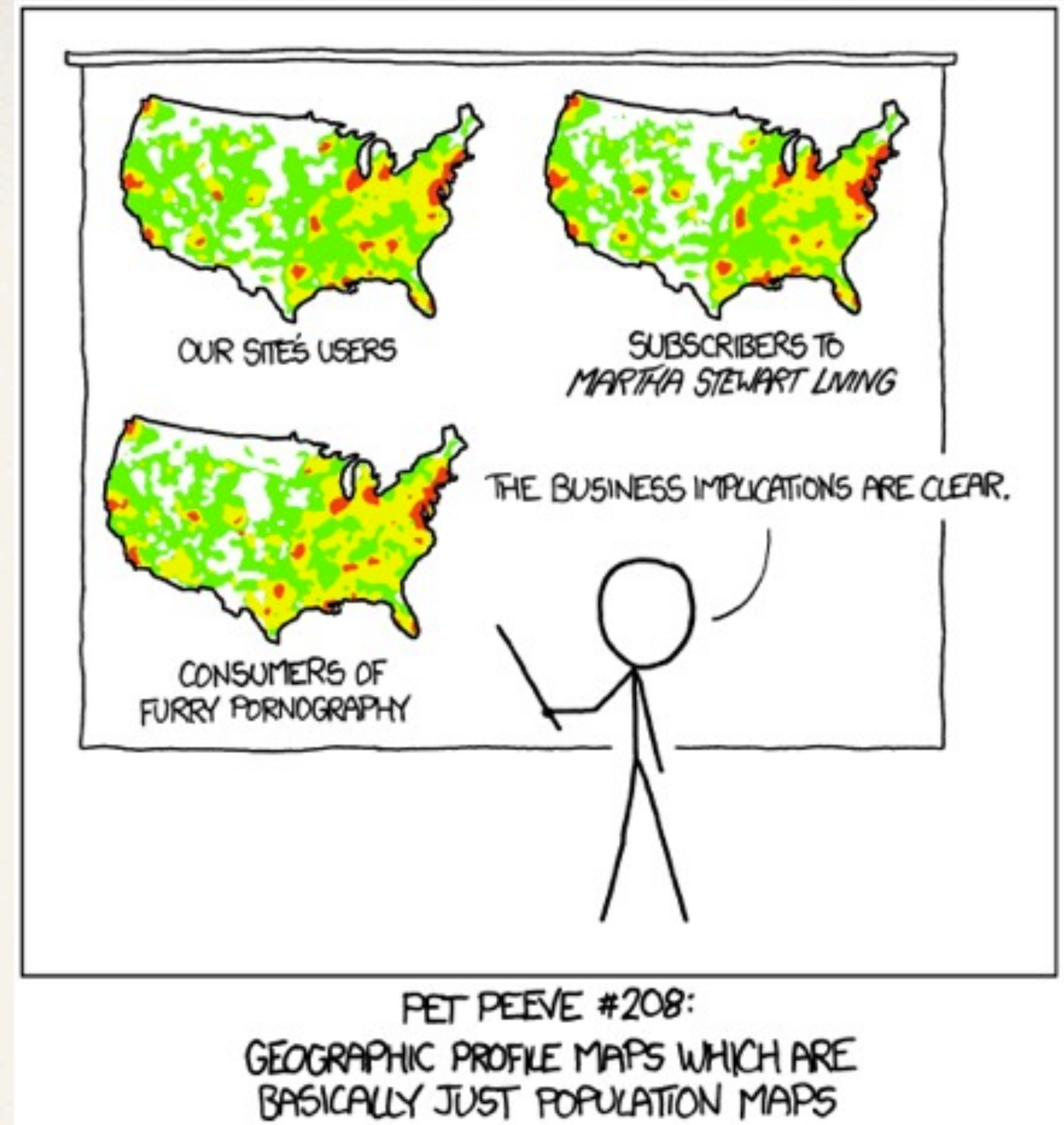


http://xkcd.com/1138/

Geospatial Visualization

C. Andrews

2014-04-08

Quantitative estimation ranking

most accurate

position, aligned scale

position, identical nonaligned scales

length

angle, slope

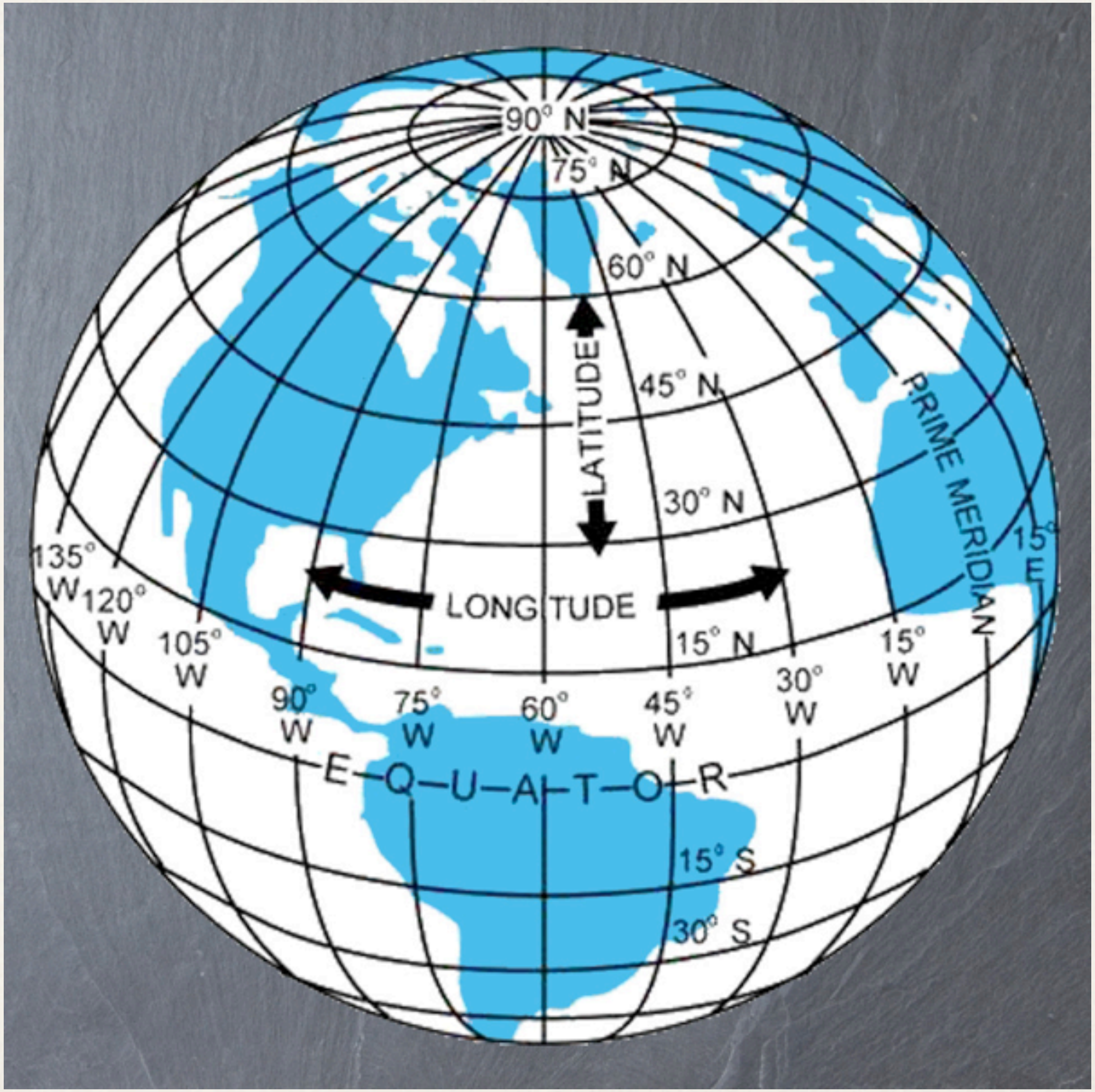
area, volume

color

least accurate

Cleveland and McGill, 1984

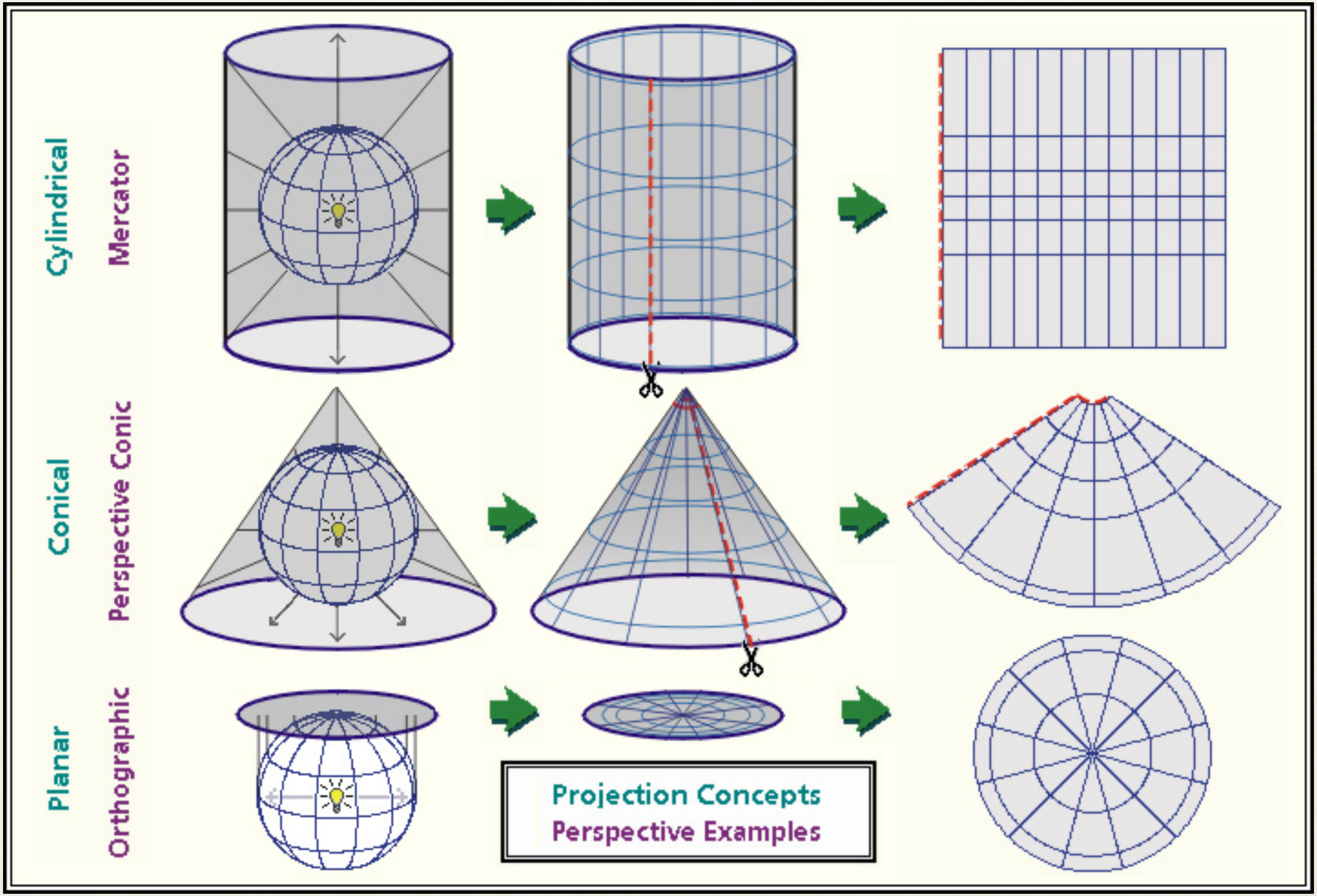
The Earth is not flat



http://sixboats.co.nz/category/tasman/

borrowed from J. Heer

Projecting a sphere



http://earth.rice.edu/mtpe/geo/geosphere/topics/mapprojections.html

Projection properties

conformal projection - preserve shape (but not area)

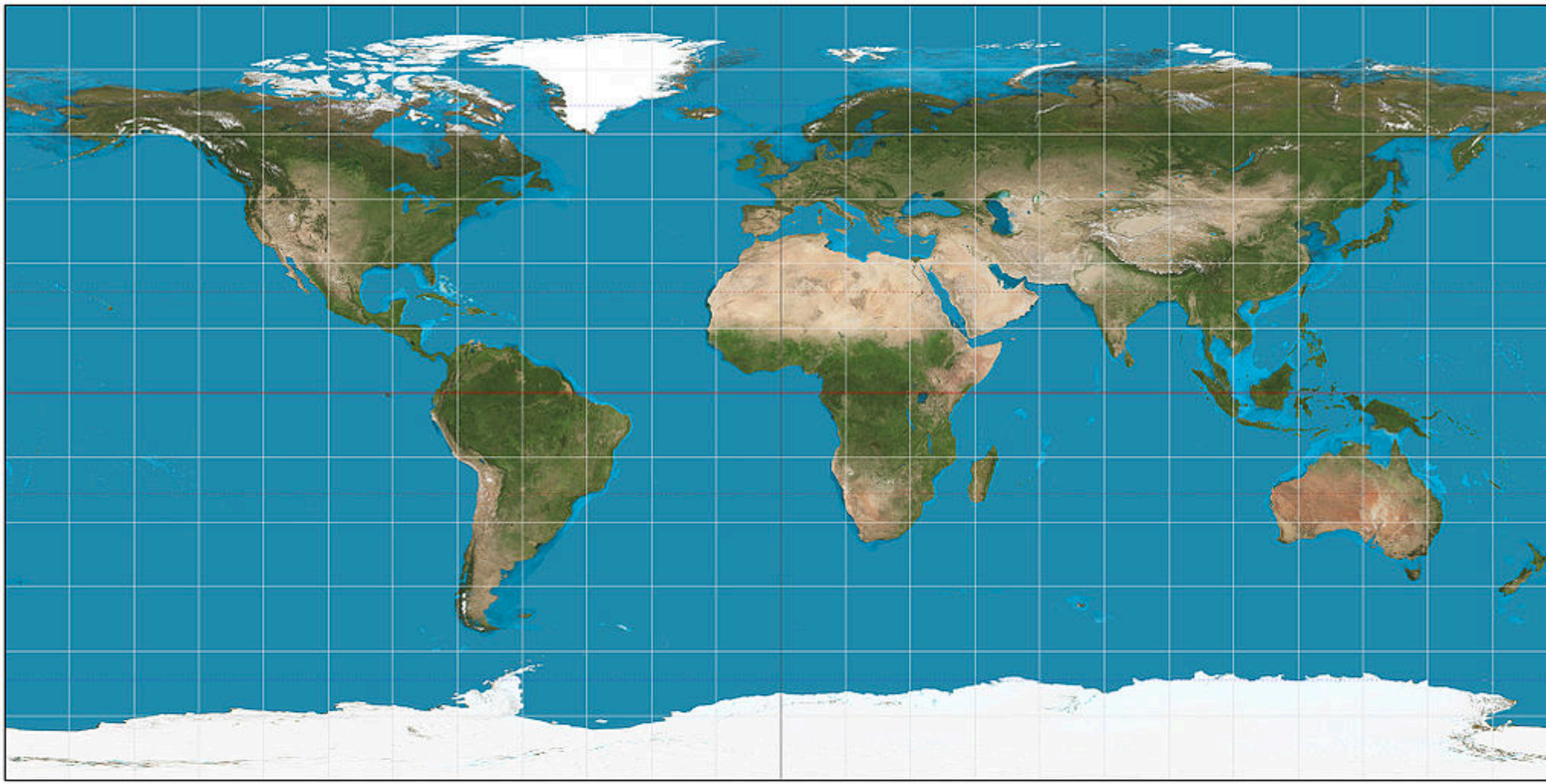
equal-area projection - preserve area (but not shape)

equidistant projection - preserve distance from some standard point

gnomic projection - preserve distance between two points

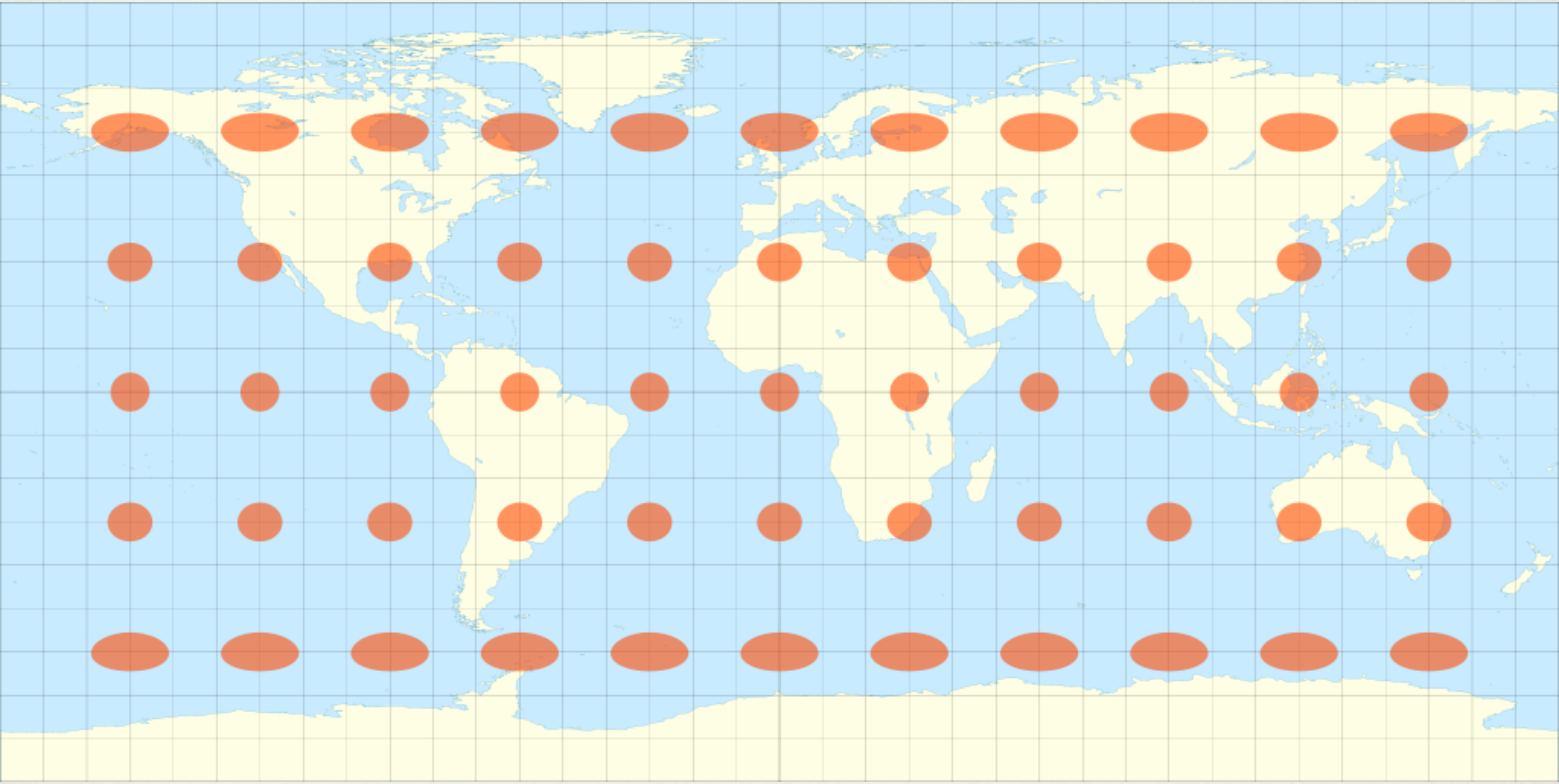
azimuthal projection - preserve direction from a central point

Equirectangular or Plate Carrée



Wikimedia Commons

Equirectangular



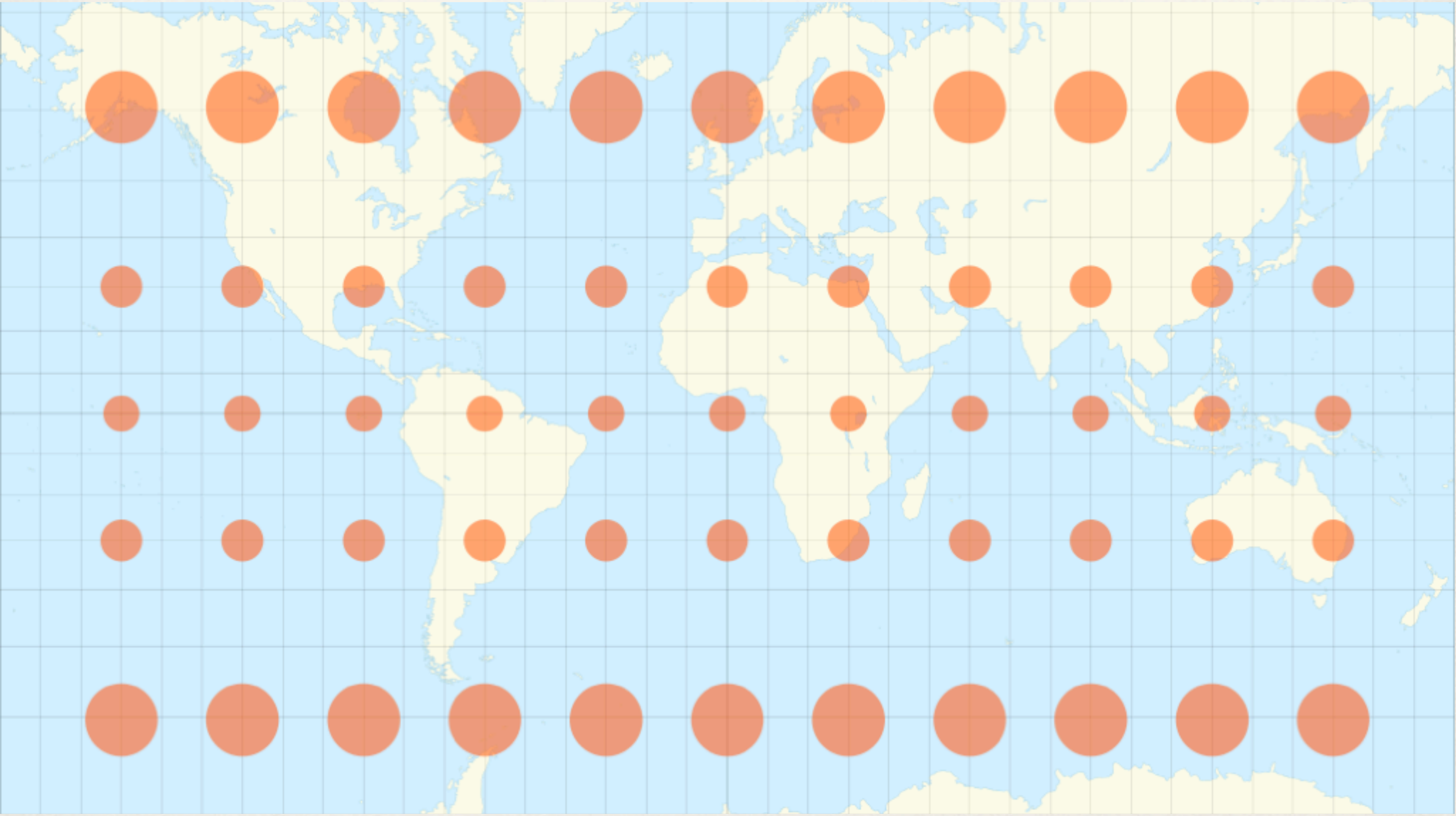
Wikimedia Commons

Mercator

Wikimedia Commons

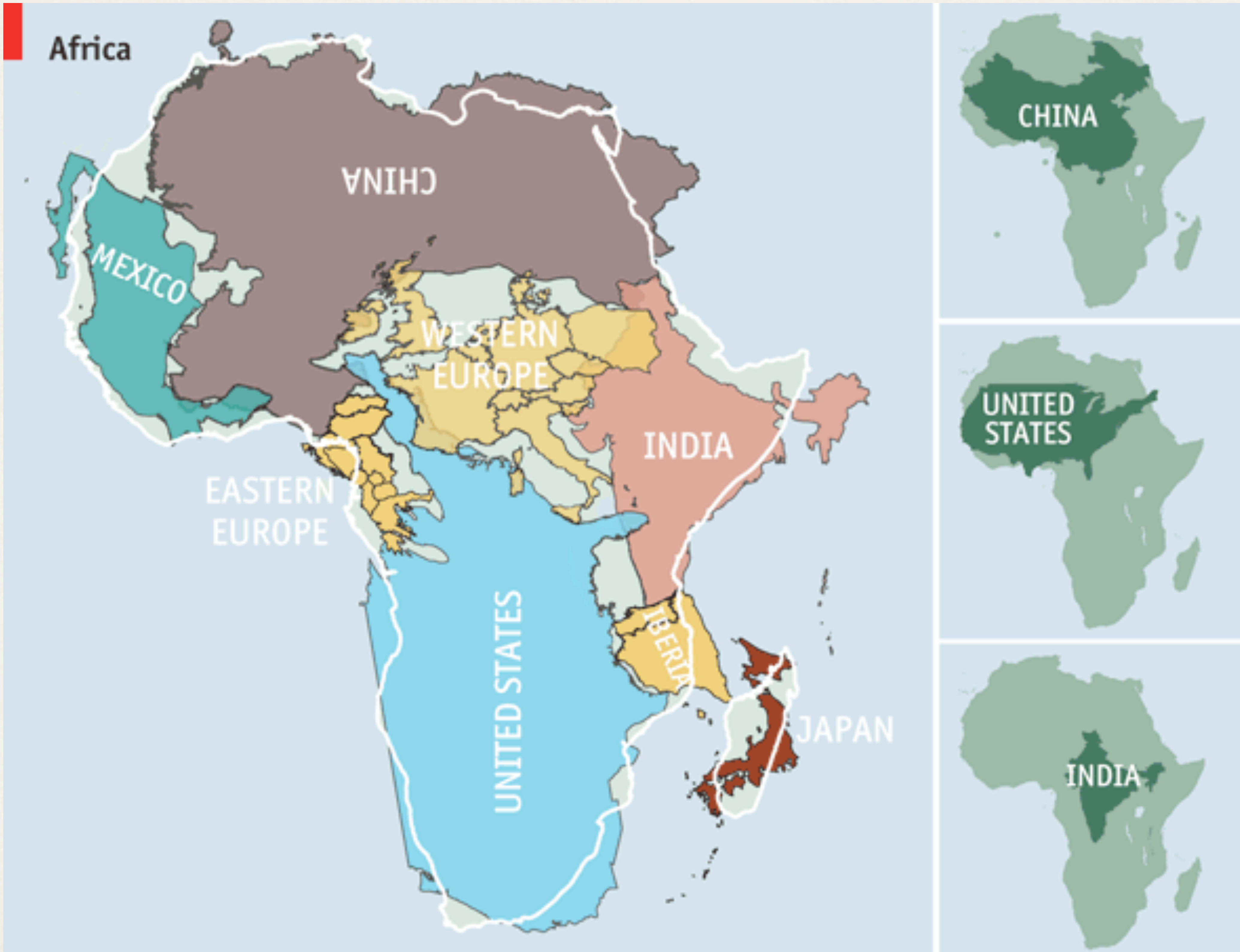

Arctic Ocean
Arctic Ocean
Greenland
Iceland
Finland
Sweden
Norway
Russia
United Kingdom
Poland
Canada
Germany
Ukraine
Kazakhstan
Mongolia
France
Italy
Spain
Turkey
North Pacific Ocean
United States
North Atlantic Ocean
China
Japan
South Korea
Afghanistan
Iraq
Iran
Pakistan
Algeria
Libya
Egypt
Saudi Arabia
India
Mexico
Mali
Niger
Sudan
Thailand
Chad
Nigeria
Ethiopia
Venezuela
Colombia
Kenya
DR Congo
Indonesia
Papua New Guinea
Tanzania
Brazil
Peru
Angola
Bolivia
Namibia
Madagascar
Botswana
Indian Ocean
South Pacific Ocean
South Atlantic Ocean
Australia
Chile
South Africa
Argentina
New Zealand
Southern Ocean

