



# VIS 2015

VAST \* INFOVIS \* SCIVIS



## Picking the “right” color map

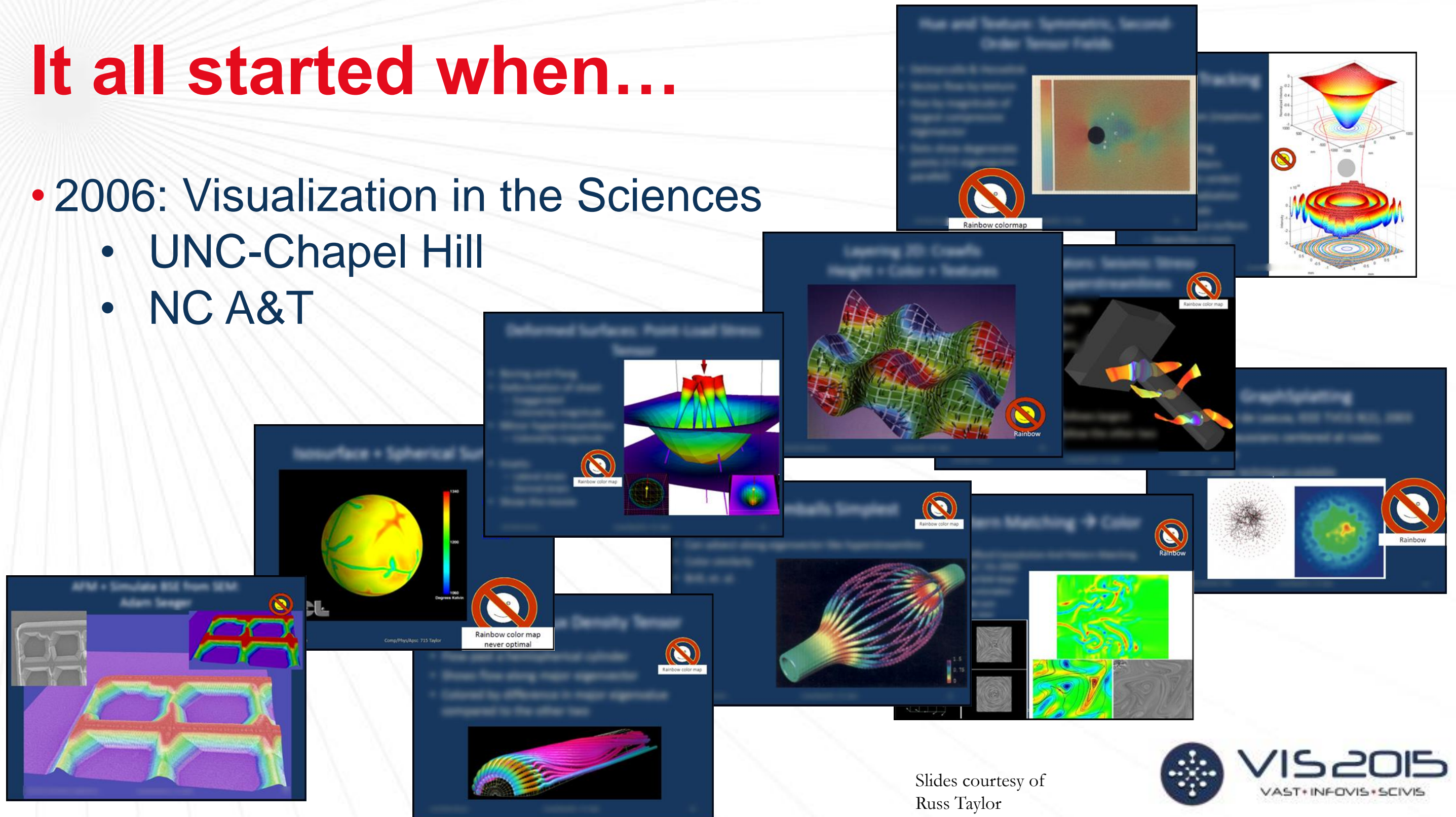
Color Mapping in VIS: Perspectives on Optimal Solutions

