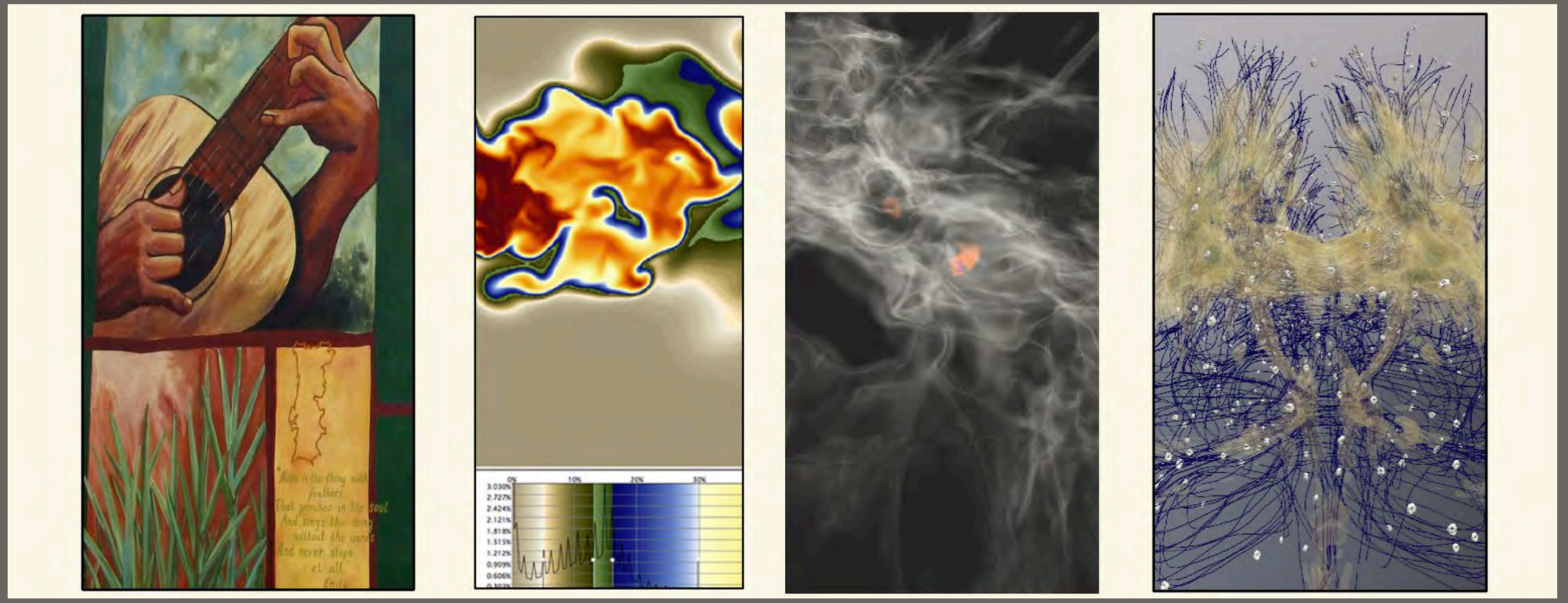
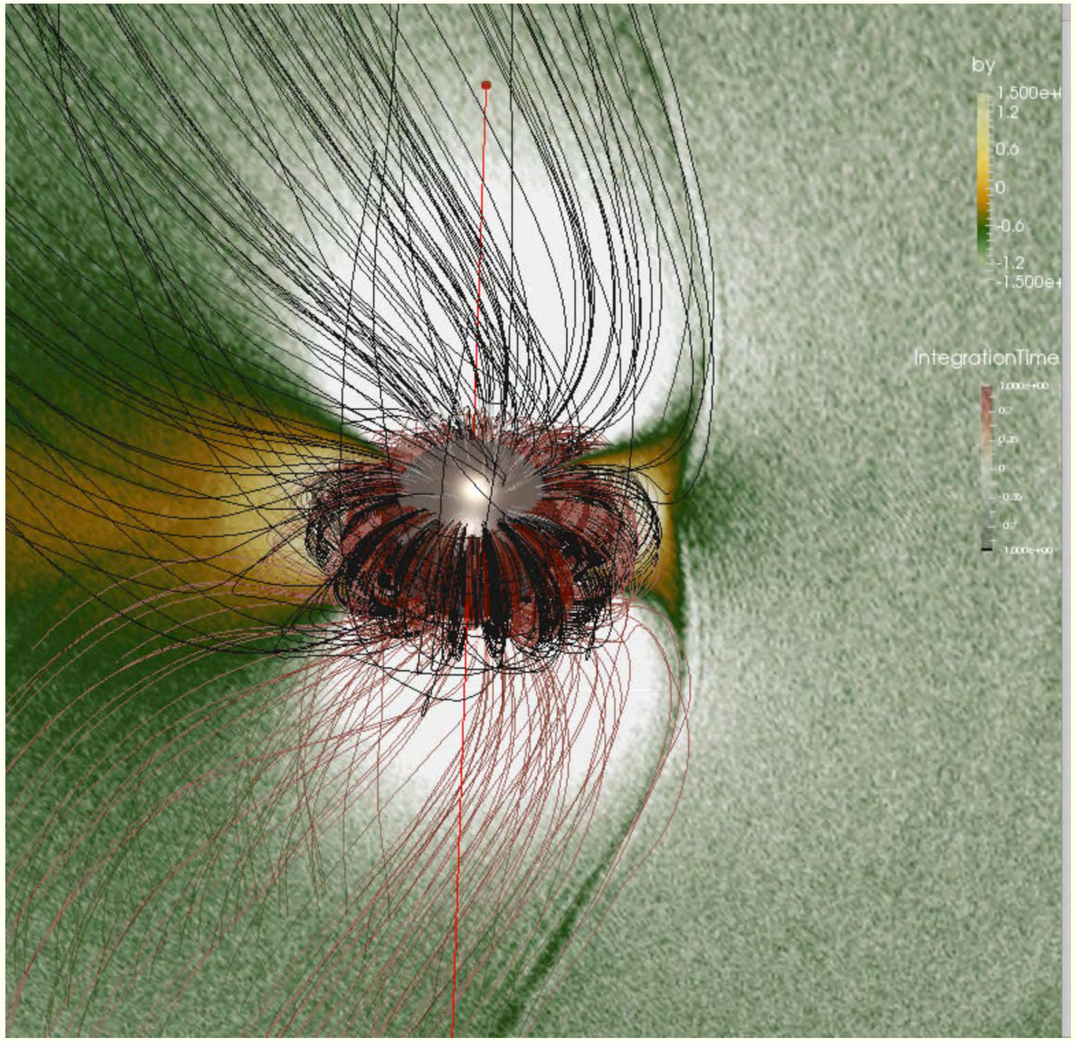
Colormapping Strategies for Large Multivariate Scientific Visualization



Francesca Samsel
Research Scientist
Texas Advanced Computing Center
University of Texas at Austin
fsamsel@tacc.utexas.edu

Color theory - creating clarity without cacophony.



Feature resolution

Attention direction

Ease of exploration

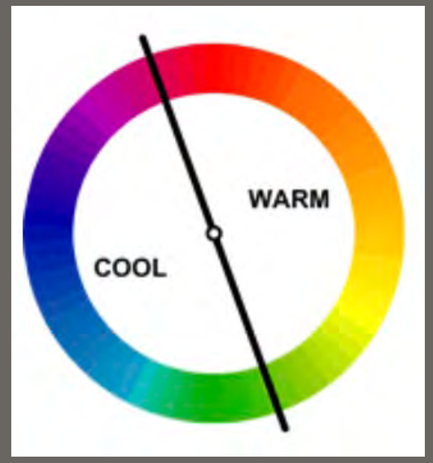
Clear communication

Affective visualizations

Color CONTRAST Theory

Types of color contrast

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

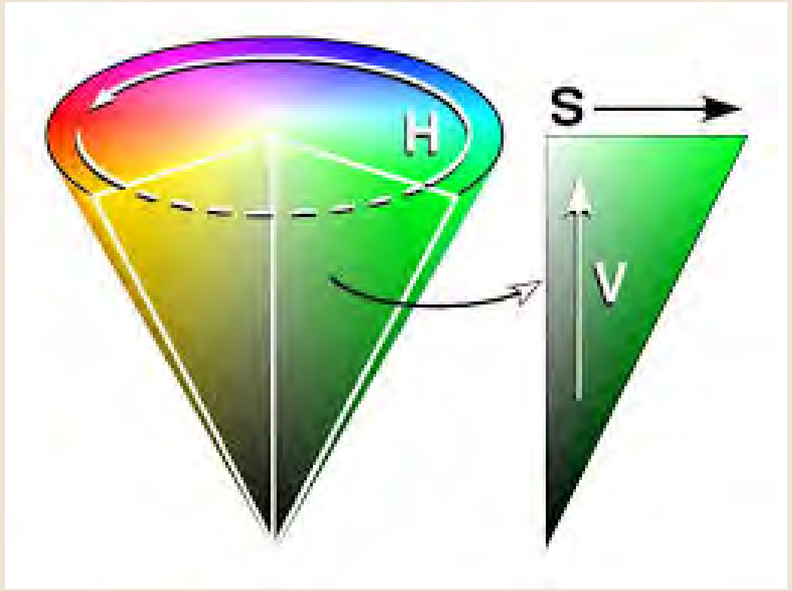


cool / warm

complimentary

analogous

Hue, Saturation and Value
the human color space

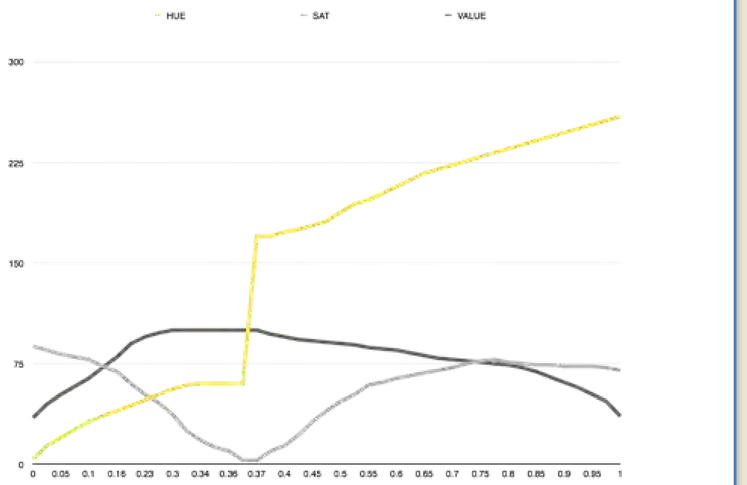


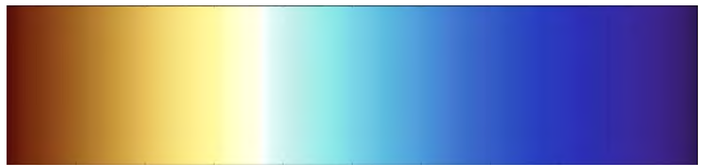
HSV / HSB color space

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

Table 1

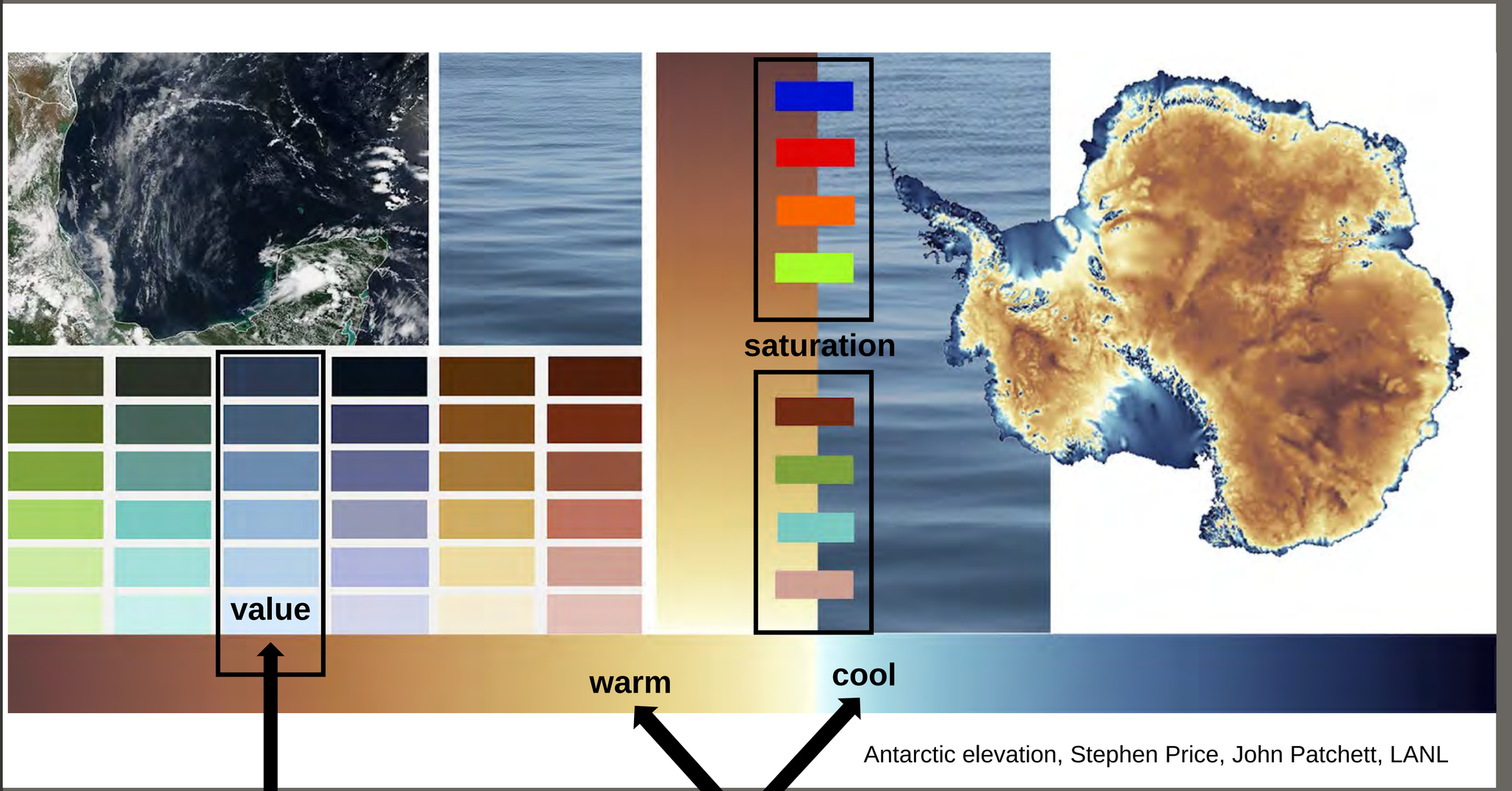
	HUE	SAT	VALUE
0	4	88	35
0.025	14	85	45
0.05	20	82	52
0.075	26	80	58
0.1	32	78	64
0.13	36	73	72
0.16	40	69	80
0.2	44	60	90
0.23	48	52	95
0.26	52	46	98
0.3	56	37	100
0.32	59	25	100
0.34	60	18	100
0.35	60	13	100
0.36	60	10	100
0.37	60	3	100
0.37	170	3	100
0.385	170	10	97
0.4	173	14	95
0.425	175	22	93
0.45	178	32	92
0.475	181	40	91
0.5	188	47	90
0.525	194	52	89
0.55	197	59	87
0.575	202	61	86
0.6	207	64	85
0.625	212	66	83
0.65	217	68	81
0.675	220	70	79
0.7	223	72	78
0.725	226	75	77
0.75	229	77	76
0.775	232	78	75
0.8	235	76	74
0.825	238	75	72
0.85	241	74	69
0.875	244	74	65
0.9	247	73	61
0.925	250	73	57
0.95	253	73	52
0.973	256	72	47
1	259	70	36





Types of
color contrast

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



hue value saturation complimentary cool warm proportion simultaneity

Color **CONTRAST** Theory

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

HOWEVER, You have a contrast budget!

Color **CONTRAST** Theory

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

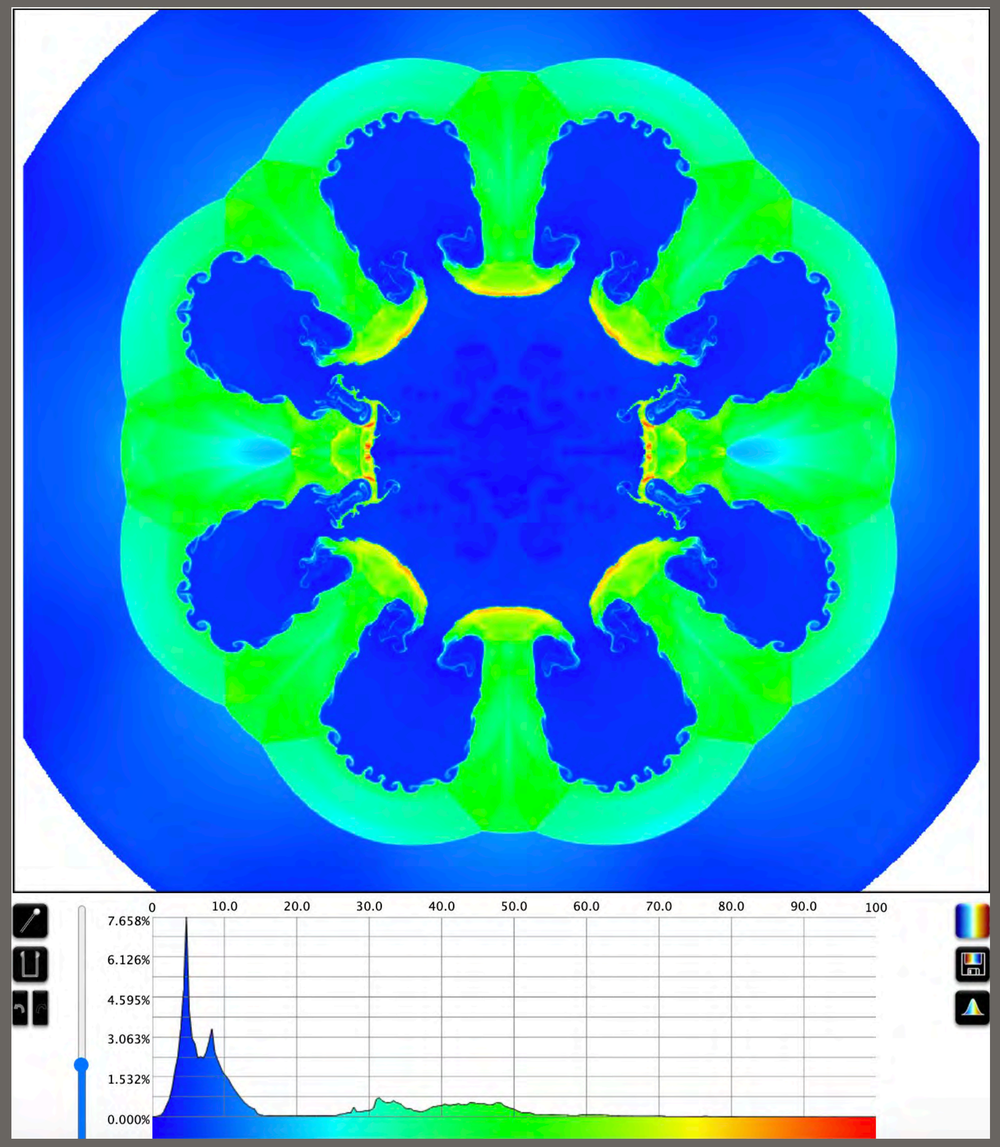
HOWEVER, You have a contrast budget!

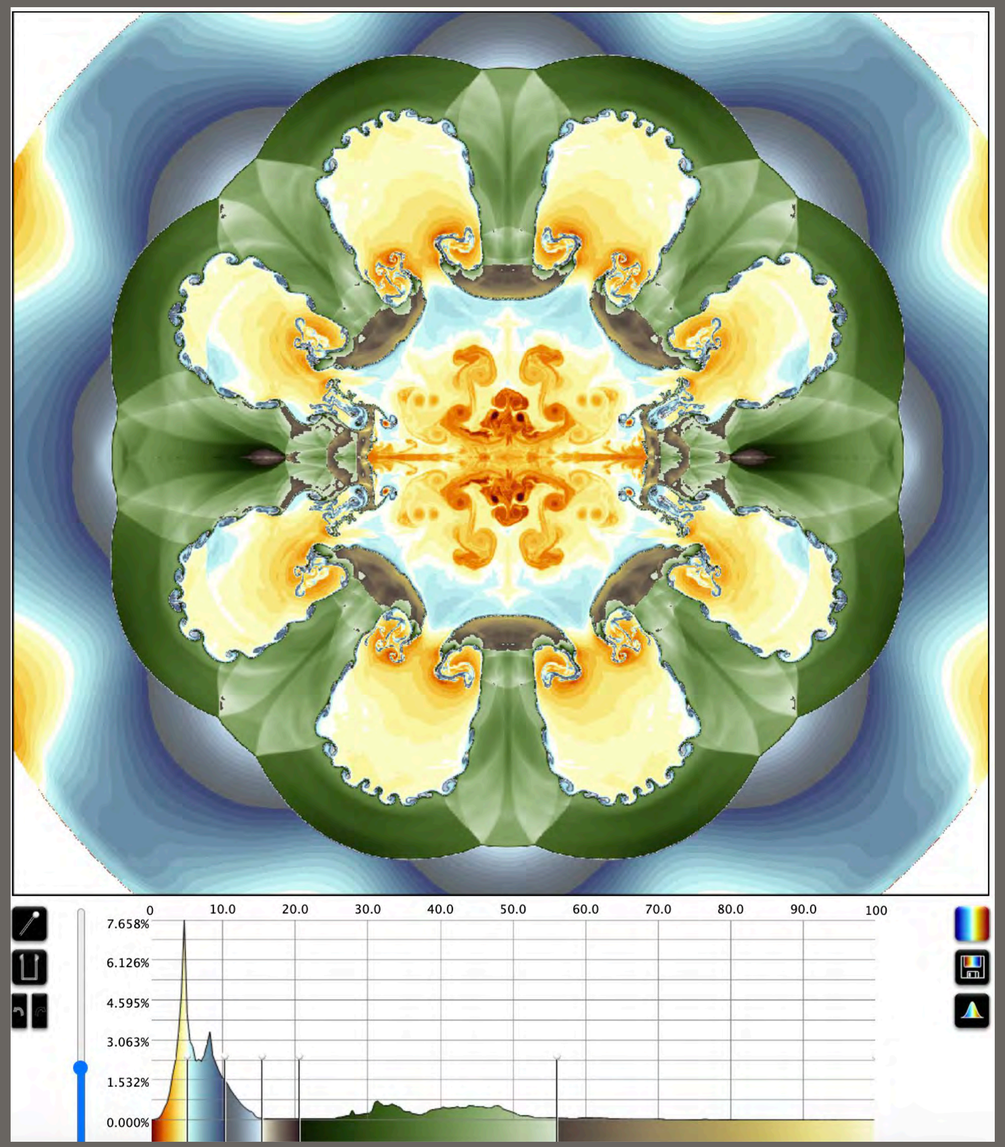
HOWEVER, You have a **contrast** budget!

