

## 2. Color Theory Principals that assist in creating effective of visualizations

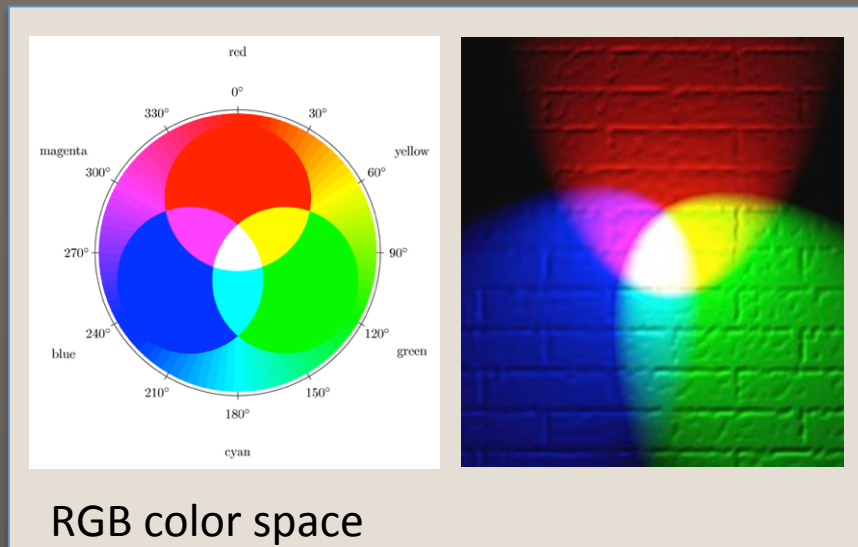
Color Contrast Theory overview,  
applied visualization examples and  
recommended color schemes and sets for specific uses

Francesca Samsel, UT

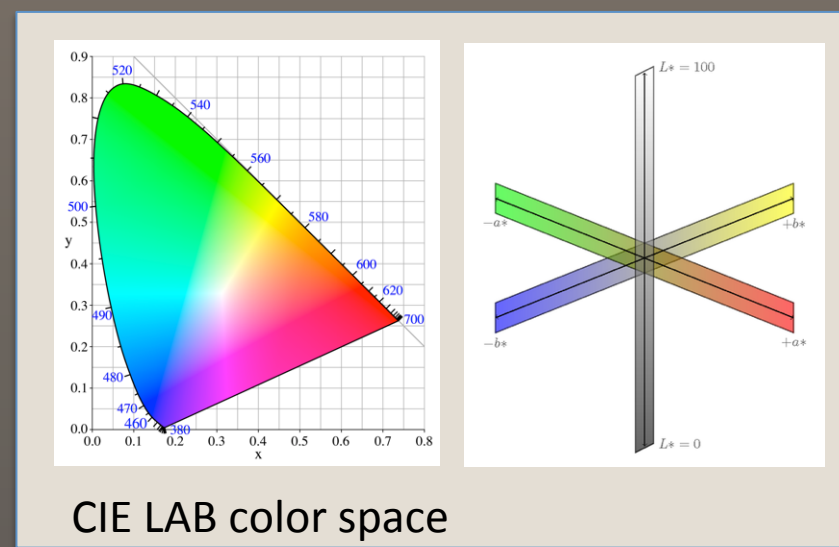


# Color Spaces

## RGB



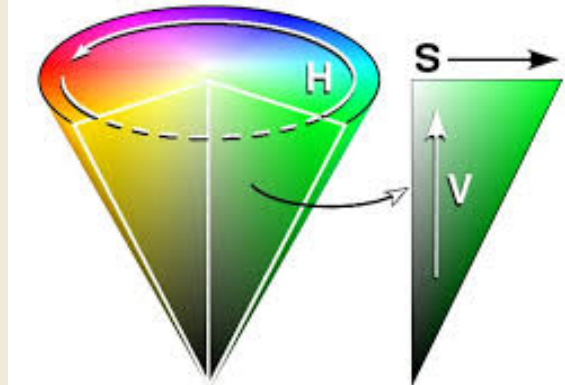
## CIE LAB



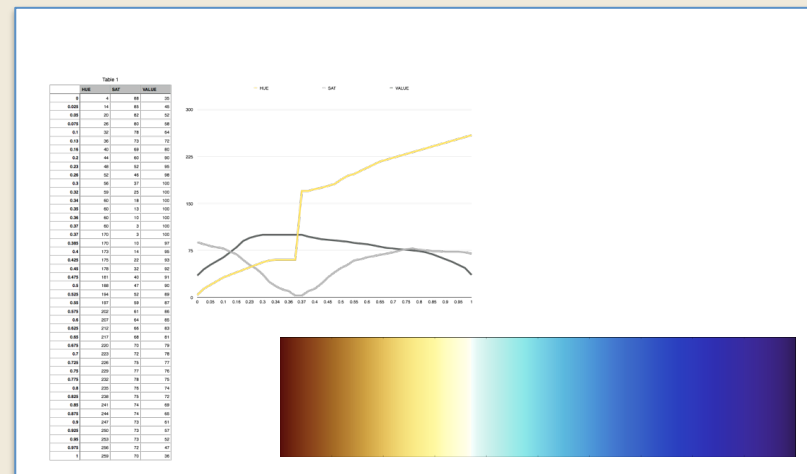
RGB is computer color space.

CIE LAB space, for perceptual accurate, is *the best interpolation space*.

# Hue, Saturation and Value the human color space



HSV, HSB color space

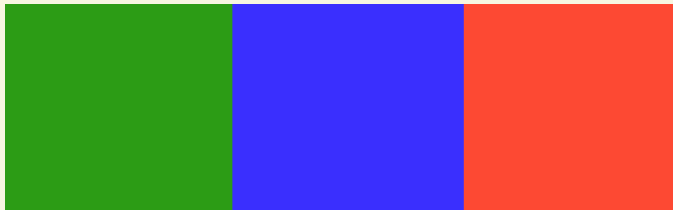


It provides the ability to make subtle adjustments in the human color language.  
Hue, Saturation and Value -- The language of color theory.

## Terms – Hue, Saturation, Value (luminance).

### Hue

What "color" is it? Green, blue, red..



### Value

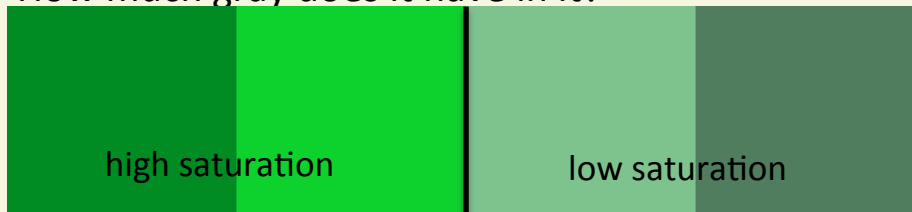
Is it light or dark?



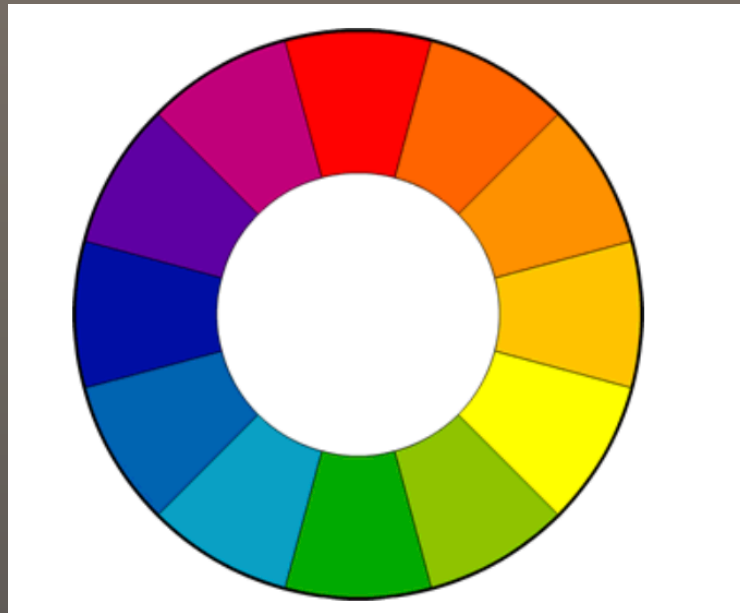
### Saturation

How pure is it?

How much gray does it have in it?



# Color Theory 101



Color is complicated because adjacent colors significantly impact our perception.

Advise:  
Keep your color palettes simple...  
or steal them from a pro.