David Borland, RENCI, UNC-Chapel Hill



# It all started when...

- 2006: Visualization in the Sciences
  - UNC-Chapel Hill
  - NC A&T

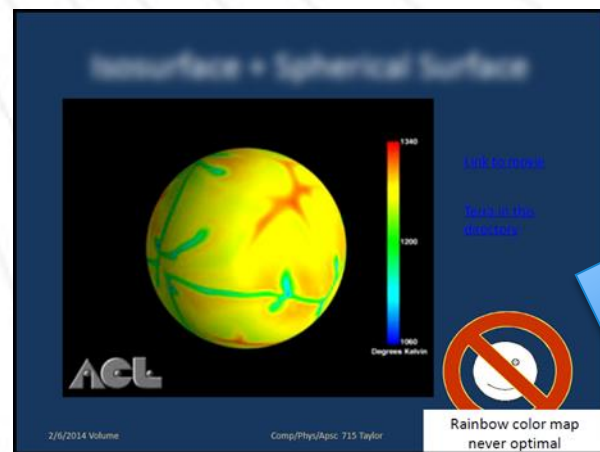


Slides courtesy of  
Russ Taylor



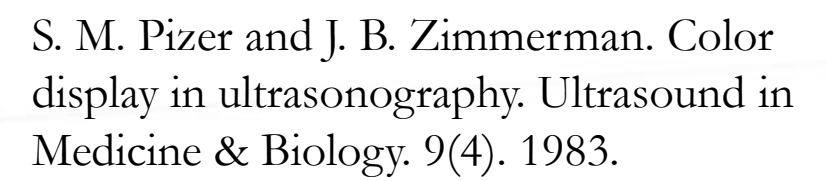
# It all started when...

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Rainbow color map  
never optimal

- Rainbow color map deficiencies already well-established...



B. E. Rogowitz and L. A. Treinish. How not to lie with visualization. *Comput. Phys.* 10(268). 1996.

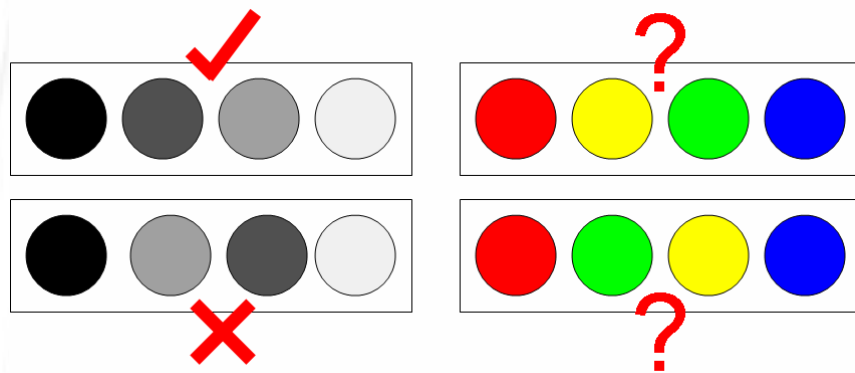
P. L. Rheingans; Task-based color scale design. Proc. SPIE 3905, 28th AIPR Workshop: 3D Visualization for Data Exploration and Decision Making. 35. 2000.

A. Light and P. J. Partlein. The end of the rainbow? Color schemes for improved data graphics. EOS Trans. Amer. Geophysical Union. 85(40). 2004.

