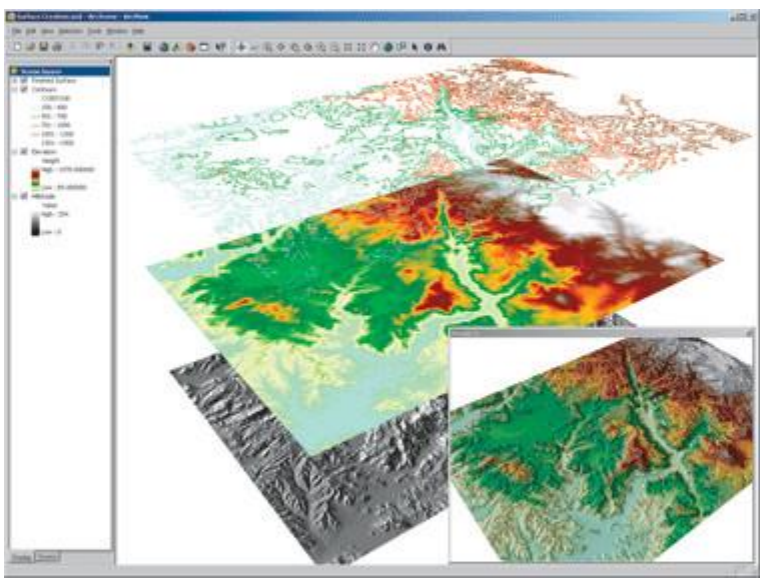
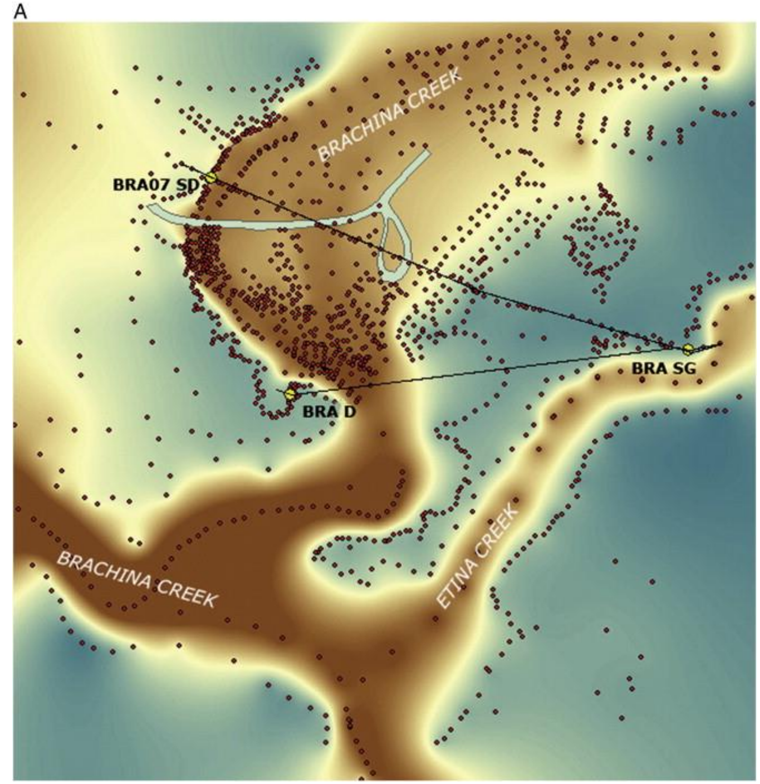
developers.google.com

5. Geospatial data visualization


www.esri.fi

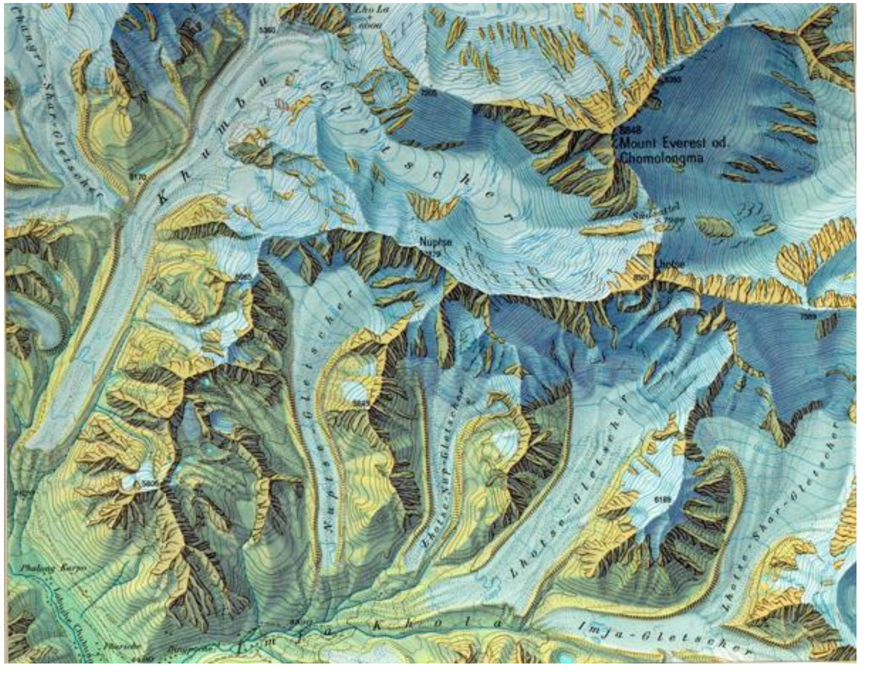
A



www.sciencedirect.com

Geospatial data

- Describe objects or events of the real world
- Often denoted as **geovisualization**



butdoesitfloat.com

Domains of usage

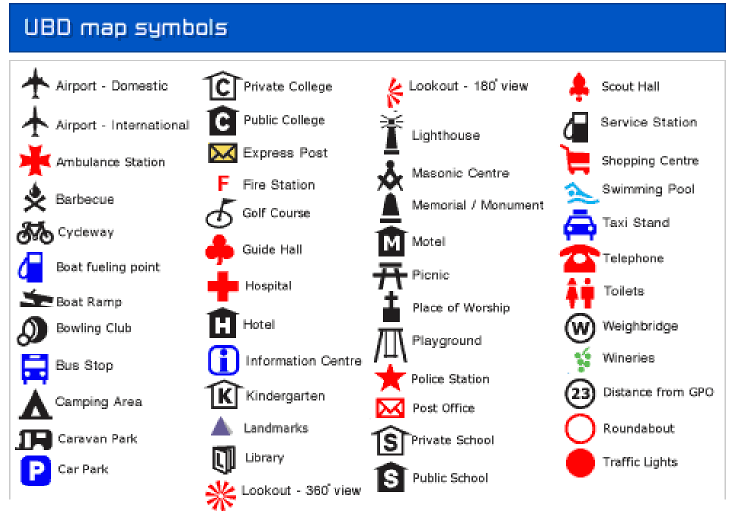
- Climate change
- Level of unemployment
- Level of education
- Analysis of customer’s behaviour
- Credit card payments
- Criminality statistics
- …

Points, lines, areas

- Maps consist of these three basic types of items
- Spatial events are divided according to their dimension:
  - Point events – 0-dimensional
  - Line events – 1-dimensional
  - Area events – 2-dimensional
  - Surface events – 2,5-dimensional

