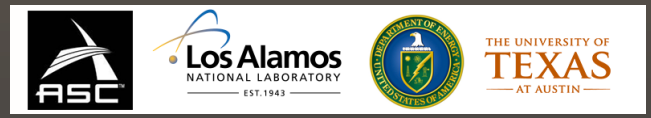
1. **Color Theory Principals**

that assist in creating effective of visualizations

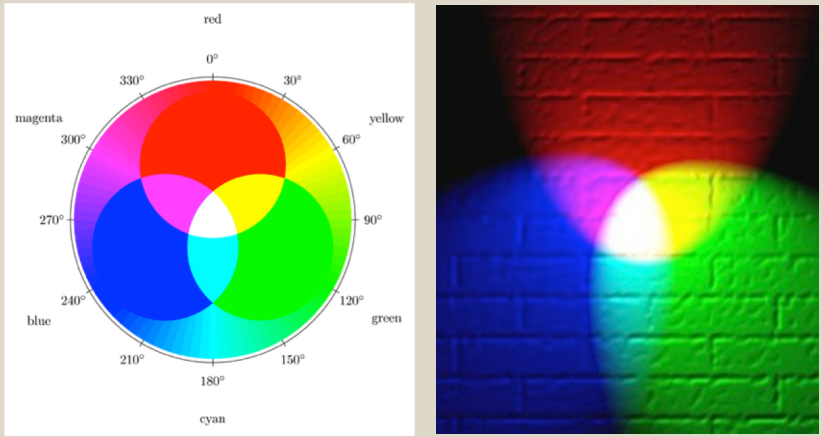
Color Contrast Theory overview,
applied visualization examples and
recommended color schemes and sets for specific uses

Francesca Samsel, UT



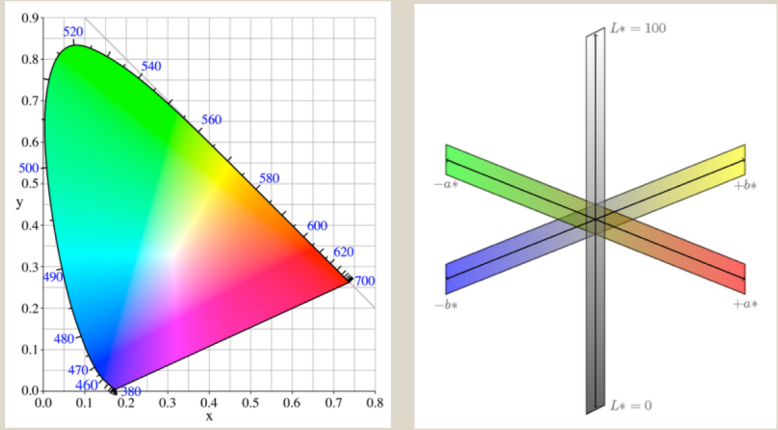
Color Spaces

RGB



RGB color space

CIE LAB



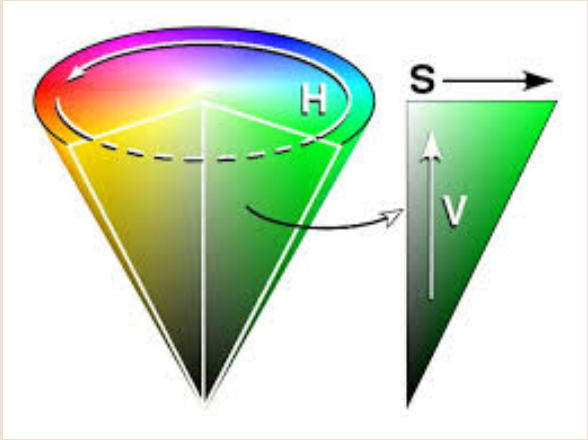
CIE LAB space

RGB is computer color space.

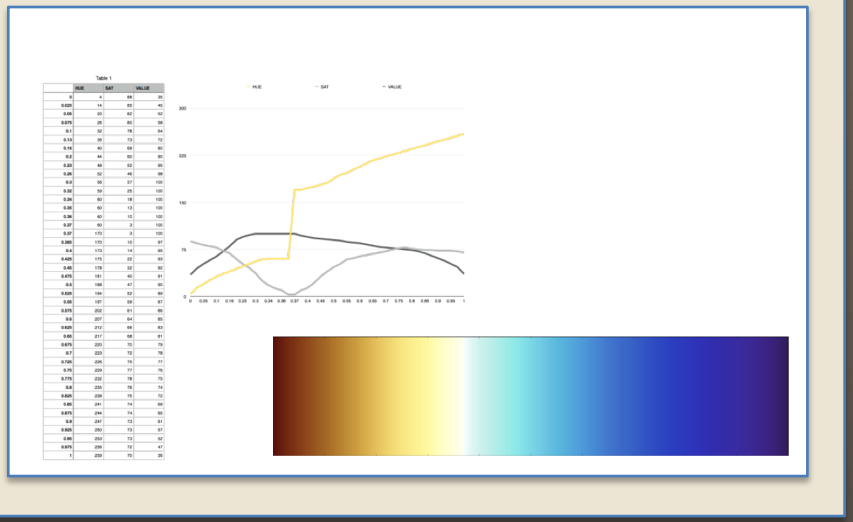
CIE LAB space, for perceptual accurate, is *the best interpolation space*.

Hue, Saturation and Value

the human color space



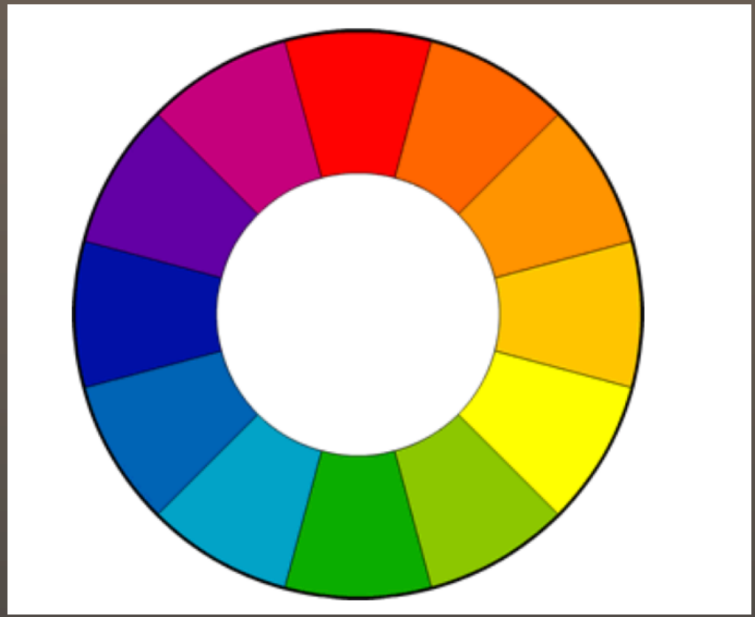
HSV, HSB color space



It provides the ability to make subtle adjustments in the human color language.

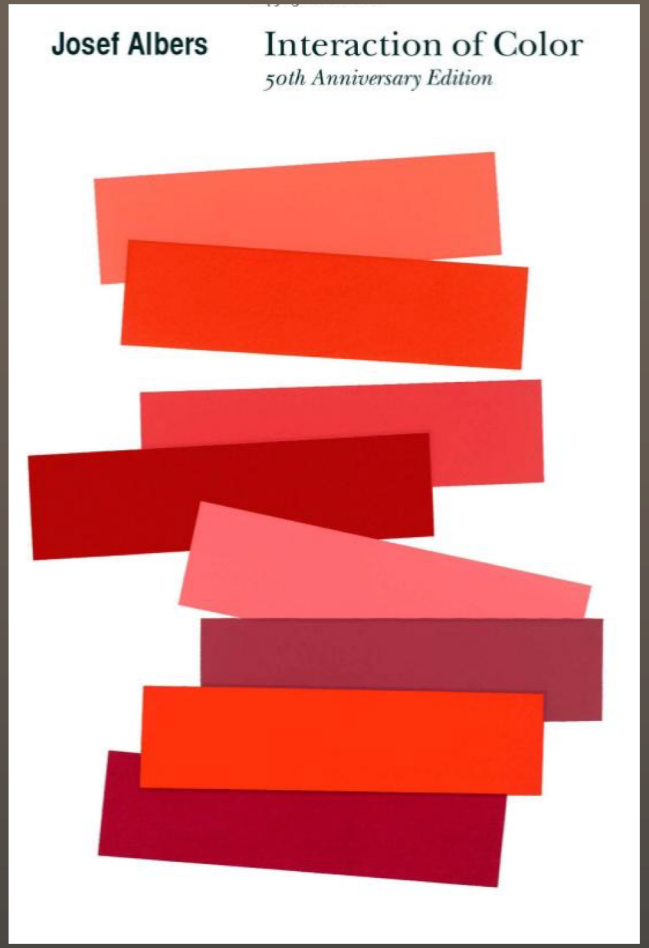
Hue, Saturation and Value -- The language of color theory.

Color Theory 101



Color is complicated because adjacent colors significantly impact our perception.

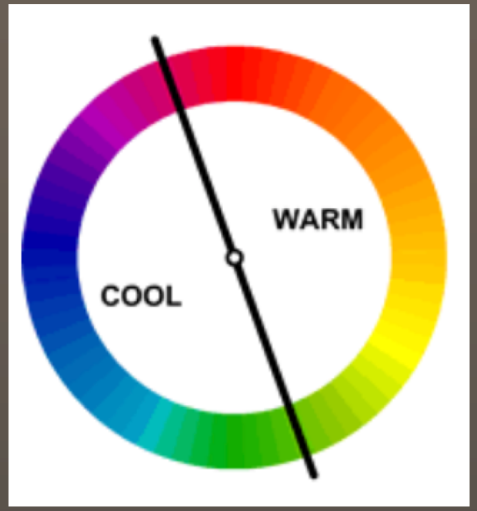
Advise:
Keep your color palettes simple…
or steal them from a pro.



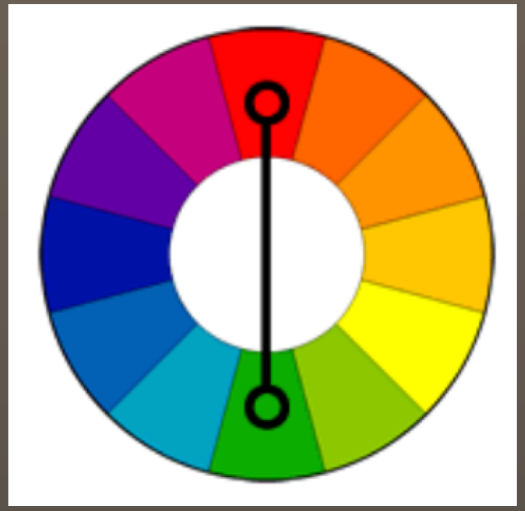
It is about **contrast,** not **color**.

- contrast type
- contrast level
- contrast organization

Types of Contrast



cool / warm colors



complimentary colors

analogous color

color contrast types

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

and….unifying contrast
analogous color

Hue: What color is it? – red, blue, yellow

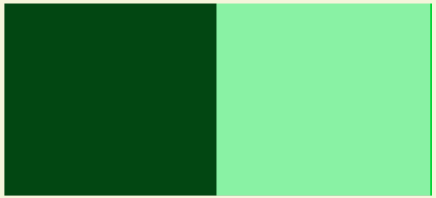
Terms – Hue, Saturation, Value (luminance)

Hue

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

Value

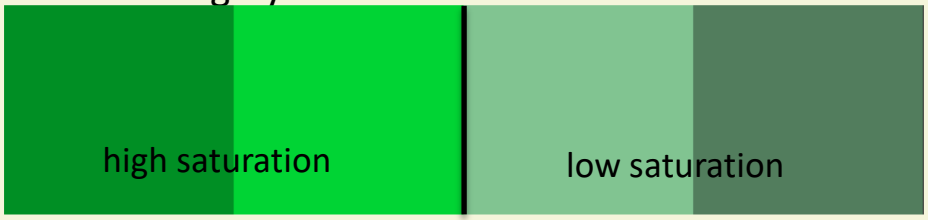
Is it light or dark?



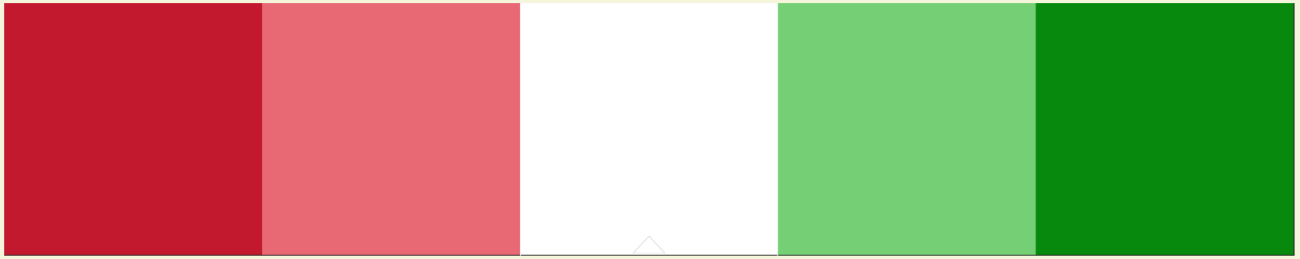
Saturation

How pure is it?

How much gray does it have in it?



Complimentary Colors

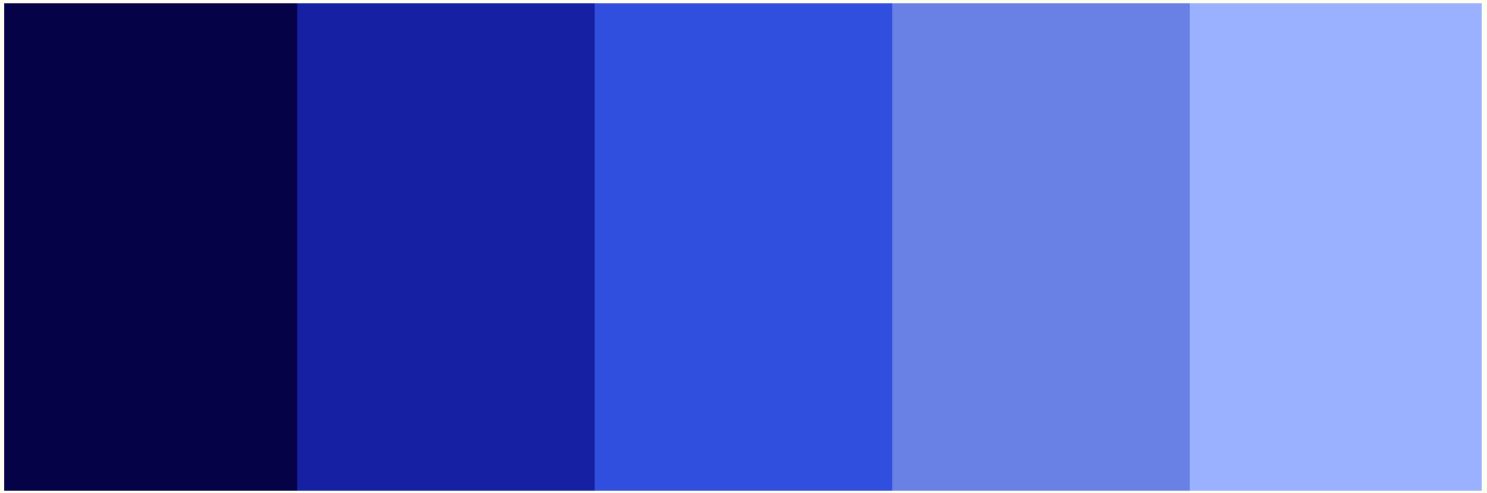


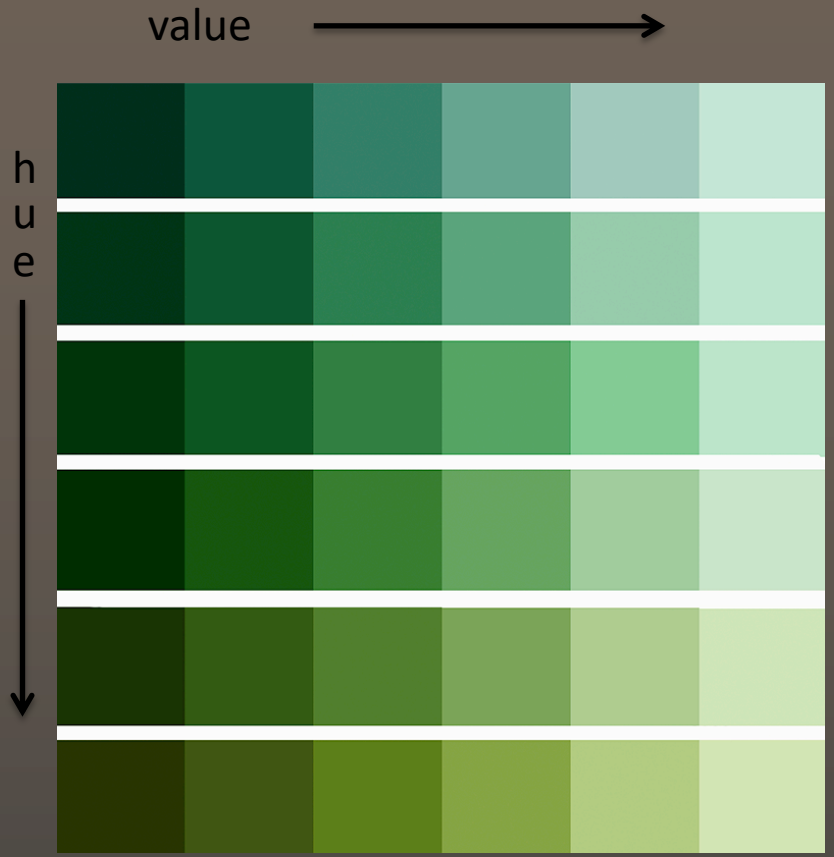
Analogous Colors

muted compliments

Value

light to dark

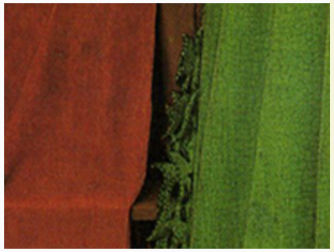




All of these characteristics occur within hues as well.