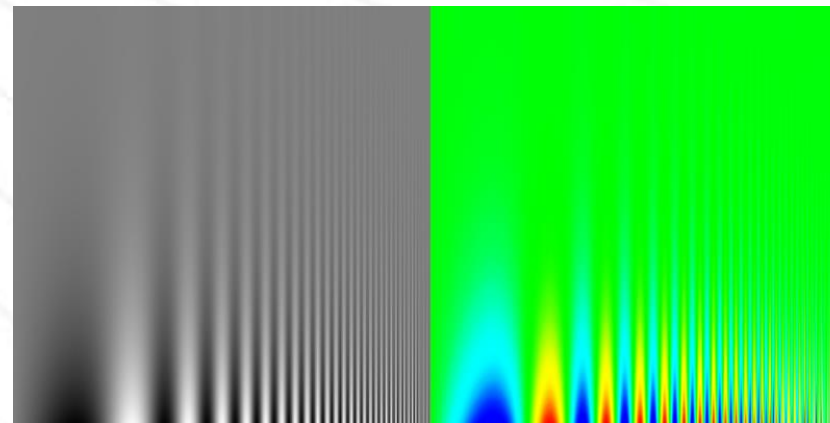


# Rainbow color map (still) considered harmful

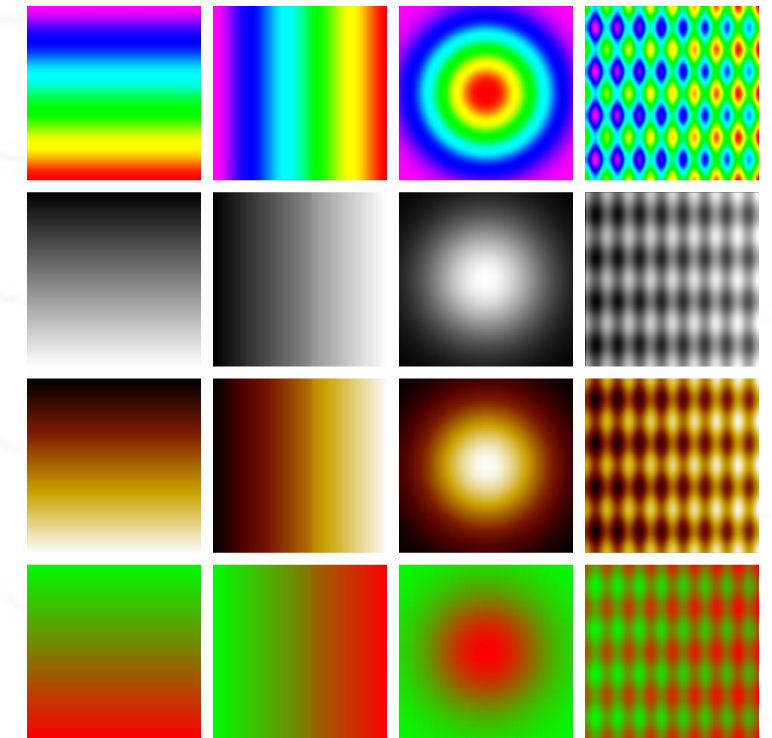
- IEEE CG&A Visualization Viewpoints
  - March/April 2007



**Confusing**  
Not perceptually ordered



**Obscuring**  
Large areas of low luminance-contrast



**Misleading**  
Sharp non-data-dependent gradients

# Rainbow color map (still) considered harmful

- Prevalence in IEEE VIS papers that used a color map

Table 1. Statistics from the 2001 through 2005 IEEE Visualization Conference proceedings papers implementing pseudocoloring to display data and that use the rainbow color map.

Year	Relevant Papers Including Medical Images (%)	Relevant Papers Excluding Medical Images (%)	Number of Pages
2001	47	62	8
2002	40	45	18
2003	52	71	32
2004	59	68	62
2005	52	59	61
Total	51	61	181

**Eight** of **nine** toolkits investigated had the rainbow as the default

# Aside: has anything changed?

- 2014 IEEE VIS Proceedings
  - VAST: 10%
  - InfoVis: 0% !!!
  - SciVis: 25%
- Toolkit defaults
  - ParaView: diverging
  - Matlab: parula



K. Moreland. Diverging color maps for scientific visualization. In Proceedings of the 5<sup>th</sup> International Symposium on Visual Computing. 2009.