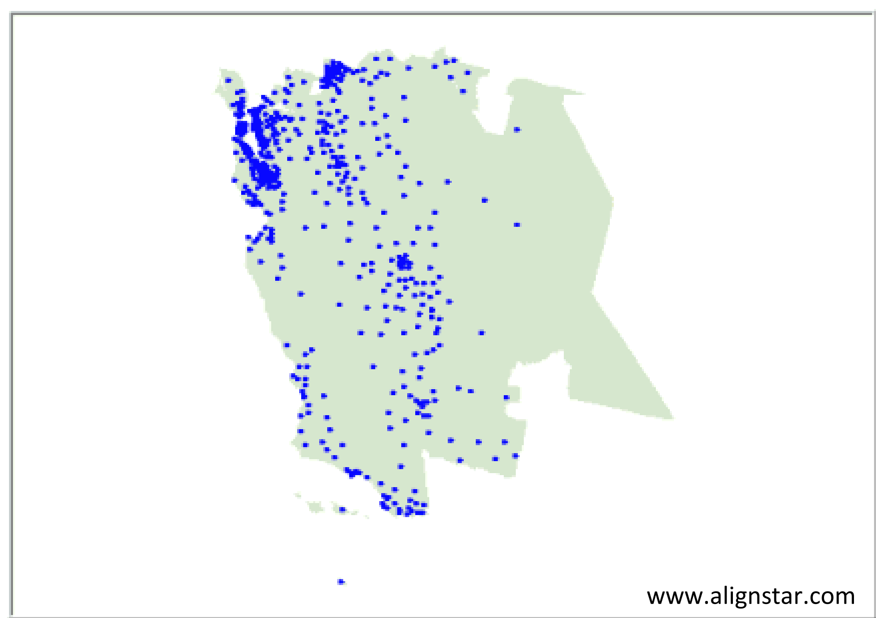
Types of maps

- Maps of symbols



wildernessnavigation.blogspot.com

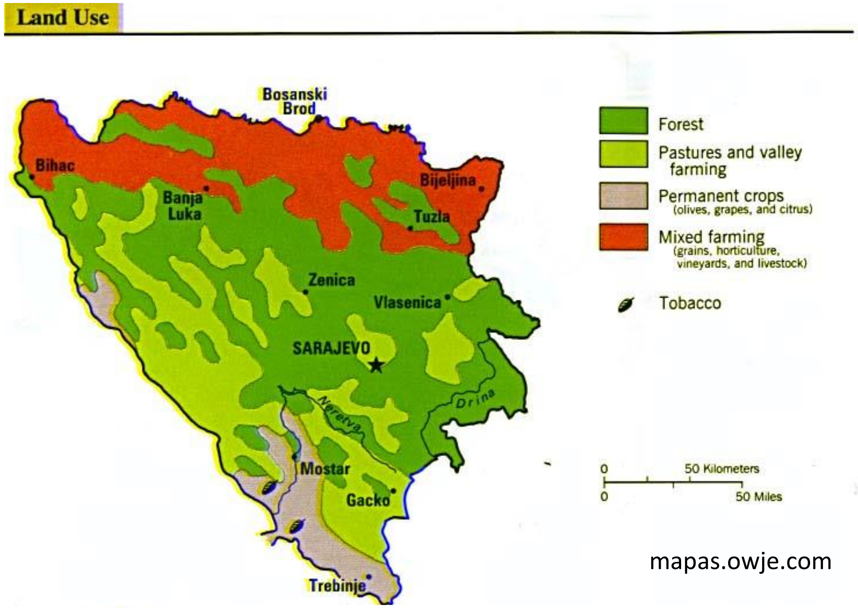
- Point maps



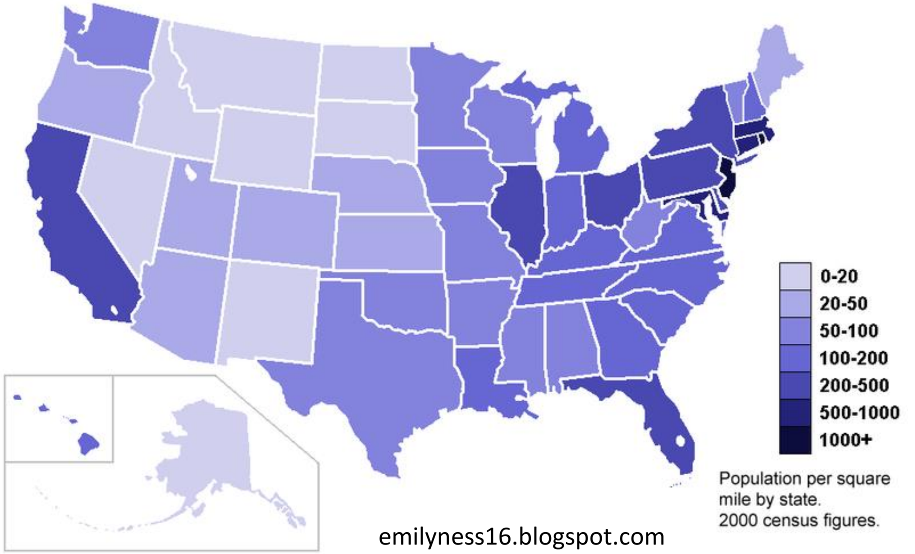
Types of maps

- Land use maps

- Choropleth maps



mapas.owje.com



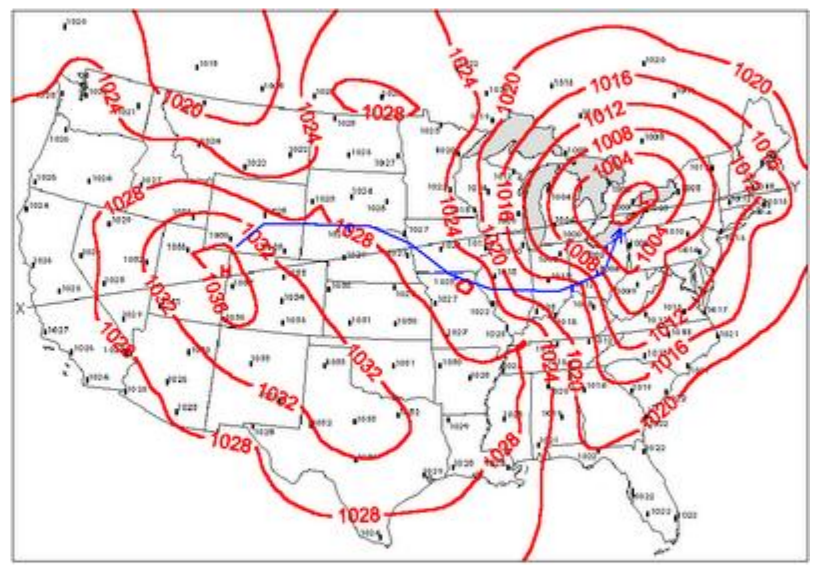
emilyness16.blogspot.com

Types of maps

- Line diagrams

commons.wikimedia.org

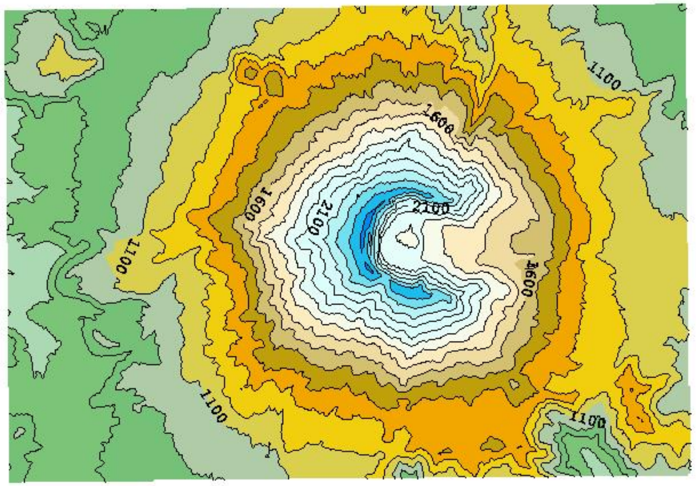
- Isoline diagrams

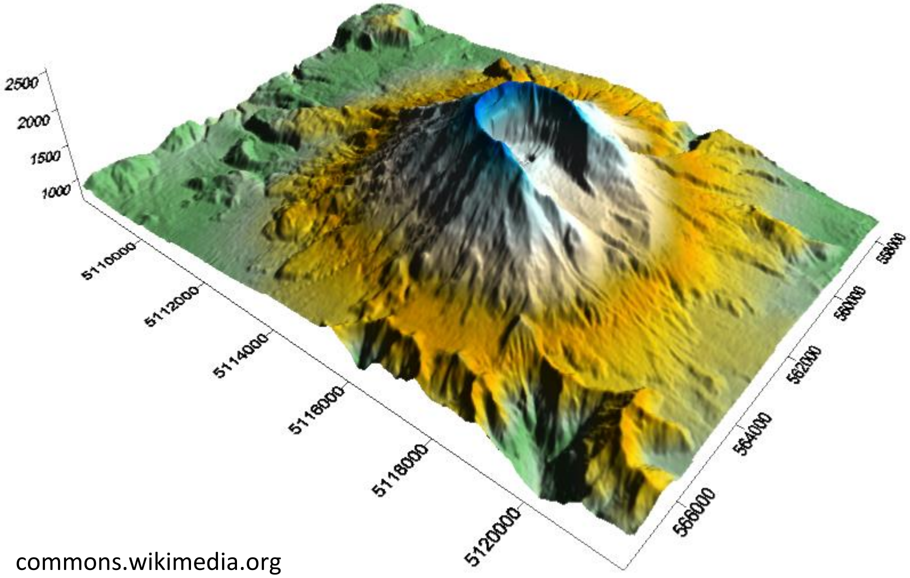


pawsomemonkey.blogspot.com

Types of maps

- Surface maps

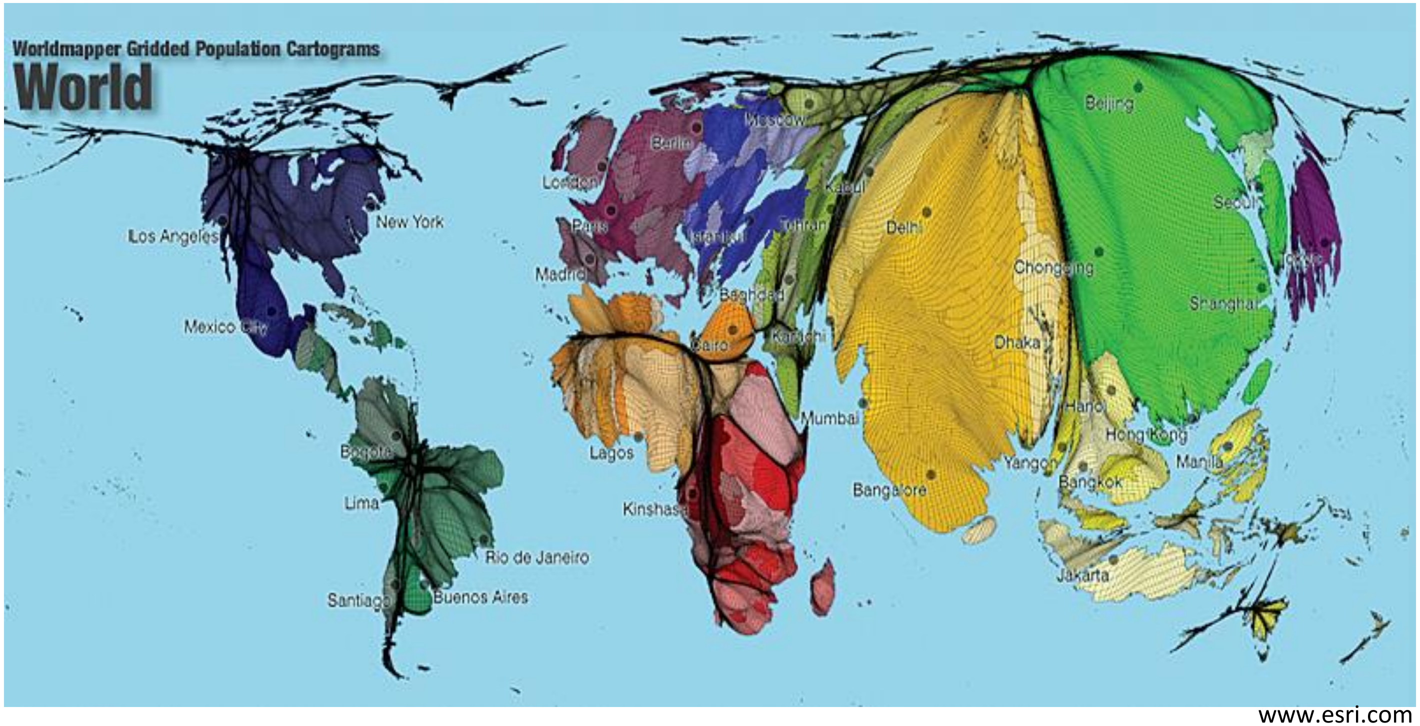




commons.wikimedia.org

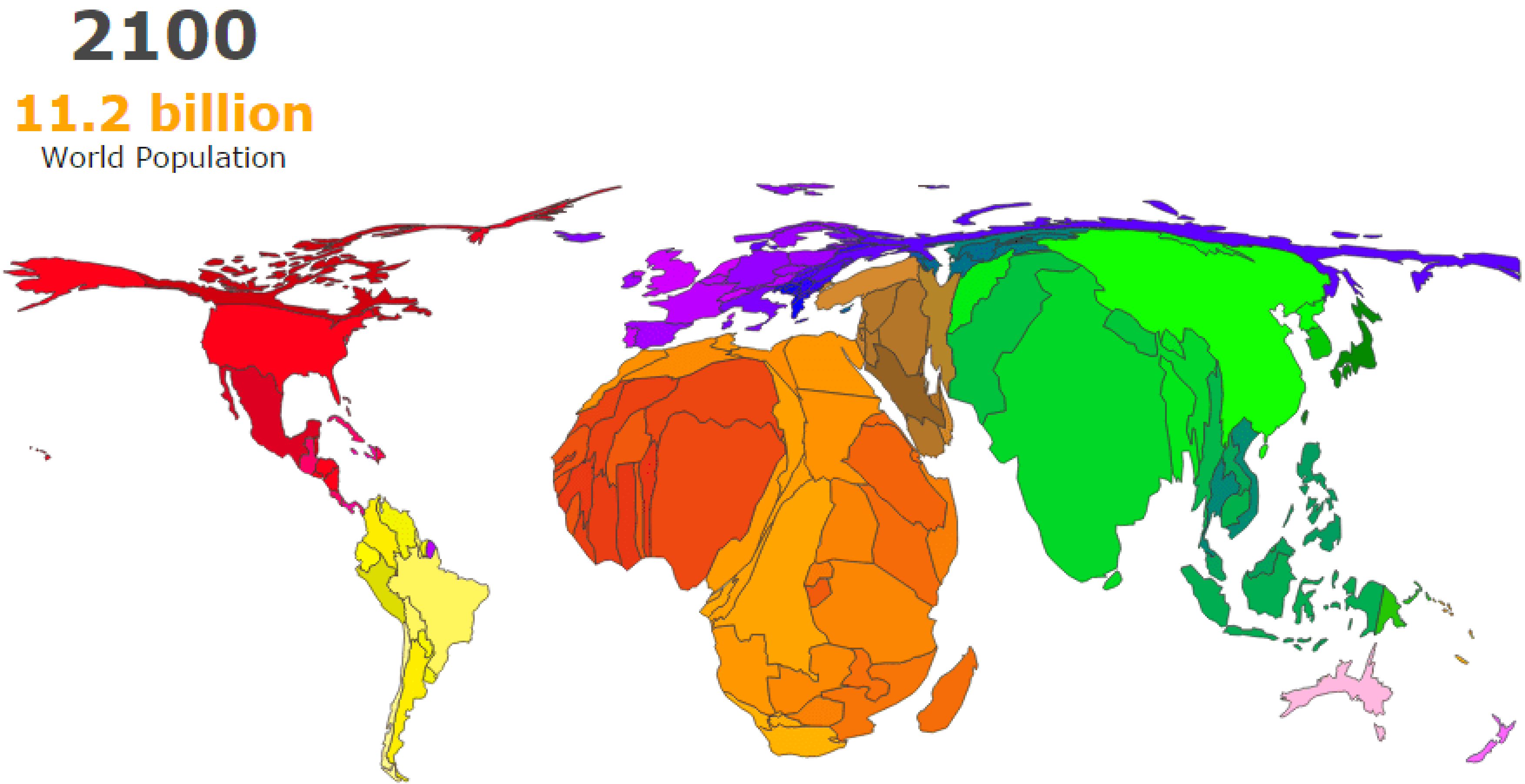
Different types of representation

- Same data visualized using different types of maps
- E.g., **cartogram** – world population

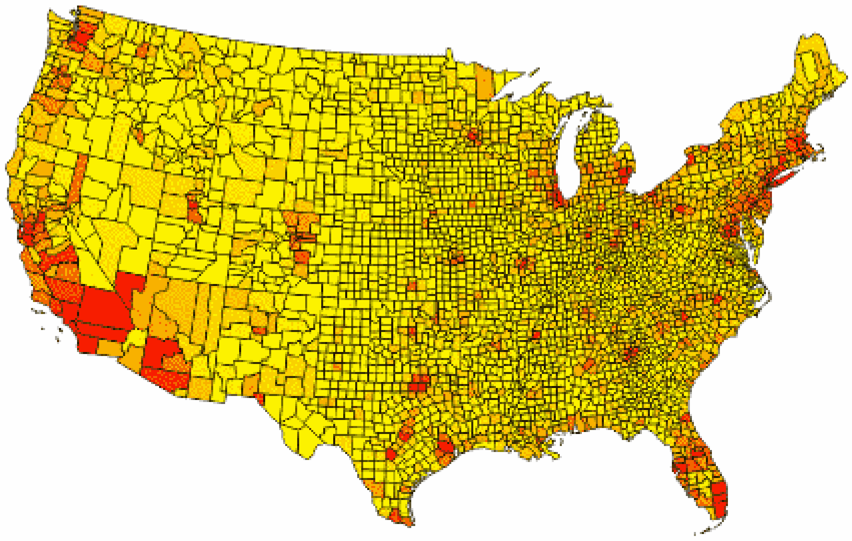


www.esri.com

Cartograms



Animated cartograms



Exploratory geovisualization

- Interaction is crucial
  - Cooperation with the user
  - Interactive querying

- Combination of maps with:
  - Statistical visualization – bar charts, line charts
  - Complex techniques for multidimensional data visualization (e.g., parallel coordinates)

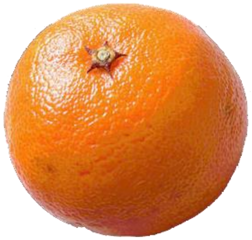
Map projection

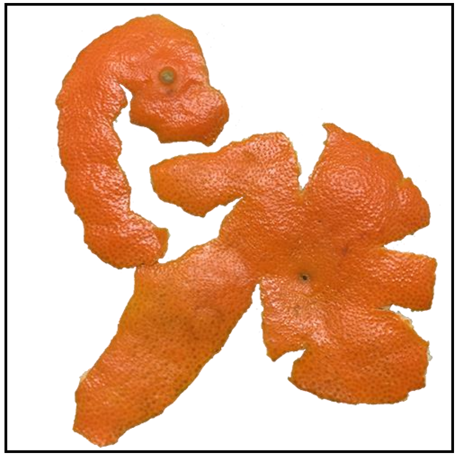
- Mapping of positions on the globe to positions on screen (from sphere to plane)
- Defined as:

$$\mathbf{\Pi: (\lambda, \phi) \rightarrow (x, y)}$$

where **λ** is longitude in range [-180, 180]

