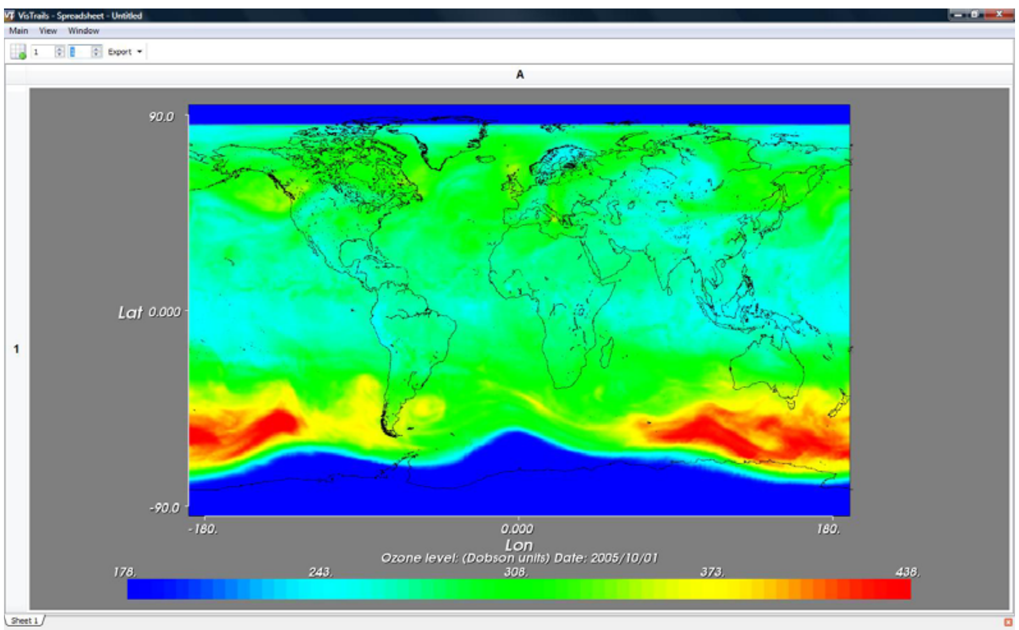
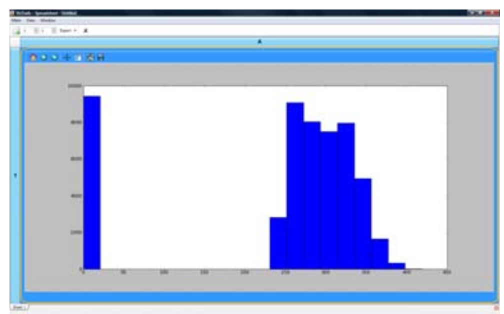
Color Mapping

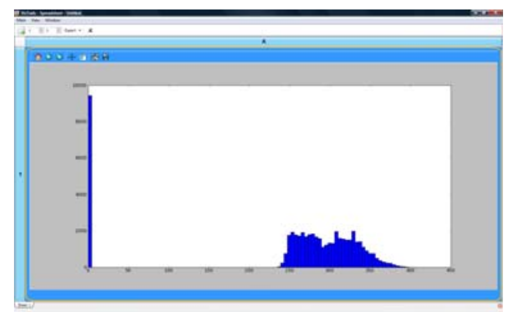
- Display scalar value through a **color map** or a **color scale**
  - Map interval on the real line to a path through color space $f : R \rightarrow \{\mathrm{RGB}, \mathrm{HSV}\}$
- (demo: ozone.vt, mpl jet)

