MONASH University

MONASH
INFORMATION
TECHNOLOGY

FIT3179 Data Visualisation

Week 07: Macro and Micro Reading, Geographic Visualisation

GROUP OF EIGHT AUSTRALIA

Quiz 5 postponed to next week!

Last presentations this week!

MONASH University

Macro and micro reading

MONASH University

- Graphics should be readable in whole images and in parts
- *Macro reading* of the visualisation.
  - This is usually the **simplest and broadest reading** and often the one the designer has intended.
- *Micro readings* of the visualisation.
  - This is the **details** or subtle story and is often personal and unique to each viewer.
- Tufte:
  - “to clarify, add detail”: provide broad overview and include detail
  - "Such [micro/macro] designs can report immense detail, organizing complexity through multiple and (often) hierarchical layers of contextual reading"

Macro and Micro Readings

MONASH University

The question we have asked each time when designing our visualisations is “what do we want to say?”

- That broad question enables us to come up with *a macro reading*... the main point of the visualisation
- It is the general idea we get from viewing a visualisation

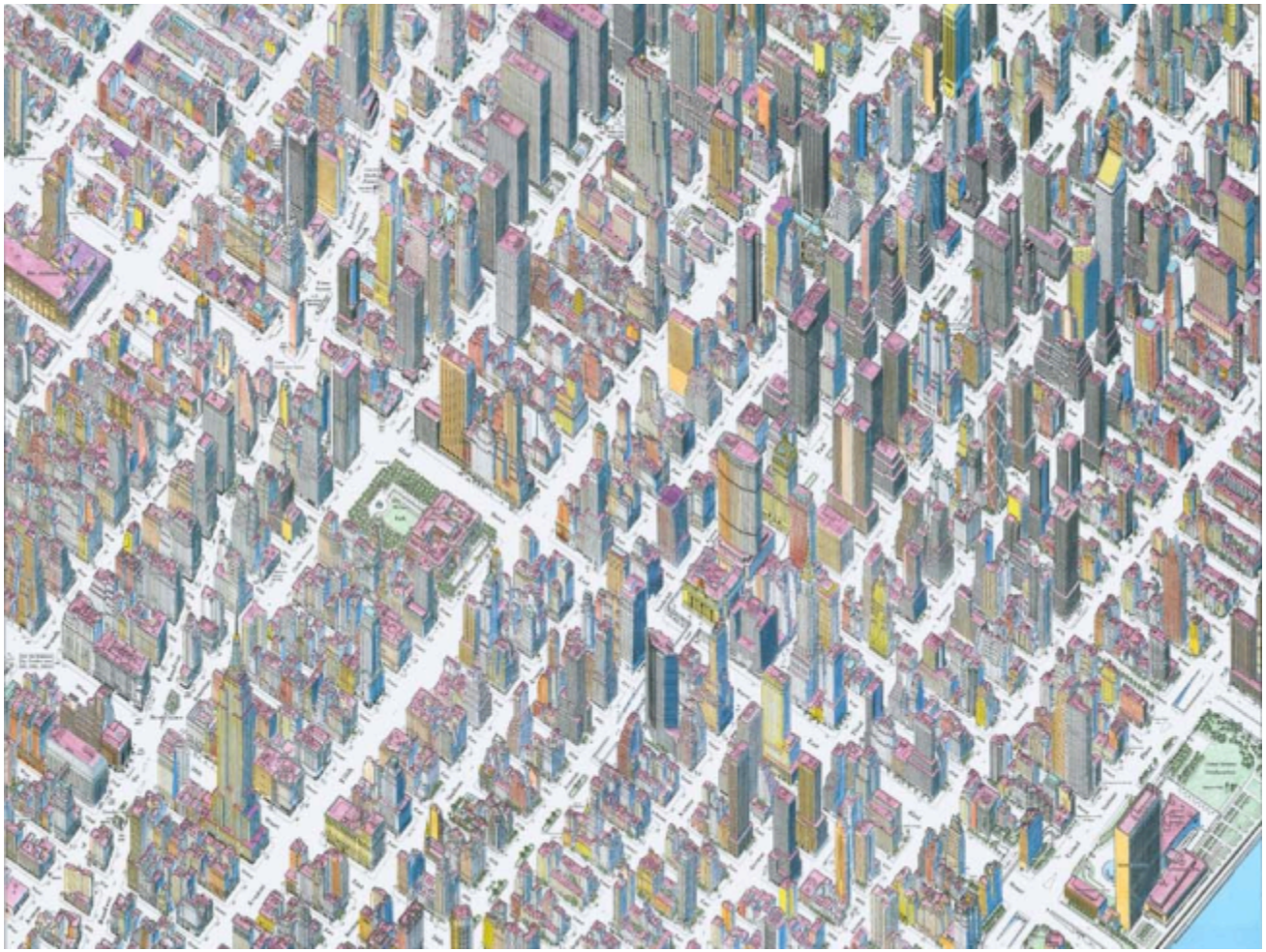
Micro readings are the details we can determine from the visualisation

- “Individual stories” about the data and information being presented
- Finding these stories may be deliberate on the part of the designer, or things that the viewer discovers

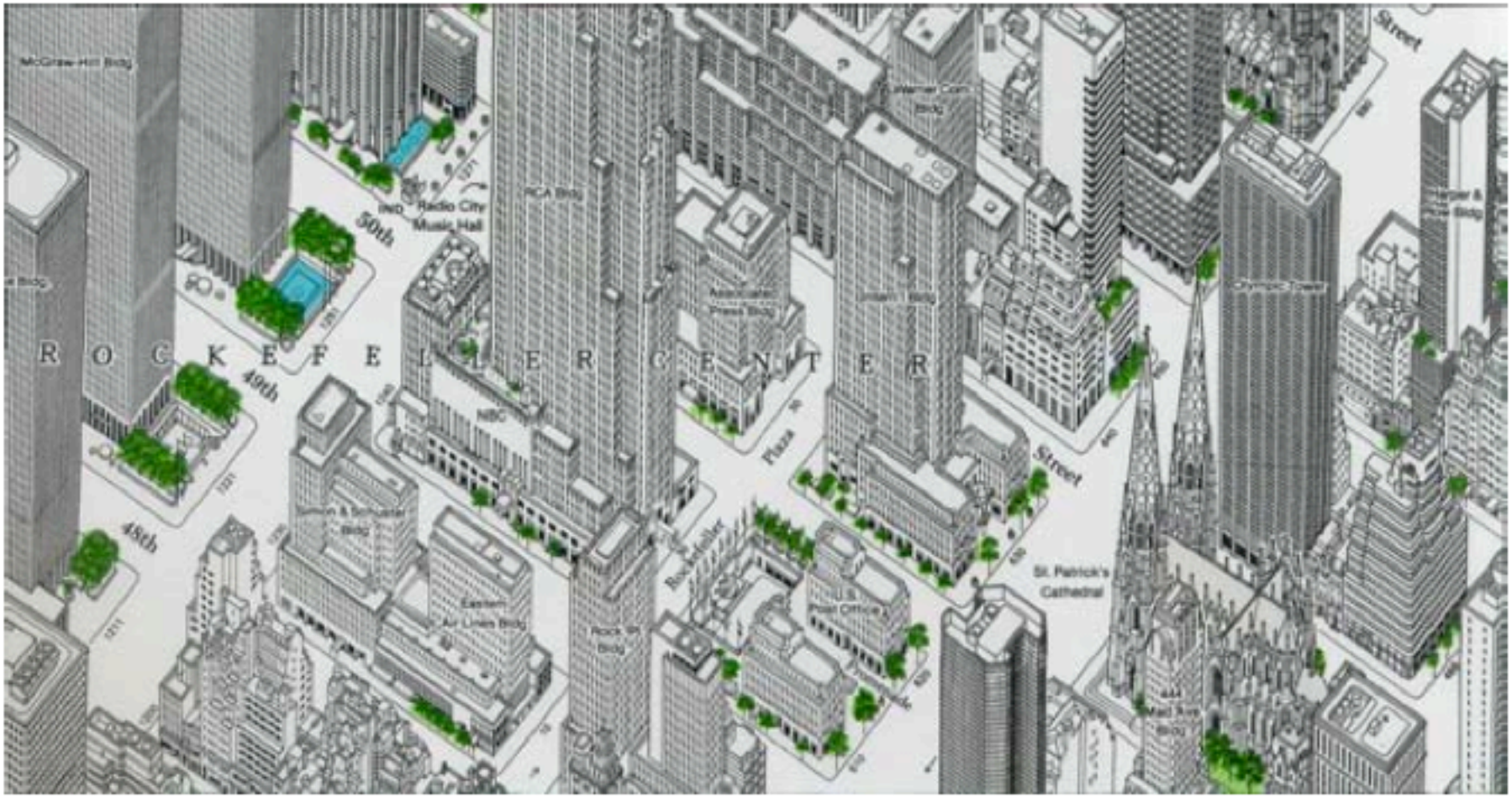
- Let’s take an example...

Constantine Anderson's NYC Map

MONASH University



Constantine Anderson's NYC Map



Macro/Micro: Constantine Anderson's NYC Map

MONASH University

This is a really famous example, one that *Tufte* discusses

- At a *macro level*, you get a sense of the whole of Manhattan
  - The scale of the buildings, the streets, the layout, and where main things are
- A *micro level* reading reveals the details...
  - A micro reading shows over 2000 pieces of text, including the names of buildings, parks, streets subway stations and the like
  - But this doesn't get in the way of a macro reading
  - The reader brings their own view to it.

Macro:

- Large landforms
- Road network
- Rivers and lake

Micro

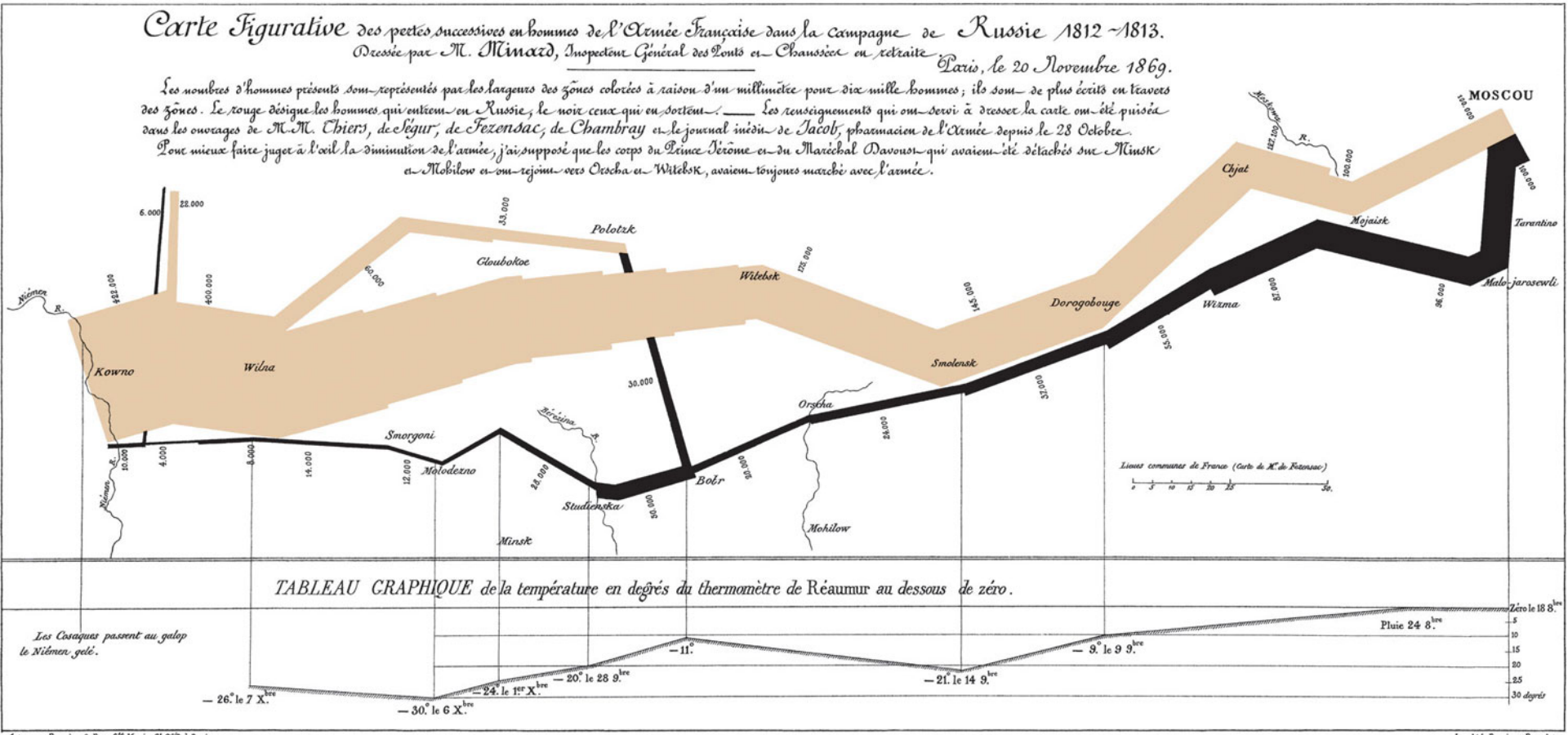
- Buildings
- Creeks
- Paths
- Orchards
- Swamps
- etc.

Macro

- Path and loss of the army
- Effect of temperature

Micro

- Fluctuation of temperature over space and time
- Place names and river names



Macro/Micro


Pont
neuf
PLACE
D'AUPHINE
Quai de l'Horloge
Quai des Orfevres
Quai de la Ferraille ou de la Megisserie
Quai des Augustins
Cour du Palais
St Michel
Cour du Palais
Carrefour des Trois Maries
Statue d'Henry
H. de Conti

Creating Macro and Micro Readings

MONASH University

Creating visualisations that work on multiple levels is not easy

- Large datasets are needed
- However always ask yourself how you can make your visualisations provide these multiple layers of meaning
  - A thoughtful consideration of different narratives means that you're thinking of different types of WHY
  - This leads to better visualisations, better knowledge and richer wisdom being generated in the users!
- Consider interactive zoomable interfaces

MONASH University

VAD chapter 8

Arrange Spatial Data

VAD: pg. 178

MONASH University

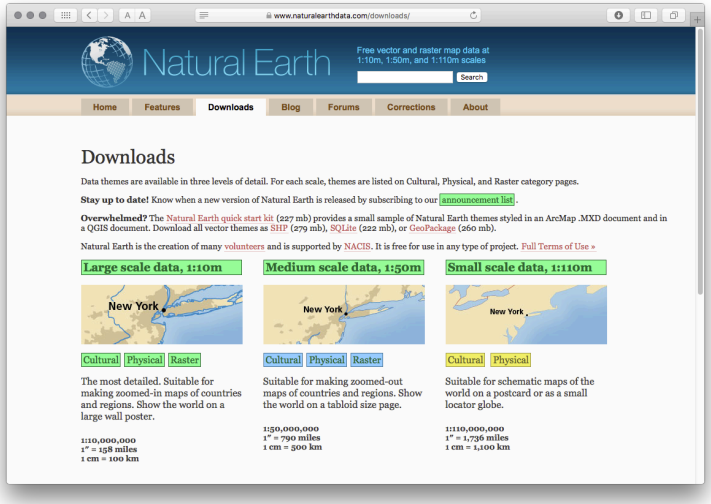
Lecture Overview

- Arrange Spatial Data
  - Map projections
  - Dot maps
  - Proportional symbol maps
  - Area cartograms
  - Flow maps
  - Bin maps
  - Isocontour
  - Colour mapping for scalar fields
  - Relief shading
  - Vector fields

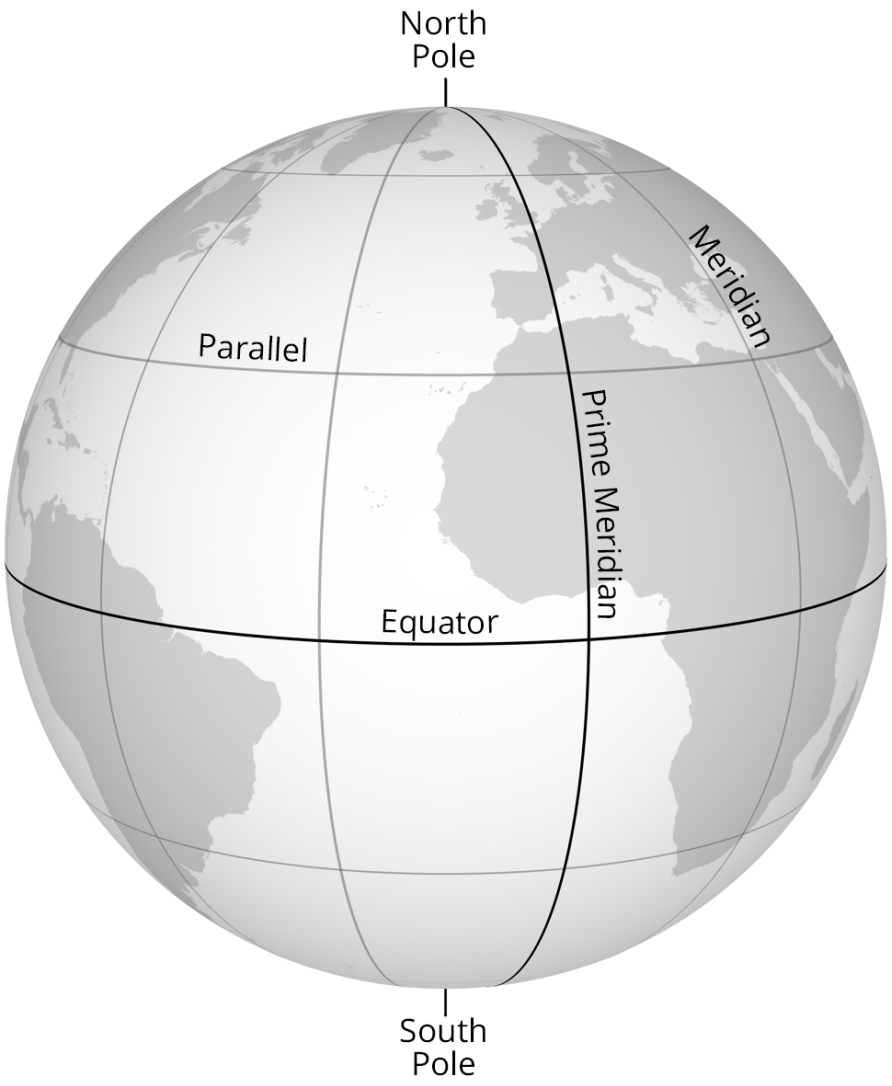
Tools and Data to Create Maps

MONASH University

- Tableau Help: https://onlinehelp.tableau.com/current/pro/desktop/en-us/maps.html
- QGIS: https://qgis.org
- ArcMap by Esri: https://en.wikipedia.org/wiki/ArcMap
- Natural Earth data: http://naturalearthdata.com

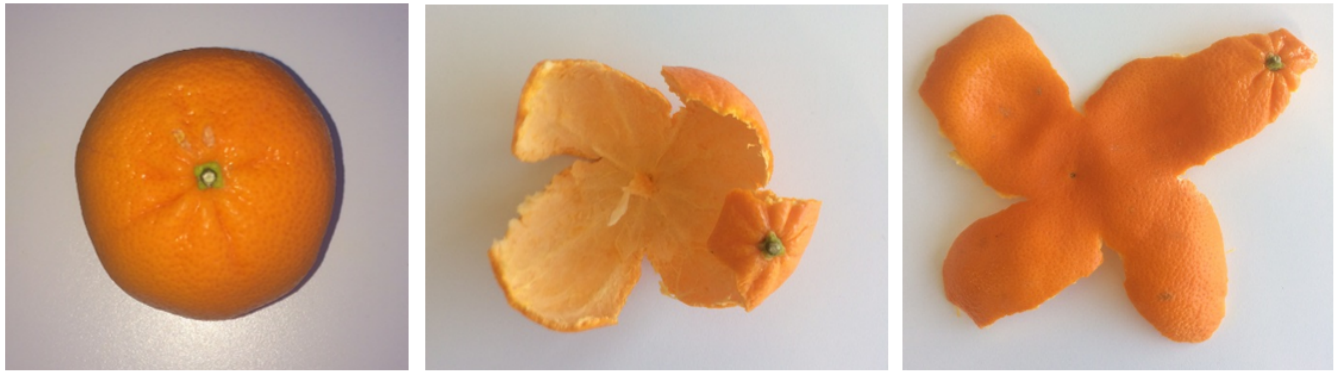


Map Projections



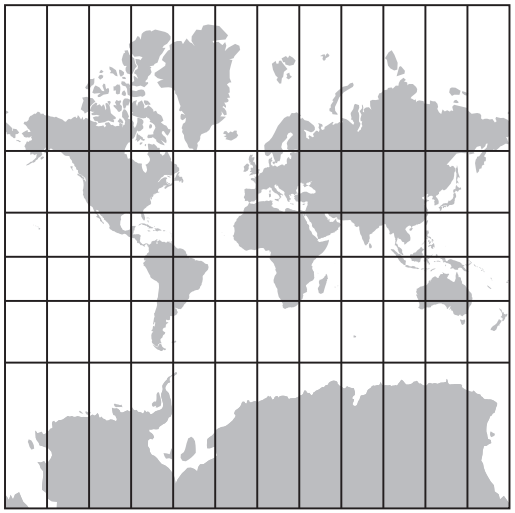
MONASH University

- Map projection is the process of transforming spherical longitude/latitude coordinates to planar x/y coordinates.
- It is a mathematical definition:
  $x = f_x(\text{lon}, \text{lat})$ and $y = f_y(\text{lon}, \text{lat})$
- Not possible without distorting the sphere.



