VACET

Visualization and Analytics Advances for SciDAC Science

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LLNL · Berkeley Lab · IDAV UC Davis · SCI Institute · Oak Ridge National Laboratory · ASCR

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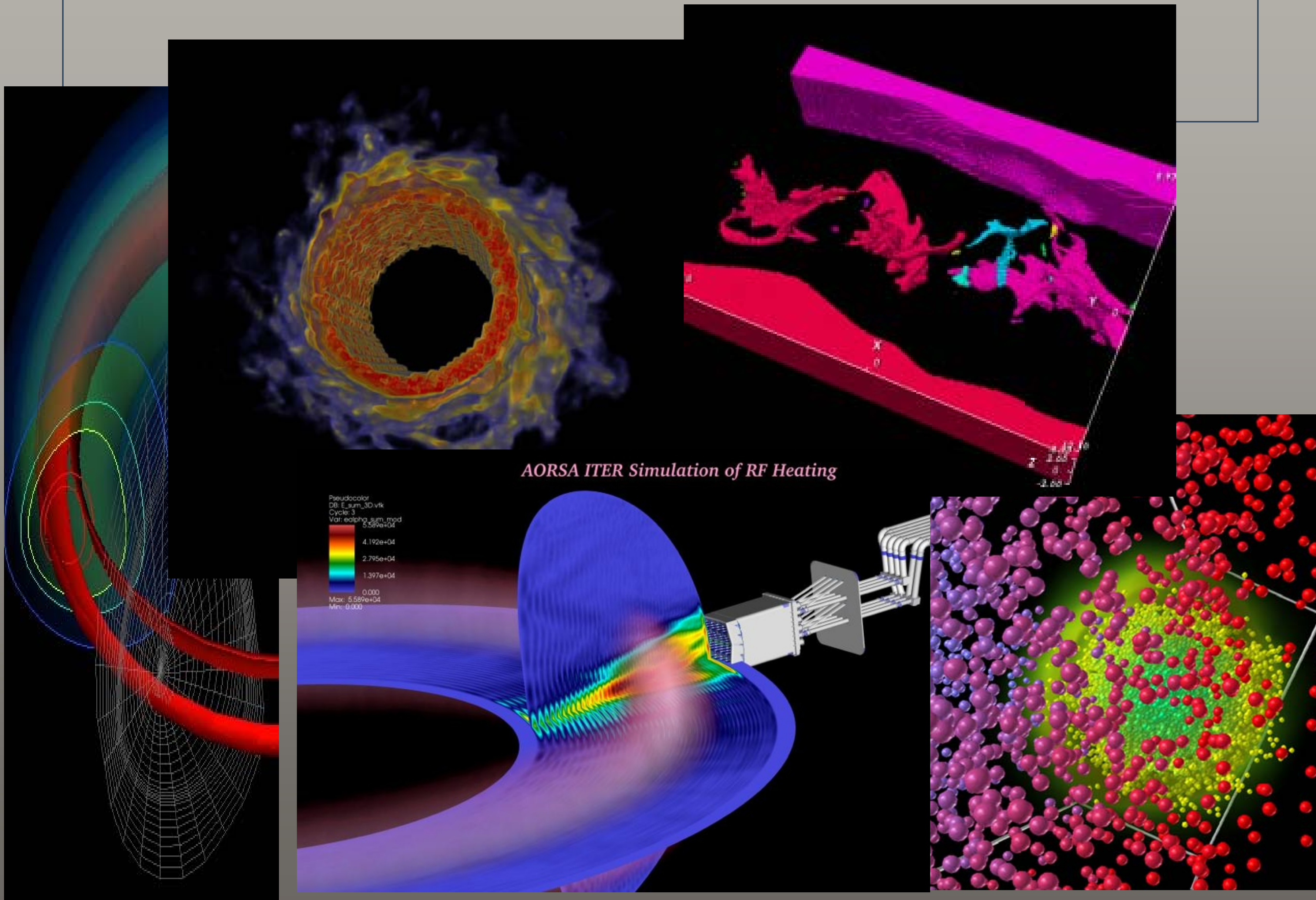
Visualization and Analytics Center for Emerging Technologies

Partners

- Lawrence Berkeley National Laboratory
- University of Utah (SCI Institute)
- UC Davis (Institute for Data Analysis and Visualization)
- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory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Cycle: 3
Var: ealpha_sum_mod
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4.192e+04
2.795e+04
1.397e+04
0.000
Max: 5.589e+04
Min: 0.000

What are the challenges?

- Challenges from the Visualization field.
- Challenges for VACET
- Challenges for Petascale

Challenges for Visualization

- Paradigm Shift
  - From: production of the
    - "picture on the wall"
    - "single killer animation"
  - To: a cornerstone of "modern" data analysis
    - Focus: data exploration
    - tools for discovery and analysis

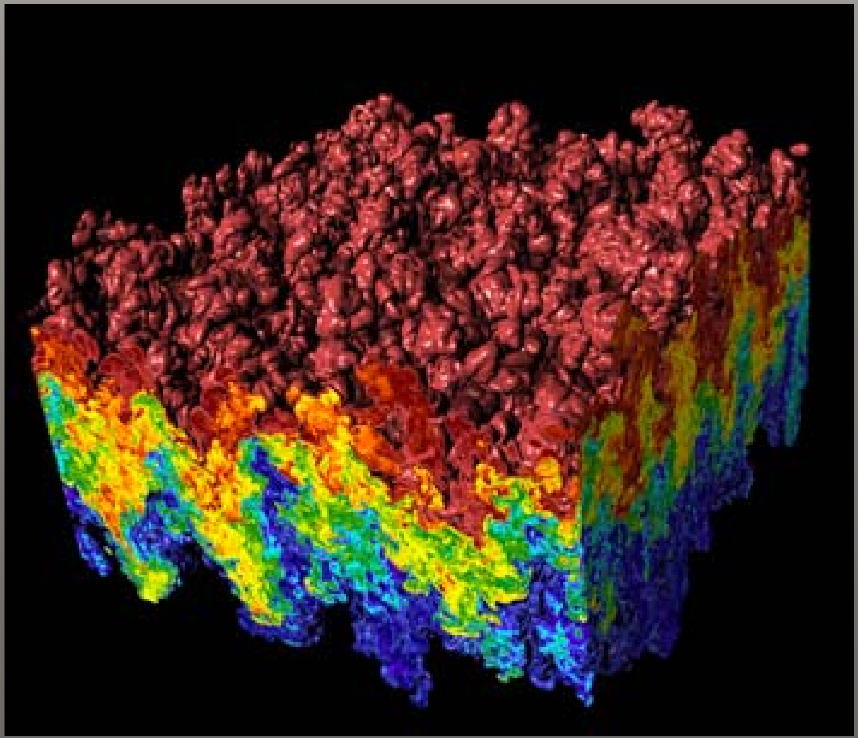
VACET

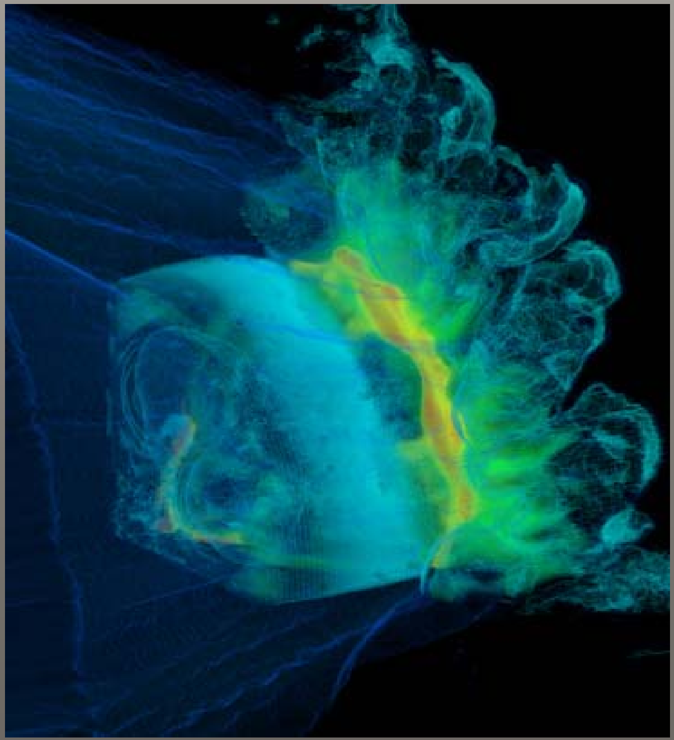
Challenges for VACET

- Deploy basic tools to the community that improve the basic understanding of visualization and analytics methods
- Identify and address the challenges in visualization and analytics in collaboration with our science stakeholders
- Integrate new methods into deployment vehicles, and repeat