2D Visualization Techniques



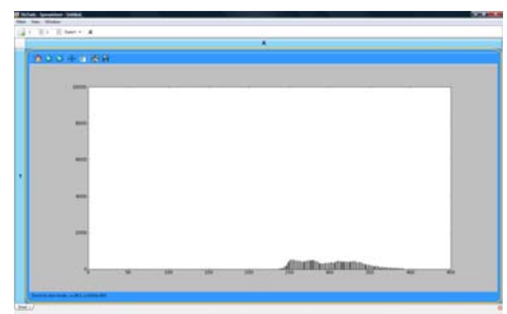


20 buckets

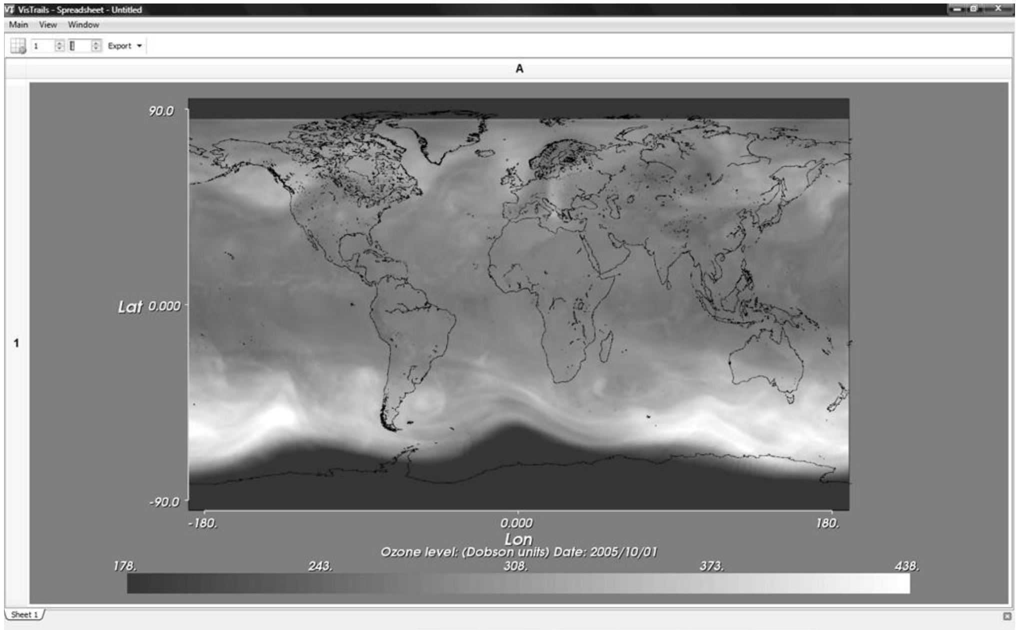


100 buckets

1000 buckets



10000 buckets

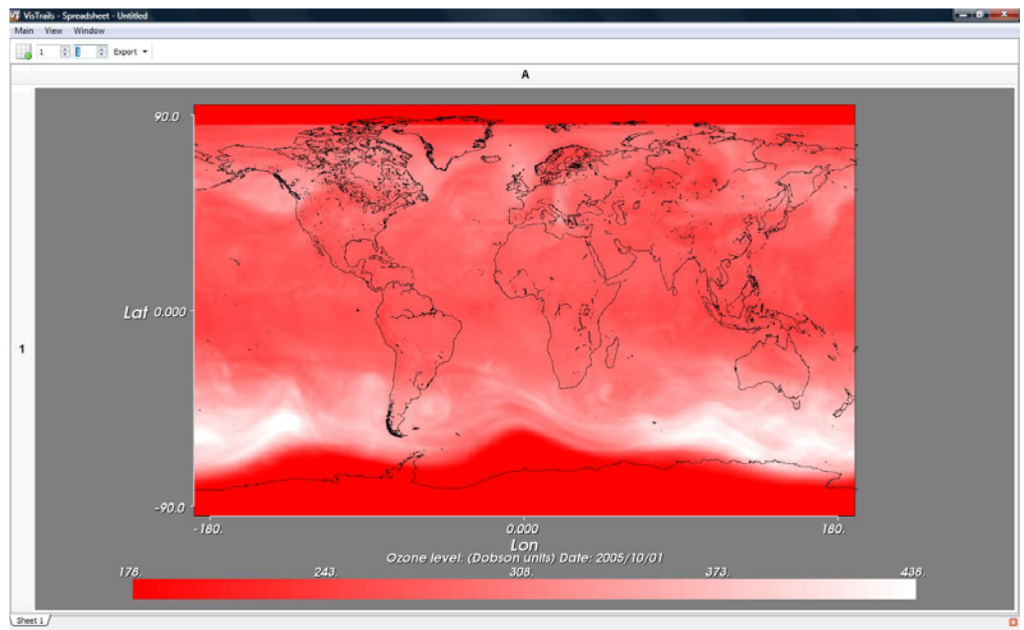


Basic Strategies

- 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)