Mercator distortion



Wikimedia Commons

True size of Africa

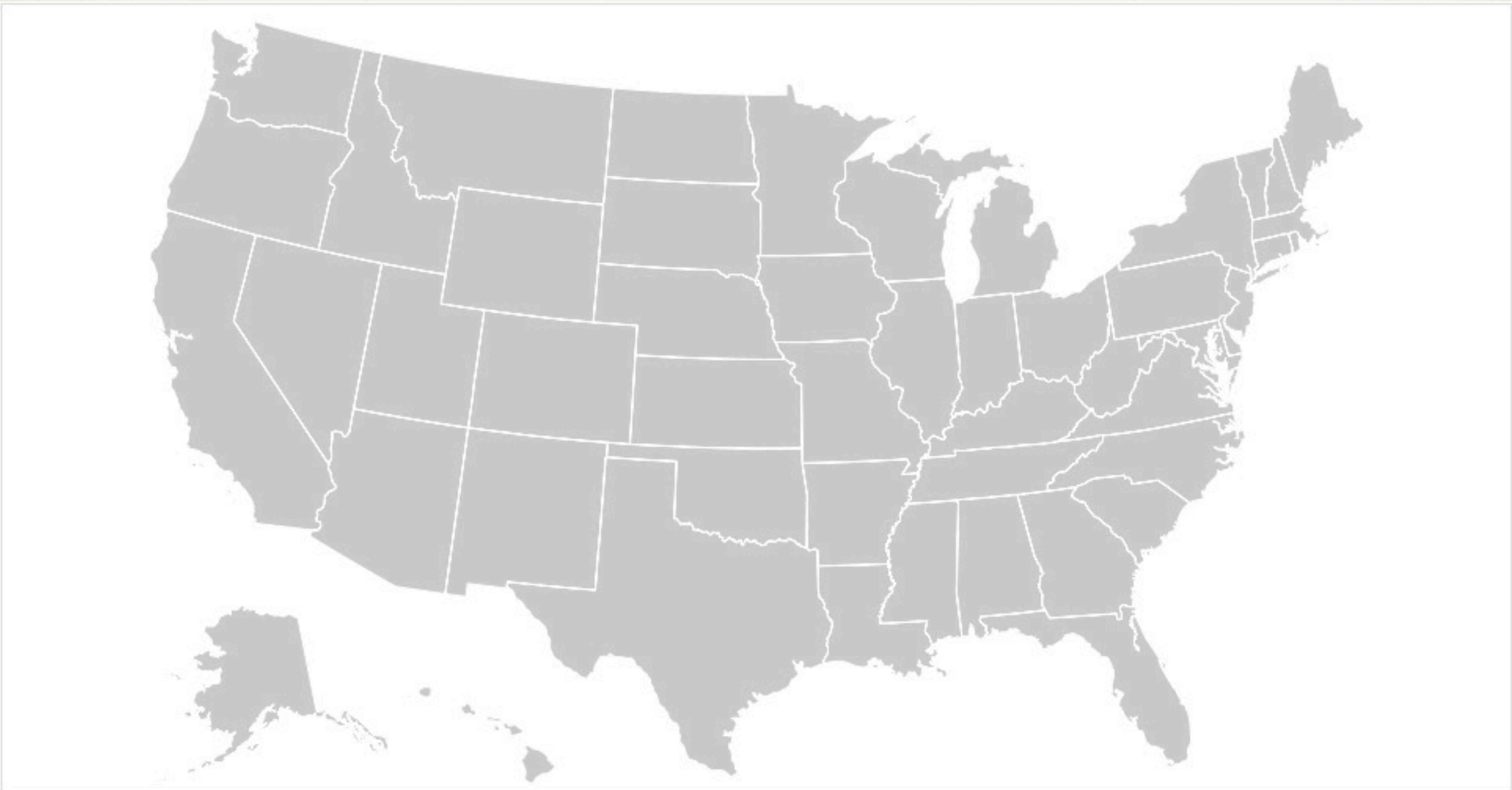


http://www.economist.com/blogs/dailychart/2010/11/cartography

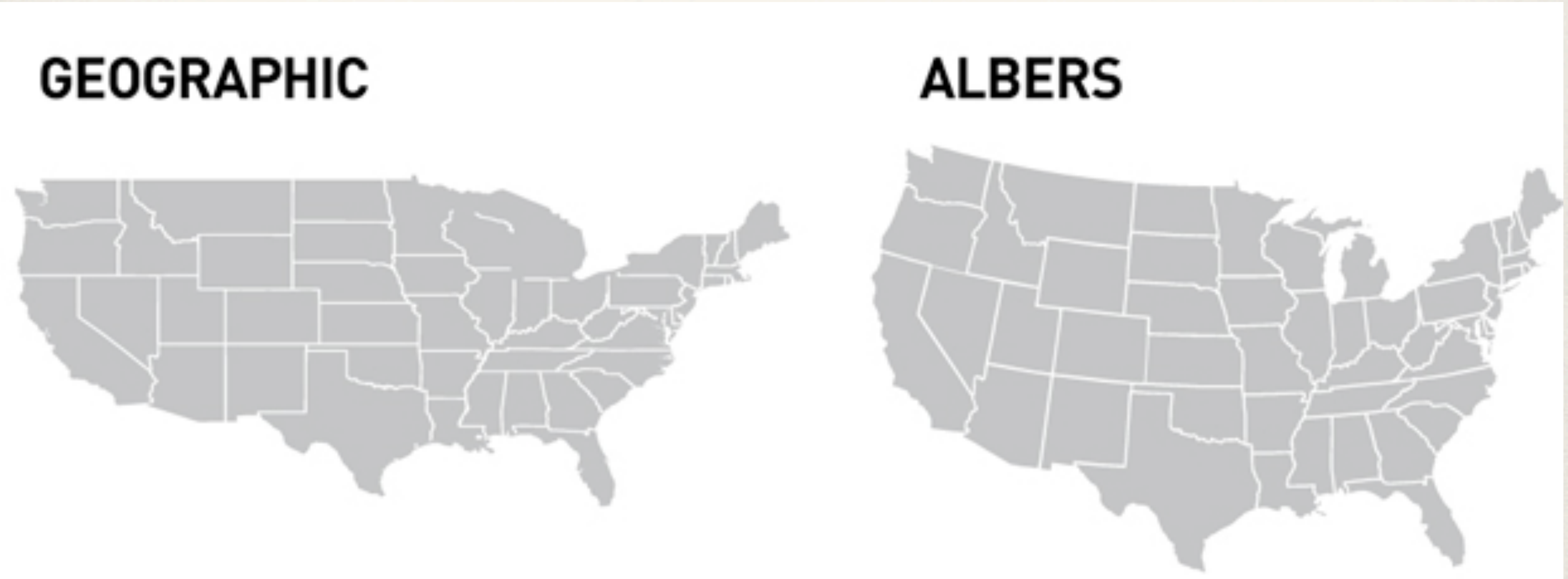
True size of Greenland

Wikimedia Commons

Albers Equal-area Conic projection

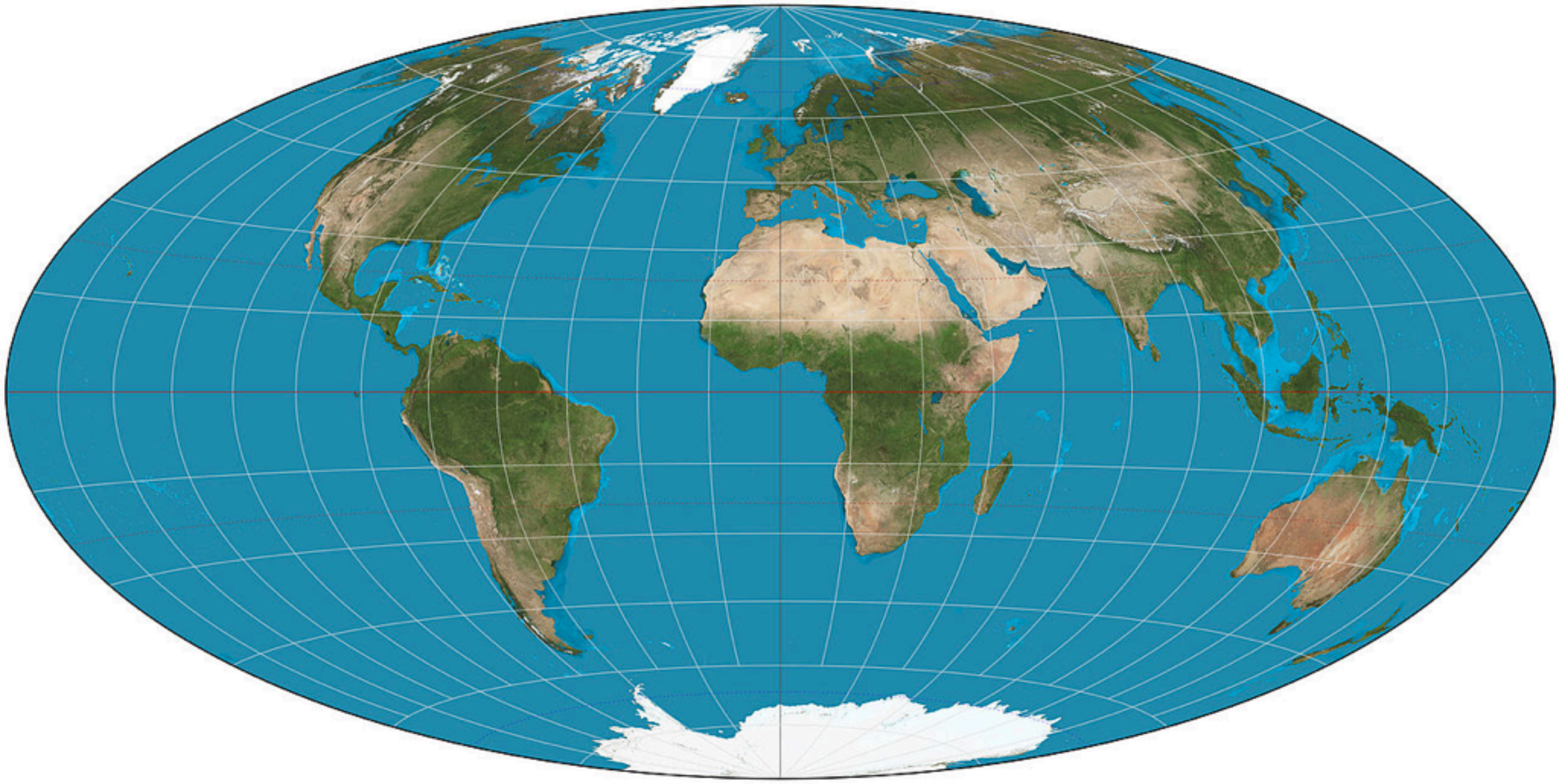


Albers vs. equirectangular



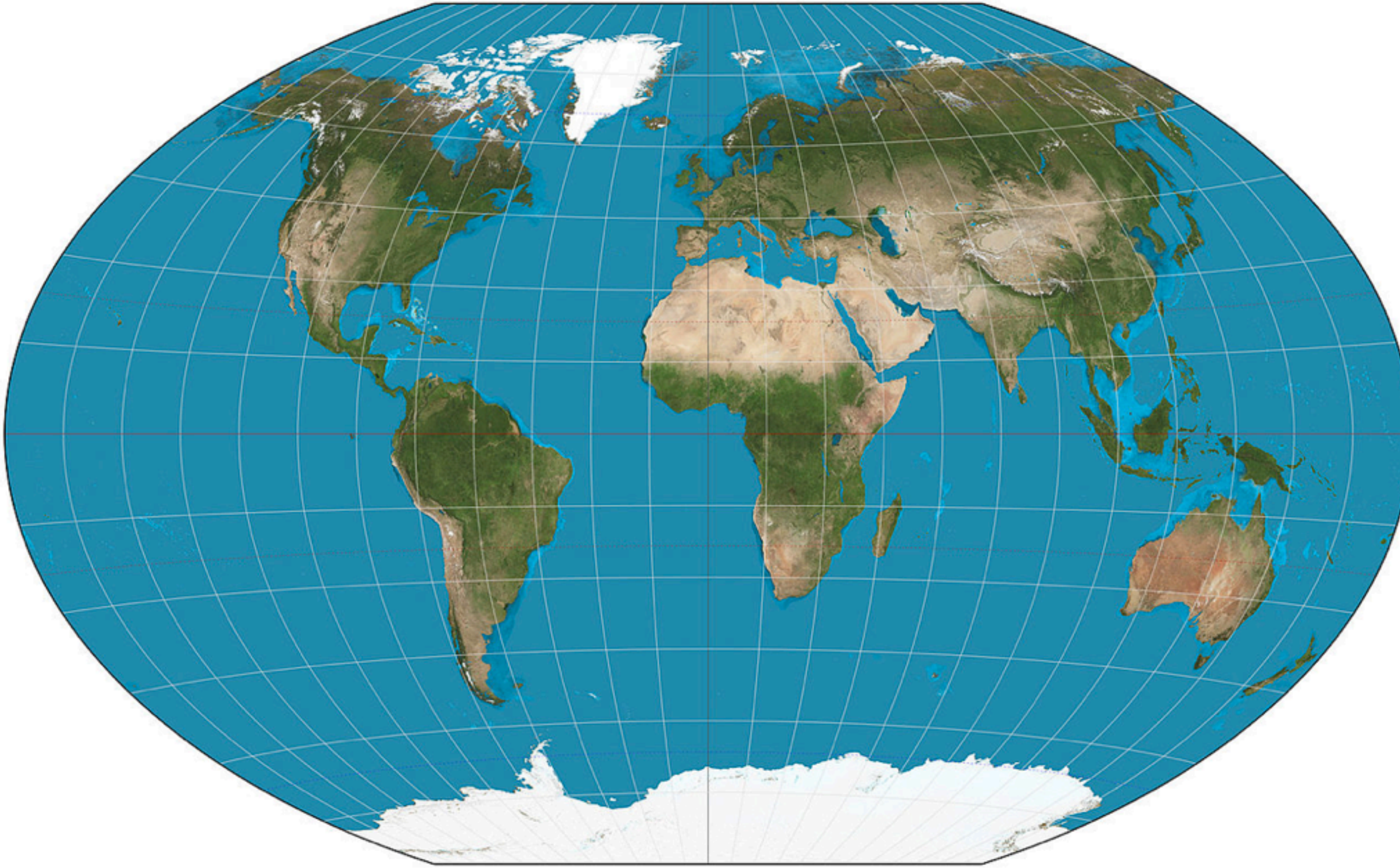
Hammer projection

modified azimuthal equal-area projection



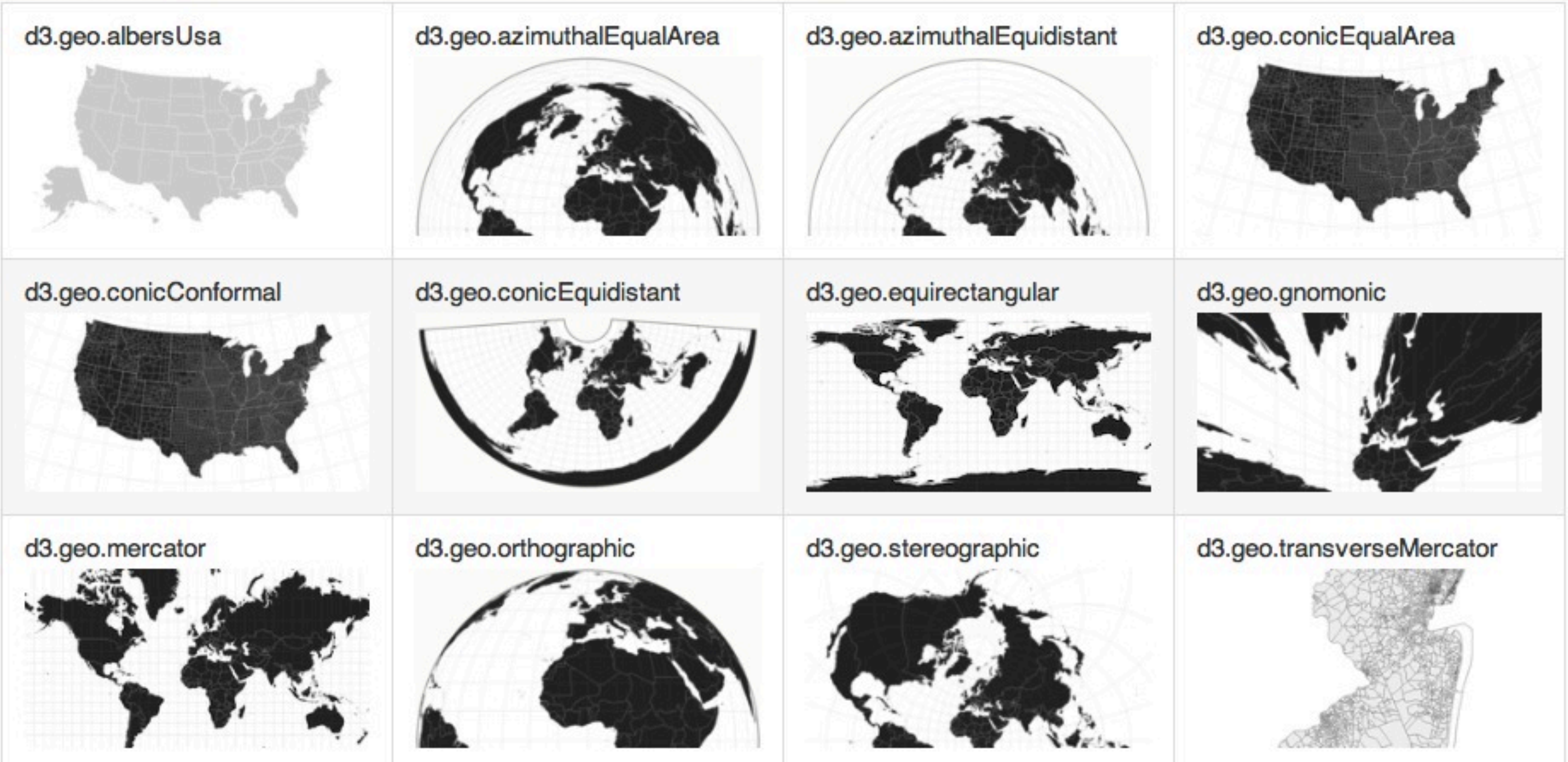
Wikimedia Commons

Winkel tripel projection



Wikimedia Commons

Projections in D3

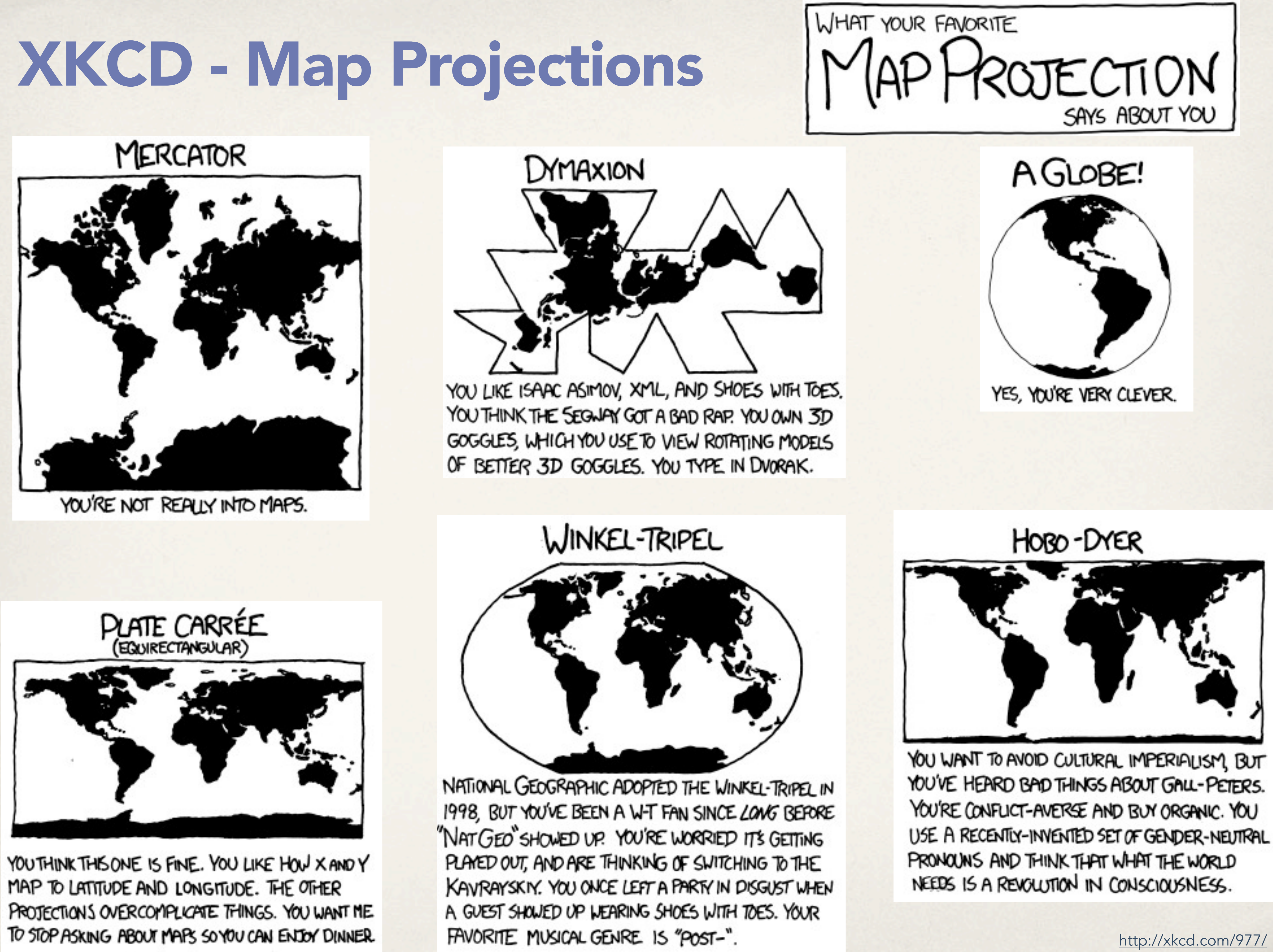


Wikipedia list of map projections

Equirectangular = equidistant cylindrical = rectangular = la carte parallélogrammatique	Cylindrical	Equidistant	Marinus of Tyre	120 (c.)	Simplest geometry; distances along meridians are conserved. Plate carrée: special case having the equator as the standard parallel.
Mercator = Wright	Cylindrical	Conformal	Gerardus Mercator	1569	Lines of constant bearing (rhumb lines) are straight, aiding navigation. Areas inflate with latitude, becoming so extreme that the map cannot show the poles.
Gauss–Krüger = Gauss conformal = (Ellipsoidal) Transverse Mercator	Cylindrical	Conformal	Carl Friedrich Gauss, Johann Heinrich Louis Krüger	1822	This transverse, ellipsoidal form of the Mercator is finite, unlike the equatorial Mercator. Forms the basis of the Universal Transverse Mercator system.
Gall stereographic similar to Braun	Cylindrical	Compromise	James Gall	1885	Intended to resemble the Mercator while also displaying the poles. Standard parallels at 45°N/S. Braun is horizontally stretched version with scale correct at equator.
Miller = Miller cylindrical	Cylindrical	Compromise	Osborn Maitland Miller	1942	Intended to resemble the Mercator while also displaying the poles.
Lambert cylindrical equal-area	Cylindrical	Equal-area	Johann Heinrich Lambert	1772	Standard parallel at the equator. Aspect ratio of π (3.14). Base projection of the cylindrical equal-area family.
Behrmann	Cylindrical	Equal-area	Walter Behrmann	1910	Horizontally compressed version of the Lambert equal-area. Has standard parallels at 30°N/S and an aspect ratio of 2.36.
Hobo–Dyer	Cylindrical	Equal-area	Mick Dyer	2002	Horizontally compressed version of the Lambert equal-area. Very similar are Trystan Edwards and Smyth equal surface (= Craster rectangular) projections with standard parallels at around 37°N/S. Aspect ratio of ~2.0.
Orthographic	Azimuthal		Hipparchos (deployed)	200 BC (c.)	View from an infinite distance.
Vertical perspective	Azimuthal		Matthias Seutter (deployed)	1740	View from a finite distance. Can only display less than a hemisphere.
Two-point equidistant	Azimuthal	Equidistant	Hans Maurer	1919	Two "control points" can be arbitrarily chosen. The two straight-line distances from any point on the map to the two control points are correct.
Peirce quincuncial	Other	Conformal	Charles Sanders Peirce	1879	
Guyou hemisphere-in-a-square projection	Other	Conformal	Émile Guyou	1887	
Adams hemisphere-in-a-square projection	Other	Conformal	Oscar Sherman Adams	1925	
Gall–Peters = Gall orthographic = Peters	Cylindrical	Equal-area	James Gall (Arno Peters)	1855	Horizontally compressed version of the Lambert equal-area. Standard parallels at 45°N/S. Aspect ratio of ~1.6. Similar is Balthasart projection with standard parallels at 50°N/S.
Sinusoidal = Sanson-Flamsteed = Mercator equal-area	Pseudocylindrical	Equal-area	(Several; first is unknown)	1600 (c.)	Meridians are sinusoids; parallels are equally spaced. Aspect ratio of 2:1. Distances along parallels are conserved.
Mollweide = elliptical = Babinet = homolographic	Pseudocylindrical	Equal-area	Karl Brandan Mollweide	1805	Meridians are ellipses.
Eckert II	Pseudocylindrical	Equal-area	Max Eckert-Greifendorff	1906	
Eckert IV	Pseudocylindrical	Equal-area	Max Eckert-Greifendorff	1906	Parallels are unequal in spacing and scale; outer meridians are semicircles; other meridians are semiellipses.
Eckert VI	Pseudocylindrical	Equal-area	Max Eckert-Greifendorff	1906	Parallels are unequal in spacing and scale; meridians are half-period sinusoids.
Goode homolosine	Pseudocylindrical	Equal-area	John Paul Goode	1923	Hybrid of Sinusoidal and Mollweide projections. Usually used in interrupted form.
Kavrayskiy VII	Pseudocylindrical	Compromise	Vladimir V. Kavrayskiy	1939	Evenly spaced parallels. Equivalent to Wagner VI horizontally compressed by a factor of $\sqrt{3}/2$
Robinson	Pseudocylindrical	Compromise	Arthur H. Robinson	1963	Computed by interpolation of tabulated values. Used by Rand McNally since inception and used by NGS 1988–98.
Tobler hyperelliptical	Pseudocylindrical	Equal-area	Waldo R. Tobler	1973	A family of map projections that includes as special cases Mollweide projection, Collignon projection, and the various cylindrical equal-area projections.
American polyconic	Pseudoconical		Ferdinand Rudolph Hassler	1820 (c.)	Distances along the parallels are preserved as are distances along the central meridian.
Azimuthal equidistant =Postel =zenithal equidistant	Azimuthal	Equidistant	Abū Rayḥān al-Bīrūnī	1000 (c.)	Used by the USGS in the National Atlas of the United States of America. Distances from centre are conserved. Used as the emblem of the United Nations, extending to 60° S.
Gnomonic	Azimuthal	Gnomonic	Thales (possibly)	580 BC (c.)	All great circles map to straight lines. Extreme distortion far from the center. Shows less than one hemisphere.
Lambert azimuthal equal-area	Azimuthal	Equal-Area	Johann Heinrich Lambert	1772	The straight-line distance between the central point on the map to any other point is the same as the straight-line 3D distance through the globe between the two points.
Stereographic	Azimuthal	Conformal	Hipparchos (deployed)	200 BC (c.)	Map is infinite in extent with outer hemisphere inflating severely, so it is often used as two hemispheres. Maps all small circles to circles, which is useful for planetary mapping to preserve the shapes of craters.
