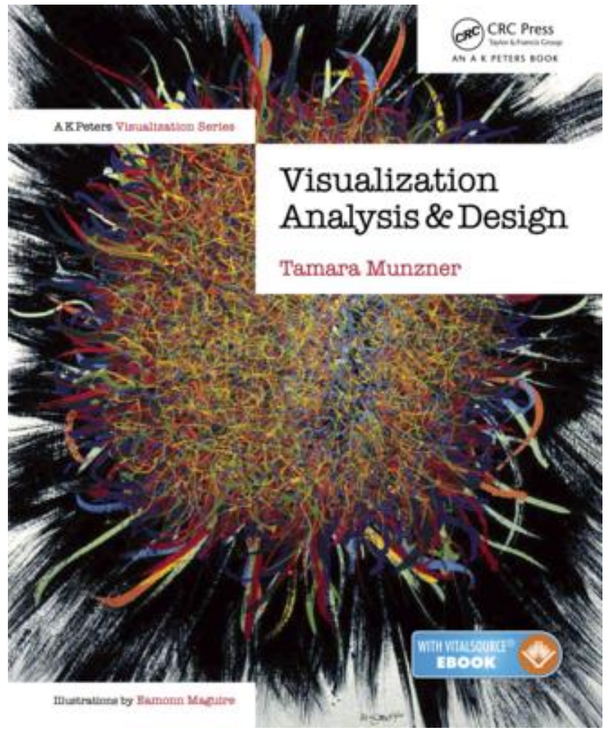
Information Visualization

Spatial Layout (b) –
Arrange Spatial Data



- Slides refer to https://www.cs.ubc.ca/~tmm/

Spatial Layout

- Arrange Tables (ch. 7)

- Arrange Spatial Data (ch. 8)

- Arrange Networks and Trees (ch. 9)

How?

Encode

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion

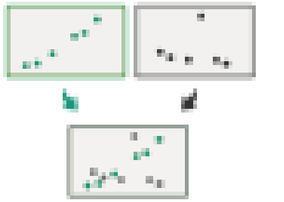
Direction, Rate, Frequency, ...

Manipulate

- Change
- Select
- Navigate

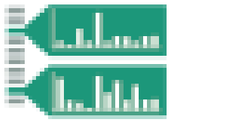
Facet

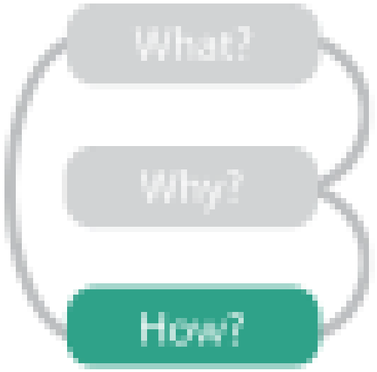
- Juxtapose
- Partition
- Superimpose



Reduce

- Filter
- Aggregate
- Embed





Arrange Spatial Data

Arrange spatial data

- **Use Given**
  - Geometry
    - *Geographic*
    - *Other Derived*

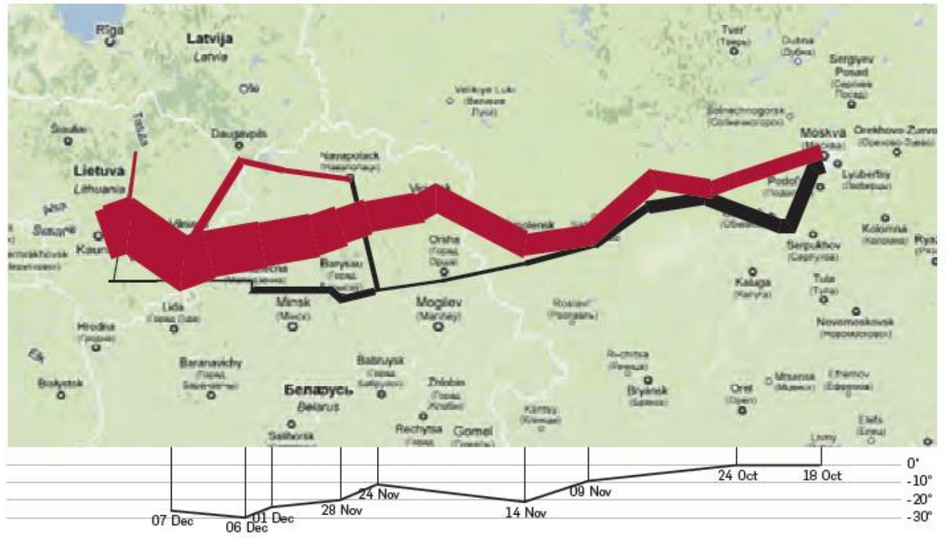
  - Spatial Fields
    - *Scalar Fields (one value per cell)*
      - *Isocontours*
      - *Direct Volume Rendering*

    - *Vector and Tensor Fields (many values per cell)*
      - *Flow Glyphs (local)*
      - *Geometric (sparse seeds)*
      - *Textures (dense seeds)*
      - *Features (globally derived)*

Geometry

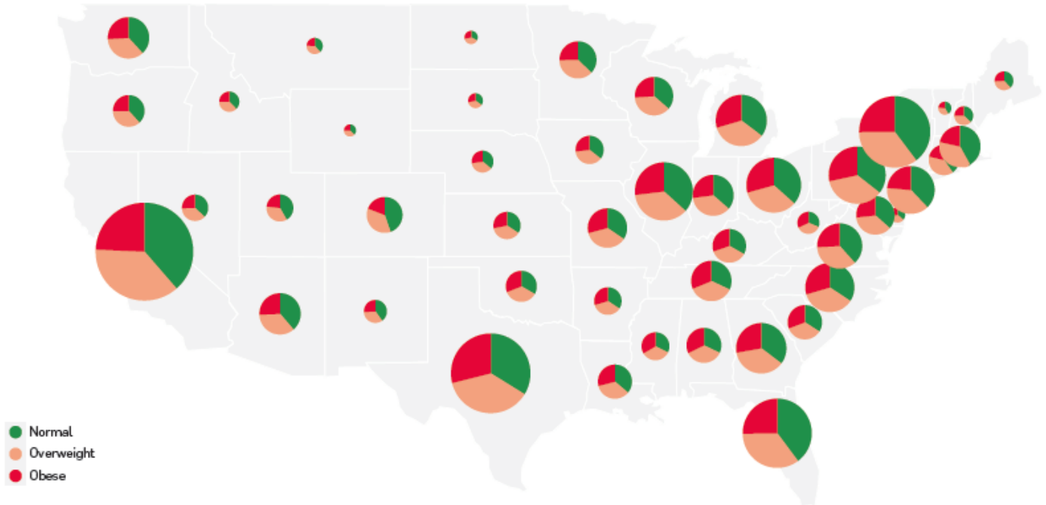
- **Use Given**
  - Geometry
    - *Geographic*
    - *Other Derived*

Maps: Figure 3a. Flow map of Napoleon's March on Moscow, based on the work of Charles Minard.



http://hci.stanford.edu/jheer/files/zoo/ex/maps/napoleon.html

Maps: Figure 3c. Graduated symbol map of obesity in the U.S., 2008.



Source: National Center for Chronic Disease Prevention and Health Promotion; http://hci.stanford.edu/jheer/files/zoo/ex/maps/symbol.html

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 zônes colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zônes. 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. Thiers, 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 Davoust qui avaient été détachés sur Minsk et Mobilow et ont rejoint vers Orscha et Witebsk, avaient toujours marché avec l'armée.

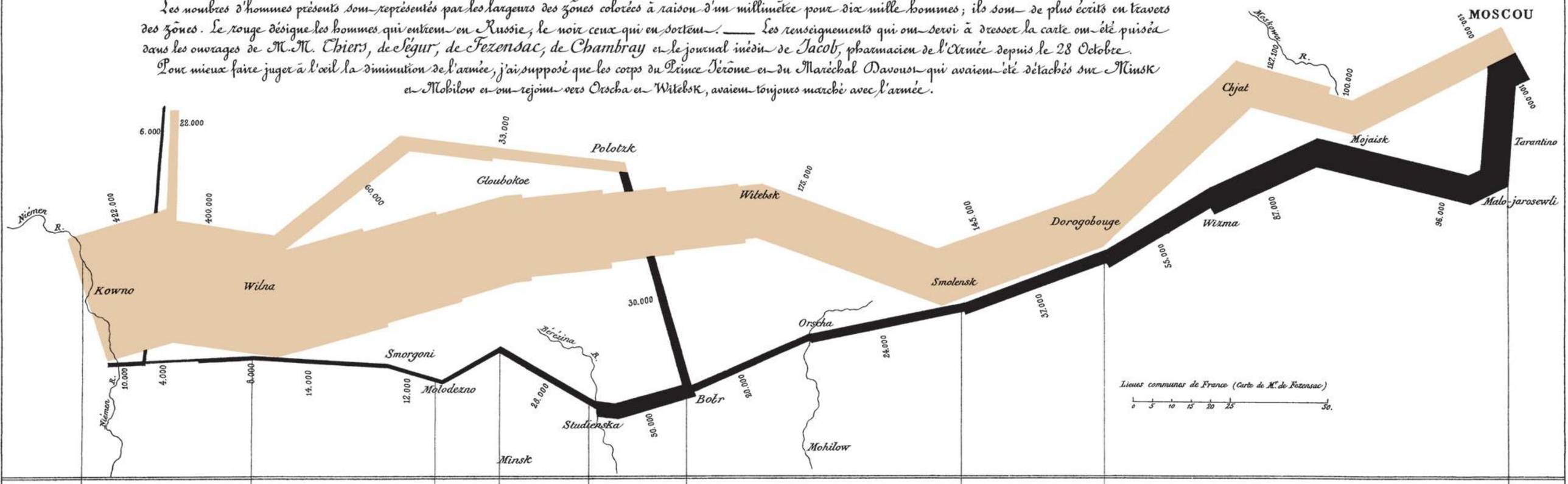
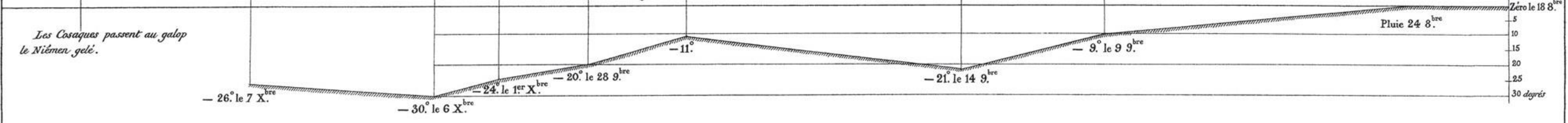


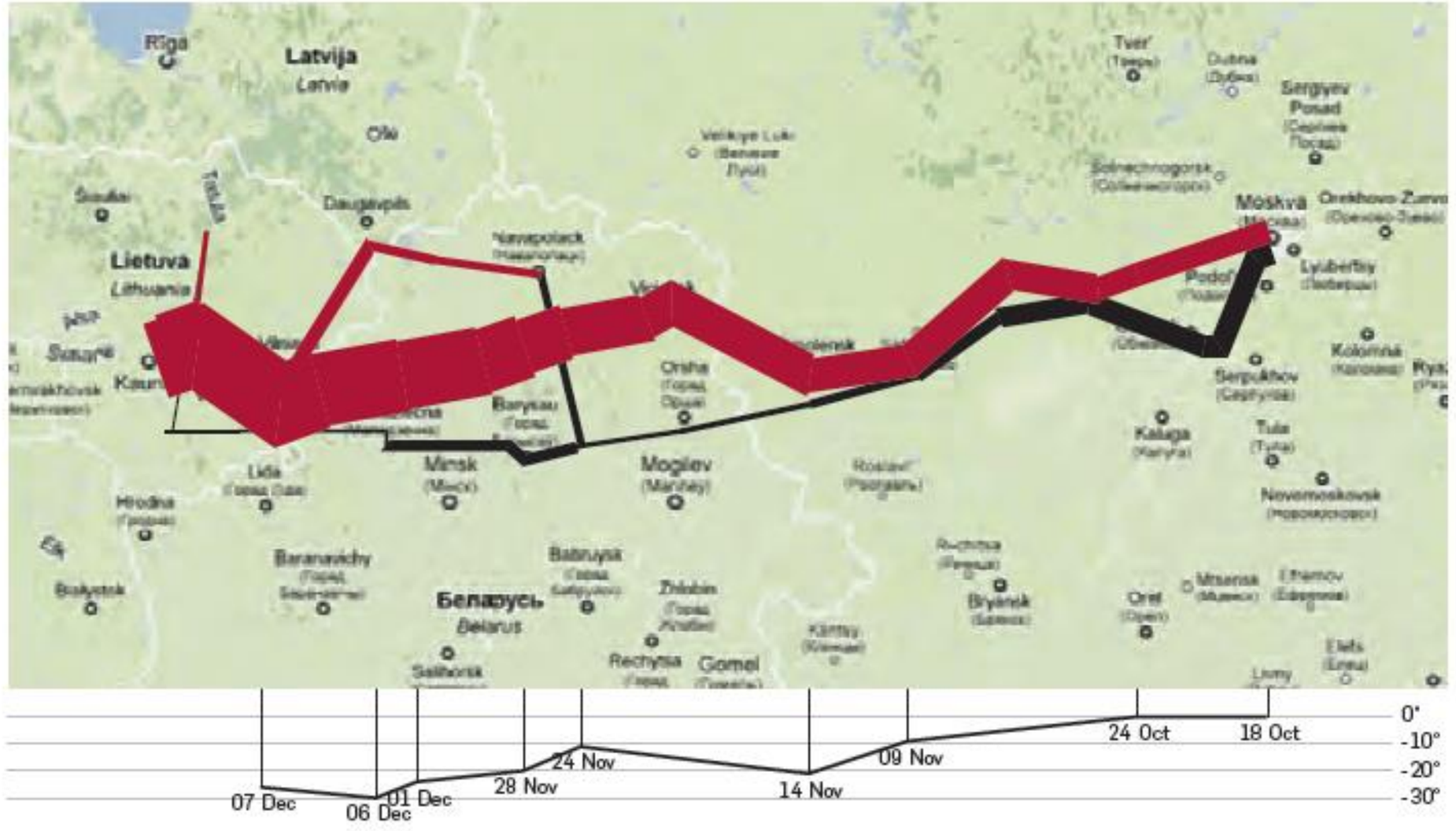
TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



Autog. par Regnier, 8. Pas. Ste Marie St Gain à Paris.

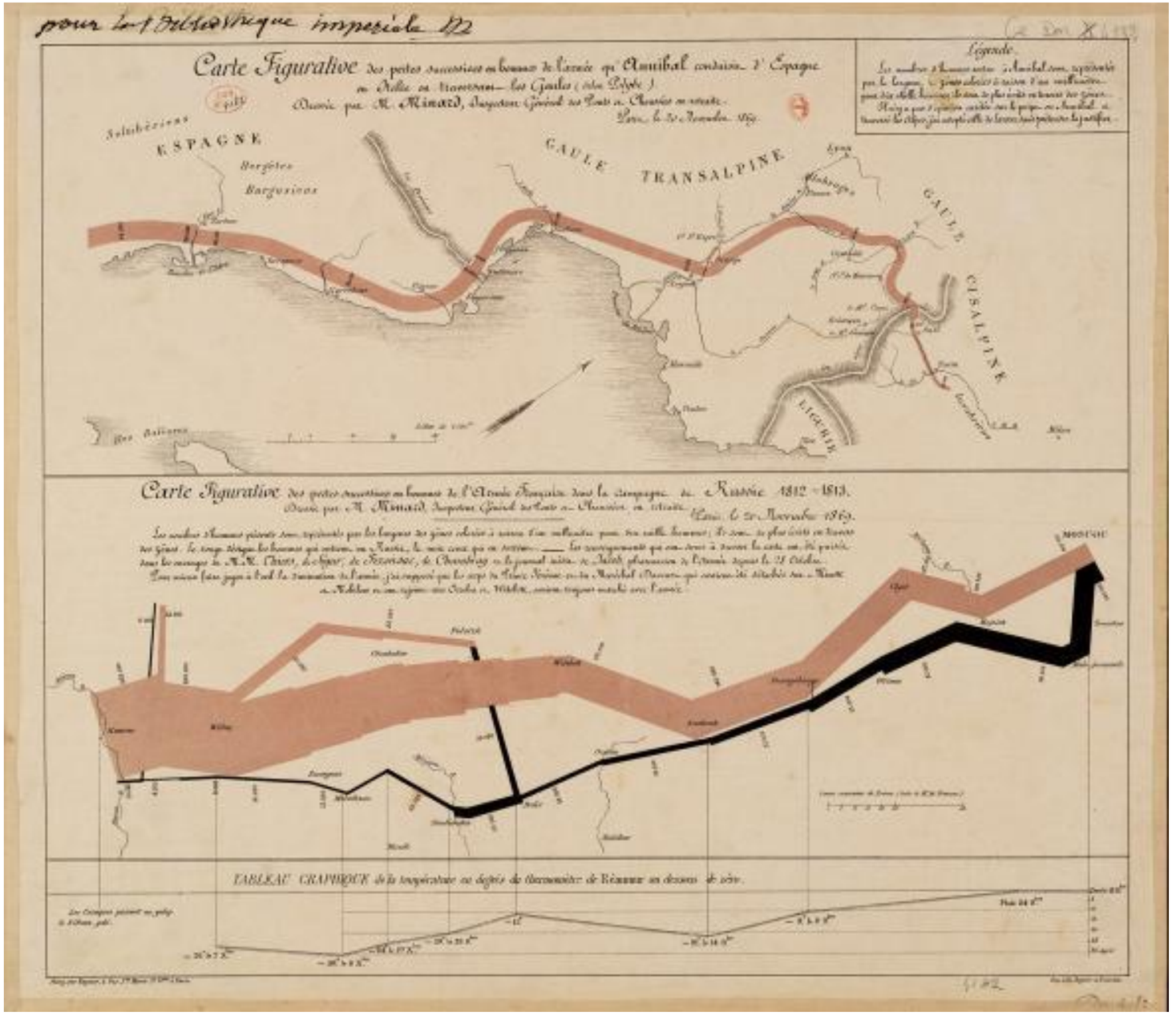
Imp. Lith. Regnier et Dourdet.

Maps: **Figure 3a. Flow map of Napoleon's March on Moscow, based on the work of Charles Minard.**

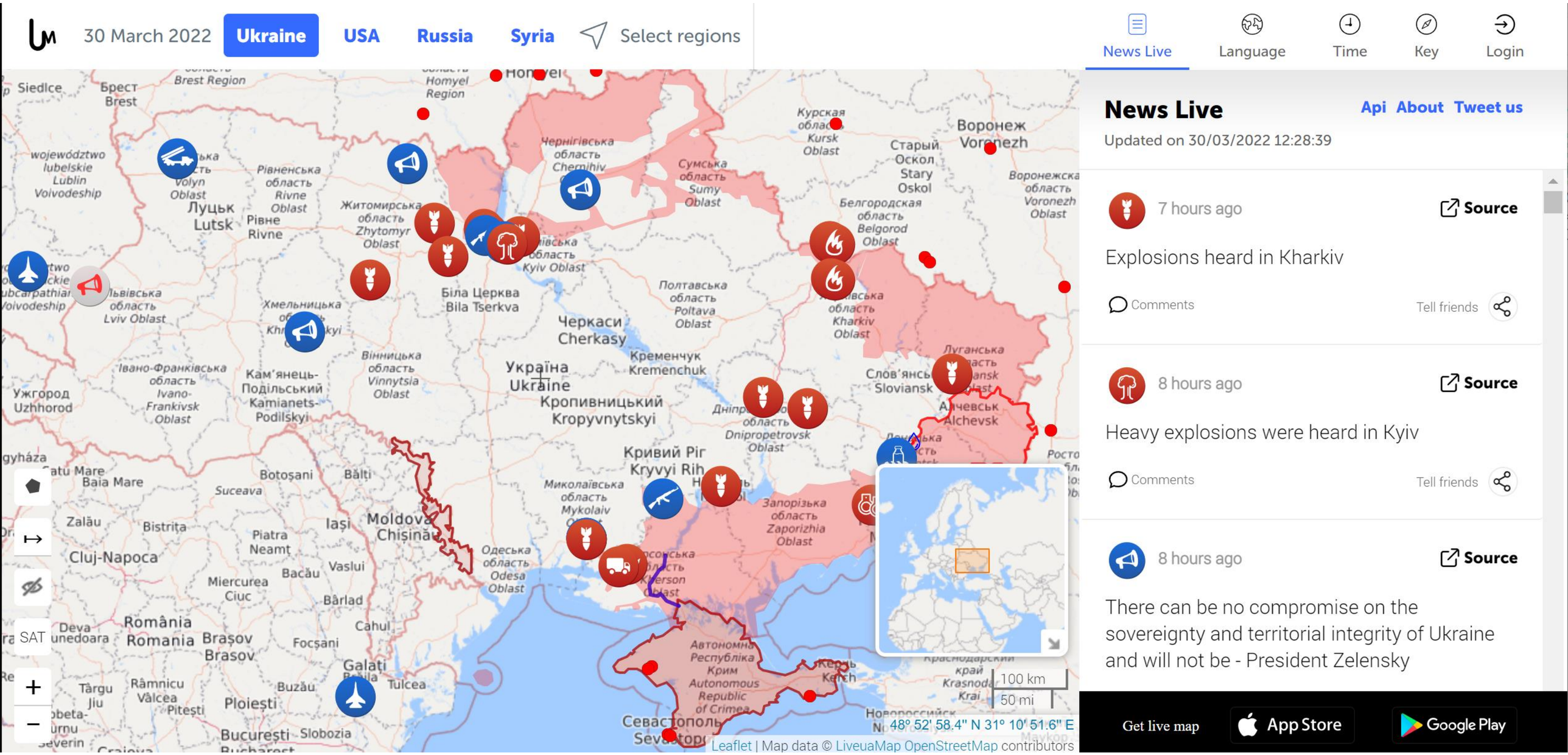


http://hci.stanford.edu/jheer/files/zoo/ex/maps/napoleon.html

pour la Bibliothèque impériale 122



https://liveuamap.com/en



20 October 2024 | Ukraine | USA | Israel-Palestine | Iran | Select regions

News Live | Language | Time | Key | Login

News Live

Api About Tweet us

Updated on 20/10/2024 18:17:27

2 hours ago — Source

At Kharkiv axis clashes yesterday near Vovchansk and Starytsya, - General Staff of Armed Forces of Ukraine reports