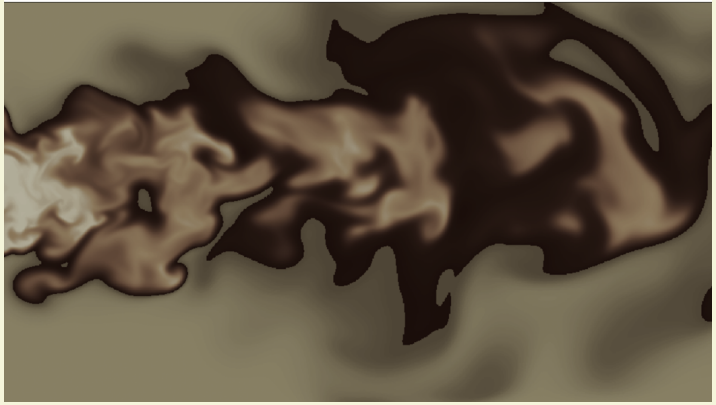
Van Eyck The Andolfini Wedding Portrait

1

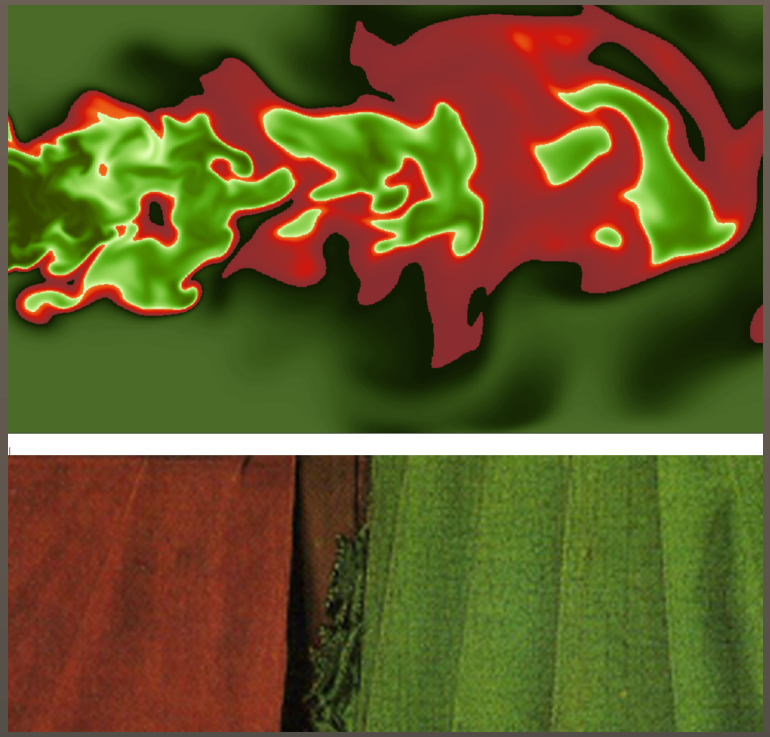


2

3



1. value contrast 2. complimentary and cool/warm contrast 3. analogous color

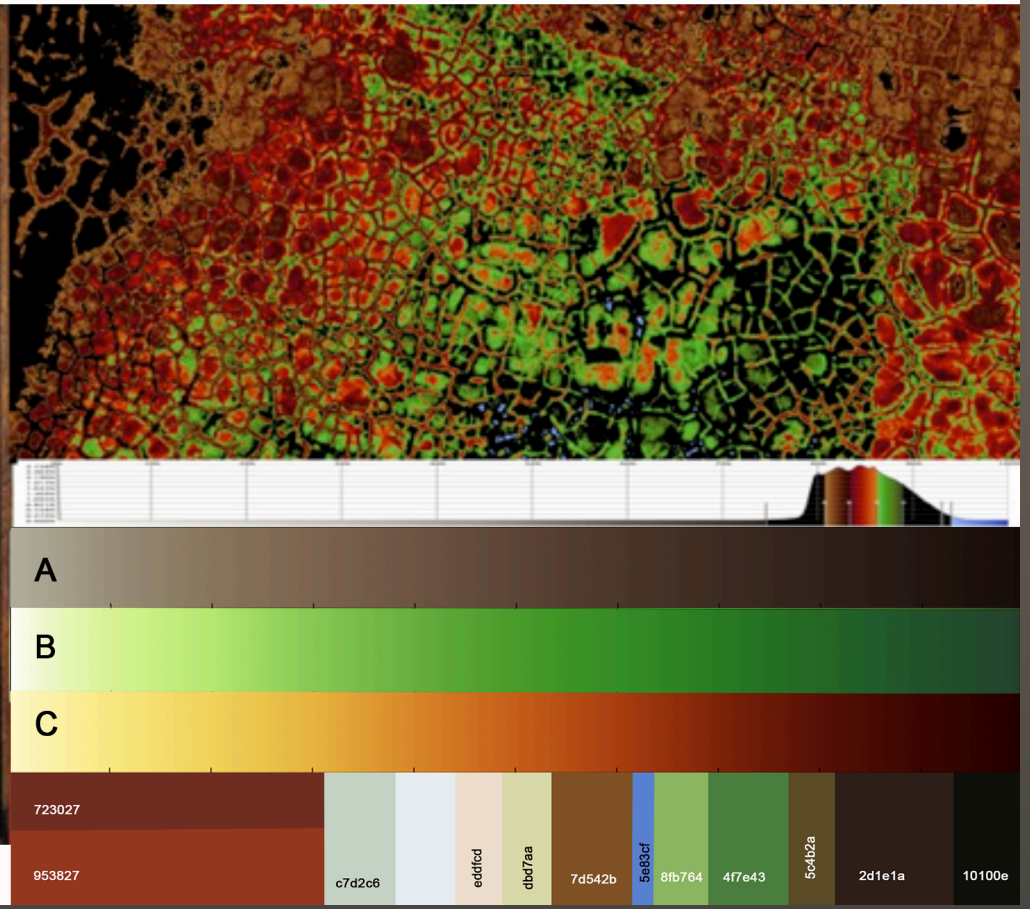


complimentary colors
cool warm contrast

analogous color

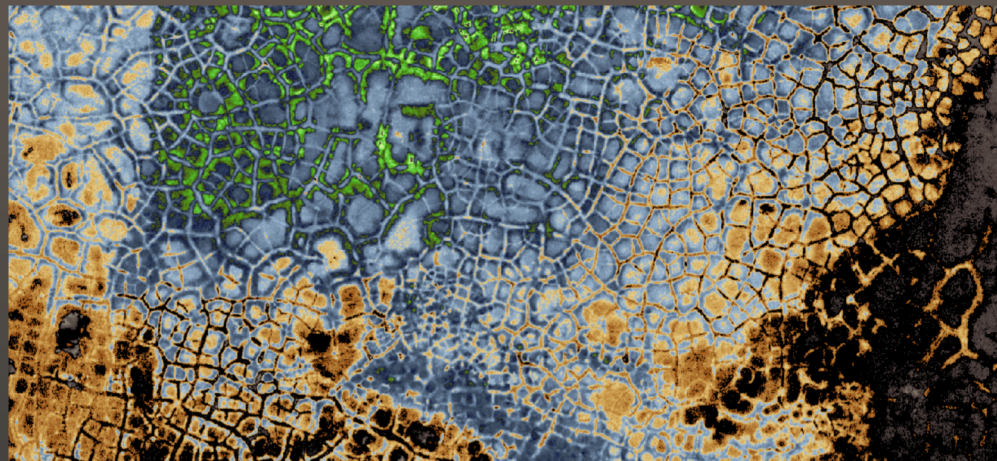
Jan van Eyck *Anolfini Wedding Portrait*

Arctic lidar data, C. Wilson



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

analogous palette
calm palette
linger a while



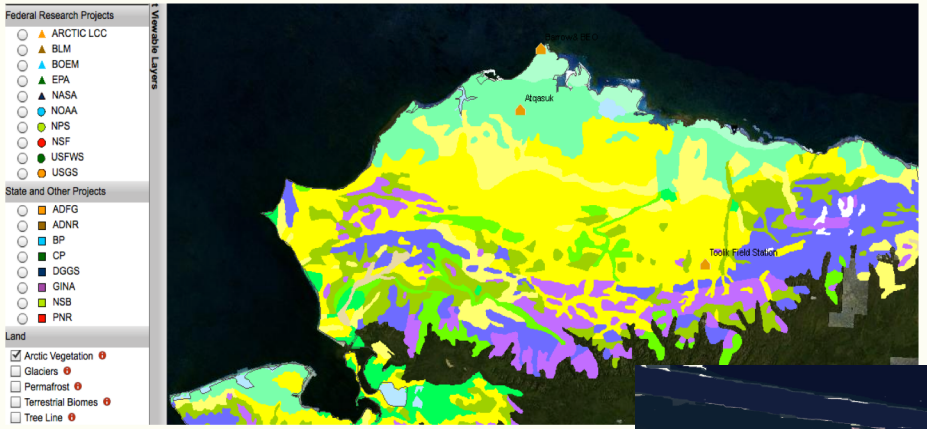
The Rules:

Contrast hierarchy:
1. value / luminance
2. cool / warm
3. everything else

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

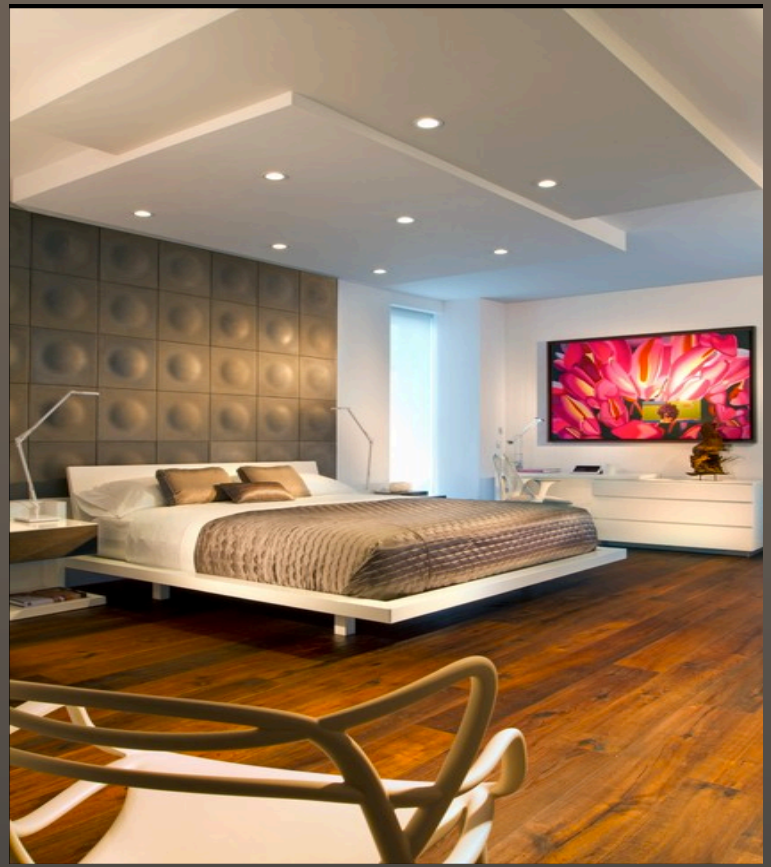
Two types of contrast are stronger than one.

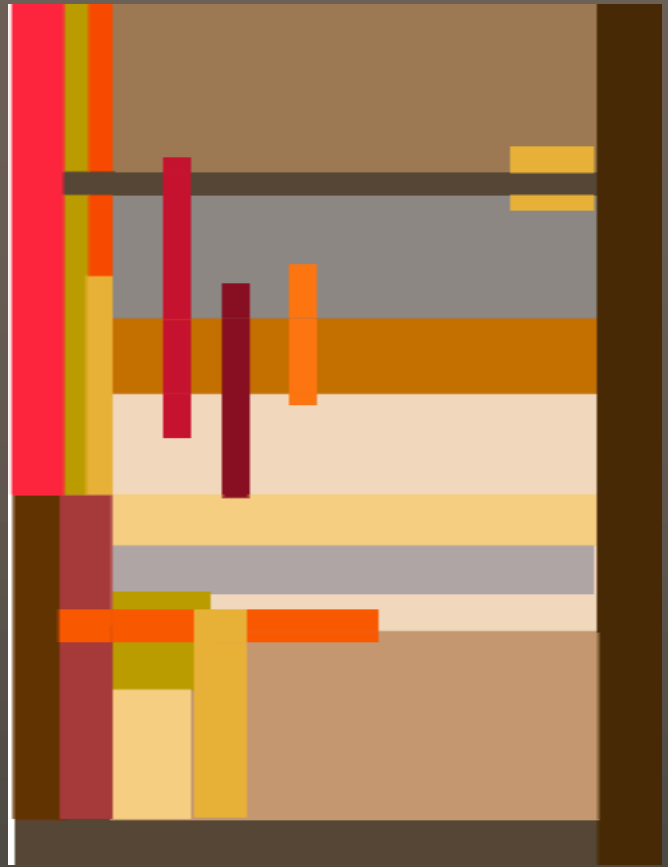
Cognitively you have a **contrast budget**.
Use only what you need and you will not go hungry.
Neutral colors are your friend.



Decor choice #1?

Or an environment for thinking ?

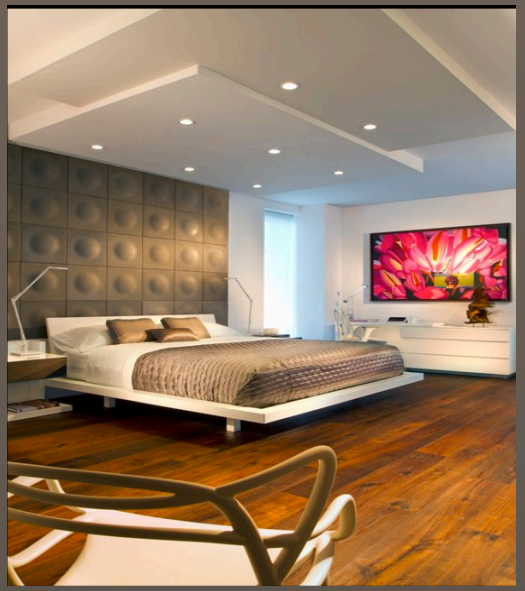




Clarity without cacophony, that's the goal.

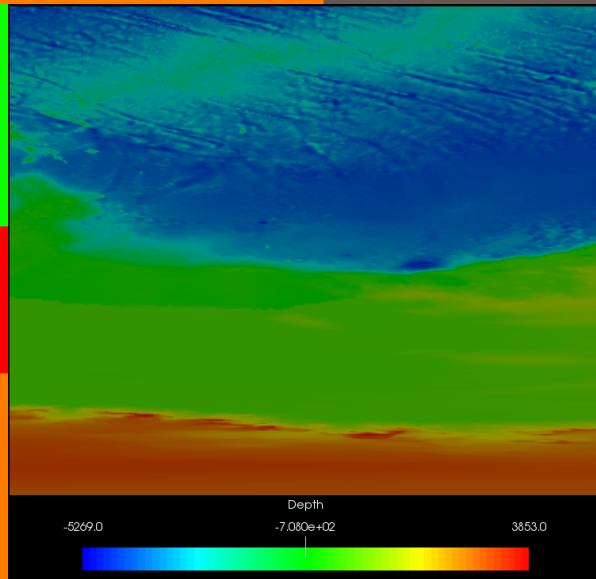
It is a matter of degree,
degree of contrast,
degree of intensity.

High intensity lowers the
potential range of contrast.
It is a matter of allocating the contrast budget.



Low intensity provides
leaves room for a
wide range of contrast.

Simultaneity of Color



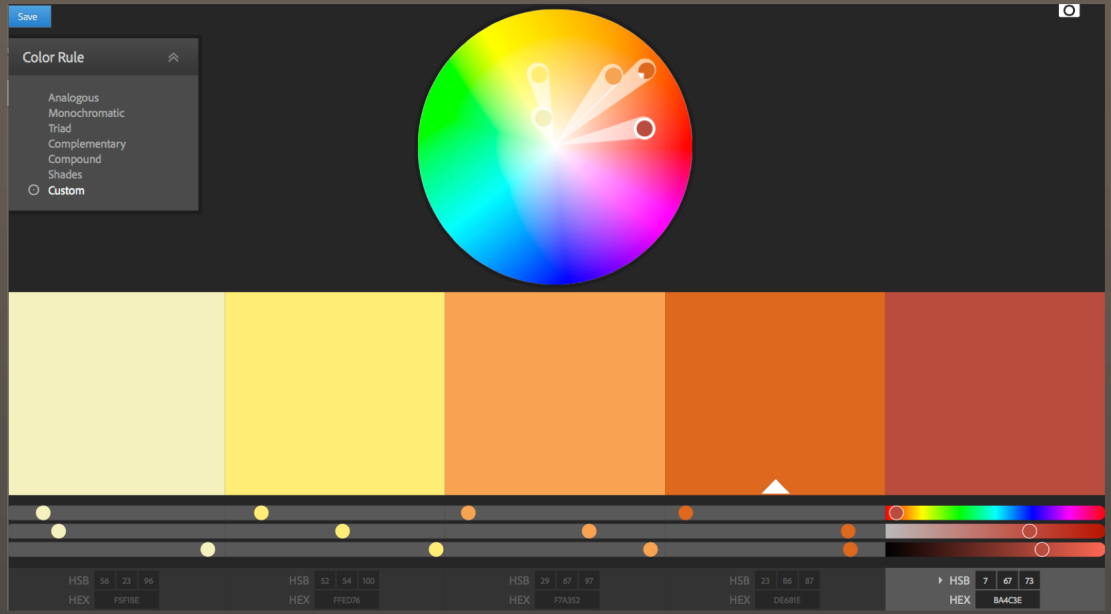
Calm, subtle, multiple-variable contrast

Analogous Color

close on the color wheel

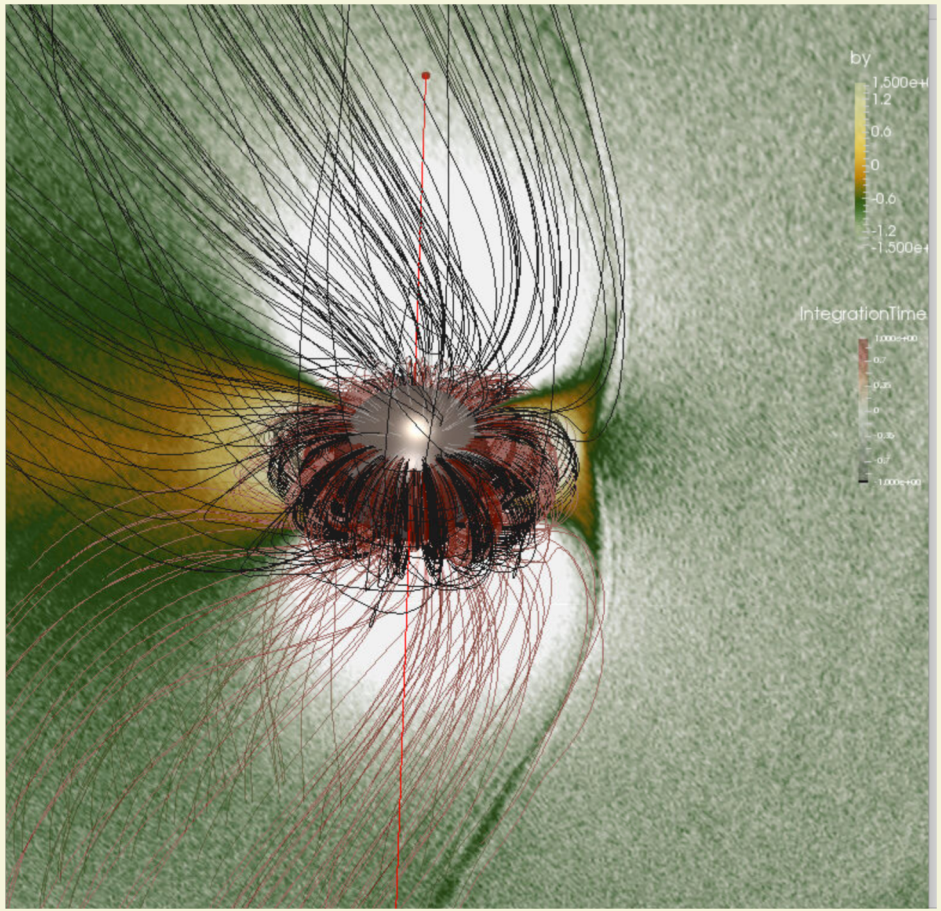
Weaving contrast

Combining harmony and contrast



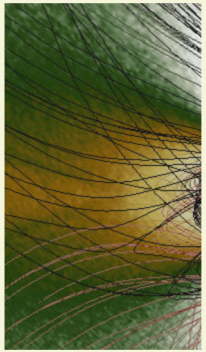
Weaving the saturation levels
to increase contrast while controlling cacophony.