VACET Tools

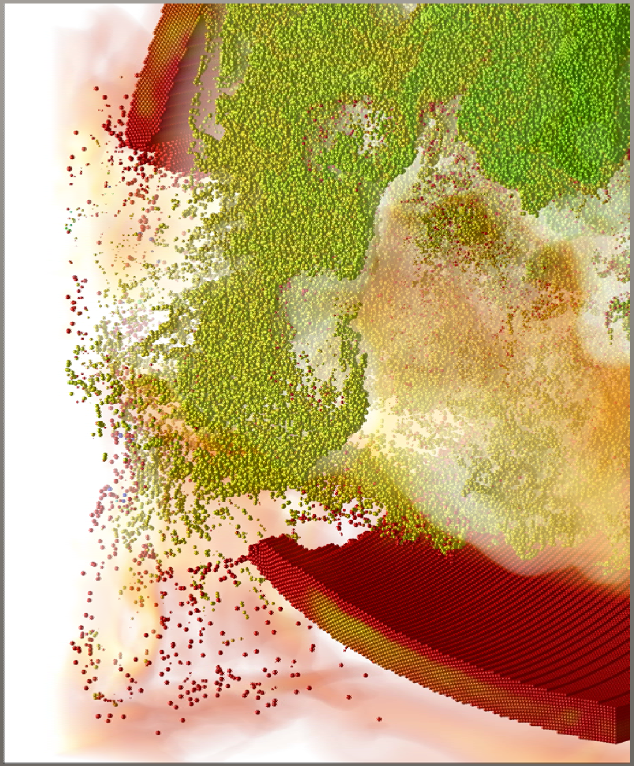
- VisIt
  - Lawrence Livermore National Laboratory

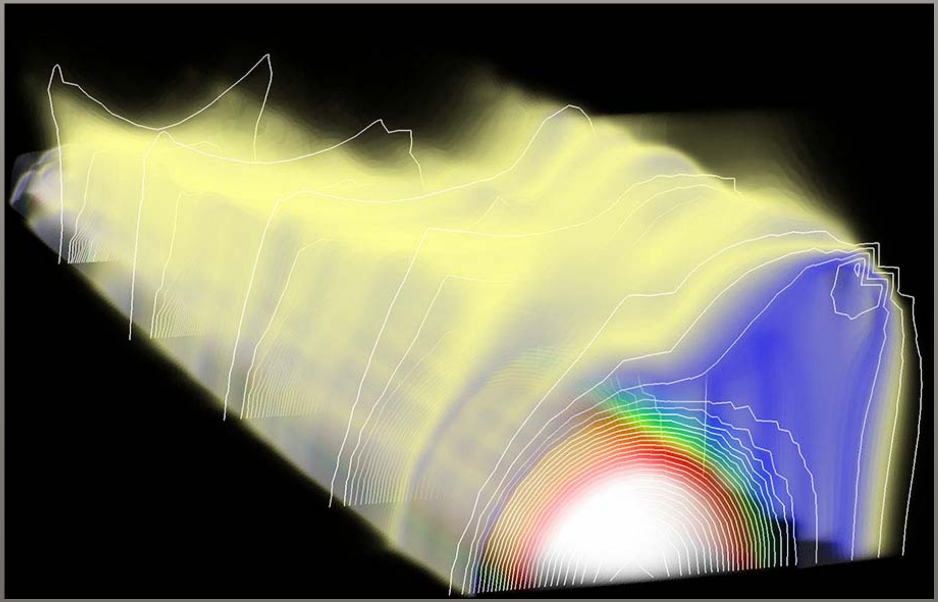




VACET Tools

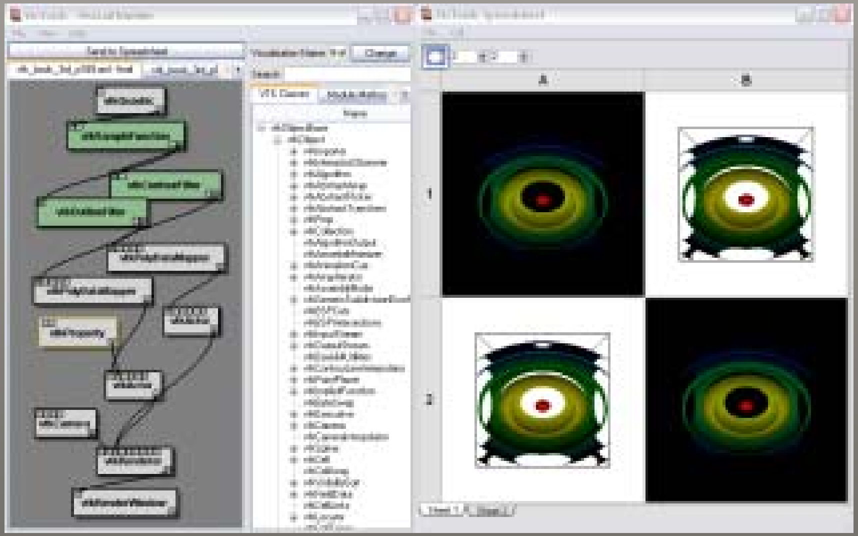
- SciRun
  - SCI Institute, Univeristy of Utah

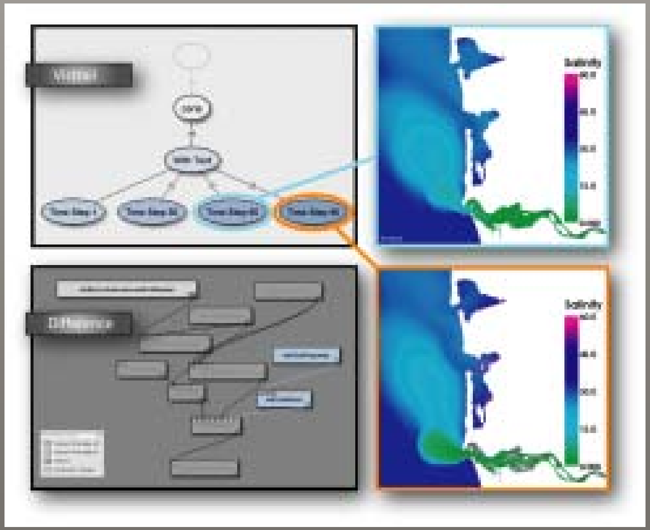




VACET Tools

- VisTrails
  - SCI Institute, Univeristy of Utah





Challenges for Petascale

- “Petascale”, “Exascale”, “Ultrascale”, “Extreme Scale”
  - “These are the adjectives that we use to indicate focus on the high end…”
  - But problems and data are growing in different ways.
  - …and the solutions change!!!

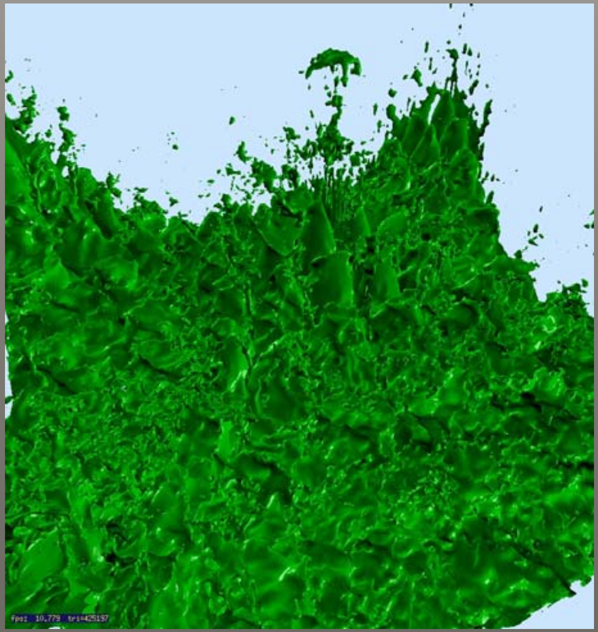
Challenges for Petascale Visualization

- Data/Information is growing along four fundamental axes
  - Spatial
  - Complexity
  - Temporal
  - Ensembles

And different questions must be answered depending on “your location” in this four-dimensional space.