3 hours ago — Source

Ukrainian air defense shot down 31 of 49 Shahed-type strike drones overnight, tracking of 13 lost, 2 drones left for Belarus. Also Russian army launched 2 Iskander-M missiles

3 hours ago — Source

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Leaflet | Map data © LiveuaMap OpenStreetMap contributors

48° 52' 58.4" N 31° 10' 51.6" E

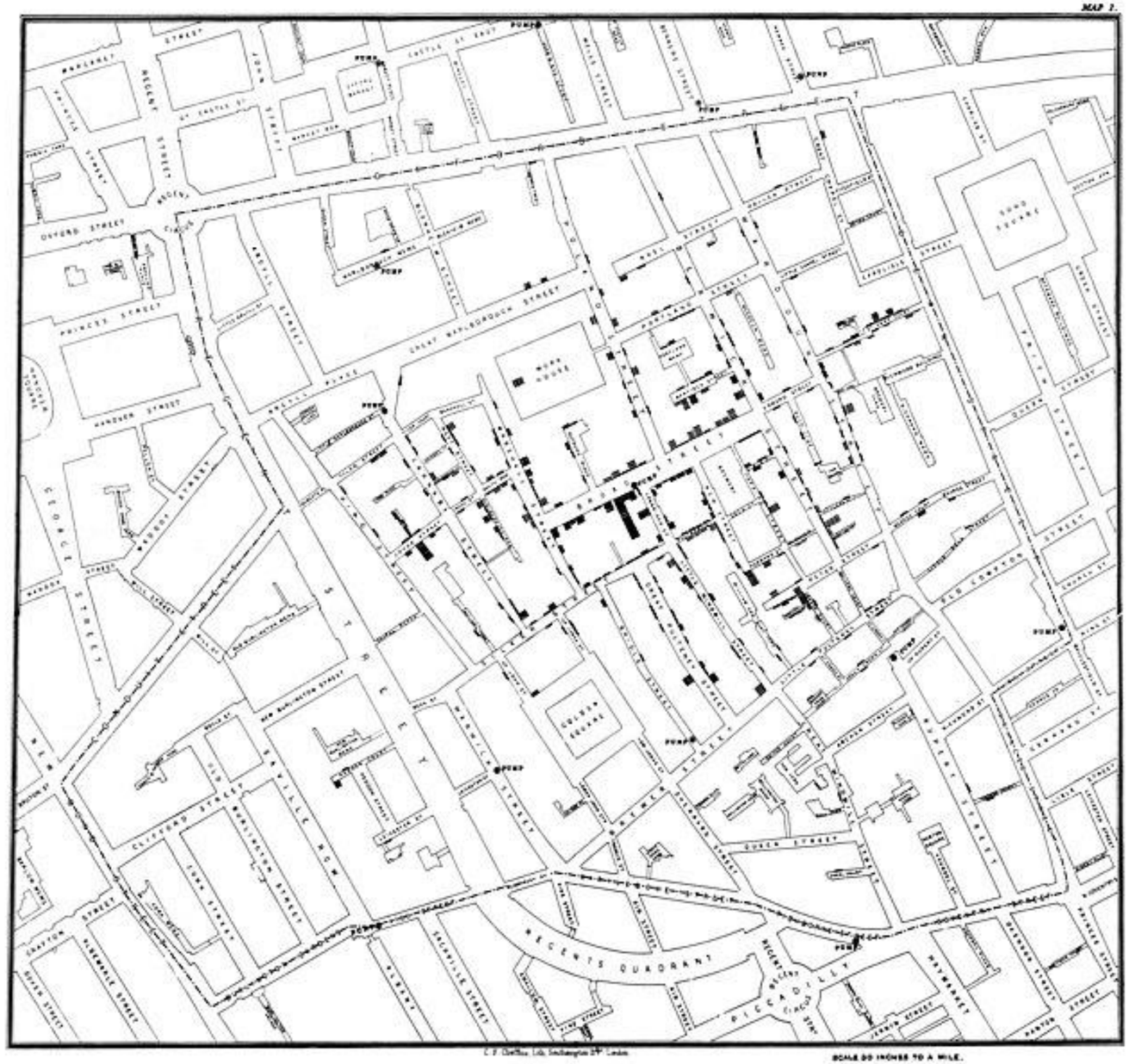
100 km
50 mi

Geometry

- We use geographic visualization when:
  - The data contains geographical attributes
  - Understanding spatial relationships is an important task

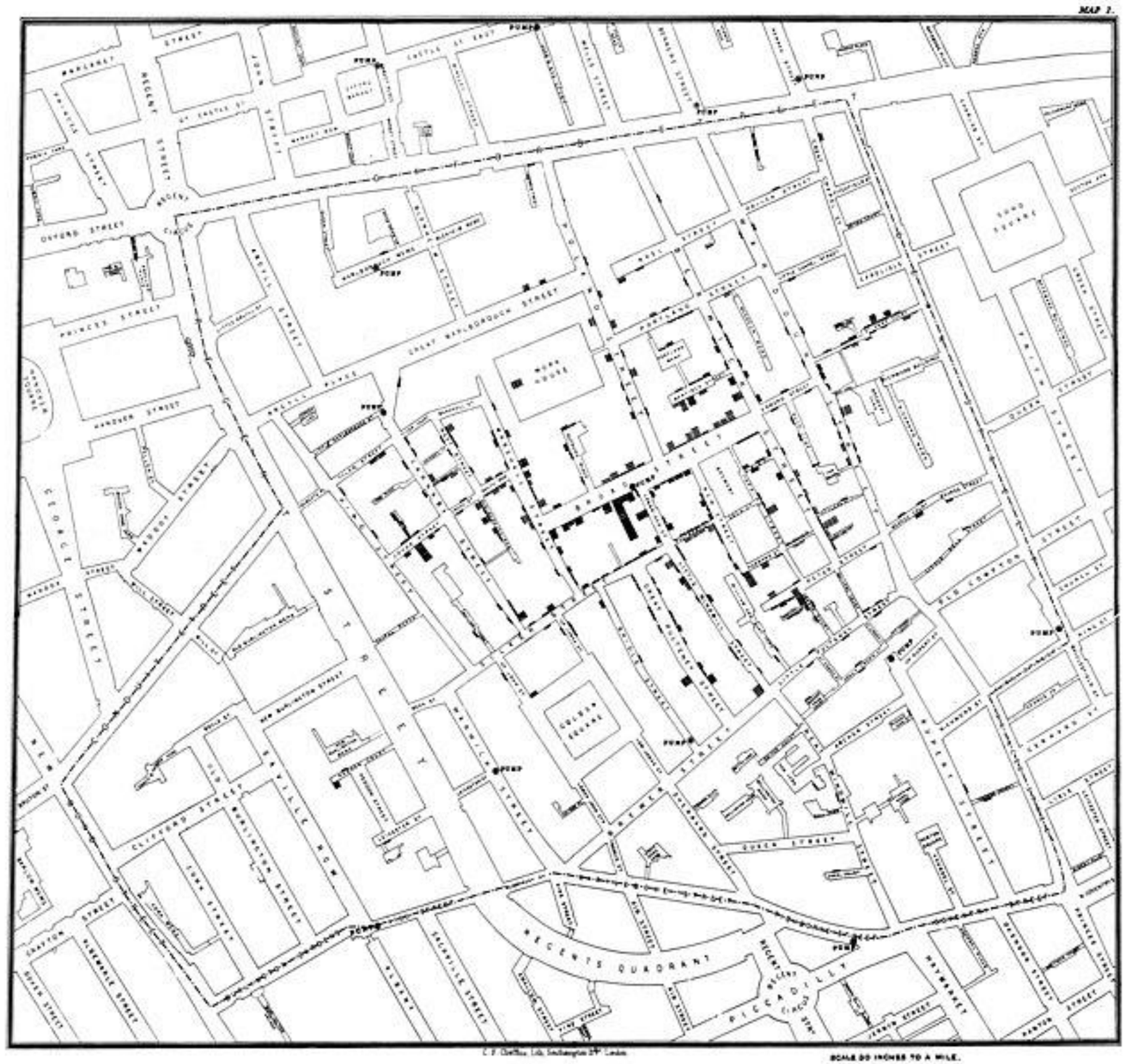
- A dataset may contain geographical information and yet creating a geographical visualization may not be relevant.
- people know where something on a map is
  - if they are familiar with the region
- maps act as an index from spatial to semantic information and vice versa
  - visually encode given spatial geometry as marks using 2D position channels

Geometry



- London, 1854: mystery outbreak

Geometry: John Snow's Cholera Map



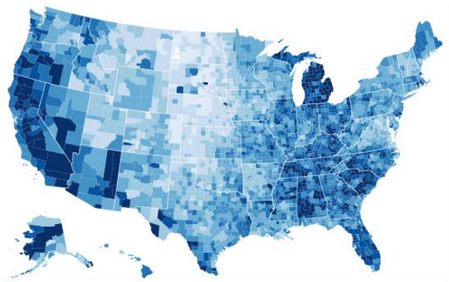
- London, 1854: mystery outbreak
- Snow mapped deaths as bars on a geo map
- cases clustered around a water pump
  - one part of a detailed statistical analysis

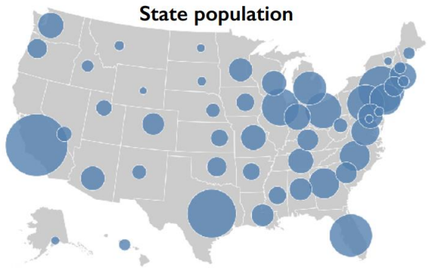
Geographic Map

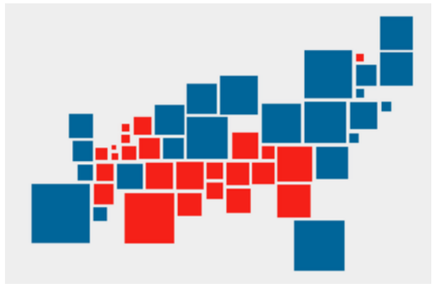
- Interlocking marks
  - shape coded
  - area coded
  - position coded

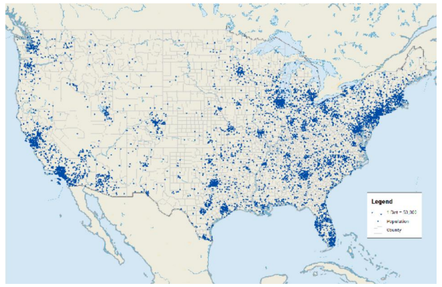
Thematic maps (專題地圖或主題圖)

- show spatial variability of attribute ("theme")
  - combine geographic / reference map with (simple, flat) tabular data
  - join together
    - region: interlocking area marks (provinces, countries with outline shapes)
      - also could have point marks (cities, locations with 2D lat/lon coords)
    - region: categorical key attribute in table
      - use to look up value attributes
- major idioms
  - choropleth
  - symbol maps
  - cartograms
  - dot density maps



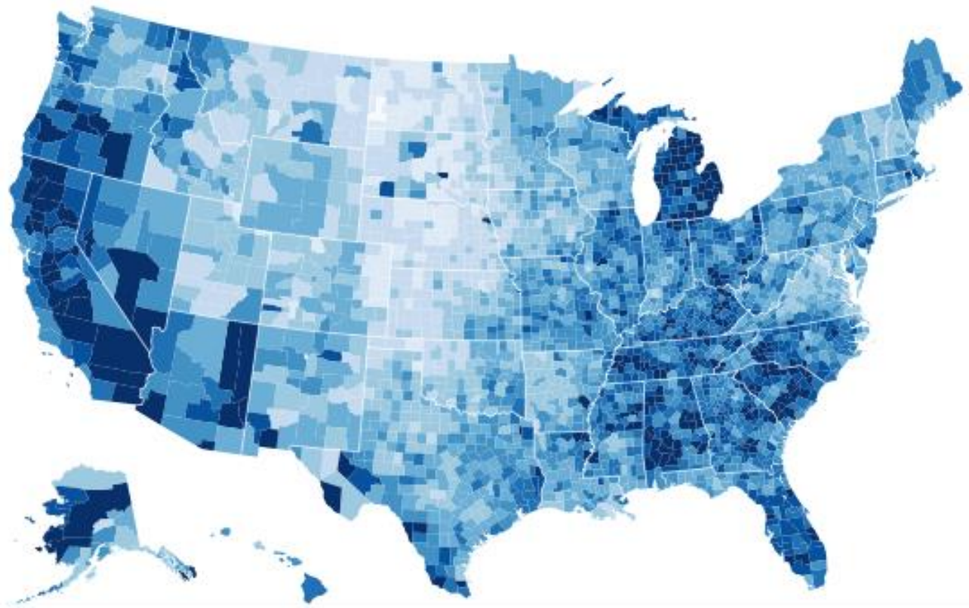






Idiom: **choropleth map**

- *use* given spatial data
  - when central task is understanding spatial relationships
- data
  - geographic geometry
  - table with 1 quant attribute per region
- encoding
  - use given geometry for area mark boundaries
  - sequential segmented colormap *[more later]*



Unemployment rate by county, August 2016

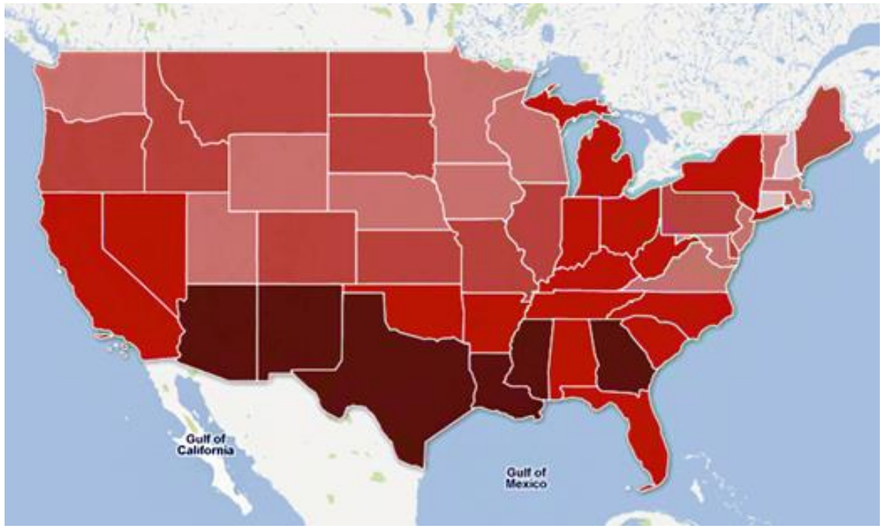
http://bl.ocks.org/mbostock/4060606

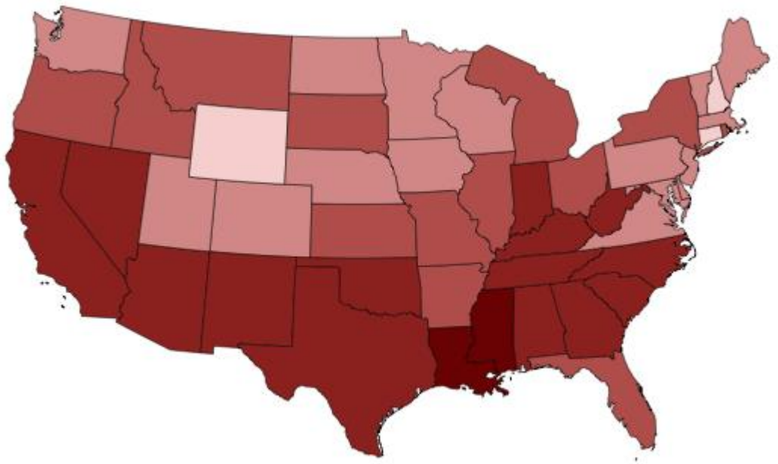
choropleth map: Pros & cons

- *pros*
  - *easy to read and understand*
  - *well established visualization (no learning curve)*
  - *data is often collected and aggregated by geographical regions*
- *cons*
  - *most effective visual variable used for geographic location*
  - *visual salience depends on region size, not true importance wrt attribute value*
    - *large regions appear more important than small ones*
  - *color palette choice has a huge influence on the result*

choropleth map: US poverty map

- *Same data, different result?*

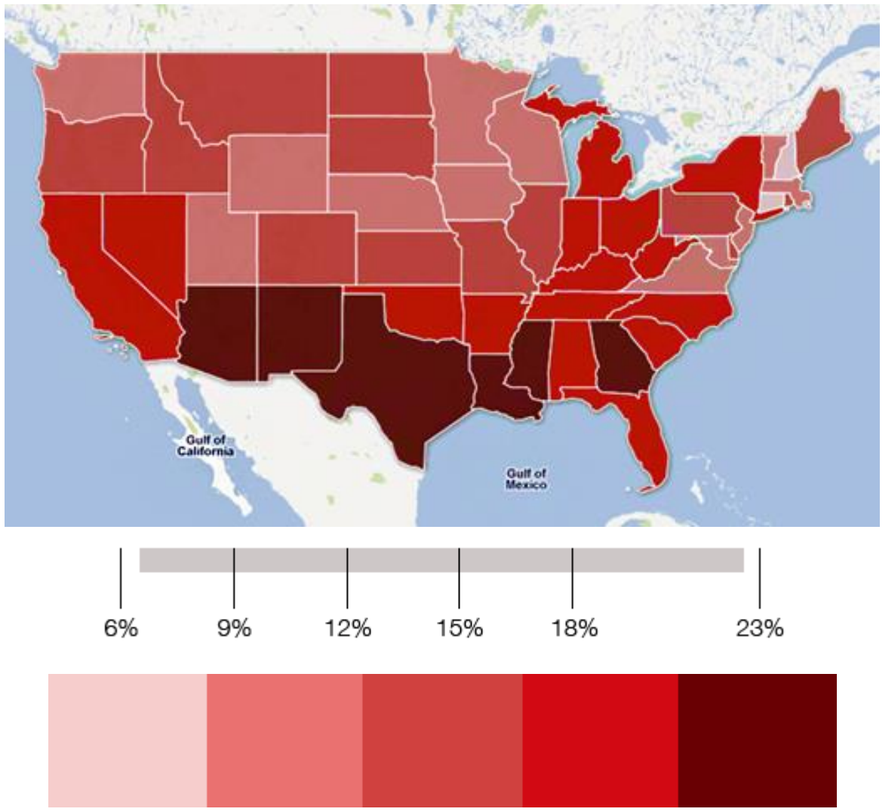


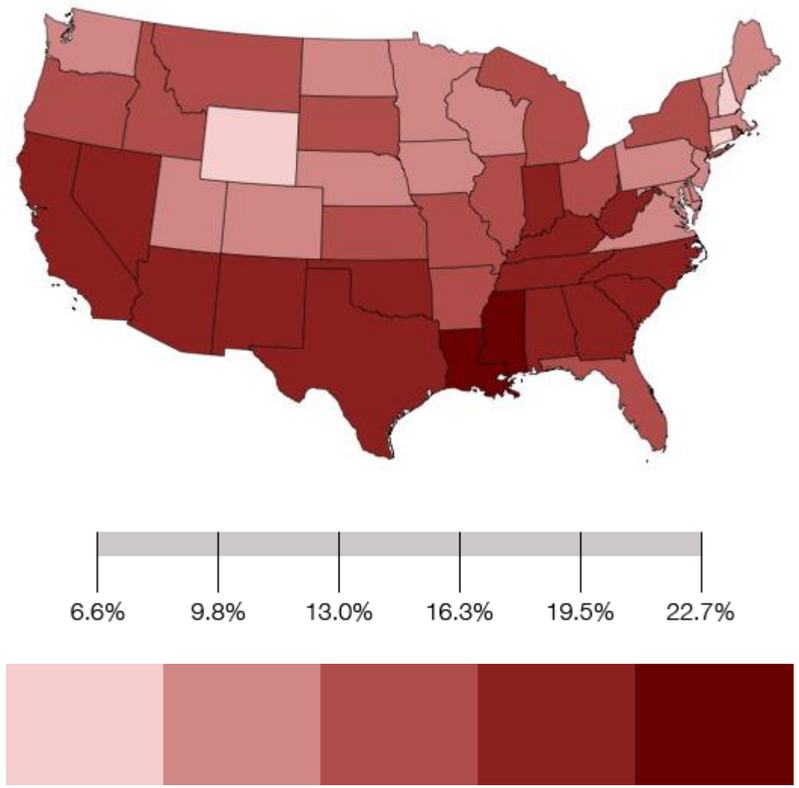


https://www.vis4.net/blog/2011/12/choropleth-maps/

dataset

choropleth map: US poverty map

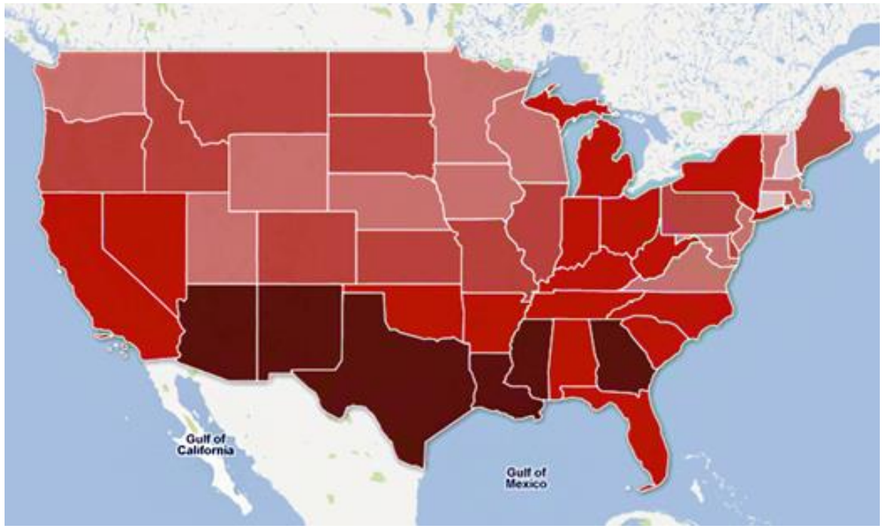




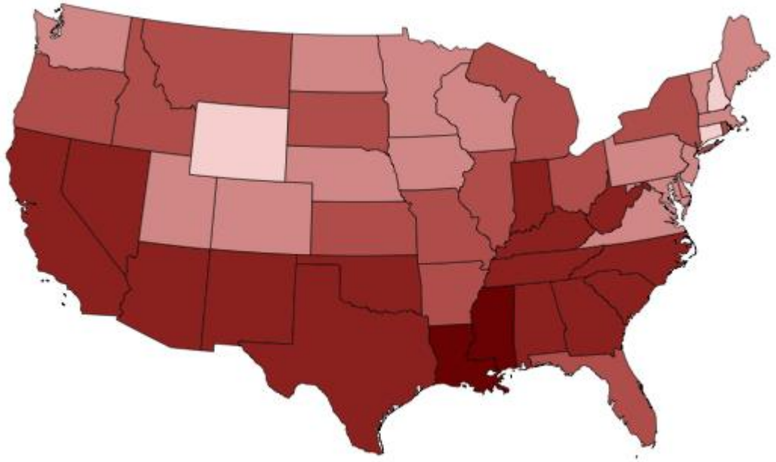
https://www.vis4.net/blog/2011/12/choropleth-maps/