S. Eddins. Rainbow color map critiques: An overview and annotated bibliography. MathWorks Technical Article. 2014.



# Aside: has anything changed?

- Climate science—Continued calls for the “end of the rainbow”
  - An open letter to the climate science community, 2014
    - Ed Hawkins et al.
    - <http://tiny.cc/endoftherainbow>
    - “So, we **undertake this pledge** – *to never again be an author on a paper which uses a rainbow colour scale.*”
    - Twitter hashtag! **#endtherainbow**
  - *Nature* correspondence article
    - Ed Hawkins, Graphics: Scrap rainbow colour scales. *Nature*. 519. 2015.
  - *Bull. Amer. Meteor. Soc.* Article
    - R. Stauffer et al. Somewhere over the rainbow: How to make effective use of colors in meteorological visualizations. *Bull. Amer. Meteor. Soc.* 96. 2015.
  - KNMI Climate Explorer
    - Changed color scales



## The end of the rainbow

© November 18, 2014 communication, journals, visualisation Ed Hawkins

### An open letter to the climate science community

Ed Hawkins, Doug McNeill, David Stephenson, Jonny Williams & Dave Carlson





# Rainbow color map (still) considered harmful

- What color map should be used?
- Depends *critically* on
  - Task
    - Absolute value comparison?
    - Local small-scale feature detection?
  - Other visualization techniques
    - Height field?
  - Data characteristics
    - Nominal/ordinal/interval/ratio?
    - High spatial frequency?
    - Noise?
    - Data distribution?



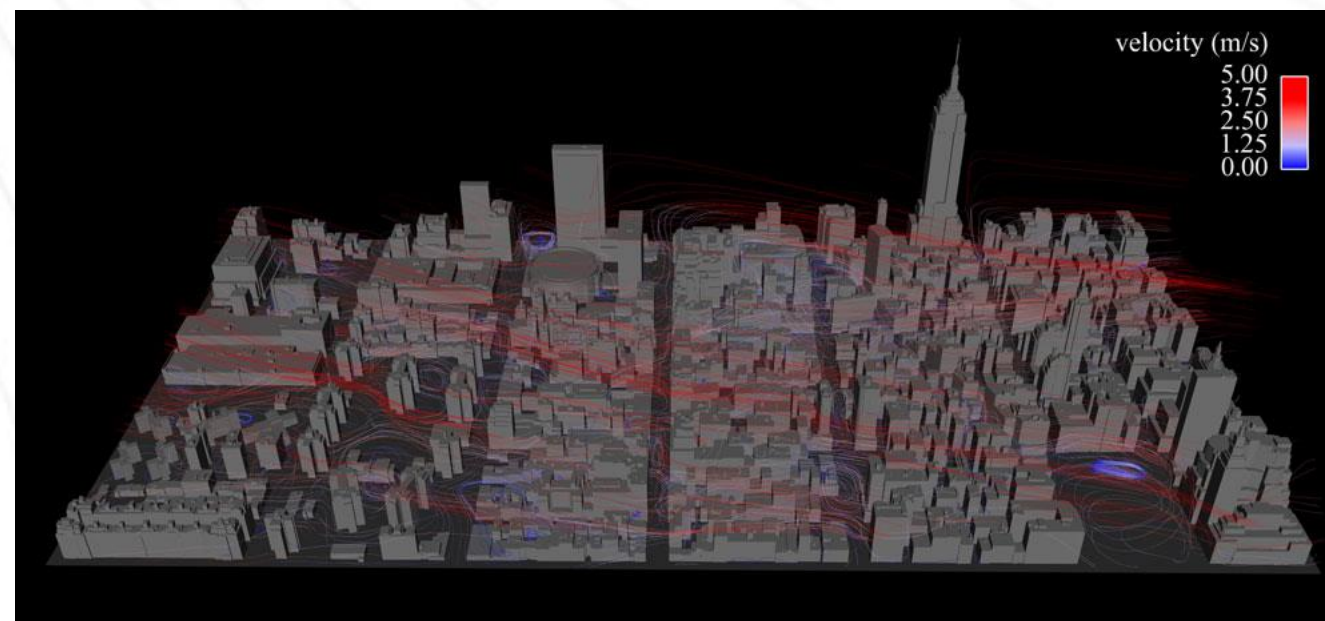
There is no  
silver bullet...

Also audience...