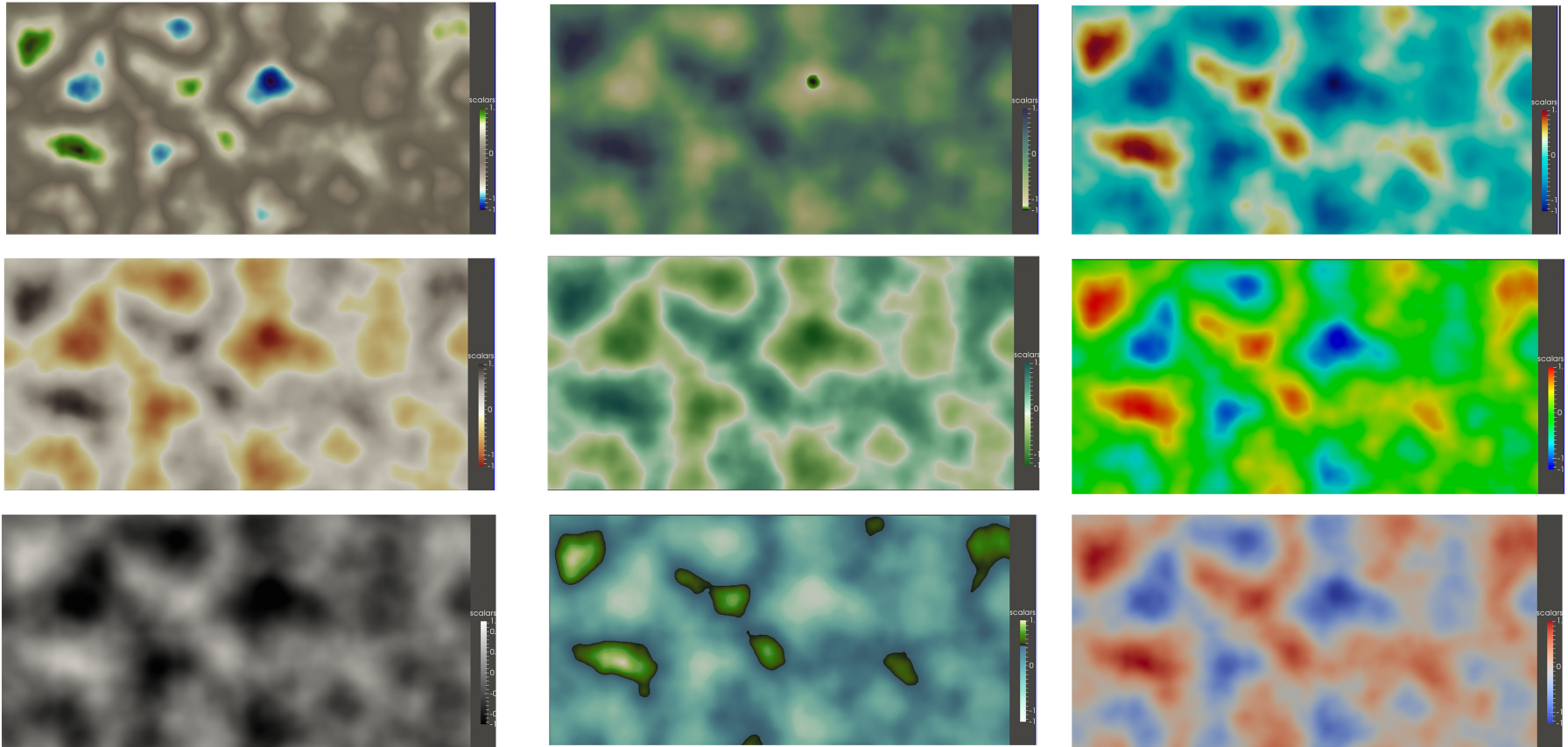


It is about **contrast**, not **color**.

- contrast type
- contrast level
- contrast organization

# Contrast Distributions

Contrast distributions within the colormap have a significant effect on the features revealed..



noise data - Abram

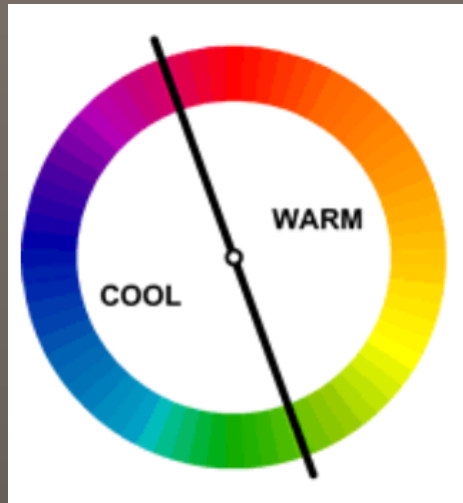


## color contrast types

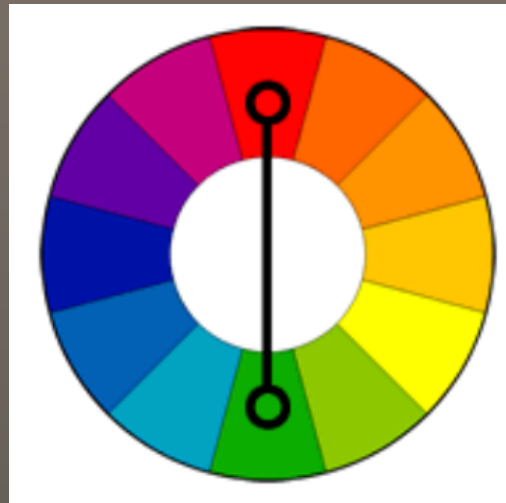
1. hue
2. value
3. saturation
4. complimentary
5. cool warm
6. proportion
7. simultaneity

and....unifying contrast  
analogous color

## Types of Color Contrast



cool / warm colors



complimentary colors



analogous color

The image displays a digital color palette interface with two main sections: 'WARM' and 'COOL'. Each section features a color wheel, a horizontal bar of five color swatches, and a control panel with sliders and color codes.

**WARM Section:**

- Color Wheel:** A circular color wheel with a white center and a rainbow gradient. A white arrow points from the center towards the red-orange area.
- Color Rule:** A dropdown menu with 'Analogous' selected. Other options include Monochromatic, Triad, Complementary, Compound, Shades, and Custom.
- Color Swatches:** Five rectangular color swatches in a horizontal row: yellow, orange, red-orange, red, and magenta.
- Control Panel:** A panel with three horizontal sliders and a 'Shades' button. The sliders have colored dots corresponding to the swatches.
- Color Codes:** Below the sliders, color codes are displayed for each swatch:

RGB 255   255   0	RGB 255   166   82	RGB 255   44   0	RGB 255   0   255
HEX #ffff00	HEX #ff9933	HEX #ff0000	HEX #ff00ff

**COOL Section:**

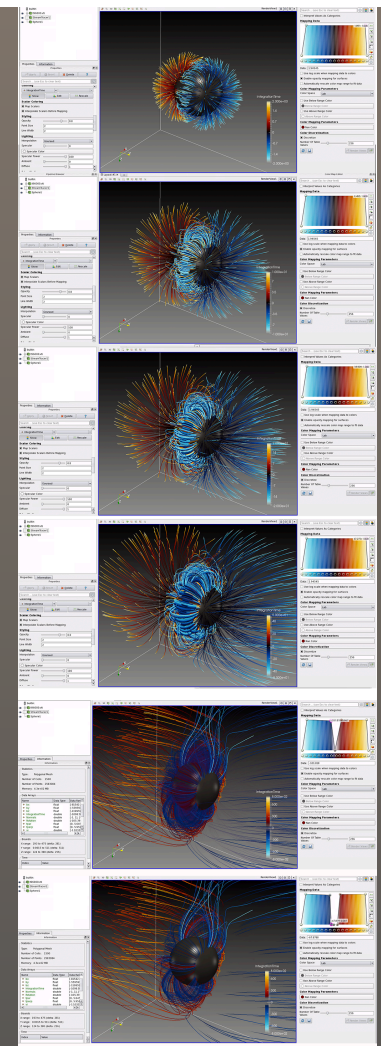
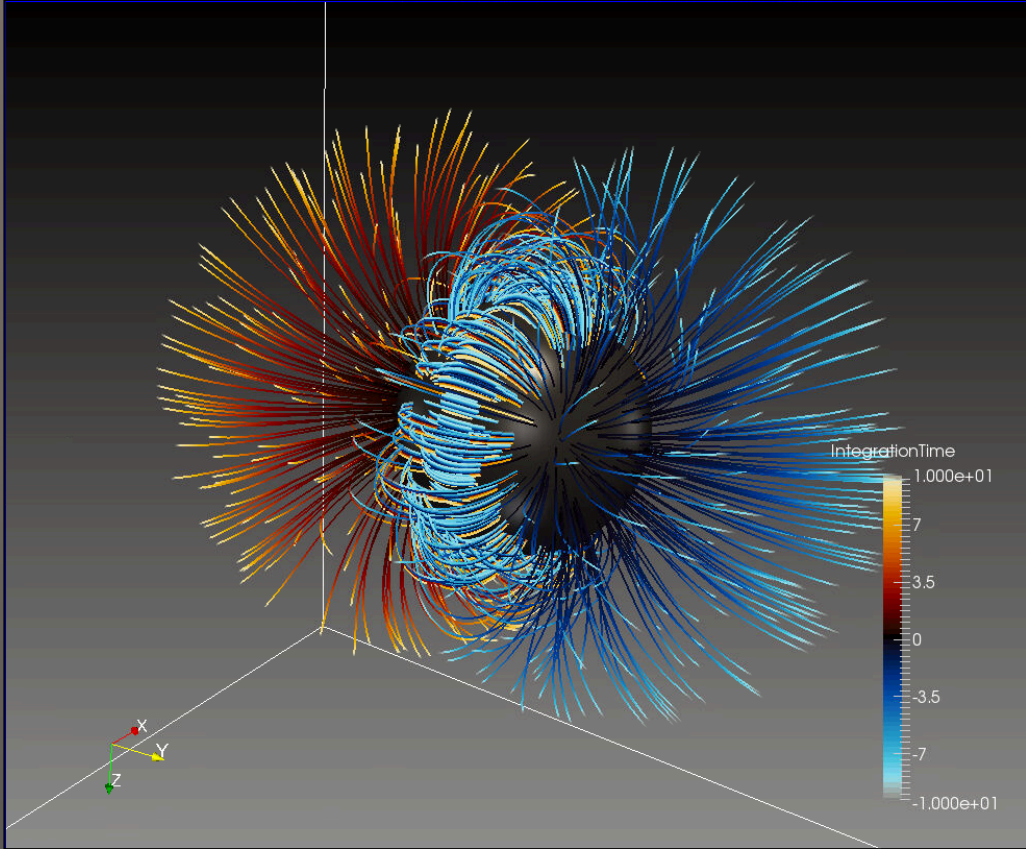
- Color Wheel:** A circular color wheel with a white center and a rainbow gradient. A white arrow points from the center towards the cyan area.
- Color Rule:** A dropdown menu with 'Analogous' selected. Other options include Monochromatic, Triad, Complementary, Compound, Shades, and Custom.
- Color Swatches:** Five rectangular color swatches in a horizontal row: blue, cyan, green, lime green, and yellow-green.
- Control Panel:** A panel with three horizontal sliders and a 'Shades' button. The sliders have colored dots corresponding to the swatches.
- Color Codes:** Below the sliders, color codes are displayed for each swatch:

RGB 0   0   255	RGB 0   255   255	RGB 0   255   0	RGB 153   255   0
HEX #0000ff	HEX #00ffff	HEX #00ff00	HEX #99ff00