Challenges for Petascale Visualization

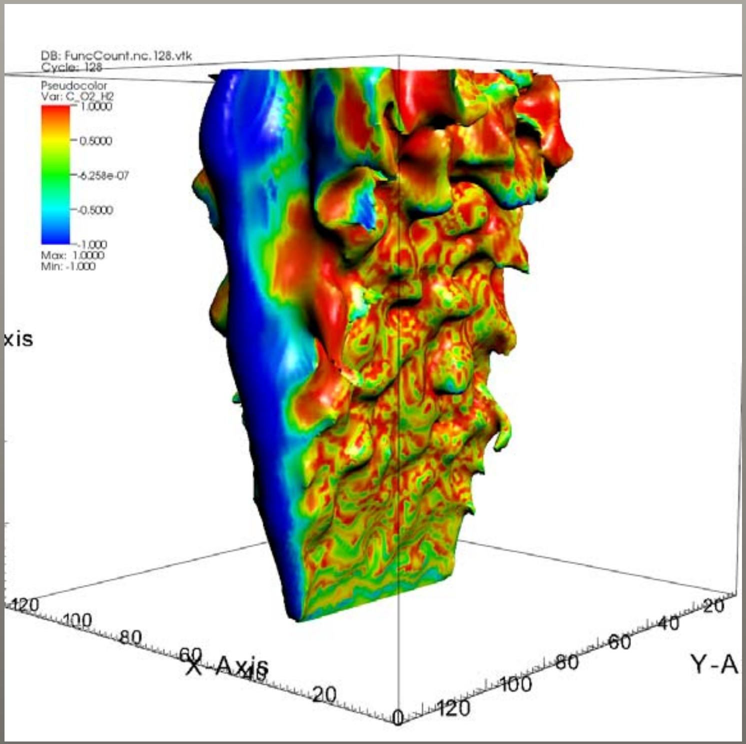
- Spatial Growth
  - Growth in grid size, and in grid complexity
  - More time steps



Martin Bertram (UC Davis)
Mark Duchaineau (LLNL)

Challenges for Petascale Visualization

- Growth in Complexity
  - Vertices contain arrays of
    - Scalar Values
    - Vector Values
    - Tensor Values
    - Functions
    - Distributions
    - ...
  - Cells contain
    - Volume Fractions
    - Distributions
    - ...



Luke Gosink (UC Davis)
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E.Wes Bethel (LBL)
John Bell (LBL)

Challenges for Petascale Visualization

- Temporal Growth
  - Analysis and visualization in the temporal domain is “highly understudied” -- because it’s difficult
  - Just producing “a movie” gives only limited understanding
  - Analysis techniques in the temporal domain.
    - Comparative techniques
    - Exploration techniques

Challenges for Petascale Visualization

- Growth of “Ensembles”
  - Researchers are performing parameter studies, where parameters are varied slightly and throughout several simulation runs.
    - Climate
    - Molecular Dynamics
    - …
  - Need: Comparative Analysis Techniques
  - Need: Uncertainty Analysis Techniques

Challenges for VACET

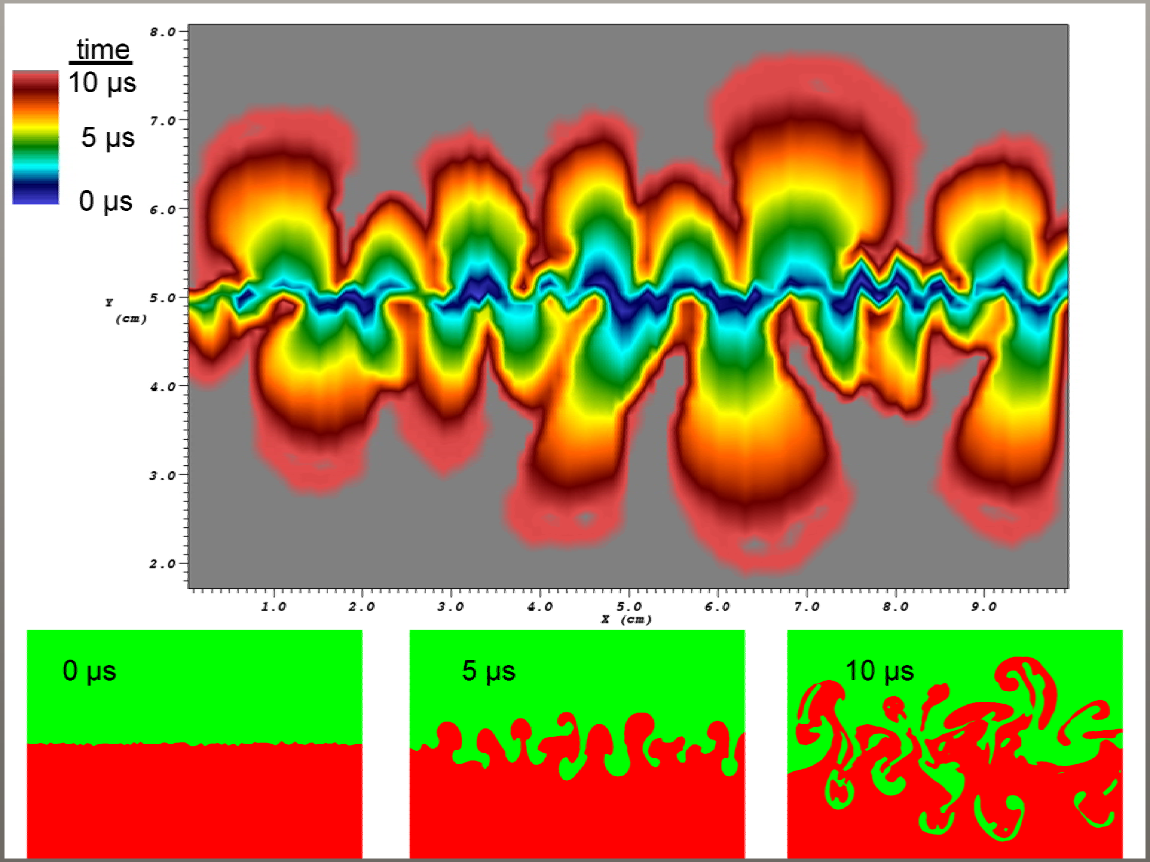
- “Research and Deploy” Strategy
  - Develop and deploy tools that address the challenges of scientific discovery.
  - Integrate our work with the challenges of the scientific domains

Comparative Visualization

- Ensembles, Complexity, Temporal
  - new data-comparative that apply to ensembles.
  - Large-scale comparative methods for time-varying data.

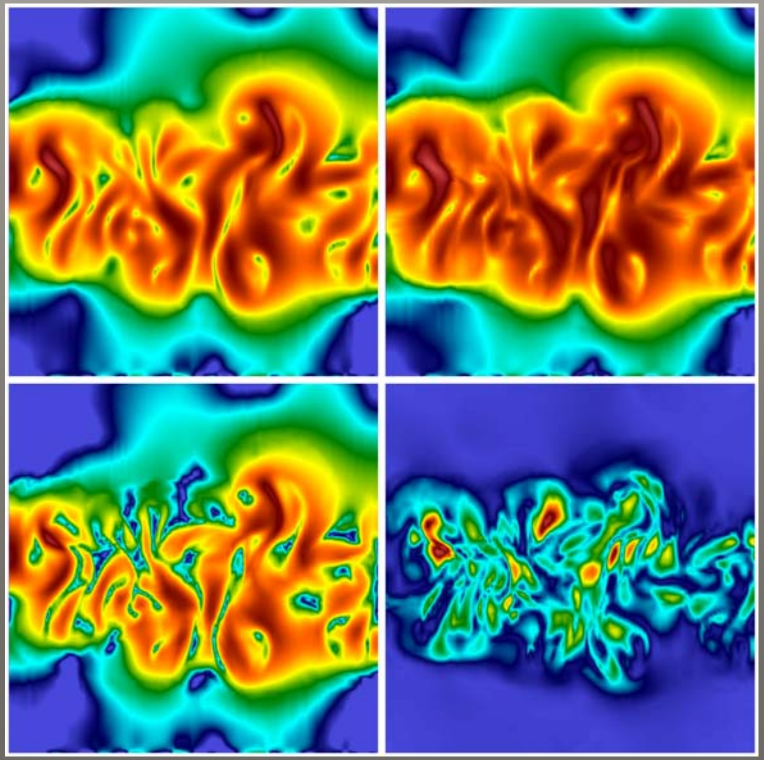
Comparative Visualization of Time-varying Data.