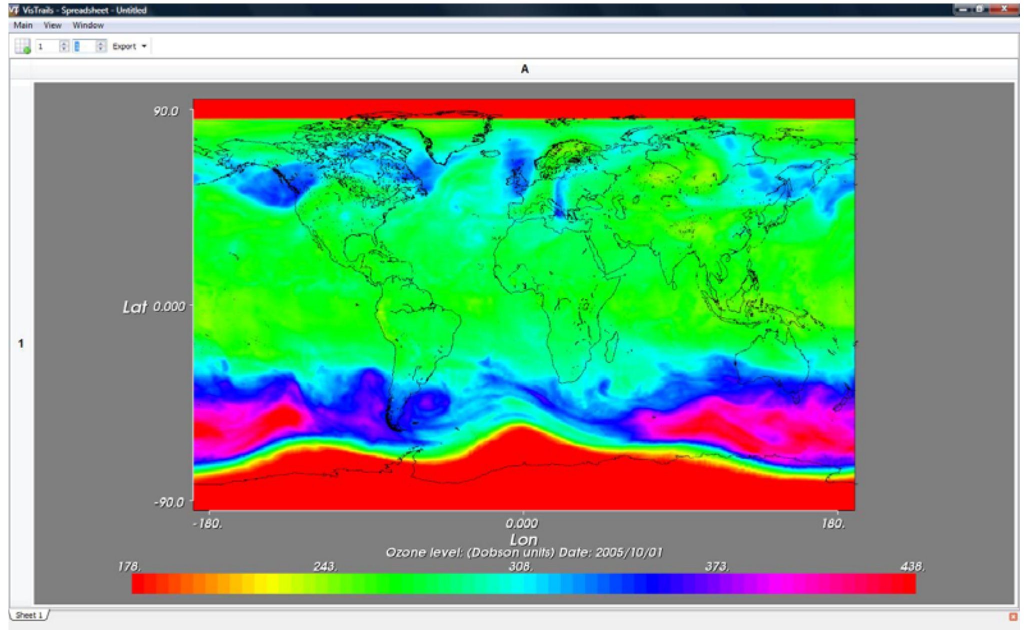
Basic Strategies

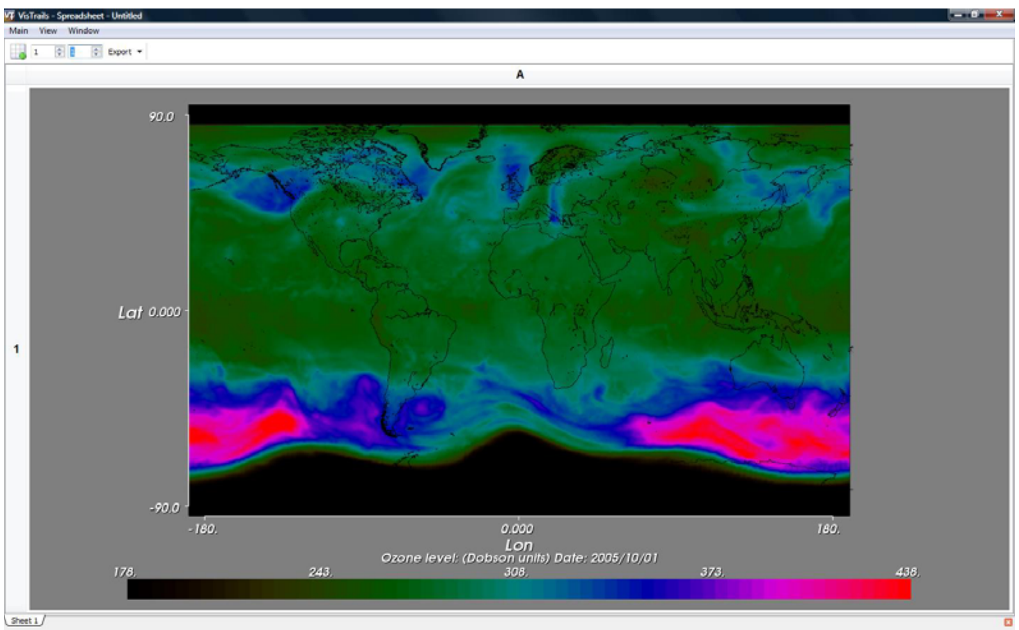
- Vary a single color model component
  - Remember color science
    - Use **hue** for **quantitative assessments**
  - (demo: ozone.py, Hue wrap, hue no wrap)