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

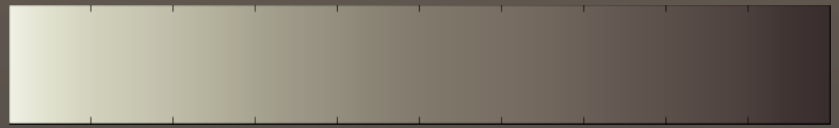
ochre

warm taupe

light cool gray taupe

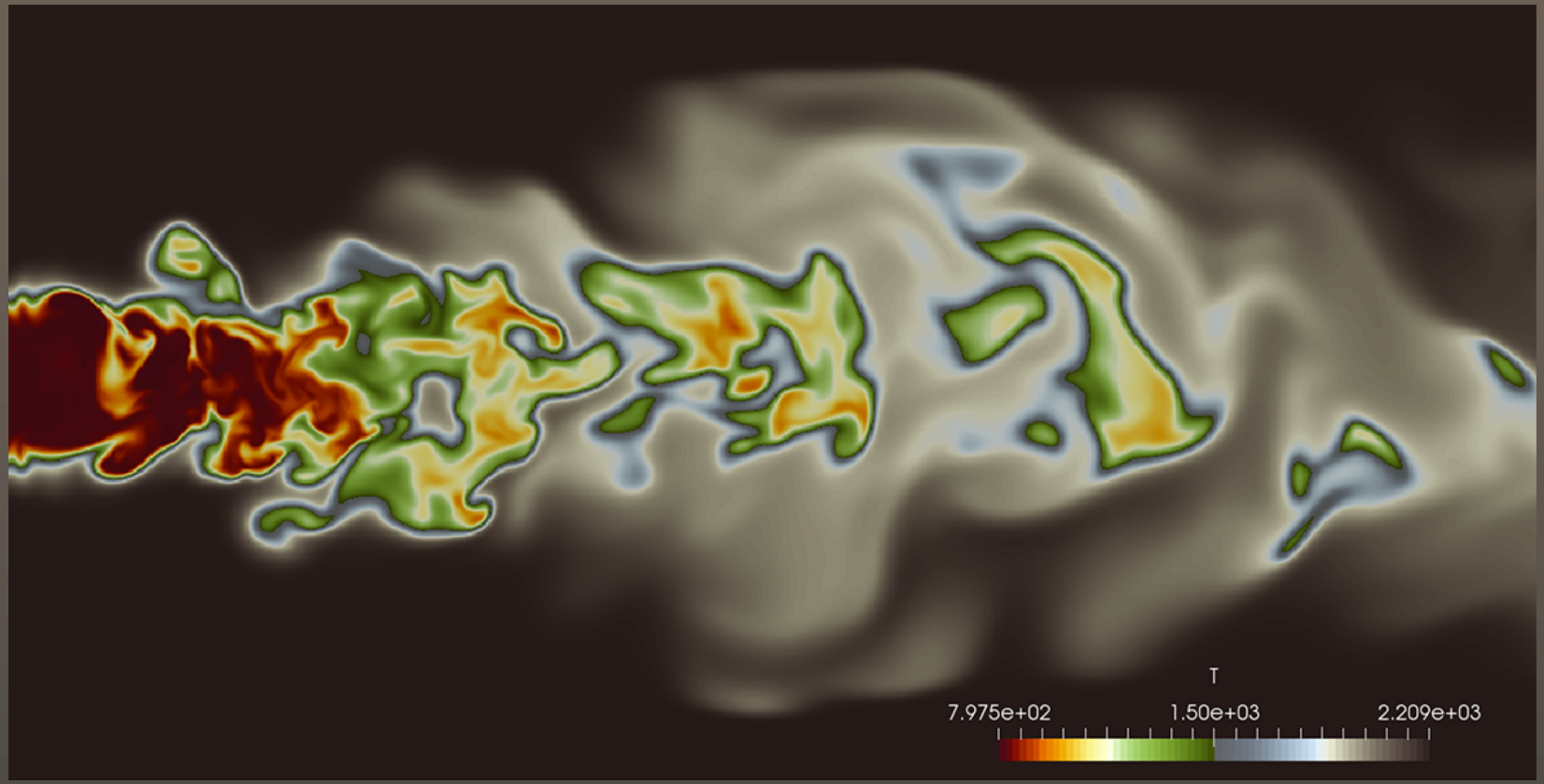
dark cool green gray

medium warm gray



Grays frame the focus colors.

red is important, gray is not….

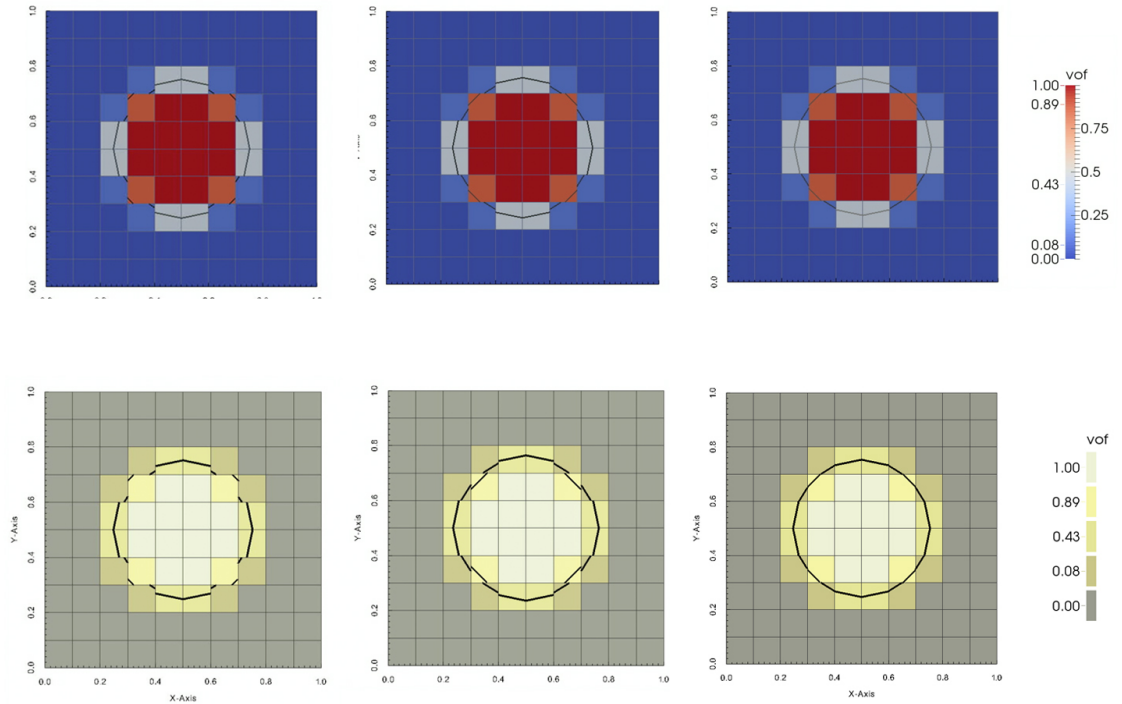


cool warm and muted cool warm

Let's get practical.

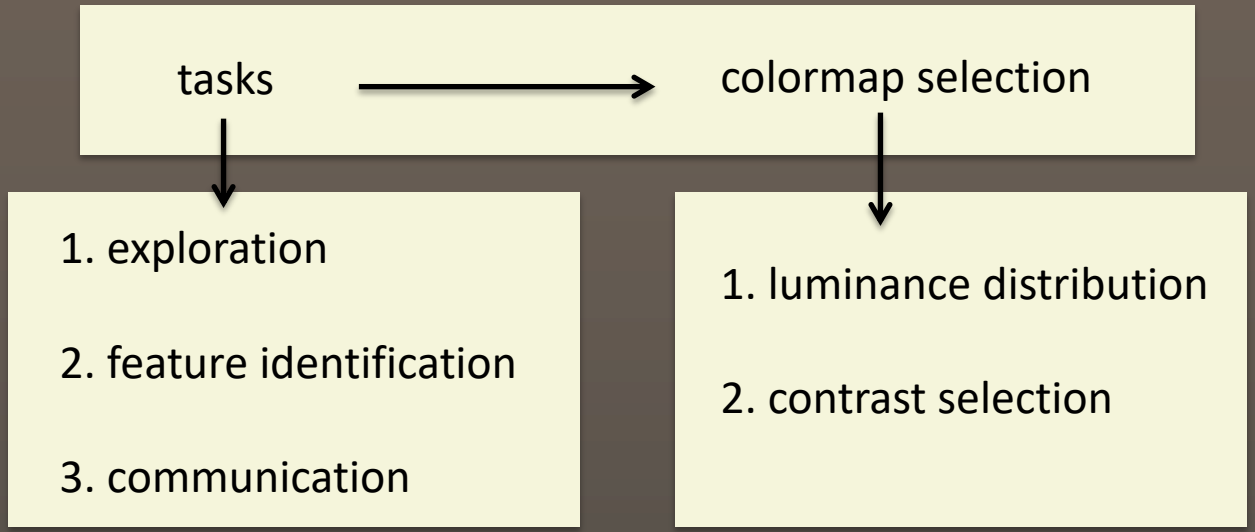
Contrast where you need it.

Minimize color volume.

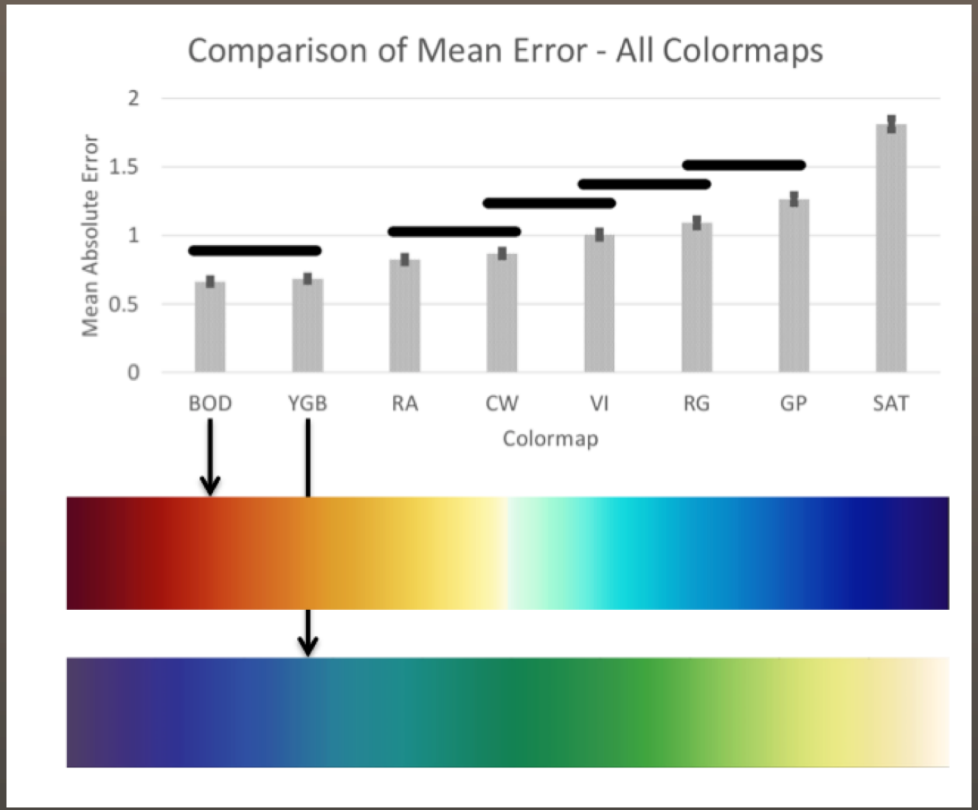


The important element is the position of the black line and how close it is to a true circle.
The second most important is the position of line within the light blue, light red and light yellow squares

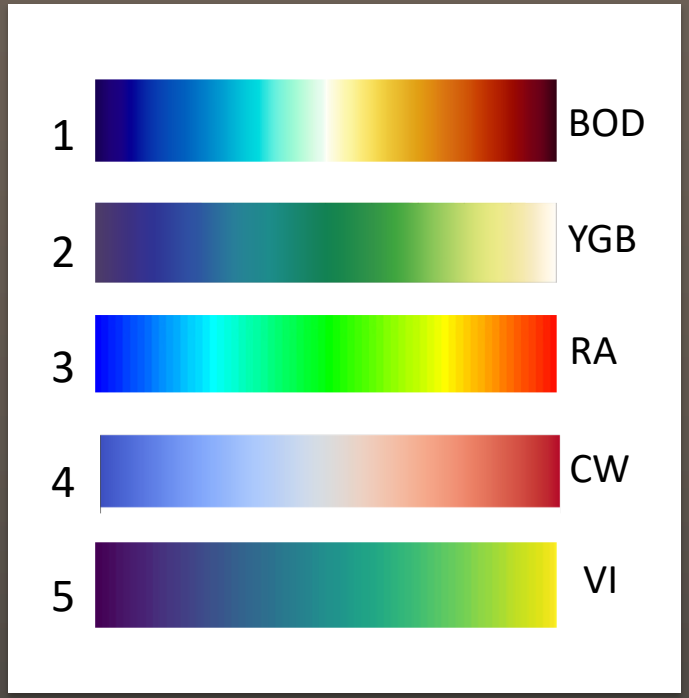
Follow the task…..



Tested alternatives



Discriminative Power



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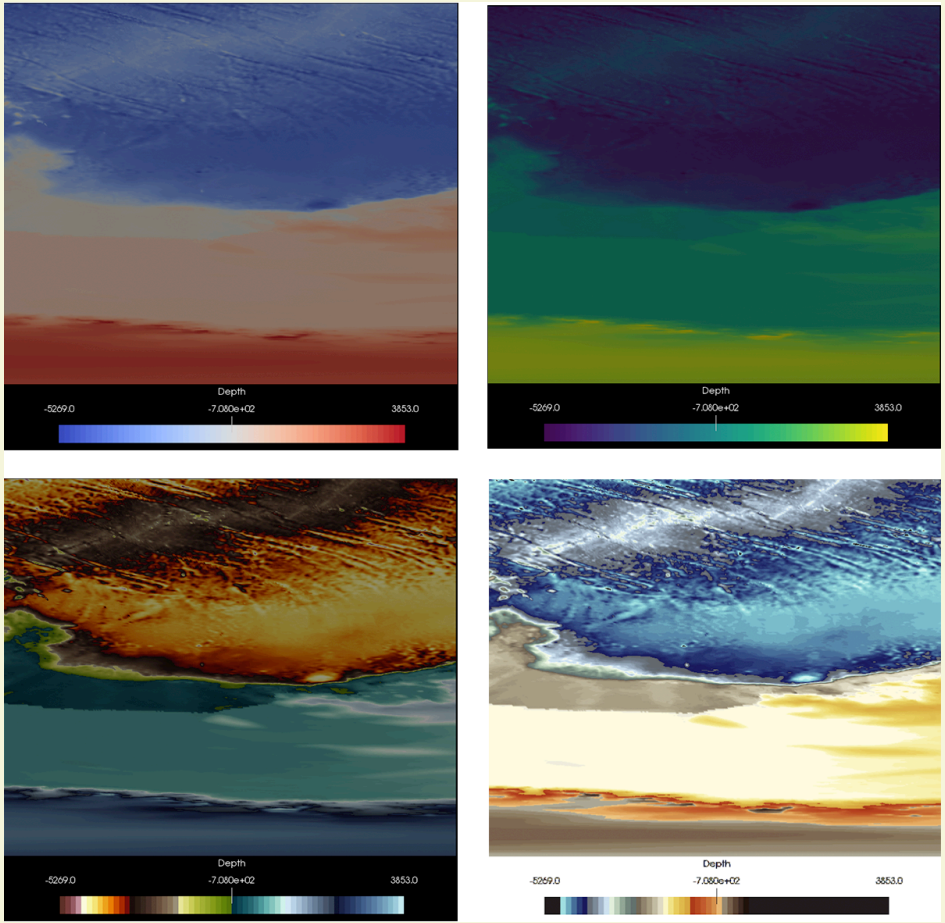
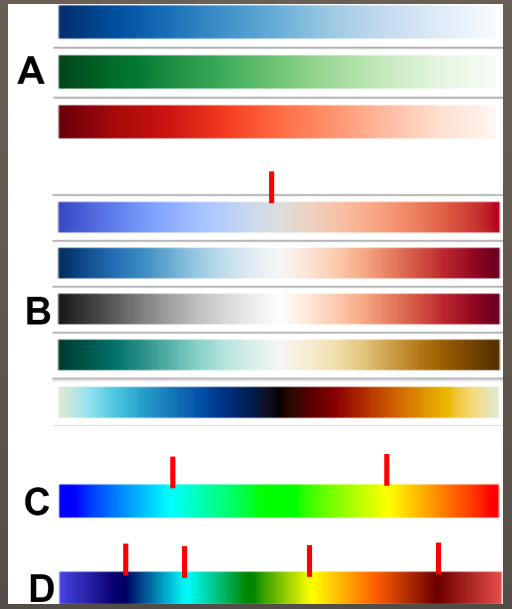
Luminance

the most powerful type of contrast
and the key to seeing your data



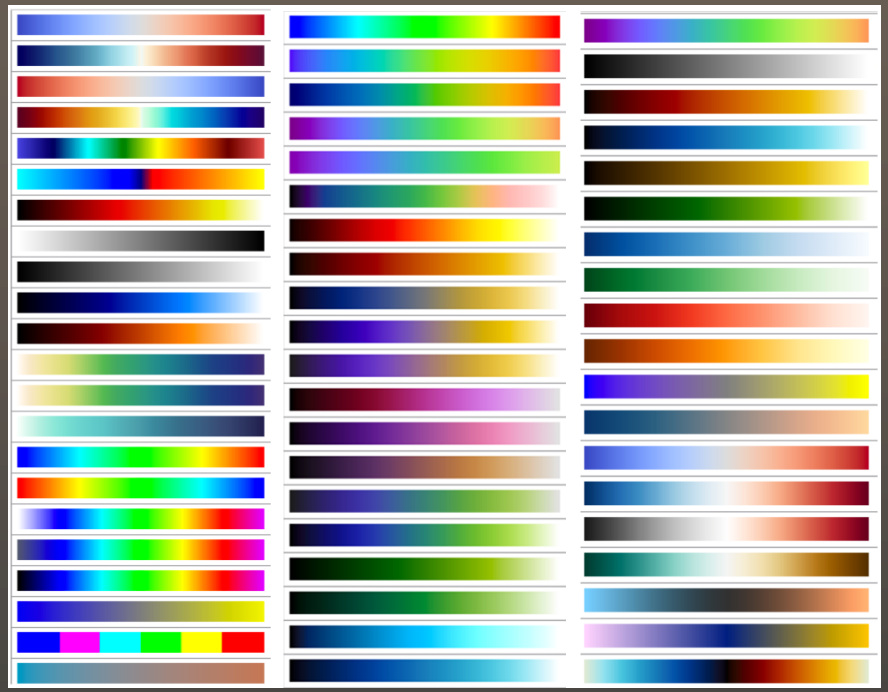
It is all about luminance allocation.