Rayleigh-Taylor Instability



Comparative Techniques and Ensembles

Studying 25 Rayleigh-Taylor Instability calculations (all at 10us)
Two "knobs": turbulent viscosity coefficient, buoyancy coefficient
Five values for each knob, 25 pairs total



Average Speed over all 25

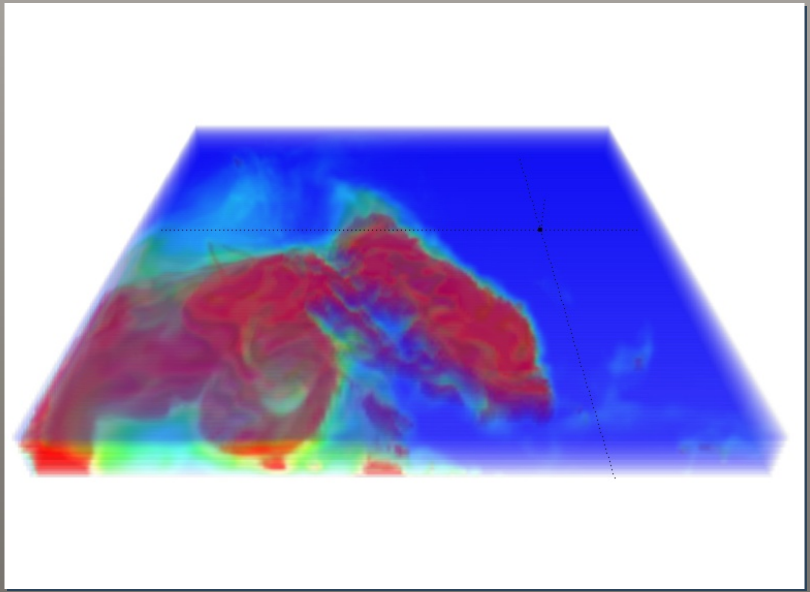
Max Speed over all 25

Min Speed over all 25

Biggest difference over all 25

Function Fields

- Complexity
  - Each data point is associated with a function.



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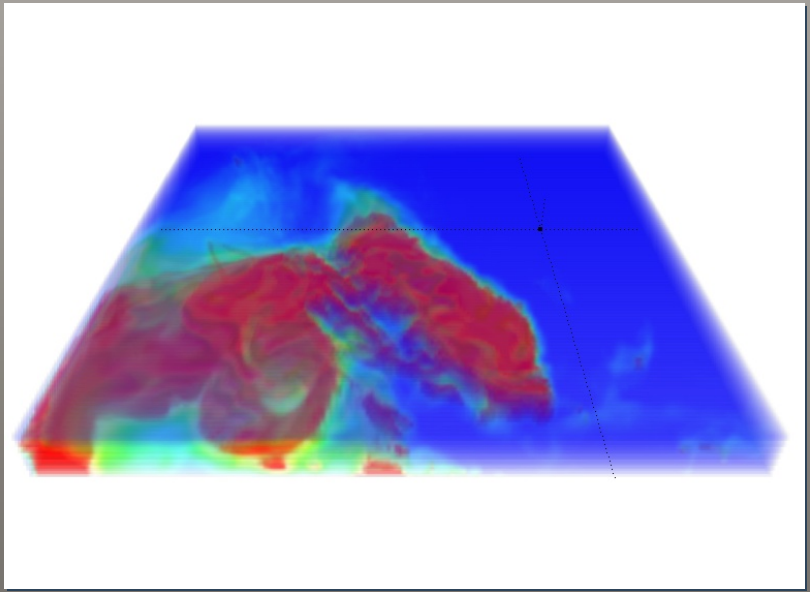

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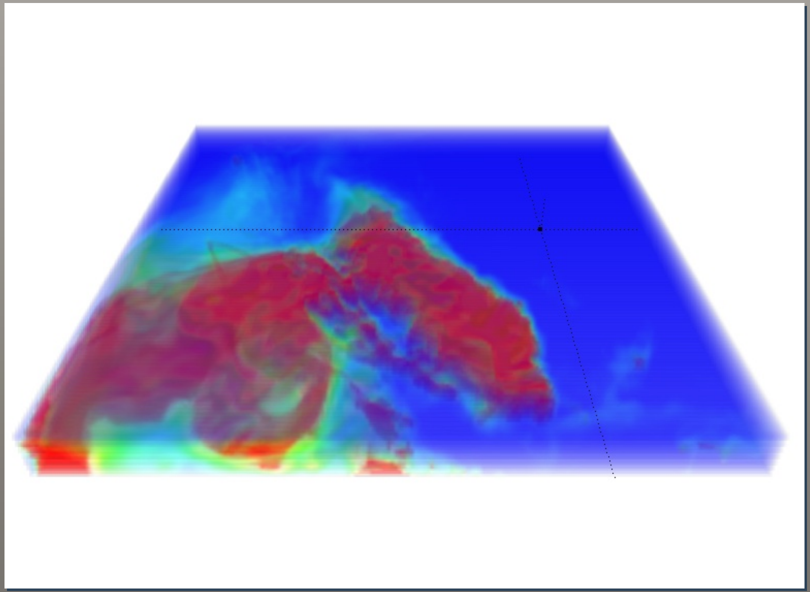

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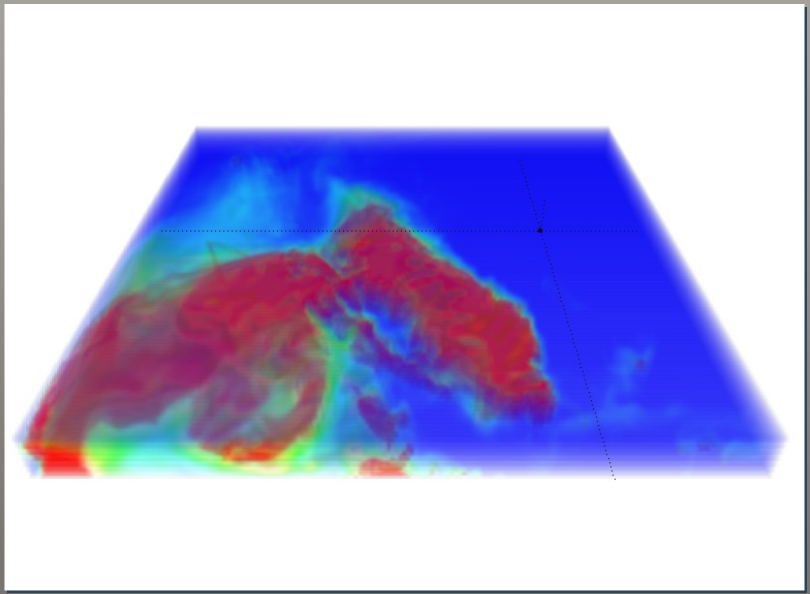

