Data Visualization (CIS 490/680)

Geospatial Data

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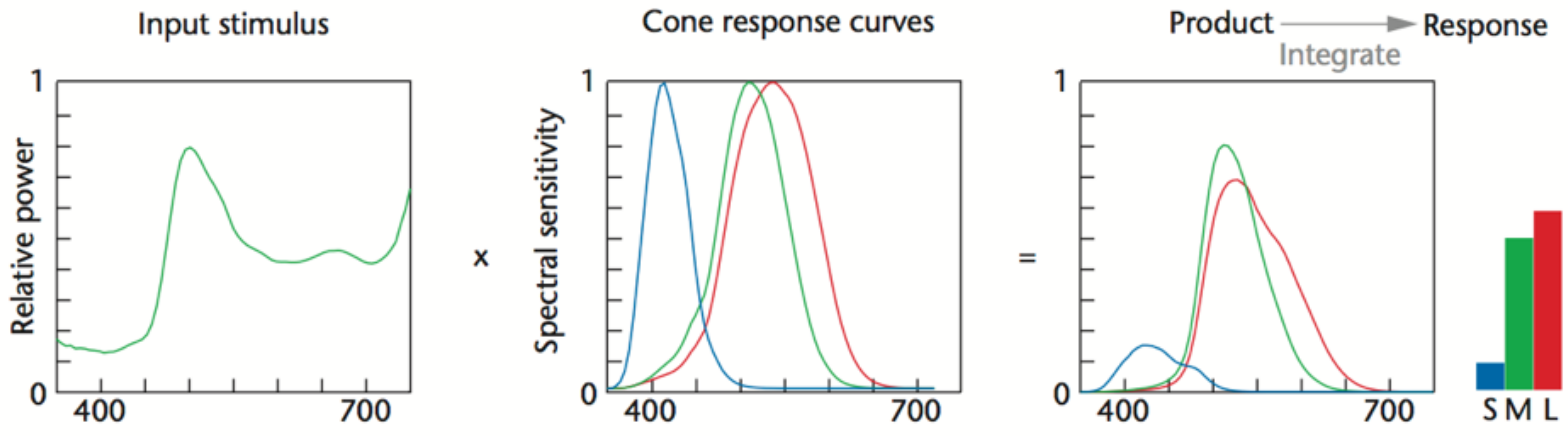
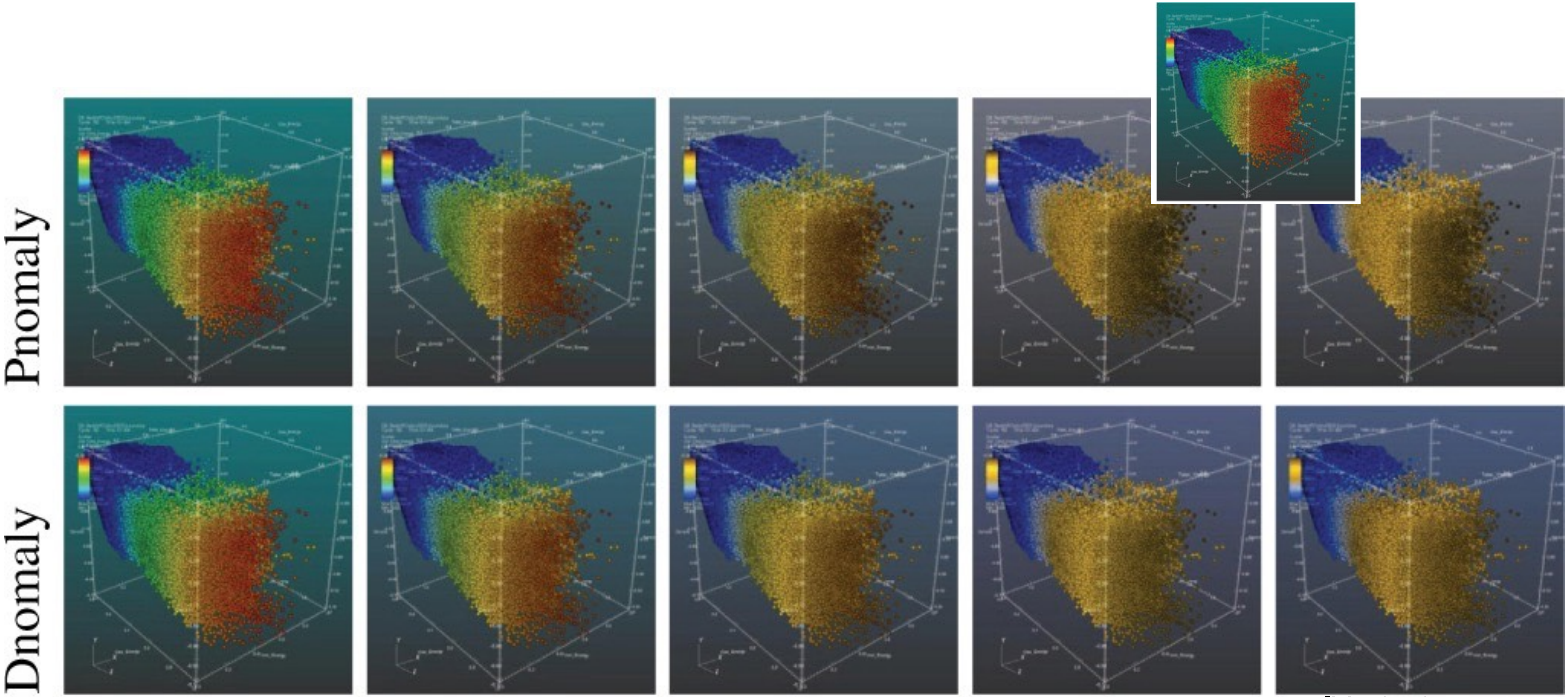
Northern Illinois University

Human Color Perception



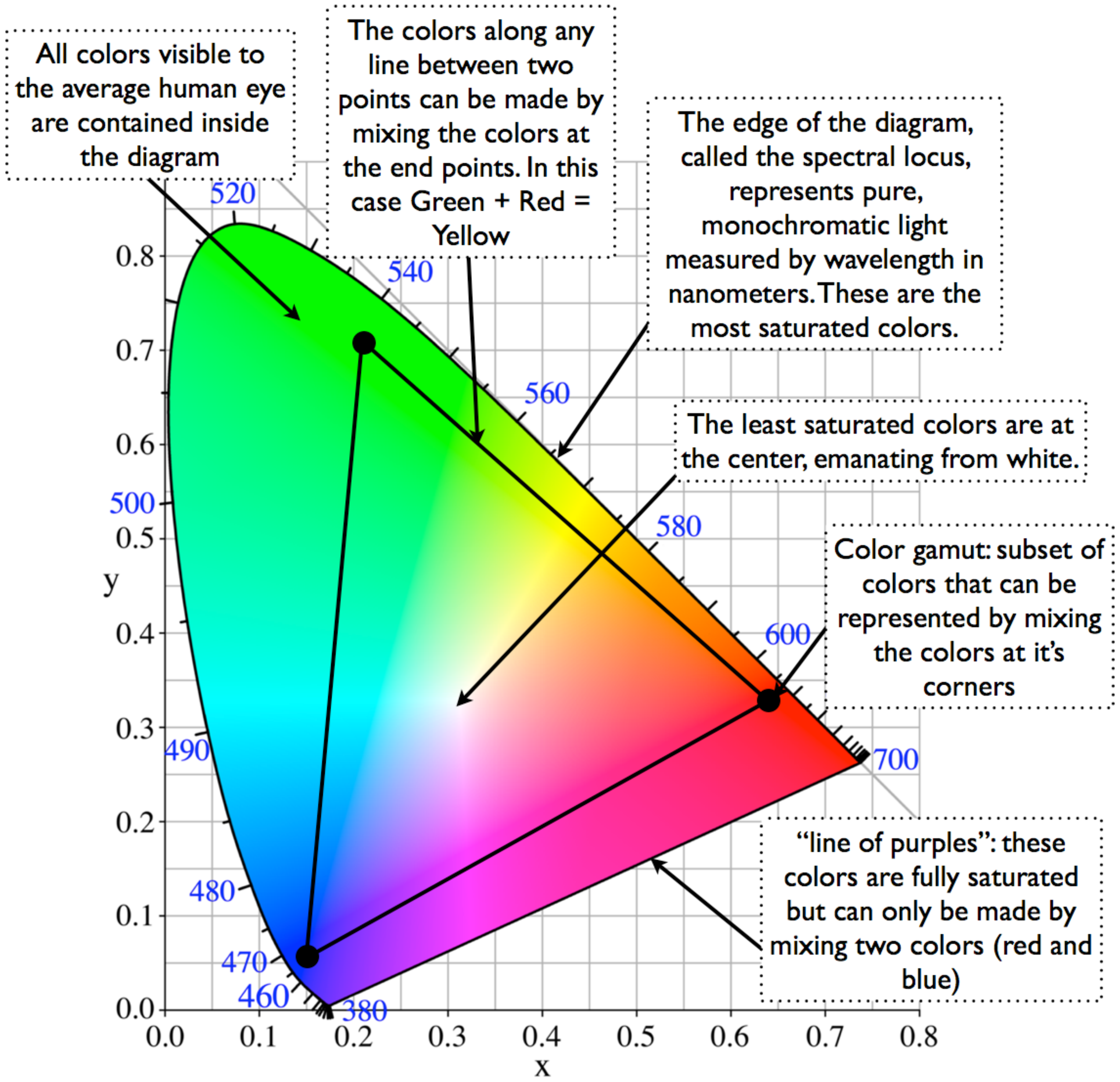
[via M. Meyer]

Simulating Color Blindness



[Machado et. al, 2009]

Color Spaces and Gamuts

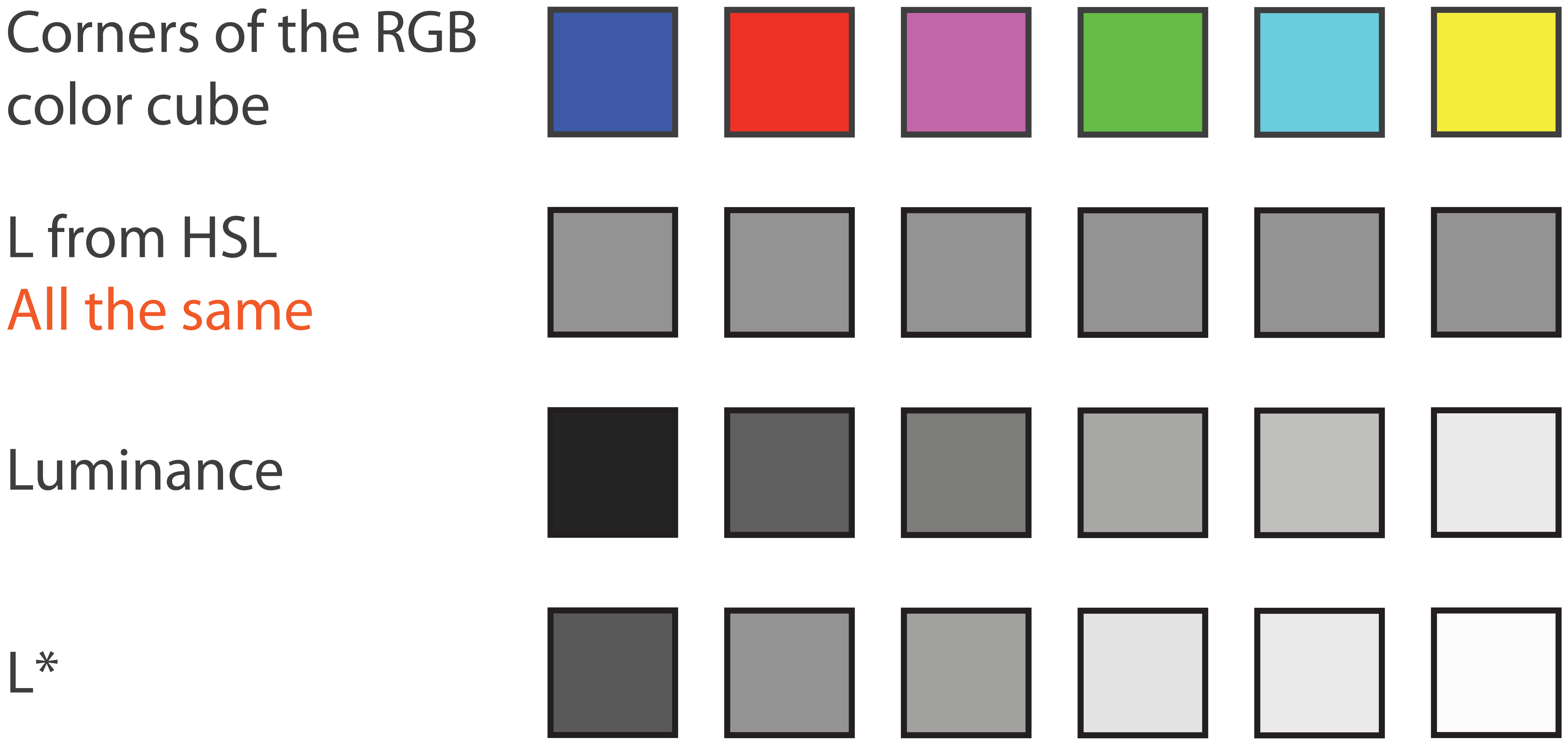


[Anatomy of a CIE Chromaticity Diagram]

- **Color space**: the organization of all colors in space
  - Often human-specific, what we can see (e.g. CIELAB)
- **Color gamut**: a subset of colors
  - Defined by corners of color space
  - What can be produced on a monitor (e.g. using RGB)
  - What can be produced on a printer (e.g. using CMYK)
  - The gamut of your monitor != the gamut of someone else's or a printer

Luminance

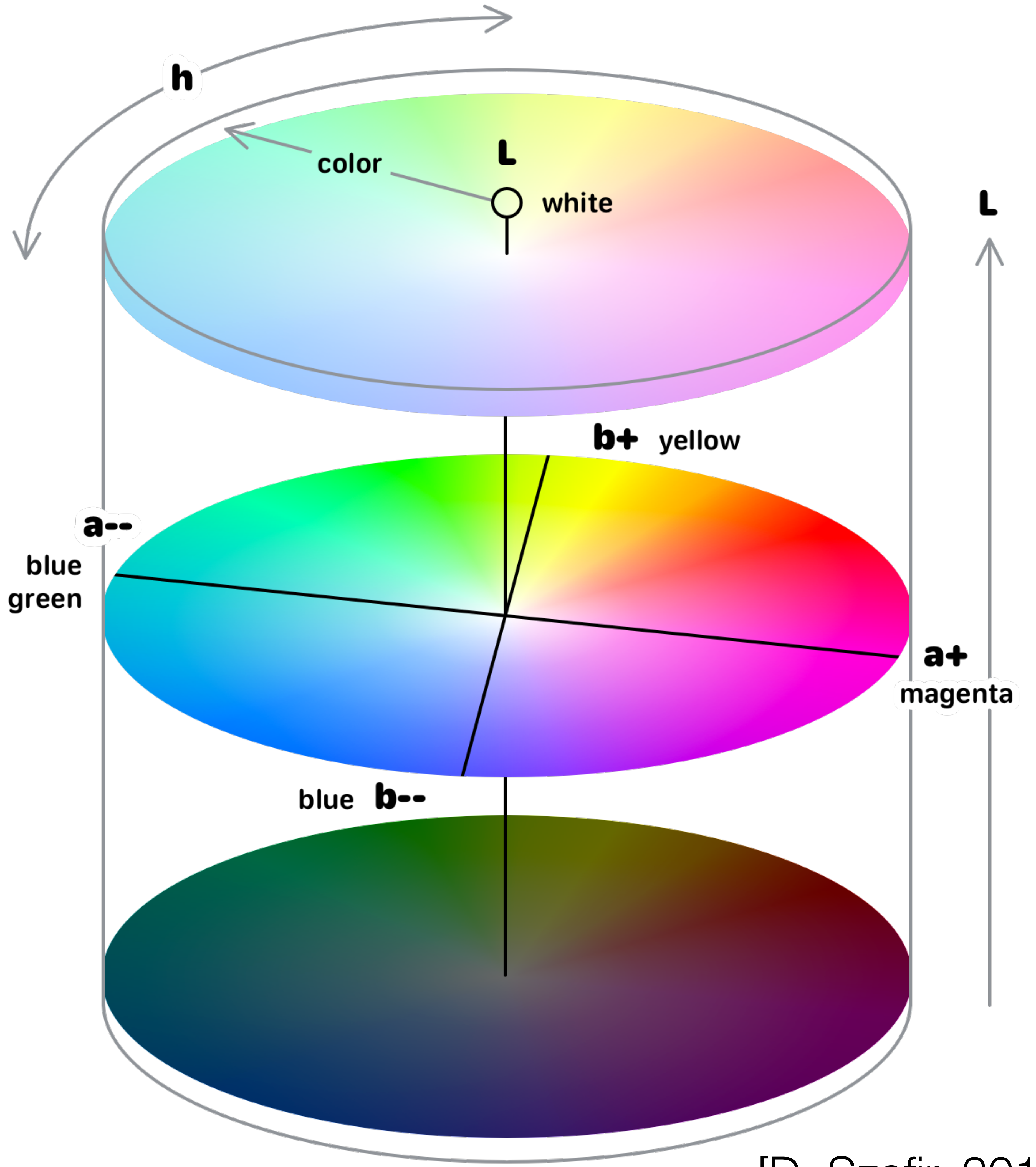
- HSL does not truly reflect the way we perceive color
- Even though colors have the same lightness, we perceive their luminance differently
- Our perception (L*) is **nonlinear**



[Munzner (ill. Maguire), 2014 (based on Stone, 2006)]

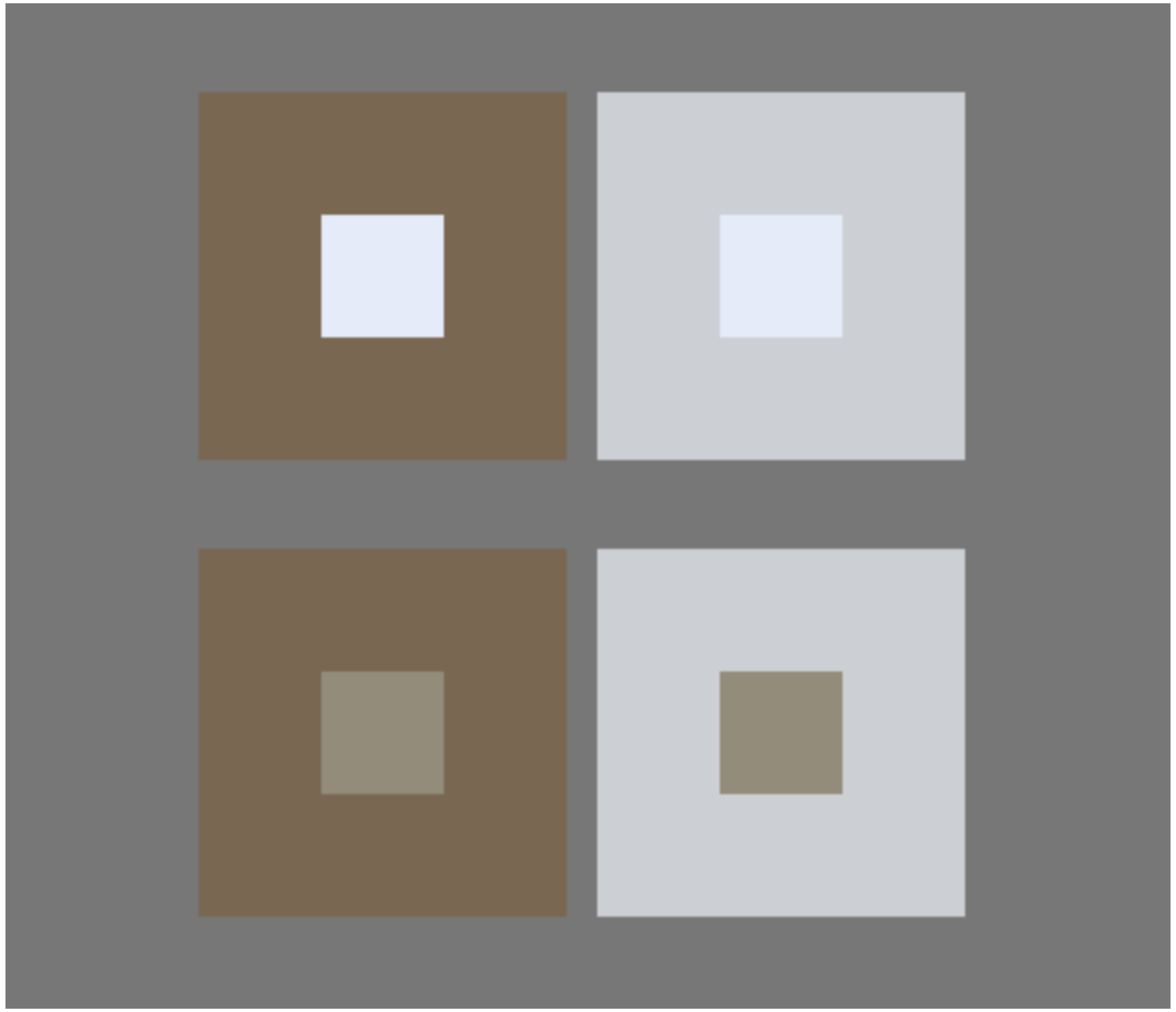
Violations of CIELAB Assumptions

- CIELAB:
  - Approximately perceptually linear
  - 1 unit of Euclidean distance = 1 Just Noticeable Difference (JND)
  - JND: people detect change at least 50% of the time
- Assumptions CIELAB makes:
  - Simple world
  - Isolation
  - Geometric



[D. Szafir, 2017]

Simultaneous Contrast



Project Proposal

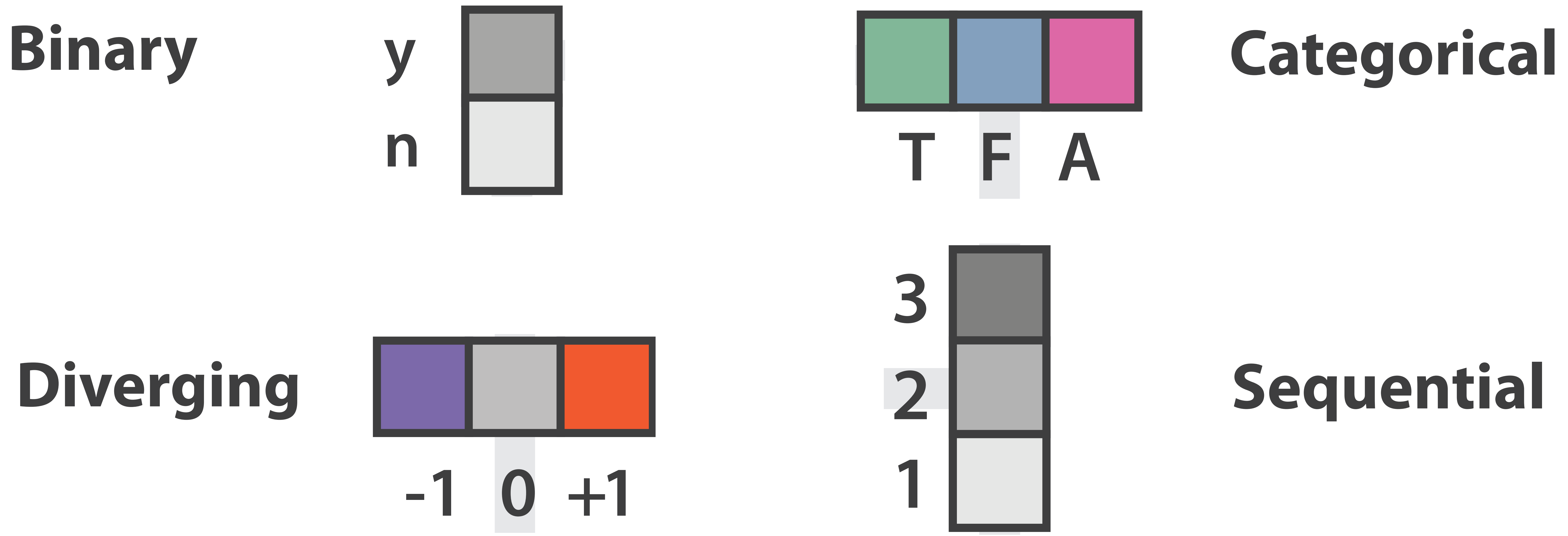
- Find an interesting subject or dataset
  - see List of lists of datasets [B. Keegan]
- Understand the data available (format, types, semantics)
- Figure out some interesting questions and tasks
- Start brainstorming about visualizations and interactions
- Inspiration:
  - Information Is Beautiful Awards
  - MBTA Viz
- Due Friday

Midterm

- Thursday, October 17
- Covers material through this week
- Format:
  - Multiple Choice
  - Free Response (often multi-part)
  - CS 680 students will have extra questions related to the research papers discussed

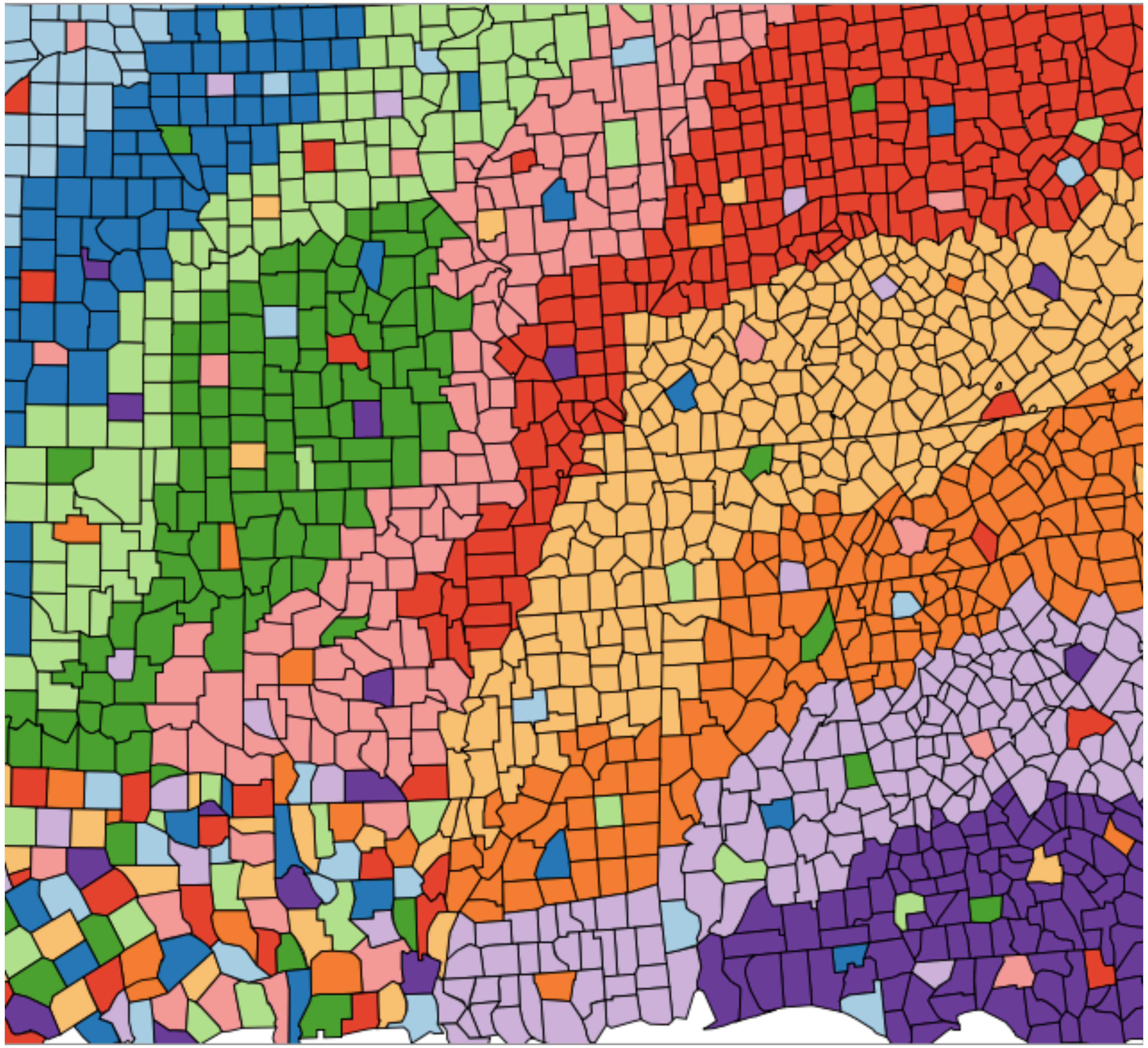
Colormap

- A colormap specifies a mapping from data values to color
- Colormap should follow the expressiveness principle
- Types of colormaps:



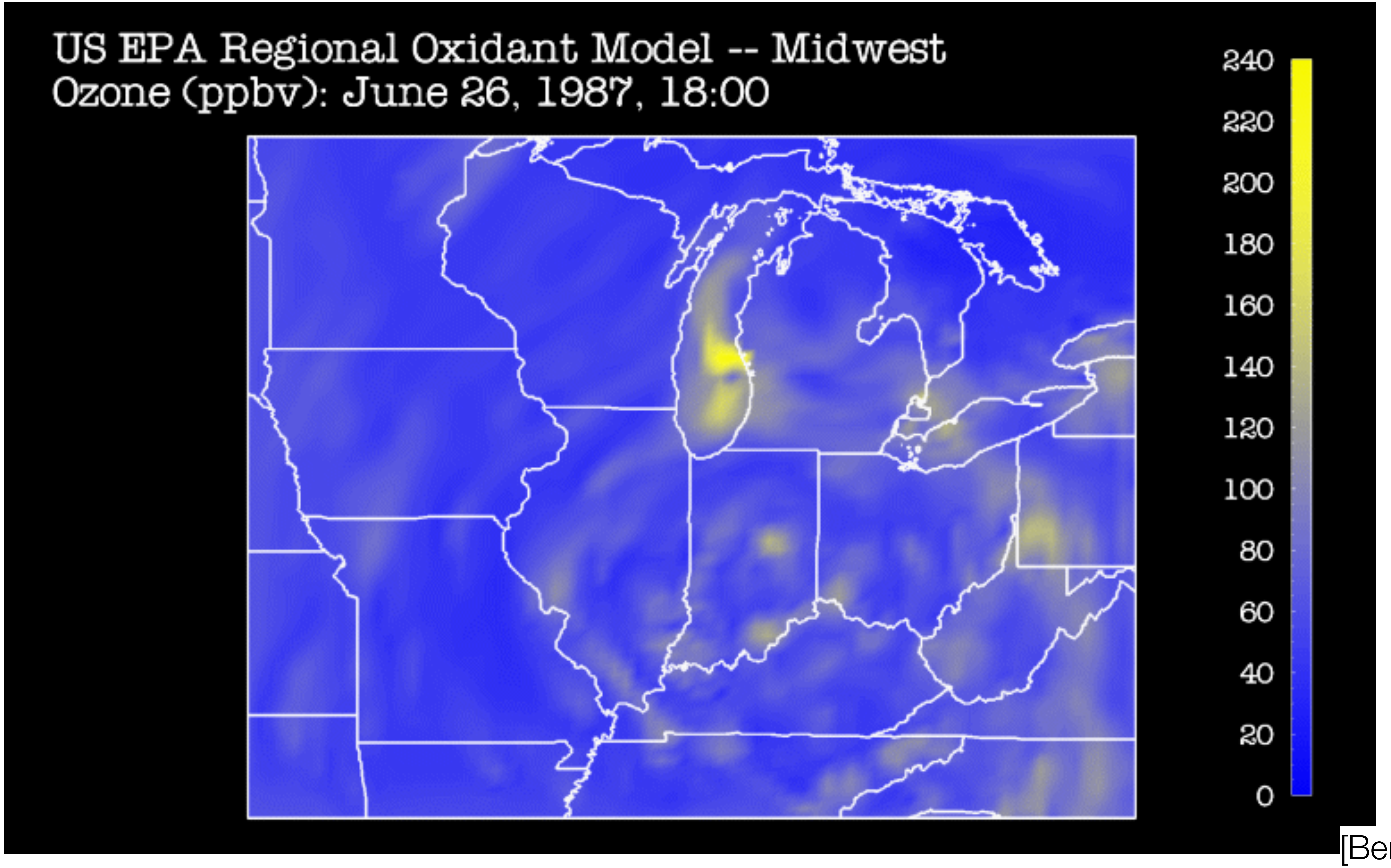
[Munzner (ill. Maguire), 2014]