Wagner VI	Pseudocylindrical	Compromise	K.H. Wagner	1932	Equivalent to Kavrayskiy VII vertically compressed by a factor of $\sqrt{3}/2$.
Collignon	Pseudocylindrical	Equal-Area	Édouard Collignon	1865 (c.)	Depending on configuration, the projection also may map the sphere to a single diamond or a pair of squares.
HEALPix	Pseudocylindrical	Equal-area	Krzysztof M. Górski	1997	Hybrid of Collignon + Lambert cylindrical equal-area
Craster parabolic =Putniņš P4	Pseudocylindrical	Equal-area	John Craster	1929	Meridians are parabolas. Standard parallels at 36°46′N/S; parallels are unequal in spacing and scale; 2:1 Aspect.
Flat-polar quartic =McBryde-Thomas #4	Pseudocylindrical	Equal-area	Felix W. McBryde, Paul Thomas	1949	Standard parallels at 33°45′N/S; parallels are unequal in spacing and scale; meridians are fourth-order curves. Distortion-free only where the standard parallels intersect the central meridian.
Quartic authalic	Pseudocylindrical	Equal-area	Karl Siemon, Oscar Adams	1937, 1944	Parallels are unequal in spacing and scale. No distortion along the equator. Meridians are fourth-order curves.
The Times	Pseudocylindrical	Compromise	John Muir	1965	Standard parallels 45°N/S. Parallels based on Gall orthographic, but with curved meridians. Developed for Bartholomew Ltd., The Times Atlas.
Loximuthal	Pseudocylindrical		Karl Siemon, Waldo Tobler	1935, 1966	From the designated centre, lines of constant bearing (rhumb lines/loxodromes) are straight and have the correct length. Generally asymmetric about the equator.
Aitoff	Pseudoazimuthal	Compromise	David A. Aitoff	1889	Stretching of modified equatorial azimuthal equidistant map. Boundary is 2:1 ellipse. Largely superseded by Hammer.
Waterman butterfly projection	Polyhedral	Compromise	Steve Waterman	1996	
Quadrilateralized spherical cube	Polyhedral	Equal-area	F. Kenneth Chan, E. M. O'Neill	1973	
Dymaxion map	Polyhedral	Compromise	Buckminster Fuller	1943	
Myriahedral projections	Polyhedral		Jarke J. van Wijk	2008	Projects the globe onto a myriahedron: a polyhedron with a very large number of faces.[23]
Craig retroazimuthal =Mecca	Retroazimuthal		James Ireland Craig	1909	
Hammer retroazimuthal, front hemisphere	Retroazimuthal		Ernst Hammer	1910	
Hammer retroazimuthal, back hemisphere	Retroazimuthal		Ernst Hammer	1910	
Littrow	Retroazimuthal		Joseph Johann Littrow	1833	
Hammer =Hammer-Aitoff variations: Briesemeister; Nordic	Pseudoazimuthal	Equal-area	Ernst Hammer	1892	Modified from azimuthal equal-area equatorial map. Boundary is 2:1 ellipse. Variants are oblique versions, centred on 45°N.
Winkel tripel	Pseudoazimuthal	Compromise	Oswald Winkel	1921	Arithmetic mean of the equirectangular projection and the Aitoff projection. Standard world projection for the NGS 1998–present.
Van der Grinten	Other	Compromise	Alphons J. van der Grinten	1904	Boundary is a circle. All parallels and meridians are circular arcs. Usually clipped near 80°N/S. Standard world projection of the NGS 1922–88.
Equidistant conic projection =simple conic	Conic	Equidistant	Based on Ptolemy's 1st Projection	100 (c.)	Distances along meridians are conserved, as is distance along one or two standard parallels[1]
Lambert conformal conic	Conic	Conformal	Johann Heinrich Lambert	1772	
Albers conic	Conic	Equal-Area	Heinrich C. Albers	1805	Two standard parallels with low distortion between them.
Werner	Pseudoconical	Equal-area	Johannes Stabius	1500 (c.)	Distances from the North Pole are correct as are the curved distances along parallels.
Bonne	Pseudoconical, cordiform	Equal-area	Bernardus Sylvanus	1511	Parallels are equally spaced circular arcs and standard lines. Appearance depends on reference parallel. General case of both Werner and sinusoidal
Bottomley	Pseudoconical	Equal-area	Henry Bottomley	2003	Alternative to the Bonne projection with simpler overall shape. Parallels are elliptical arcs. Appearance depends on reference parallel.
B.J.S. Cahill's Butterfly Map	Polyhedral	Compromise	Bernard Joseph Stanislaus Cahill	1909	
Cahill–Keyes projection	Polyhedral	Compromise	Gene Keyes	1975	

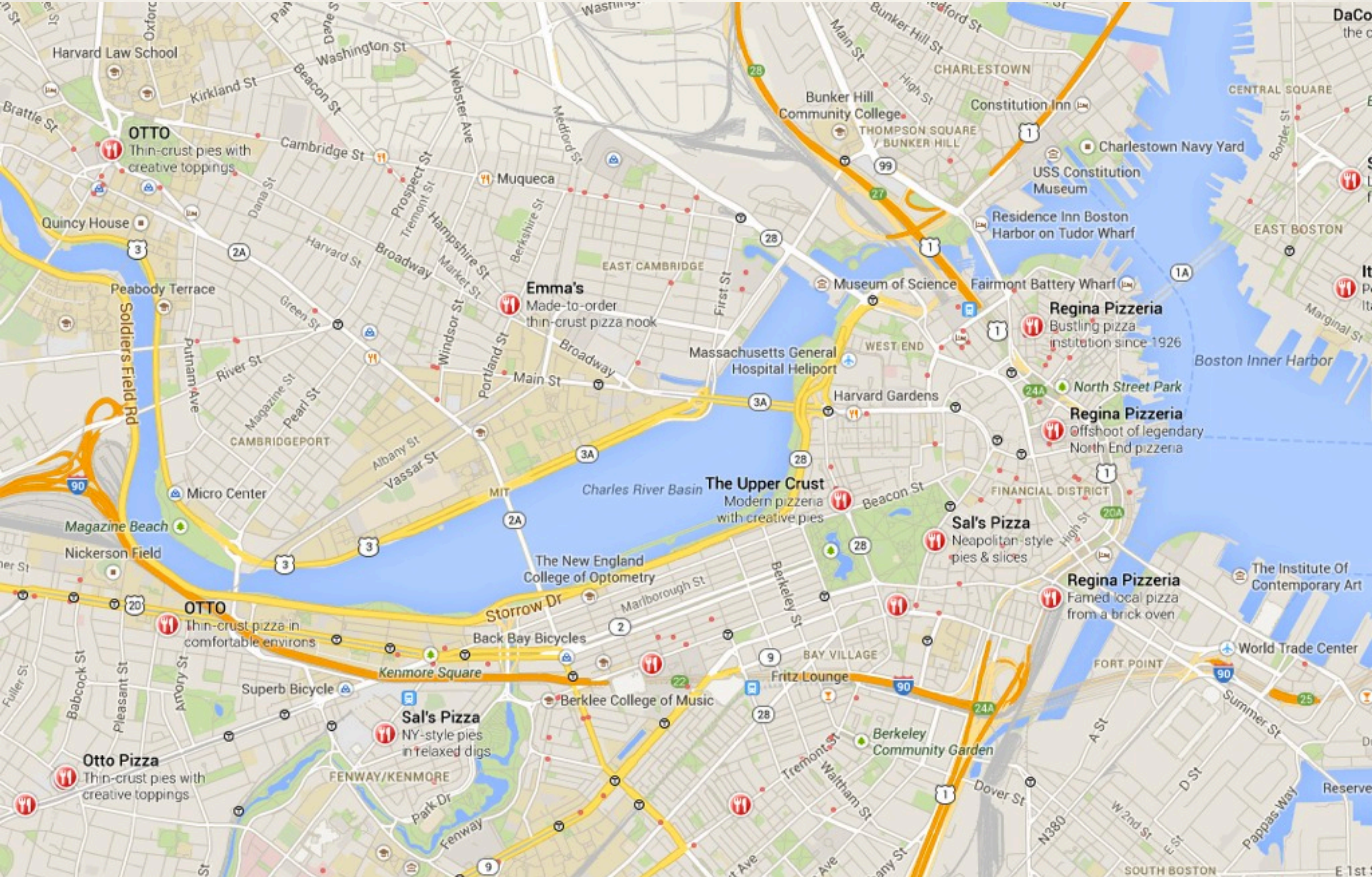
http://en.wikipedia.org/wiki/List_of_map_projections

XKCD - Map Projections

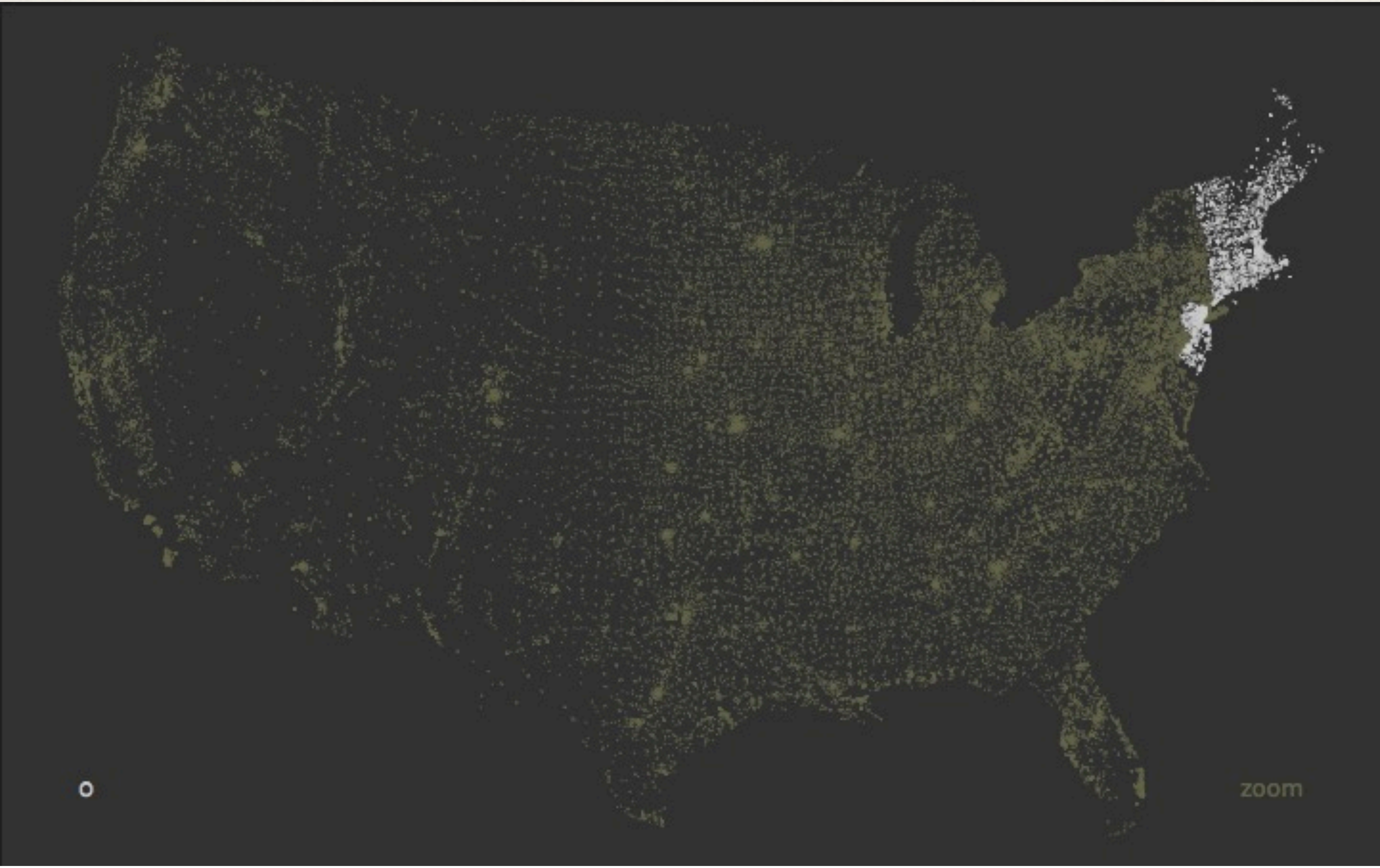


http://xkcd.com/977/

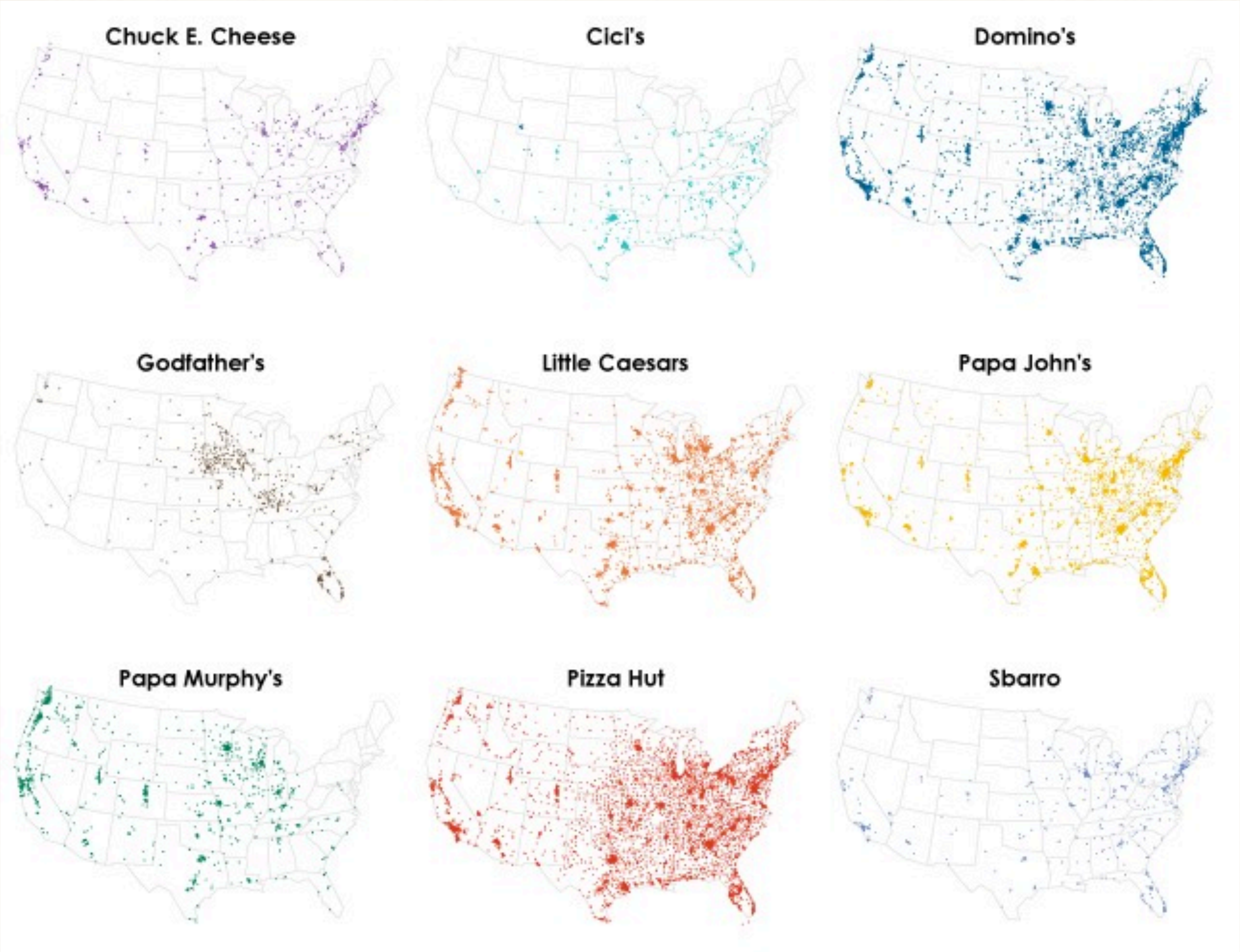
Dot maps


Harvard Law School
Kirkland St
Washington St
Beacon St
Brattle St
OTTO
Thin-crust pies with creative toppings
Cambridge St
Muqueca
Quincy House
Harvard St
Broadway
Hampshire St
EAST CAMBRIDGE
First St
Peabody Terrace
Soldiers Field Rd
Emma's
Made-to-order thin-crust pizza nook
Main St
River St
Putnam Ave
Magazine St
Pearl St
CAMBRIDGEPORT
Albany St
Vassar St
Micro Center
Magazine Beach
Nickerson Field
MIT
Charles River Basin
The Upper Crust
Modern pizzeria with creative pies
Massachusetts General Hospital Heliport
Museum of Science
WEST END
Harvard Gardens
Beacon St
The New England College of Optometry
Storrow Dr
Marlborough St
Back Bay Bicycles
OTTO
Thin-crust pizza in comfortable environs
Kenmore Square
Superb Bicycle
Sal's Pizza
NY-style pies in relaxed digs
Berklee College of Music
Fritz Lounge
BAY VILLAGE
Berkeley St
Otto Pizza
Thin-crust pies with creative toppings
FENWAY/KENMORE
Park Dr
Fenway
Babcock St
Pleasant St
Amory St
Tremont St
Waltham St
Berkeley Community Garden
Dover St
CHARLESTOWN
Bunker Hill St
Main St
High St
Bunker Hill Community College
THOMPSON SQUARE / BUNKER HILL
Constitution Inn
Charlestown Navy Yard
USS Constitution Museum
Residence Inn Boston Harbor on Tudor Wharf
CENTRAL SQUARE
EAST BOSTON
Fairmont Battery Wharf
Regina Pizzeria
Bustling pizza institution since 1926
Boston Inner Harbor
North Street Park
Regina Pizzeria
Offshoot of legendary North End pizzeria
FINANCIAL DISTRICT
Sal's Pizza
Neapolitan-style pies & slices
Regina Pizzeria
Famed local pizza from a brick oven
The Institute Of Contemporary Art
World Trade Center
FORT POINT
Summer St
A St
D St
W 2nd St
Pappas Way
SOUTH BOSTON
Marginal St
Border St