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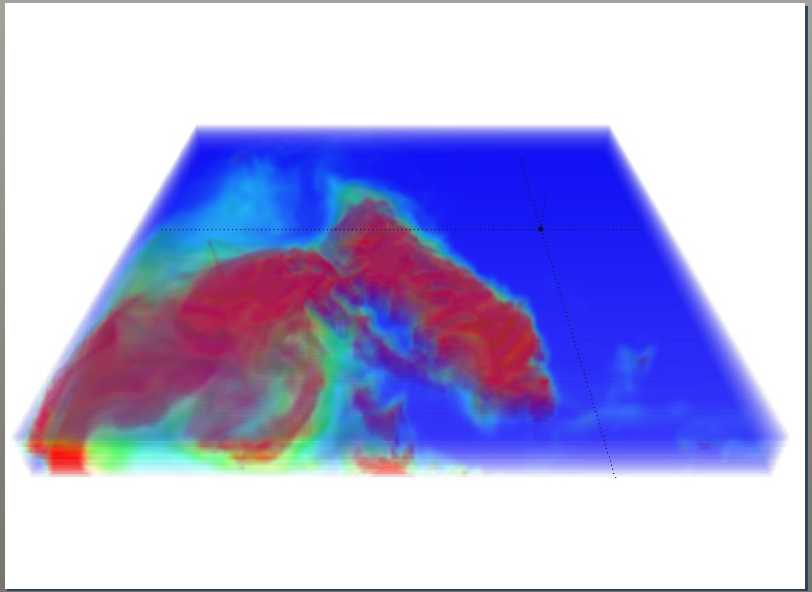

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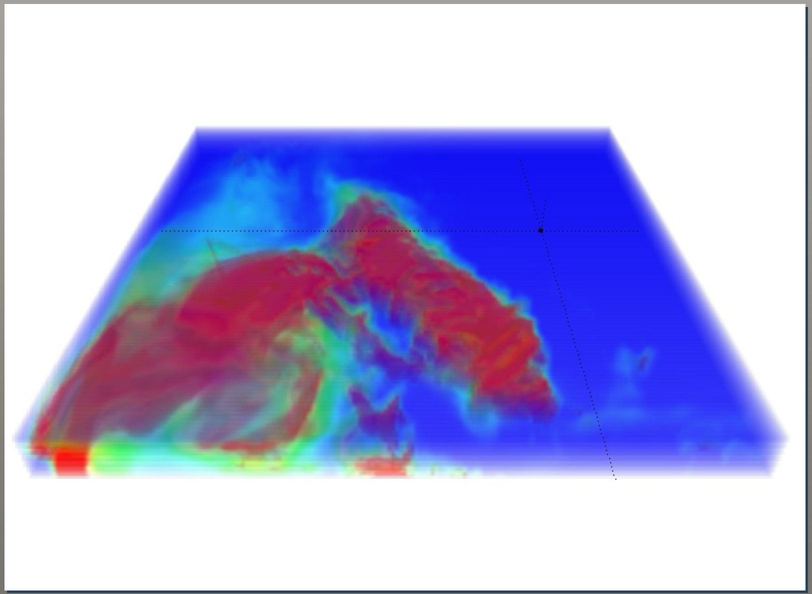

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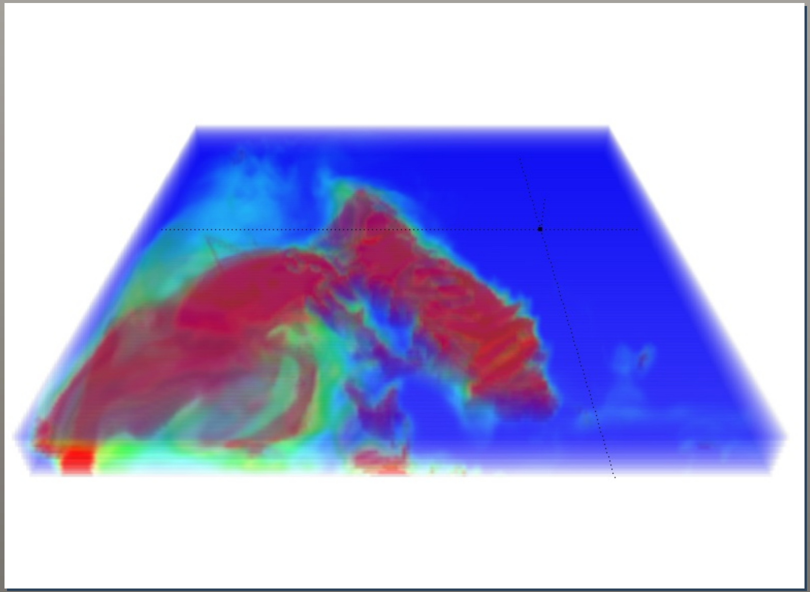

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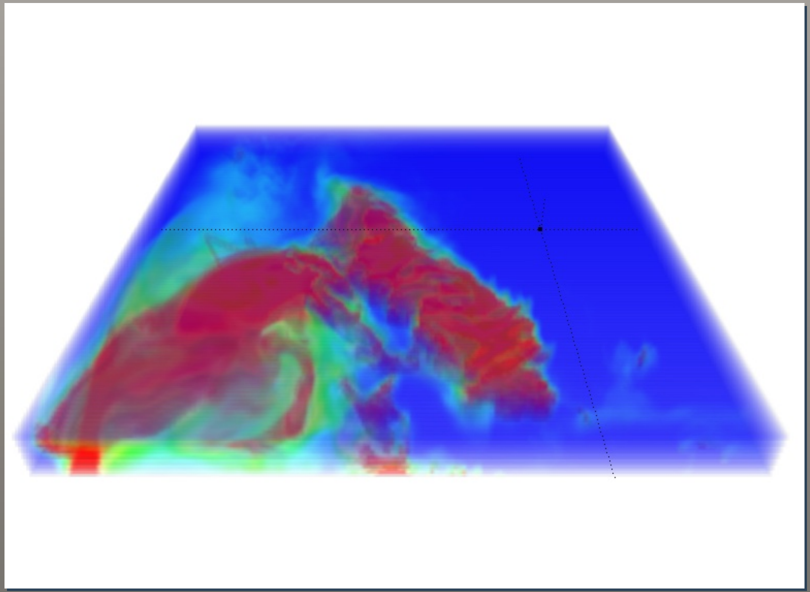

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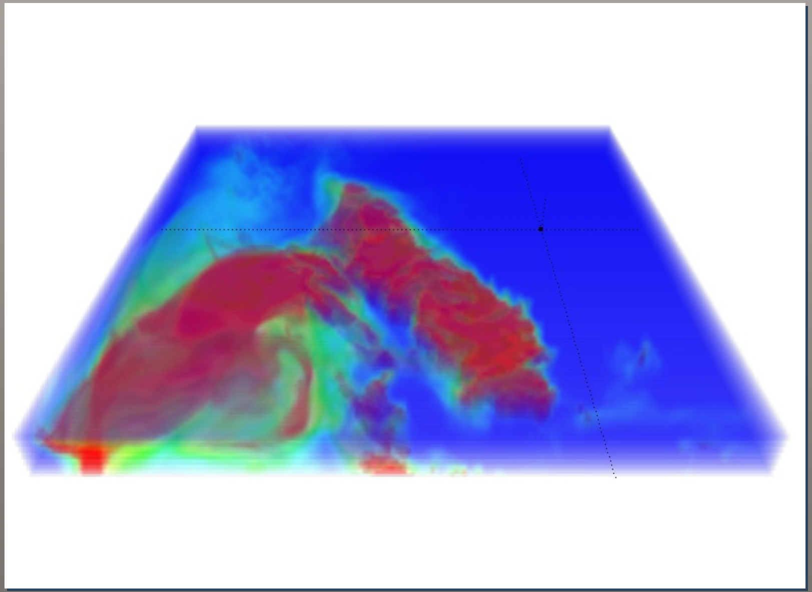

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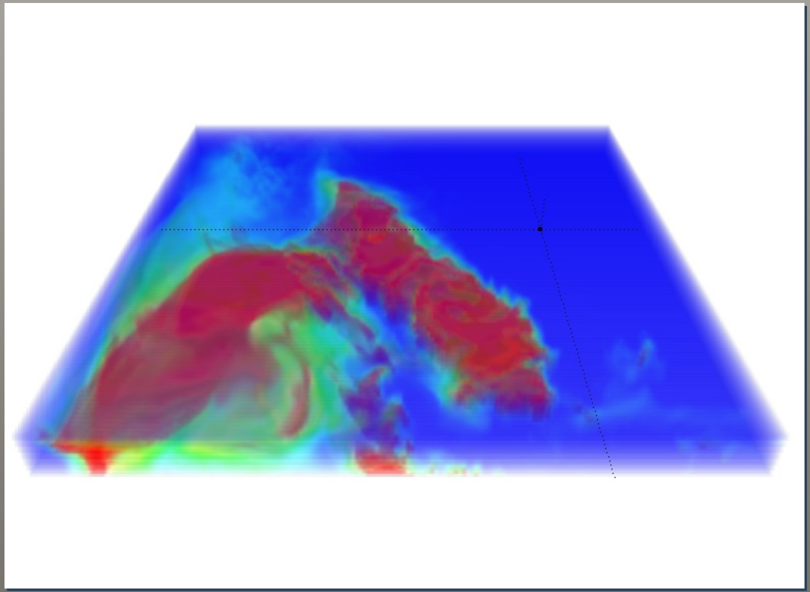

