2D Scalar Visualization

Thanks to Drs. Rheingans and Hansen for material for these slides

Color Mapping

- Display scalar value through a **color map** or a **color scale**
  - Map interval on the real line to a path through color space $f : R \to \{\mathrm{RGB}, \mathrm{HSV}\}$
- (demo: ozone.vt, mpl jet)

Basic Strategies

- Vary a single color model component
  - Remember color science: relative brightness vs absolute brightness
    - Use **brightness** for **qualitative assessments**
  - (demo: ozone.vt, Red-White, making it grey)

Basic Strategies

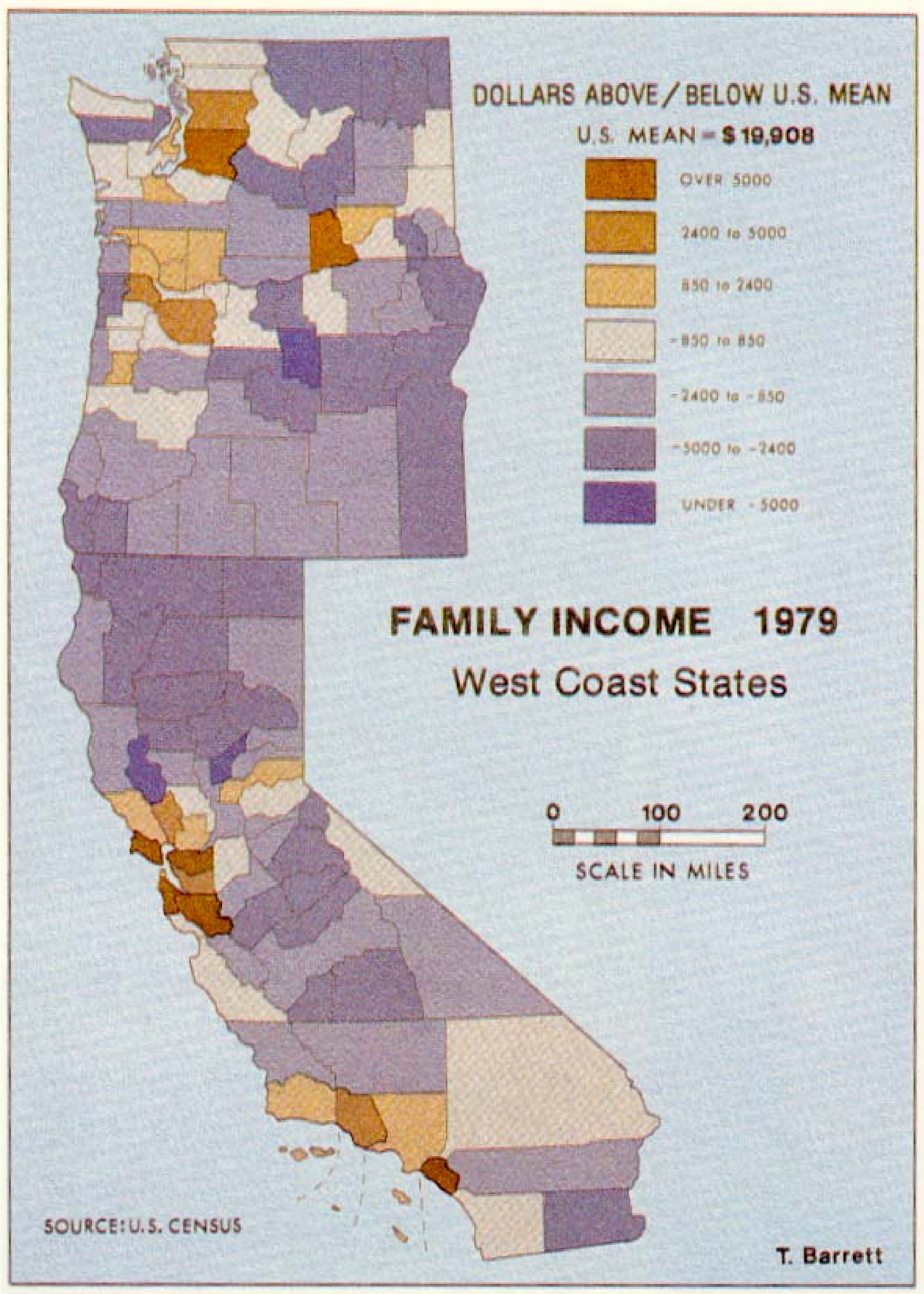
- Vary a single color model component
  - Remember color science
    - Use **hue** for **quantitative assessments**
  - (demo: ozone.py, Hue wrap, hue no wrap)

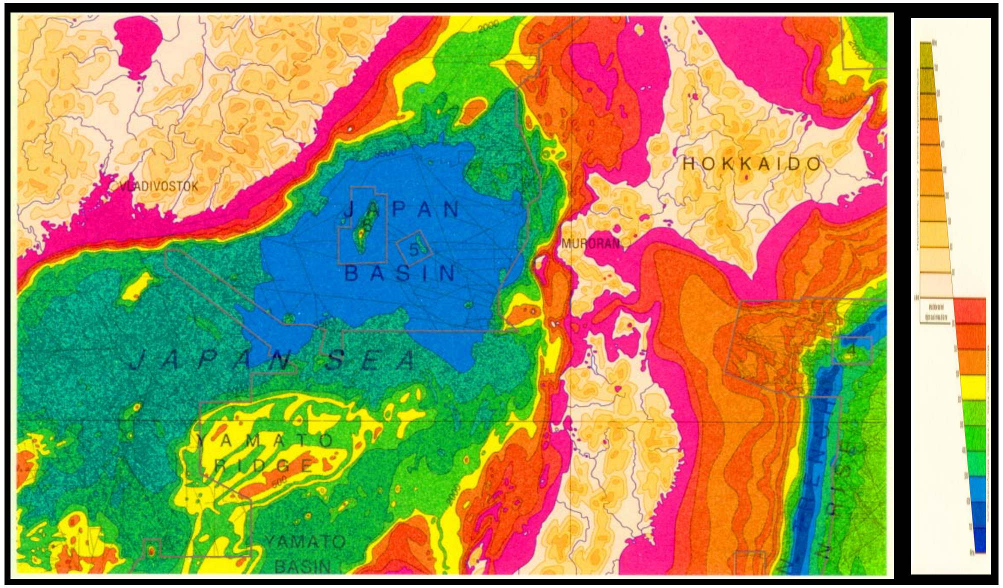
Basic Strategies

- Redundant Cues
  - Fault tolerance: provide same info in multiple ways
- Easy with color scales
- (demo: ozone.vt, Redundant *)

