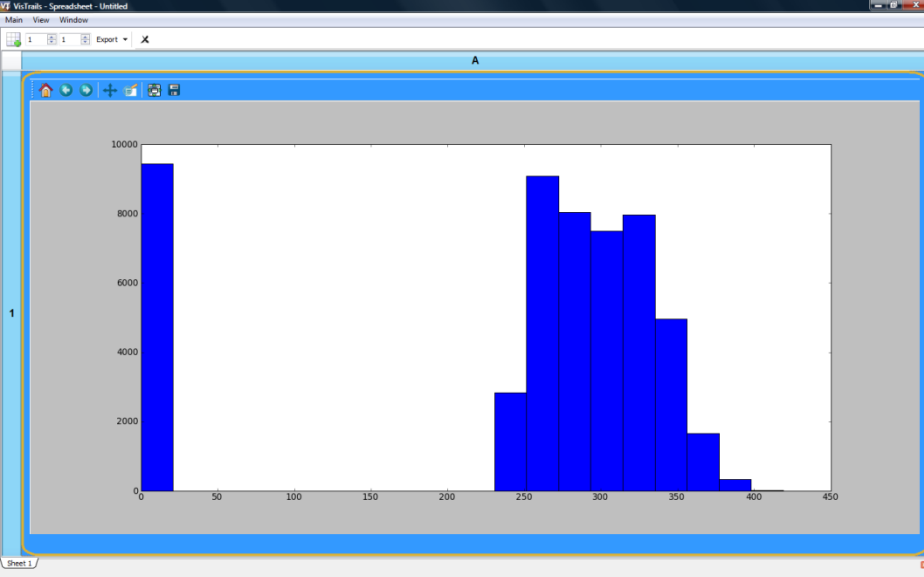
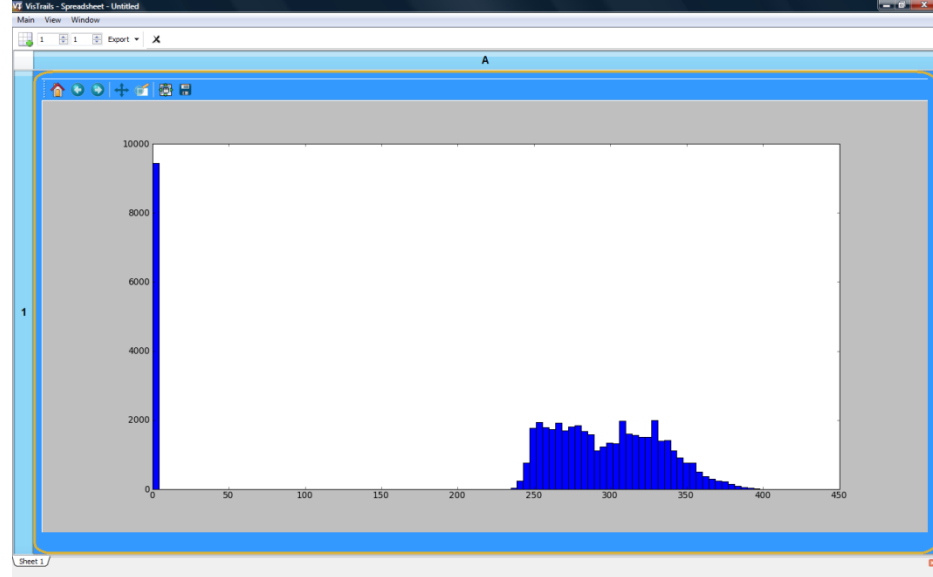


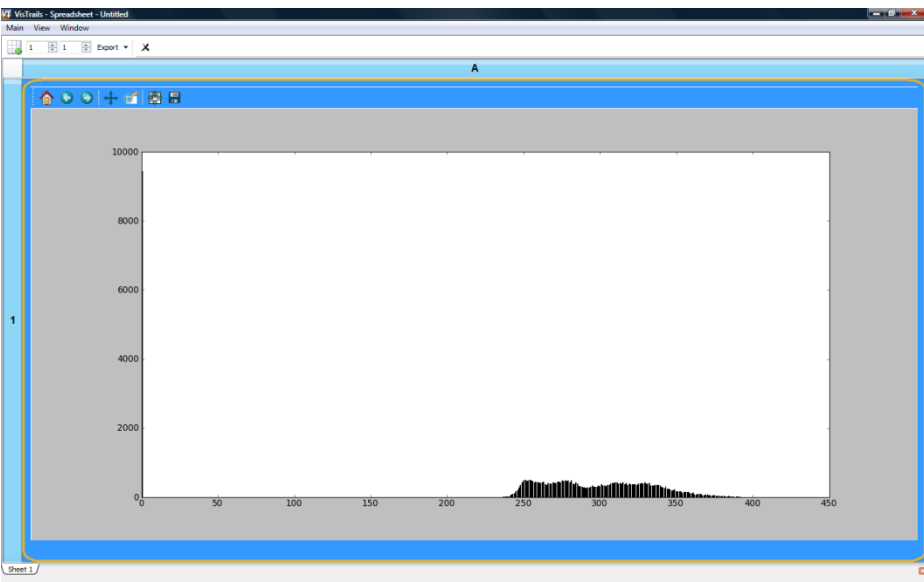
2D Visualization Techniques



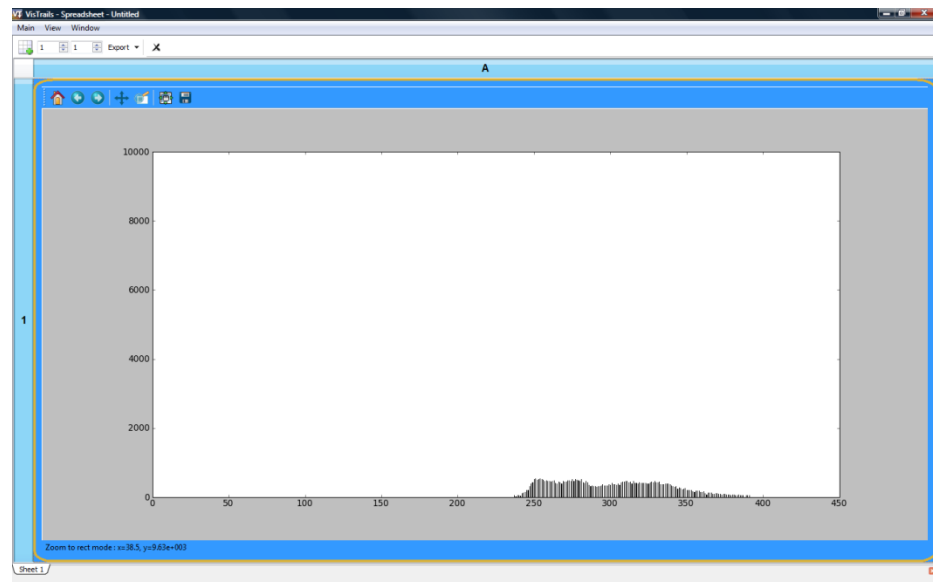
20 buckets



100 buckets



1000 buckets

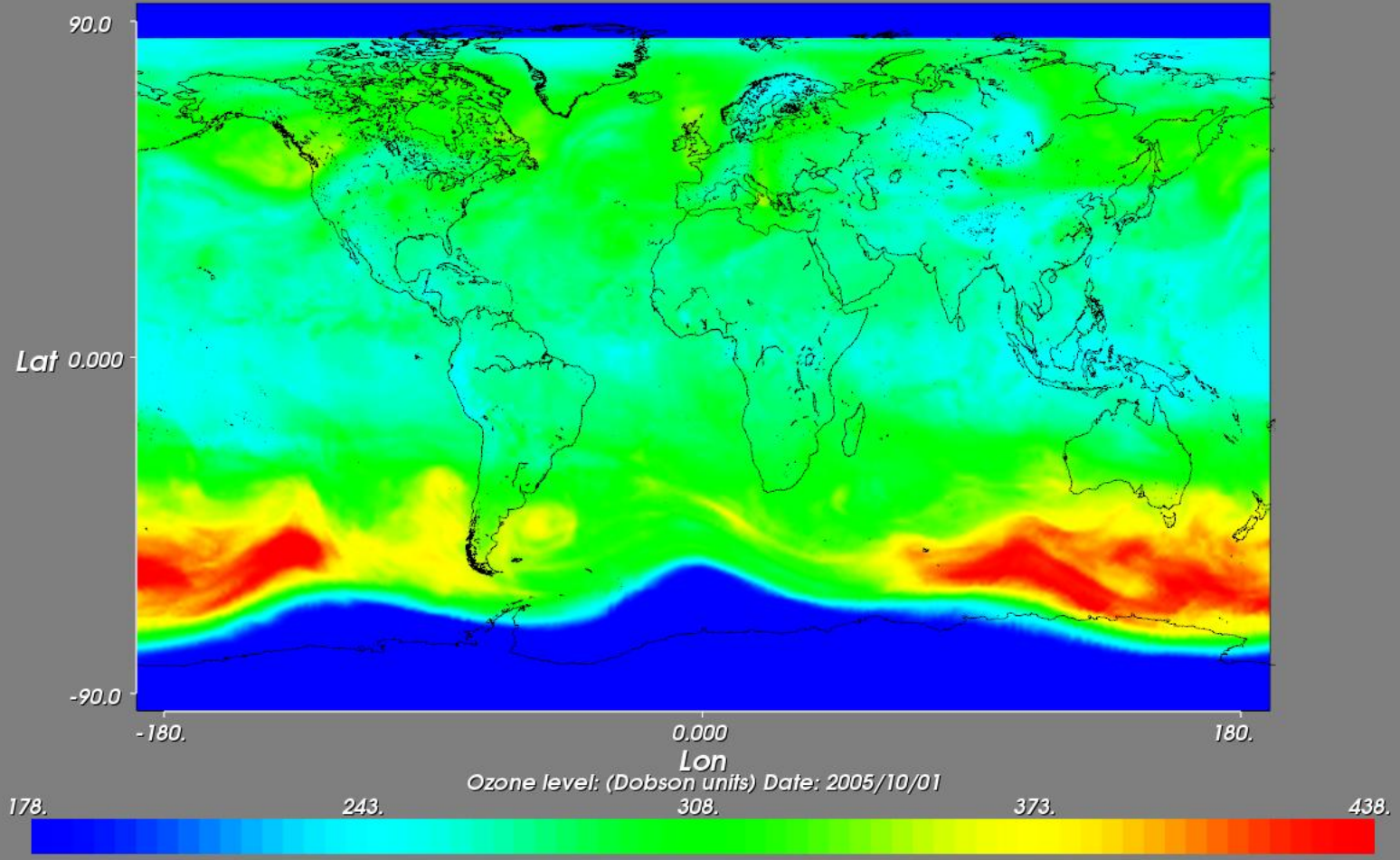


10000 buckets

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 $f : R \rightarrow \{\text{RGB, HSV}\}$
- (demo: ozone.vt, mpl jet)