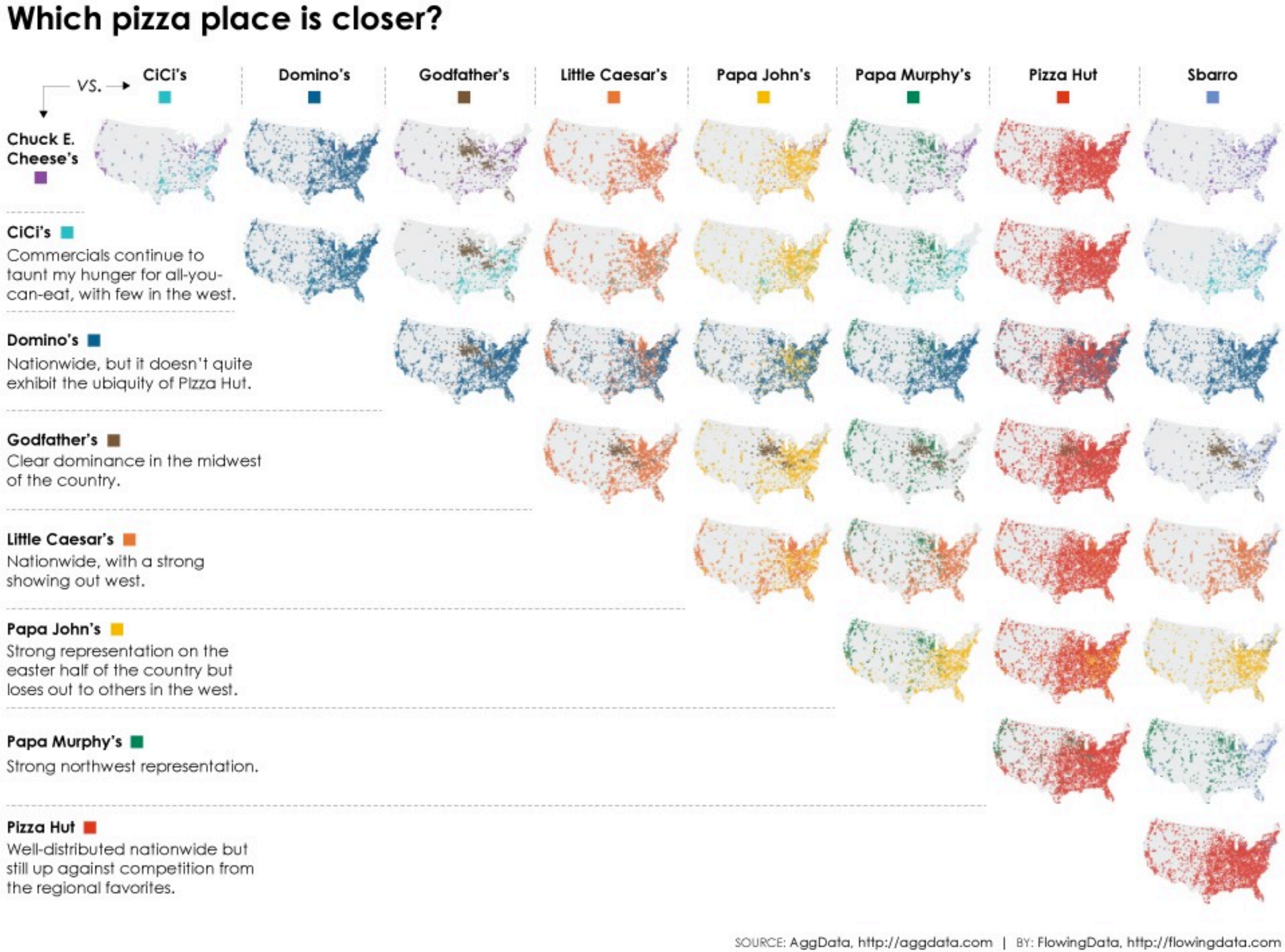
Dot map



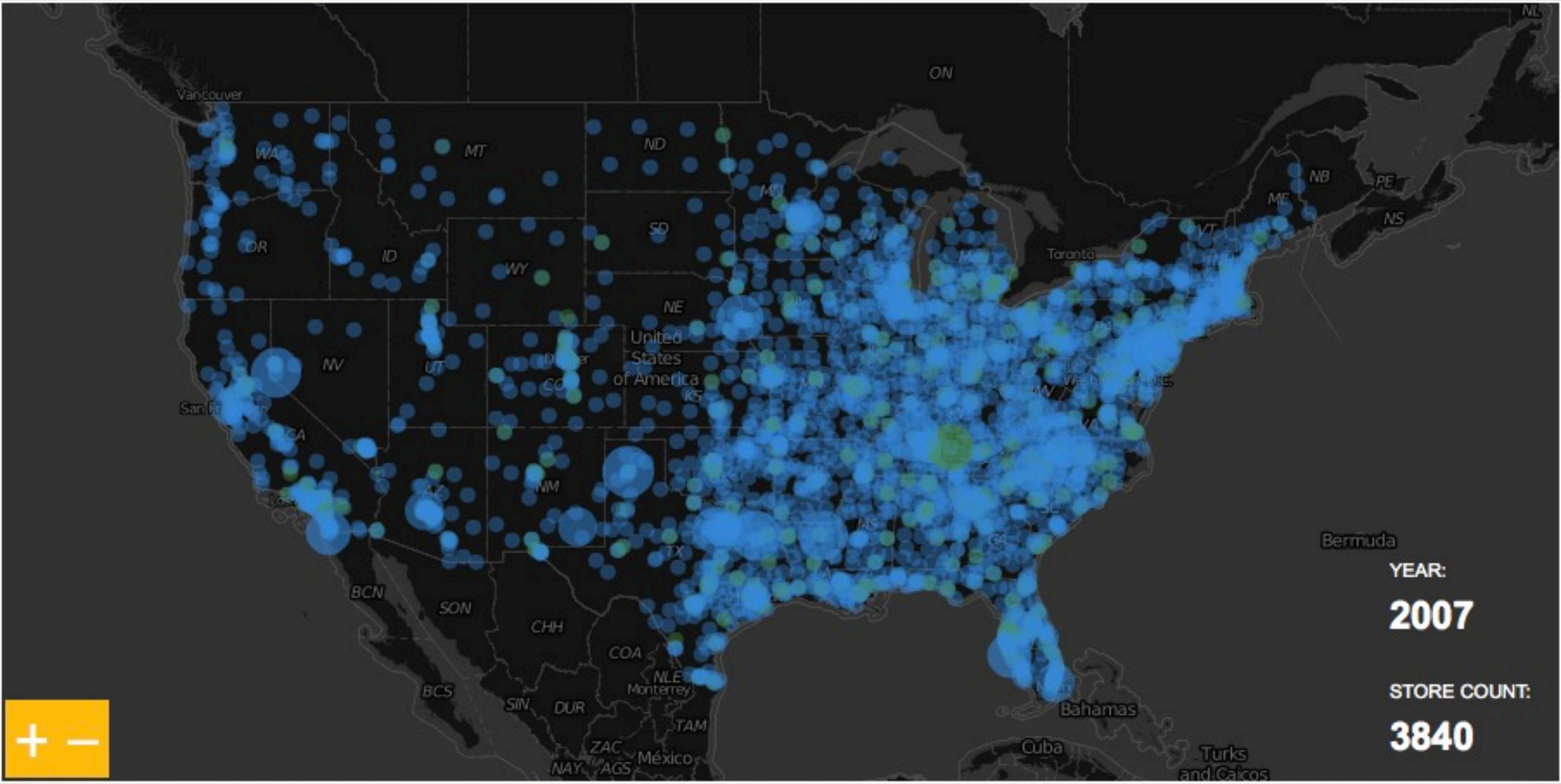
Dot map



http://flowingdata.com/2013/10/14/pizza-place-geography/

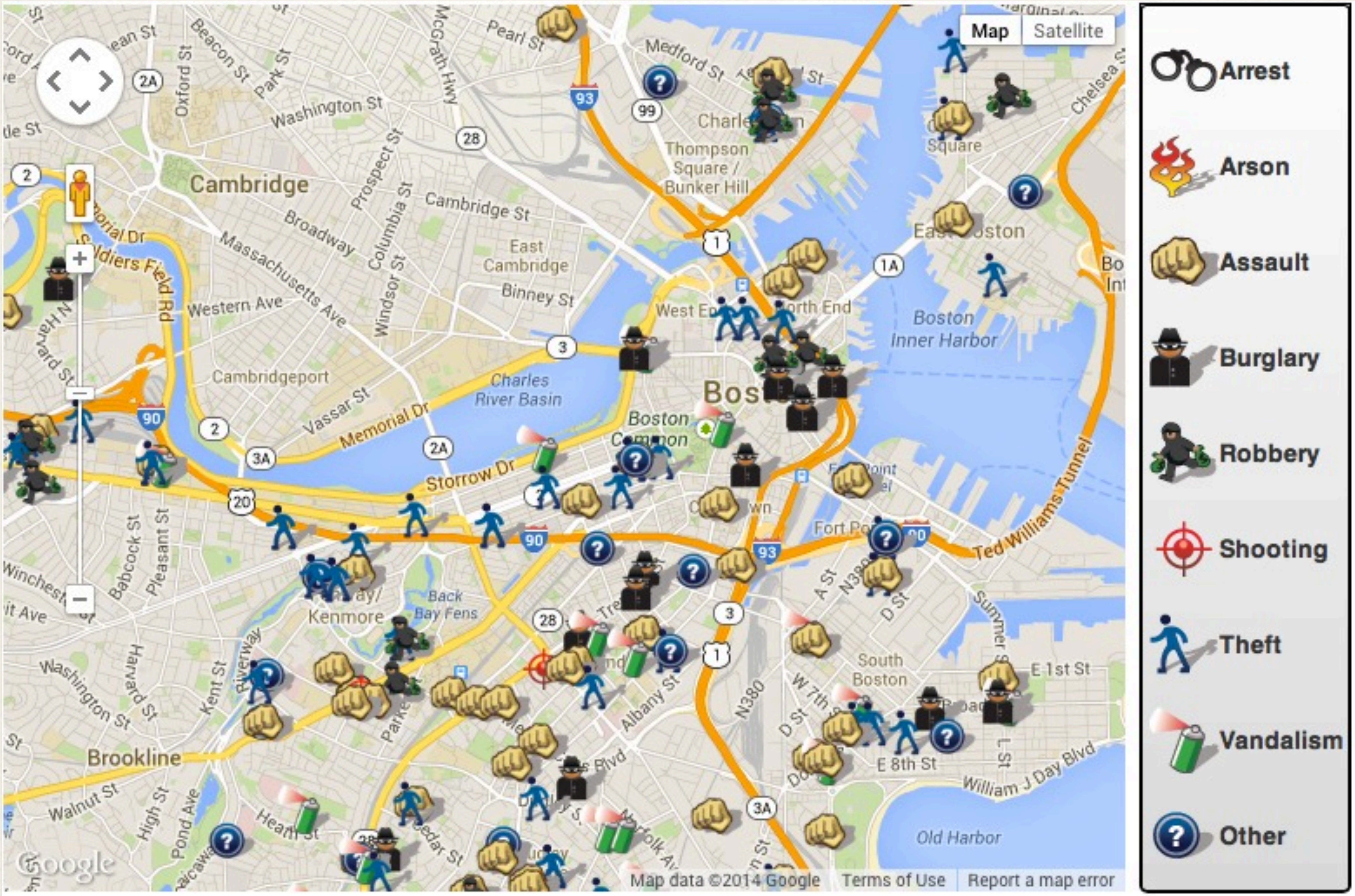

Which pizza place is closer?
VS.
CiCi's
Domino's
Godfather's
Little Caesar's
Papa John's
Papa Murphy's
Pizza Hut
Sbarro
Chuck E. Cheese's
CiCi's
Commercials continue to taunt my hunger for all-you-can-eat, with few in the west.
Domino's
Nationwide, but it doesn't quite exhibit the ubiquity of Pizza Hut.
Godfather's
Clear dominance in the midwest of the country.
Little Caesar's
Nationwide, with a strong showing out west.
Papa John's
Strong representation on the easter half of the country but loses out to others in the west.
Papa Murphy's
Strong northwest representation.
Pizza Hut
Well-distributed nationwide but still up against competition from the regional favorites.
SOURCE: AggData, http://aggdata.com | BY: FlowingData, http://flowingdata.com

The Growth of Walmart



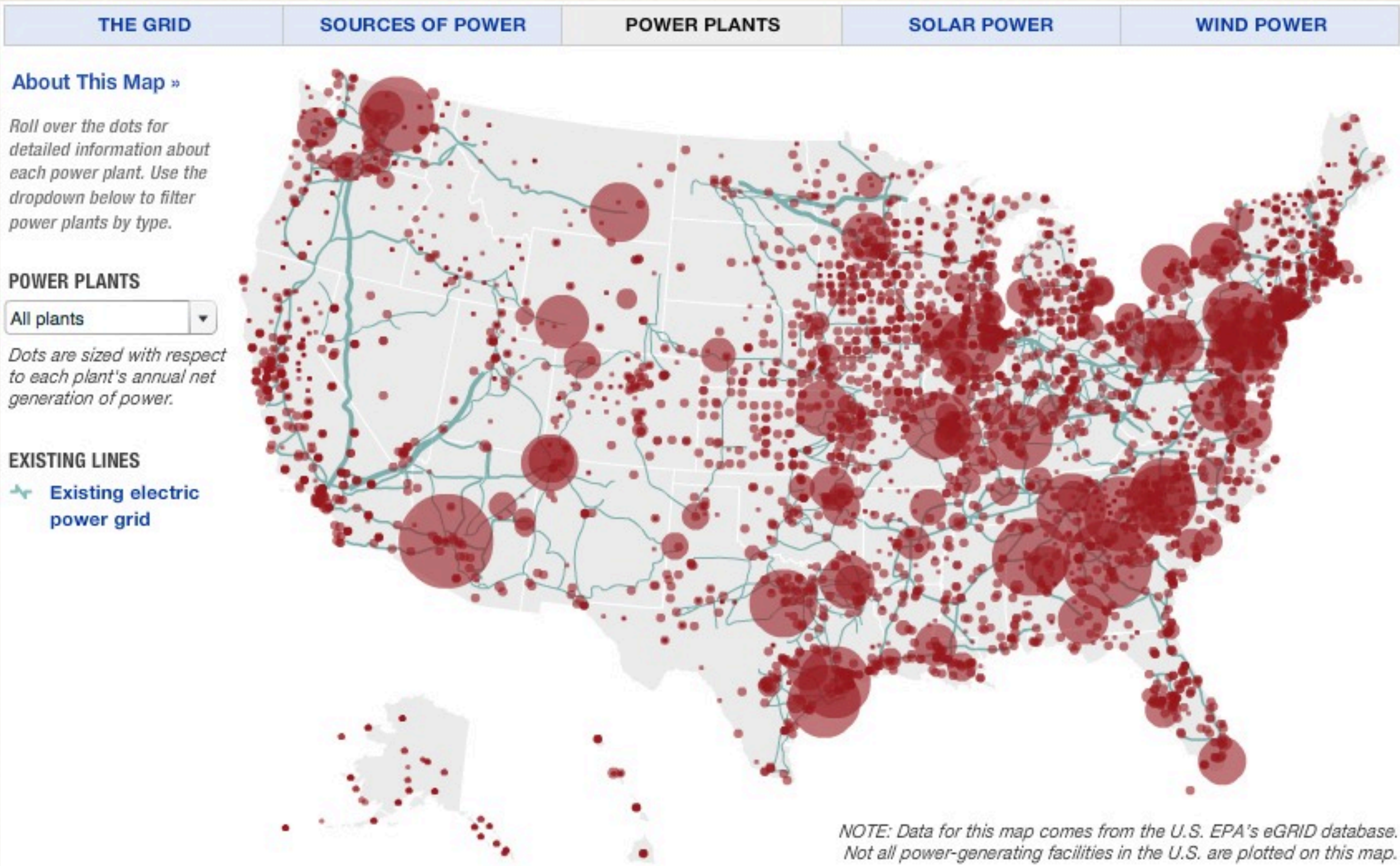
http://projects.flowingdata.com/walmart/

Dot maps with icons



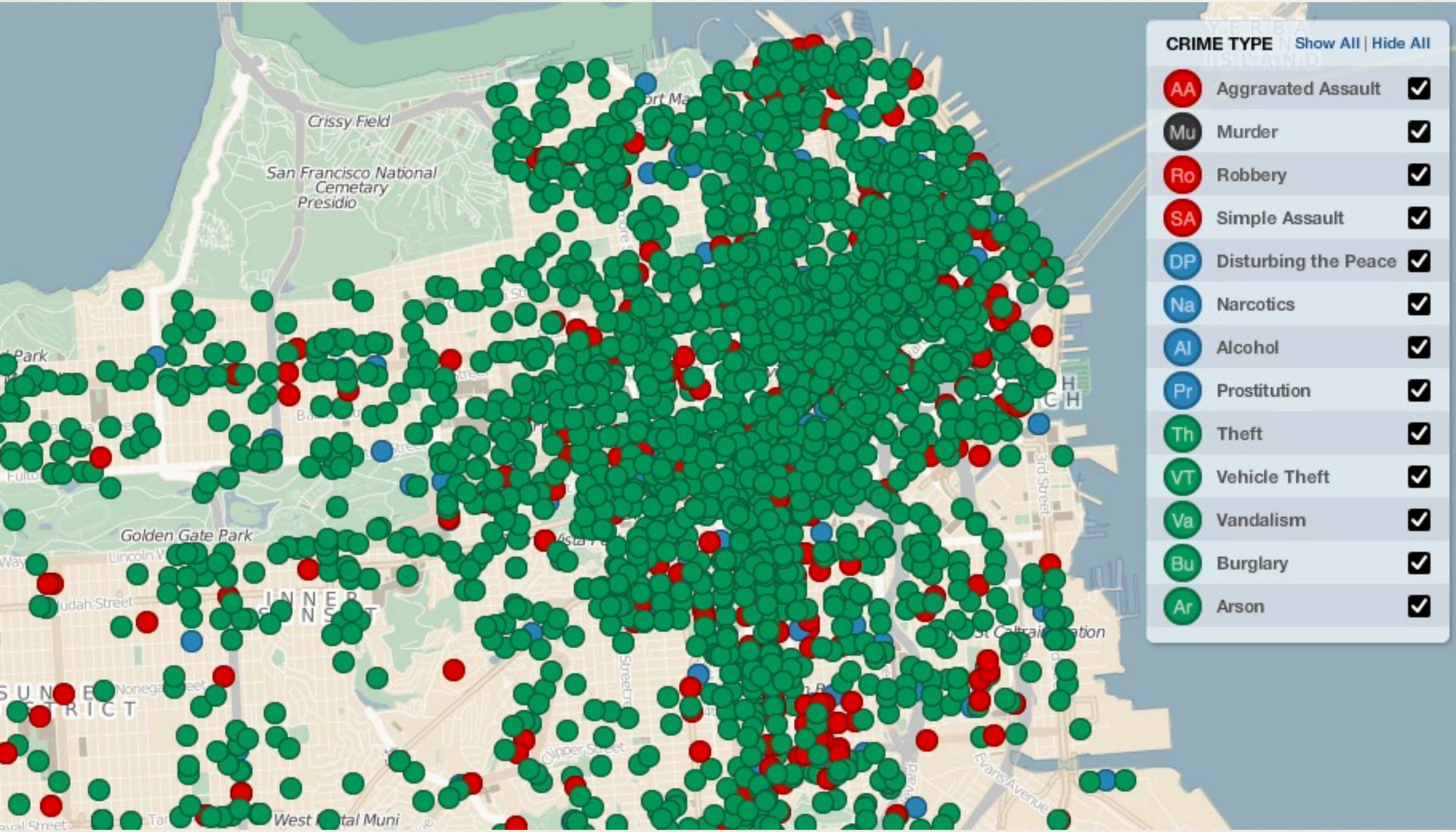
http://spotcrime.com/ma/boston

Dot map with size encoding



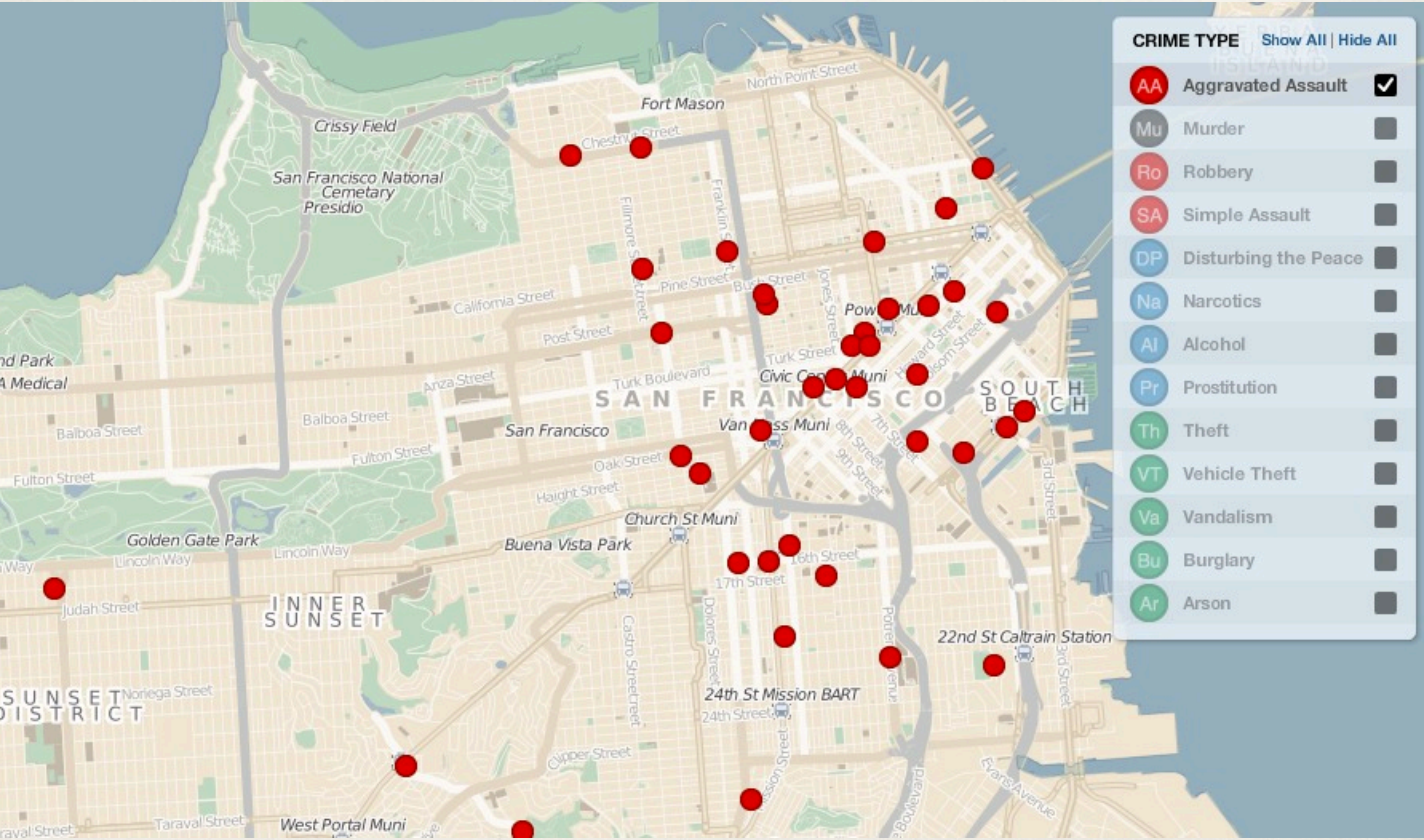
http://www.npr.org/templates/story/story.php?storyId=110997398

Dot map - What's the problem?