dataset

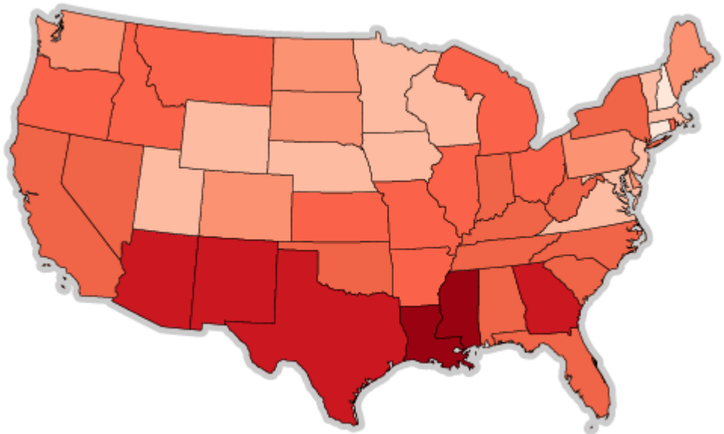
choropleth map: US poverty map



a large jump



equidistant HSV colors

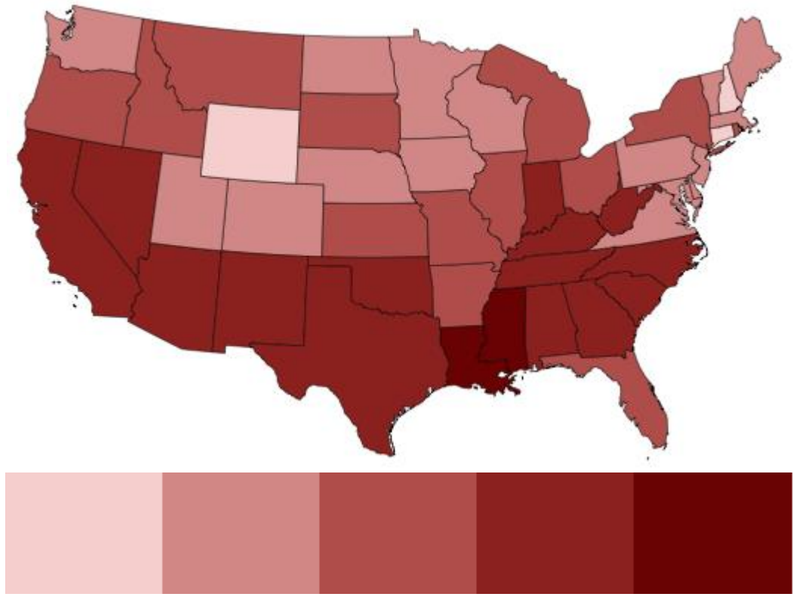


a hand-picked color scale from colorbrewer2.org

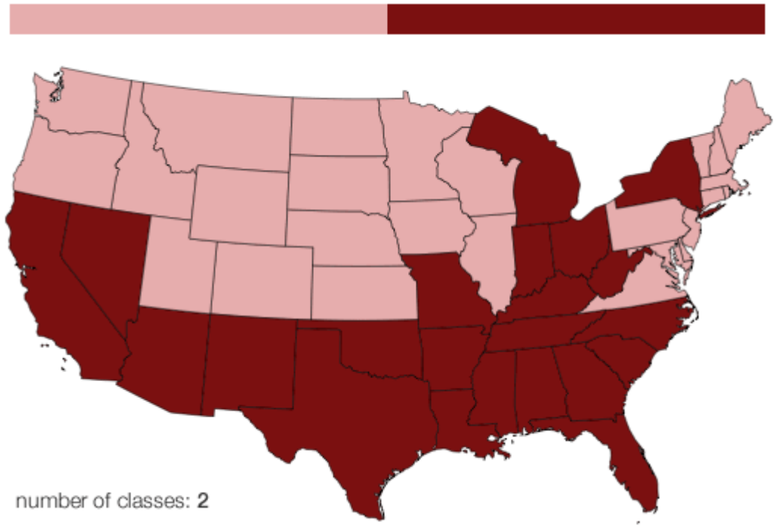
https://www.vis4.net/blog/2011/12/choropleth-maps/

choropleth map: US poverty map

- *better think twice about your class count*



equidistant HSV colors



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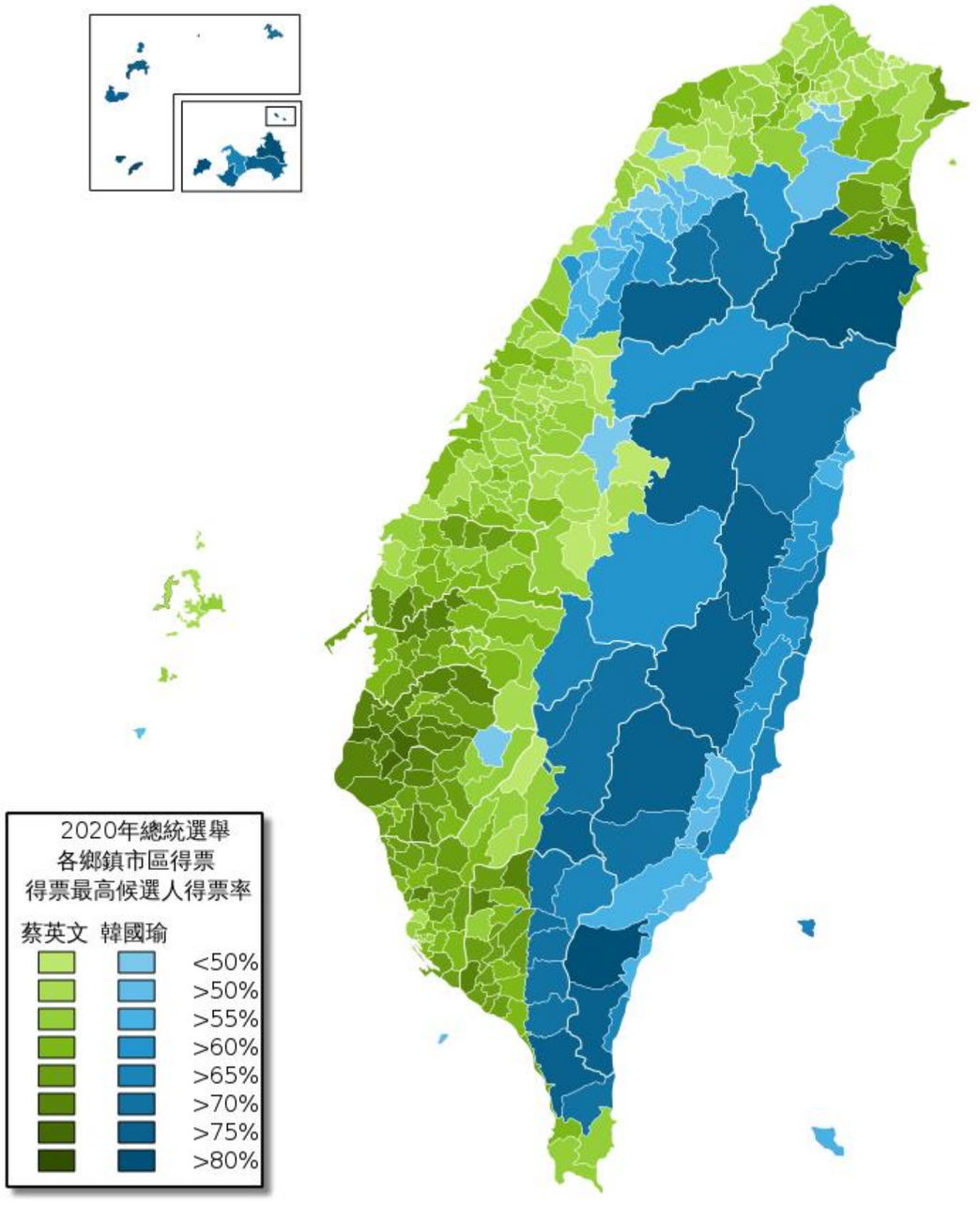
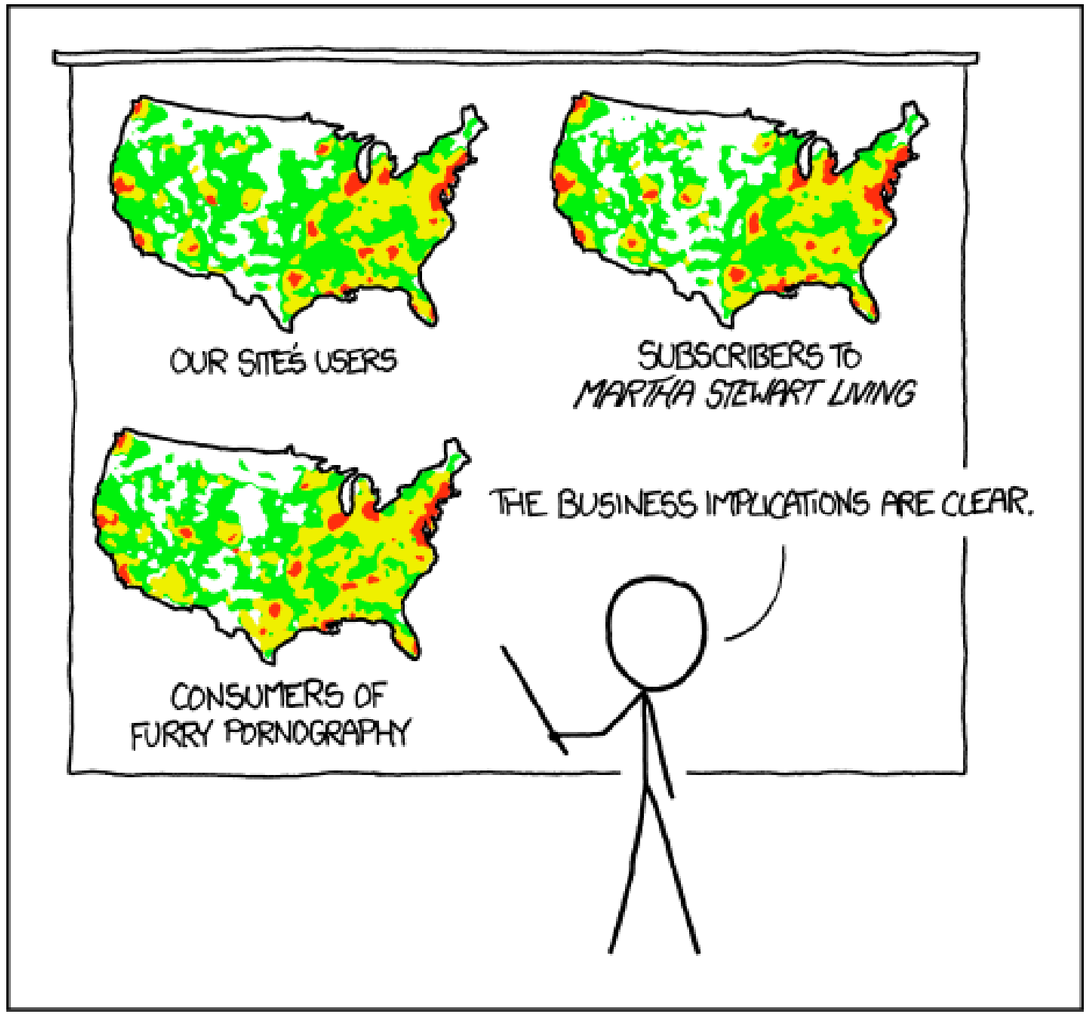

2020年總統選舉
各鄉鎮市區得票
得票最高候選人得票率
蔡英文 韓國瑜
<50%
>50%
>55%
>60%
>65%
>70%
>75%
>80%

Beware: Population maps trickiness!

- beware!
- absolute vs relative again
  - population density vs per capita
- investigate with Ben Jones Tableau Public demo
  - Are Maps of Financial Variables just Population Maps?
  - yes, unless you look at per capita(relative) numbers



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

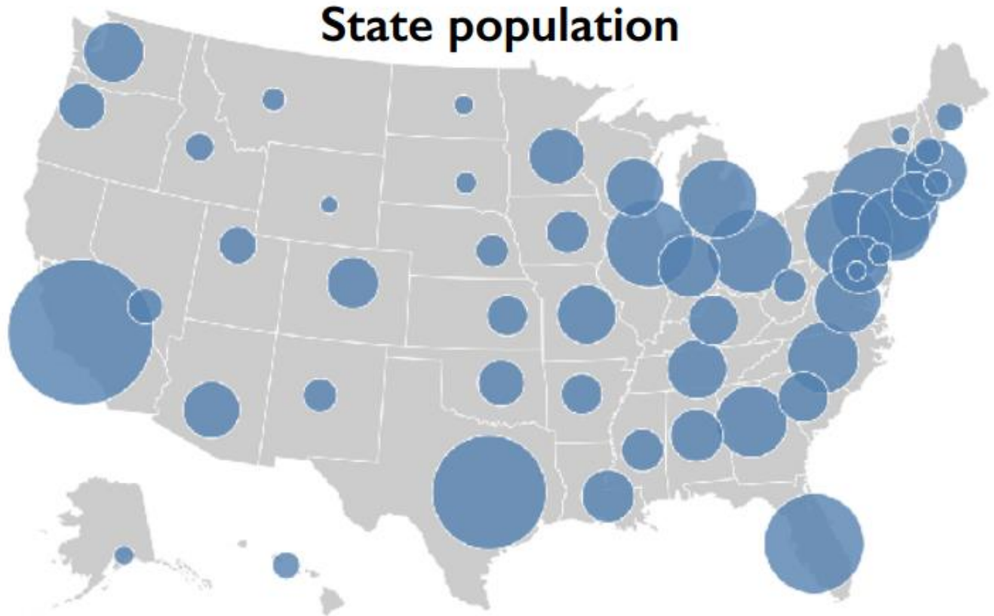
[https://xkcd.com/1138]

choropleth map: Recommendations

- *only use when central task is understanding spatial relationships*
- *show only one variable at a time*
- *normalize when appropriate*
- *be careful when choosing colors & bins*
- *best case:*
  - *regions are roughly equal sized*

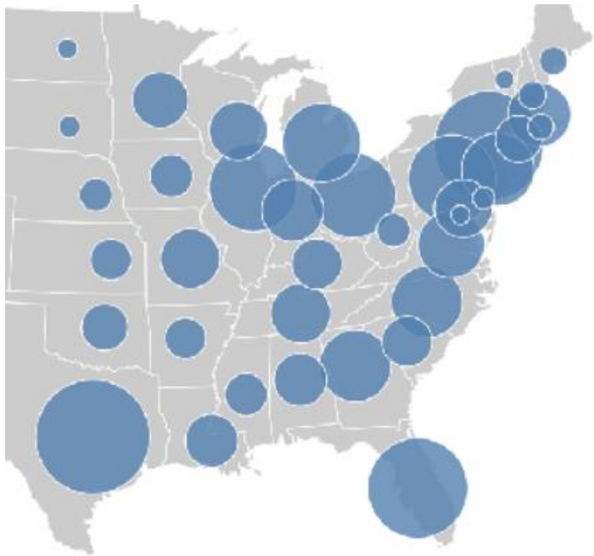
Idiom: Symbol maps

- *symbol is used to represent aggregated data (mark or glyph)*
  - *allows use of size and shape and color channels*
- *aka proportional symbol maps, graduated symbol maps*
- *keep original spatial geometry in the background*
- *often a good alternative to choropleth maps*

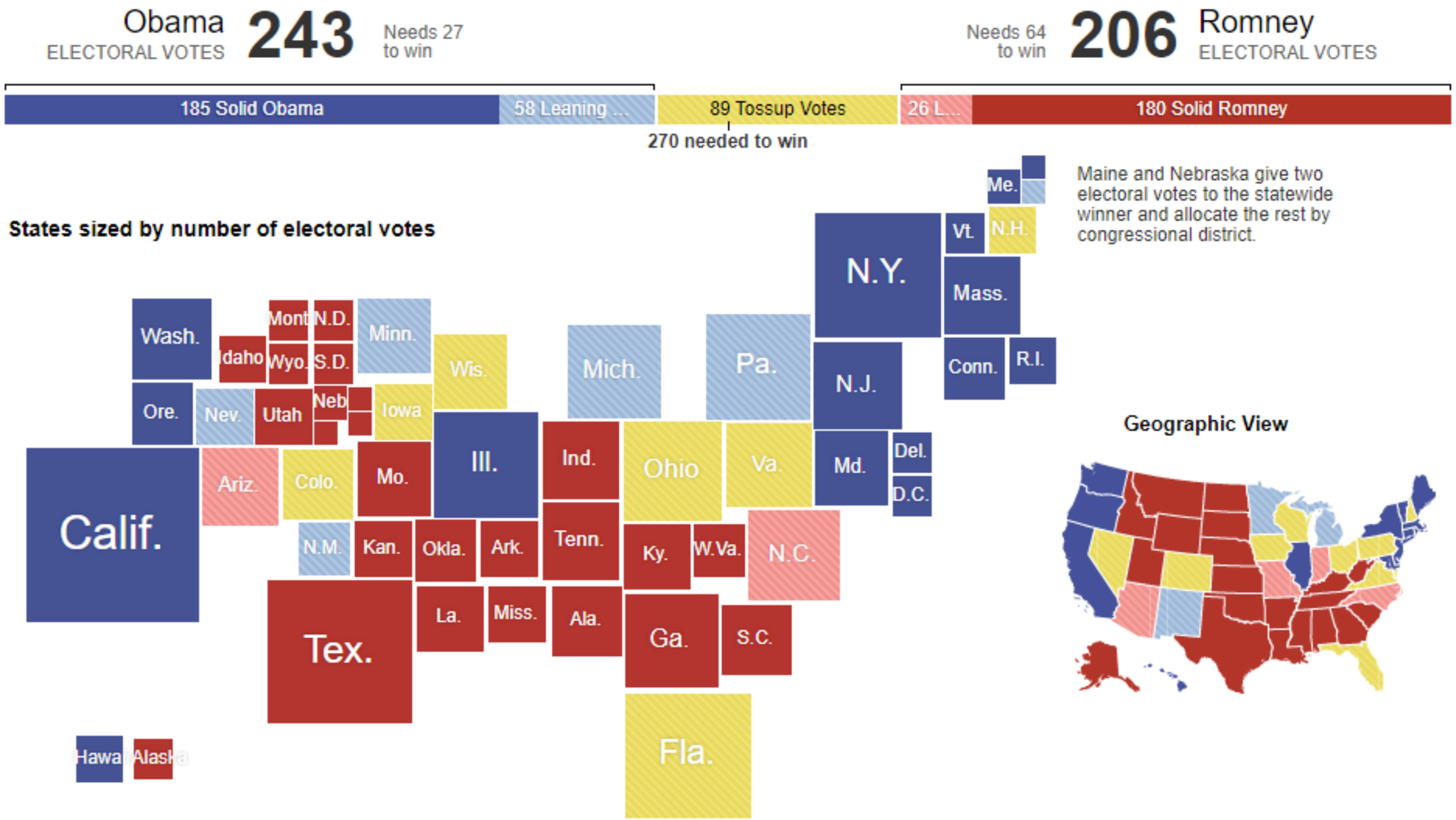


Symbol maps: Pros & cons

- *pros*
  - *somewhat intuitive to read and understand*
  - *mitigate problems with region size vs data salience*
    - *marks: symbol size follows attribute value*
    - *glyphs: symbol size can be uniform*
- *cons*
  - *possible occlusion / overlap*
    - *symbols could overlap each other*
    - *symbols could occlude region boundaries*
  - *complex glyphs may require explanation / training*



Cartograms (示意地圖，又稱比較統計地圖)



[A New York Times assessment of how states may vote in 2012.]