Categorical Colormap Guidelines



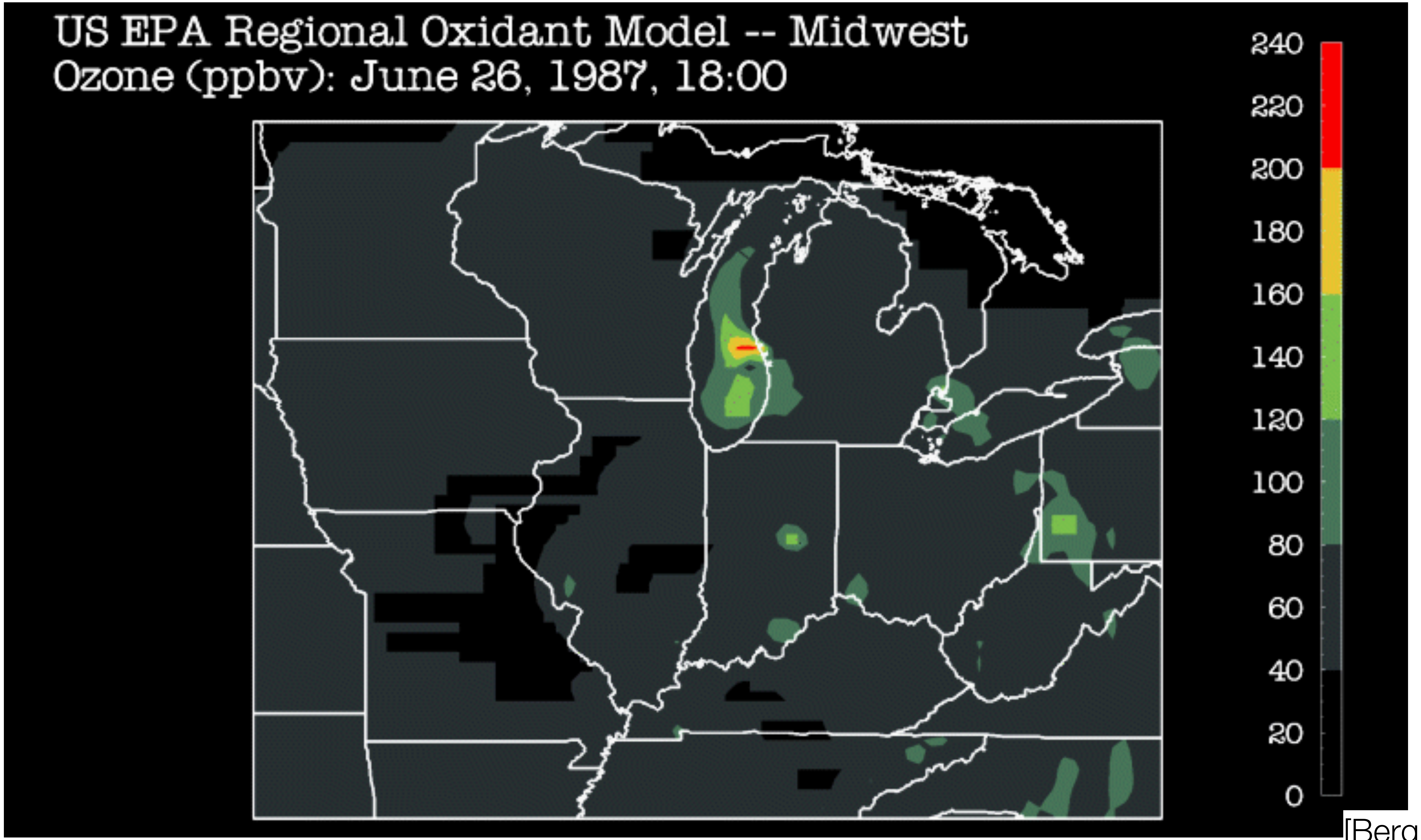
- Don't use too many colors (~12)
- Use other categories or create groups if you have too many values!
- Nameable colors help
- Be aware of luminance (e.g. difference between blue and yellow)
- Think about other marks you might wish to use in the visualization

Continuous Colormap for Ordered Data



[Bergman et al., 1995]

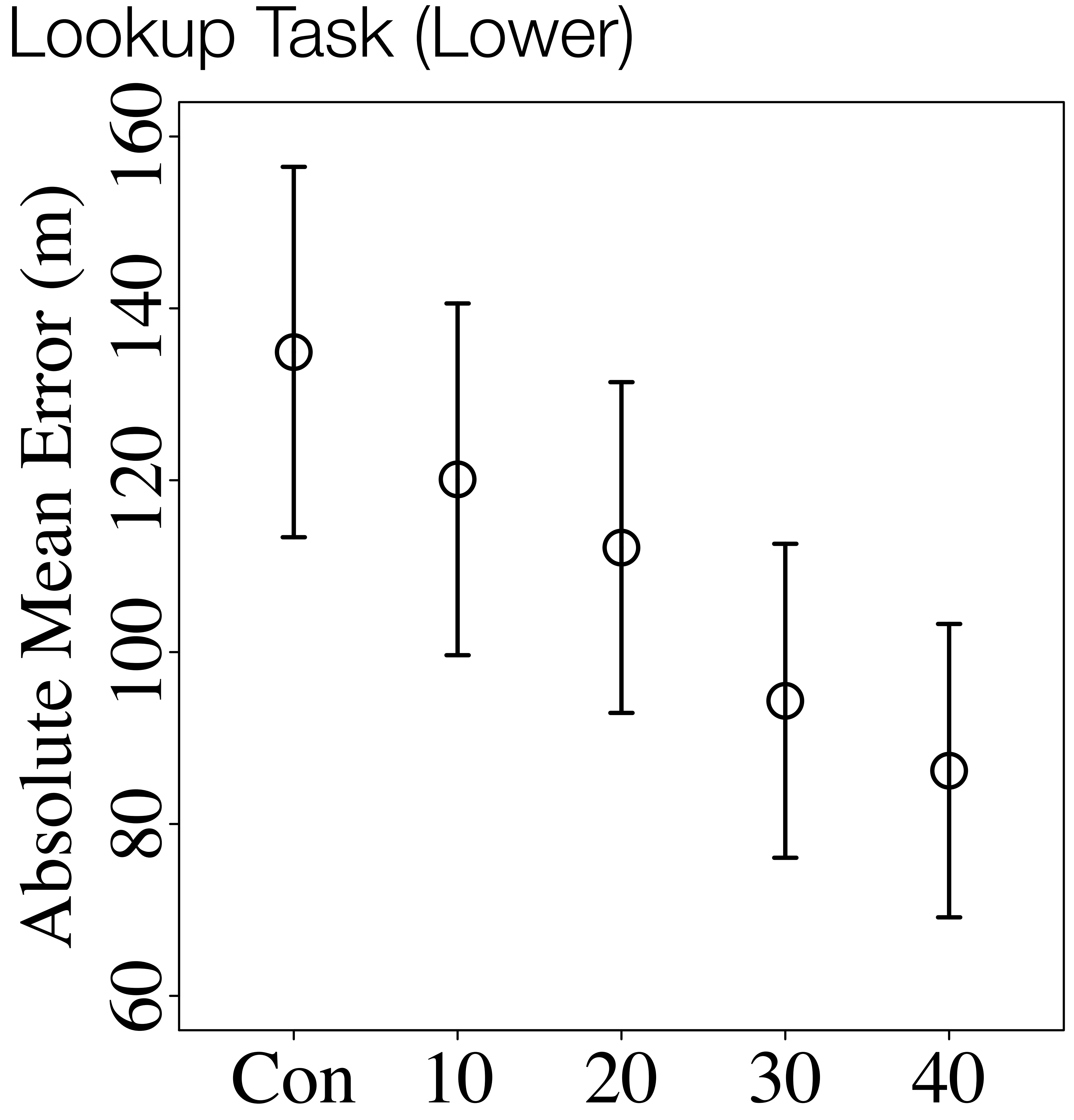
Segmented Colormap for Ordered Data



[Bergman et al., 1995]

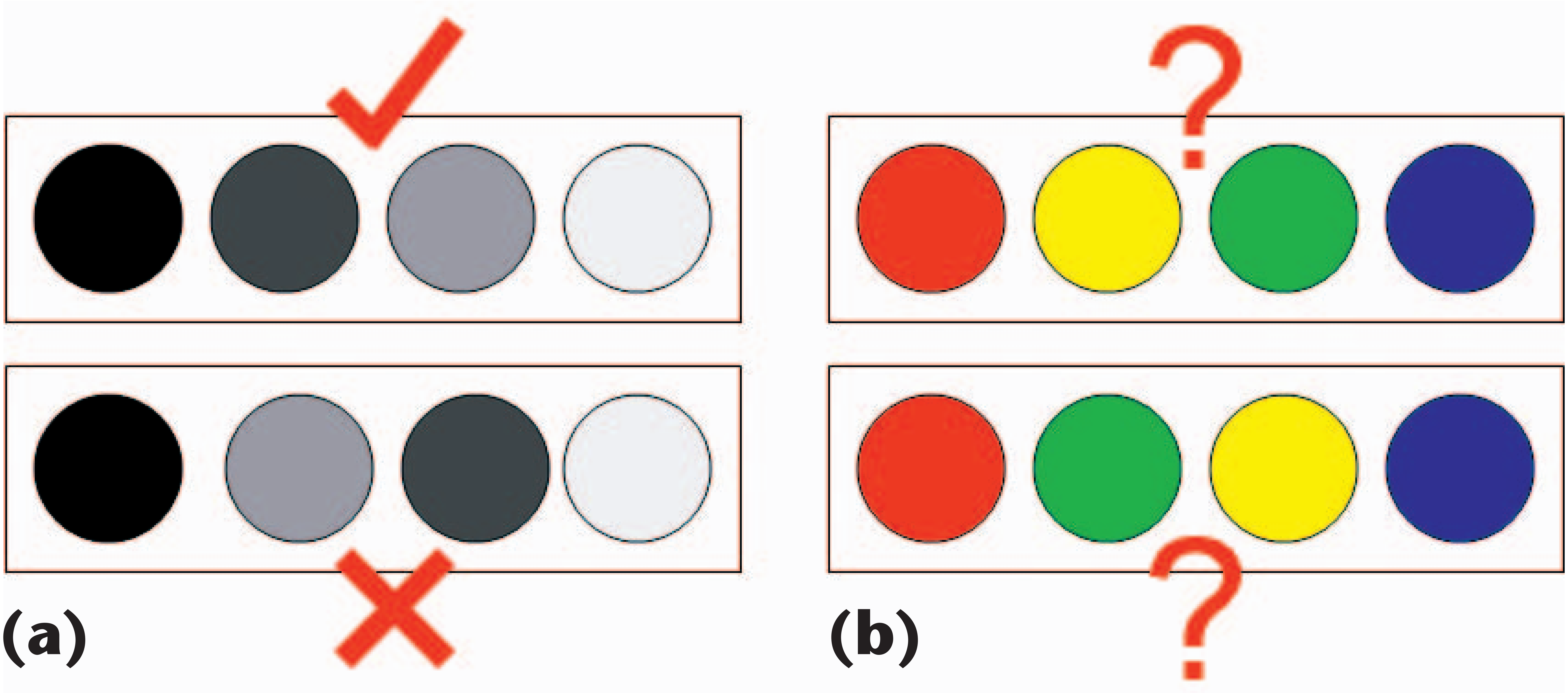
Continuous vs. Segmented Test Results

- "[C]ontrary to the expressiveness principle, no cases were found in which a continuous encoding of 2D scalar field data was advantageous for task accuracy, and for some tasks, specific binned encodings facilitated accuracy."
- "[S]upport for the counterintuitive finding that decisions with binned encoding were slower than those made with continuous encoding"
- Word of caution: single image!



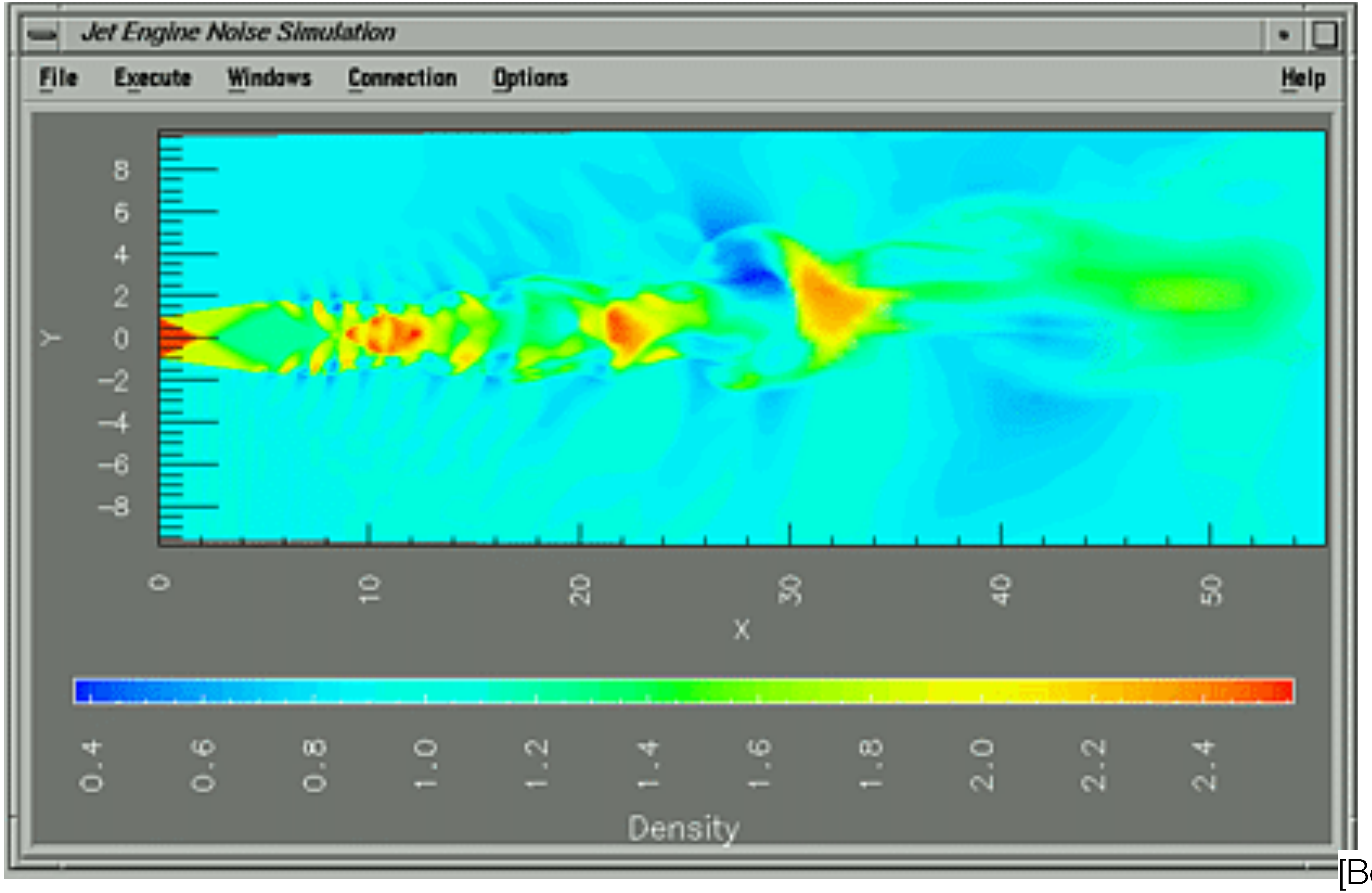
[Padilla et al., 2017]

Ordering Color?



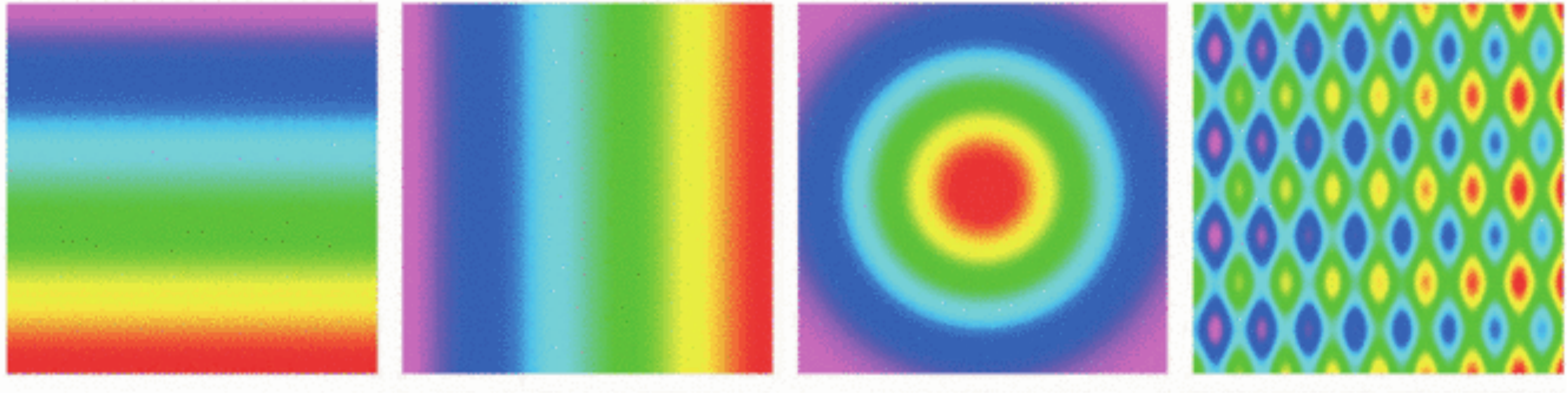
[Borland & Taylor, 2007]

Rainbow Colormap



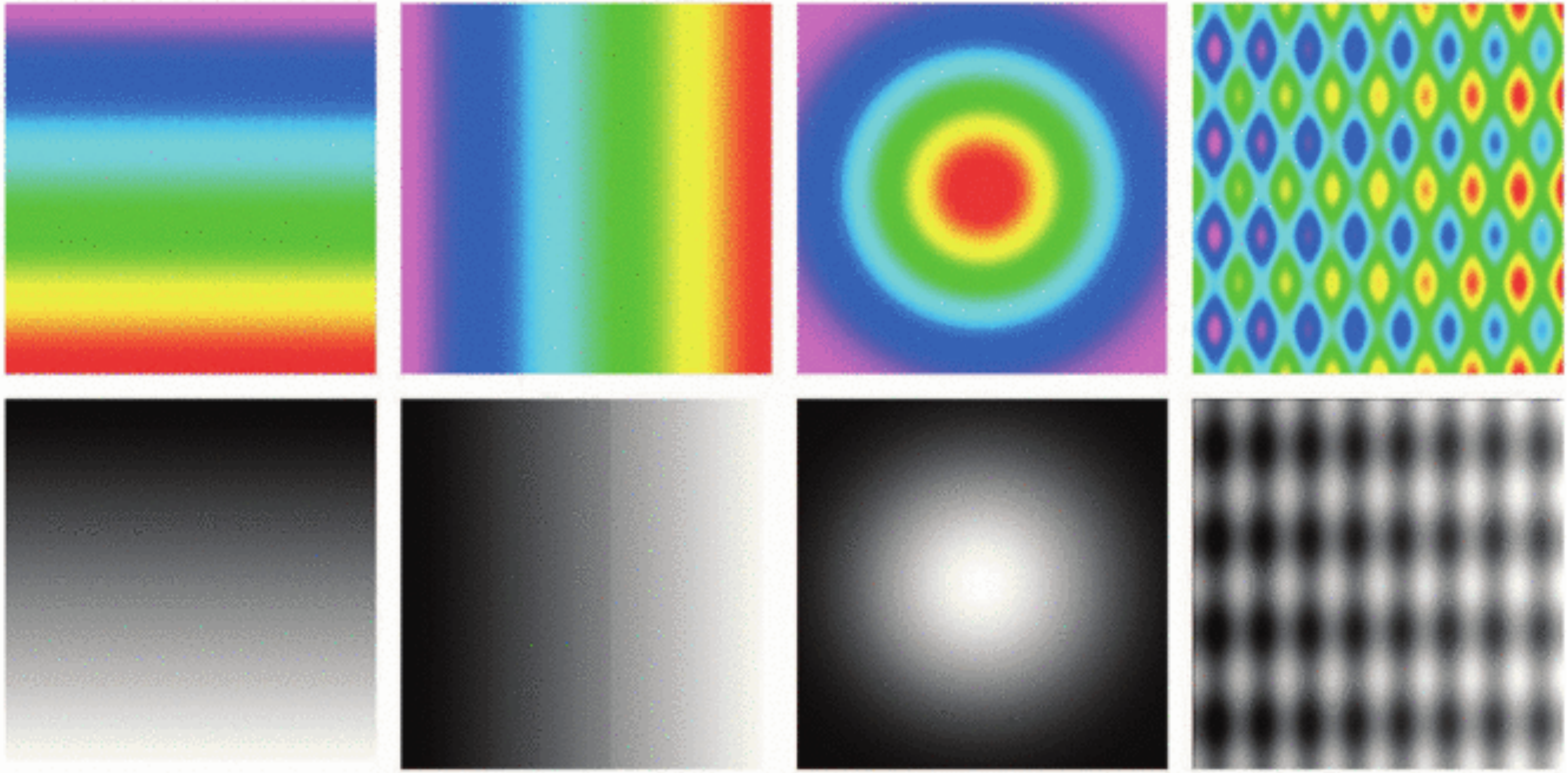
[Bergman et al., 1995]

Artifacts from Rainbow Colormaps



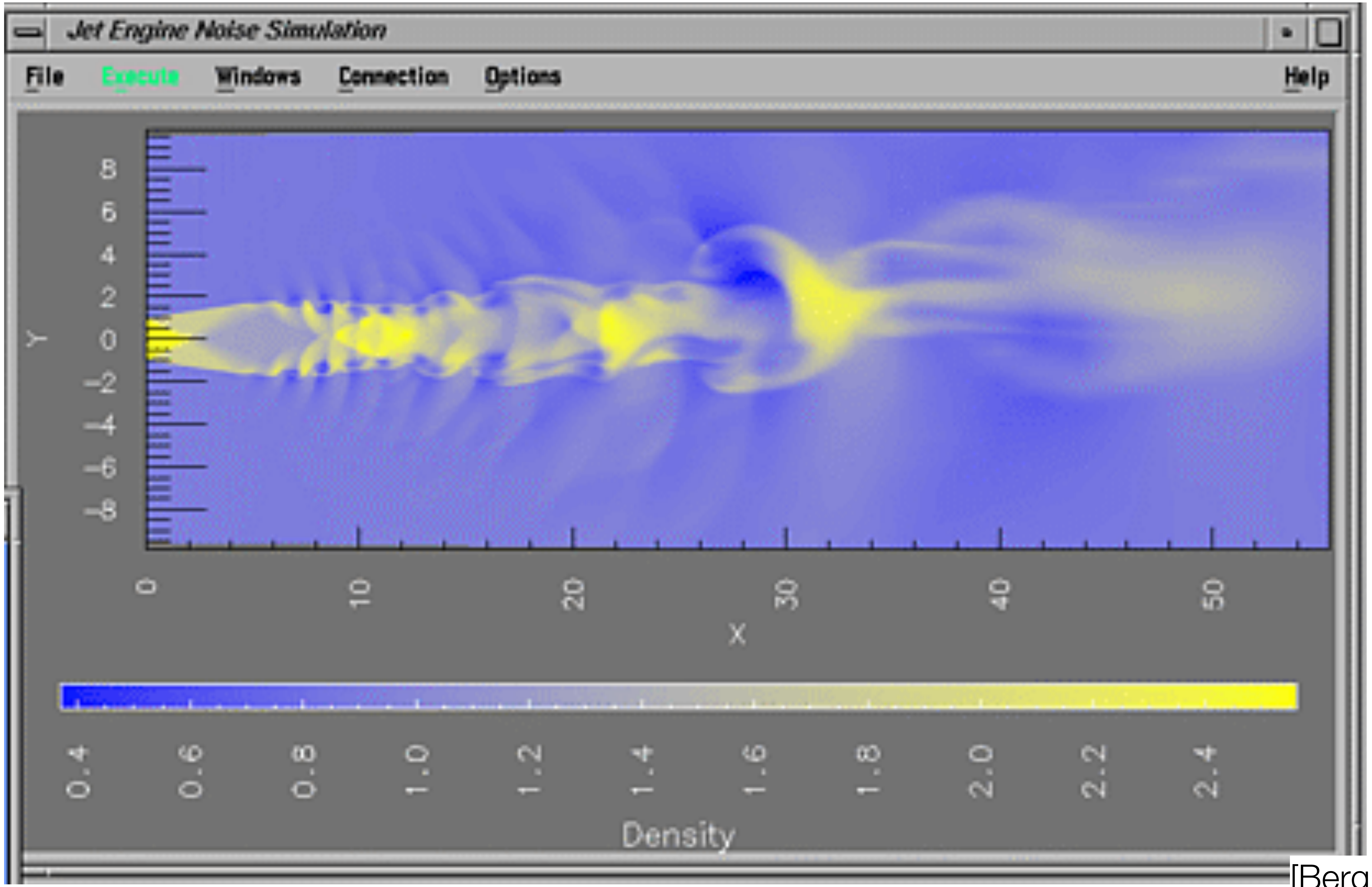
[Borland & Taylor, 2007]

Artifacts from Rainbow Colormaps



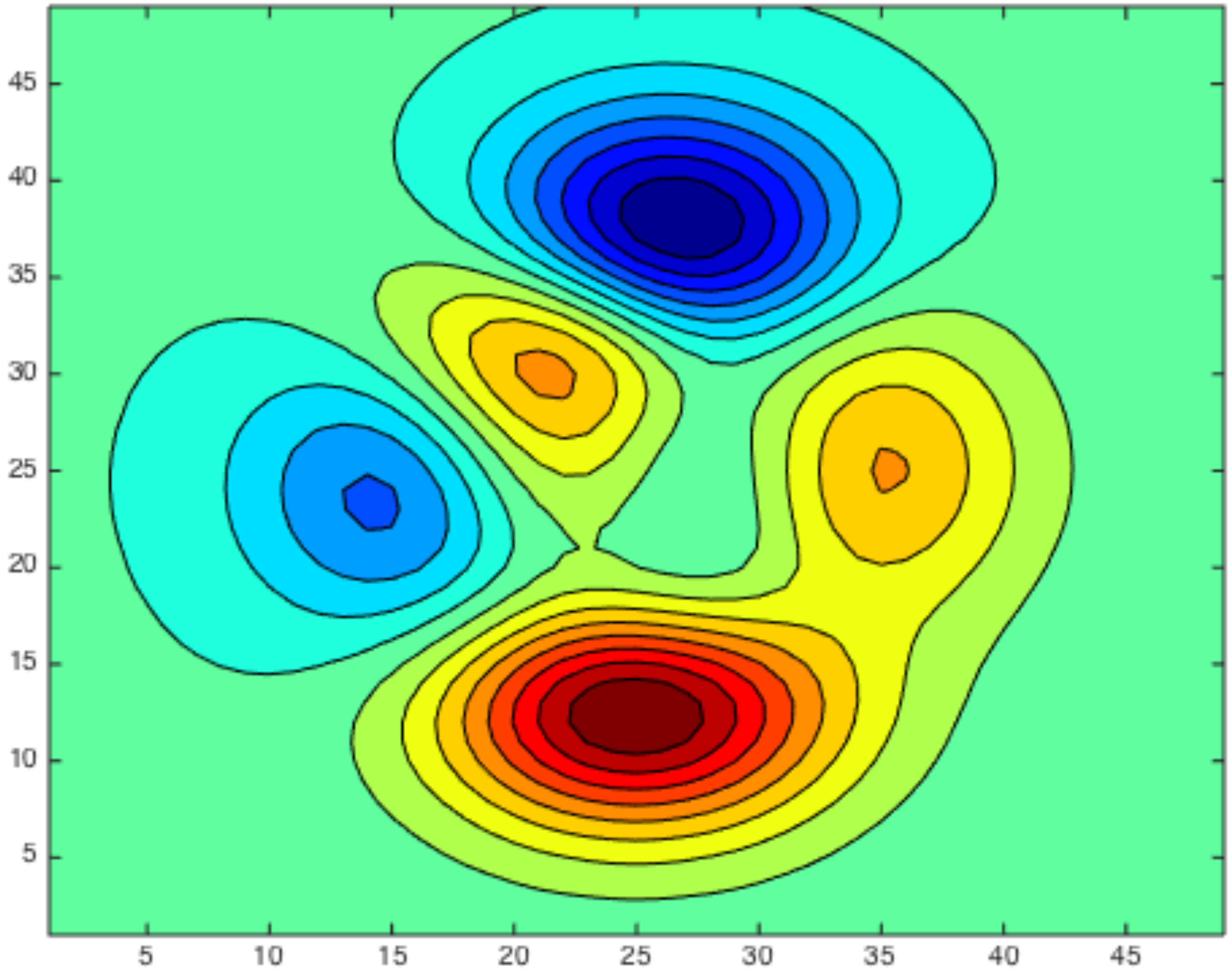
[Borland & Taylor, 2007]