**Labels:**

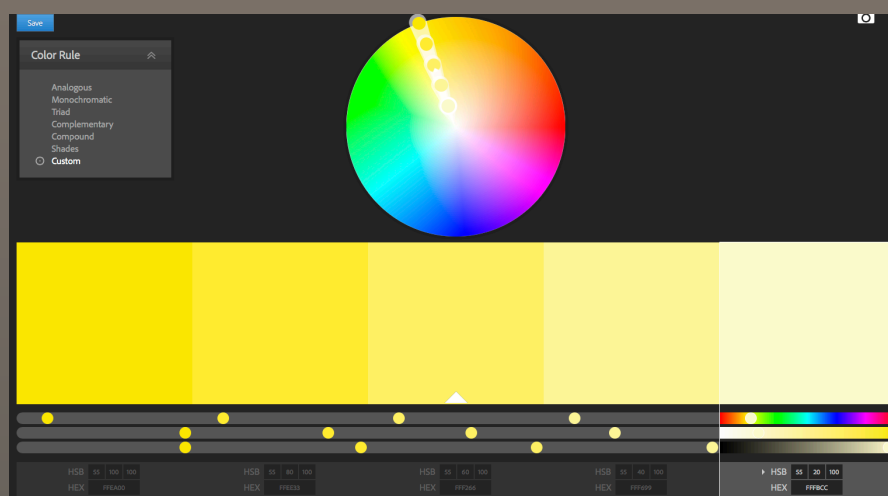
- WARM:** A white text label centered below the warm color palette.
- COOL:** A white text label centered above the cool color palette.
- all in full saturation:** A white text label centered at the bottom of the interface.

cool warm contrast  
convergent map

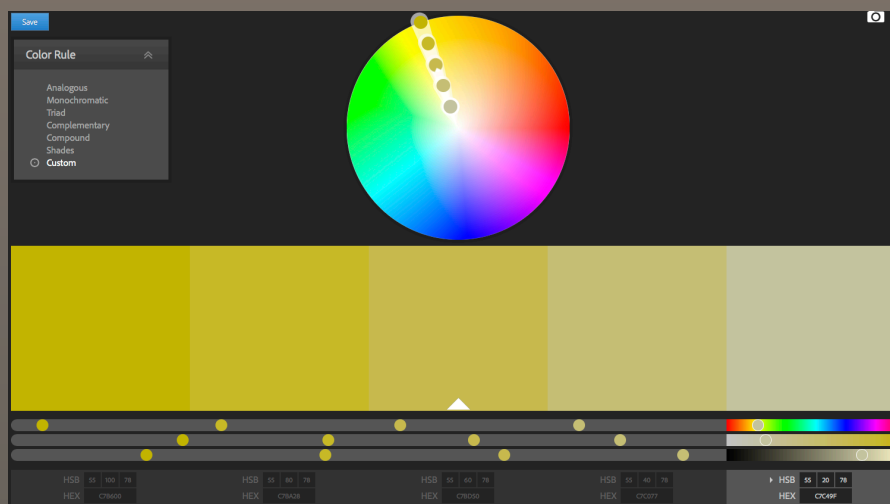


H3D integration time 96000

Saturation and Value are intertwined.

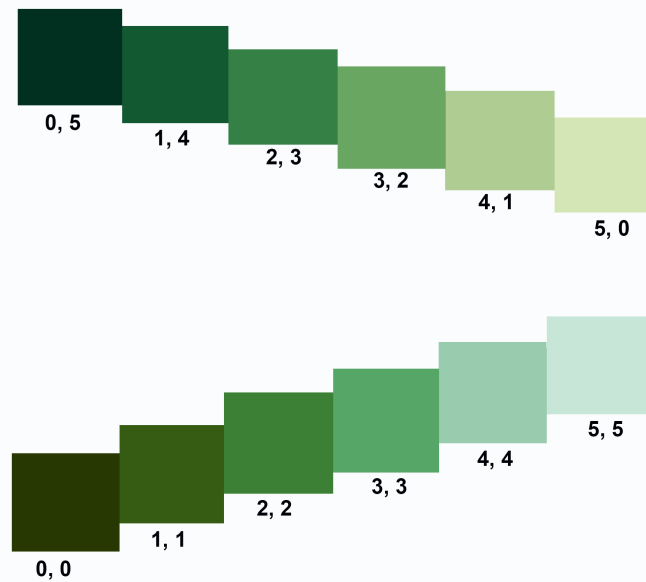
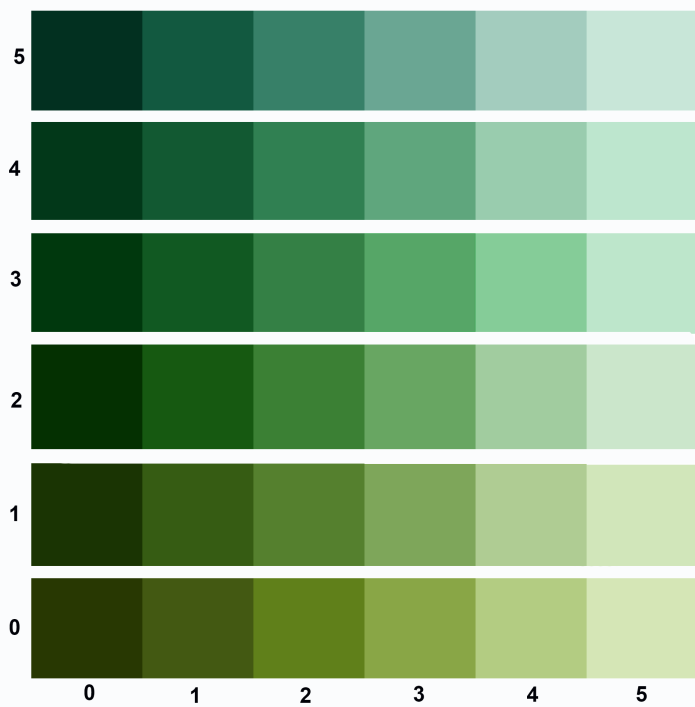


change in saturation and value.



change in saturation level ONLY.

Yellow is tricky because the saturation is so strongly and influenced by value changes.



Hue and Value Change

subtle variations in hue and contrast

perceptually but not numerically linear

Color Rule

- Analogous
- Monochromatic
- Triad
- Complementary
- Compound
- Shades
- Custom



Color	HSB	HEX
Light Yellow	56 23 96	F5F1BE
Yellow	41 51 100	FFD77E
Orange	29 67 97	F7A352
Dark Orange	19 79 87	DE652F
Red	9 84 73	BA341D

warm colors, increasing in saturation and value

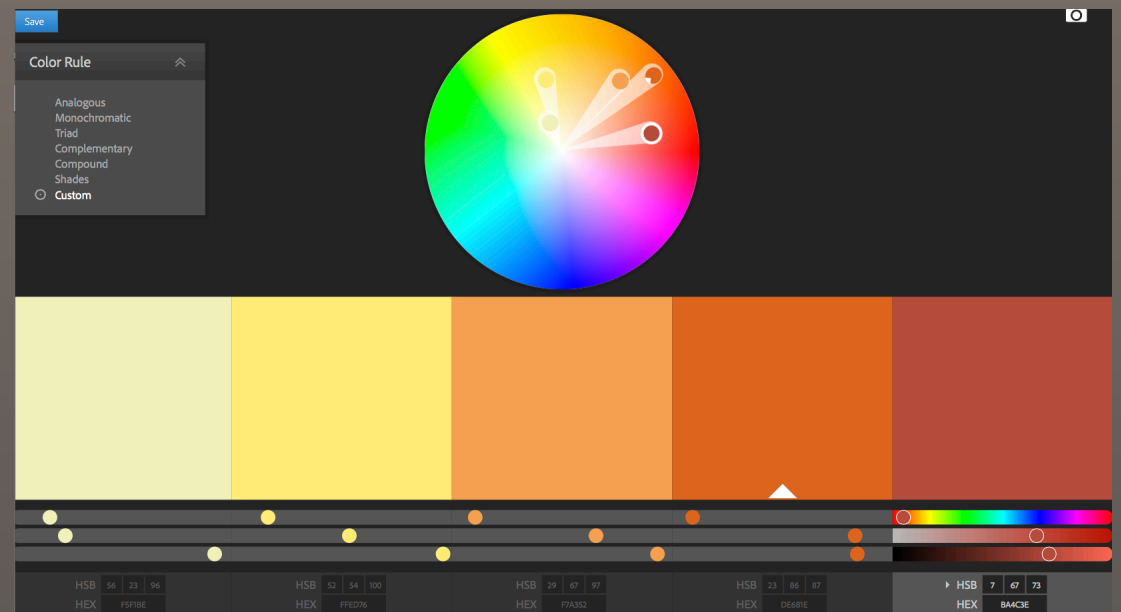
*Calm, subtle, multiple-variable contrast*

### Analogous Color close on the color wheel



### Weaving contrast

Combining harmony and contrast



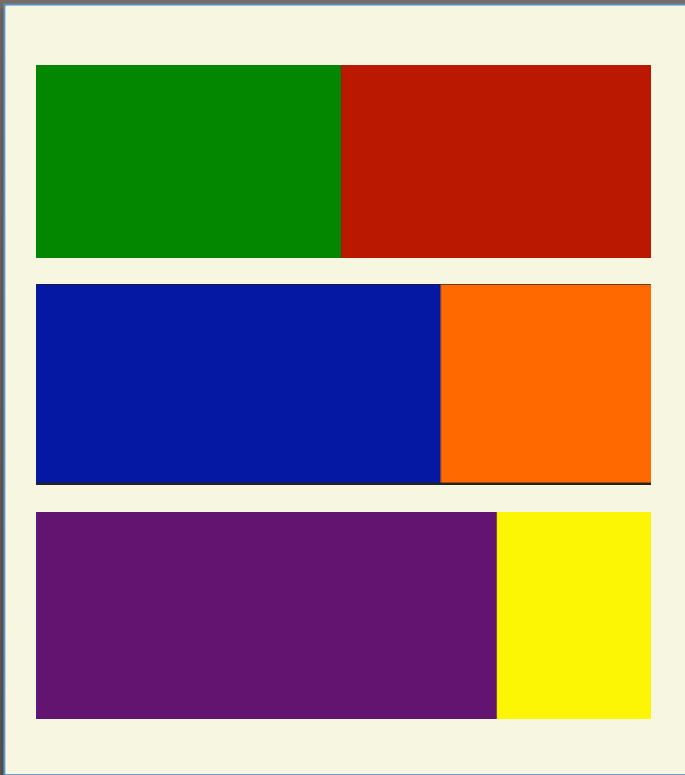
Weaving the saturation levels  
to increase contrast while controlling cacophony.