http://sanfrancisco.crimespotting.org

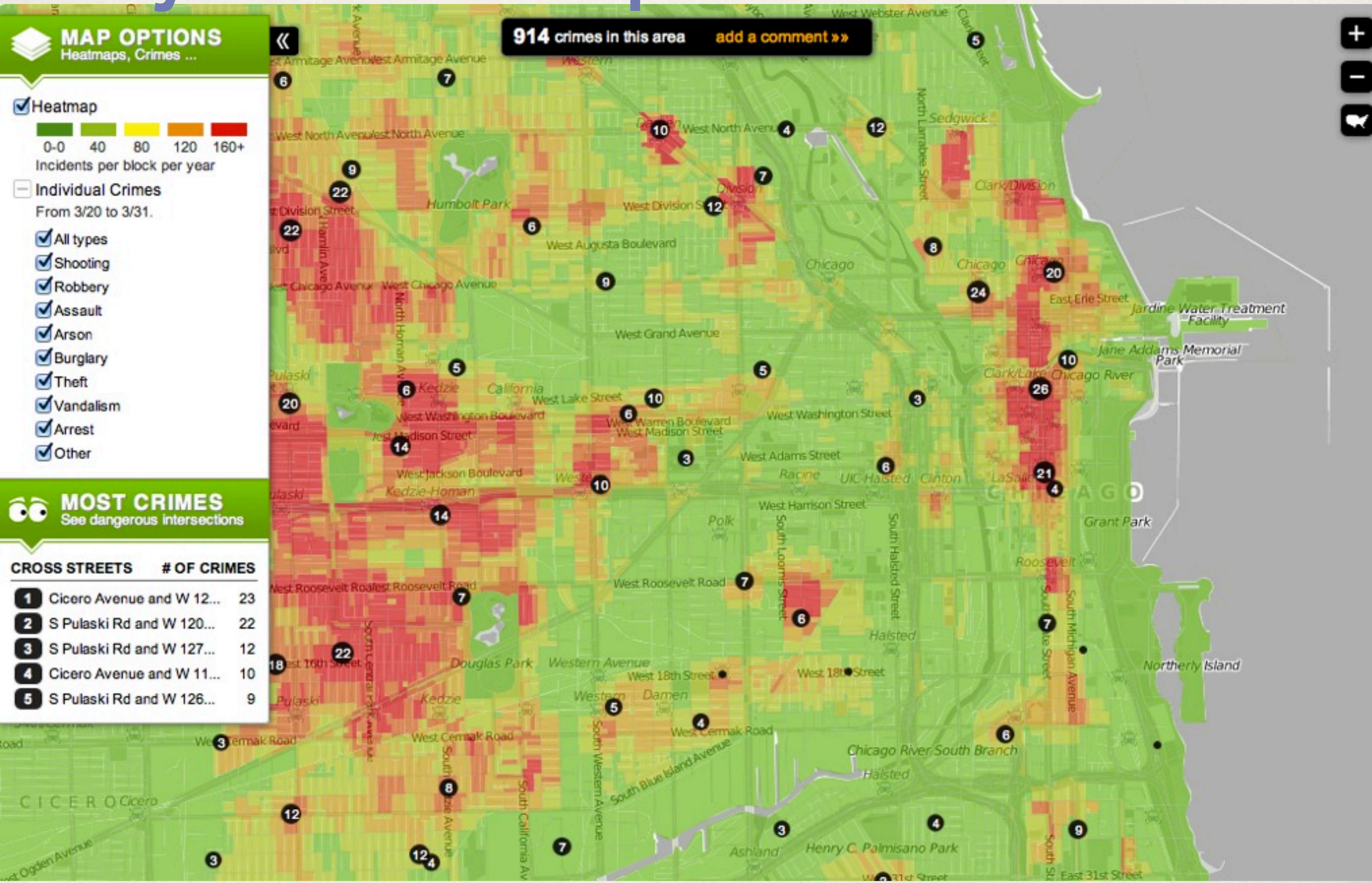
Dot map - What's the problem?



k-Means clustering

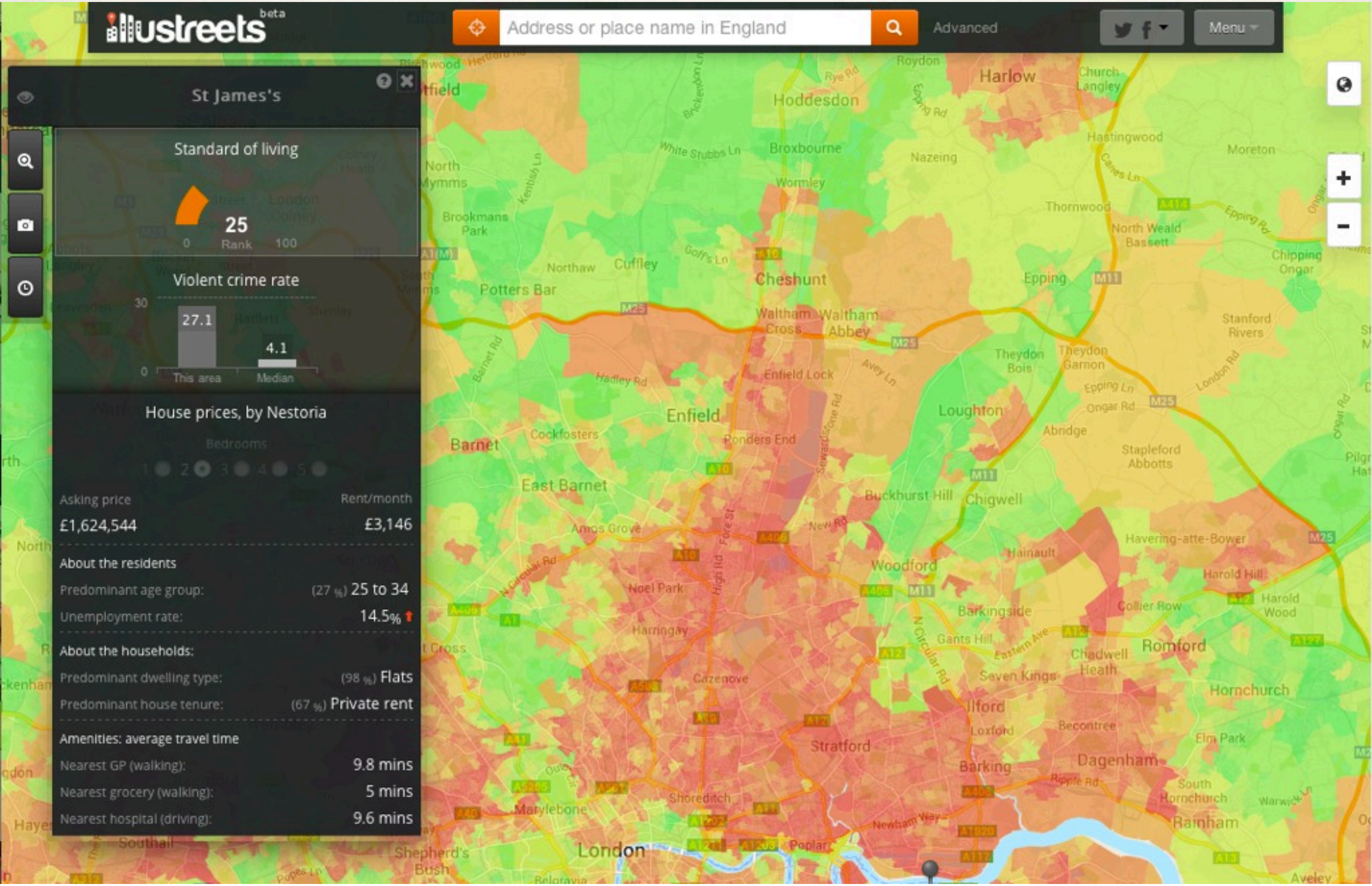
http://polymaps.org/ex/cluster.html

Dasymetric area map

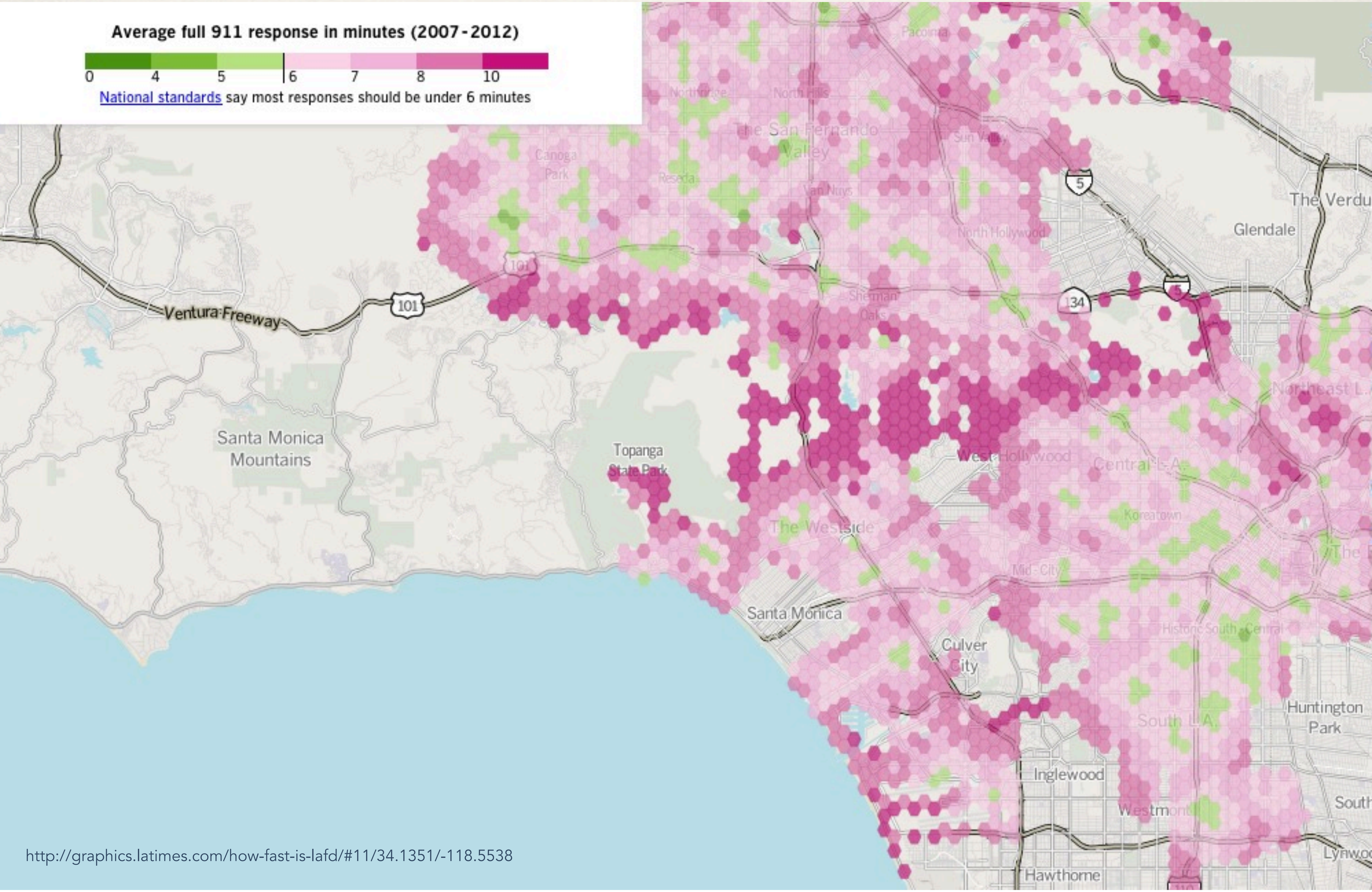


Illustreets

http://illustreets.co.uk/explore-england/

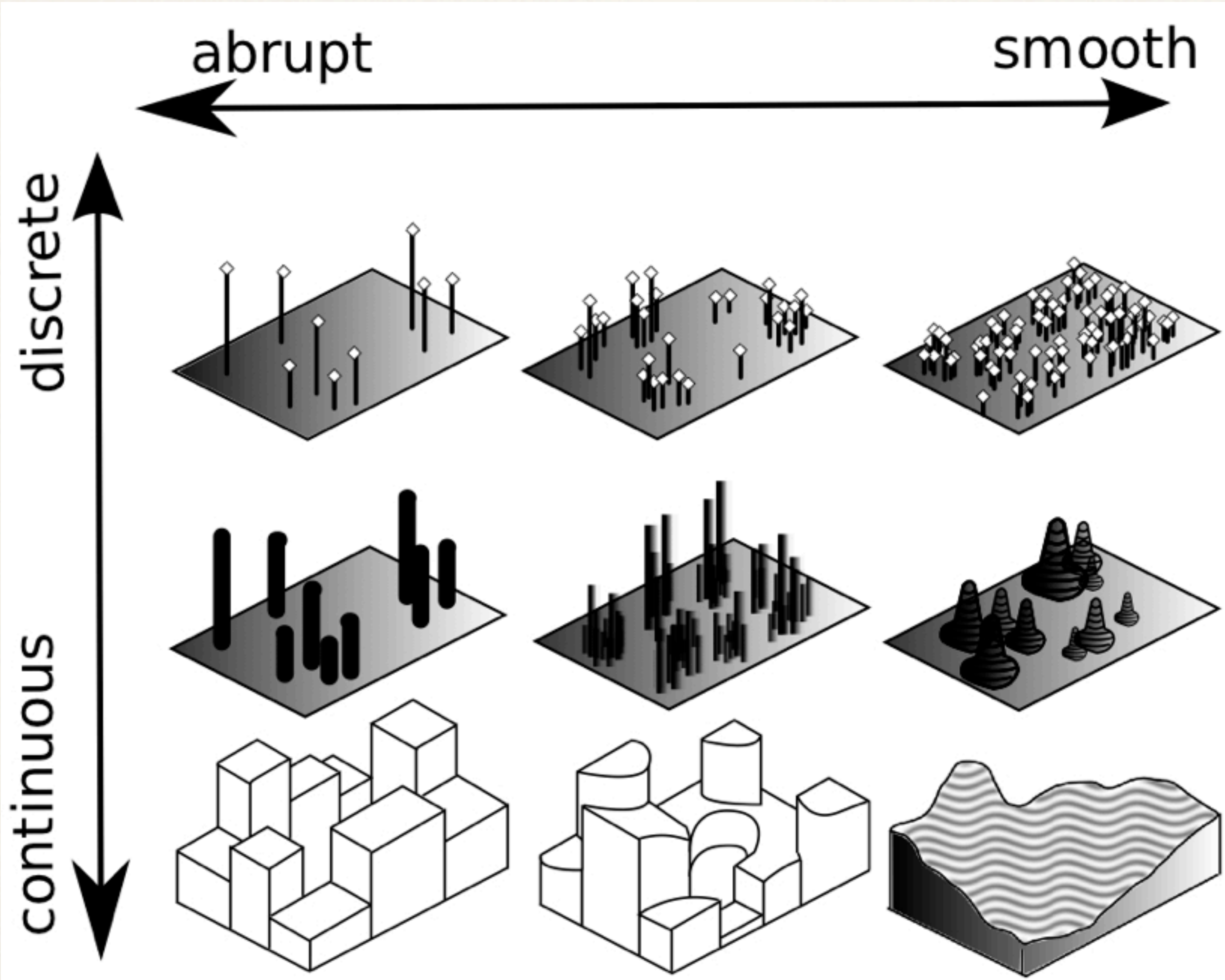


Binning

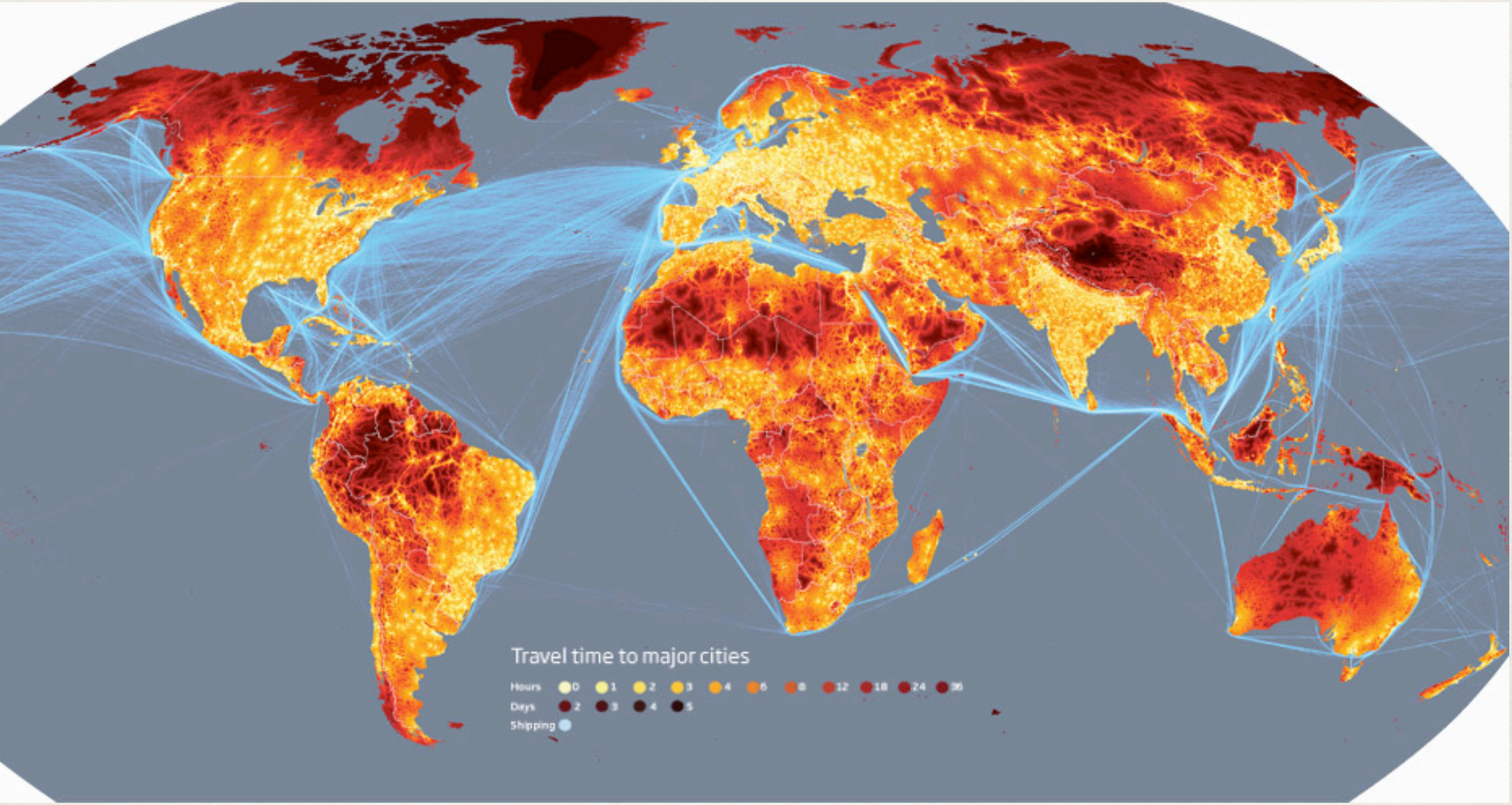


http://graphics.latimes.com/how-fast-is-lafd/#11/34.1351/-118.5538

Map style

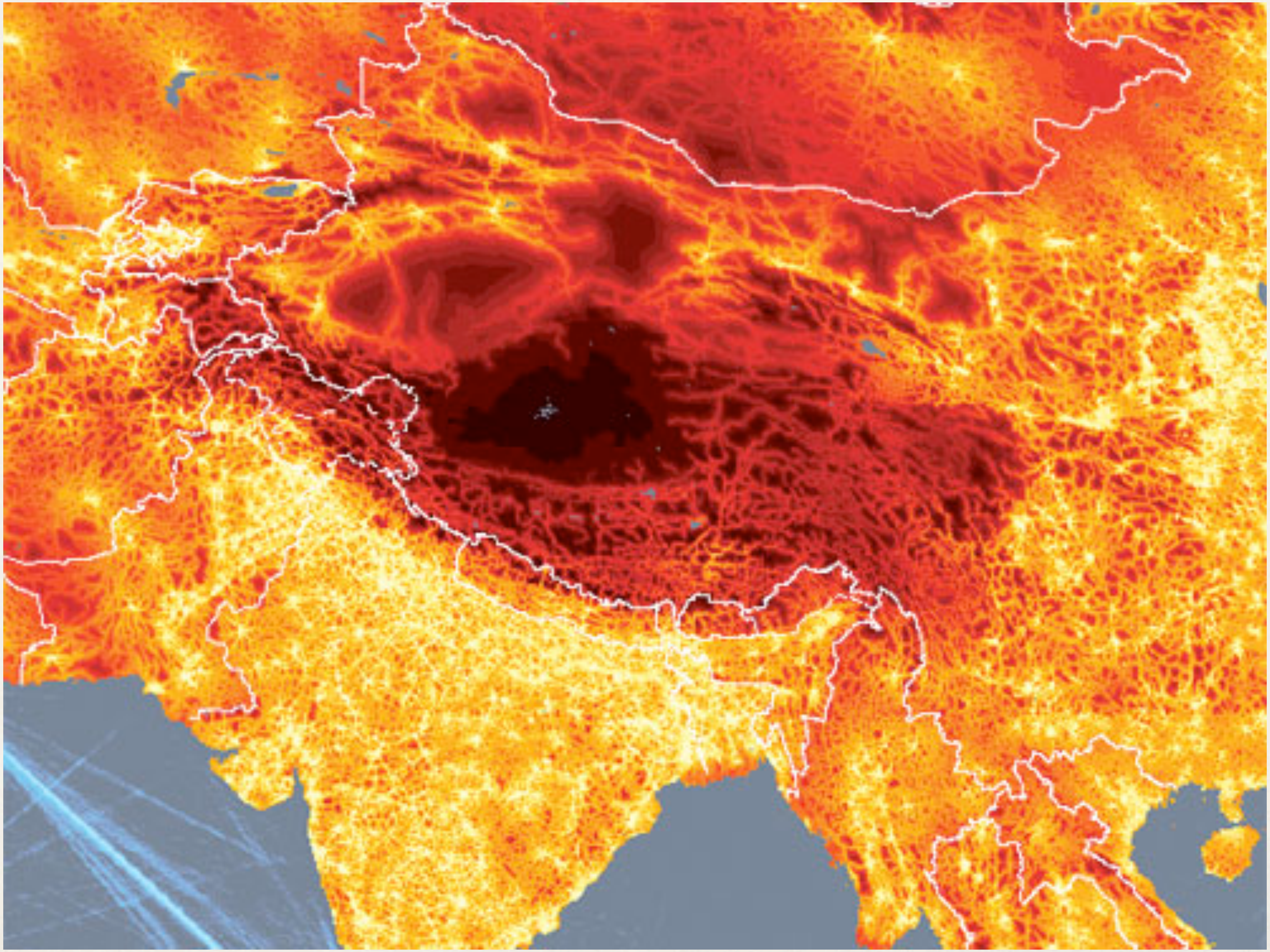


Continuous mapping



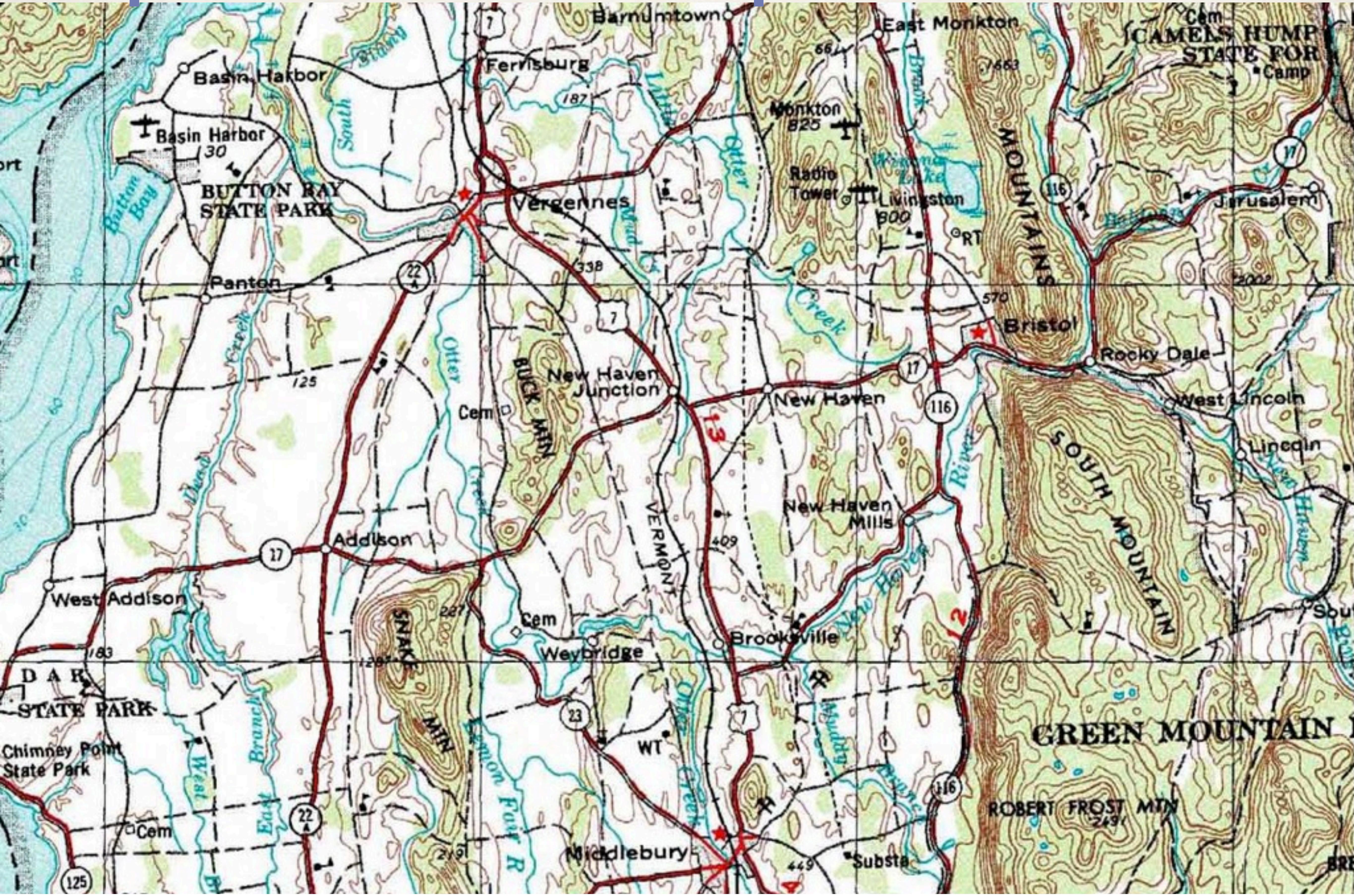
http://www.newscientist.com/gallery/small-world/1