Two-Hue Colormap



[Bergman et al., 1995]

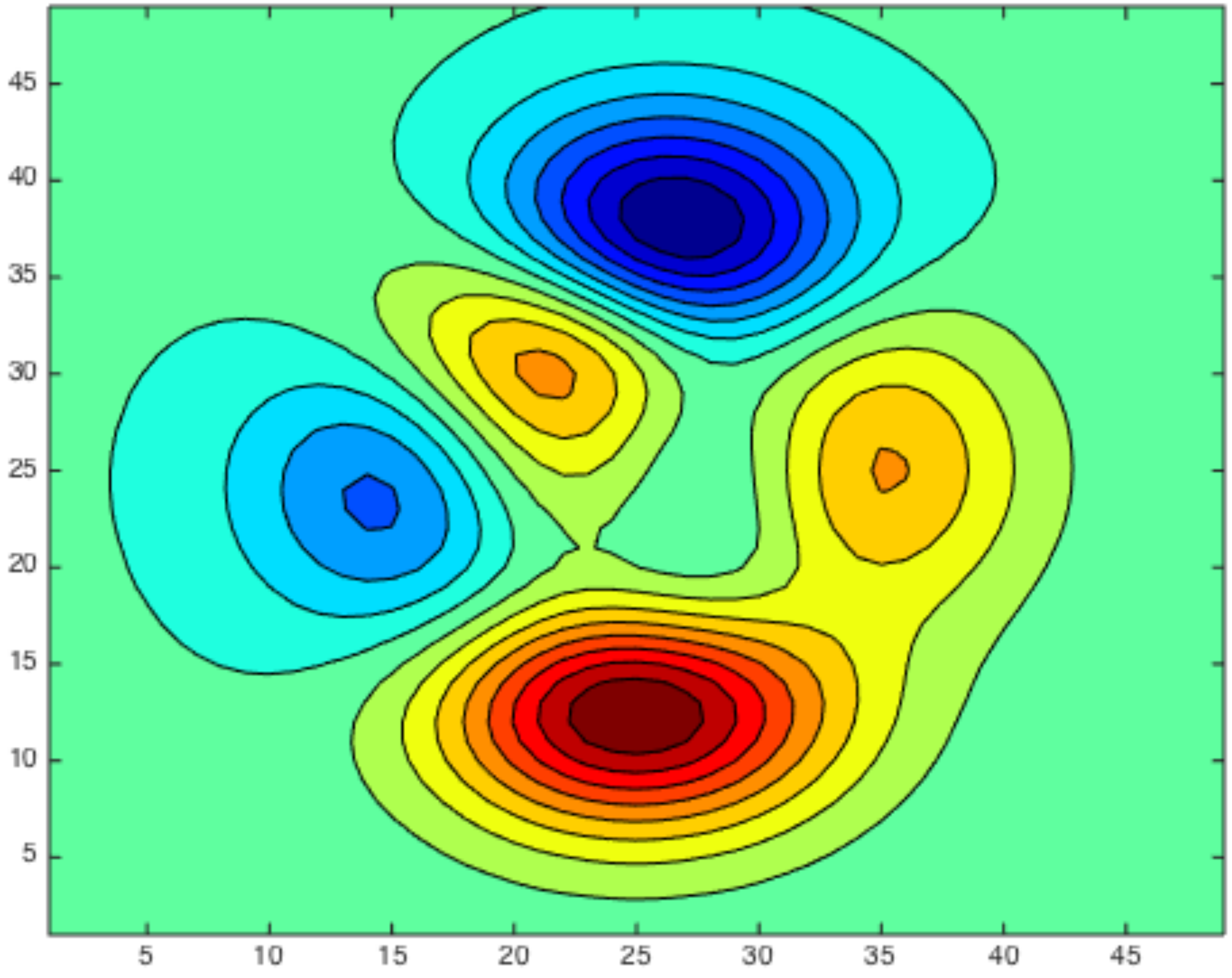
"Get It Right in Black and White" - M. Stone



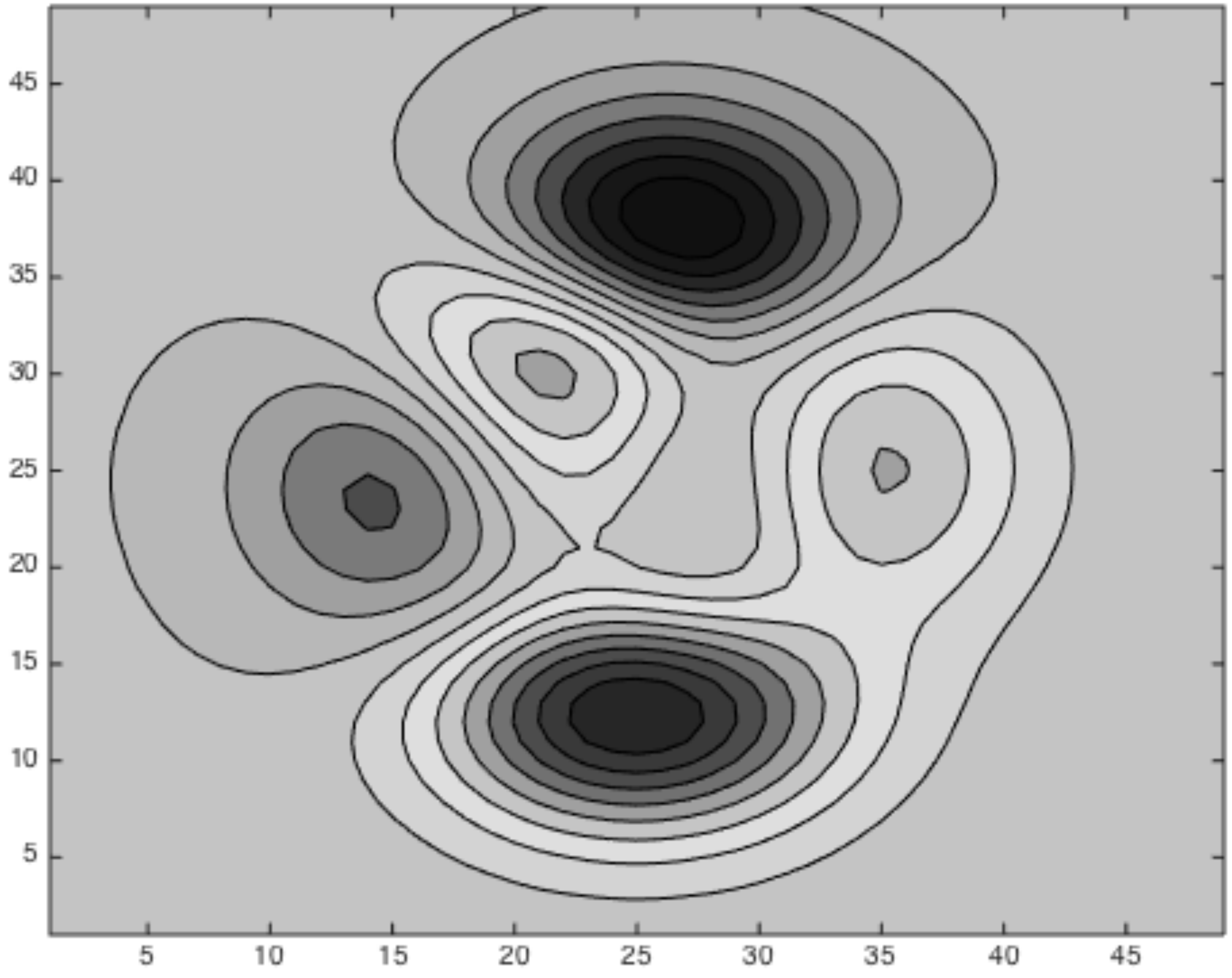
jet colormap

[S. Eddins (Matlab Blog), 2014]

"Get It Right in Black and White" - M. Stone

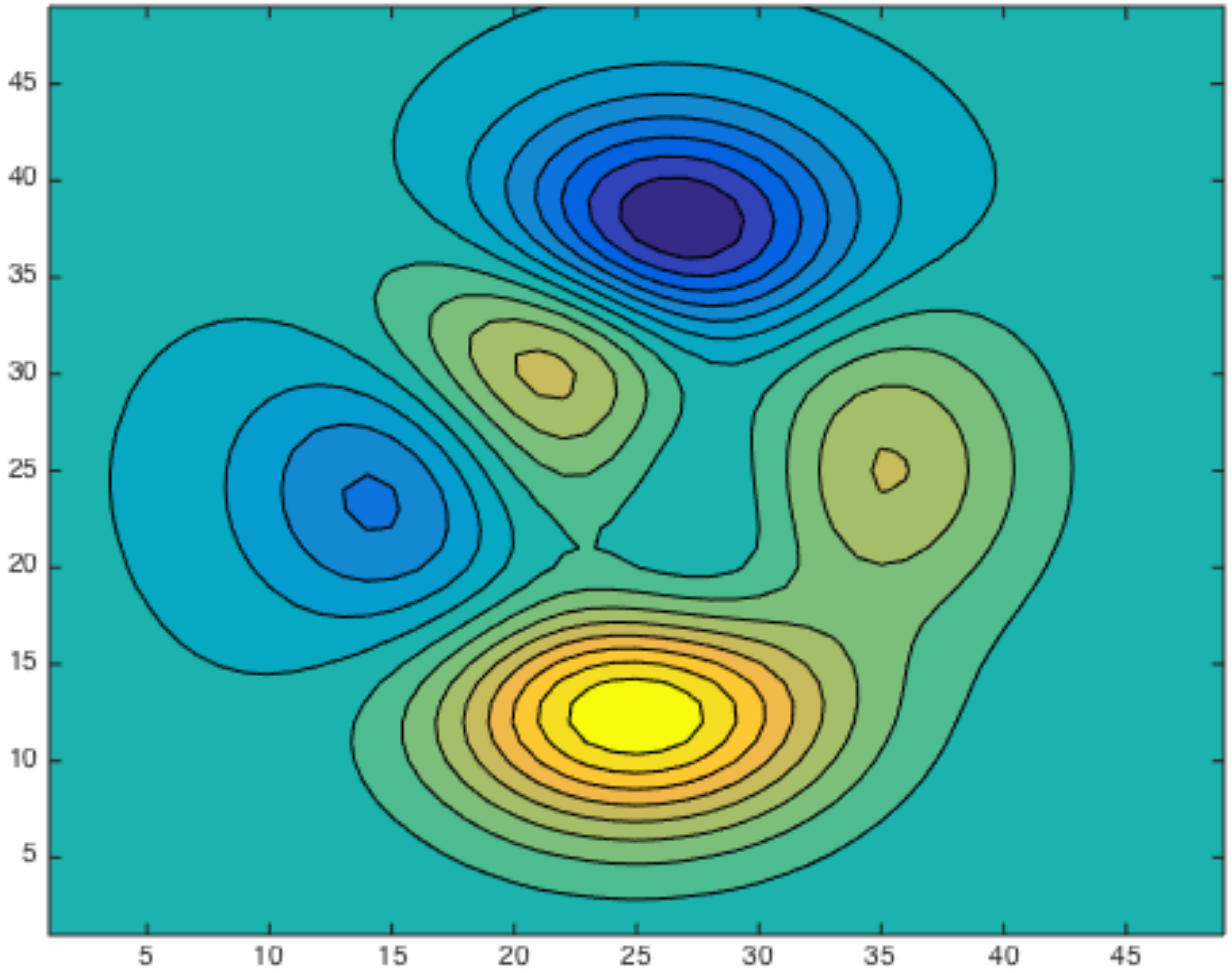


jet colormap



[S. Eddins (Matlab Blog), 2014]

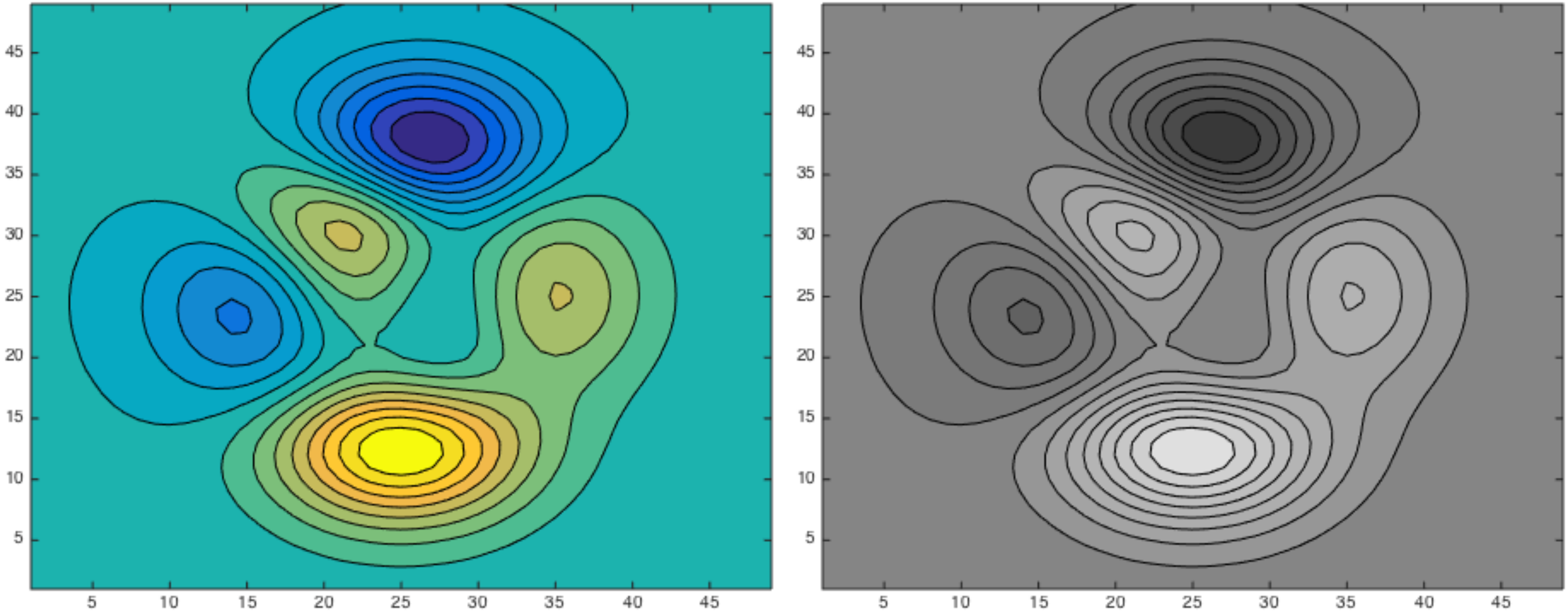
"Get It Right in Black and White" - M. Stone



parula colormap

[S. Eddins (Matlab Blog), 2014]

"Get It Right in Black and White" - M. Stone



parula colormap

[S. Eddins (Matlab Blog), 2014]

Isoluminant Rainbow Colormap

Original

Isoluminant

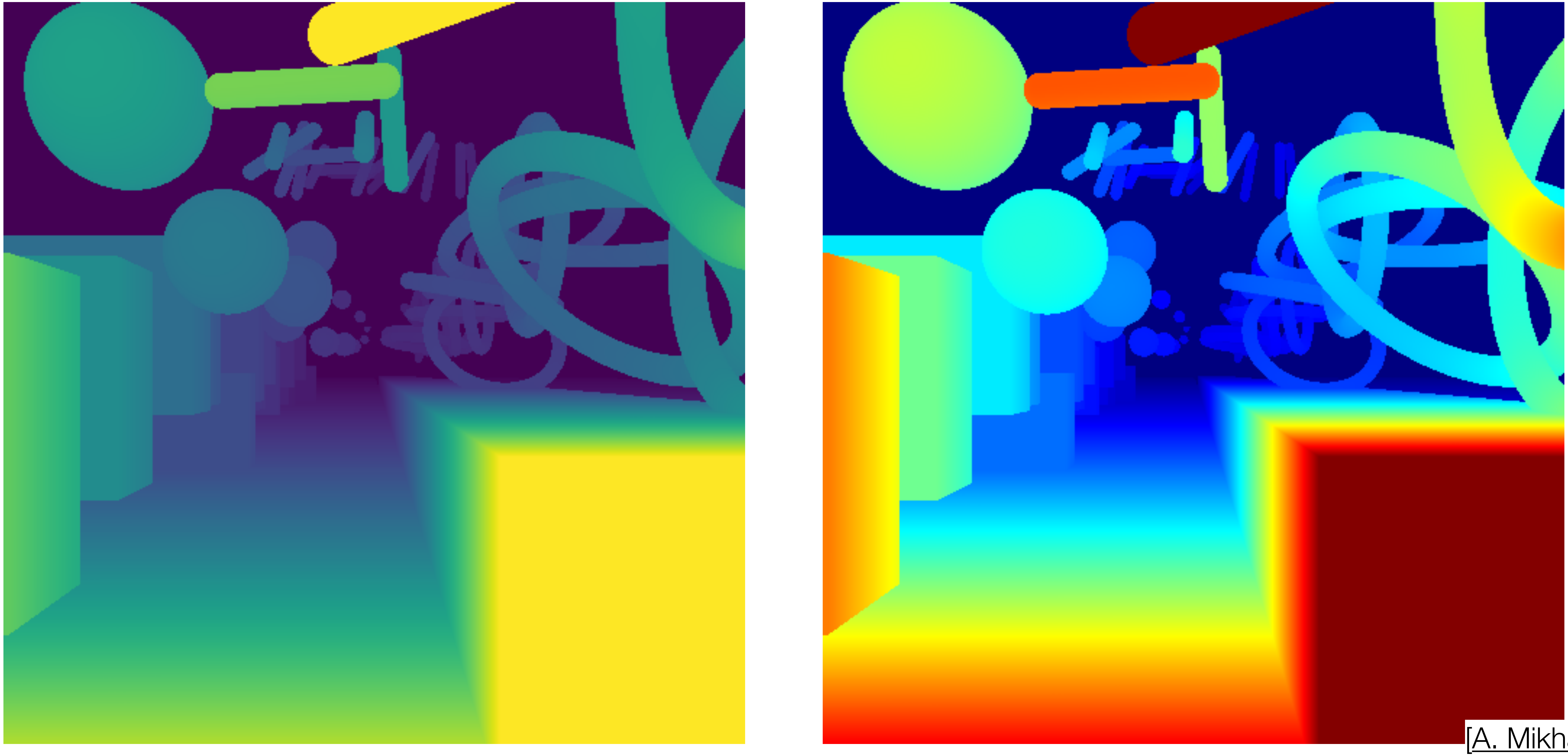
[Kindlmann et al., 2002]

Turbo Colormap (August 2019)

Jet

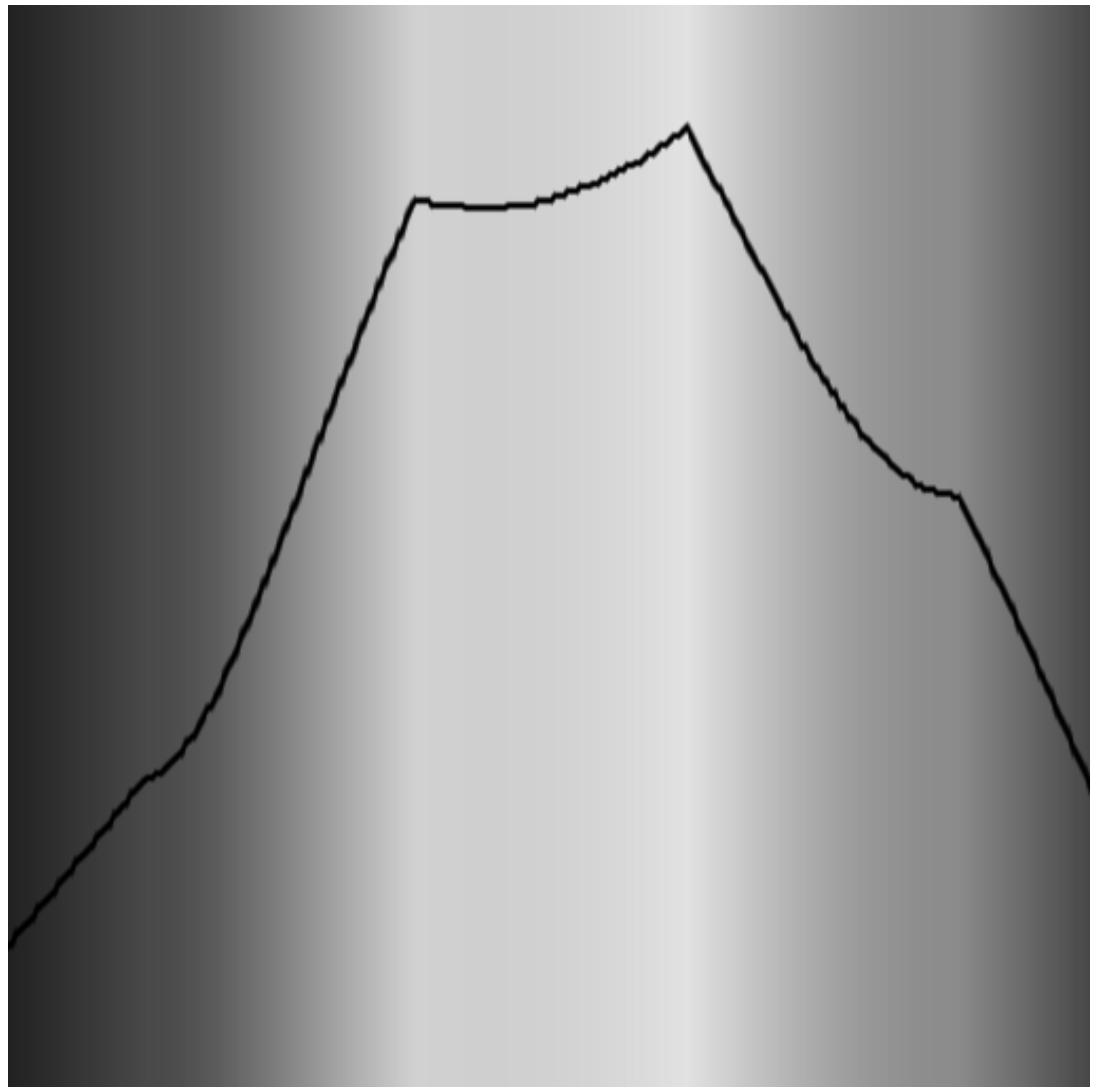
Turbo

Turbo: More Detail in Disparity Maps?

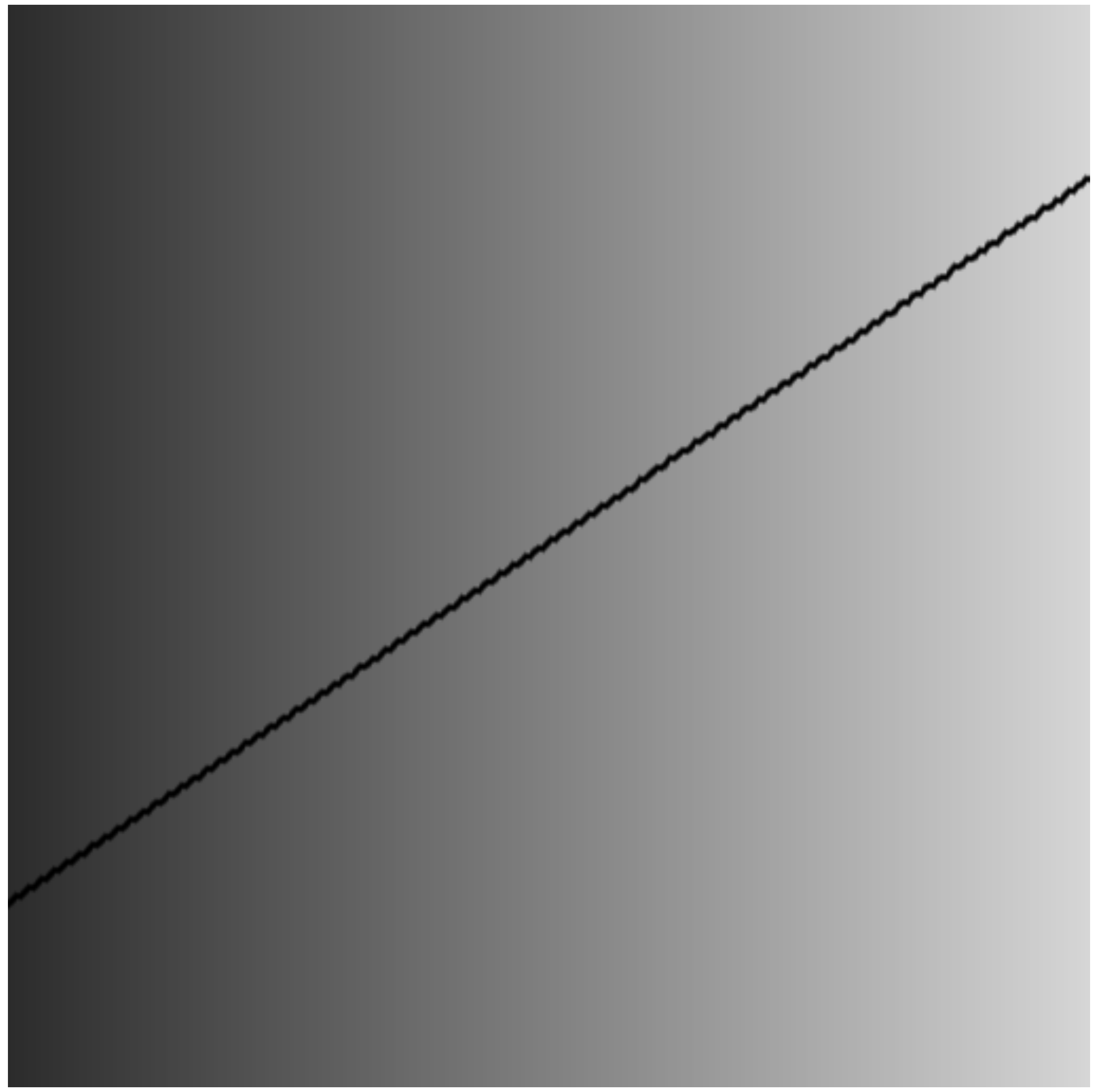


[A. Mikhailov]

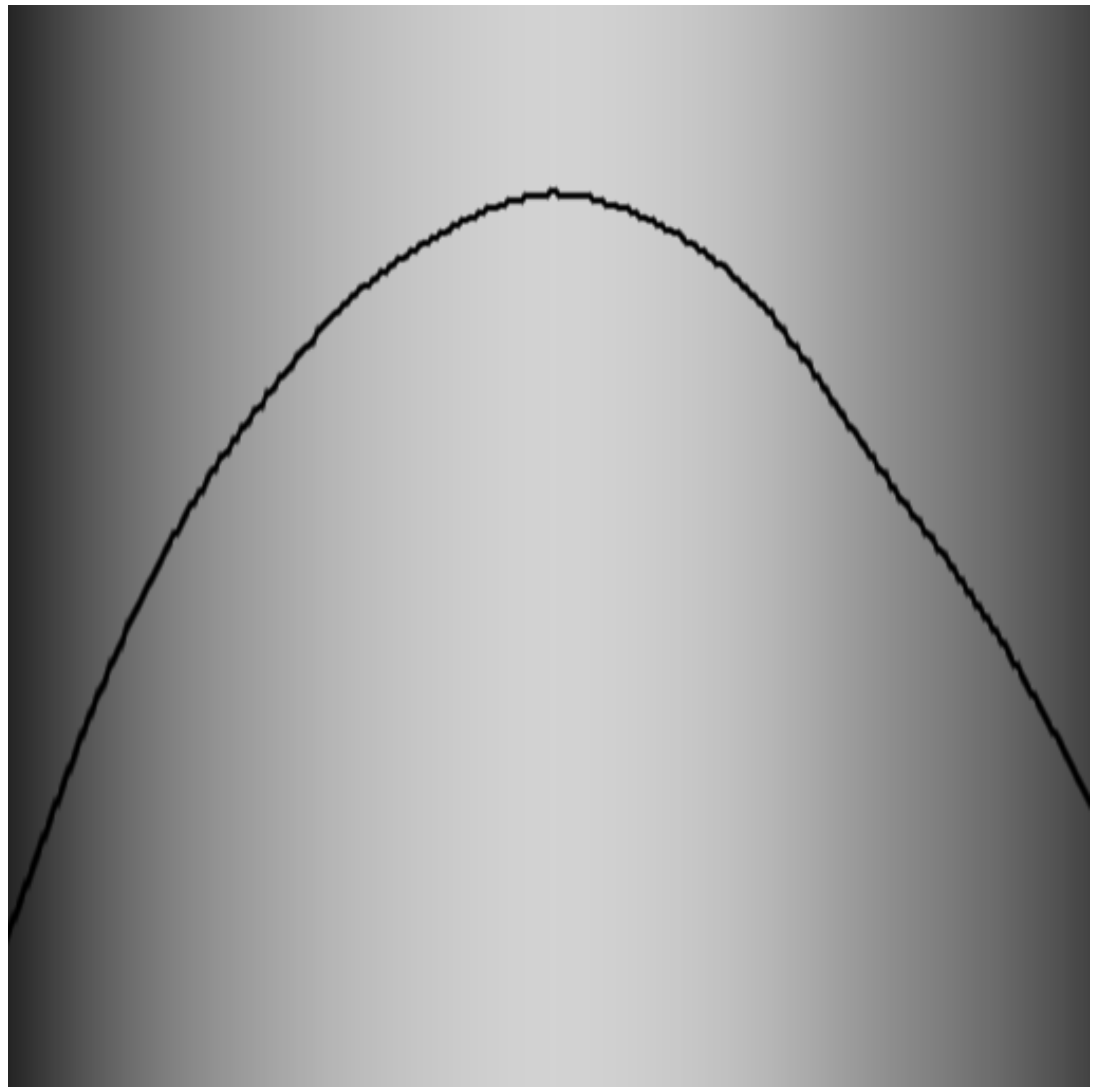
Turbo: Lightness Profiles



Jet



Viridis



Turbo

[A. Mikhailov]