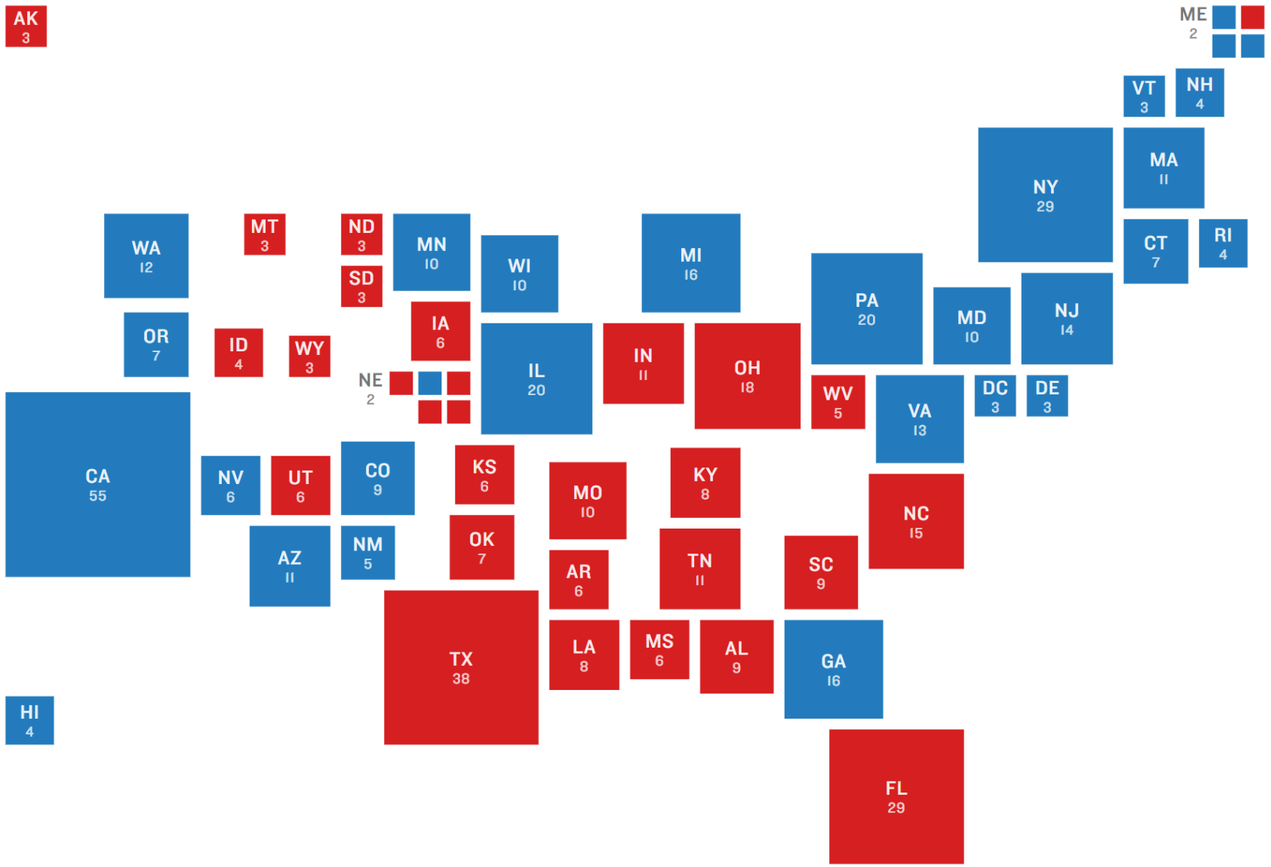
PRESIDENTIAL RESULTS

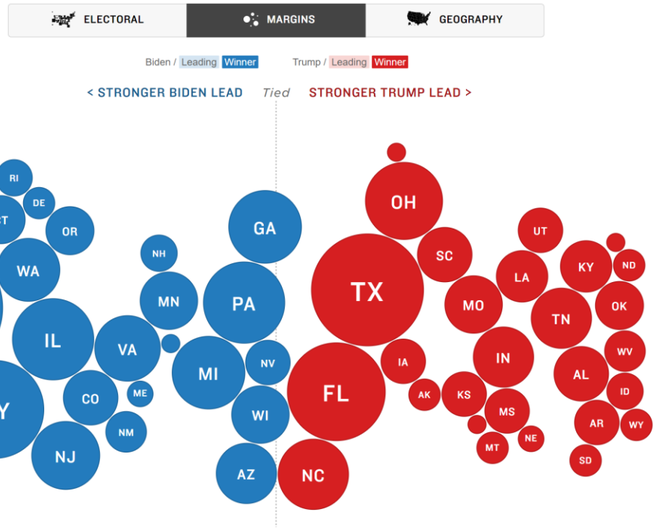
BIDEN ✓ **306**

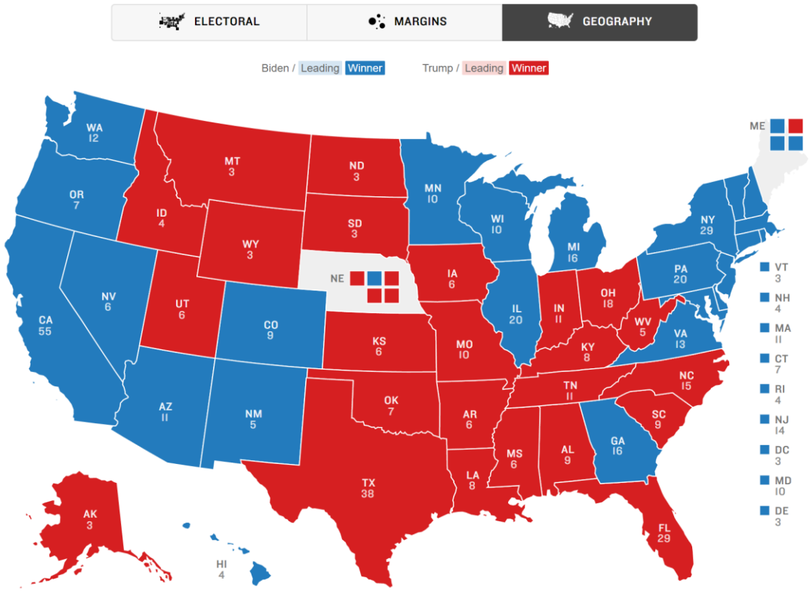
TRUMP **232**

ELECTORAL | MARGINS | GEOGRAPHY

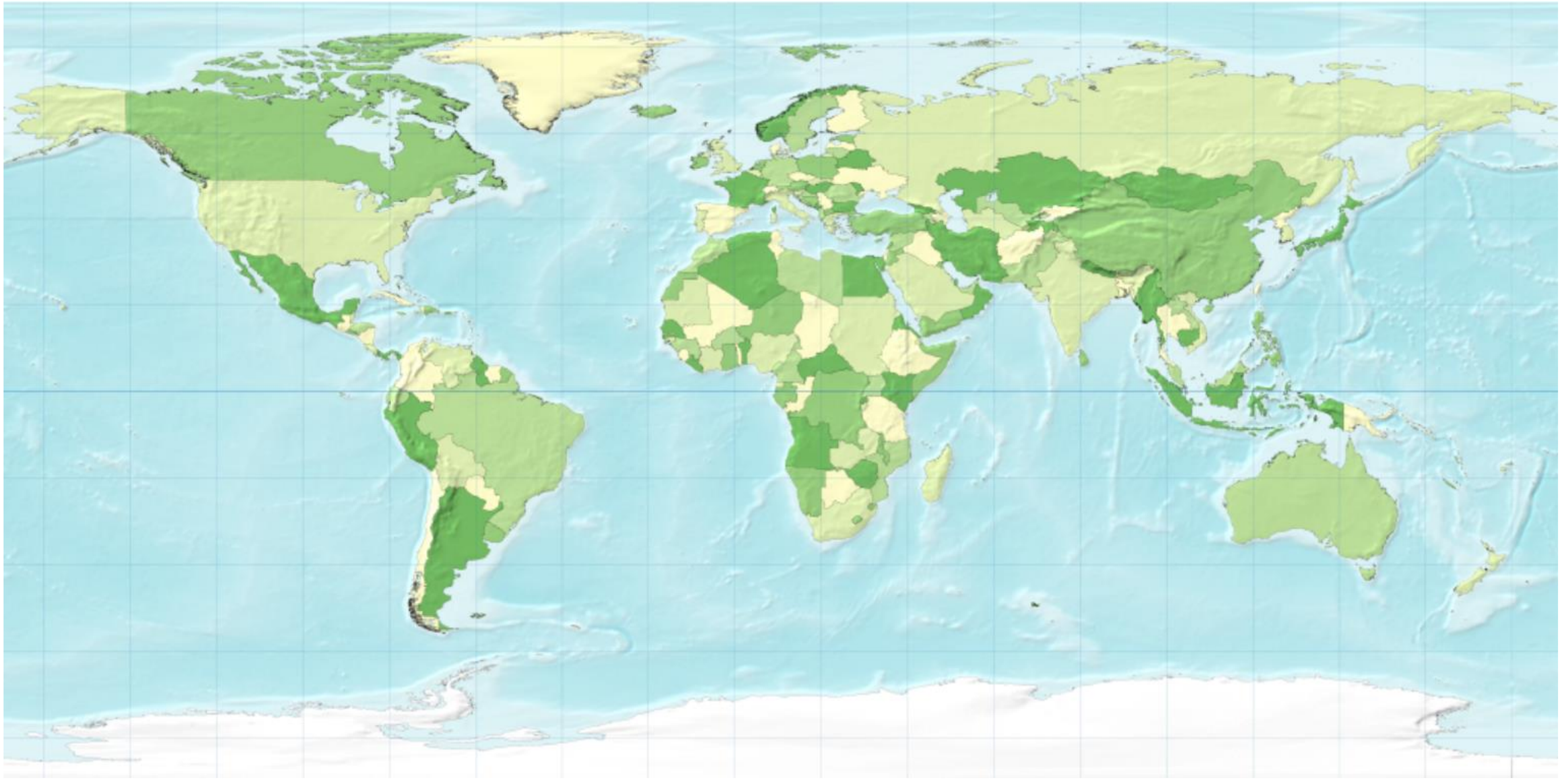
Biden / Leading Winner Trump / Leading Winner







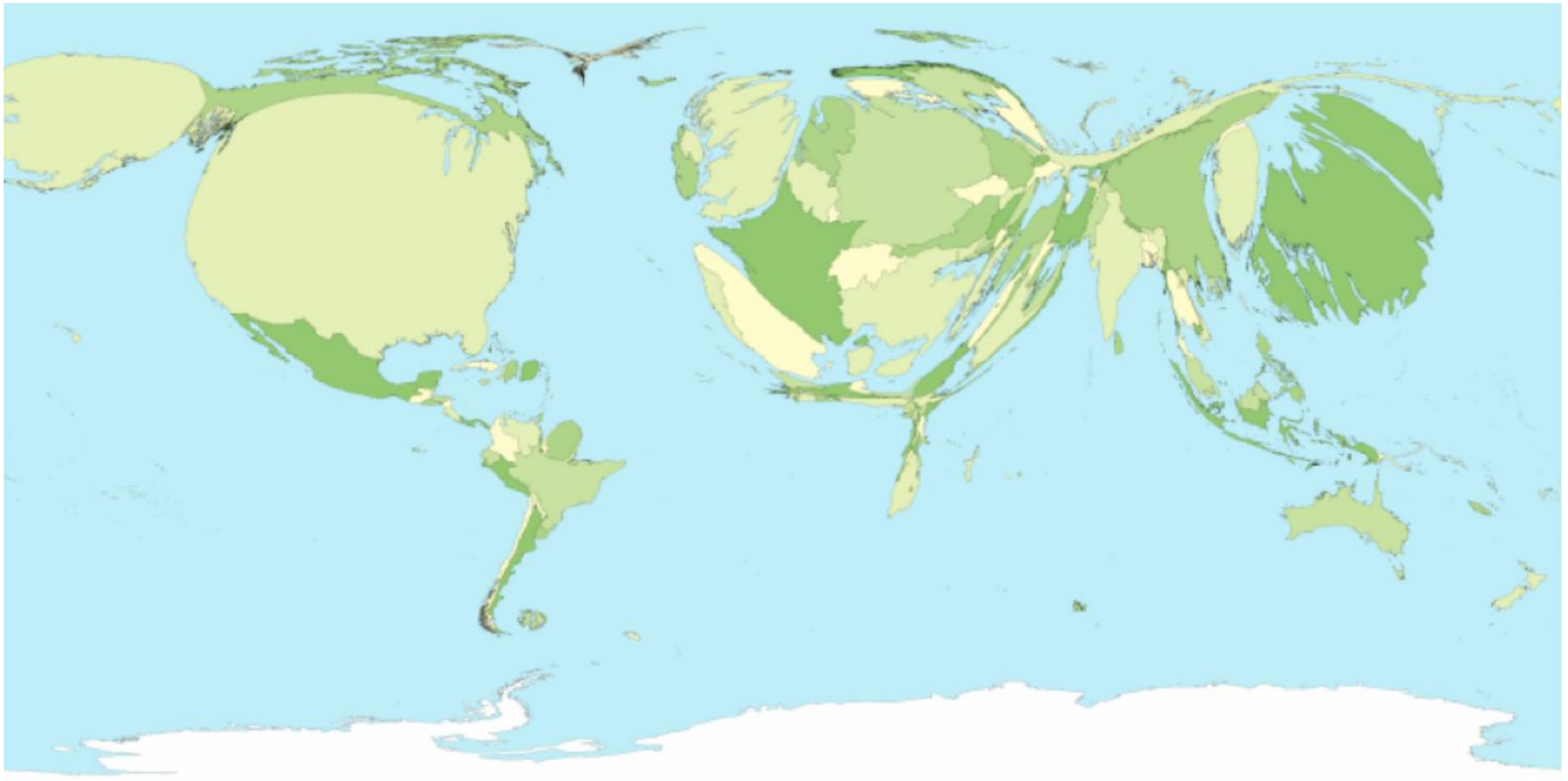
https://apps.npr.org/elections20-interactive/



Idiom: Contiguous Cartogram: Population

Cartograms distort size & shape of geographic regions so that the area directly encodes a data variable

Idiom: Contiguous Cartogram: GDP



Idiom: Contiguous Cartogram: GDP

- *interlocking marks:*

  shape, area, and position coded

- *derive new interlocking marks*
  - *based on combination of original interlocking marks and new quantitative attribute.*
- *algorithm to create new marks*
  - *input: target size*
  - *goal: shape as close to the original as possible*
  - *requirement: maintain constraints*
    - *relative position*
    - *contiguous boundaries with their neighbors*

Greenhouse Emissions

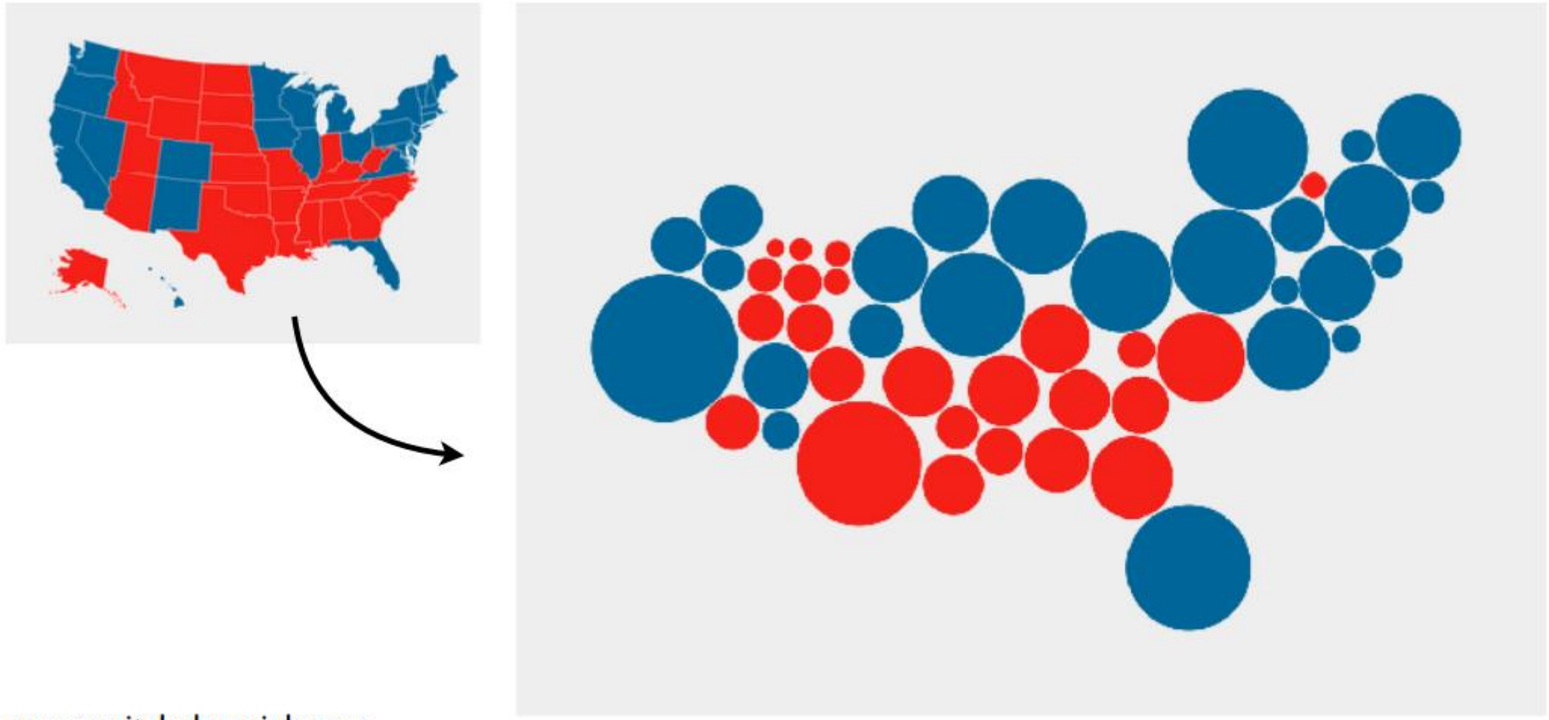
Child Mortality

Cartogram: Pros & cons

- *pros*
  - *can be intriguing and engaging*
  - *best case: strong and surprising size disparities*
- *cons*
  - *require substantial familiarity with original dataset & use of memory*
    - *compare distorted marks to memory of original marks*
    - *mitigation strategies: transitions or side by side views*
  - *major distortion is problematic*
    - *may be aesthetically displeasing*
    - *may result in unrecognizable marks*
  - *difficult to extract exact quantities*

Idiom: Dorling cartogram

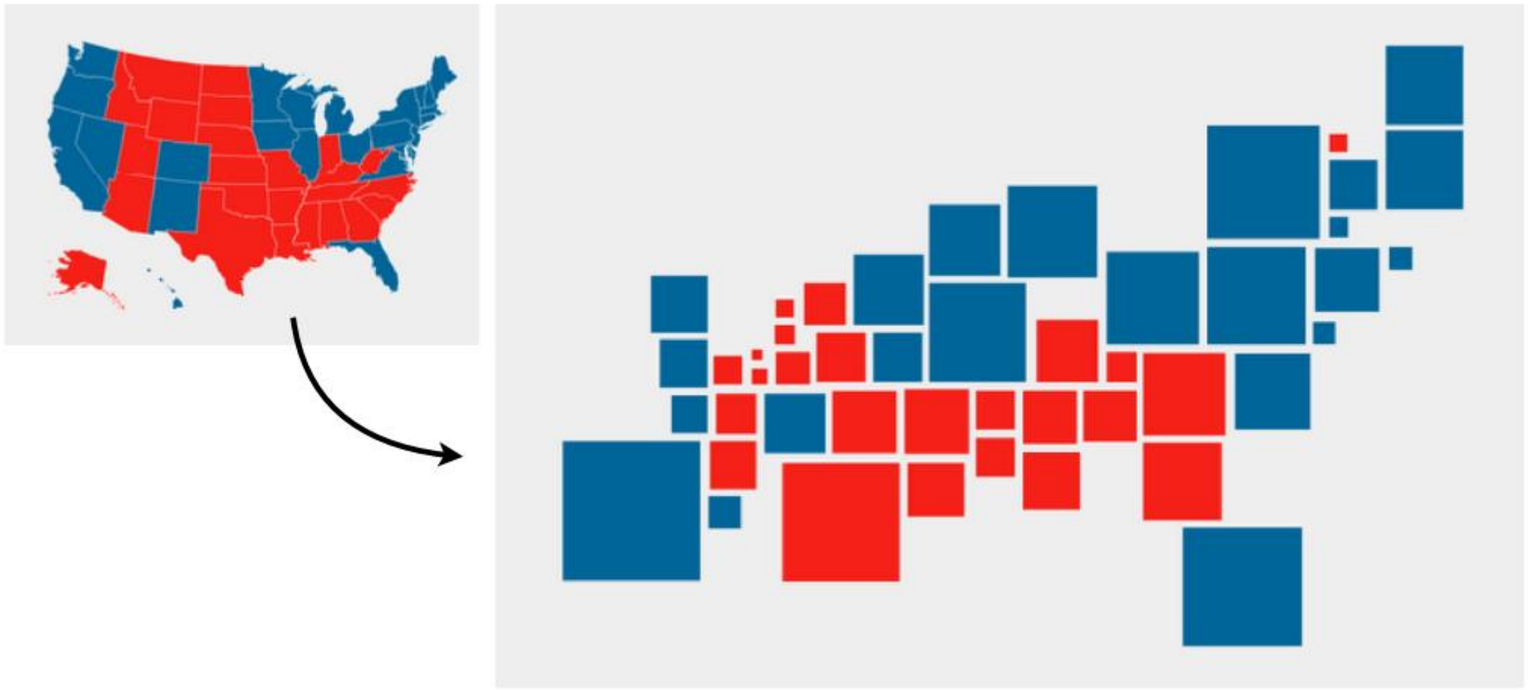
- *sized circles represent quantity of interest*
  - *one for each geographic region*
- *geometric shapes in place of geographic area*
  - *stylized rather than realistic, relax shape constraints*



communityhub.esriuk.com

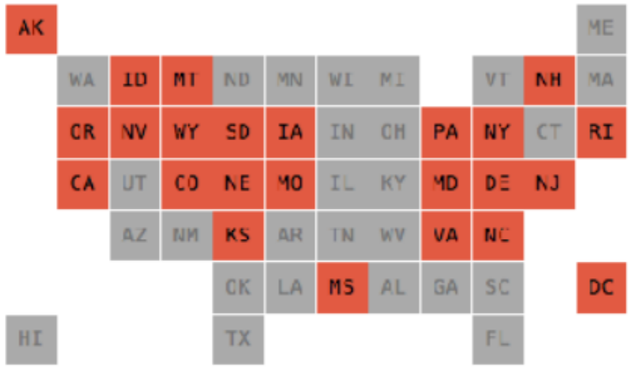
Idiom: Demers cartogram

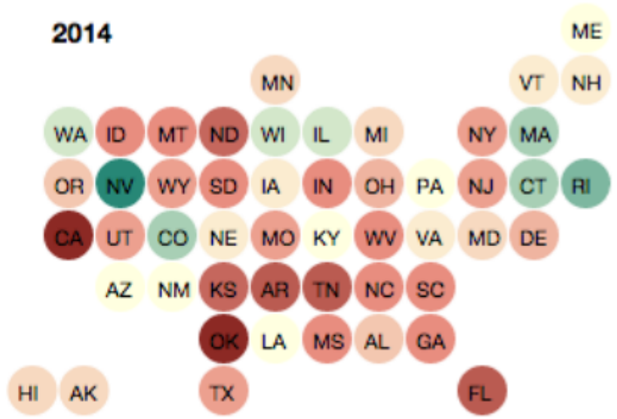
- *variation of Dorling cartogram: rectangles not circles*