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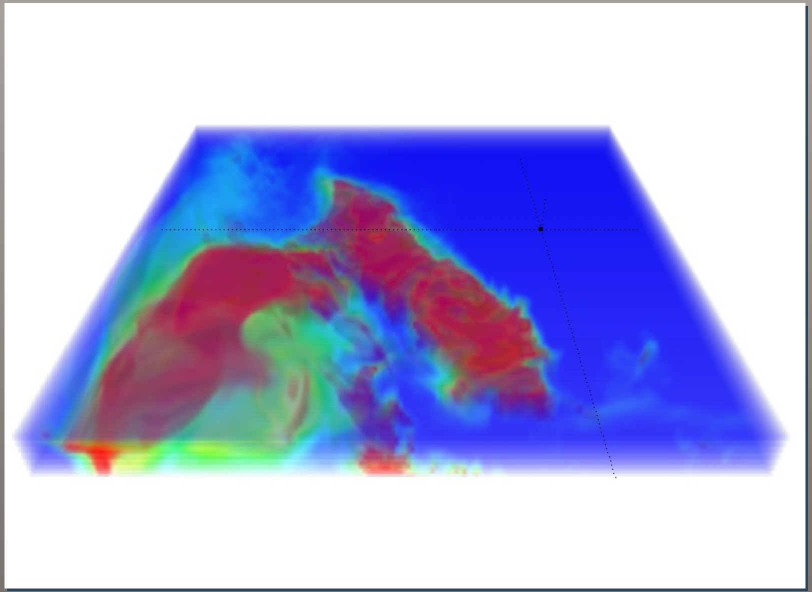

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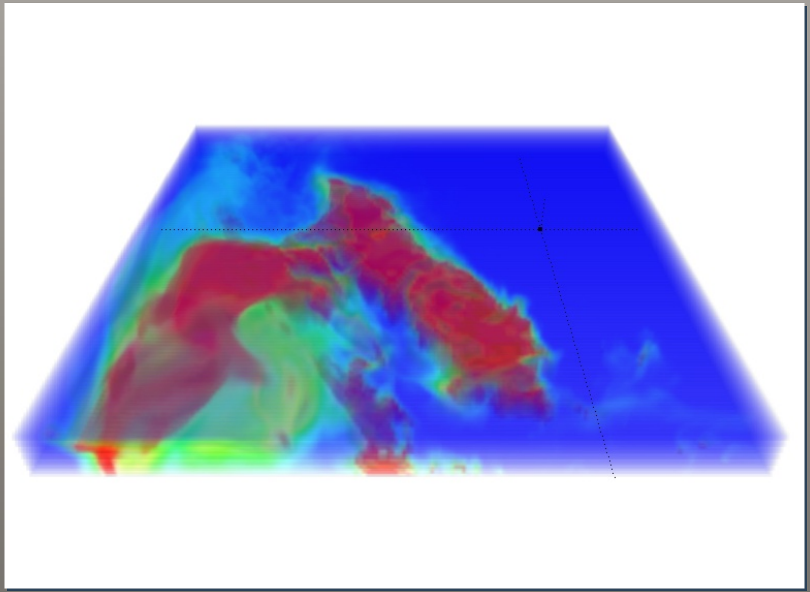

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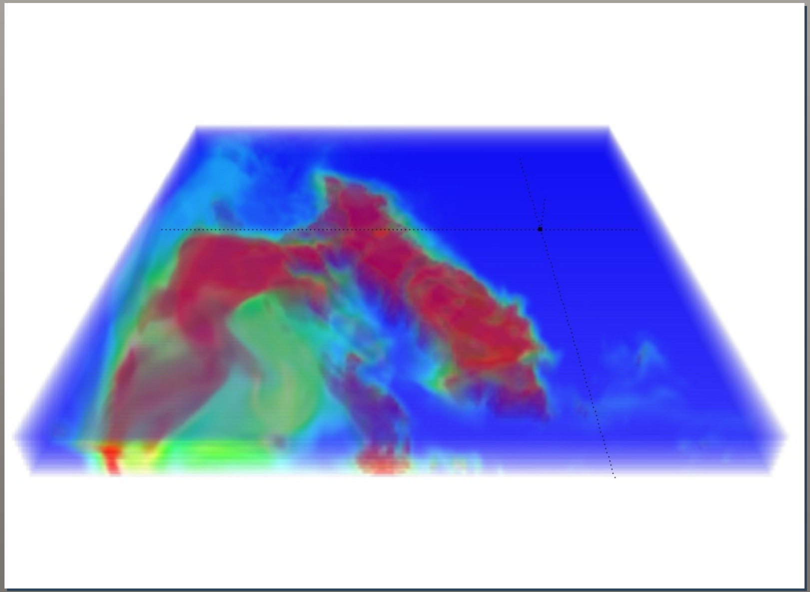

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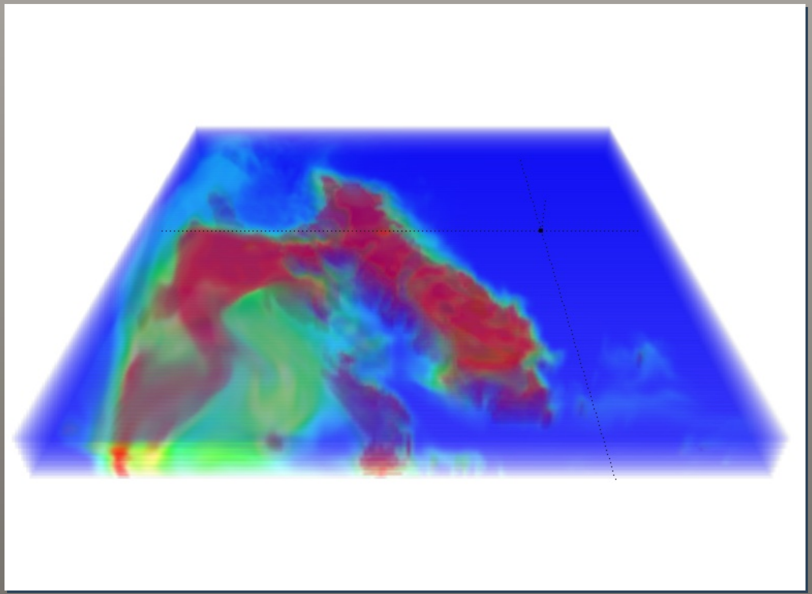

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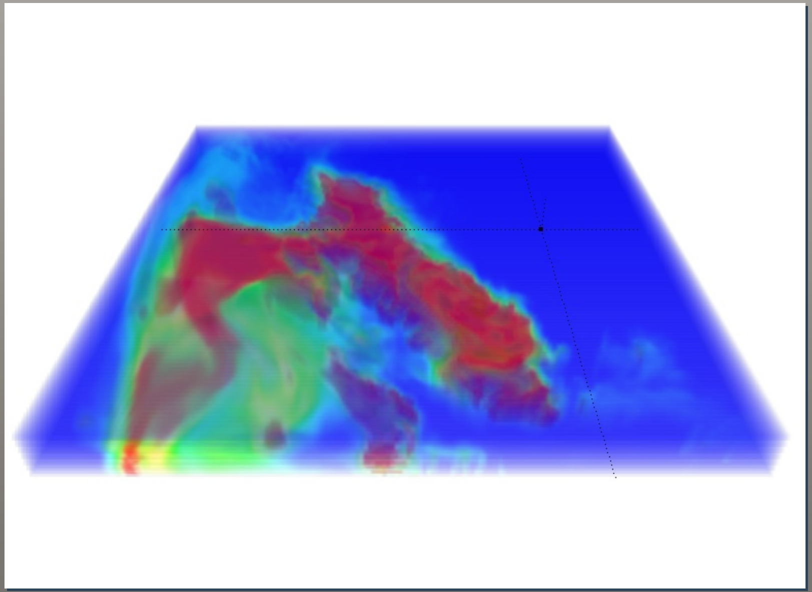