Basic Strategies

- If there is a **neutral**, zero-like scalar in the field, use a **double-ended** scale
    - Alternatively, if you want to emphasize both extremes.
- (demo: ozone.py, Double-Ended)


DOLLARS ABOVE / BELOW U.S. MEAN
U.S. MEAN = $19,908
OVER 5000
2400 to 5000
850 to 2400
-850 to 850
-2400 to -850
-5000 to -2400
UNDER -5000
FAMILY INCOME 1979
West Coast States
0 100 200
SCALE IN MILES
SOURCE: U.S. CENSUS
T. Barrett


VLADIVOSTOK
JAPAN
BASIN
JAPAN SEA
YAMATO
RIDGE
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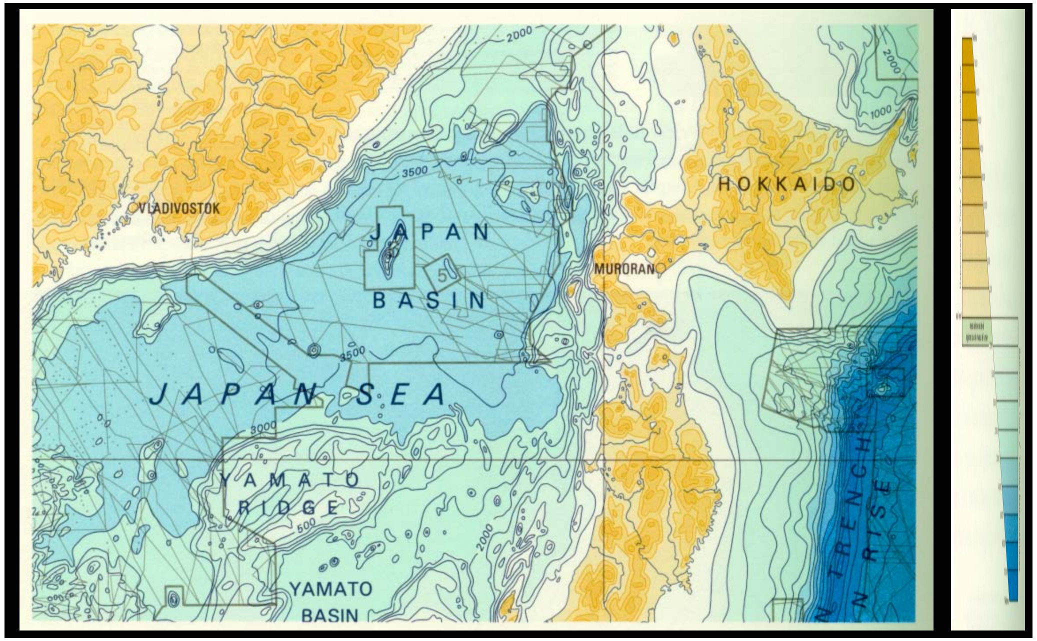
BASIN
HOKKAIDO
MURORAN


VLADIVOSTOK
JAPAN
BASIN
JAPAN SEA
YAMATO
RIDGE
YAMATO
BASIN
HOKKAIDO
MURORAN
TRENCH
RISE

Some Standard Color Scales

- Gray
- Linearized Gray
- Rainbow
- Magenta
- Heated
- Optimal
- Linearized Optimal
- Blue-Cyan
- Blue-Yellow

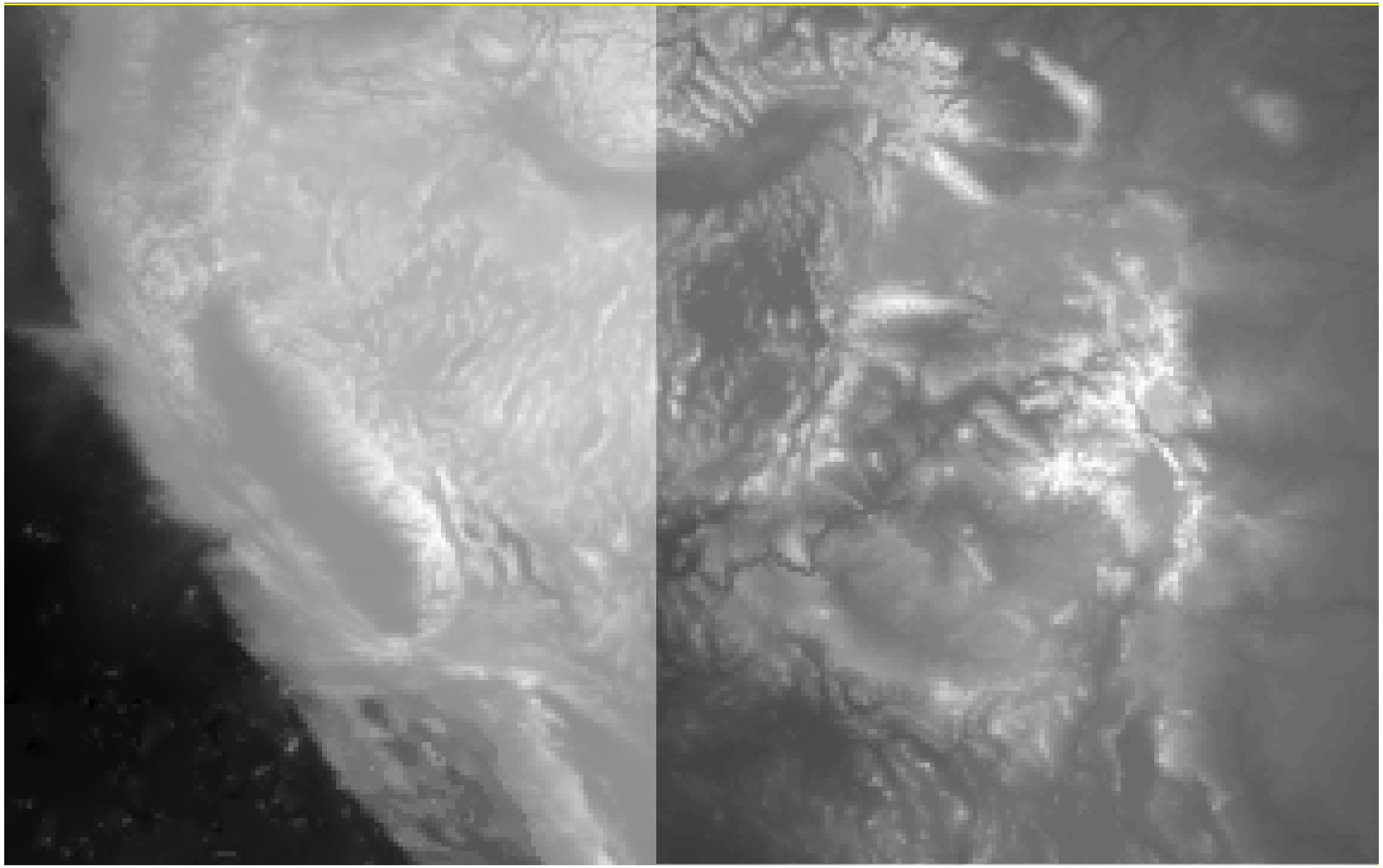
Gray, Linearized Gray

- Gray

- Linearized Gray

- Are these really different?