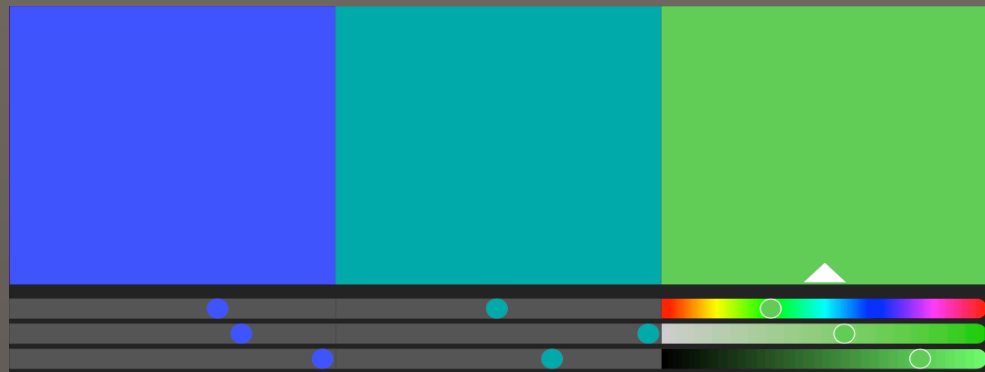
## Proportion

Balancing the natural intensity of color

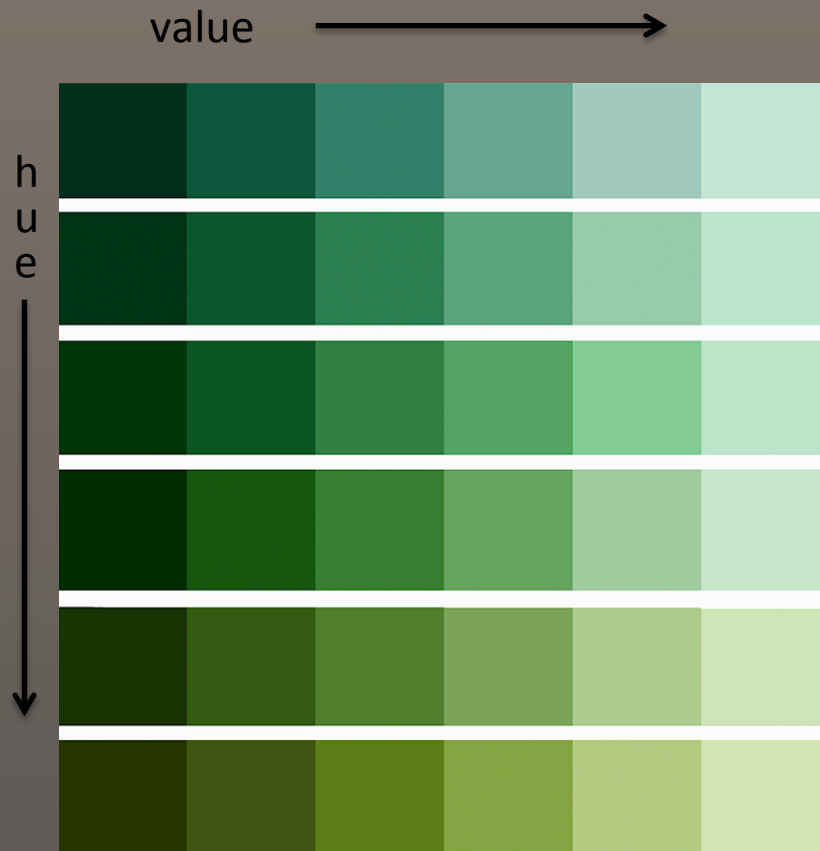
Think of color as sound. You are balancing the volume.



Equalizing the "volume" of the color

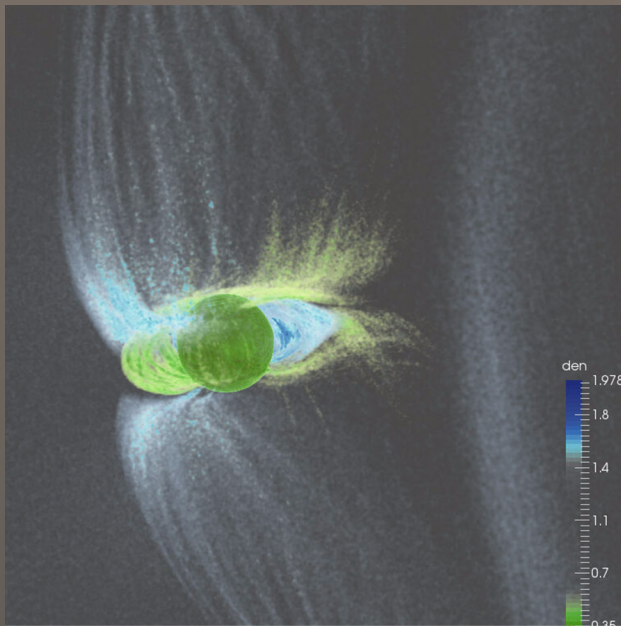


Balancing the proportion based on inherent color properties of the hue in that specific range

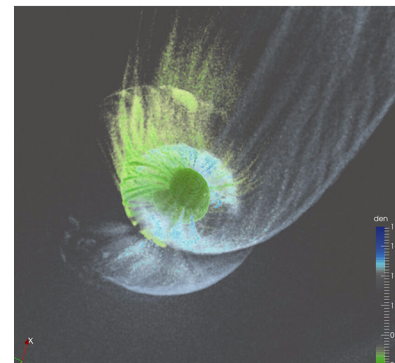
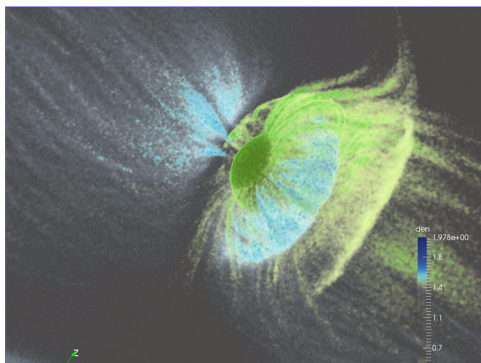
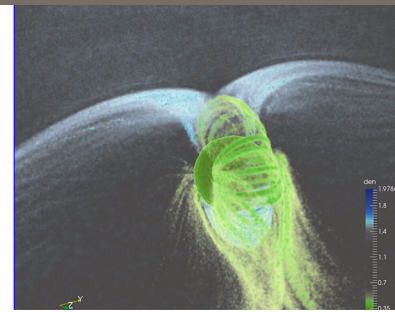
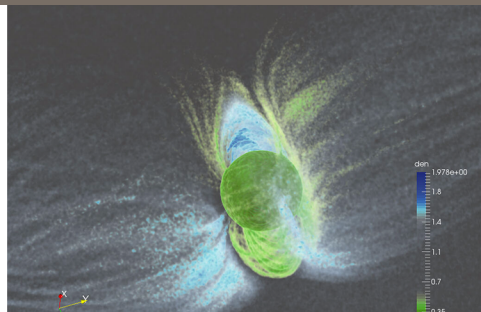


All of these characteristics occur within hues as well.