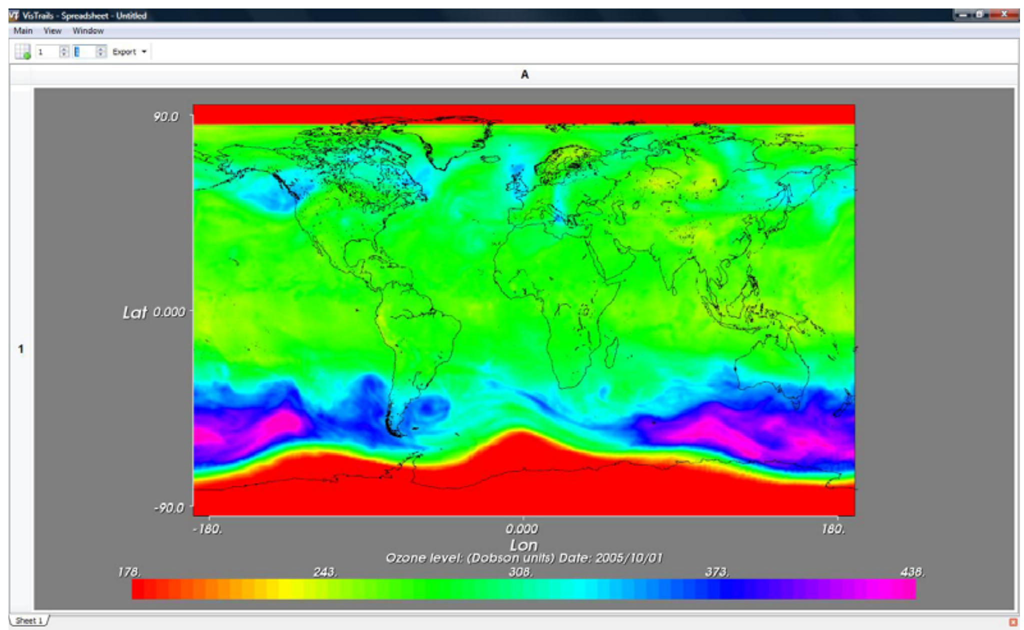


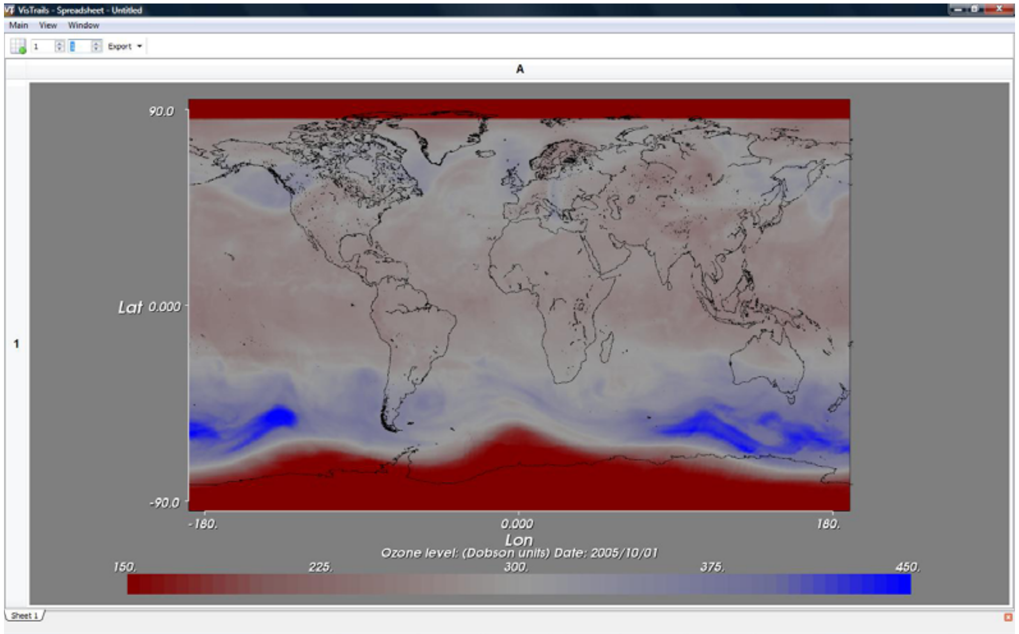
Basic Strategies

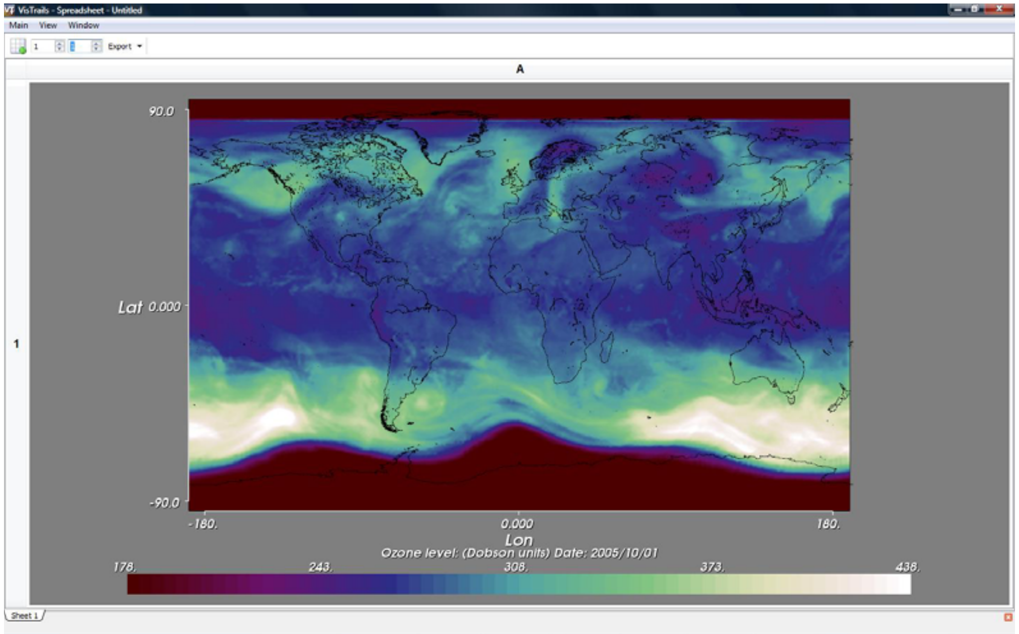
- Redundant Cues
  - Fault tolerance: provide same info in multiple ways
- Easy with color scales
- (demo: ozone.vt, Redundant *)