Gray vs. Linear Gray

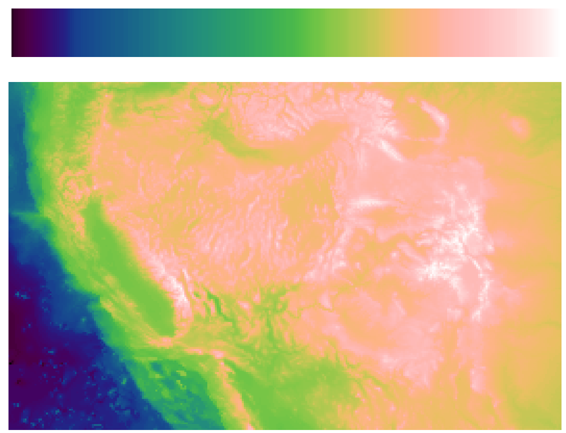


Gray　　　　Linearized Gray

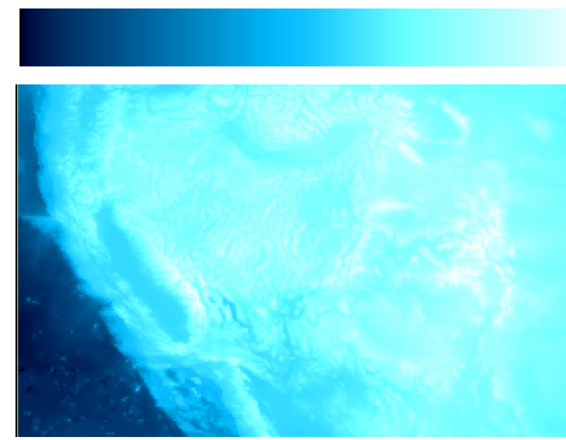
More color scales..