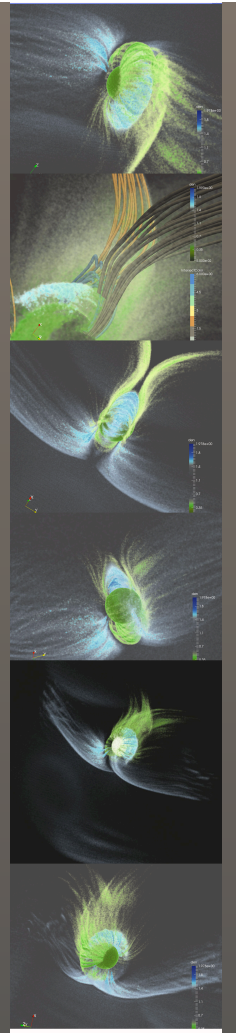
# Analogous color palette



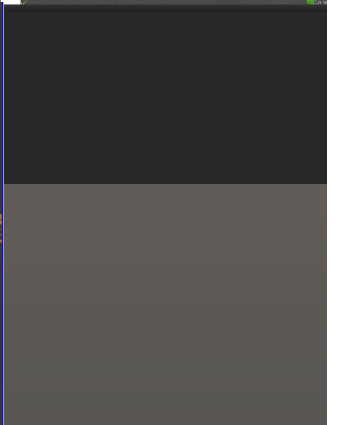
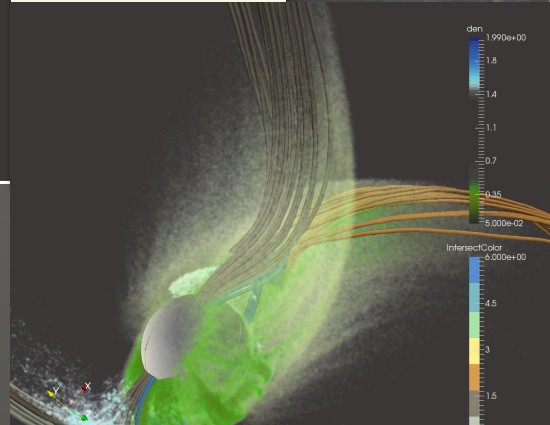
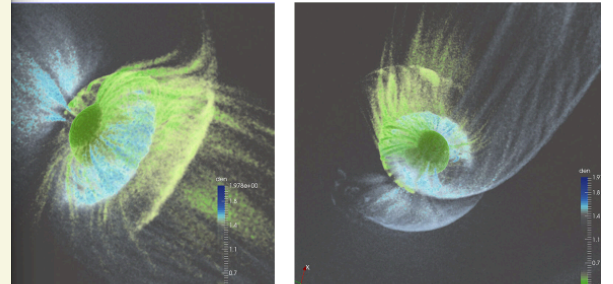
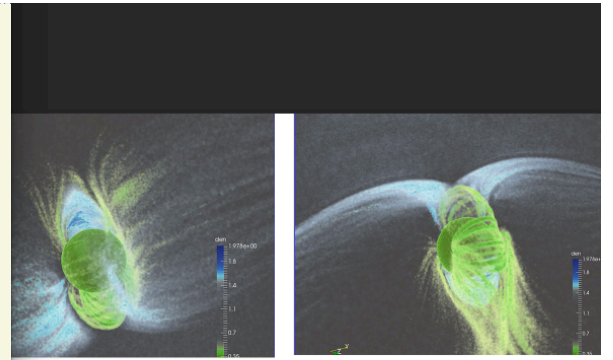
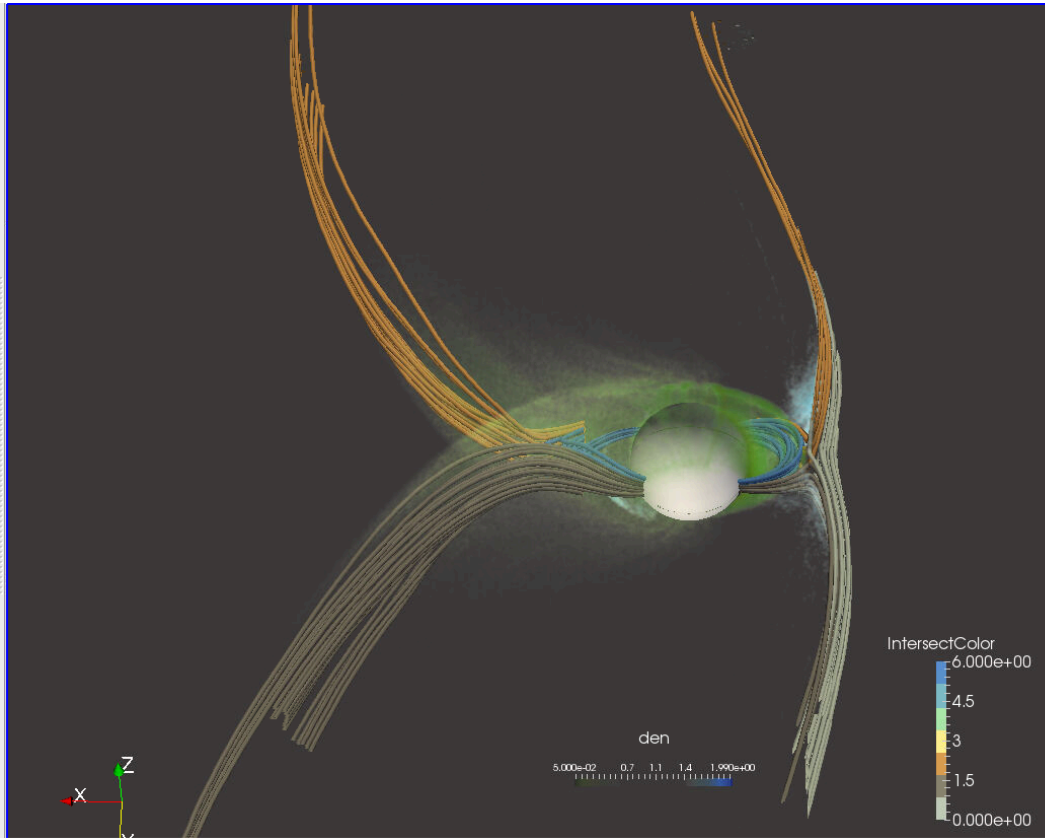
H3D density



variables of equal importance

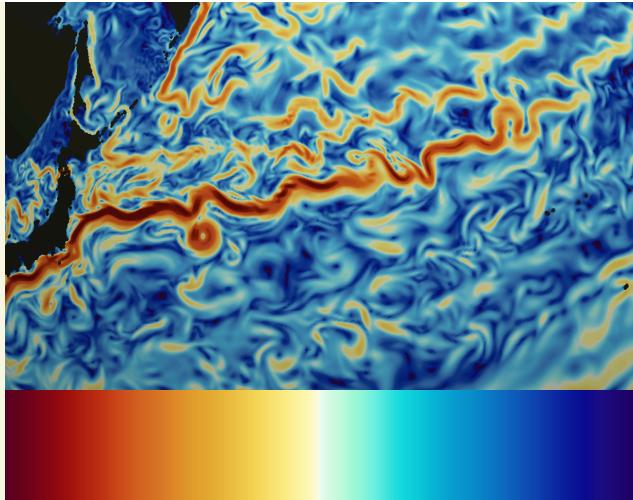
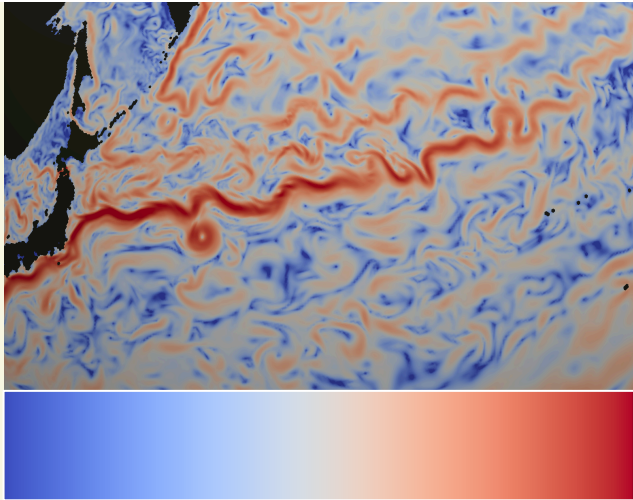