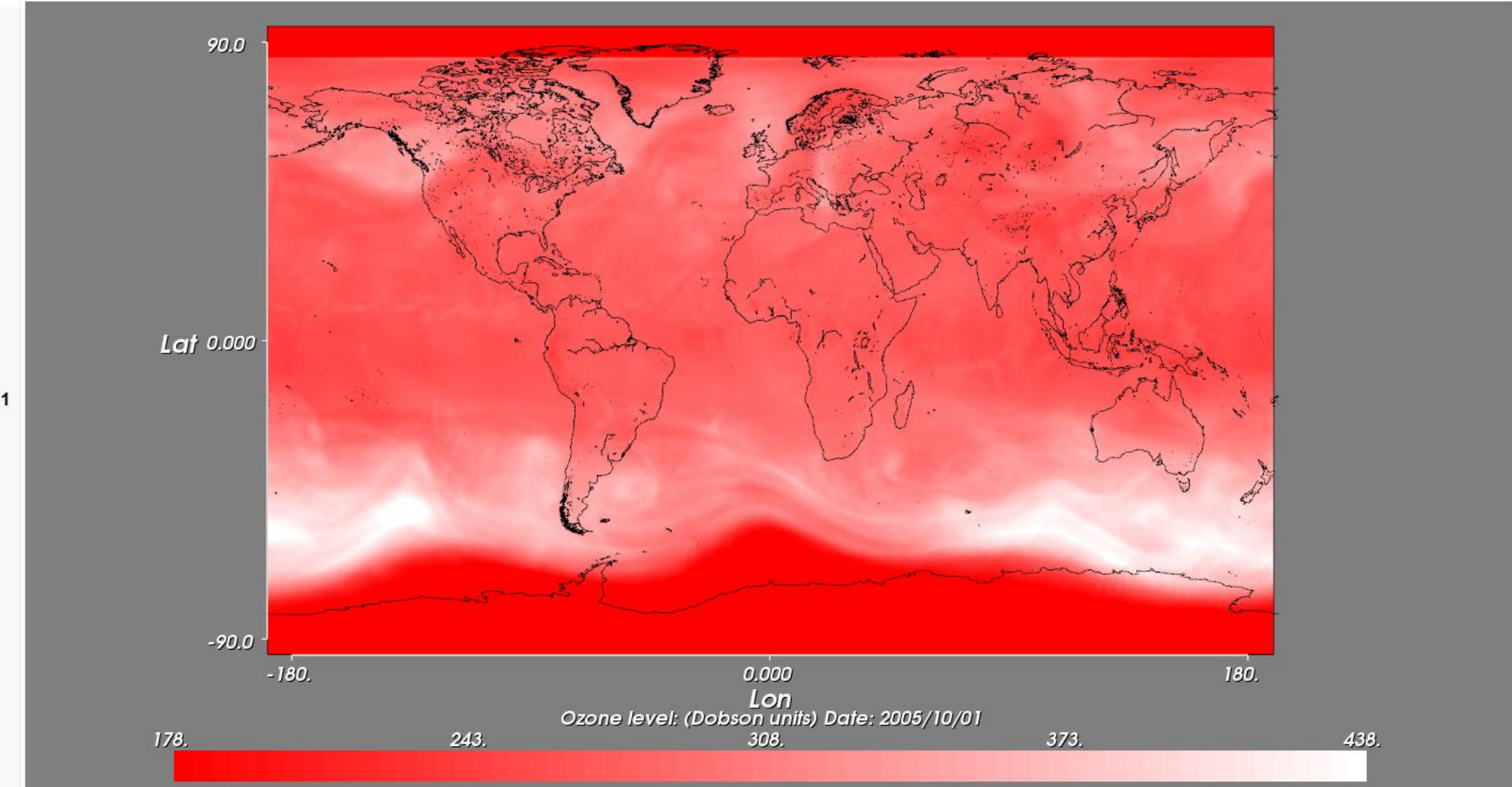
A



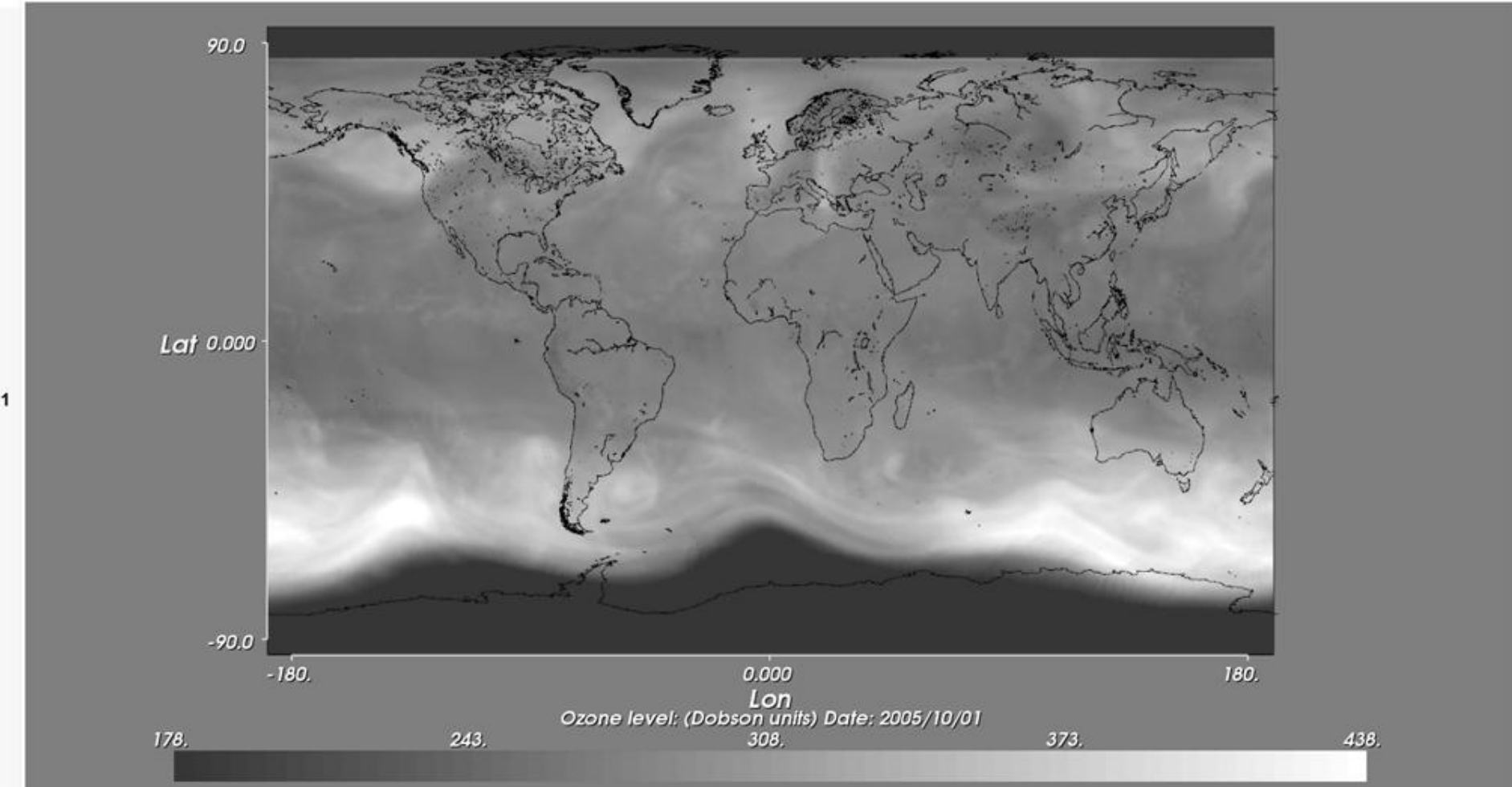
Basic Strategies

- 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)