Magenta

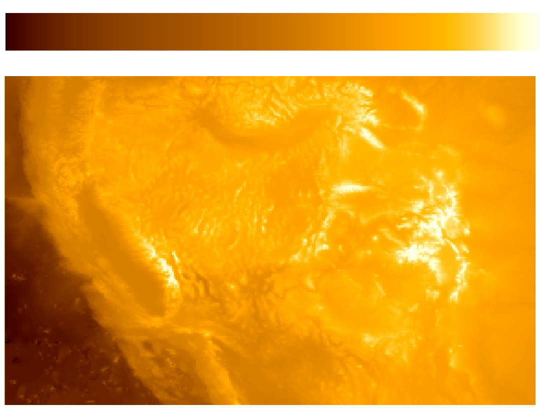
Rainbow



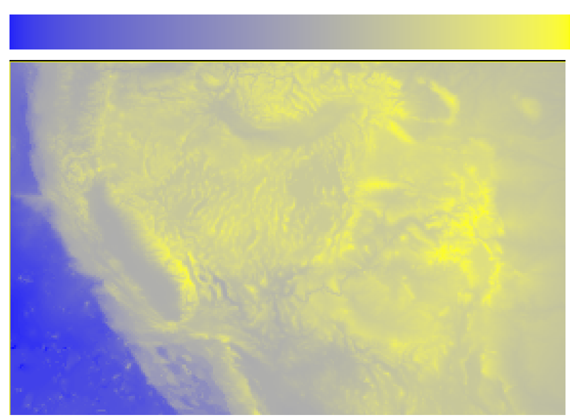
Blue-Cyan



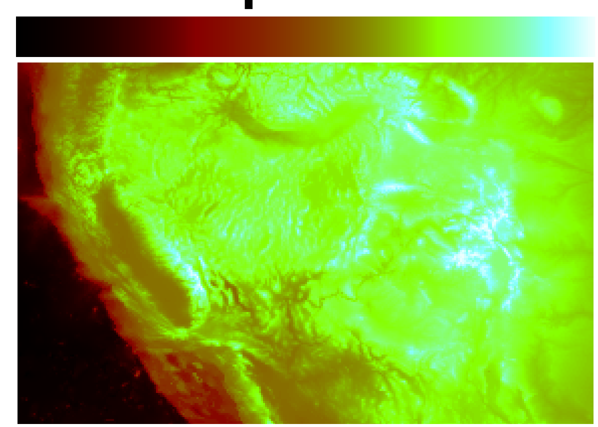
Heated



Blue-Yellow

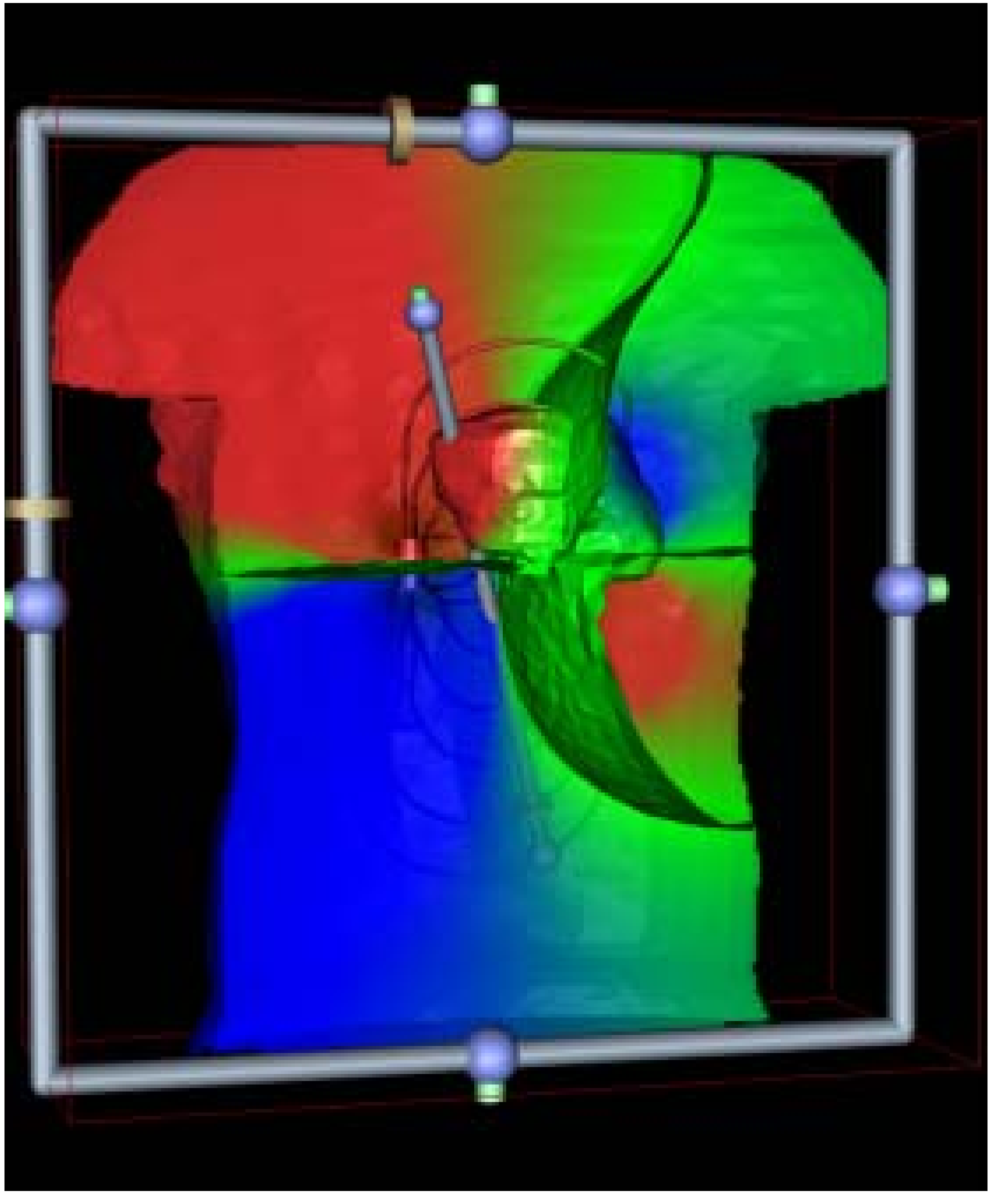


Optimal



Remember Cultural Issues

- Sometimes colors have connotations
- A colorbar might not be enough help, people love to jump to conclusions
  - Red “bad”, green “good” not universal, so it’s even worse!
  - If you can’t help it, at least be aware

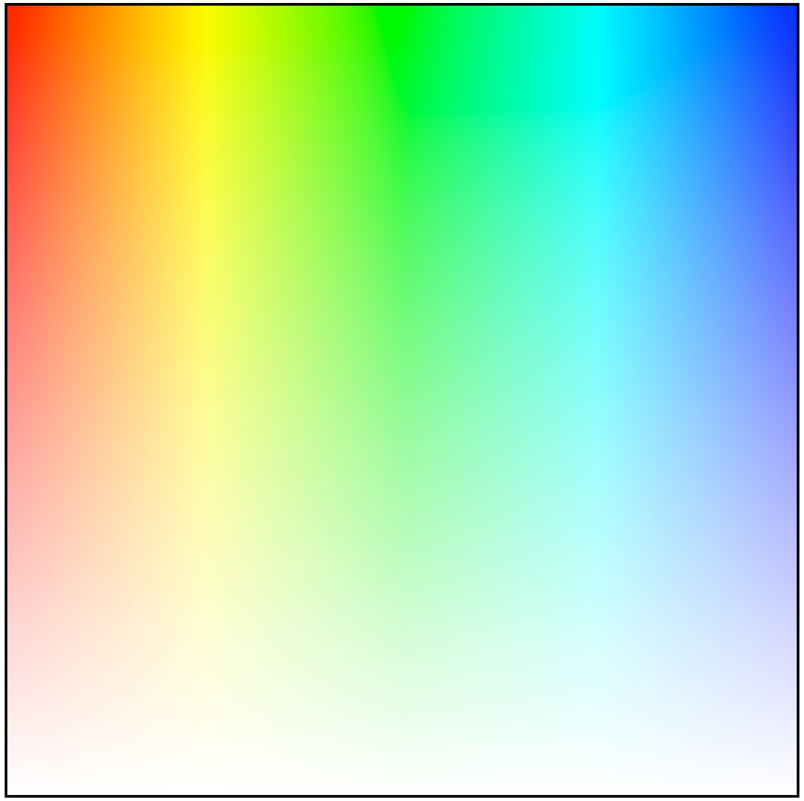


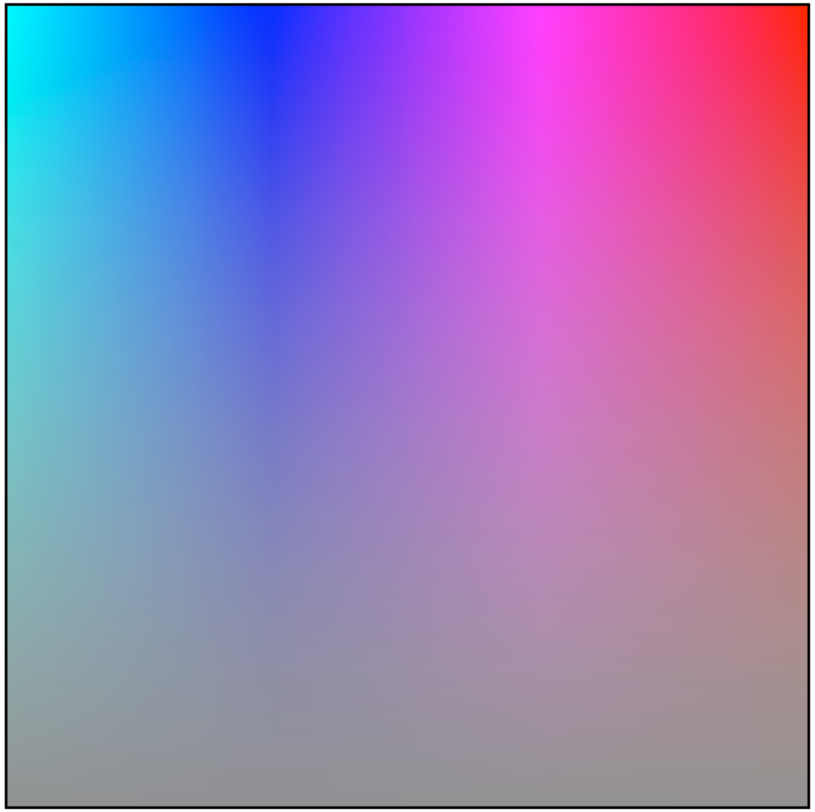
Bivariate color scales

- We intuitively perceive colors along three axes
  - use that to display more information in a single picture
  - Good: less waste
  - Bad: less redundancy, interference