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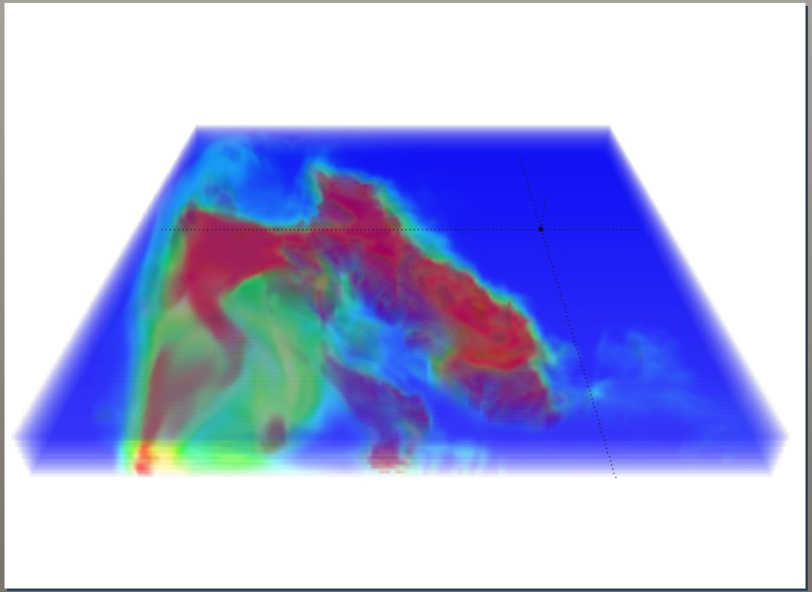

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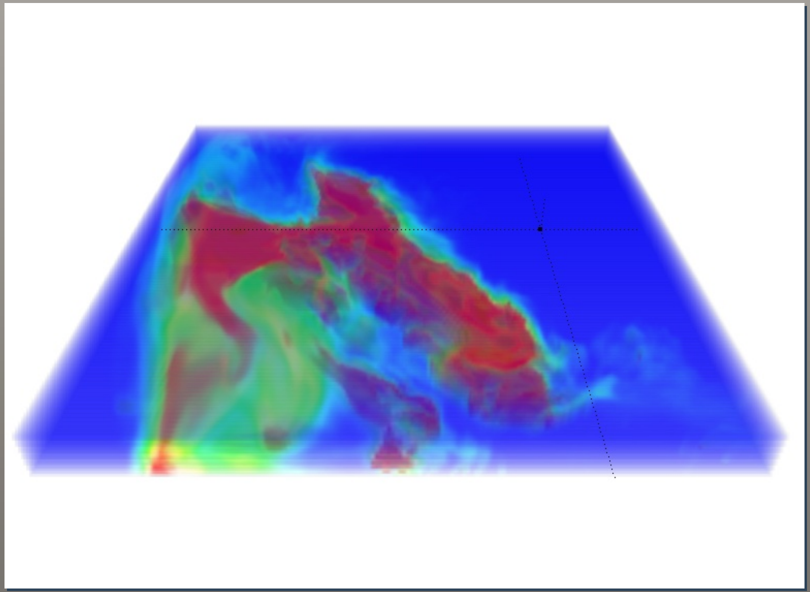

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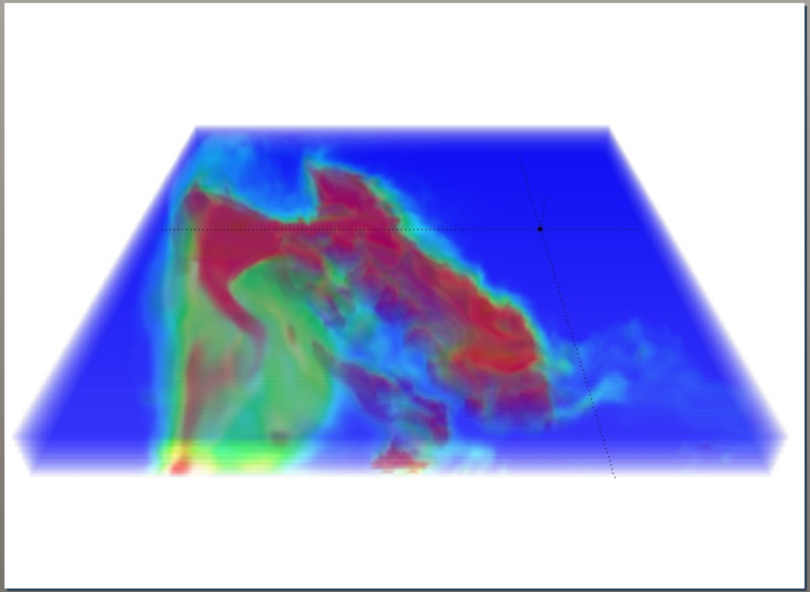

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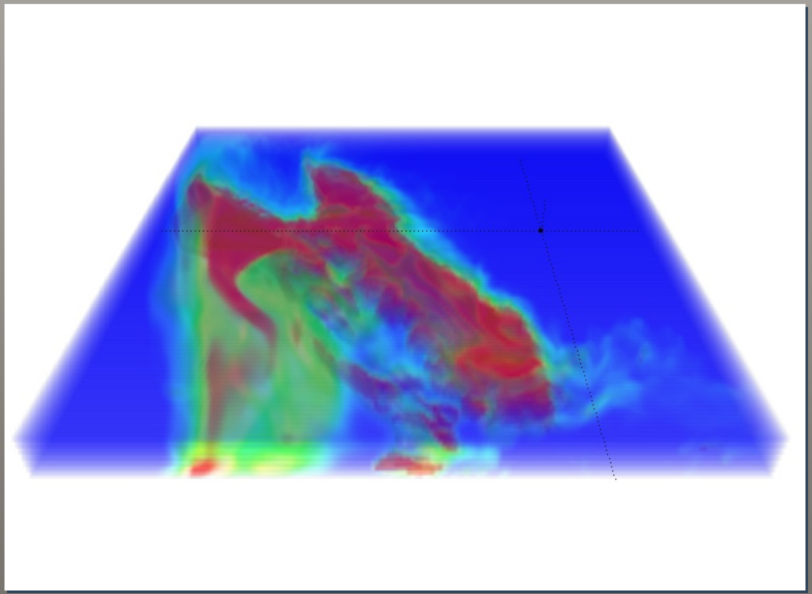

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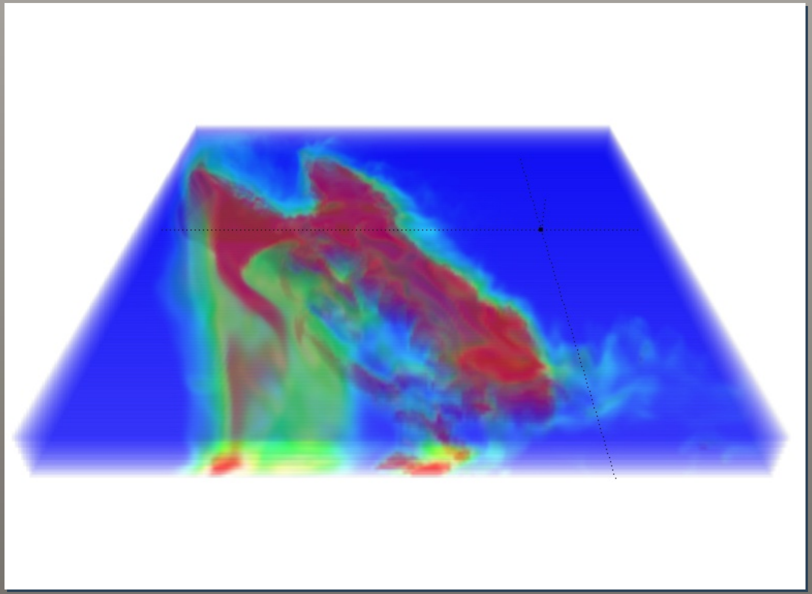