A



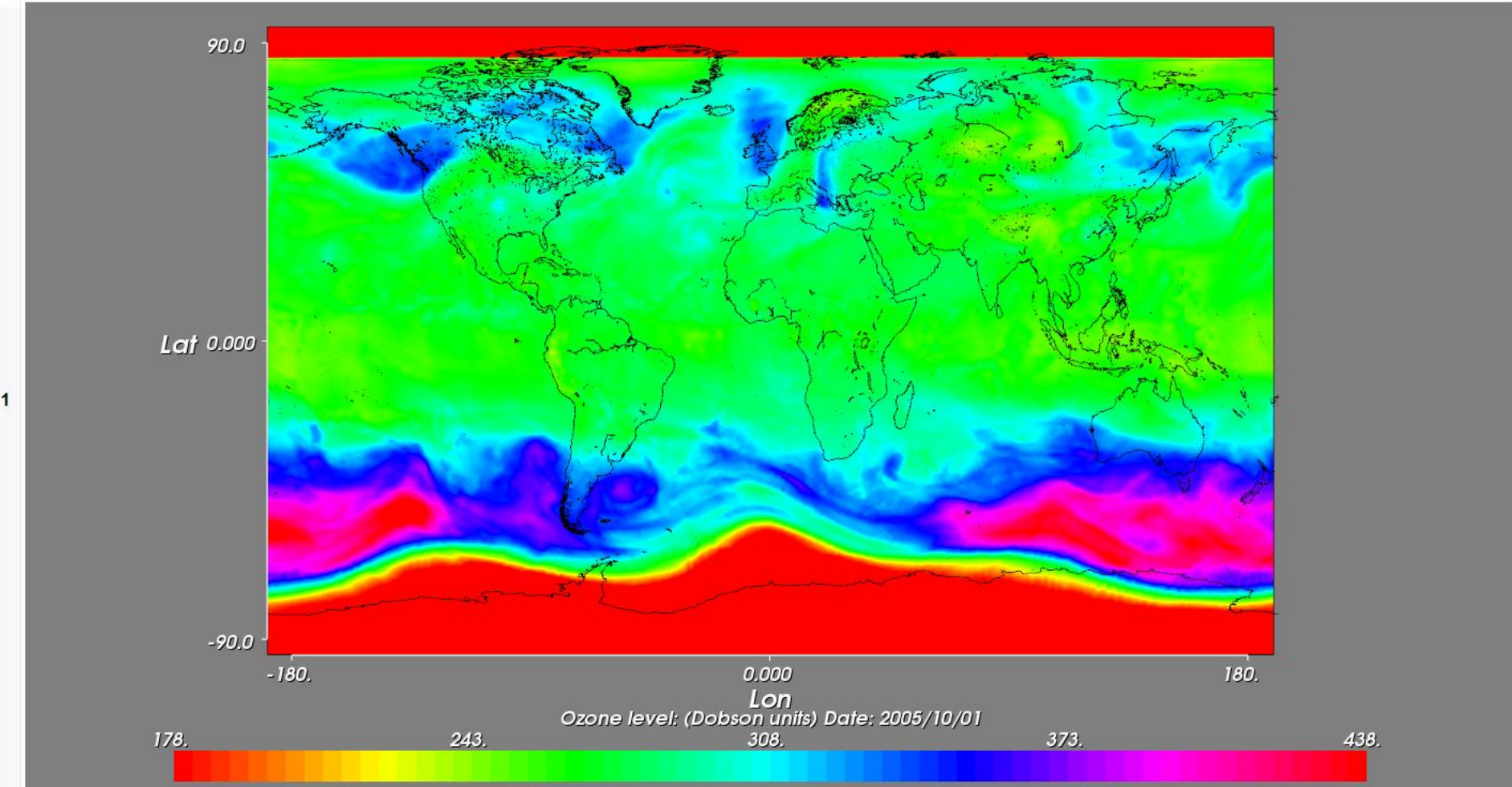
A



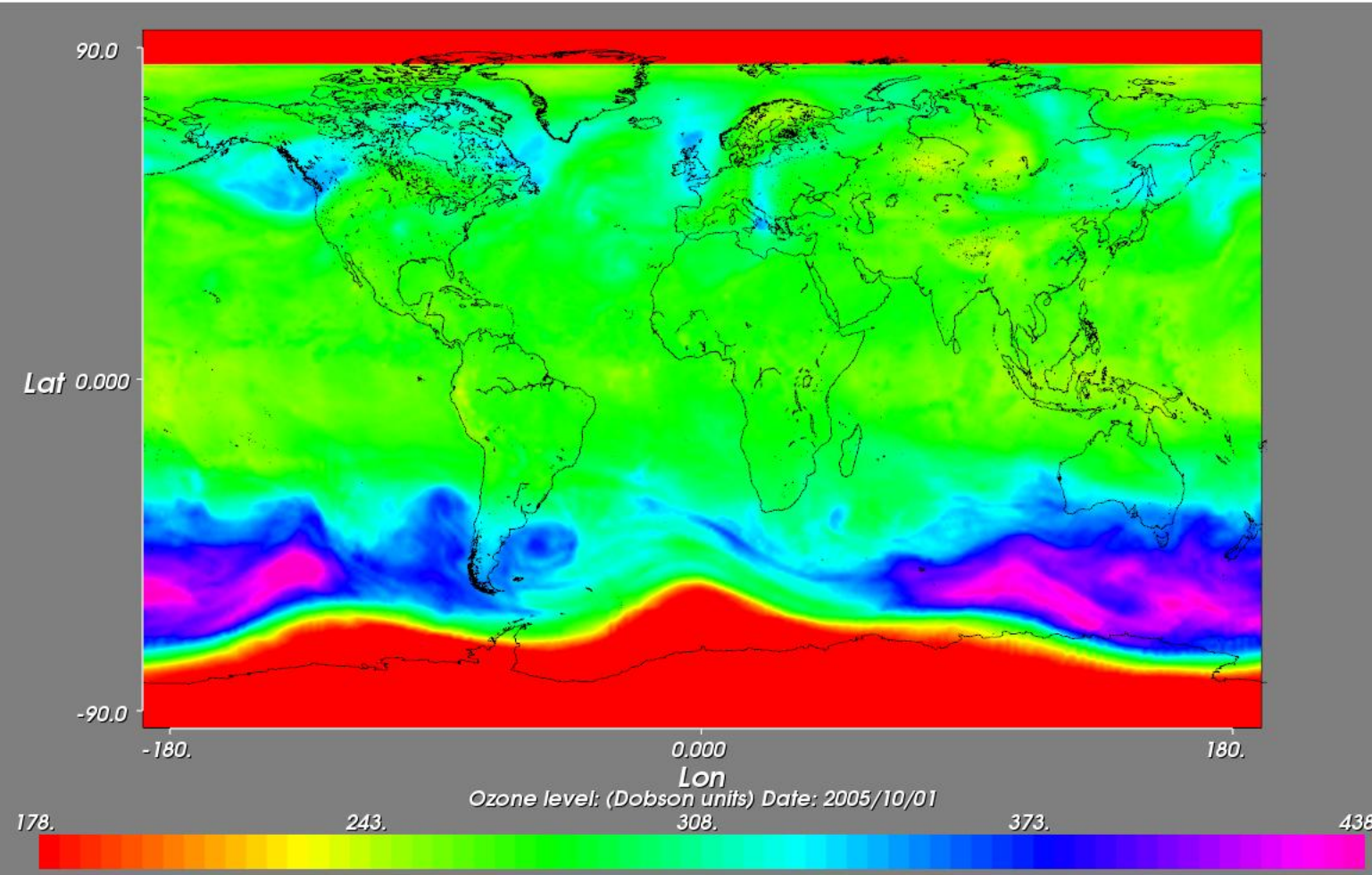
Basic Strategies

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

A



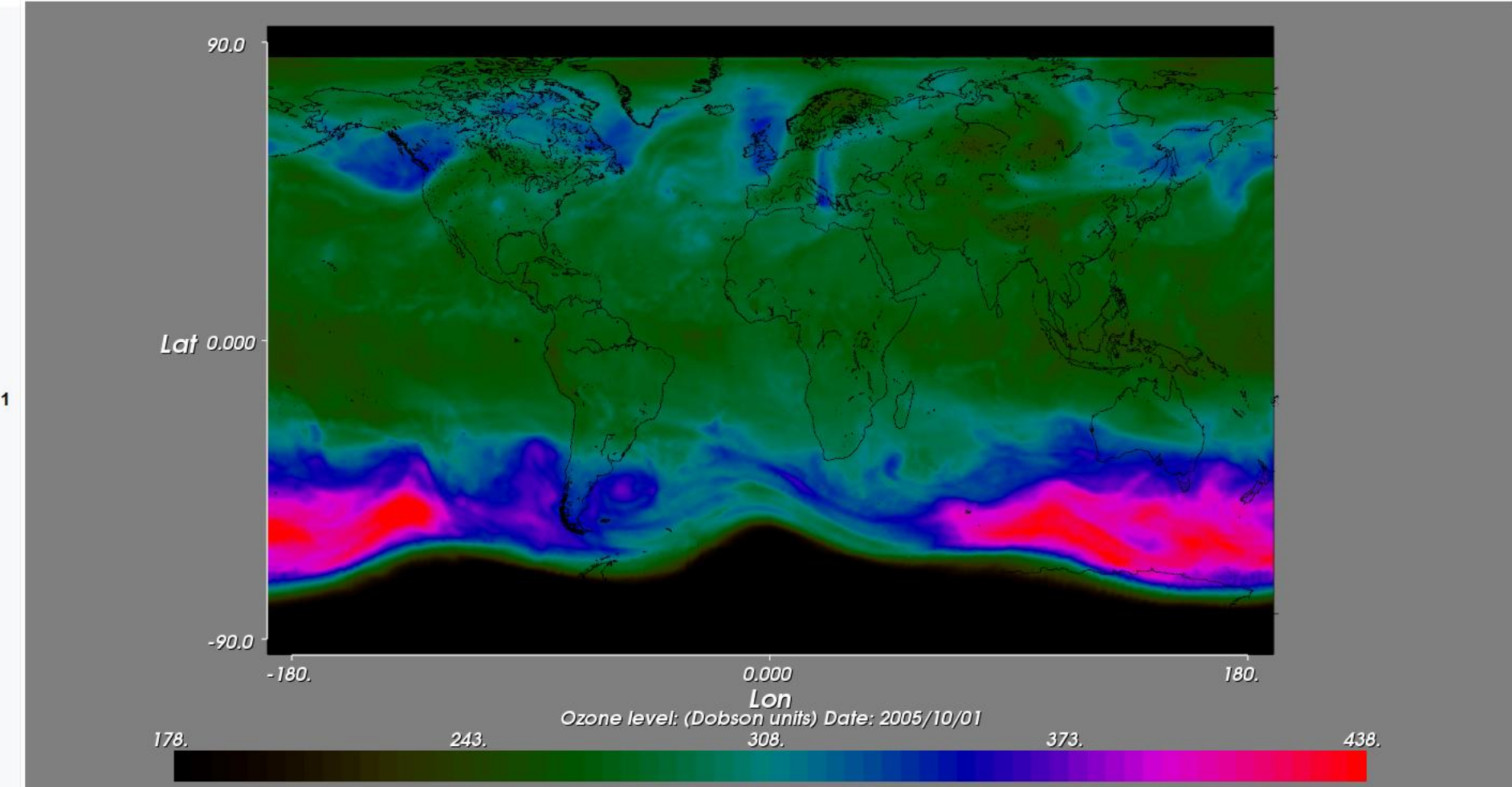
A



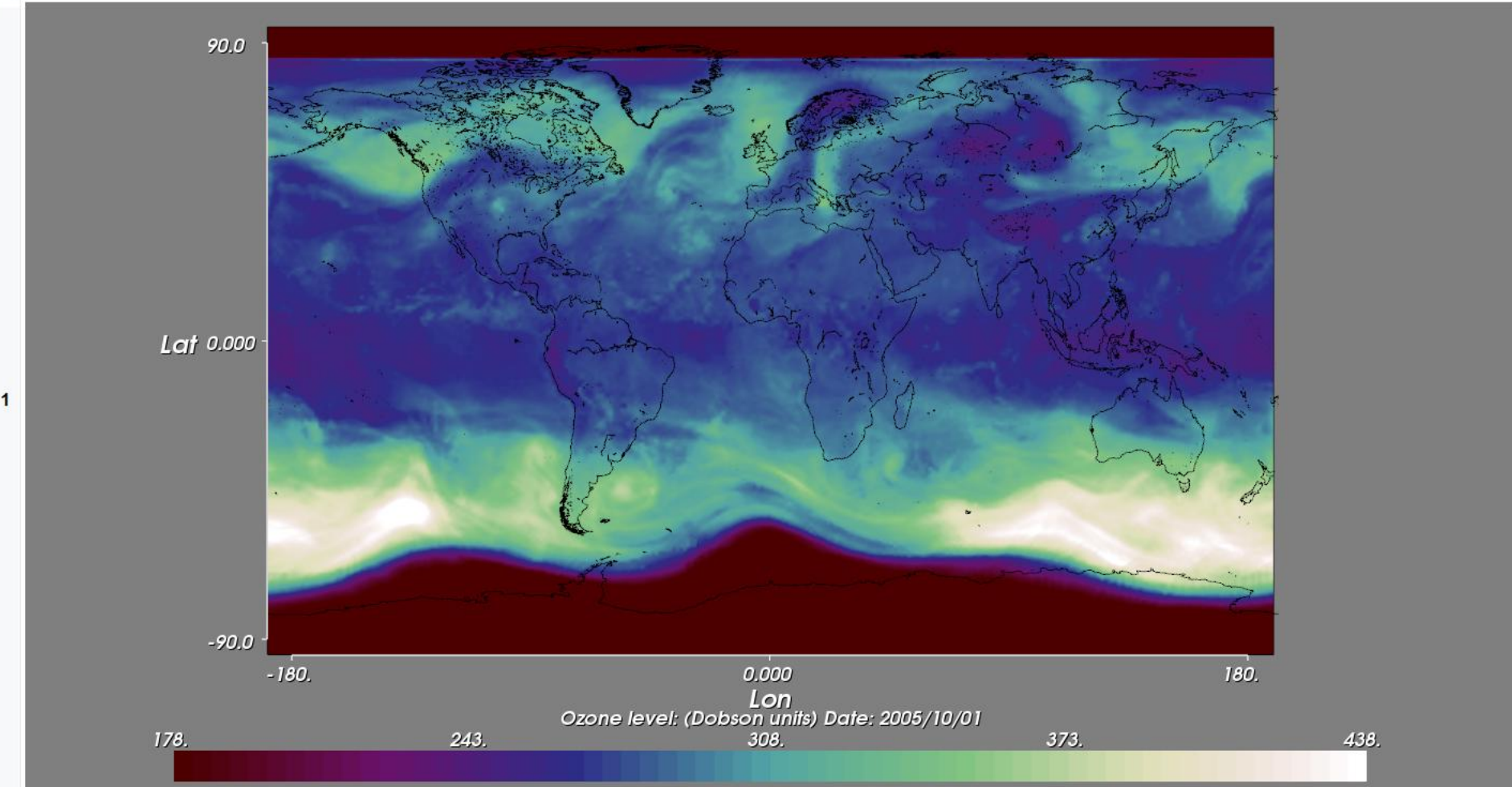
Basic Strategies

