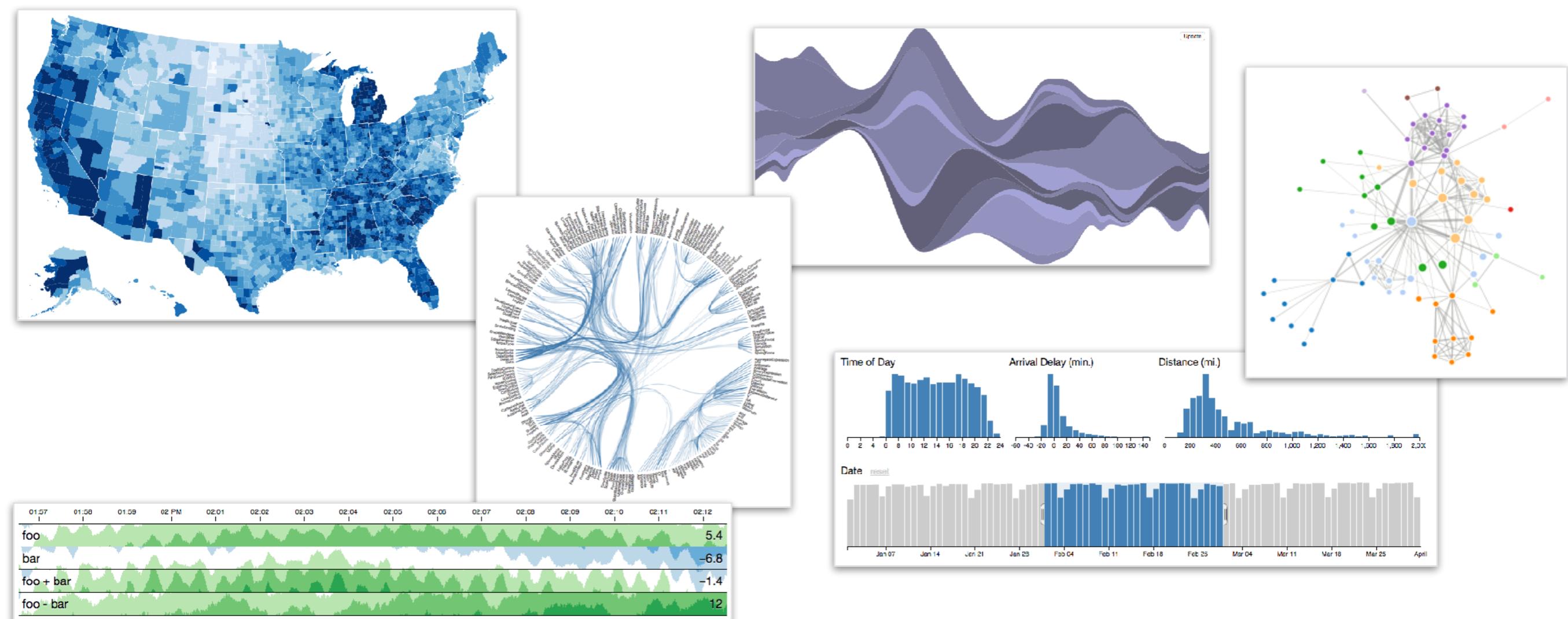
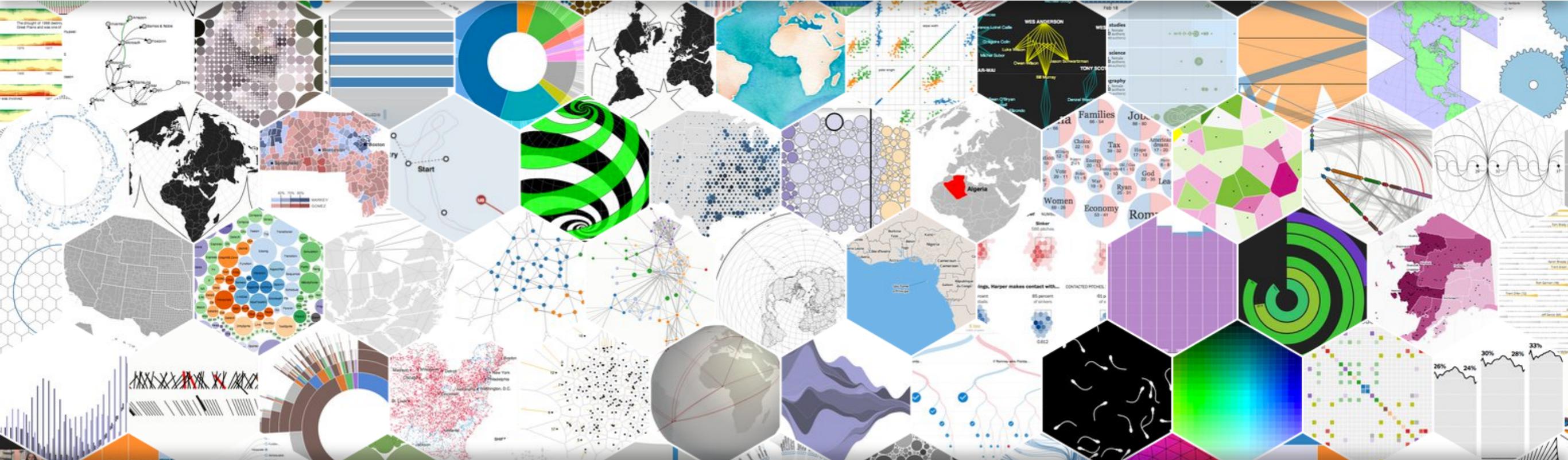
Autog. par Regnier, 8. Pas. S<sup>e</sup> Marie St. G<sup>e</sup>me à Paris.

Imp. Lith. Regnier et Dourdet.

Le but de mes cartes figuratives est moins d'exposer des résultats statistiques, mieux établis par des nombres, que d'en faire saisir promptement les rapports à l'oeil, rapports qui arrivent spontanément à l'intelligence par les figures et qui n'y pénètrent par les nombres que par l'intermédiaire d'un calcul mental. Les cartes figuratives sont tout-à-fait dans l'esprit du siècle où l'on cherche à économiser le temps de toutes les manières possibles.

*Carte figurative et approximative de l'importance des ports maritimes de l'Empire français mesurée par les tonnages effectifs des navires entrés et sortis en 1857. [Minard, 1859]*

The aim of my figurative maps is less to exhibit statistical results, which could be better established by numbers, than to make relationships quickly apparent to the eye, relationships that are instantly grasped where numbers would require the mediation of a mental calculation. The figurative maps are thoroughly in the spirit of the century in which one seeks to save time in all ways possible.



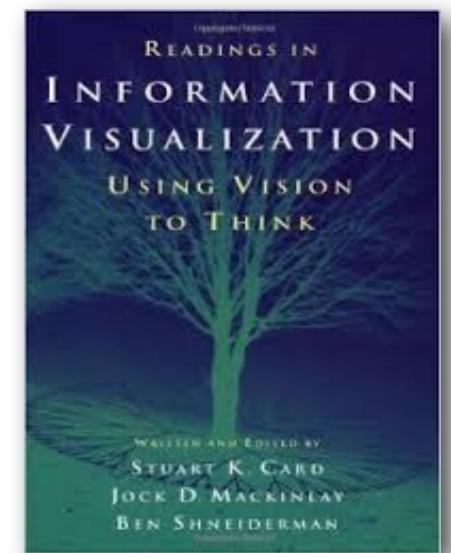
# Visualizing data helps:

- make comparisons
- spot outliers, discover patterns, identify correlations
- understand its structure
- gain new insights (answer questions you didn't know you had)
- make decisions
- communicate findings to an audience

# What is *information* visualization?

- Official definition:

*The use of computer-supported, interactive, visual representations of abstract data to amplify cognition*

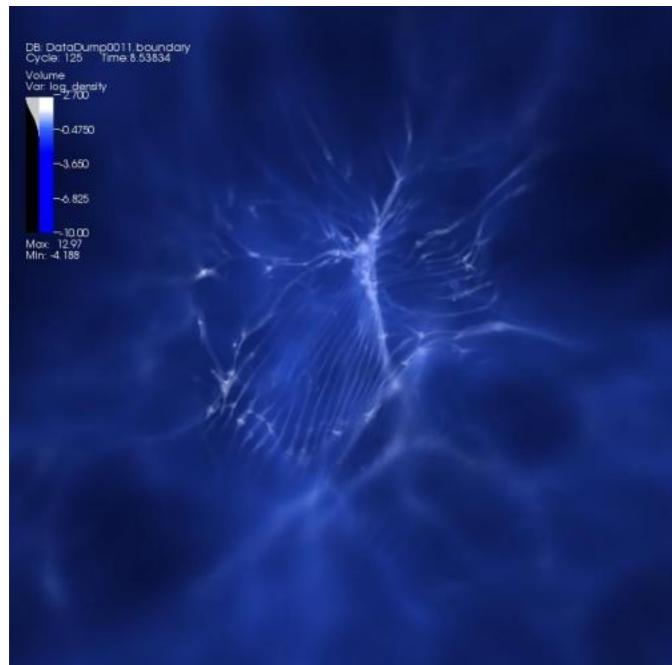


Stuart K. Card, Jock D. Mackinlay, and Ben Shneiderman (Eds.). 1999.  
*Readings in Information Visualization: Using Vision to Think.*  
Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.

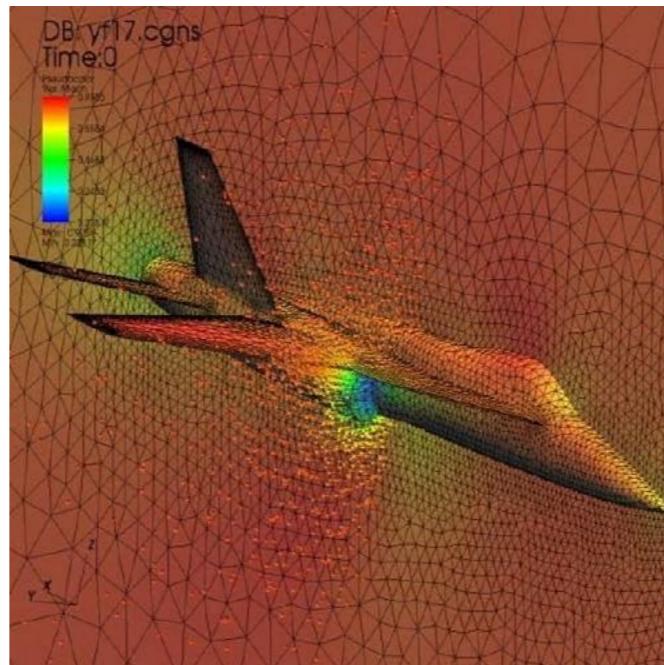
- Focus on abstract (non-spatial) data and interaction

# What is information visualization?

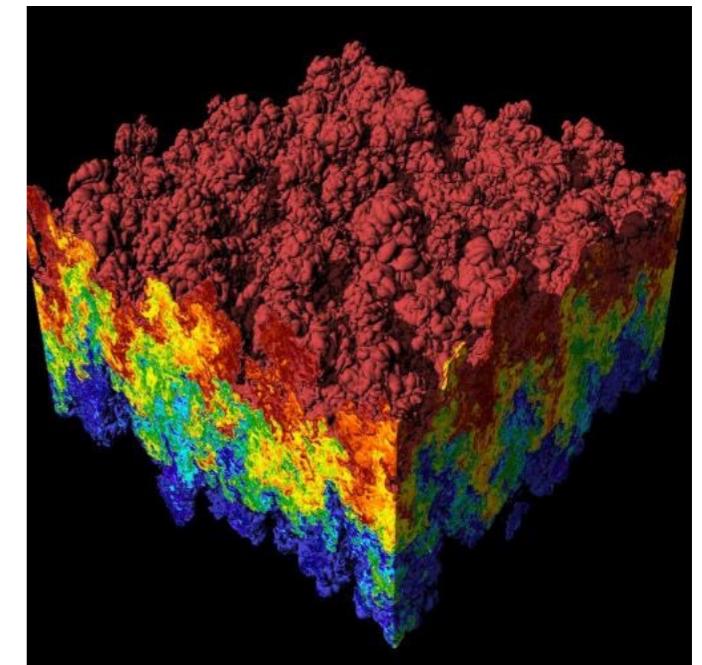
- InfoVis  $\neq$  SciVis



<http://en.wikipedia.org/wiki/File:StarFormation.jpg>



[http://en.wikipedia.org/wiki/File:YF-17\\_aircraft\\_Plot.jpg](http://en.wikipedia.org/wiki/File:YF-17_aircraft_Plot.jpg)

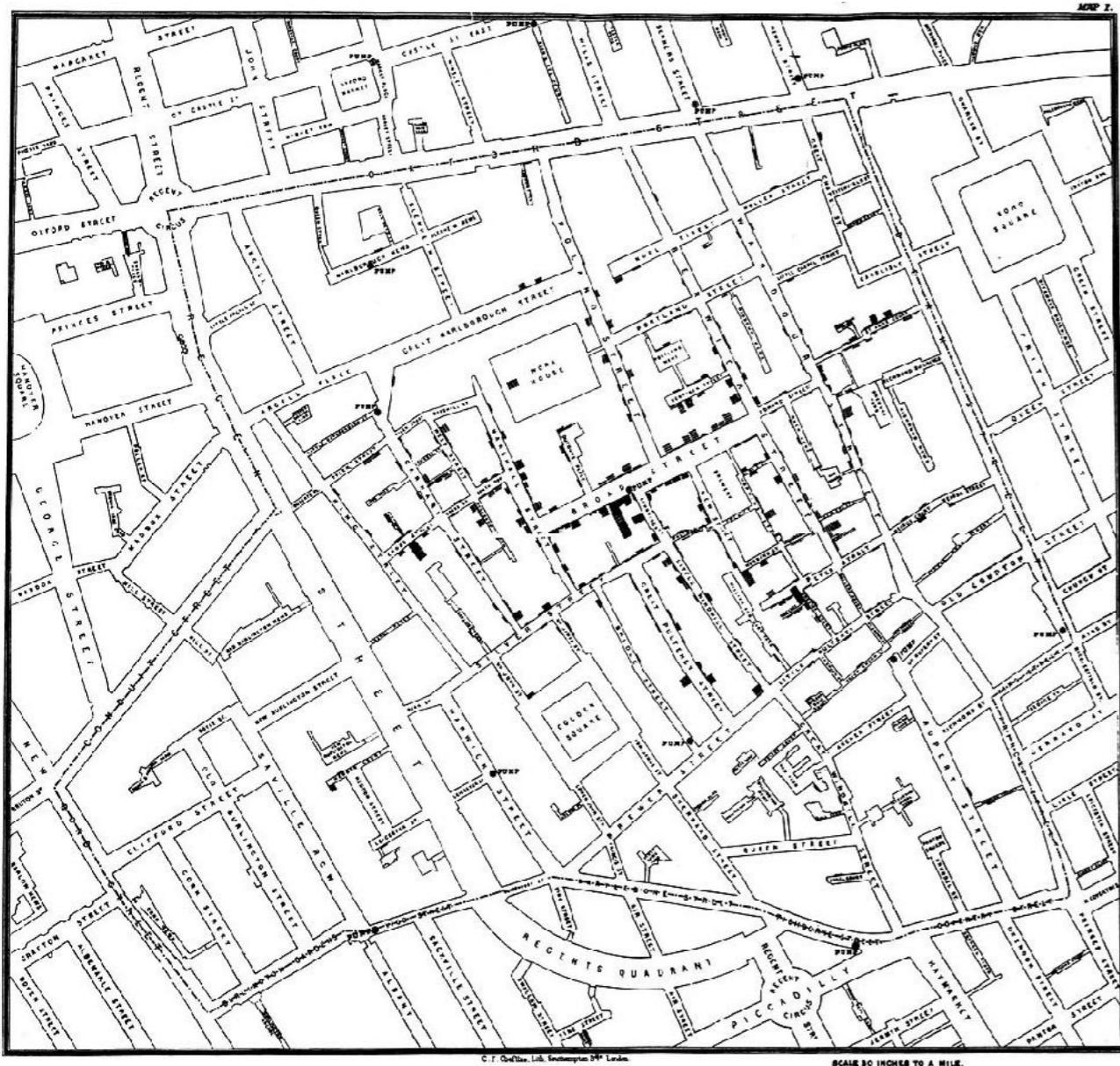


[http://en.wikipedia.org/wiki/File:Rayleigh-Taylor\\_instability.jpg](http://en.wikipedia.org/wiki/File:Rayleigh-Taylor_instability.jpg)

(top) William Playfair's trade-balance time-series chart,

(bottom) Exports and Imports of Scotland to and from different parts for one Year from Christmas 1780 to Christmas 1781  
Both published in his Commercial and Political Atlas, 1786, retrieved from [http://en.wikipedia.org/wiki/William\\_Playfair](http://en.wikipedia.org/wiki/William_Playfair)