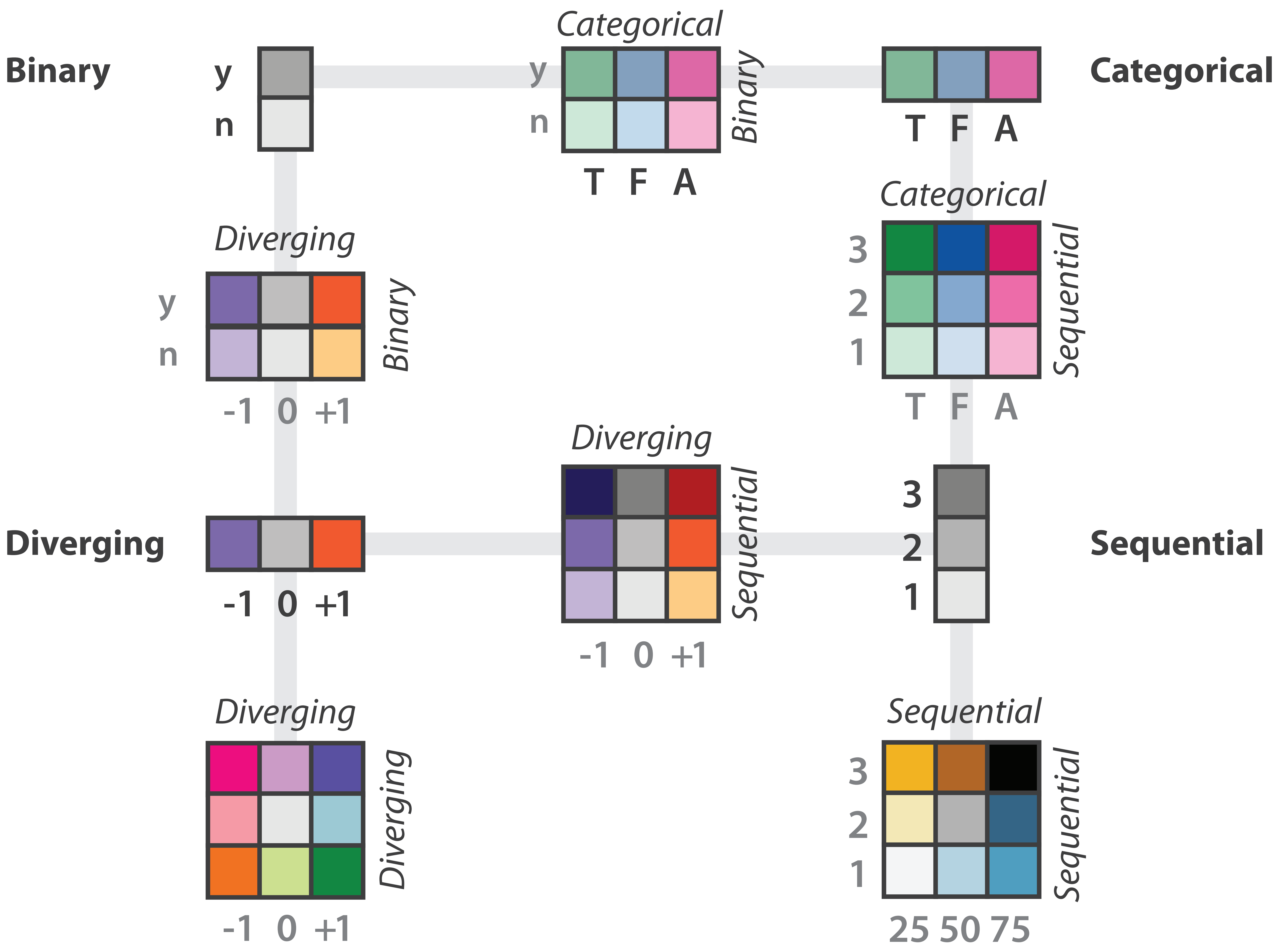
Turbo Discussion

- Turbo is an improvement over jet
- Some fields (e.g. meteorology) have long used rainbow-like colormaps
- Argument is that segments are more easily located
- Turbo post claims that hue is prioritized in attention, but this seems to misinterpret the study…
- Brightness and saturation are more important than hue in attracting attention [Camgöz et al., 2004 h/t J. Stevens]

D3's color scales

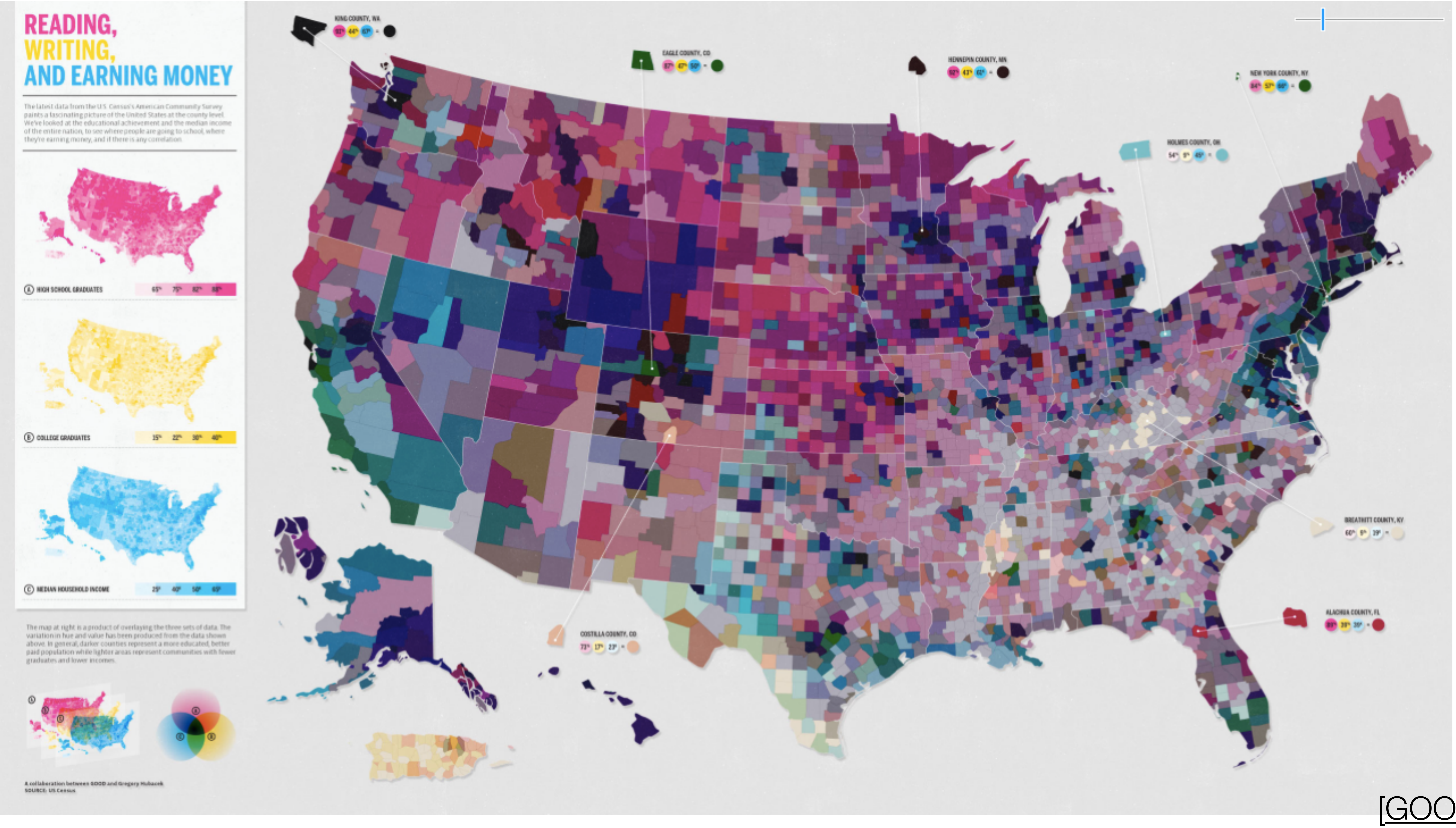
- https://github.com/d3/d3-scale-chromatic
- In v5, included in default bundle (no separate import)
- D3's built-in color scales
- Derived from ColorBrewer
- Sequential and diverging scales created using interpolation
- Hue **can** change, but be careful
- Color ramp [M. Bostock]

Bivariate Colormaps



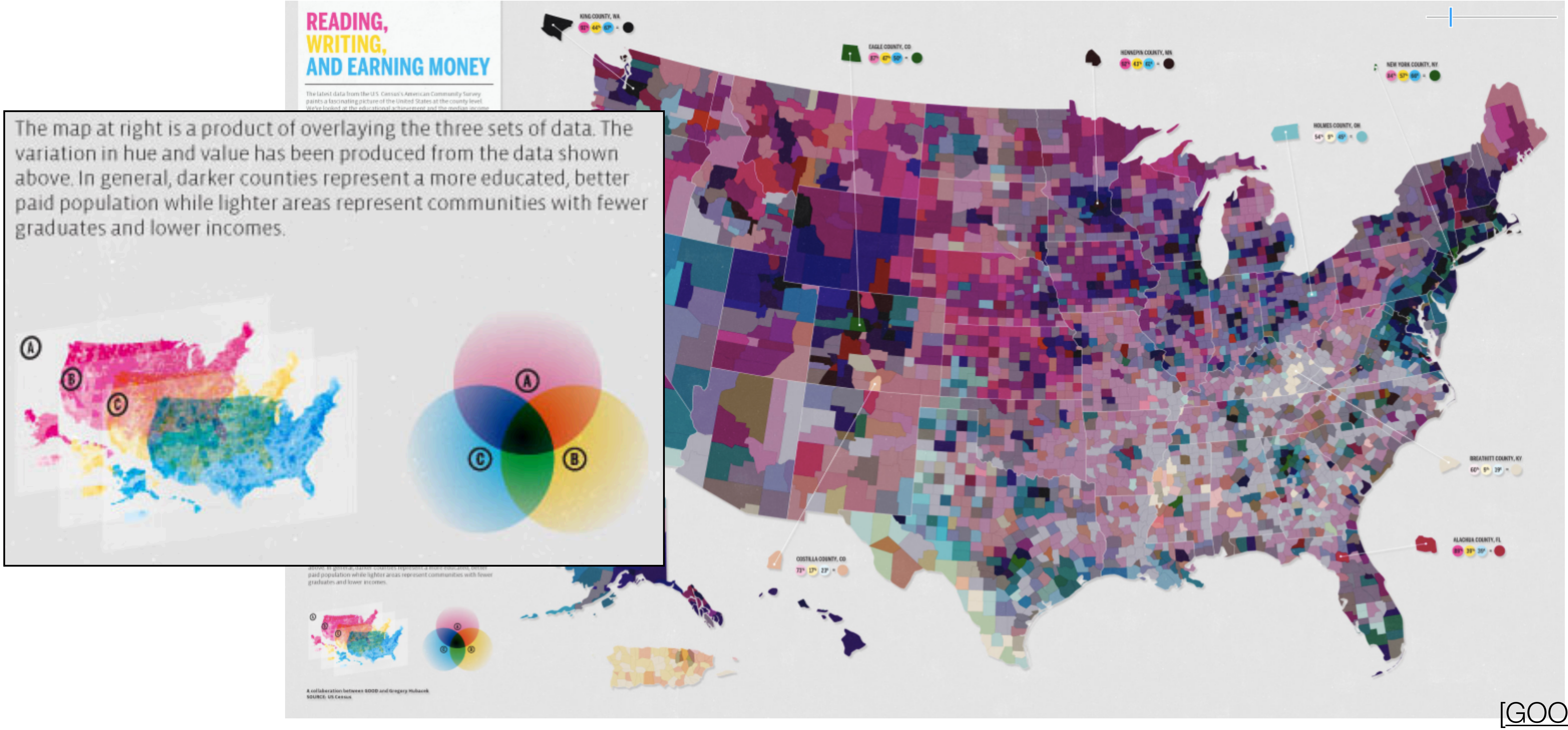
[Munzner (ill. Maguire), 2014]

Remember Separable vs. Integral



[GOOD]

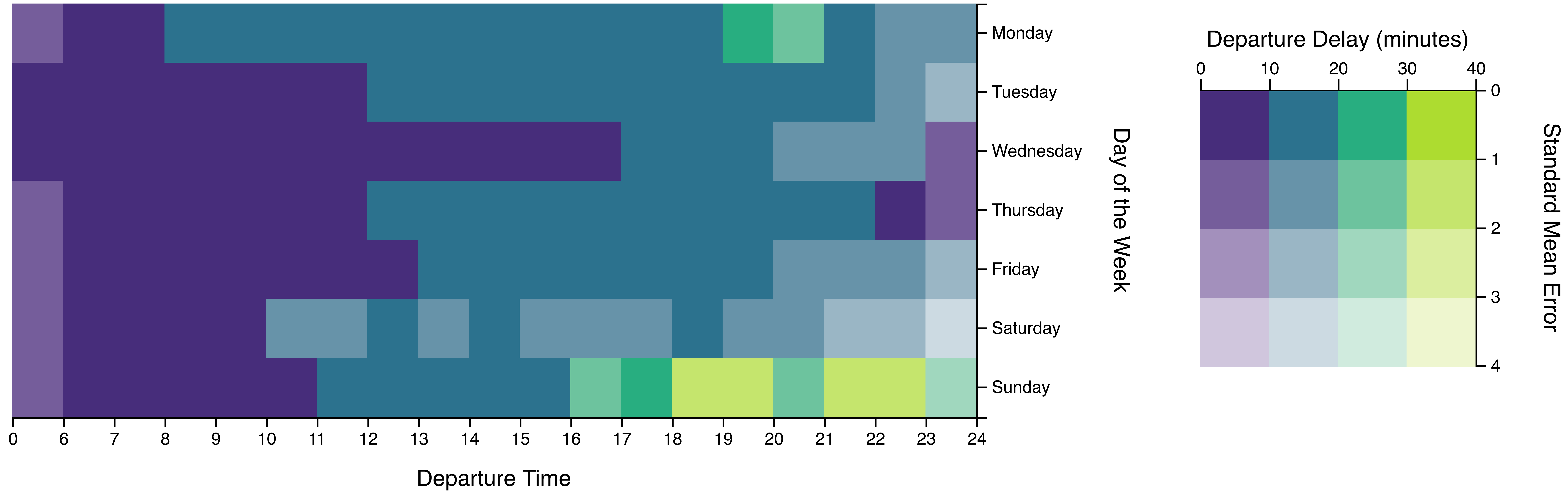
Remember Separable vs. Integral



[GOOD]

What about uncertain data?

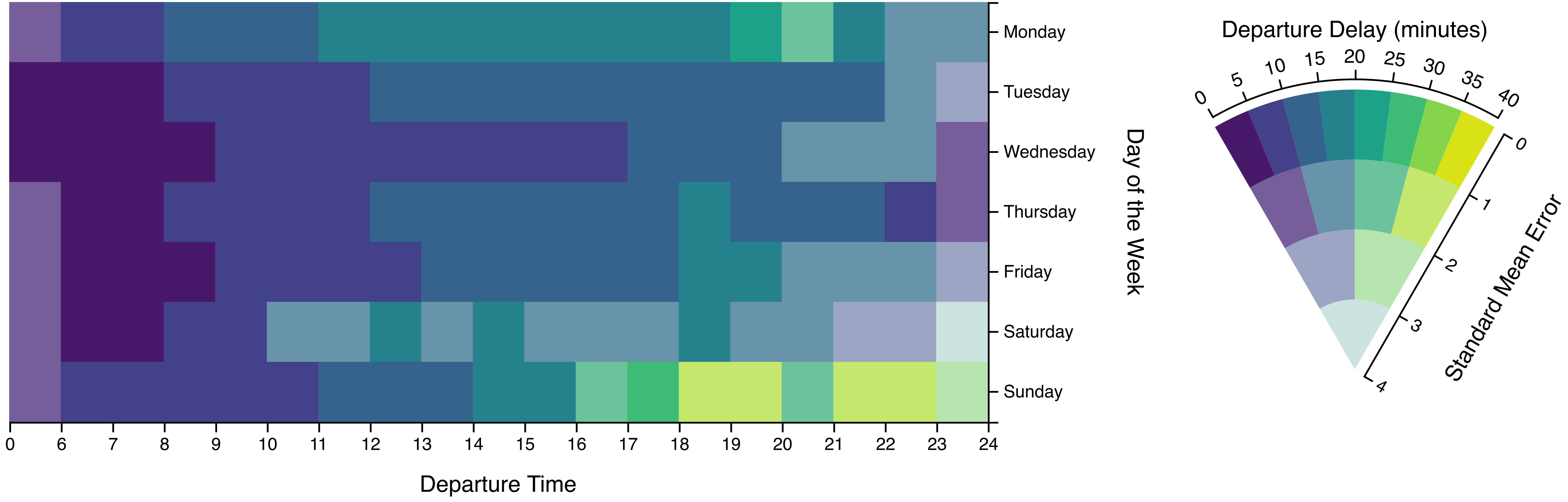
Bivariate Colormap (Uncertainty → Saturation)



[Correll et al., 2018]

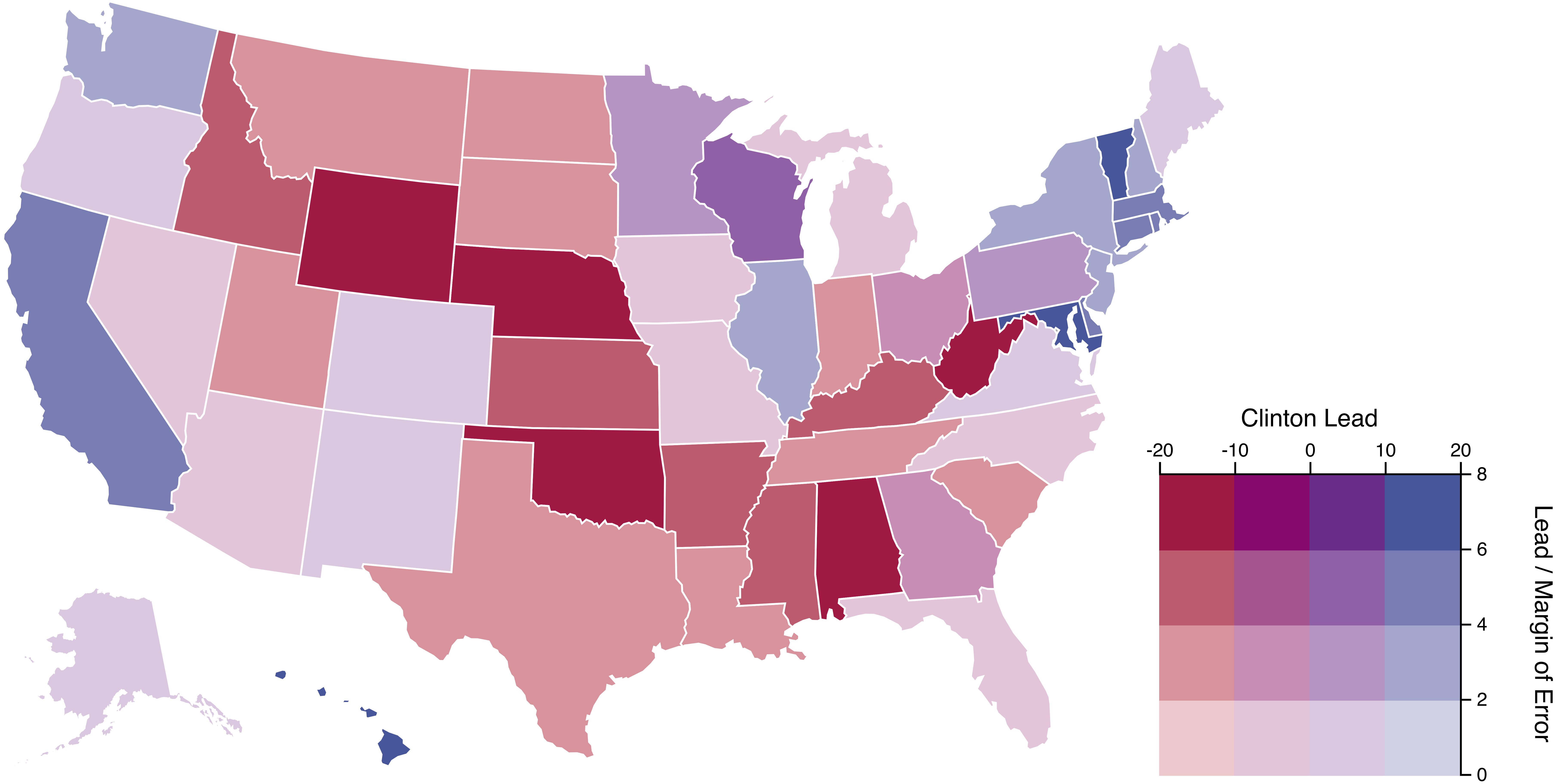
Value-Suppressing Uncertainty Palette (VSUP)

Same Channels, just binned differently



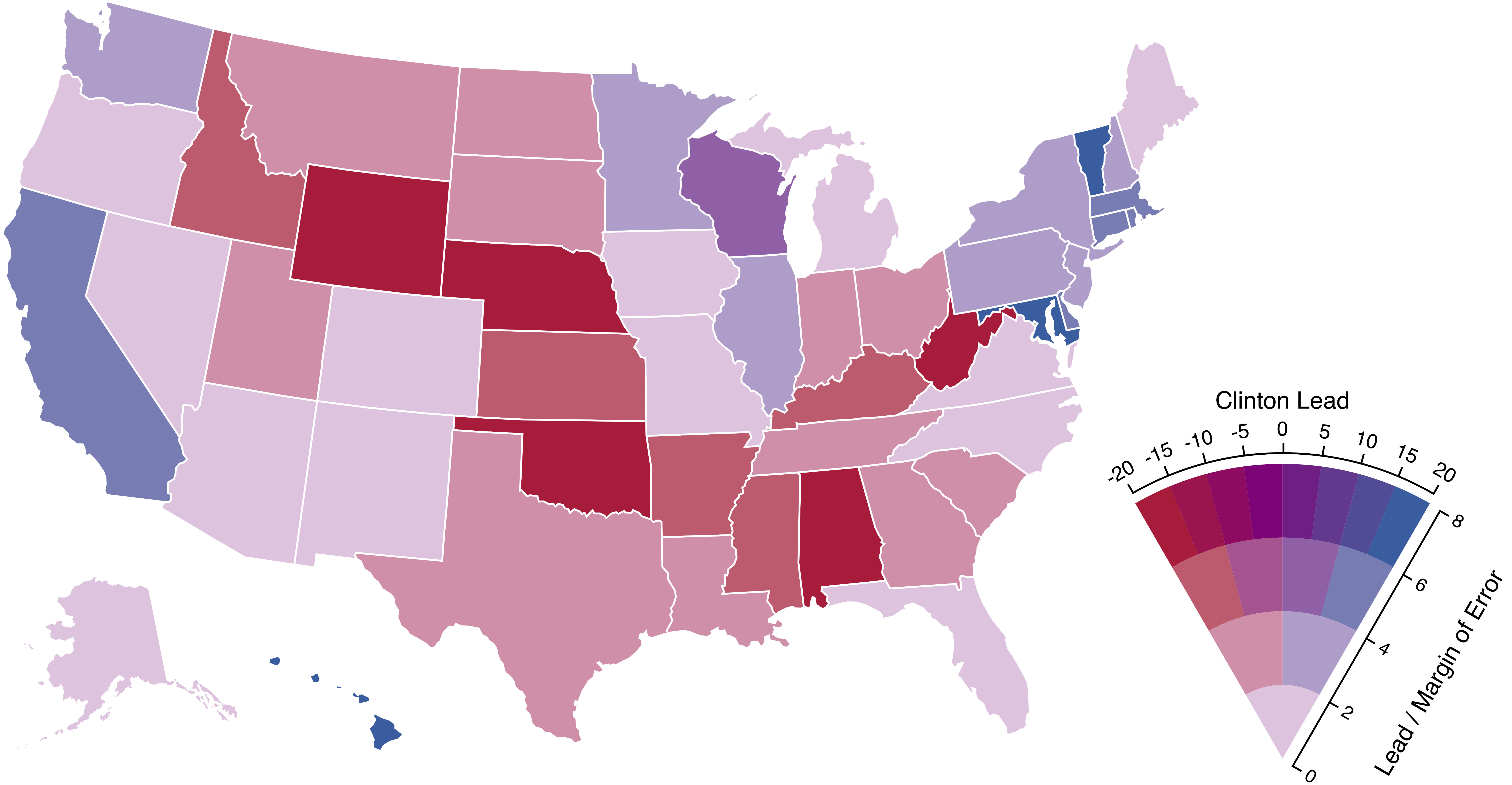
[Correll et al., 2018]

Bivariate Colormap (Uncertainty → Saturation)



[Correll et al., 2018]

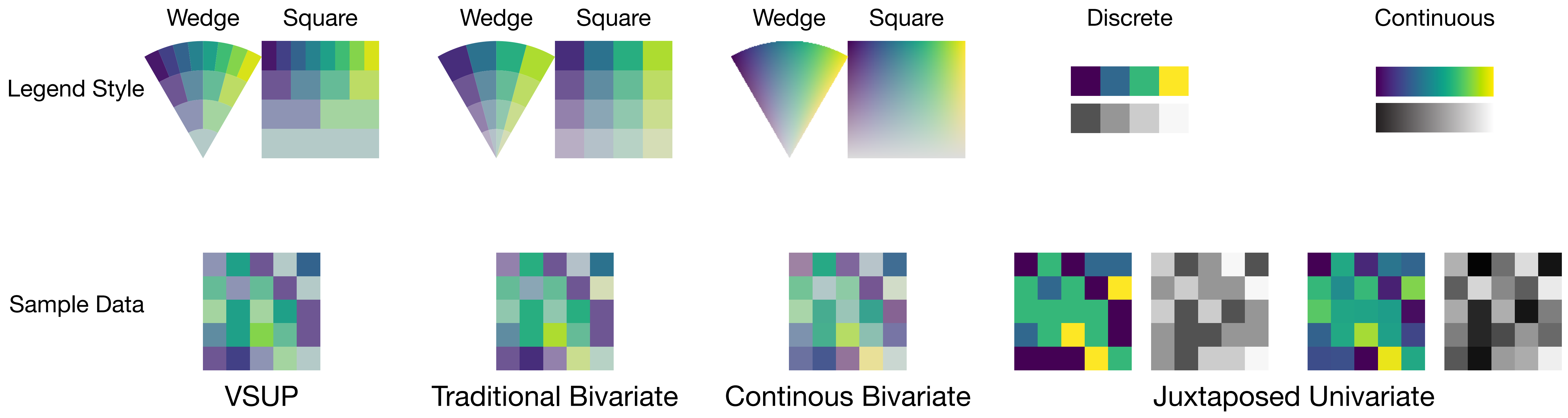
Value-Suppressing Uncertainty Palette

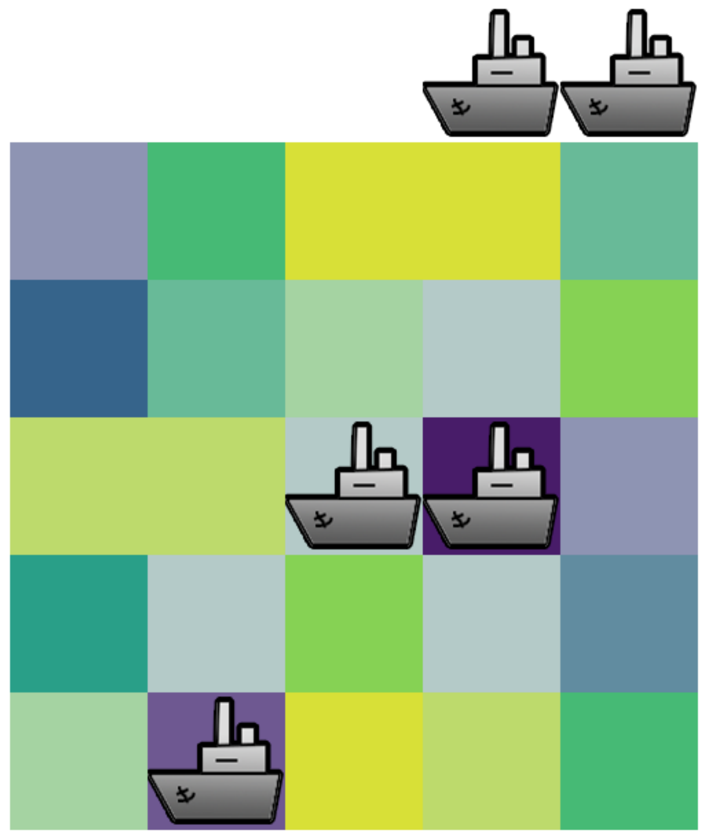


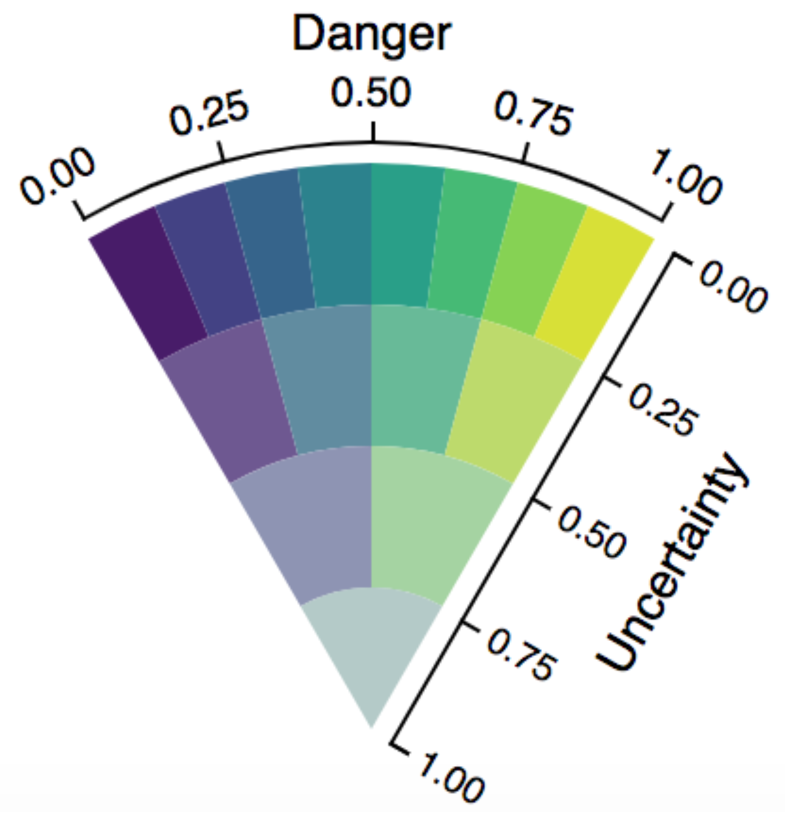
[Correll et al., 2018]