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

A



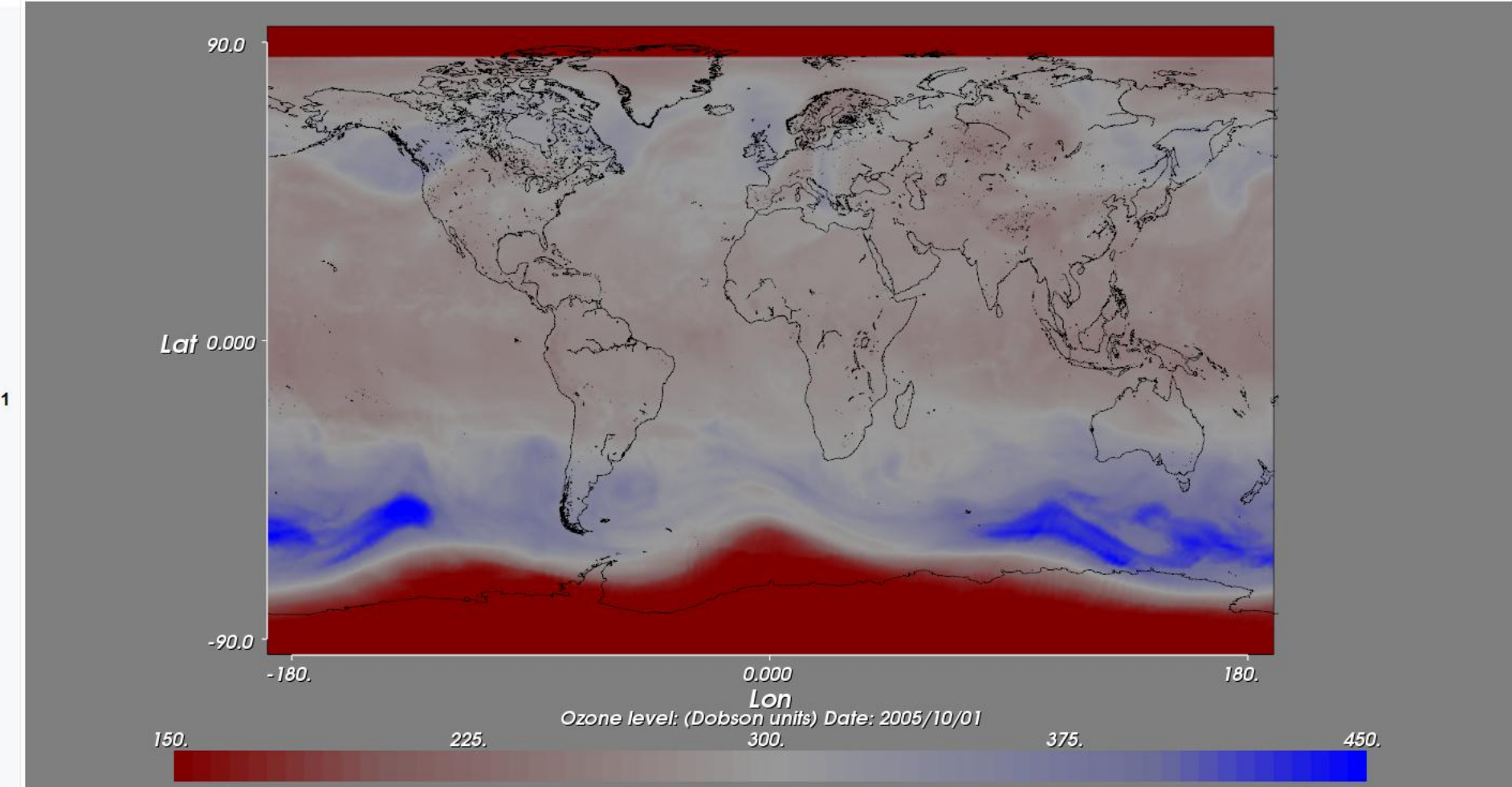
A

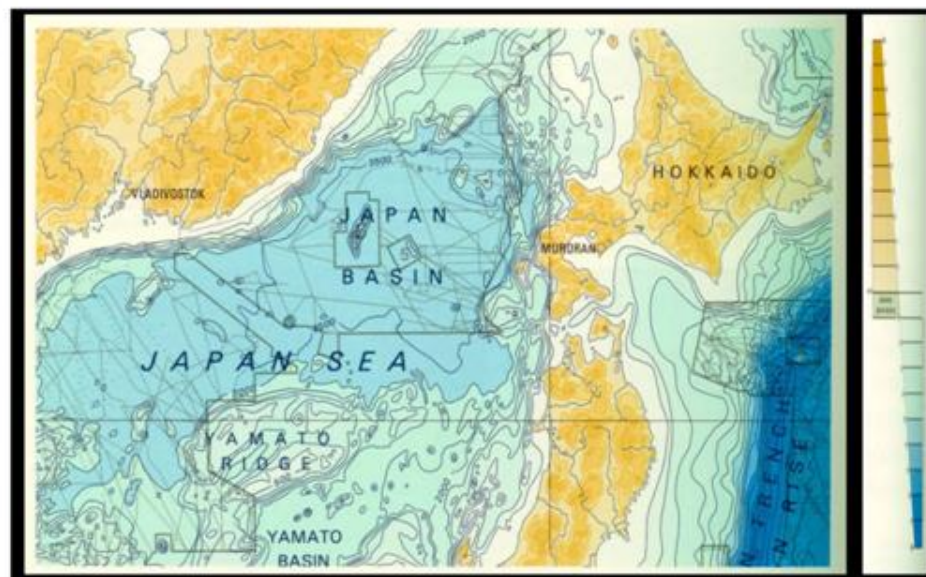
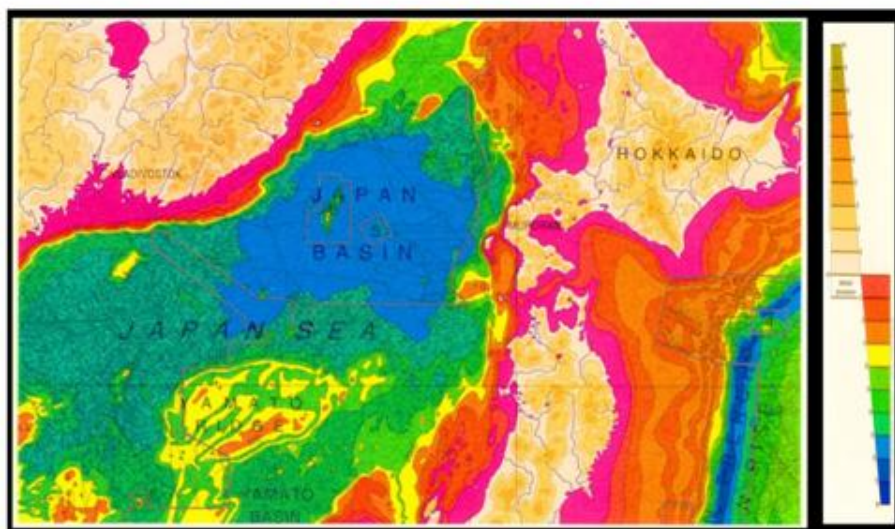
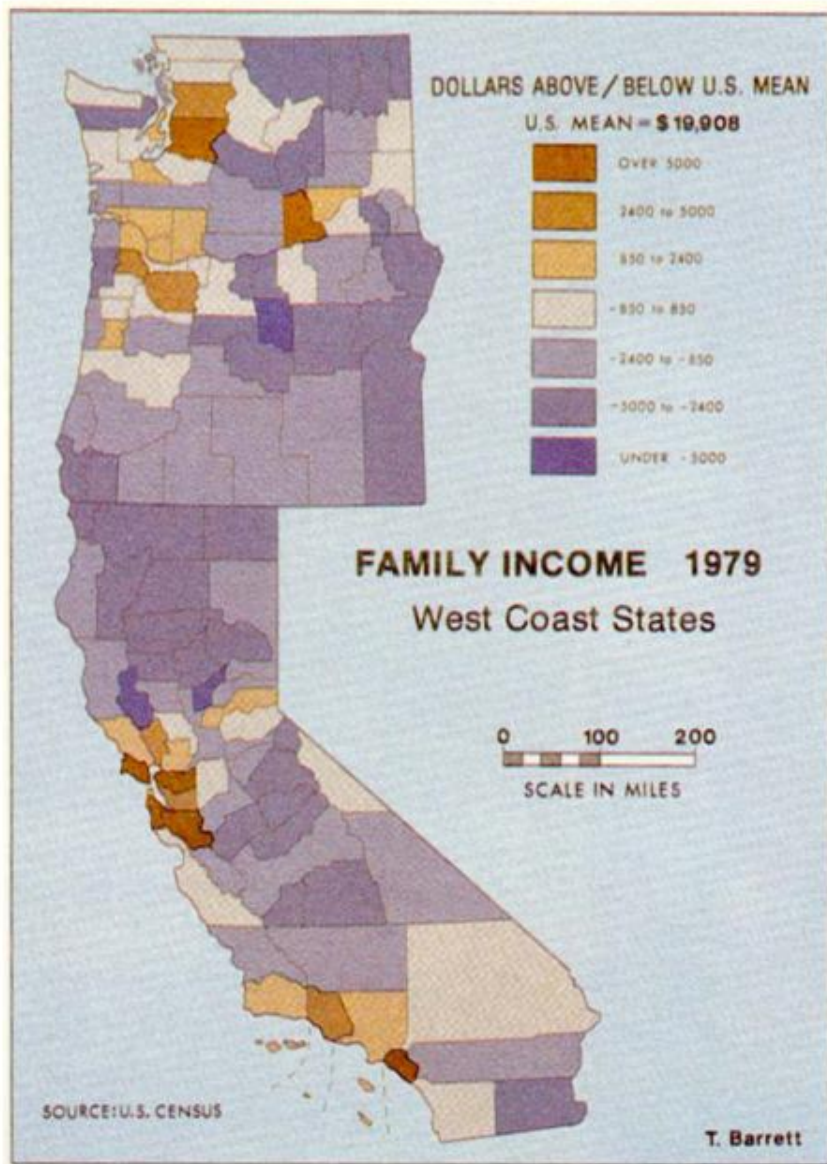


Basic Strategies

- 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)