Snow-cholera-map.jpg

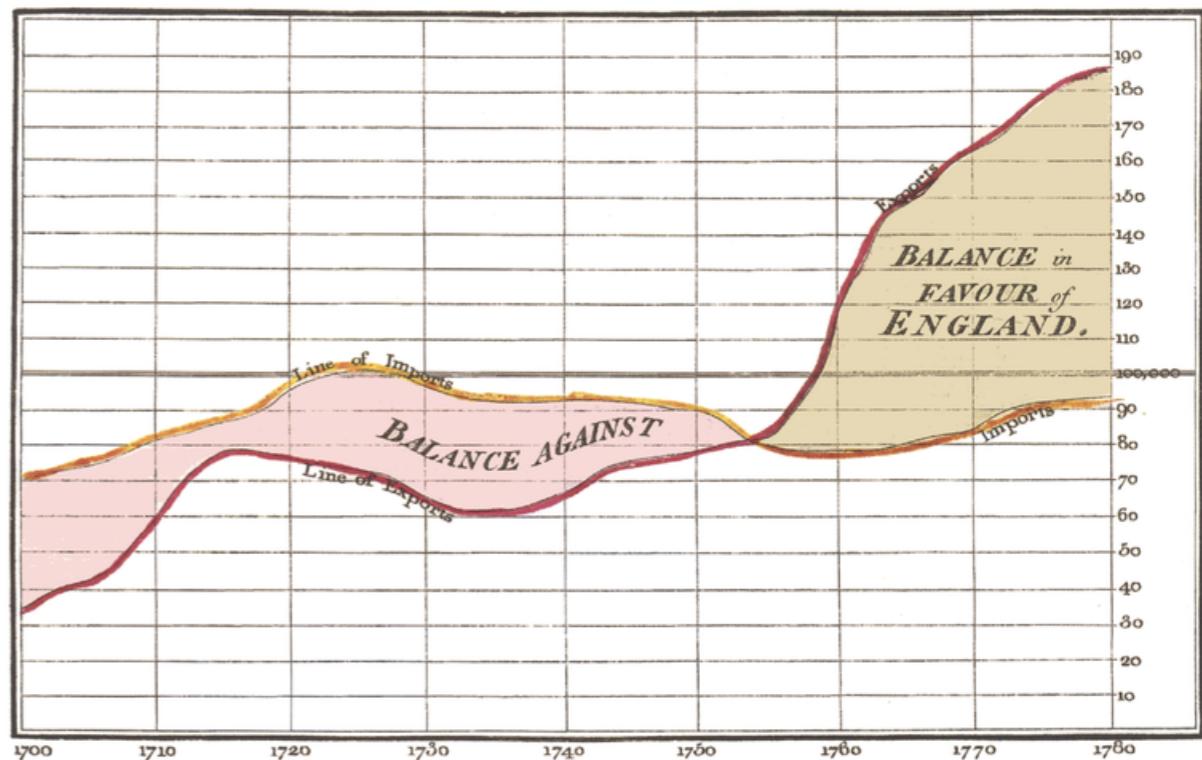


London Cholera Outbreak

Original map made by John Snow in 1854

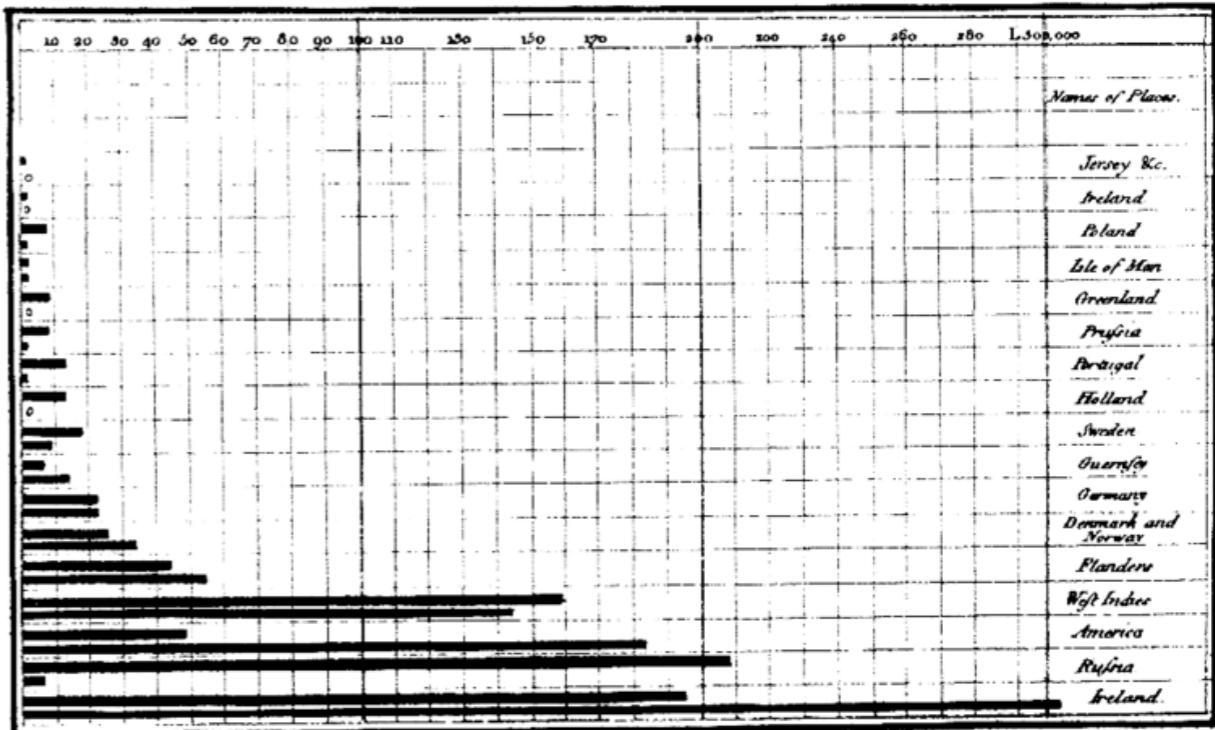
from <http://commons.wikimedia.org/wiki/File:Snow-cholera-map-1.jpg>

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

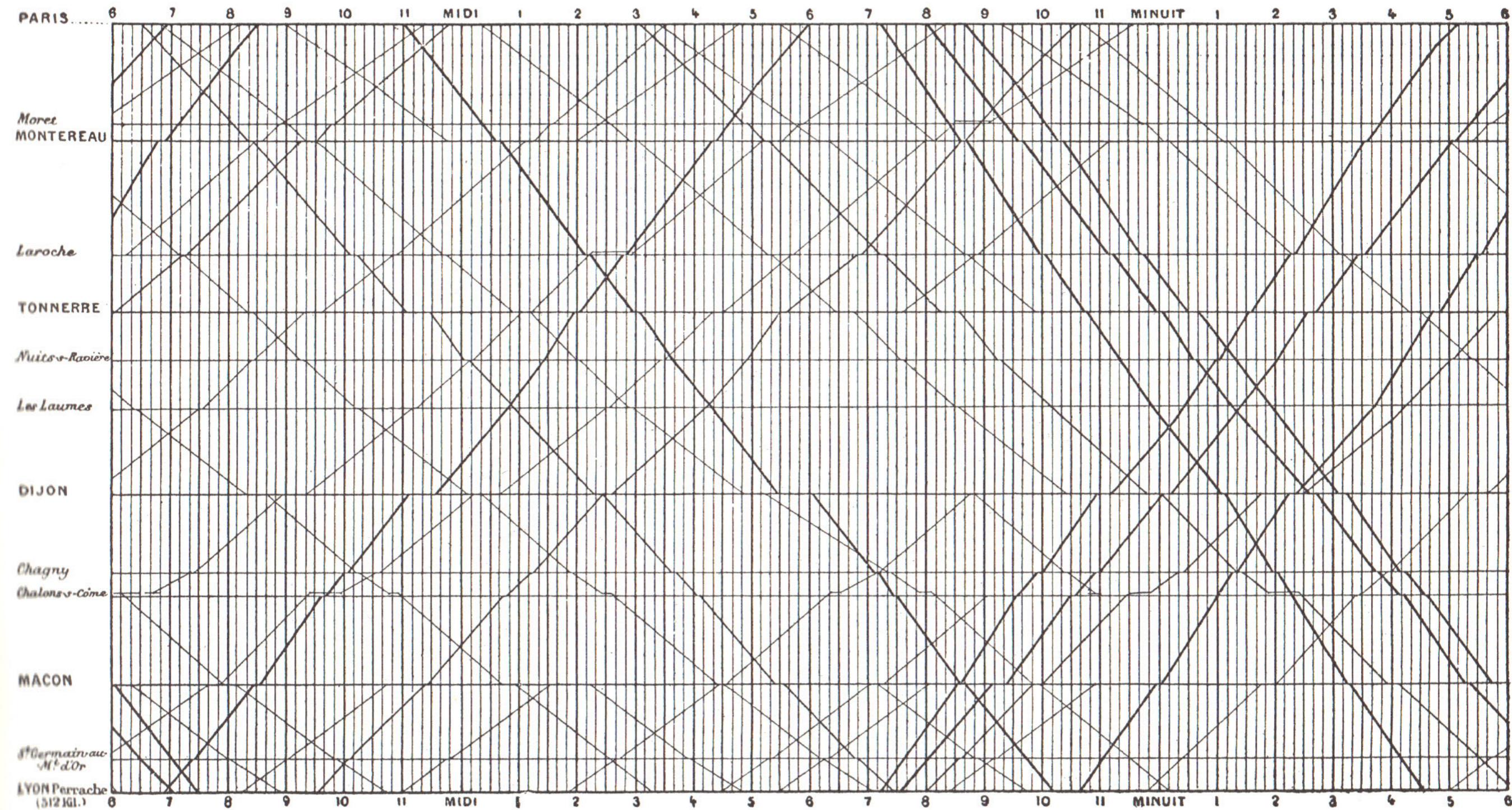


Published as the Act directs, 10<sup>th</sup> May 1786, by W<sup>m</sup> Playfair  
Neale sculpt 352, Strand, London.

Exports and Imports of SCOTLAND to and from different parts for one Year from Christmas 1780 to Christmas 1781.

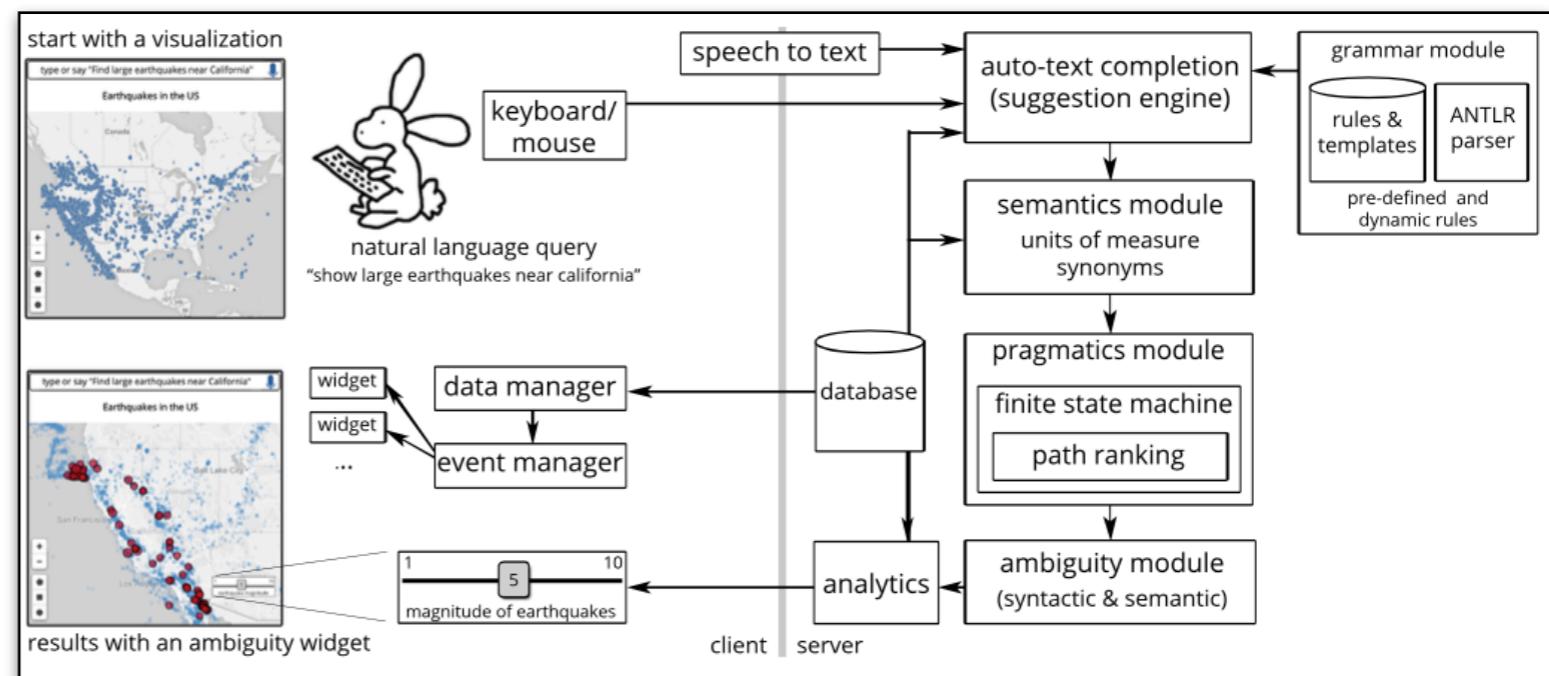
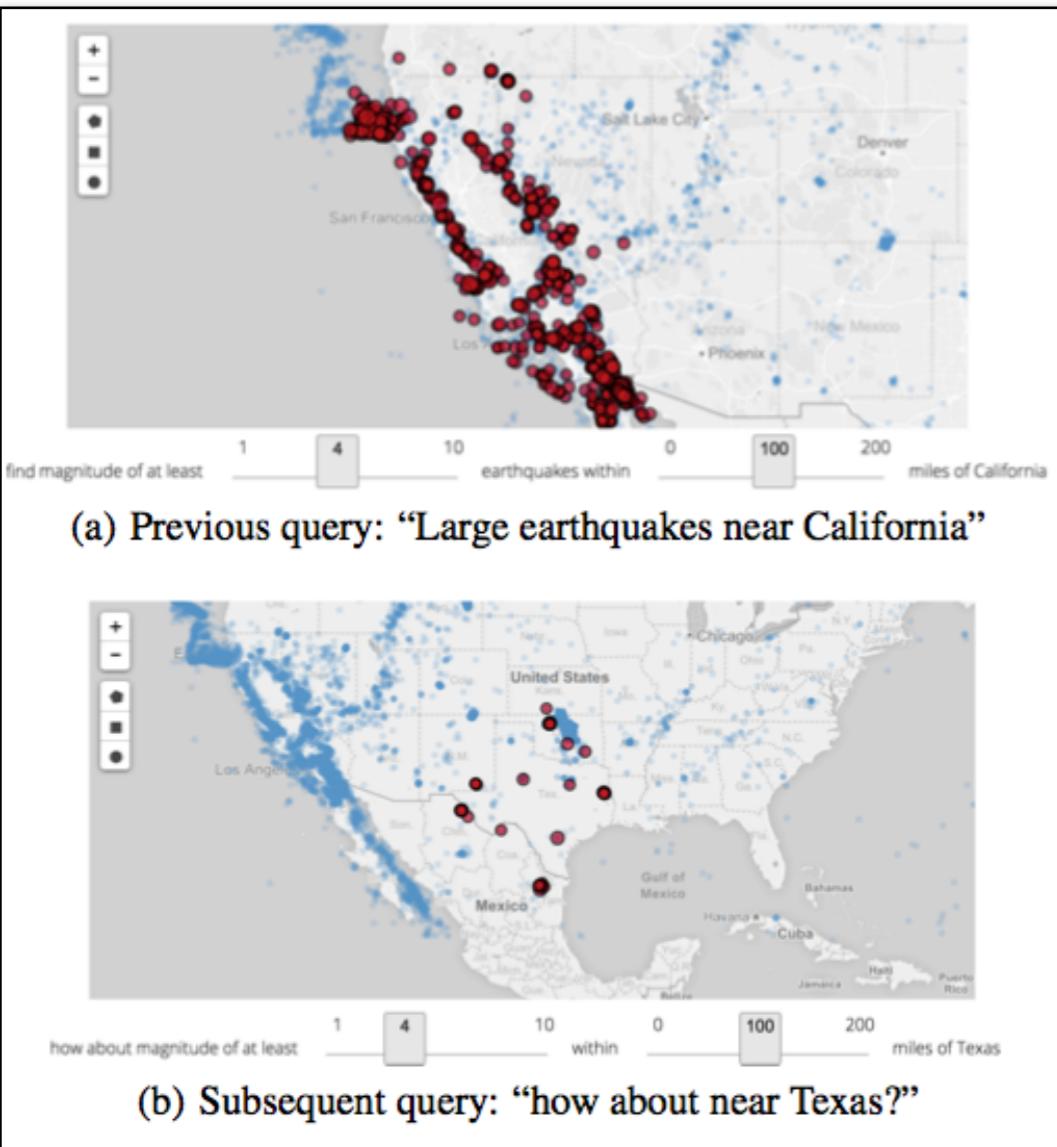


The upright divisions are Ten Thousand Pounds each. The Black Lines are Exports the Ribbed Lines Imports.  
Published as the Act directs, 10<sup>th</sup> May 1786, by W<sup>m</sup> Playfair  
Neale sculpt 352, Strand, London.