Evaluation

- Tasks:
  - Identification: locate spatial regions

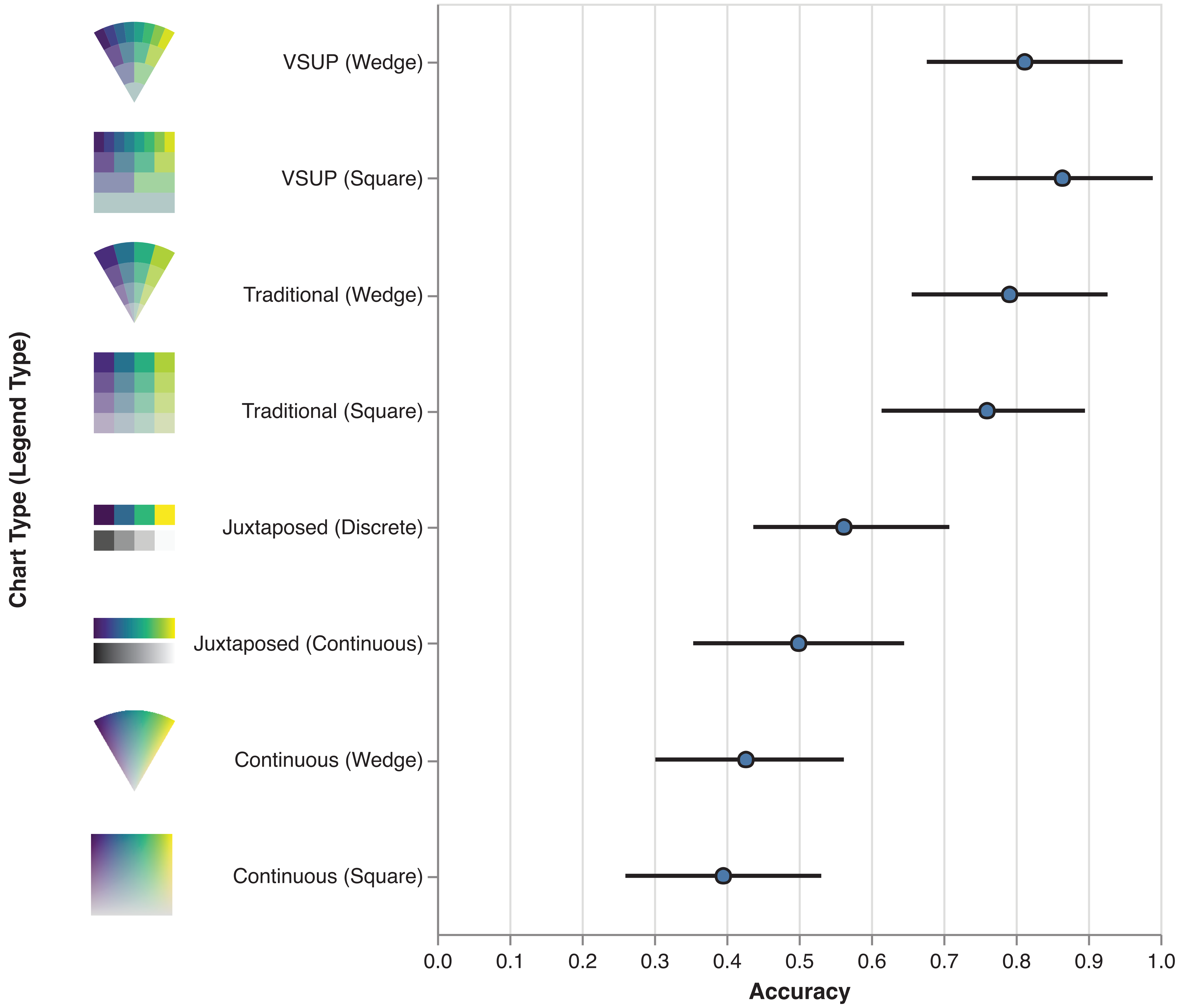


  - Prediction: place  "safest locations"



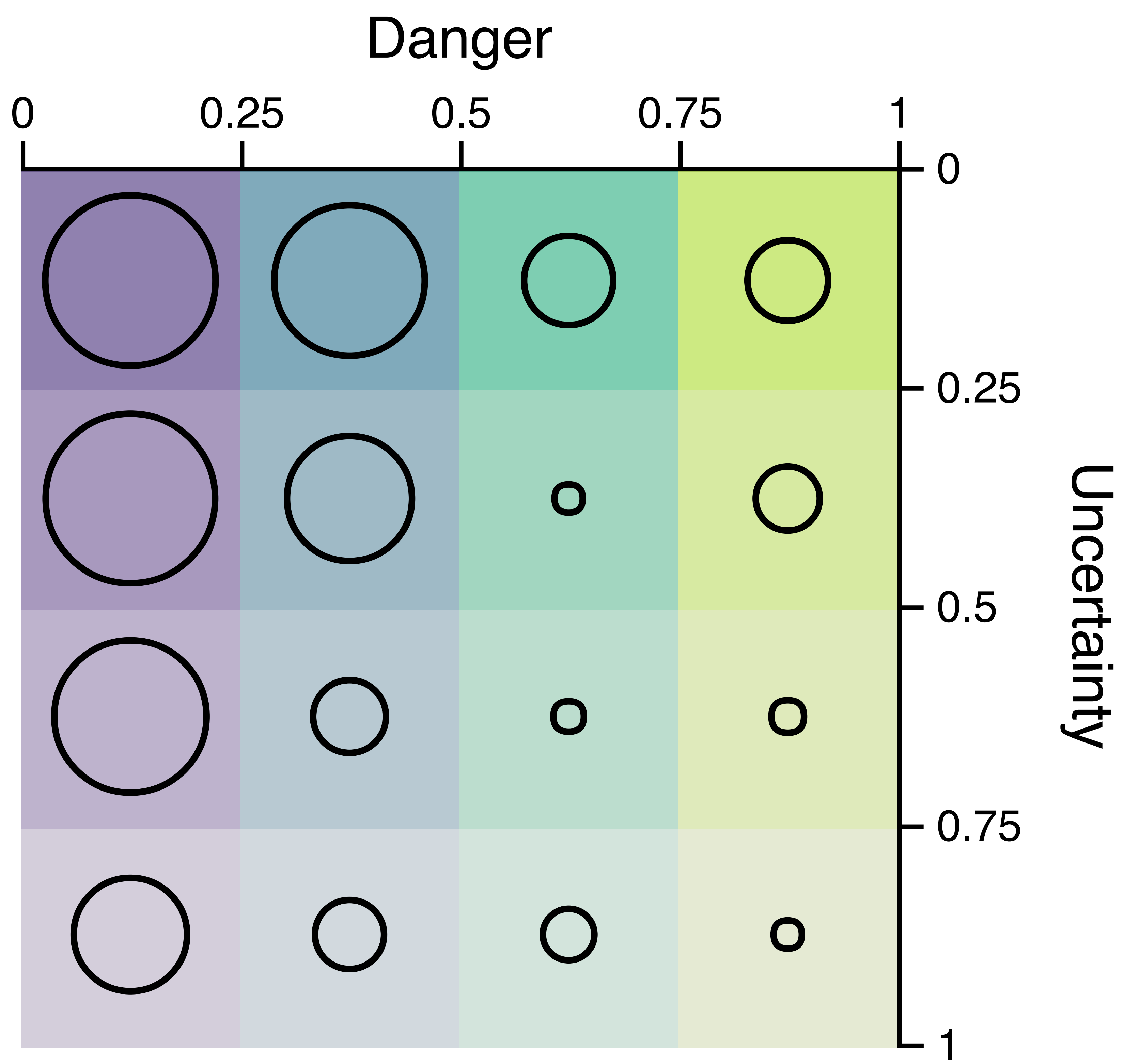
[Correll et al., 2018]

Identification Results

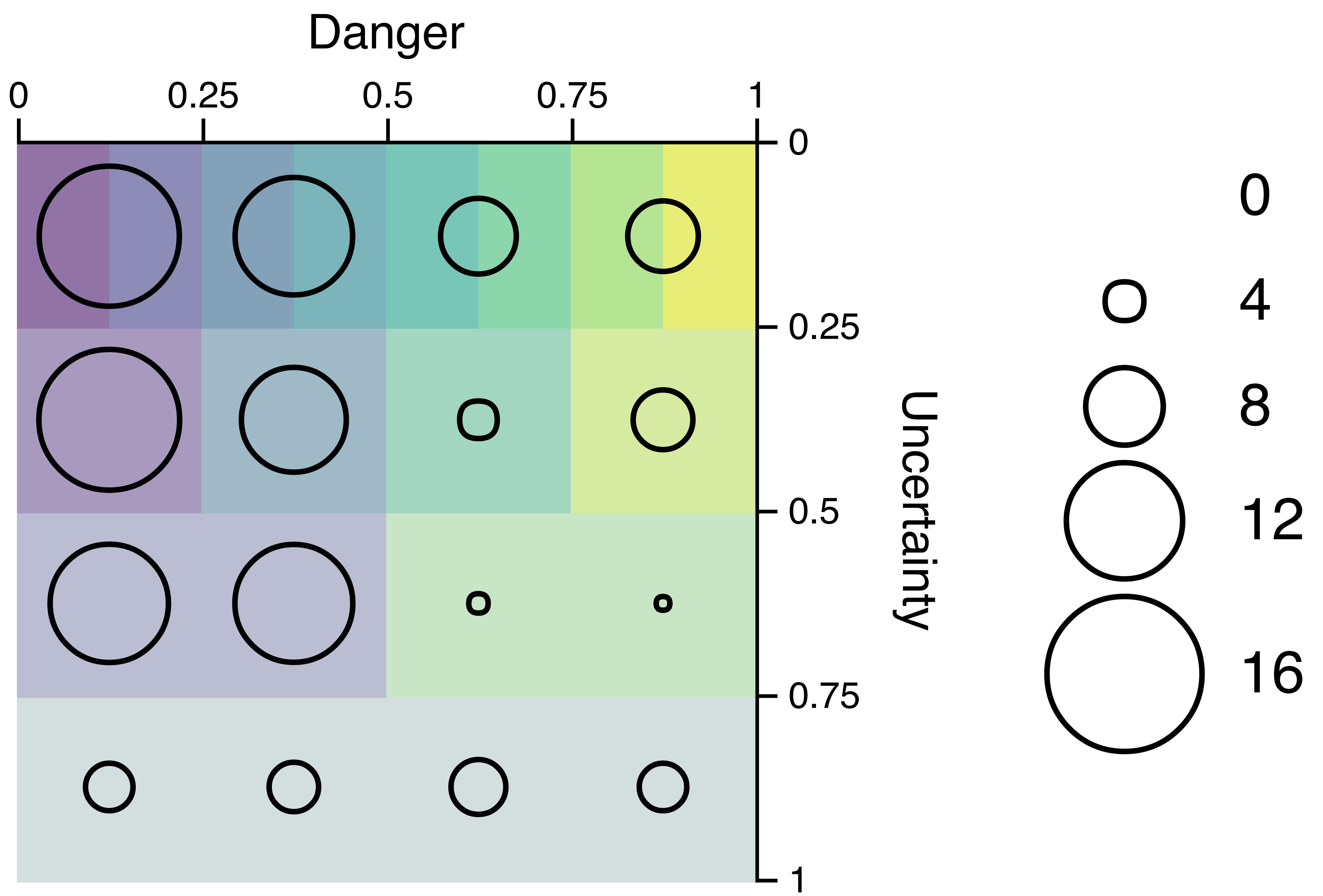


[Correll et al., 2018]

Prediction Results



Traditional Bivariate Map



VSUP

[Correll et al., 2018]

Results & Conclusions

- Legend shape has no significant effect
  - Some indication that people avoid high uncertainty with VSUPs
  - Tradeoff is that people do choose targets with higher danger when using a VSUP
- VSUPs present uncertainty information **simultaneously** (superimposed) instead of juxtaposed
- VSUPs encode value and uncertainty via **discrete, quantized bins** instead of continuously

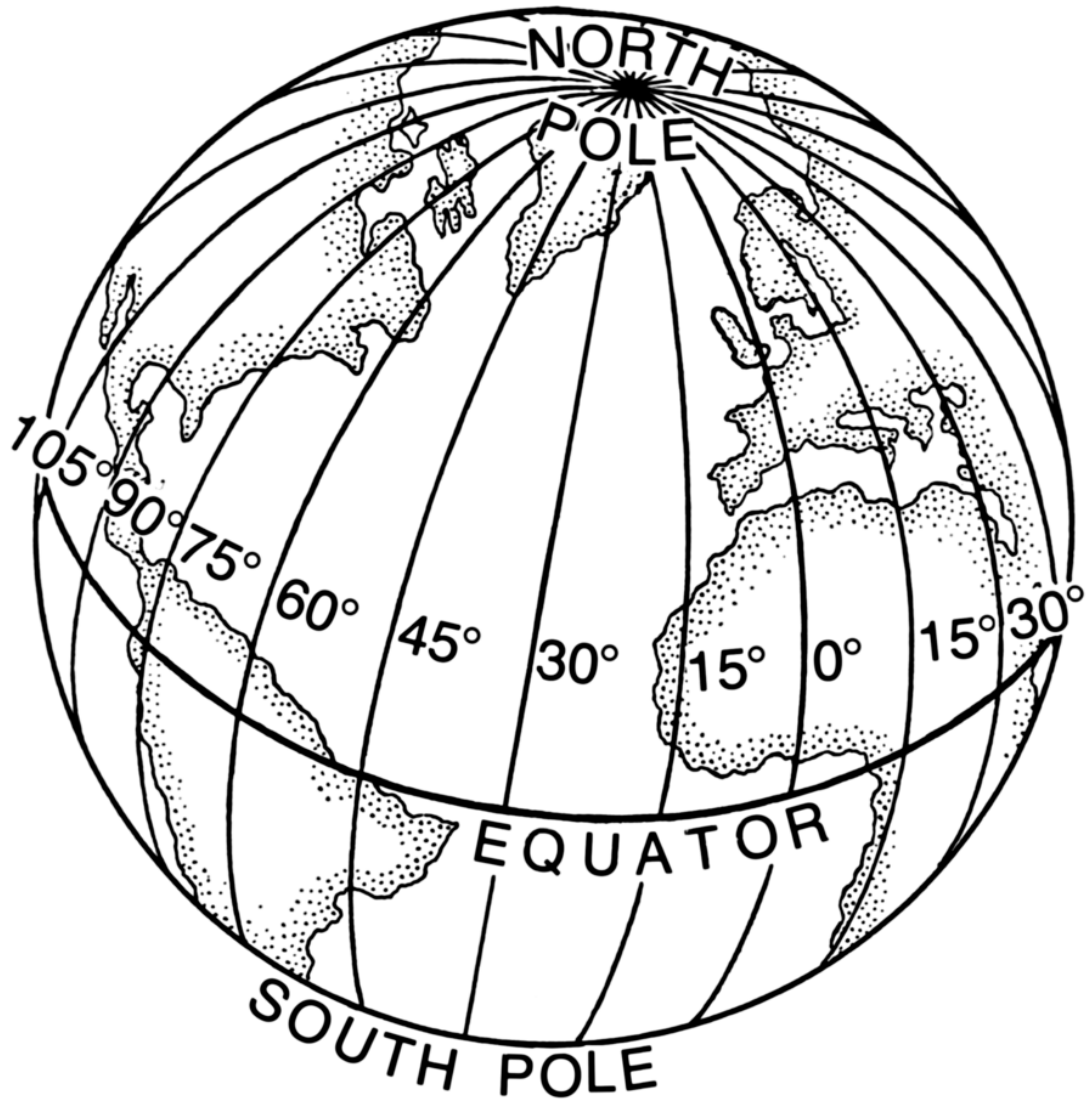
[Correll et al., 2018]

Geospatial Data

Geographic Data

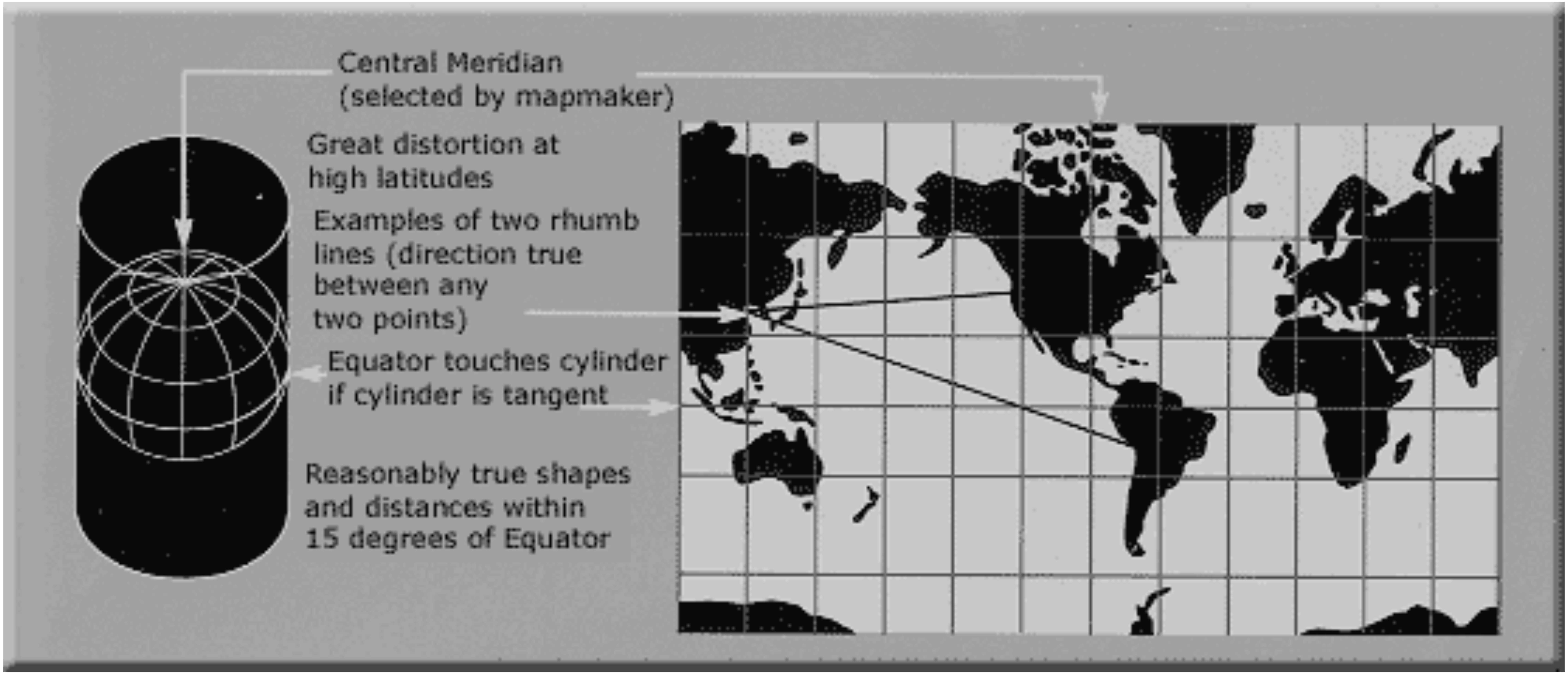
- Spatial data (have positions)
- Cartography: the science of drawing maps
  - Lots of history and well-established procedures
  - May also have non-spatial attributes associated with items
  - Thematic cartography: integrate these non-spatial attributes (e.g. population, life expectancy, etc.)
- Goals:
  - Respect cartographic principles
  - Understand data with geographic references with the visualization principles

Map Projection



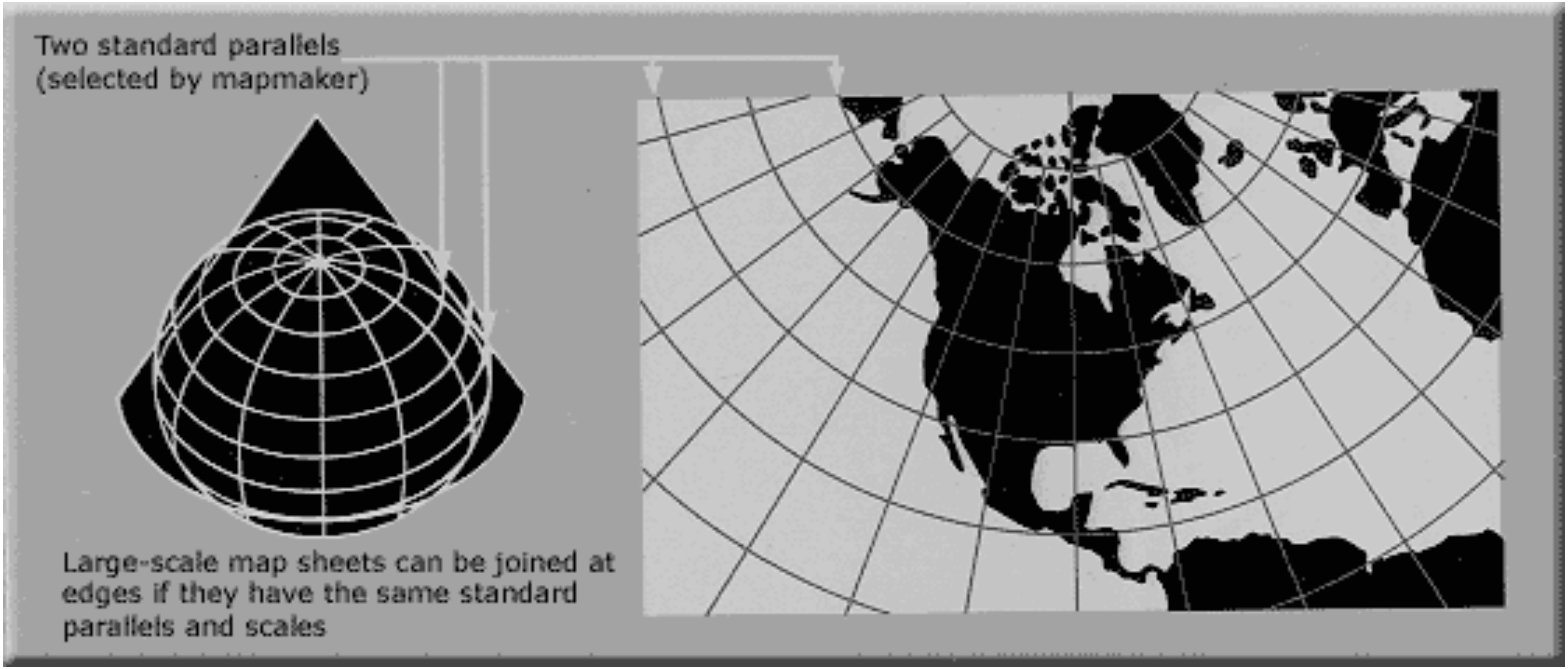
[P. Foresman, Wikimedia]

Flattening the Sphere?



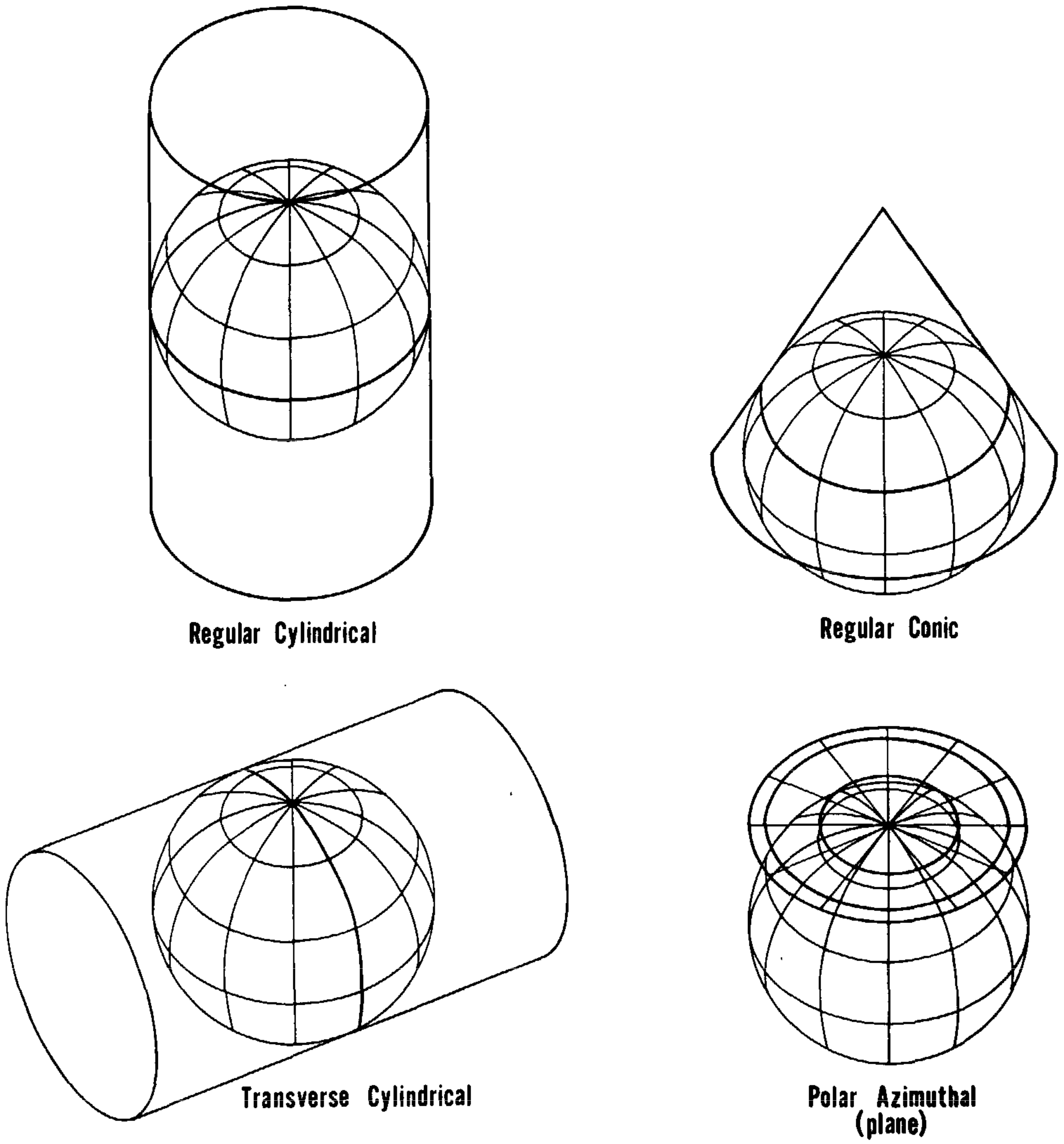
[USGS Map Projections]

Lambert Conformal Conic Projection



[USGS Map Projections]

Standard Projections

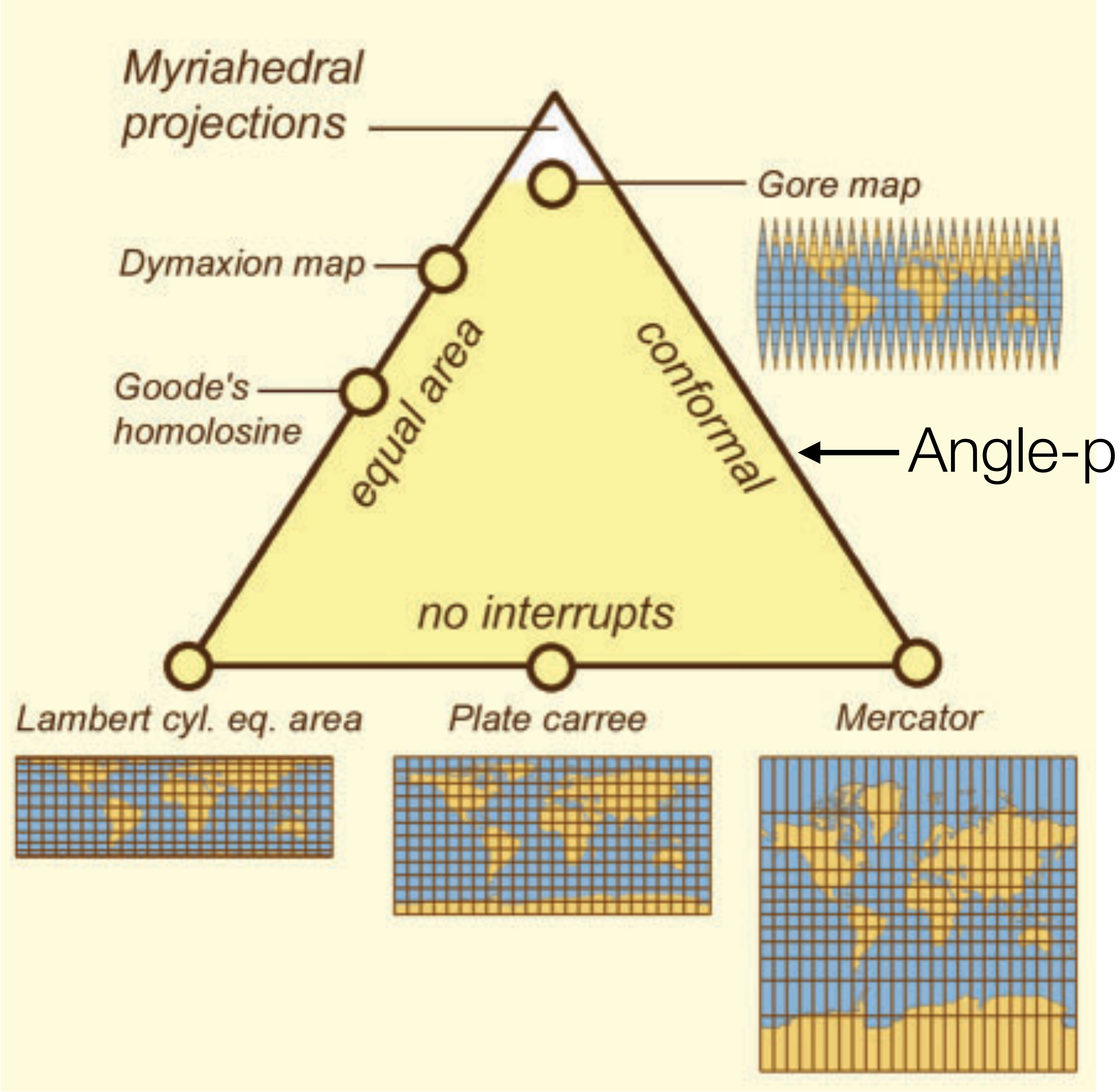


[J. P. Snyder, USGS]

Map Projections

[xkcd]