Map Projection Distortion

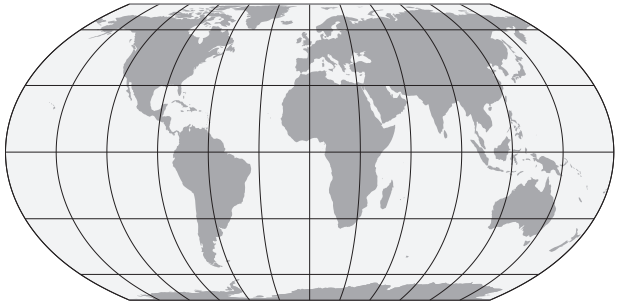
- The relative **area** of objects or **angles** are distorted.



Mercator projection

Example of an *angle-preserving (*or *conformal)* projection. Area is hugely inflated towards the poles. Not useful for showing the entire world.

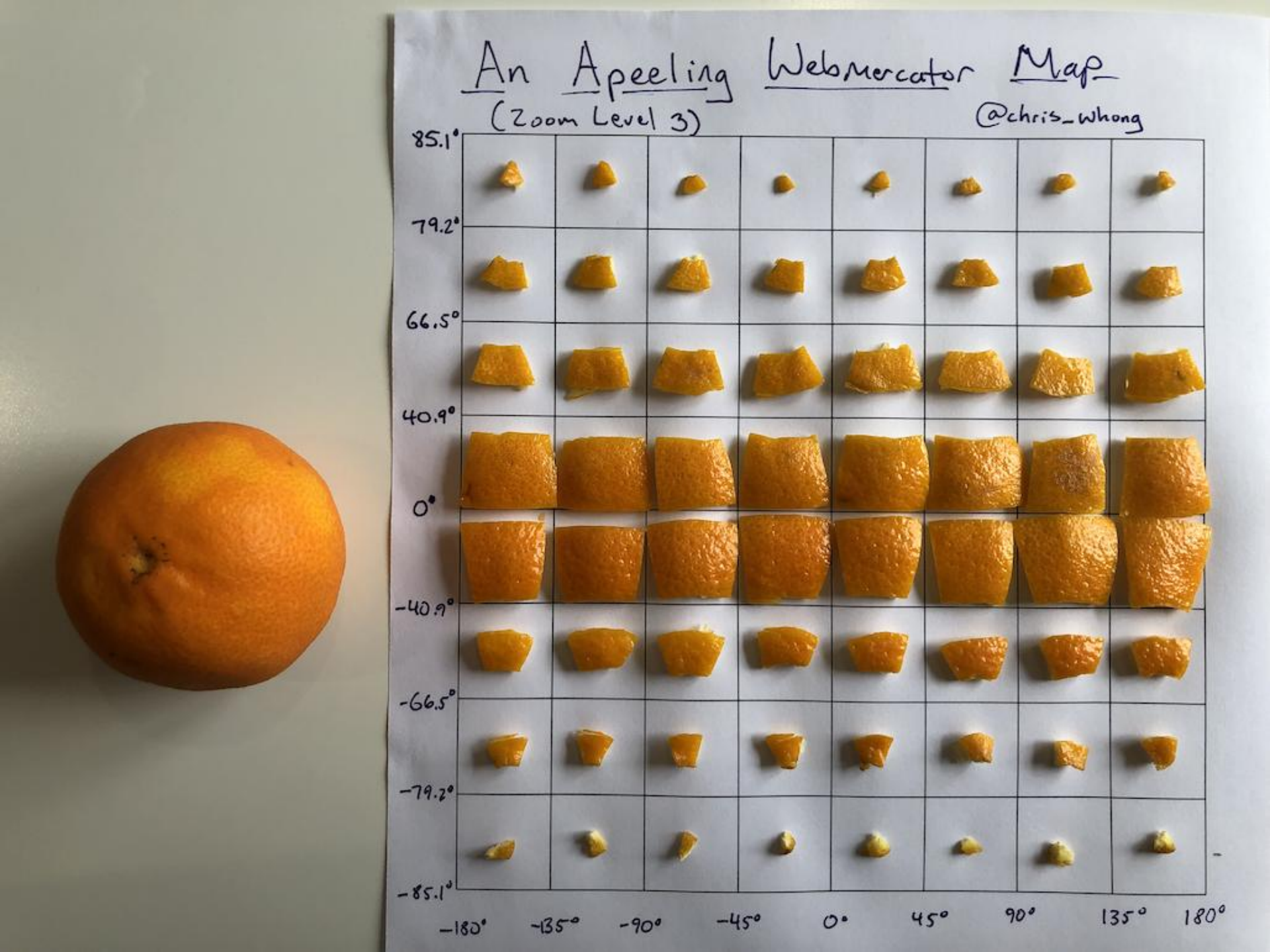
Specific to Mercator: Use for naval navigation, where bearings are measured on a *map showing a small section of the world*.



Equal Earth projection

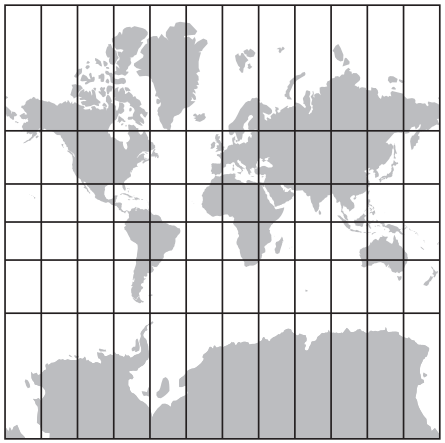
Example of an *area-preserving (*or *equal-area)* projection. Angles (and shapes) are increasingly distorted towards the border of the map. Useful when the size of areas is compared.

Specific to Equal Earth and other similar projections: Useful for showing the entire world.


An Apeeling WebMercator Map
(Zoom Level 3)
@chris_whong
85.1°
79.2°
66.5°
40.9°
0°
-40.9°
-66.5°
-79.2°
-85.1°
-180°
-135°
-90°
-45°
0°
45°
90°
135°
180°

Map Projections

- Mercator is a poor choice for world maps.
- Tableau uses Mercator as default.
- Google Maps showed Mercator until 2 August 2018 on world maps.



https://www.google.com/maps

Map Projections

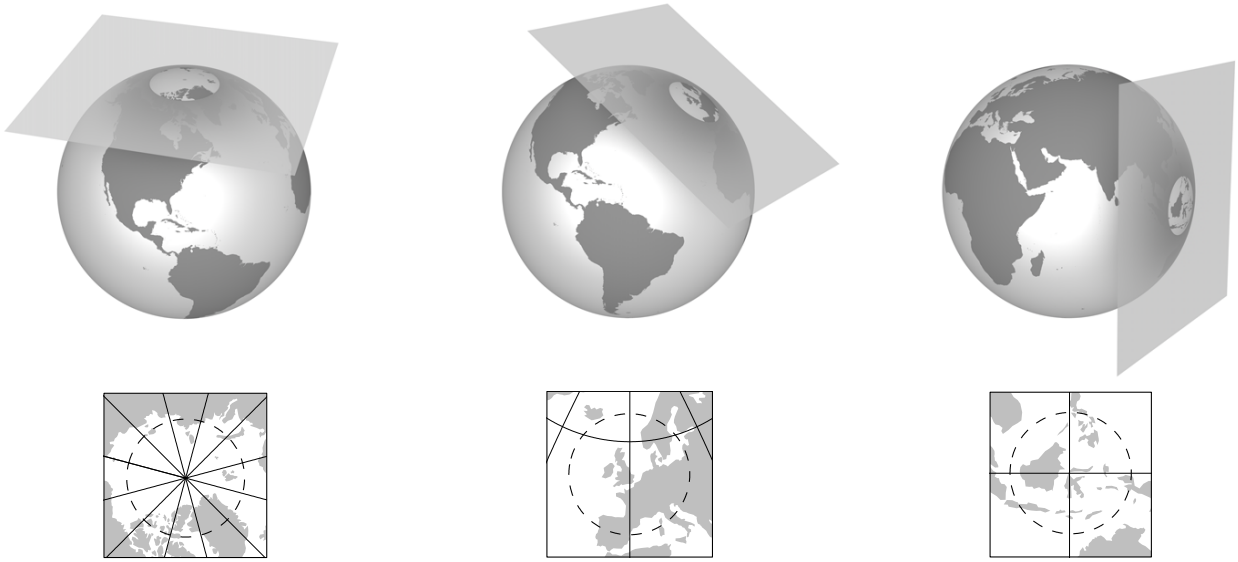
Developable surfaces

- cylinder: cylindrical projection
- cone: conic projection
- plane: azimuthal projection

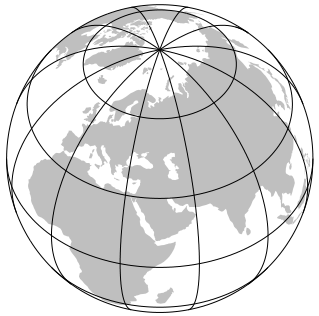
Developable surfaces are a conceptual model: project onto surface, than unwrap the surface.

Map Projections

Azimuthal projections (where the developable surface is a plane) show characteristic spider web pattern on poles. They are good for showing a square-shaped area.



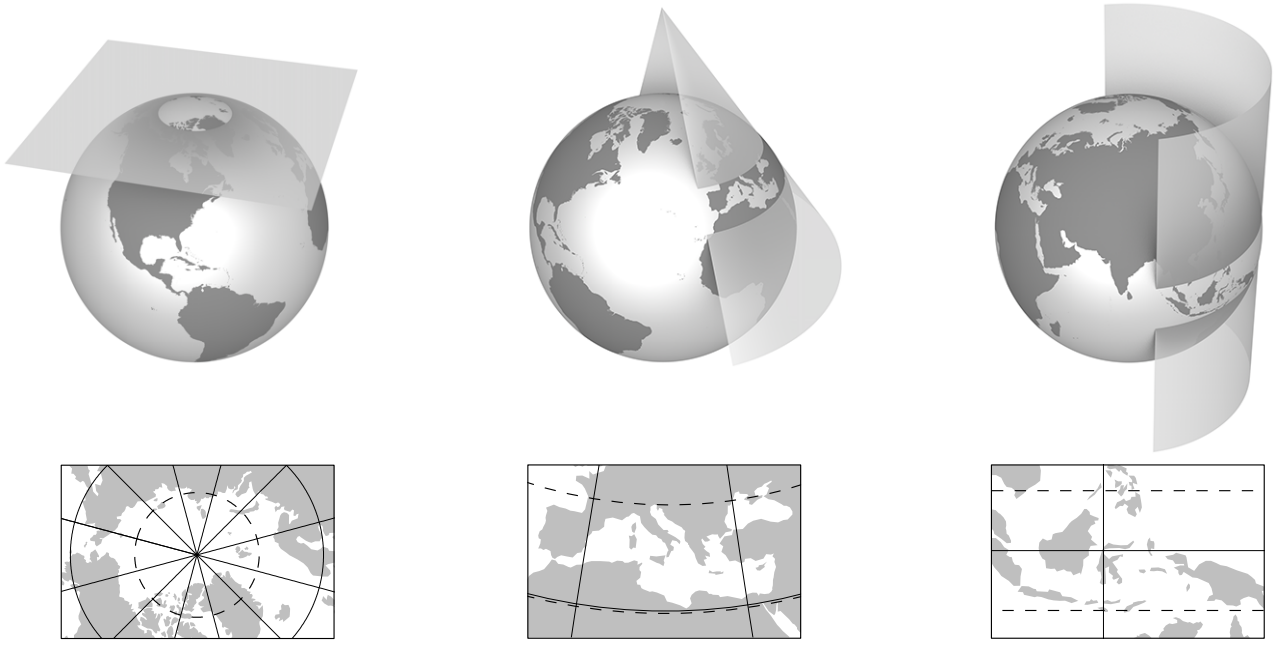
Azimuthal projections are also good to show the location of a country on a hemisphere map.



Map Projections

When maps use a landscape format, select a projection where the projective surface is close to the sphere. This minimizes distortion of the map.

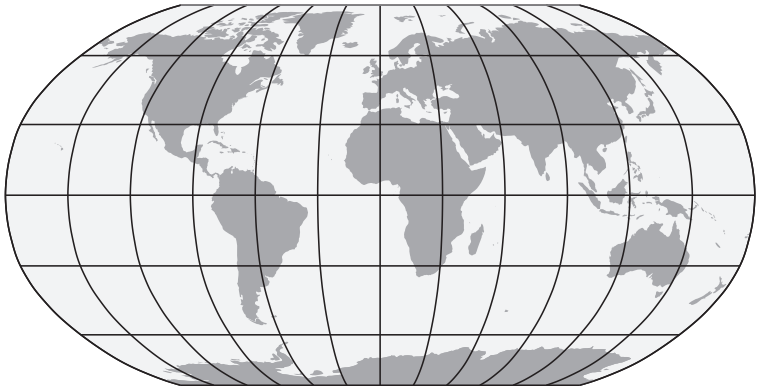
Poles: azimuthal (straight meridians and concentric parallels)
Intermediate latitudes: conic (straight meridians, curved parallels)
Equator: cylindrical (straight meridians and straight parallels)



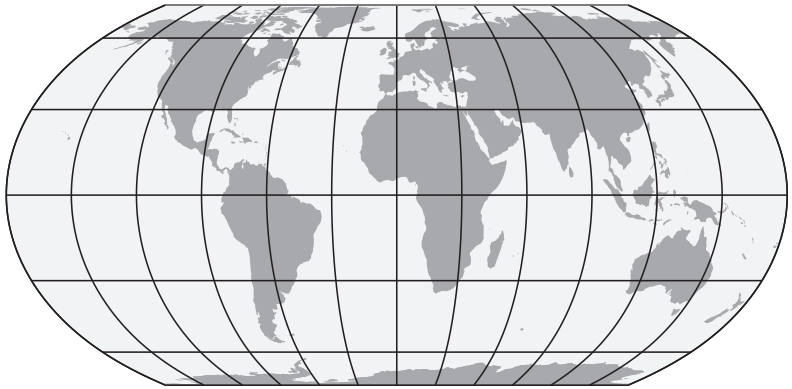
Map Projections

Maps showing the entire world are not usually using a developable surface.
World maps with straight parallels and curved meridians are called pseudocylindrical.