E. J. Marey, *La Méthode Graphique* (Paris, 1885), p.20.

# Arbitrarily-selected recent techniques & systems



eviza.mov

Vidya Setlur et al. 2016. Eviza: A Natural Language Interface for Visual Analysis. In Proceedings of the 29th Annual Symposium on User Interface Software and Technology (UIST '16). ACM, 365-377. <https://doi.org/10.1145/2984511.2984588>

# Arbitrarily-selected recent techniques & systems

**Bi-manual interaction**

**Filtering**

**Highlighting**

**Hiding**

**Cutting**

**Painting**

**Inking**

**Activating Ink**

**Searching ink**

Hugo Romat et al. 2019. ActiveInk: (Th)Inking with Data. Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. ACM, New York, NY, USA, Paper 42, 1–13.<https://doi.org/10.1145/3290605.3300272>

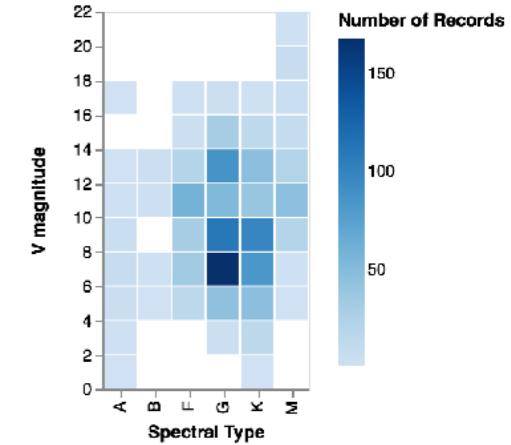
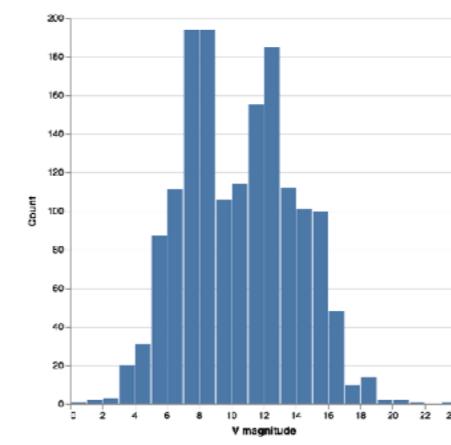
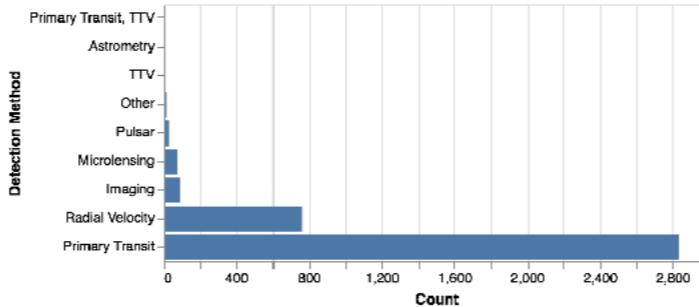
# Typical questions that visualizations can help answer:

- How is a measure distributed?
- How do groups differ from each other?
- Do individual items fall into groups? Is there a relationship between attributes of items?
- How does an attribute vary continuously?
- How are objects related to each other in a network or hierarchy?
- Where are objects located?

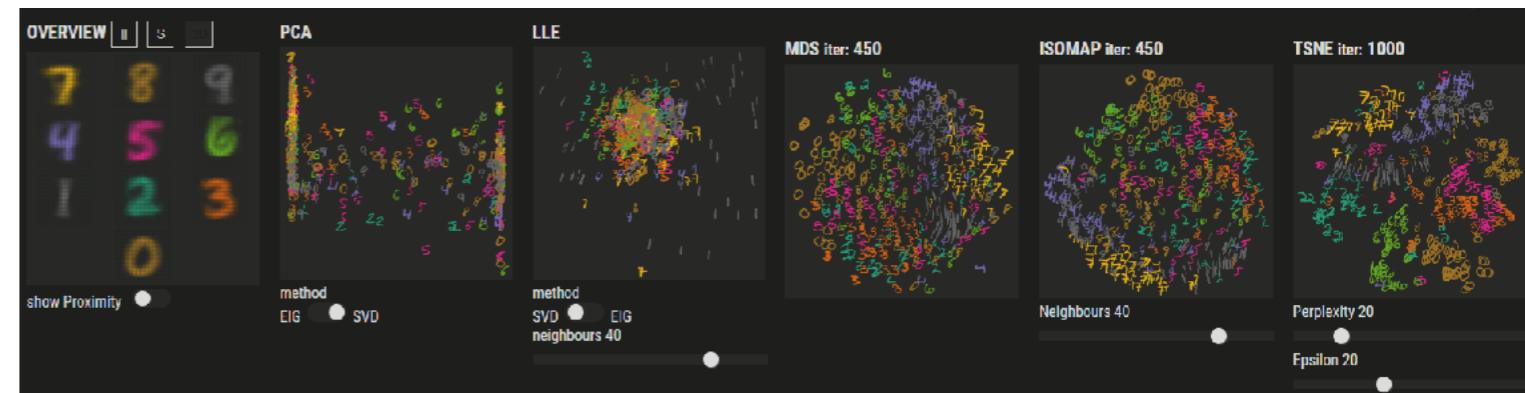
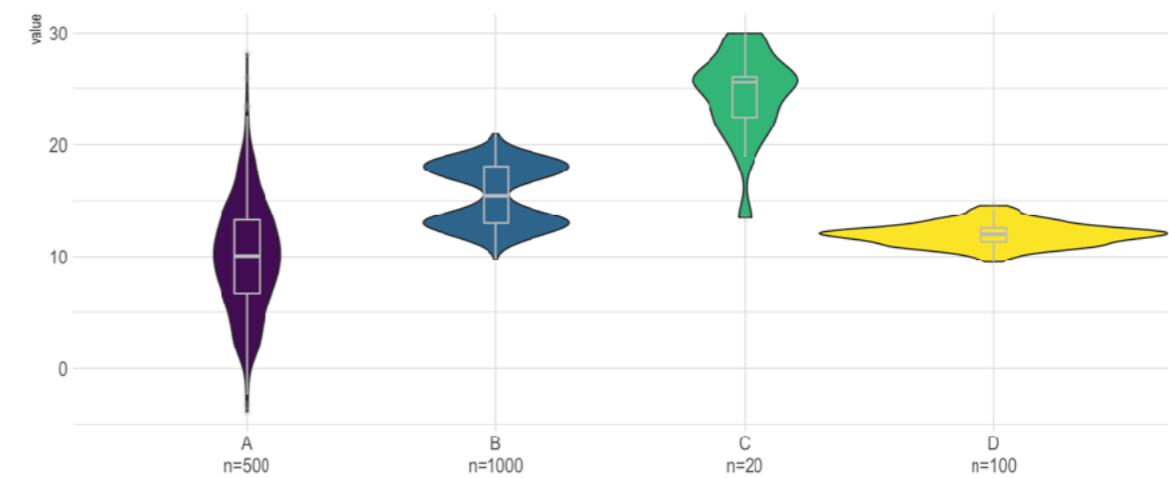
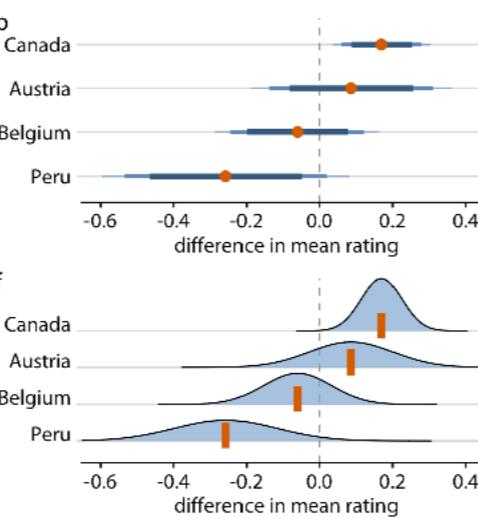
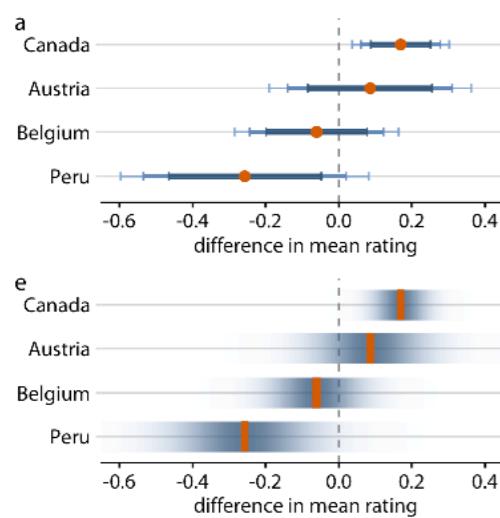
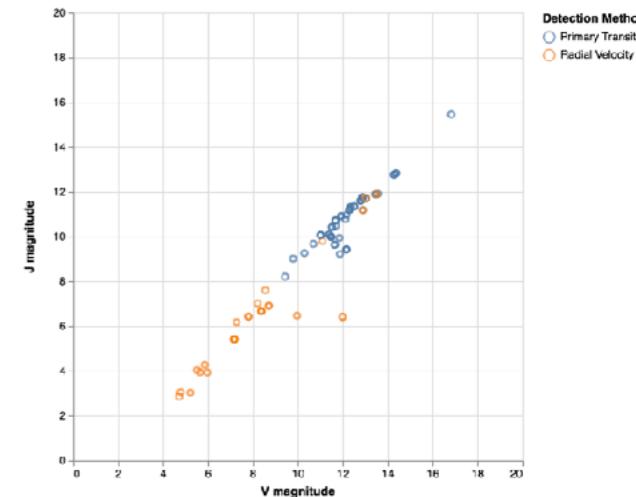
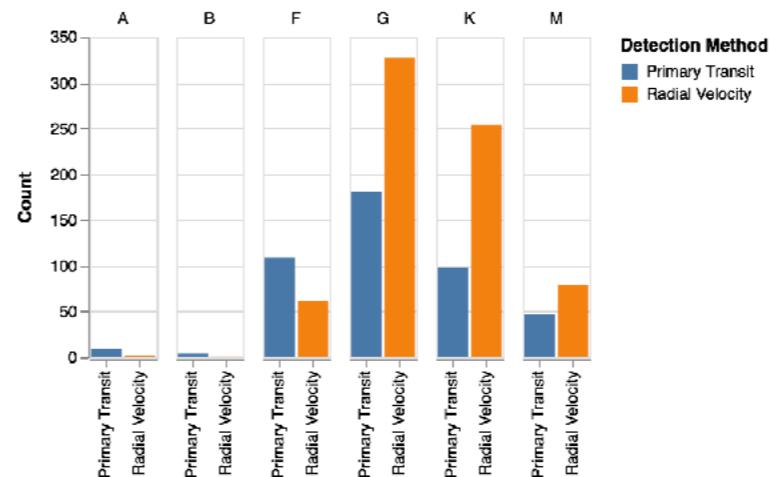
... that are often not trivial to answer by looking at the raw data...

# name	mass	radius	orbital_period	eccentricity	discovered	detection_type	ra	dec	mag_v	mag_i	mag_j
11 Com b	19.4		326.03	0.231	2008	Radial Velocity	185.1791667	17.7927778	4.74		
11 Oph b	21.0		730000.0		2007	Imaging	245.6041667	-24.0872222			
11 UMi b	10.5		516.22	0.08	2009	Radial Velocity	229.275	71.8238889	5.02		
14 And b	5.33		185.84	0.0	2008	Radial Velocity	352.8208333	39.2361111	5.22	4.1	3.02
14 Her b	4.64		1773.4	0.369	2002	Radial Velocity	242.5958333	43.8216667	6.67		
16 Cyg B b	1.68		799.5	0.689	1996	Radial Velocity	295.4625	50.5175	6.2		
18 Del b	10.3		993.3	0.08	2008	Radial Velocity	314.6083333	10.8391667	5.52		4.03
1RXS 1609 b	14.0	1.7			2008	Imaging	242.375	-21.0827778		10.99	9.82
1SWASP J1407 b	20.0		3725.0		2012	Primary Transit	211.950000016	-39.761944469	12.4		
24 Boo b	0.91		30.3506	0.042	2018	Radial Velocity	217.162500013	49.845000026	5.6		
24 Sex b	1.99		452.8	0.09	2010	Radial Velocity	155.8666667	0.9022222	7.38		
24 Sex c	0.86		883.0	0.29	2010	Radial Velocity	155.8666667	0.9022222	7.38		
2M 0103-55 (AB) b	13.0				2013	Imaging	15.9	-55.2656			7.5
2M 0122-24 b	20.0	1.0			2013	Imaging	20.7125	-24.6142			
2M 0219-39 b	13.9	1.44			2015	Imaging	34.841666674	-39.423055569			
2M 0441+23 b	7.5				2010	Imaging	70.4375	23.0308333			14.2
2M 0746+20 b	30.0	0.97	4640.0	0.487	2010	Imaging	116.6791667	20.0088889			
2M 1207-39	24.0				2001	Imaging	181.8875	-39.5483333	20.15	15.95	13.0
2M 1207-39 b	4.0				2004	Imaging	181.8875	-39.5483333	20.15	15.95	13.0
2M 1938+46 b	1.9		416.0		2015	Pulsar	294.637500011	46.066388903			
2M 2140+16 b	20.0	0.92	7340.0	0.26	2010	Imaging	325.1208333	16.4216667			
2M 2206-20 b	30.0	1.3	8686.0	0.0	2010	Imaging	331.5958333	-20.785			
2M 2236+4751 b	12.5				2016	Imaging	339.104166675	47.861944471	12.5		
2M J2126-81 b	13.3				2016	Imaging	321.366666676	-81.6411113	9.0		
2MASS J0249-0557 (AB) c	11.6				2018	Astrometry	42.484952078	-5.95983636252			
2MASS J0249-0557A	48.0				2018	Astrometry	42.484952078	-5.95983636252			
2MASS J0249-0557B	44.0				2018	Astrometry	42.484952078	-5.95983636252			
2MASS J11193254 AB	3.7		32850.0		2017	Imaging	169.885595844	-11.6296389116			
2MASS J1450-7841 A	40.0				2017	Imaging	222.670833347	-78.693888911			
2MASS J1450-7841 B	40.0				2017	Imaging	222.675000014	-78.694722245			
2MASS J2250+2325 b	30.0				2017	Imaging	342.562500005	23.426111127			
30 Ari B b	9.88		335.1	0.289	2009	Radial Velocity	39.2416667	24.6480556	7.1		
38 Vir b	4.51		825.9	0.03	2016	Primary Transit	193.296489462	-3.55309929126	6.11		
4 Uma b	7.1		269.3	0.432	2007	Radial Velocity	130.0541667	64.3280556	5.79		
42 Dra b	3.88		479.1	0.38	2009	Radial Velocity	276.4958333	65.5636111	4.83		
47 Uma b	2.53		1078.0	0.032	1996	Radial Velocity	164.8708333	40.4294444	5.1		
47 Uma c	0.54		2391.0	0.098	2001	Radial Velocity	164.8708333	40.4294444	5.1		
47 Uma d	1.64		14002.0	0.16	2010	Radial Velocity	164.8708333	40.4294444	5.1		
51 Eri b	9.1	1.11	14965.0	0.21	2015	Imaging	69.4005514287	-2.47354859817	5.223		

How is a measure distributed?

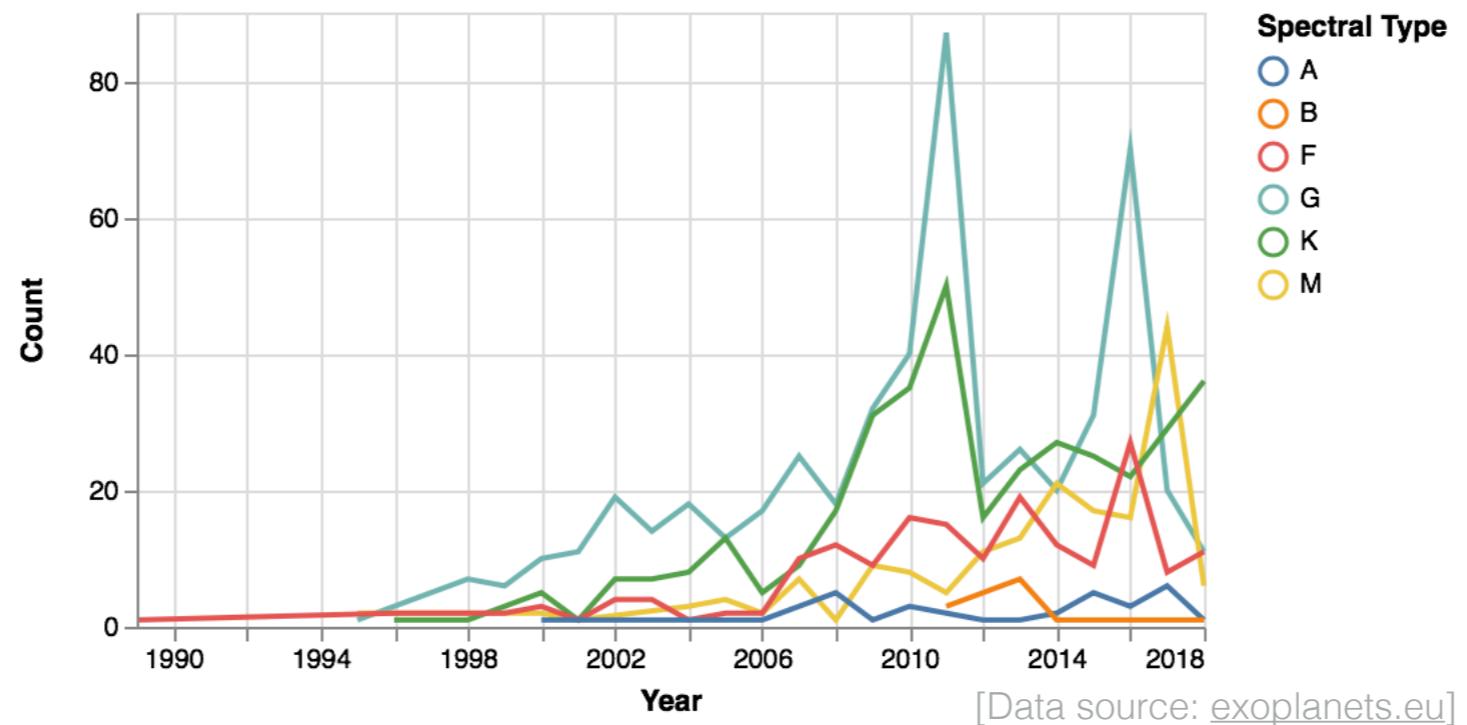


How do groups differ from each other?