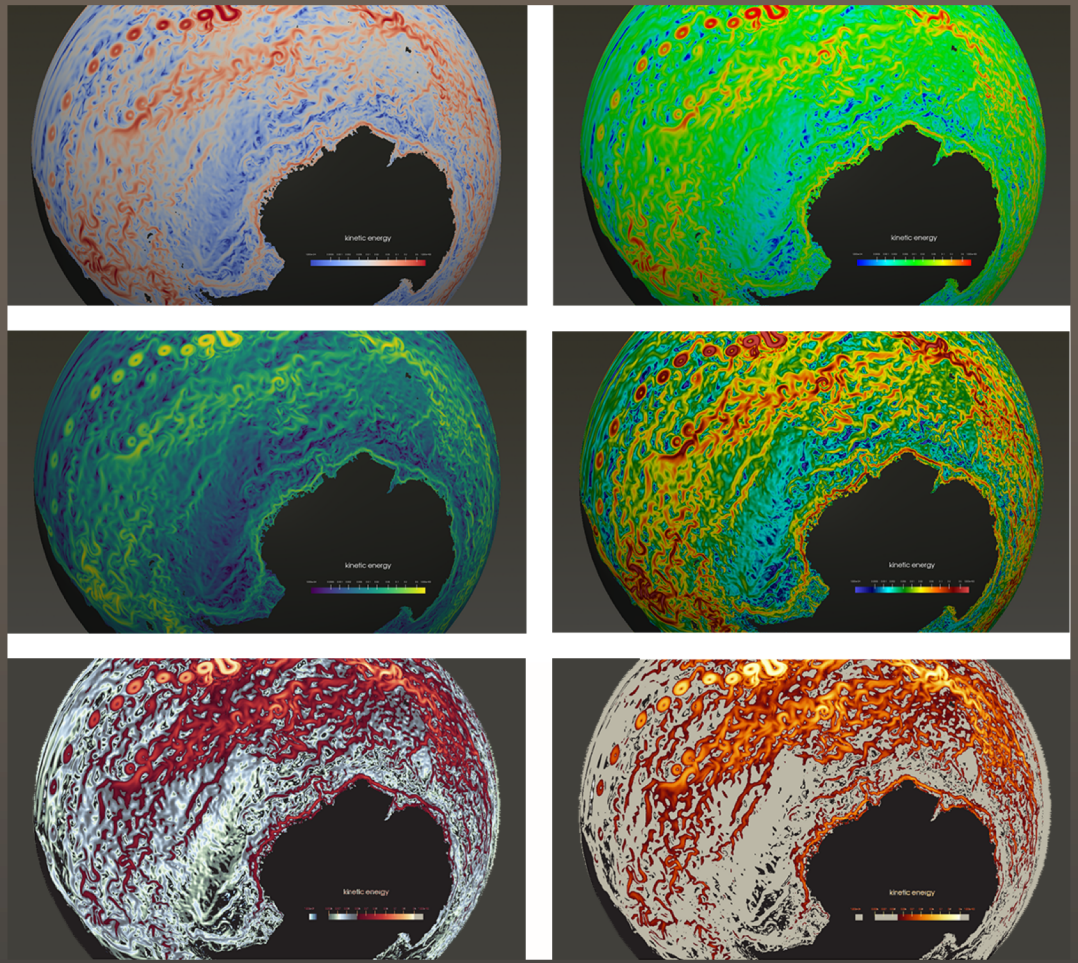
ParaView has 97 colormaps,
…of limited impact.



luminance distributions

ParaView's colormap selections

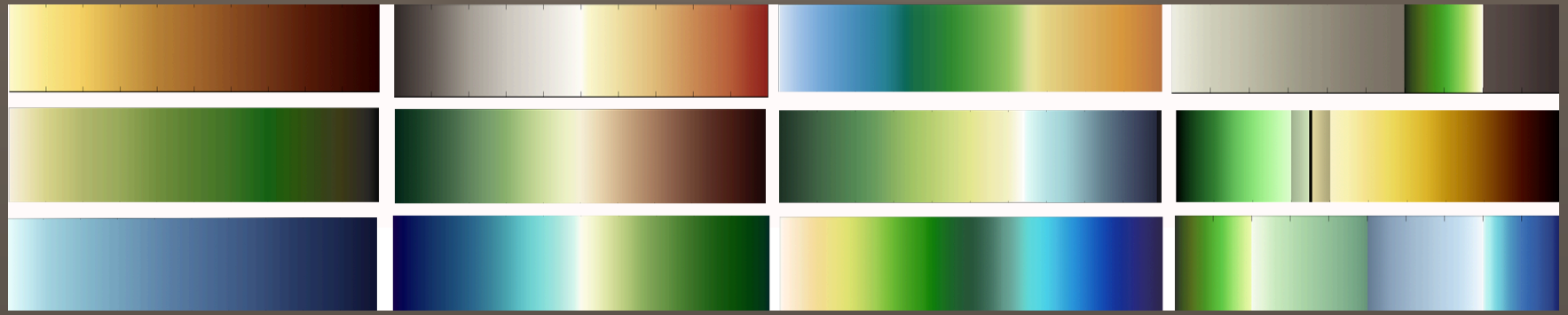




Use the color to focus on what is important.

Here it is the kinetic energy.

Luminance Distribution



linear

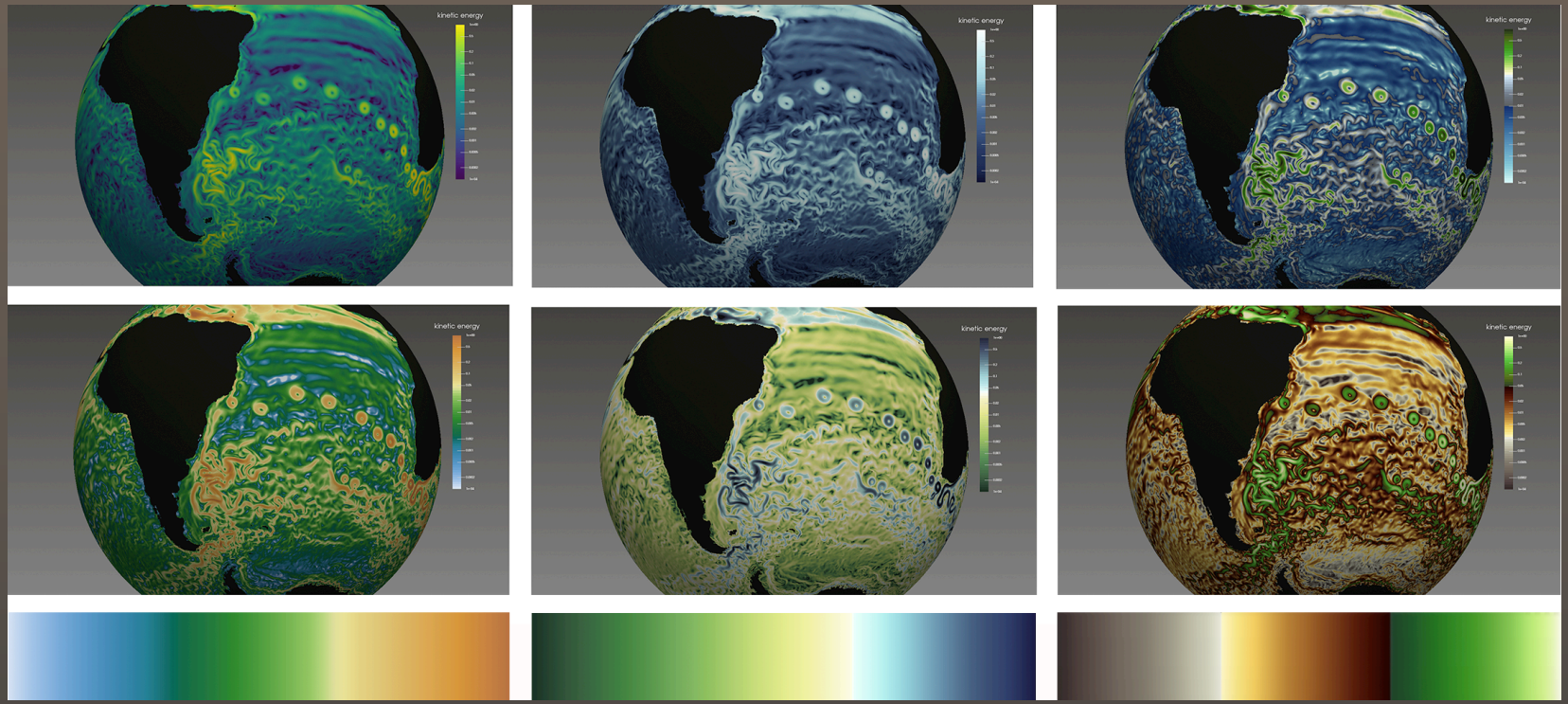
divergent

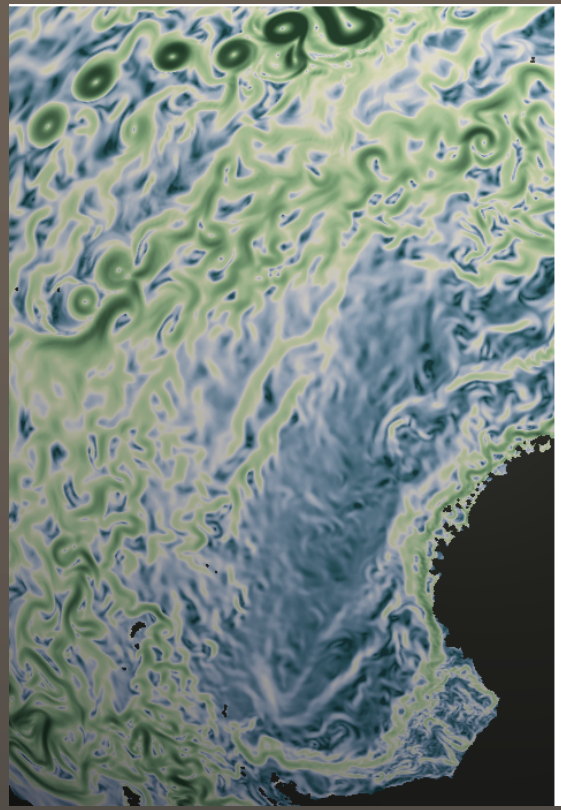
alternate luminance

structured colormaps

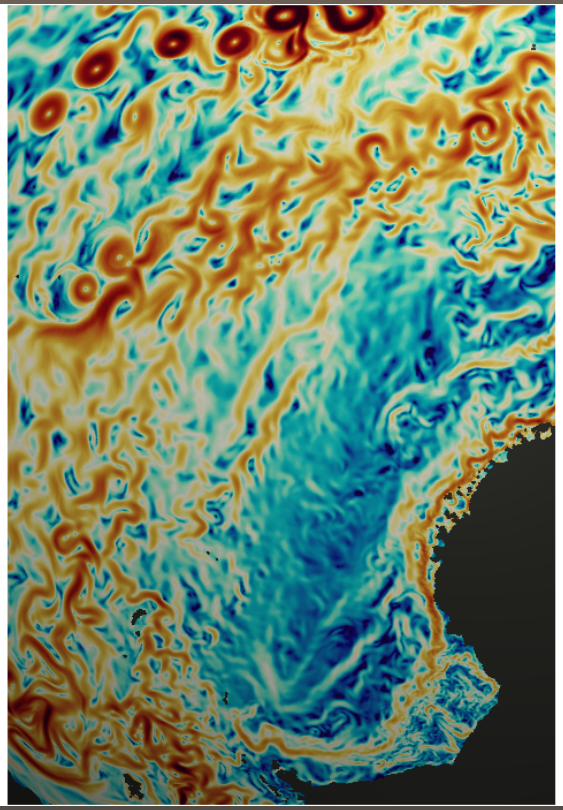
For focus and or resolution power,
match the luminance structure of your data and or areas of importance.