density and ?  
H3D Daughton, LANL

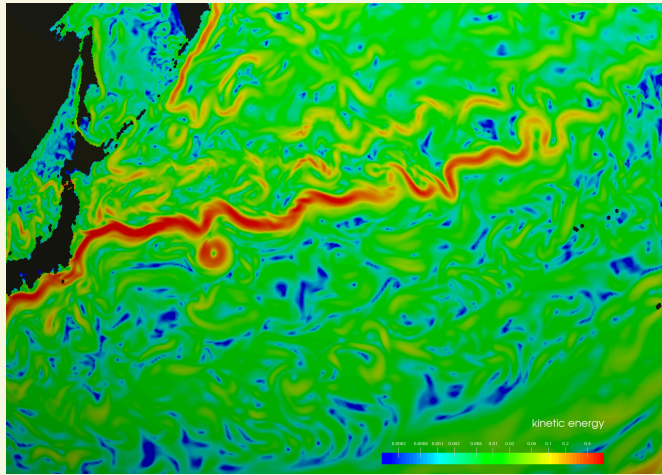


volume rendering - cool analogous color palette

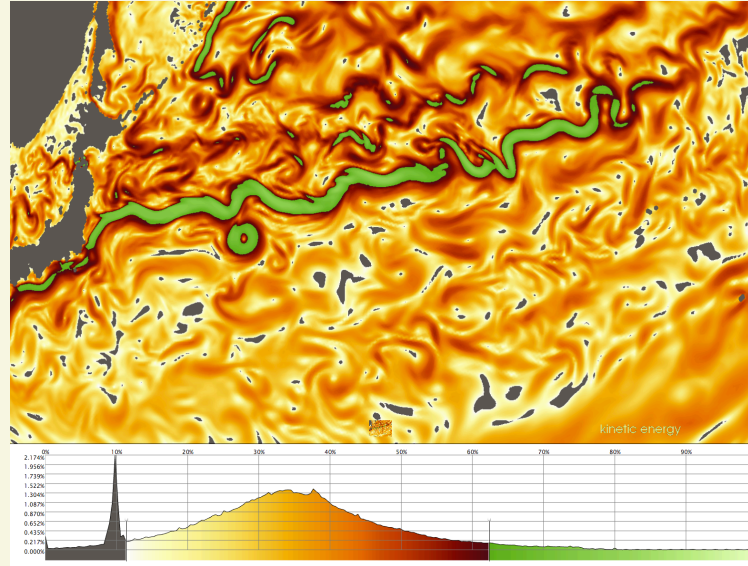
use a warm palette for the streamlines



increased saturation and hue ranges



isolating features via cool warm contrast



Van Eyck The Andolfini Wedding Portrait



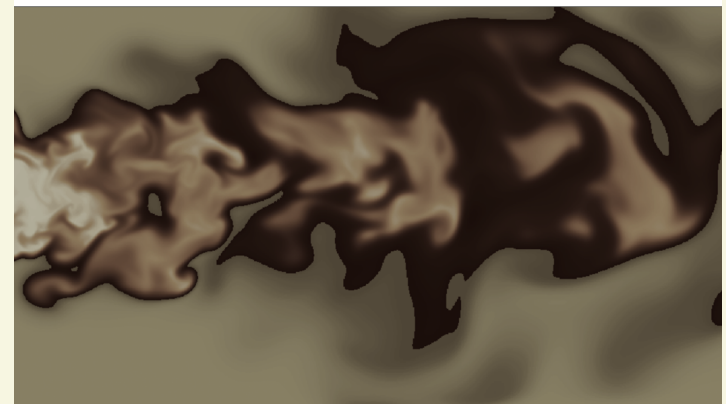
1



2



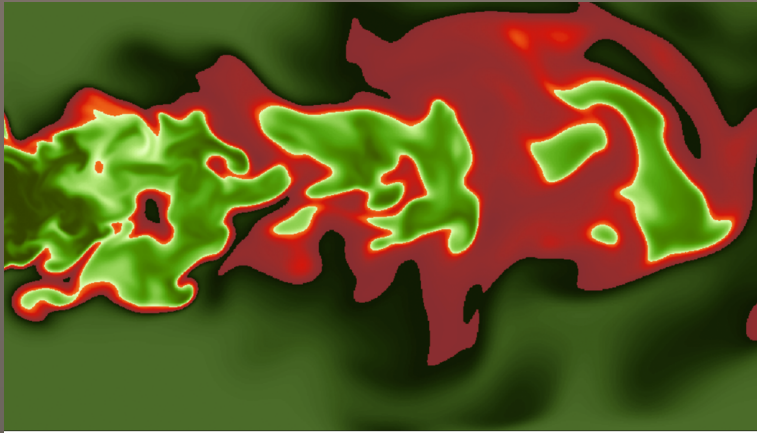
3



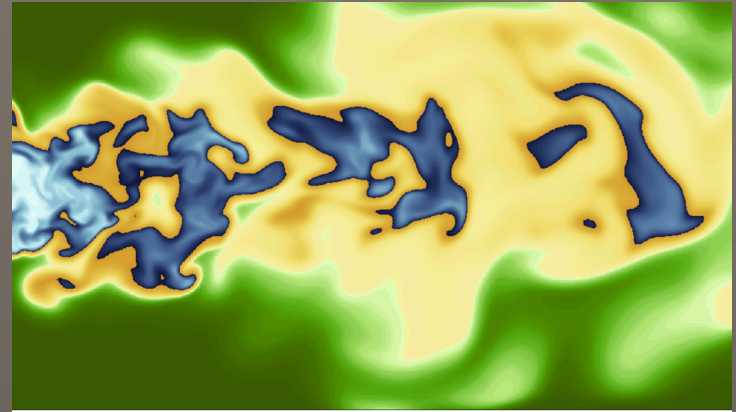
1. value contrast

2. complimentary and cool/warm contrast

3. analogous color



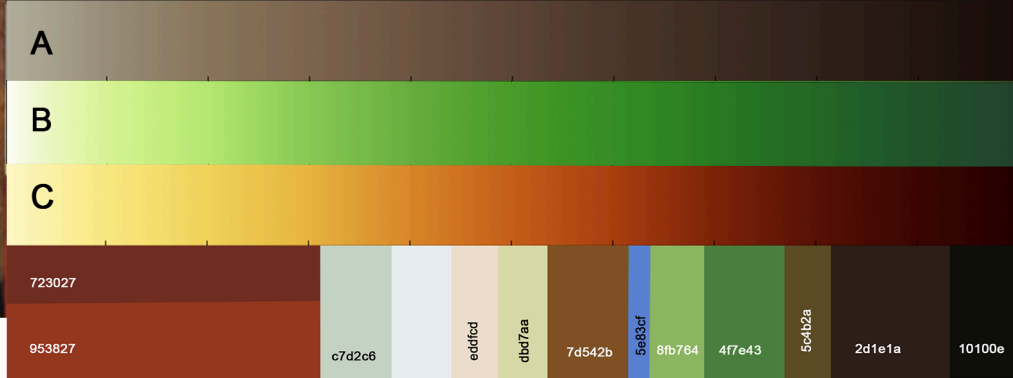
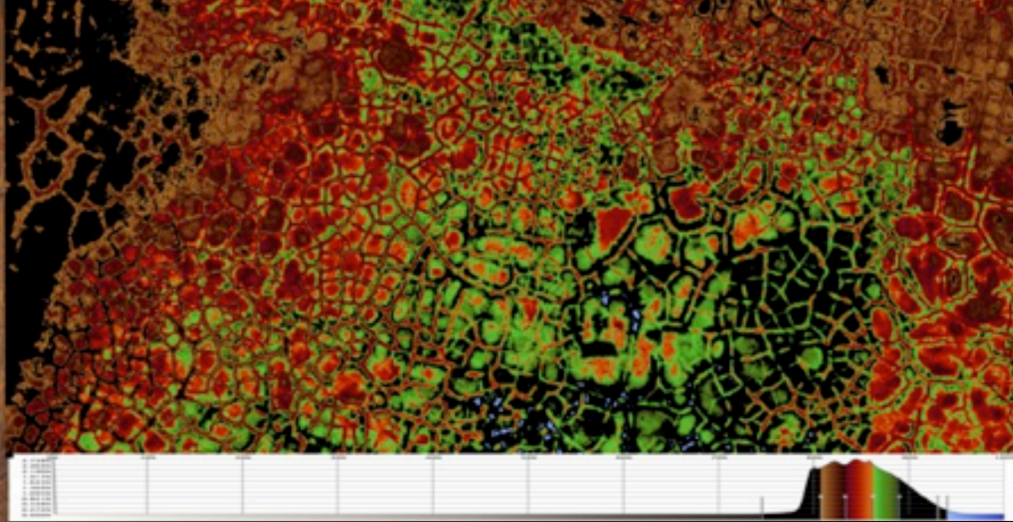
complimentary colors  
cool warm contrast



analogous color

Jan van Eyck *Anolfini Wedding Portrait*

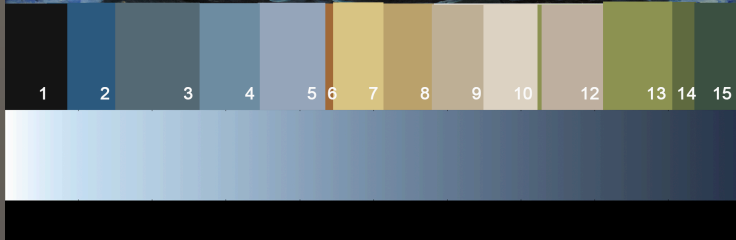
Arctic lidar data, C. Wilson



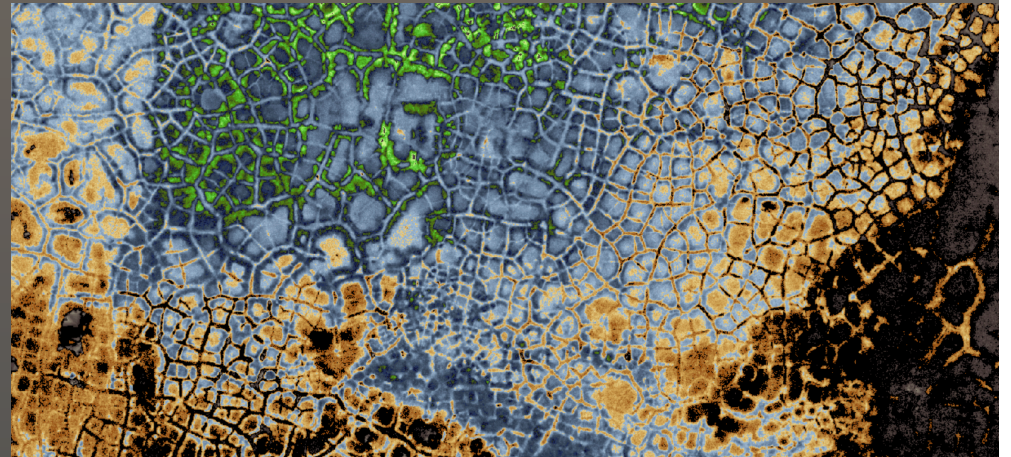
Colormaps: A. VanEyck Brown, B. 1028gr2, c. yel15

color palette on SciVisColor.org

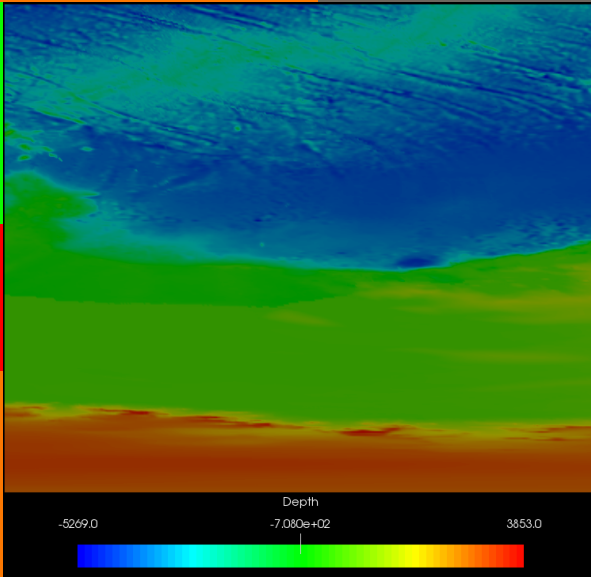




analogous palette  
calm palette  
linger a while



# Simultaneity of Color



Federal Research Projects

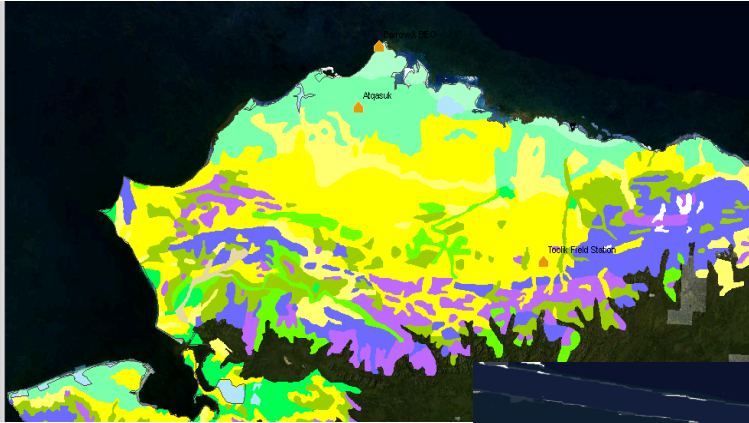
- ARCTIC LCC
- BLM
- BOEM
- EPA
- NASA
- NOAA
- NPS
- NSF
- USFWS
- USGS