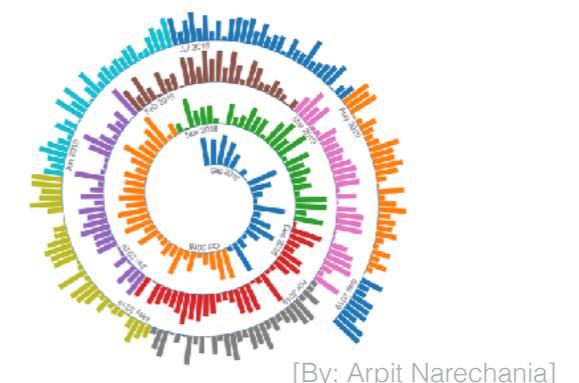
All things related to dimensionality reduction.

# How does an attribute vary continuously? (s#05)



The independent variable is often time...

... for which we have the notion of seasonal patterns,

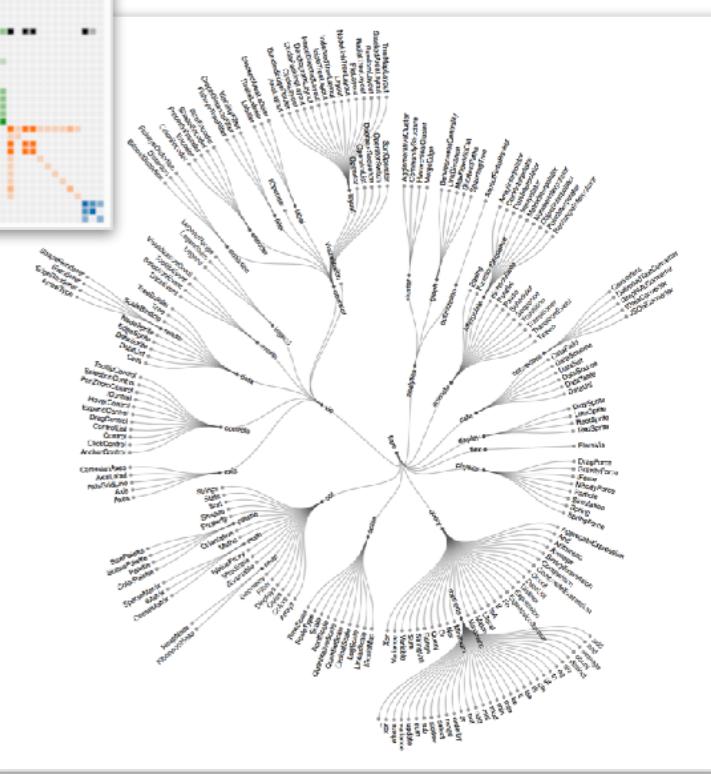
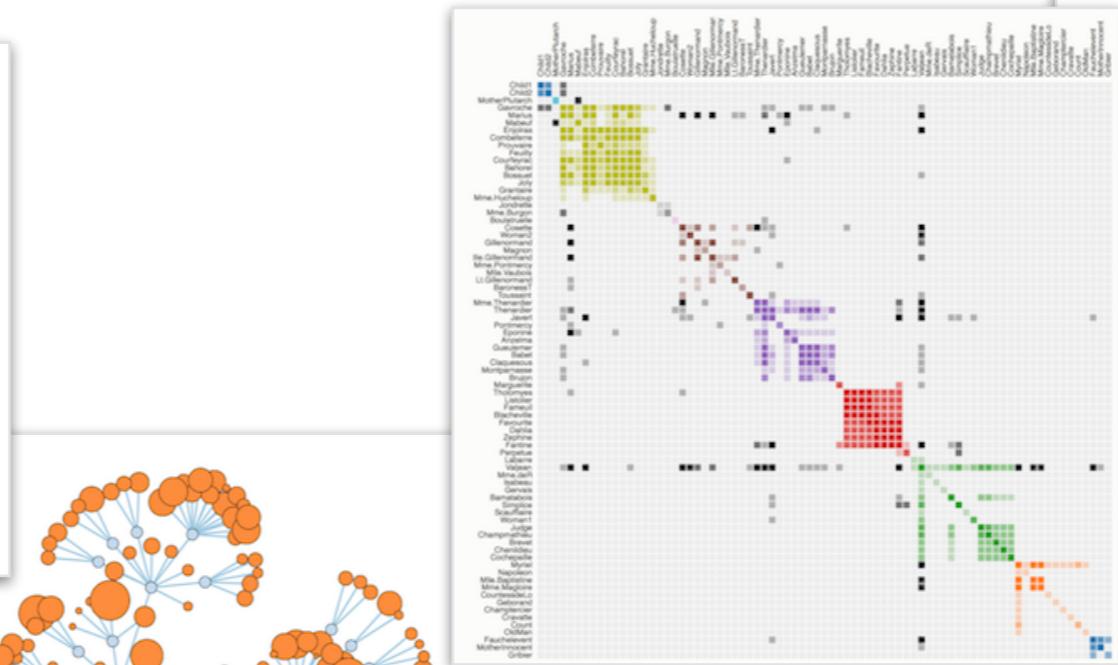
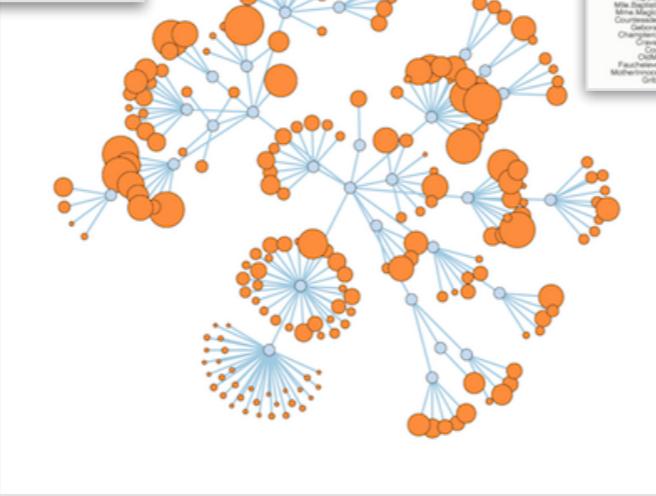
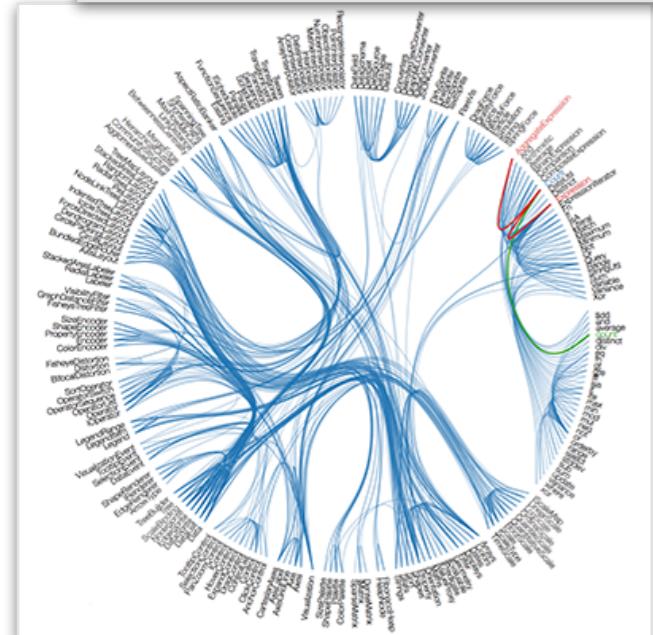
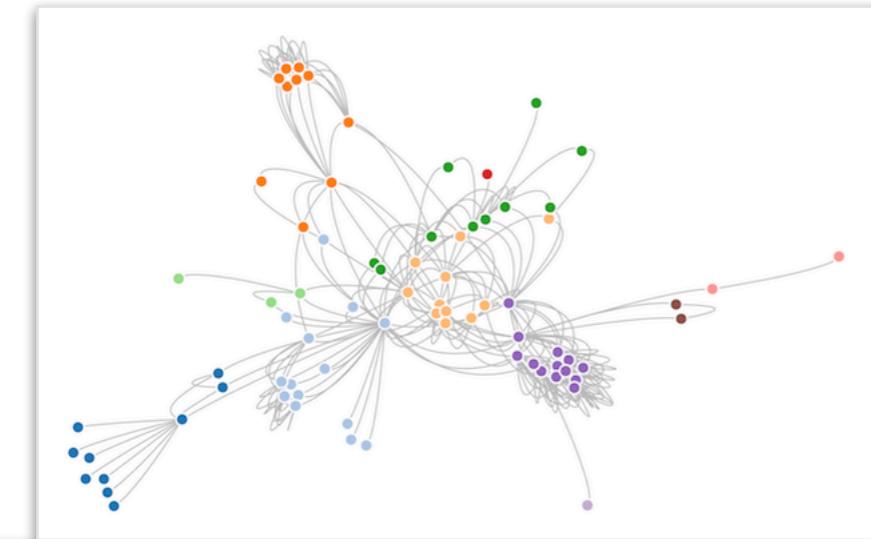


... which translates to the more general notion of repeating patterns when the independent variable is something else, like distance.

# How are objects related to each other? (s#07-s#08)

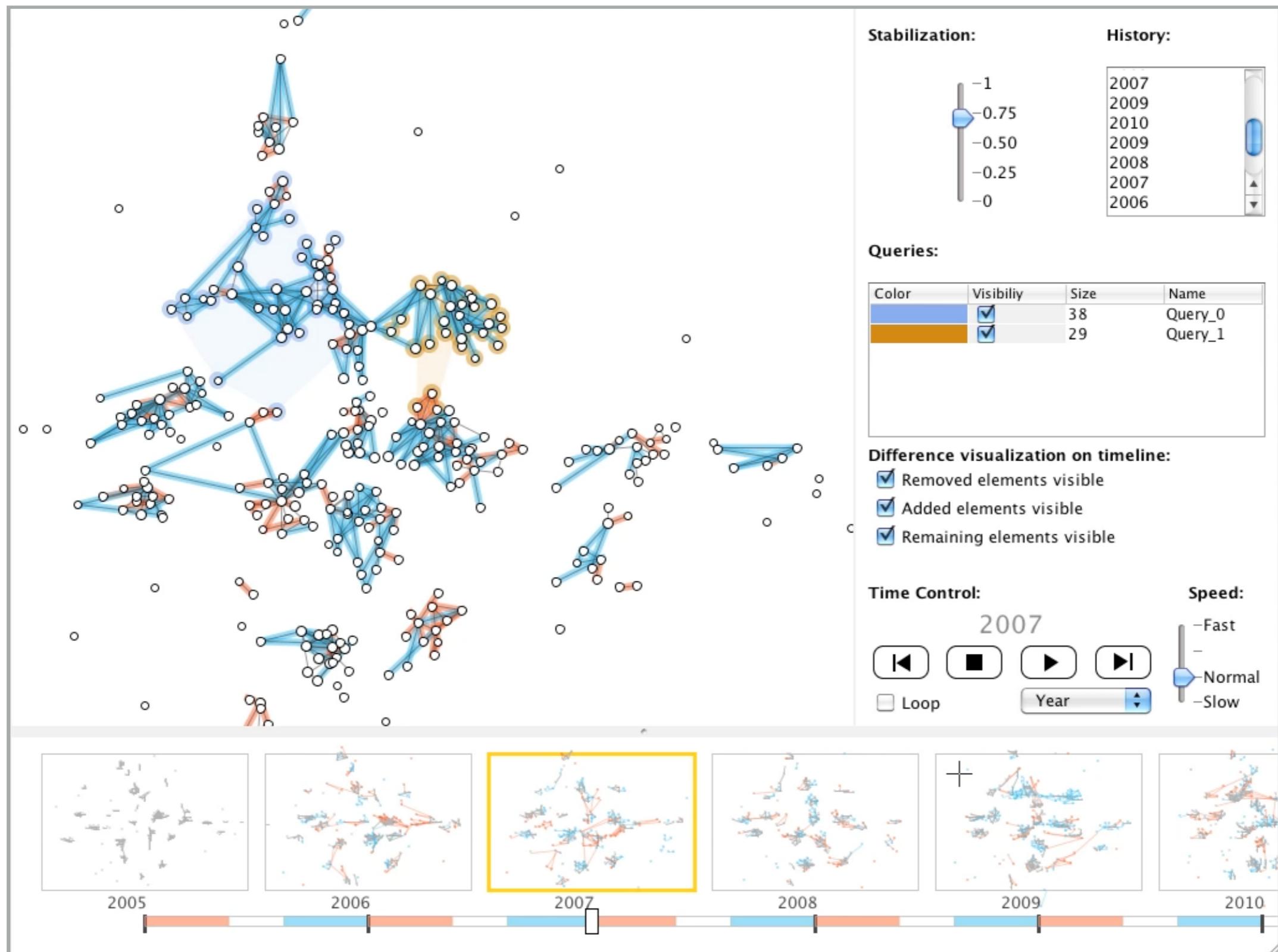
Hierarchical structures (trees)

Graph structures (networks)



# Graphs (s#07-08)

graph\_diaries.mov



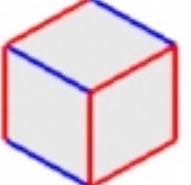
B. Bach et al., GraphDiaries: Animated Transitions and Temporal Navigation for Dynamic Networks, IEEE Transactions on Visualization and Computer Graphics (TVCG), Volume 20, Issue 5, pages 740-754, May 2014