Use it wisely.

Less is more.

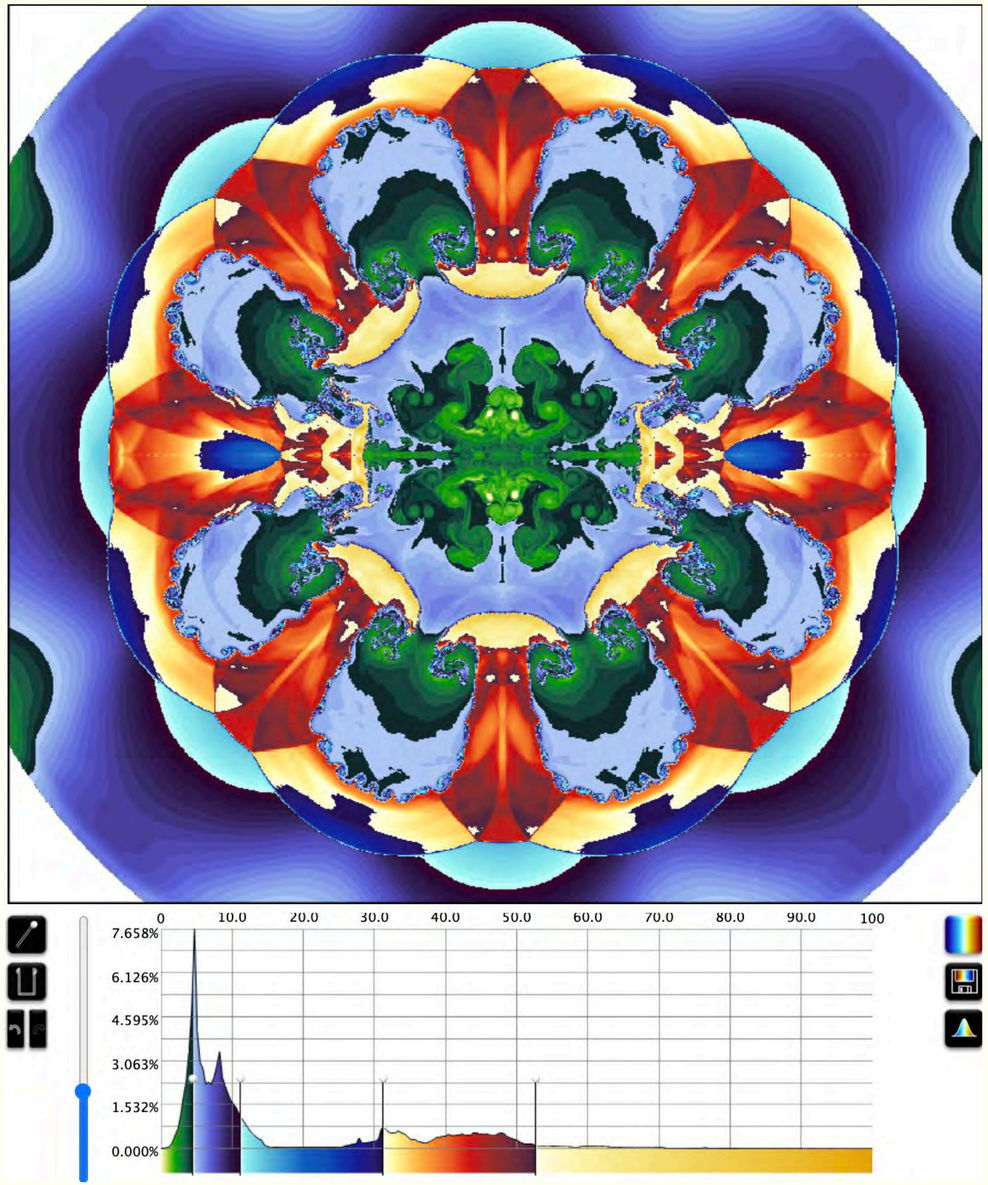
Color contrast provides the content





M. Larsen, LLNL

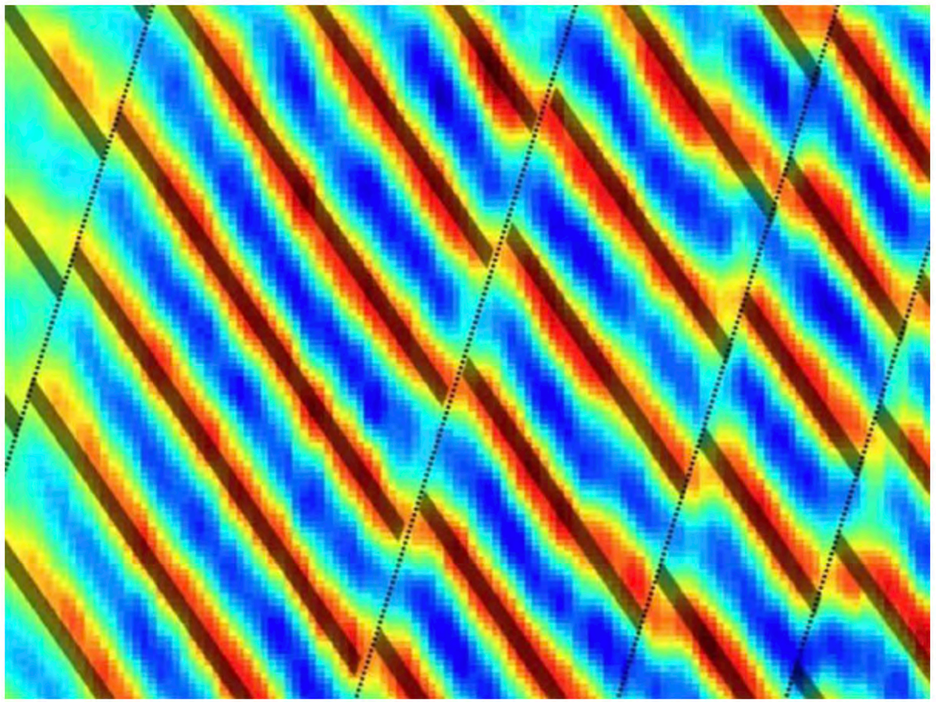
Colors Interact



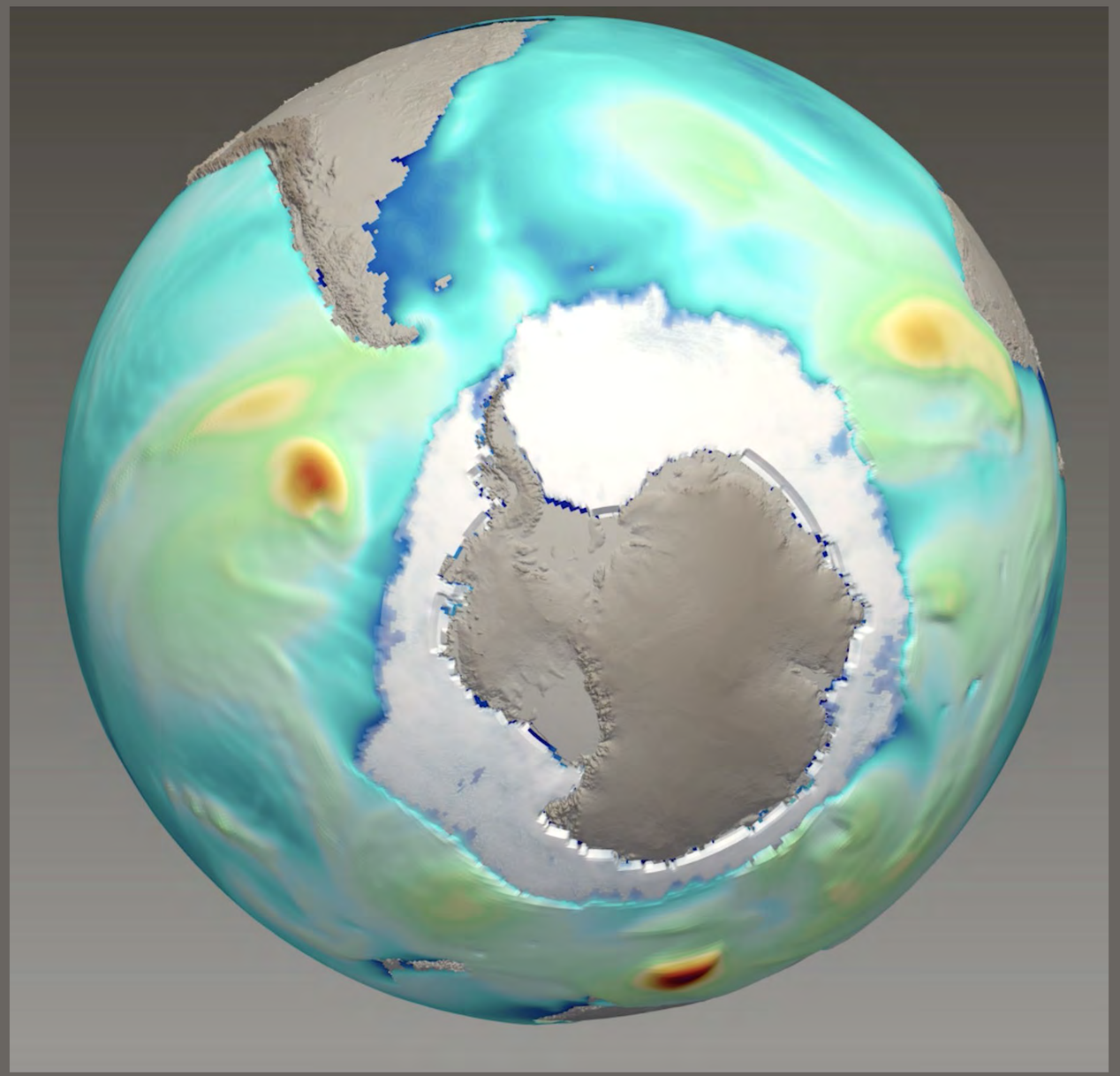
It is not the hues themselves but the relationships.

nature briefing

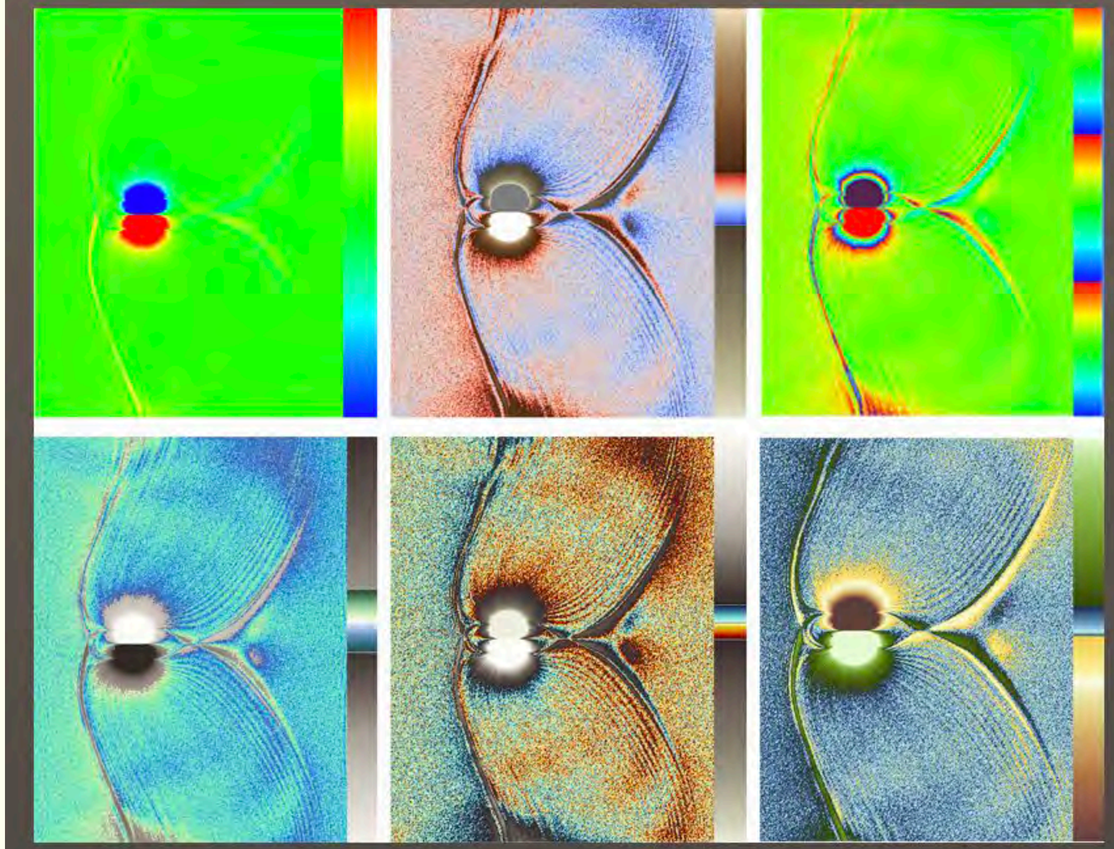
Hello *Nature* readers,
Today we welcome the detection of long-sought 2D structures called anyons, explore how to map the Universe's invisible magnetic fields and learn how sewage surveillance could be used to track coronavirus outbreaks.



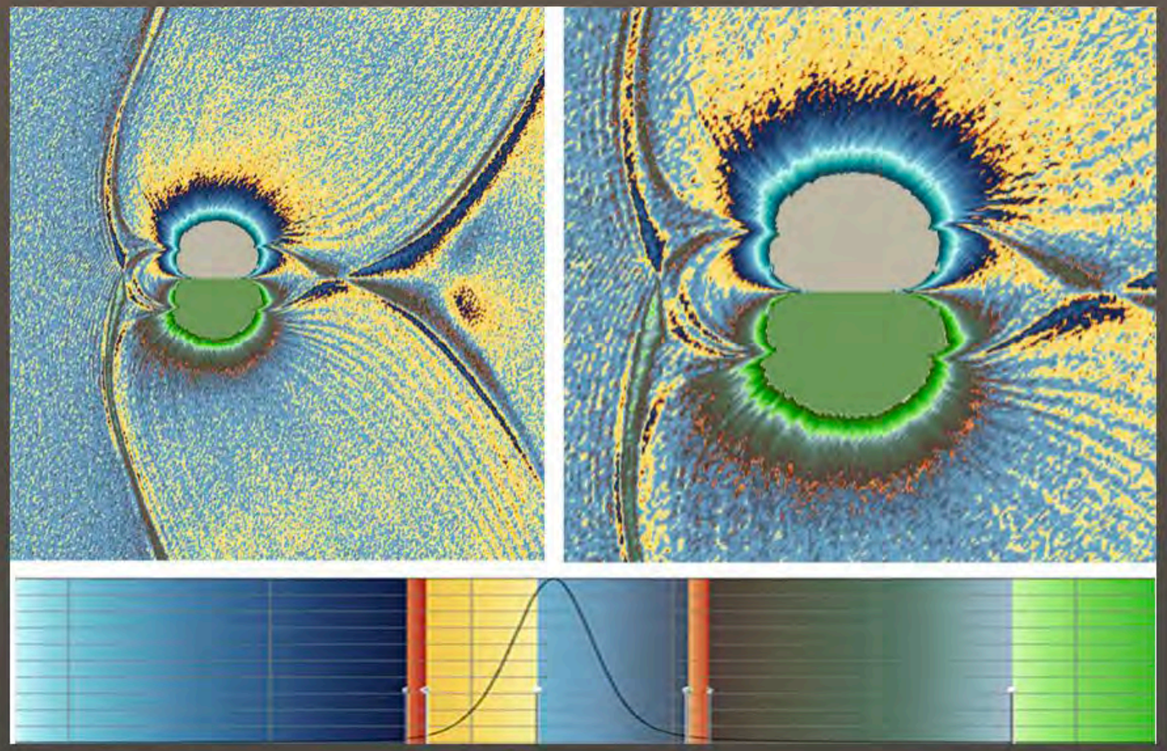
This 'pyjama stripe' interference pattern denotes the presence of anyons in an electronic system. (James Nakamura and Michael Manfra)



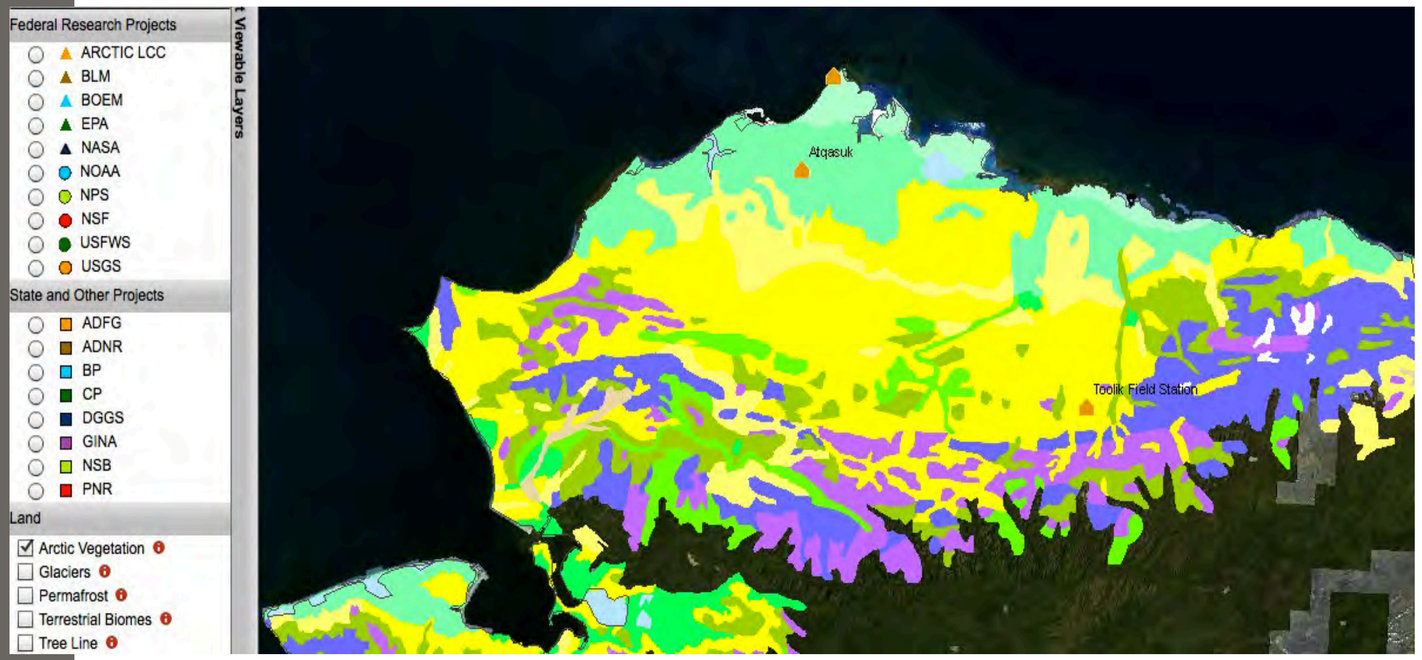
Color Theory Strategies



Tuning your colormap to:
see **more data**;
more clearly and;
communicate to others
more **effectively and efficiently.**



