Exceptional service in the national interest

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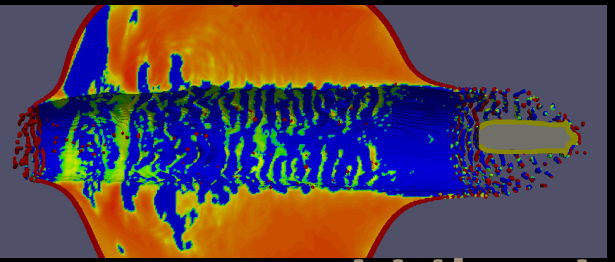
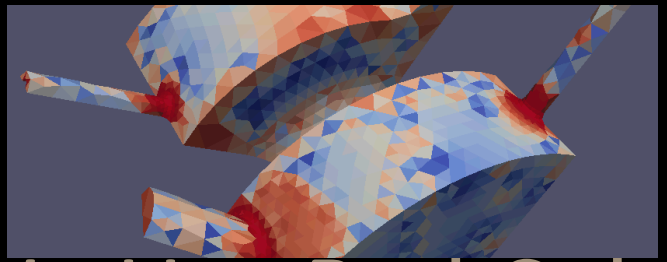
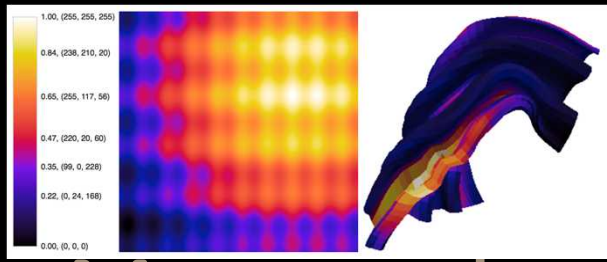
SAND2016-1259C







Why We Use Bad Color Maps and What You Can Do About It

Human Vision and Electronic Imaging (HVEI) 2016

Kenneth Moreland Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | CCR Center for Computing Research

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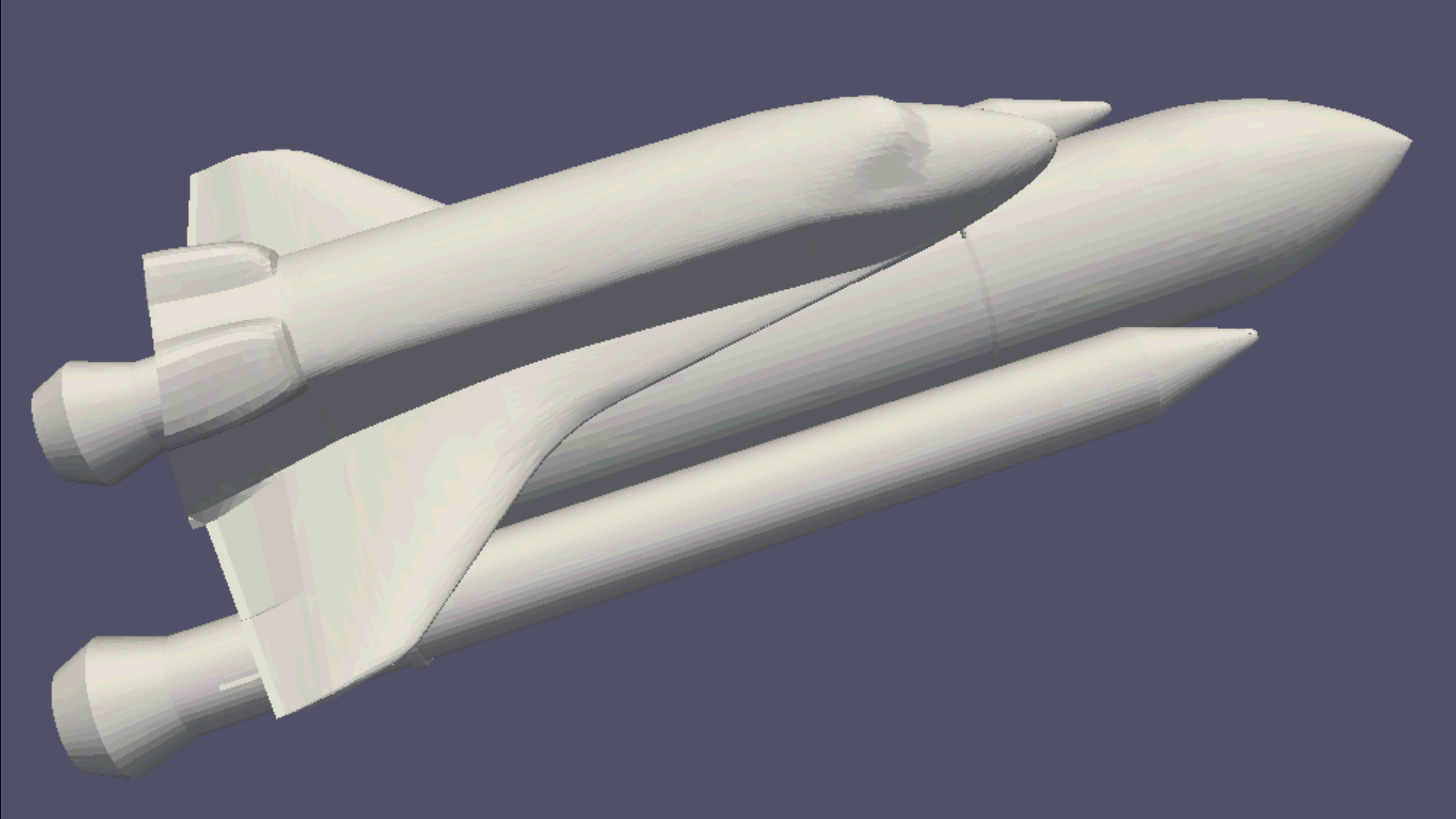

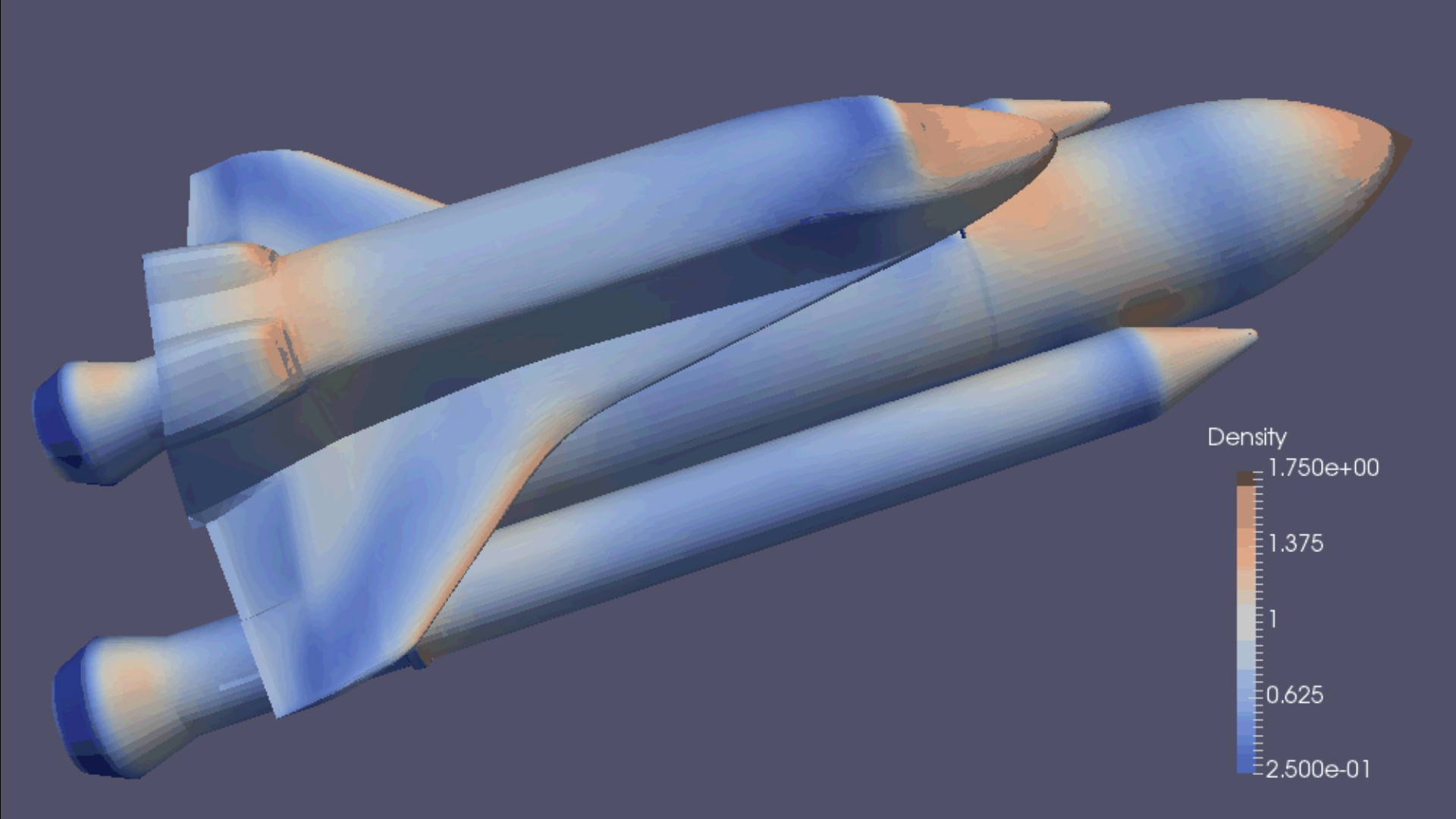
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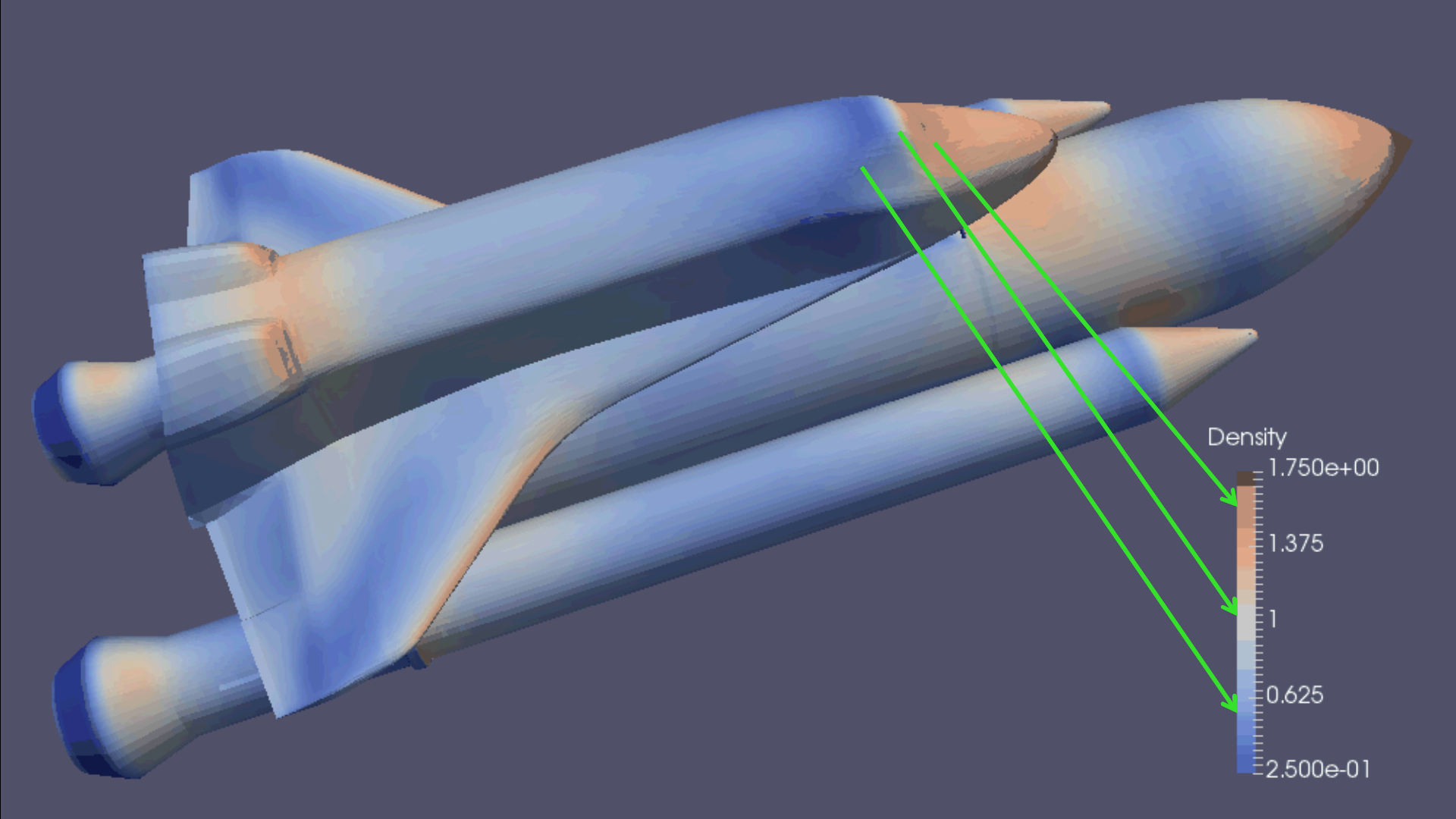
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1
0.625
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Rainbow: Know Thy Enemy