Domain intuitive
Alternate luminance distributions

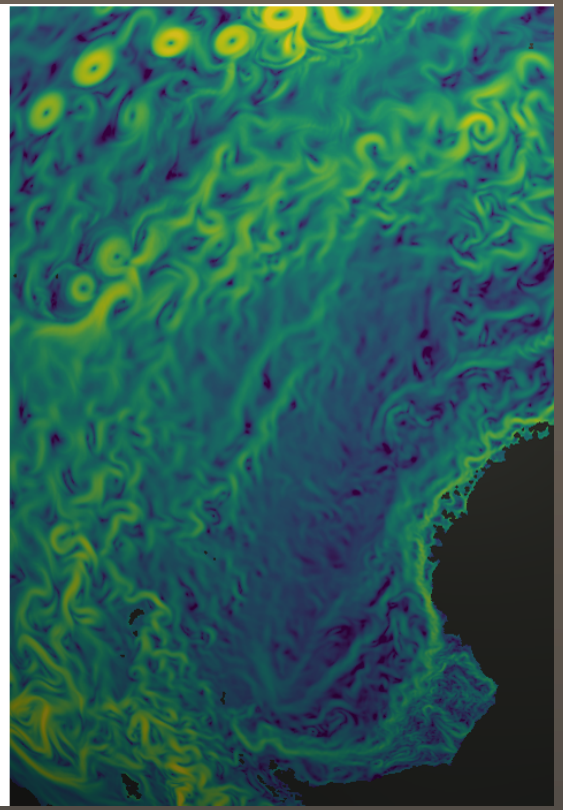




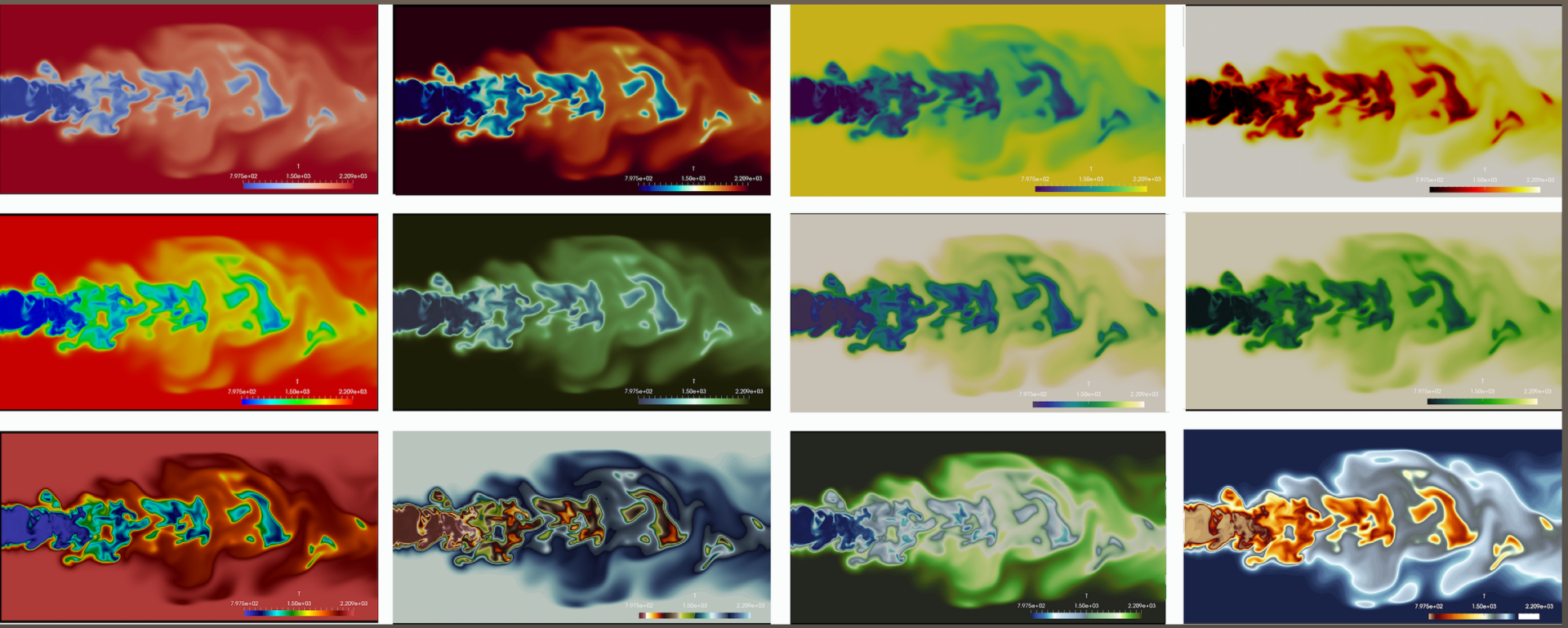
low value contrast



higher value contrast



lowest value contrast

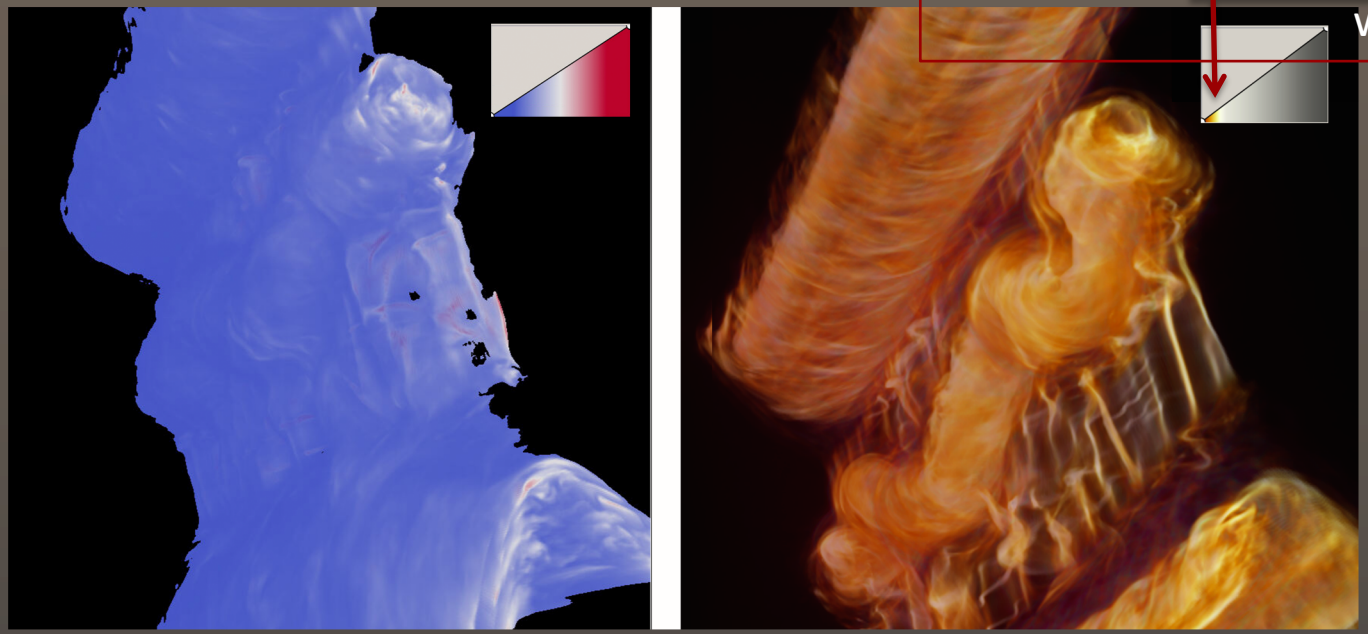


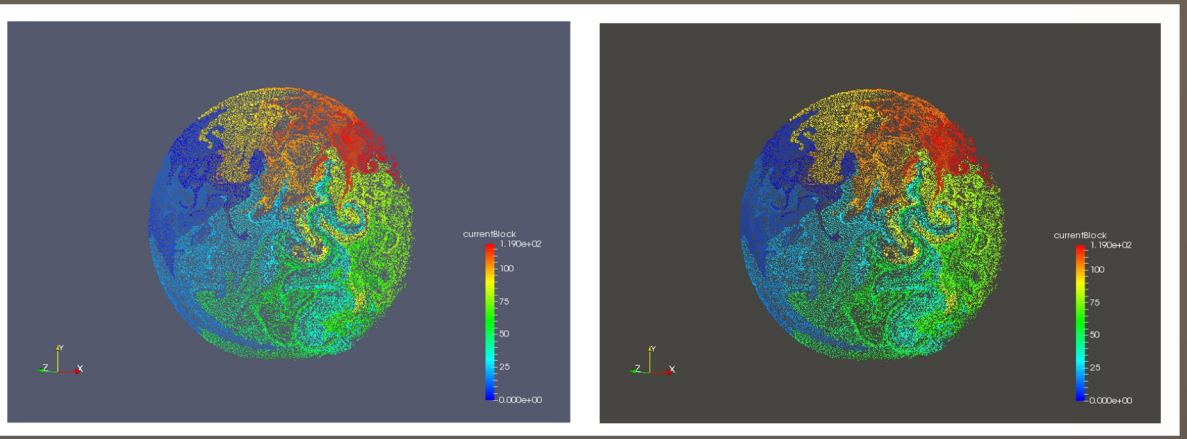
The colormap dictates the focus of your visualization.
That is why having control is important.

Contrast allocation

Placing the contrast where it reveals structure

Aligning the **contrast** distribution with the data



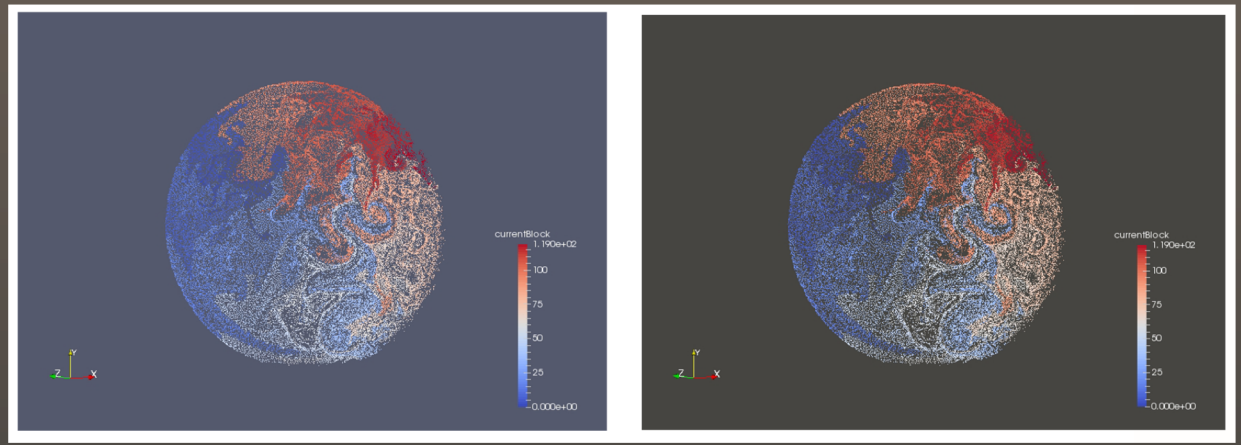


Change the Paraview background default!

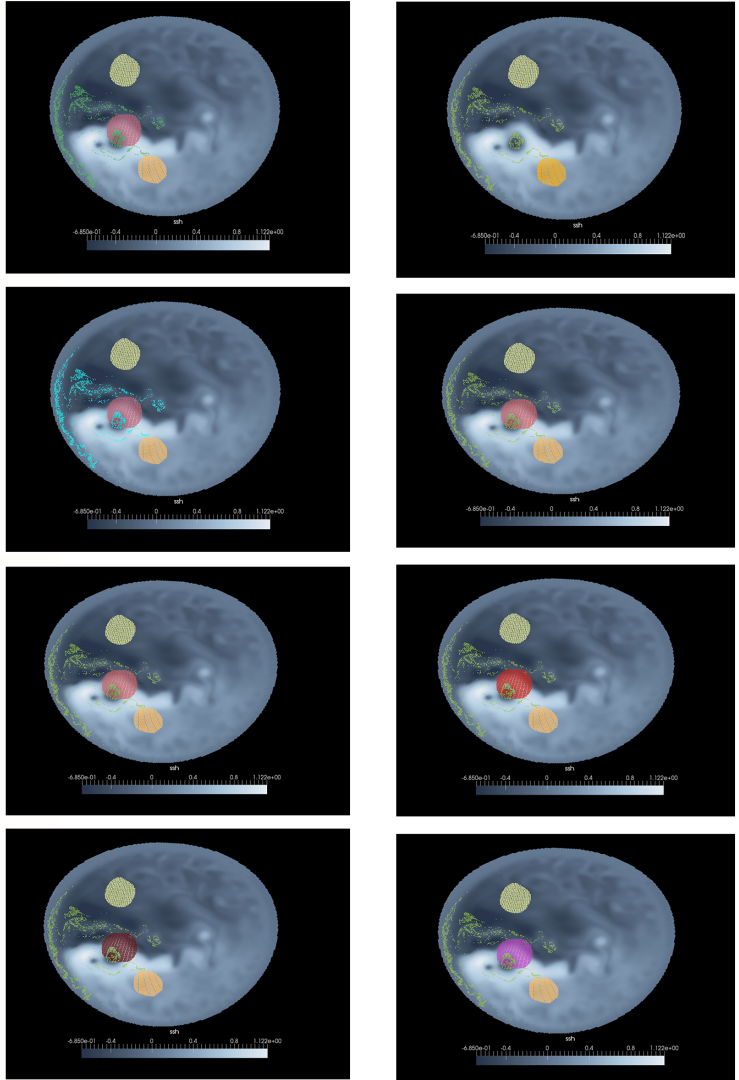
Your life and vis will be calmer.

RGB 107 107 107

The only difference is the **background color**.



In general, cool colormaps such as the ParaView default,
need a warm background but in reality,
the ParaView background is almost always worse.



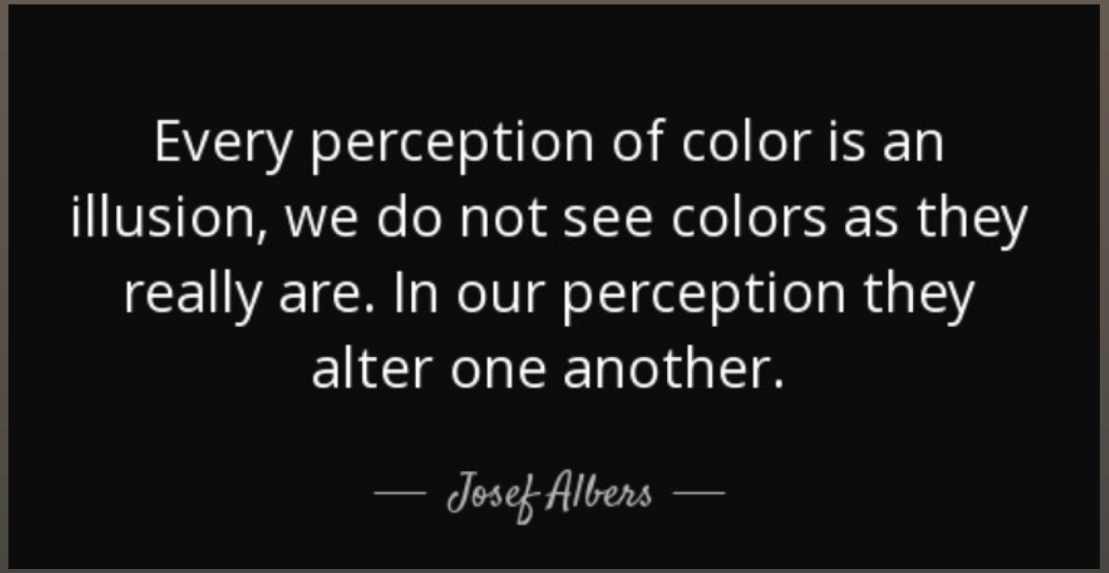
Subtle but important differences.

We have done the legwork
so that you do not have to!

SciVisColor.org!

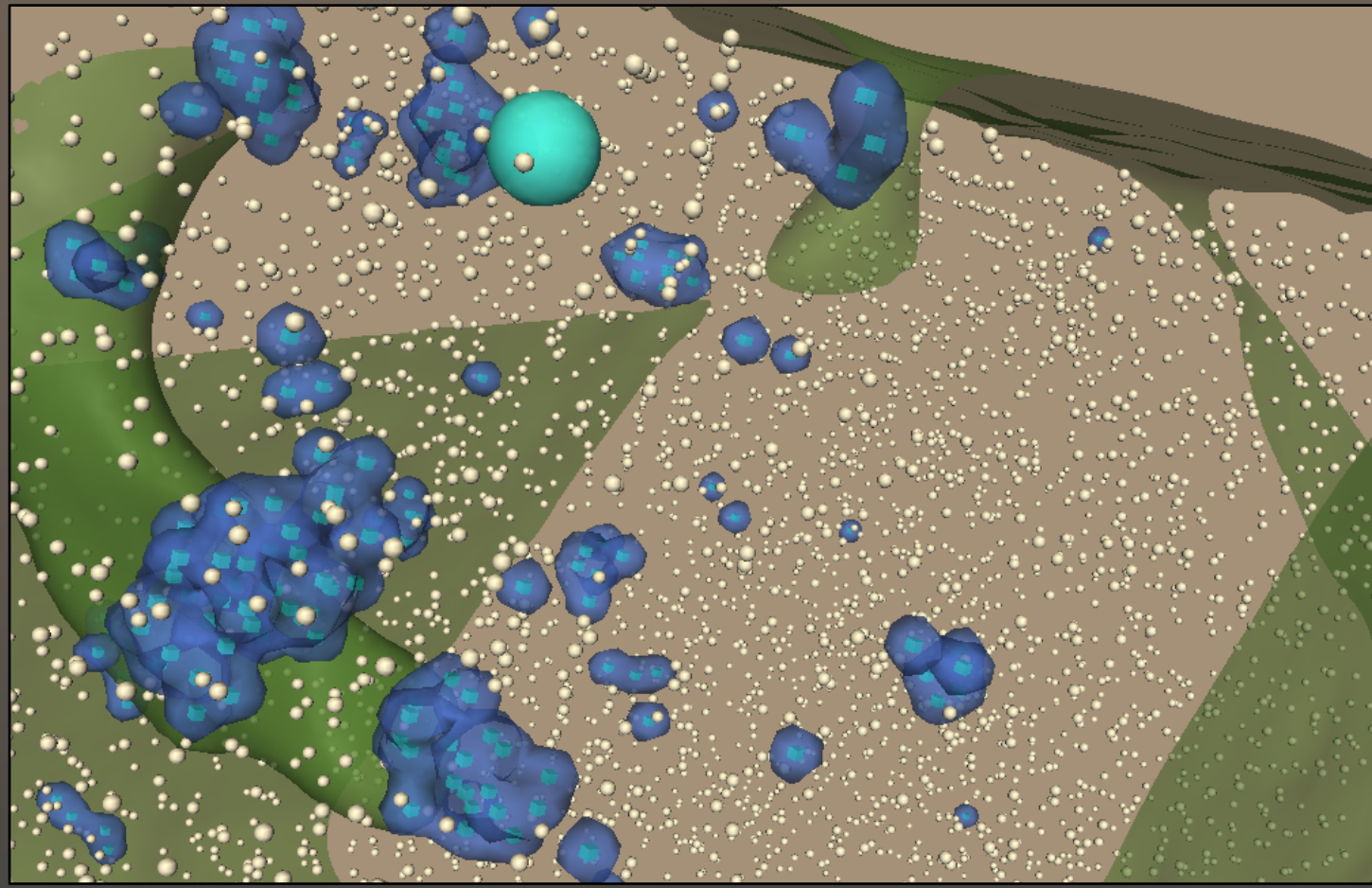
A few words about Color Sets …

This is where things get tricky because….

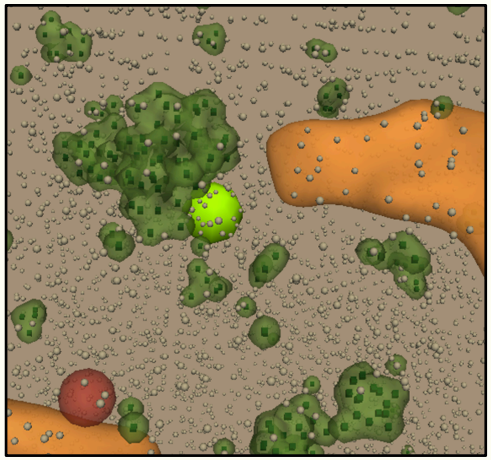


Color Contrast
Color Hierarchy

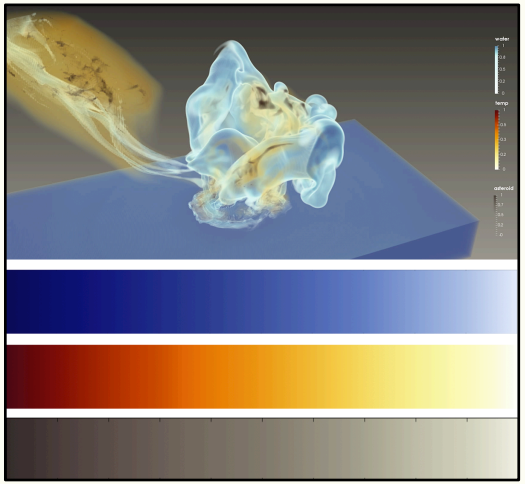
Using color to
organize,
categorize
and direct attention



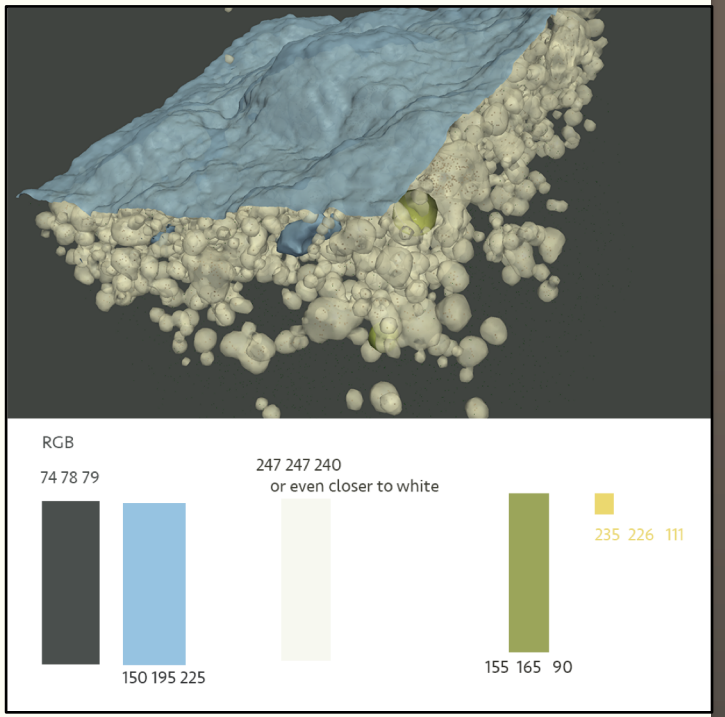
Relationships based on color theory



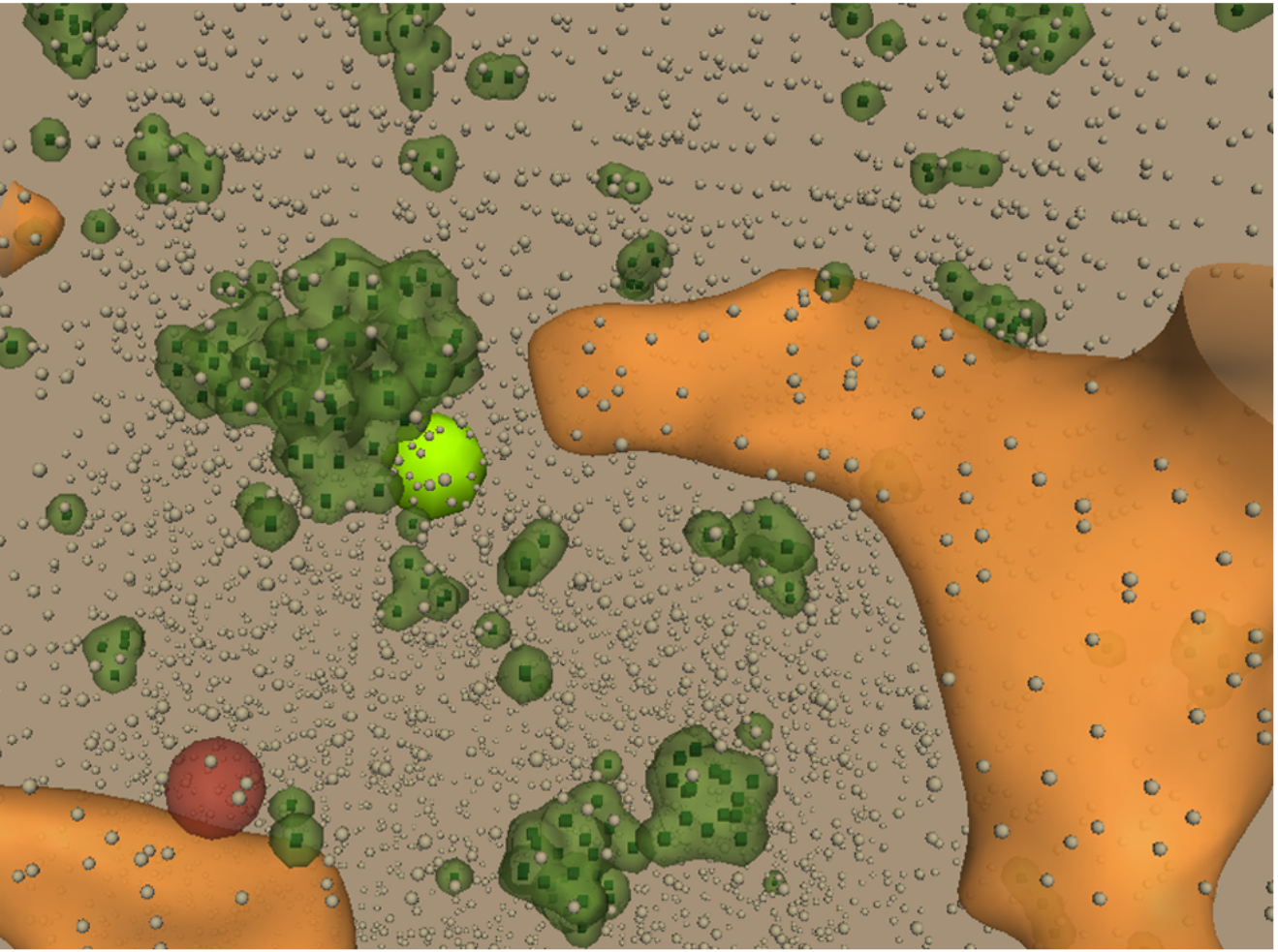
discrete color sets
for organizing 3D data