Continuous mapping

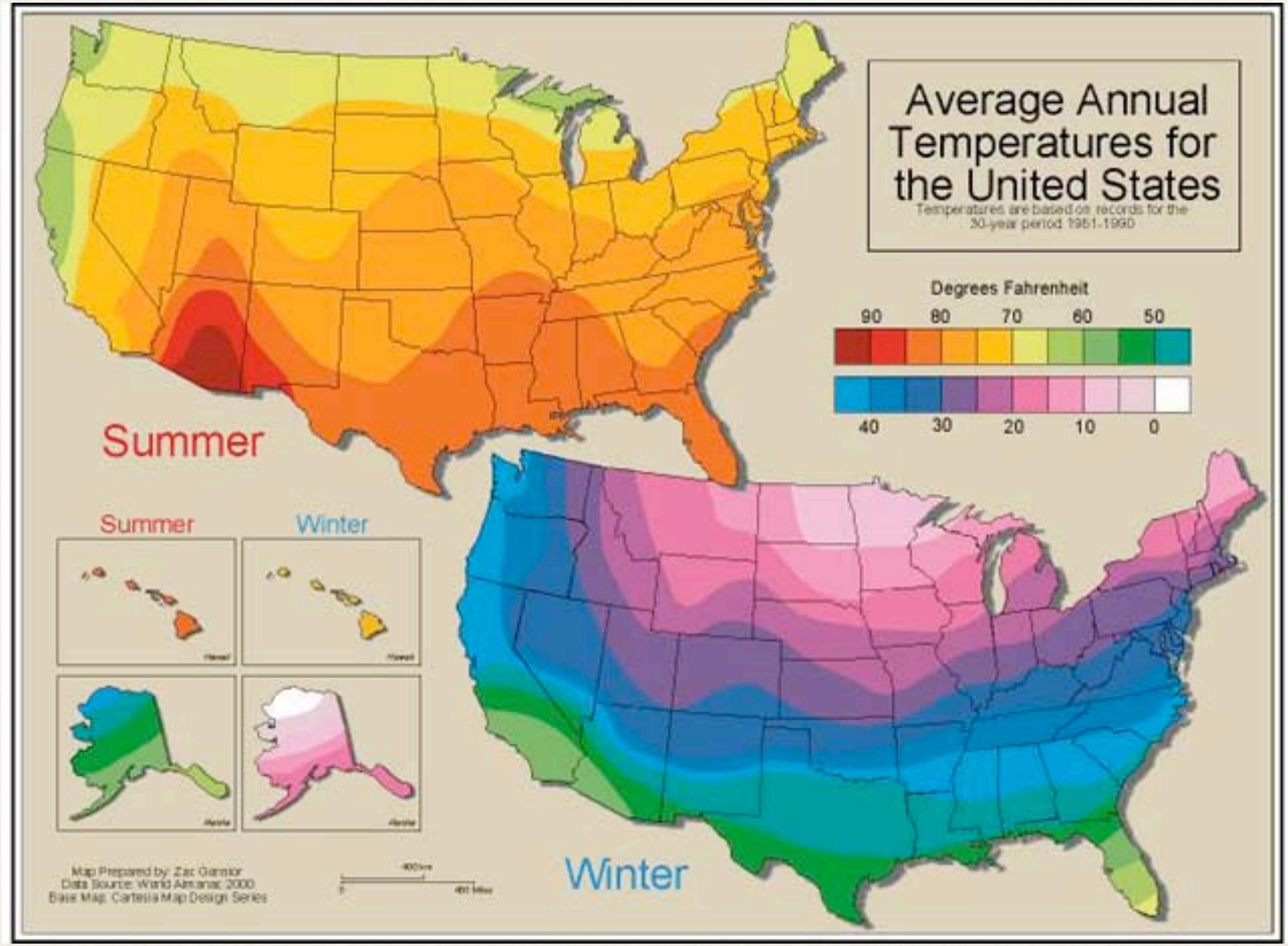


http://www.newscientist.com/gallery/small-world/1

Isopleth or isarithmic maps

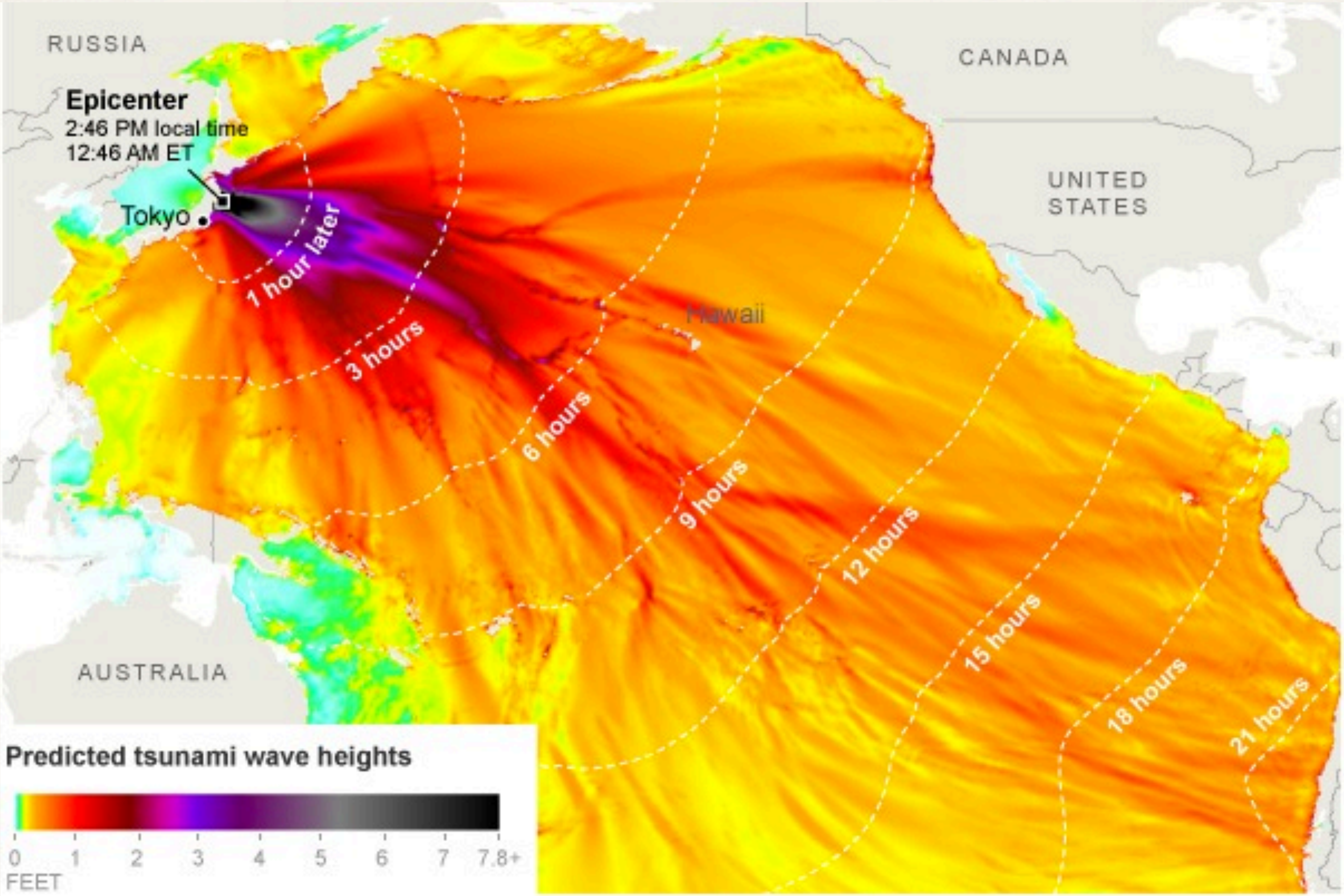


Isopleth or isarithmic maps



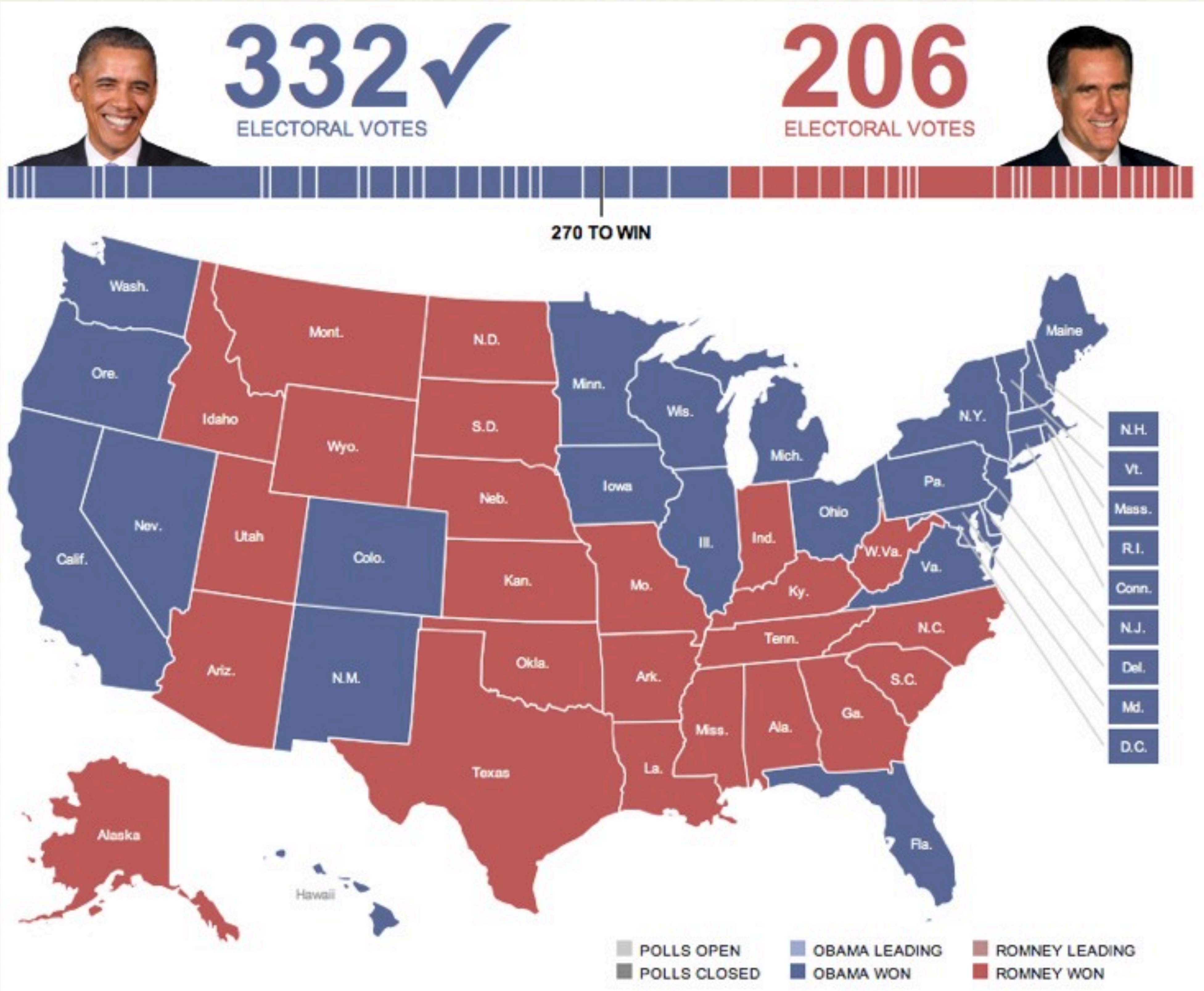
Heatmap + isochrones

iso == "same", chrones" == time



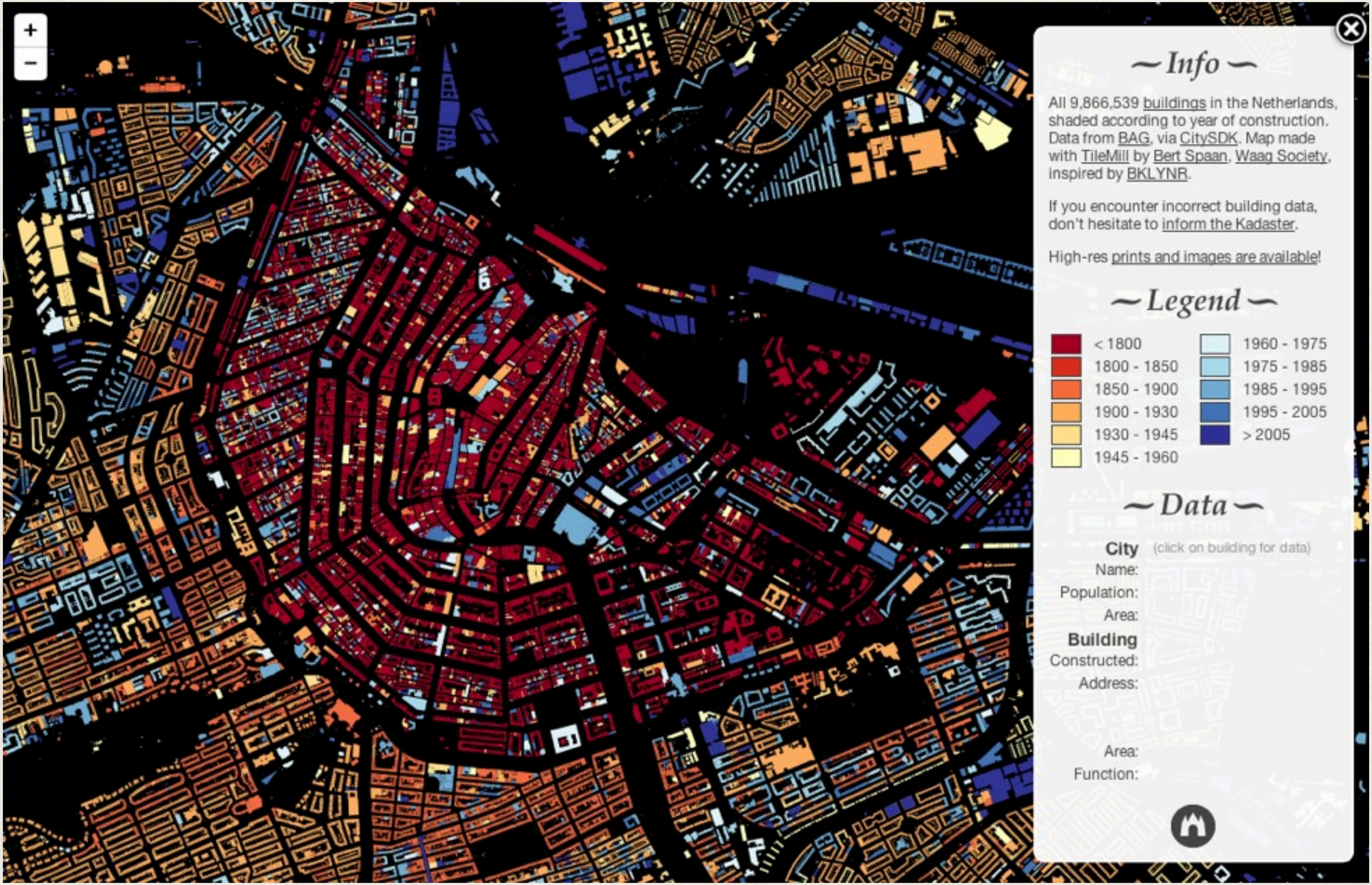
http://www.nytimes.com/

Choropleth maps



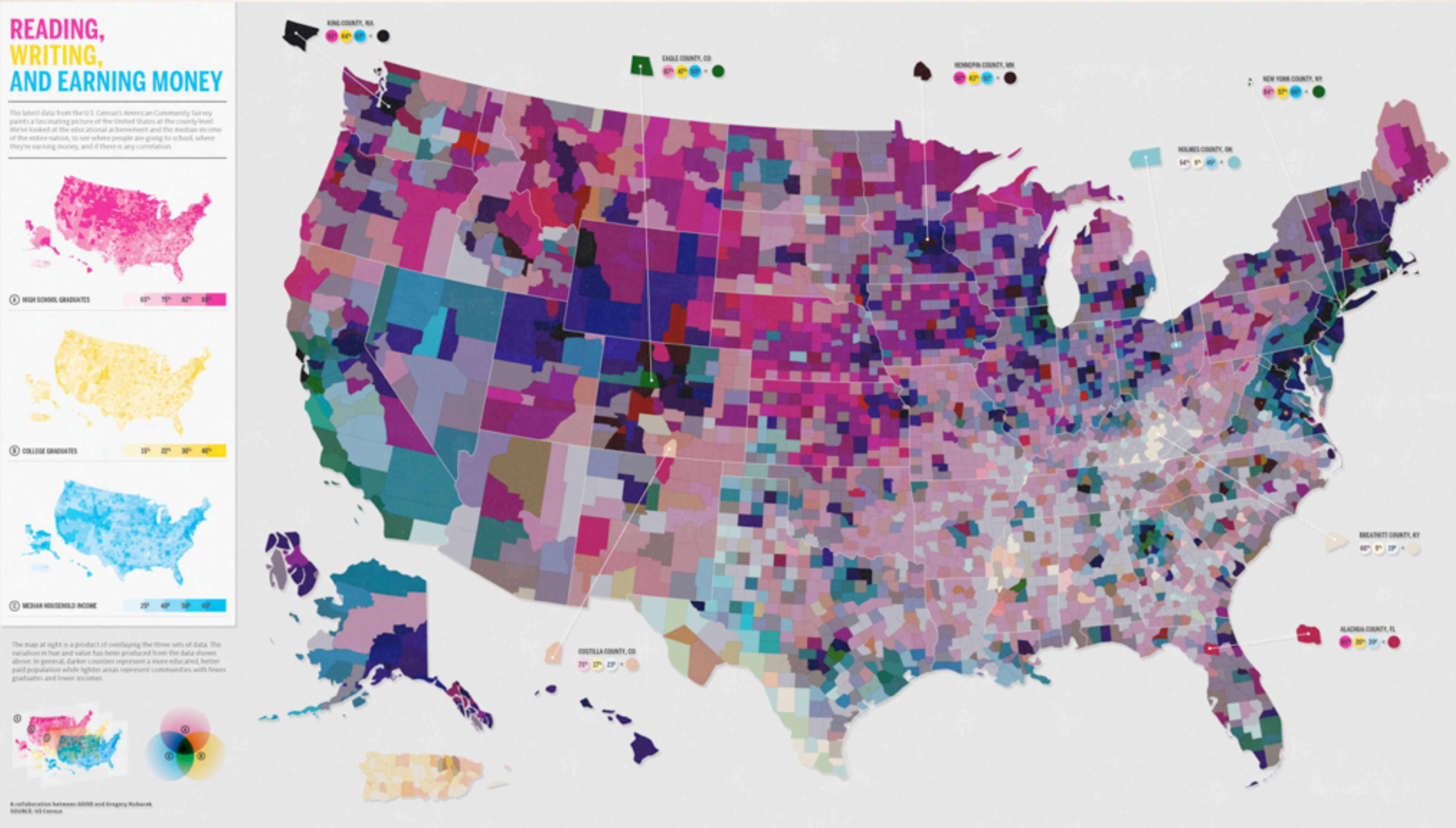
http://elections.huffingtonpost.com/2012/results

Building ages in Amsterdam



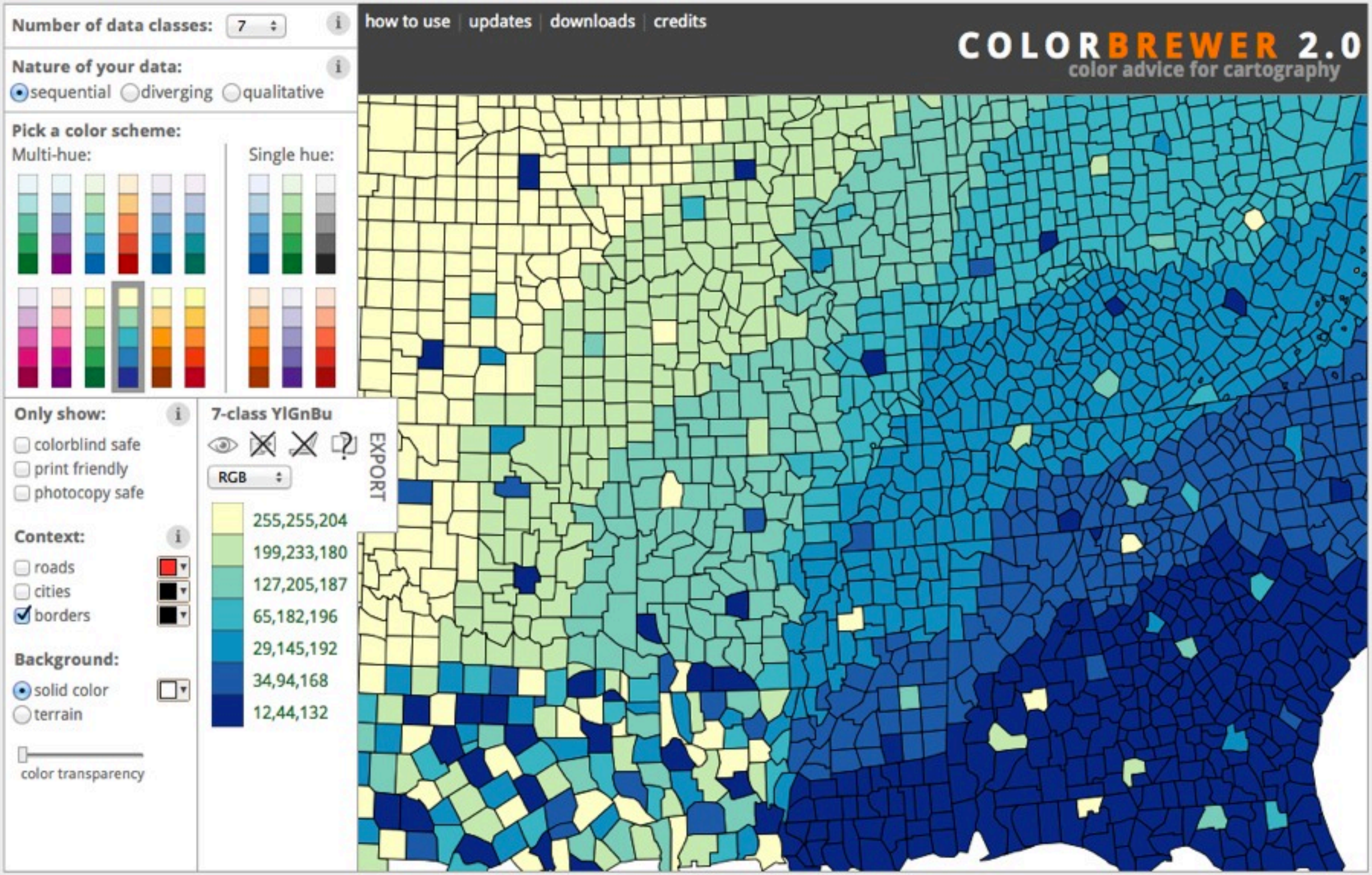
http://citysdk.waag.org/buildings

Using color



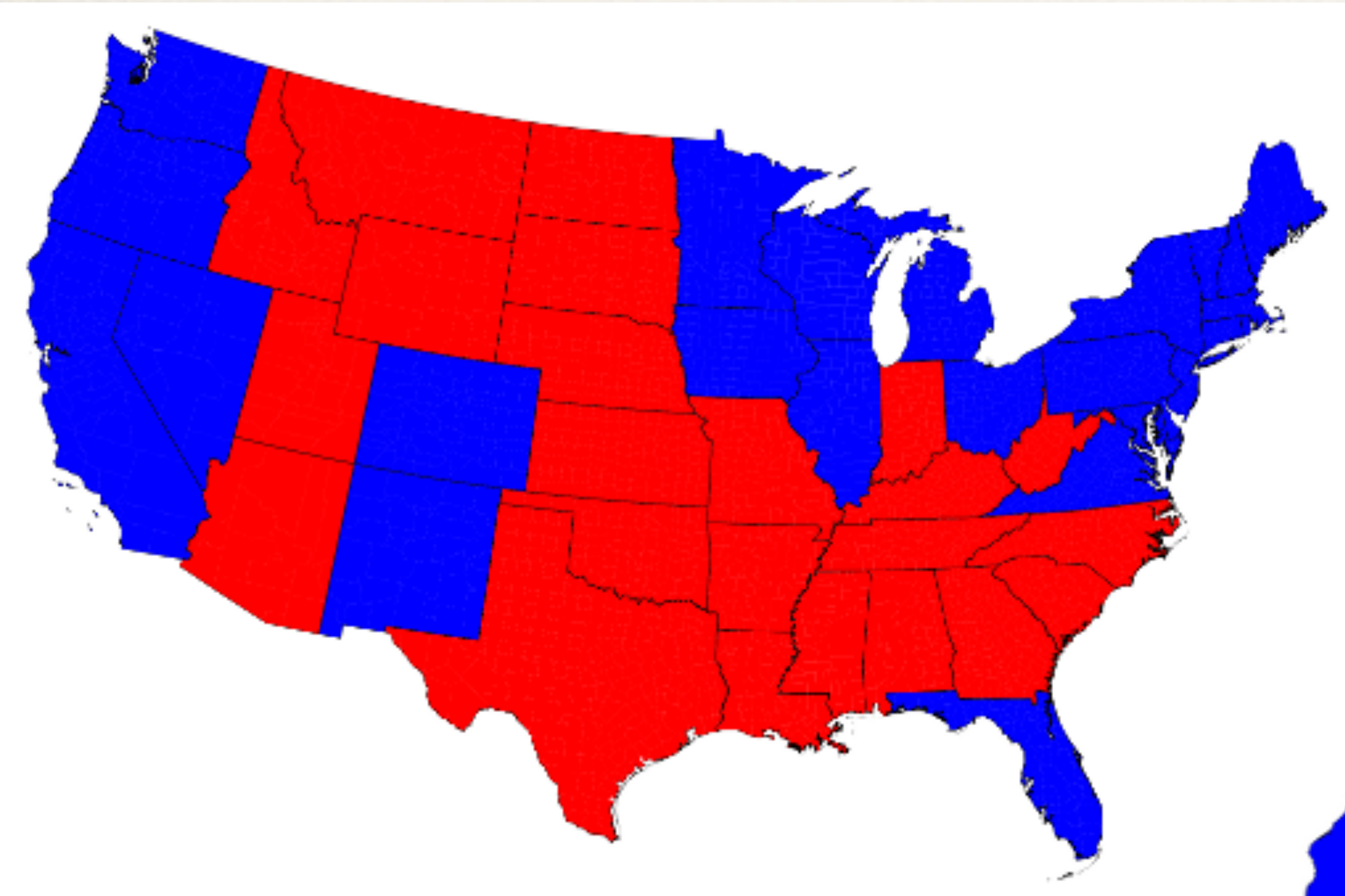
http://awesome.good.is/transparency/web/1101/census-data/flat.html