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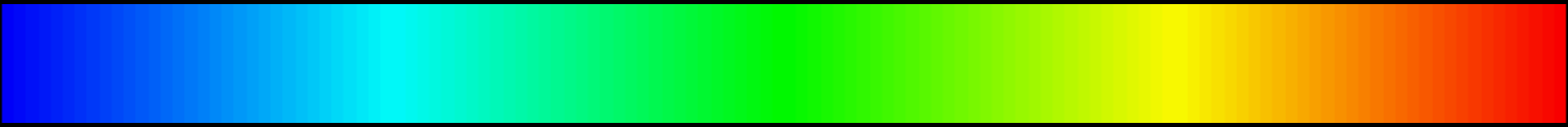
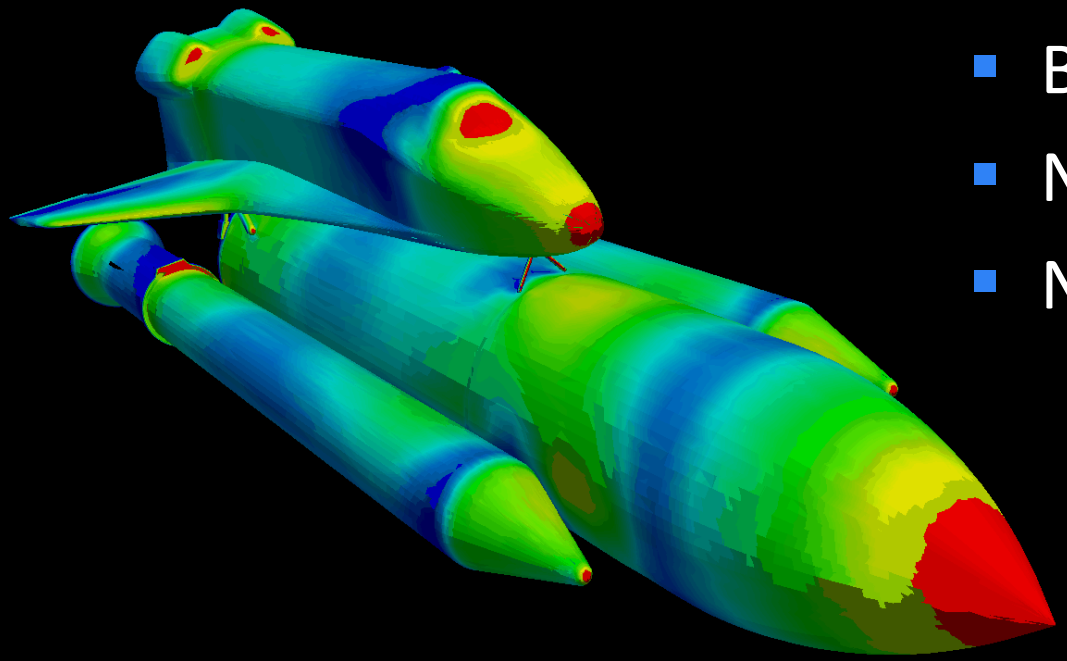
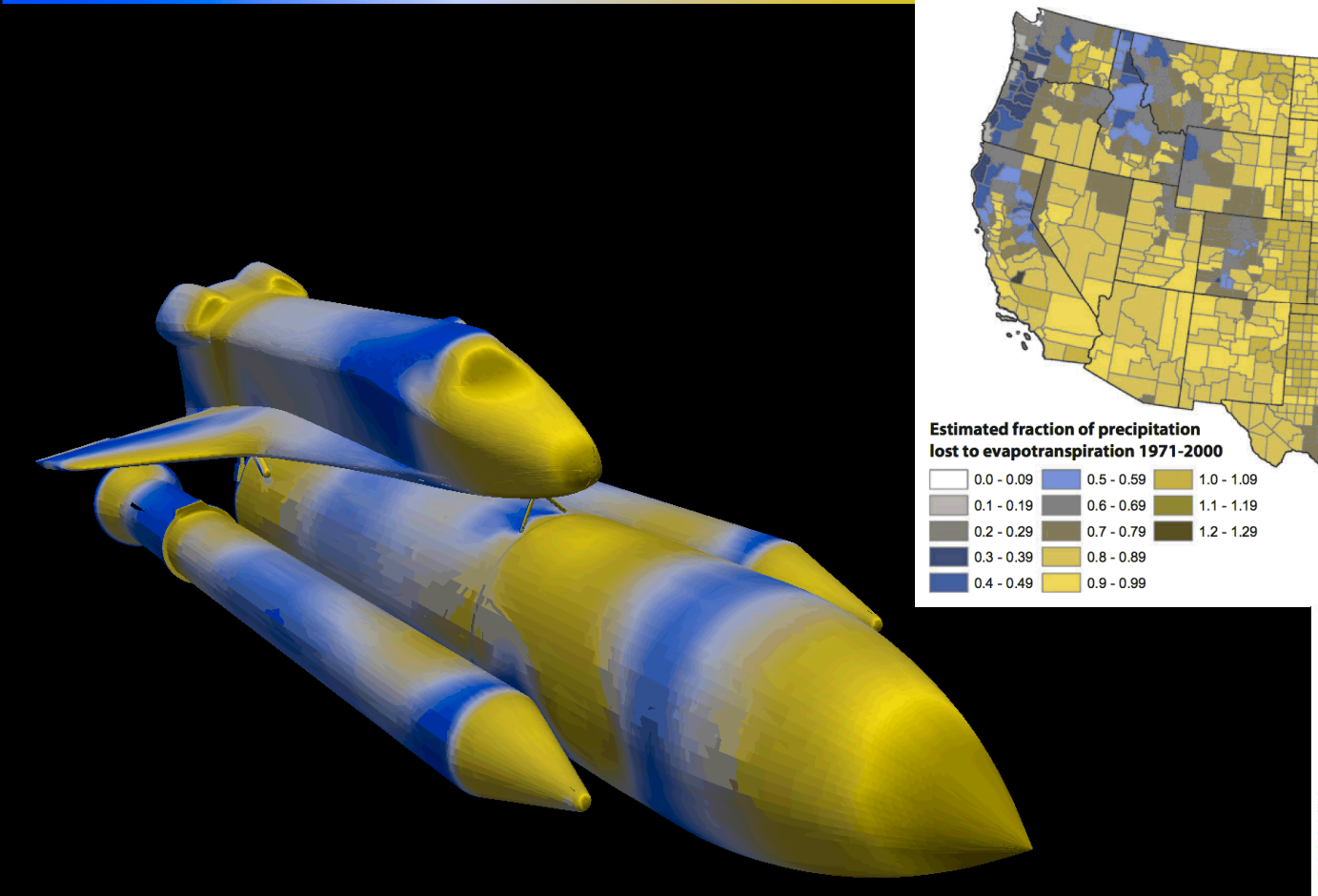
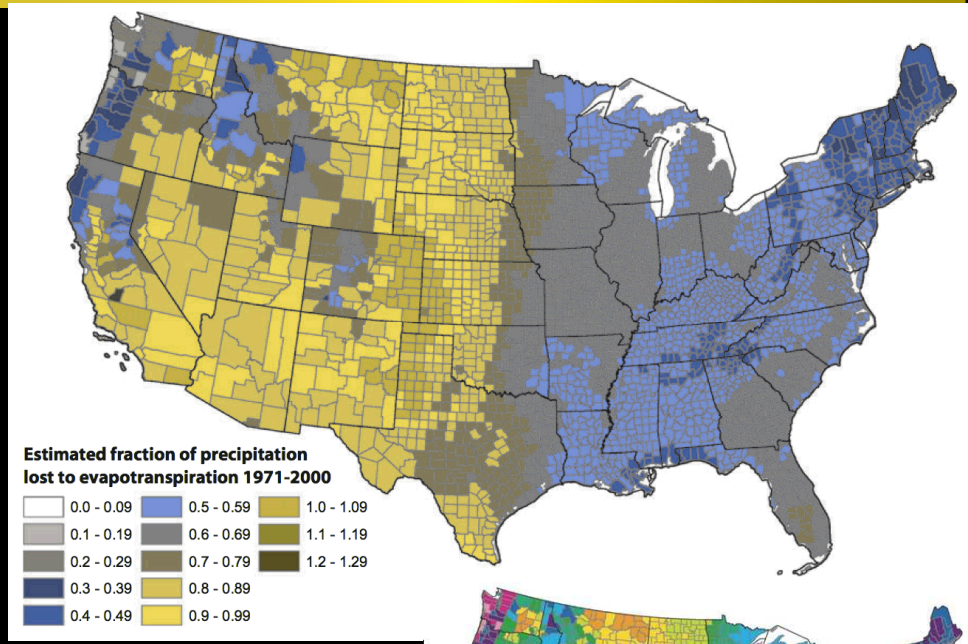
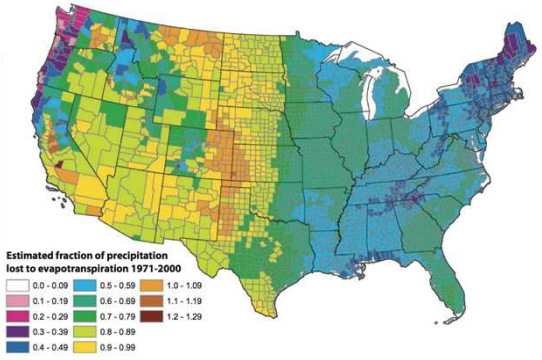




- Garish
- Bad for color deficiencies
- No implicit order
- Not perceptually even




Estimated fraction of precipitation
lost to evapotranspiration 1971-2000
0.0 - 0.09
0.1 - 0.19
0.2 - 0.29
0.3 - 0.39
0.4 - 0.49
0.5 - 0.59
0.6 - 0.69
0.7 - 0.79
0.8 - 0.89
0.9 - 0.99
1.0 - 1.09
1.1 - 1.19
1.2 - 1.29