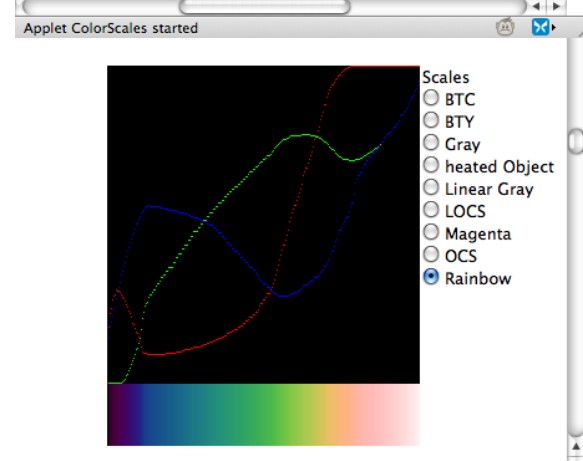
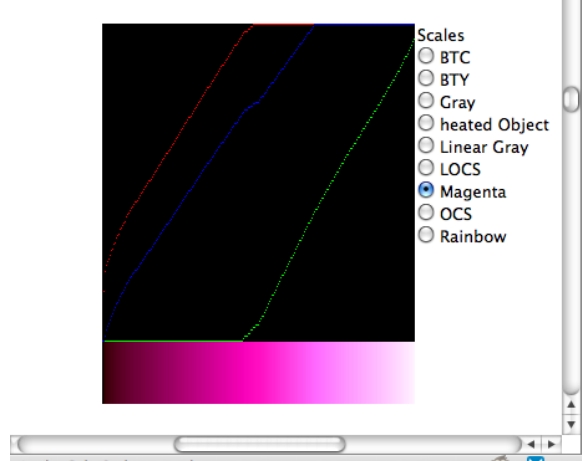
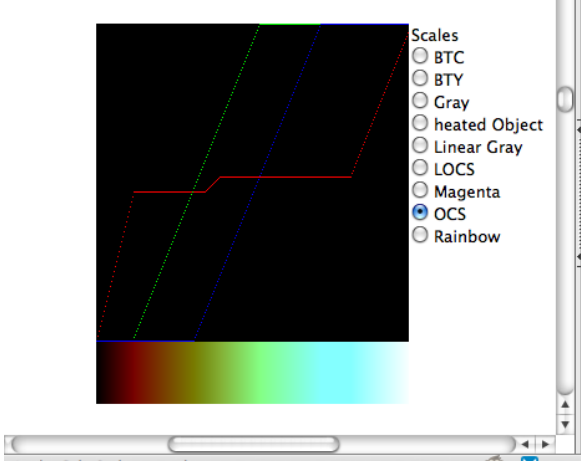
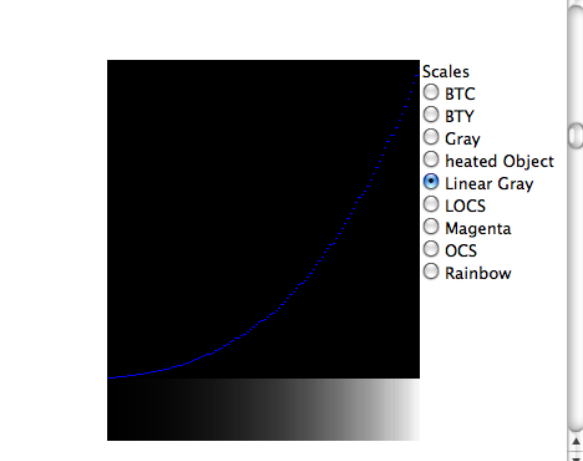
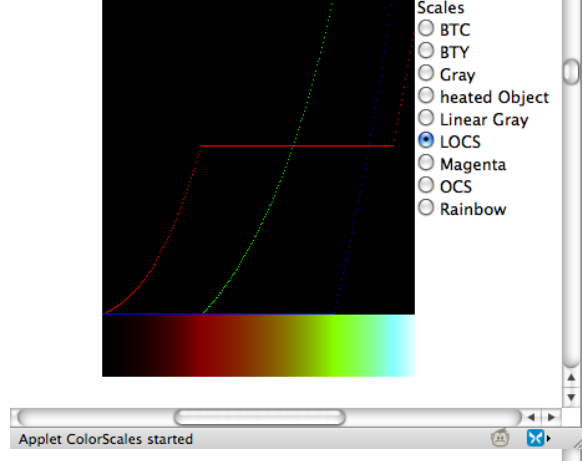
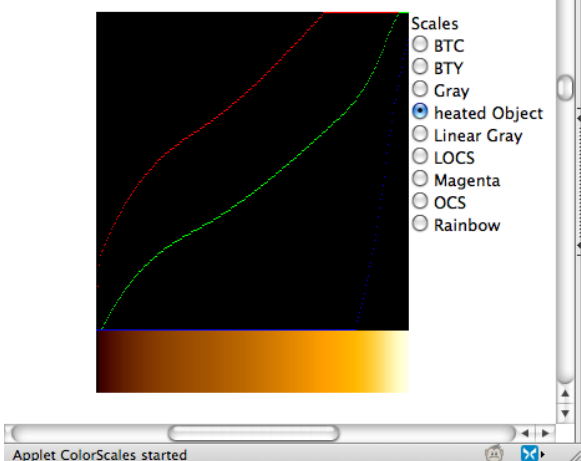
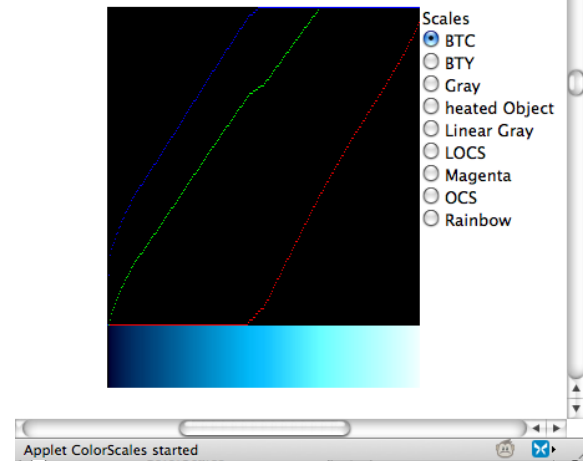
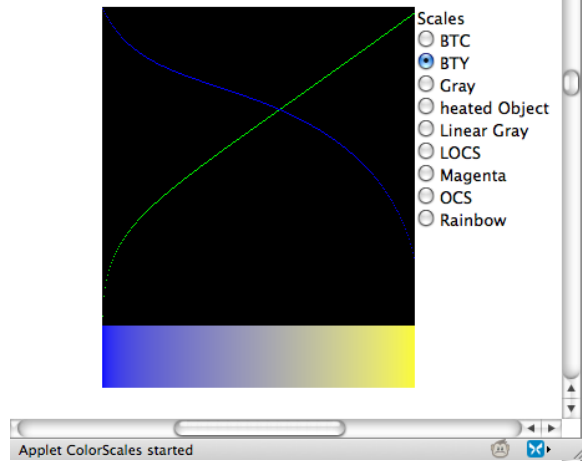
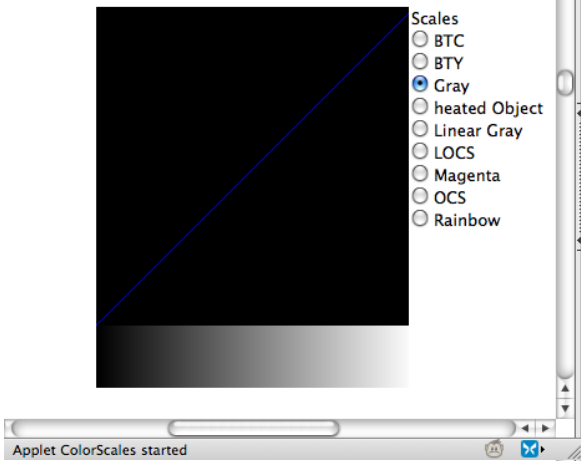
A





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, Linearized Gray

- Gray

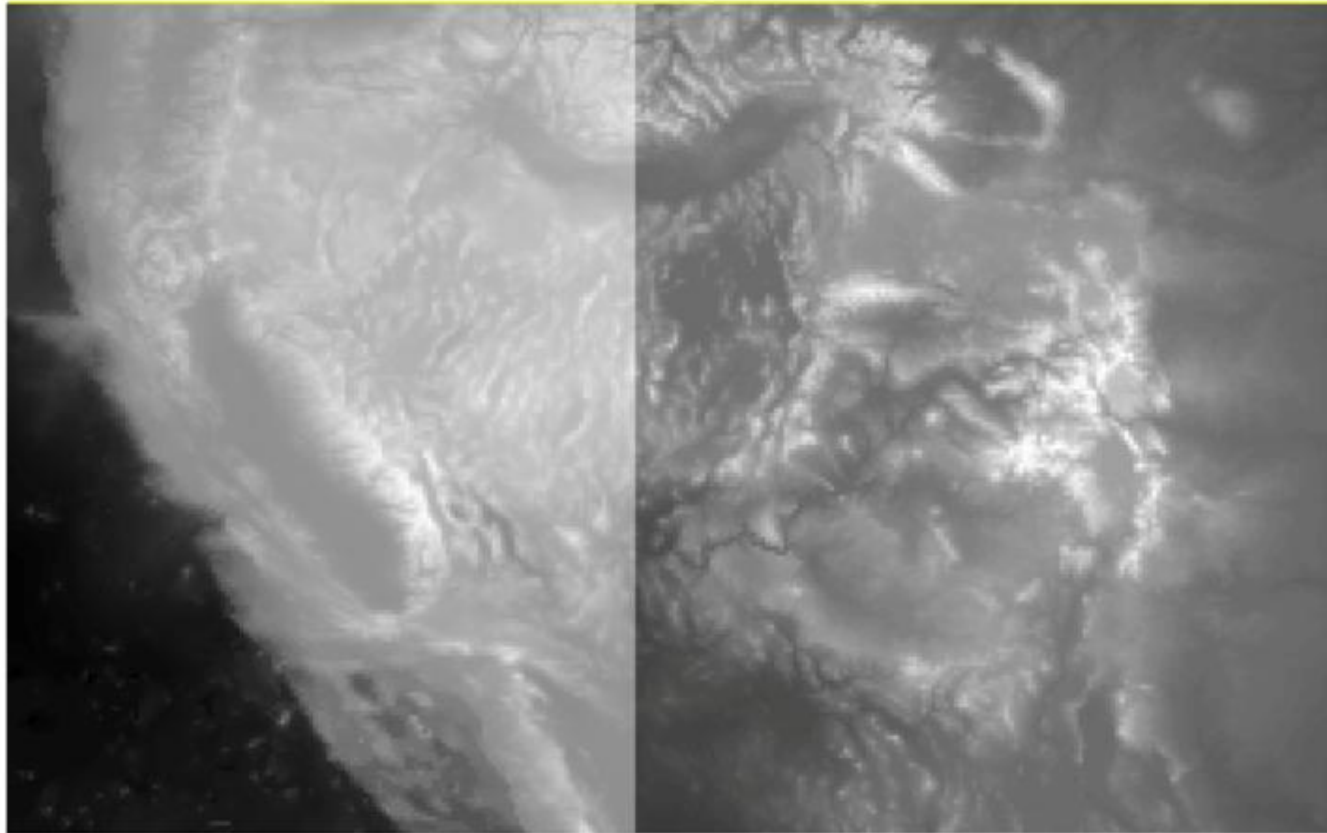


- Linearized Gray



- Are these really different?

Gray vs. Linearized Gray



Gray

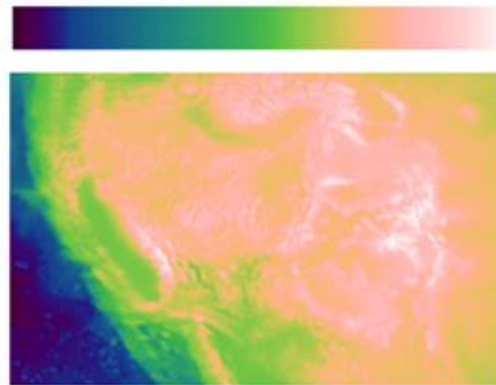
Linearized Gray

More color scales..