Hue vs Brightness

- Changes of hue imply change in brightness





Hue vs Brightness

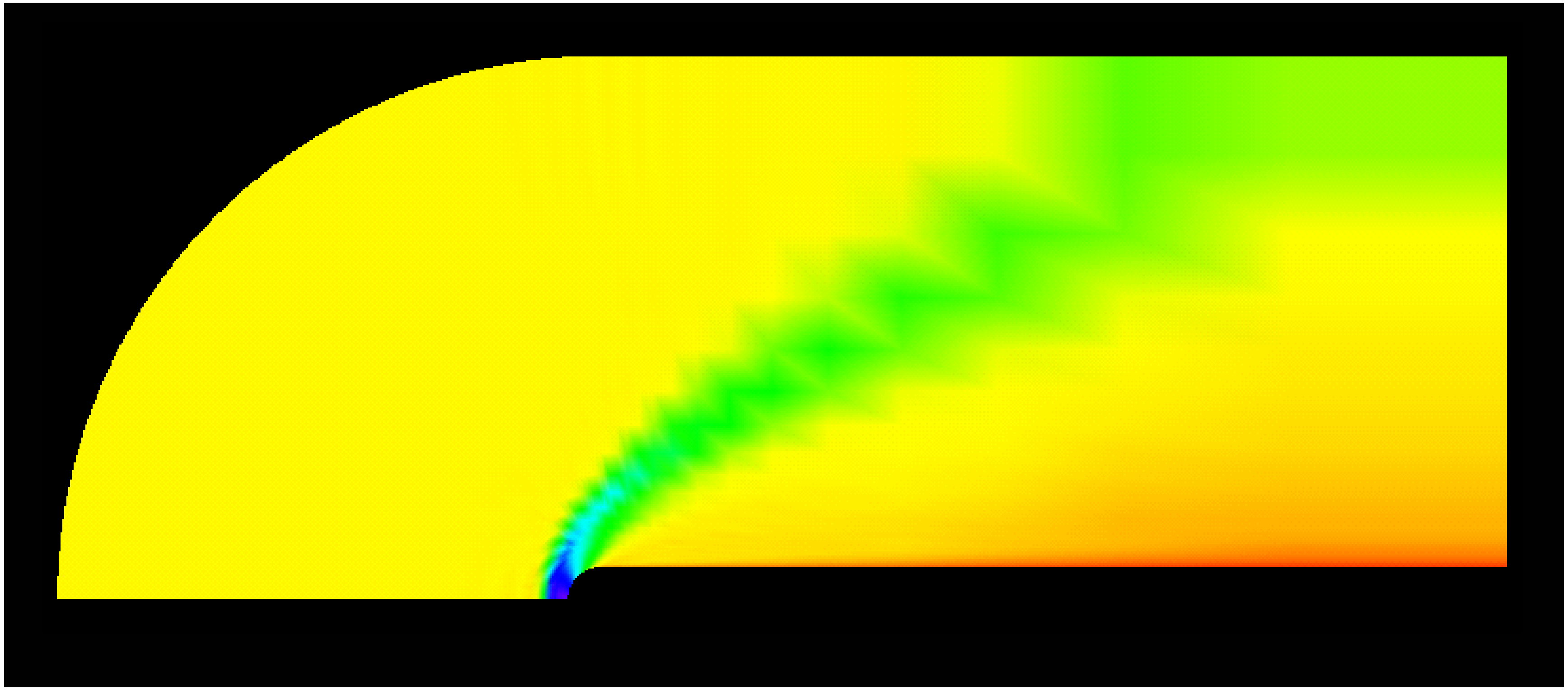
- **Isoluminant** colormaps
  - (watch out for gamma!)

How to design colorscales

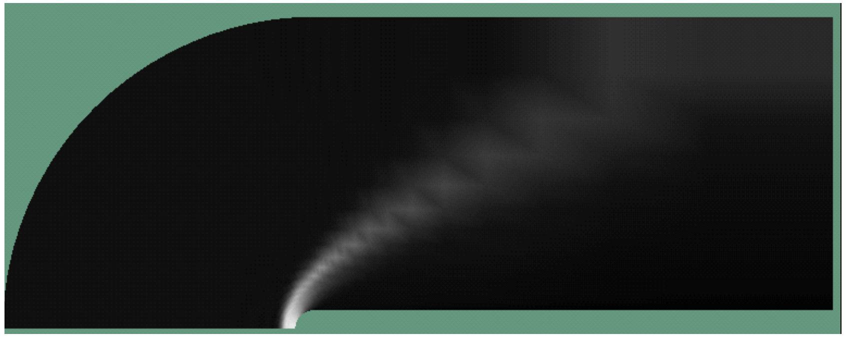
- **Trumbo's** principles:
  - Ordered values should be represented by ordered colors
  - Significantly different levels should be given significantly different colors
  - Bivariate colormaps should preserve univariate information
    - To show correlation, use "above diagonal", "on diagonal", "below diagonal"