Estimated fraction of precipitation
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0.0 - 0.09
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0.2 - 0.29
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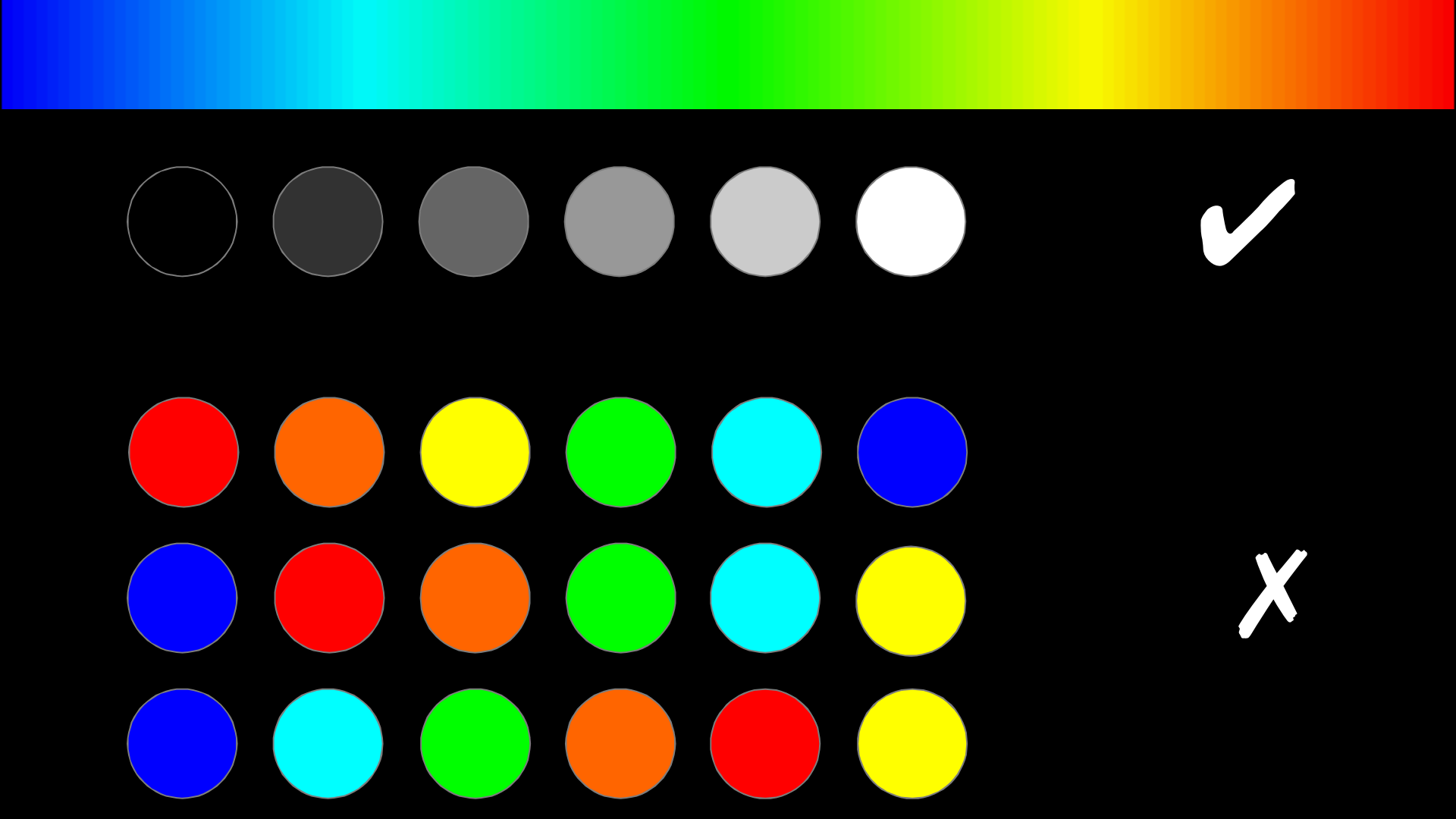
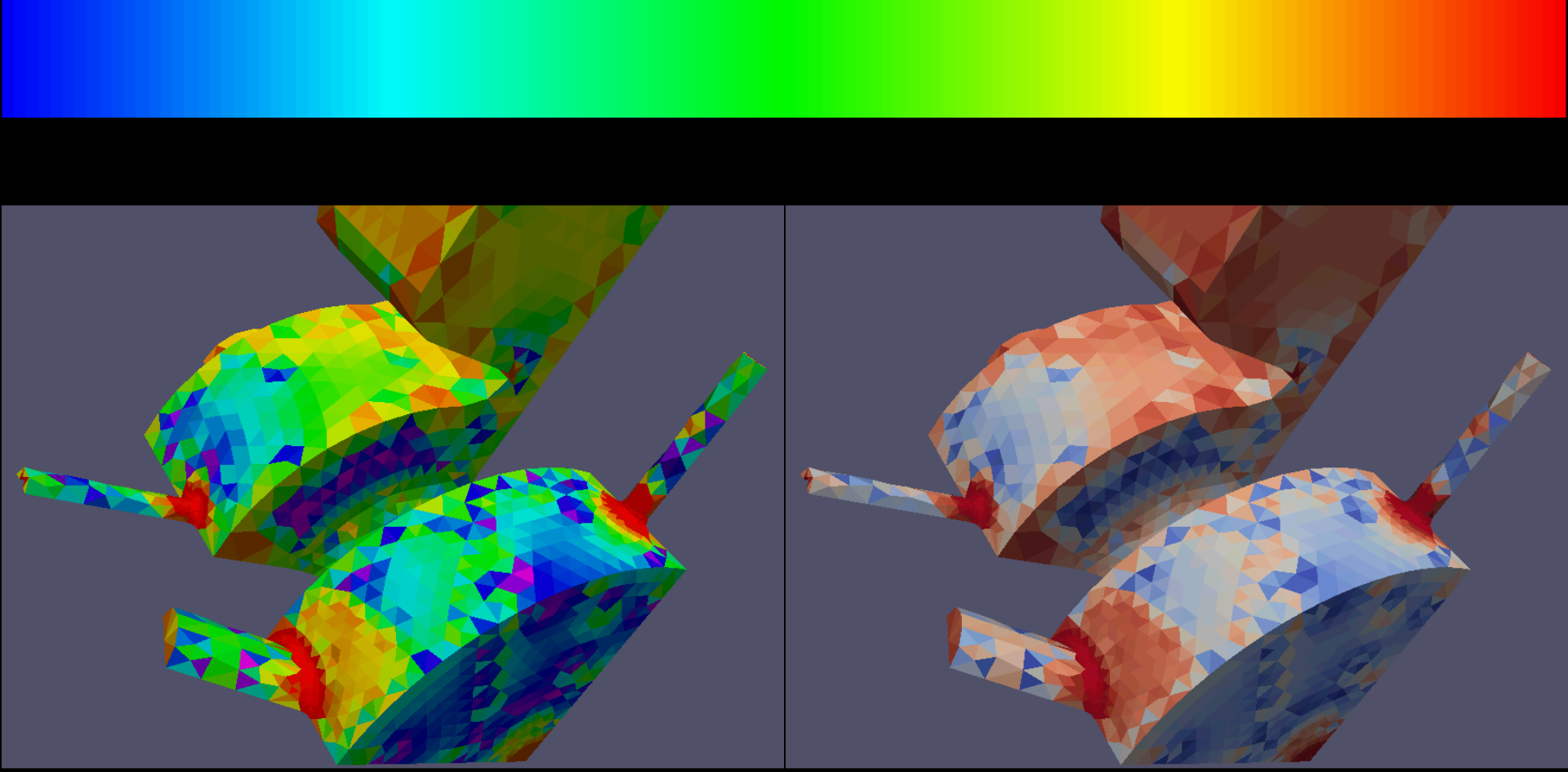
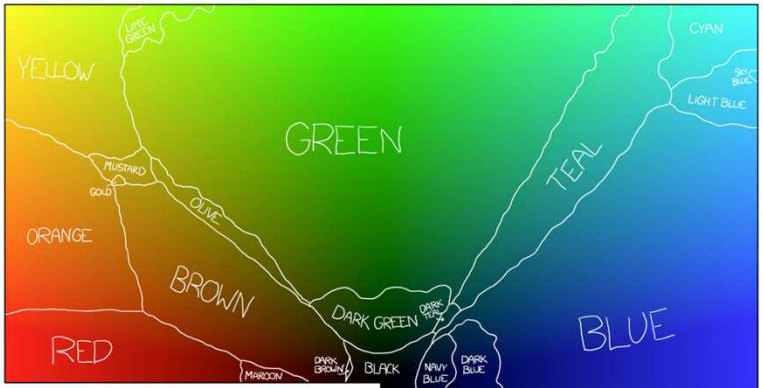
0.4 - 0.49
0.5 - 0.59
0.6 - 0.69
0.7 - 0.79
0.8 - 0.89
0.9 - 0.99
1.0 - 1.09
1.1 - 1.19
1.2 - 1.29