# Collaboration-specific color-map design

- IEEE CG&A Visualization Viewpoints
  - July/August 2011
- Collaboration with Alan Huber
  - UNC-Chapel Hill Institute for the Environment
  - US Environmental Protection Agency

Data:  
Simulated airflow in  
downtown Manhattan



Three data subsets of interest:

1. XY velocity magnitude
2. XY velocity angle
3. Z velocity component

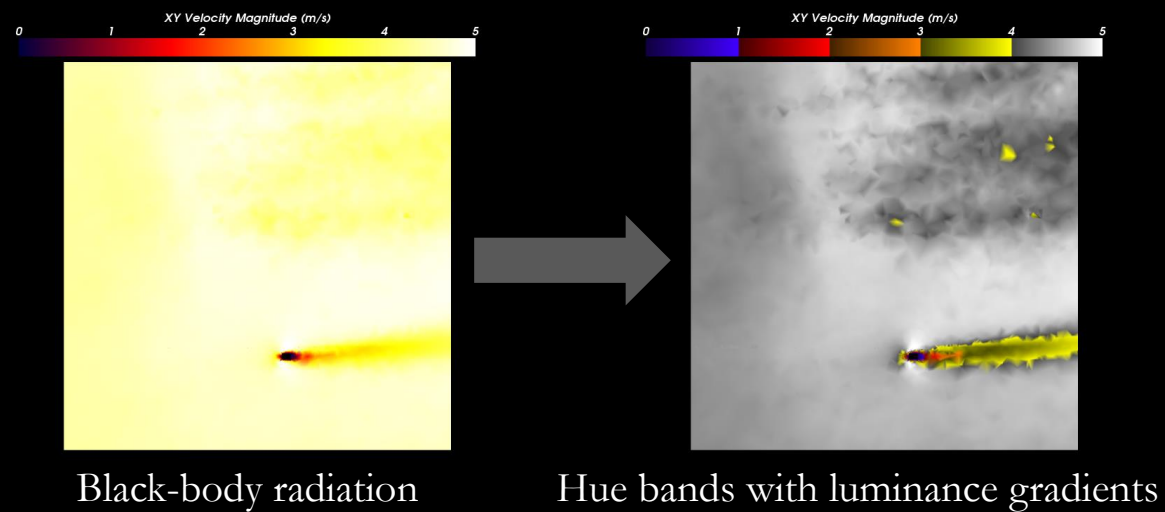


# Collaboration-specific color-map design

- Three data subsets of interest

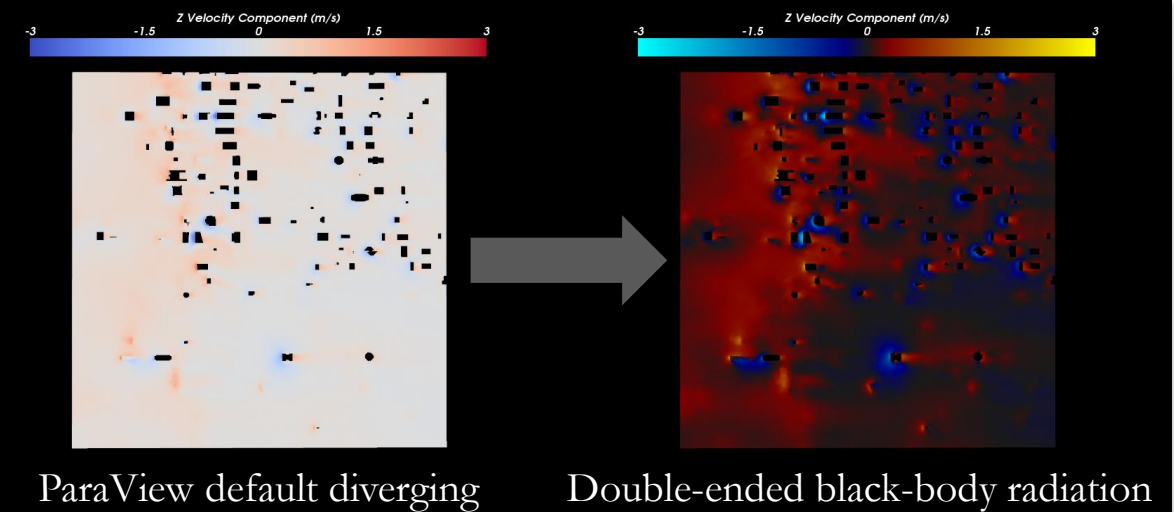
1

XY velocity  
magnitude



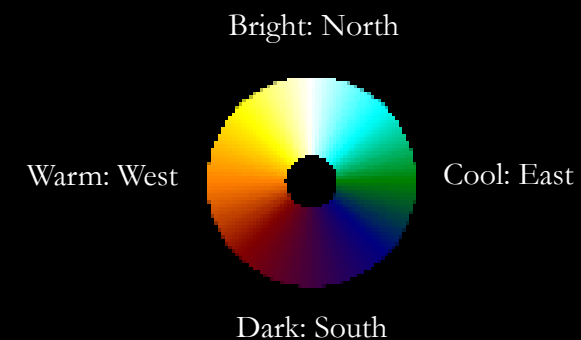
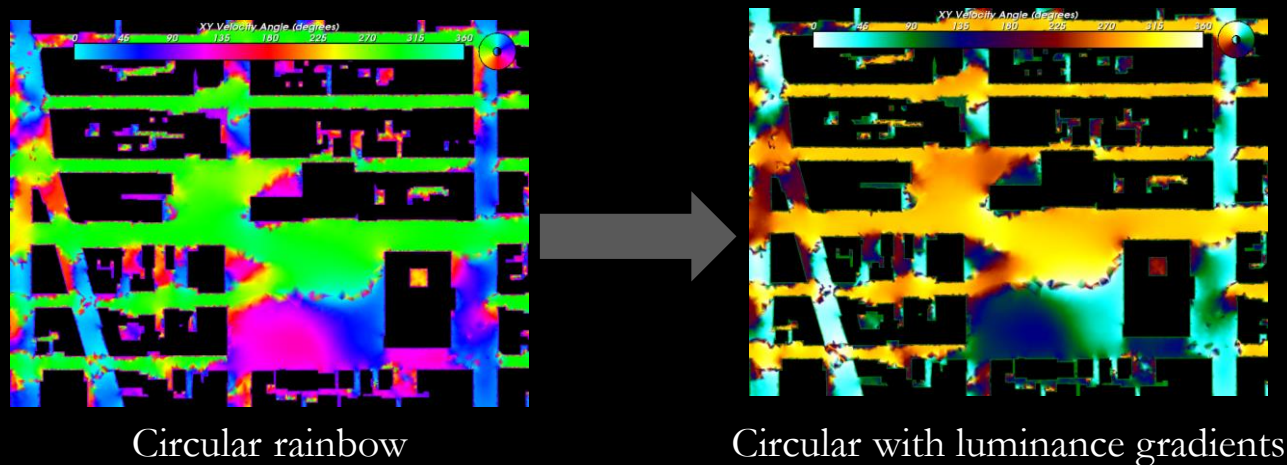
3