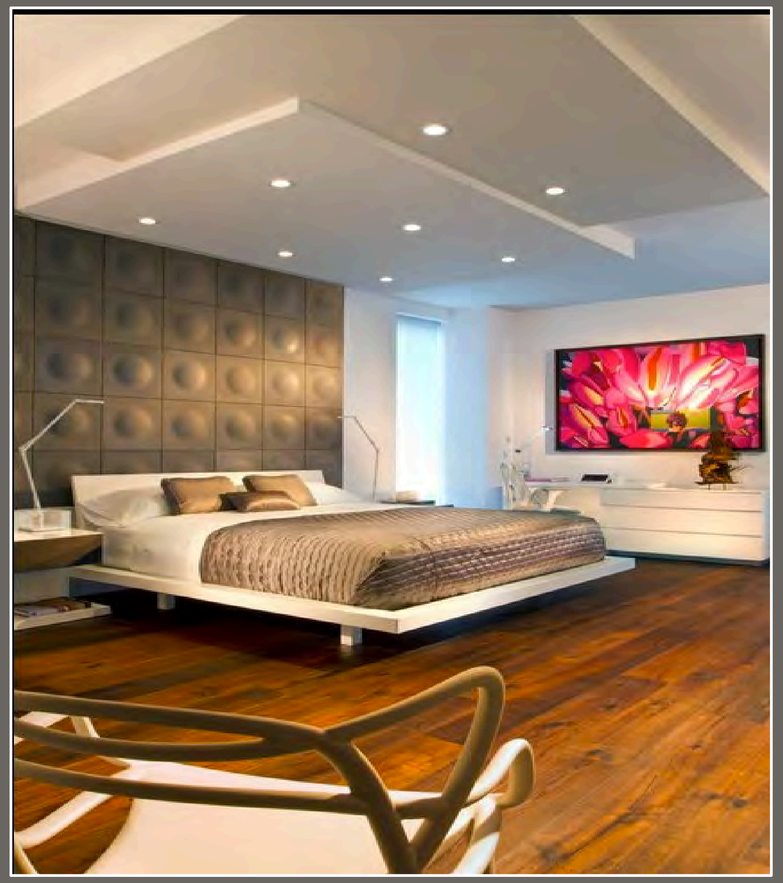
Simultaneity in discrete palettes

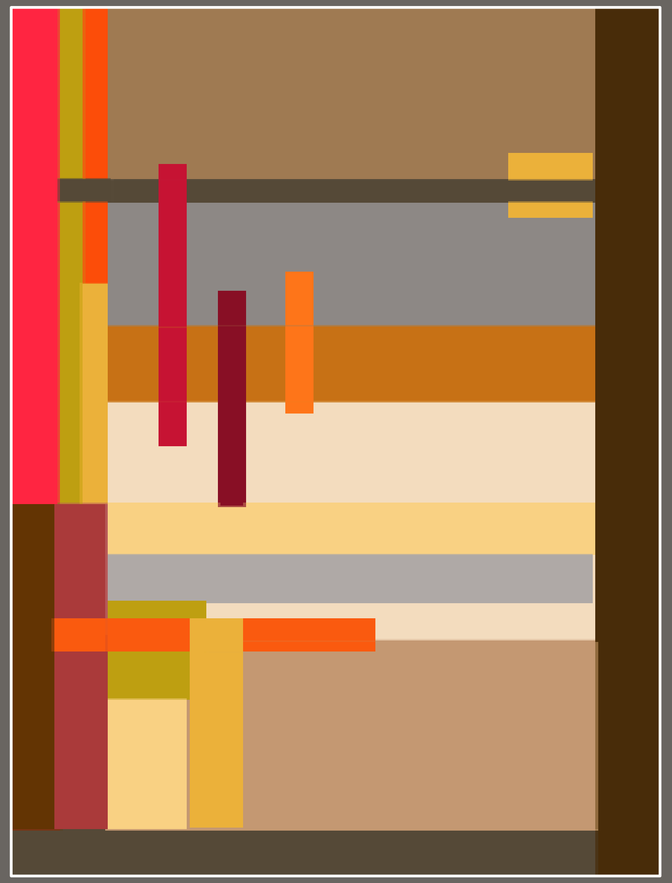


Contrast

providing clarity

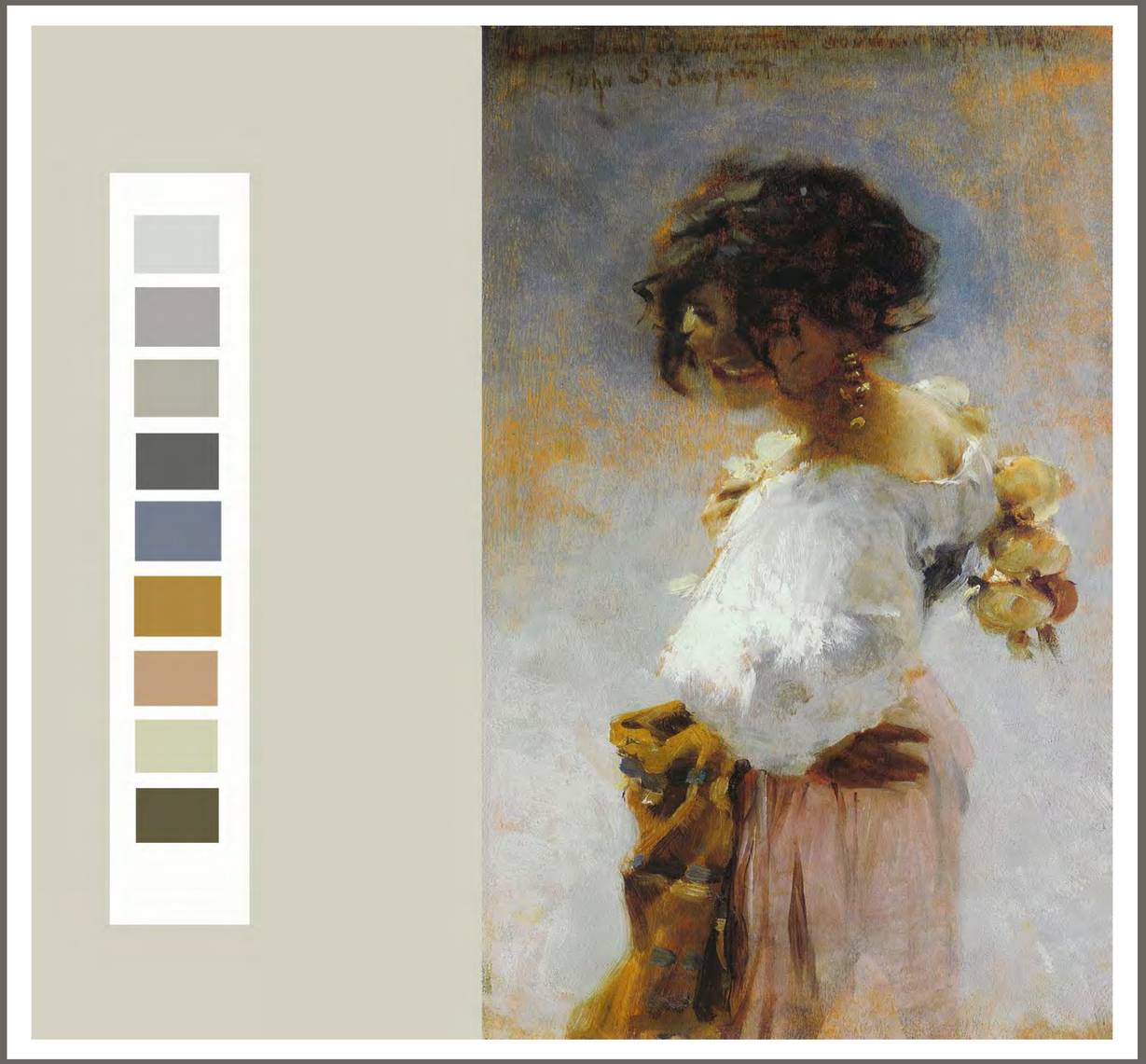
without cacophony.



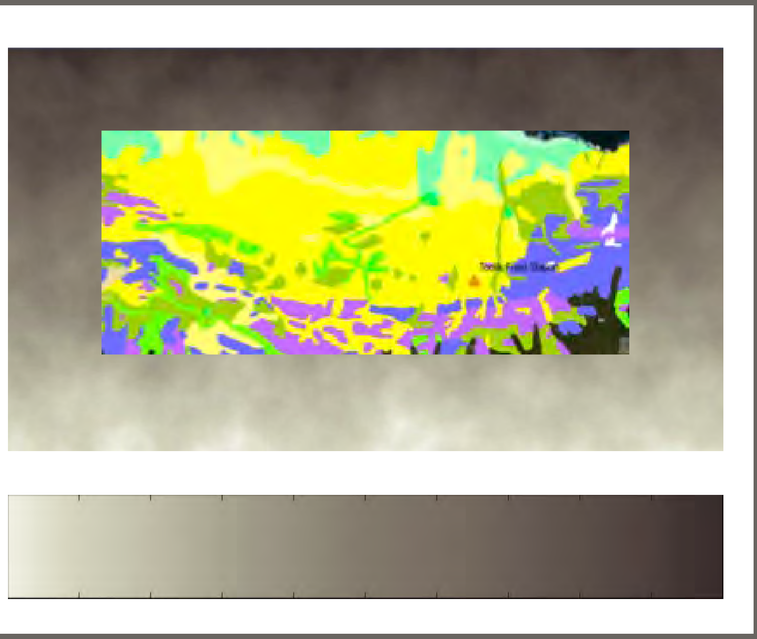


Creating an environment for contemplation

Neutral hues



a little color goes
a long way



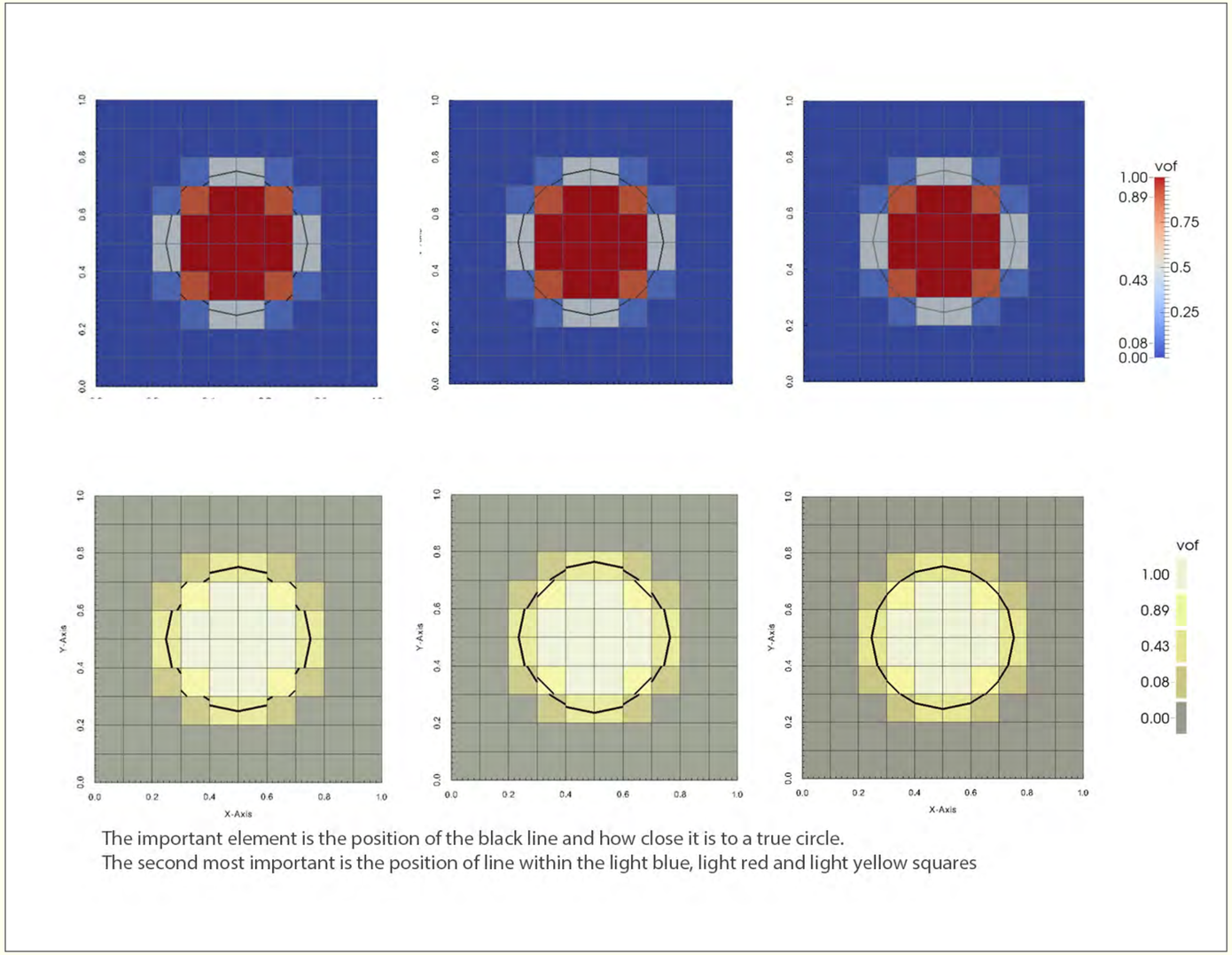
Grays frame the focal hues.

Focus Attention

Principles:

1. Value Contrast is the most powerful type of contrast.

2. Less is more.
Use neutrals for
contextual information.

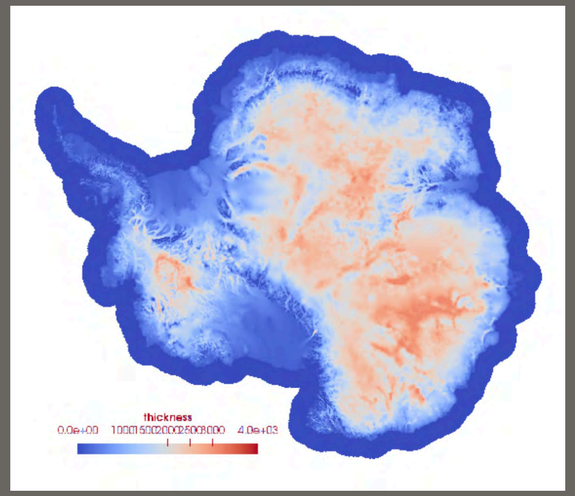


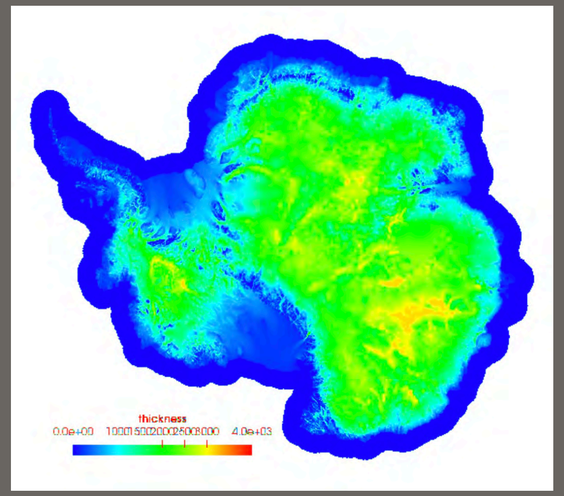
The important element is the position of the black line and how close it is to a true circle.
The second most important is the position of line within the light blue, light red and light yellow squares

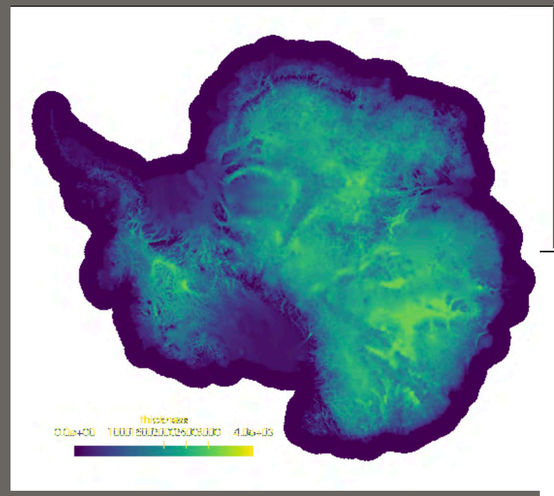
Place the contrast where you need it,
using only as much as you need.

Contrast Allocation

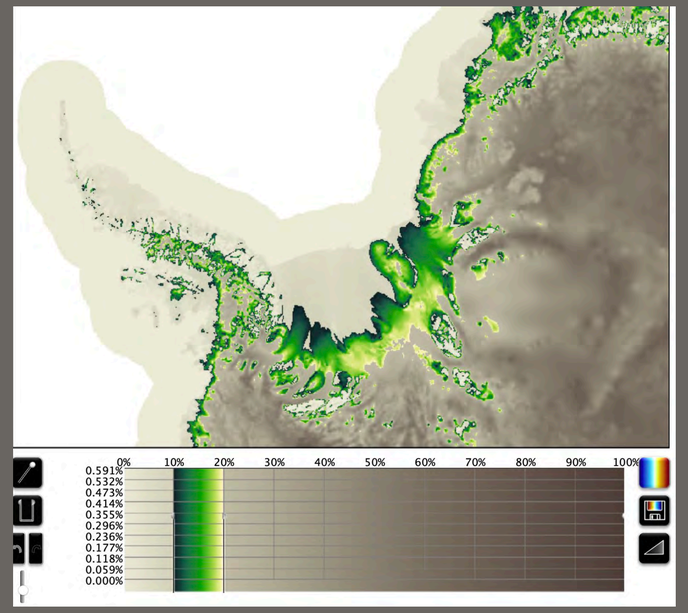
Place the contrast in the regions of interest.

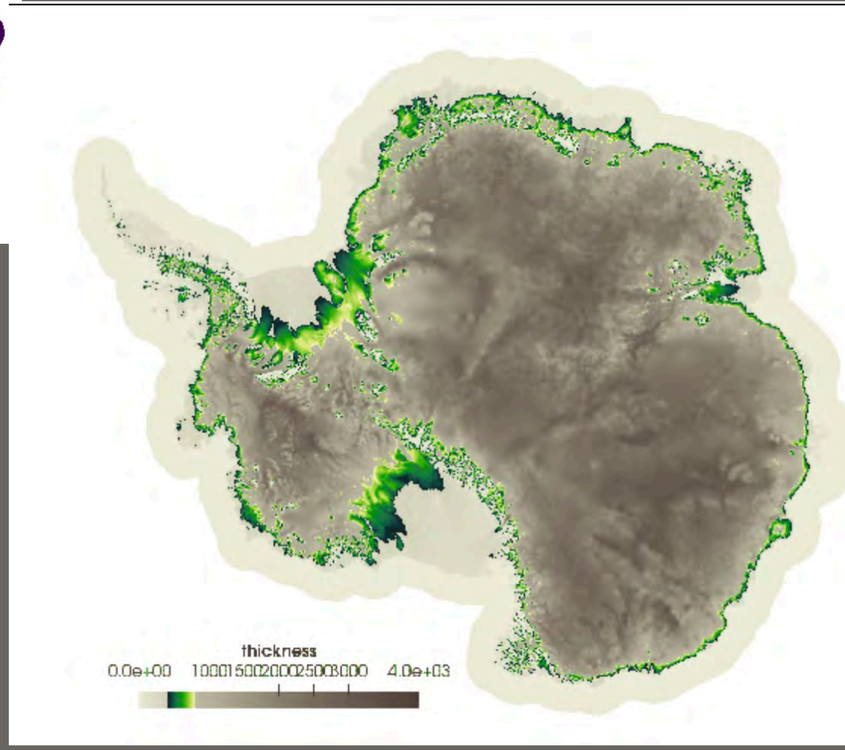






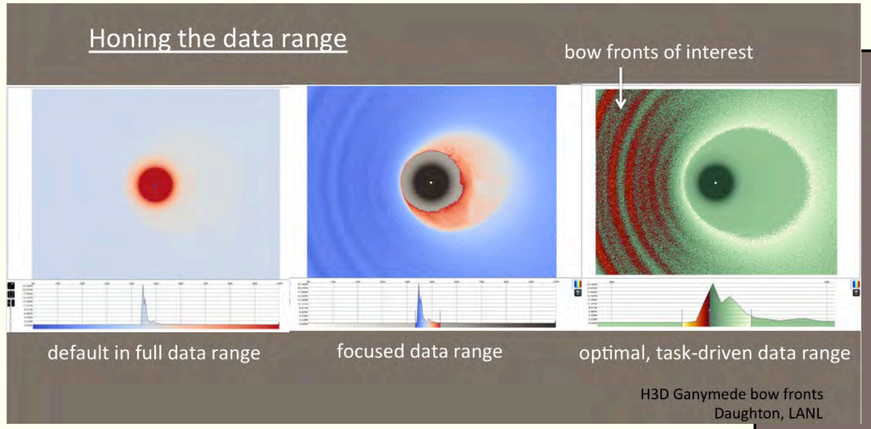
Common default colormaps



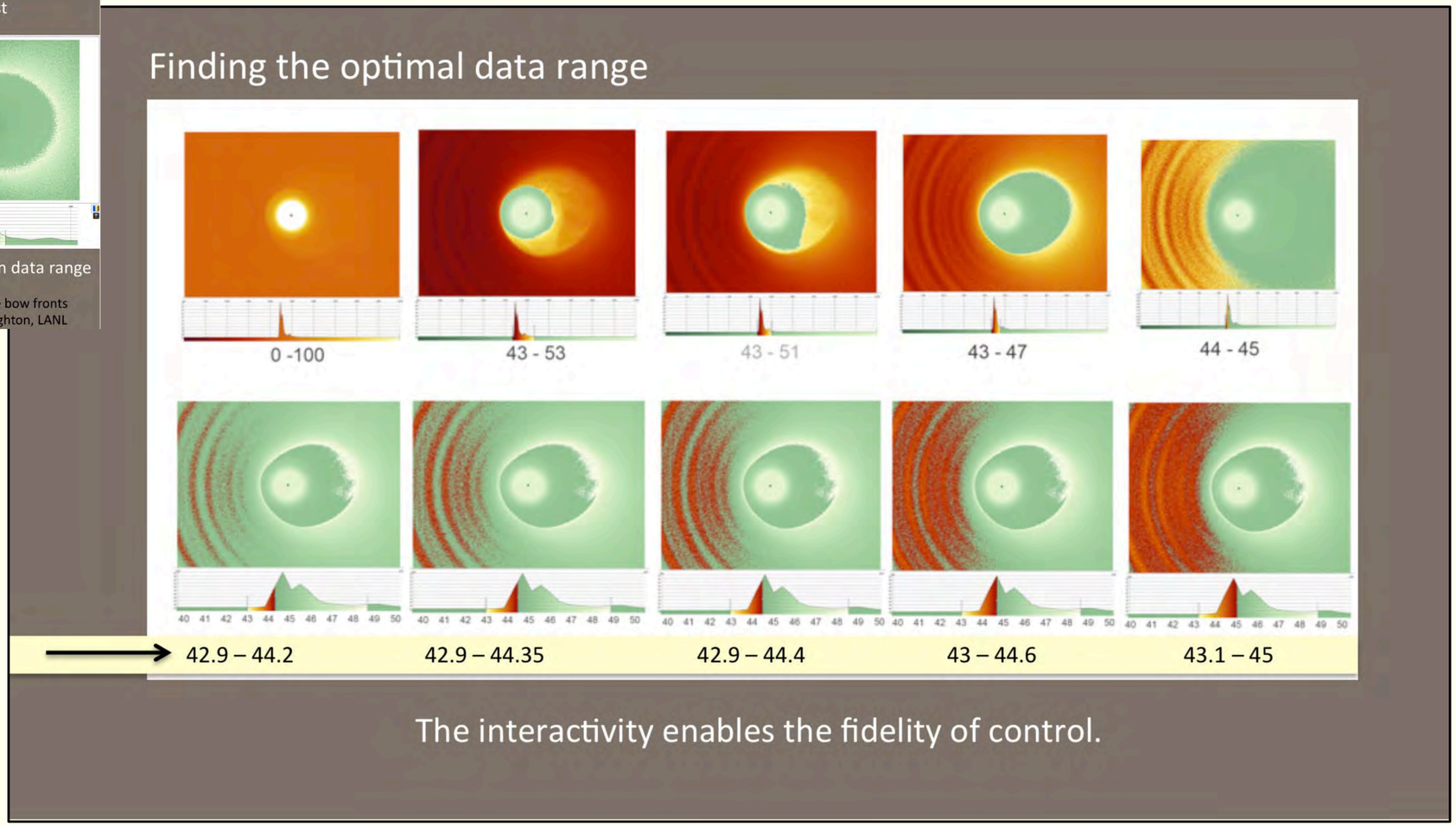


Not all data benefits from a
custom colormap, but some do.
Be aware of the gains and loses.