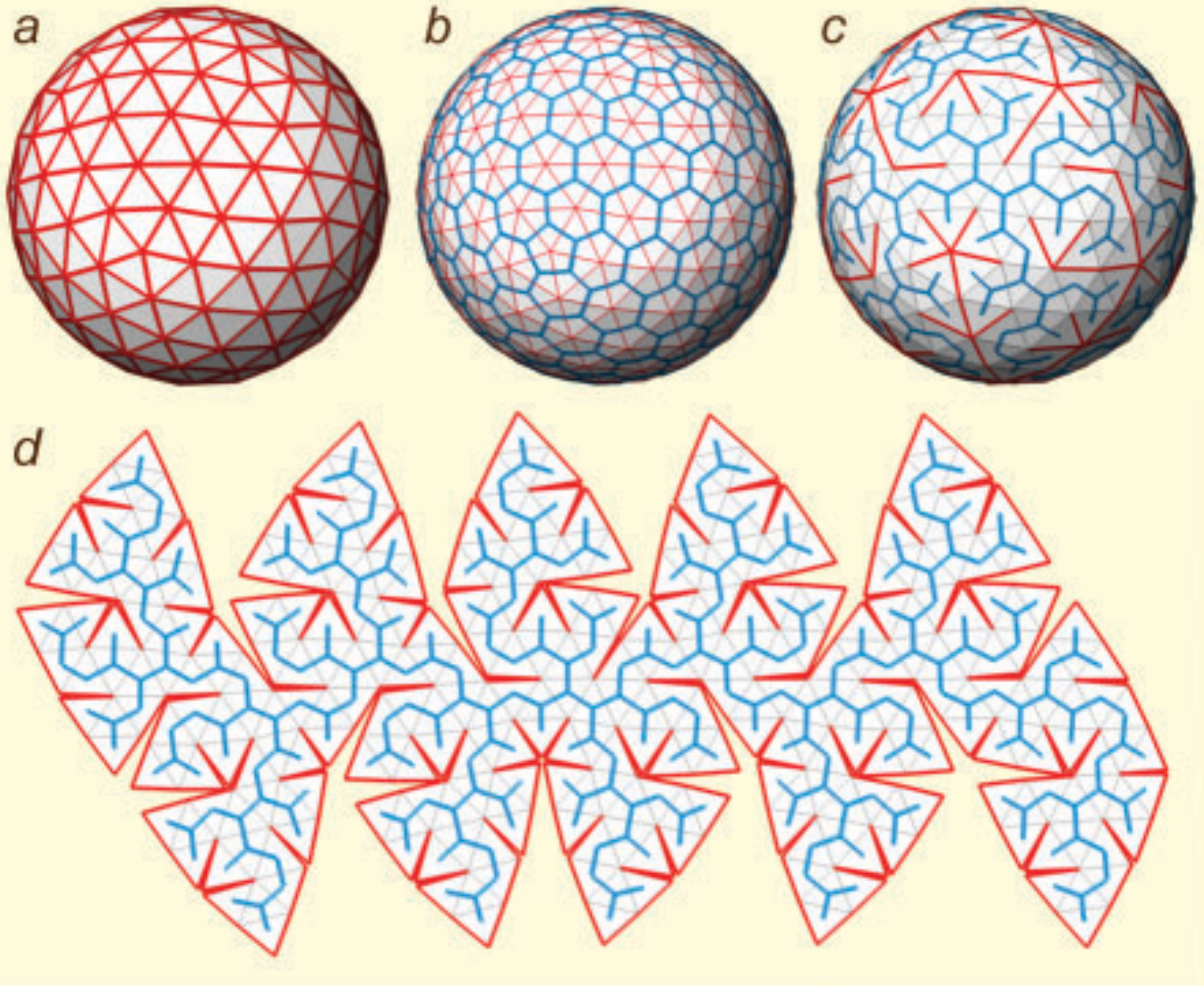
Projection Classification



Angle-preserving

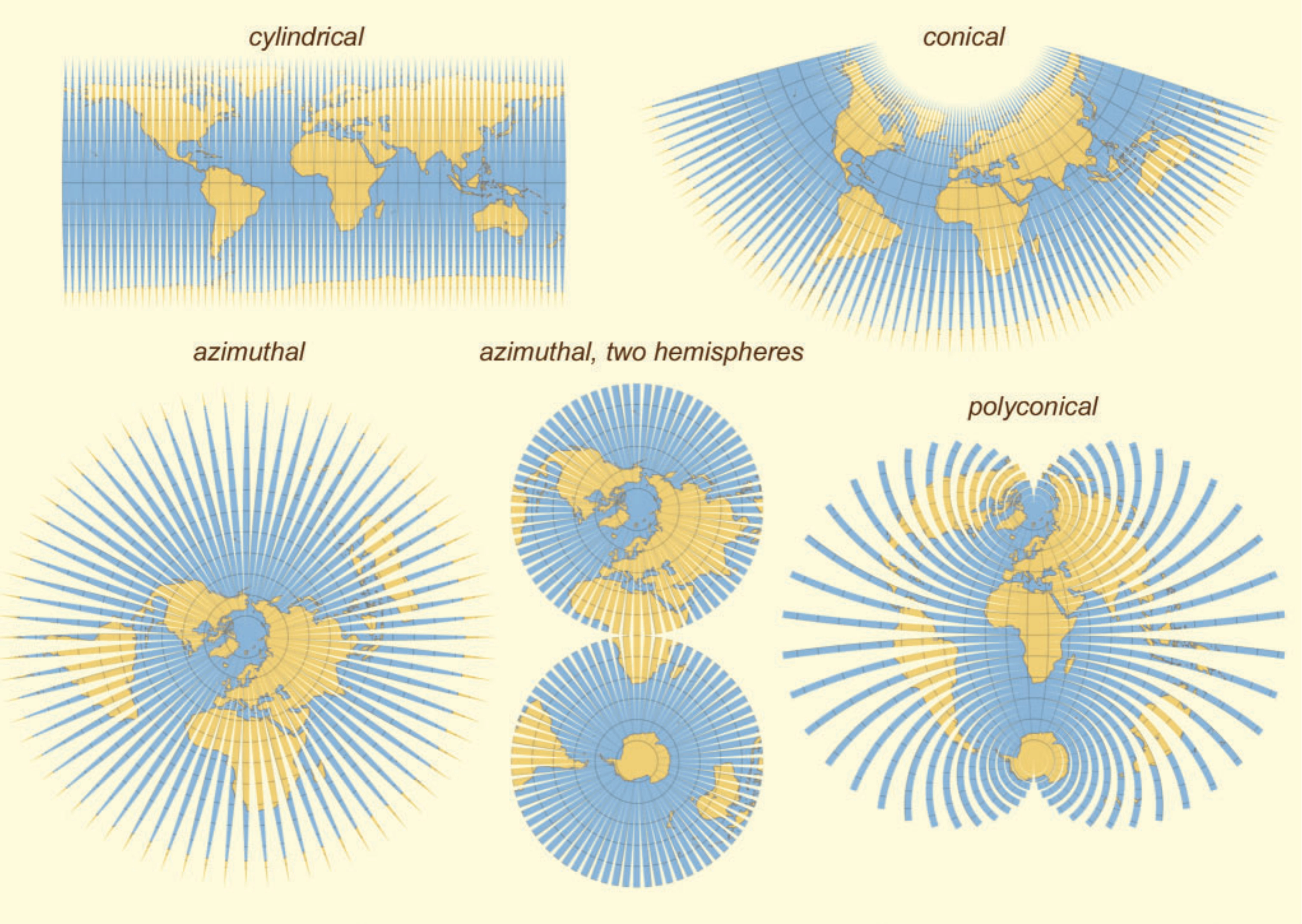
[J. van Wijk, 2008]

Myriahedral Projections



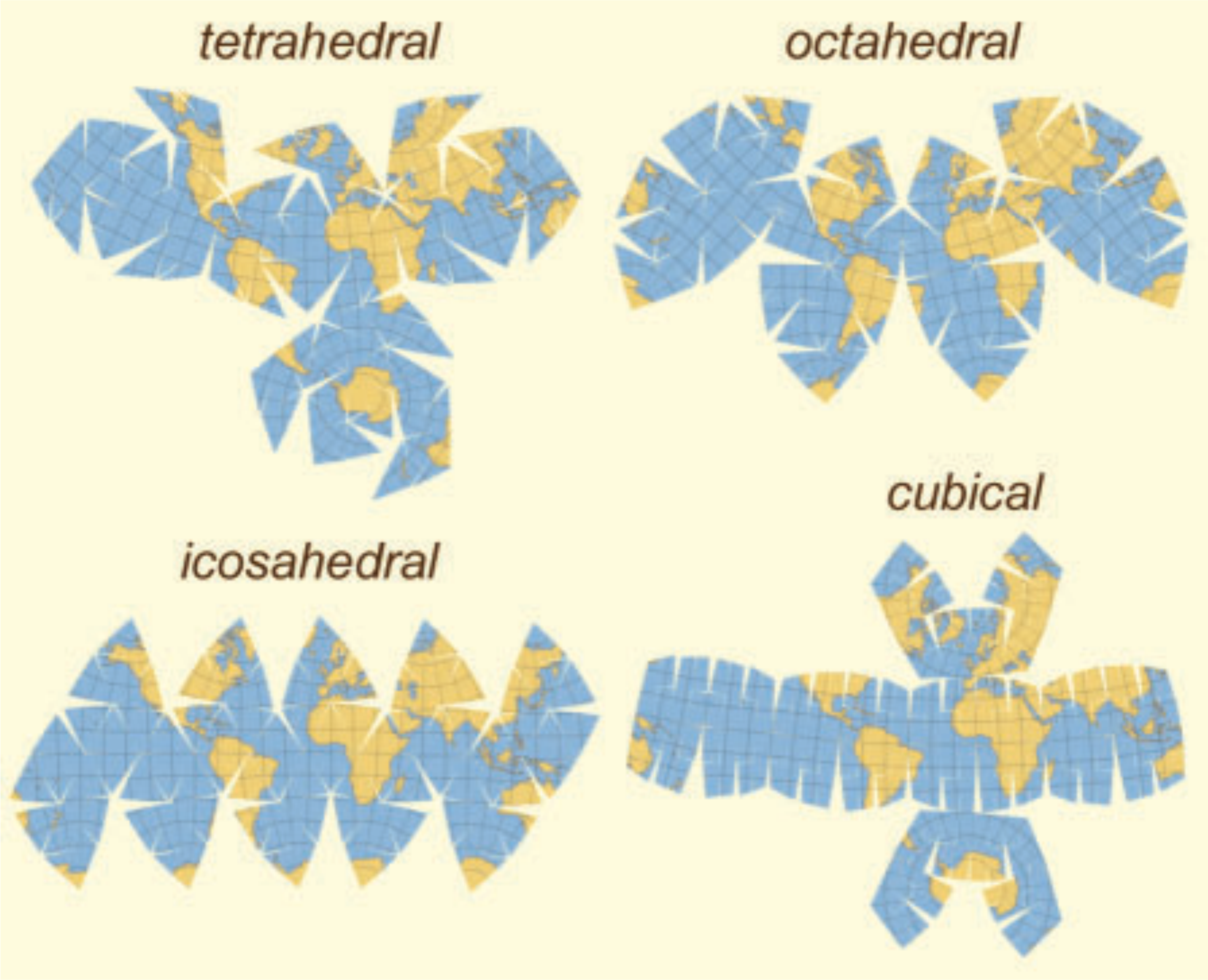
[J. van Wijk, 2008]

Cut along parallels or meridians (graticules)



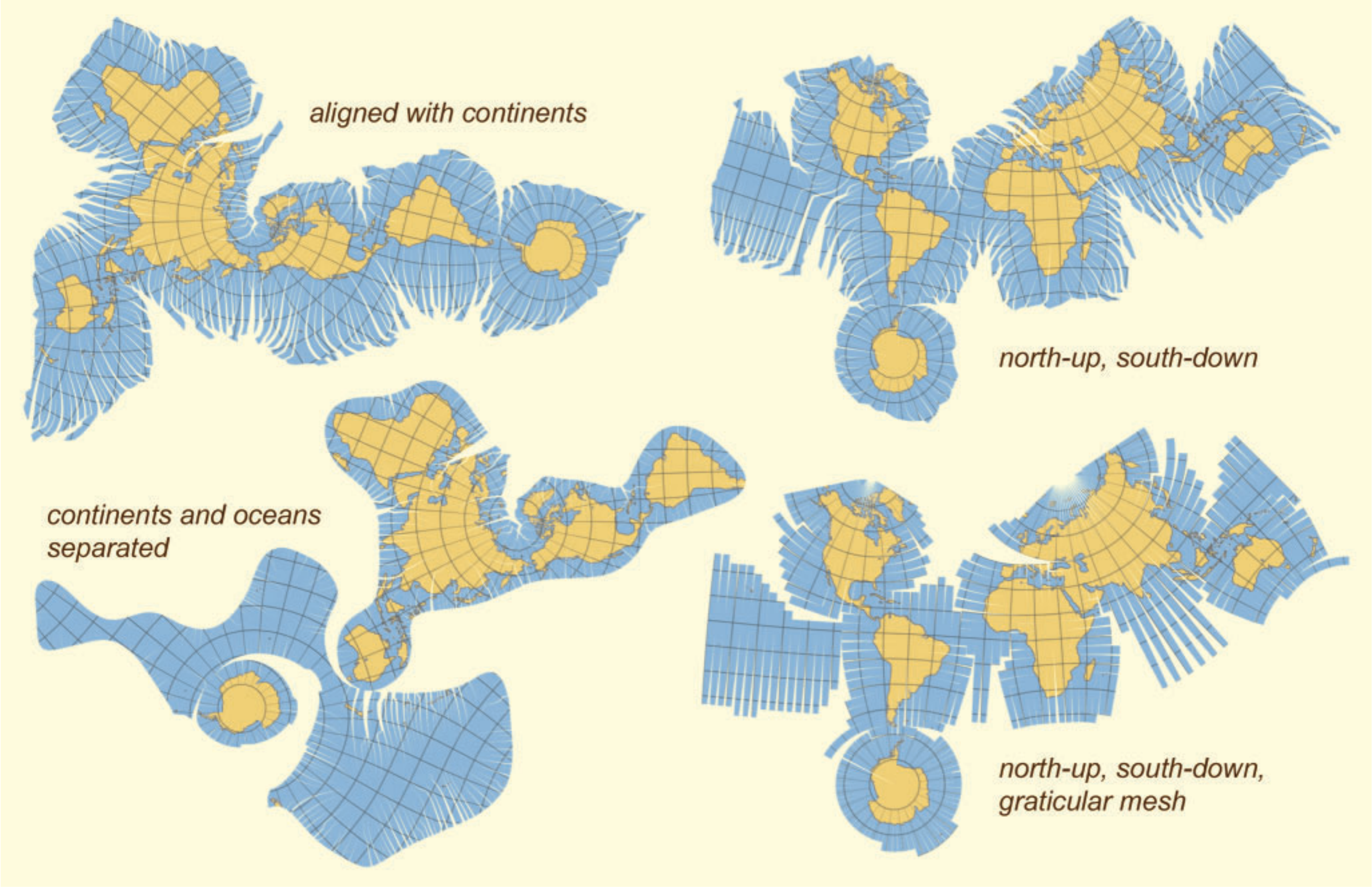
[J. van Wijk, 2008]

Subdividing regular polyhedra



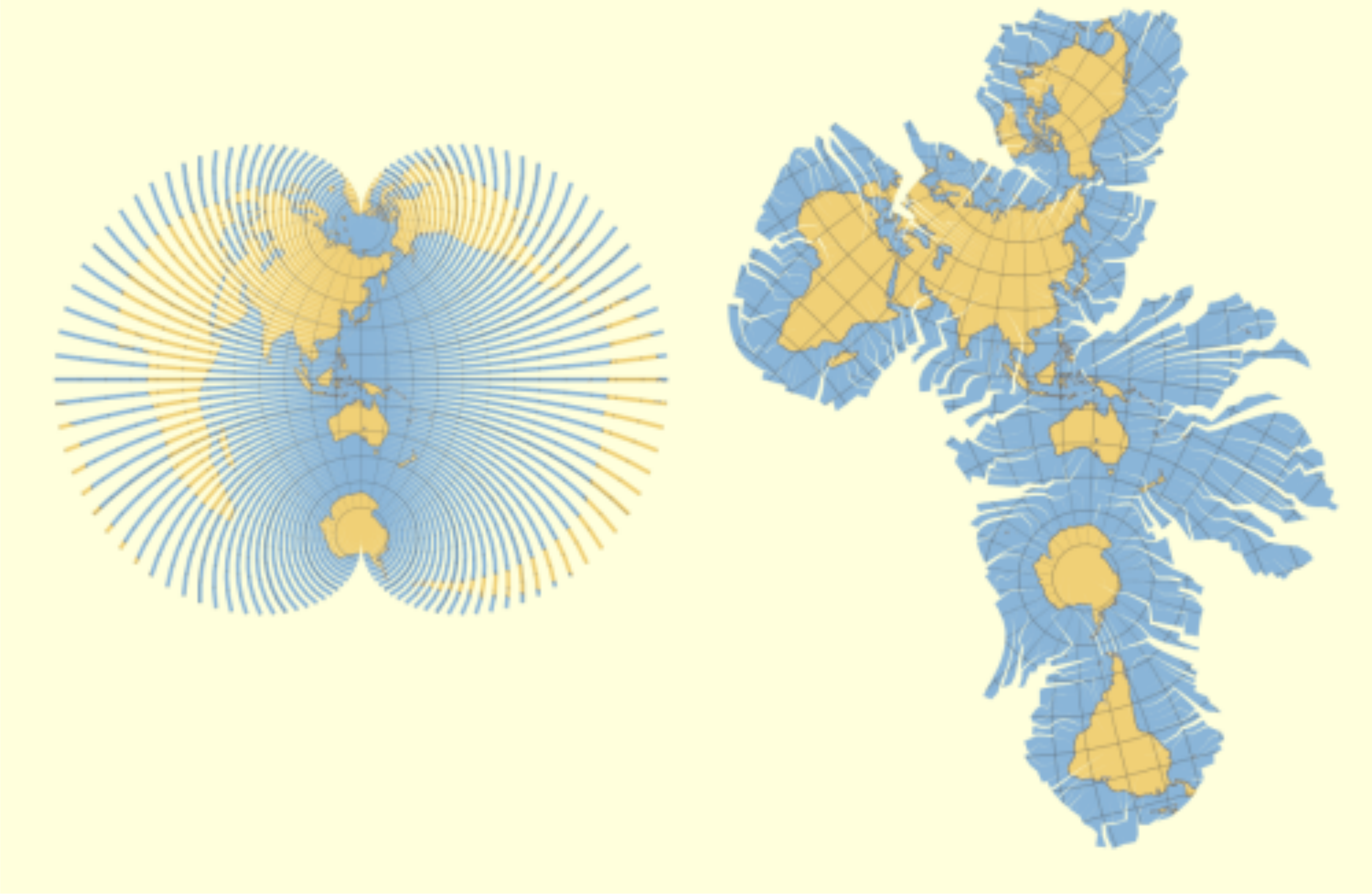
[J. van Wijk, 2008]

Geographically-aligned



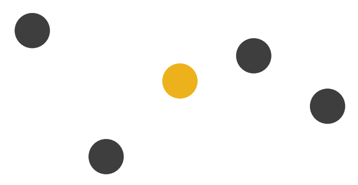
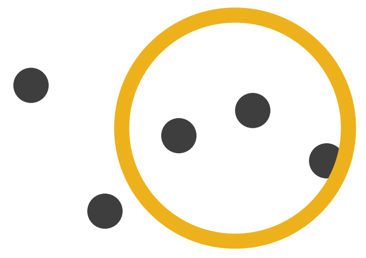
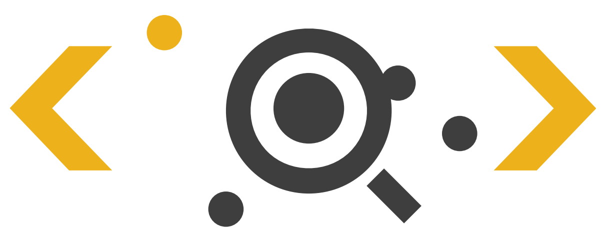
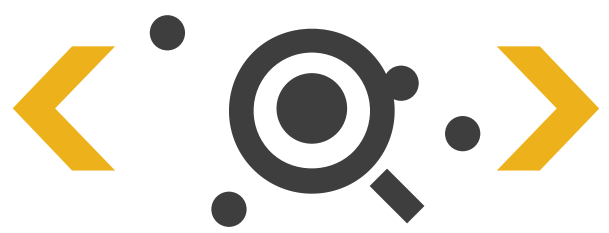
[J. van Wijk, 2008]

Australia-centric



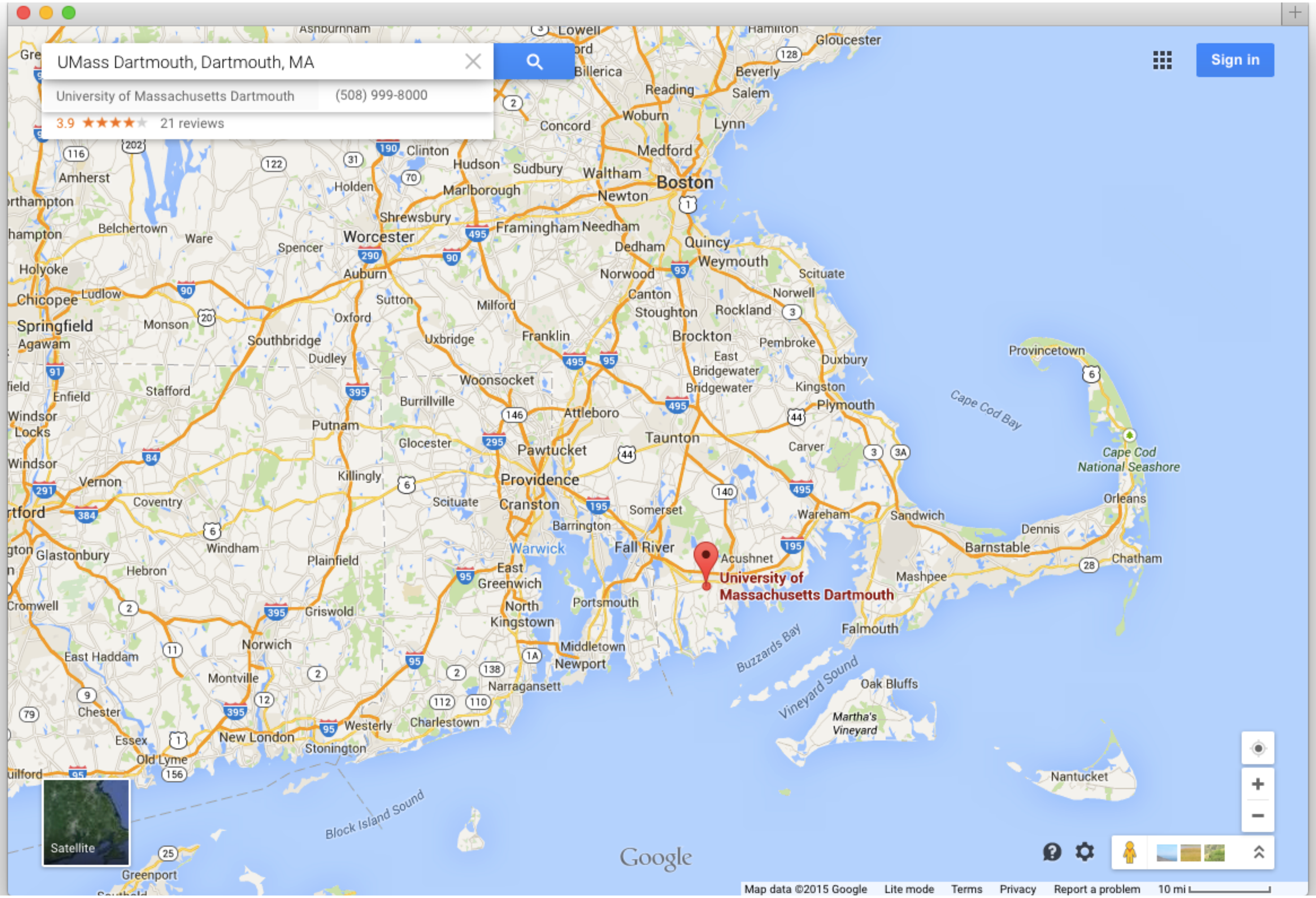
[J. van Wijk, 2008]

Search Tasks

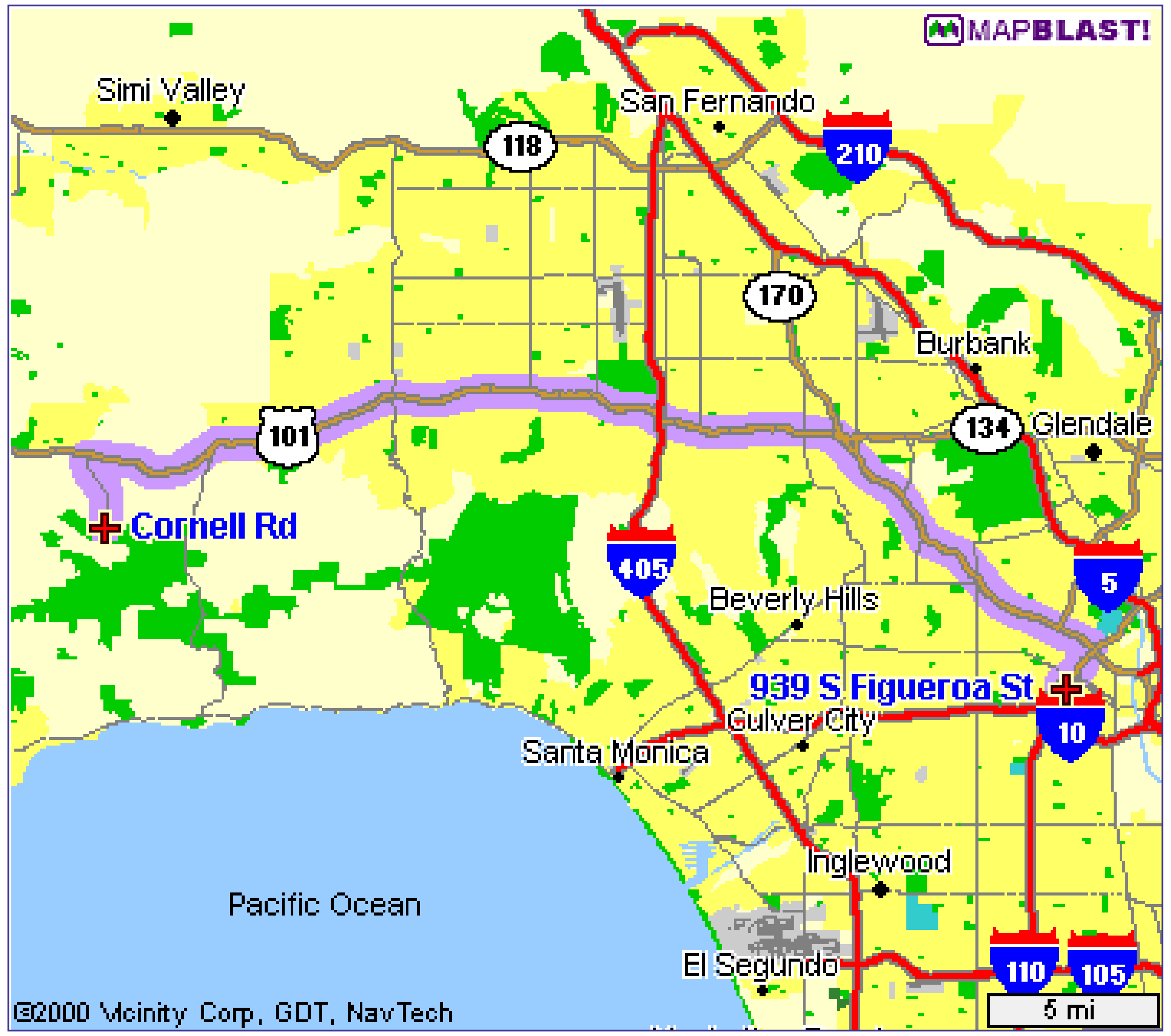
	Target known	Target unknown
Location known	 *Lookup*	 *Browse*
Location unknown	 *Locate*	 *Explore*

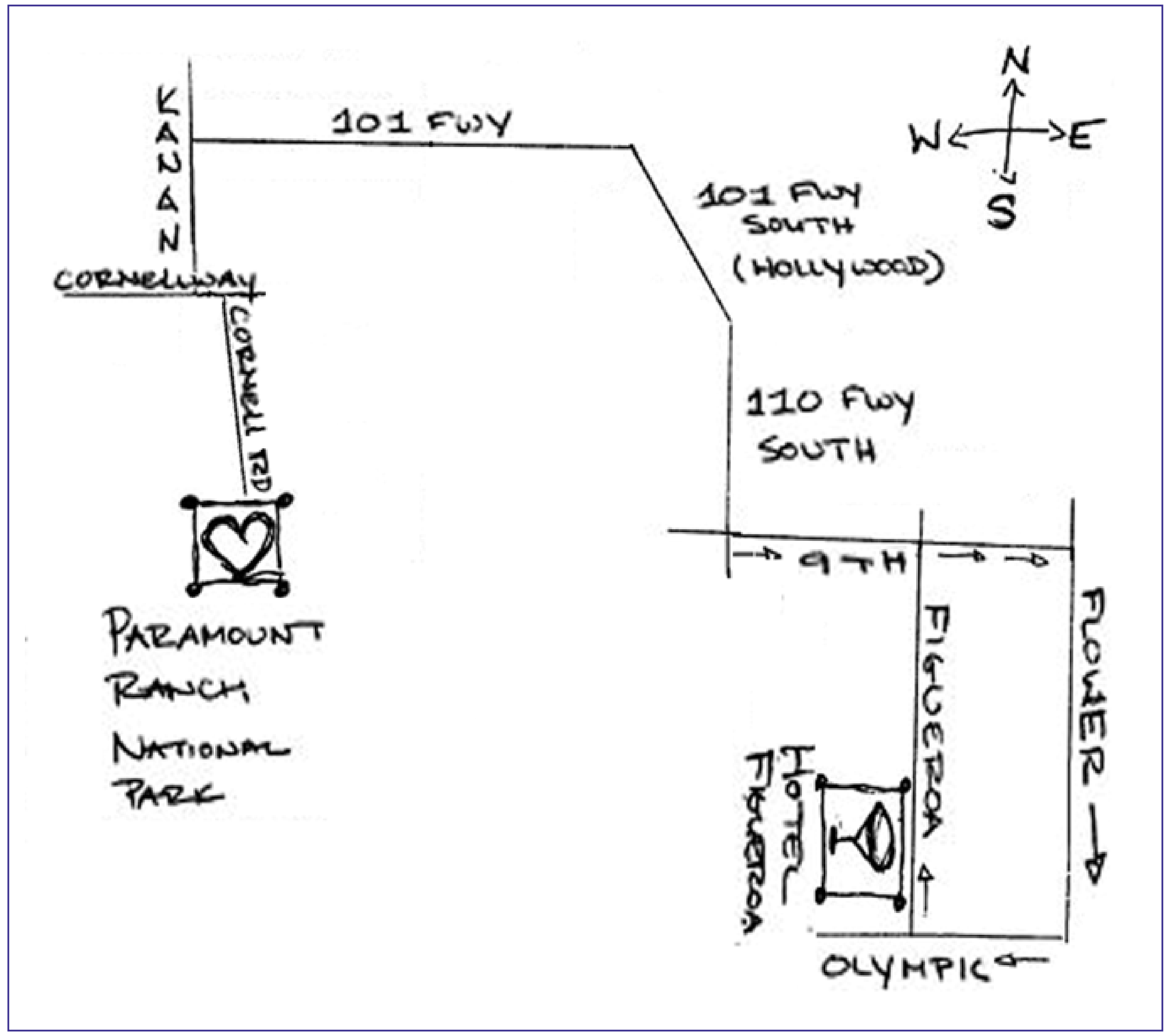
[Munzner (ill. Maguire), 2014]