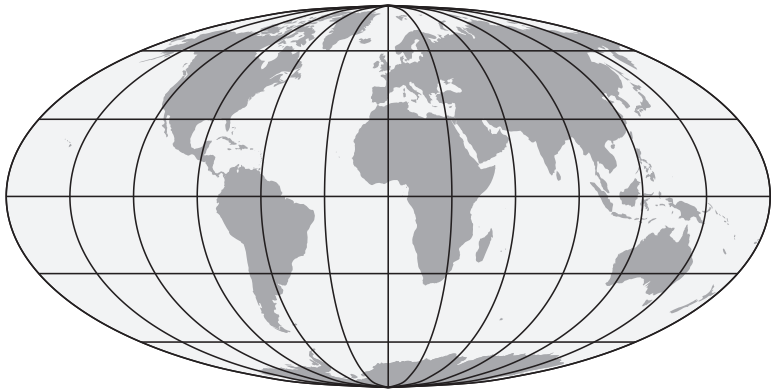
Robinson



Equal Earth



Mollweide



Map Projections

- Use Projection Wizard to select a map projection
- http://projectionwizard.org

More information
Jenny et al. (2017). A Guide to Selecting Map Projections for World and Hemisphere Maps
Šavrič et al (2016). Projection Wizard – An online map projection selection tool

Map Projections

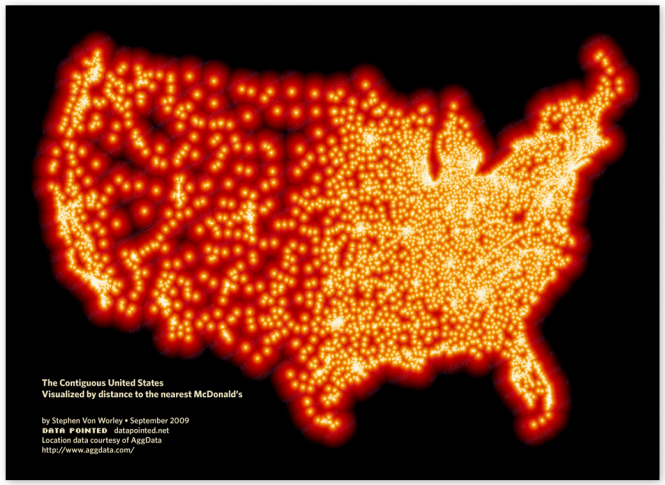
MONASH University

- To use other projections in Tableau:
  - Transform geospatial data to other projection with a Geographic Information System (GIS): QGIS (https://qgis.org/, free and open source) or ArcMap by Esri (commercial).
  - Load transformed data and trick Tableau to think the data is in Mercator coordinates.
  - For instructions, see https://community.tableau.com/people/sarah.battersby.0/blog/2017/05/12/working-with-projected-data-in-tableau-part-i-map-projection-basics and https://community.tableau.com/people/sarah.battersby.0/blog/2017/05/12/working-with-projected-data-in-tableau-part-ii-data-manipulation

Dot maps

- What?
  - Geographic points or regions with quantitative attribute per region
- Why?
  - Task: show spatial distribution, density.
- How?
  - Marks: points
    one point represents n observations
  - Channel: number of points
  - Scalability: millions of points or hundreds of regions
  - Requires area preserving map projection

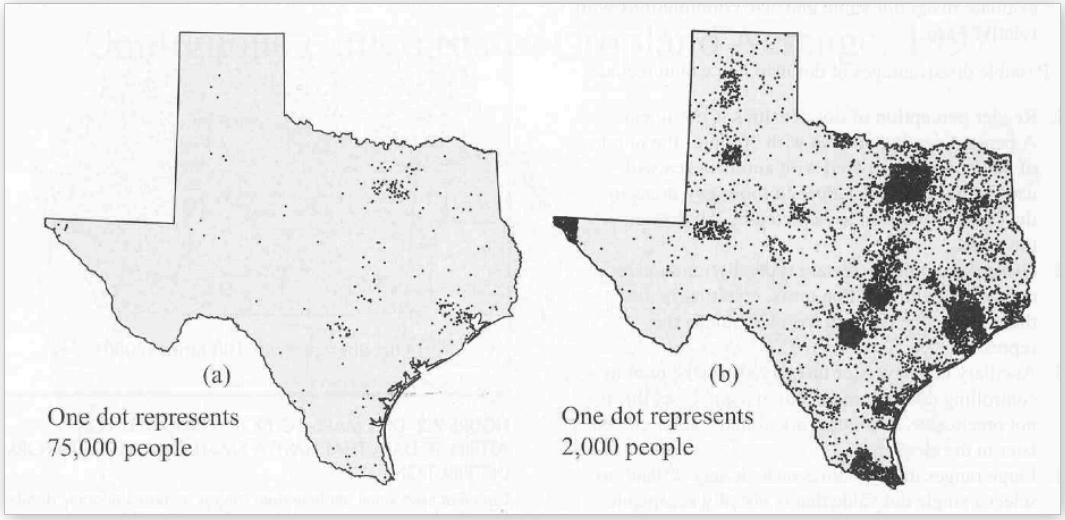
1 dot = 1 restaurant



1 dot = 1000 cows

Dot maps

- Dot maps do not work well with strongly varying density
  - in map (a) dots are too sparse; no pattern in large areas of the map
  - in map (b) dots are too dense; dots form black areas

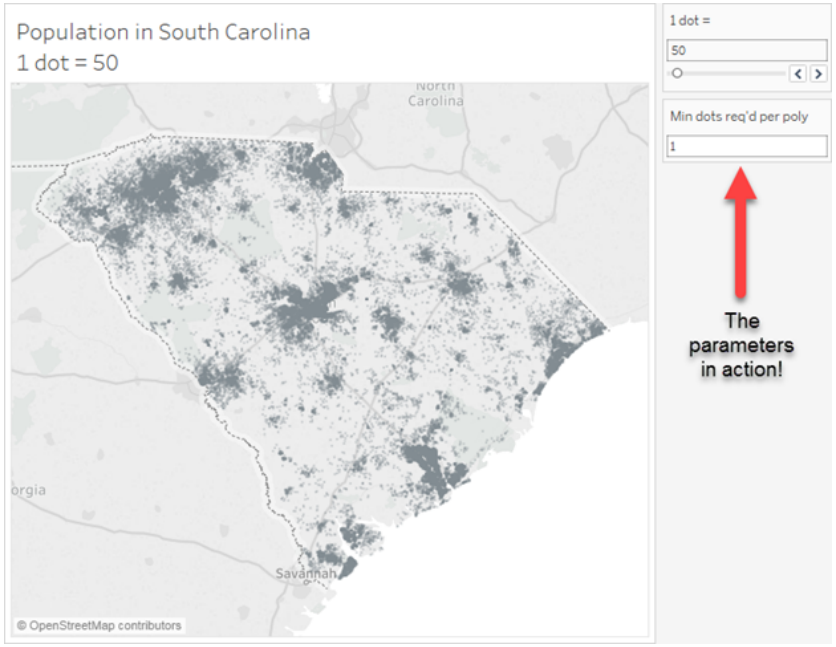


- Alternative to dot maps:
  - choropleth or bin map by counting points per area
  - convert to scalar field and use isocontours or colour mapping

Dot maps

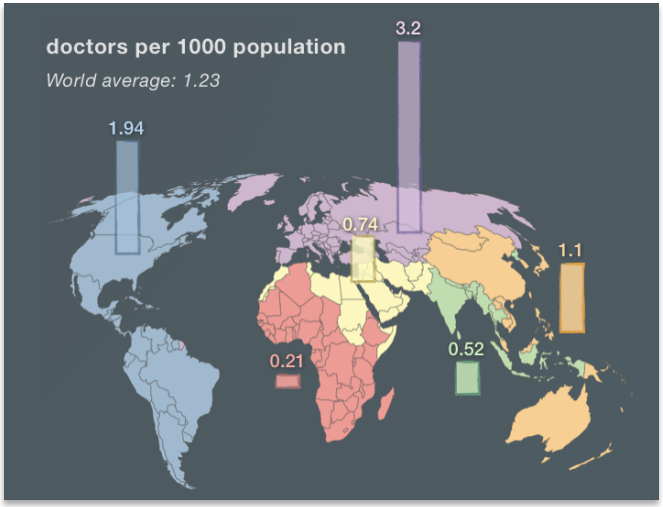
- Dot maps in Tableau:

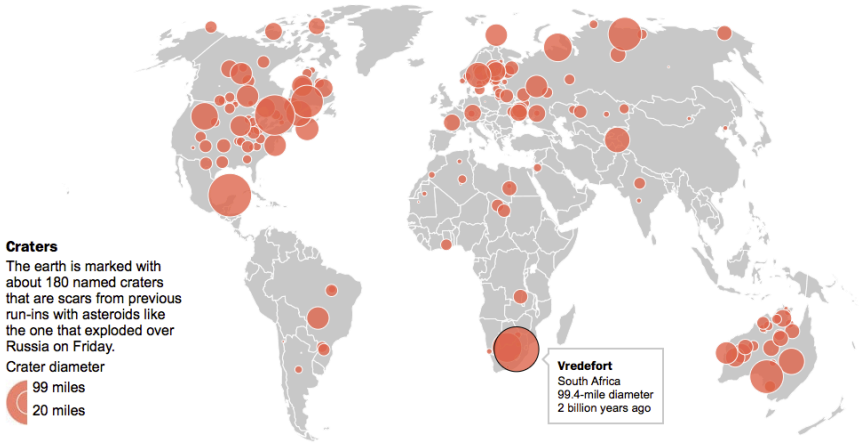
https://community.tableau.com/people/sarah.battersby.0/blog/2018/03/07/dot-density-maps-in-tableau-postgresql



Proportional Symbol Map

- What?
  - Geographic points with quantitative attribute
- Why?
  - Task: show spatial distribution.
- How?
  - Marks: lines or areas
  - Channel: size (length, area, volume) or angle (for pie charts)
  - Scalability: dozens of points

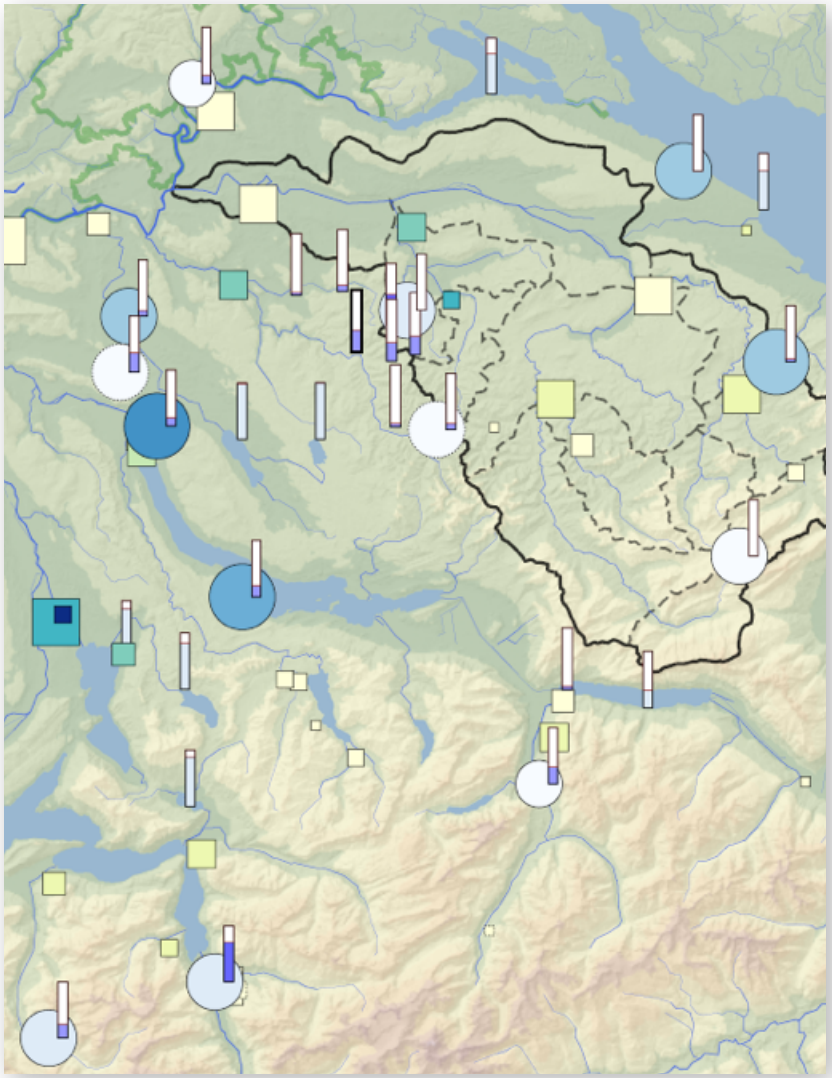




Source: The Washington Post, http://www.washingtonpost.com/wp-srv/special/world/russia-meteor/index.html

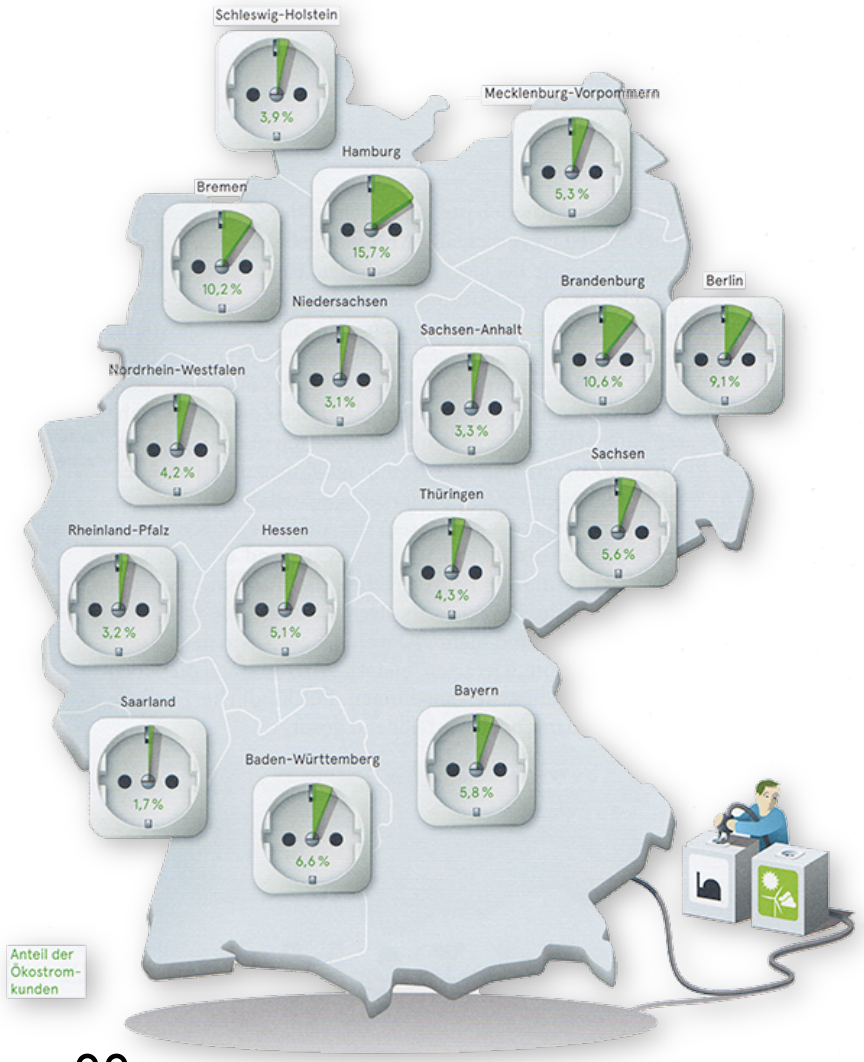
Proportional Symbol Map

- Framed bar charts
- Area-proportional circles and squares



Proportional Symbol Map

- Pie charts



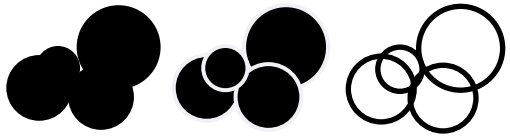
Percentage of alternative energy customers

Source: Stolz, M. & Block, J., Deutschlandkarte, 2012, Zeit Magazin

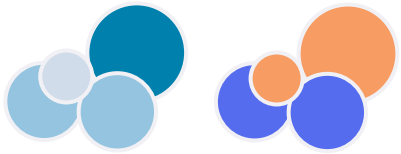
Design Principles for Proportional Symbol Maps

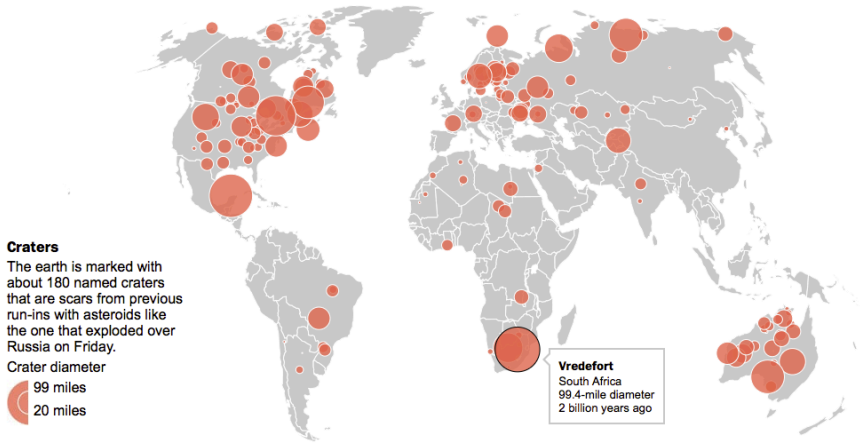
MONASH University

Reduce clutter with stroke and transparency



Can vary colour with same attribute or with a second attribute





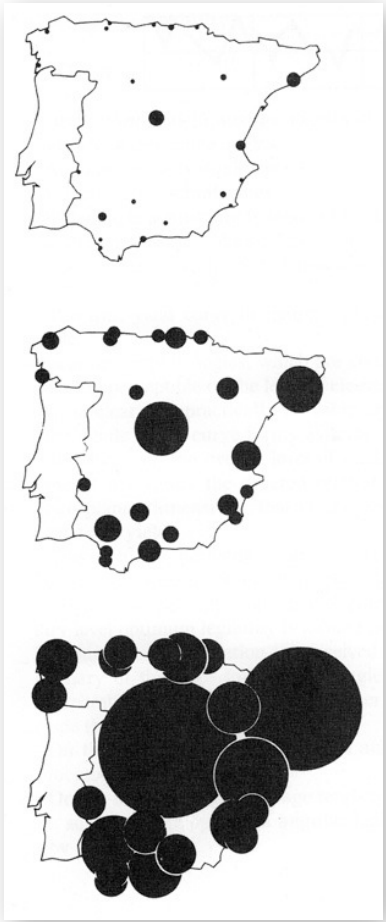
Source: The Washington Post, http://www.washingtonpost.com/wp-srv/special/world/russia-meteor/index.html

Symbol size

Too small

Good

Too large

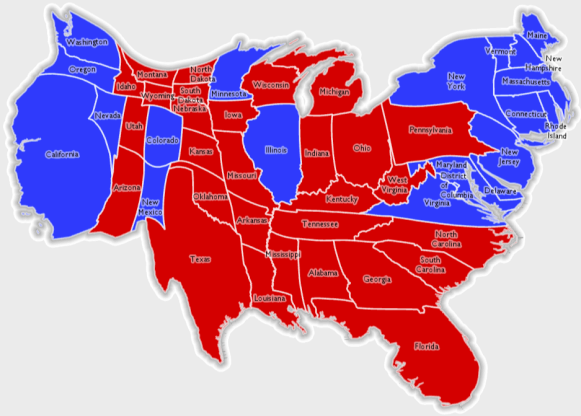


Area Cartograms

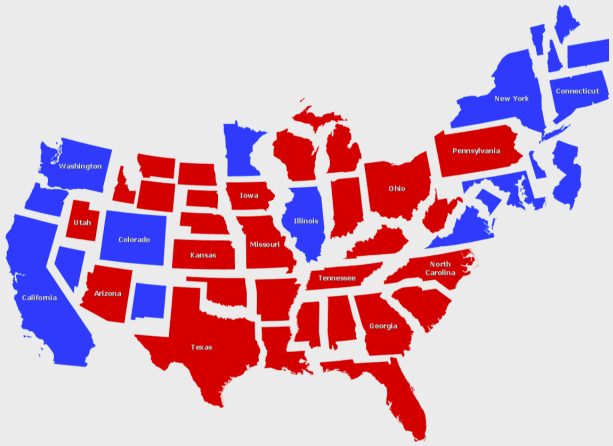
- What?
  - Areas with quantitative attribute
- Why?
  - Task: identify, compare.
- How?
  - Marks: scaled areas
  - Channel: size of areas
  - Scalability: up to a few dozens