Contrast in the Focal Areas



ColorMoves:
Interactive allocation of contrast

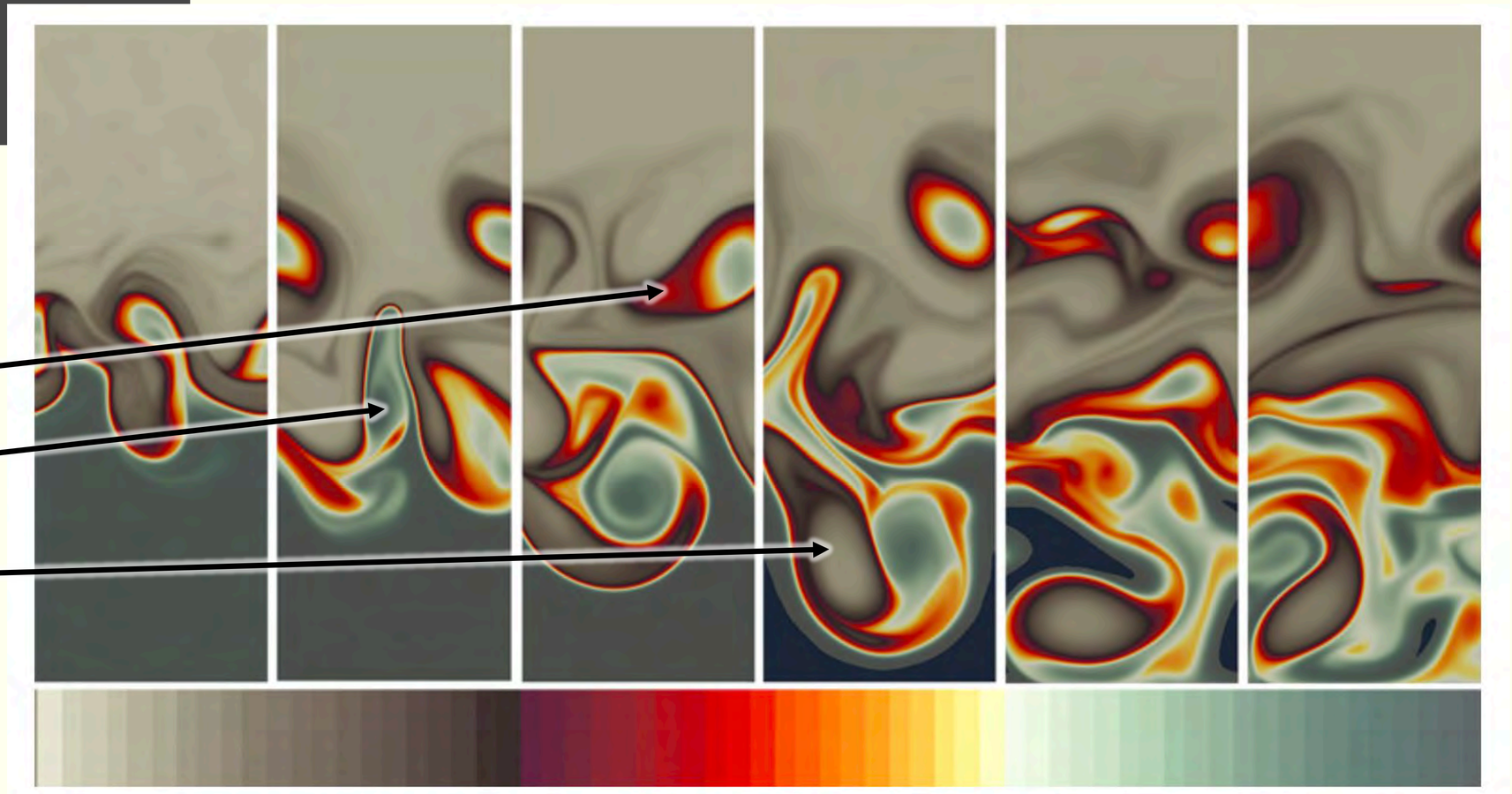


https://sciviscolor.org/ColorMoves

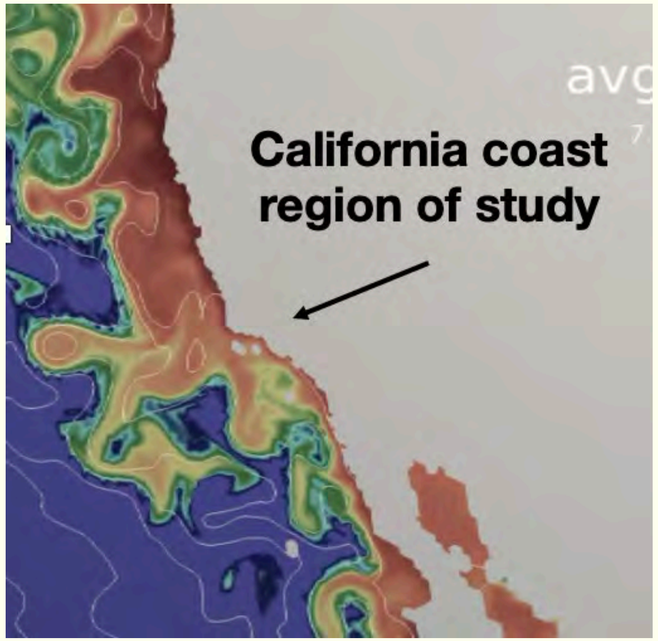
Hierarchy of Attention

1. Saturation levels direct attention

2. Hue contrast



To come: Addressing colorblindness

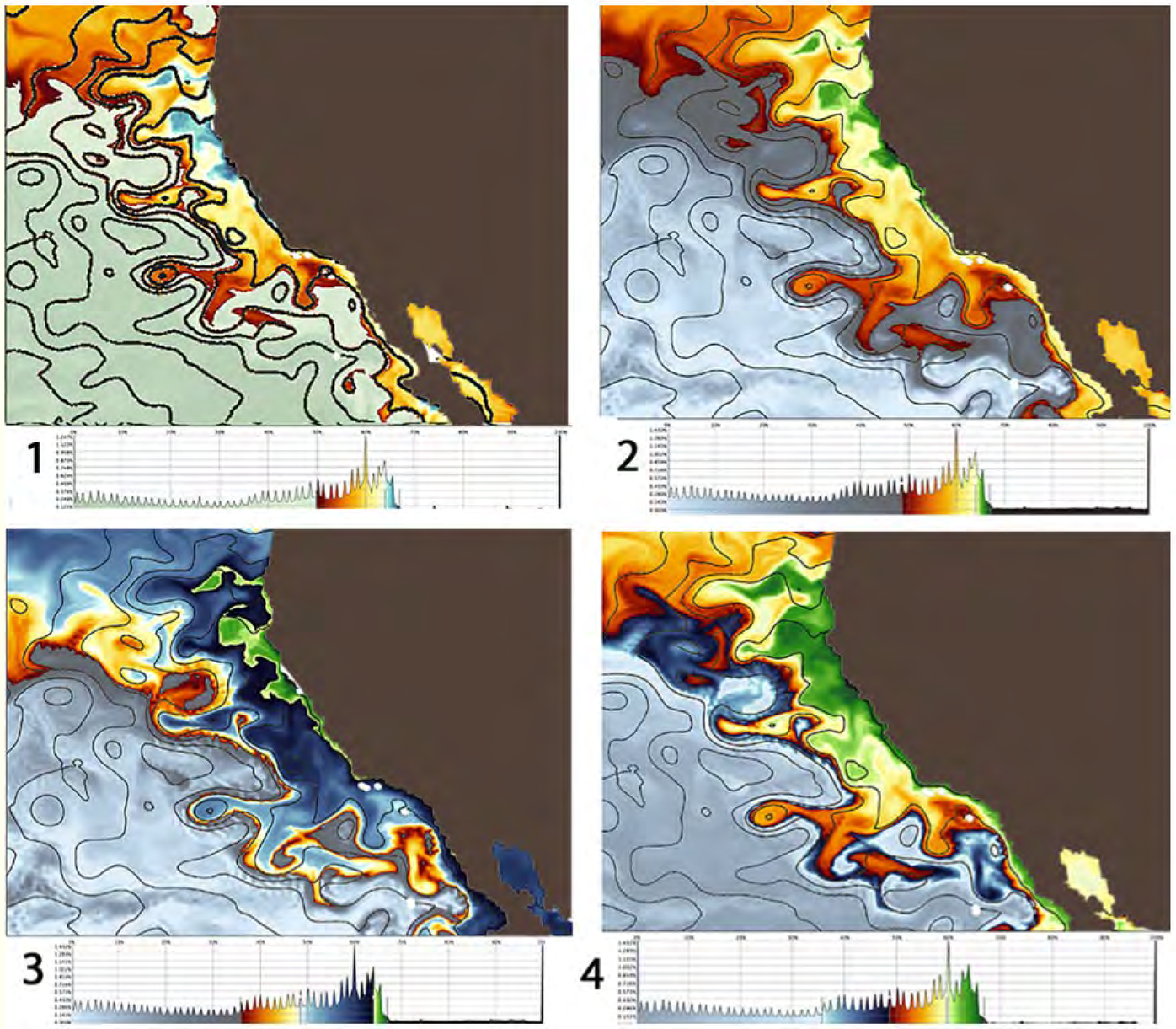


Associative Color / Semantic Color

Three data categories:

1. Optimal location for algae growth
2. Algae will not grow
3. Open ocean

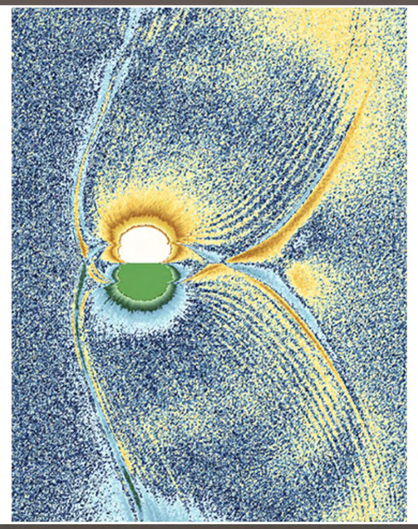
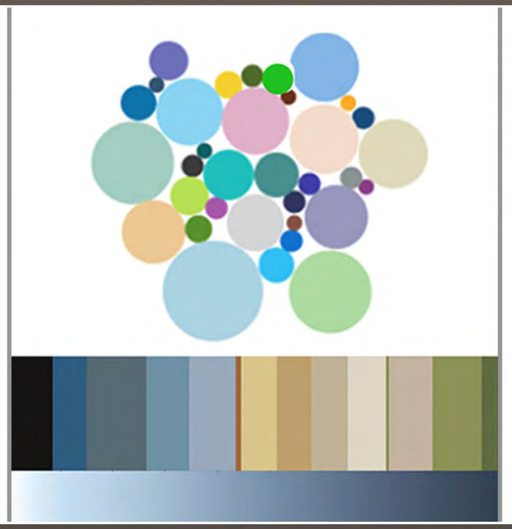
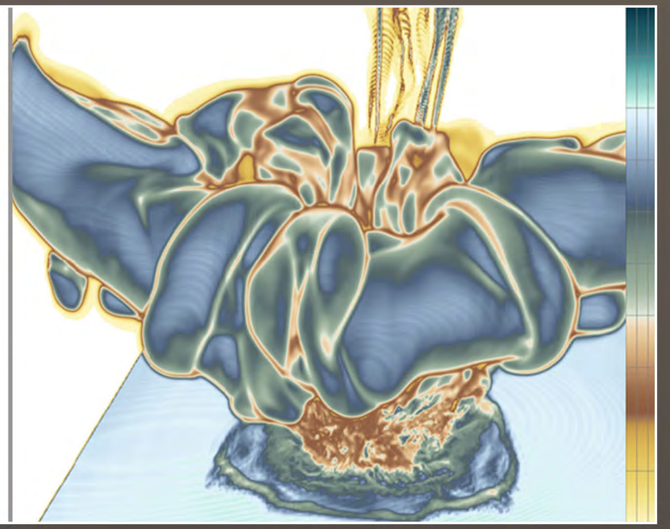
Associative Color



Affective Color

Affect impacts engagement and memory

Art, Affect and Color:
Creating Engaging Expressive Scientific Visualizations

Most read publication

The Arnolfini Wedding Portrait
Van Eyck, 1491

1. Value
2. Complimentary, Cool Warm
3. Analogous
4. Associative / Semantic

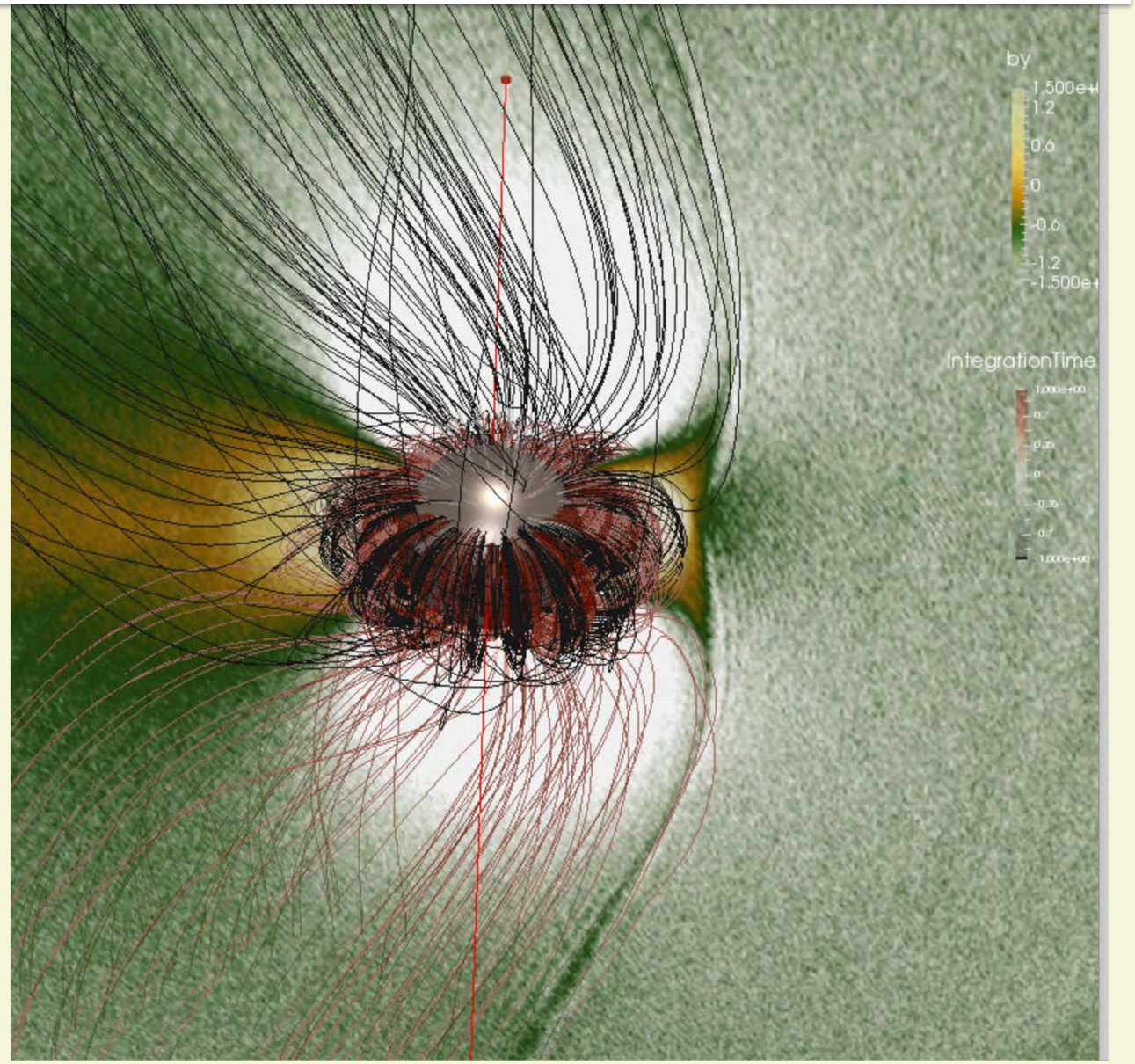
Types of color contrast

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

Artists closely the location, proportion, distribution of hues and types of contrast to direct attention and convey content.

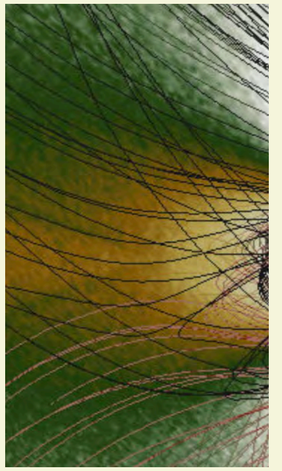
Multiple types of contrast allocated for clarity