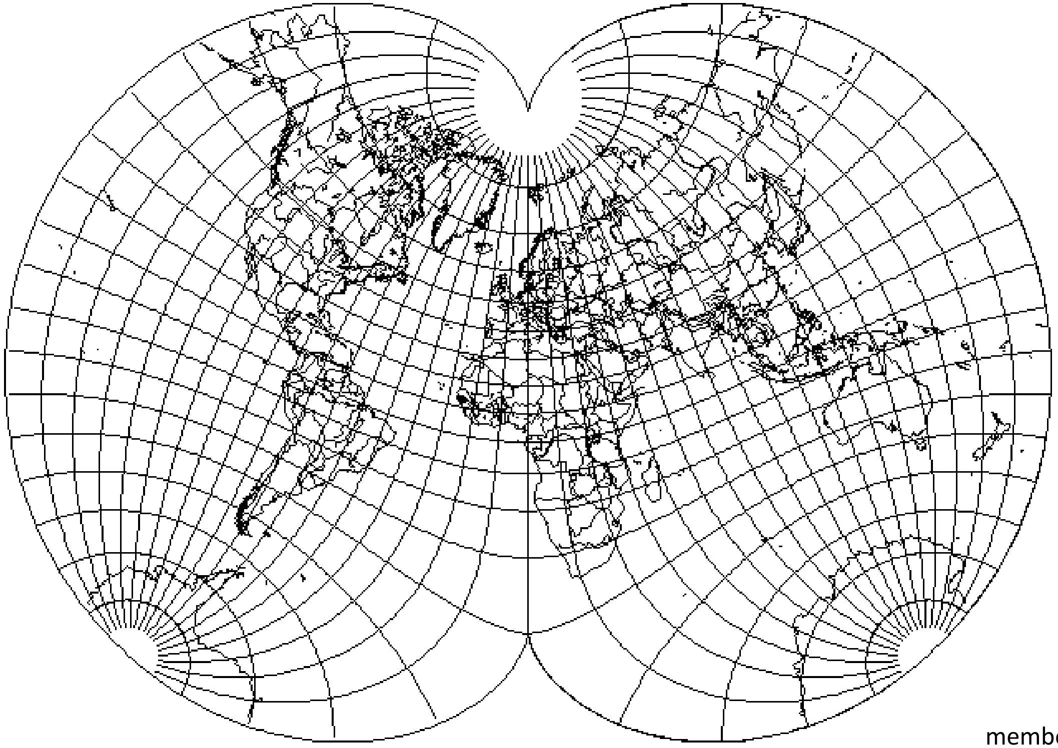
ϕ is latitude in range [-90, 90]





Map projections

- Conformal projections
  - Preserve local angles → shapes, the area is not preserved



members.shaw.ca

Map projections

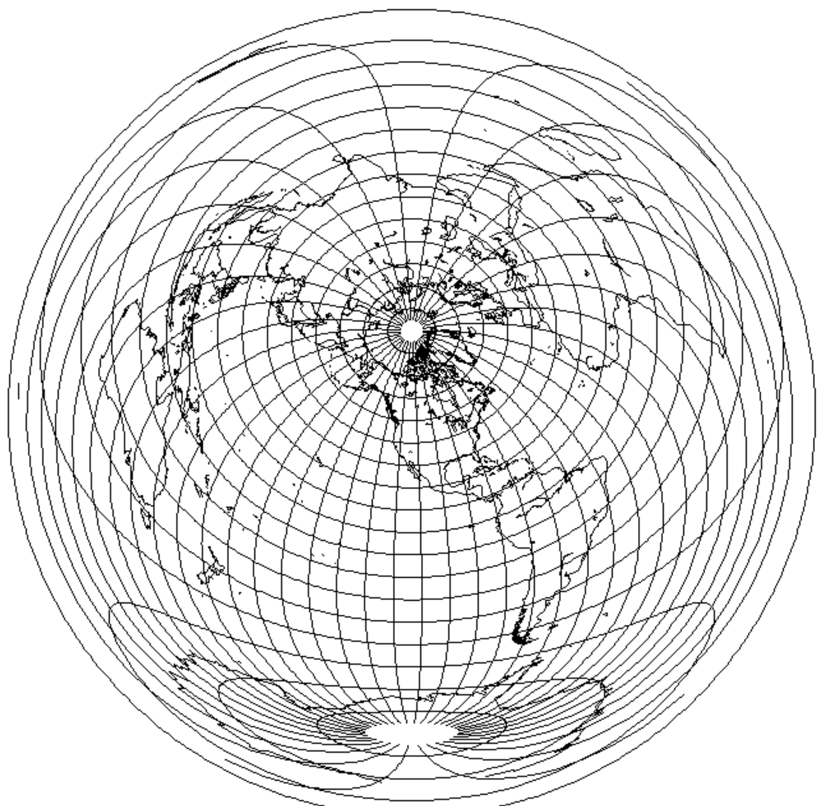
- Equivalent projections, equal area
  - Show only part of the map, distorts shape and angles

The Lambert planar equal-area projection is mathematically derived to display the property of equivalence.

http://gis.nic.in/gisprimer/projections1.html

Map projections

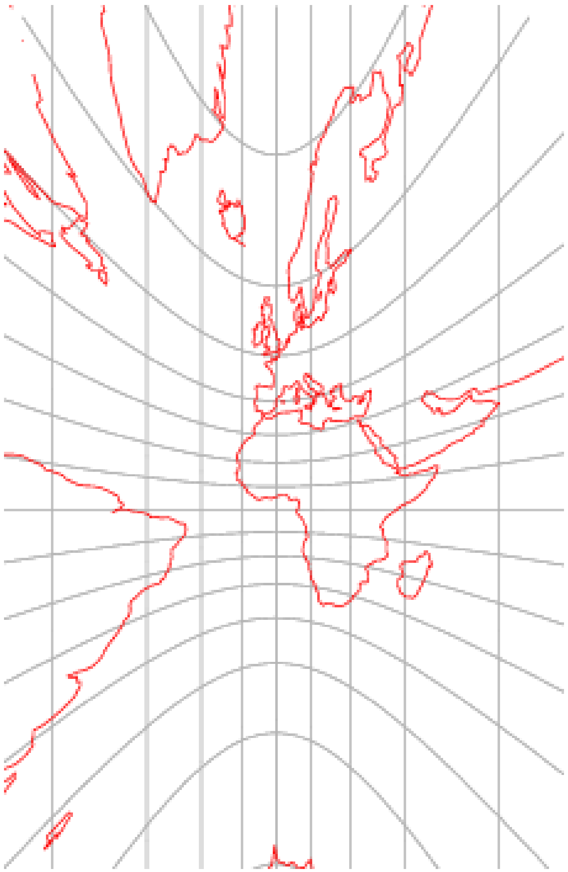
- Equidistant projections
  - Preserve distance from point or line



members.shaw.ca

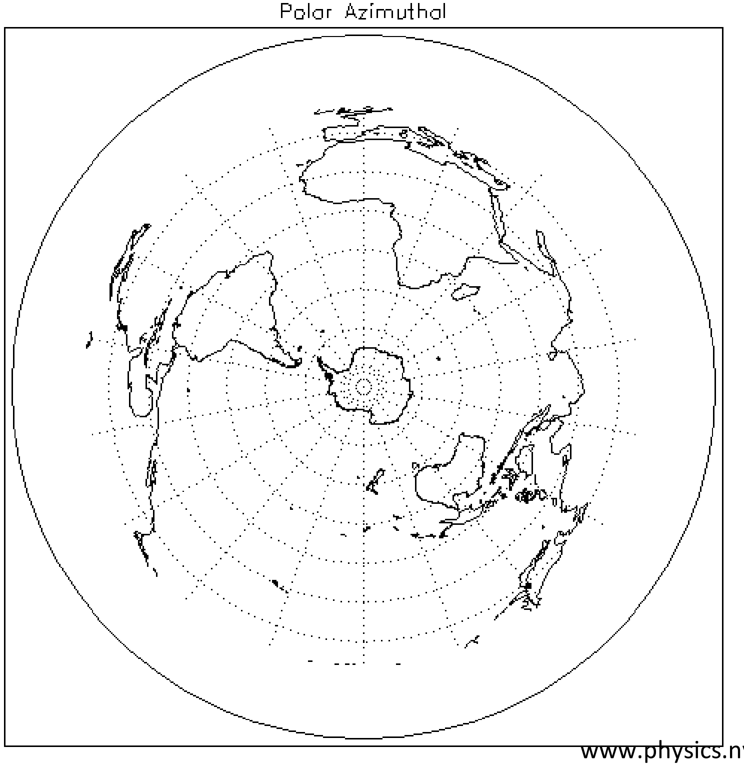
Map projections

- Gnomonic projections
  - Show meridians and parallels of latitude as lines
  - Preserve the shortest path between two points
  - We cannot show the whole hemisphere (borders are heading to infinity)



Map projections

- Azimuthal projections
  - Preserve the direction from the central point, radially symmetrical

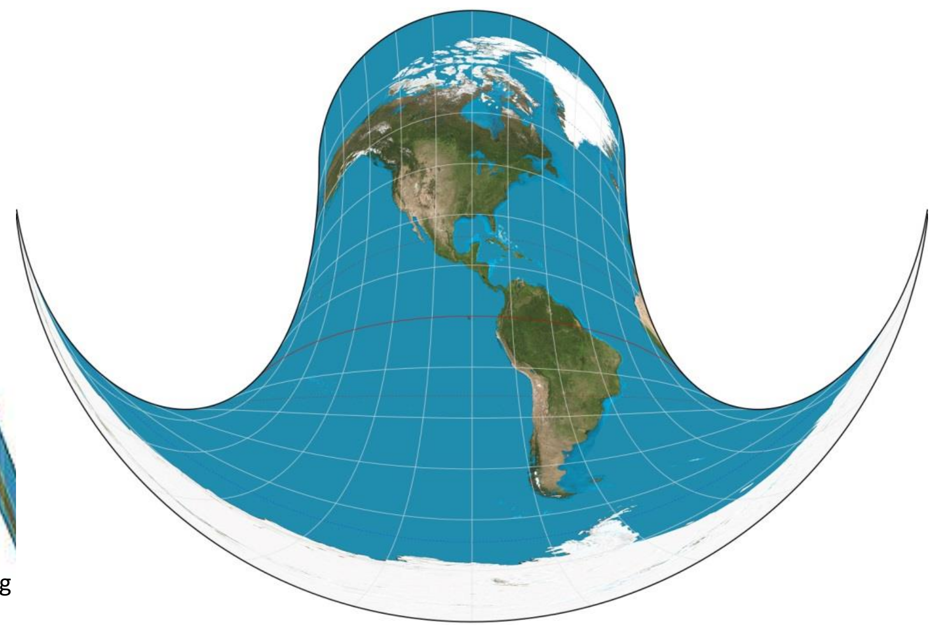


www.physics.nyu.edu

Map projections

- Retroazimuthal projection
  - Direction from point S to a fixed point L corresponds to the direction from S to L on the map