Magenta



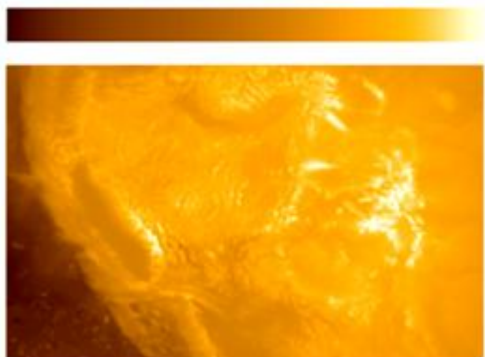
Rainbow



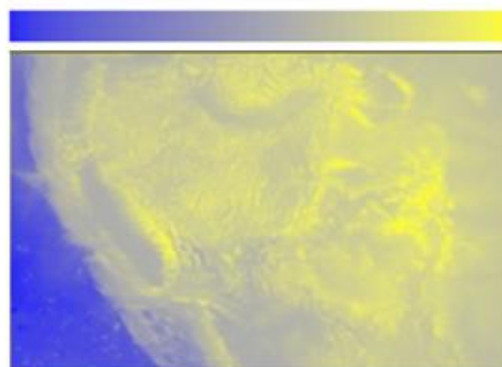
Blue-Cyan



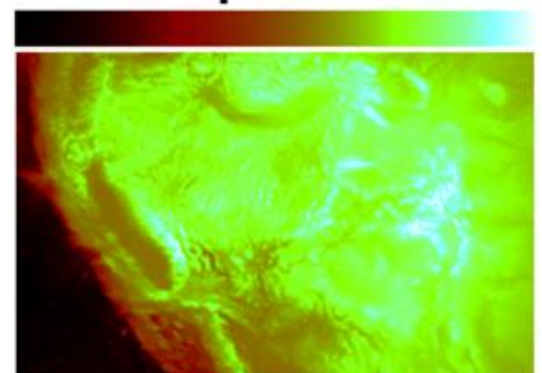
Heated



Blue-Yellow

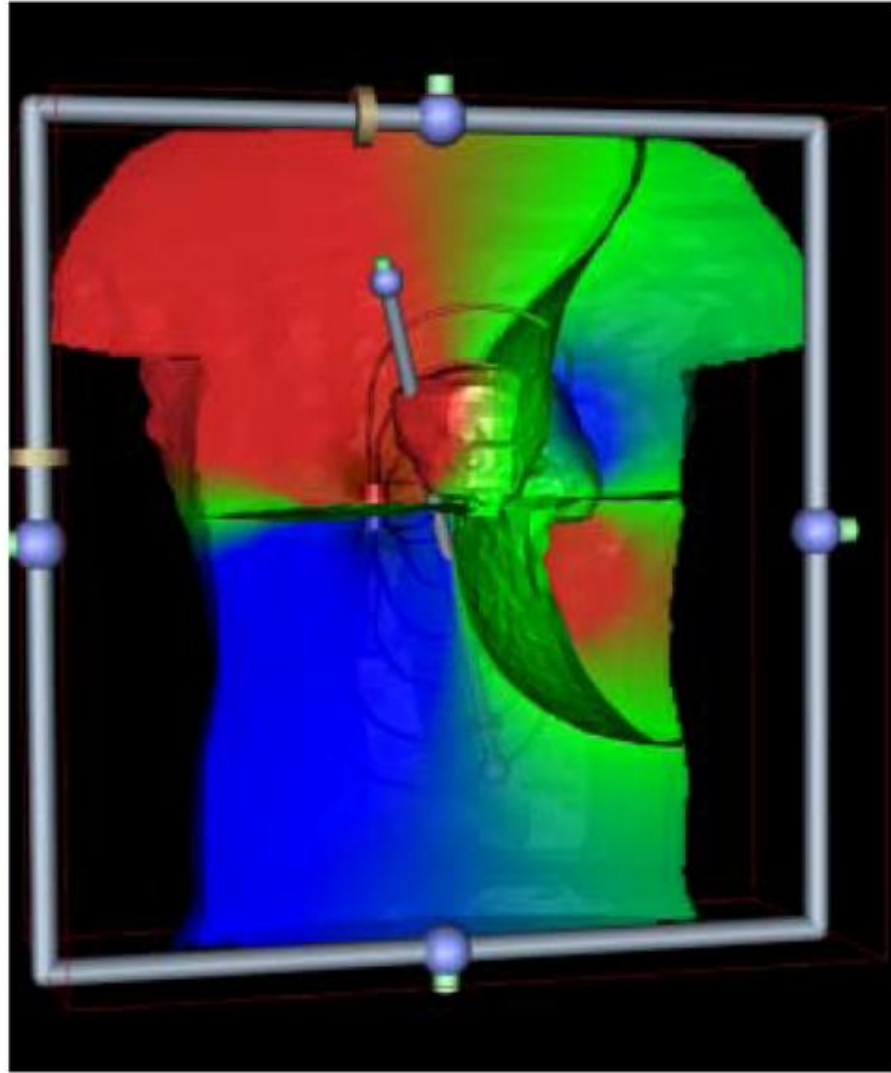


Optimal



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

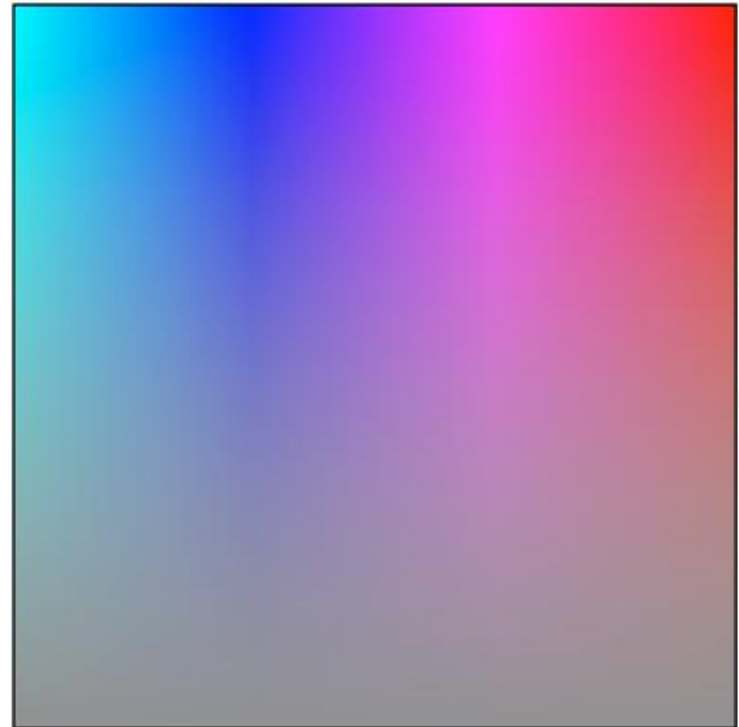
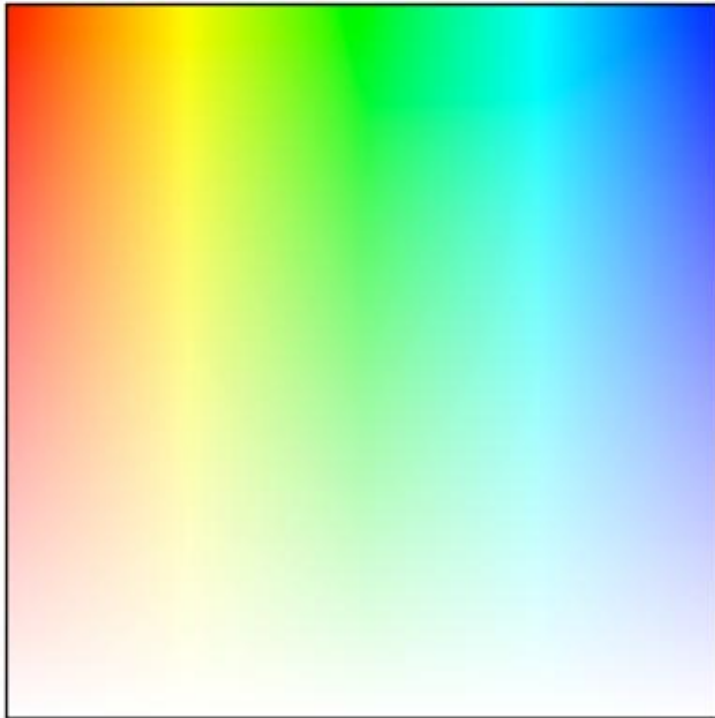


Bivariate color scales

- 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!)

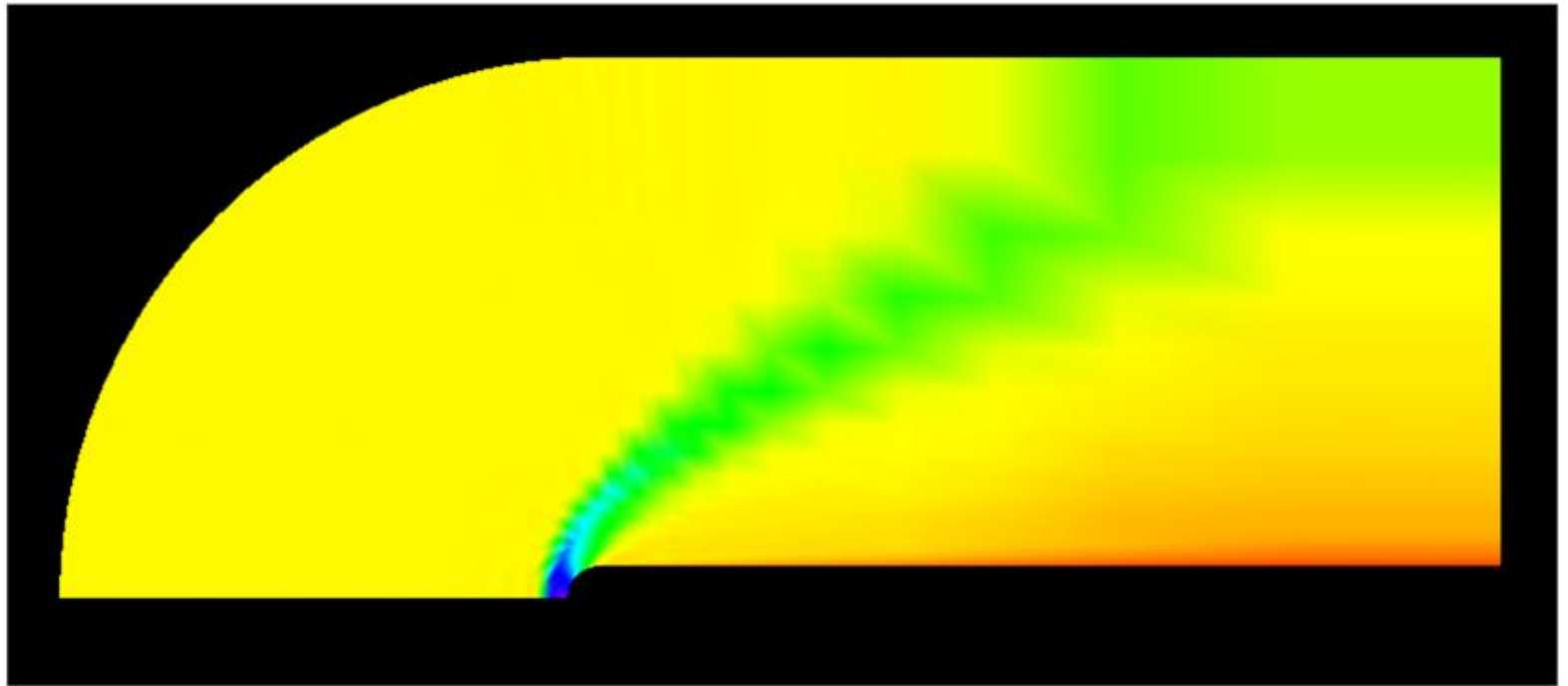


How to design colorscales

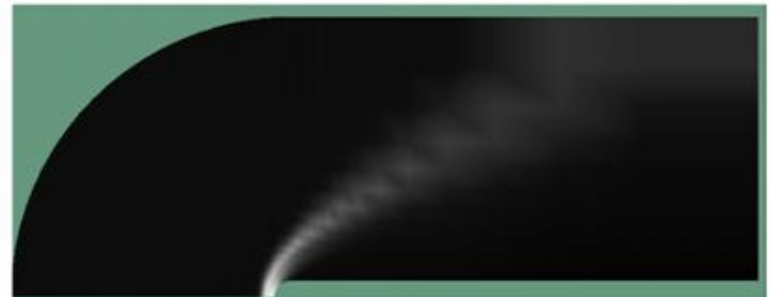
- **Trumbo's** principles:
 - Ordered values should be represented by ordered colors
 - Significantly different levels should be given significantly different colors
 - Bivariate colormaps should preserve univariate information
 - To show correlation, use “above diagonal”, “on diagonal”, “below diagonal”