a

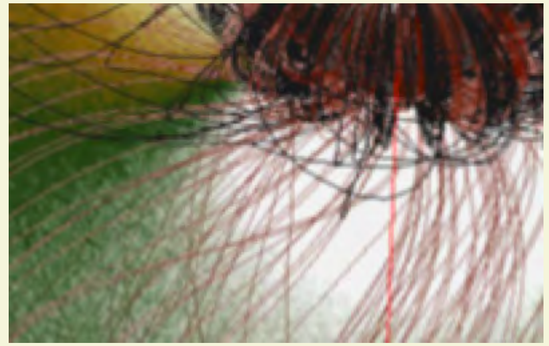


Saturation and value

Analogous color



Complimentary color

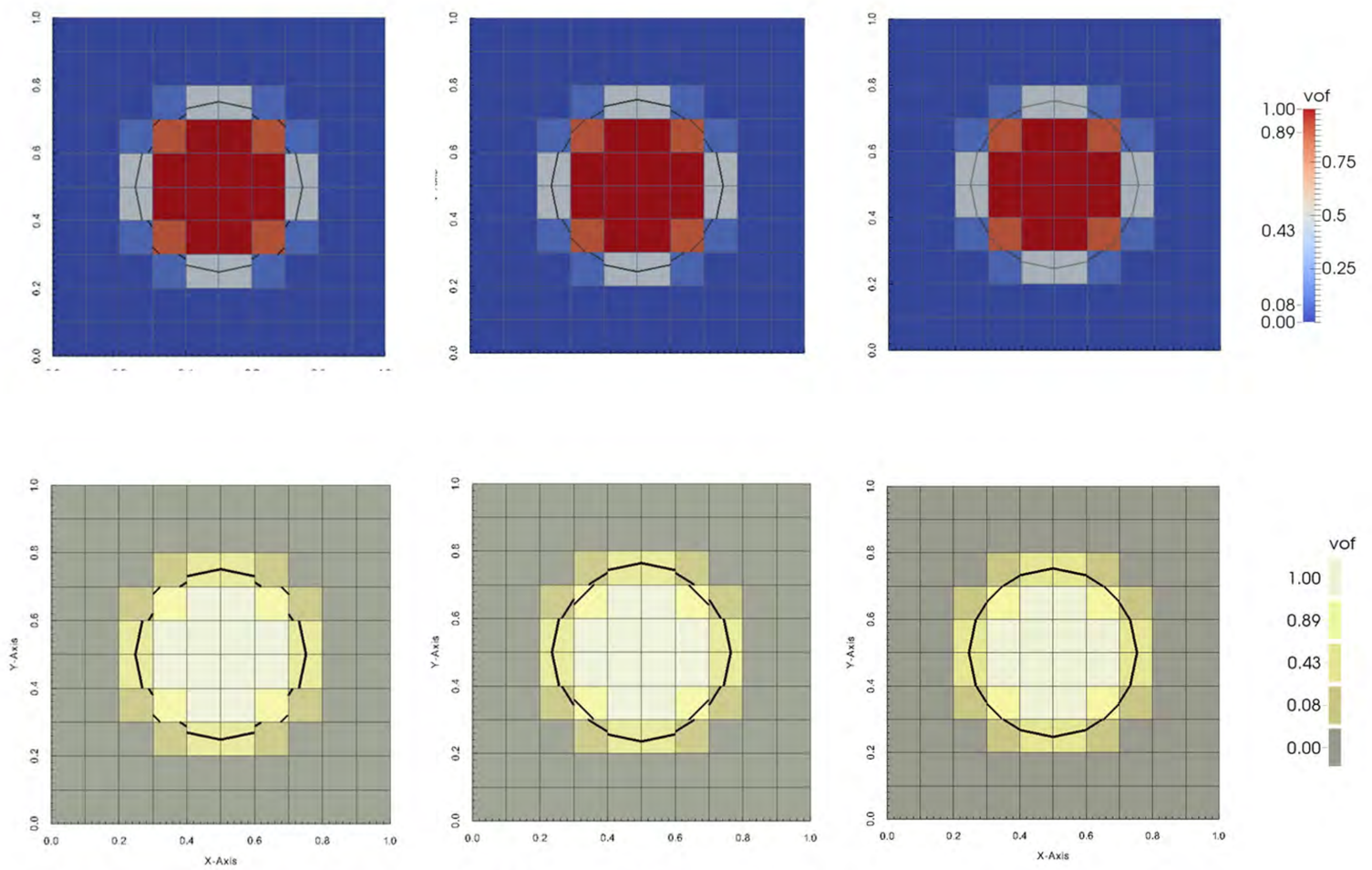


Value Contrast

1. Value contrast is the strongest type of contrast and the most intuitive for scalar data.

2. Less is More.

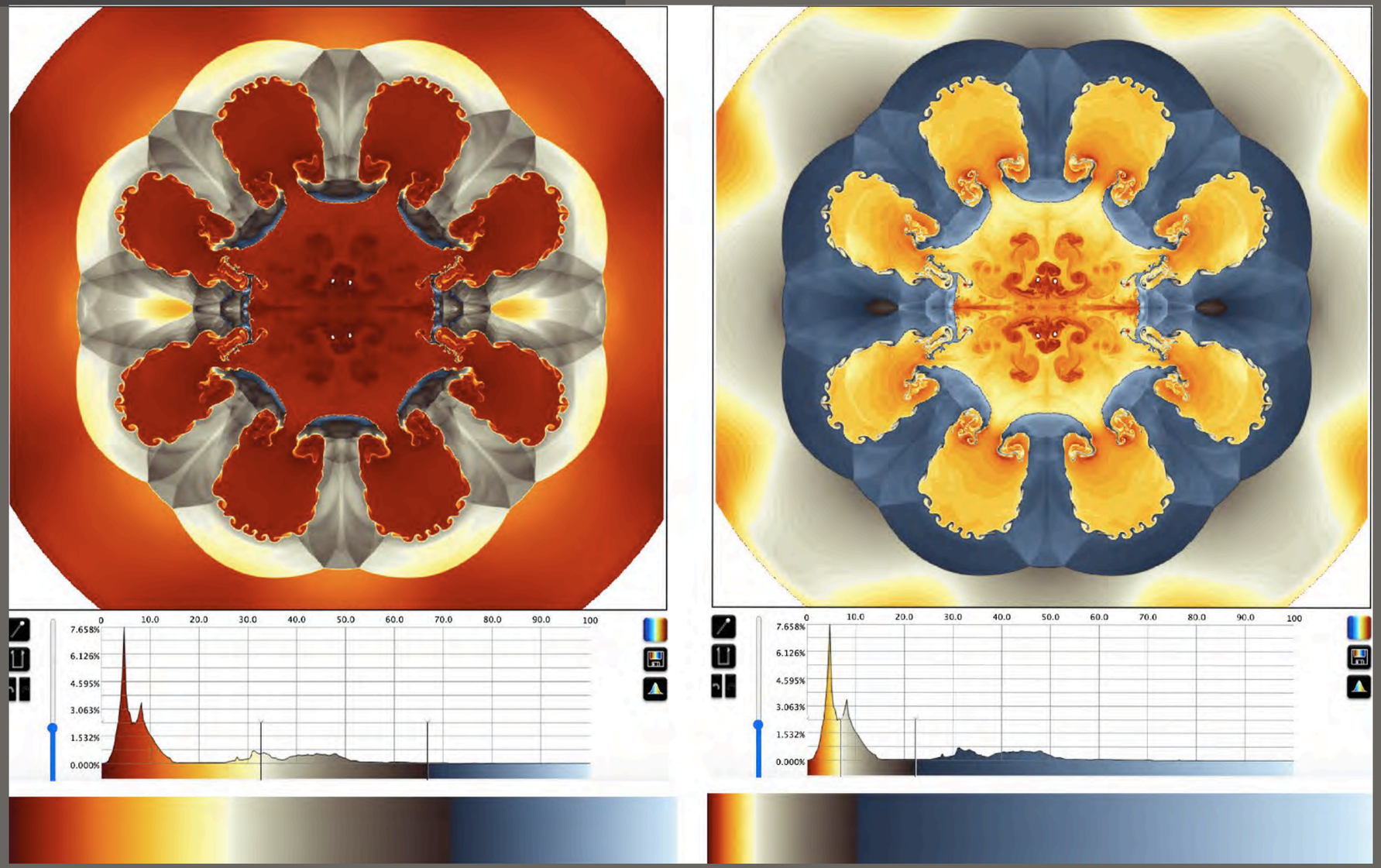
Align the contrast with the goals of the visualization, using only as much contrast as you need.



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

Recommended Starting Points

Wave colormaps - Providing a starting point

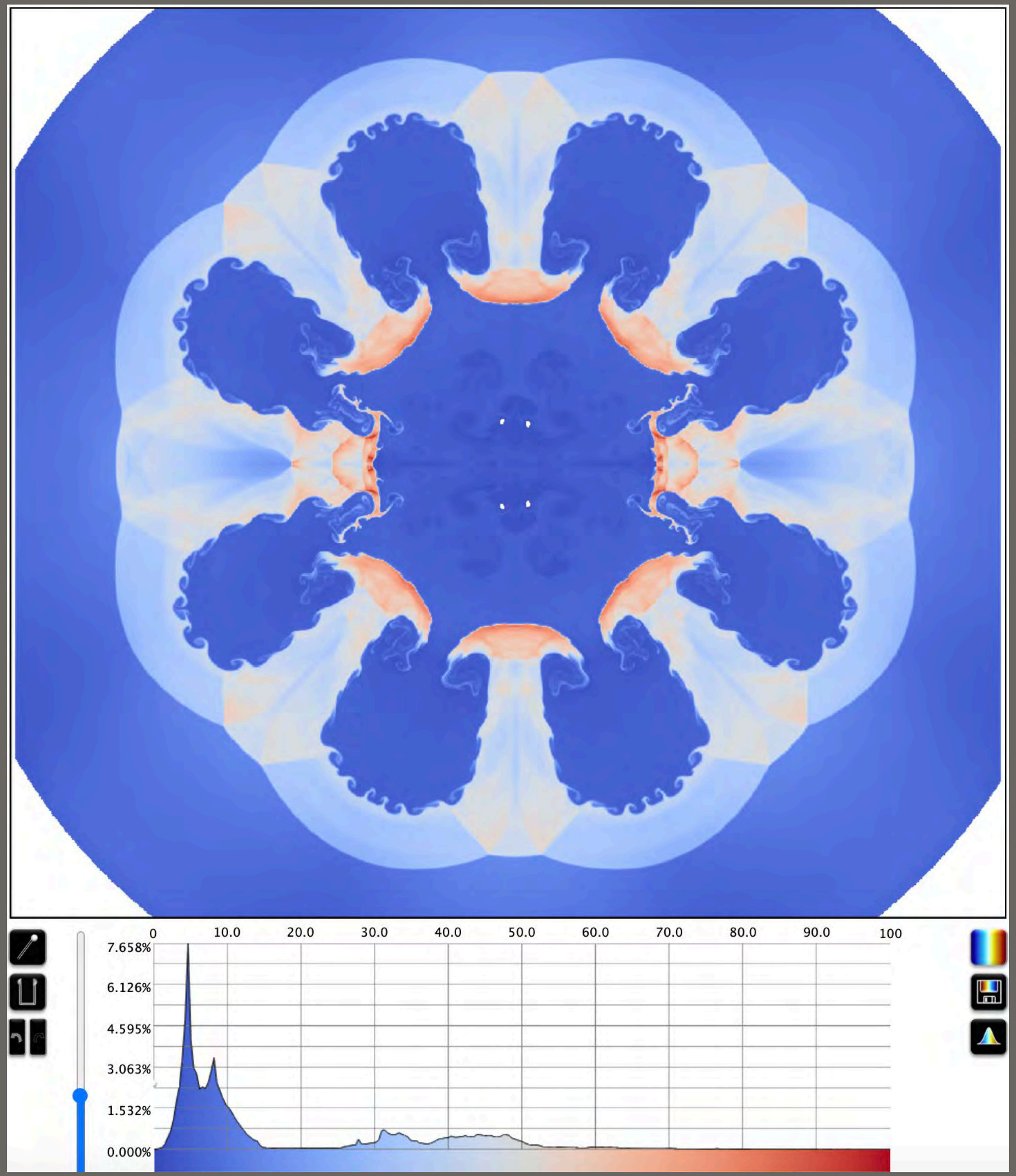


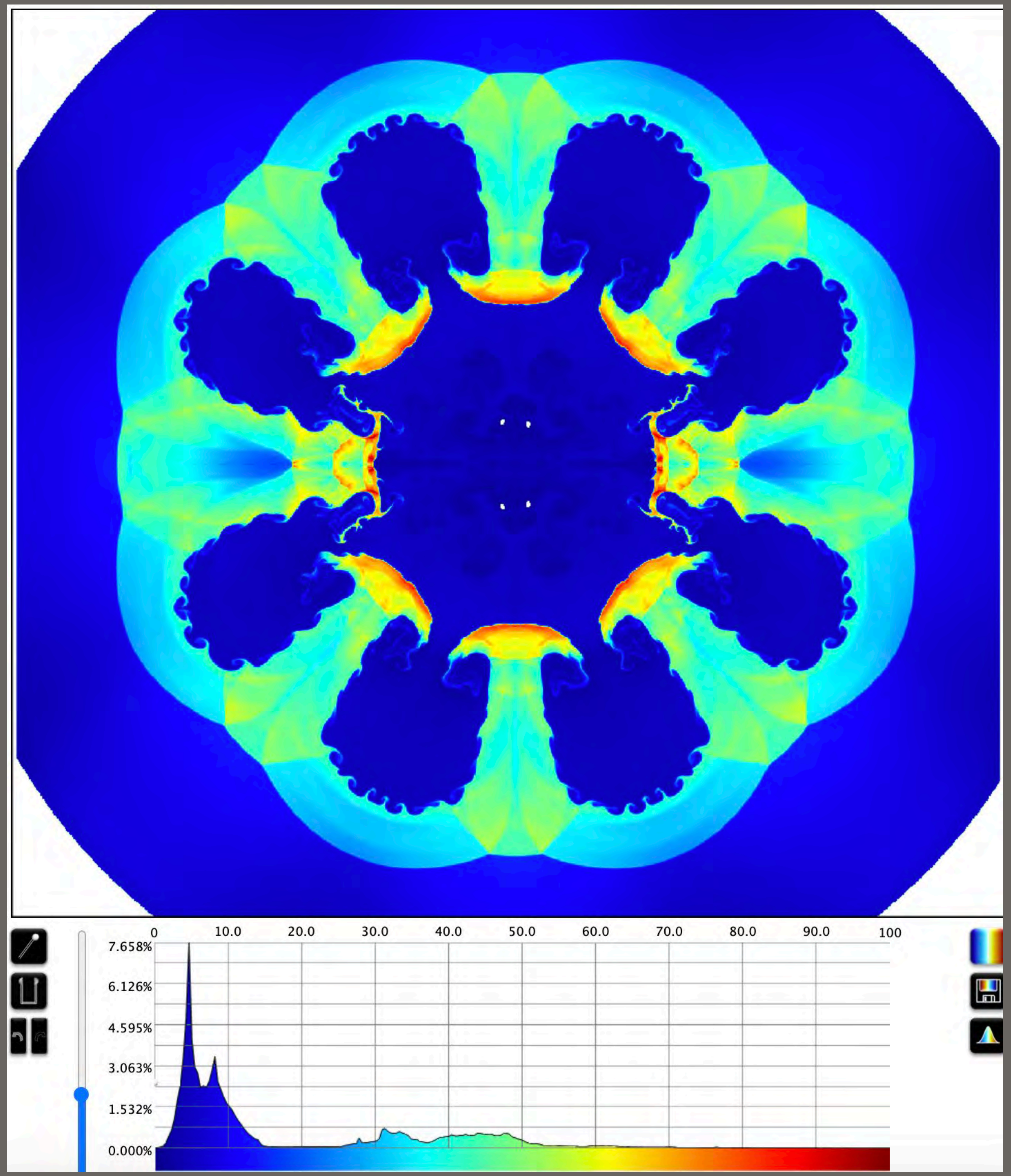
Internal confinement fusion

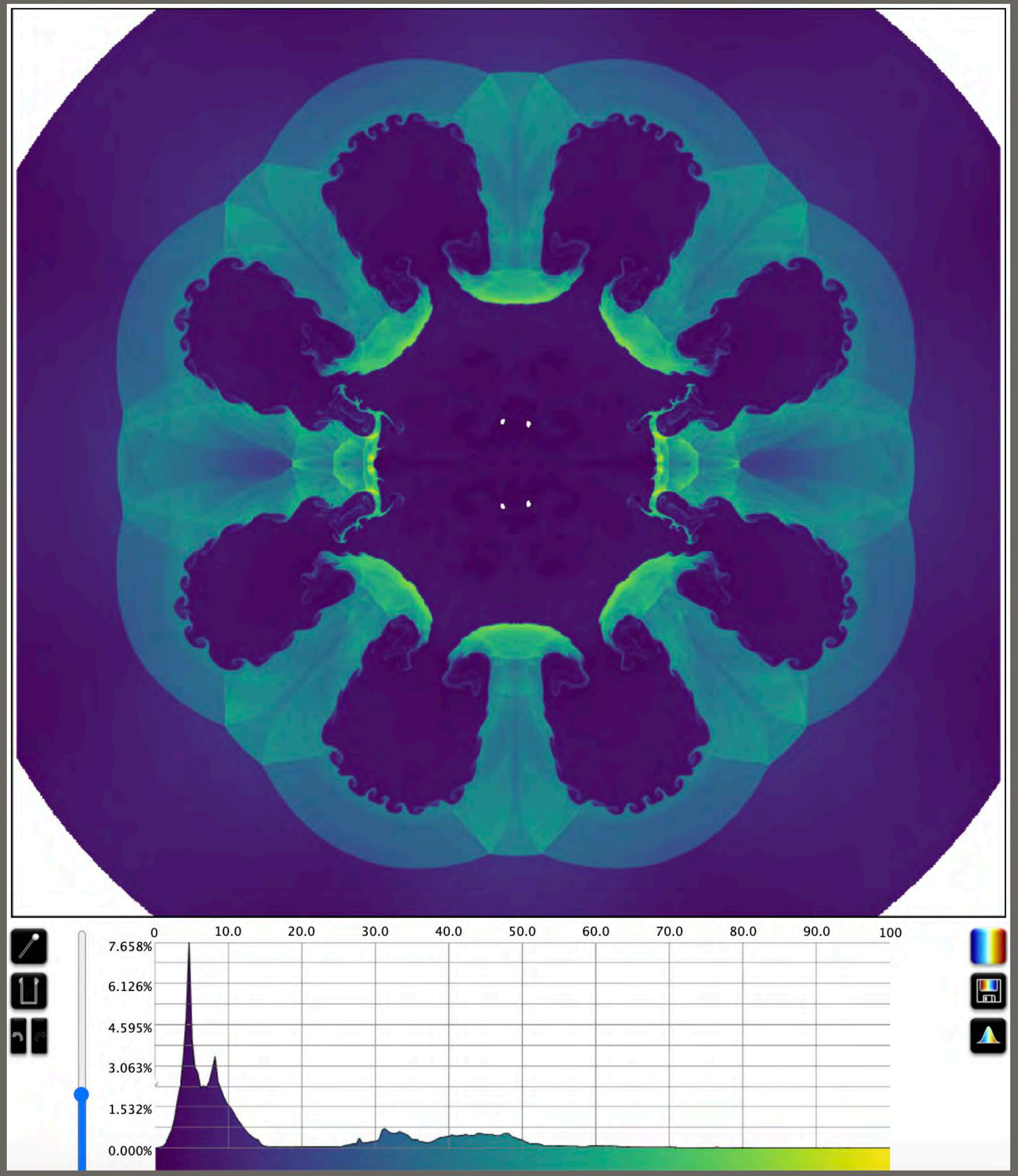
Matthew Larsen, LLNL

Colormap Selection

One-size does not fit all.



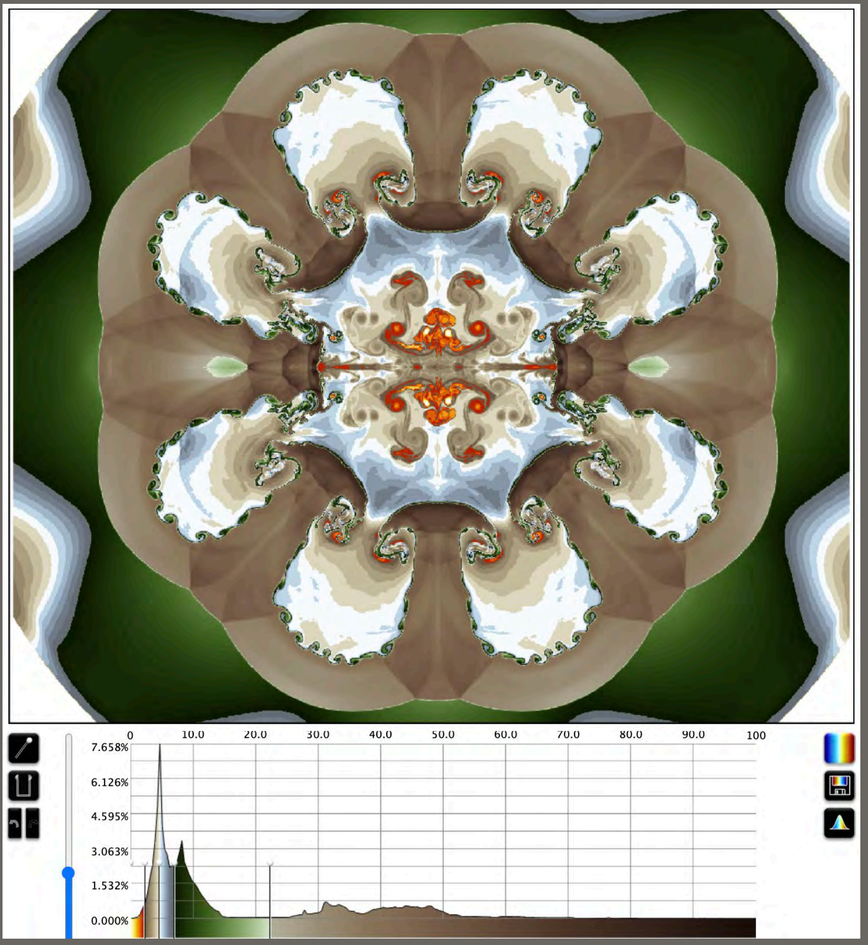


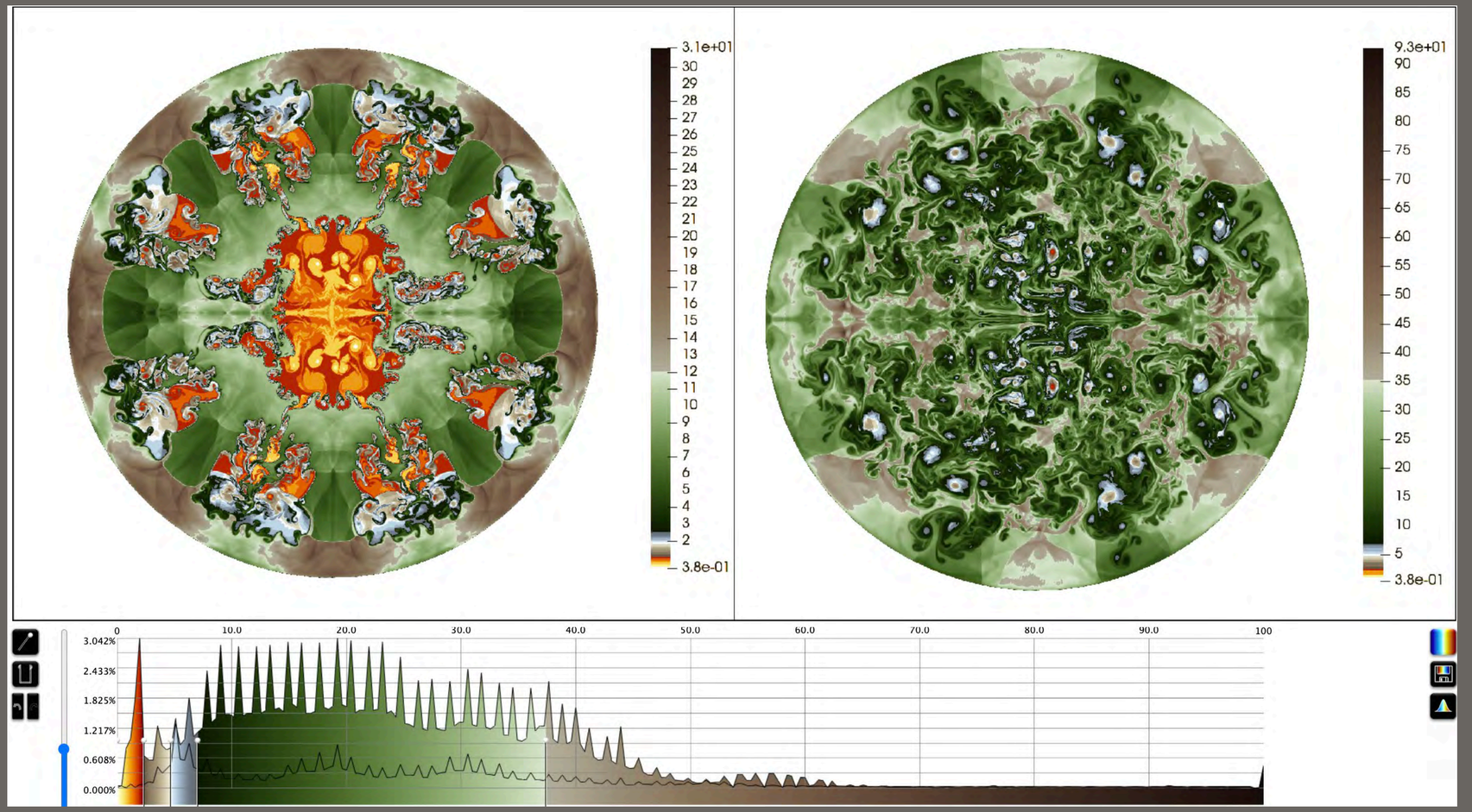


Software needs to offer more than defaults.