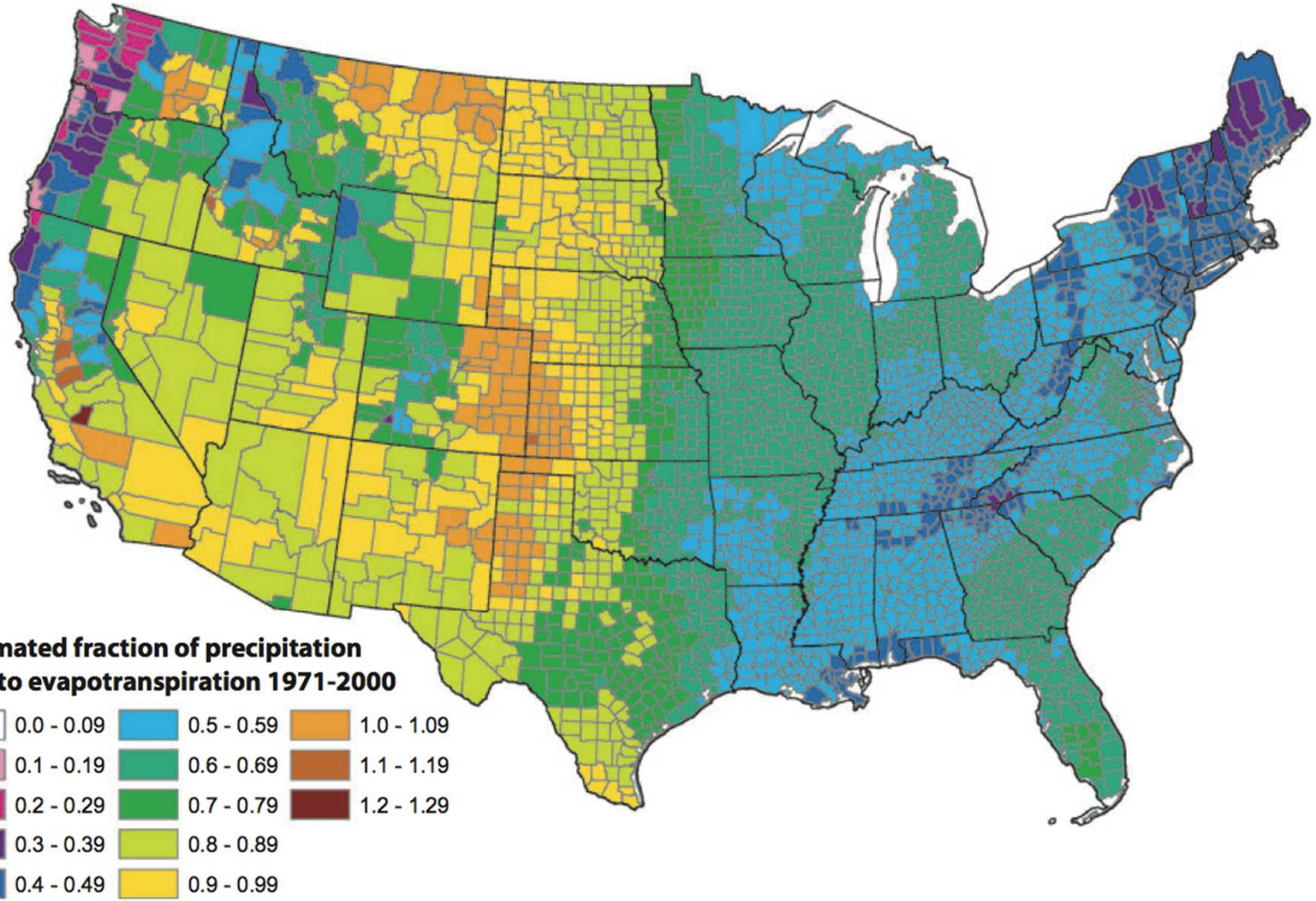




Blue Cyan Green Yellow Orange Red



THIS CHART SHOWS THE DOMINANT COLOR NAMES OVER THE THREE FULLY-SATURATED FACES OF THE RGB CUBE (COLORS WHERE ONE OF THE RGB VALUES IS ZERO)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0.1 - 0.19
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0.3 - 0.39
0.4 - 0.49
0.5 - 0.59
0.6 - 0.69
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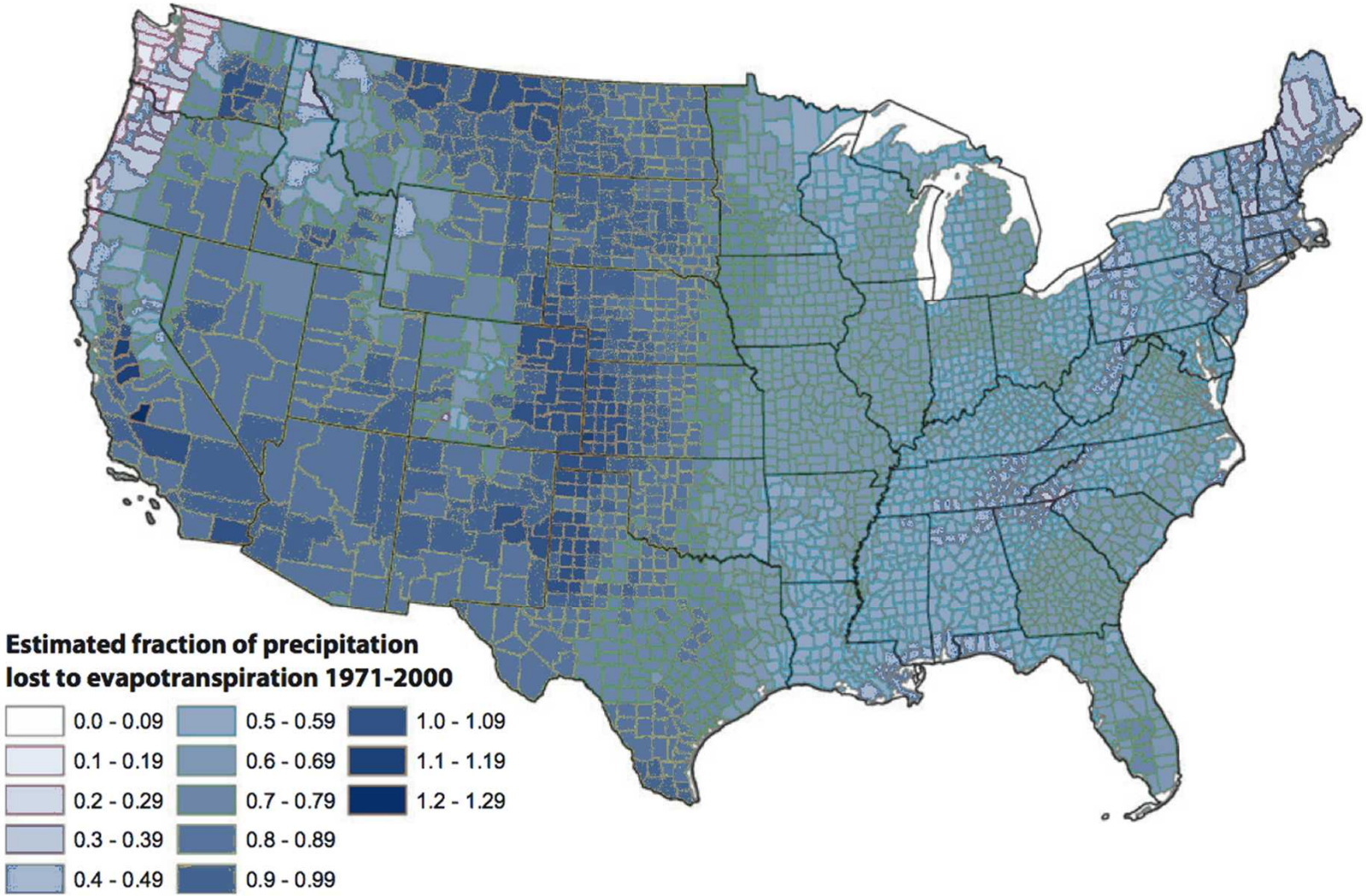
0.8 - 0.89
0.9 - 0.99
1.0 - 1.09
1.1 - 1.19
1.2 - 1.29


Estimated fraction of precipitation
lost to evapotranspiration 1971-2000
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0.1 - 0.19
0.2 - 0.29
0.3 - 0.39
0.4 - 0.49
0.5 - 0.59
0.6 - 0.69
0.7 - 0.79
0.8 - 0.89
0.9 - 0.99
1.0 - 1.09
1.1 - 1.19
1.2 - 1.29

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Why We Use Bad Colors

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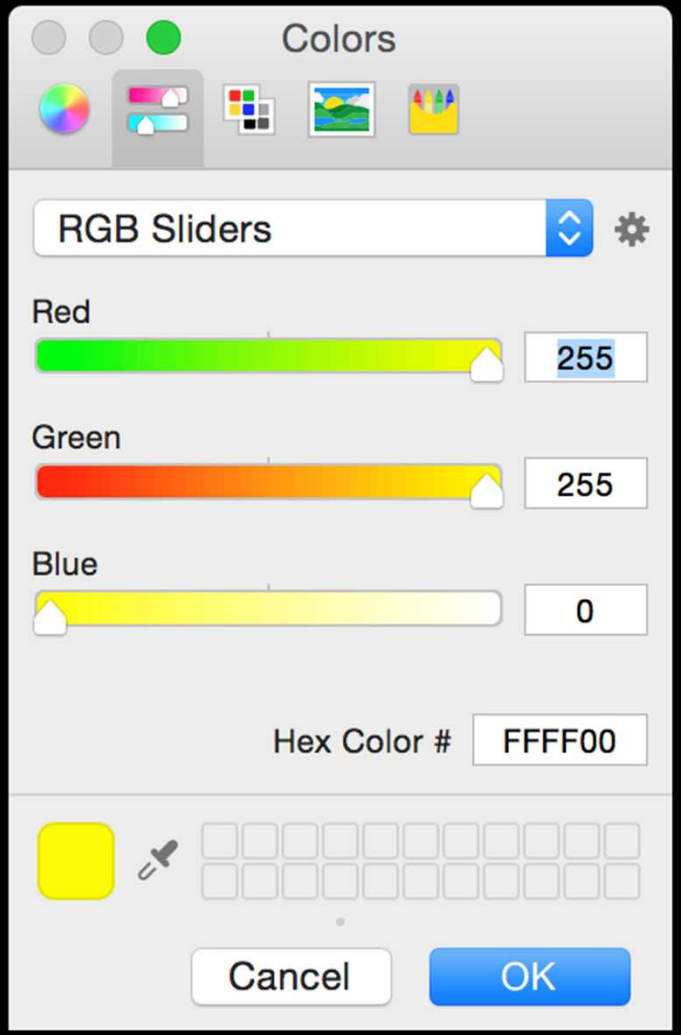
Reason 1

Simplicity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Green
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Blue
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Hex Color #
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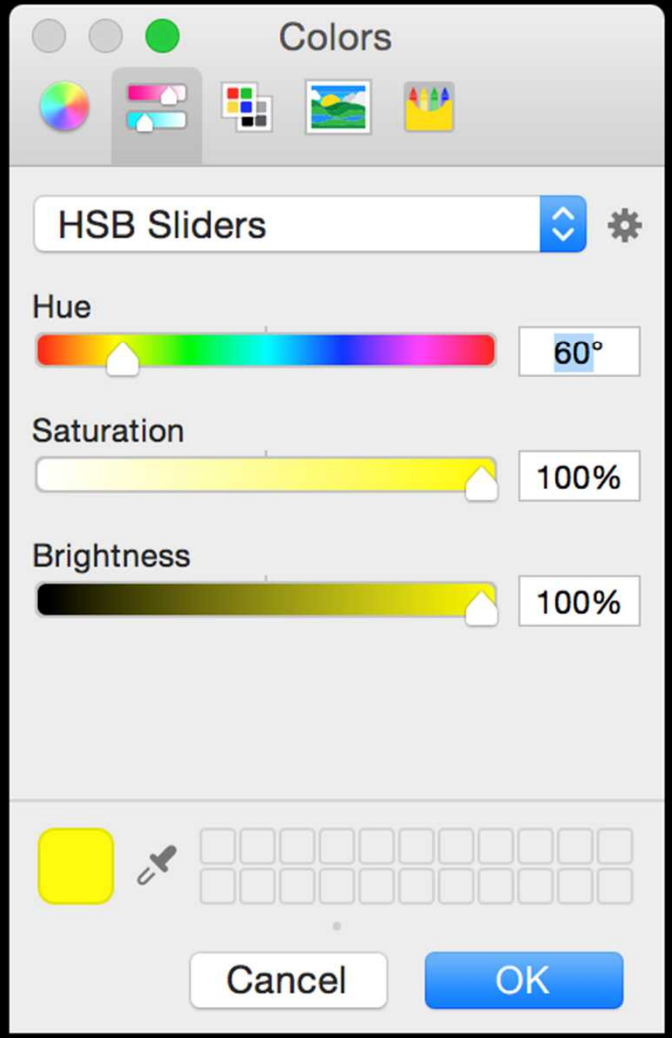
Cancel
OK

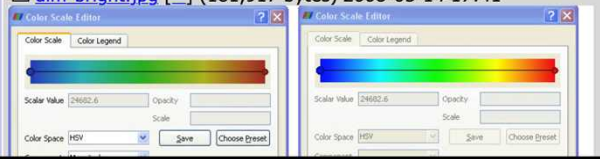

Colors
HSB Sliders
Hue
60°
Saturation
100%
Brightness
100%
Cancel
OK

View Issue Details [Jump to Notes] [Issue History] [Print]

ID	Project	Category	View Status	Date Submitted	Last Update
0007024	ParaView	(No Category)	public	2008-05-14 17:41	2008-05-14 19:31

Reporter	Jon Goldman				
Assigned To	Ken Moreland				
Priority	high	**Severity**	minor	**Reproducibility**	always
Status	closed	**Resolution**	no change required		
Platform		**OS**		**OS Version**	
Product Version					
Target Version		**Fixed in Version**			