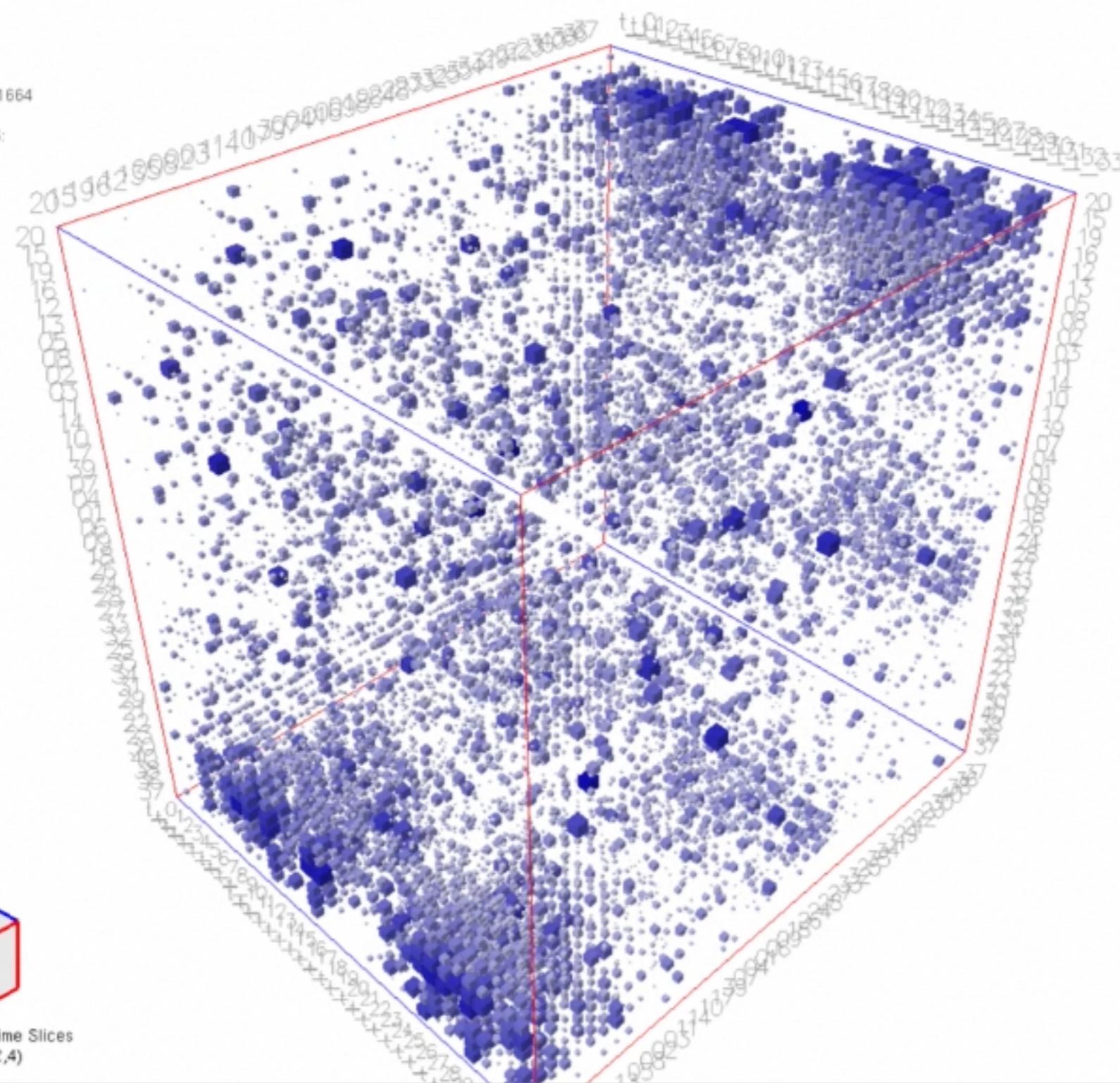
# Graphs (s#07-08)

cubix.m4v

GRAPH:  
Nodes: 40  
Edges: 57556  
Times: 34  
Cube Density: 0.009451664

VISUAL PARAMETERS:  
fps: 0.0

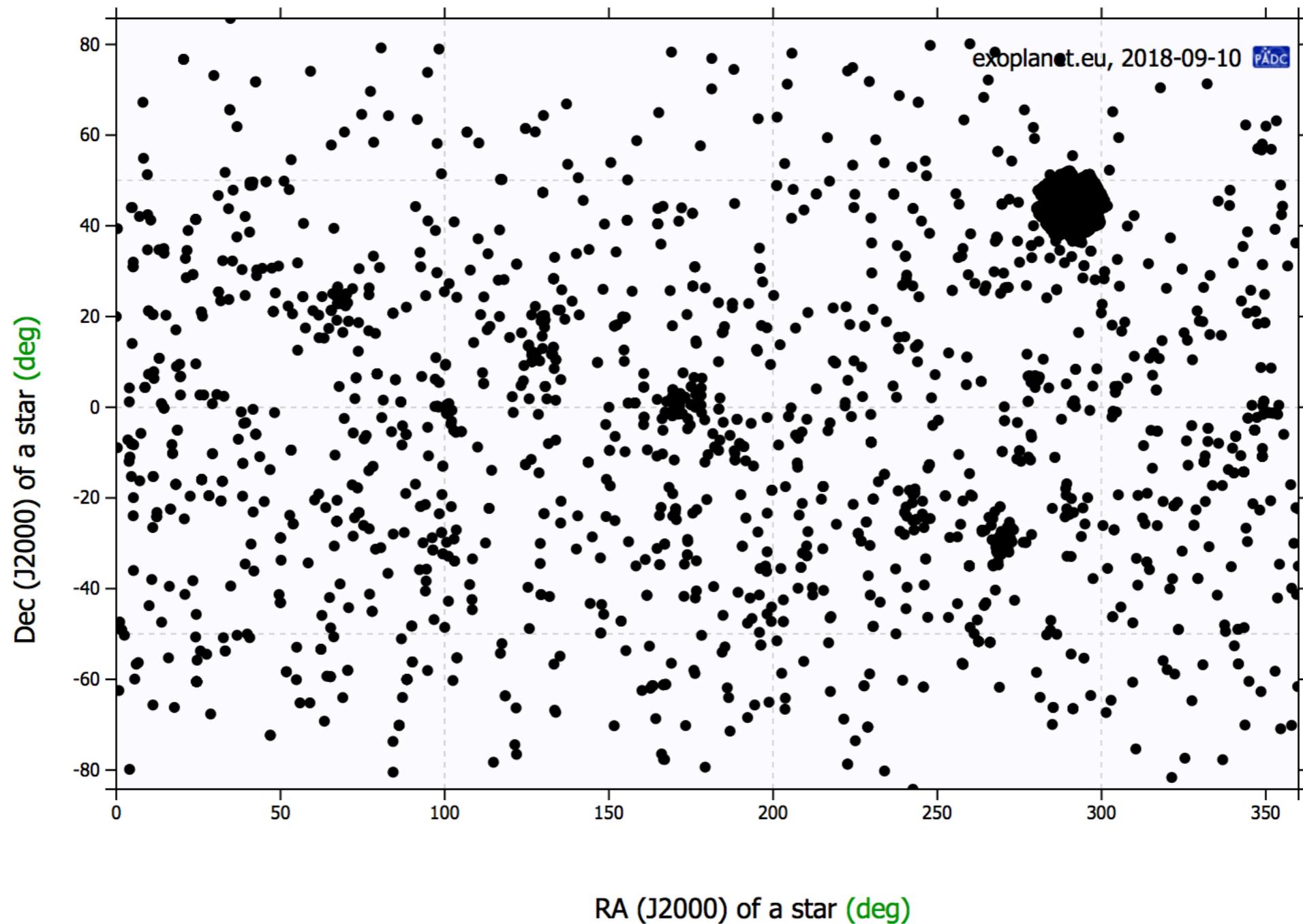
3D (1)  
  
 Vertex Slices (3,5)   Time Slices (2,4)



- Cell Color Encoding:
- Edge Weight (light to blue)
  - Edge Weight Diverging (re...)
  - Time (blue to orange)
  - None (all same gray)
- Cell Shape:
- Edge Weight 1 (small to la...)
  - Edge Weight 2 (small to la...)
  - None (equal size)
- Adapt Weight
- Logarithmic scale
- Diverging scale
- Topological Order
- Name Ordering
- Inverse Filter
- Time Range: 0 34
- Edge weight: 
- Cell Opacity: F V
- Show Self Edges
- Show Non-Self Edges
- Animation Speed: Slow Fast

B. Bach et al., Visualizing Dynamic Networks with Matrix Cubes, CHI '14: Proceedings of the 32nd SIGCHI conference on Human Factors in computing systems, pages 877-886, April 2014, Toronto, Canada

# Where are objects located?



# Maps (s#06)

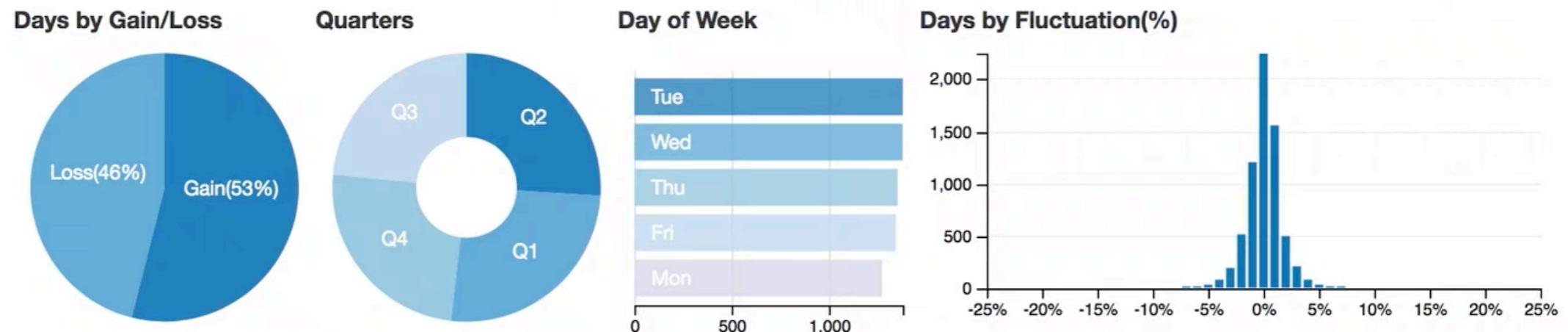
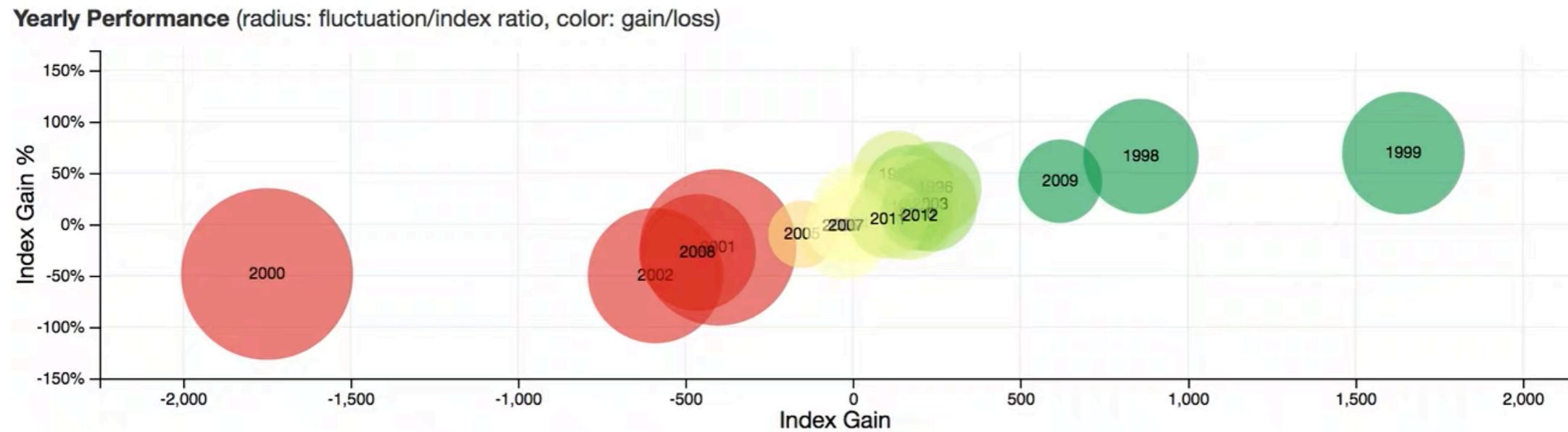
M.-J. Lobo et al., An Evaluation of Interactive Map Comparison Techniques. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, 3573-3582. <https://doi.org/10.1145/2702123.2702130>



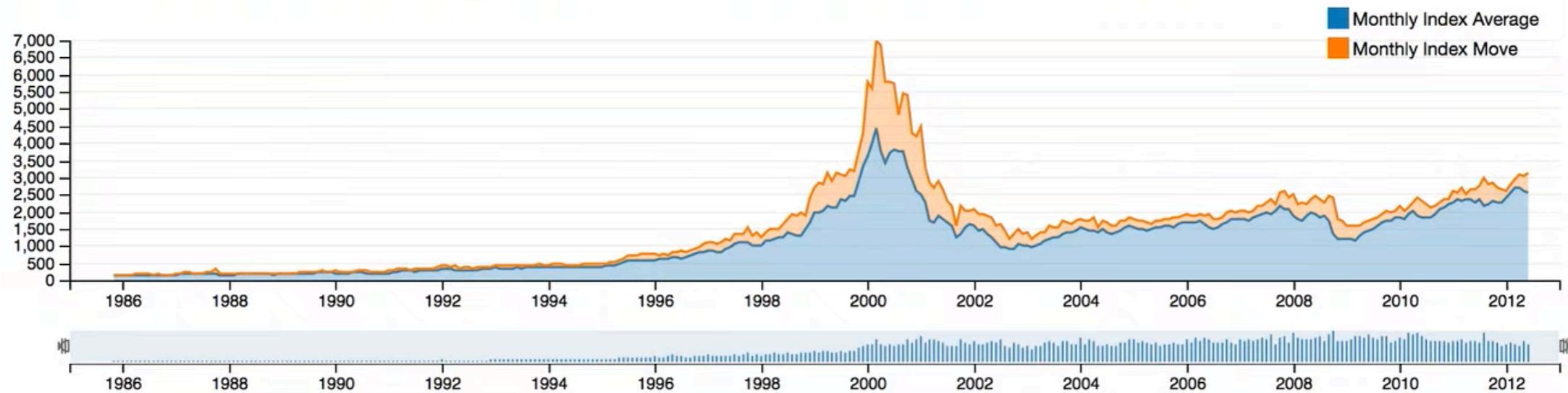
W. Willett et al. Lightweight Relief Shearing for Enhanced Terrain Perception on Interactive Maps. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, 3563-3572. <https://doi.org/10.1145/2702123.2702172>

Combinations of questions: coordinated multiple views, brushing & linking, etc.

## Nasdaq 100 Index 1985/11/01-2012/06/29



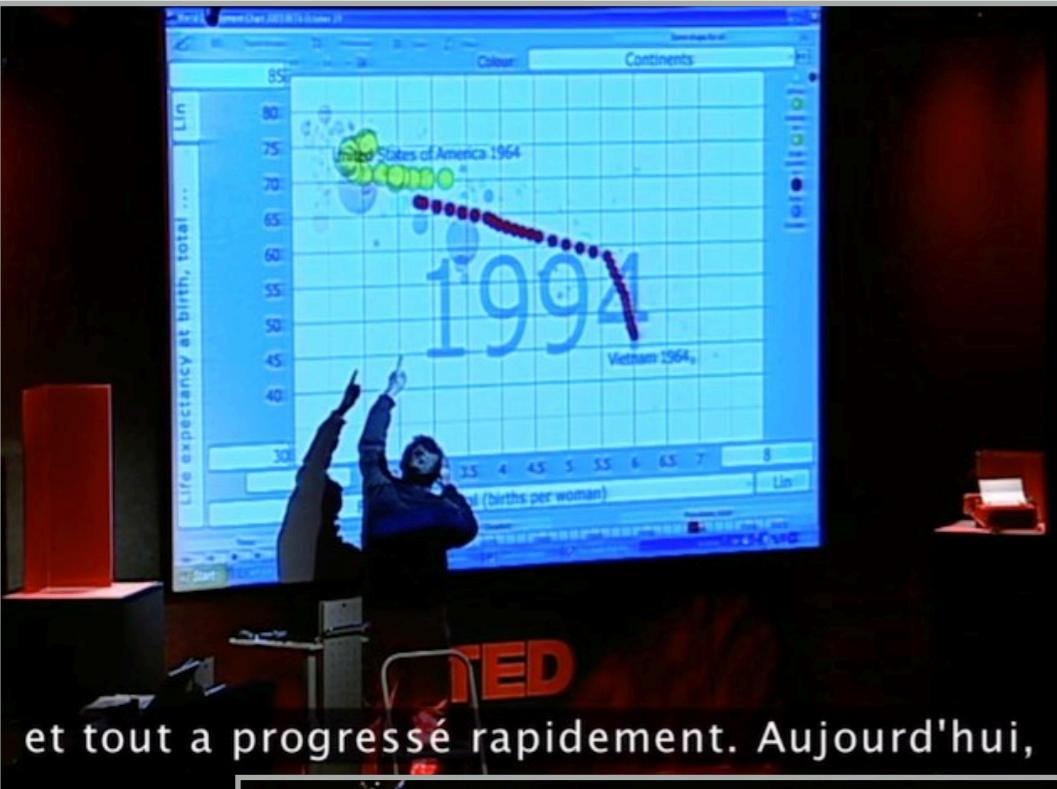
**Monthly Index Abs Move & Volume/500,000 Chart range: [01/01/1985 -> 12/31/2012] [reset](#)**



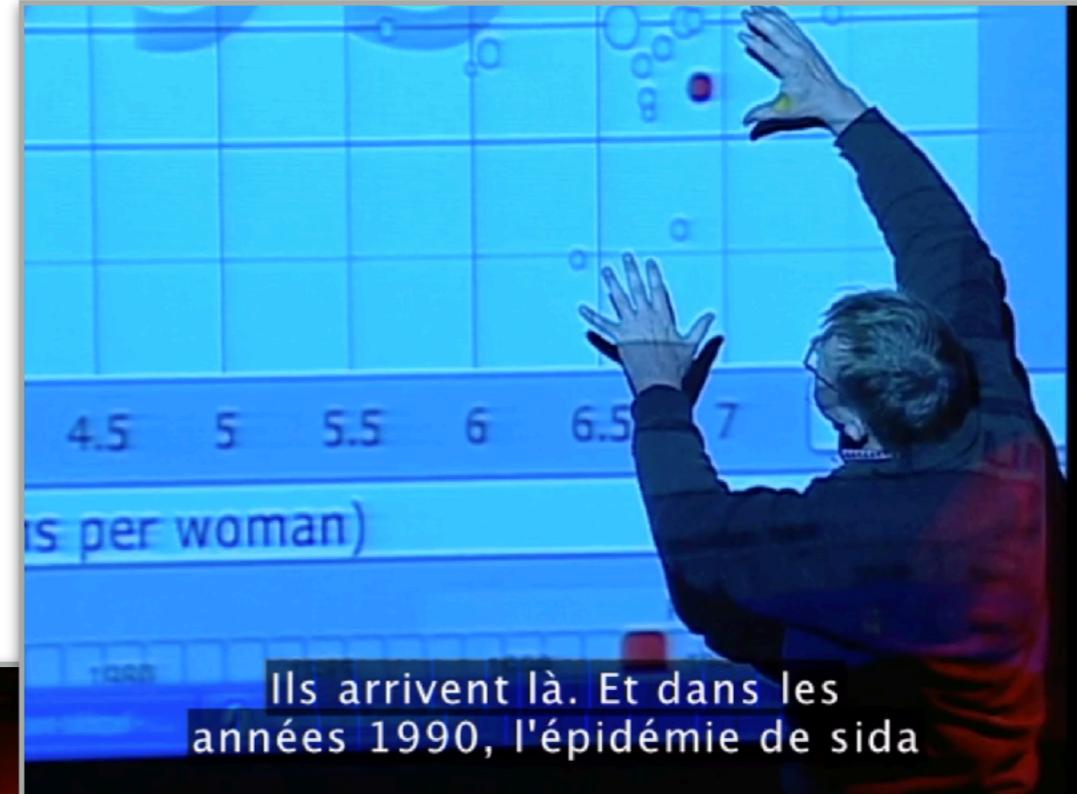
# Visualization for the purpose of communication