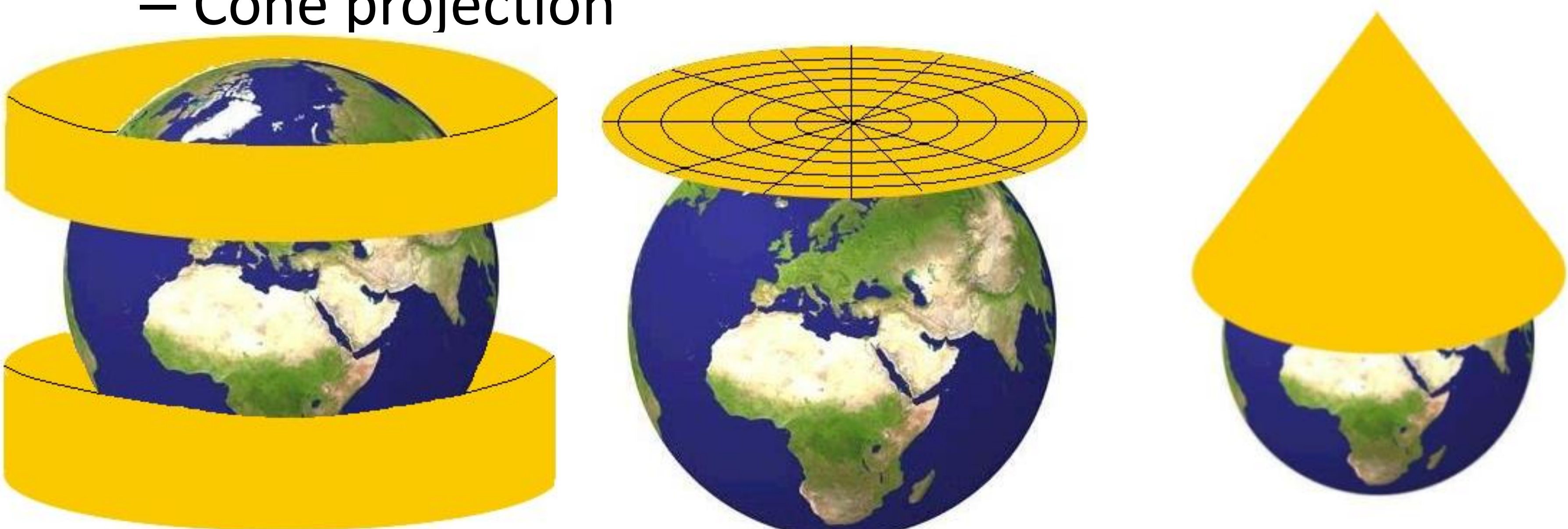
en.wikipedia.org



commons.wikimedia.org

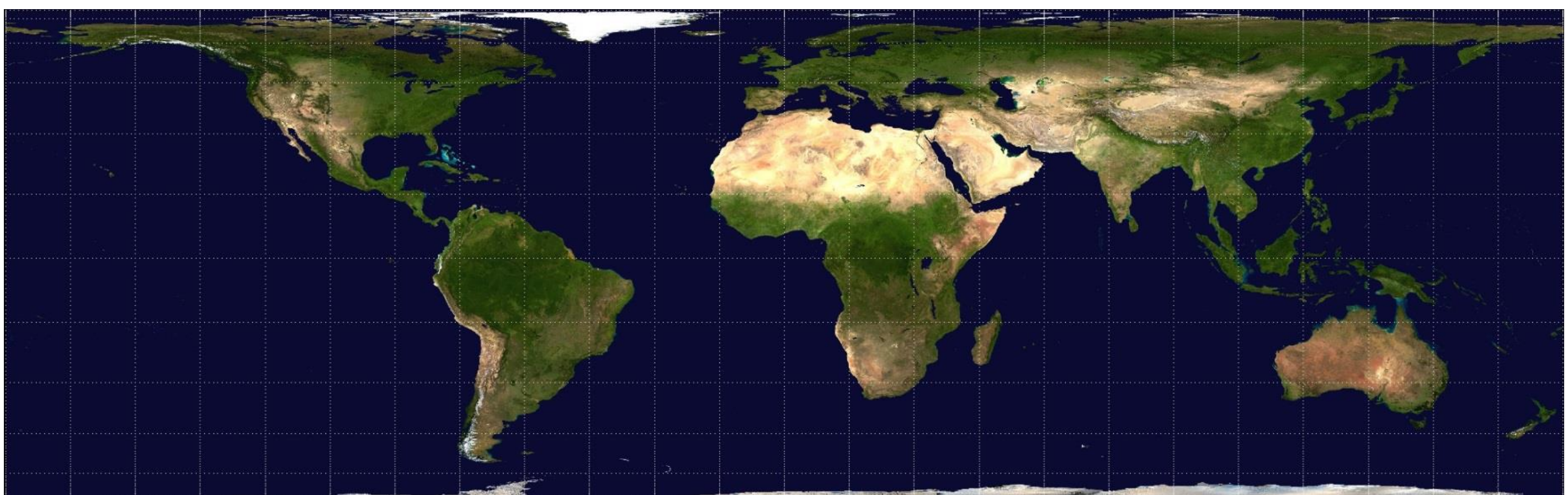
Map projections – classification according to type of surface

- Sphere can be projected onto different surfaces:
  - Cylindrical projection
  - Planar projection
  - Cone projection



Cylindrical projection

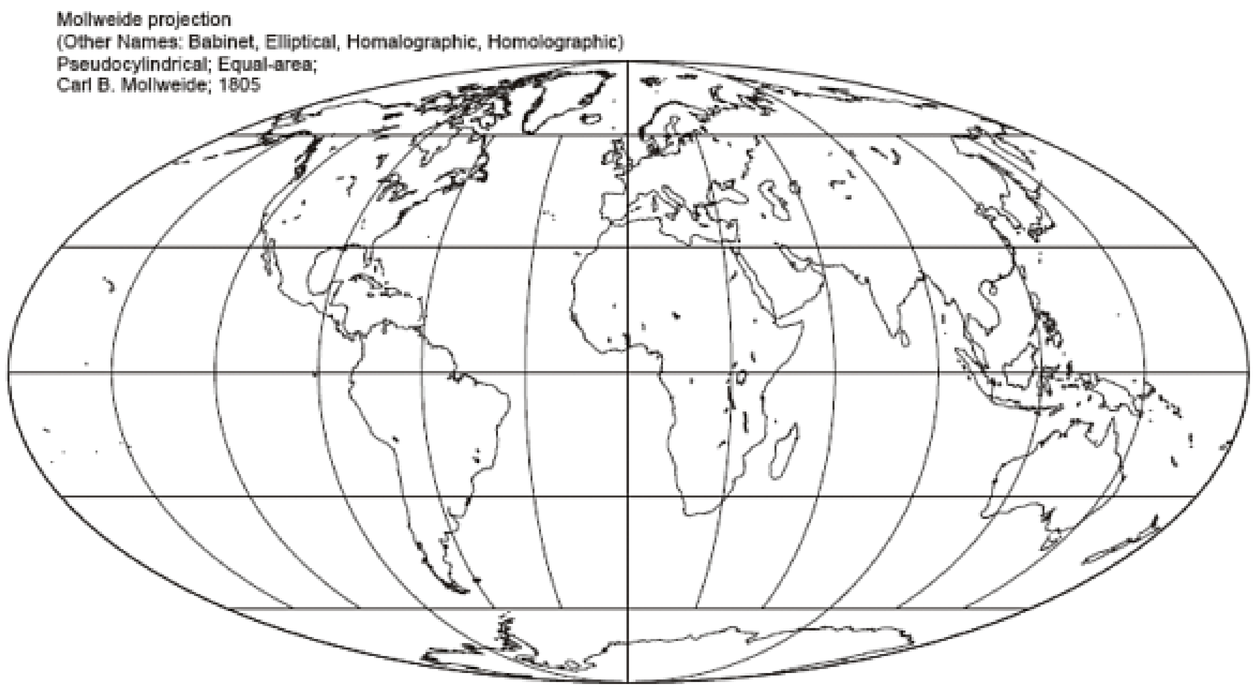
- Projecting the sphere surface onto cylinder positioned around the sphere
- Shows the whole spherical surface
- Conformal projection – preserves local angles



commons.wikimedia.org

Pseudo-cylindrical projection

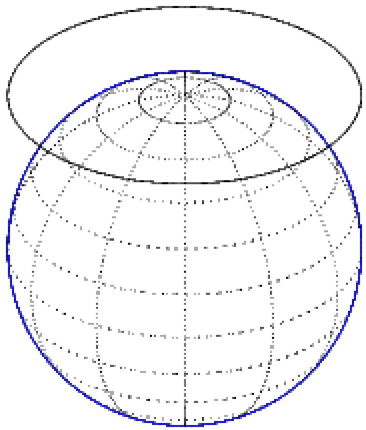
- Prime meridian and parallels are straight lines, other meridians are distorted

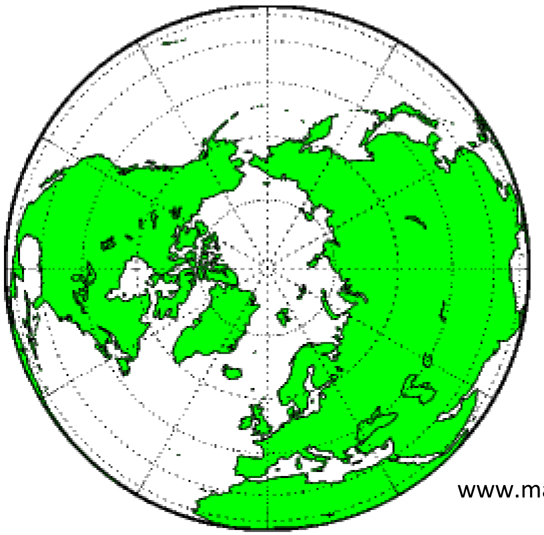


www.geowebguru.com

Planar projection

- Azimuthal projection mapping the sphere surface onto a plane tangential to the sphere
- Tangential point corresponds to the center of projection





www.mathworks.com

Cone projection

- Mapping of sphere surface on the tangential cone
- Latitude = spheres with centers in the center of projection
- Longitude = straight lines from the center of projection

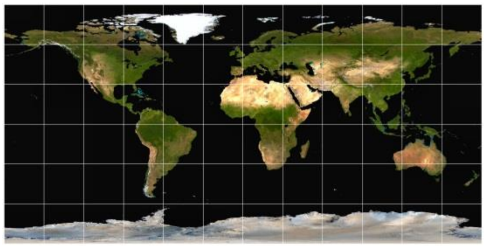
en.wikipedia.org

Examples of commonly used map projections

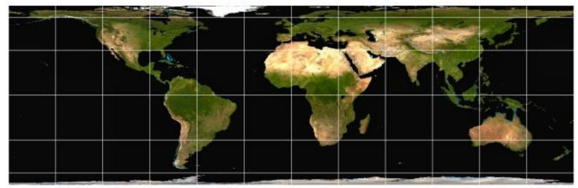
- Variables used in map projections:

ϕ	measured degrees of latitude in radians
λ	measured degrees of longitude in radians
x	horizontal axis of the two-dimensional map
y	vertical axis of the two-dimensional map
ϕ_0; λ_0	latitude of the standard parallel resp. meridian measured in radians