Summary	0007024: Want bright HSV Color Space back
Description	The default HSV Color Space in the Color Scale editor is dim. Can the old bright HSV be added back in (not replace the dim one, just added back)? See image for comparison dim/bright.
Tags	No tags attached.
Project	
Topic Name	
Type	
Attached Files	dim-bright.jpg [^] (181,917 bytes) *2008-05-14 17:41*



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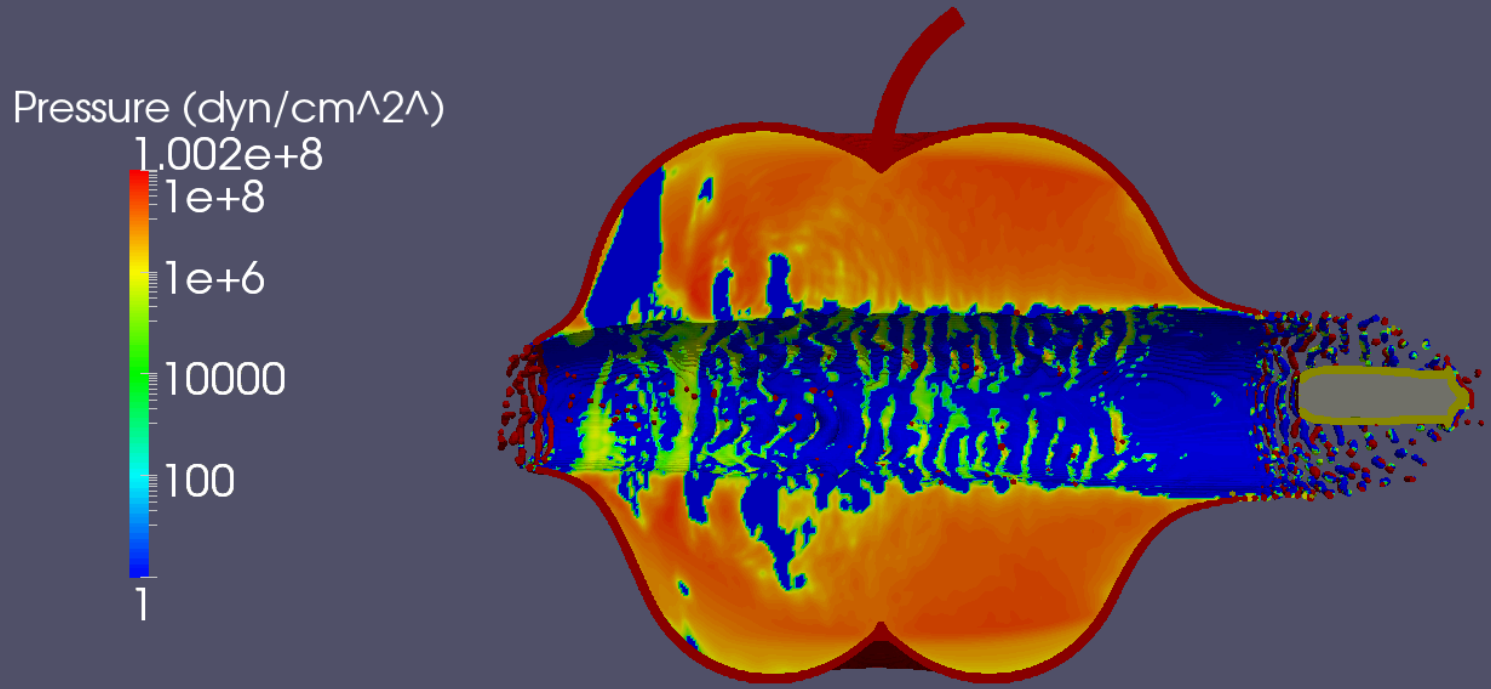
Reason 2

Aesthetics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1e+8
1e+6
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100
1

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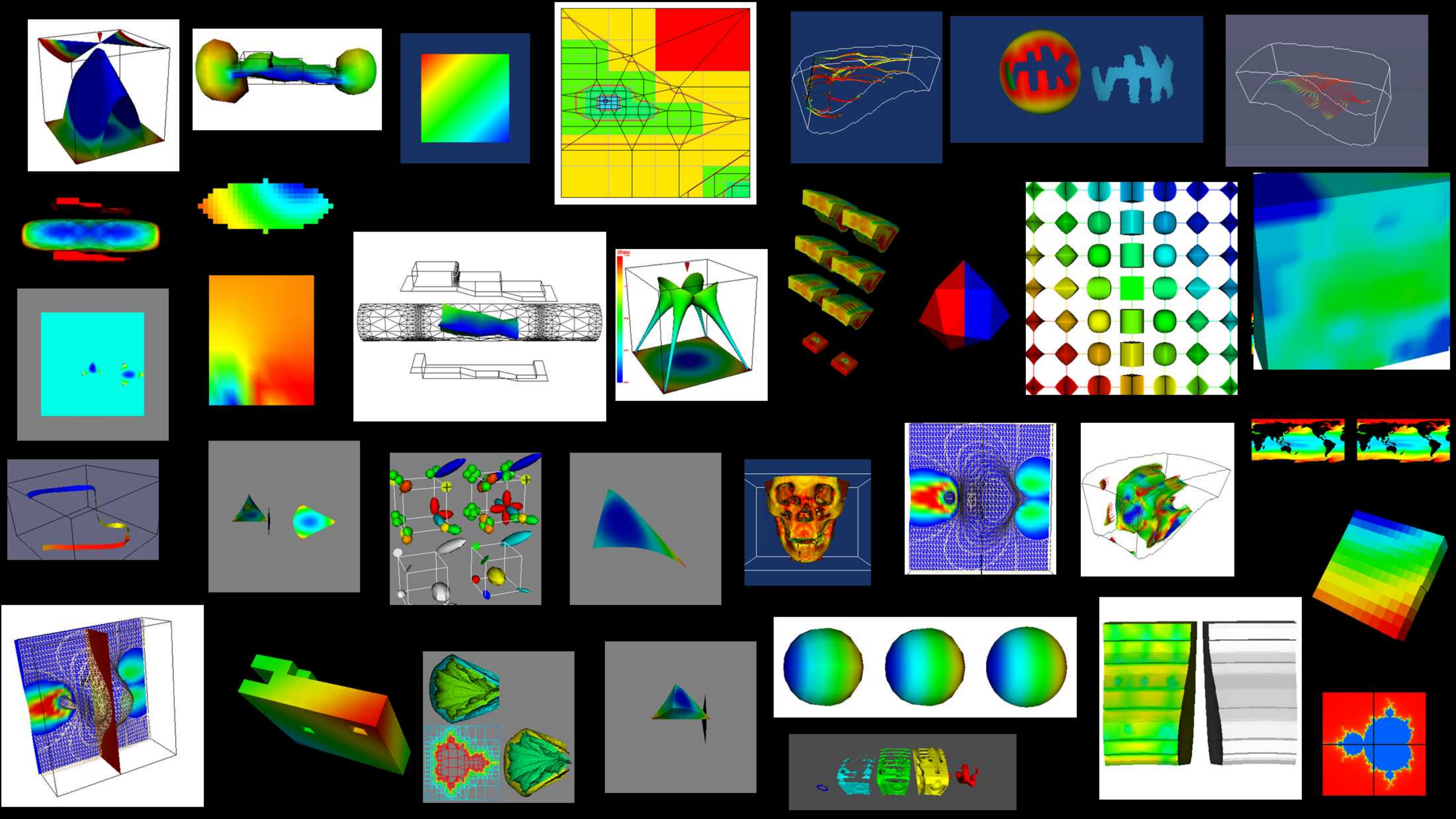
Reason 3

Inertia


vtk
vtk

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How We Can Promote Good Color Use

Education

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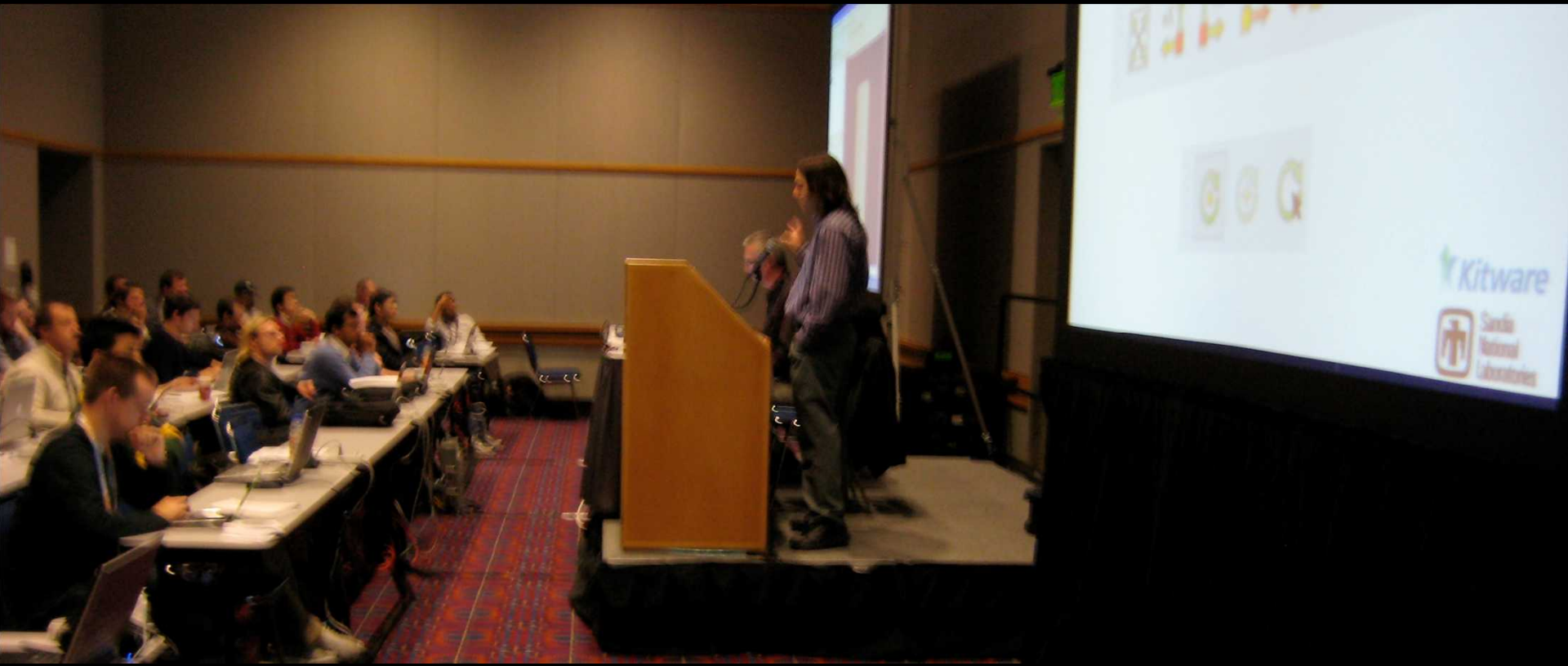