## Data storytelling

HansRosling\_2006-480p-en.mp4



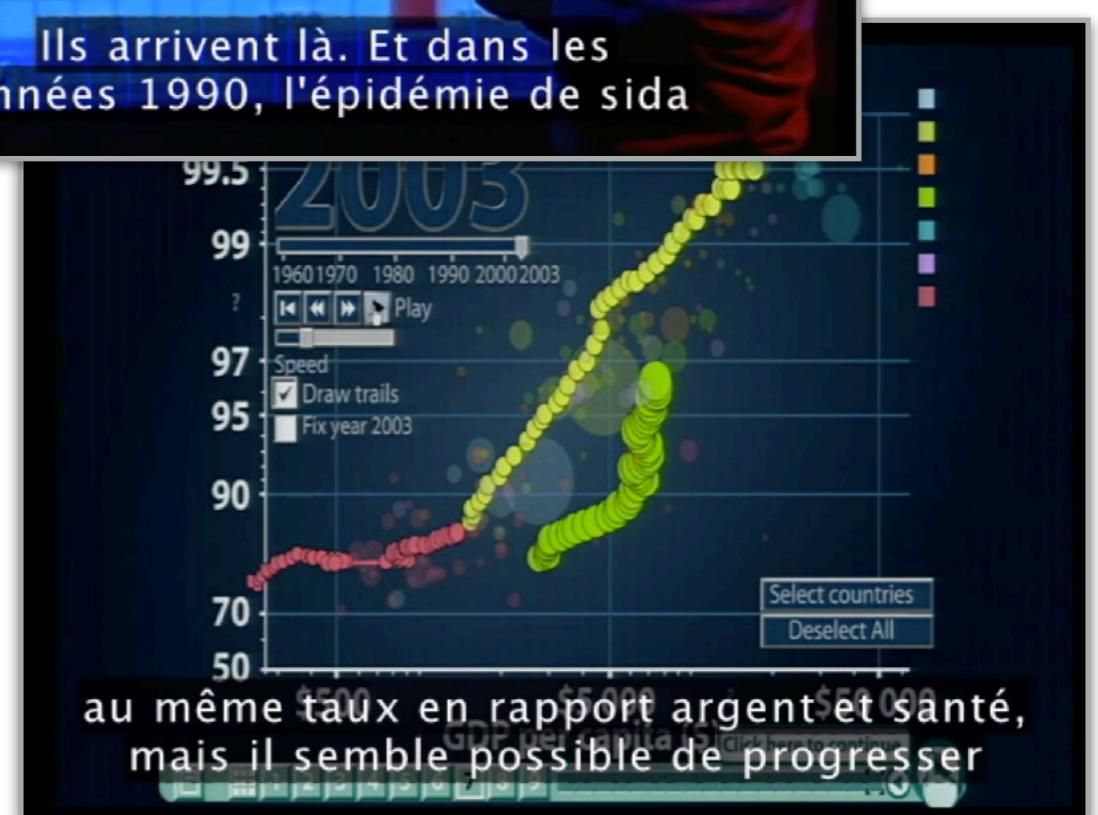
et tout a progressé rapidement. Aujourd'hui,



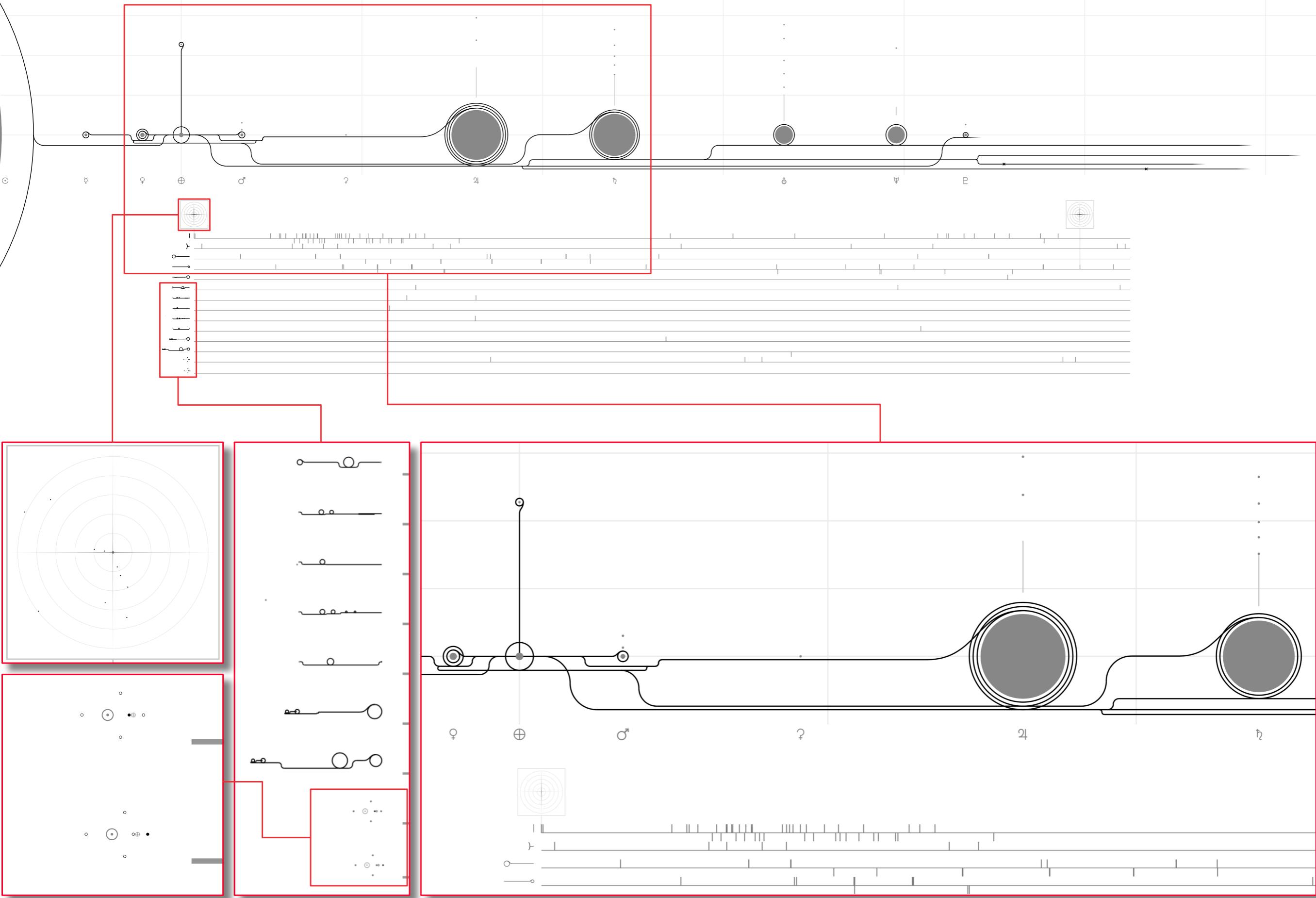
Ils arrivent là. Et dans les années 1990, l'épidémie de sida



se fond avec l'économie des pays. C'est pourquoi l'ordinateur



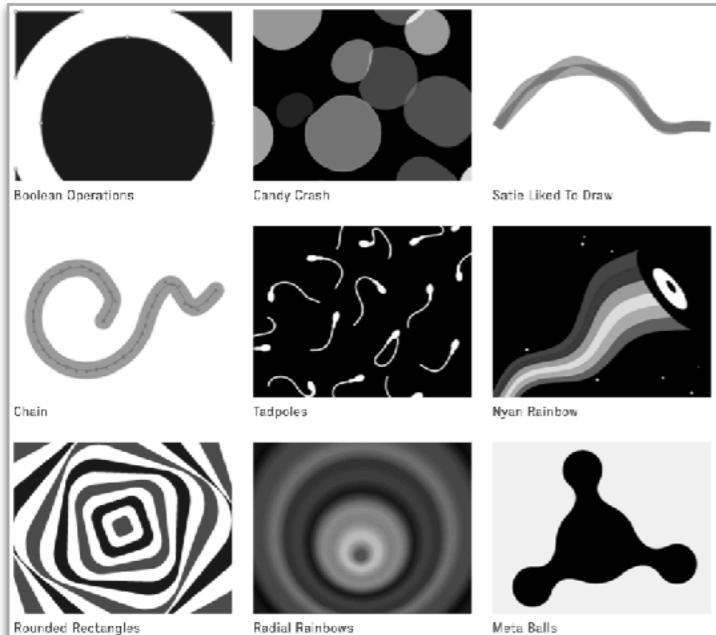
au même taux en rapport argent et santé, mais il semble possible de progresser



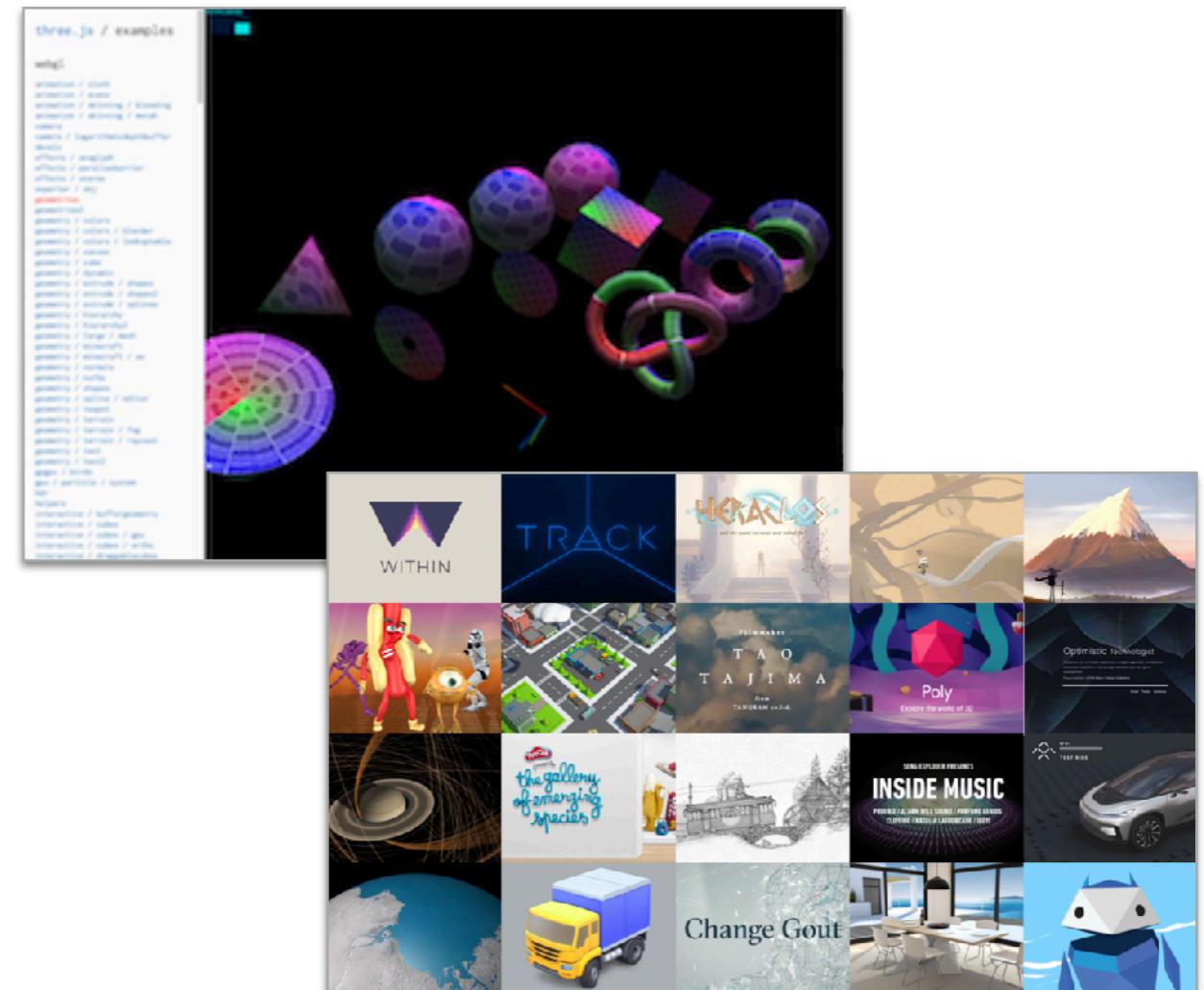
# Software Systems Toolkits & Frameworks

# Low-level Graphics Toolkits - Web

(non-exhaustive)