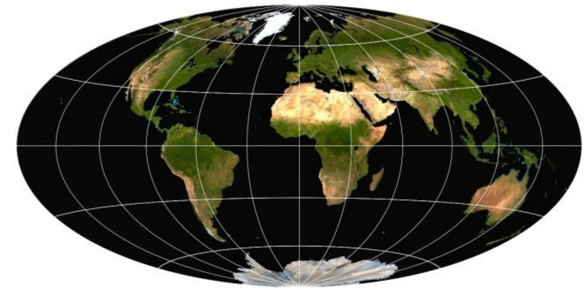
Different map projections



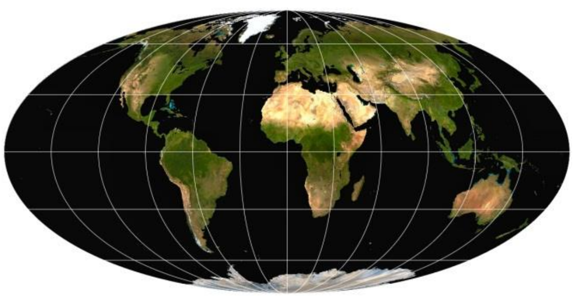
Equirectangular



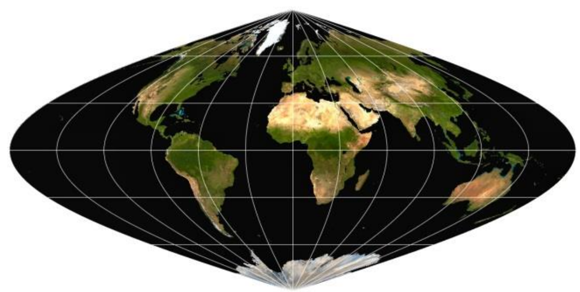
Lambert cylindrical



Hammer-Aitoff



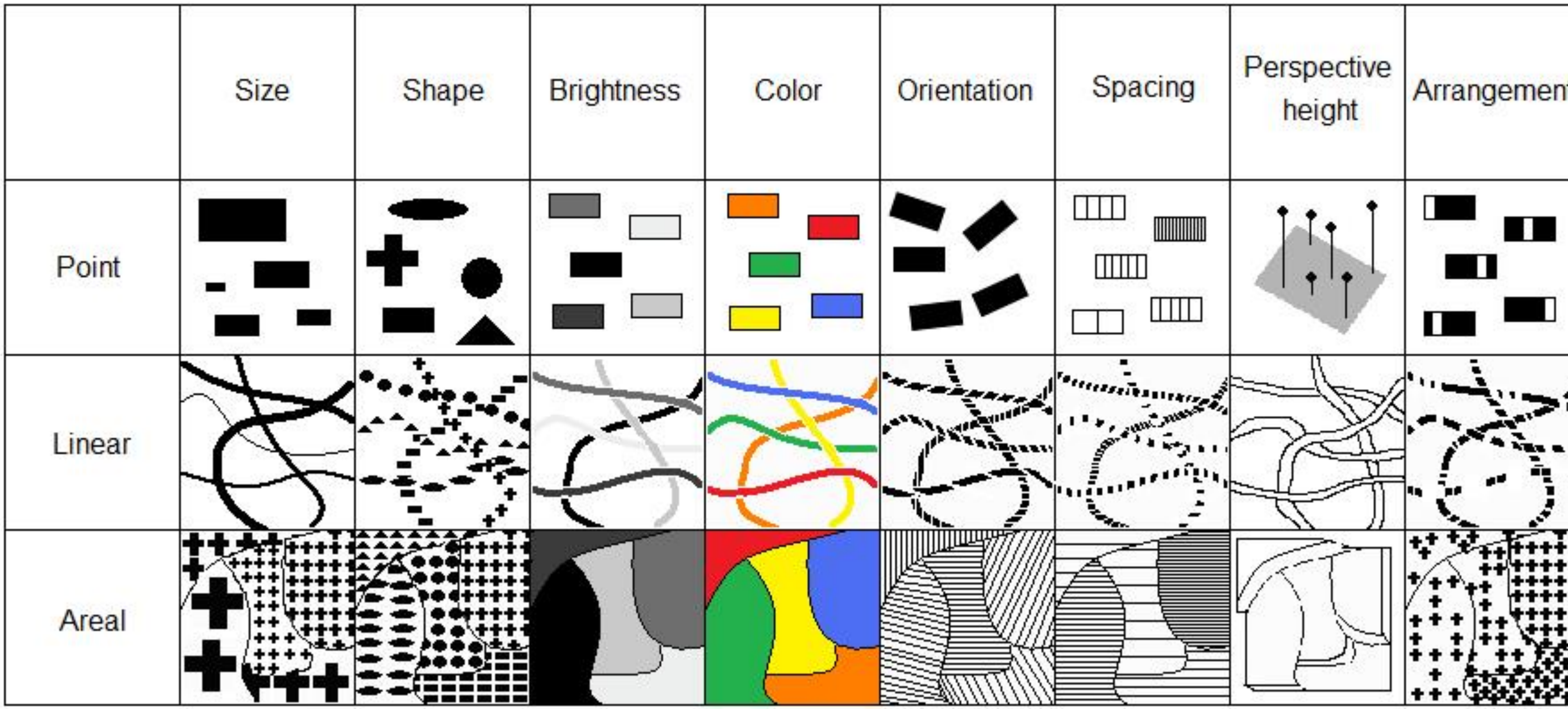
Mollweide



Cosinusodial

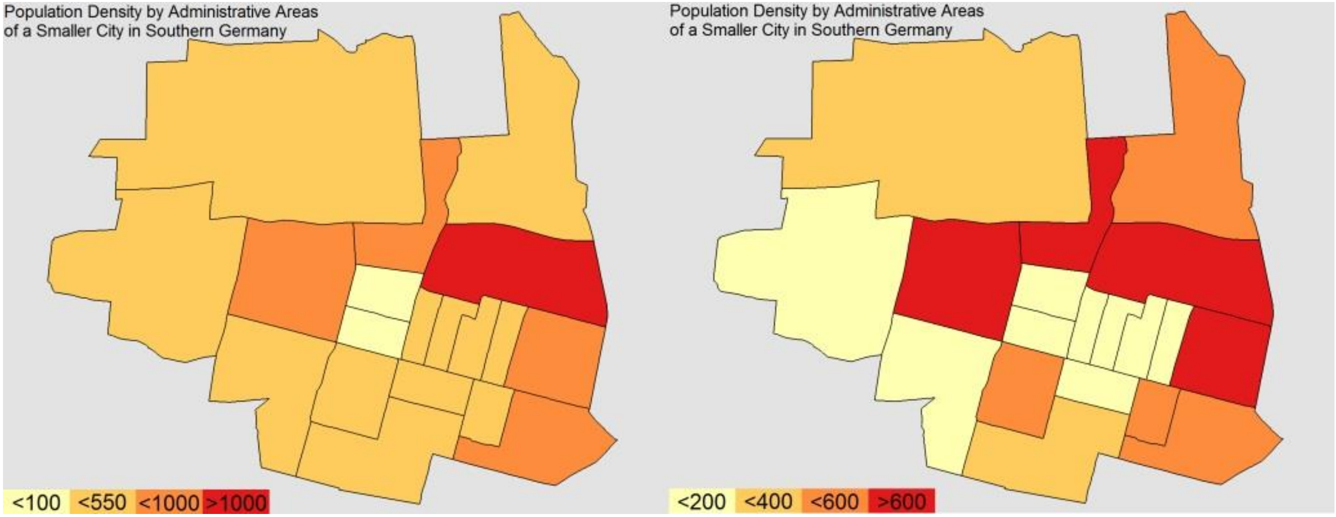
Albers equal-area conic

Visual variables for spatial data



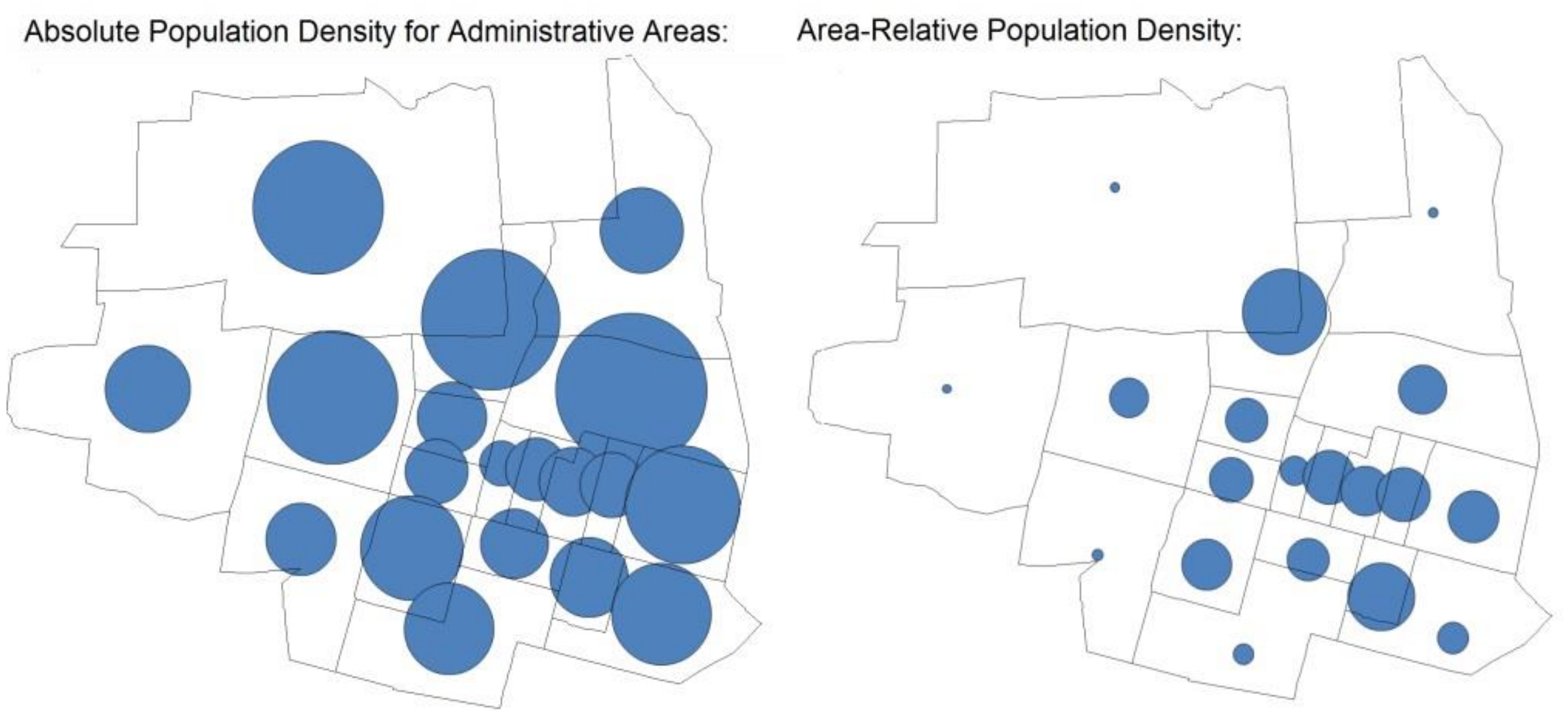
Influence of input data corrections onto the resulting map

- Sampling, segmentation, normalization, … can influence the map a lot
- Different thresholds → different „borders“→ different results:



Influence of input data corrections onto the resulting map

- Difference between absolute and relative (here according to population size) mapping

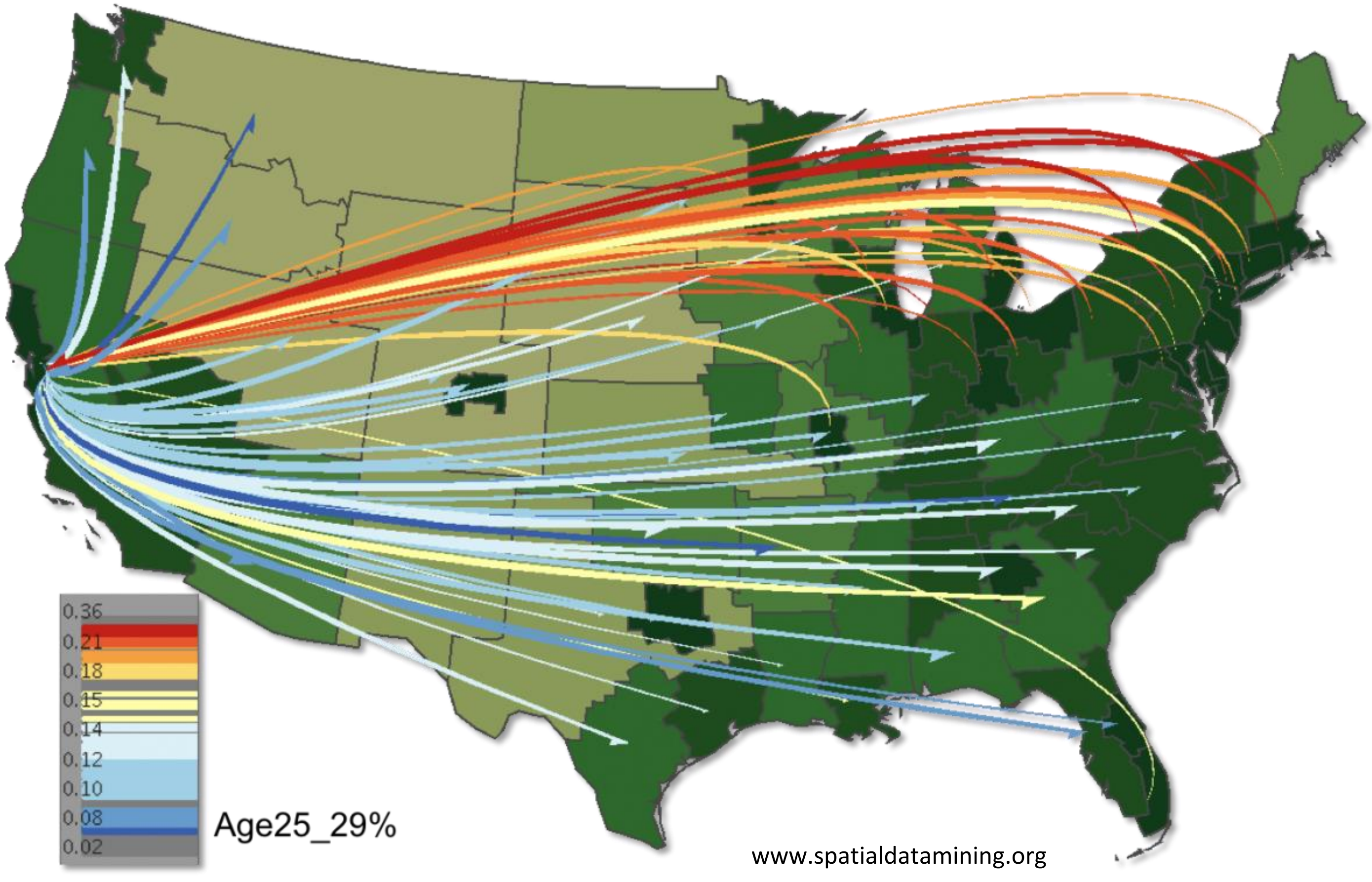


Influence of input data corrections onto the resulting map

- Different clustering = different maps

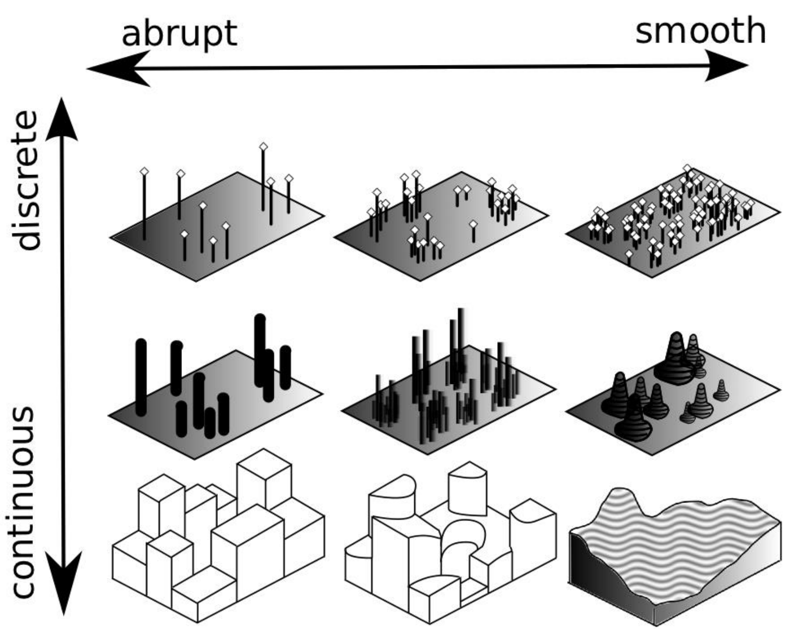
Geovisualization

- Three basic types of objects:
  - Points
  - Lines
  - Areas



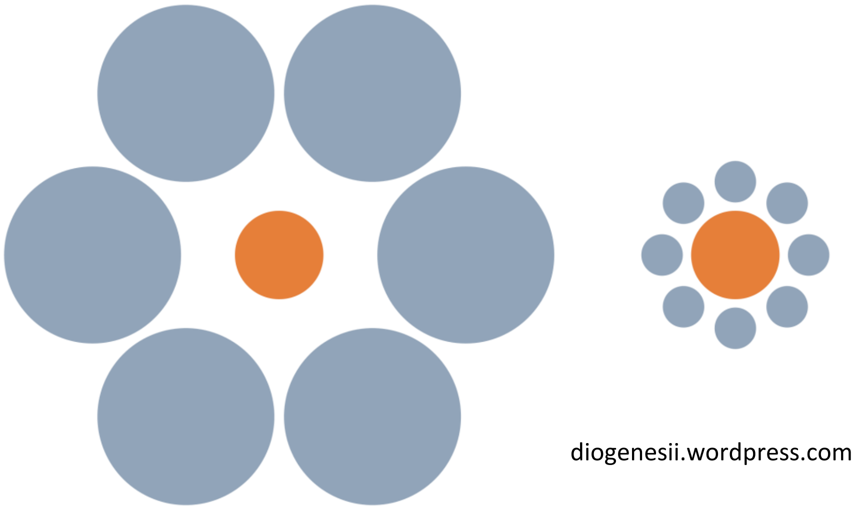
Point data visualization

- Discrete, but can describe a continuous phenomenon (e.g., measuring of temperature in a given spot)
- From discrete to continuous, from smooth to abrupt