sets for multiple 3D variables



categorical sets

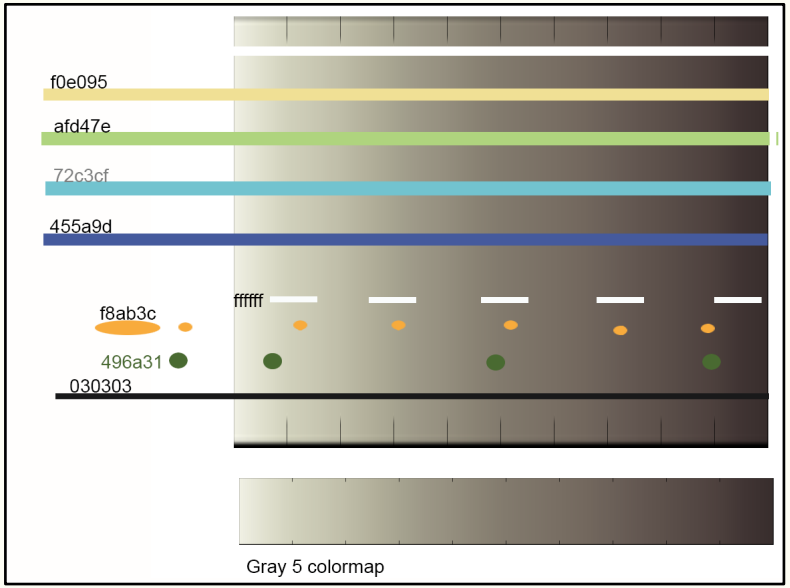


related

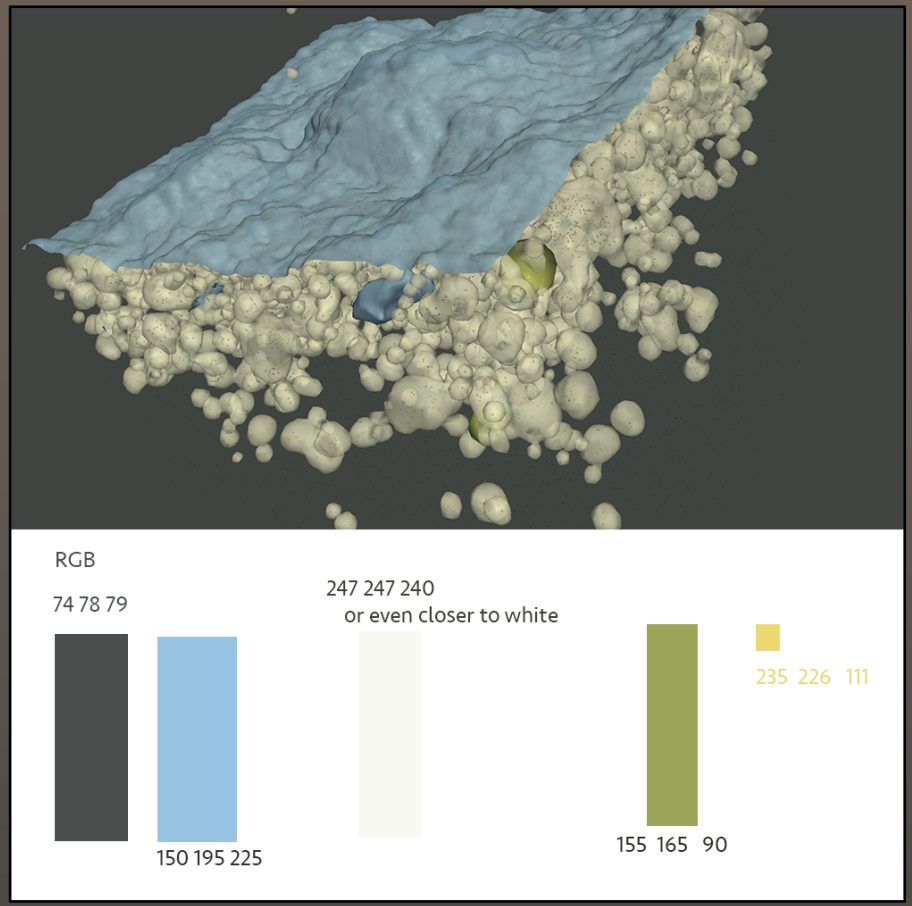
different

related

Ready-made sets

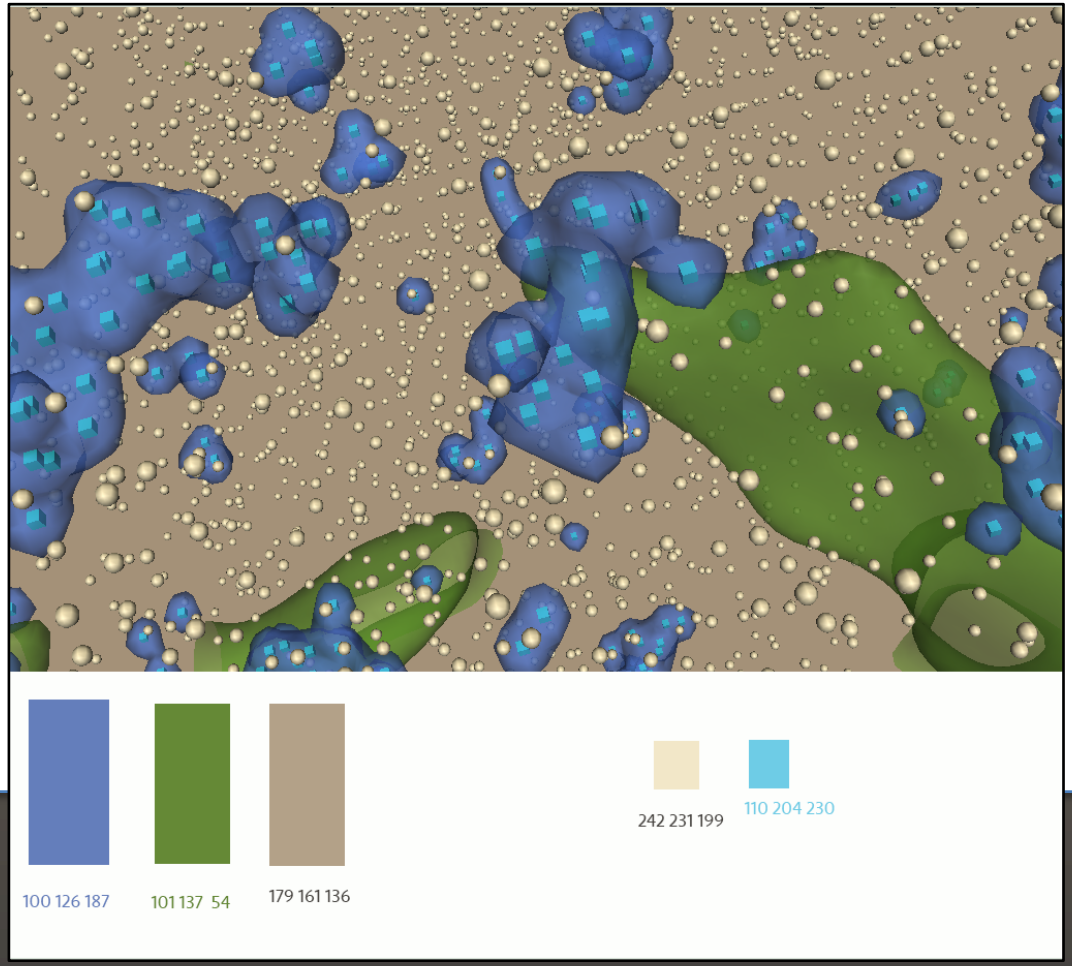


Available at SciVisColor.org

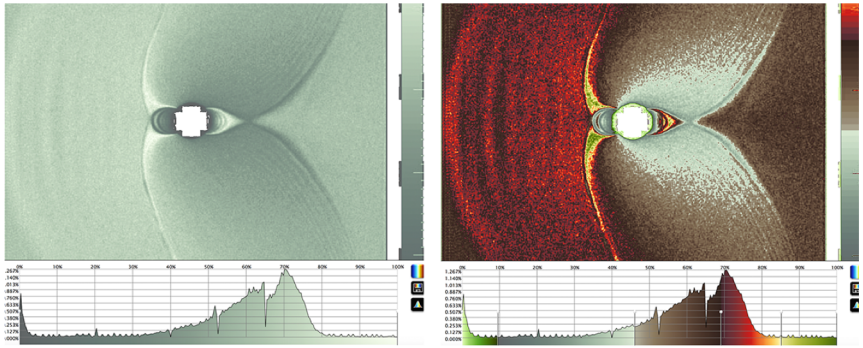


Visualization and Analysis of Large-Scale Atomistic Simulations of Plasma–Surface Interactions
Wathsala Widanagamaachchi, Karl D. Hammond, Li-Ta Lo,3 Brian D. Wirth, Francesca Samsel, Christopher Sewell, James Ahrens, Valerio Pascucci

Analogous color sets using hue to align the visualization components.

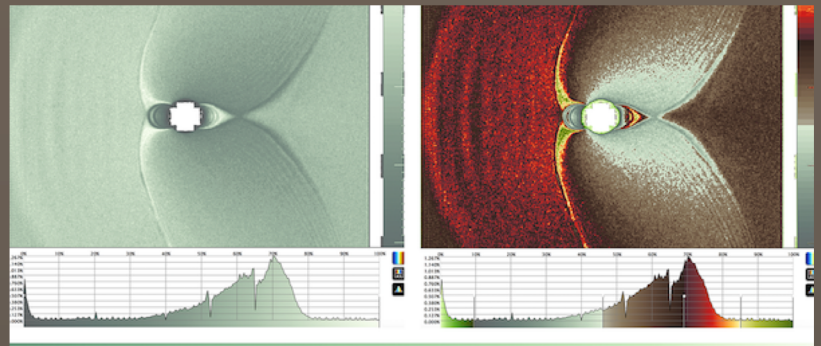


Aligning the characteristics of colormaps to their usage



Colormap Properties	Colormap Usage
cool, light, muted	contextual data
neutral, dark, muted	least important data
warm, saturated hue-spanning	highlight larger areas of important data
cool, saturated, narrow hue	highlight small areas of important data

Color Scale Sets

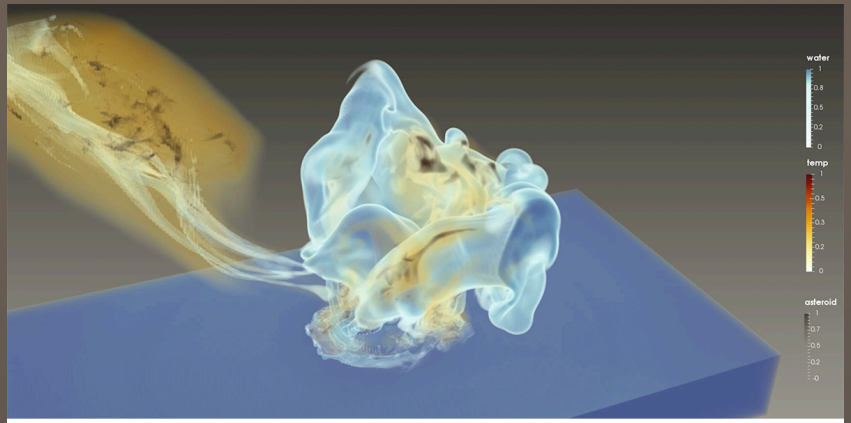


green 7

brown 4

red 2

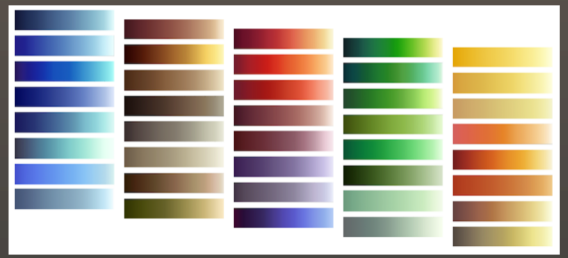
green 4



blue 4

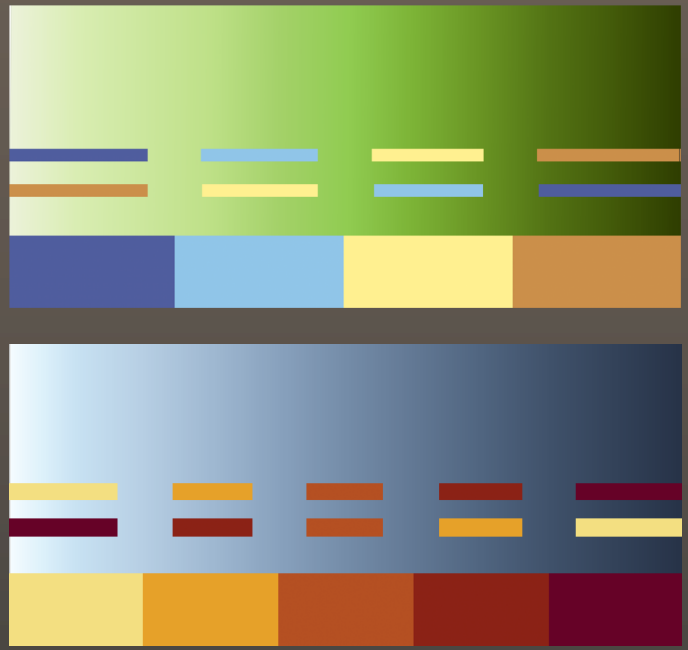
yellow 15

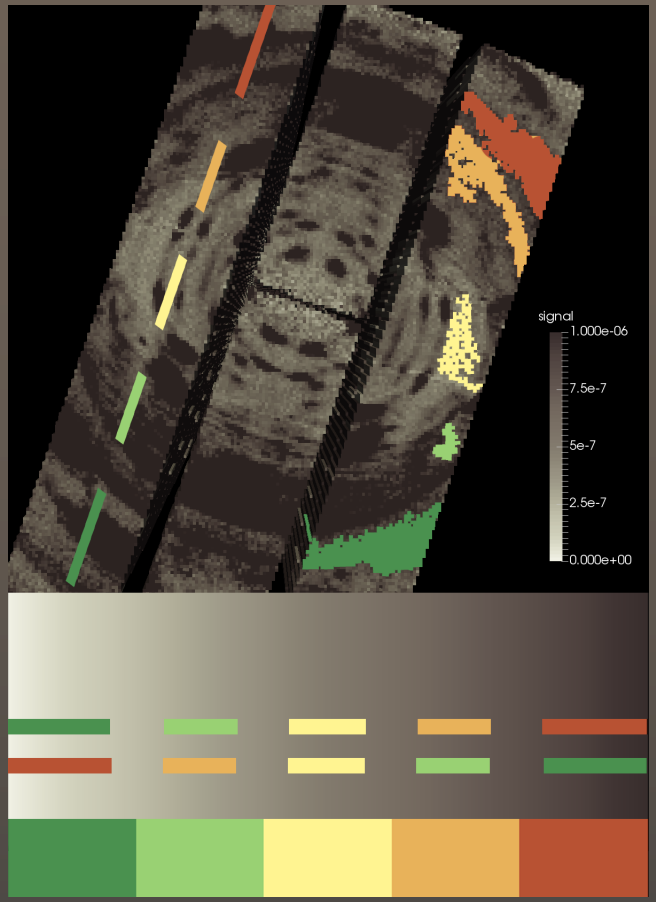
brown 7



See SciVisColor.org
for color map documentation.