Idiom: Grid cartogram

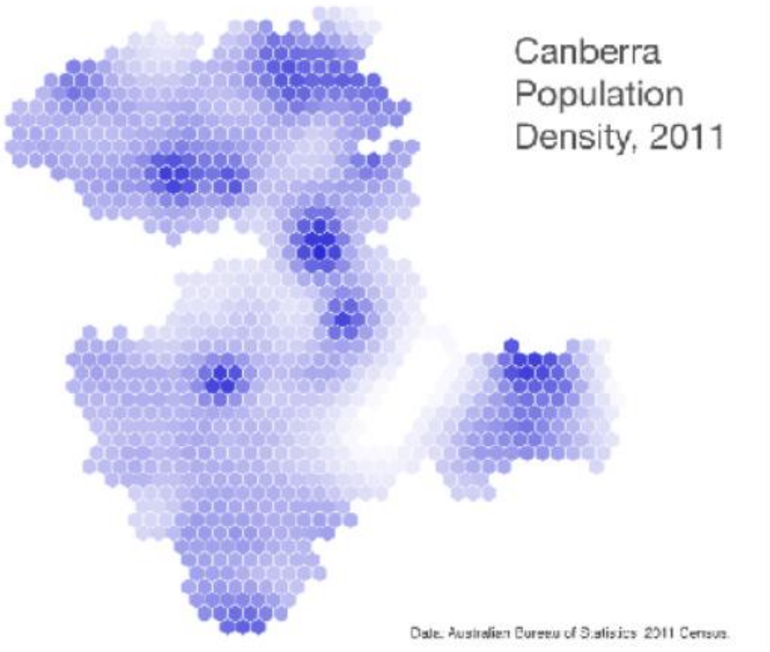
- *uniform-sized shapes arranged in rectilinear grid*
- *maintain approximate spatial position and arrangement*

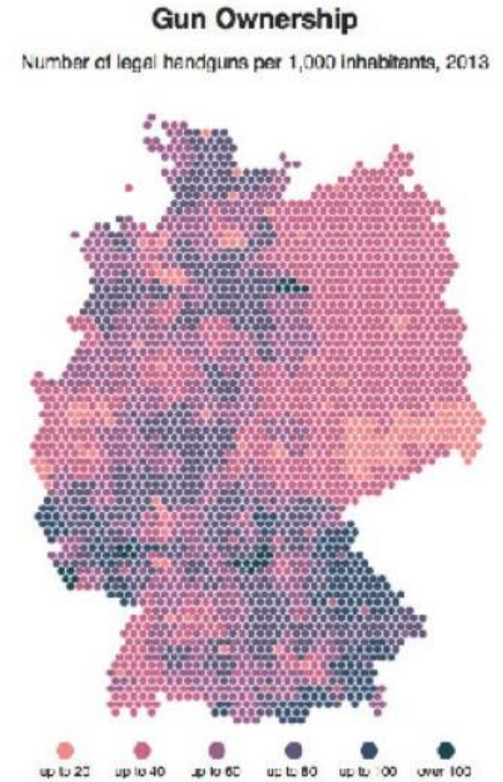


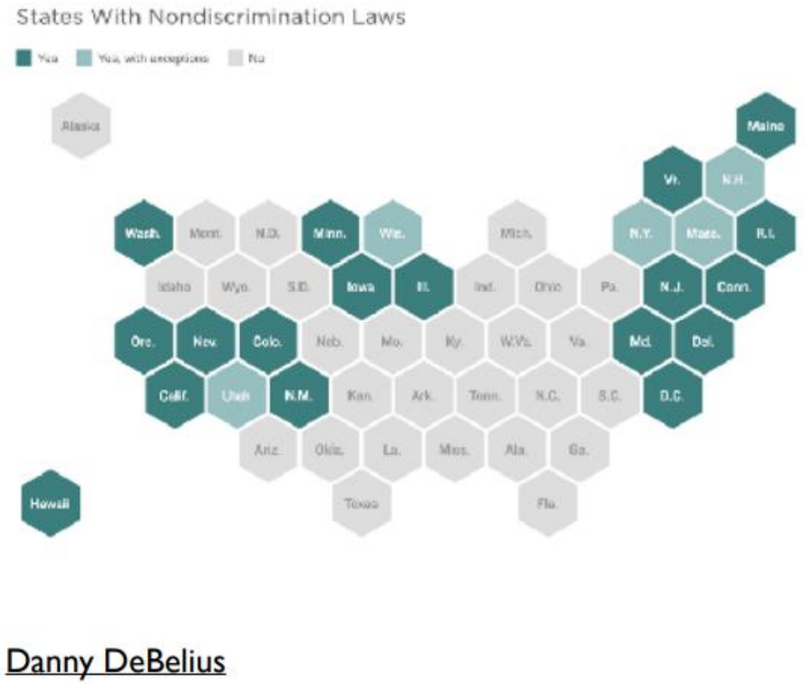


Idiom: Hexagonal cartogram

- *uniform-sized hexagons arranged in grid*
- *maintain as many border adjacencies as possible*





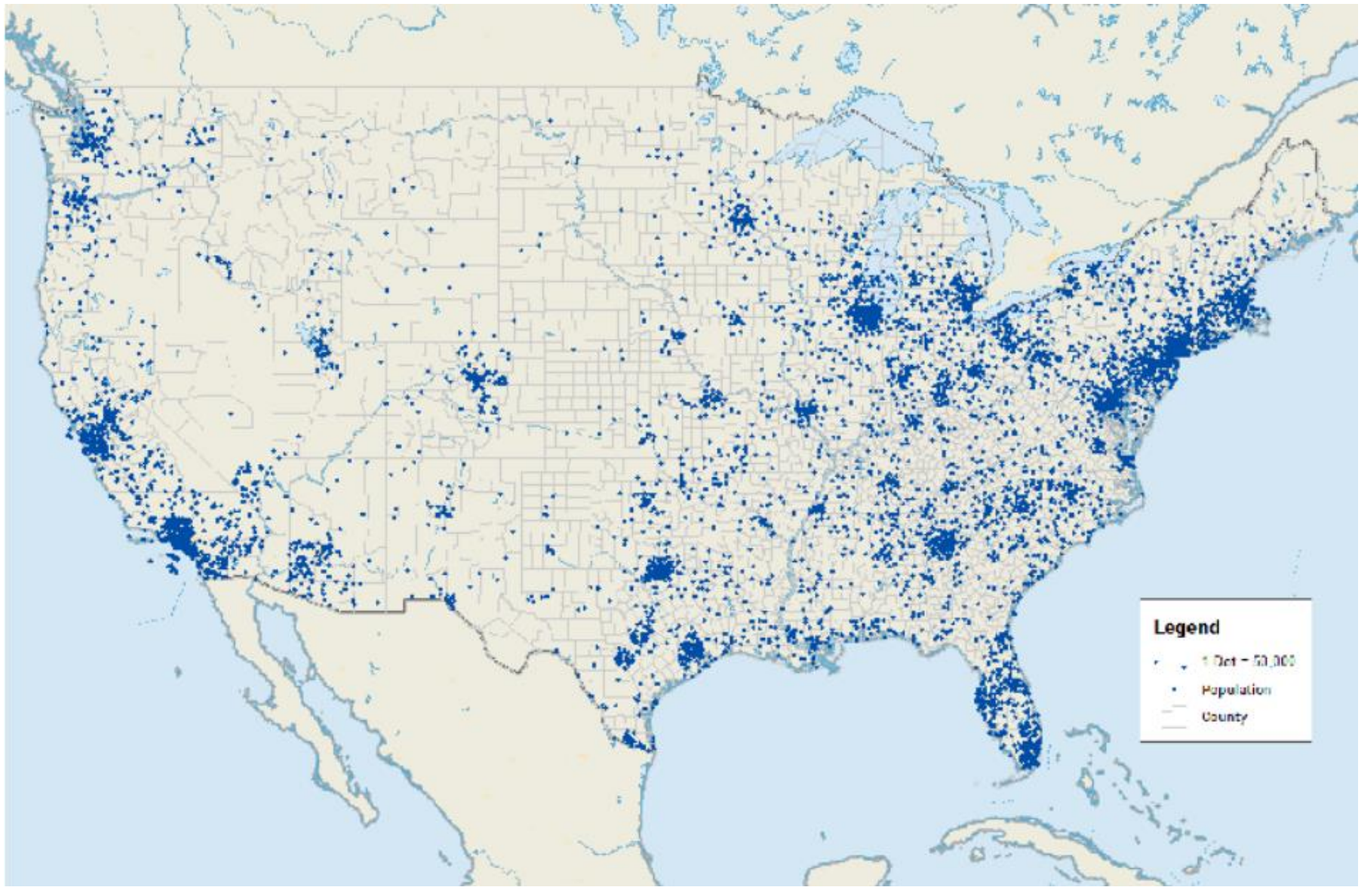


Cartogram: Recommendations

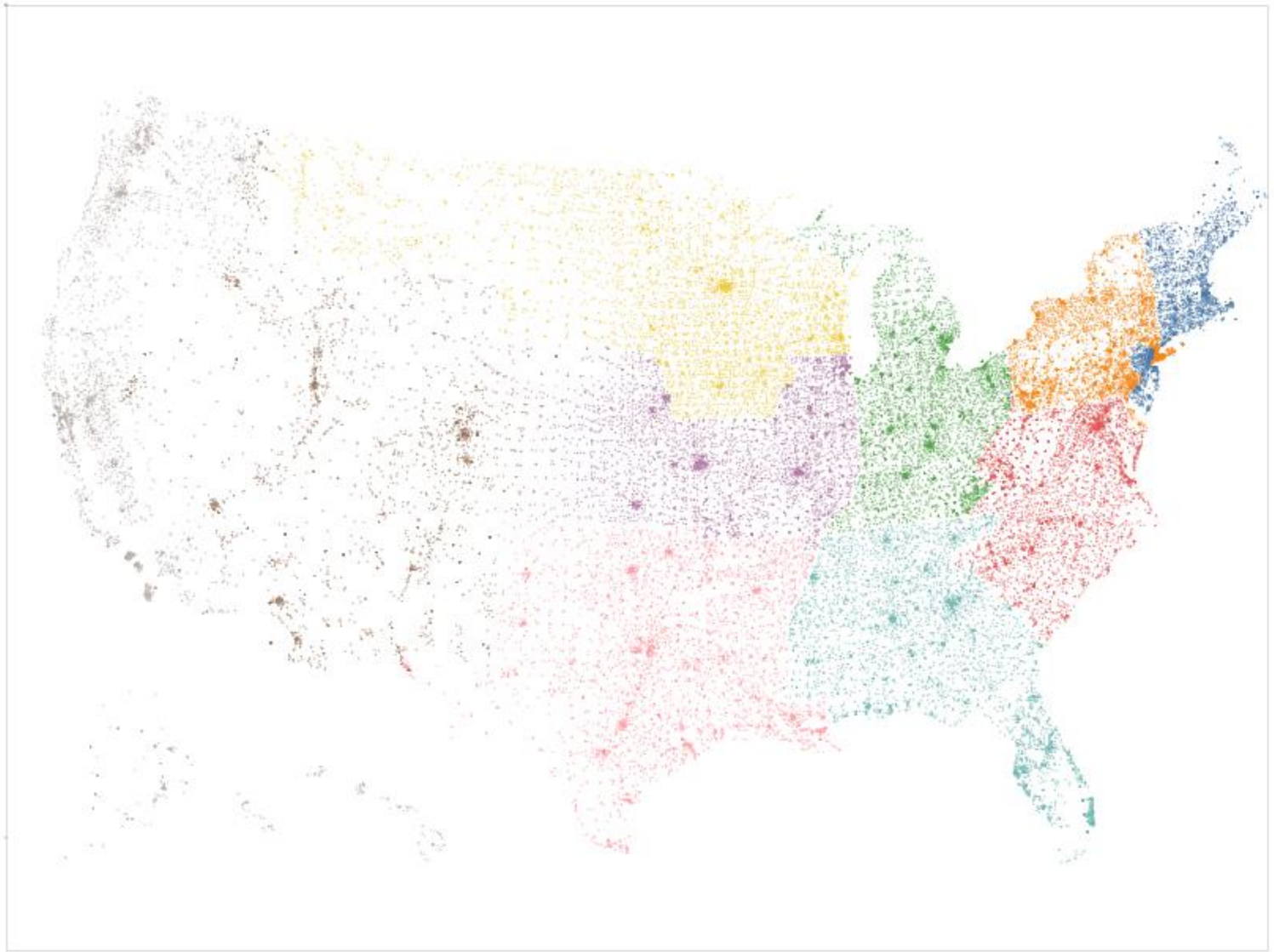
- *non-contiguous cartograms often easier to understand*
  - *hex cartograms especially good trade-off between stylized and familiar*
    - *uniform size has benefit of regularity*

Idiom: Dot density maps

- *visualize distribution of a phenomenon by placing dots*
- *one symbol represents*
  - *a constant number of items dots have uniform size &shape*
  - *allows use of color channel*
- *task:*
  - *show spatial patterns, clusters*



Dot Density Map: One Dot per Zipcode in the U.S.



Valid US Cities and Zip Codes

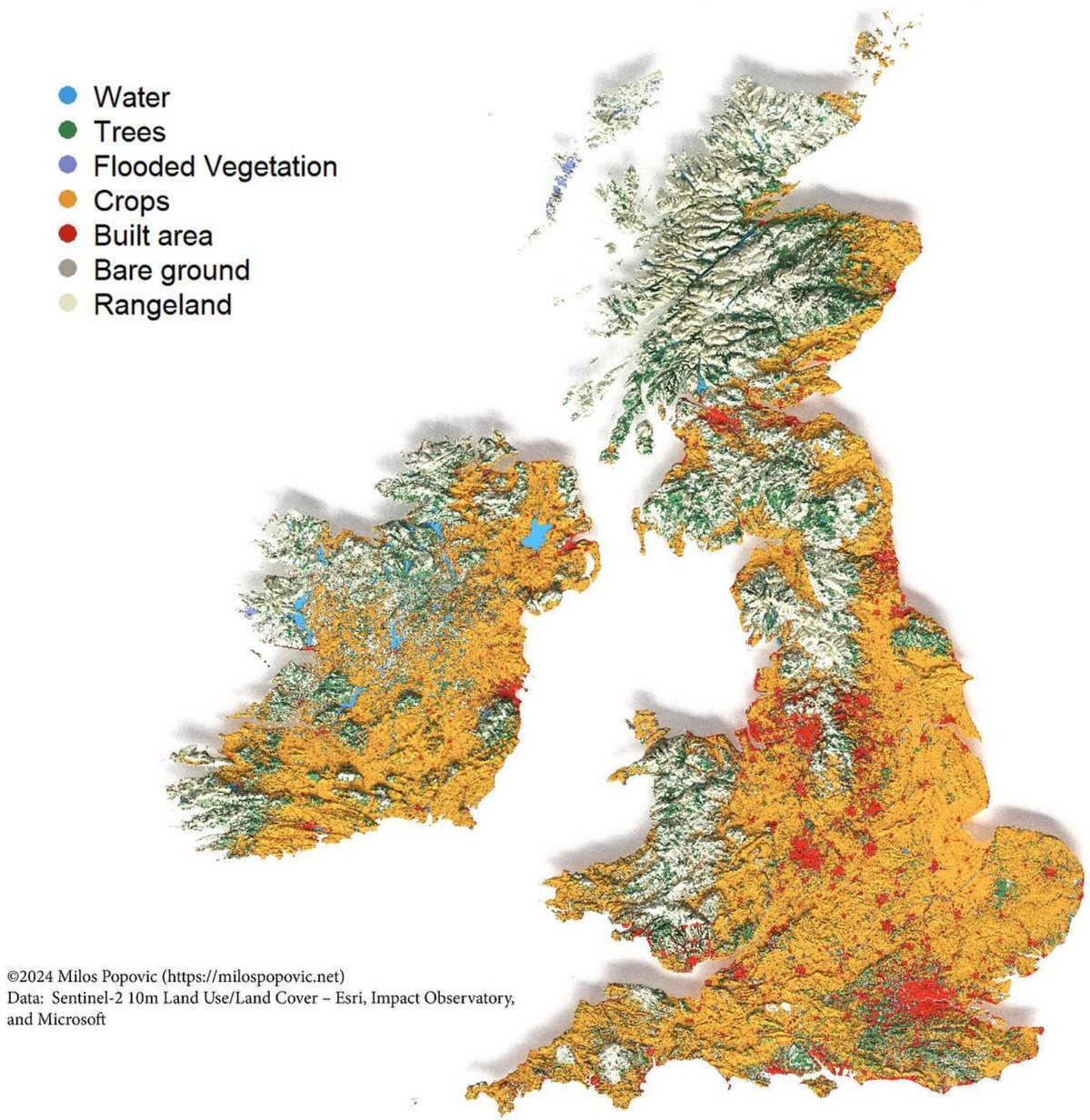
State	City	ZIP Code(s)
Alabama (AL)	Huntsville	35801 thru 35816
Alaska (AK)	Anchorage	99501 thru 99524
Arizona (AZ)	Phoenix	85001 thru 85055
Arkansas (AR)	Little Rock	72201 thru 72217
California (CA)	Sacramento Los Angeles Beverly Hills	94203 thru 94209 90001 thru 90089 90209 thru 90213
Colorado (CO)	Denver	80201 thru 80239
Conneticut (CT)	Hartford	06101 thru 06112
Deleware (DE)	Dover	19901 thru 19905
District of Columbia (DC)	Washington	20001 thru 20020

https://vega.github.io/editor/#/examples/vega-lite/geo_circle

Milos Popovic

Land cover in 2023

British Isles and Ireland



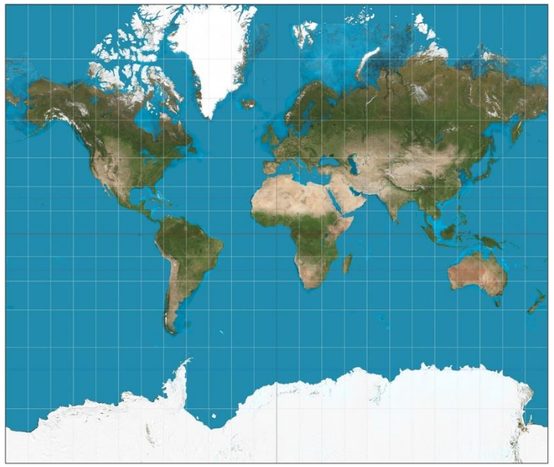
Data: Sentinel-2 10m Land Use/Land Cover – Esri, Impact Observatory, and Microsoft

Dot density maps: Pros and cons

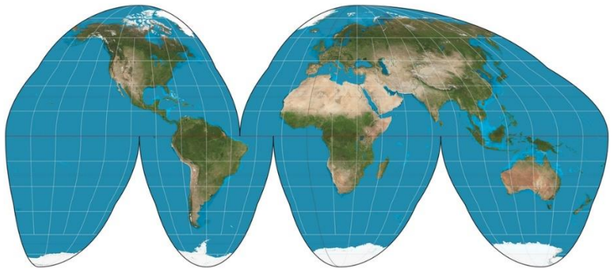
- *pros*
  - *straightforward to understand*
  - *avoids choropleth non-uniform region size problems*
- *cons*
  - *challenge: normalization*
    - *many dot maps primarily show population density (with which the target variable is correlated) instead of the effect of interest*
    - *same challenge as choropleths*
  - *perceptual disadvantage: difficult to extract quantities*
  - *performance disadvantage: rendering many dots can be slow*