Point maps

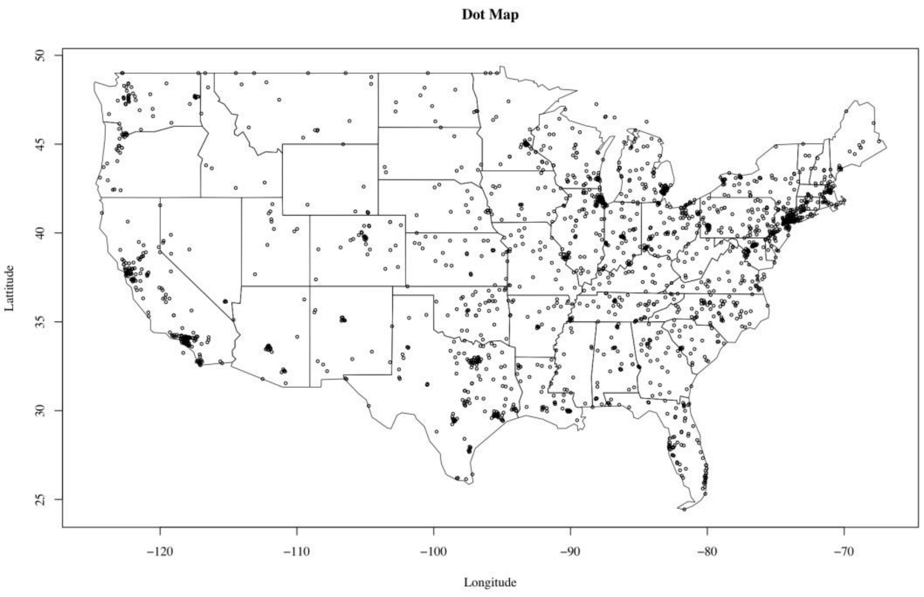
- Quantitative parameter can be mapped onto size or color
- Beware of size – correct values for symbol sizes does not mean that we are percieving it correctly!!!
- Ebbinghaus illusion:

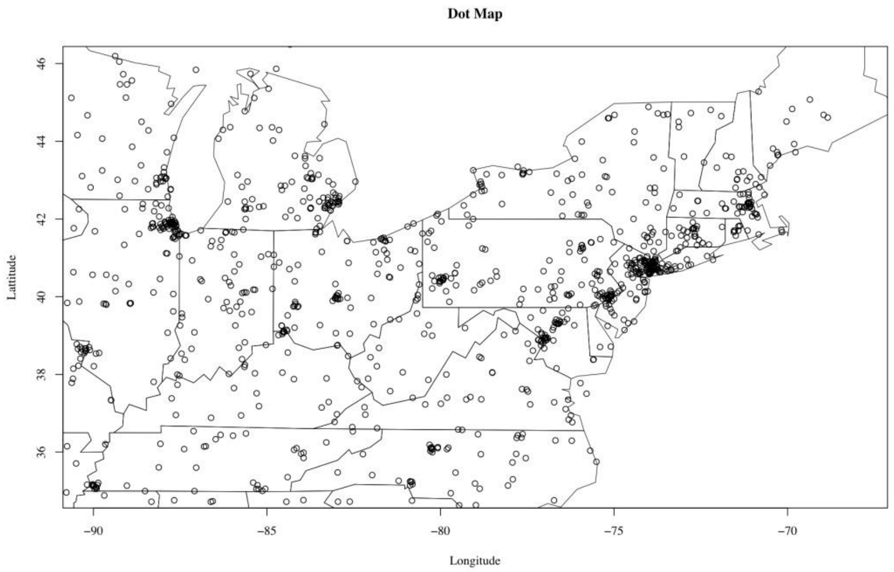


diogenesii.wordpress.com

Distribution of points

- Possible overlaps in areas with dense data

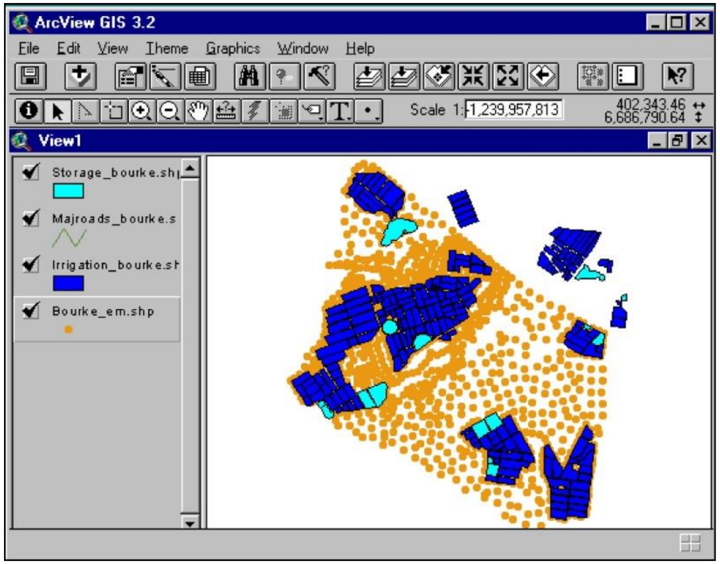




Daniel A. Keim, Christian Panse, and Mike Sips. "Visual Data Mining of Large Spatial Data Sets." In Databases in Networked Information Systems, Lecture Notes in Computer Science, 2822, Lecture Notes in Computer Science, 2822, pp. 201–215. Berlin: Springer, 2003.

Methods for visualizing dense point maps

- 2.5D visualization aggregating data points to regions



- Data points visualized as bars

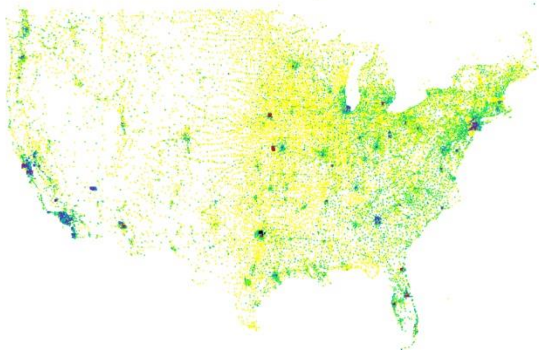
PixelMaps

- Shifting the overlapping pixels
- Recursive algorithm utilizing quad-tree
  - Dividing into 4 subregions
  - We divide until the space in the subregion is bigger than the number of pixels in this subregion
  - Finally we perform the „pixel placement“ algorithm – it places the first data item to its correct position and the subsequent data items are placed to the nearest free positions

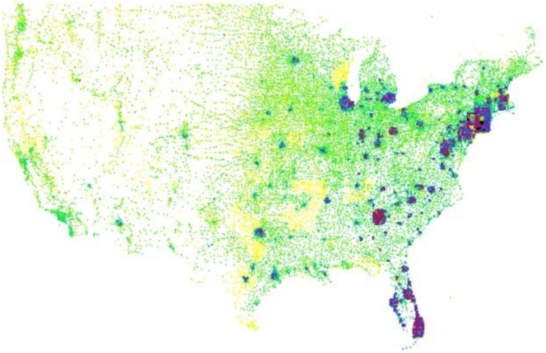
PixelMaps

- Problem – in datasets with high overlaps the positioning depends on the order of the data stored

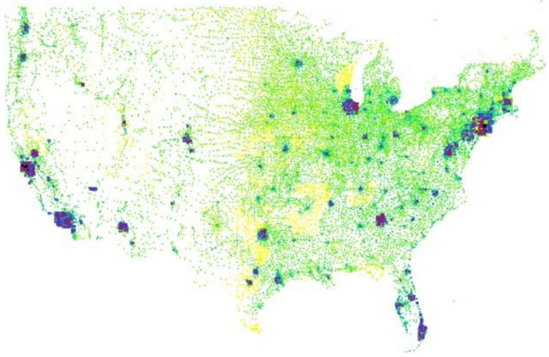
  in database



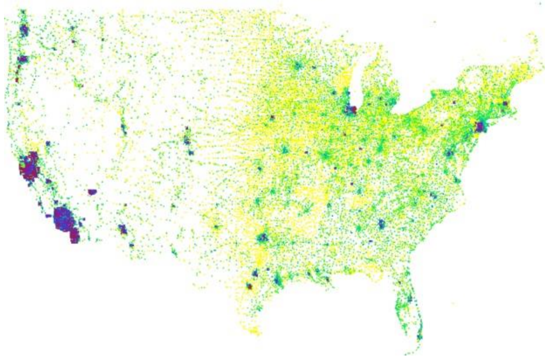
0:00 am (EST)



6:00 am (EST)



10:00 pm (EST)

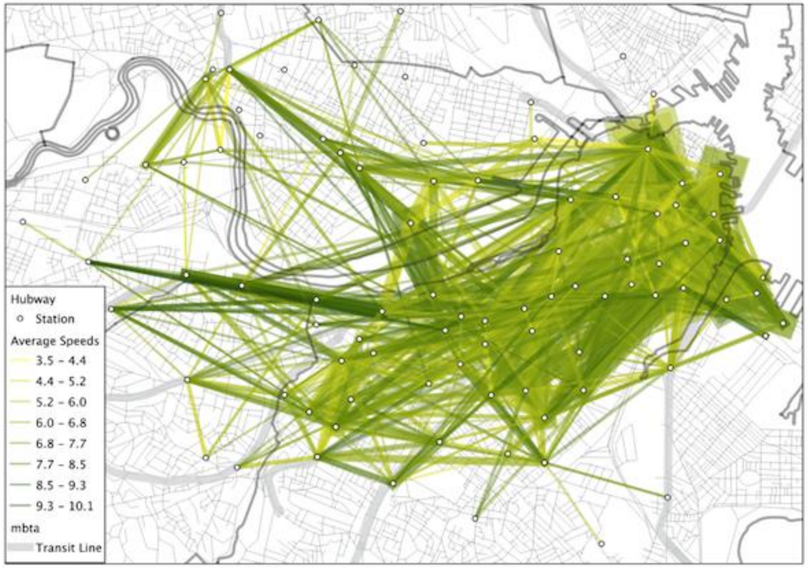


6:00 pm (EST)

Line data visualization

- Representation of linear phenomena using line segments between two endpoints defined by their longitude and latitude
- Other parameters of data mapped onto line width, pattern,

  color, labeling

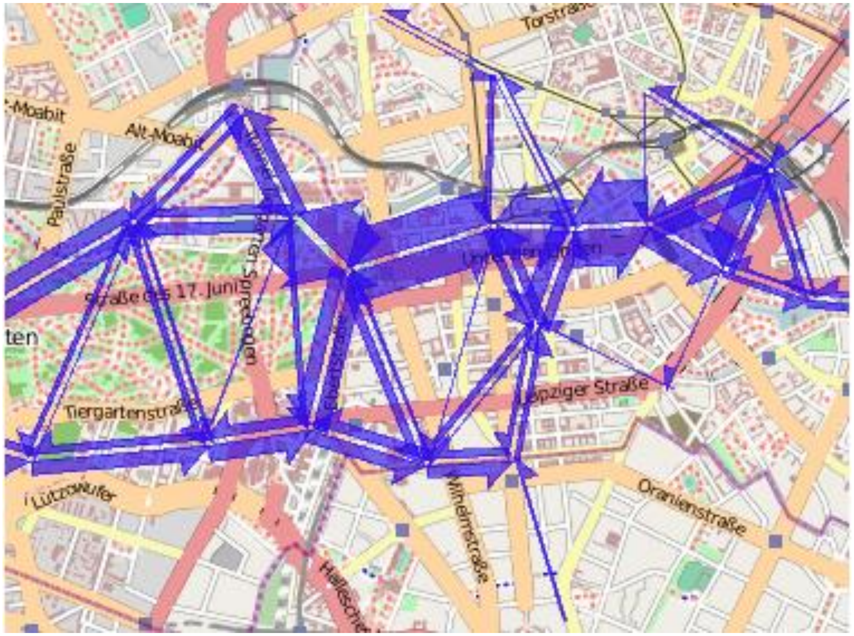


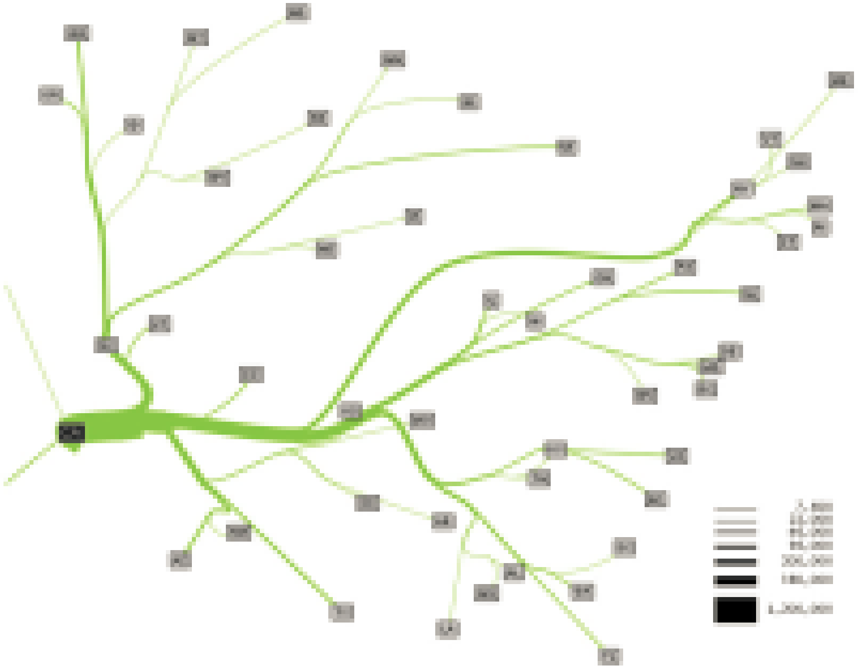
www.theatlanticcities.com

Flow maps

- Eliminating line intersections and deformations of node positions while keeping their relative position