Tracking data over time

Selecting focal areas to track over time



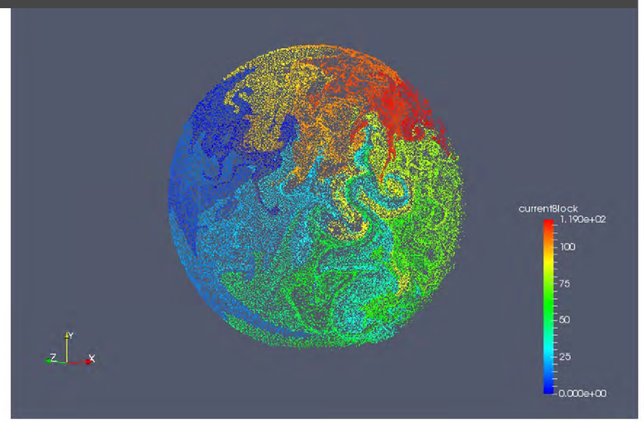


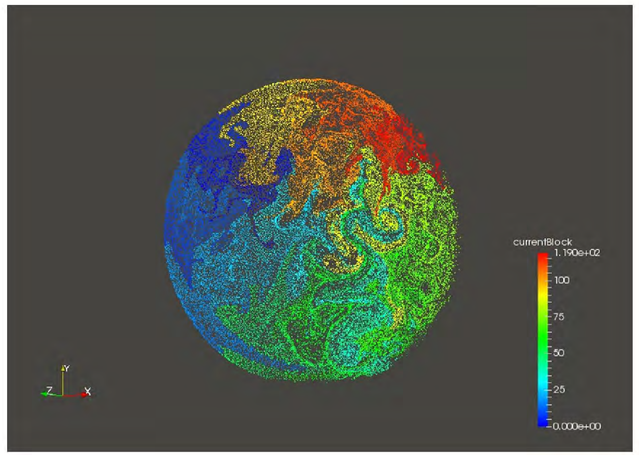
M. Larsen

ColorMoves
SciVisColor.org

Cool - Warm Contrast

Use cool warm and value contrast
to select background hues, neutrals are best.



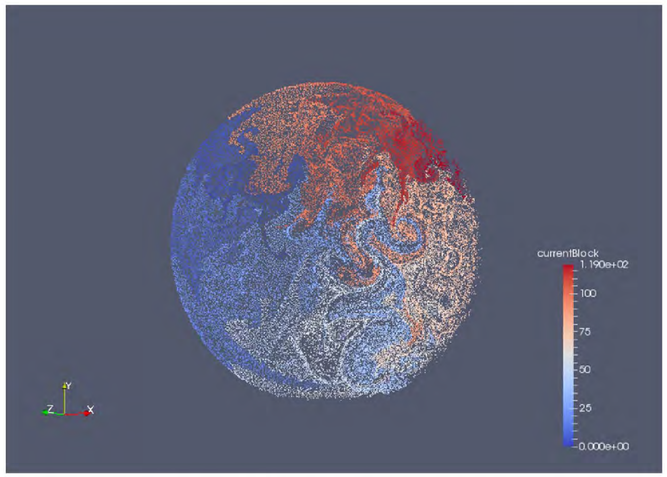


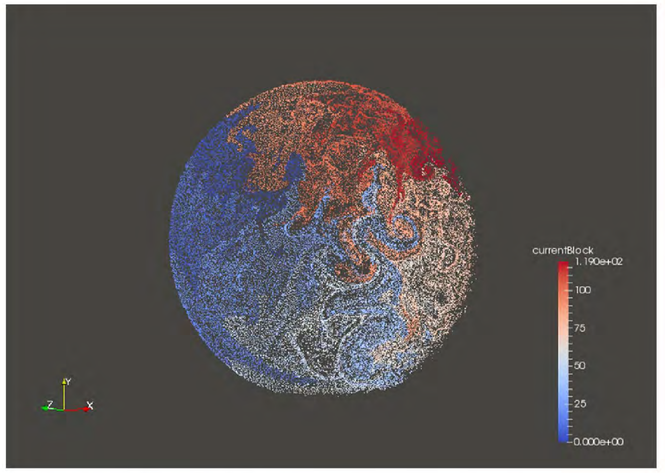
Change the Paraview background default!

Your life and vis will be calmer.

RGB 107 107 107

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



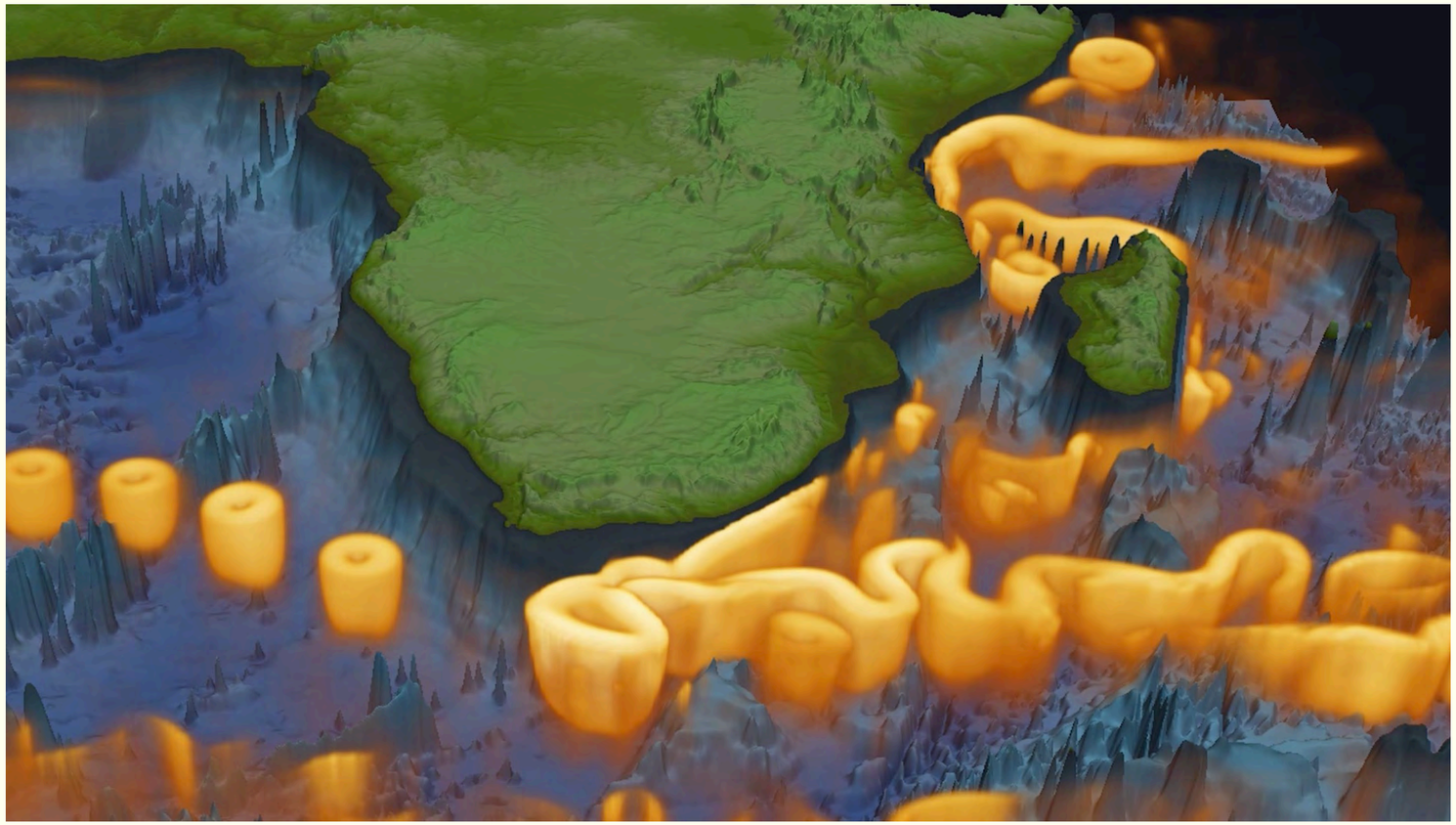


In general, cool colormaps such as the ParaView default,
need a warm background but in reality,
the ParaView background is almost always worse.

Hue Contrast

1. Primary hues provide the strongest contrast.
2. Hues have inherent hierarchy.

3-Dimensional Vis



yellow 15

contextual color

Focal point:
- Warm hue range
- High saturation
- Use of semantic color

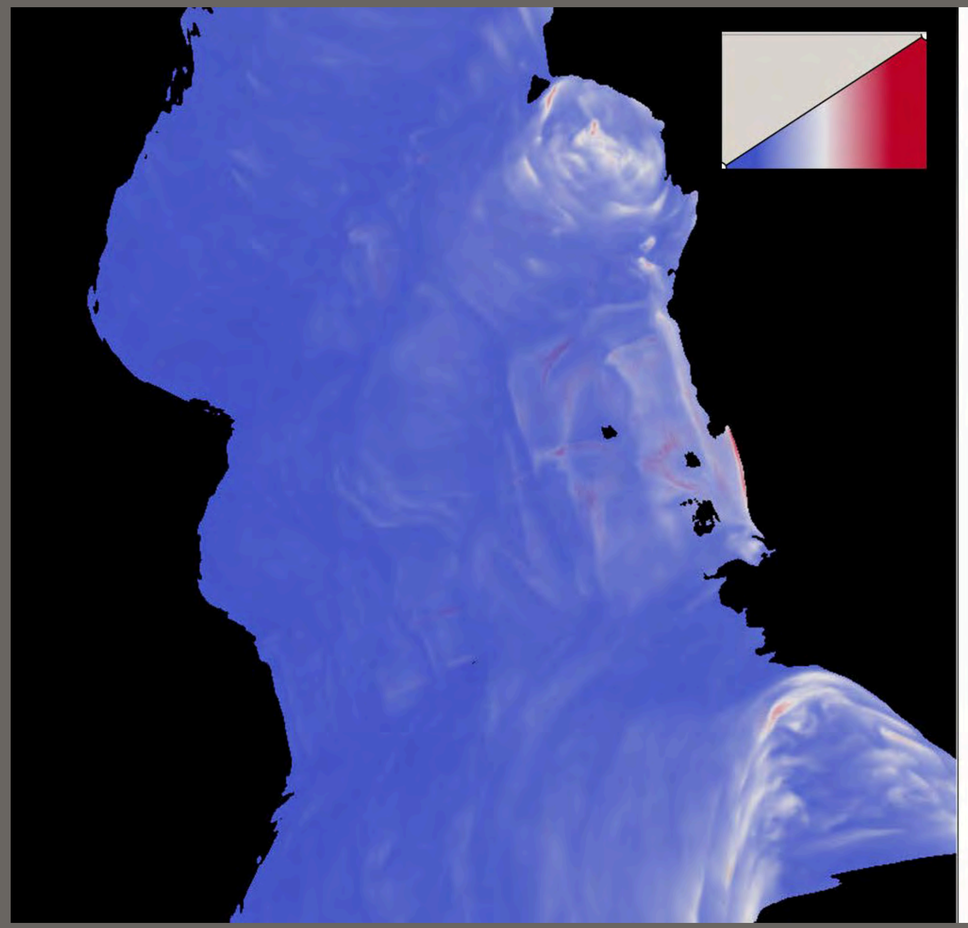
3D Data, single variable

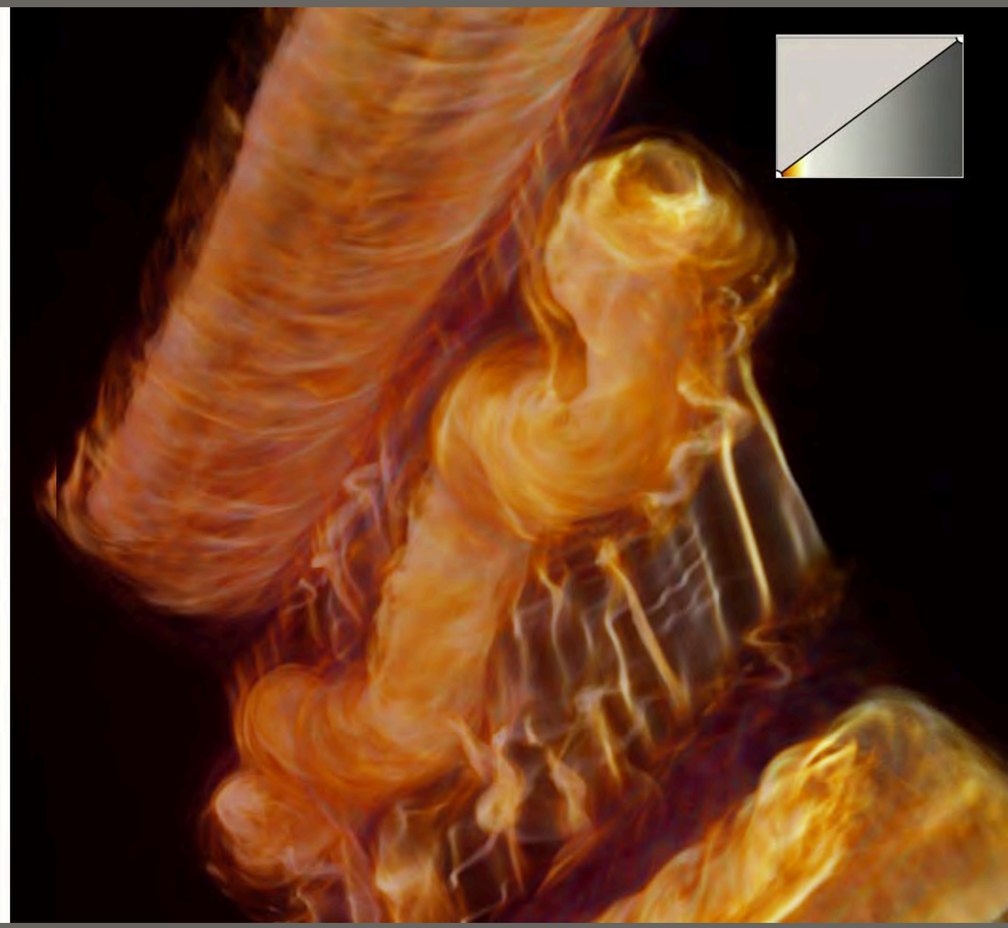
Many choices:

volume,
slices, isosurfaces
streamlines

opaque, transparent
glyphs or points

Start with
THE GOAL.

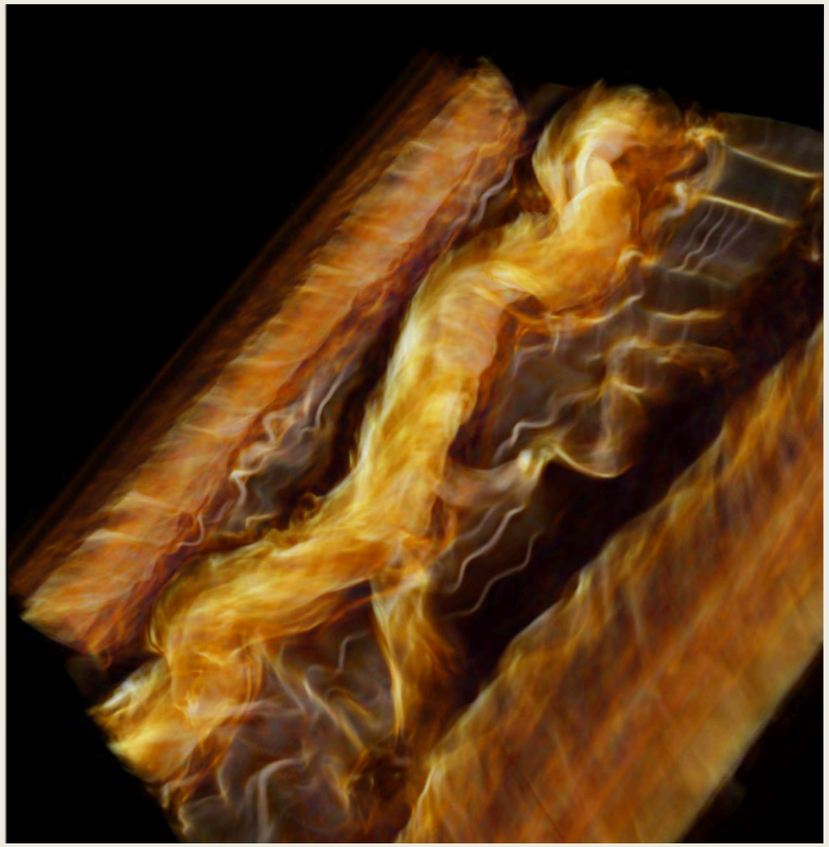


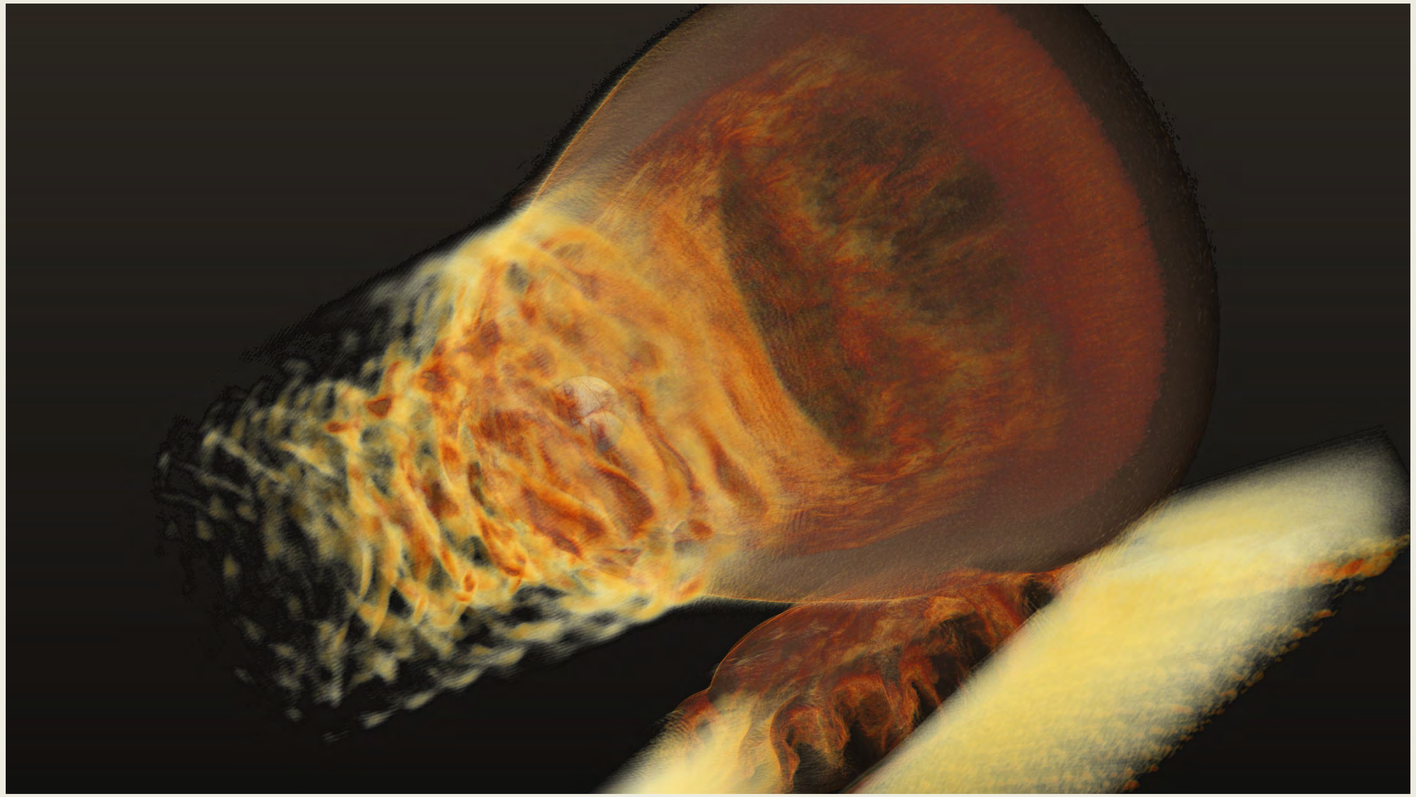


Experimenting with the opacity distribution is key.