Z velocity  
component



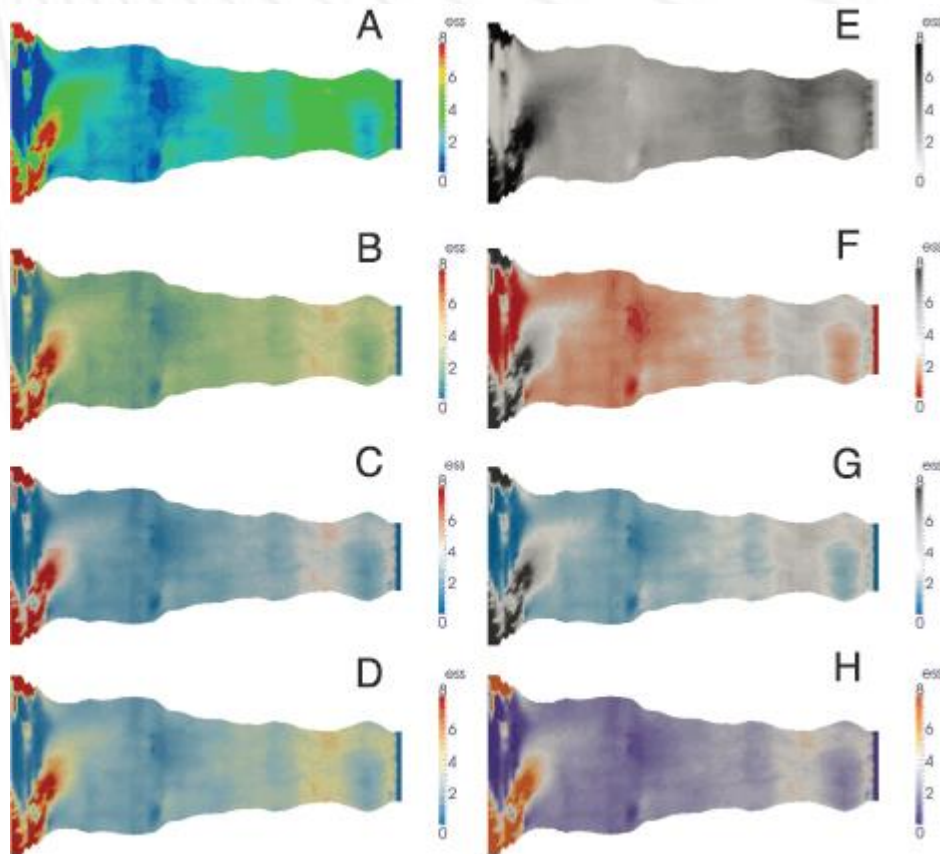
2

XY velocity  
angle



# Picking a good color map is important

- Visualization choices matter

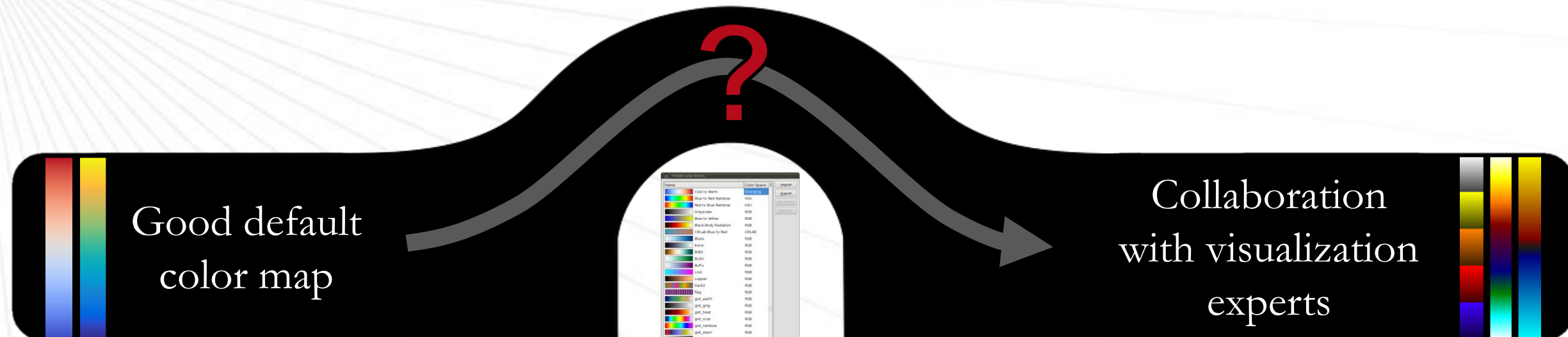


“...a perceptually appropriate color map leads to fewer diagnostic mistakes than a rainbow color map.”

M. Borkin, et al. Evaluation of artery visualizations for heart disease diagnosis. IEEE Transactions on Visualization and Computer Graphics. 17(12). 2011



# Picking the “right” color map...



- Challenging, but widely applicable
- In many cases good enough

- Can be helpful
- Not feasible in most cases

Choosing a good color map  
can be difficult

- Potentially multiple tasks for a given visualization
- Competing visualization elements
- Many, many choices...



ParaView wiki

How to **empower** the user without **overwhelming** them..?