Trumbo's Principle #1

Bad

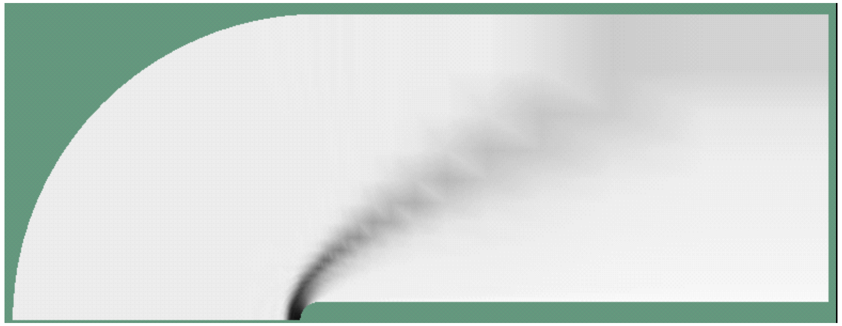


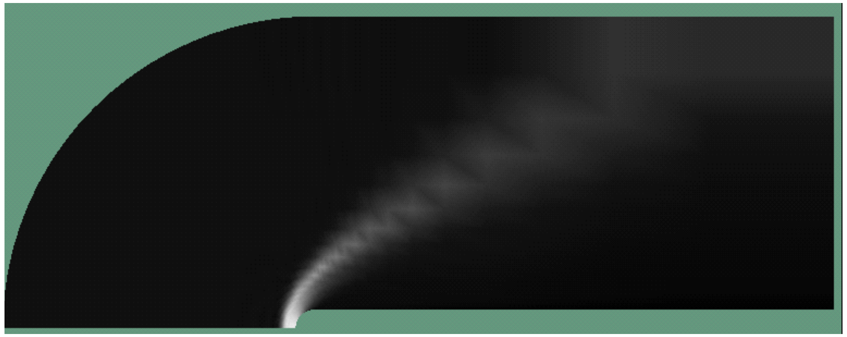
Better



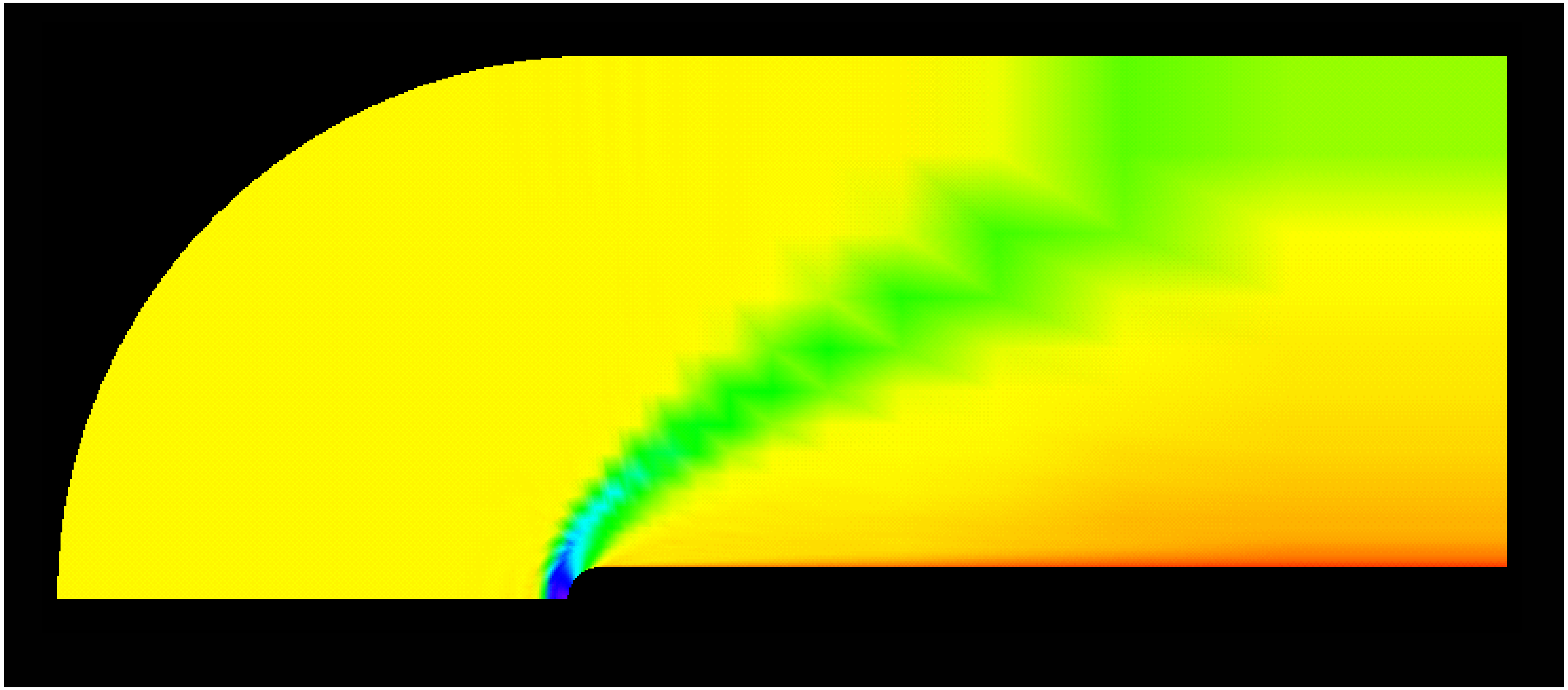
Trumbo's Principle #2

Bad

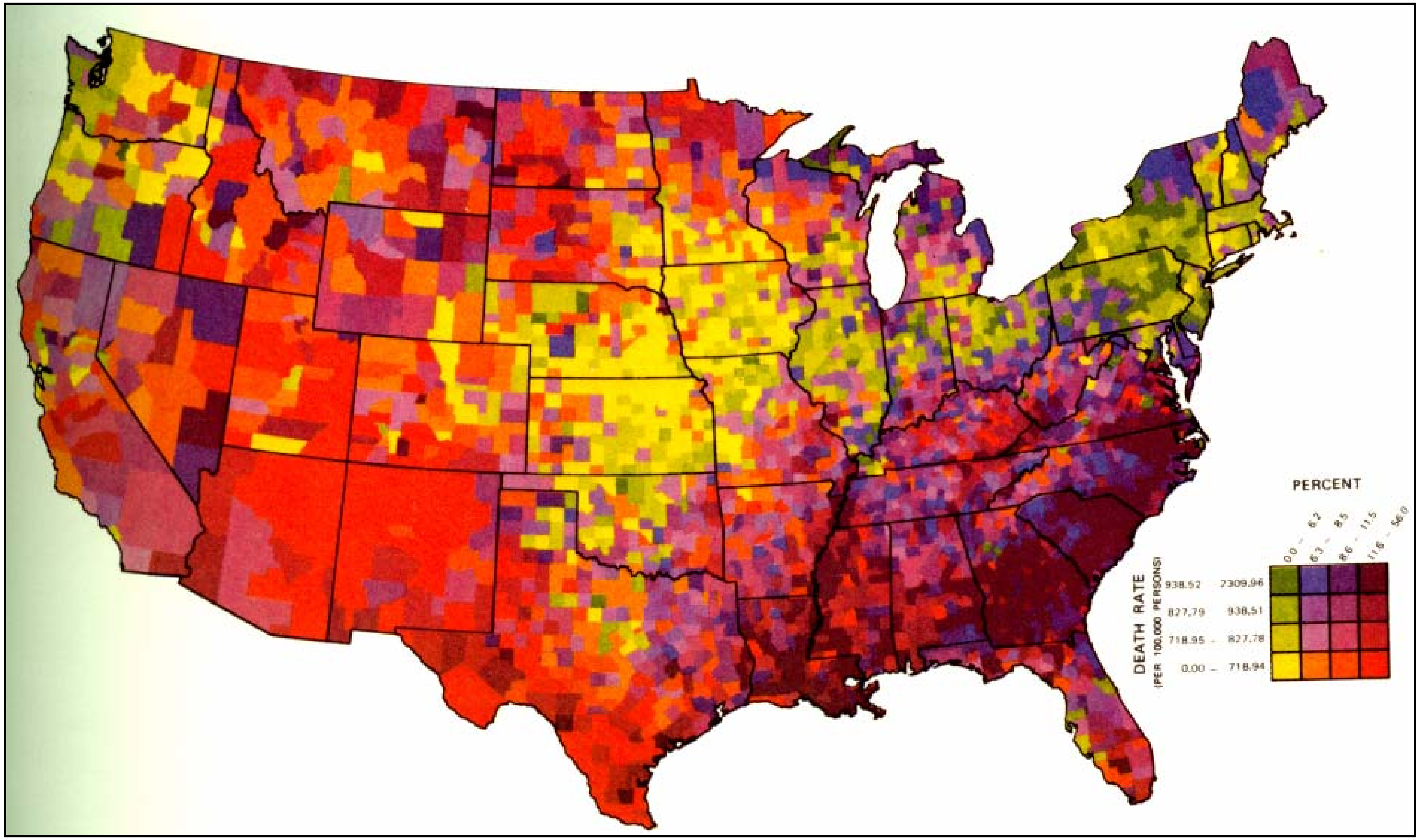




Better



Trumbo's Principles #3, 4



Tufte '83, pg. 153

Heightfields

- We use height in 1D plots, let's use it in 2D plots
  - Direct intuition with topography
  - (demo: elevation.vt)

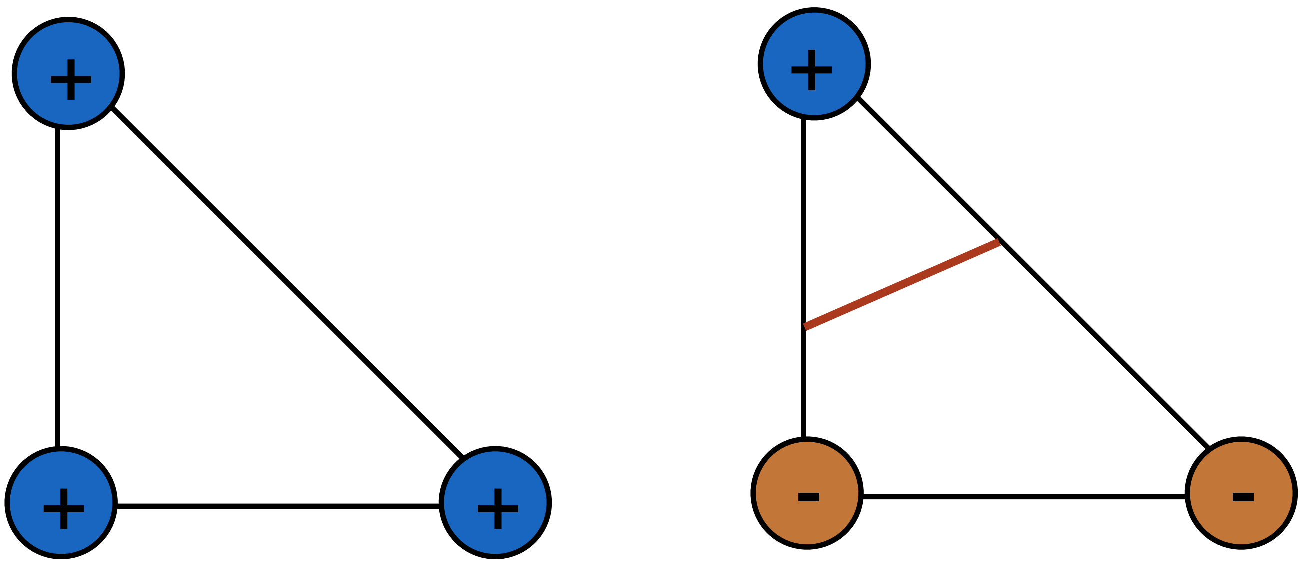
Contour Lines

- Draw lines of constant value