Population

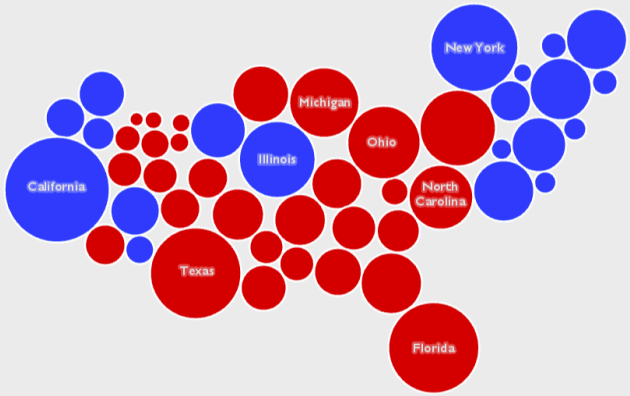
Area Cartograms



Contiguous cartogram
Examples:
https://worldmapper.org
Software:
http://scapetoad.choros.ch



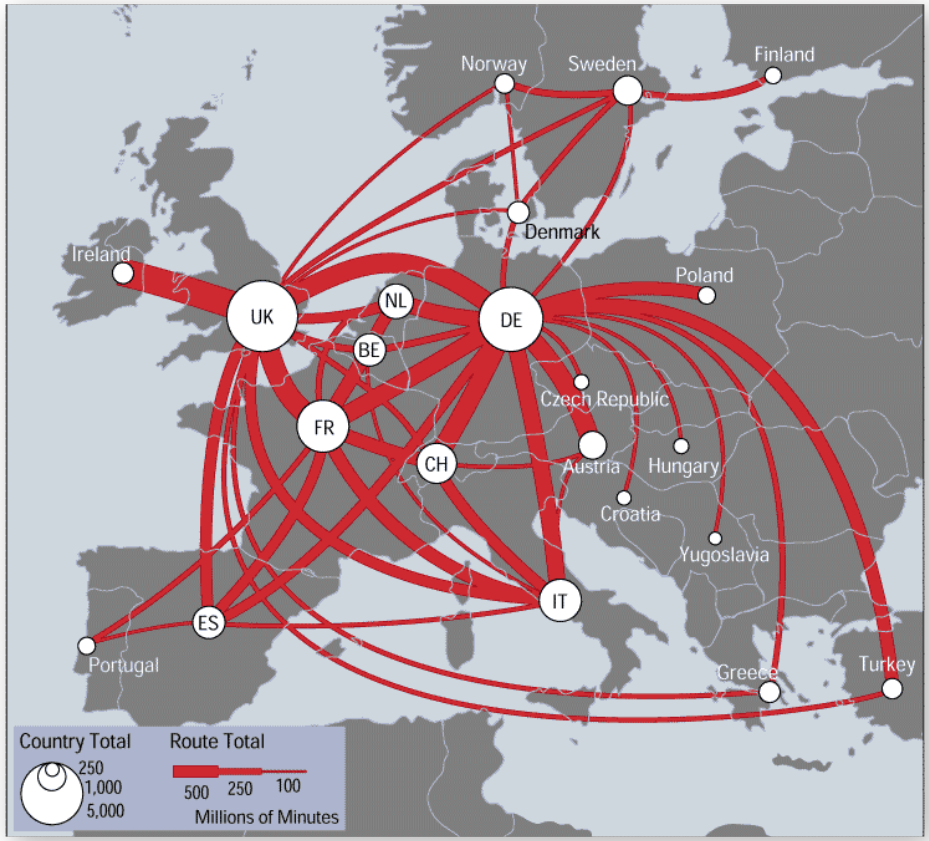
Non-contiguous cartogram



Dorling cartogram
D3 example:
http://mbostock.github.io/protovis/ex/cartogram.html

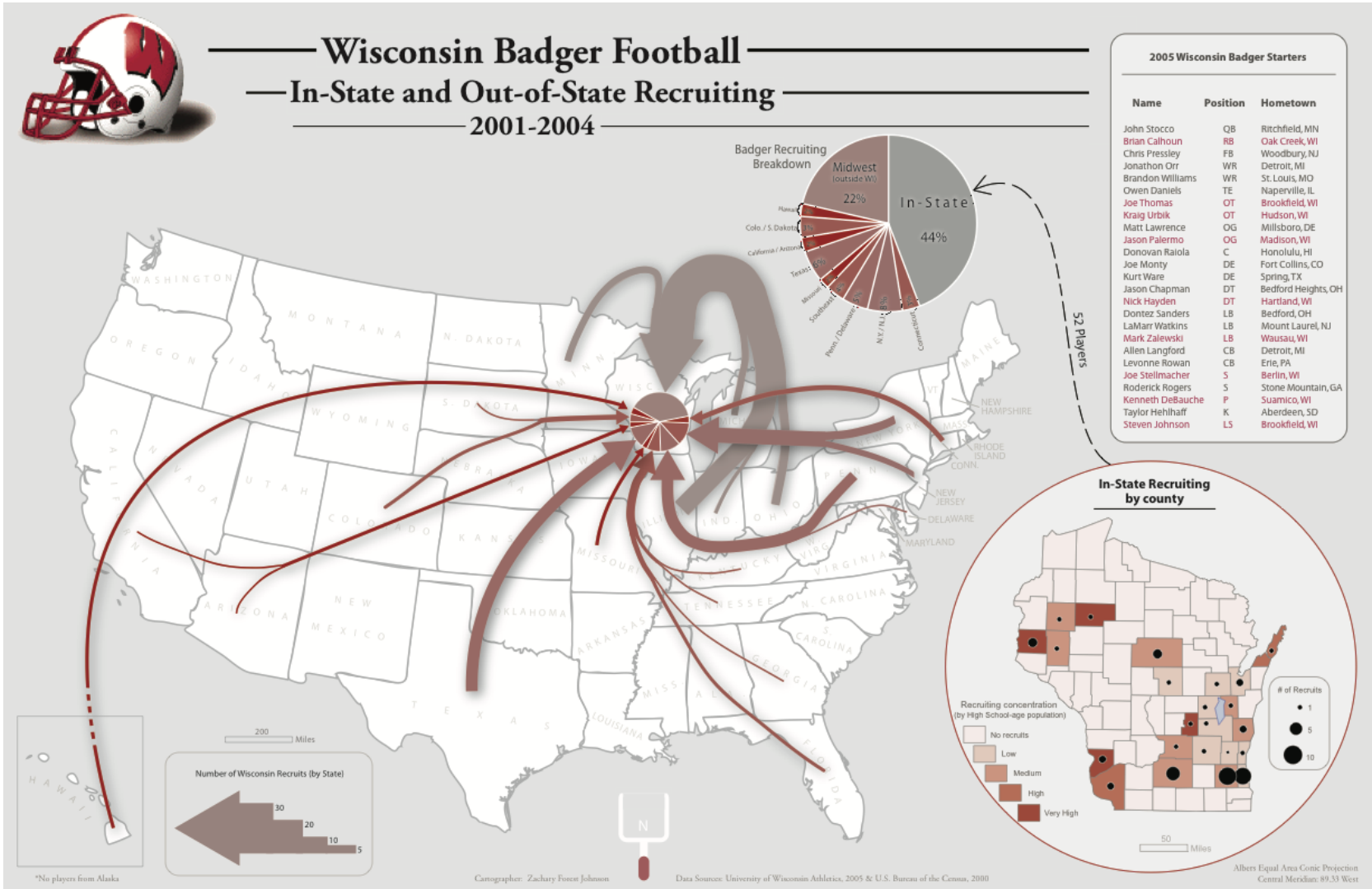
Origin-destination Flow maps

- What?
  - Geographic flow in network
- Why?
  - Show flows between origin and destination locations; geometry of flows is unknown or irrelevant. Task: discover connections.
- How?
  - Marks: straight or curved lines
  - Channel: size (width) for quantity, hue for qualitative data
  - Scalability: up to 50 or 100 flows