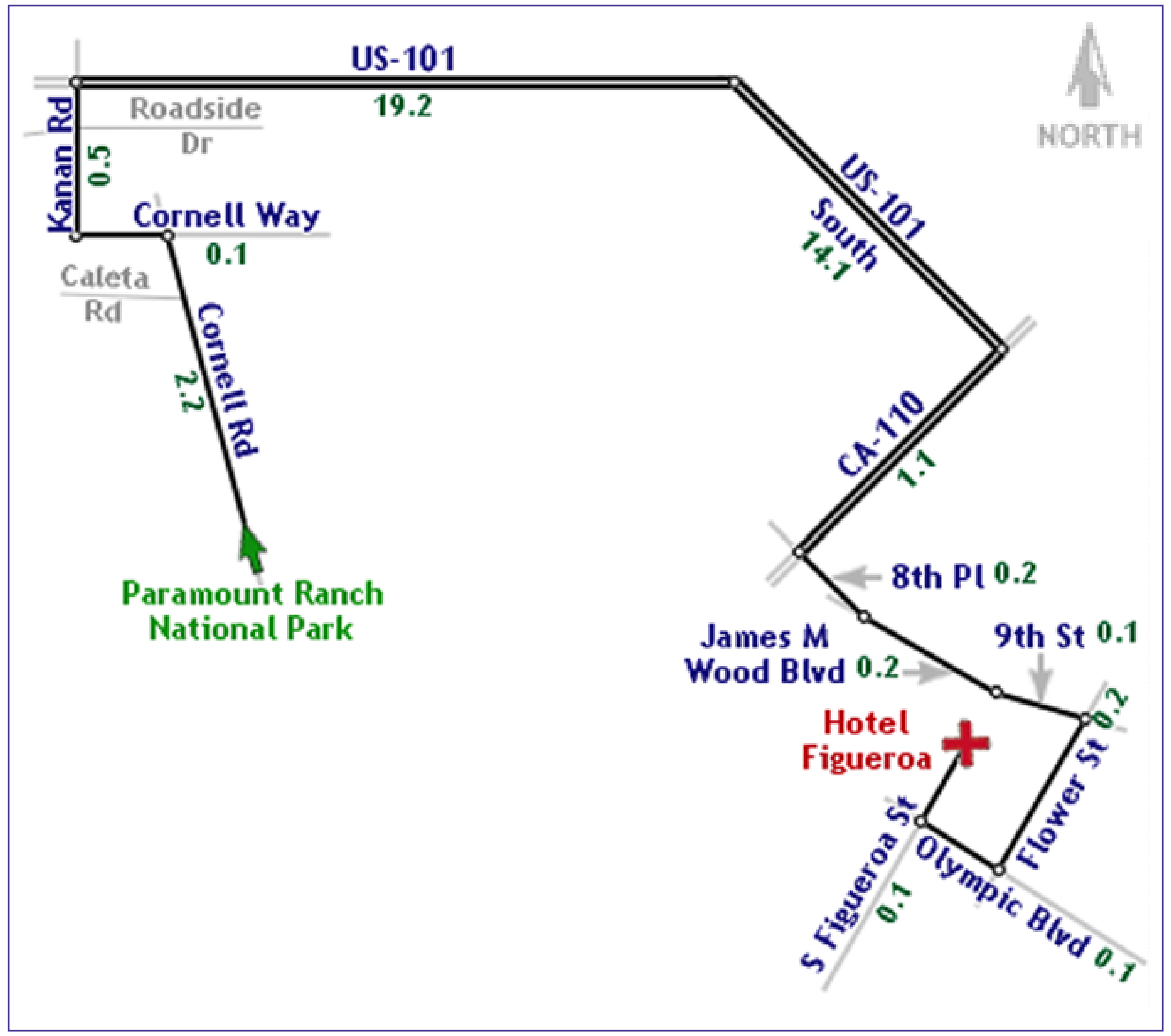
Lookup


UMass Dartmouth, Dartmouth, MA
University of Massachusetts Dartmouth
(508) 999-8000
3.9 ★★★★ 21 reviews
Sign in
University of Massachusetts Dartmouth
Boston
Providence
Worcester
Springfield
Satellite
Google
Map data ©2015 Google
Lite mode
Terms
Privacy
Report a problem
10 mi

Route Maps

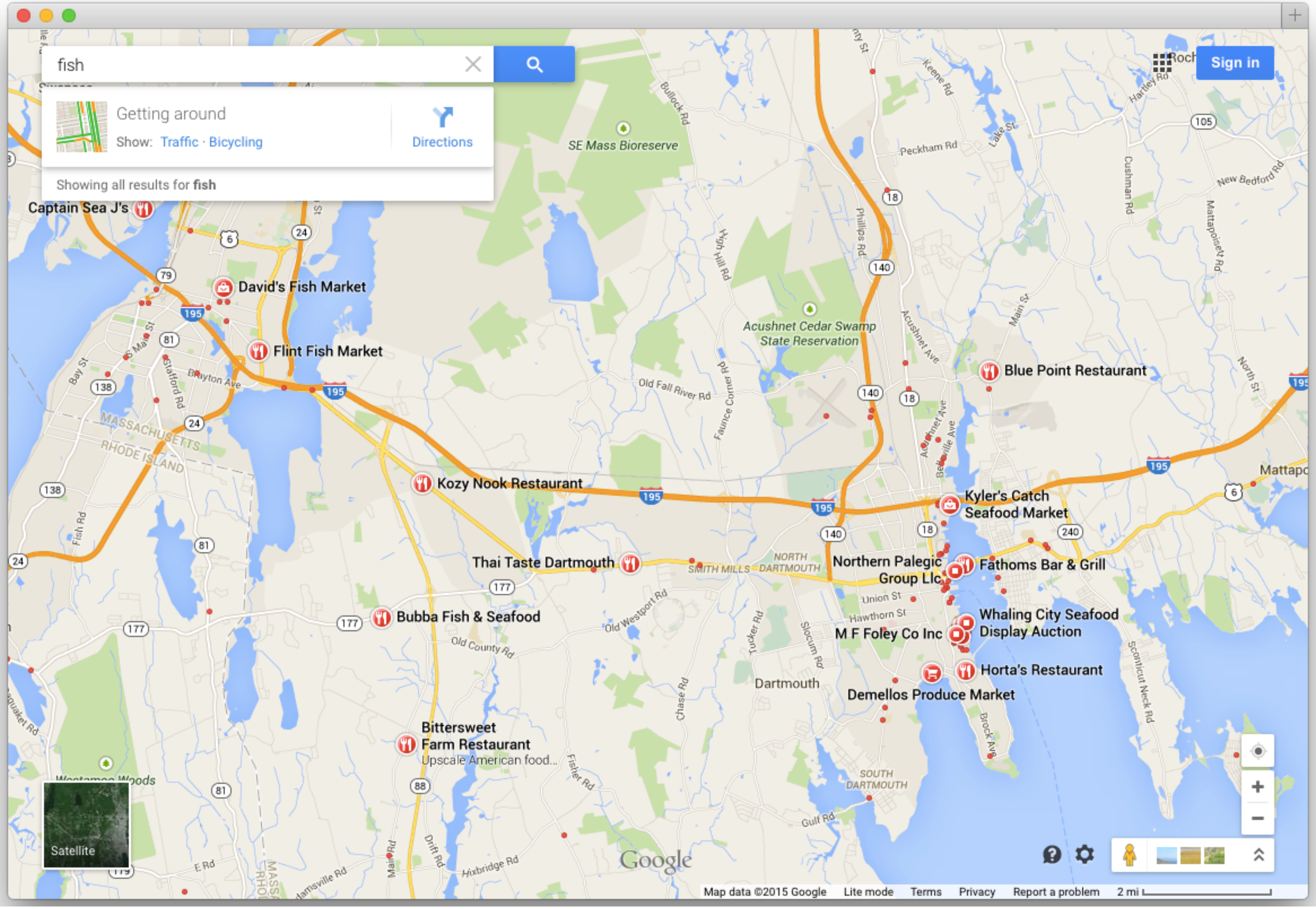






[Agrawala & Stolte, 2001]

Locate



fish
Getting around
Show: Traffic · Bicycling
Directions
Showing all results for fish
Sign in
Captain Sea J's
David's Fish Market
Flint Fish Market
Kozy Nook Restaurant
Thai Taste Dartmouth
Bubba Fish & Seafood
Bittersweet
Farm Restaurant
Upscale American food...
Blue Point Restaurant
Kyler's Catch
Seafood Market
Northern Palegic
Group Llc
Fathoms Bar & Grill
Whaling City Seafood
Display Auction
M F Foley Co Inc
Horta's Restaurant
Demellos Produce Market
SE Mass Bioreserve
Acushnet Cedar Swamp
State Reservation
Dartmouth
MASSACHUSETTS
RHODE ISLAND
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Google
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Adding Data

- Discrete: a value is associated with a specific position
  - Size
  - Color Hue
  - Charts
- Continuous: each spatial position has a value (fields)
  - Heatmap
  - Isolines

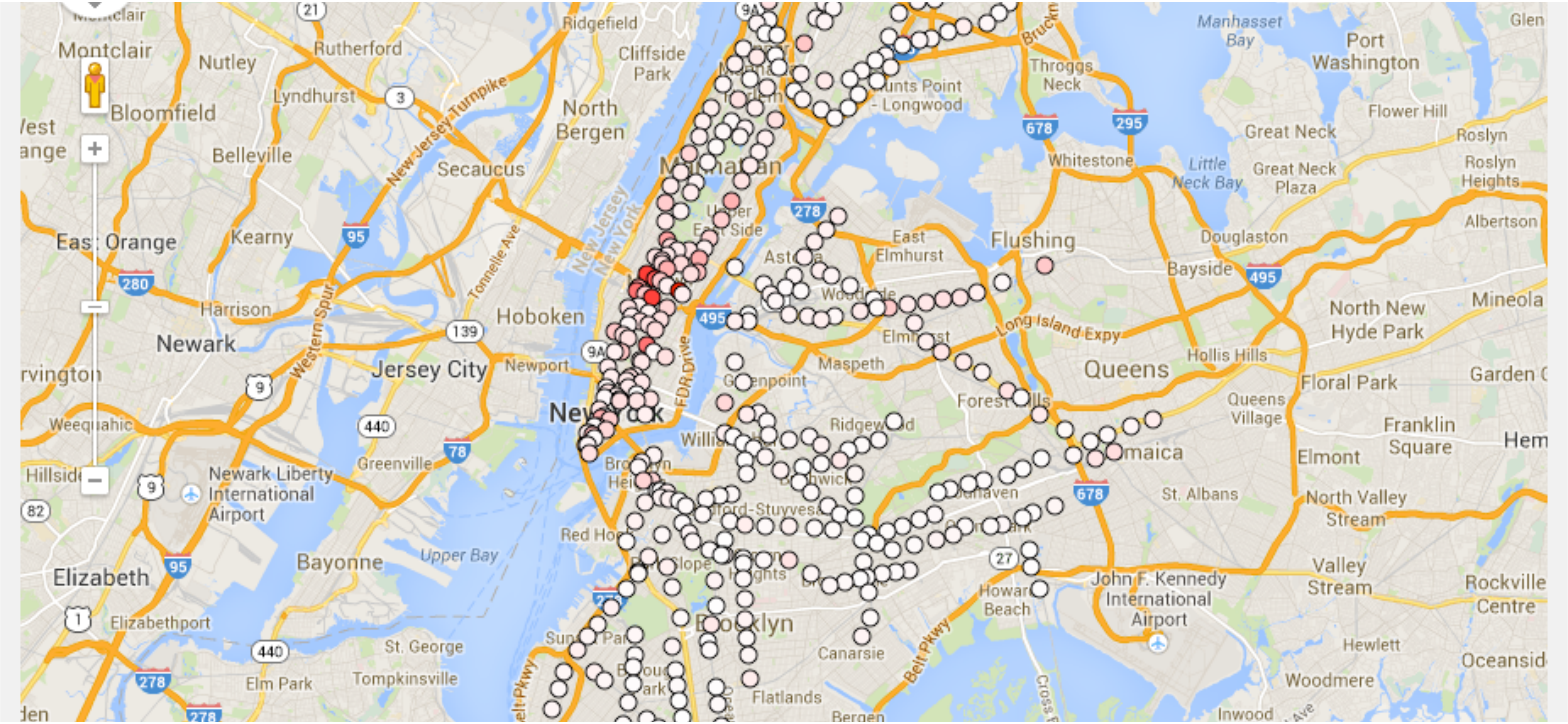
Discrete Categorical Attribute: Shape

[Acadia NP, National Park Service]

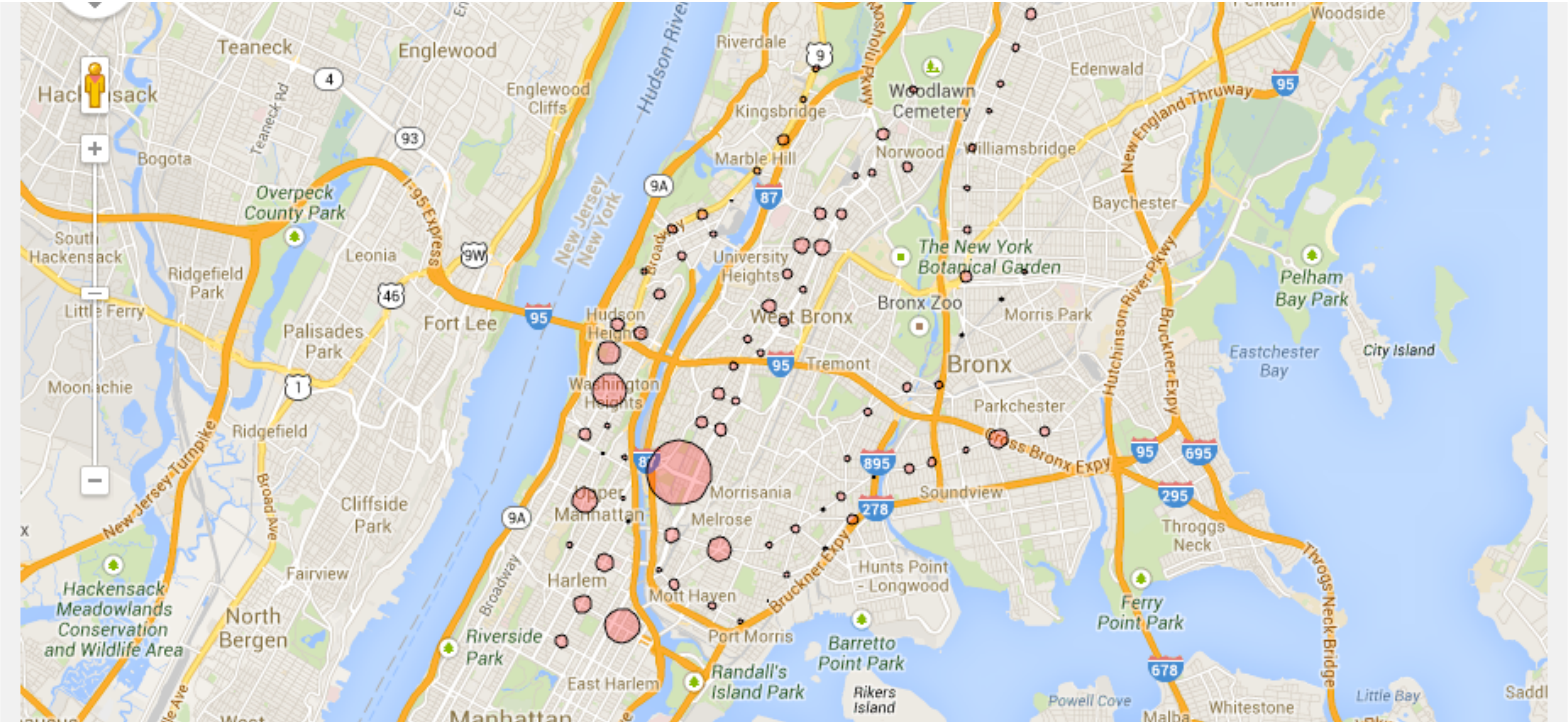
Discrete Categorical Attribute: Shape

[Acadia NP, National Park Service]

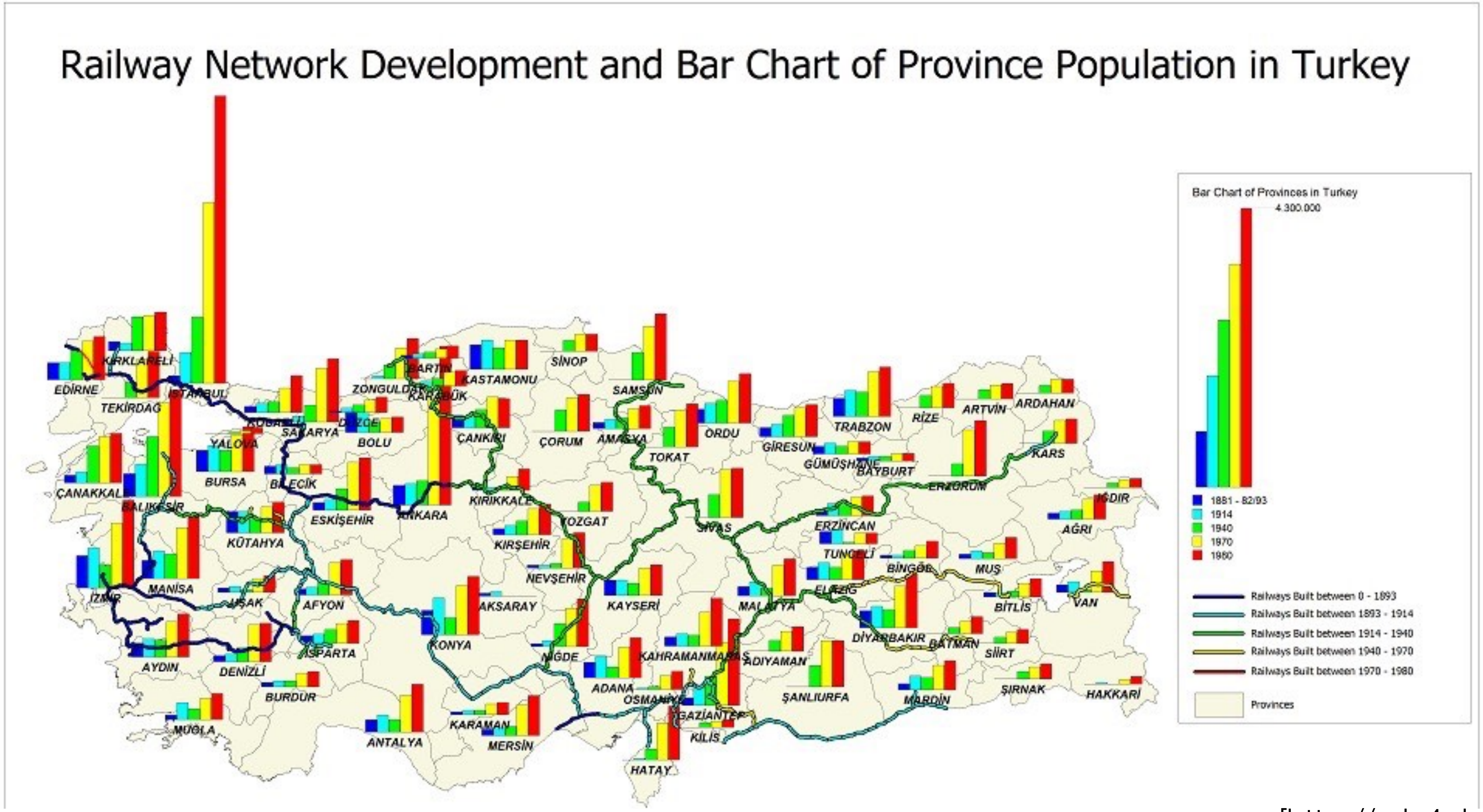
Discrete Quantitative Attribute: Color Saturation



Discrete Quantitative Attribute: Size

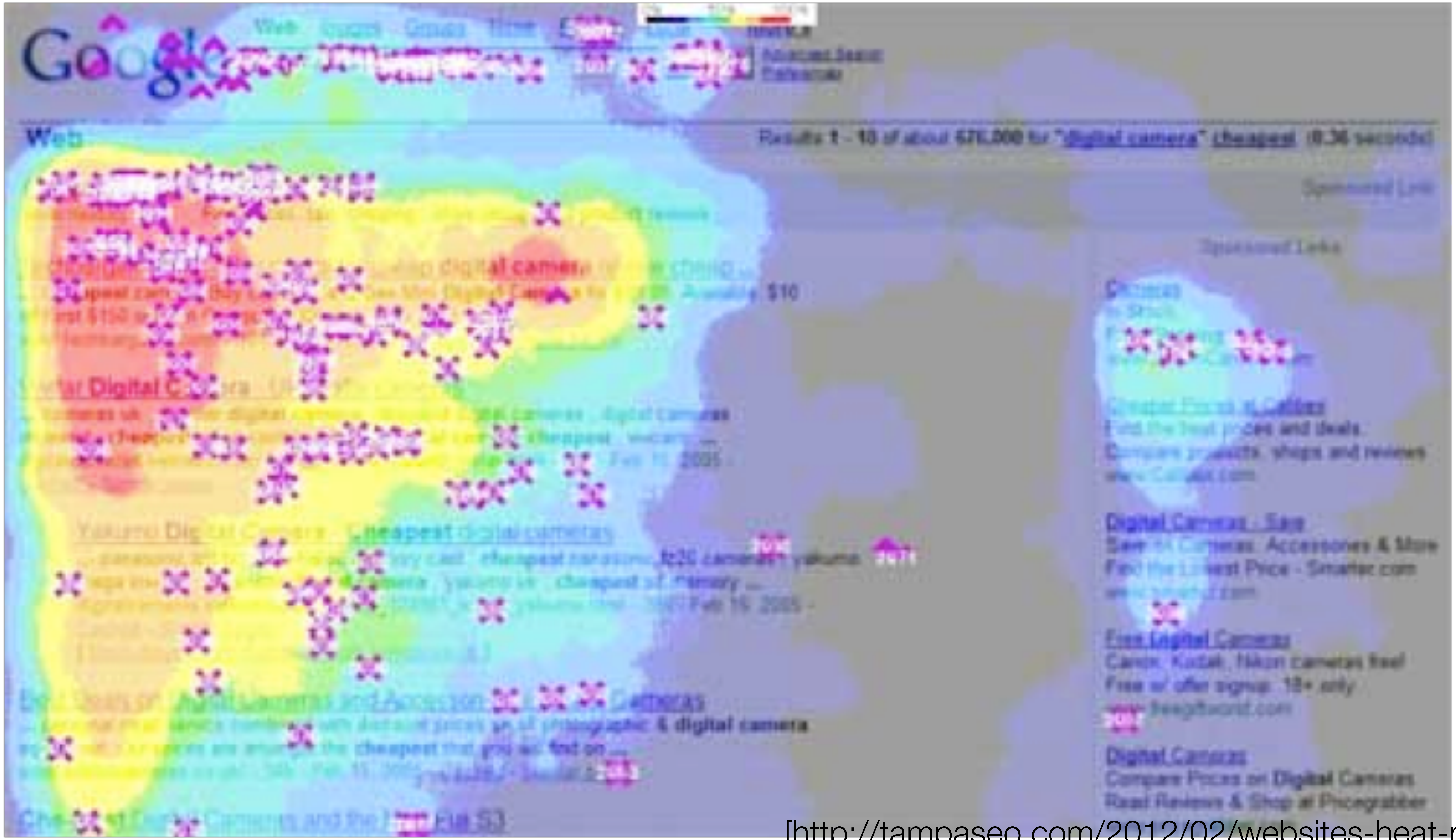


Discrete Quantitative Attributes: Bar Chart



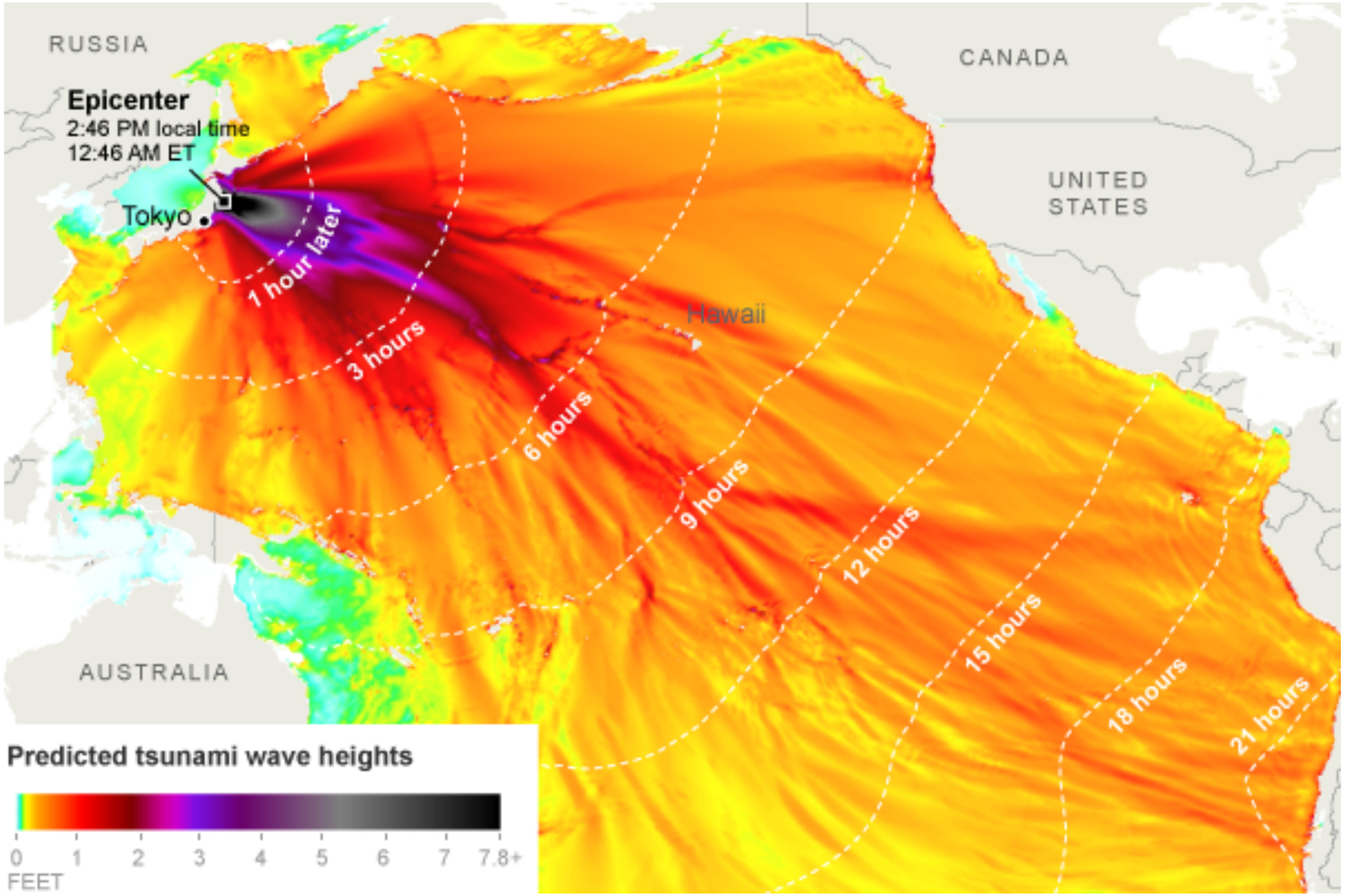
[http://mis4gis.com/hgistr.org/]

Continuous Quantitative Attribute: Color Hue



[http://tampaseo.com/2012/02/websites-heat-mapping-users/]

Time as the attribute



[NYTimes]

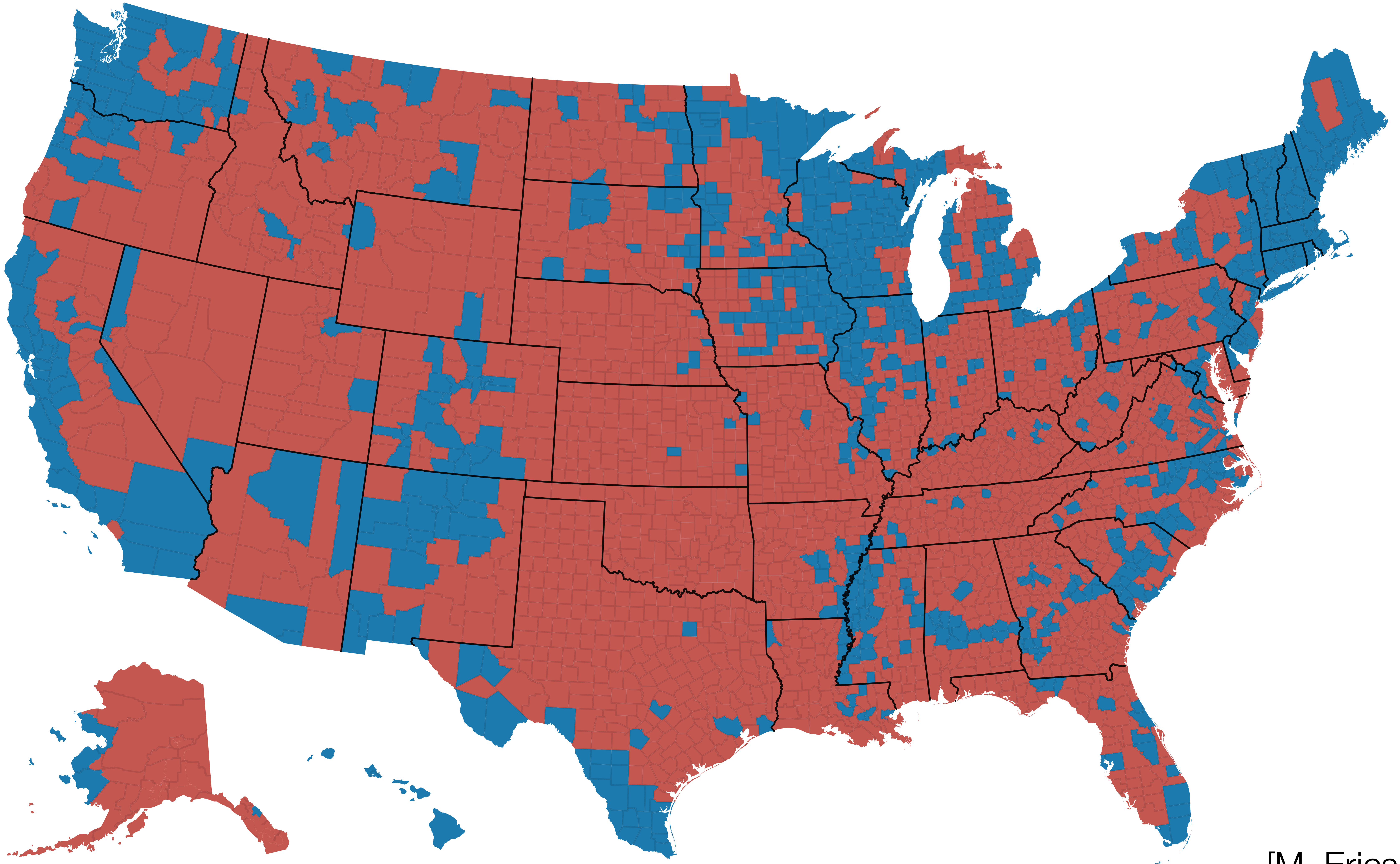
Isolines

[USGS via Wikipedia]

Isolines

- Scalar fields:
  - value at each location
  - sampled on grids
- Isolines use **derived data** from the scalar field
  - Interpret field as representing continuous values
  - Derived data is **geometry**: new lines that represent the same attribute value
- Scalability: dozens of levels
- Other encodings?