Progress with Education

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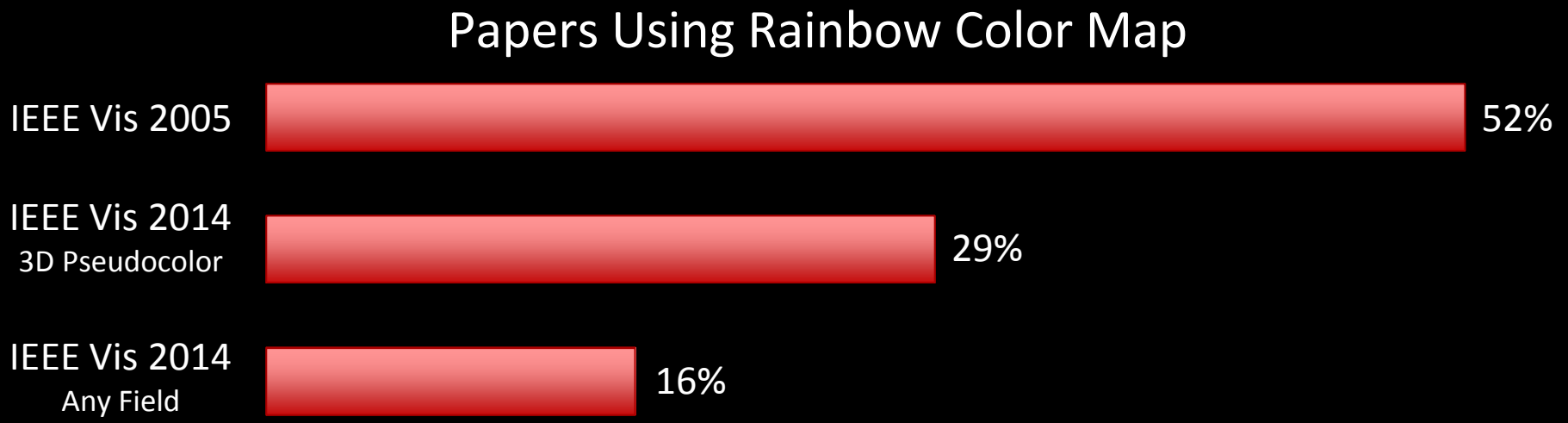

Admonishment

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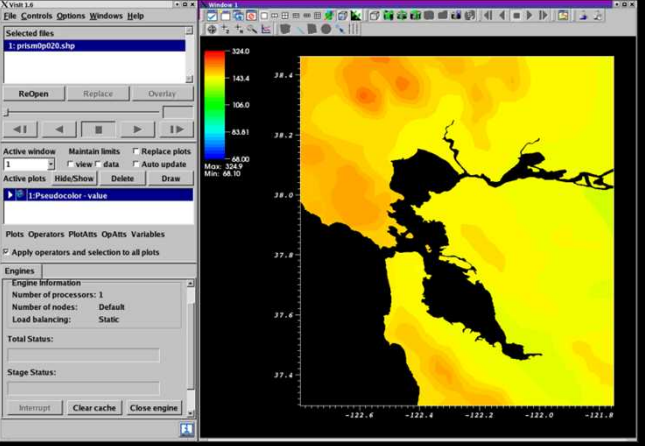
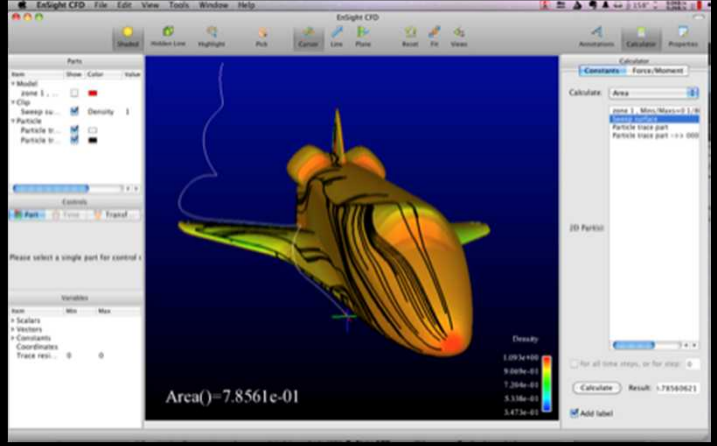
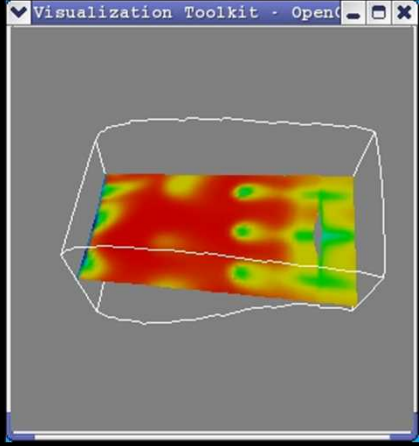


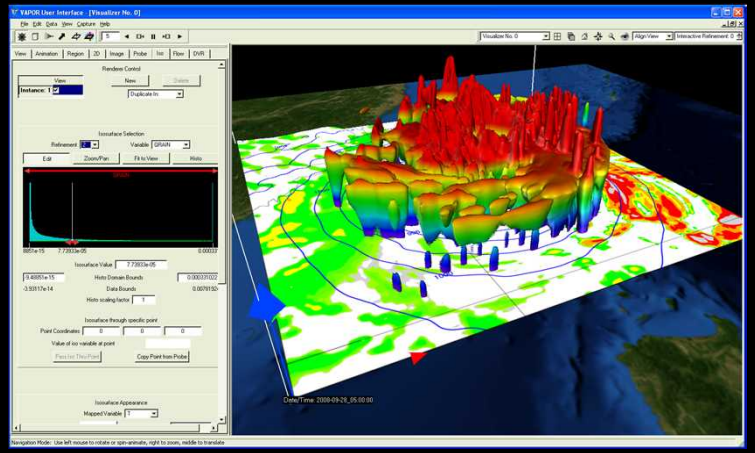
VisIt



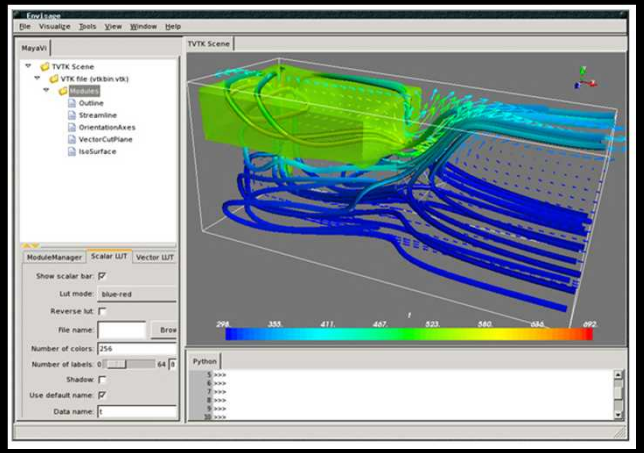
EnSight



VTK



VAPOR



MayaVi

Simplification

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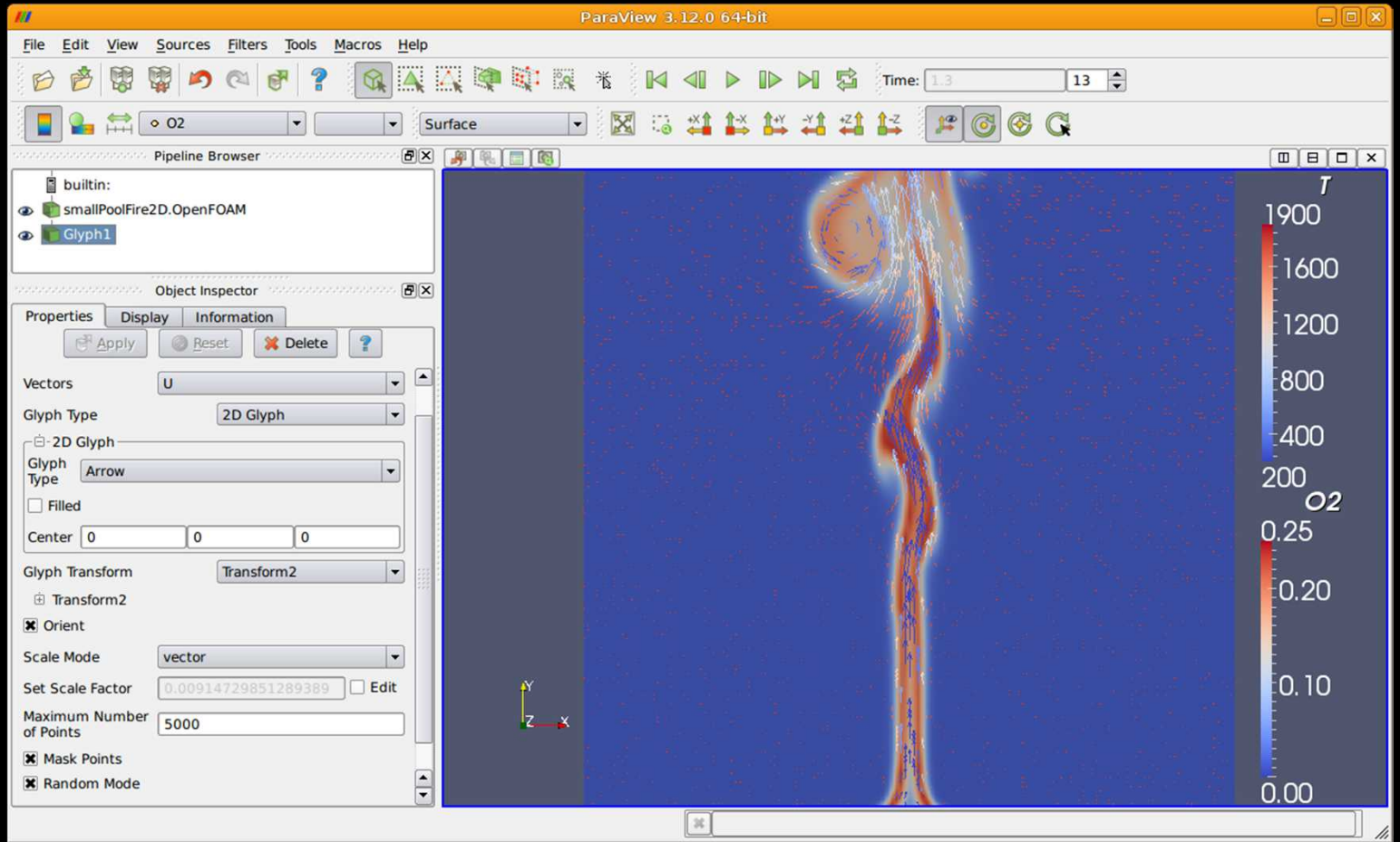
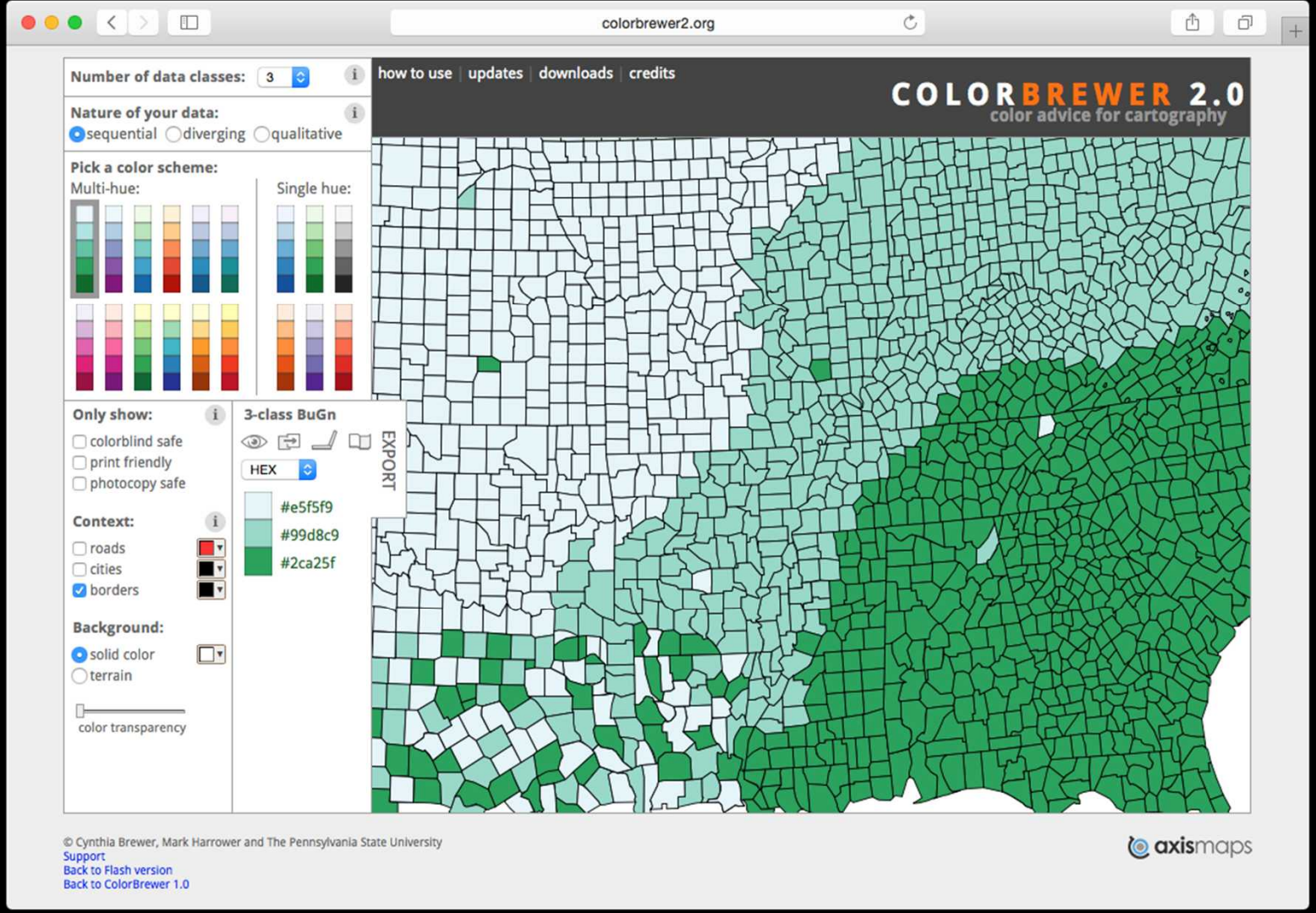
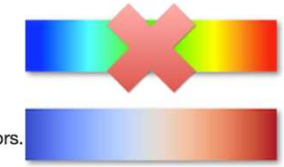