Telecommunication

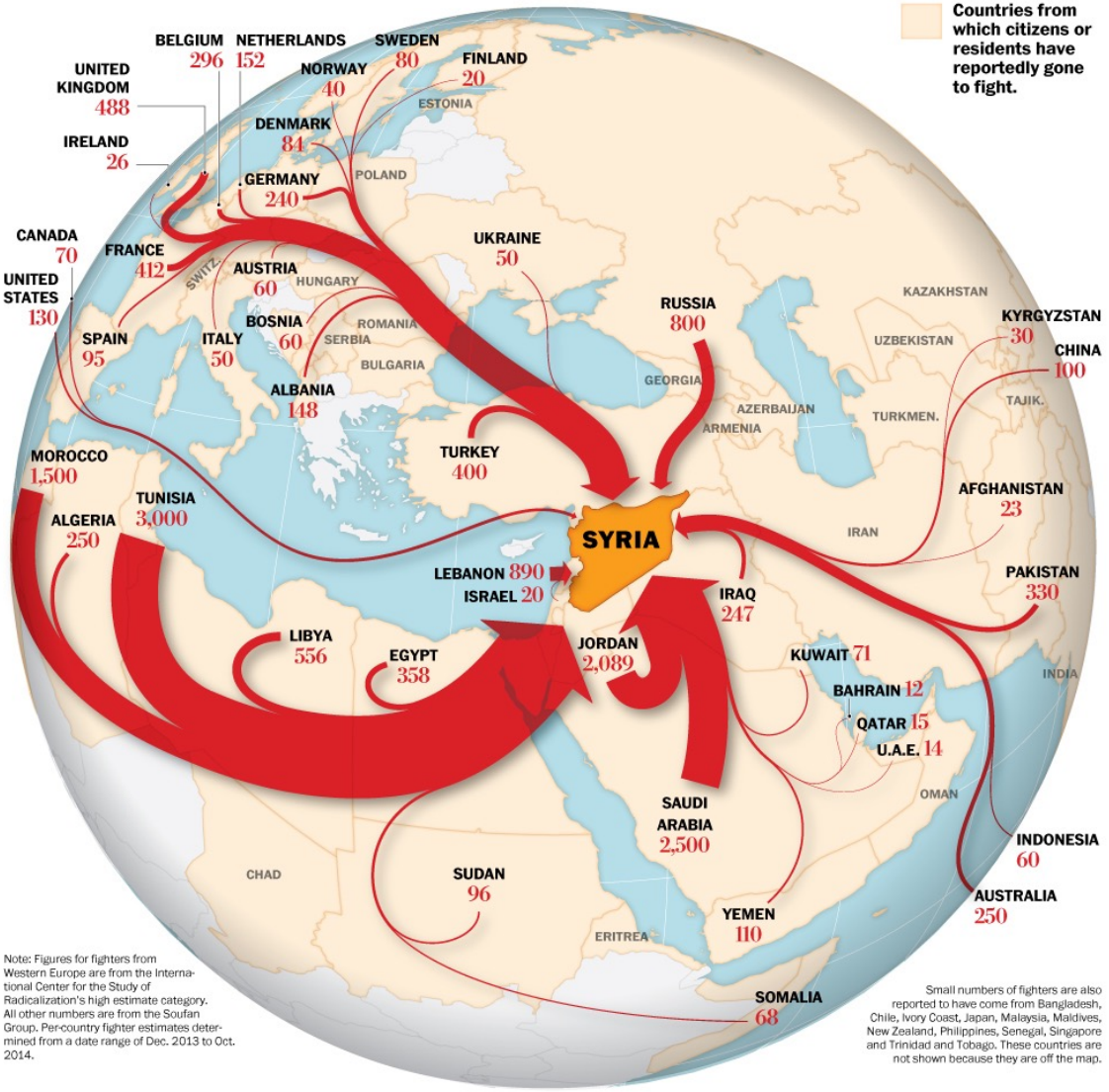
Origin-destination Flow maps



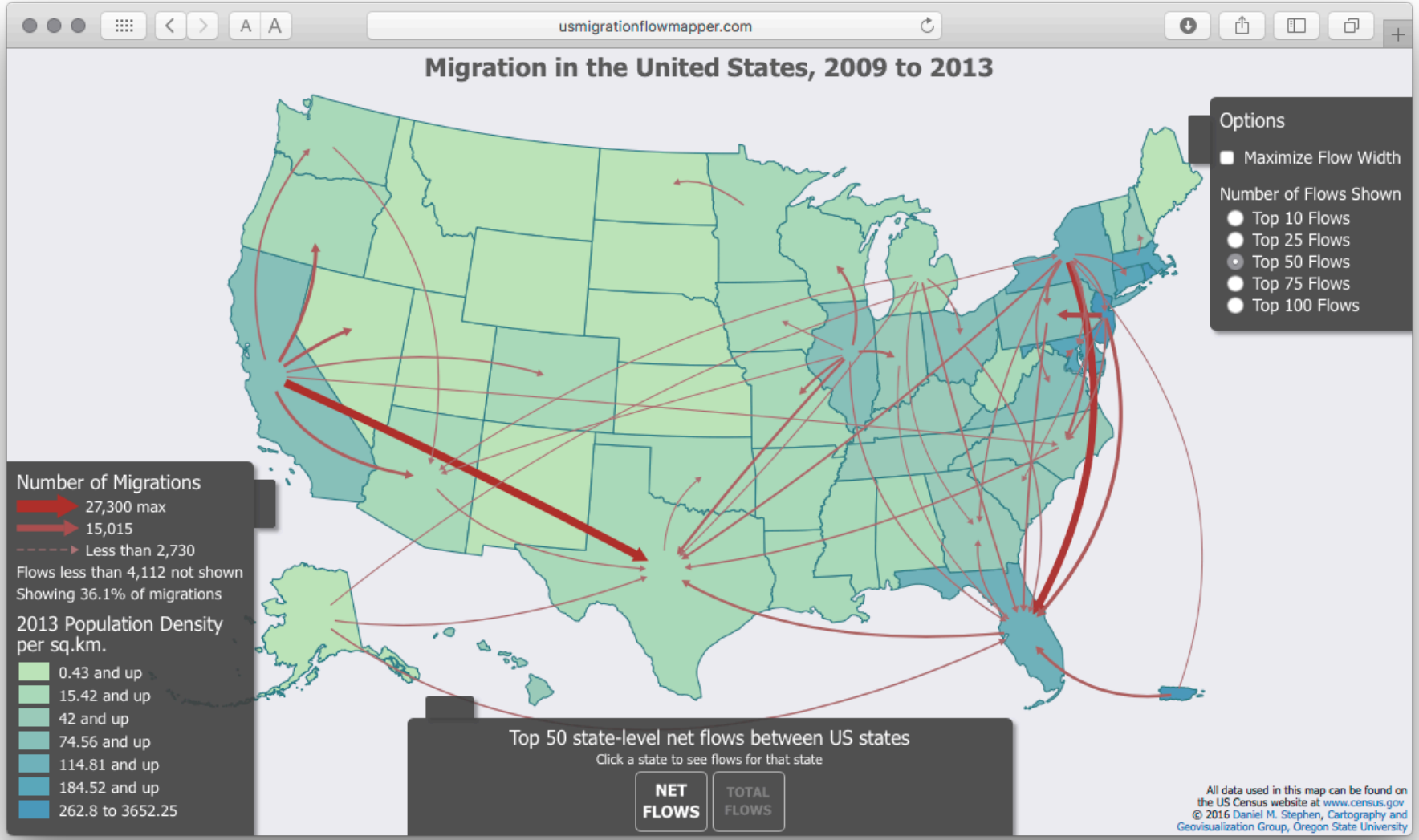
Origin-destination Flow maps

Foreign Fighters
Flow to Syria

Washington Post
October 2014

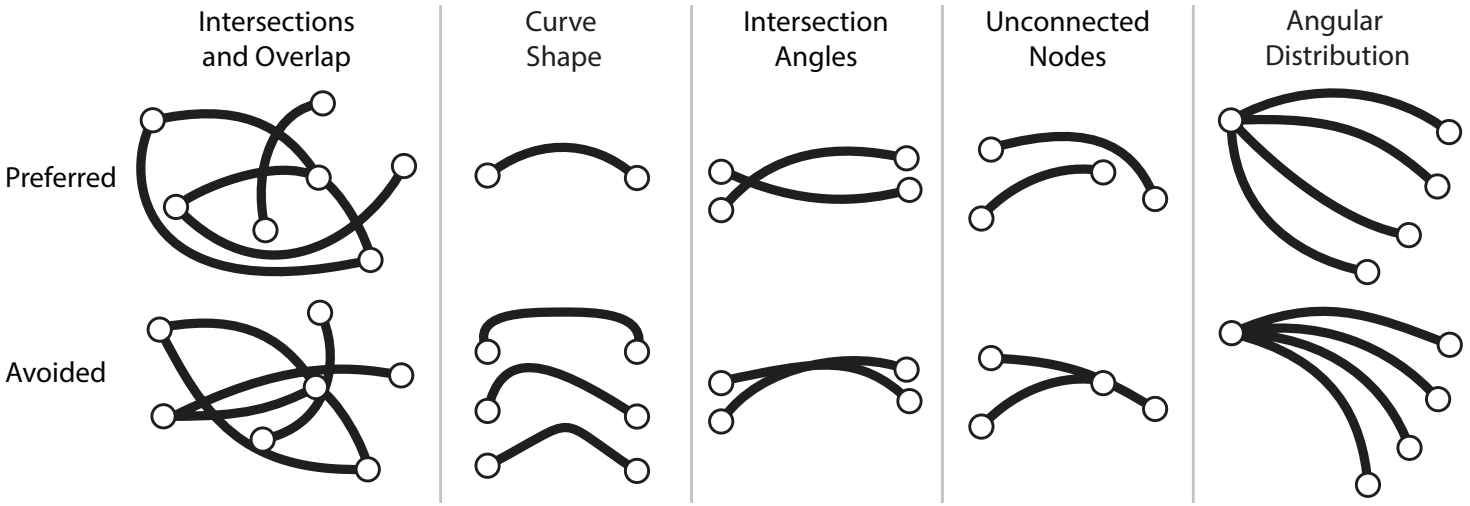


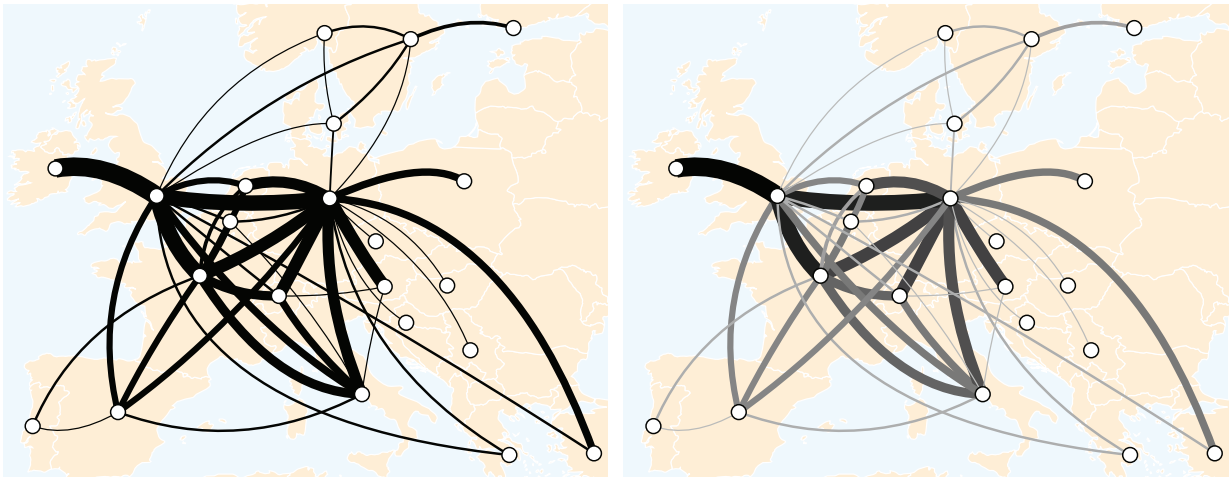
Origin-destination Flow Maps



Source: http://usmigrationflowmapper.com

Design Principles for Origin-destination Flow Maps



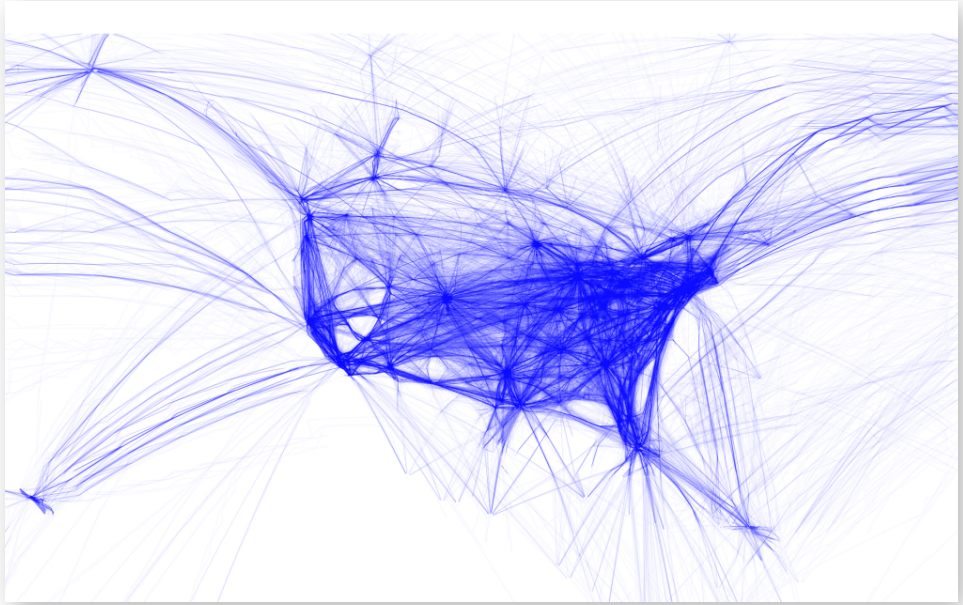


Source: Jenny et al. (2018). Design principles for origin-destination flow maps. Cartography and Geographic Information Science.
http://berniejenny.info/pdf/2017_Jenny_etal_DesignPrinciplesForODFlowMaps.pdf

Flow Maps with Path Geometry

MONASH University

- What?
  - Geographic flow lines (e.g., taxi trajectories, migrating animals, airplanes, etc.)
- Why?
  - Task: discover connections, densities, temporal patterns.
- How?
  - Marks: lines
  - Channel: colour
  - 2D or 3D
  - Scalability: up to 100s of flows



Flow Maps with Path Geometry

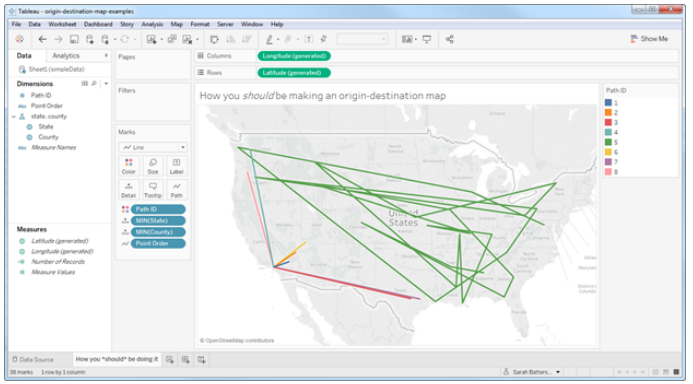
http://mapdesign.icaci.org/2014/12/mapcarte-340365-airspace-the-invisible-infrastructure-by-nats-2014/

http://nats.aero/blog/2014/11/take-guided-tour-uk-skies/

Flow maps

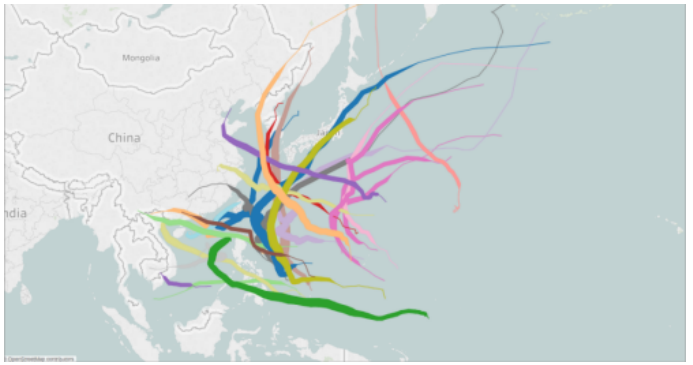
- Tableau
  - Origin-destination flow maps

    https://community.tableau.com/people/sarah.battersby.0/blog/2018/01/12/origin-destination-maps-or-flow-maps



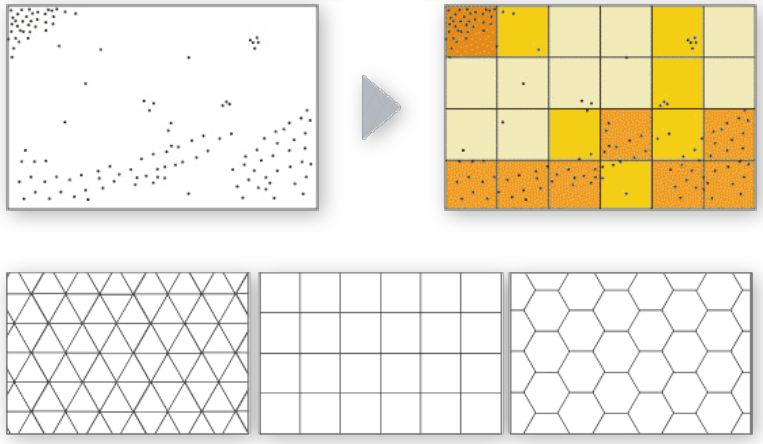
  - Flow paths

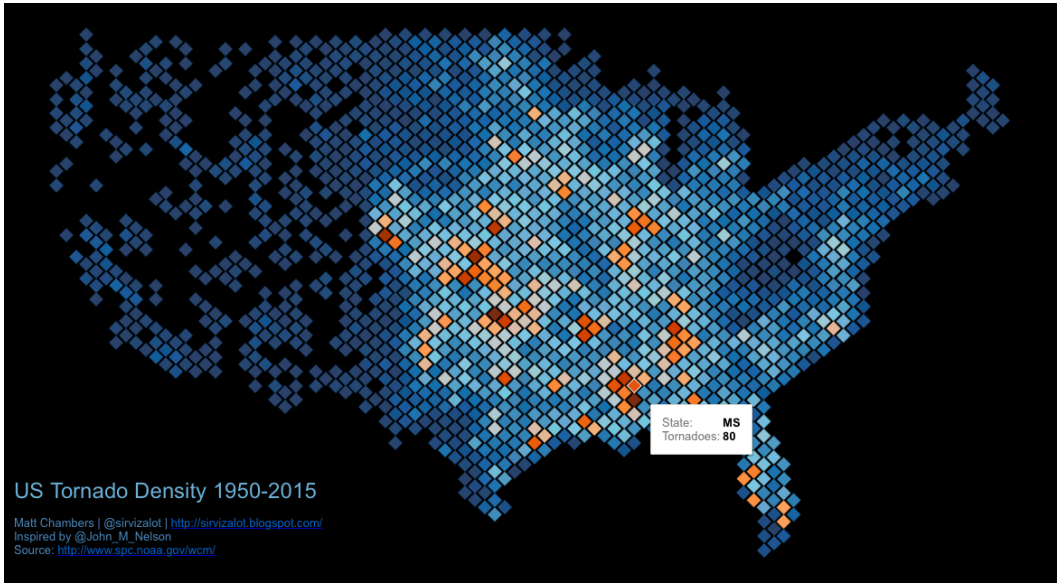
    https://onlinehelp.tableau.com/current/pro/desktop/en-us/maps_howto_flow.html



Bin maps

- What?
  - Geographic points
- Why?
  - Task: find correlation, trends, outliers.
- How?
  - Marks: regular areas (triangles, squares, hexagons)
  - Channel: Luminance for quantitative attribute (also hue)
  - Scalability: millions of points

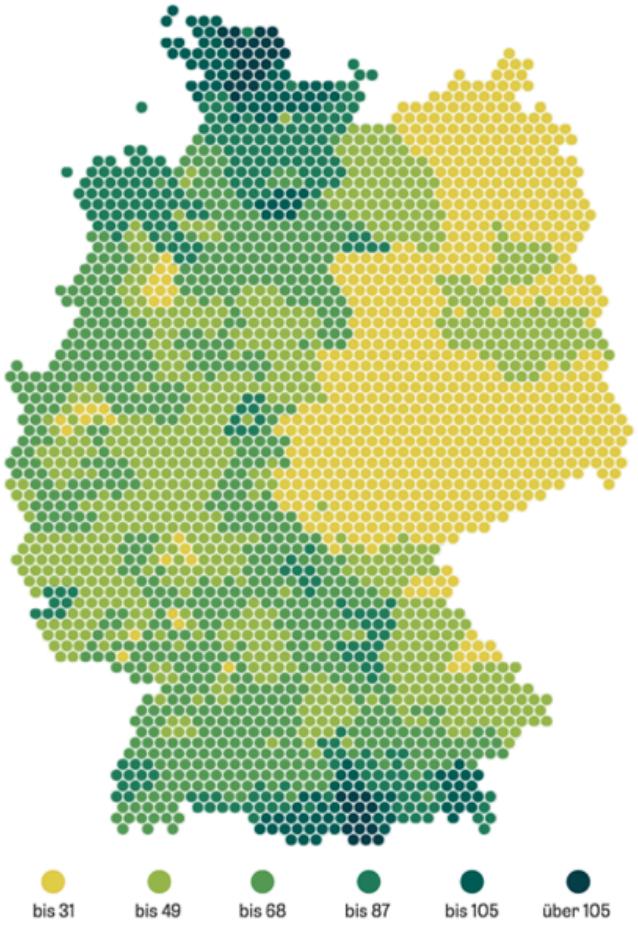




Bin map created with Tableau
https://www.tableau.com/about/blog/2016/7/how-create-density-maps-using-hexbins-tableau-56511

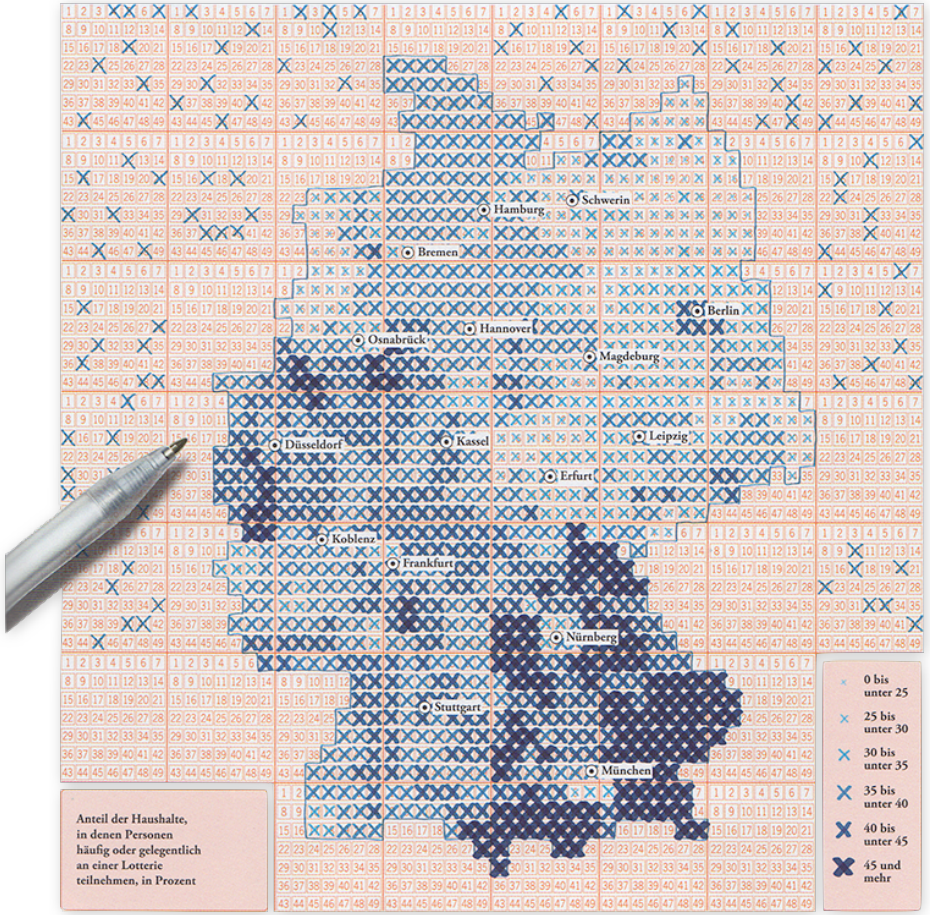
Bin maps

Camper vans per 10,000 people, 2014



Totals should be normalised when correlated with population.

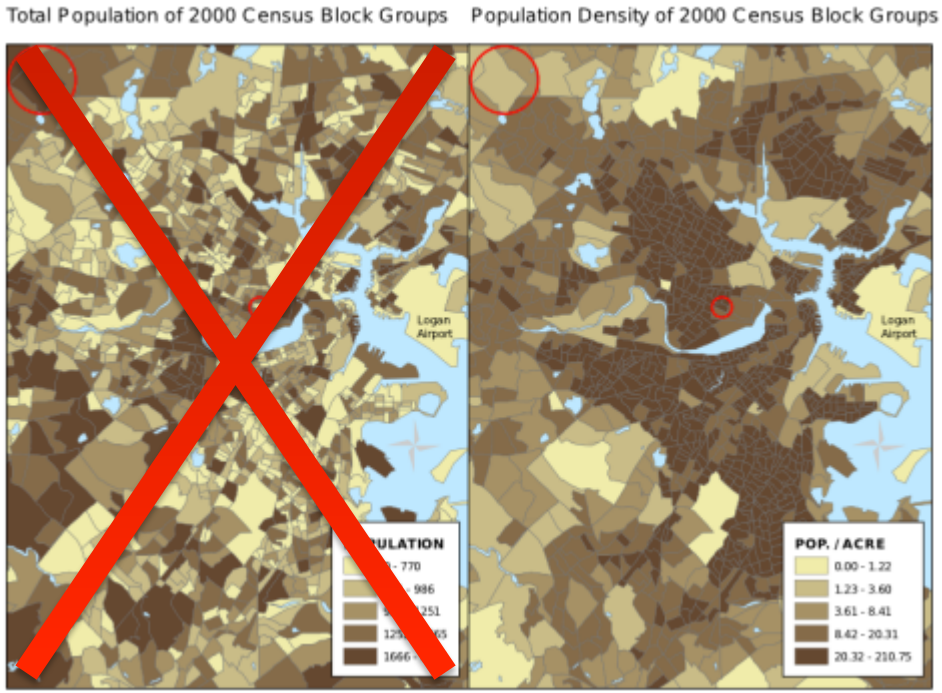
Households with lottery players
(class limits at 25, 30, 35, 40, and 45 percent)



Stolz, M. & Block, J. Deutschlandkarte, 2012, Zeit Magazin

Choropleth

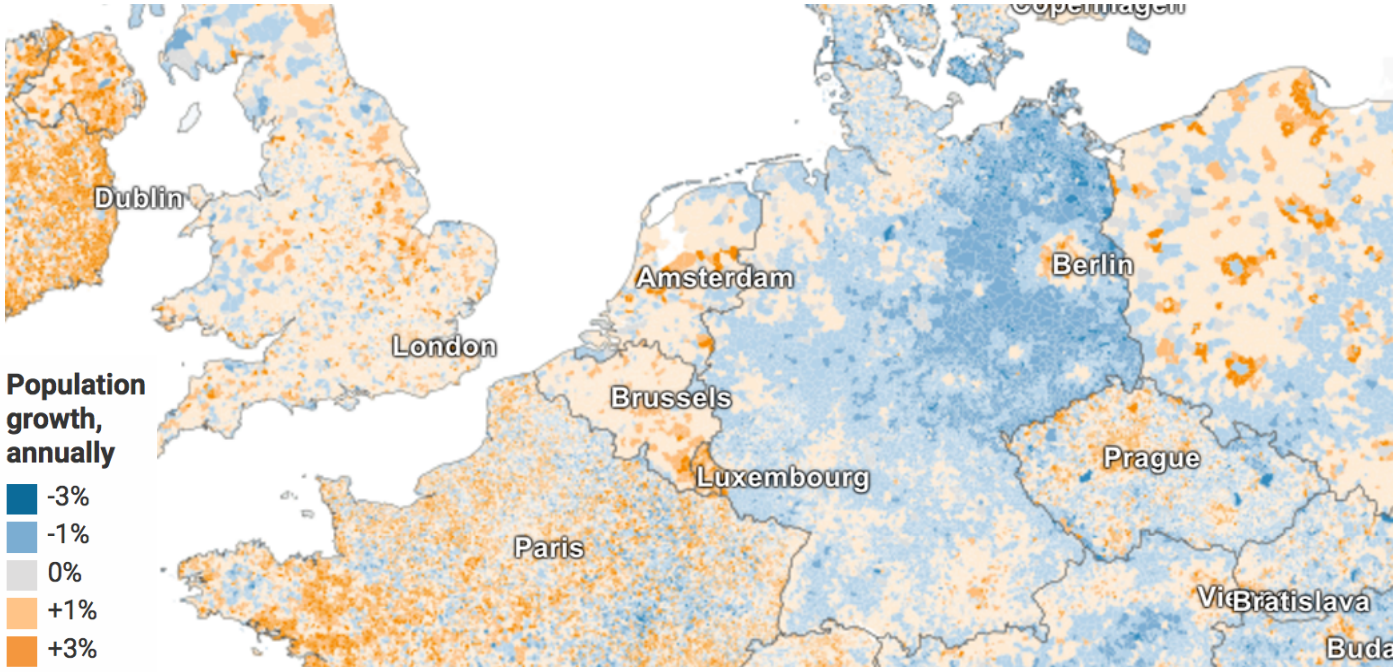
- What?
  - Geographic region data
  - Quantitative attribute per region
- Why?
  - Task: find correlation, trends, outliers.
- How?
  - Marks: geographic regions
  - Channel: Luminance for quantitative attribute (also hue)
  - Scalability: hundreds of regions