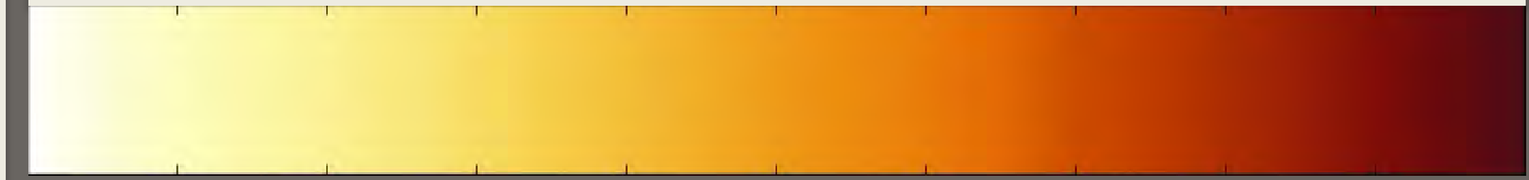
Volume Rendering

Some colormaps work well for specific uses.



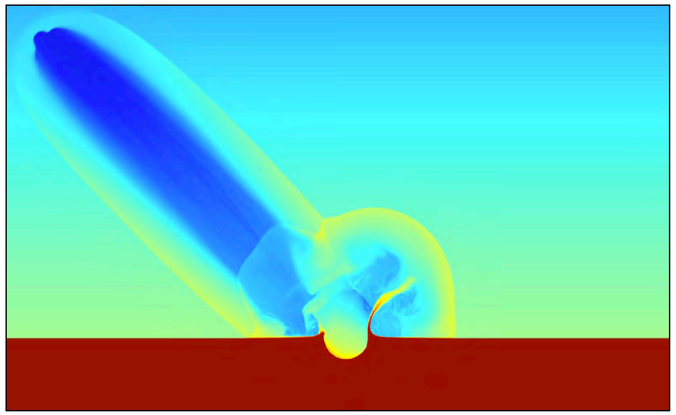


H3D, Daughton, LANL



This colormap works well for many volume renderings because of the combination of multiple light hues and the intuitive continuous scale.

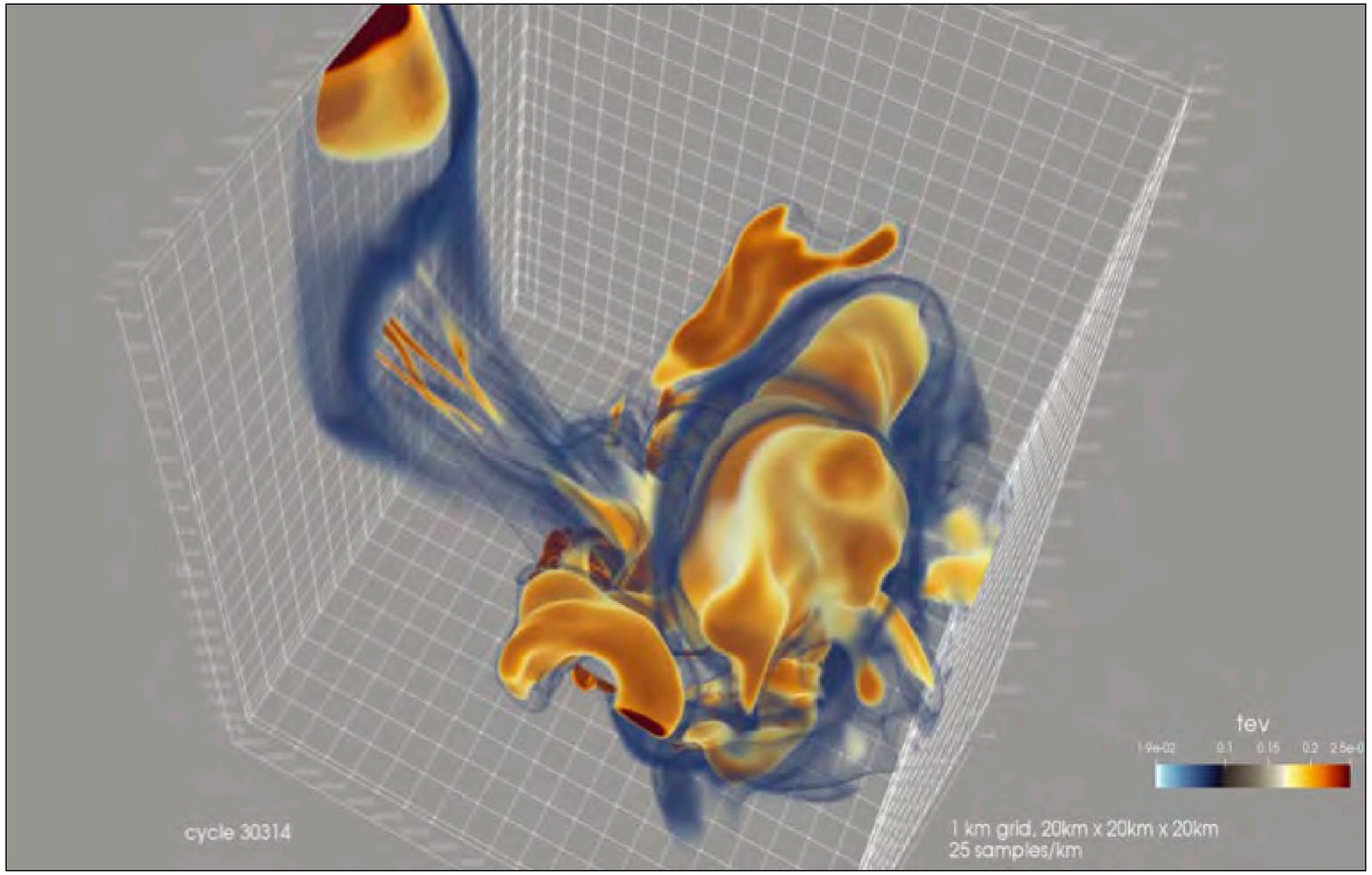
From the scientist…



Galen Gisler, LANL

Same data…

Employing volume rendering, opacity and color theory!



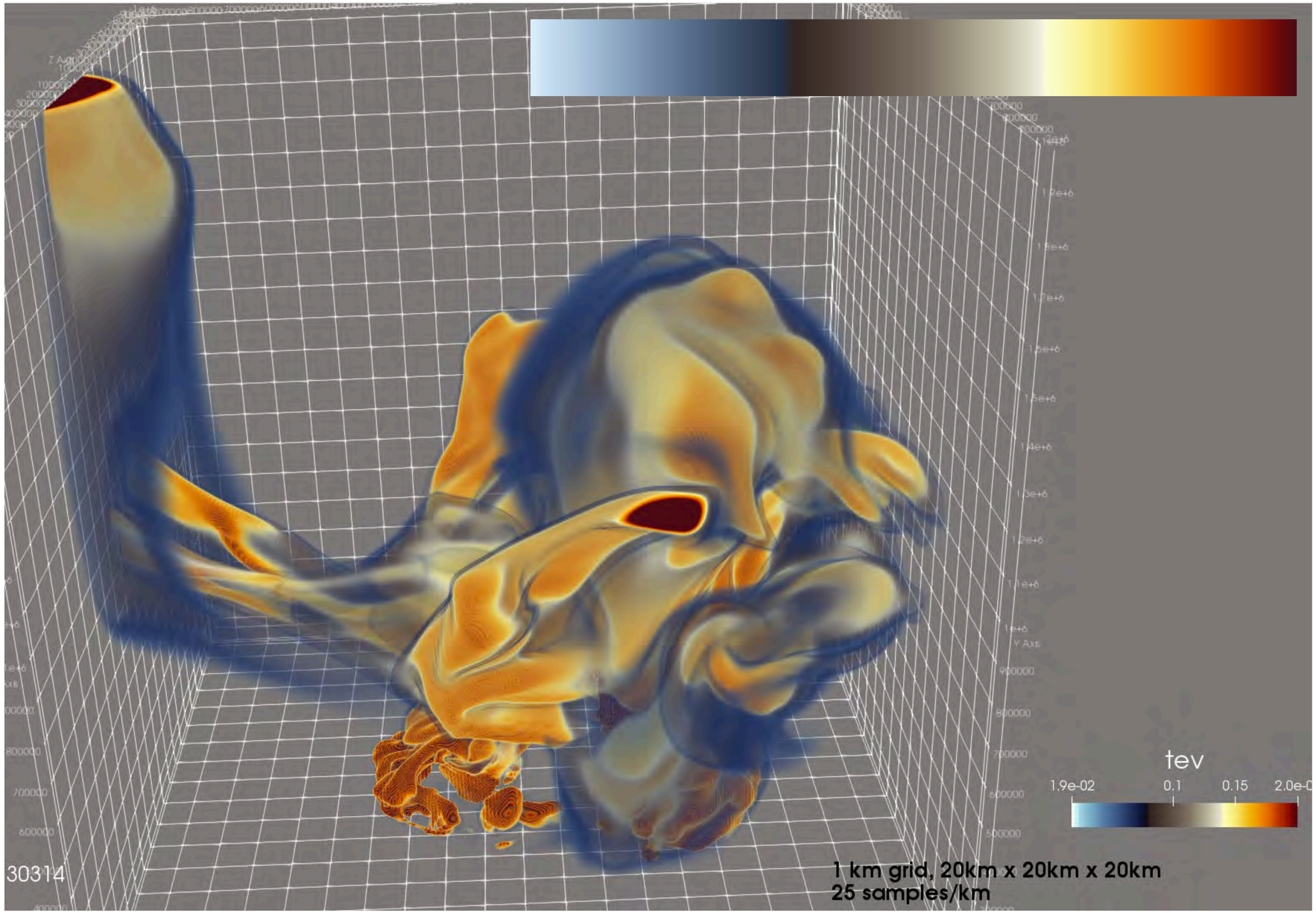
Beautiful?

There is a reason why we identify certain images, environments, etc., as beautiful.

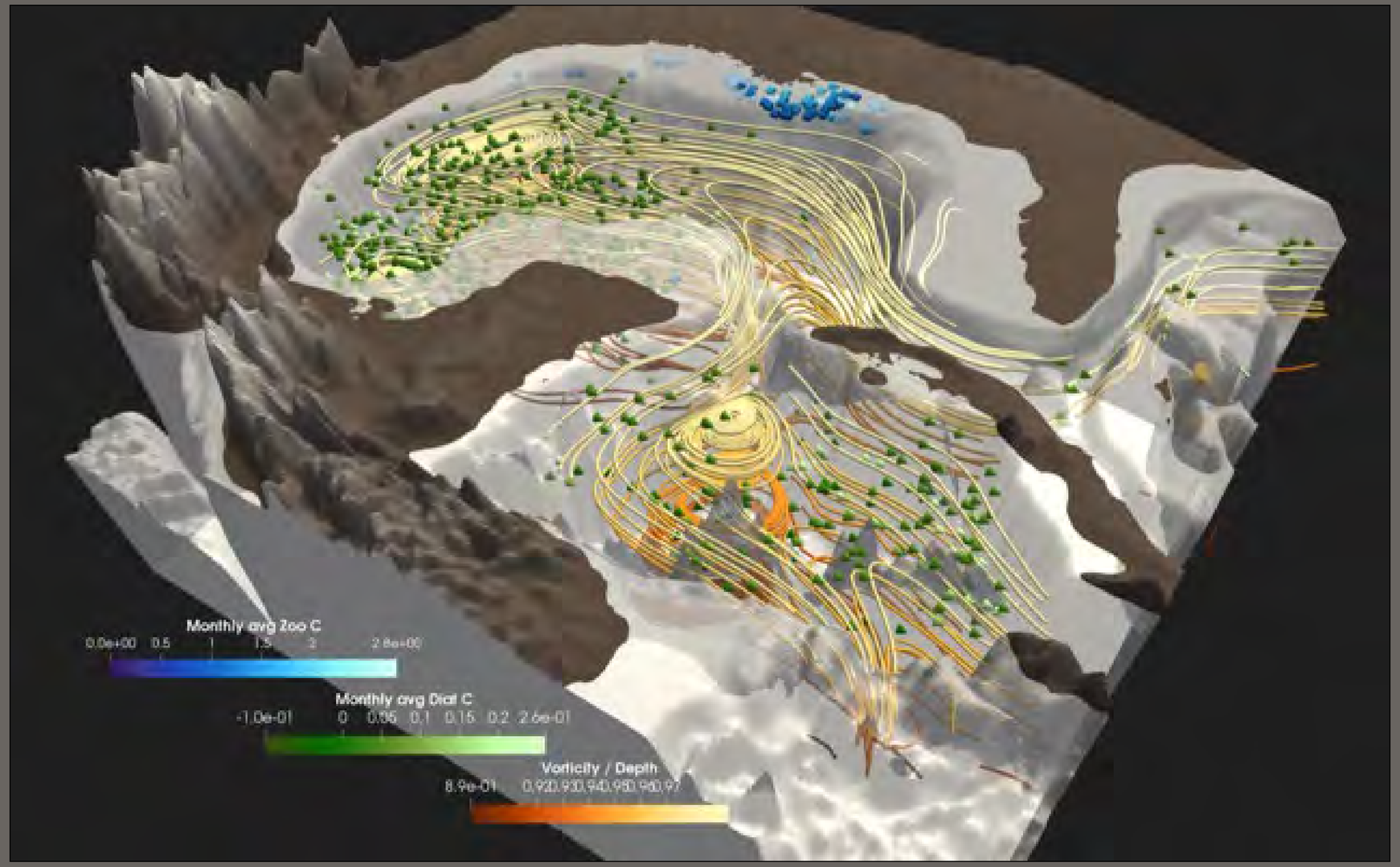
It has to do with balance and harmony.

It engages and makes you want to linger.

Contrast Types: cool -warm; saturation

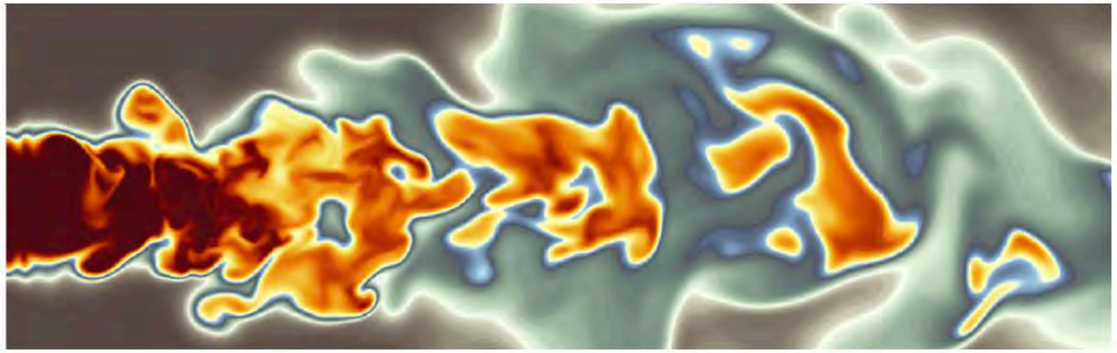


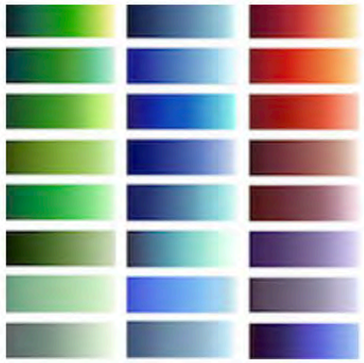
2D representation of sampled Gulf of Mexico biogeochemistry data



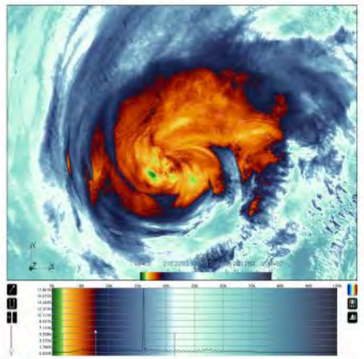
sampling enabling multiple volumetric data variables to be rendered clearly in a 3D representation

SciVisColor: Color Tools and Strategies for Scientific Visualization

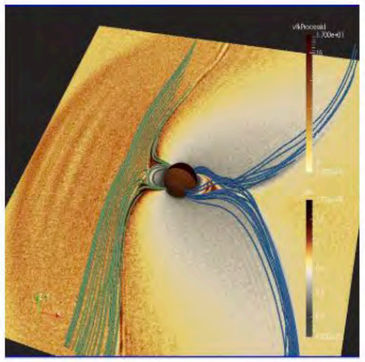




Colormaps



ColorMoves

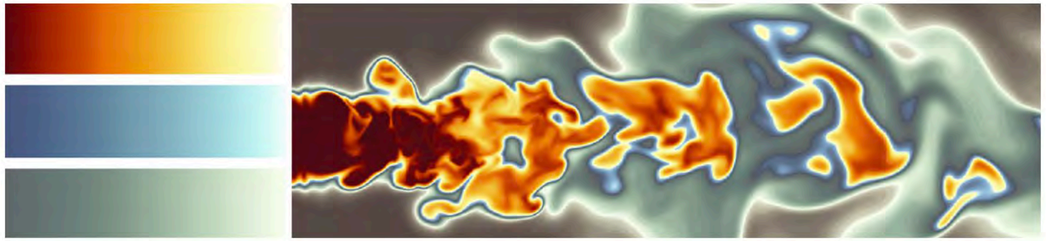


Color Sets

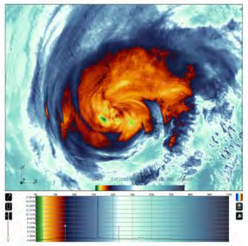
SciVisColor.org

www.SciVisColor.org

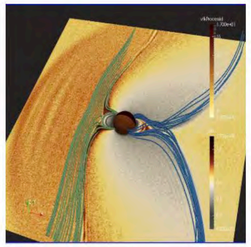
SciVisColor: Color Tools and Strategies for Scientific Visualization