colorbrewer2.org
Number of data classes: 3
Nature of your data:
sequential diverging qualitative
Pick a color scheme:
Multi-hue:
Single hue:
Only show:
colorblind safe
print friendly
photocopy safe
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency
3-class BuGn
HEX
#e5f5f9
#99d8c9
#2ca25f
EXPORT
how to use | updates | downloads | credits
COLORBREWER 2.0
color advice for cartography
© Cynthia Brewer, Mark Harrower and The Pennsylvania State University
Support
Back to Flash version
Back to ColorBrewer 1.0
axismaps

Diverging Color Maps for Scientific Visualization

"**Diverging Color Maps for Scientific Visualization.**" Kenneth Moreland. In *Proceedings of the 5th International Symposium on Visual Computing*, December 2009. DOI 10.1007/978-3-642-10520-3_9.



Abstract

One of the most fundamental features of scientific visualization is the process of mapping scalar values to colors. This process allows us to view scalar fields by coloring surfaces and volumes. Unfortunately, the majority of scientific visualization tools still use a color map that is famous for its ineffectiveness: the rainbow color map. This color map, which naively sweeps through the most saturated colors, is well known for its ability to obscure data, introduce artifacts, and confuse users. Although many alternate color maps have been proposed, none have achieved widespread adoption by the visualization community for scientific visualization. This paper explores the use of diverging color maps (sometimes also called ratio, bipolar, or double-ended color maps) for use in scientific visualization, provides a diverging color map that generally performs well in scientific visualization applications, and presents an algorithm that allows users to easily generate their own customized color maps.

Full Paper

Diverging Color Maps for Scientific Visualization (Expanded): This version of the paper has some material in addition to that of the original publication. There is more background information and more figures to make the material easier to understand. There are also some added algorithms and tables to make it easier to create the color map. At one point I had all this fitting in 8 pages using two column formatting. Unfortunately, the ISVC formatting is less compact and I had to dramatically cut out material to get it to fit. If you wish, you can also view the originally published material.

Supplemental Materials

- These smooth diverging color maps are used in the following systems. Try them today.
  - ParaView, a free, open-source, large-scale, general-purpose scientific visualization tool.
  - Rgnuplot, an R interface for gnuplot.
  - Gamera, a framework for building document analysis applications (represented in the false_color plugin).
  - gencolormap, a simple tool for building color maps of different types.

- If you want to get started quickly with the cool/warm color map recommended in this paper, I have created some tables of values you can import directly into your application. I have stored the tables in CSV files. I provide both a small table containing 33 values and a large table containing 257 values. For each, I also have a version that defines color channels using unsigned bytes (integers in the range [0, 255]) and another that uses floats (real numbers in the range [0, 1]).
  CoolWarmUChar33.csv CoolWarmUChar257.csv
  CoolWarmFloat33.csv CoolWarmFloat257.csv

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Simple Practical Advice

Scalar Fields on 3D Surface

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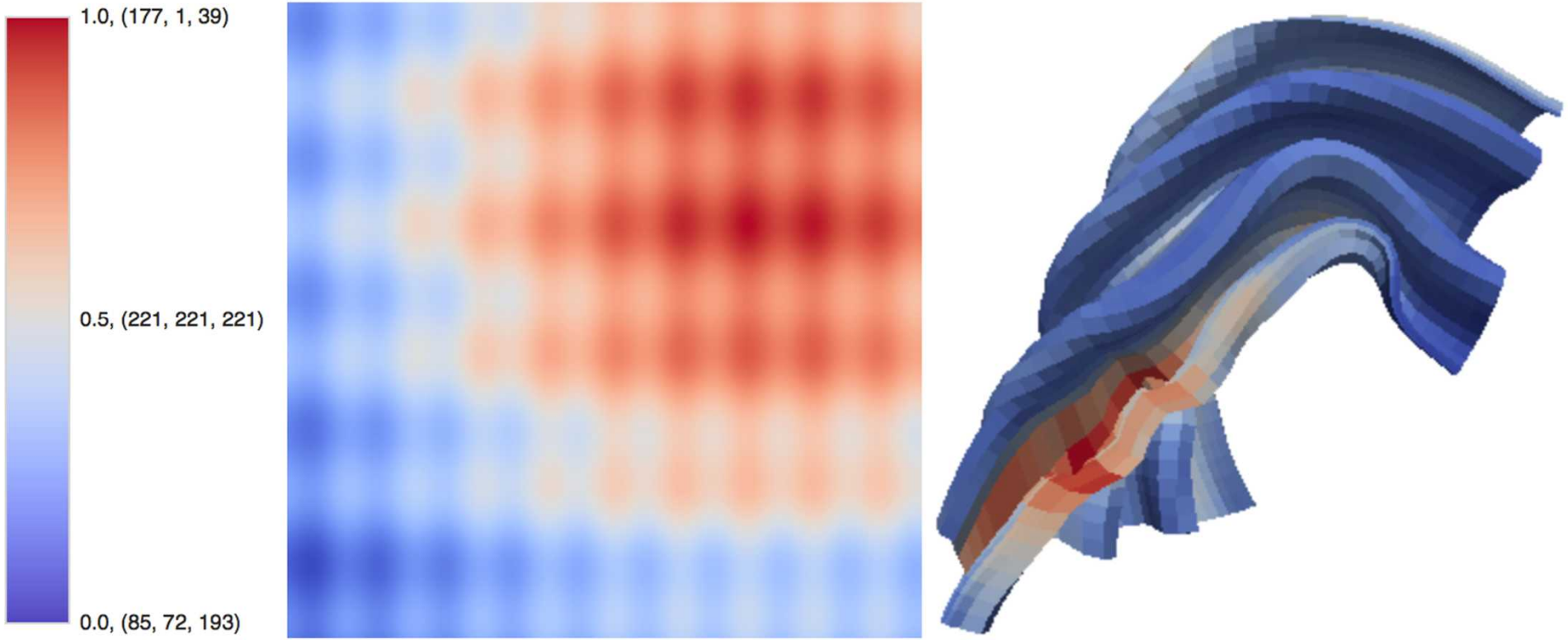
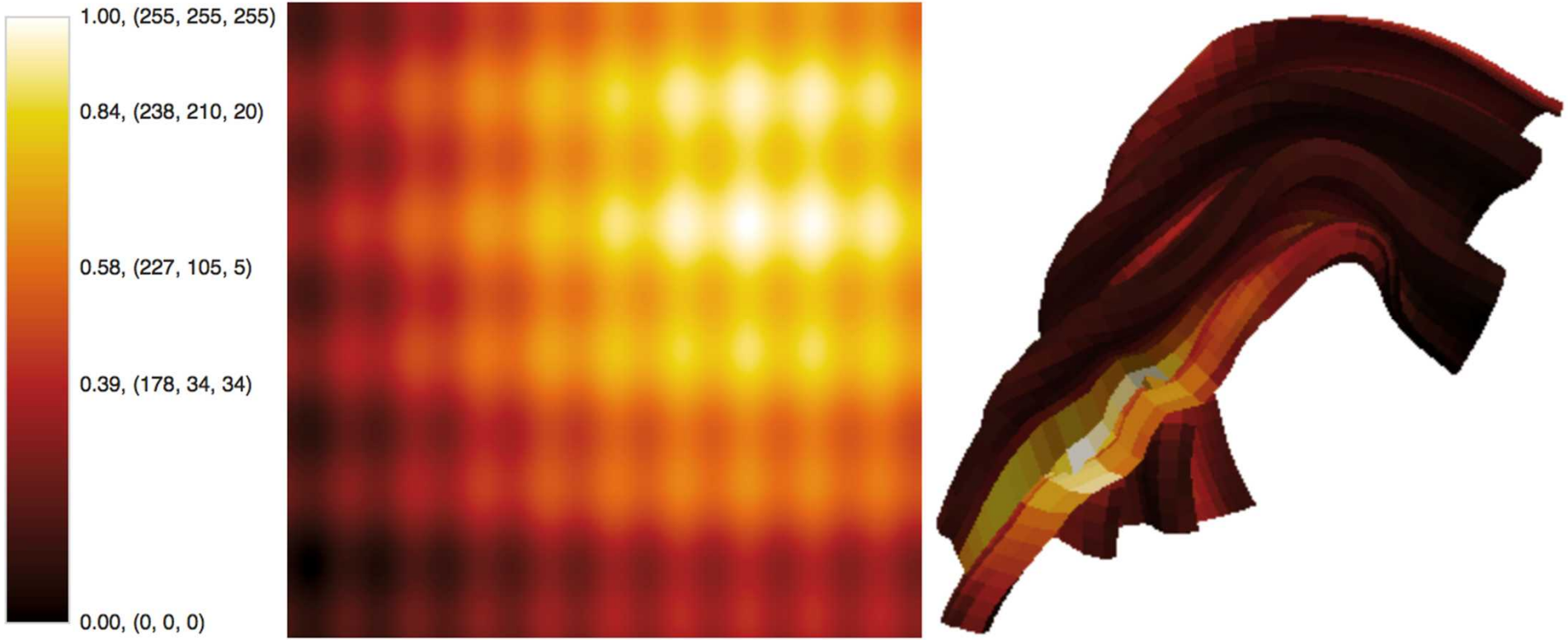
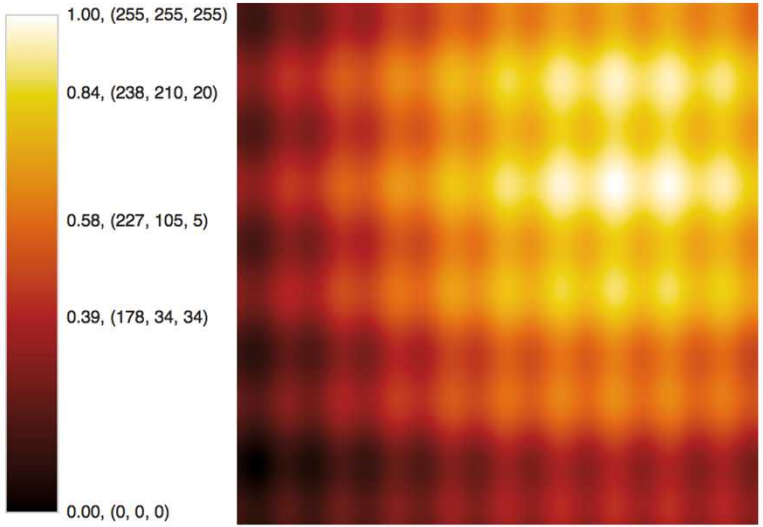