https://en.wikipedia.org/wiki/Choropleth_map

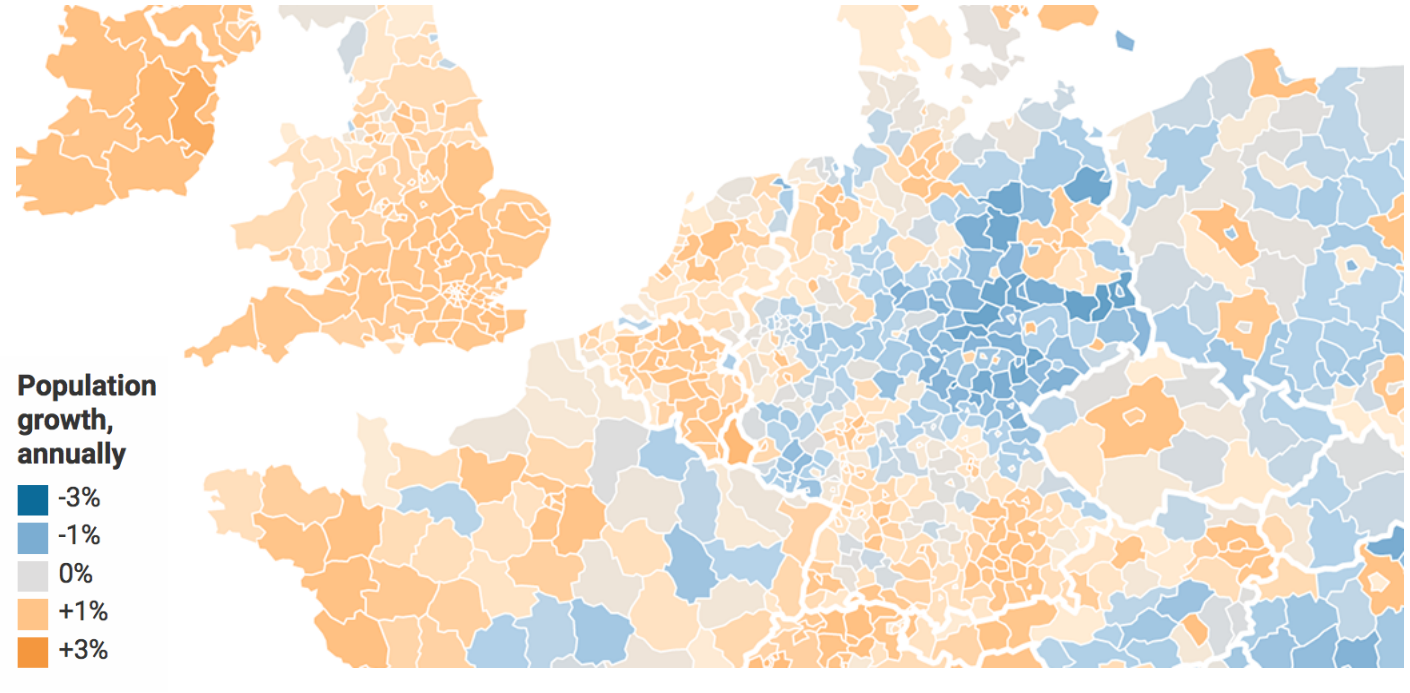
Important: Normalise total counts!
See week 1 lecture.

Choropleth – Level of Detail



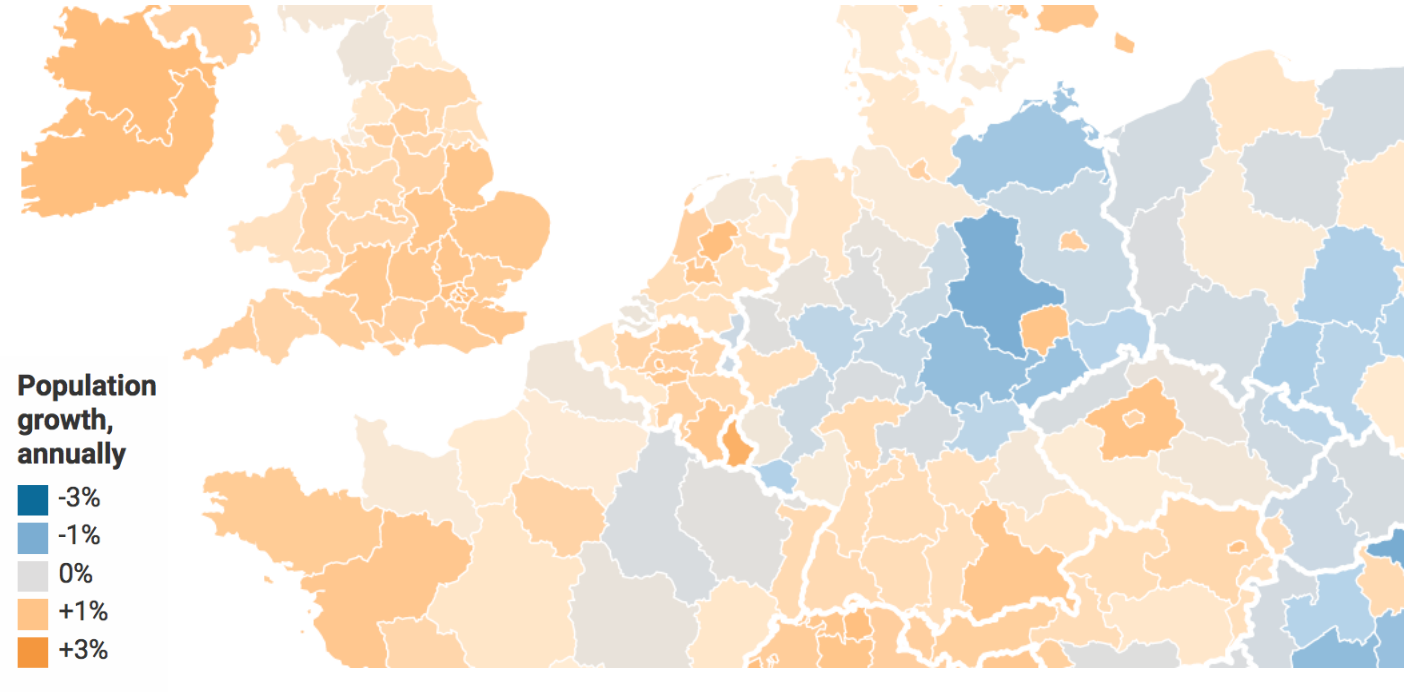
https://blog.datawrapper.de/weekly-chart-europegrowth/

Choropleth – Level of Detail



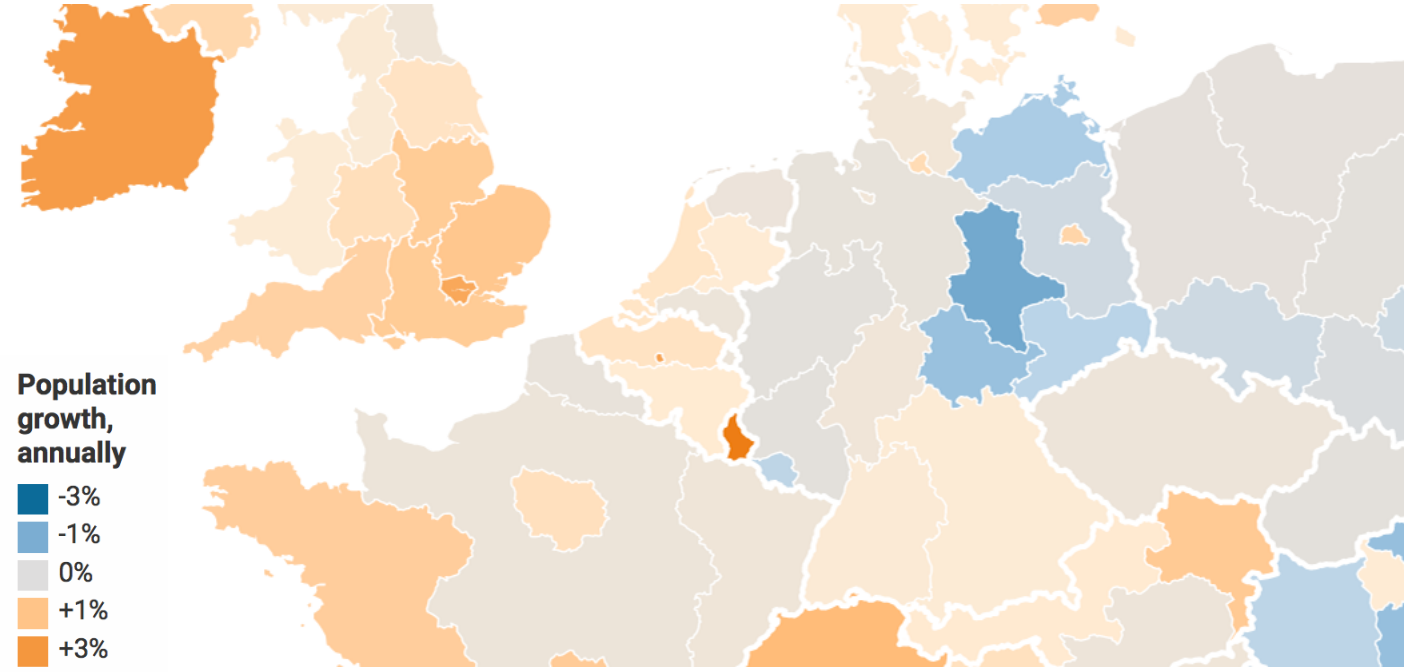
https://blog.datawrapper.de/weekly-chart-europegrowth/

Choropleth – Level of Detail



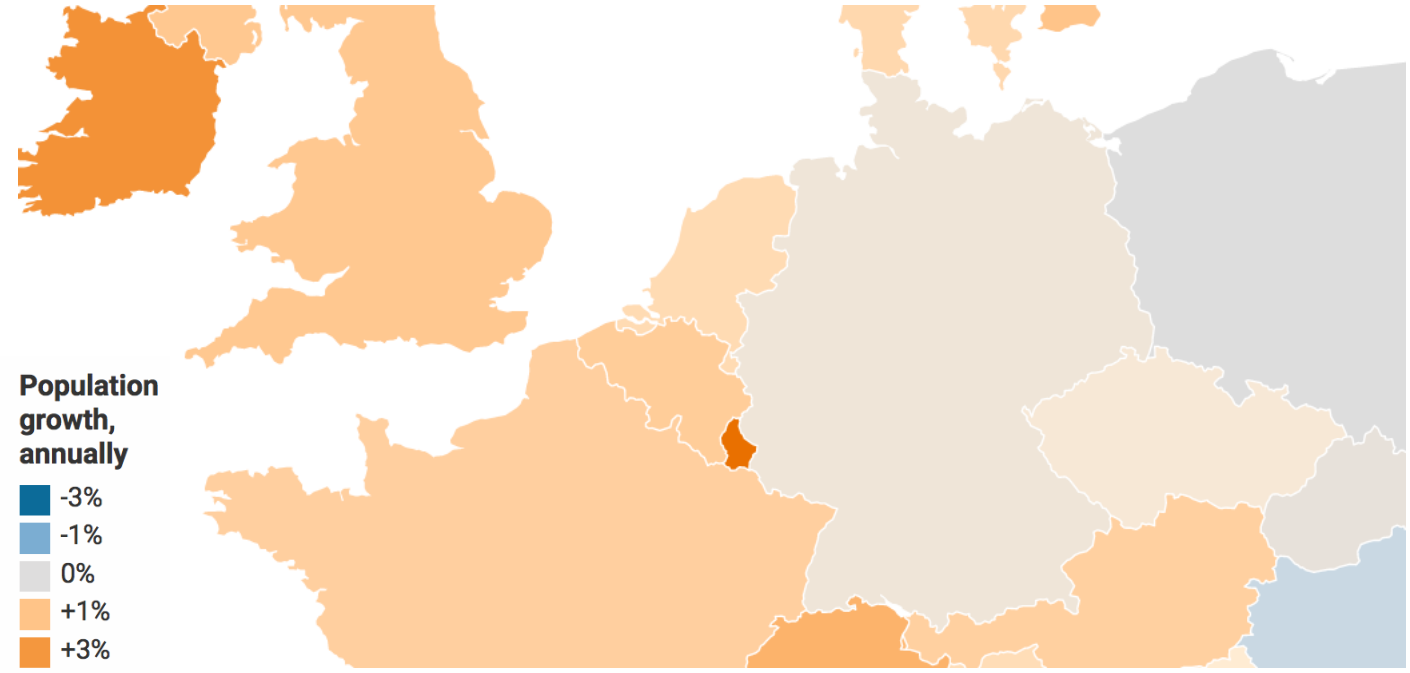
https://blog.datawrapper.de/weekly-chart-europegrowth/

Choropleth – Level of Detail



https://blog.datawrapper.de/weekly-chart-europegrowth/

Choropleth – Level of Detail



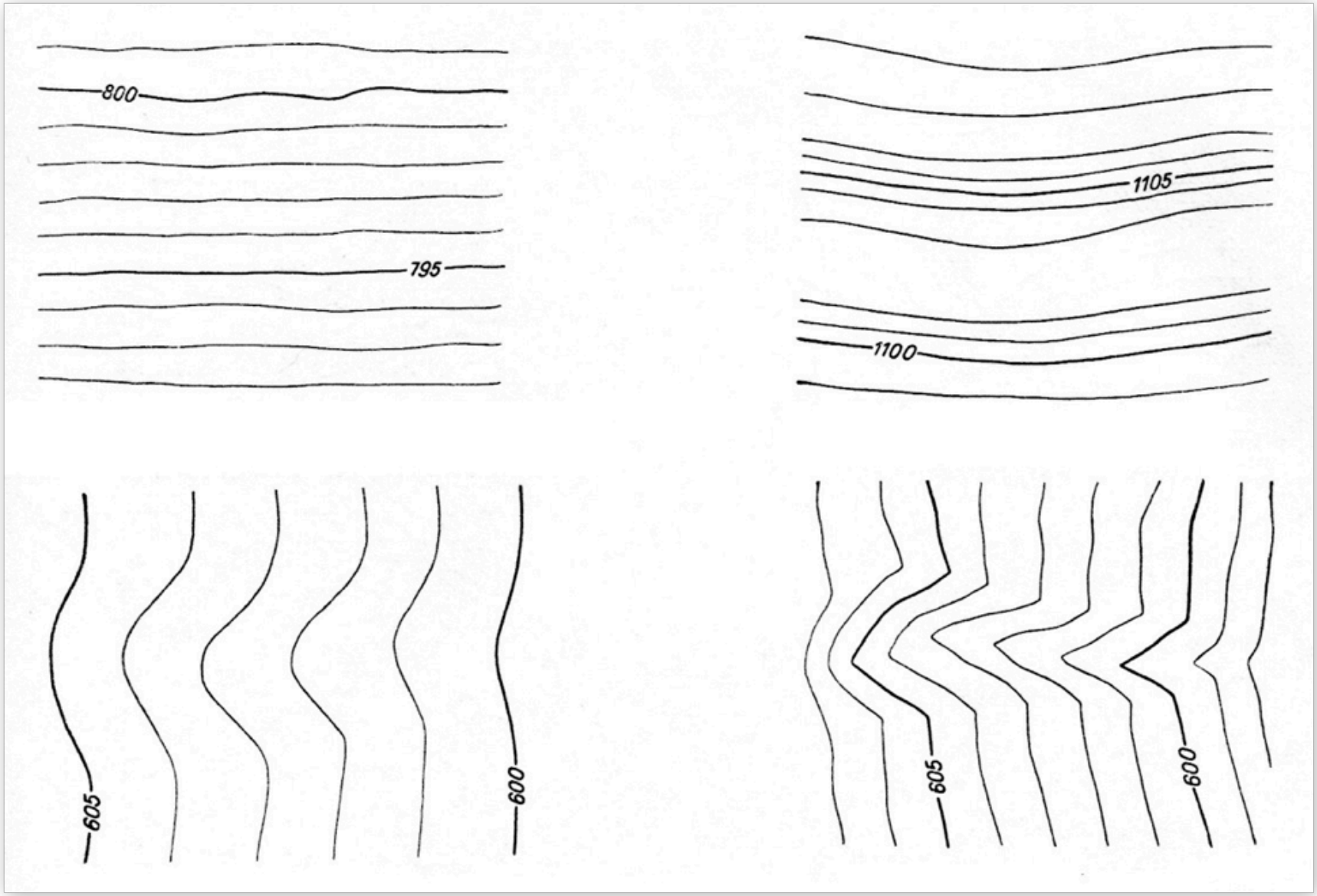
https://blog.datawrapper.de/weekly-chart-europegrowth/

Scalar fields: isocontours

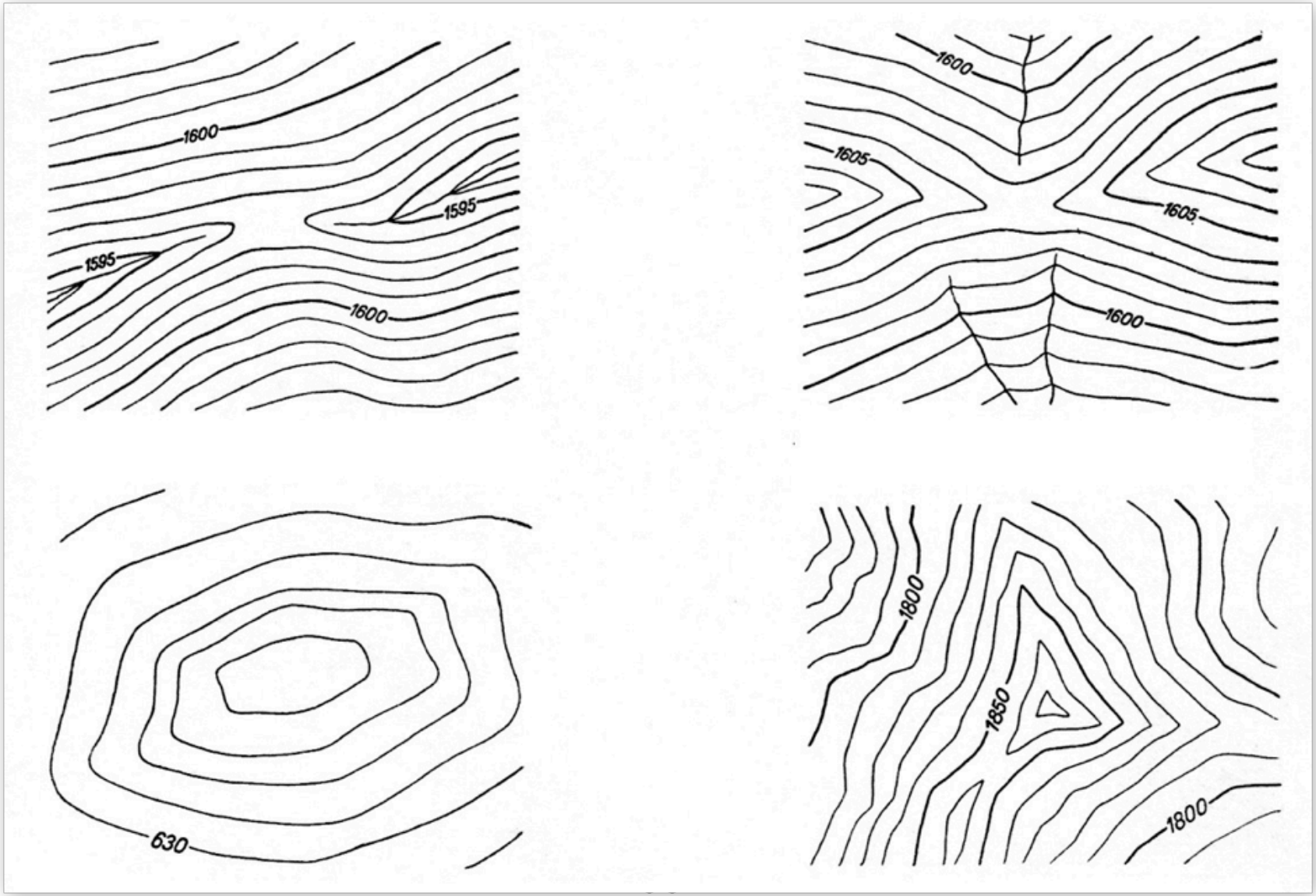
MONASH University

- What?
  - Geographic map
  - Scalar field (elevation or other data)
- Why?
  - Task: find maxima, areas of change and other features relative to geometry
- How?
  - Marks: isocontours show level-sets in field
  - Scalability: dozens of contour lines