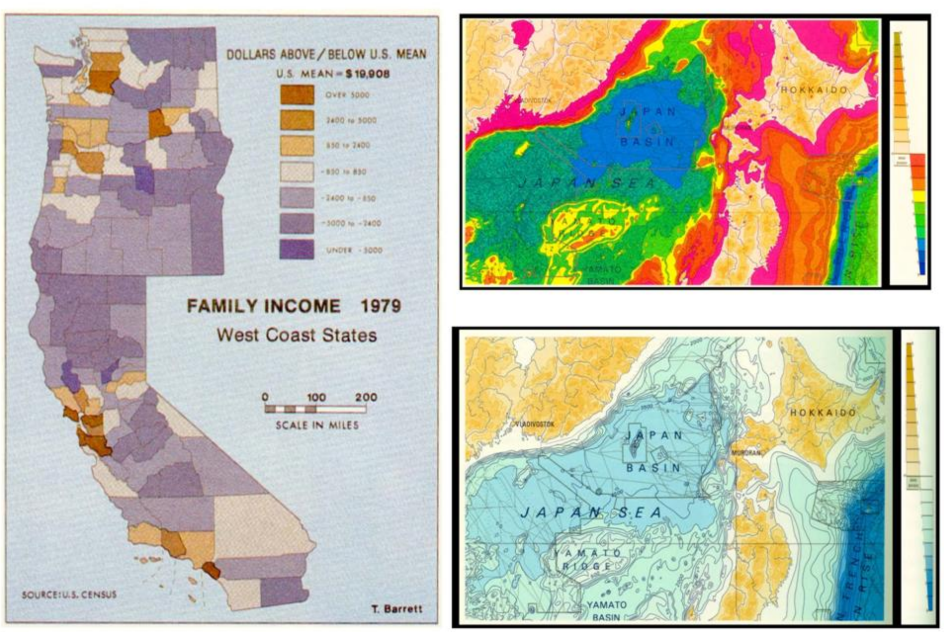












Basic Strategies

- 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)

Gray, Linearized Gray

- Gray

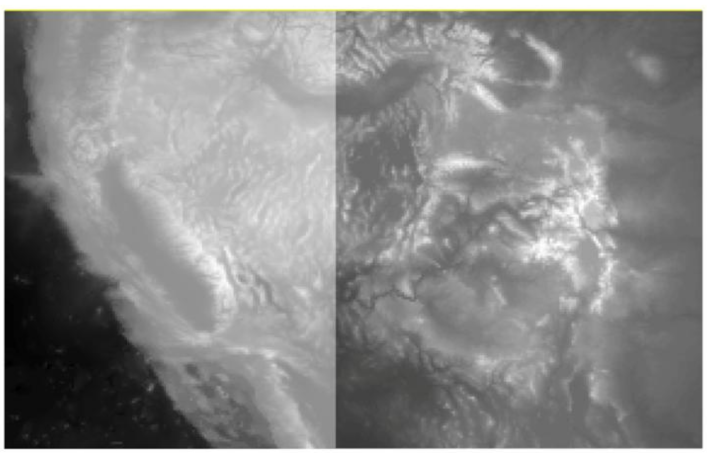
- Linearized Gray

- Are these really different?