Scalar Field on 2D Plane

Sandia National Laboratories

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0.58, (227, 105, 5)
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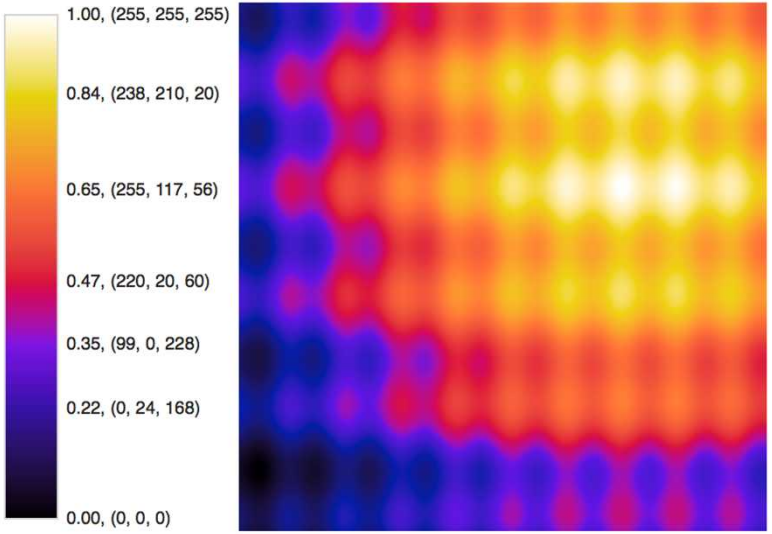
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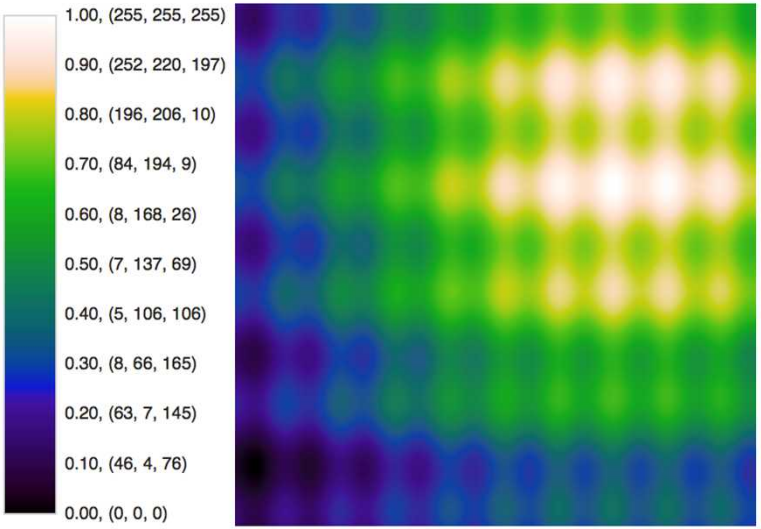
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0.50, (7, 137, 69)
0.40, (5, 106, 106)
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0.10, (46, 4, 76)
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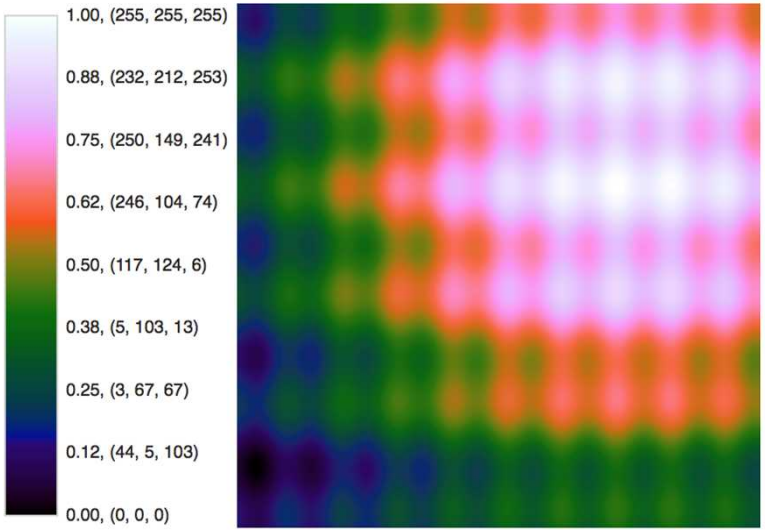
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0.88, (232, 212, 253)
0.75, (250, 149, 241)
0.62, (246, 104, 74)
0.50, (117, 124, 6)
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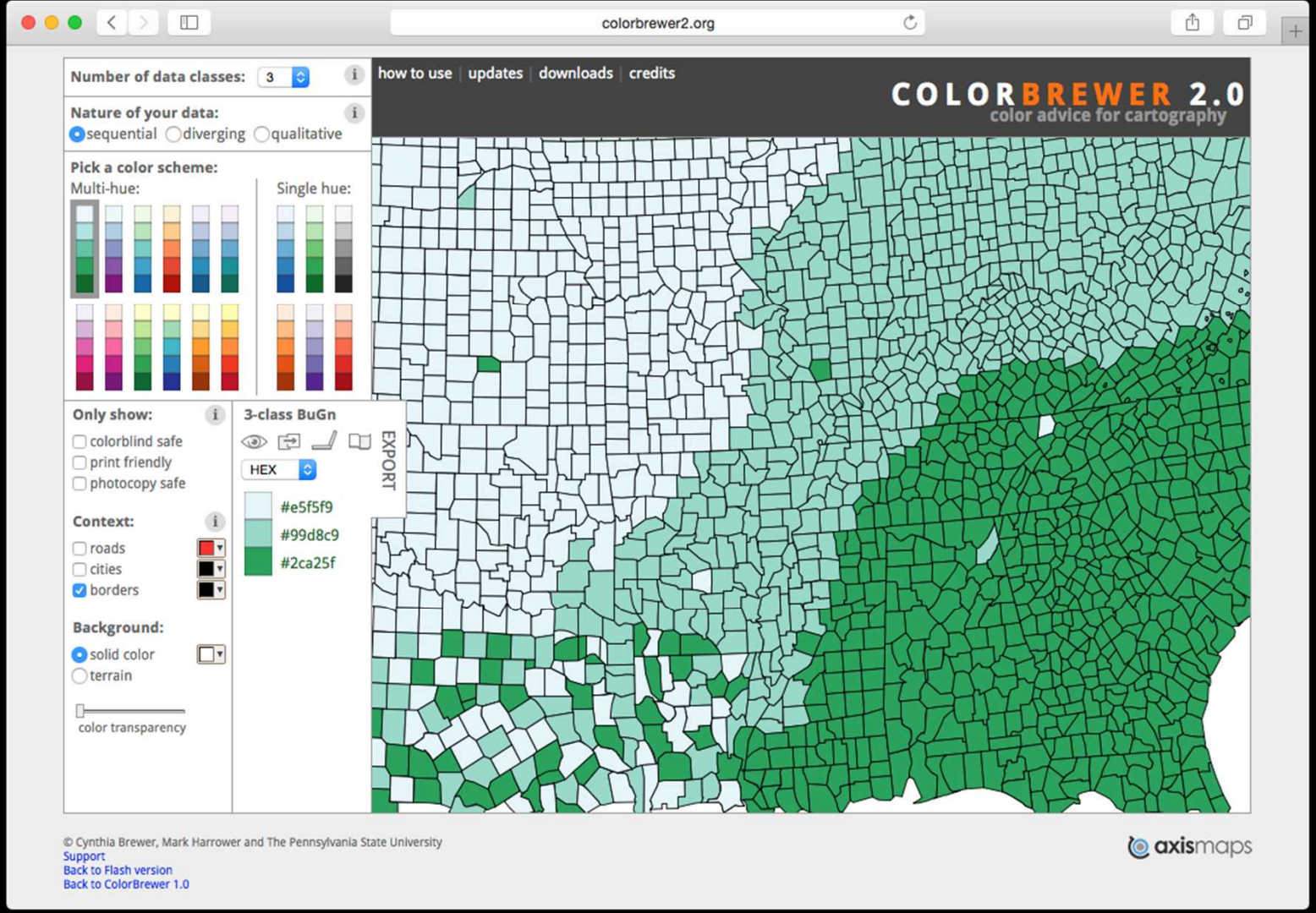
colorbrewer2.org
Number of data classes: 3
Nature of your data:
sequential diverging qualitative
Pick a color scheme:
Multi-hue:
Single hue:
Only show:
colorblind safe
print friendly
photocopy safe
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency
3-class BuGn
HEX
#e5f5f9
#99d8c9
#2ca25f
EXPORT
how to use | updates | downloads | credits
COLORBREWER 2.0
color advice for cartography
© Cynthia Brewer, Mark Harrower and The Pennsylvania State University
Support
Back to Flash version
Back to ColorBrewer 1.0
axismaps

Color Map Advice for Scientific Visualization

This page provides advice for using colors in scientific visualization. More specifically, this page provides color maps that you can use while using pseudocoloring of a scalar field. The color maps are organized by how and where they are best used. Each color map shows some example usage and provides color tables in CSV format so that they can readily be used in rendering system textures or entered into visualization software. For simplicity, the color tables are provided in many different lengths and with colors expressed in both bytes (integers between 0 and 255) and floats (decimals between 0.0 and 1.0). Each color map also has instructions on getting these colors in the ParaView visualization application. Where applicable, IPython notebooks containing details about how each color map is generated. You can either run the code directly with the appropriate software or copy/paste scripts into your own interpreter.

This work originates from the paper "**Why We Use Bad Color Maps and What You Can Do About It.**" Details about this paper are given below. Another related publication is "**Diverging Color Maps for Scientific Visualization,**" which describes specifics about one particular type of color map. Details of this paper and the techniques used can be found on its companion page.

Color Maps

3D Surfaces

In general a color map should use changes in luminance (brightness) to communicate changes in value. However, in a 3D sceen, shading cues, which are themselves changes in brightness, are vital to understanding shapes. Thus, you have to avoid having the brightness changes in the color map interfear with the brightness changes in shading and vice versa. You achieve this by limiting the color map to reasonably bright colors. Because this reduces the total range of brightness in the color map, I find it most effective to use a diverging (double-ended) color map.

Smooth Cool Warm

This color map uses the techniques based on "Diverging Color Maps for Scientific Visualization" by Kenneth Moreland. It is a diverging (double-ended) color map with a smooth transition in the middle to prevent artifacts at the midpoint. There are several more color maps of a similar nature described here.

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