Trumbo's Principle #1

Bad

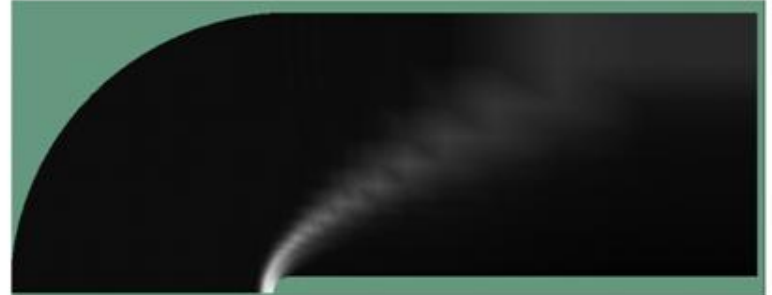


Better

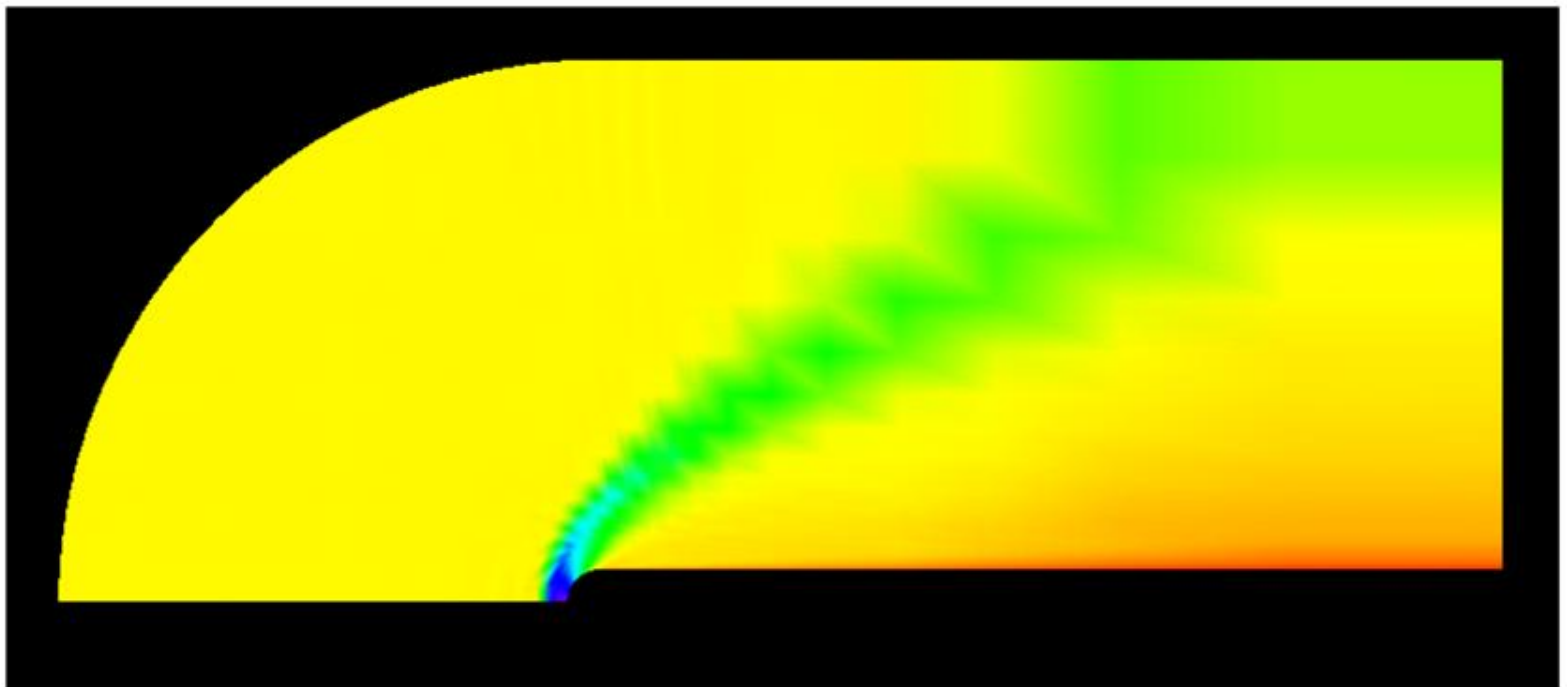


Trumbo's Principle #2

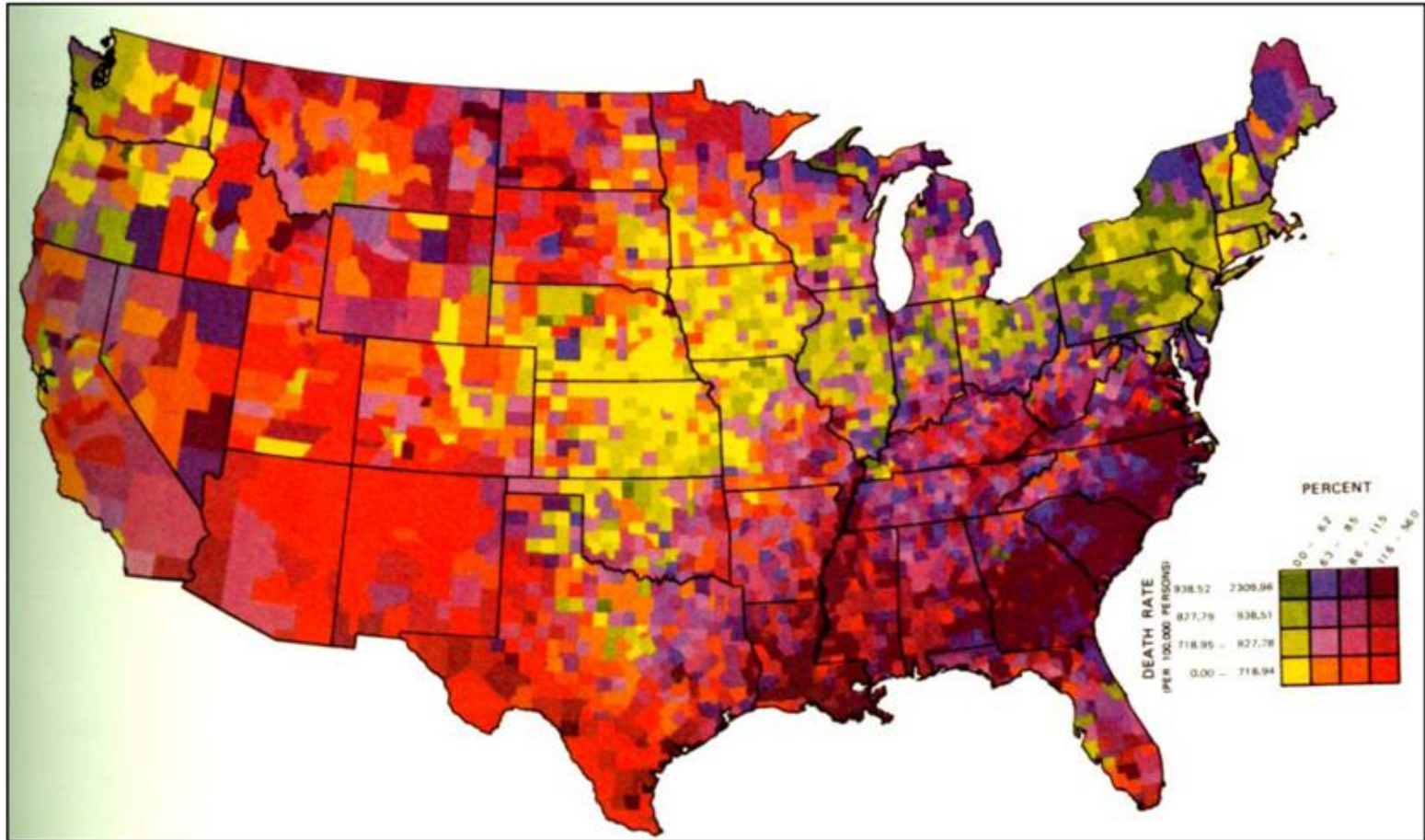
Bad



Better



Trumbo's Principles #3, 4



Tufte '83, pg. 153

Heightfields

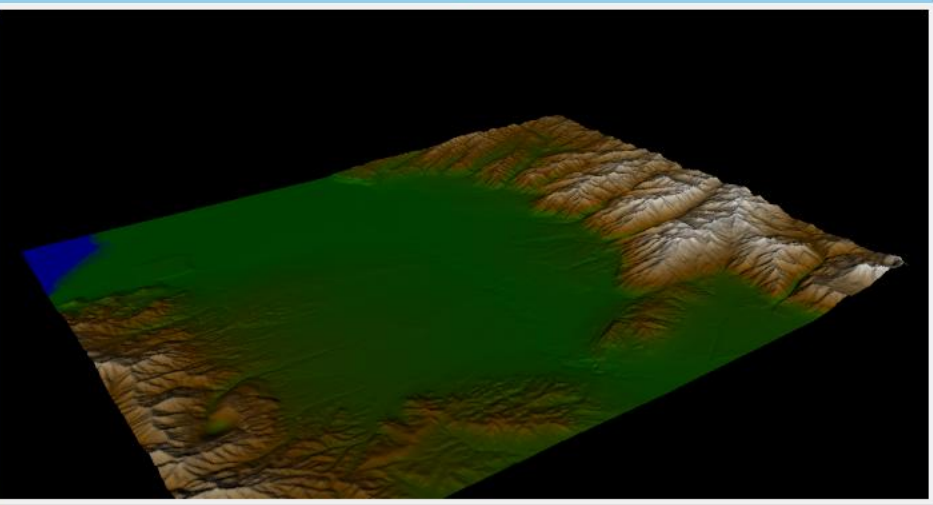
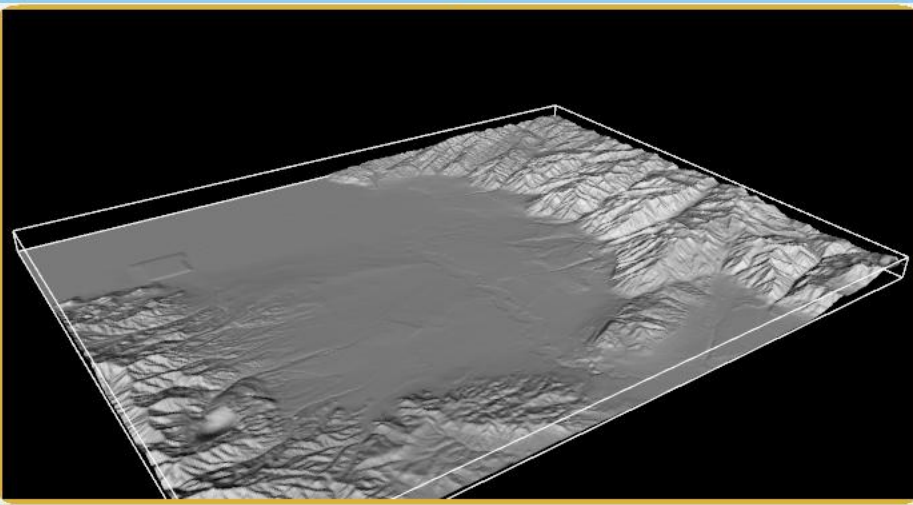
- We use height in 1D plots, let's use it in 2D plots
 - Direct intuition with topography
 - (demo: `elevation.vt`)

Contour Lines

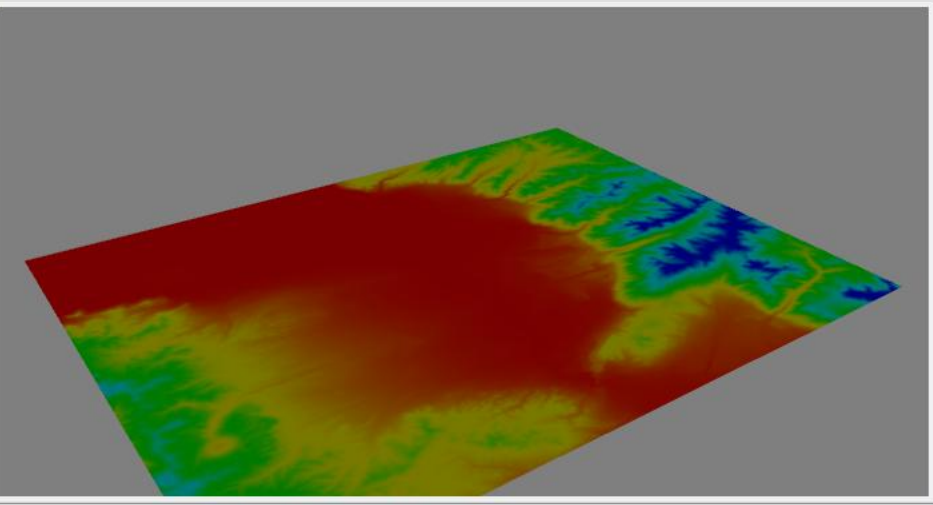
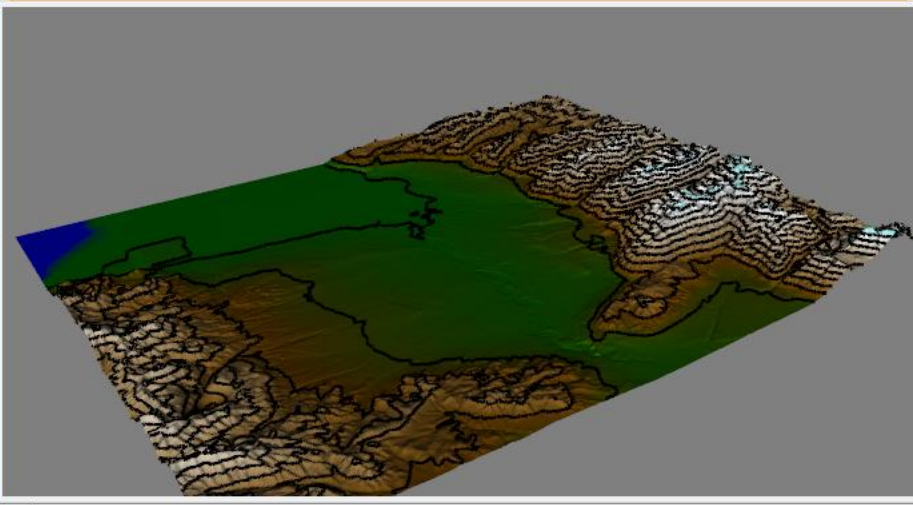
- Draw lines of constant value
- They bound regions of contiguous values
 - Loops or lines through end of dataset
- Multiple contours
 - Why?
- (demo: elevation.vt, Contours)