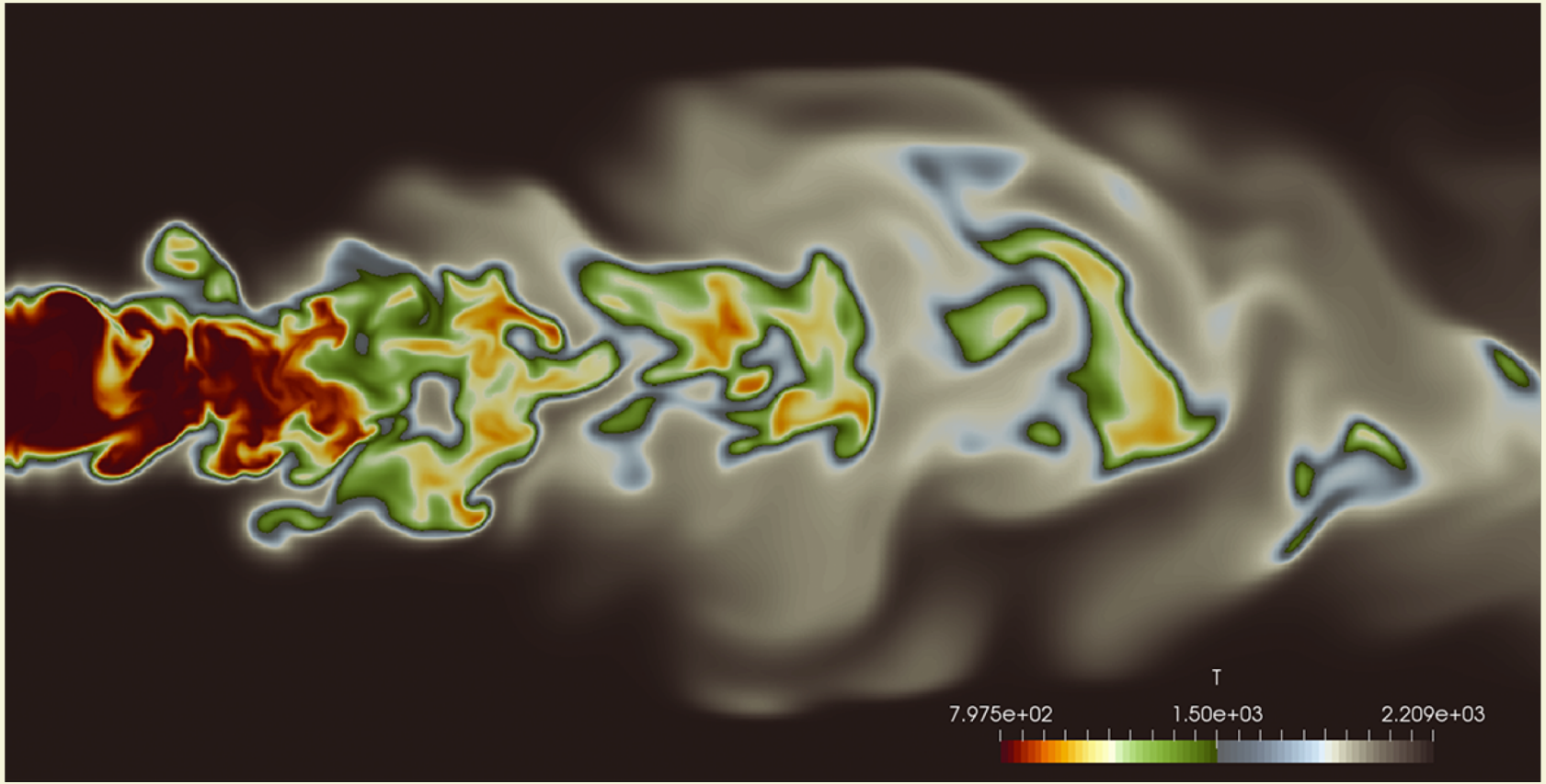
Color sets:
color scales with discrete colors
visible across color scale ranges





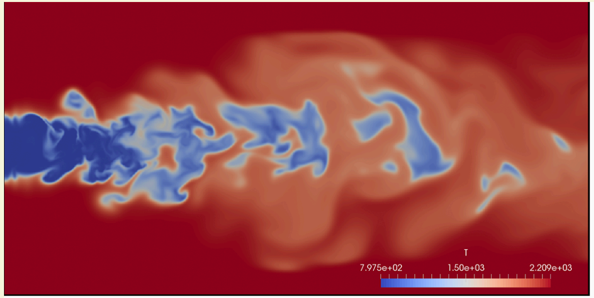
Available in SciVisColor.org!

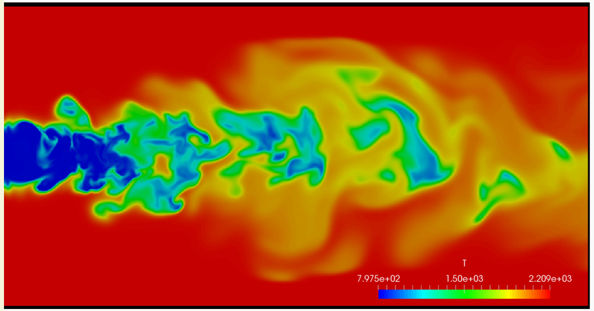
Alternative colormap structures

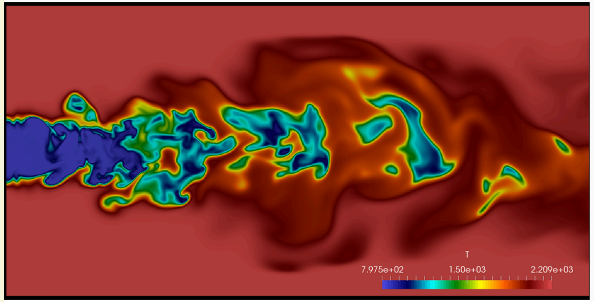


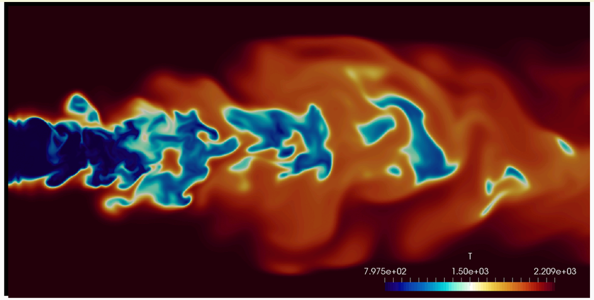
J.Chen, Combustion Simulation

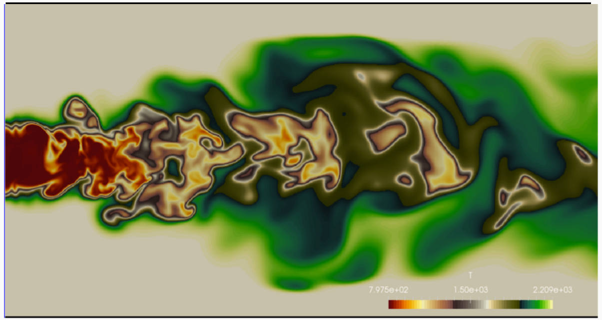
commonly
used

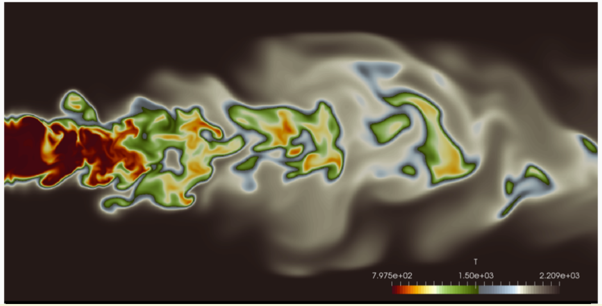




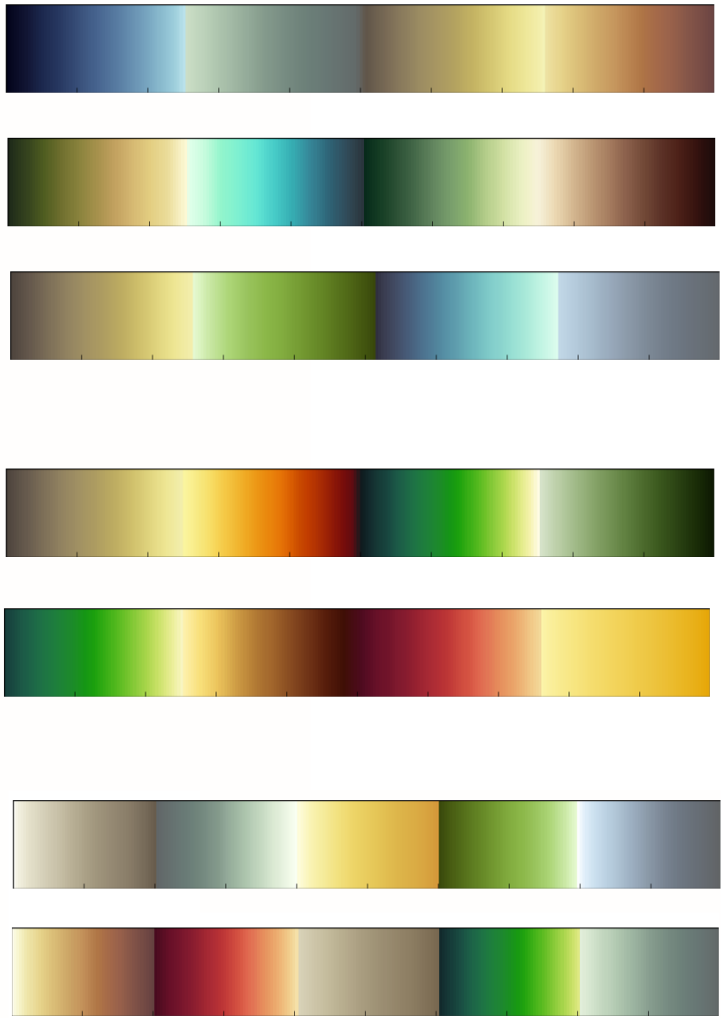








suggested
alternatives



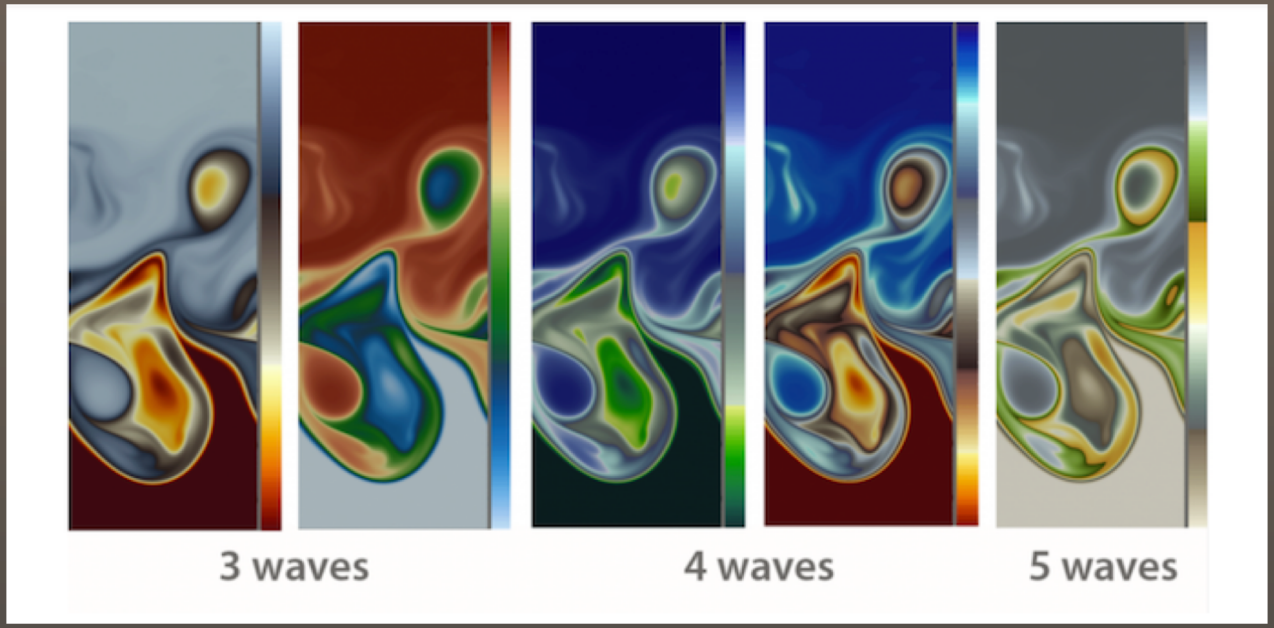
Colormap Waves

Multiple value spans within one colormap

Designed as an easy means of placing contrast and emphasis where it is most needed.

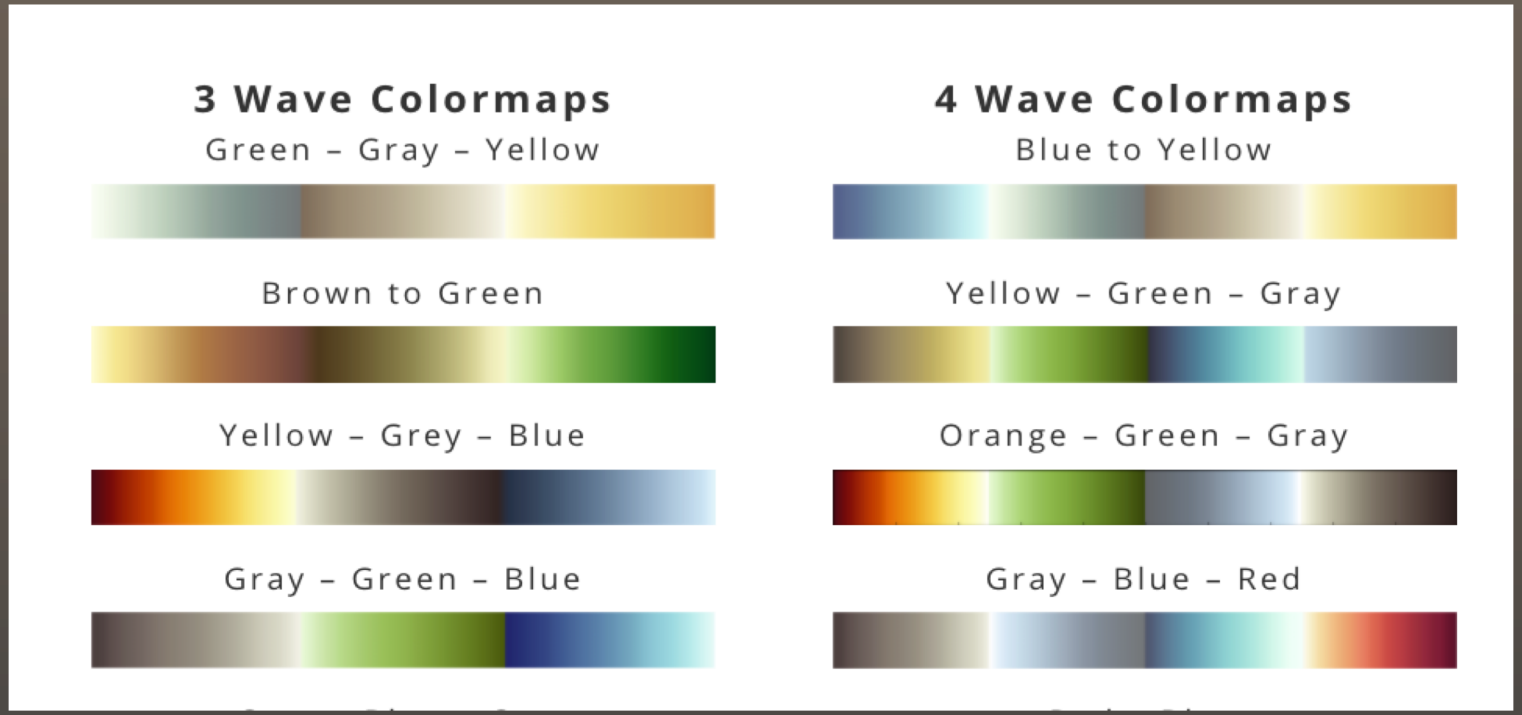
These can be created in ColorMoves.
Documentation soon to be on SciVisColor.org.

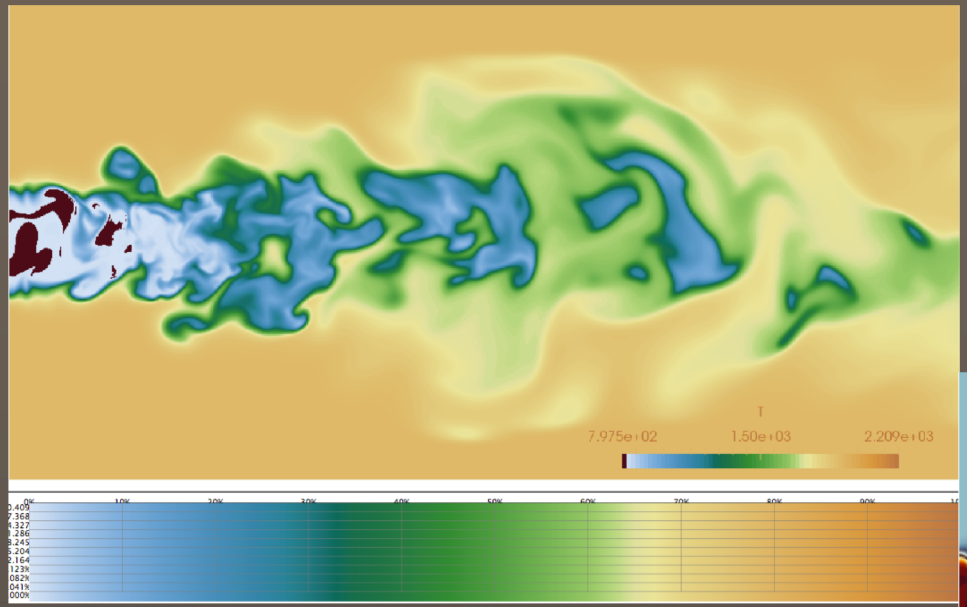
Selecting the number of waves for your colormap.



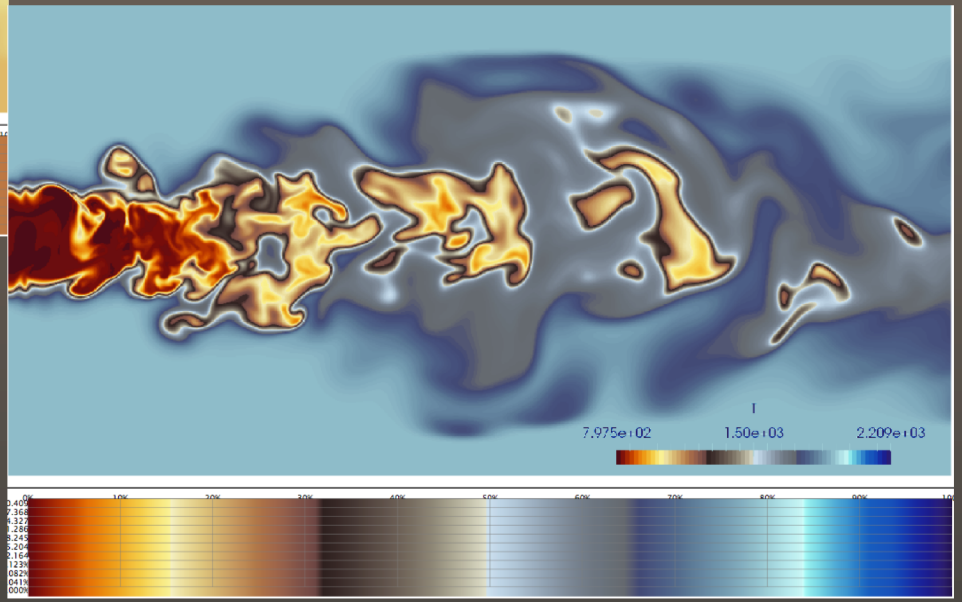
Use only as many luminance scales (waves) as needed.
You can use more waves if you select less saturated color scales.

Select the wave color map based on
the areas of your data you want to emphasize.