State and Other Projects

- ADFG
- ADNDR
- BP
- CP
- DGGS
- GINA
- NSB
- PNR

Land

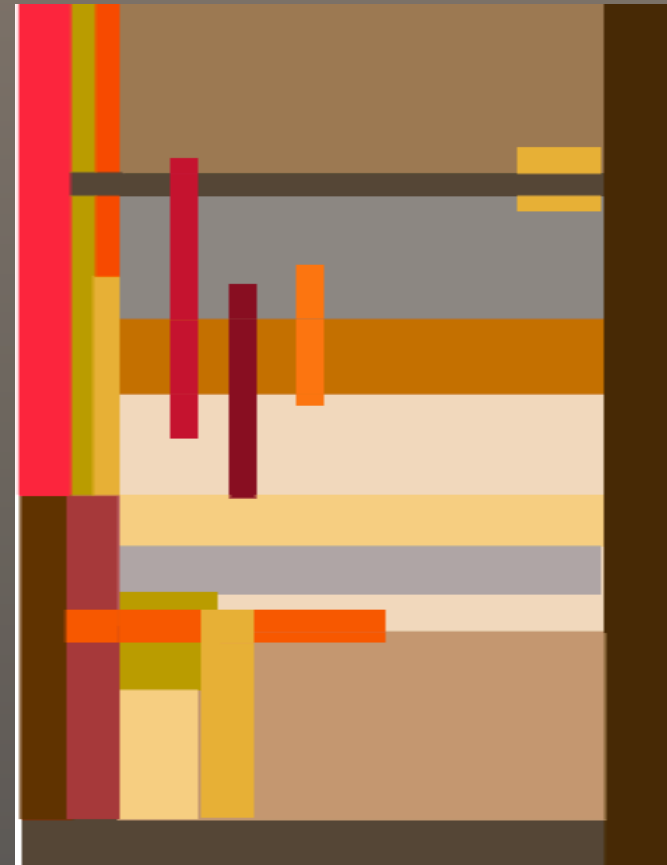
- Arctic Vegetation
- Glaciers
- Permafrost
- Terrestrial Biomes
- Tree Line



Decor choice #1?



Or an environment for thinking ?



Clarity without cacophony, that's the goal.

It is a matter of degree,  
degree of contrast,  
degree of intensity.

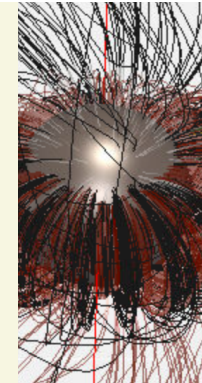
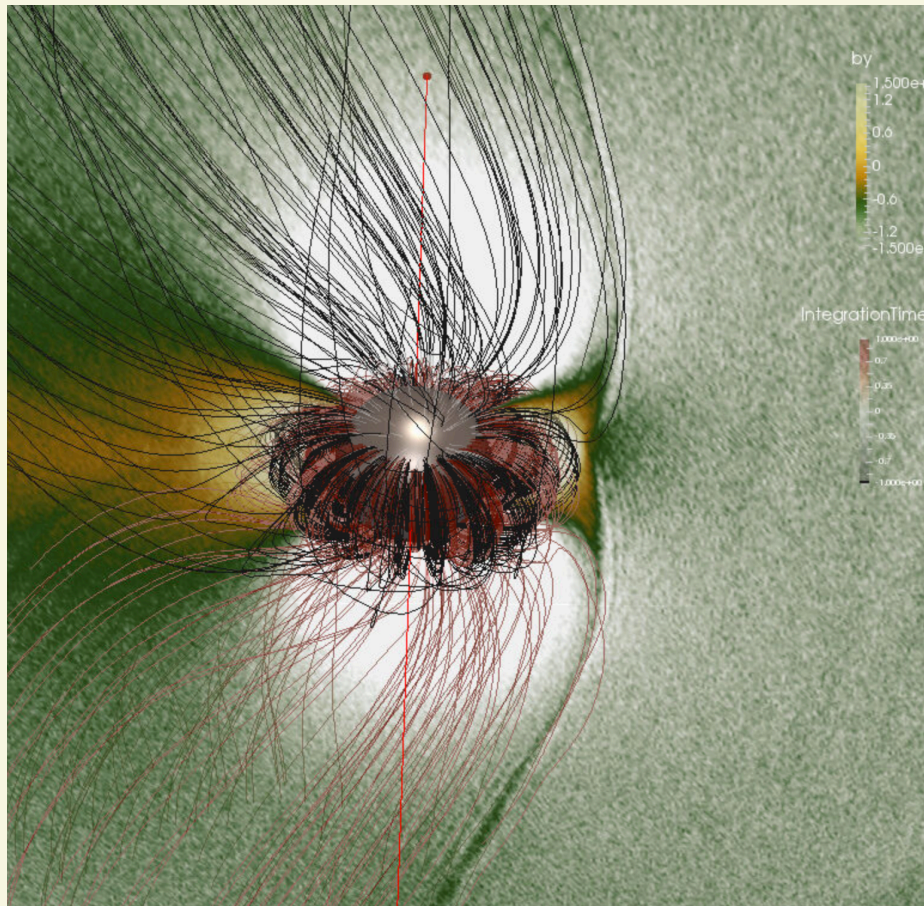


High intensity lowers the  
potential range of contrast.  
It is the budget issue.



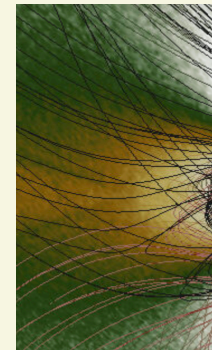
Low intensity provides  
wide range of contrast.

## Employing multiple types of contrast

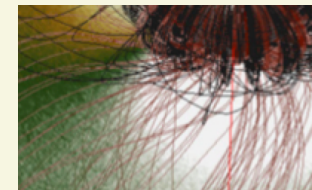


saturation  
and  
value

analogous  
color



complimentary  
color



# Neutrals

the power  
of neutrals

a little color goes  
a long way



neutral gray

cool gray

warm gray

dark warm gray

medium cool blue gray

ochre

warm taupe

light cool gray taupe

dark cool green gray

medium warm gray

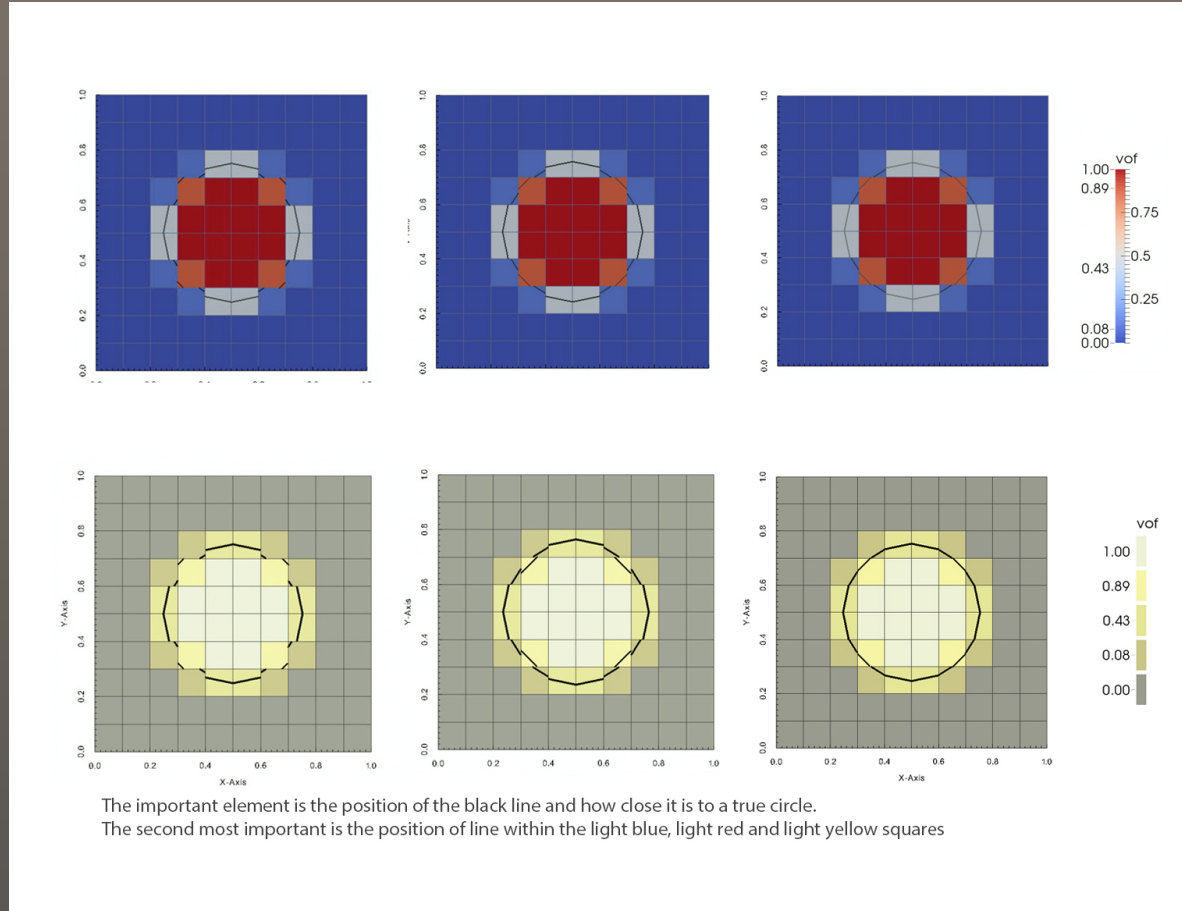
Grays frame the focus colors.