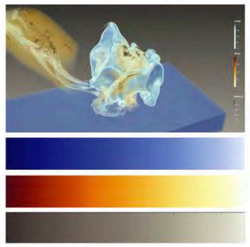
Colormaps



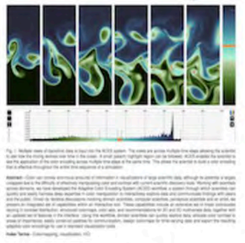
ColorMoves



Color Sets

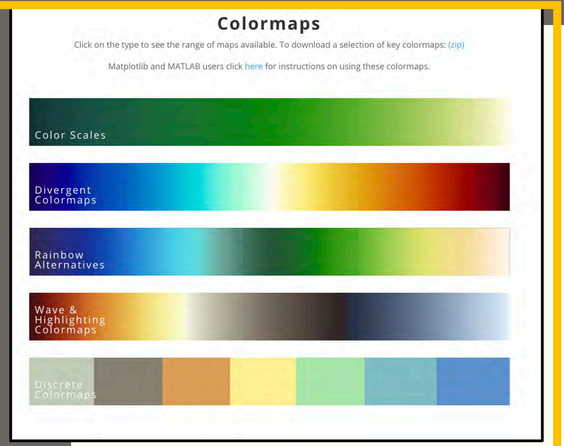


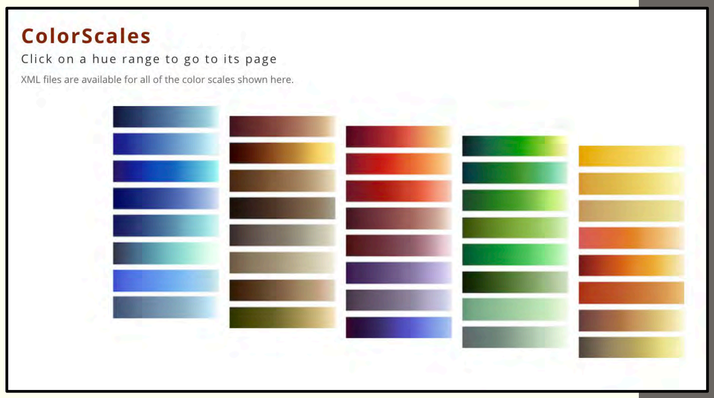
Color Strategies

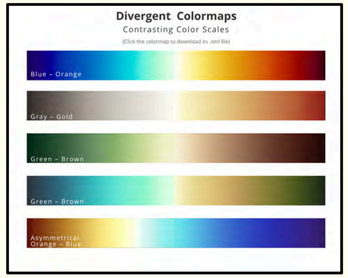


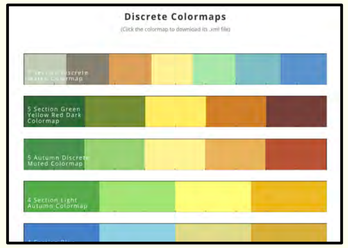
Publications

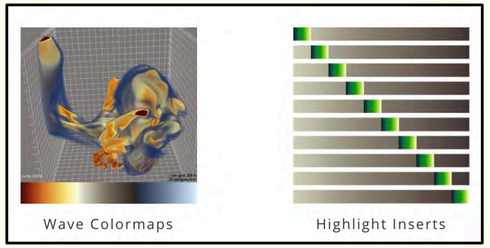
Tutorials

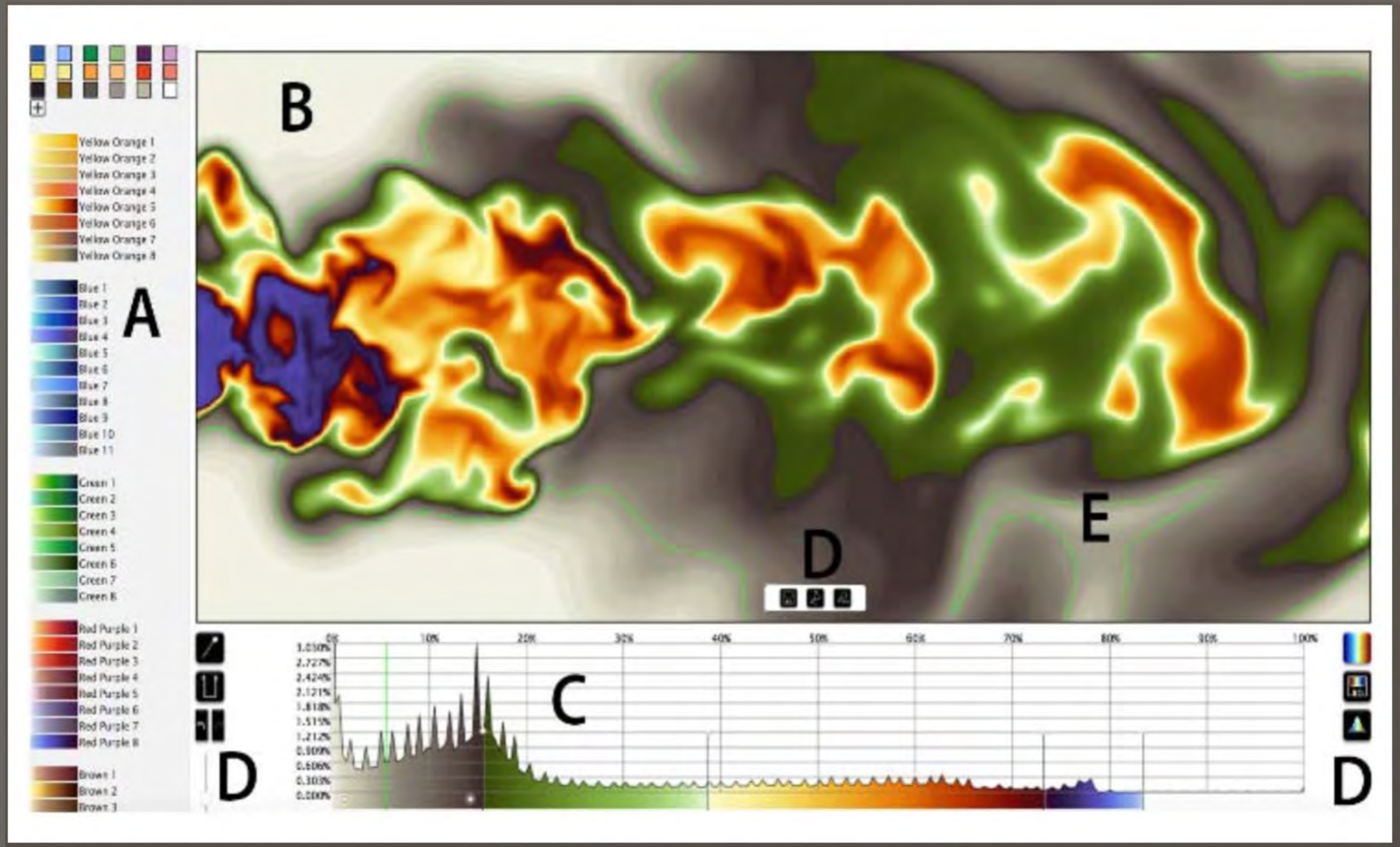










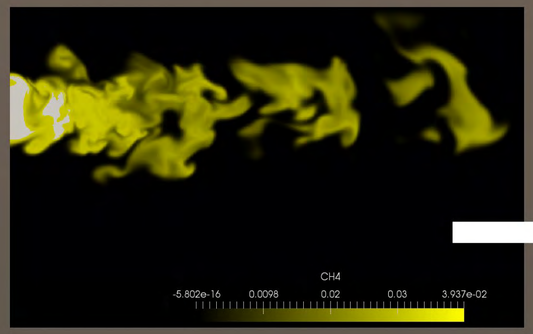


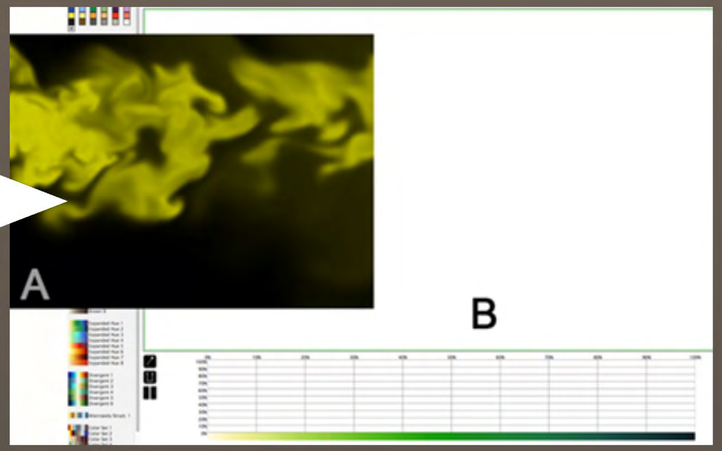
pin - splitting

U – nesting

colormap selector

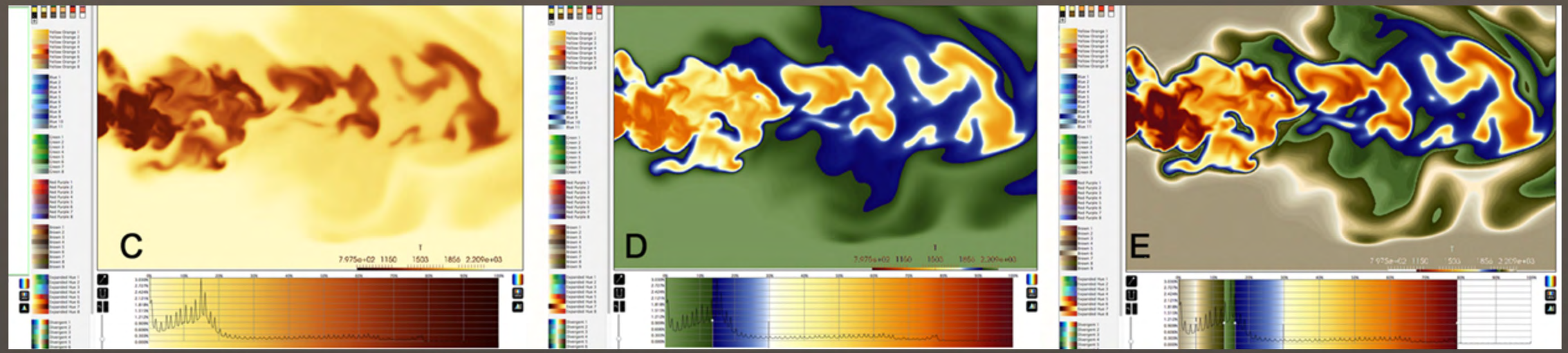
export colormap





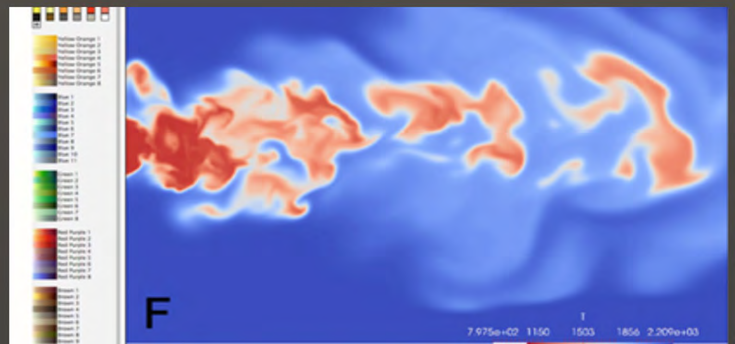
ColorMoves

SciVisColor.org

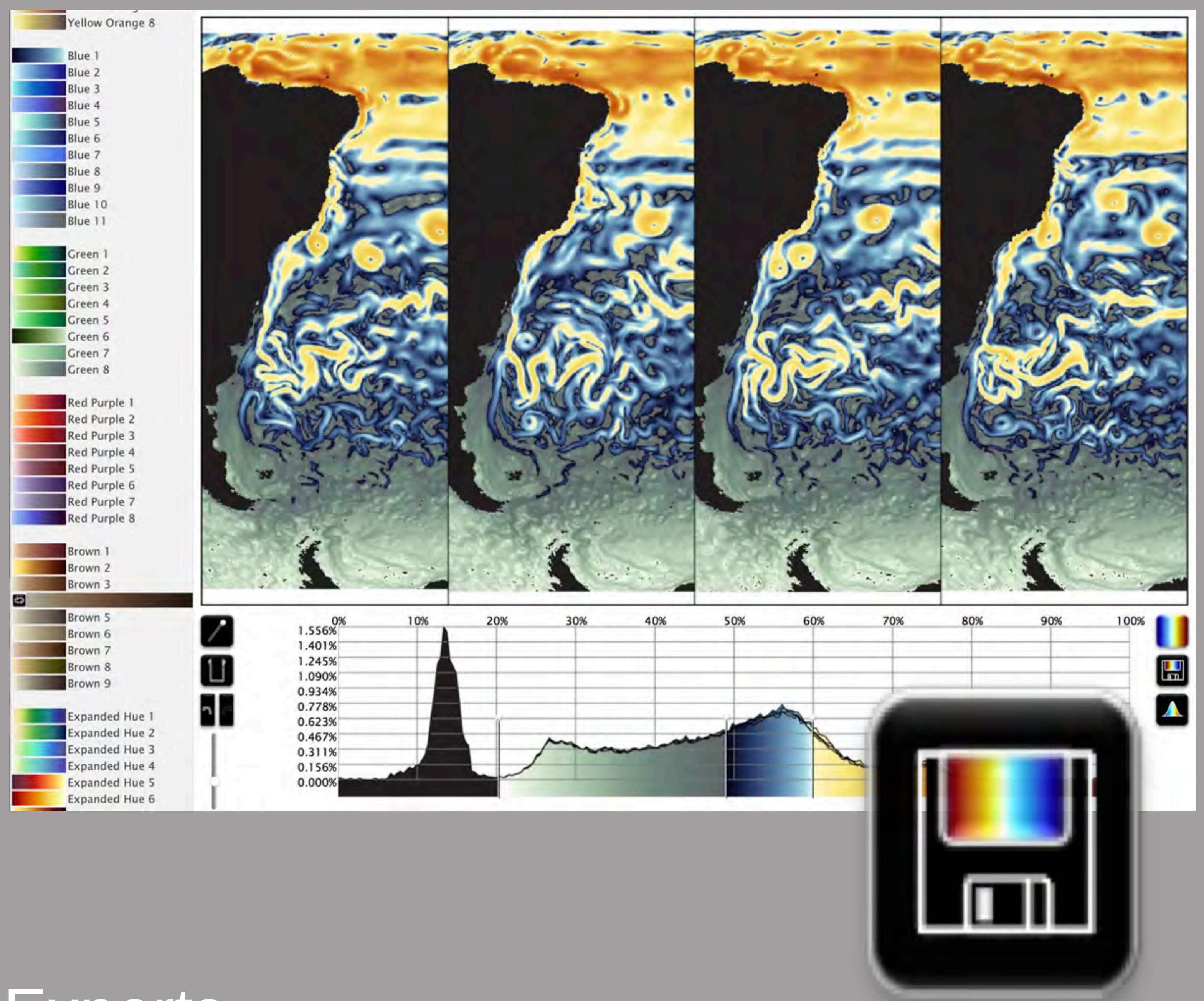


Constructing colormaps tuned to the data structures and visualization tasks.

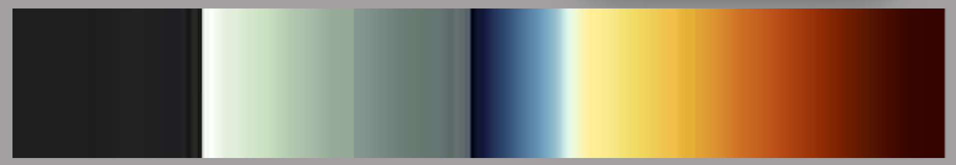
Commonly used
cool warm colormap



ColorMoves

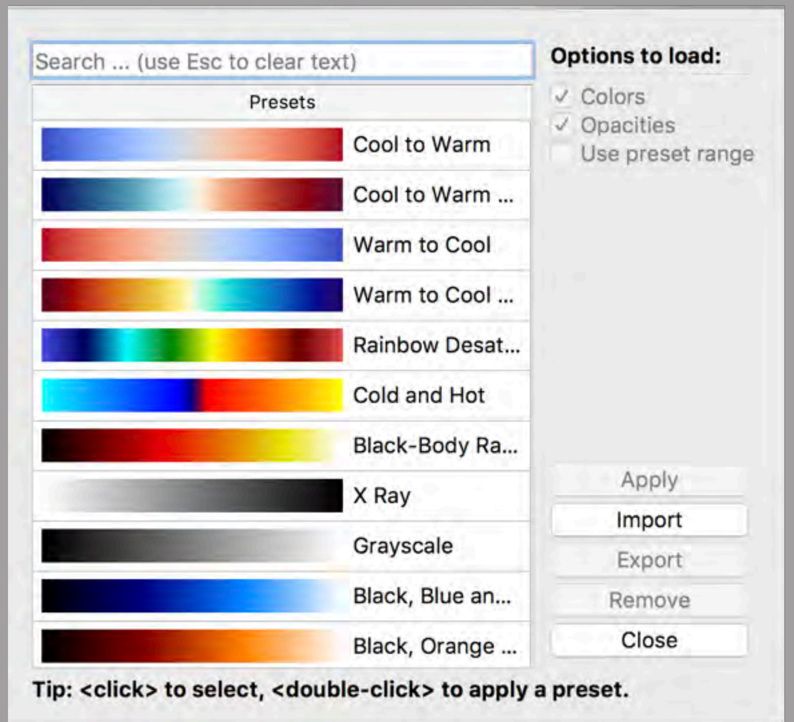


Exports
.xml or .json
And .png of the colormap

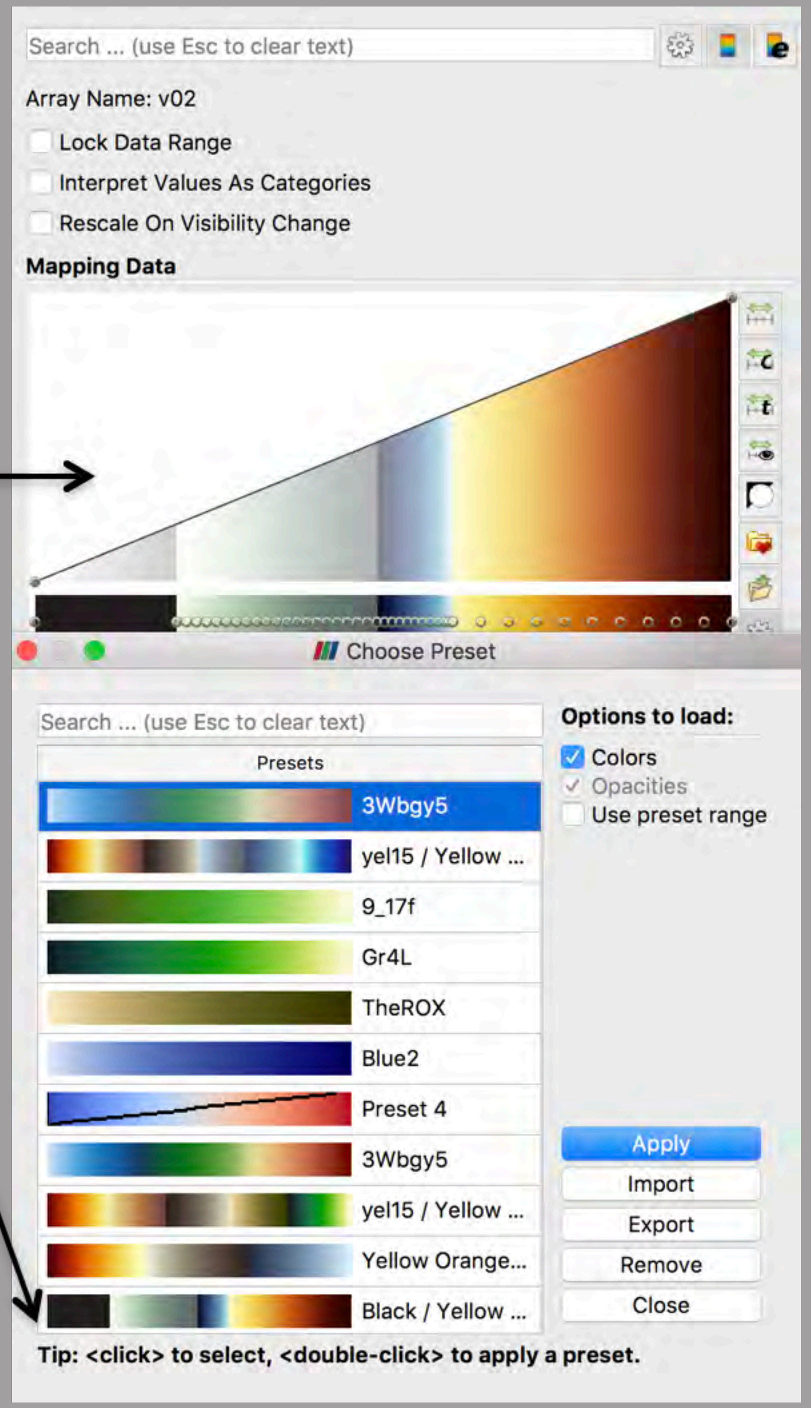


Exporting from ColorMoves
Applying to data

ParaView color editor



Imports .xml



Moving forward…..

Goals:

Easy to use solutions.

Color flexibility incorporated into the visualization program.

Provide guidance.

Easy saving and storing of past colormaps and sets.

Automating the color selection:

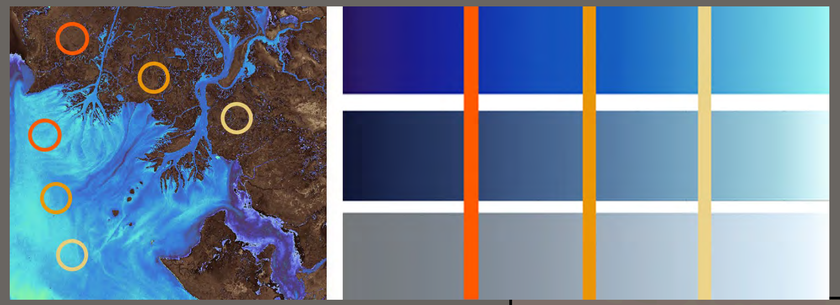
many approaches, not much research**.**

specifically……

Color is powerful but complex.
It is all about relationships.

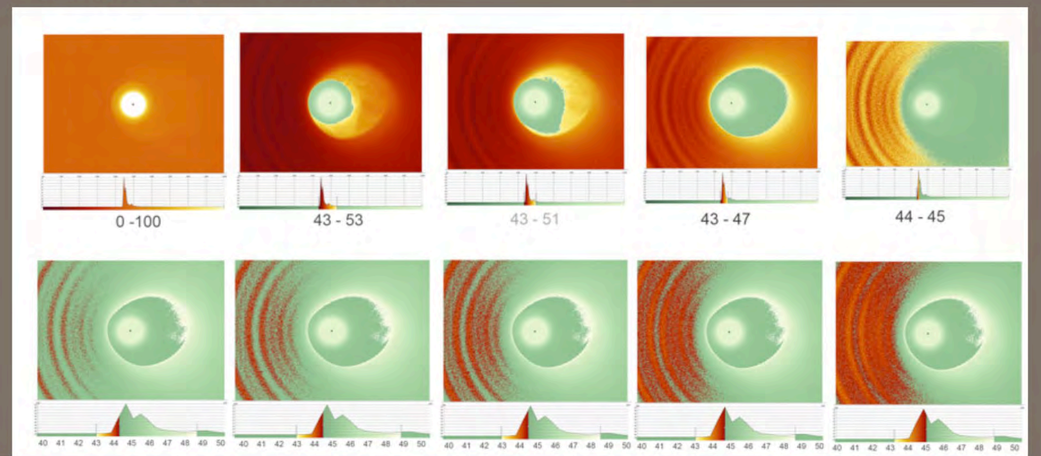
How do you provide the ability to quickly and easily apply appropriate color maps and palettes internally with in the visualization tool?

How do we help guide selection?

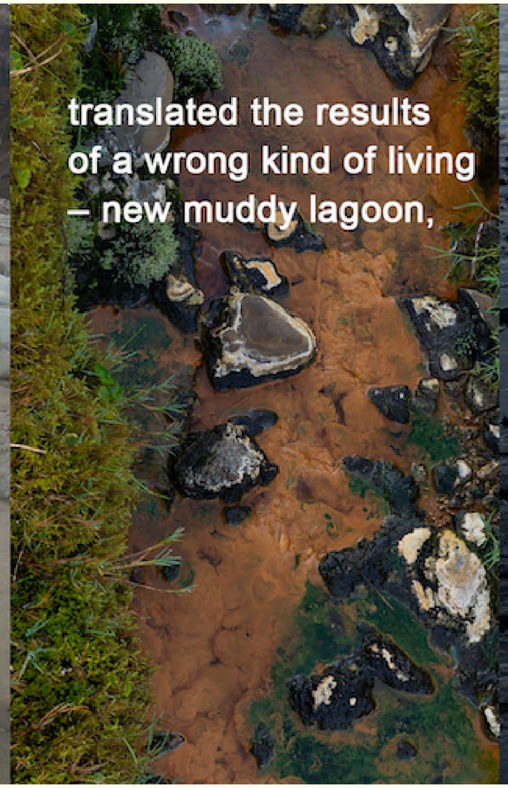


How do we provide enough but not too much flexibility?

Finding the optimal data range



Provide Context and Wonder



AGU funded work with Michael Smith, poet.

Francesca Samsel
fsamsel@tacc.utexas.edu

SciVisColor.org