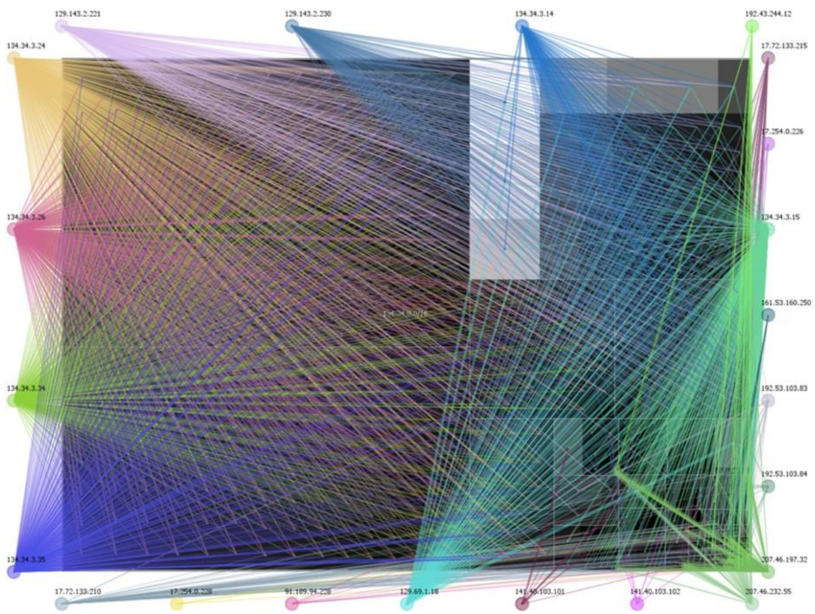
- Flow of tourists in Berlin vs. migration from California

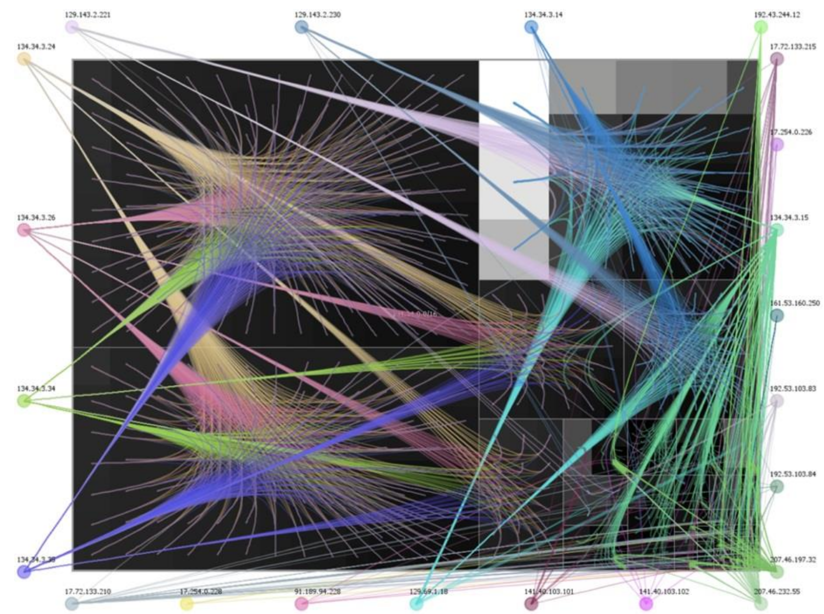




Flow maps

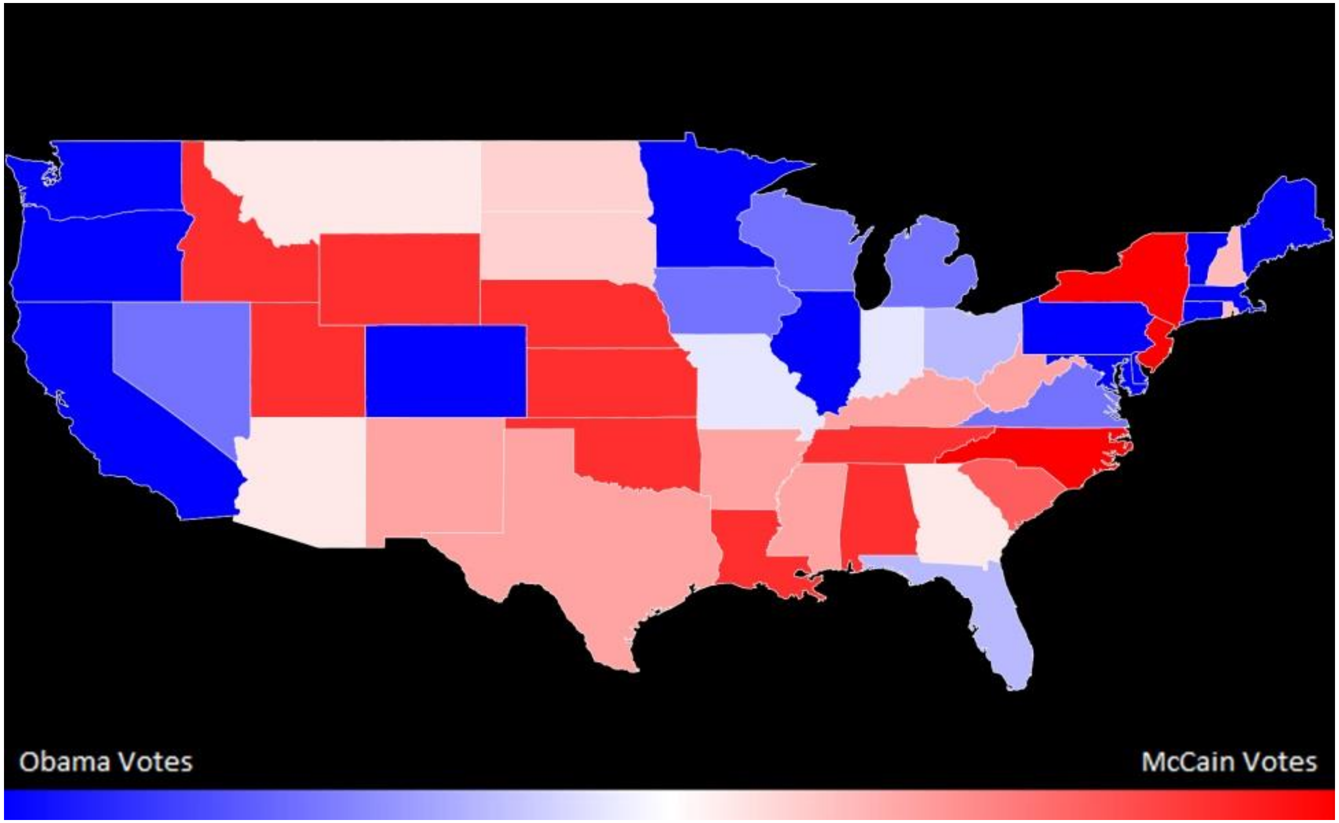
- Edge bundling – highlighting relations, bending of edges





Area data visualization

- **Thematic maps** are the most commonly used
- Most popular = **choropleth maps**



Area data visualization

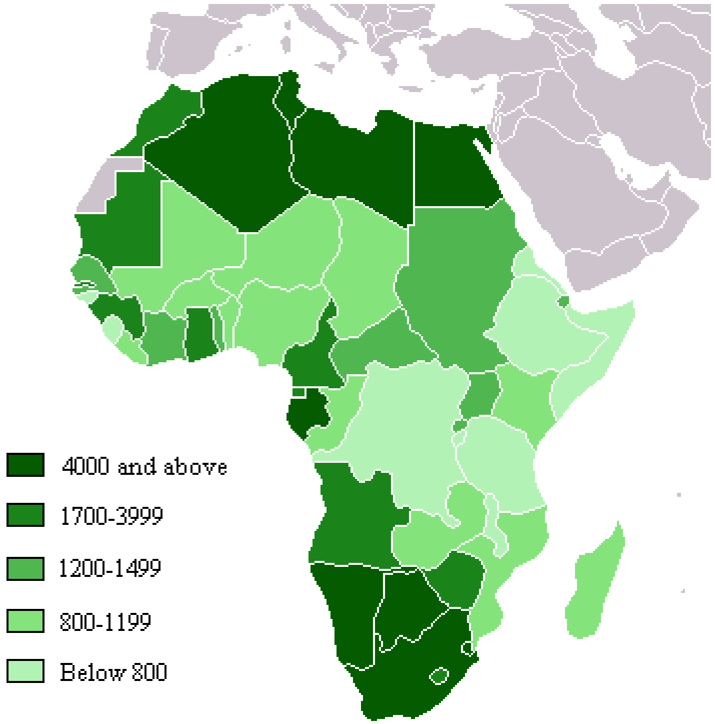
- Dasymetric maps – if we don't know the data distribution according to regions
- Isarhytmic maps – contours of continuous phenomena

Area data visualization

- Isometric maps – contours derived from real data points (e.g., temperature at a given spot)
- Isopleths – data point is considered to be the center of gravity in a given region
- Cartograms – scaling of region size in order to visualize statistical information

Choropleth maps

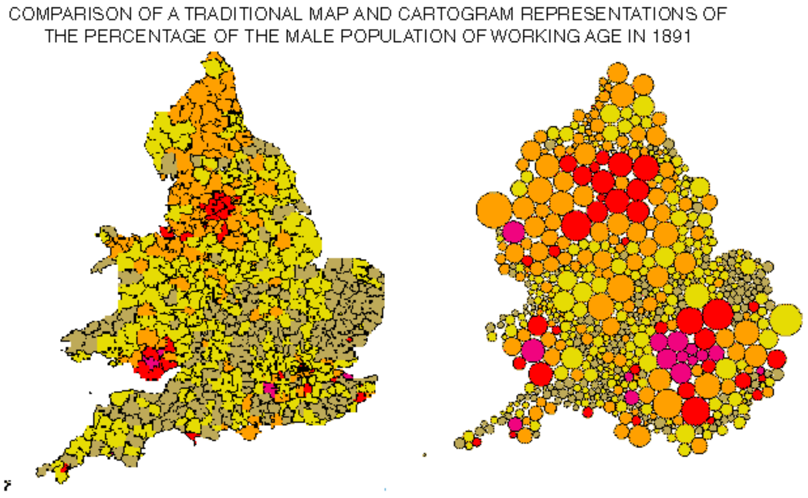
- Area phenomena visualized as shaded polygons enclosed by a contour
- Countries, parcs, …
- Problem:
  – Interesting values in densely populated areas
  – mostly small polygons



ahunsberger.blogspot.com

Cartograms

- Generalization of thematic maps, tries to avoid problems of choropleth maps
- Size of regions is changing according to given input variable associated with the geographic position of input data



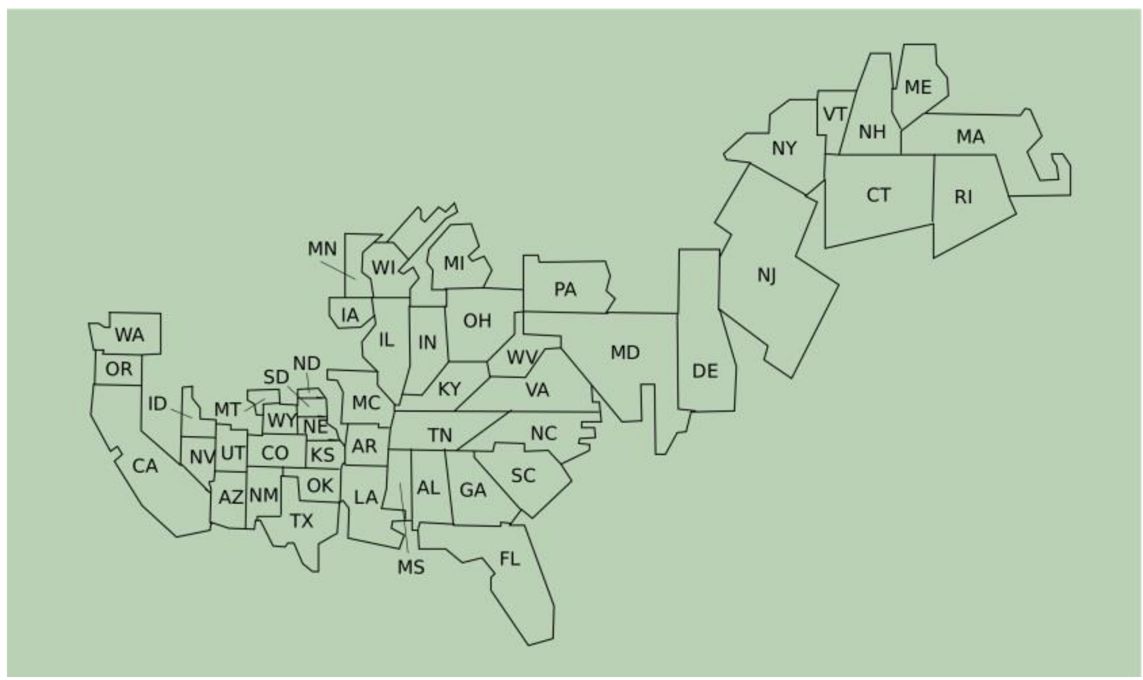
www.csiss.org

Noncontinuous cartograms

- Do not preserve topology
- Scaled polygons are positioned inside the original polygons
- Original size of polygons limits the size of the resulting polygons (especially when enlarging them)