Choropleth (Two Hues)



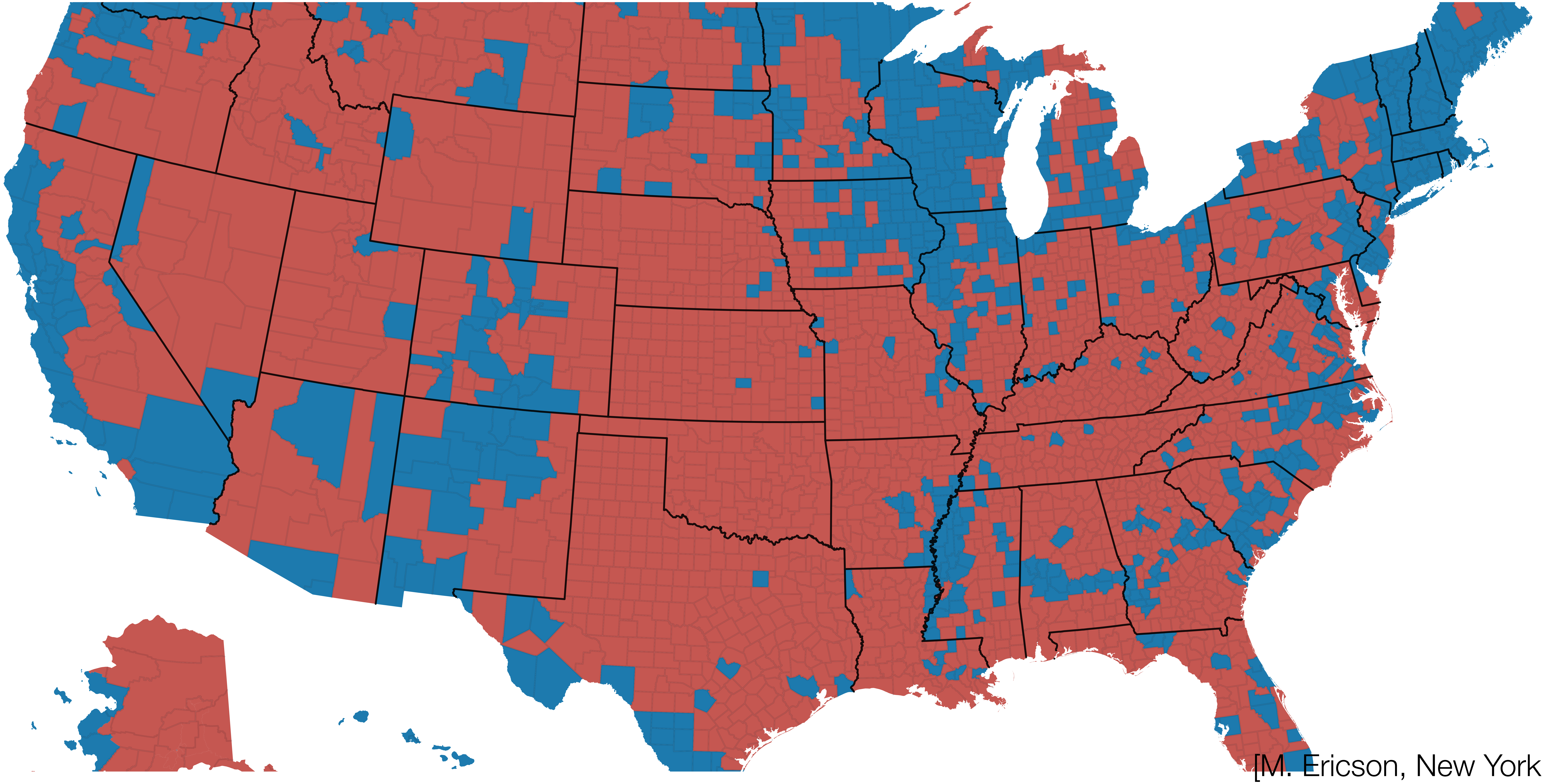
[M. Ericson, New York Times]

Choropleth Map

- Data: geographic geometry data & one quantitative attribute per region
- Tasks: trends, patterns, comparisons
- How: area marks from given geometry, color hue/saturation/luminance
- Scalability: thousands of regions

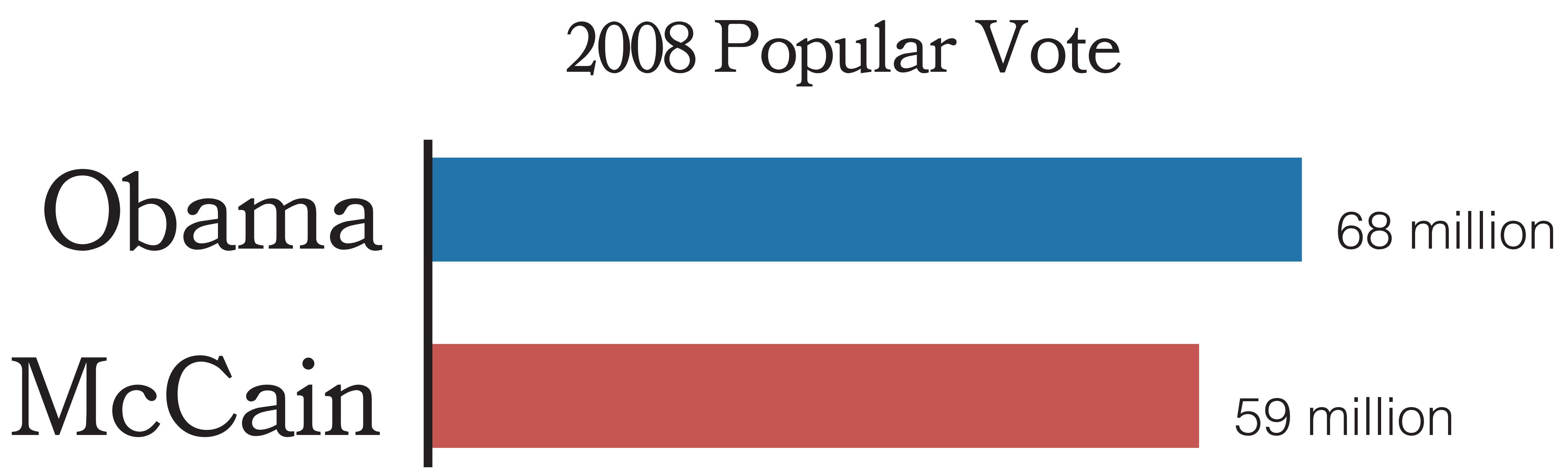
- Design choices:
  - Colormap
  - Region boundaries (level of summarization)

Choropleth (Two Hues)



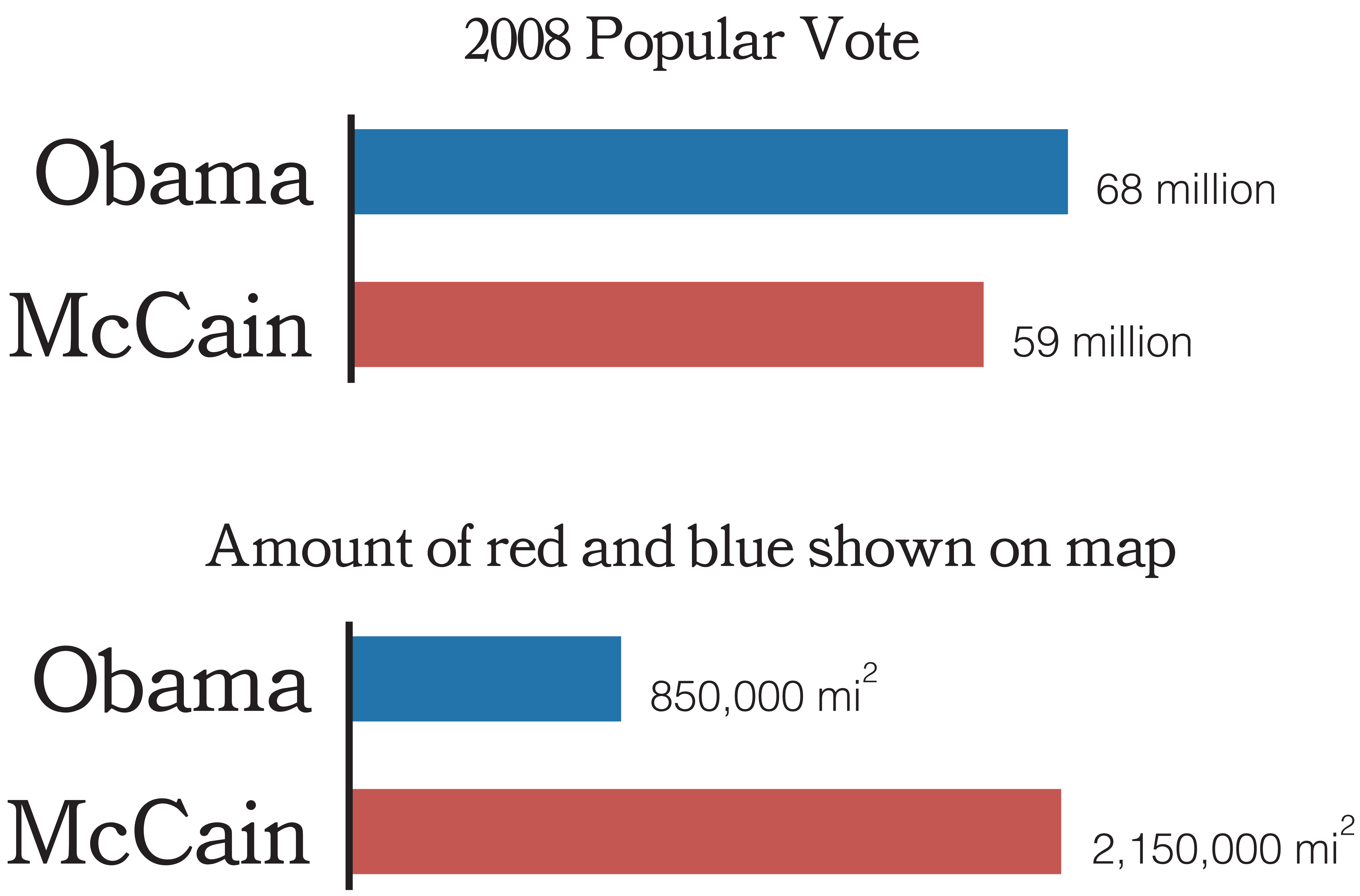
[M. Ericson, New York Times]

Problem?



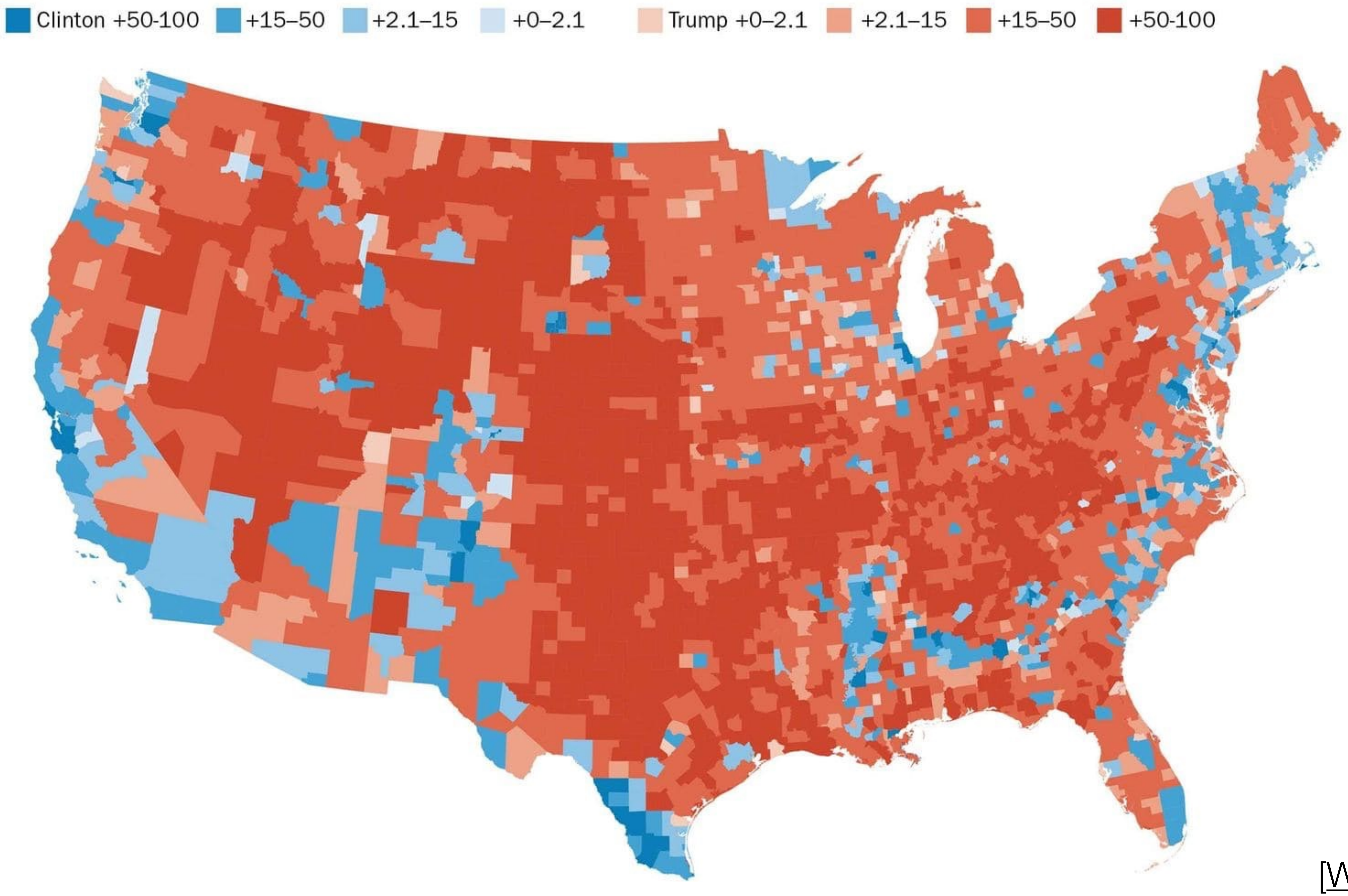
[M. Ericson, New York Times]

Problem?



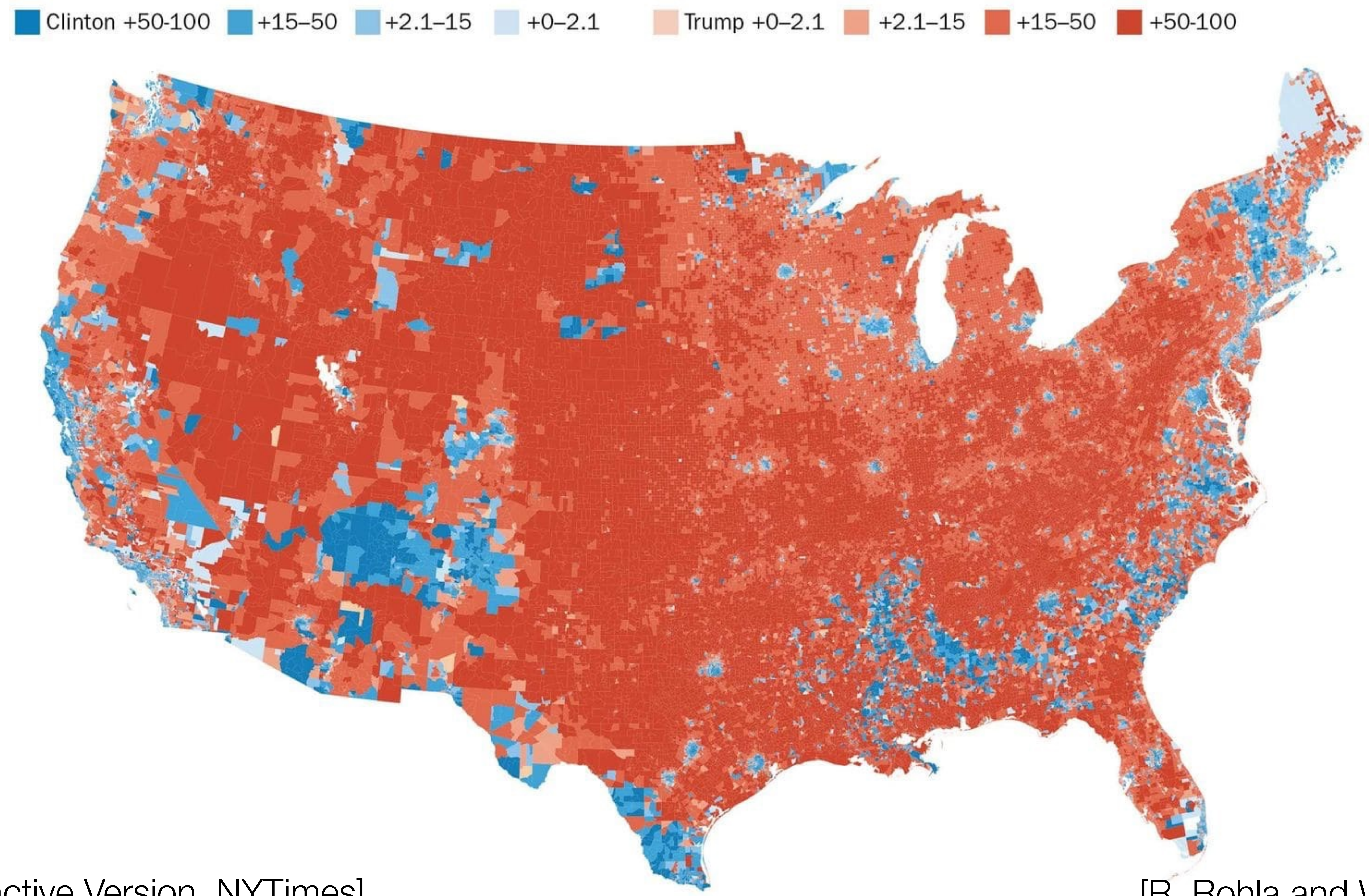
[M. Ericson, New York Times]

Adding Saturation



[Washington Post, 2018]

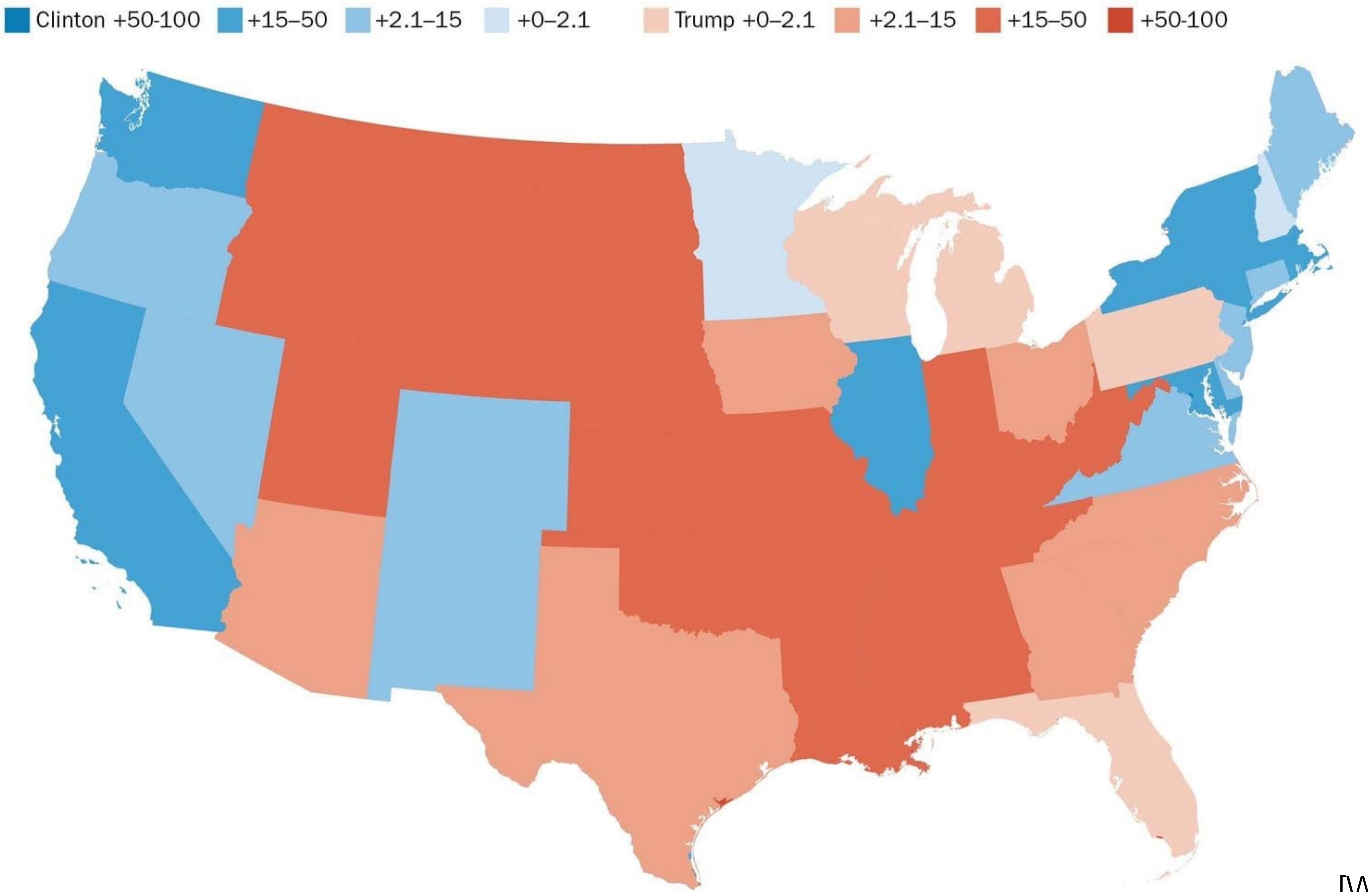
Aggregation: 2016 Election by Precinct



[Interactive Version, NYTimes]

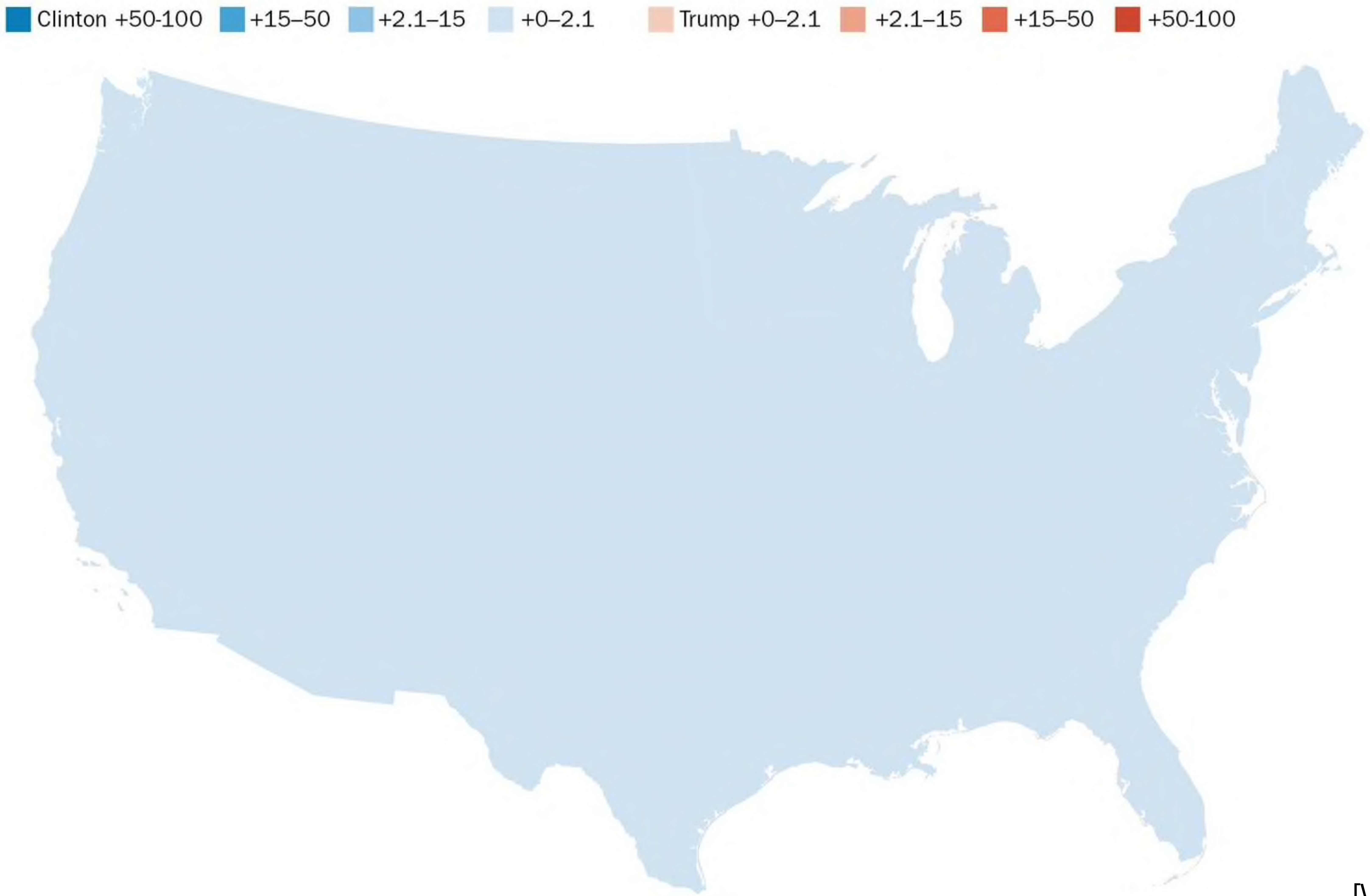
[R. Rohla and Washington Post, 2018]

Aggregation: 2016 Election by State



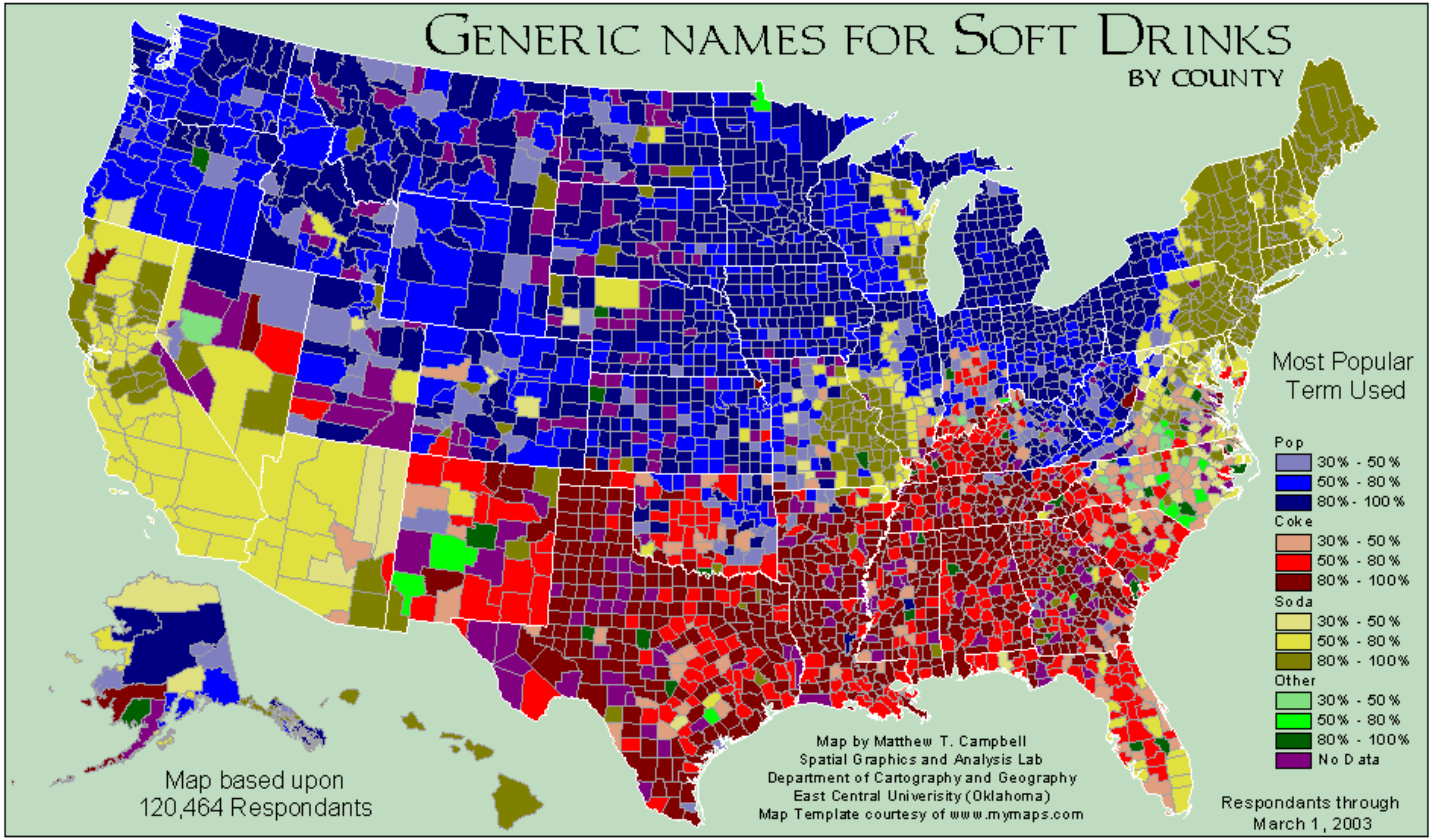
[Washington Post, 2018]

Aggregation: 2016 Election by Country



[Washington Post, 2018]

Area Marks and Color Hue & Saturation



[popvssoda.com]