Projection

- Projection

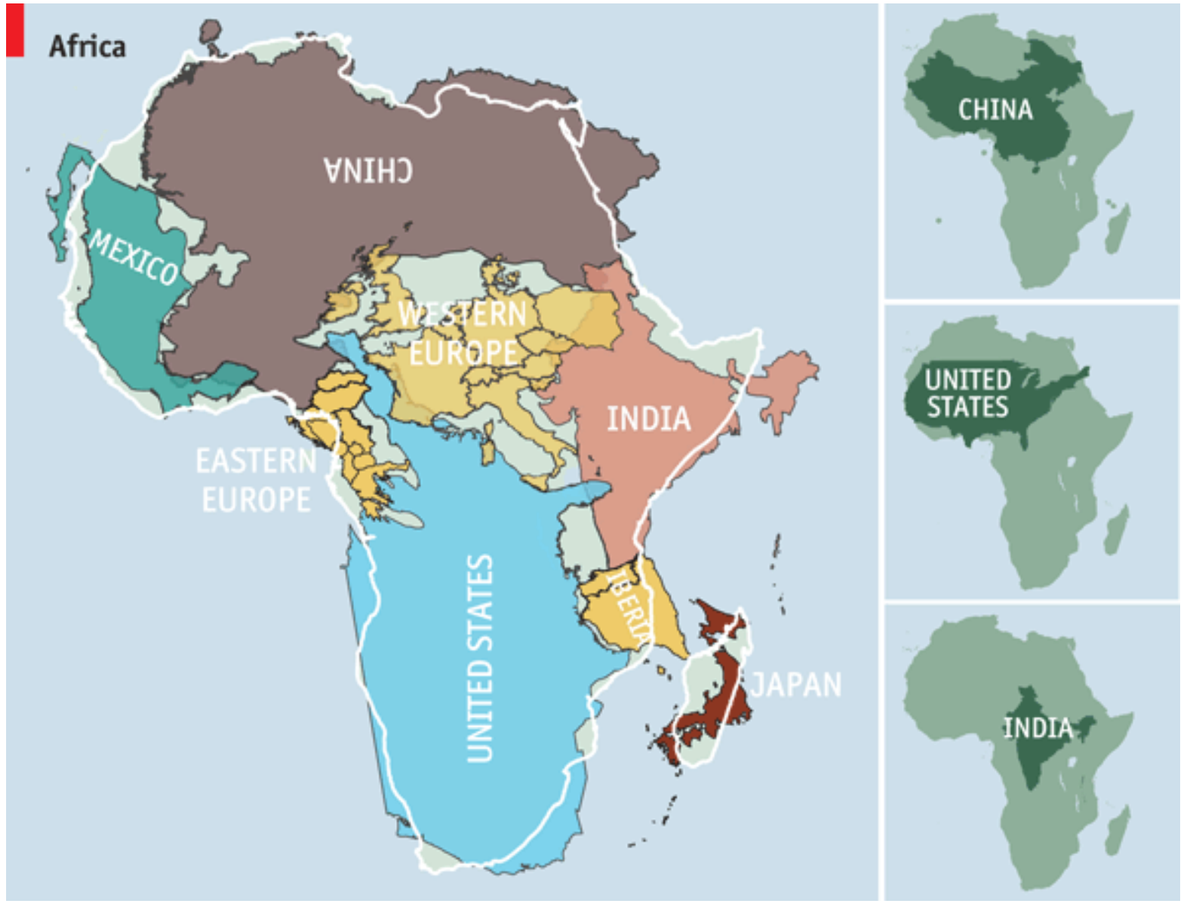


麥卡托投影法

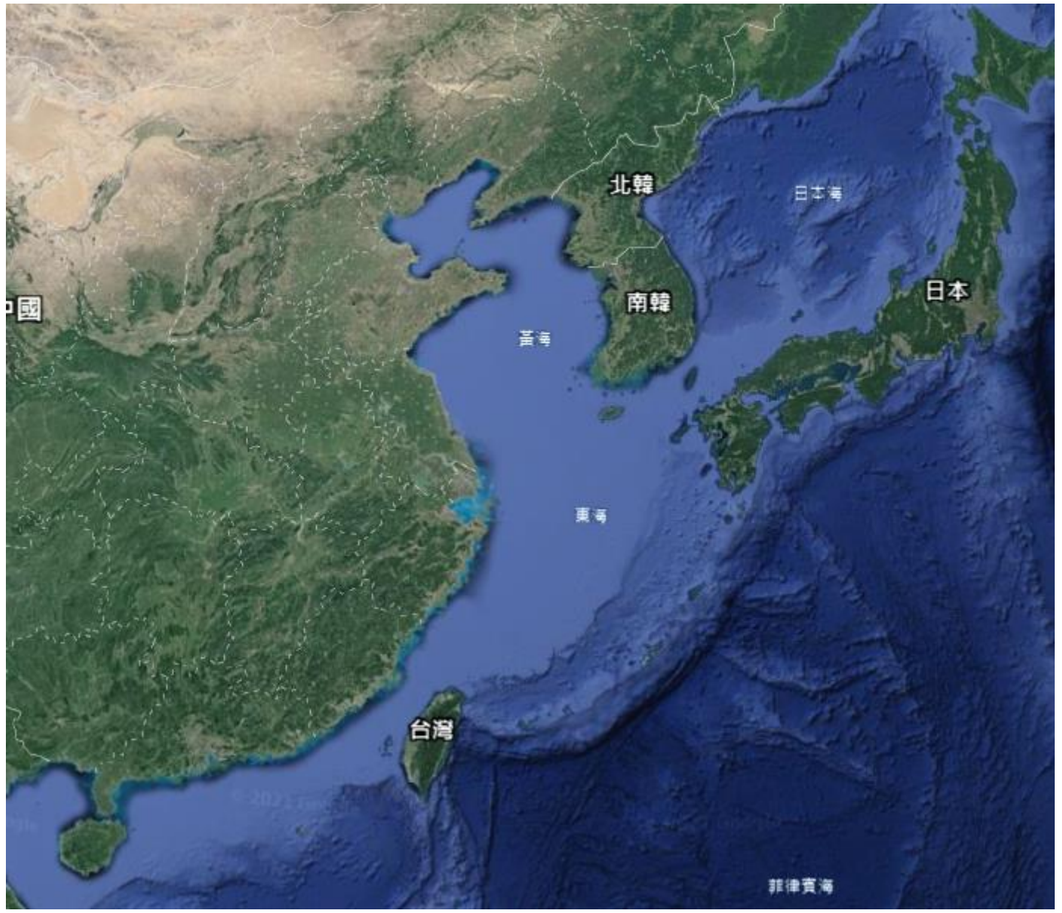


古德投影法

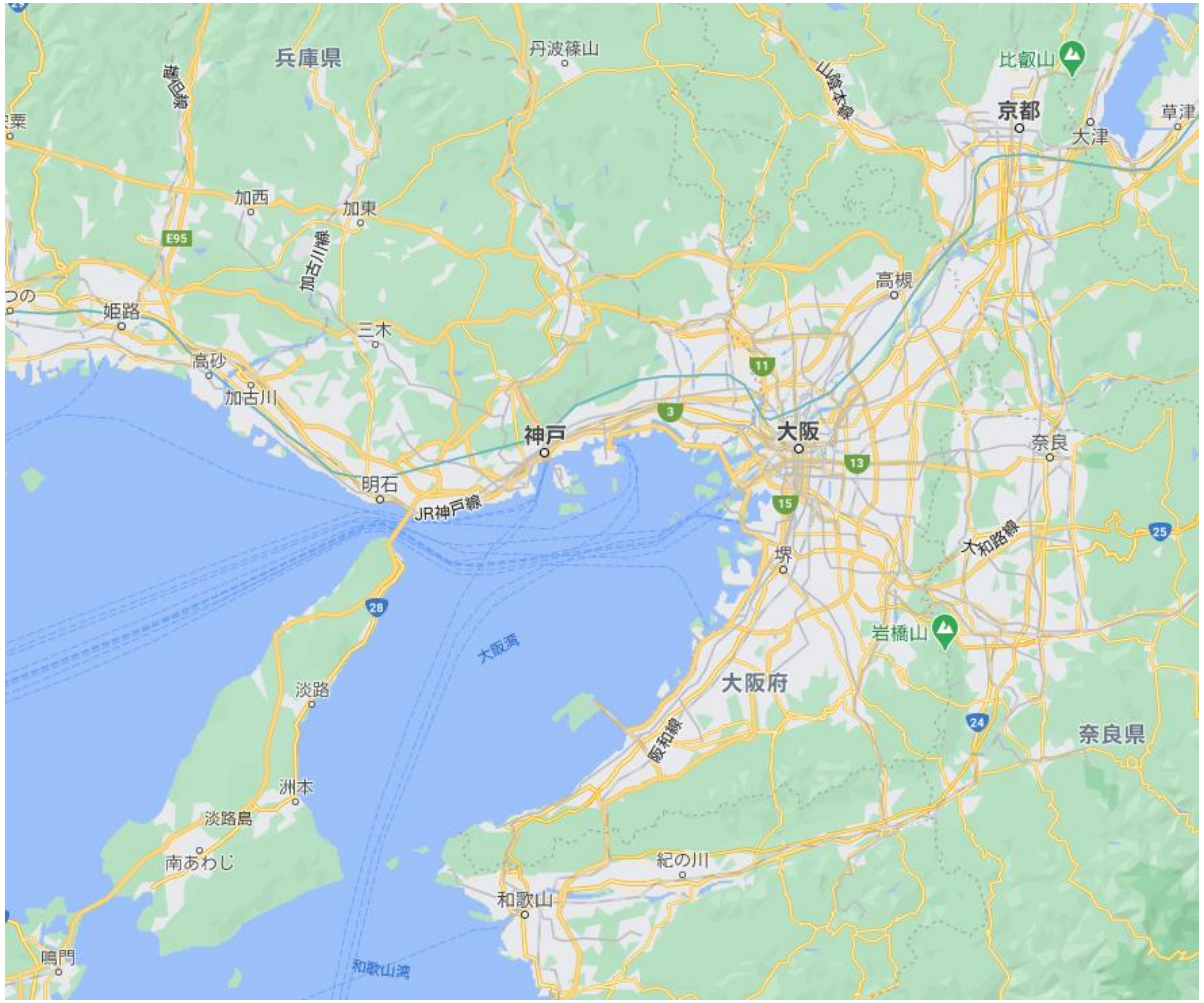
Distortion

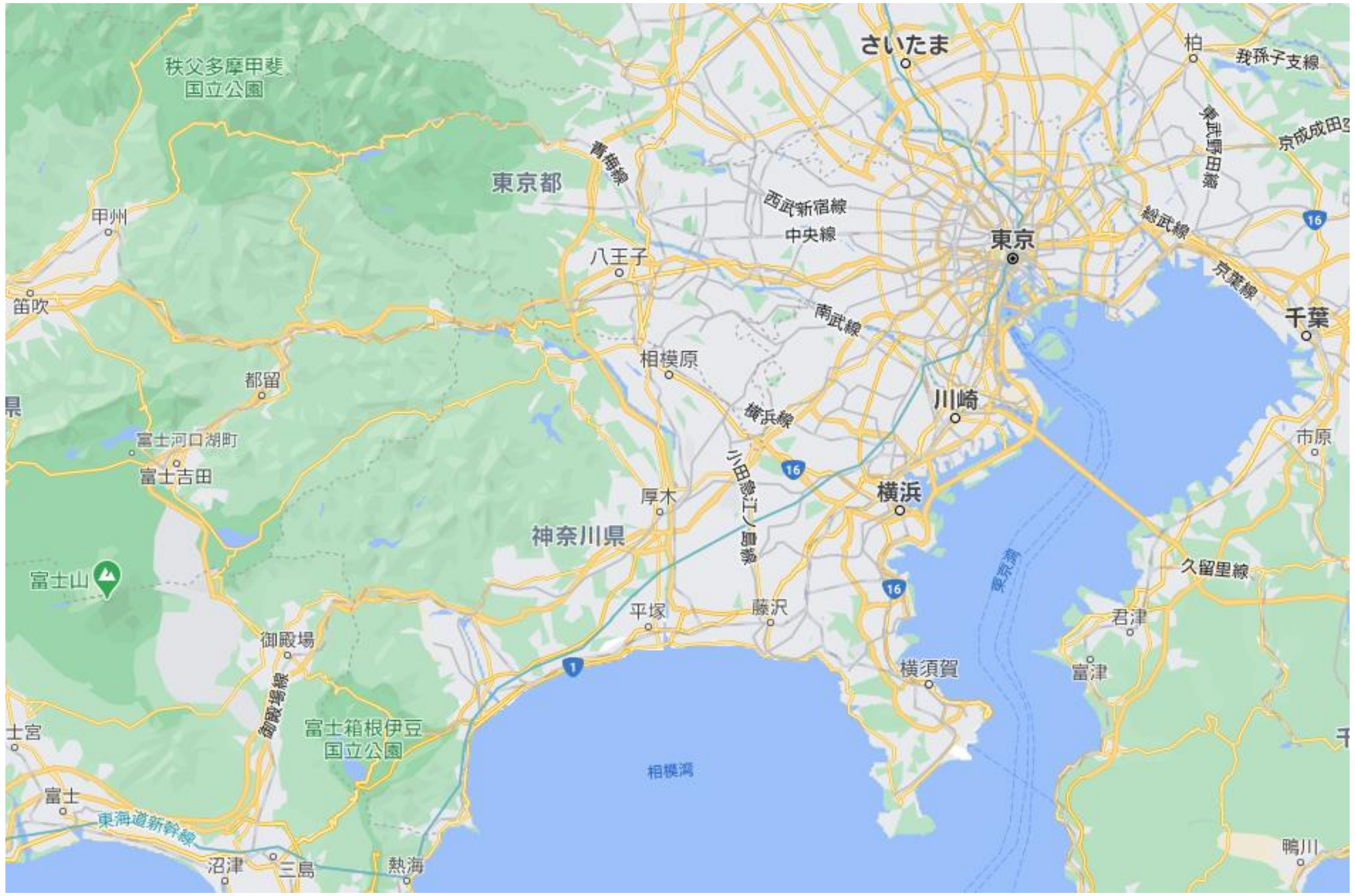


麥卡托投影法(局部)



地球儀(局部)


兵庫県
丹波篠山
比叡山
京都
大津
草津
加西
加東
姫路
高砂
加古川
三木
高槻
神戸
大阪
奈良
明石
JR神戸線
堺
大和路線
岩橋山
淡路
大阪湾
大阪府
奈良県
阪和線
洲本
淡路島
南あわじ
紀の川
和歌山
鳴門
和歌山湾

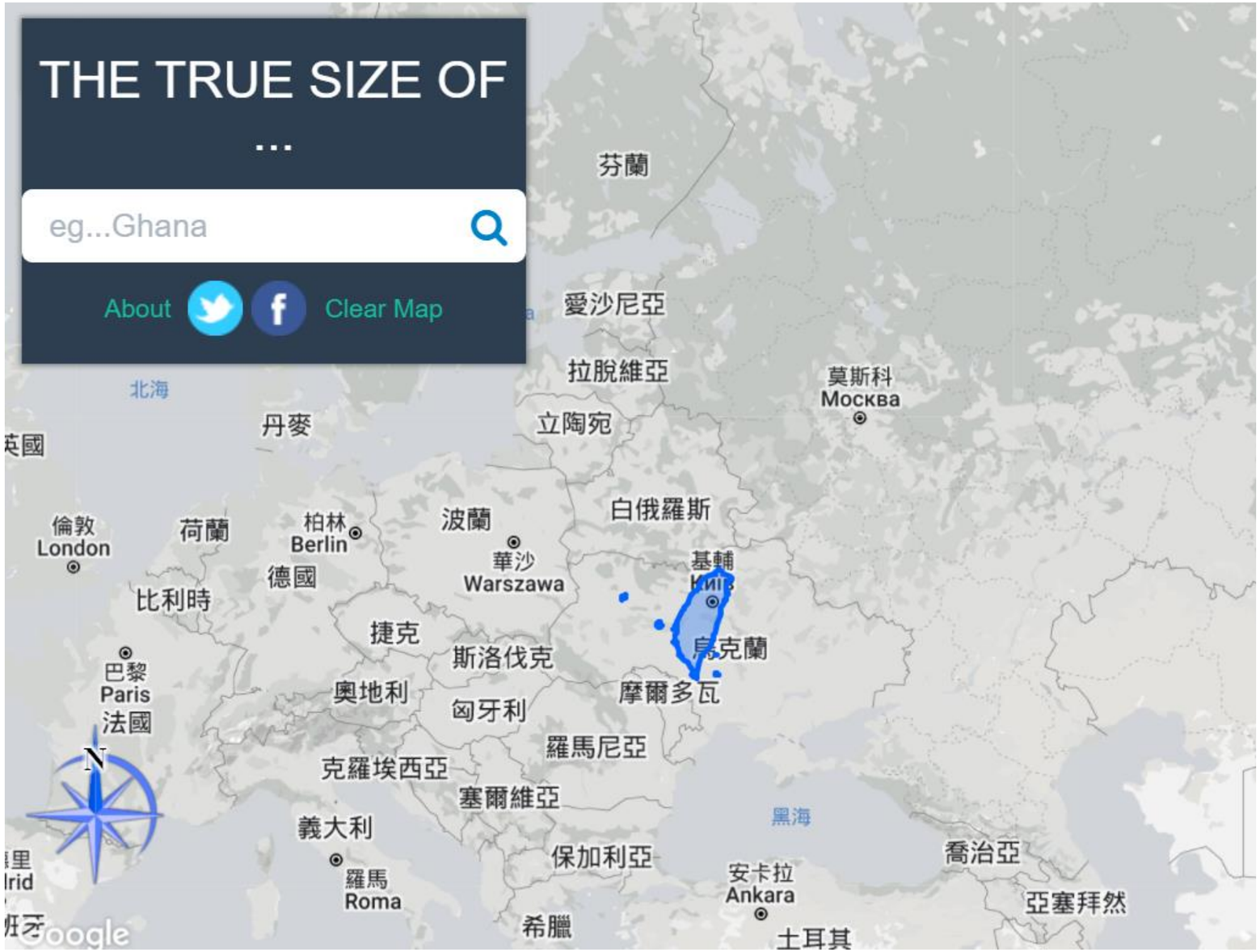

秩父多摩甲斐
国立公園
さいたま
柏
我孫子支線
東京都
青梅線
西武新宿線
中央線
東京
京成成田空
総武線
甲州
八王子
笛吹
南武線
千葉
相模原
都留
川崎
横浜線
市原
富士河口湖町
富士吉田
小田急江ノ島線
厚木
横浜
神奈川県
富士山
久留里線
平塚
藤沢
御殿場
君津
横須賀
富津
富士箱根伊豆
国立公園
相模湾
富士
東海道新幹線
沼津
三島
熱海
鴨川

一張圖秒懂日本大小完整版！

http://fake-hipster-daily.blogspot.tw/2015/10/blog-post.html

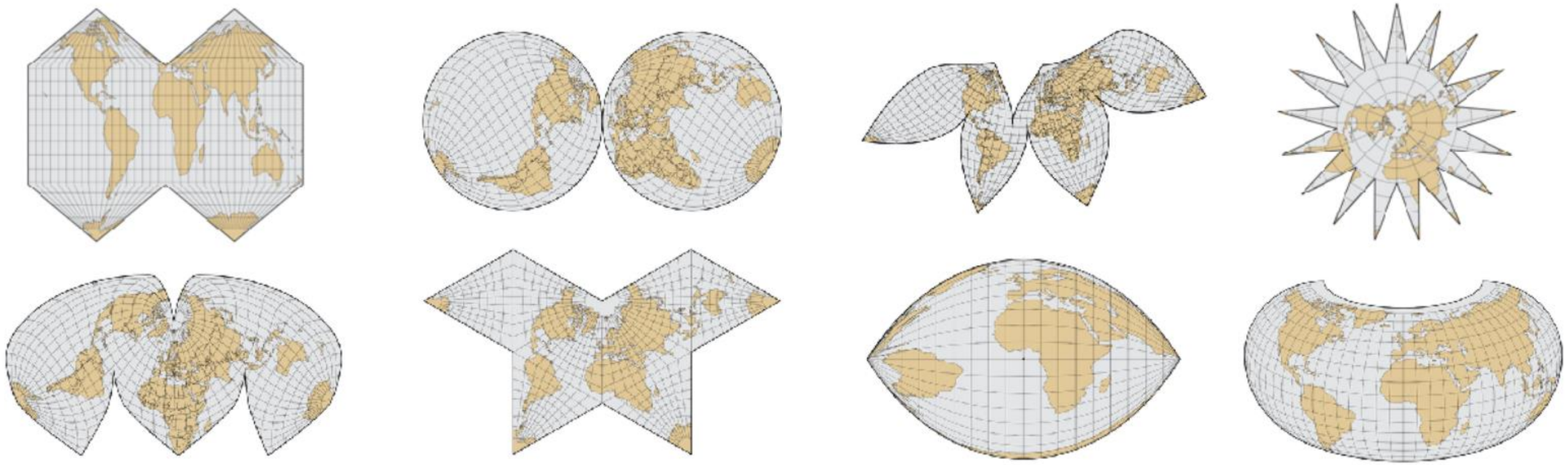
一張圖秒懂日本大小完整版！
http://fake-hipster-daily.blogspot.tw/2015/10/blog-post.html

The true size of



Map Projection

- mathematical functions that map 3D surface geometry of the Earth to 2D maps
- all projections of sphere on plane necessarily distort surface in some way
- interactive: philogb.github.io/page/myriahedral/ and jasondavies.com/maps