Isocontours

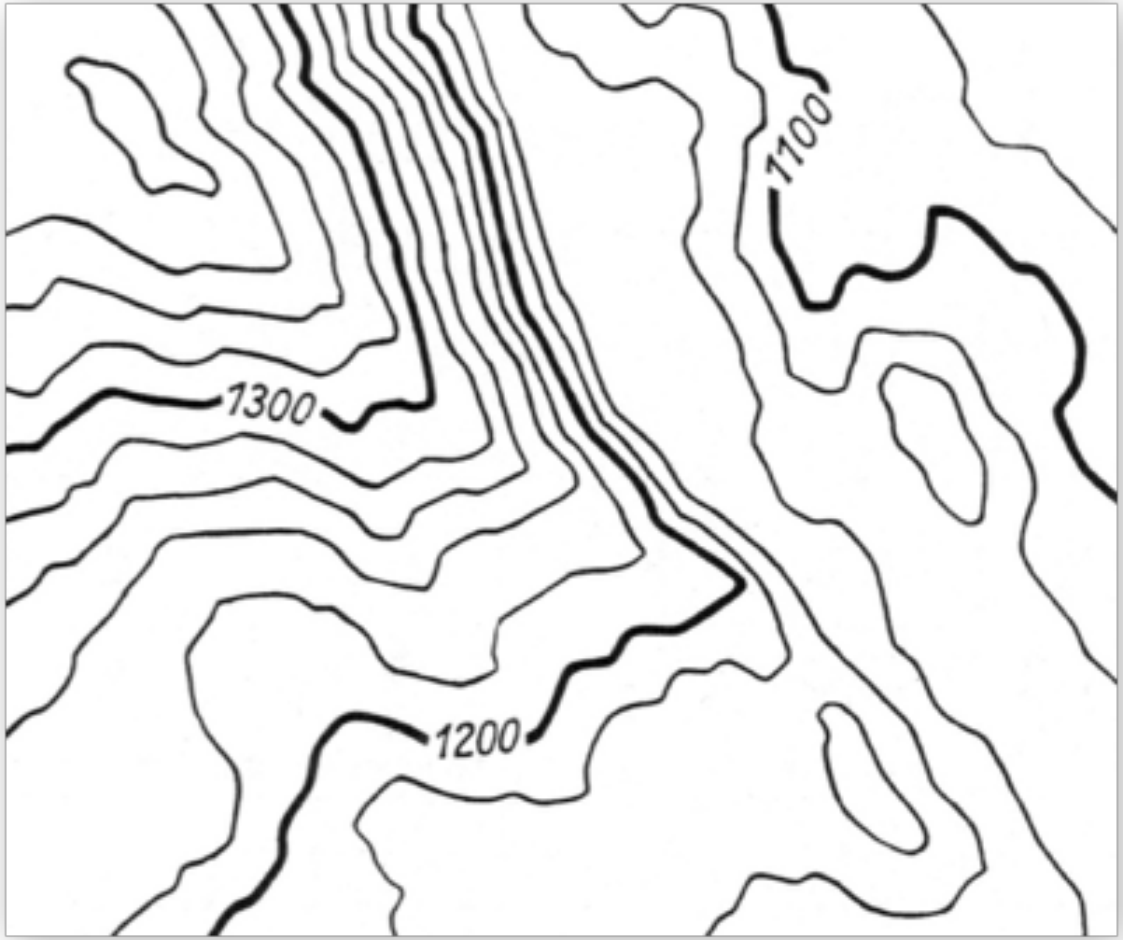


Isocontours



Isocontours: terminology

Isocontours = contour lines = contours

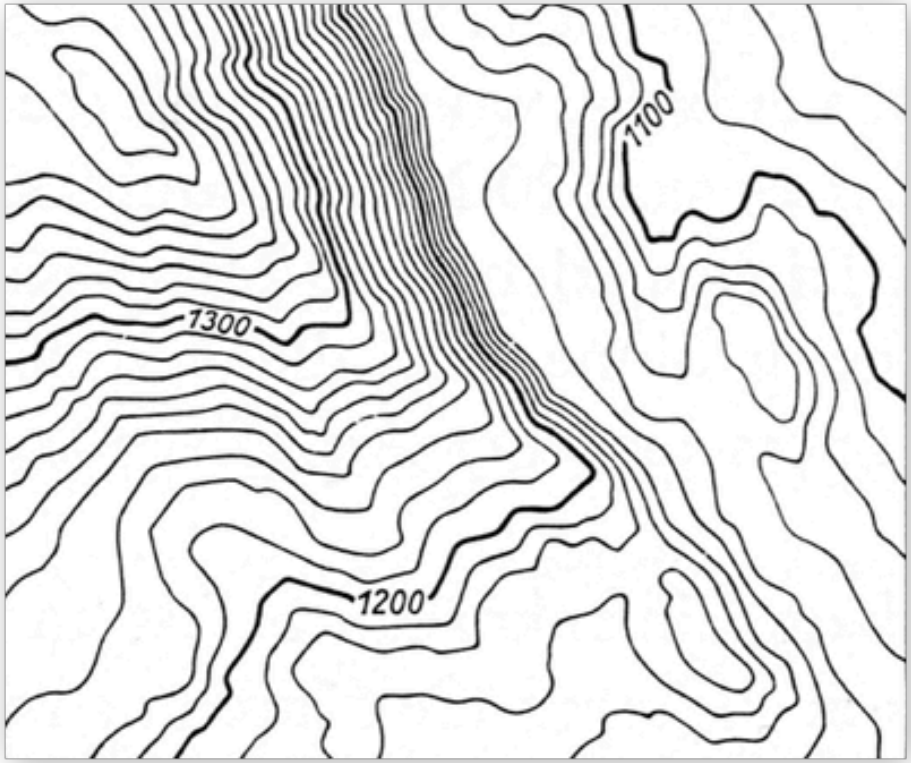


Intermediate contour

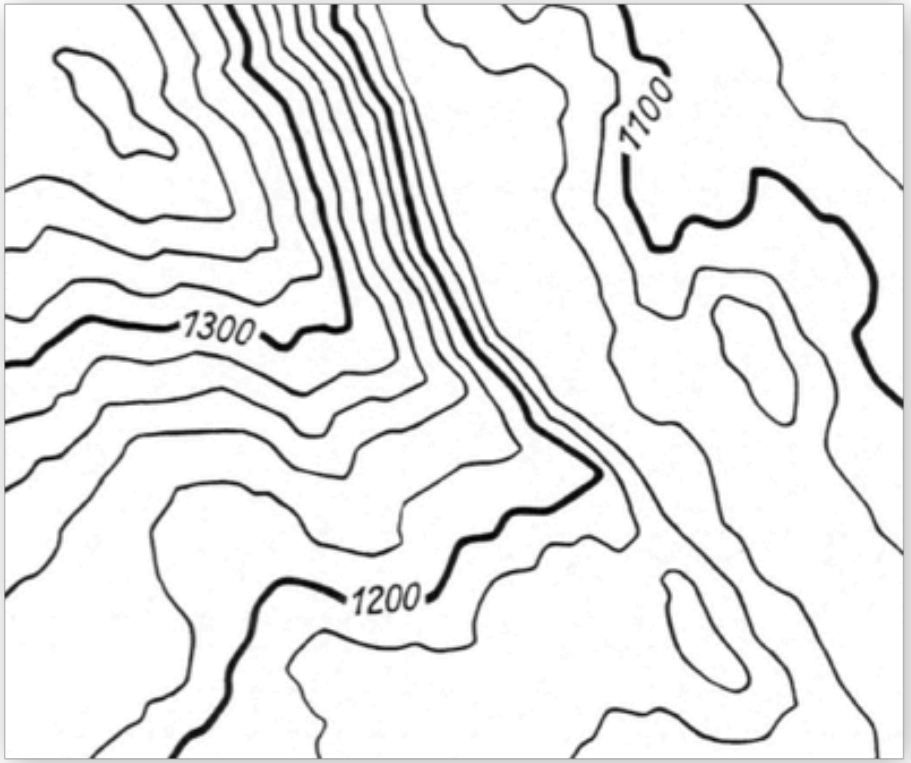
Index contour: thicker and labeled

Contour interval (here 20 meters)

Isocontours: contour interval



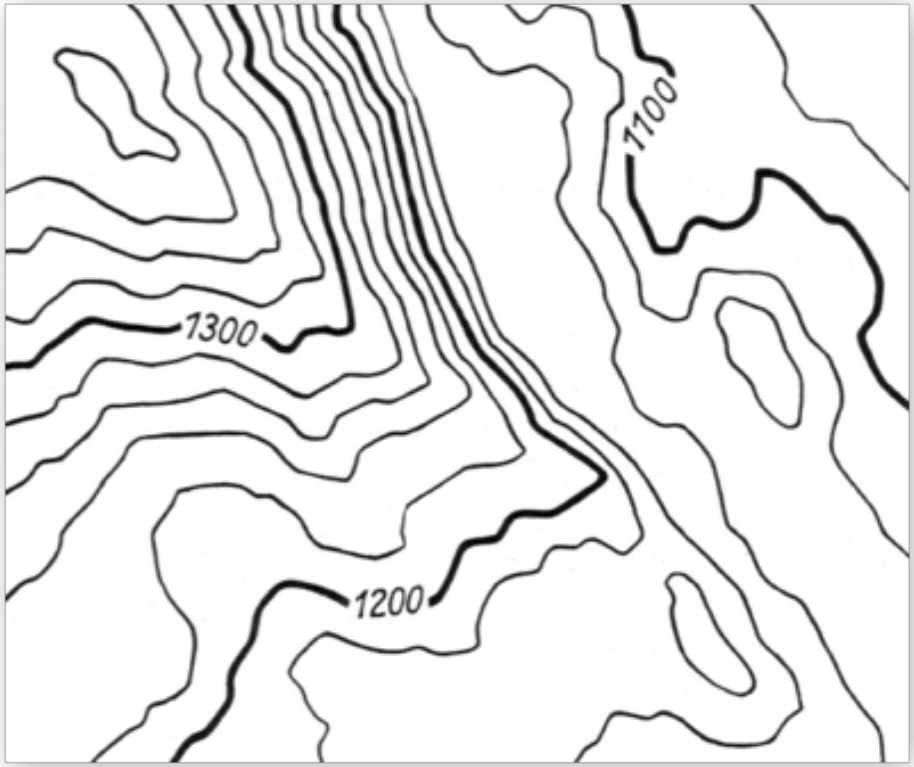
Small contour interval: more information and details, contours too dense in steep areas



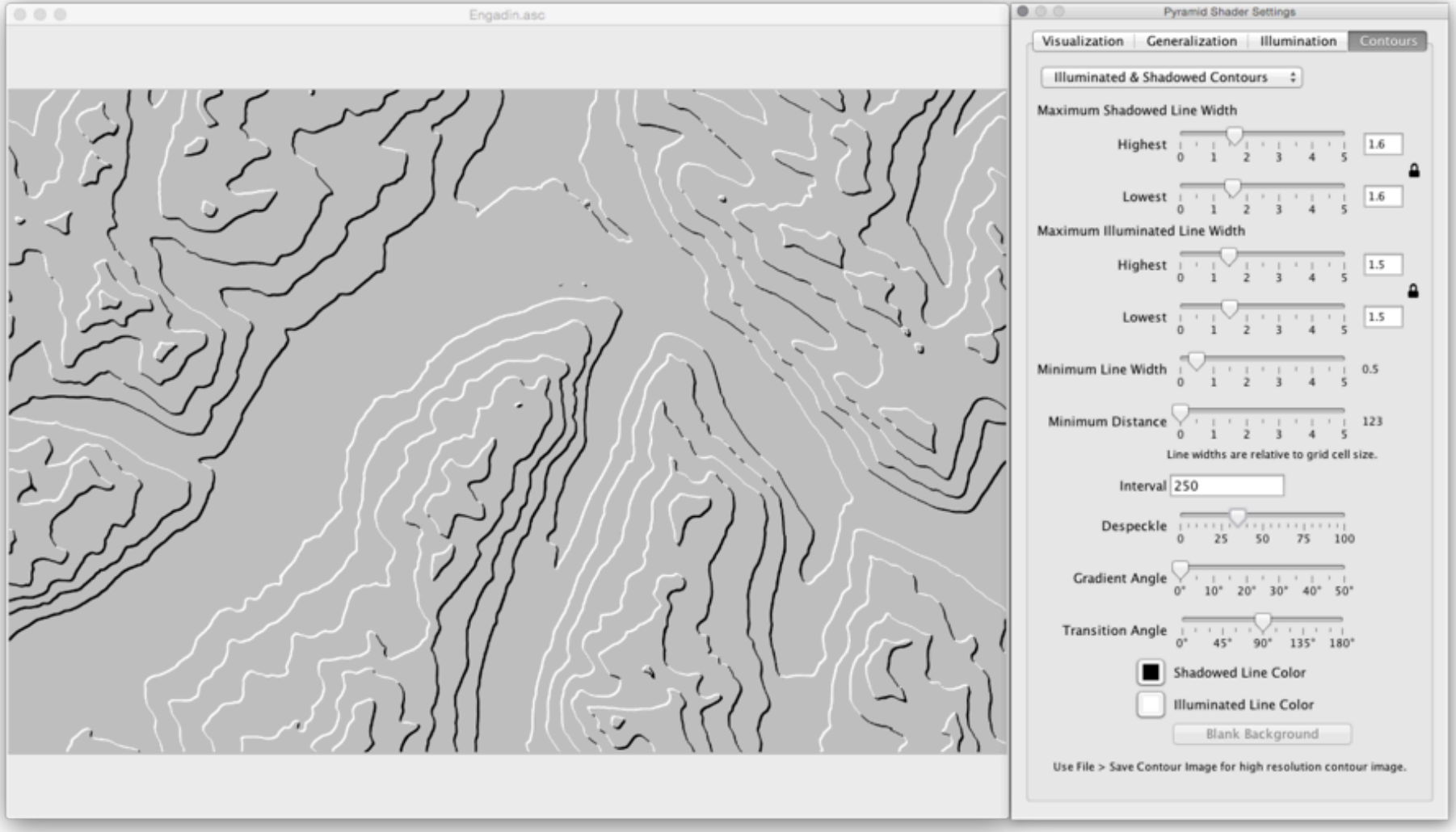
Appropriate contour interval

Isocontours: interval

- Equal intervals: vertical distance between regular contours needs to be constant. Irregular systems would be confusing.
- “Round” numbers that are simple to add (e.g., 5, 10, 20, 25, 50, 100, etc.)
- Choice based on distance between contours: map scale, type of terrain (maximum slope)