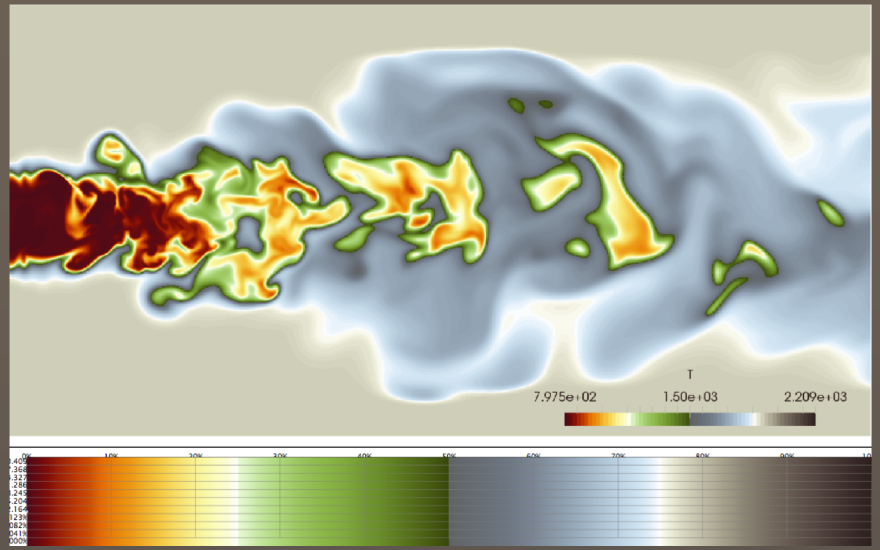




equal distribution of saturation

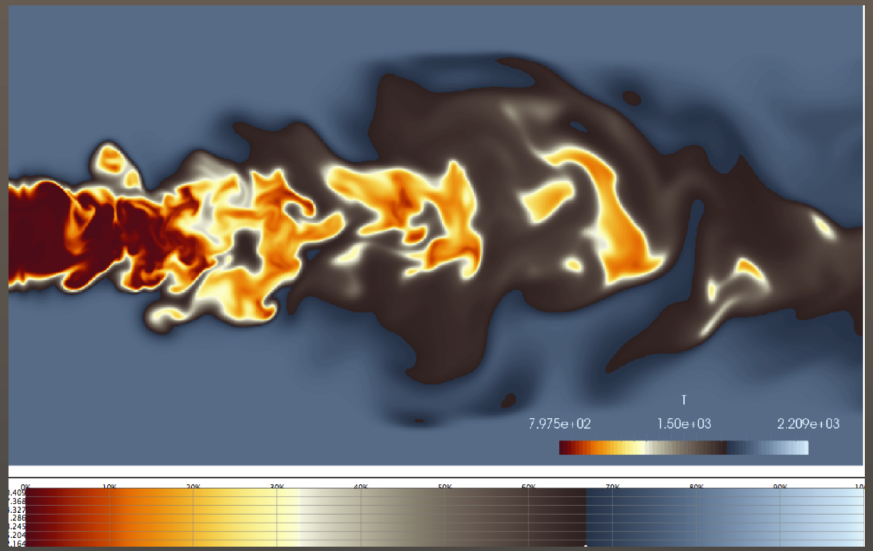


saturation focused on the outliers



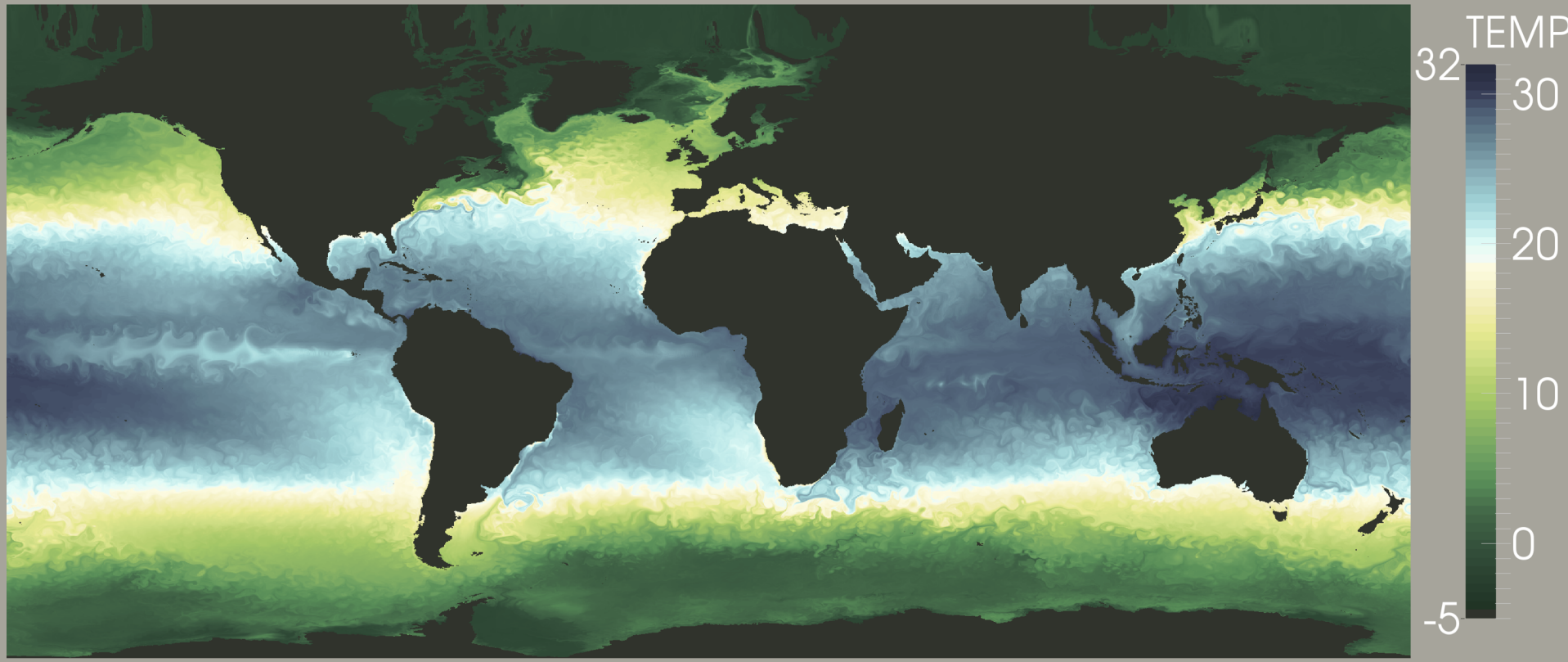
saturation in the lower 50%

Focusing attention
using saturation levels

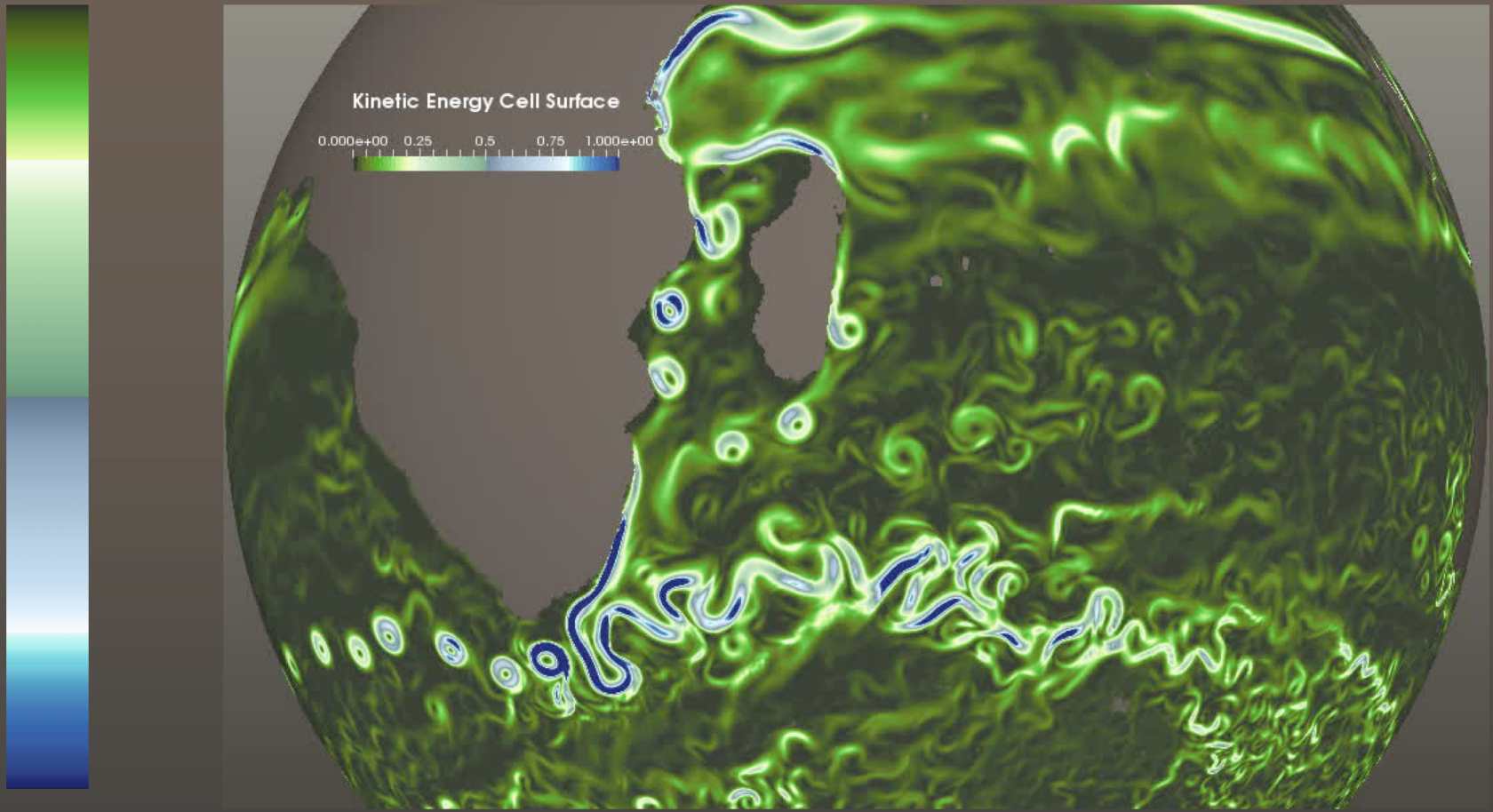


saturation in the lower 30%

Asymmetrical value distribution

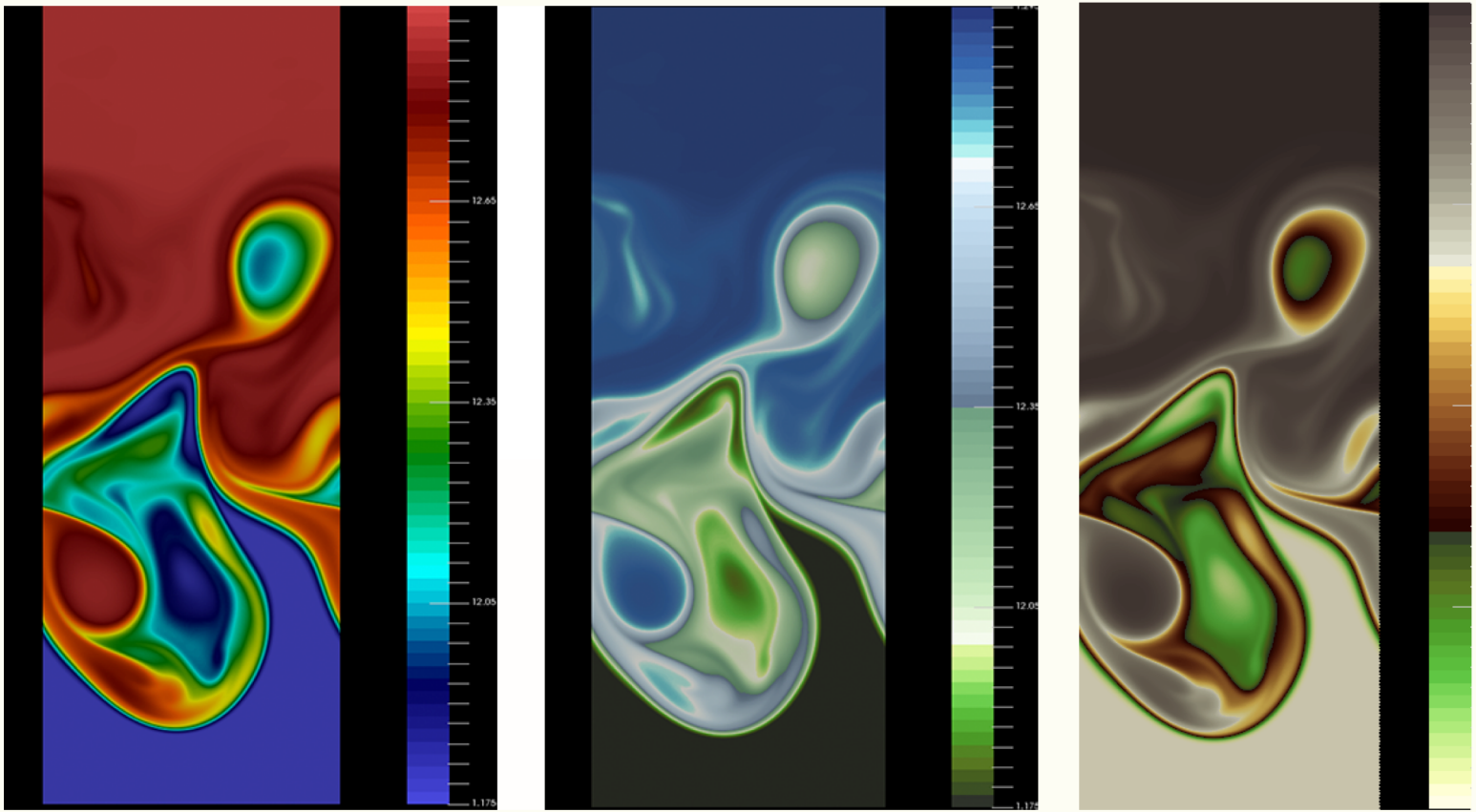


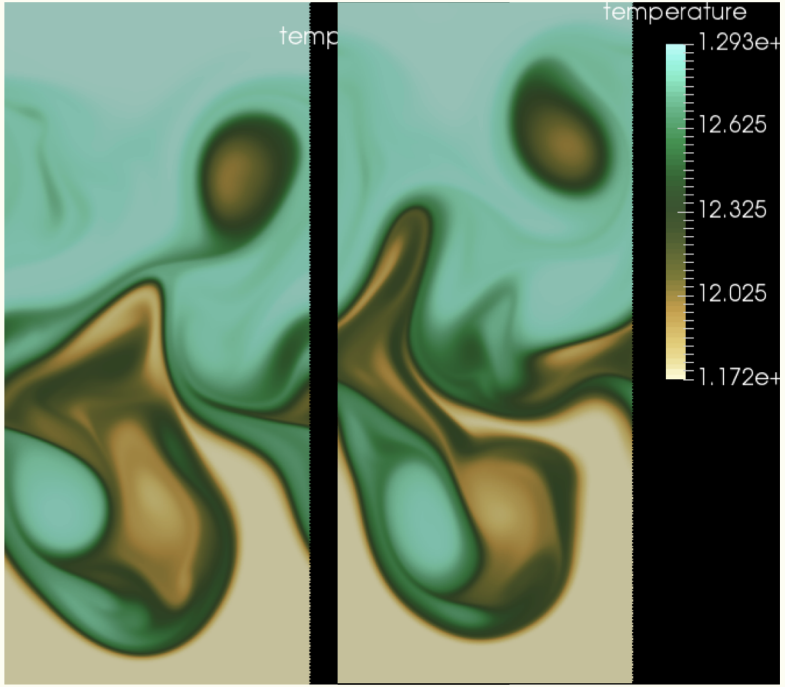
Interesting data is often in the center or on the ends.

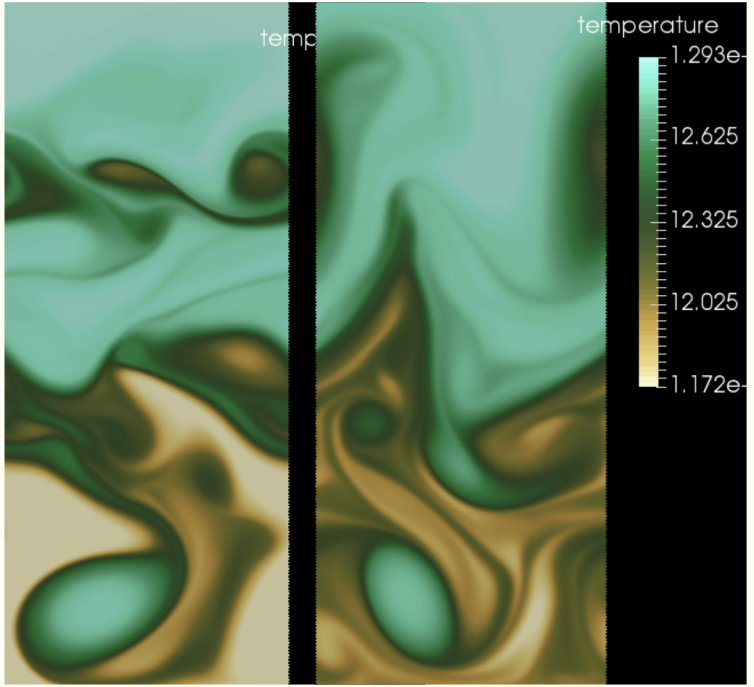


video

Detail without cacophony

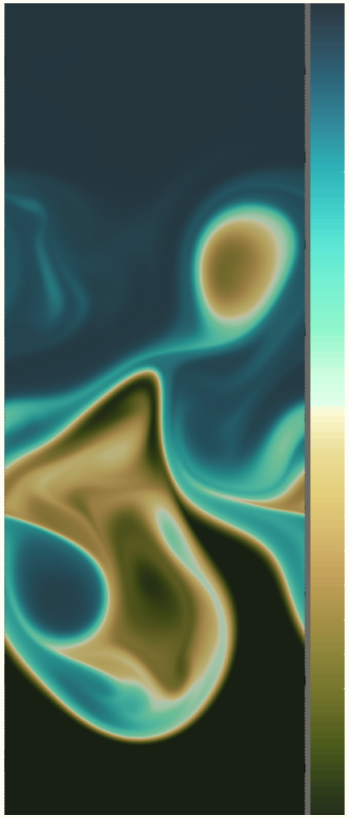


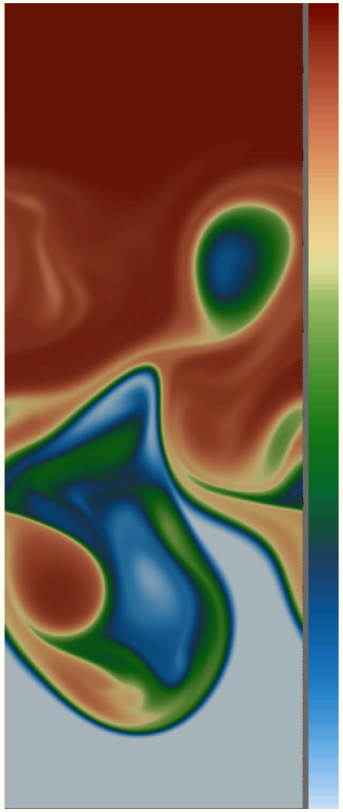




Convergent colormaps

Given we have these…





Why use these….