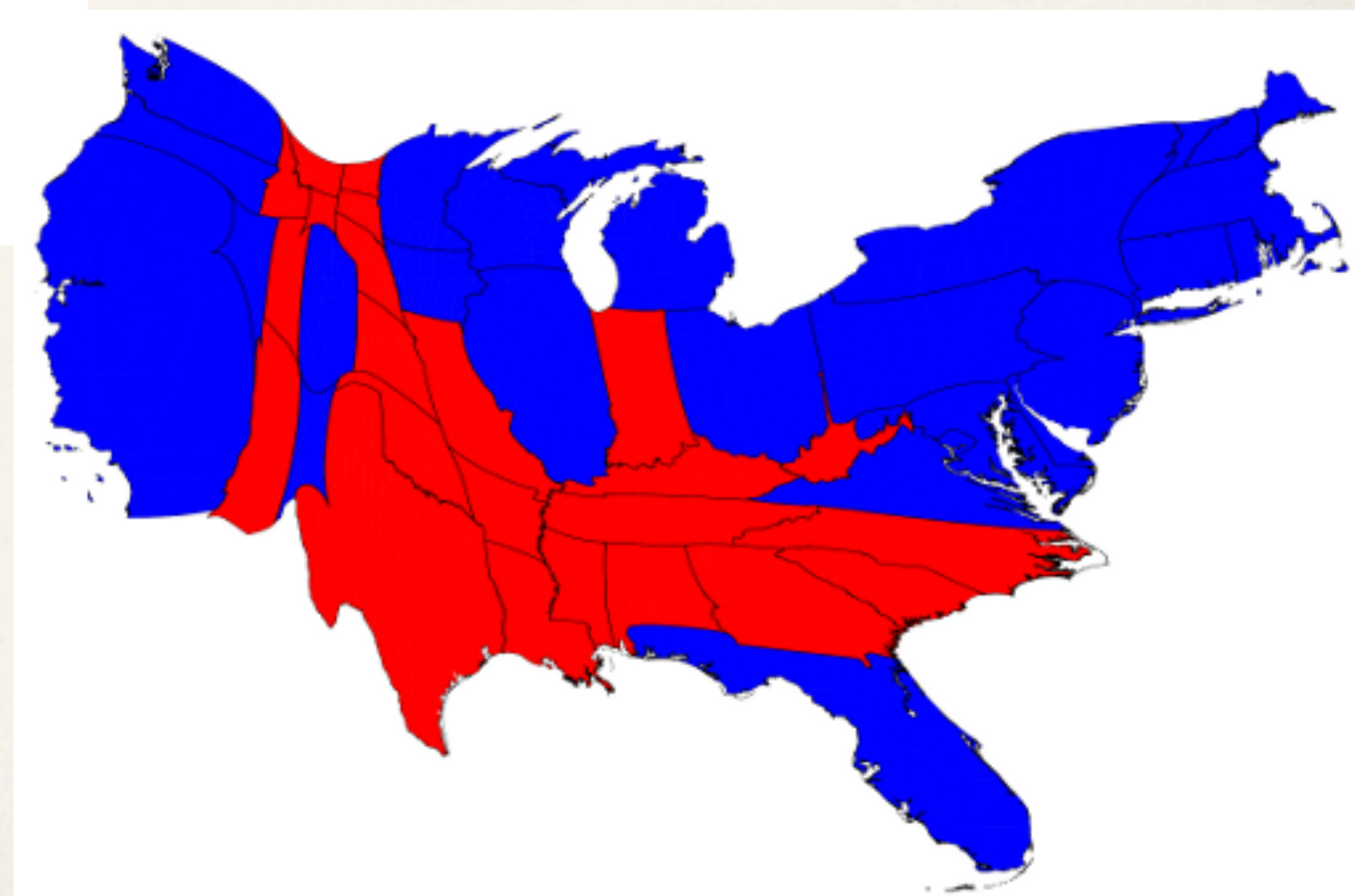
Color Brewer



http://colorbrewer2.org

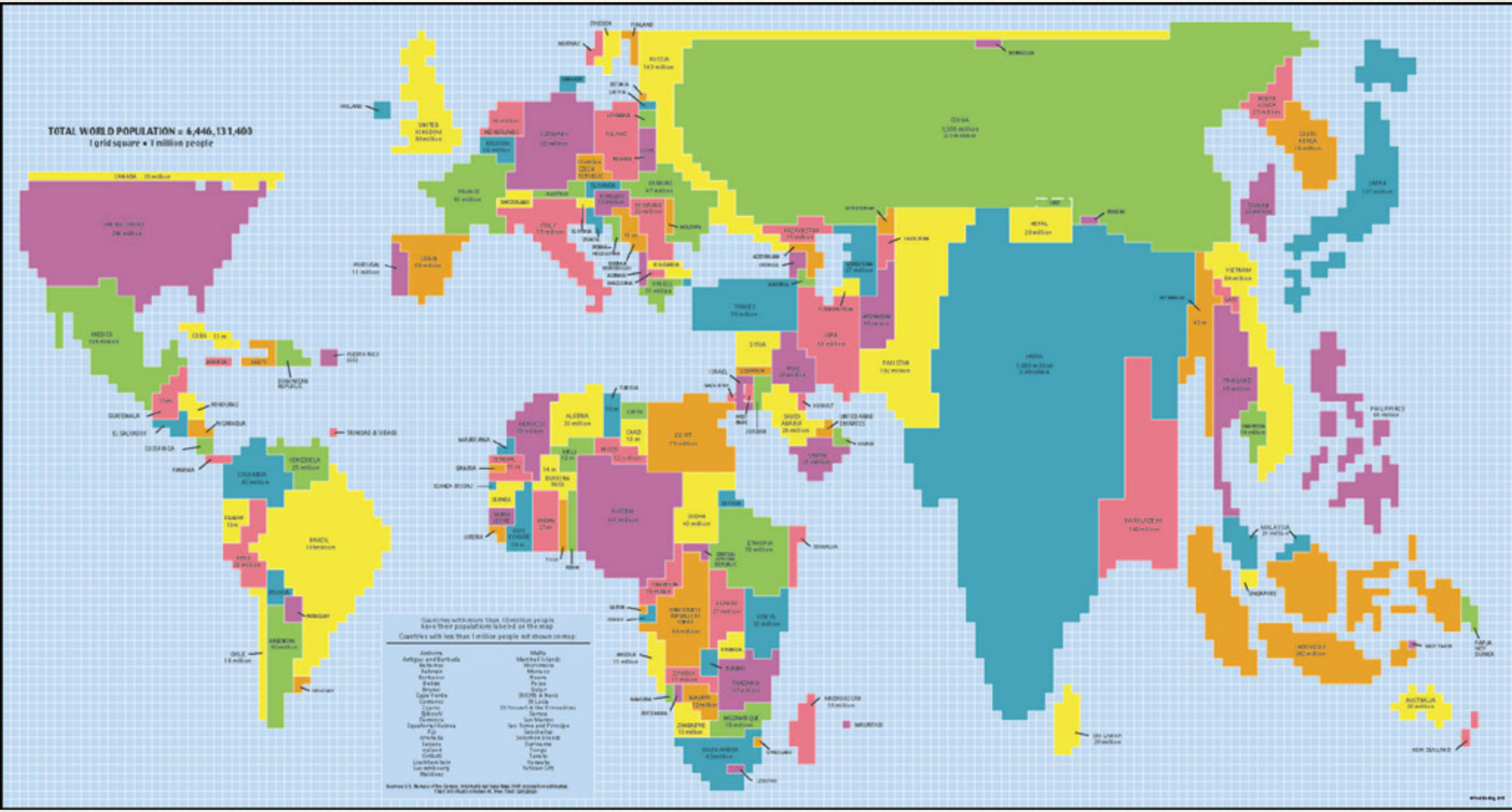
Cartograms





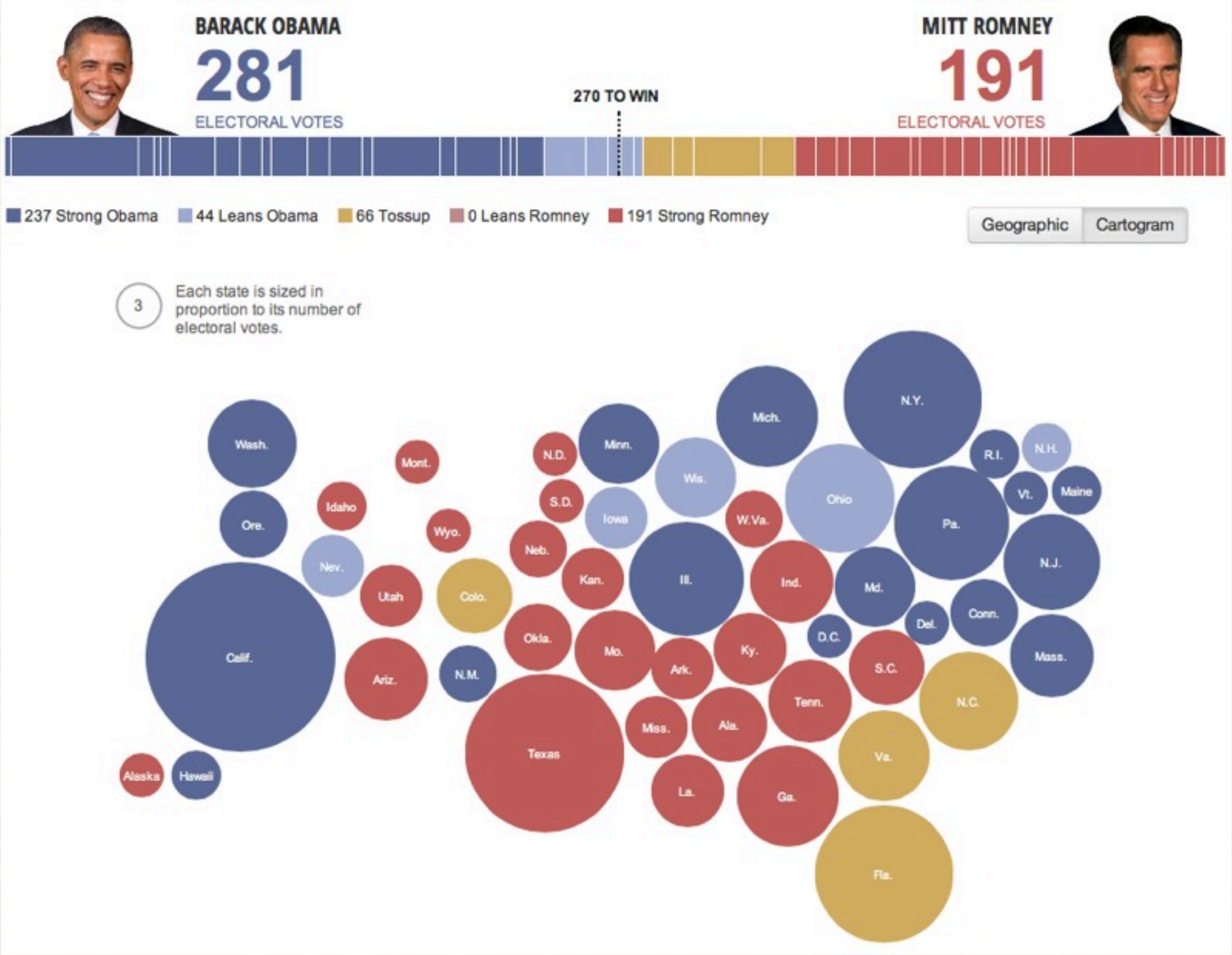
http://www-personal.umich.edu/~mejn/election/2012/

Rectangular cartogram



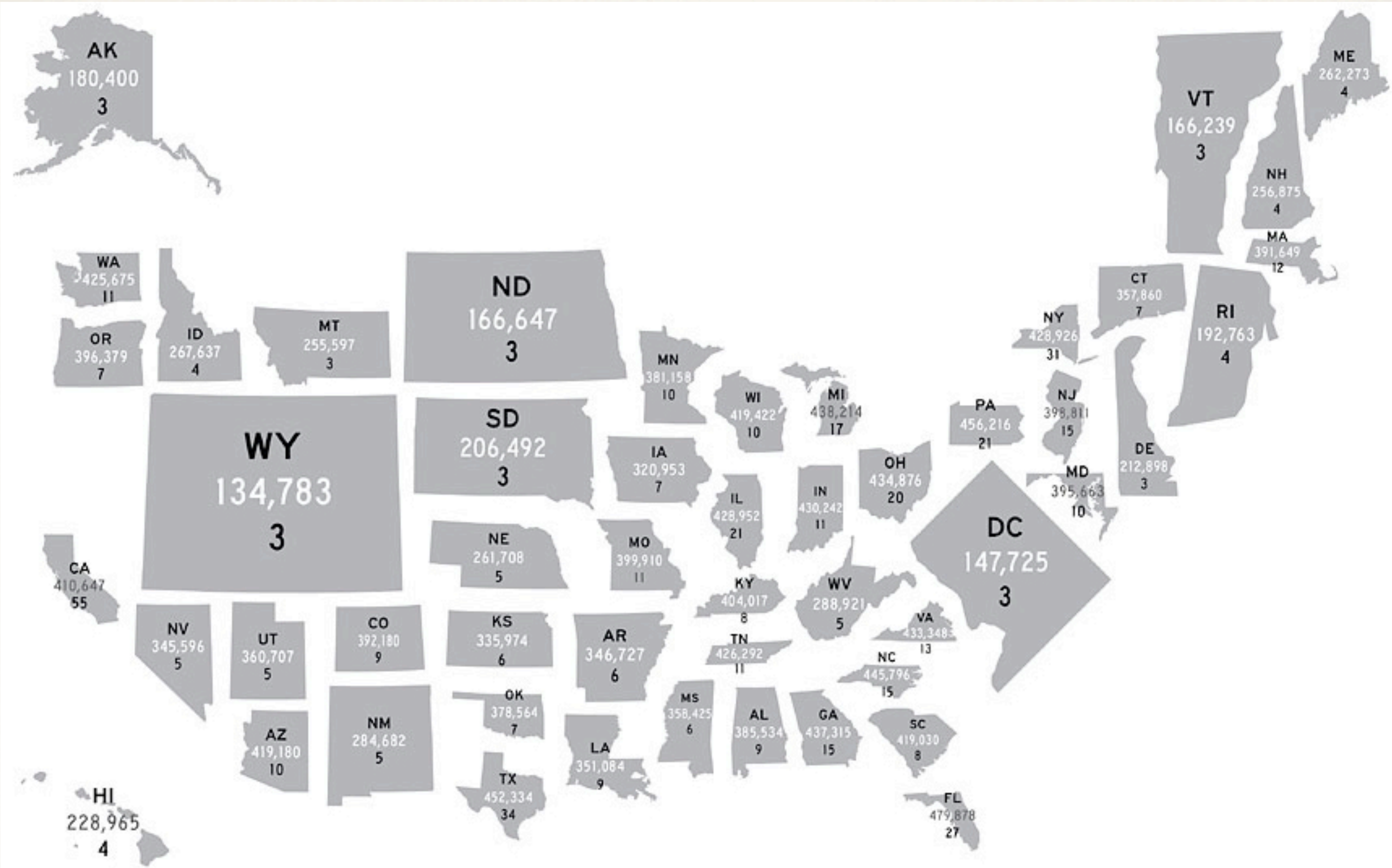
http://aphuge-ch2-population.blogspot.com

Circular cartogram



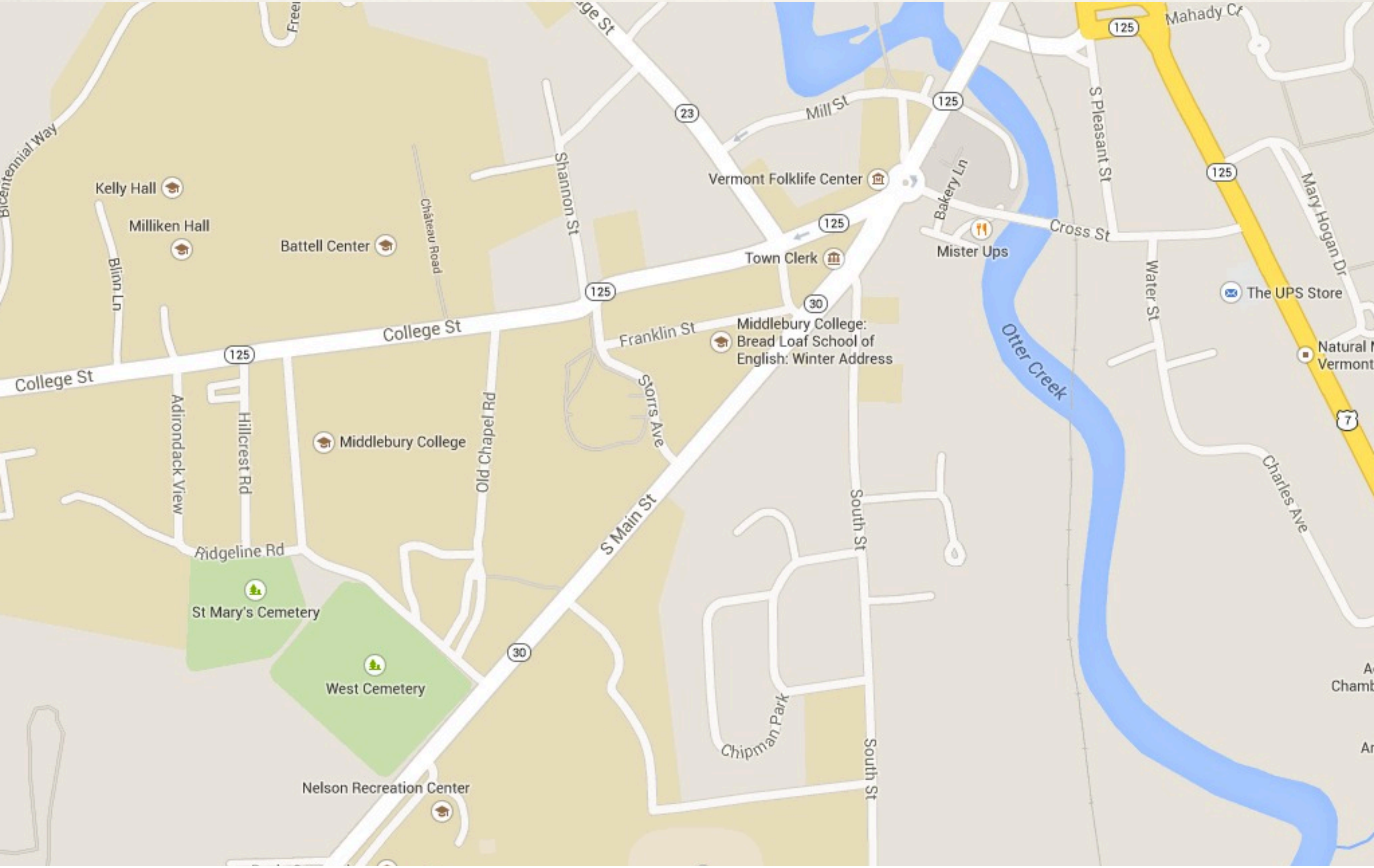
http://elections.huffingtonpost.com/2012/romney-vs-obama-electoral-map#cartogram