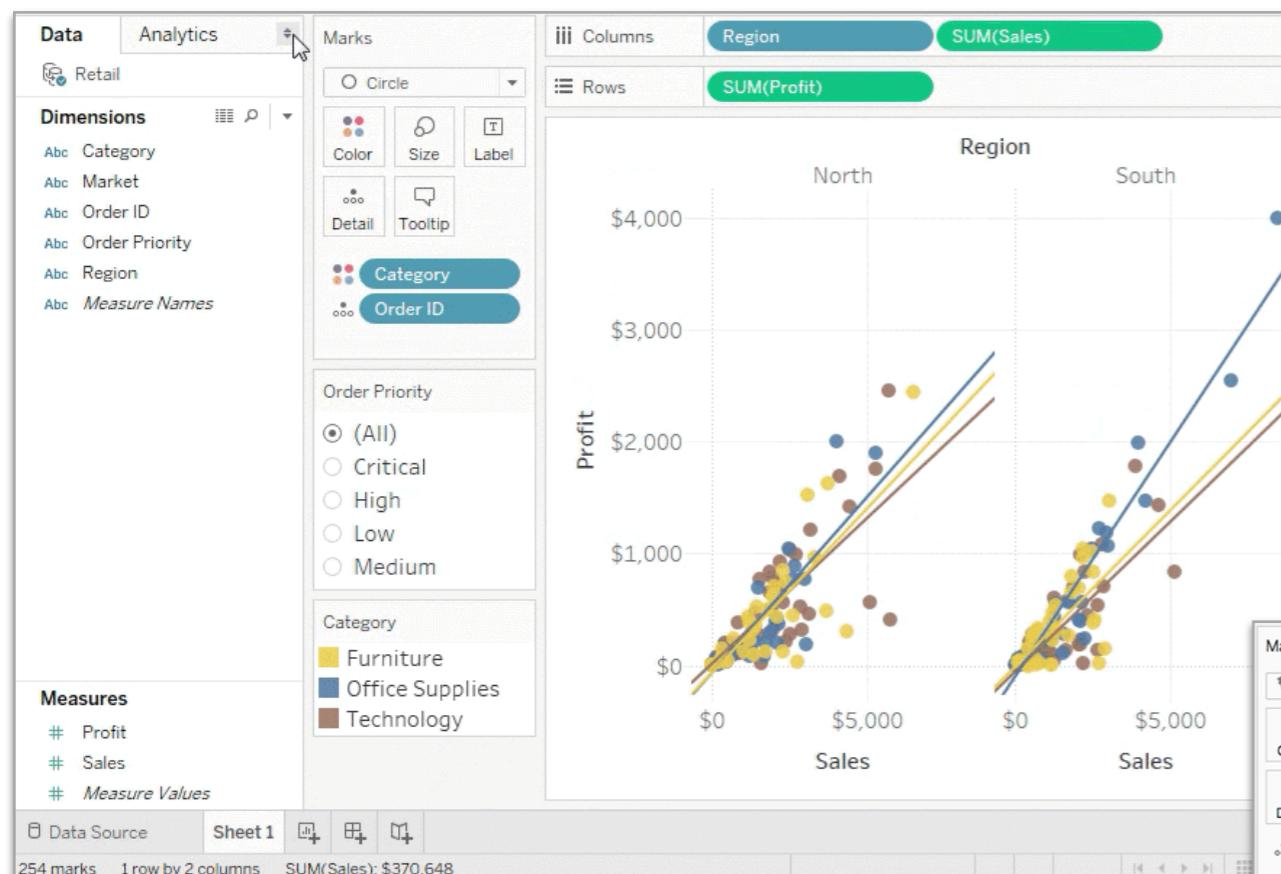
<http://paperjs.org>



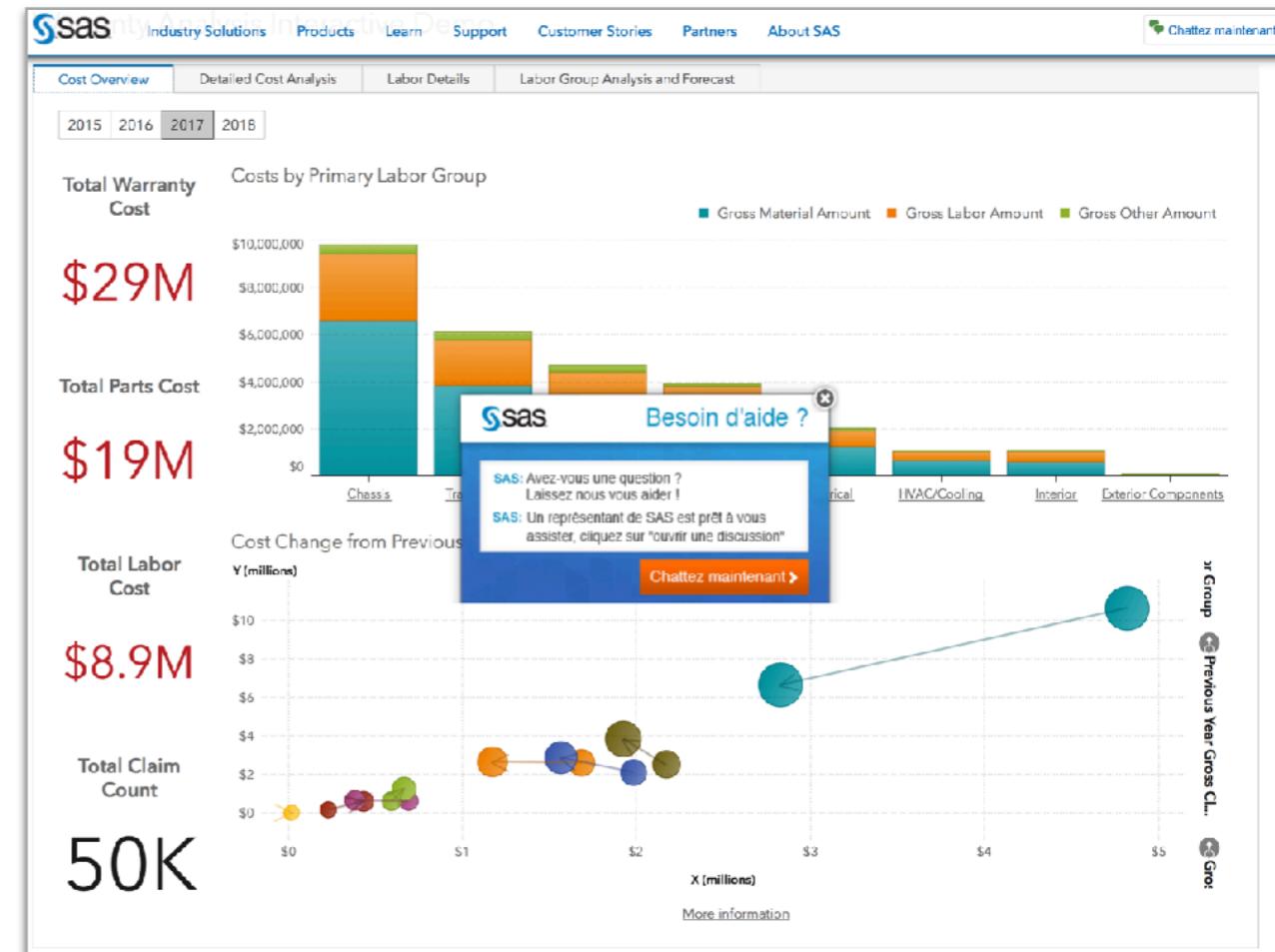
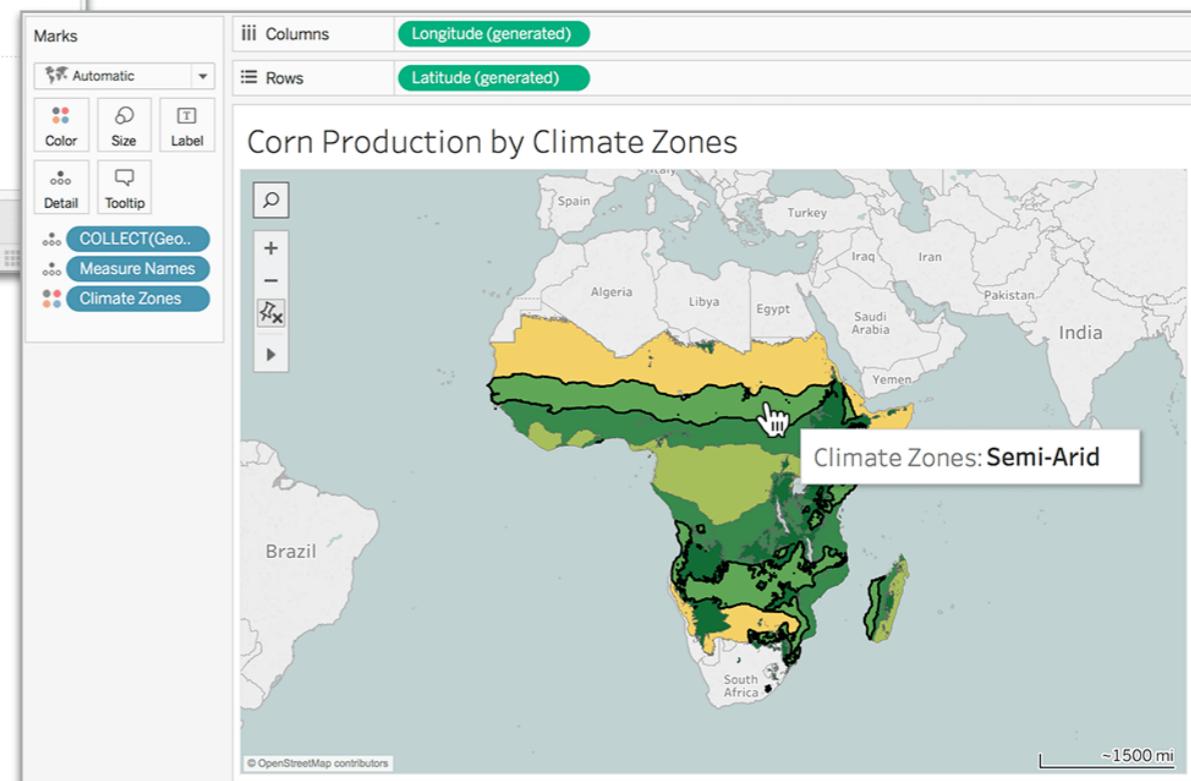
<https://threejs.org>

# Visualization Systems

(non-exhaustive)



<http://www.tableausoftware.com/products/desktop>



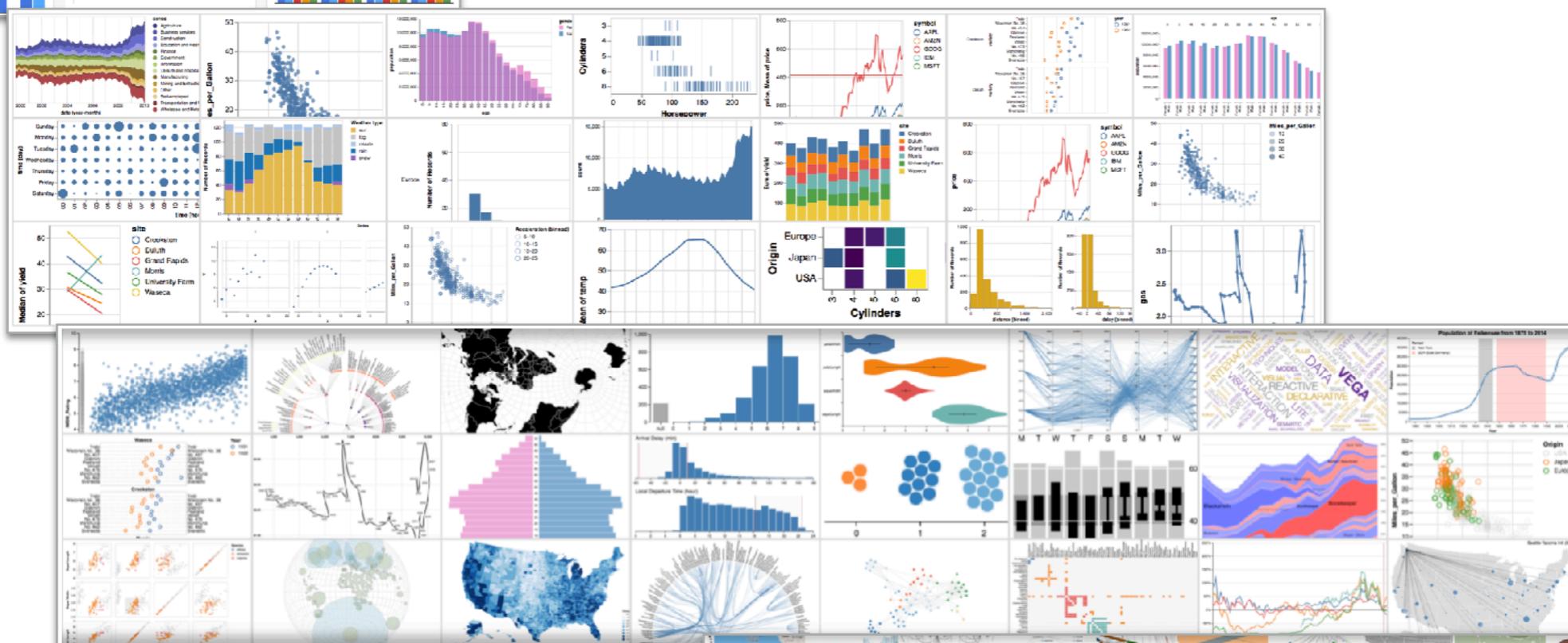
[https://www.sas.com/en\\_us/software/visual-analytics.html](https://www.sas.com/en_us/software/visual-analytics.html)

# Different solutions, at different levels of abstraction:

<https://developers.google.com/chart/>



<https://vega.github.io/vega-lite/>



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



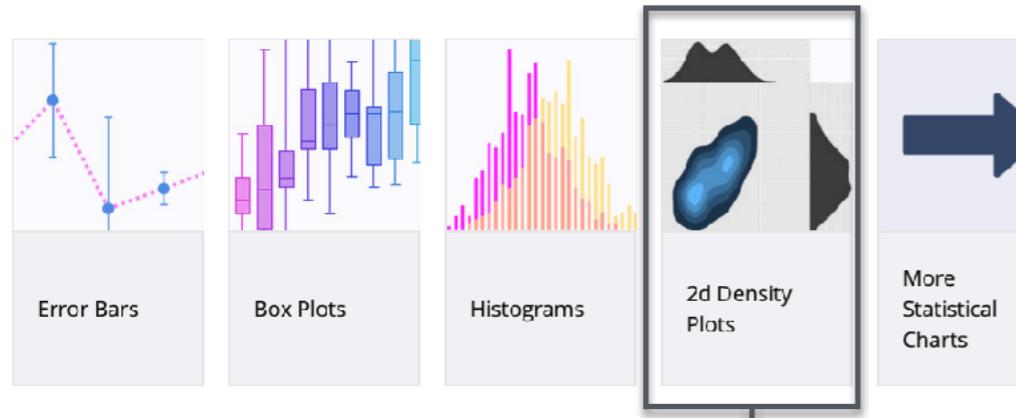
<https://d3js.org>

## Basic Charts

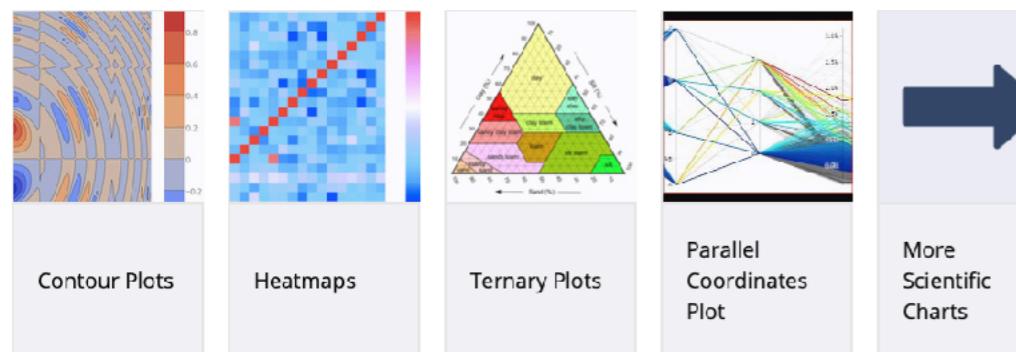


<https://plot.ly/javascript>

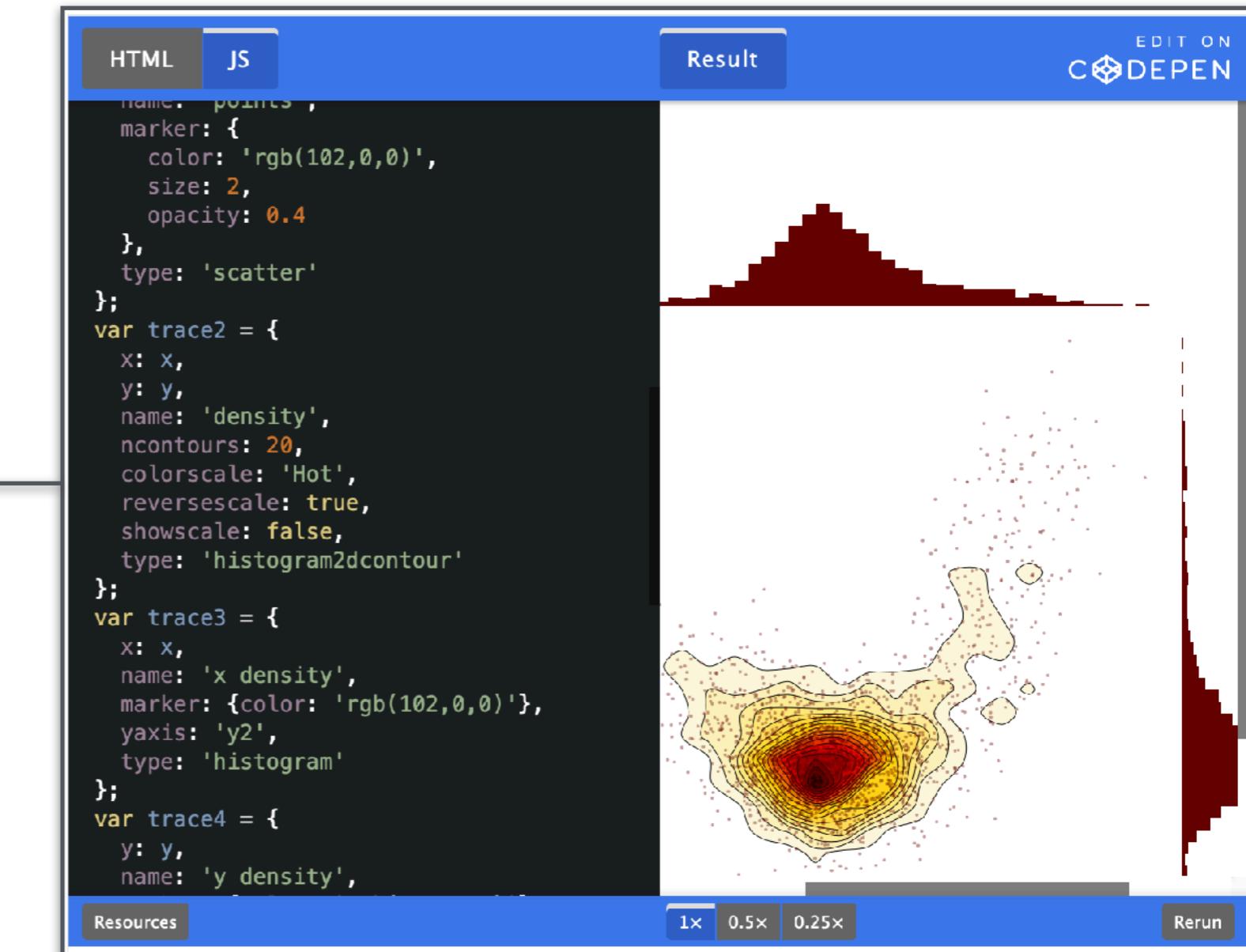
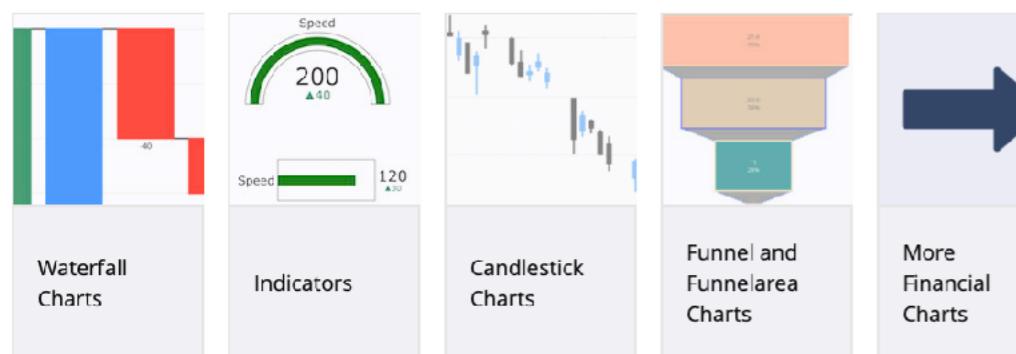
## Statistical Charts