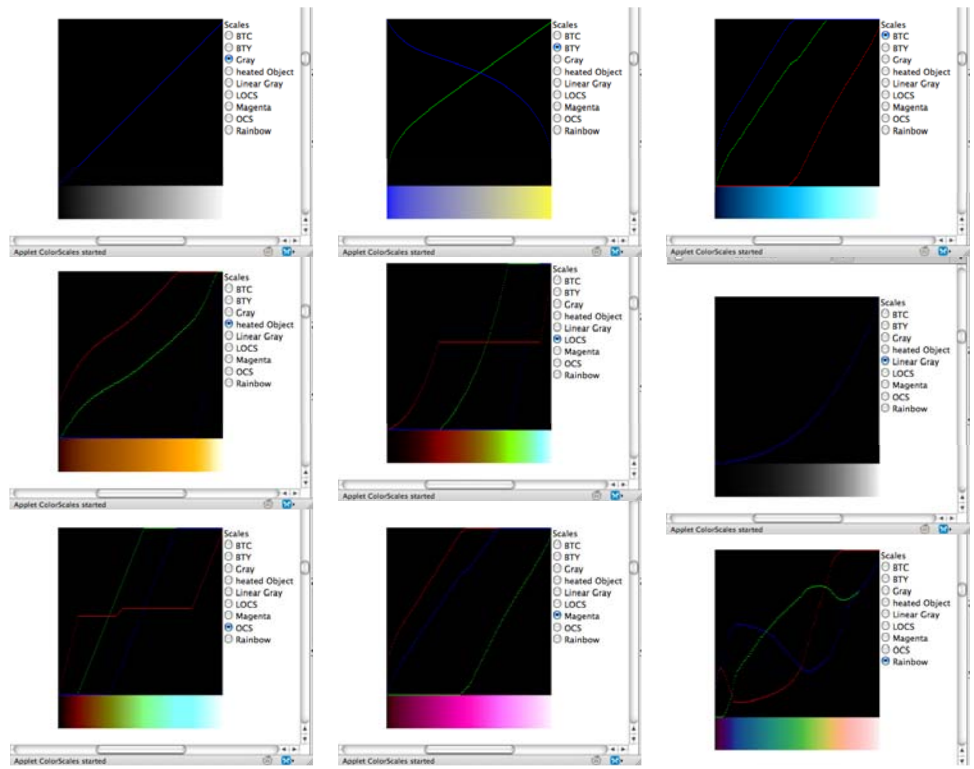
Some Standard Color Scales

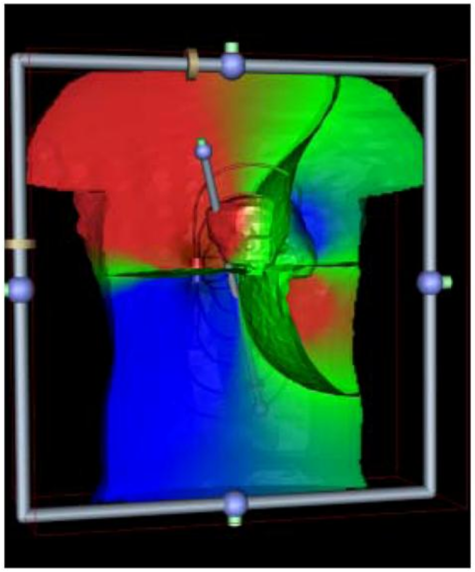
- Non-linearized grayscale
- Linearized grayscale (perceptually linearized)
- Rainbow scale (perceptually linearized)
- Heated-Object scale (perceptually linearized)
- Magenta scale (perceptually linearized)
- Optimal color scale
- Linearized optimal color scale (perceptually linearized)
- Blue to Cyan
- Blue to yellow

Gray vs. Linear Gray

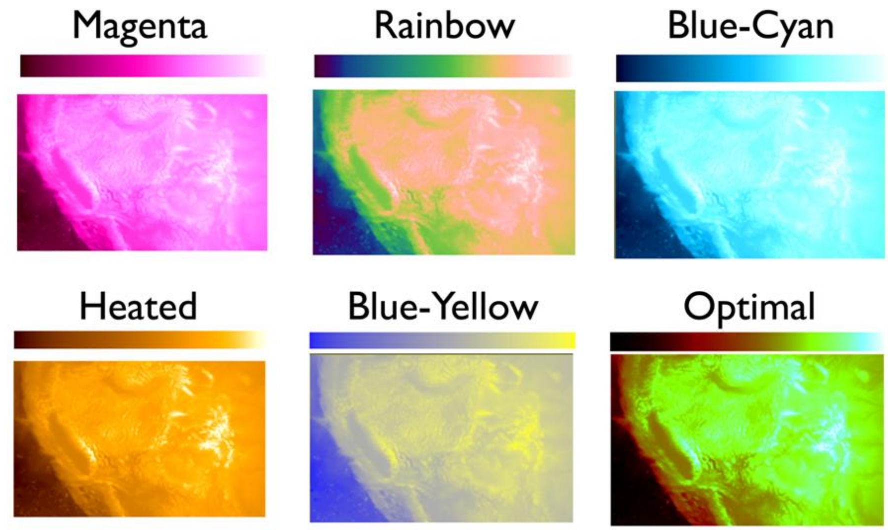


Gray Linearized Gray





More color scales..



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

Remember Cultural Issues

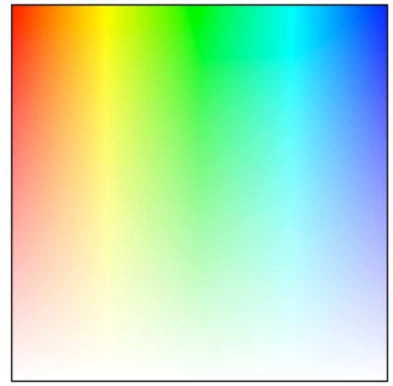
- Sometimes colors have connotations
- A colorbar might not be enough help, people love to jump to conclusions
  - Red “bad”, green “good” not universal, so it’s even worse!
  - If you can’t help it, at least be aware

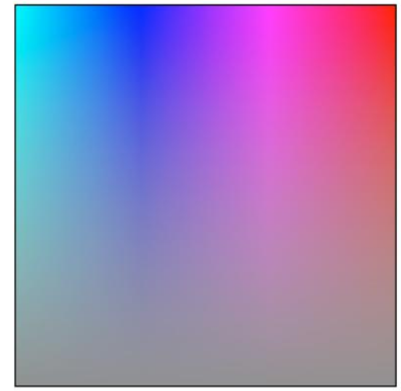
How to design colorscales

- **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"