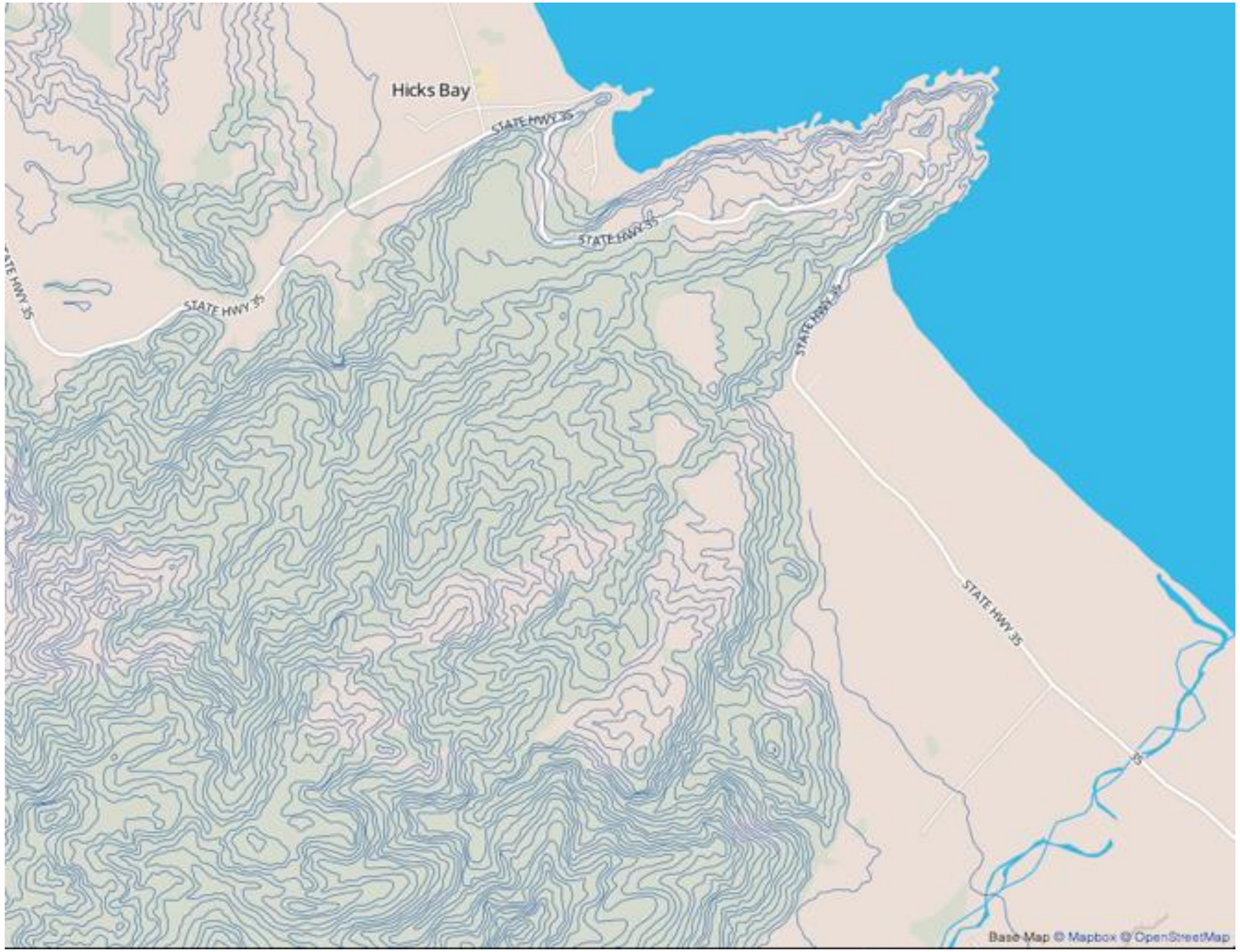
Spatial Field

- Scalar field
  - Slice
  - Isoline/isosurface
  - Direct volume rendering

- Vector and Tensor field

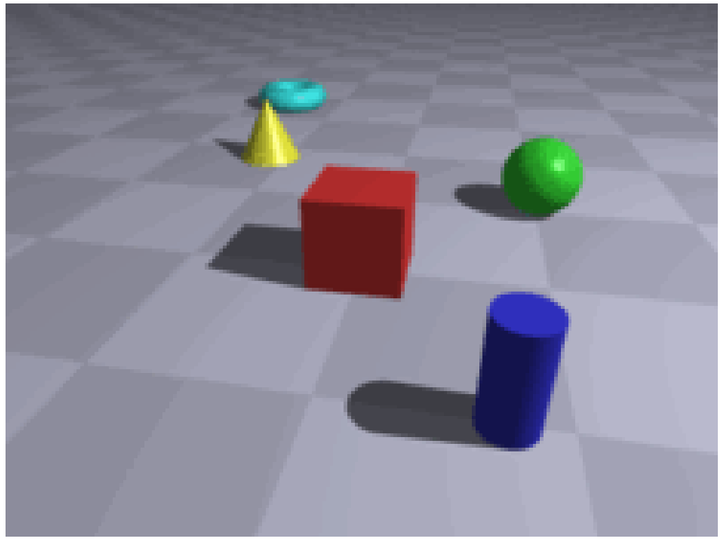
Idiom: **topographic map (地形圖或等高線圖)**

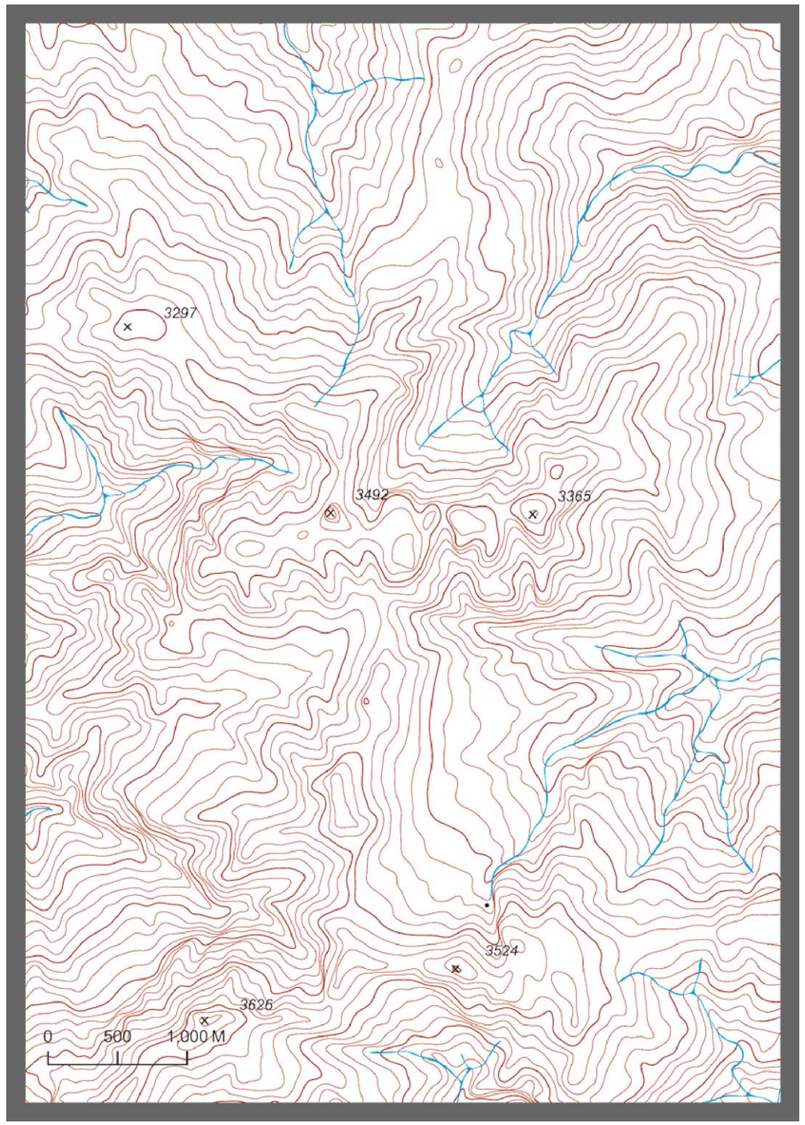
- data
  - geographic geometry
  - scalar spatial field
    - 1 quant attribute per grid cell
- derived data
  - isoline geometry
    - isocontours computed for specific levels of scalar values



Land Information New Zealand Data Service

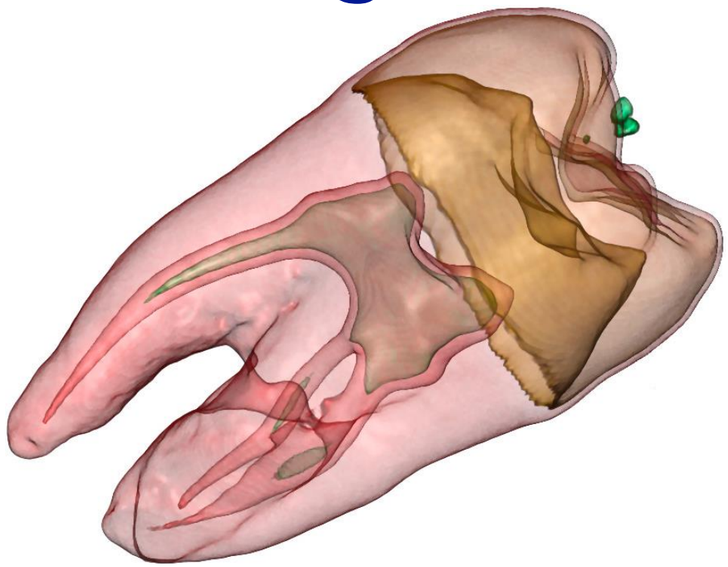
Wiggle stereoscopy



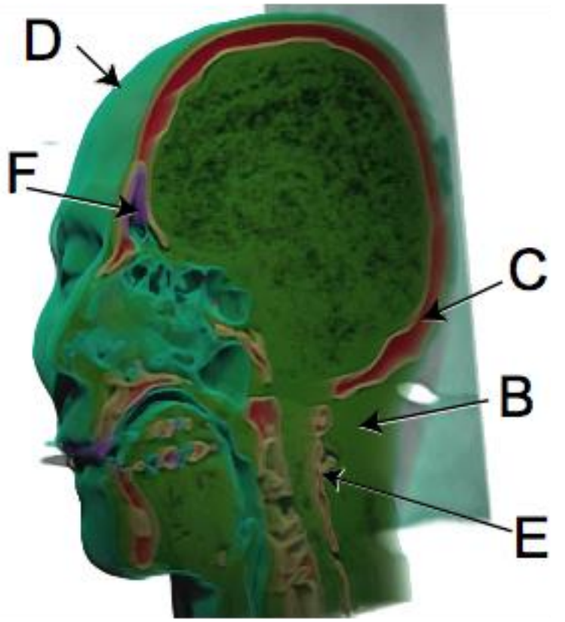


Idioms: **isosurfaces, direct volume rendering**

- data
  - scalar spatial field
    - 1 quant attribute per grid cell
- task
  - shape understanding, spatial relationships
- isosurface
  - derived data: isocontours computed for specific levels of scalar values
- direct volume rendering
  - transfer function maps scalar values to color, opacity
    - no derived geometry

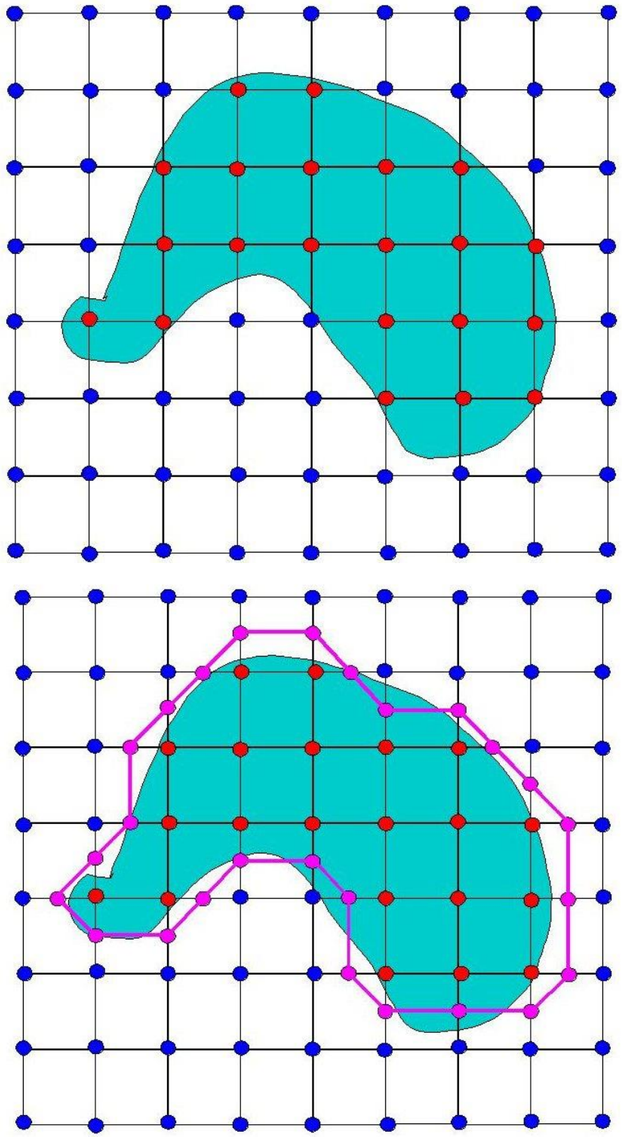


[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]

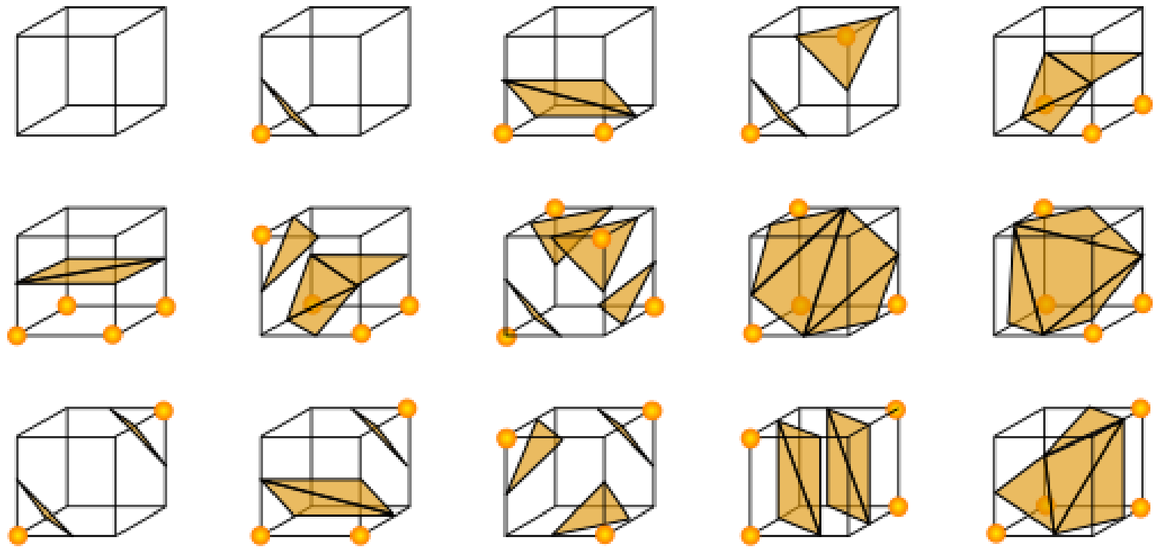


[Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

Marching cubes [1987]



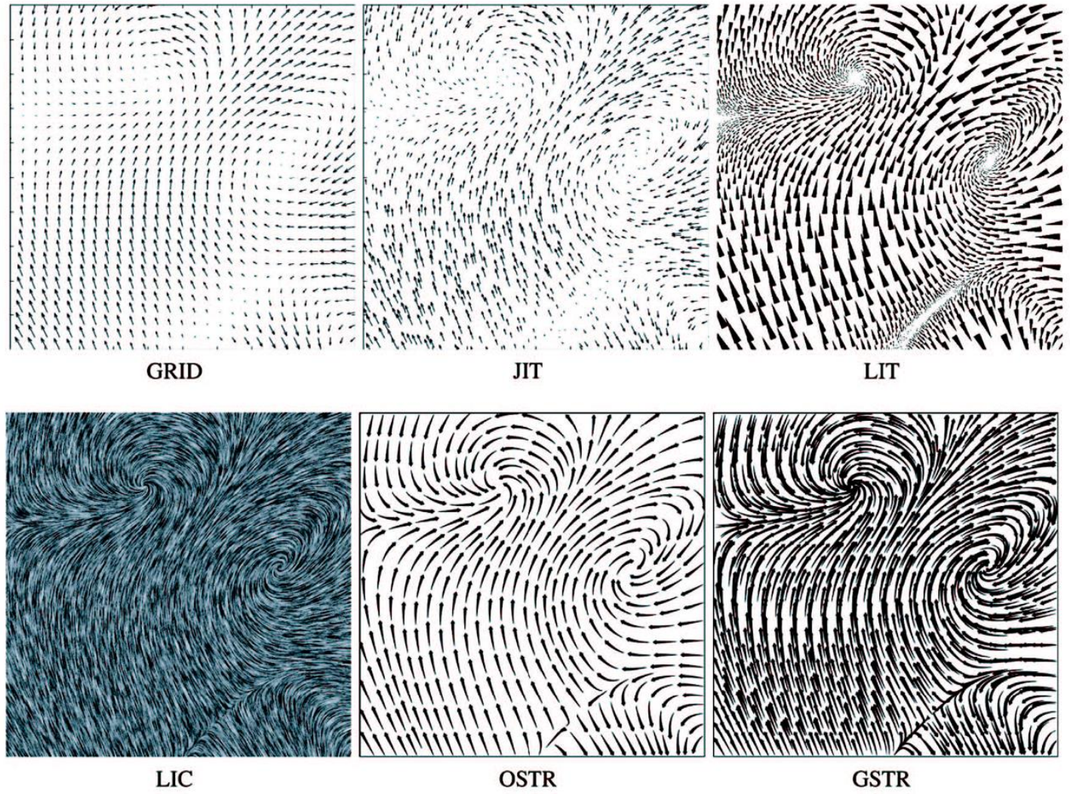
2D



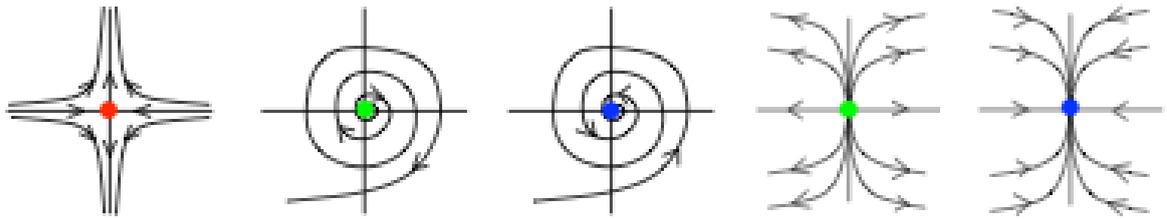
3D

Vector and tensor fields

- data
  - many attribs per cell
- idiom families
  - flow glyphs
    - purely local
  - geometric flow
    - derived data from tracing particle trajectories
    - sparse set of seed points
  - texture flow
    - derived data, dense seeds
  - feature flow
    - global computation to detect features



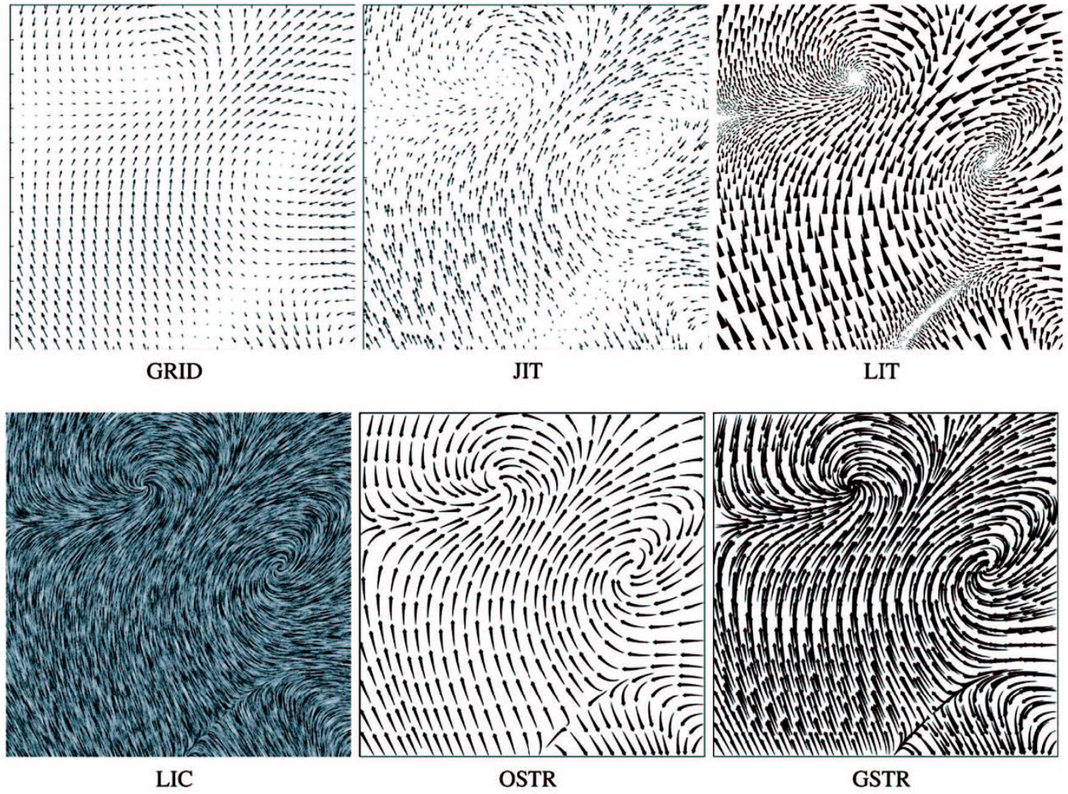
[Comparing 2D vector field visualization methods: A user study. Laidlaw et al. IEEE Trans. Visualization and Computer Graphics (TVCG) 11:1 (2005), 59–70.]



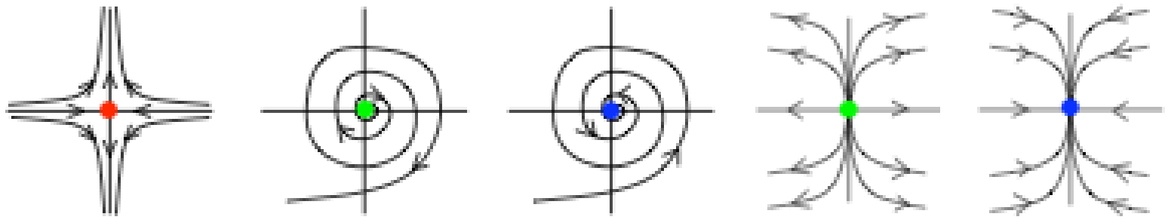
[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

Vector fields

- empirical study tasks
  - finding critical points, identifying their types
  - identifying what type of critical point is at a specific location
  - predicting where a particle starting at a specified point will end up (advection)

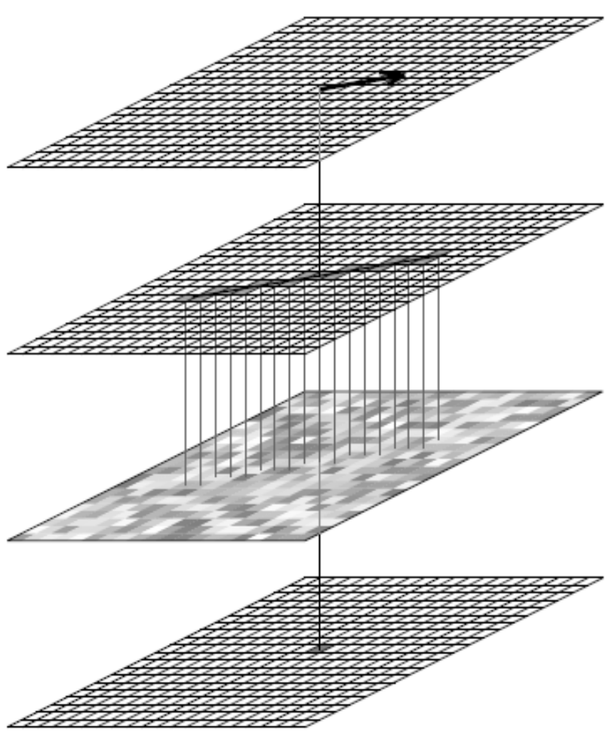


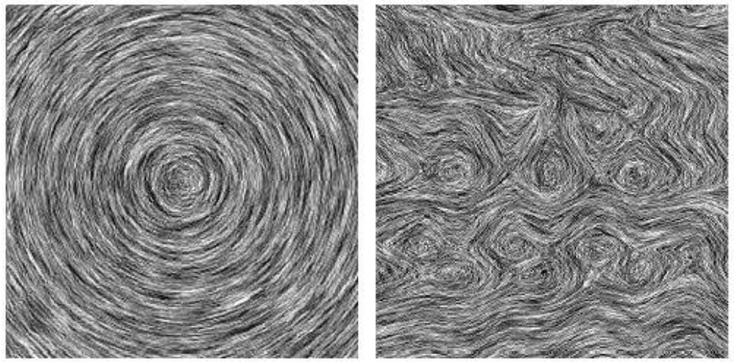
[Comparing 2D vector field visualization methods: A user study. Laidlaw et al. IEEE Trans. Visualization and Computer Graphics (TVCG) 11:1 (2005), 59–70.]