- They bound regions of contiguous values
  - Loops or lines through end of dataset
- Multiple contours
  - Why?
- (demo: elevation.vt, Contours)

Computing Contours

- Simplest case: triangles
  - Let's use Rolle's theorem: if along a line [a, b], $\mathrm{sgn}(f(a)) \neq \mathrm{sgn}(f(b))$ there exists a root of f in [a, b]
  - It's enough to know it roughly, since we're sampling the scalar field anyway

Contouring triangles



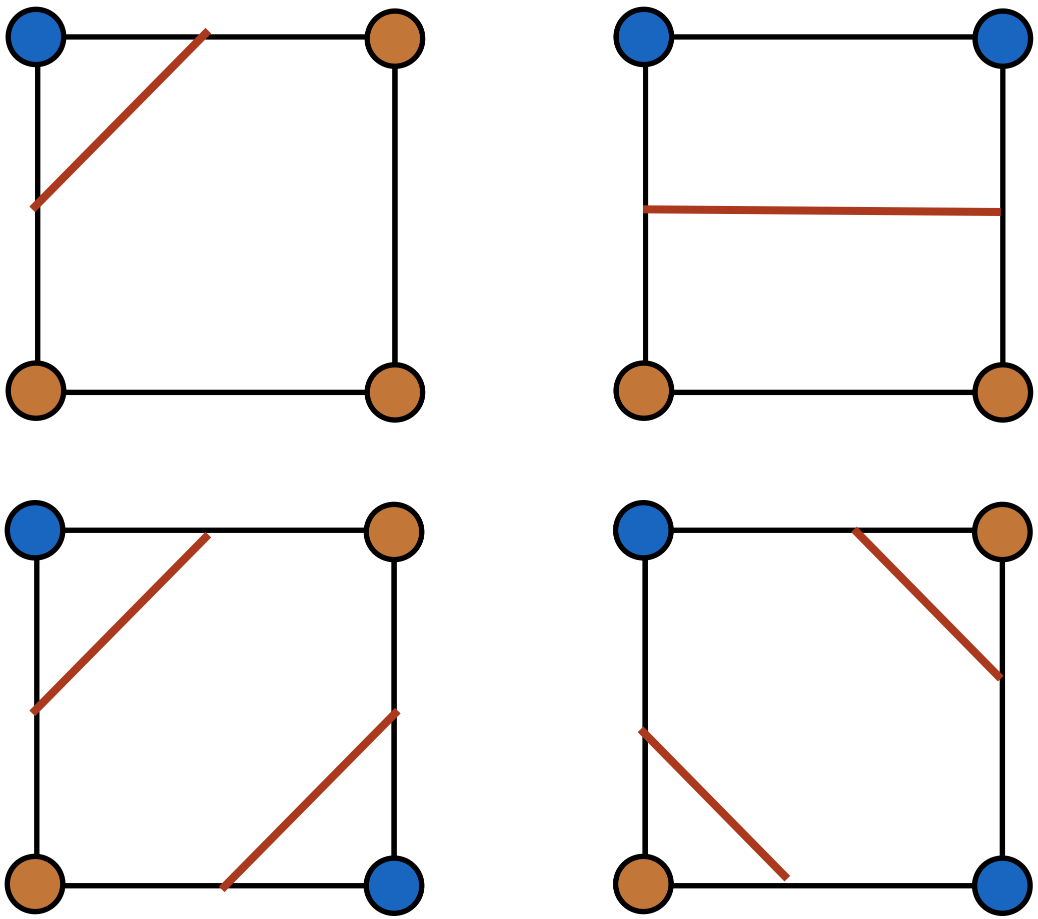
Only these two cases. Why?