A

B



1

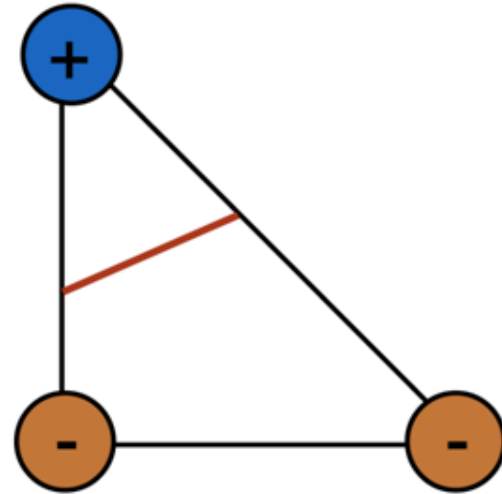
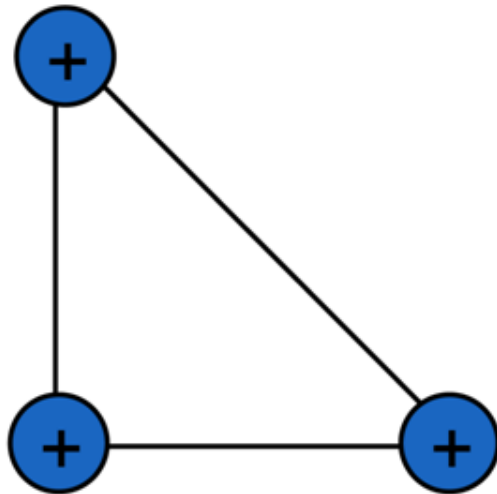


2

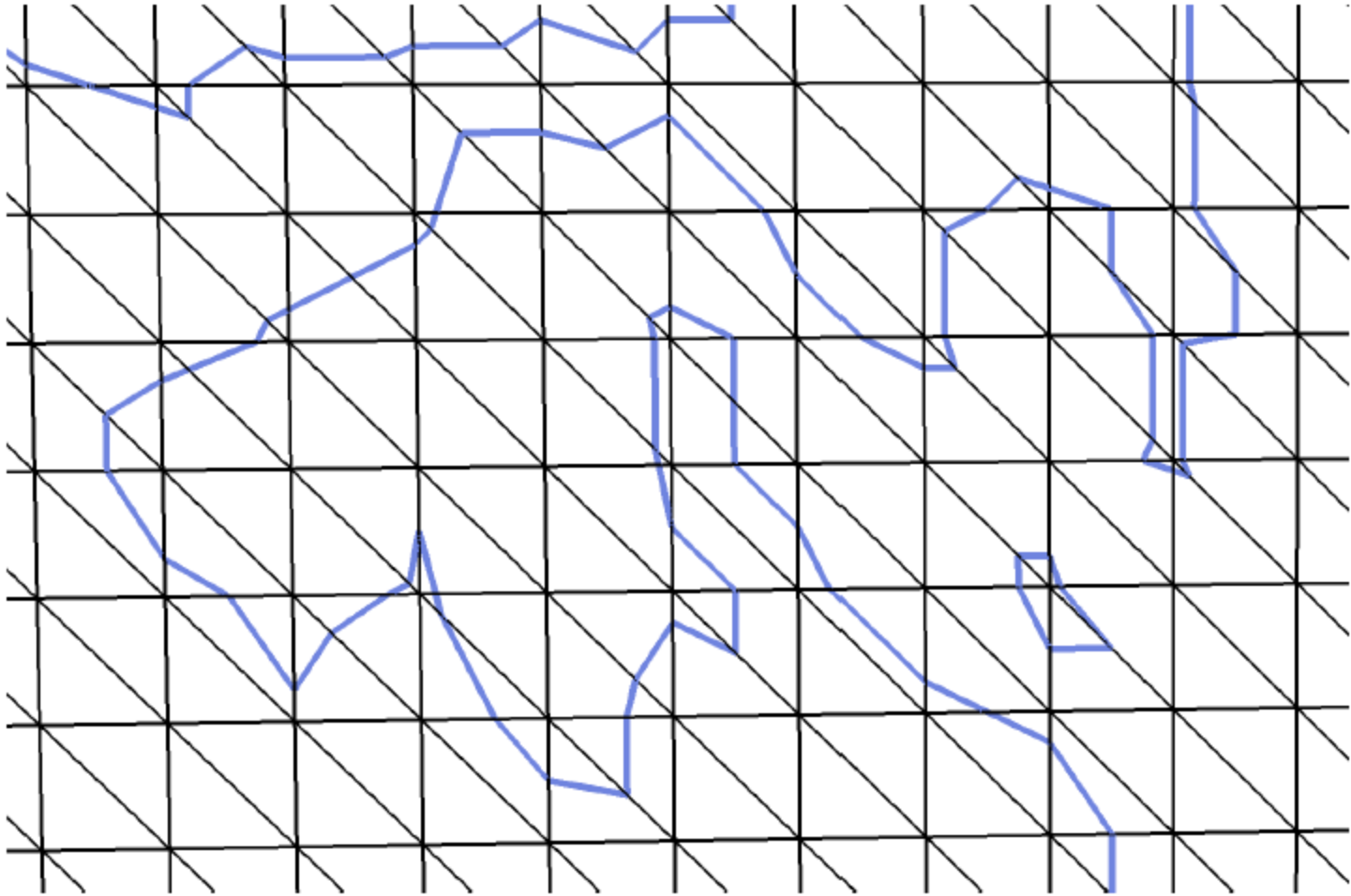
Computing Contours

- Simplest case: triangles
 - Let's use Rolle's theorem: if along a line $[a, b]$, $\text{sgn}(f(a)) \neq \text{sgn}(f(b))$ 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

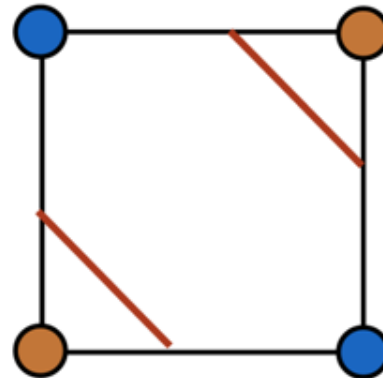
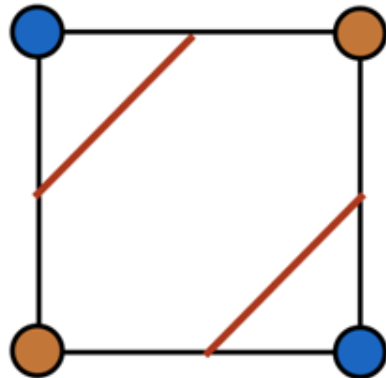
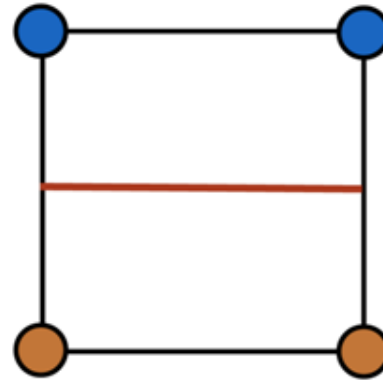
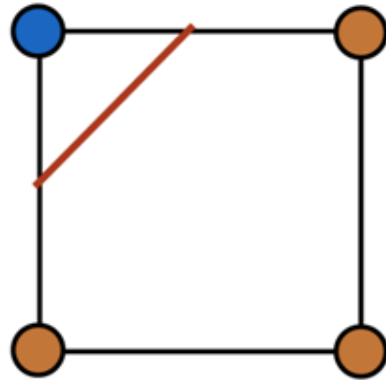


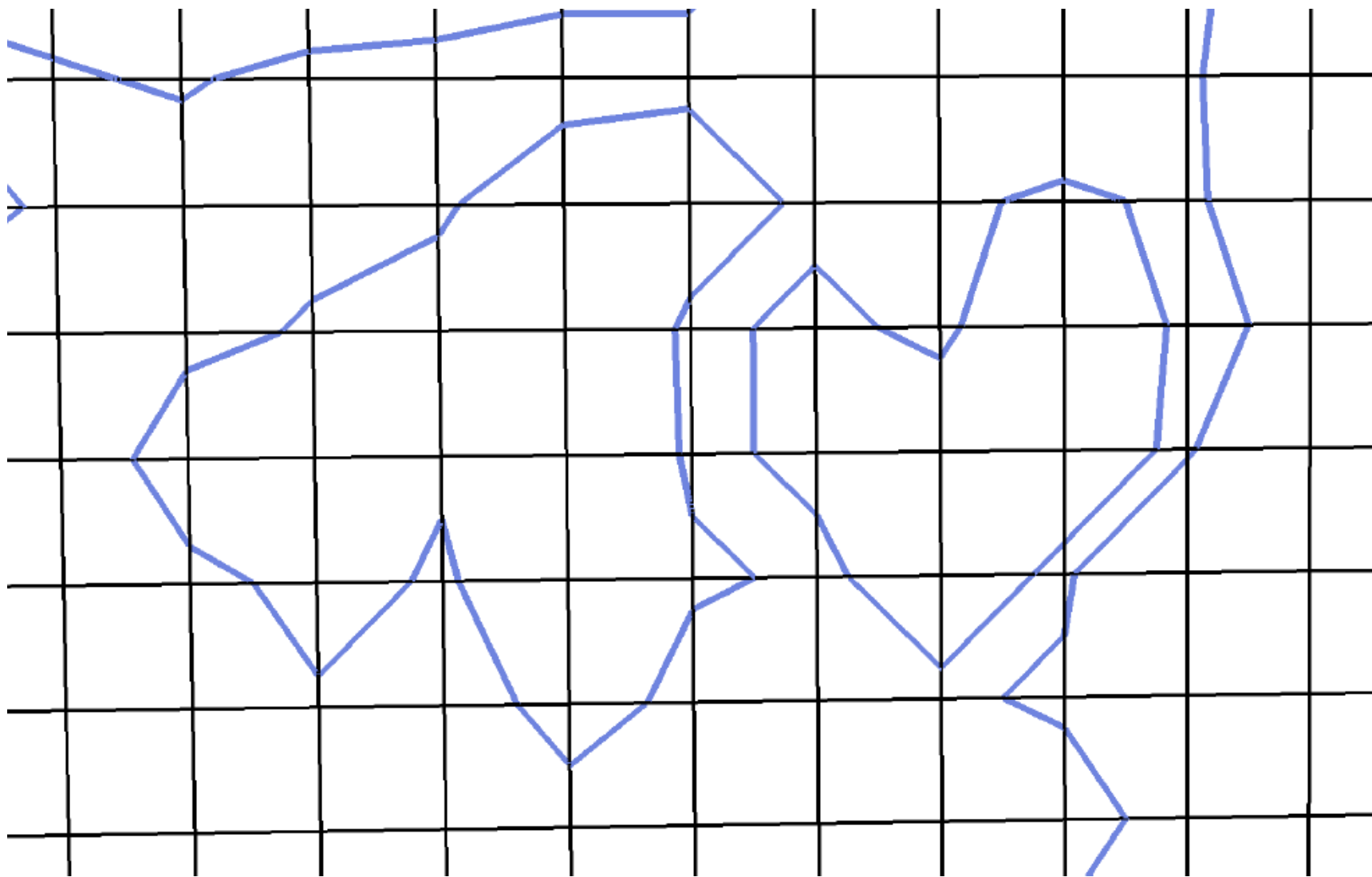
Only these two cases. Why?



Contouring squares

- More cases





Resolving the ambiguity