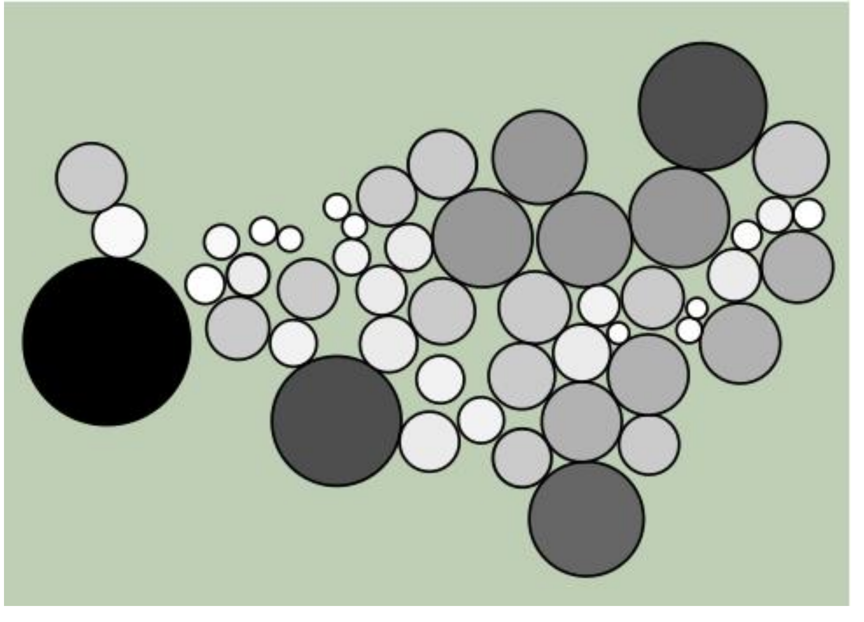
Noncontiguous cartograms

- Scaling all polygons to their desired size
- Polygons do not preserve global topology and neighboring



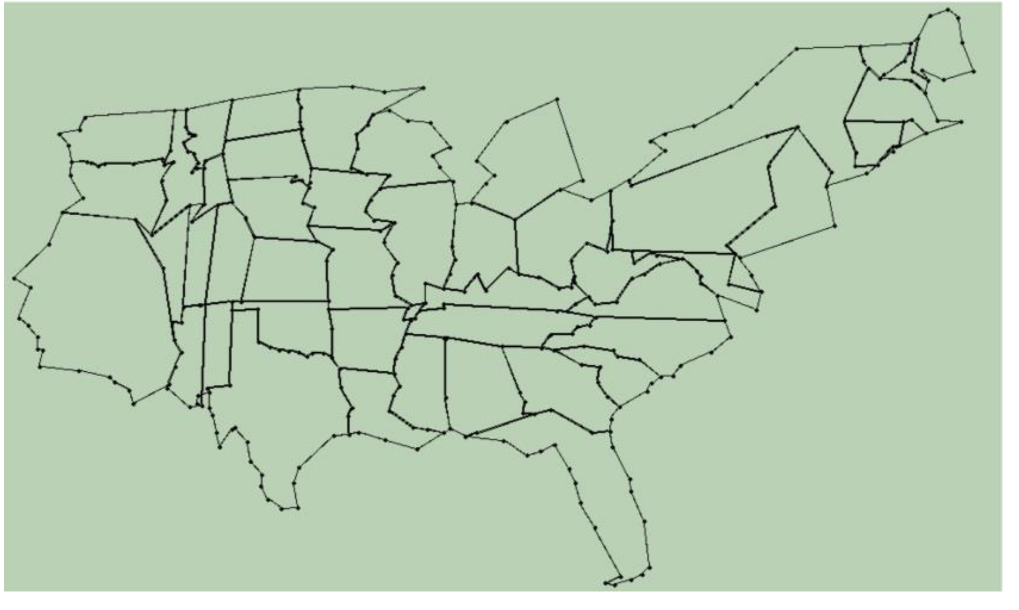
Circular cartograms

- Ignore the original shape of input polygons, they are represented by circles
- Relaxation of area and topological limitations = similar problems as the previous case



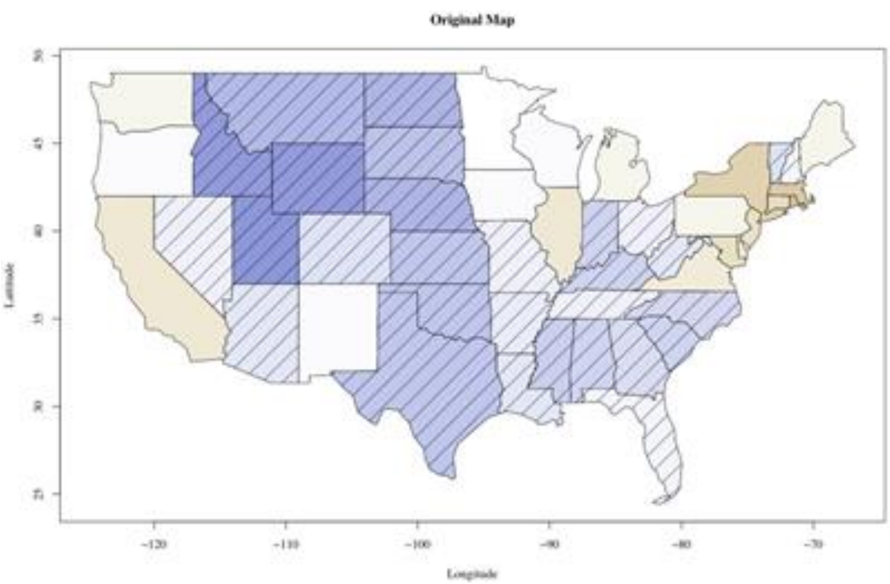
Continuous cartograms

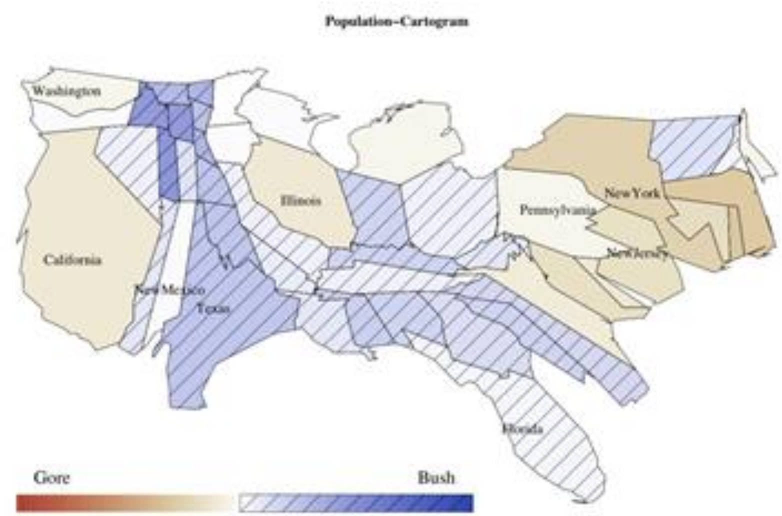
- Preserve the topology of the map
- Relaxation of area and shape limitations
- From all cartograms, this type preserves the best the topology of the original map



Cartograms

- Manual creation is complicated, automatic techniques are therefore popular
- Preserve shape x preserve area

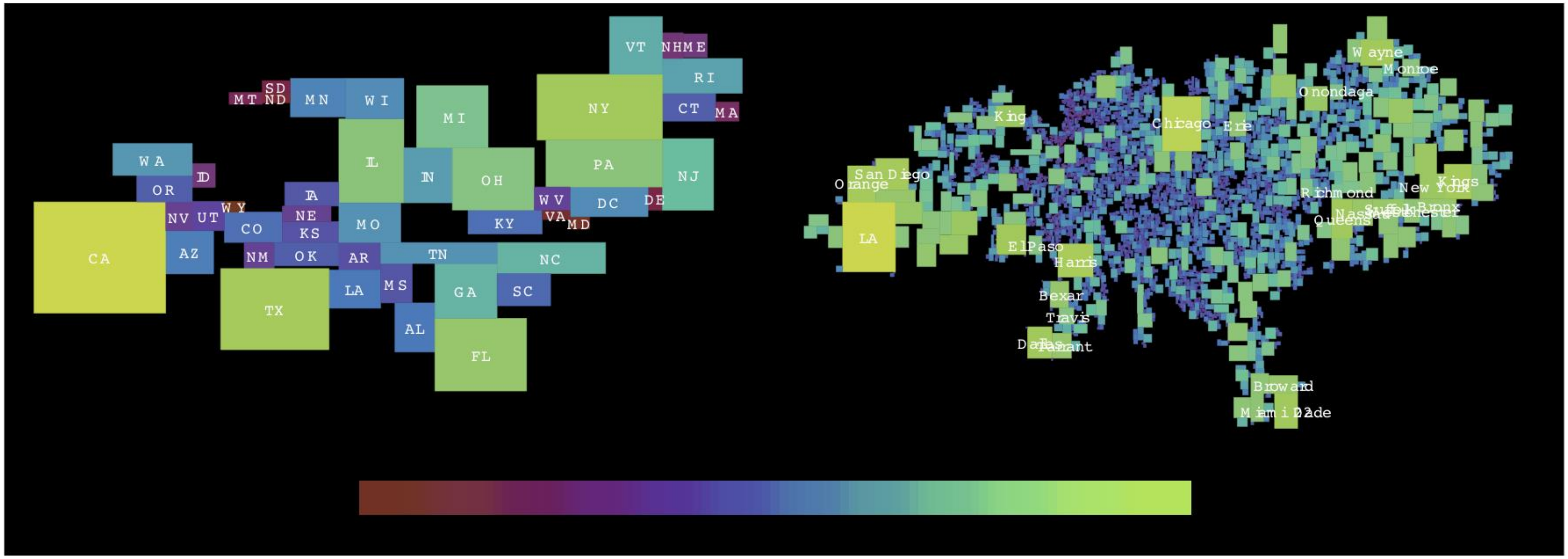




Rectangular cartogram

- Approximation of regions by rectangles
- Division of the available screen space
- Rectangles are positioned as close as possible to the original positions and to the original neighbors
- **RecMap** algorithm

RecMap algorithm

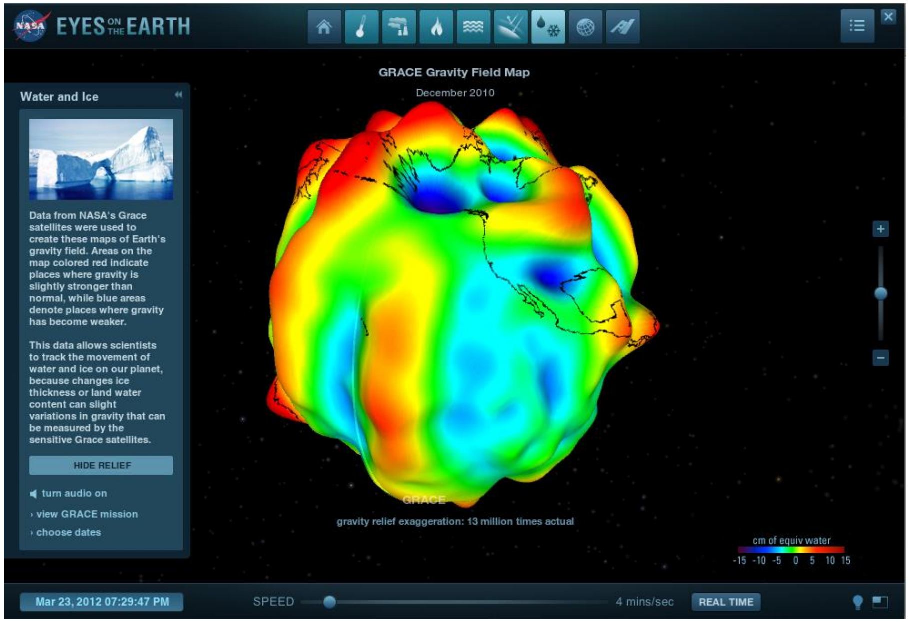


Map labeling

- Positioning of text or image labels to the proximity of points, lines, and polygons
- Set of different algorithms solving this problem, with different efficiency and quality of results
- Mostly based on heuristic methods

NASA Updates Eyes on Earth Visualization Site

- https://eyes.nasa.gov/eyes-on-the-earth.html



SpaceTime cube

- Geographic location on map
- Time in z-axis