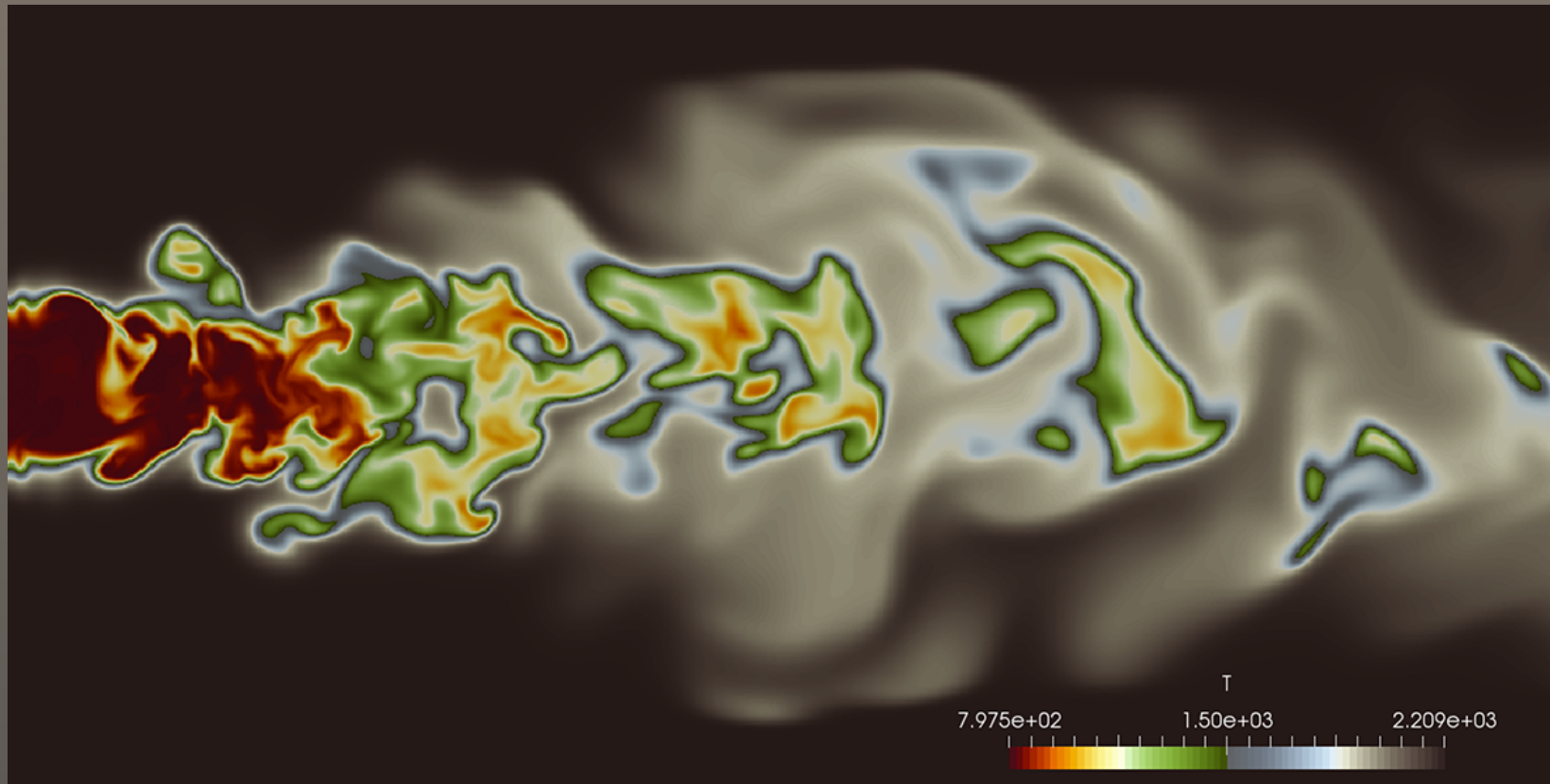
# Using neutral colors to maximize contrast and focus attention

Contrast  
where you need it.

Minimize  
color volume.

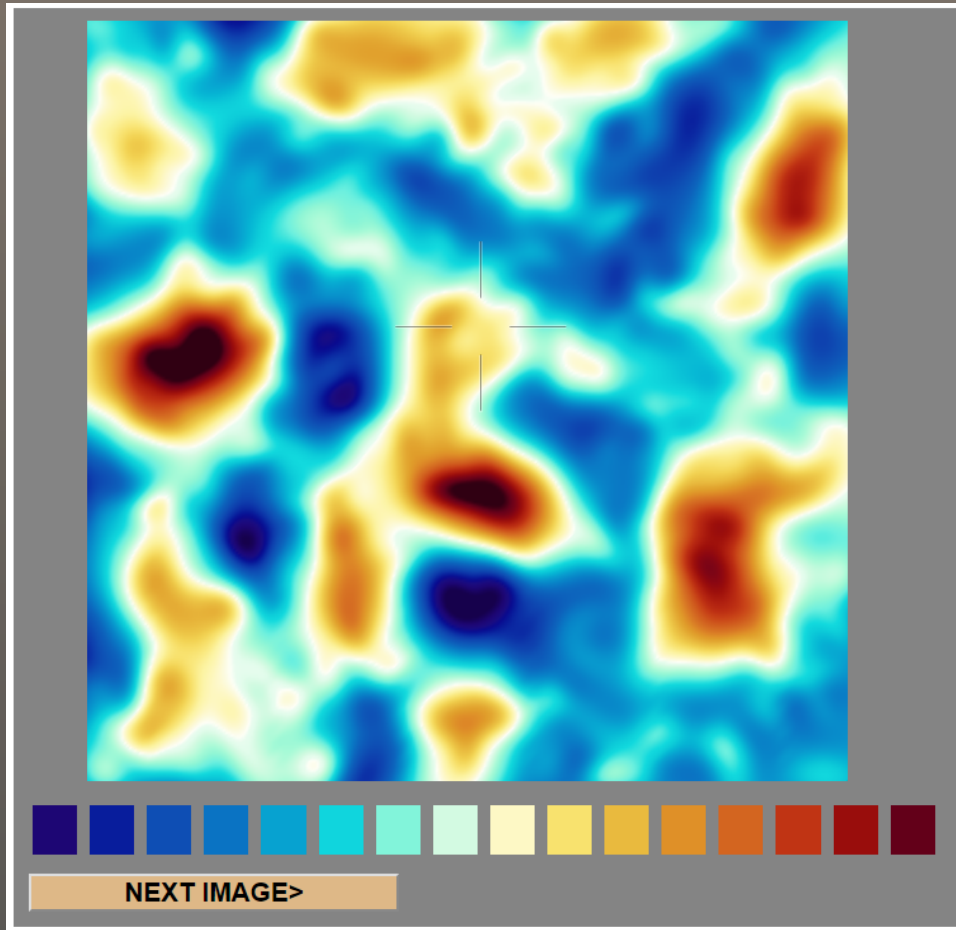


red is important, gray is not...

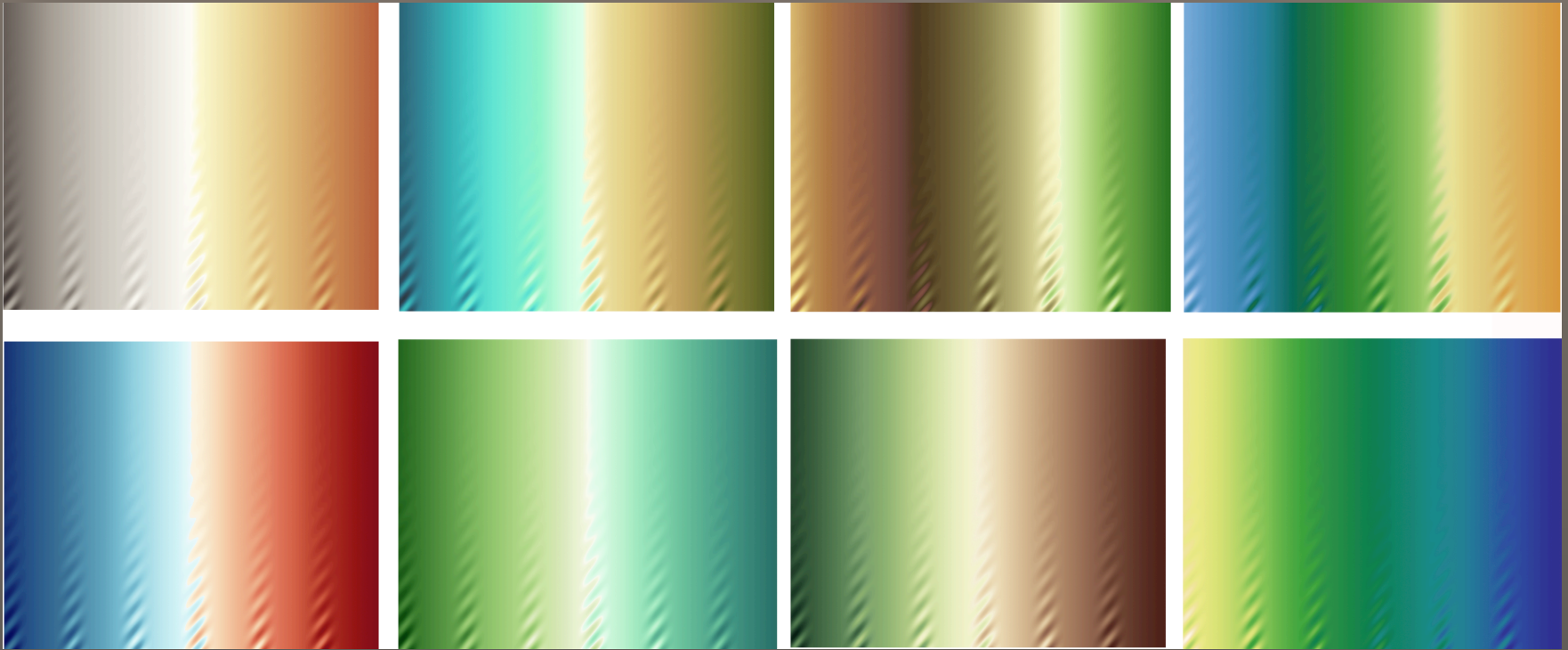


cool warm and muted cool warm

## Colormap testing



All recommendations are based on user testing and or basic color theory principles.



Testing for resolving power.

## The Rules:

**Cognitively** you have a **contrast budget**.

Use only what you need and you will not go hungry.

Neutral colors are your friend.

Two types of contrast are stronger than one.

**Follow contrast hierarchy:**

1. value / luminance
2. cool / warm
3. everything else

Your **background** choice is as important as your colormap.