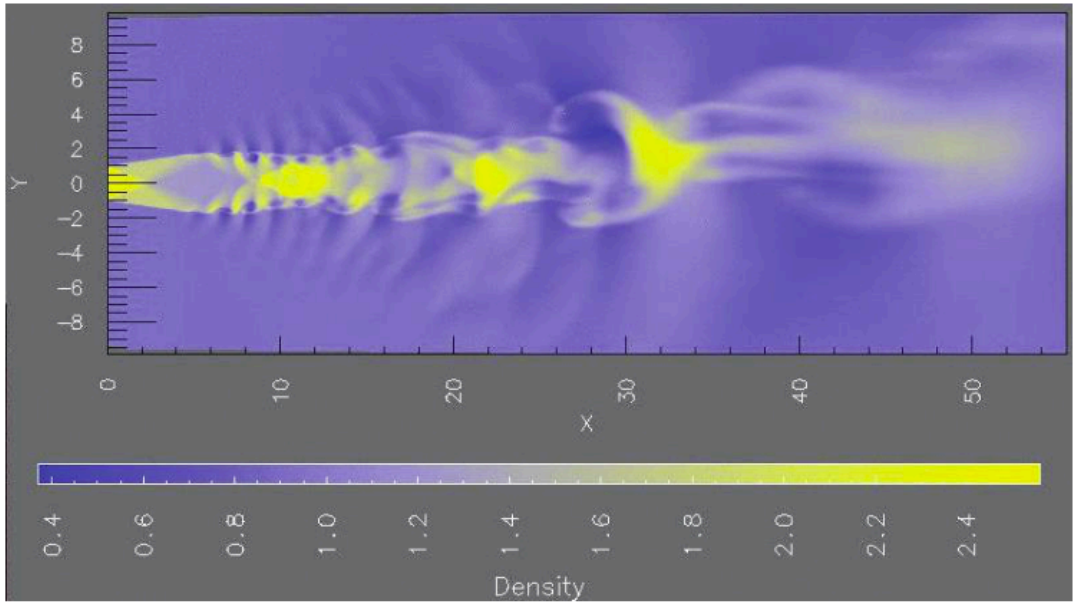
Illuminated contours



Pyramid Shader: http://terraincartography.com/PyramidShader/

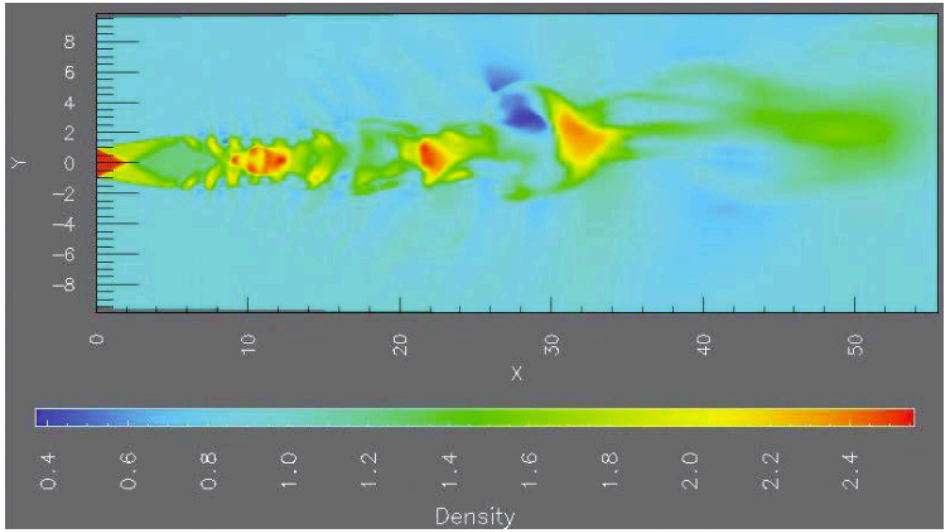
Scalar field: Colour mapping

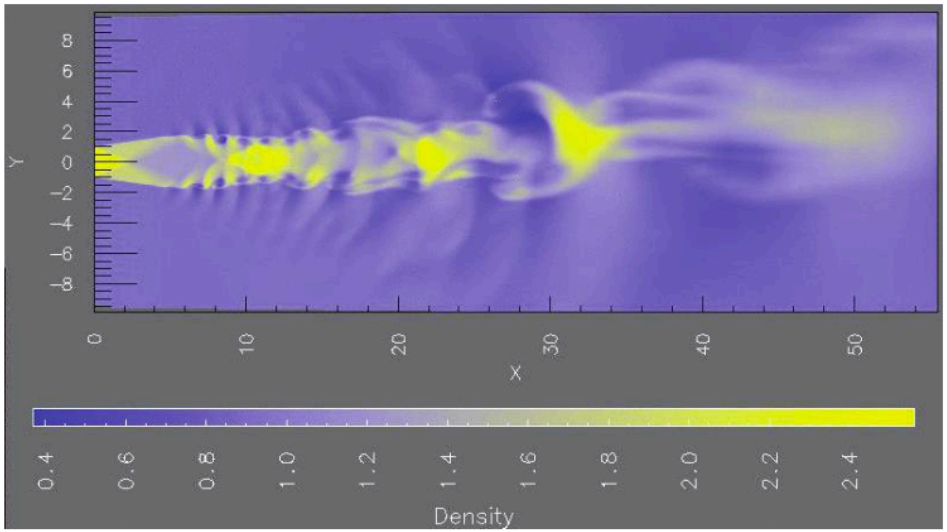
- What?
  - Scalar field
- Why?
  - Task: identify features
- How?
  - Marks: colour image,
  - Mapping of scalar field attributes to colour ramp



Scalar field: Colour mapping

- Avoid rainbow colour map, better only two hues





Wikipedia's Hypsometric Color Schema

Atlas of Yellowstone, University of Oregon Infographics Lab

Shaded relief: a special case for terrain scalar field

- What?
  - Scalar field with elevation
- Why?
  - Task: identify landforms
- How?
  - Marks: greyscale image

Manual relief shading. Source: http://shadedreliefarchive.com

Shaded relief

Shaded relief

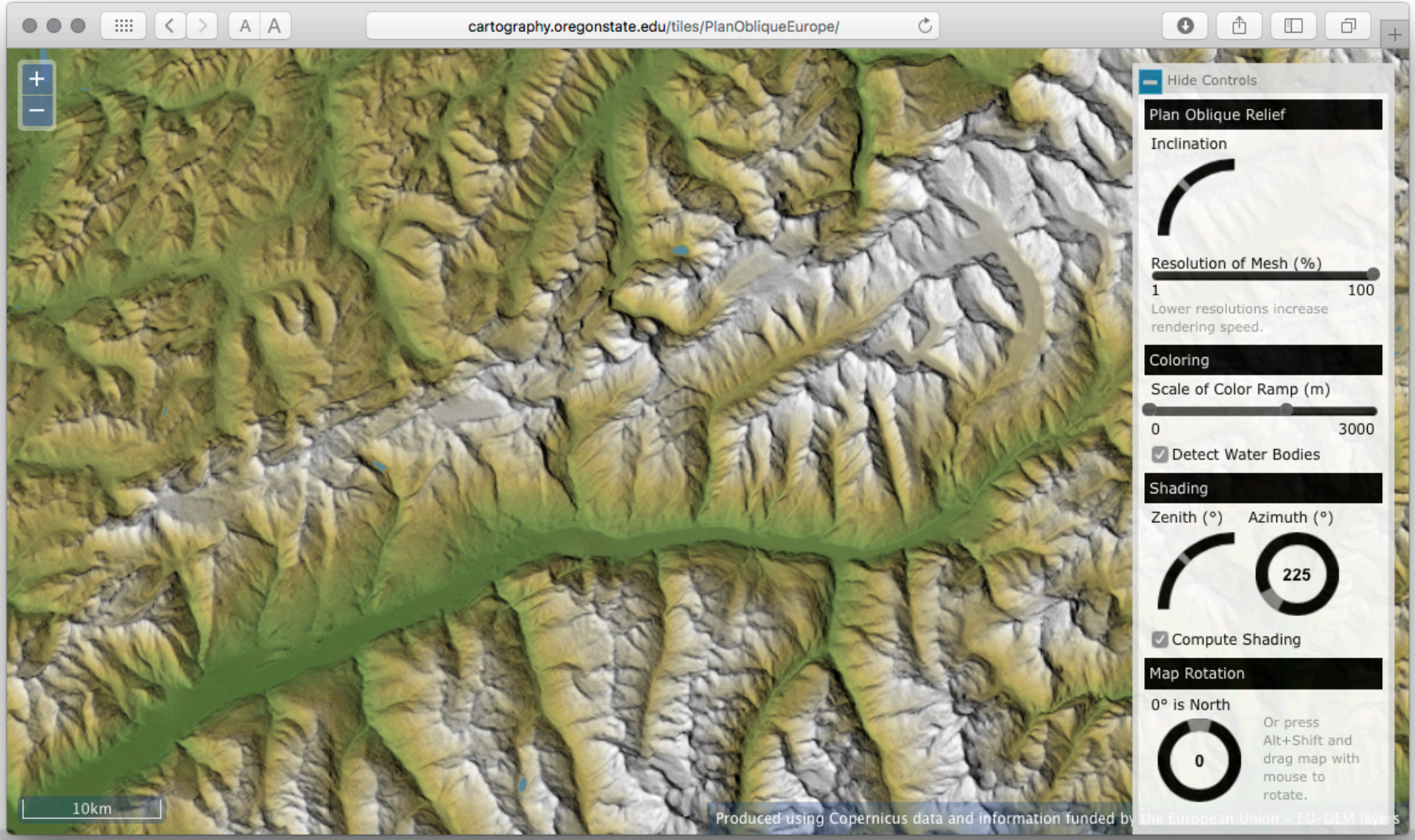
Shaded relief: top-left illumination

Shaded relief: top-left illumination

Shaded relief

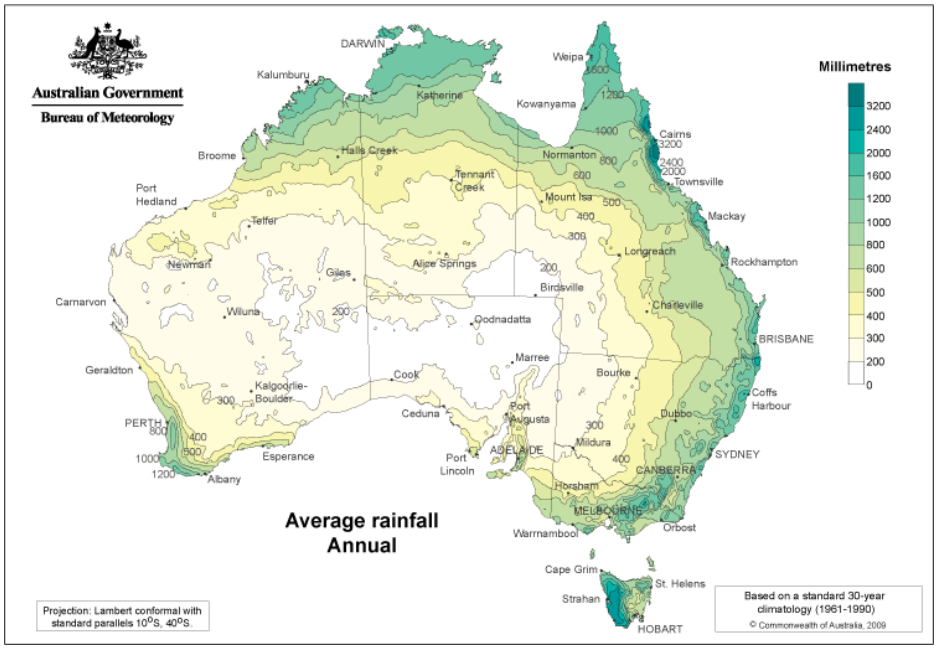
- Effective visual impression, but reader cannot extract scalar field values.
- Illumination from top-left to avoid inversed terrain effect
- Computed from scalar field (terrain model) with illumination model
- More information
  - www.reliefshading.com
  - www.shadedrelief.com
  - www.shadedreliefarchive.com (manual relief shading art)

Shaded Relief and Colour



Source: http://cartography.oregonstate.edu/tiles/PlanObliqueEurope/

Isocontours and Colour



Isocontours and Shaded Relief

MONASH University

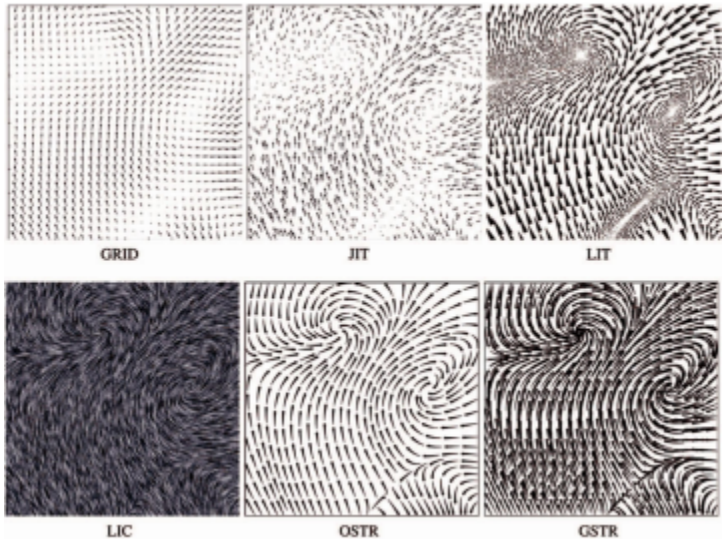
Comparing contours, shaded relief and colour mapping

	+	–
Contour lines	values can be extracted	difficult to read, difficult to extract overview, problematic with very steep and very flat sections
Shaded relief	small details and large forms are both easy to read	only graphical impression, no absolute values can be extracted
Colour mapping	good for showing overview	only approximate values can be extracted. On maps: commonly used green colour for lower areas can be mistaken for landcover.

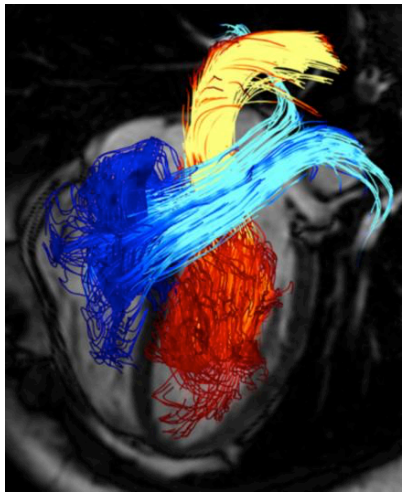
Vector Fields

MONASH University

- What?
  - 2D or 3D vector field
  - Geographic or other spatial features
  - Derived: flow lines
- Why?
  - Task: find features, query shape
- How?
  - Marks: derived lines
  - Channels: colour and opacity
  - Scalability: millions of samples represented by hundreds of stream-lines

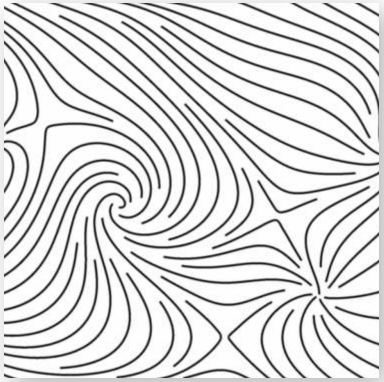


[Laidlaw, David H., et al. "Comparing 2D vector field visualization methods: A user study." *IEEE Transactions on Visualization and Computer Graphics* 11.1 (2005): 59-70.]

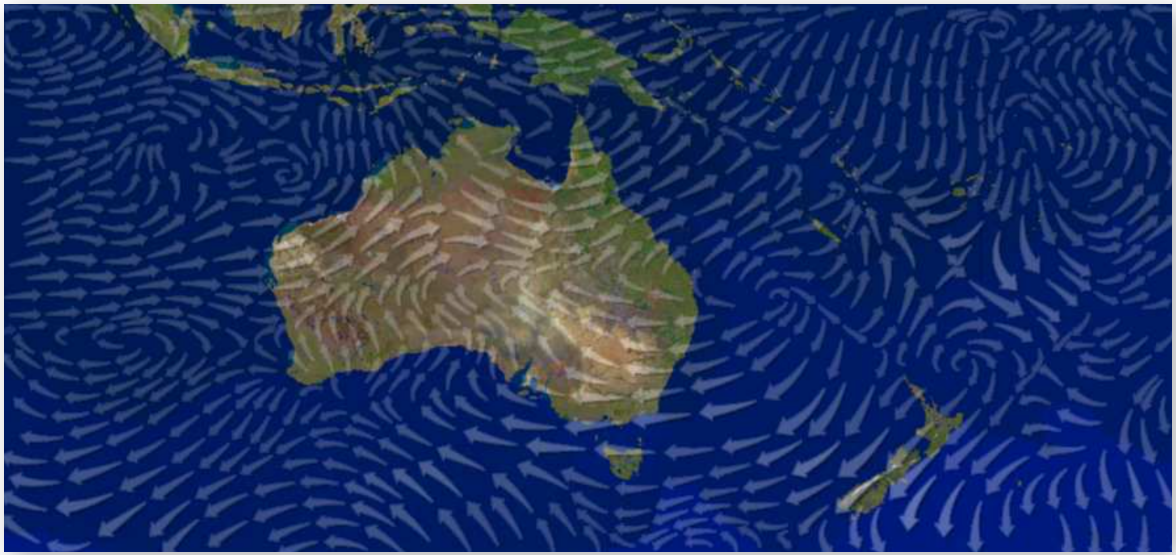


Vector Fields: Streamline placement

Regular distribution of seeds (centers)

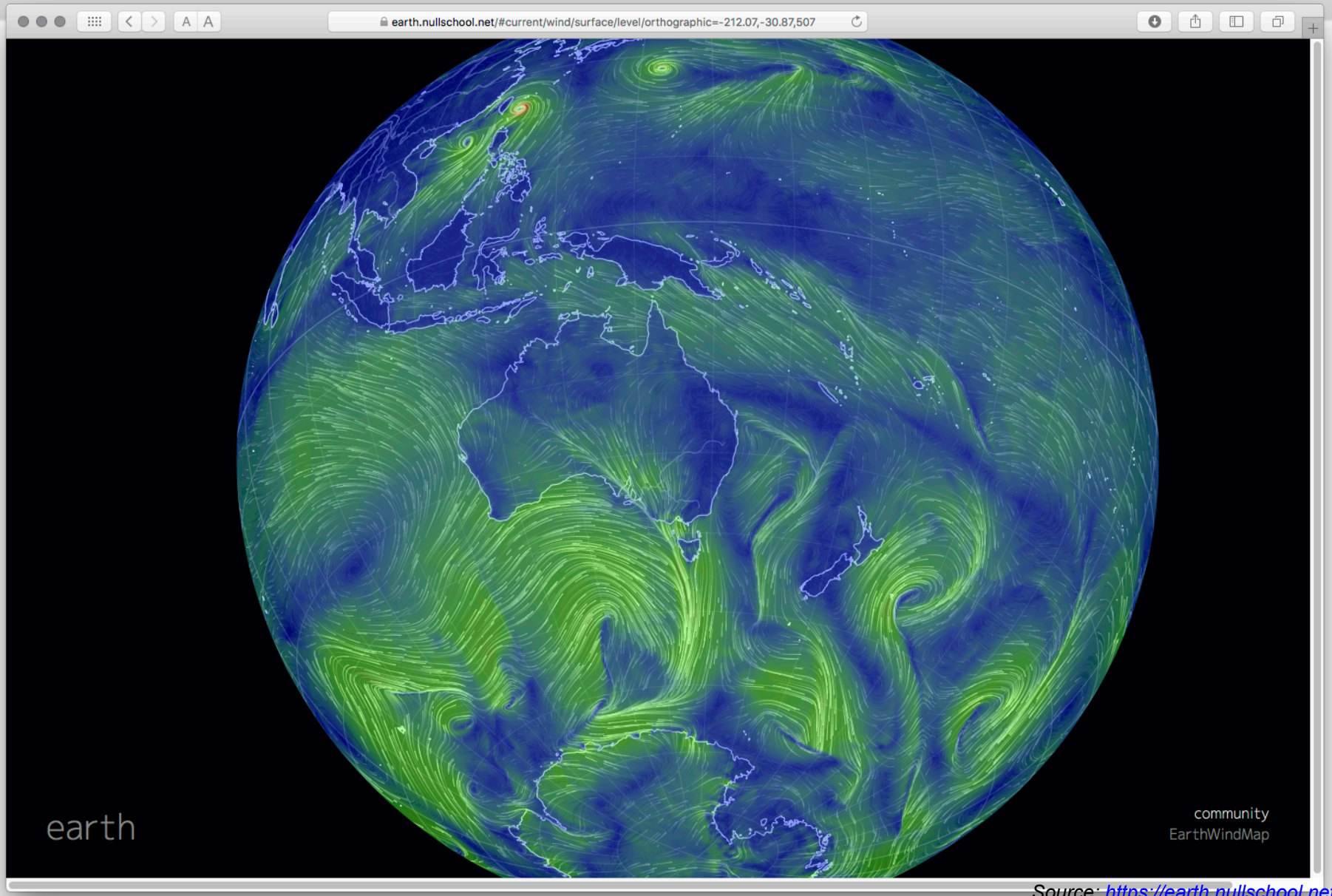


Optimized placement streamlines



Source: Turk and Banks: Image-Guided Streamline Placement

Vector Fields



Source: https://earth.nullschool.net