Hue vs Brightness

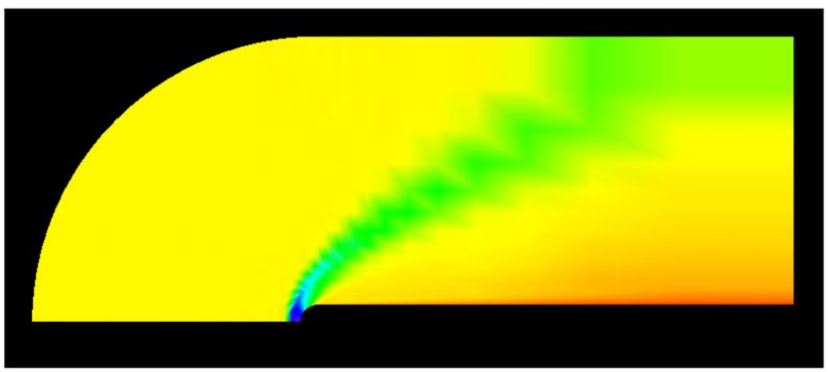
- Changes of hue imply change in brightness





Trumbo's Principle #1

Bad



Better

Hue vs Brightness

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

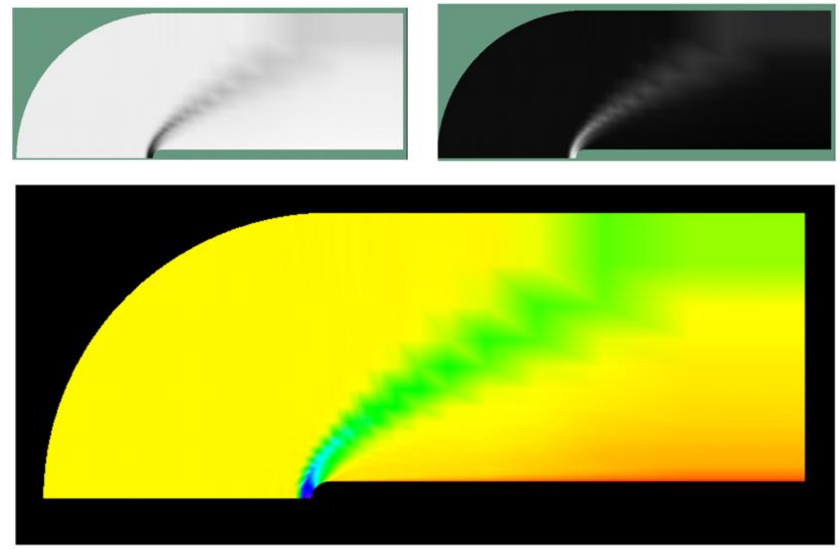
Heightfields

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

Trumbo's Principle #2

Bad

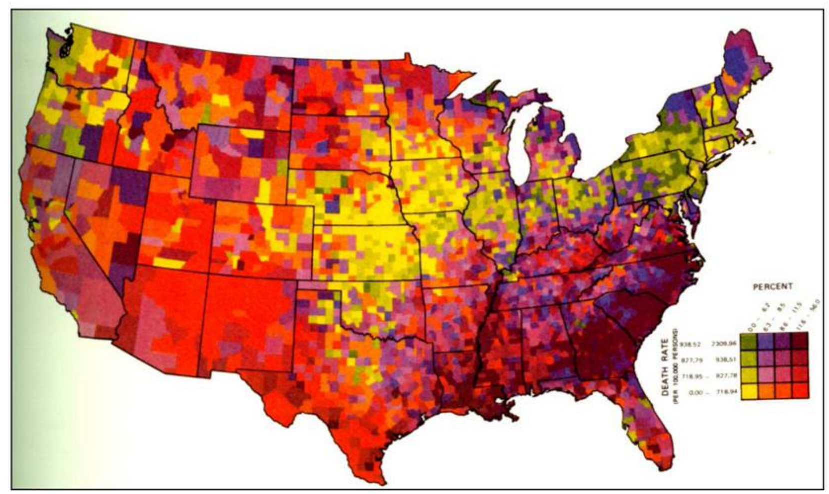
Better



Contour Lines

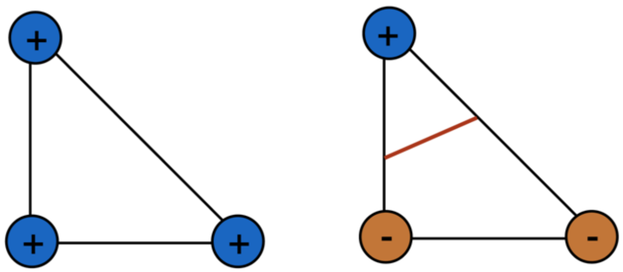
- Draw lines of constant value
- They bound regions of contiguous values
  - Loops or lines through end of dataset
- Multiple contours
  - Why?
- (demo: elevation.vt, Contours)