Non-contiguous cartograms

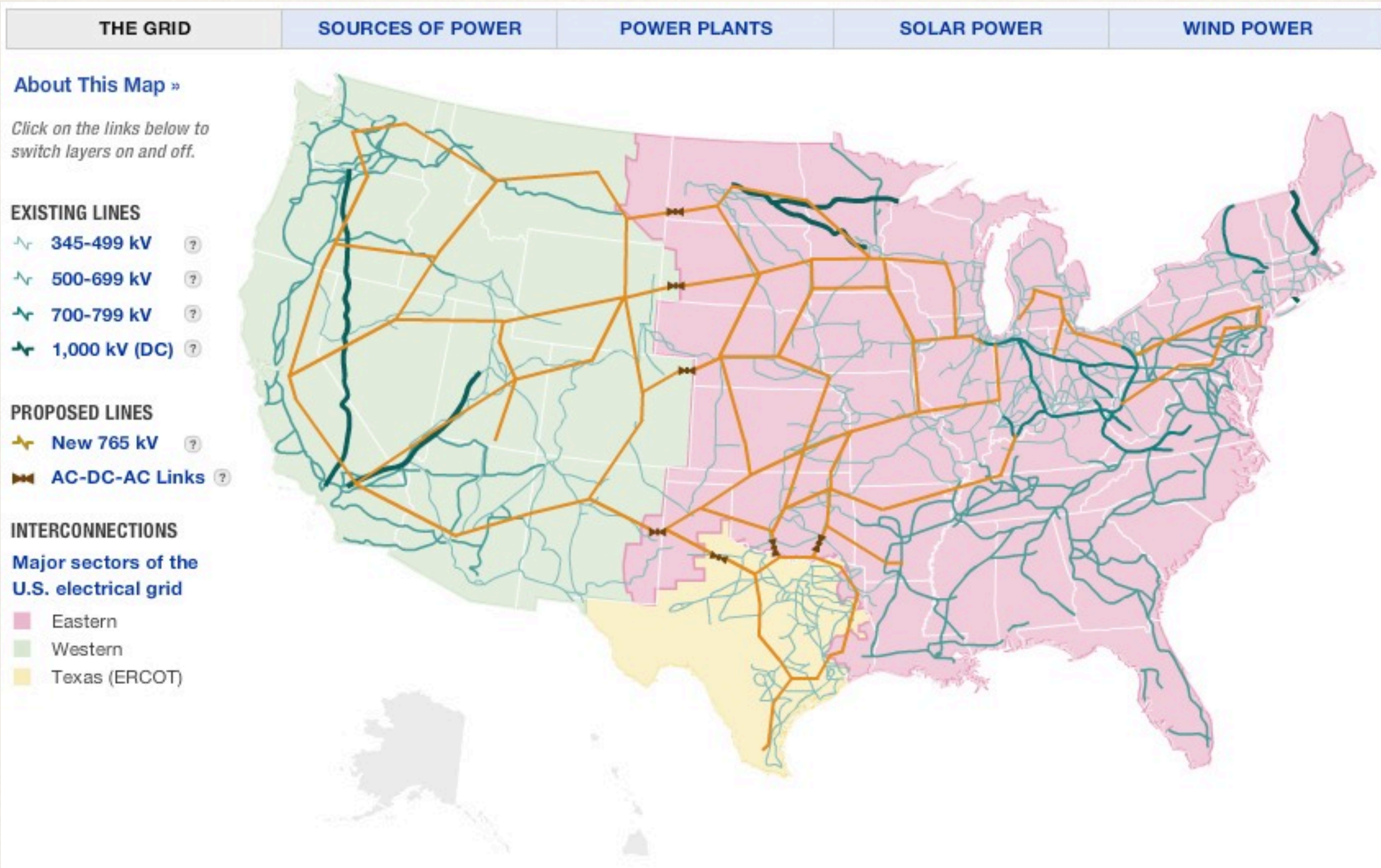


http://indiemaps.com/

Line data

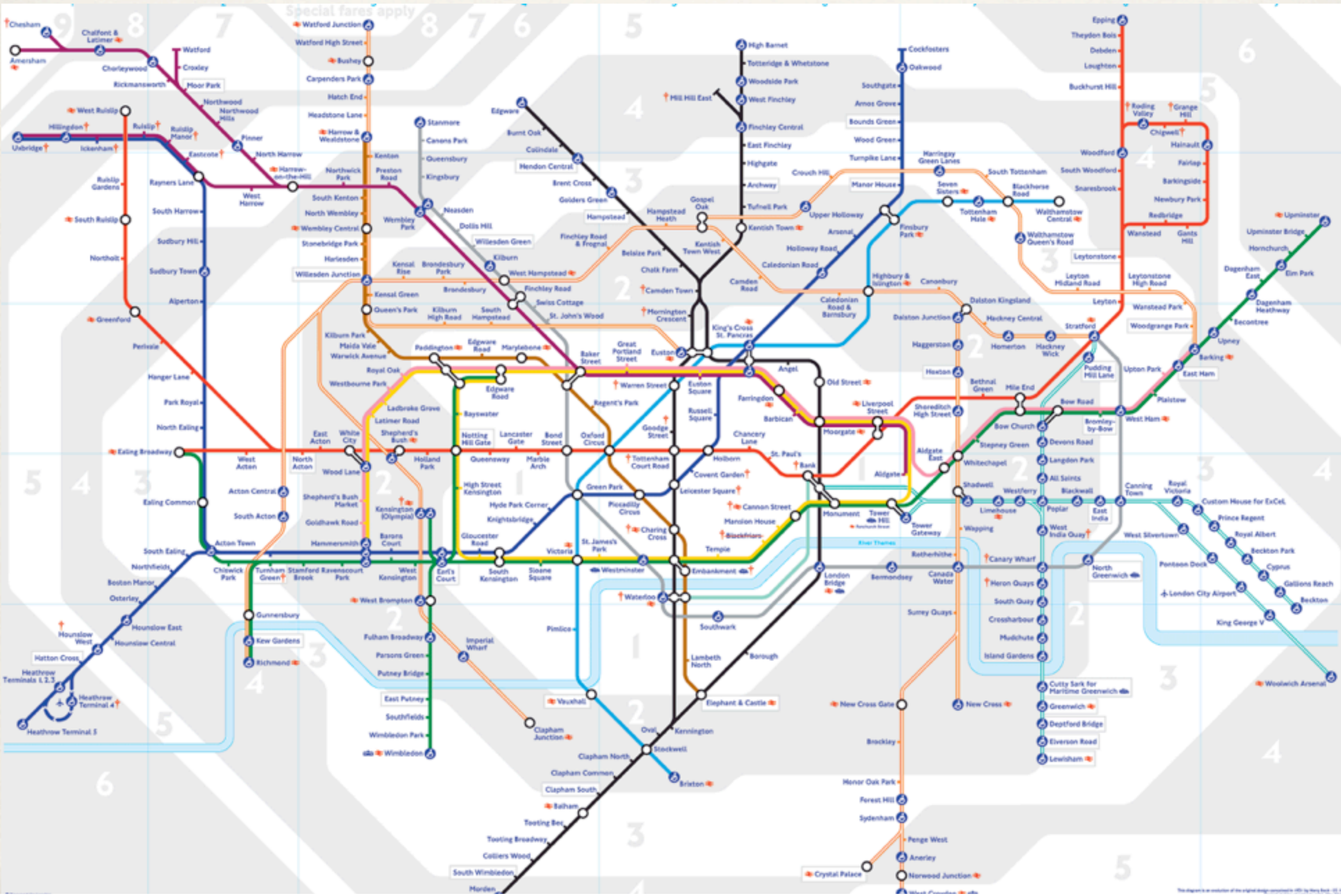

Kelly Hall
Milliken Hall
Battell Center
Château Road
Shannon St
Vermont Folklife Center
Mill St
Bakery Ln
Town Clerk
Mister Ups
Cross St
S Pleasant St
Mahady Ct
Mary Hogan Dr
The UPS Store
Water St
College St
Franklin St
Middlebury College: Bread Loaf School of English: Winter Address
Otter Creek
Storrs Ave
Blinn Ln
Adirondack View
Hillcrest Rd
Middlebury College
Old Chapel Rd
S Main St
South St
Charles Ave
Ridgeline Rd
St Mary's Cemetery
West Cemetery
Chipman Park
Nelson Recreation Center
Bicentennial Way
125
23
30
7

Network data



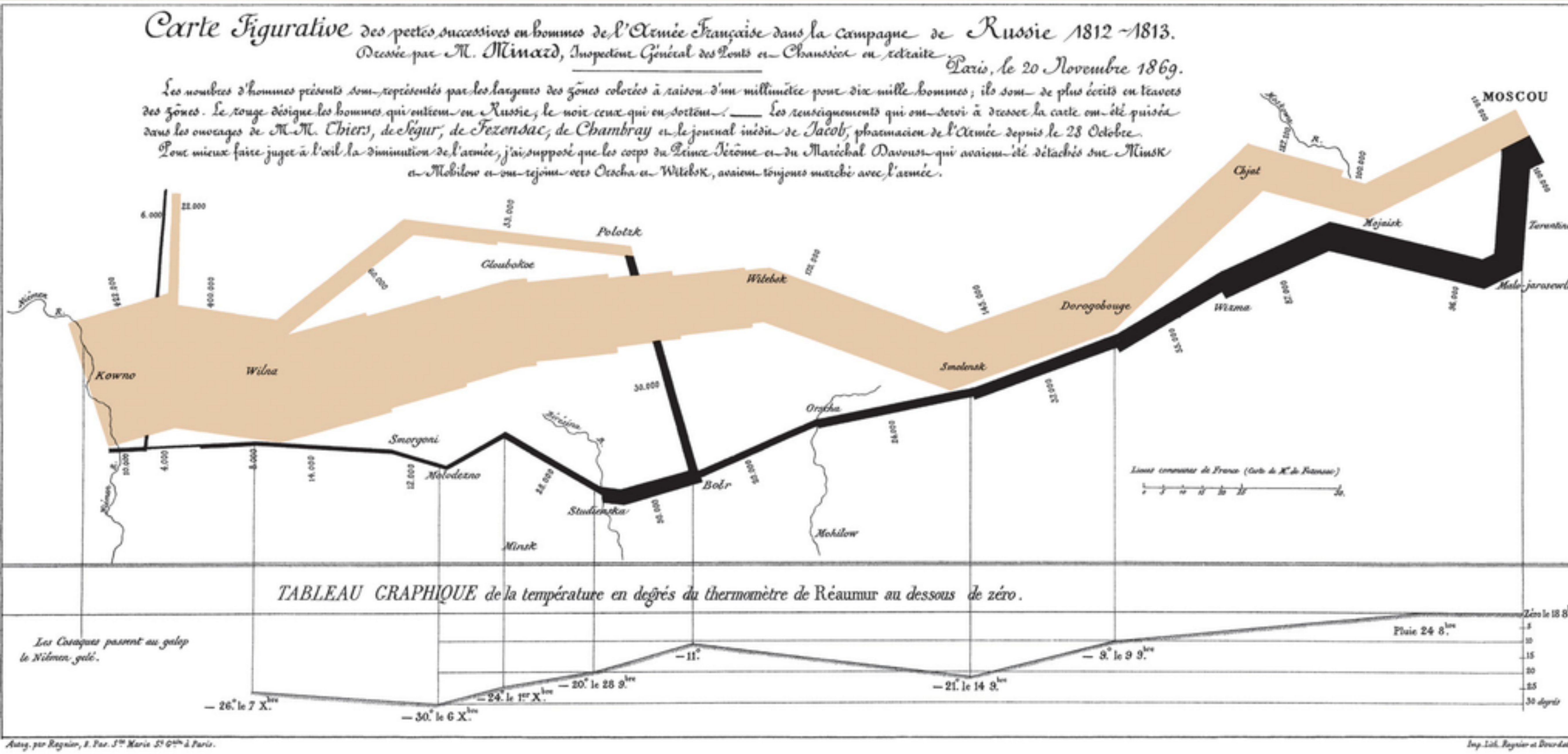
http://www.npr.org/templates/story/story.php?storyId=110997398

London tube map



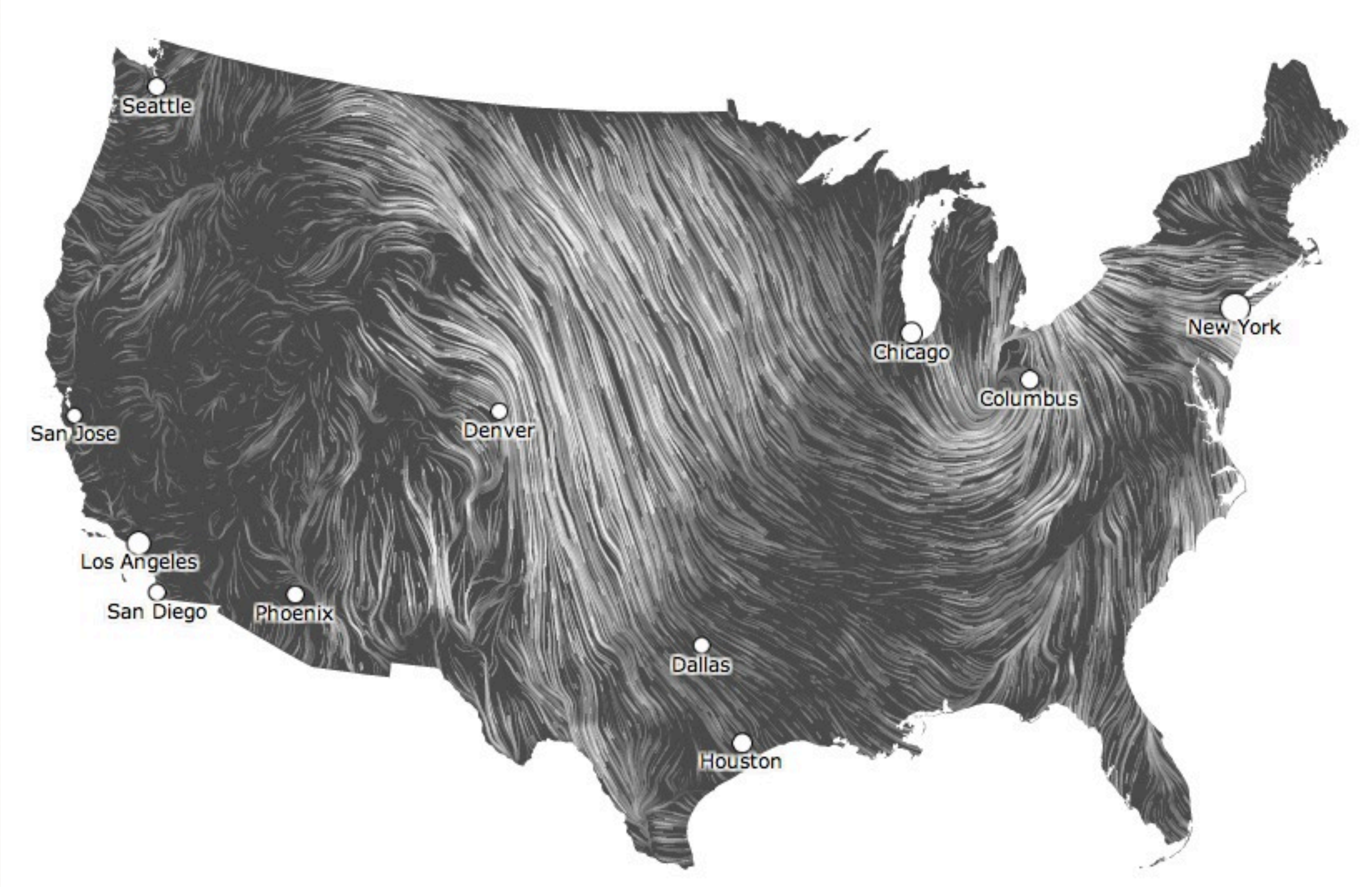
Flow map

Minard's map of Napoleon's invasion of Russia



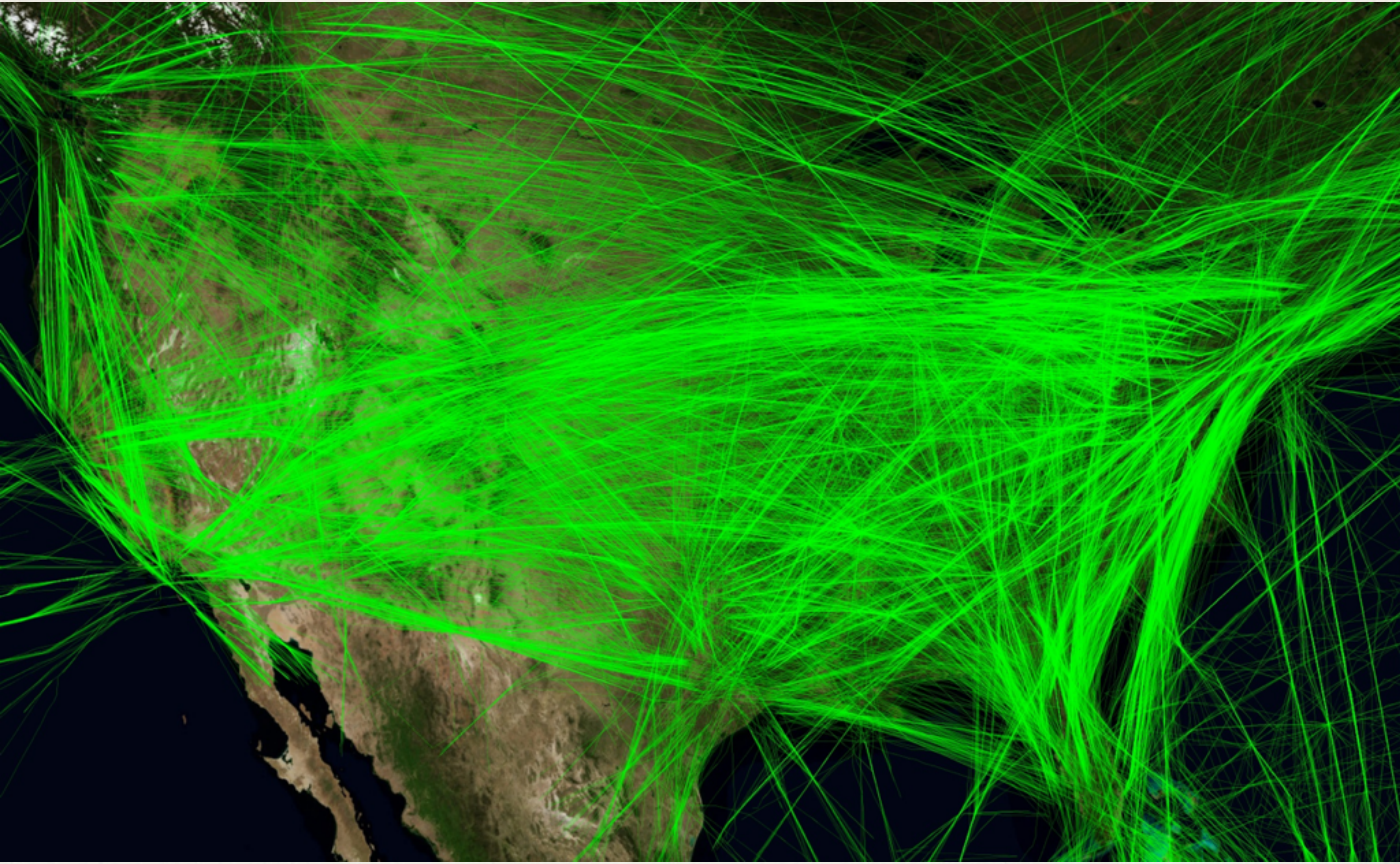
Wikimedia Commons

Flow map

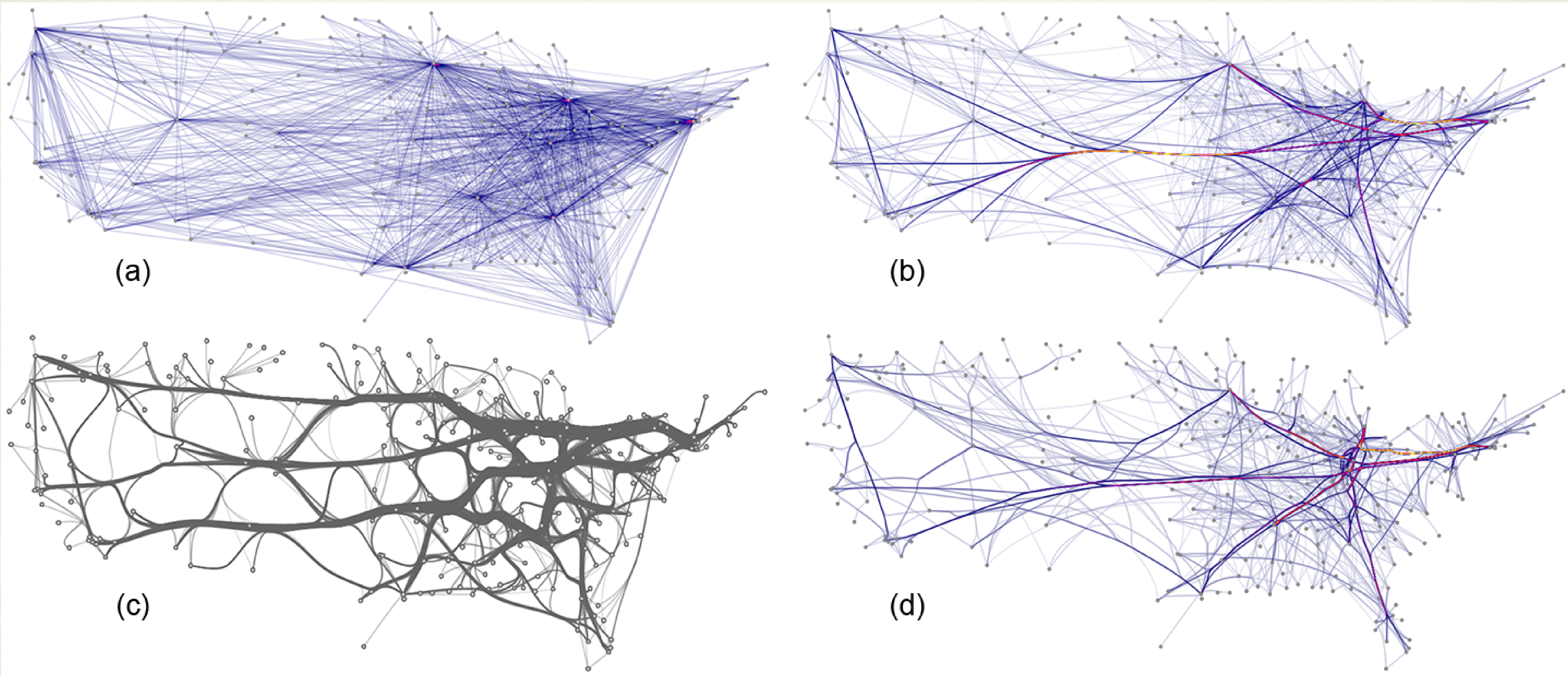


http://hint.fm/wind/

Airline flight path



https://www.metabunk.org/threads/visualizing-flight-paths-above-30-000-feet.812/



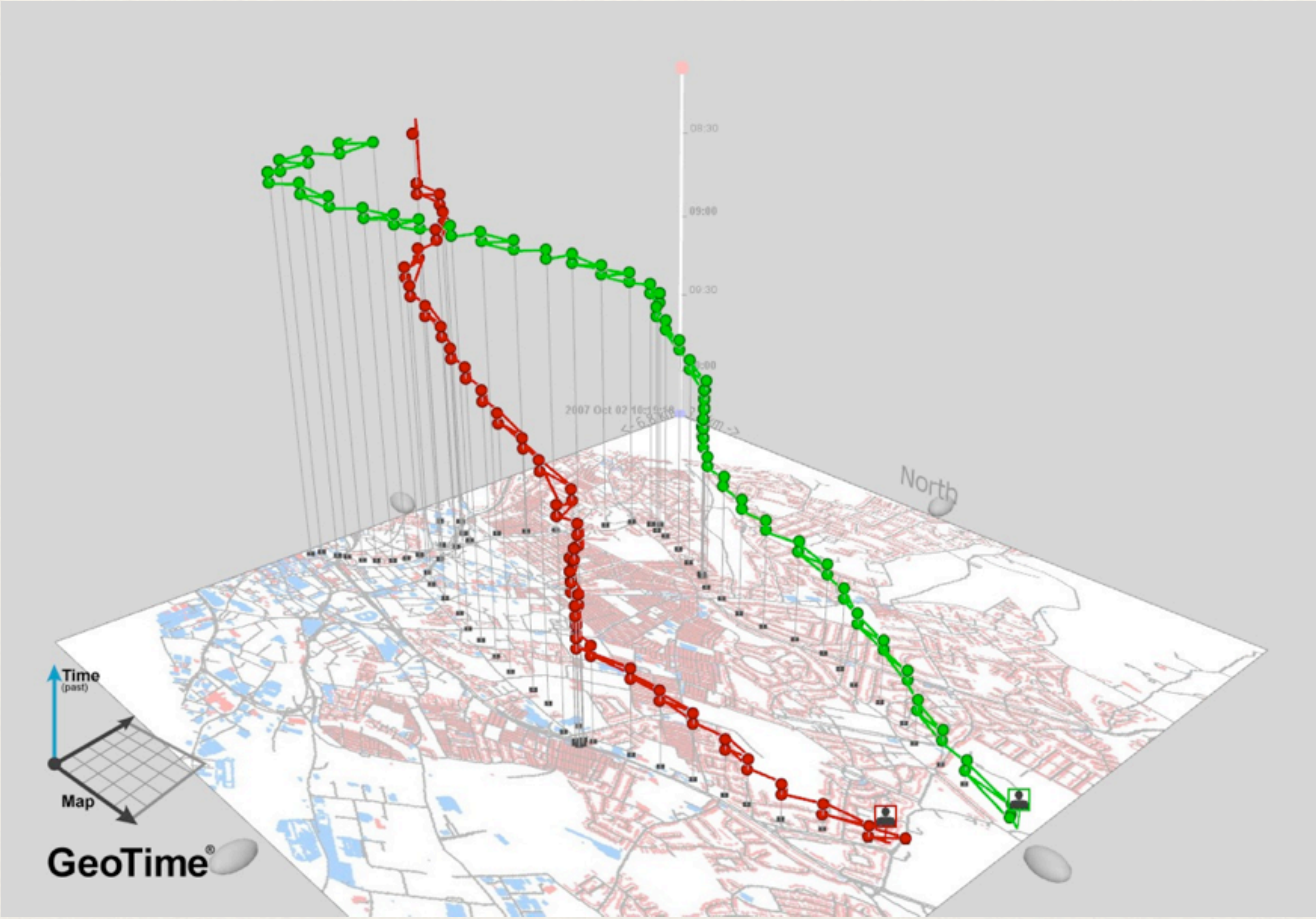
Holden and van Wijk, “Force Directed Edge Bundling for Graph Visualization”, 2009

http://www.spatialanalysis.ca/2011/global-connectivity-mapping-out-flight-routes/

Alternatives - Bristle maps

Kim et al., "Bristle Maps: A Multivariate Abstraction Technique for Geovisualization"

Alternatives - GeoTime



http://www.geotime.com