[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

Imaging Vector Fields Using Line Integral Convolution





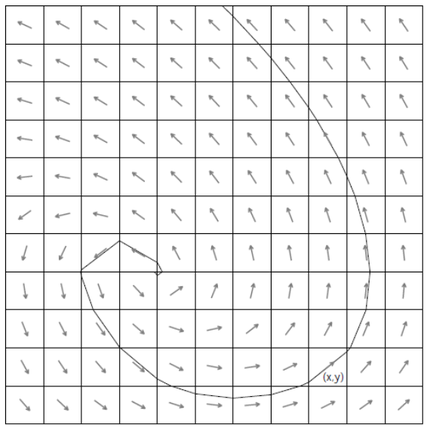
$$P_0 = (x + 0.5, y + 0.5)$$

$$P_i = P_{i-1} + \frac{V(\lfloor P_{i-1} \rfloor)}{\| V(\lfloor P_{i-1} \rfloor) \|} \Delta s_{i-1} \qquad (1)$$

$V(\lfloor P \rfloor)$ = the vector from the input vector field at lattice point $(\lfloor P_x \rfloor, \lfloor P_y \rfloor)$

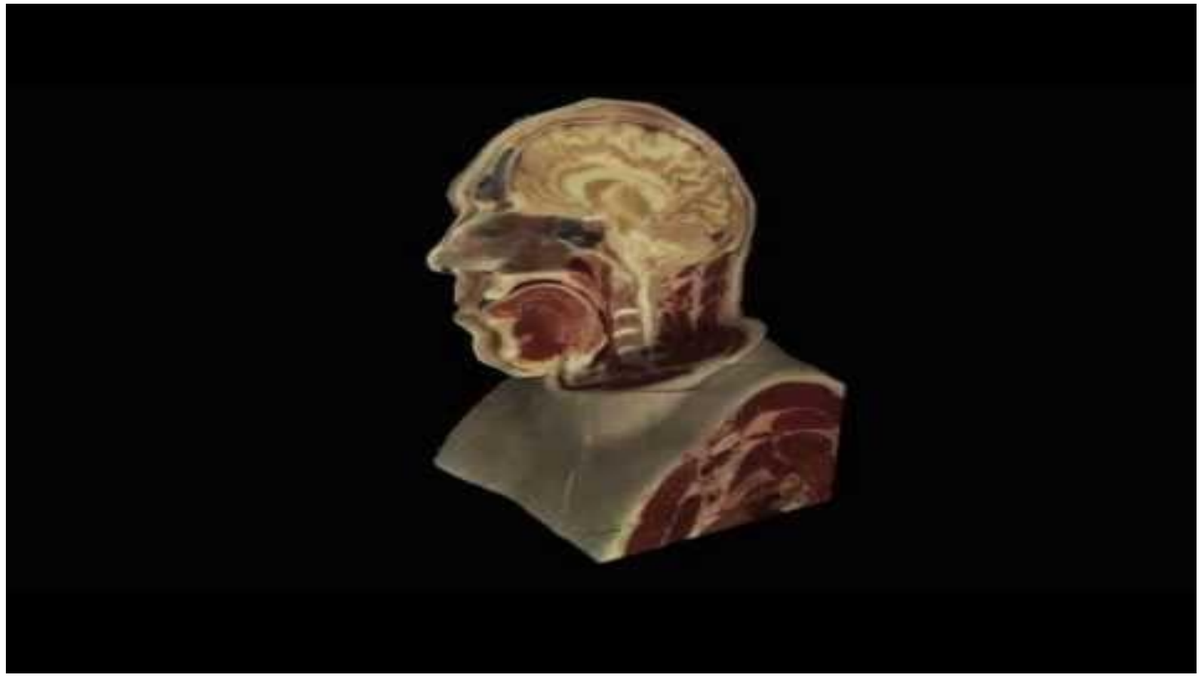
$$s_e = \begin{cases} \infty \text{ if } V \| e \\ 0 \text{ if } \dfrac{\lfloor P_c \rfloor - P_c}{V_c} < 0 \\ \dfrac{\lfloor P_c \rfloor - P_c}{V_c} \text{ otherwise} \end{cases} \quad \text{for } (e, c) \in \begin{Bmatrix} (top, y) \\ (bottom, y) \\ (left, x) \\ (right, x) \end{Bmatrix} \qquad (2)$$

$$\Delta s_i = \min (s_{top}, s_{bottom}, s_{left}, s_{right})$$



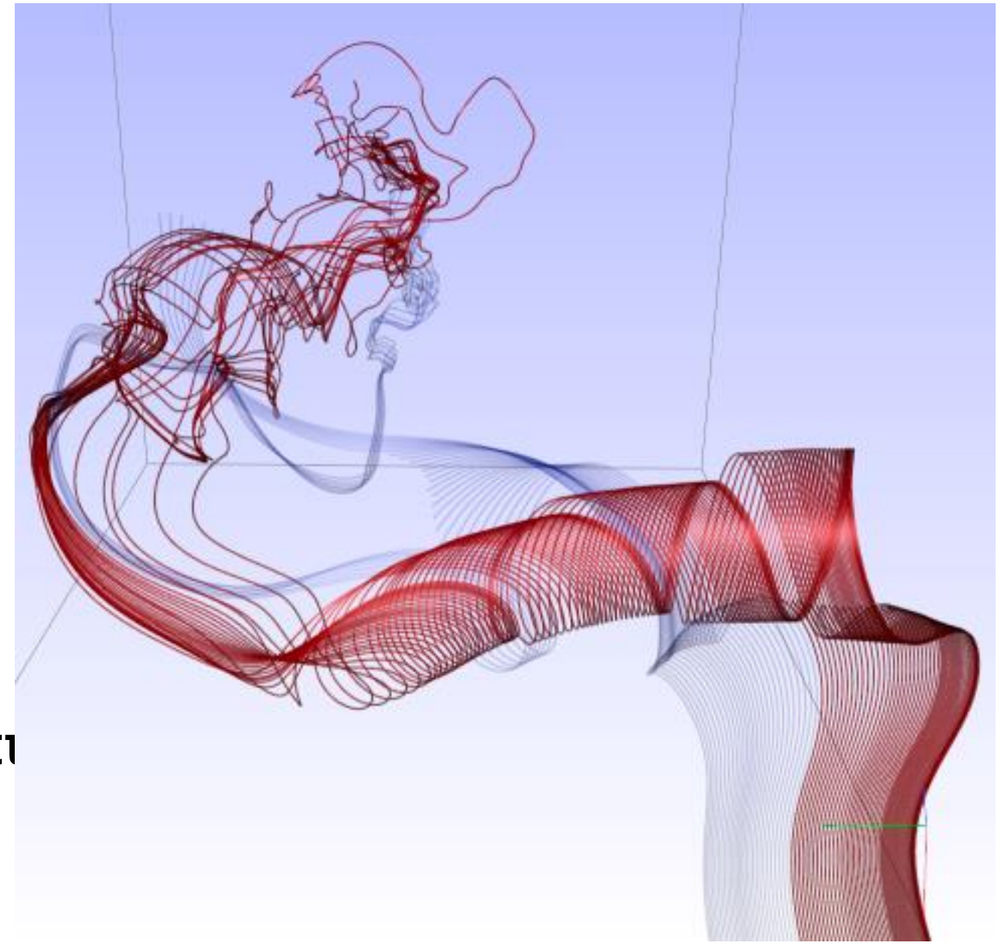
Visible Human Project

- Planning began in 1986 the data set of the male was completed in November 1994 and the one of the female in November 1995
- Each of the resulting 1,871 "slices" was photographed in both analog and digital, yielding 15 gigabytes of data



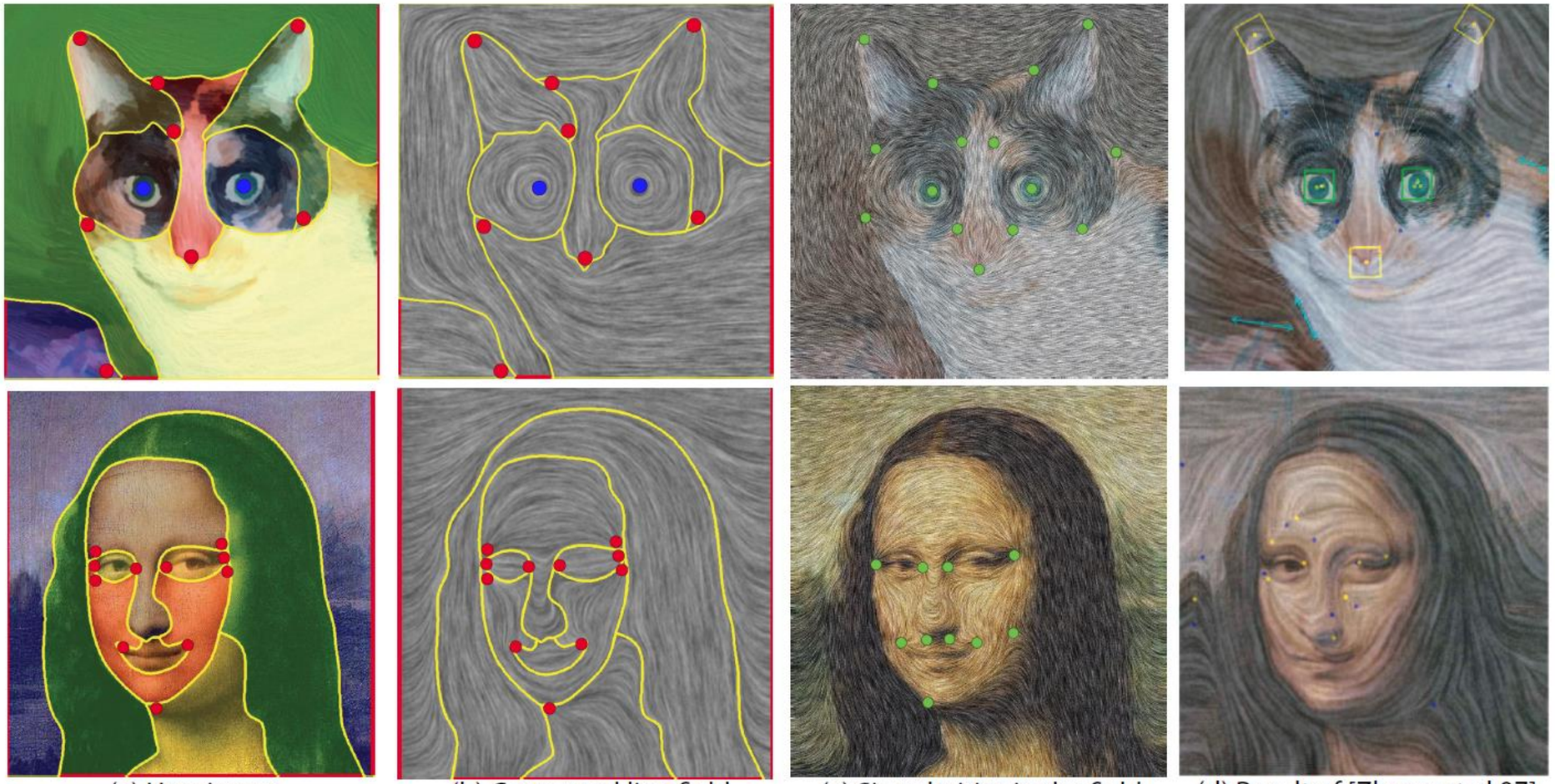
Idiom: **similarity-clustered streamlines**

- data
  - 3D vector field
- derived data (from field)
  - streamlines: trajectory particle will follow
- derived data (per streamline)
  - curvature, torsion, tortuosity
  - signature: complex weighted combination
  - compute cluster hierarchy across all signatu
  - encode: color and opacity by cluster
- tasks
  - find features, query shape
- scalability
  - millions of samples, hundreds of streamlines



[Similarity Measures for Enhancing Interactive Streamline Seeding. McLoughlin,. Jones, Laramee, Malki, Masters, and. Hansen. IEEE Trans. Visualization and Computer Graphics 19:8 (2013), 1342–1353.]

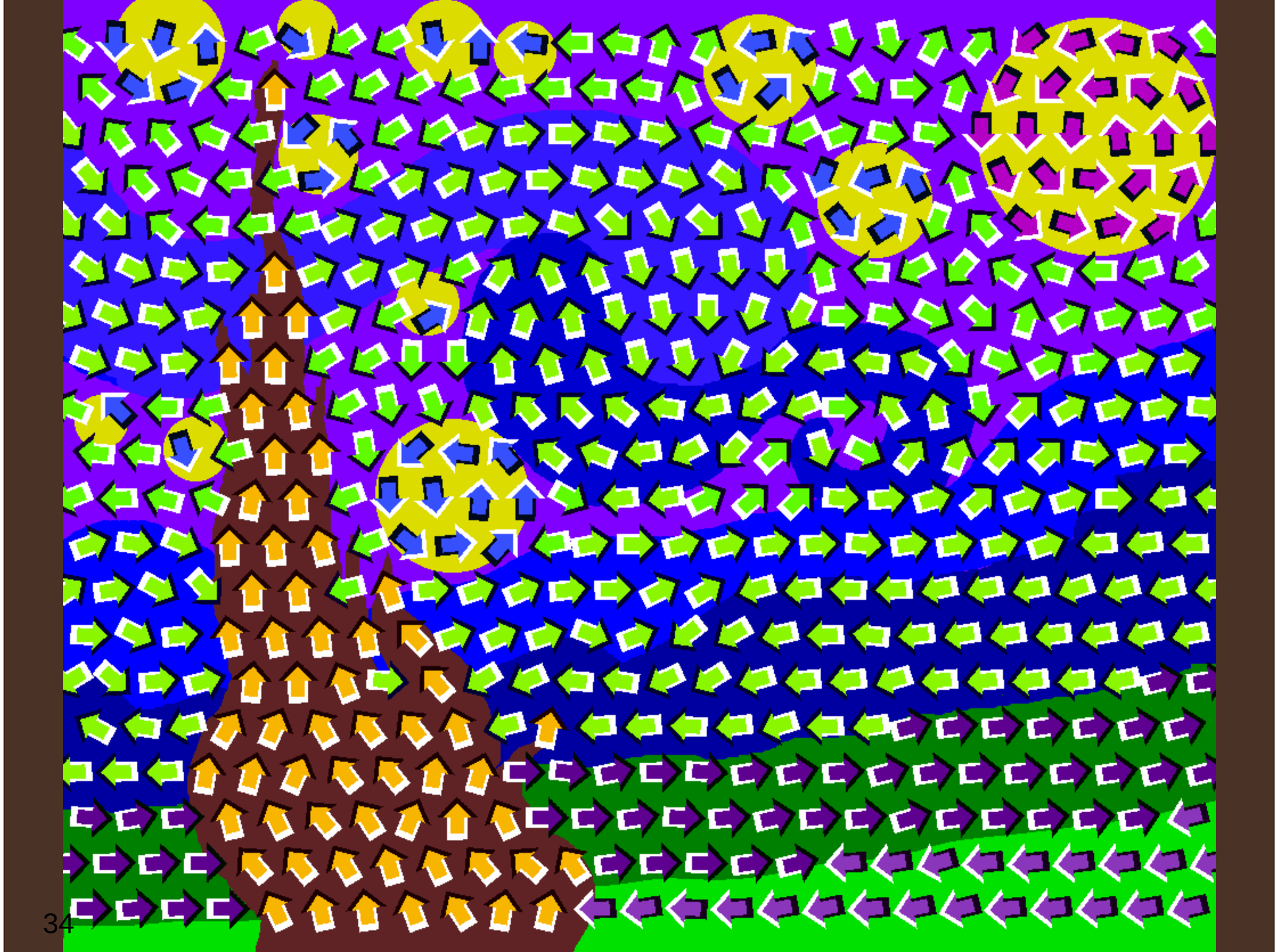
Region-based Line Field Design Using Harmonic Functions

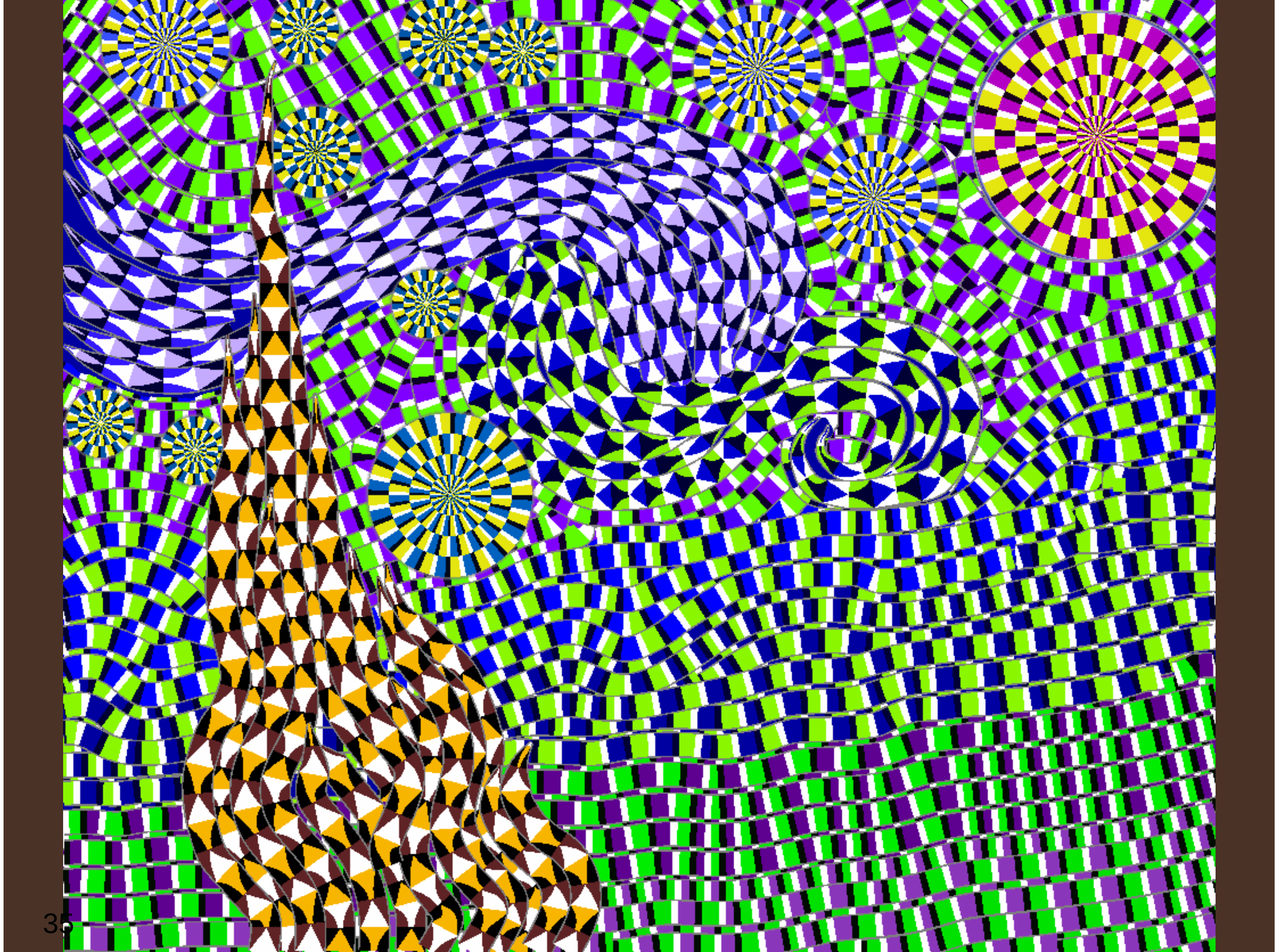


(a) User input (b) Computed line field (c) Singularities in the field (d) Result of [Zhang et al 07]

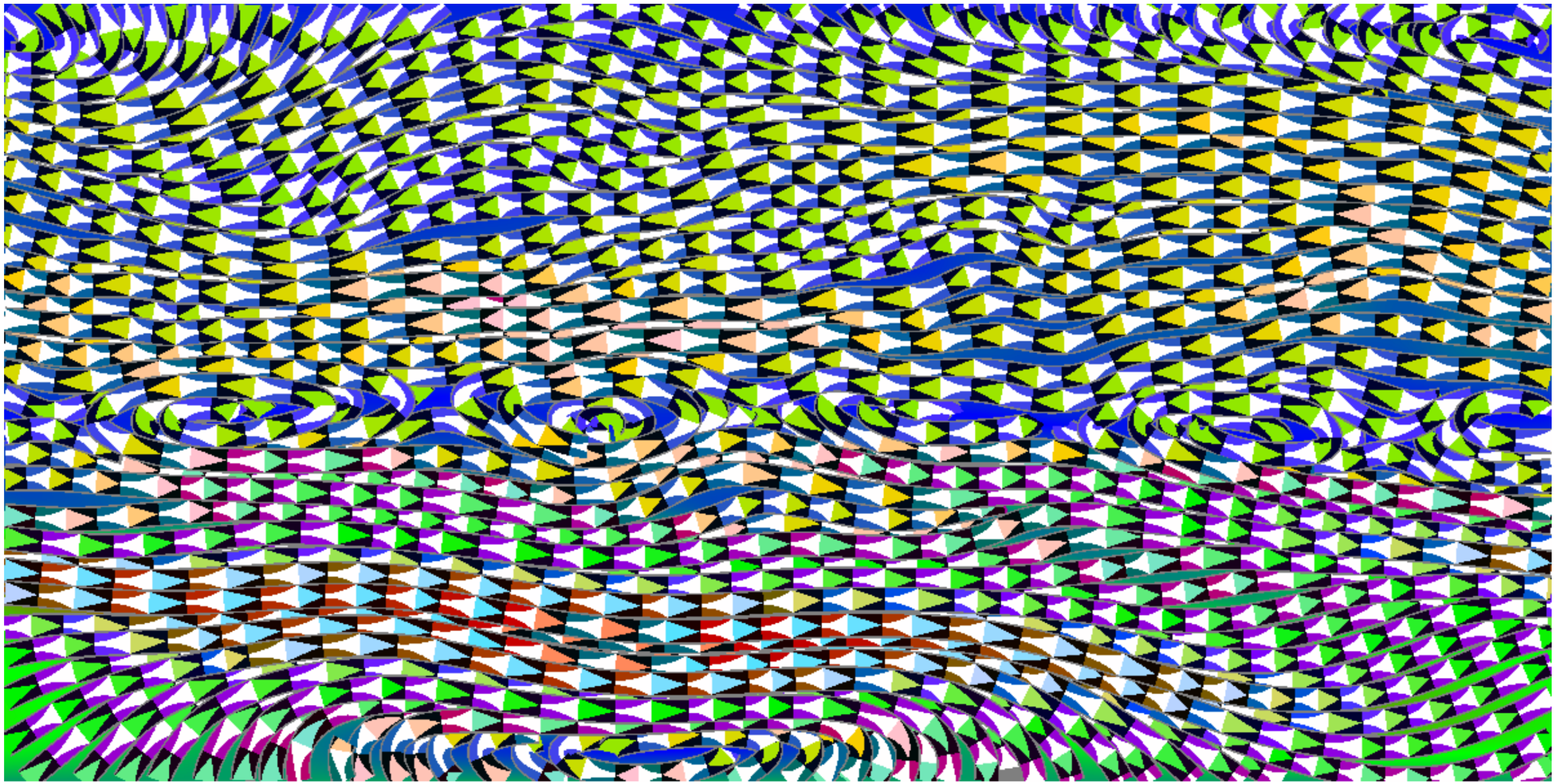
Starry Night with Motion Illusion

Region Map





More RAP Shapes



Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - *Chap 8: Arrange Spatial Data*
- How Maps Work: Representation, Visualization, and Design. MacEachren. Guilford Press, 1995.
- Overview of visualization. Schroeder and. Martin. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 3–39. Elsevier, 2005.
- Real-Time Volume Graphics. Engel, Hadwiger, Kniss, Reza-Salama, and Weiskopf. AK Peters, 2006.
- Overview of flow visualization. Weiskopf and Erlebacher. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 261–278. Elsevier, 2005.