Trumbo's Principles #3, 4

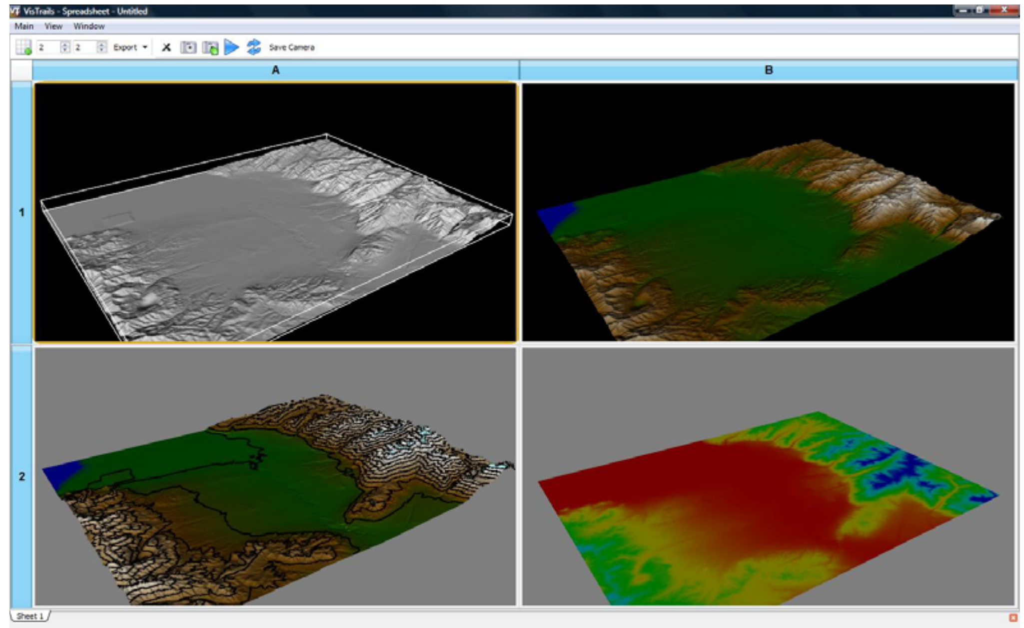


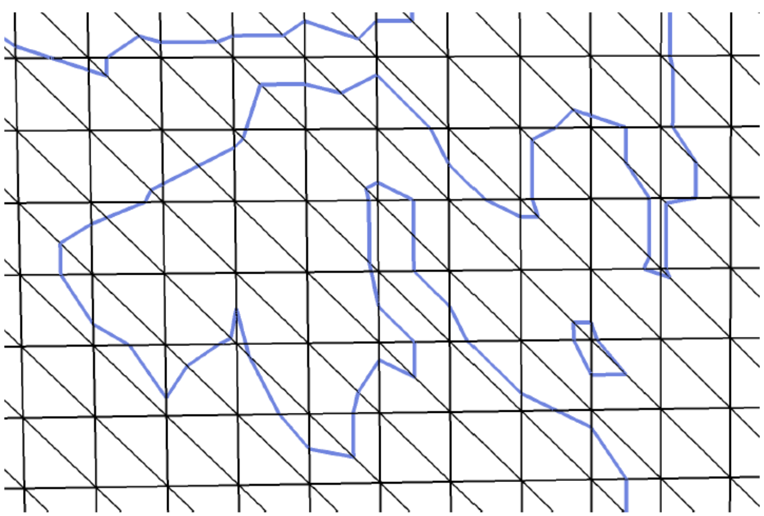
Tufte '83, pg. 153

Contouring triangles



Only these two cases. Why?

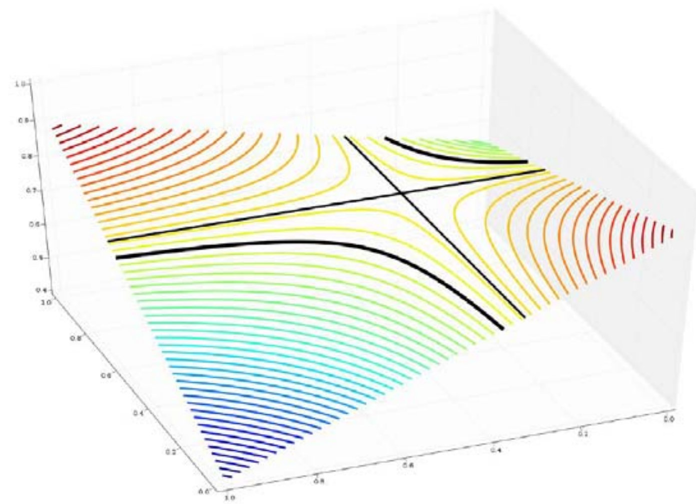




Computing Contours

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

Resolving the ambiguity



Contouring squares

- More cases