Contouring squares

- (demo, elevation.vt, contours)

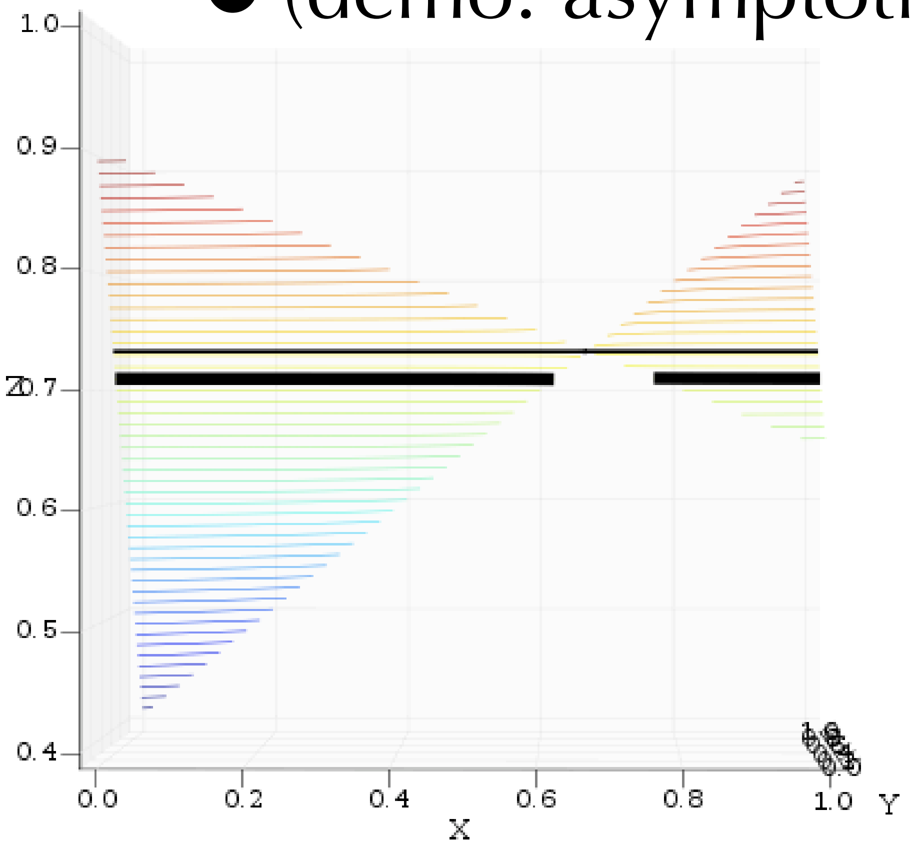
Contouring squares

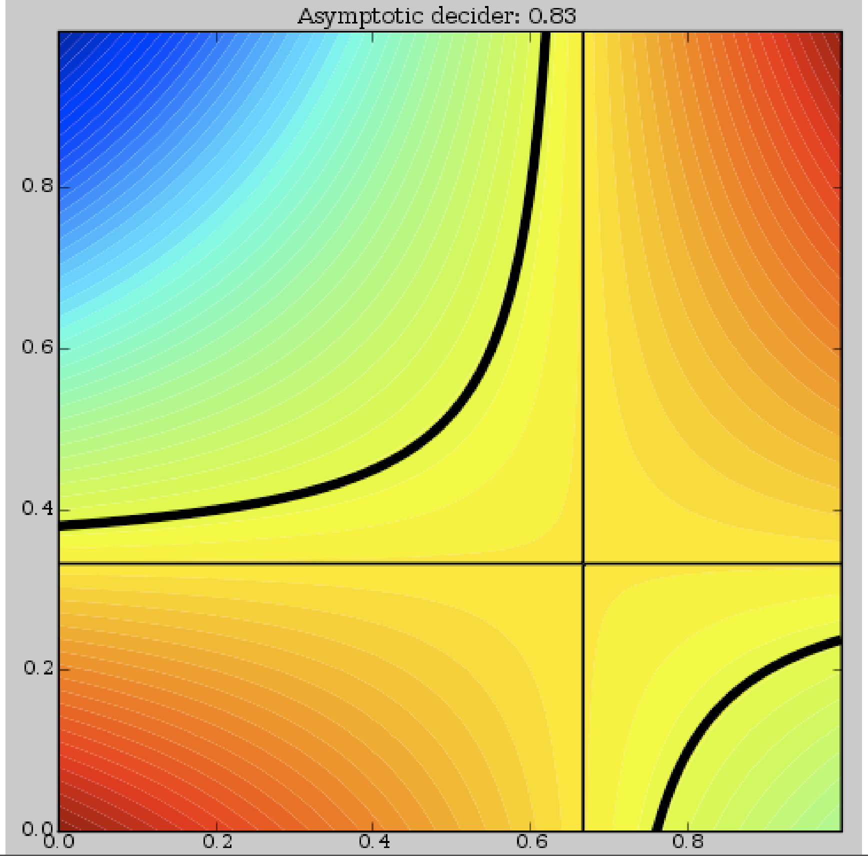
- More cases



Resolving the ambiguity

- Goes back to interpolation...
- (demo: asymptotic_decider.vt)





Resolving the ambiguity

- Simple! Compare value with asymptote scalar, and use that