## Scientific Charts



## Financial Charts



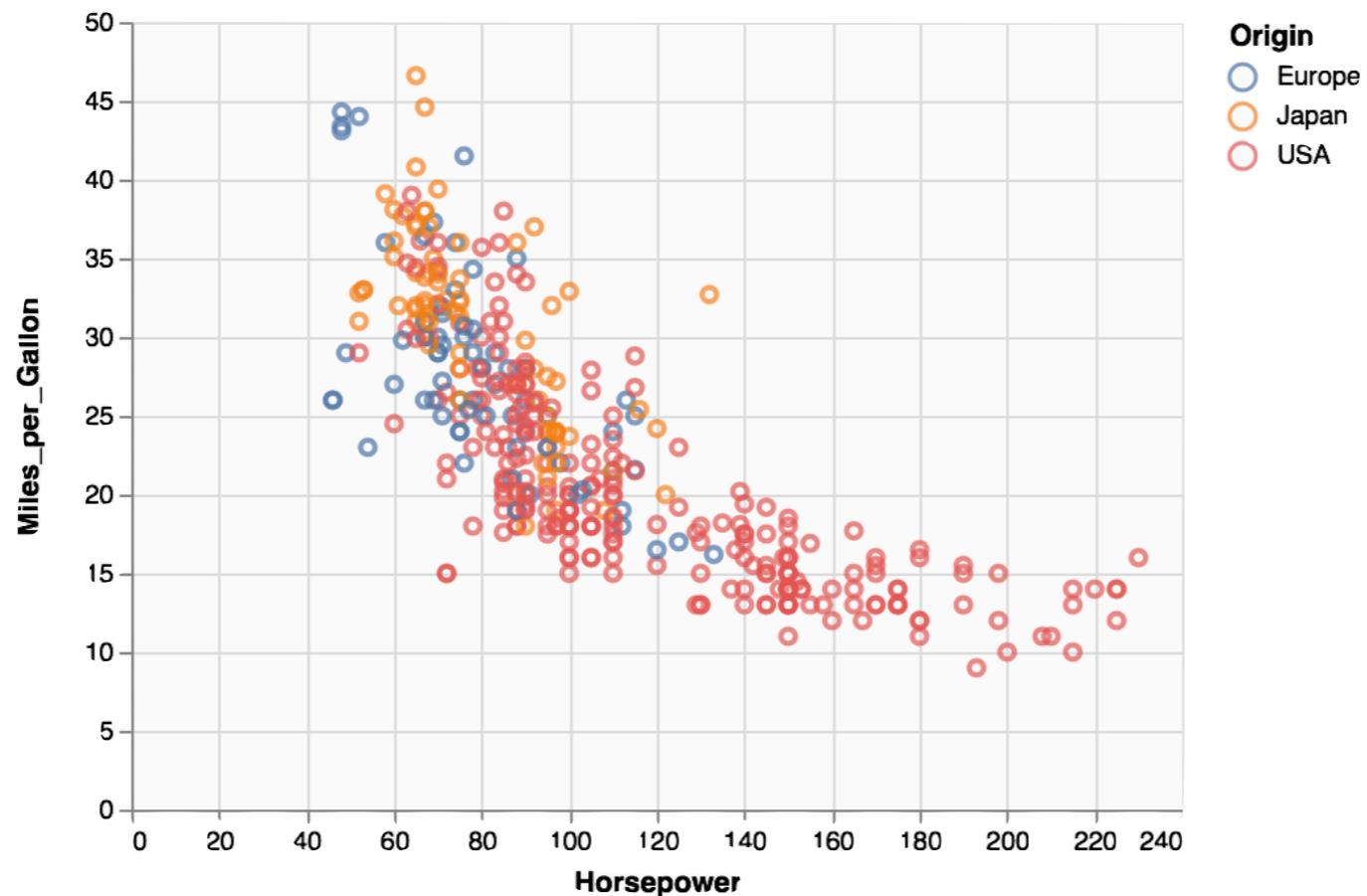
# Bridges

(non-exhaustive)

```
import altair as alt

# load a simple dataset as a pandas DataFrame
from vega_datasets import data
cars = data.cars()

alt.Chart(cars).mark_point().encode(
    x='Horsepower',
    y='Miles_per_Gallon',
    color='Origin',
).interactive()
```



# Bridges

(non-exhaustive)

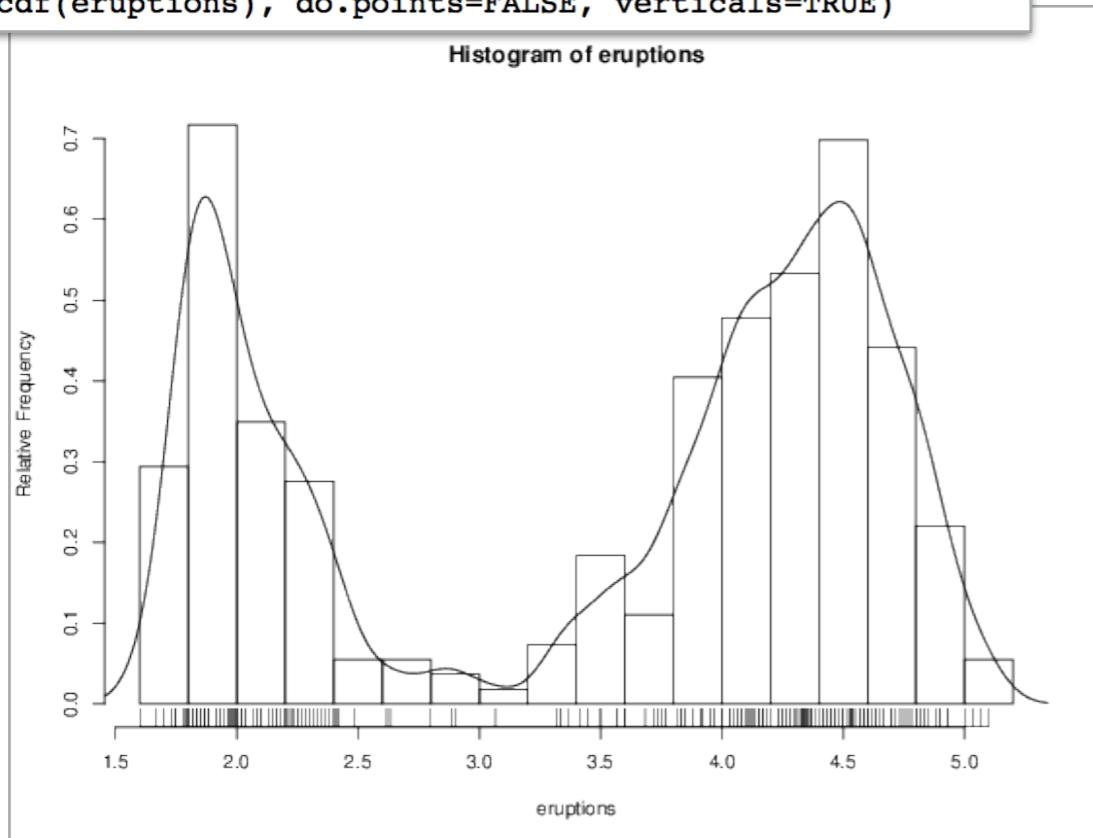
The screenshot shows the RStudio interface with the following components:

- Top Bar:** Shows the path `~/packages/r2d3 - master - RStudio` and various toolbars.
- Code Editor:** A file named `bars.js` containing D3.js code for creating a bar chart. The code defines a function to preview the chart using the `r2d3` package.
- Environment Tab:** Shows the Global Environment pane with the message "Environment is empty".
- Plots Tab:** Displays a blue stepped bar chart generated by the `r2d3` package.
- Console Tab:** Shows the R startup message and workspace loading information.
- Terminal Tab:** Shows the command `> r2d3::r2d3(data=c(0.3, 0.6, 0.8, 0.95, 0.40, 0.20), script="bars.js")`.



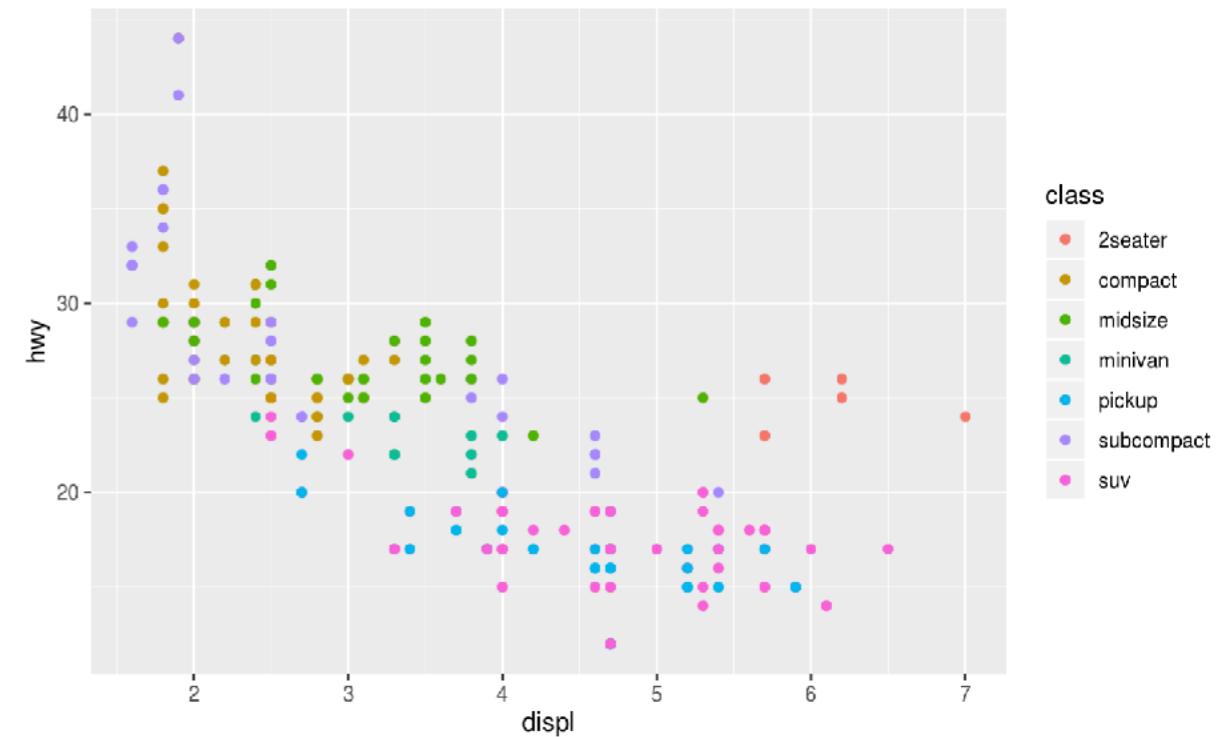
# R, ggplot2

```
> hist(eruptions, seq(1.6, 5.2, 0.2), prob=TRUE)
> lines(density(eruptions, bw=0.1))
> rug(eruptions) # show the actual data points
> plot(ecdf(eruptions), do.points=FALSE, verticals=TRUE)
```



```
library(ggplot2)

ggplot(mpg, aes(displ, hwy, colour = class)) +
  geom_point()
```



<http://www.r-project.org>

<https://ggplot2.tidyverse.org>



Ferdio – Dataviz Project  
<http://datavizproject.com>

visualising data

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ADOBECOLOR ADOBE EDGE ADOBE ILLUSTRATOR AESOP STORY ENGINE AFFINITY DESIGNER AIZHTML

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<http://www.visualisingdata.com/resources>

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 Bubble Map, Bullet Graph, Calendar, Candlestick Chart, Chord Diagram, Choropleth Map  
 Circle Packing, Connection Map, Density Plot, Donut Chart, Dot Map, Dot Matrix Chart  
 Error Bars, Flow Chart, Flow Map, Gantt Chart, Heatmap, Histogram

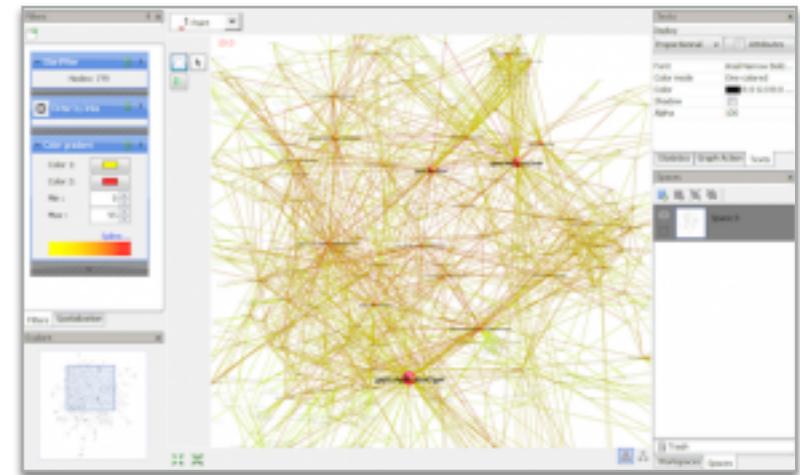
The Data Visualisation Catalogue  
<https://datavizcatalogue.com>

# Network Tools

(non-exhaustive)

- Gephi

<https://gephi.github.io>



- Cytoscape

<http://www.cytoscape.org>



- Tulip

<http://tulip.labri.fr>



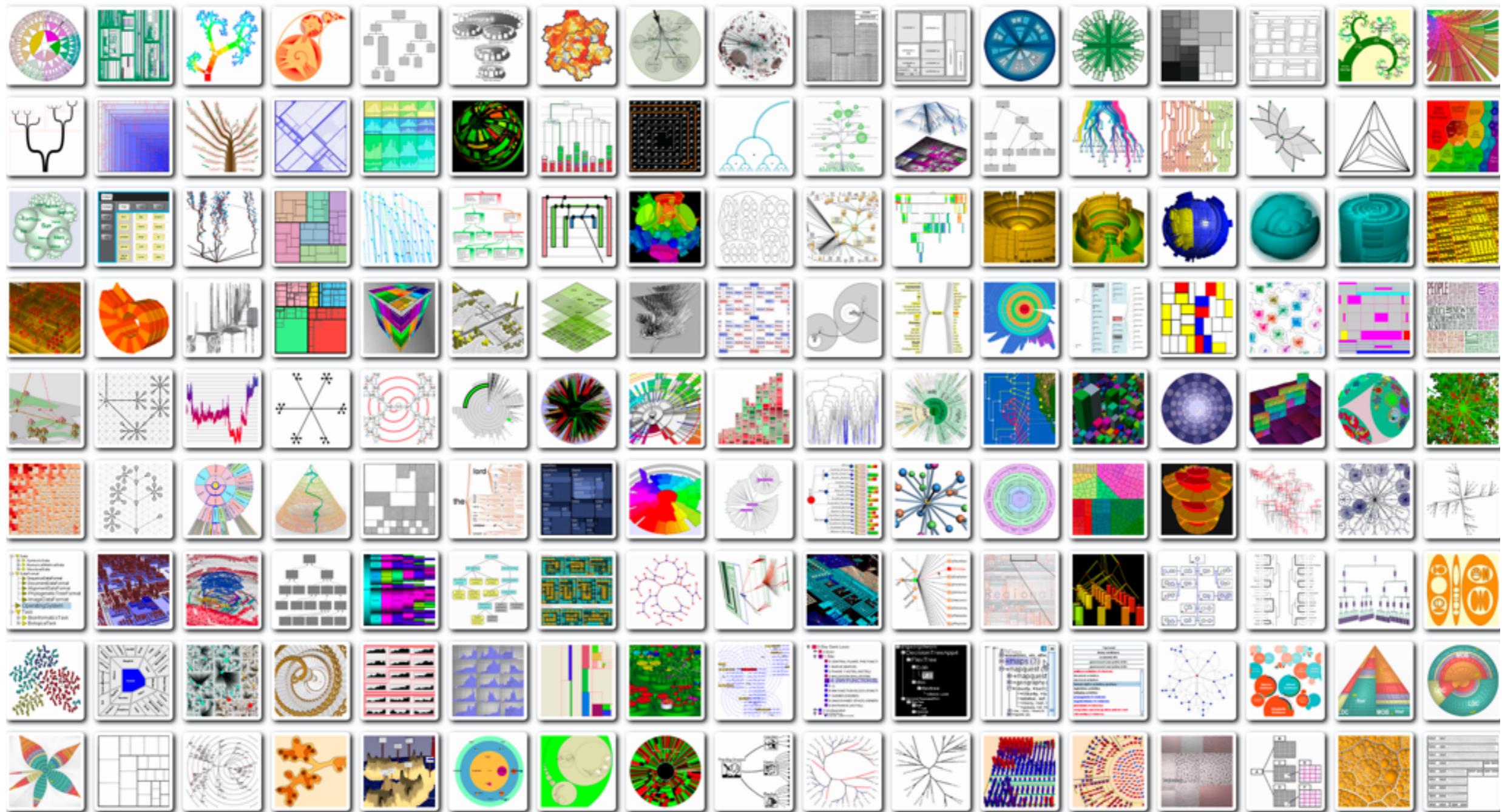
- Pajek

<http://mrvar.fdv.uni-lj.si/pajek/>

- D3 + Cola.js

<http://marvl.infotech.monash.edu/webcola/>

# Tree Tools



<http://treevis.net>