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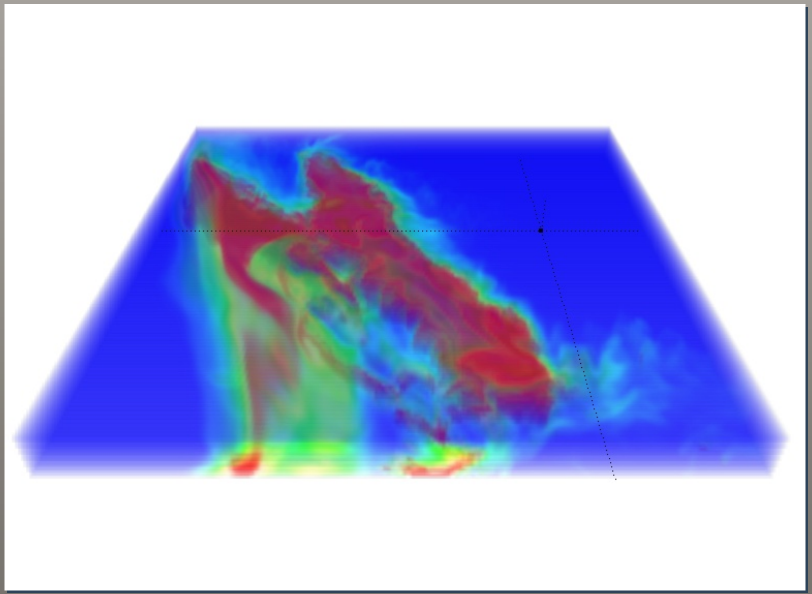

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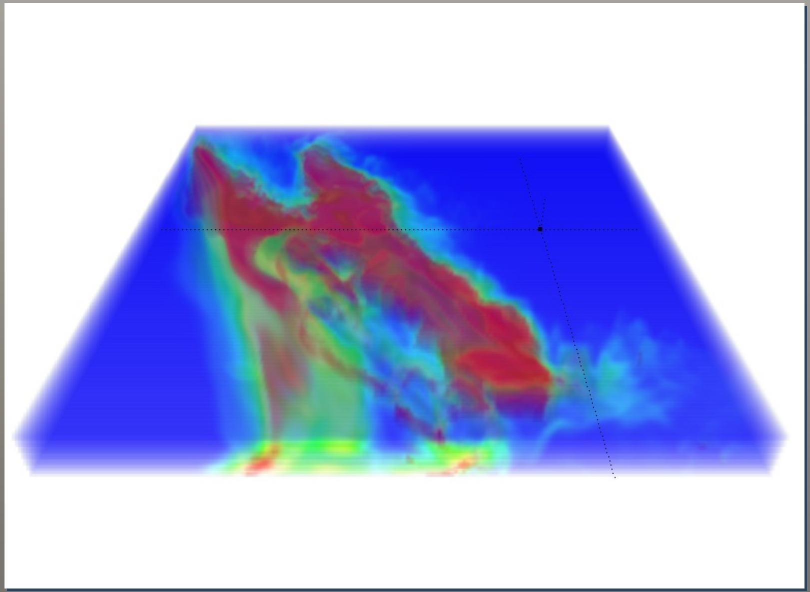

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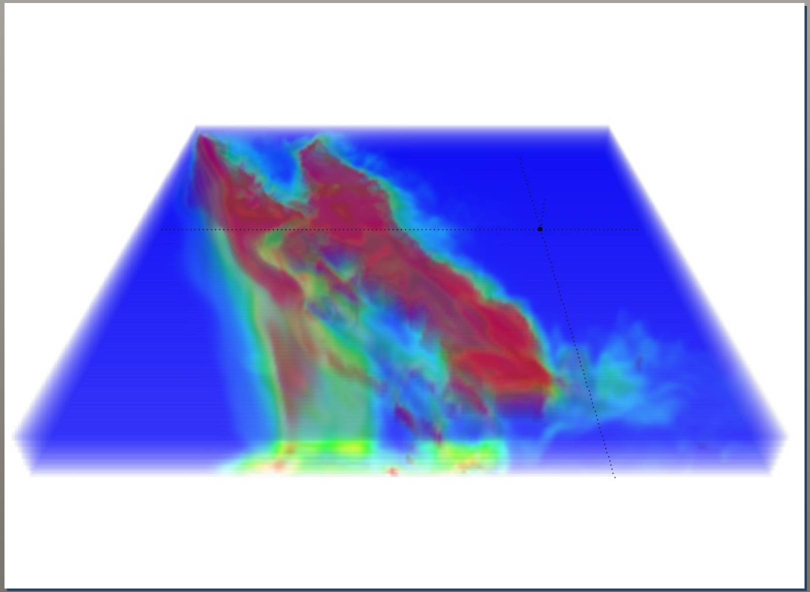

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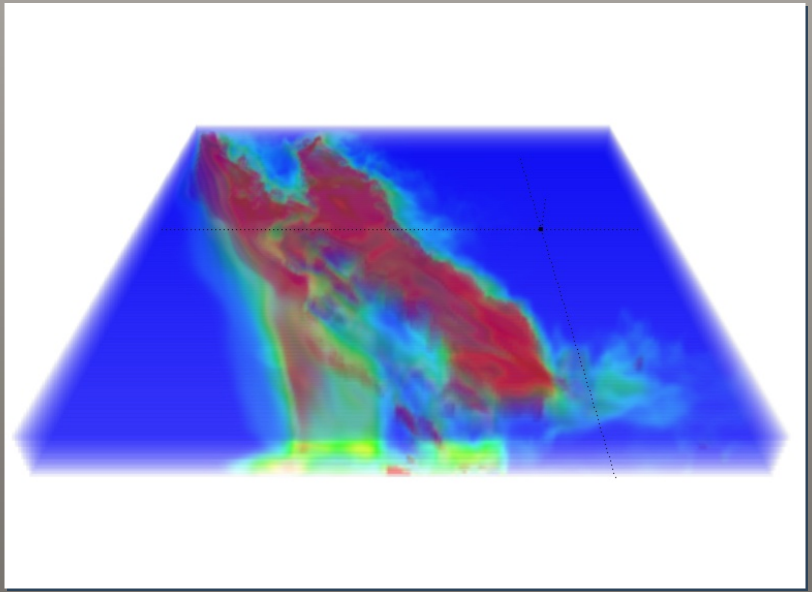

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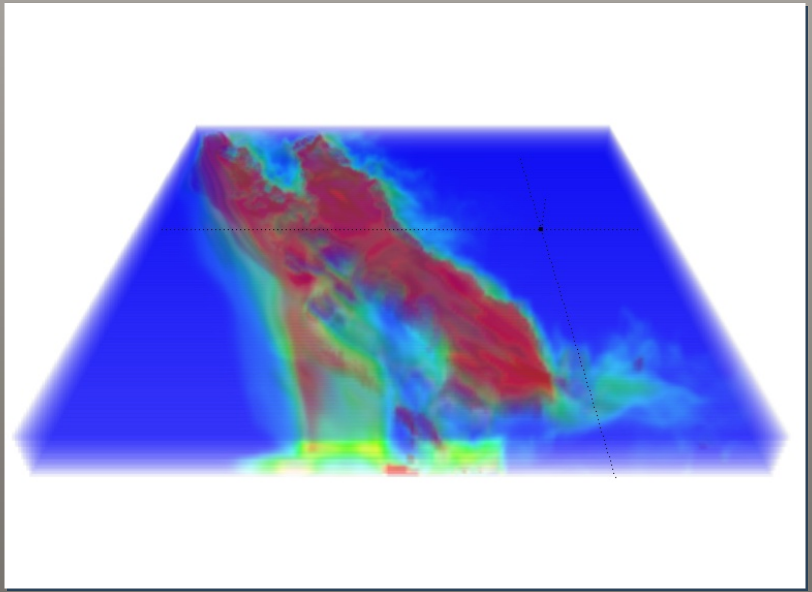

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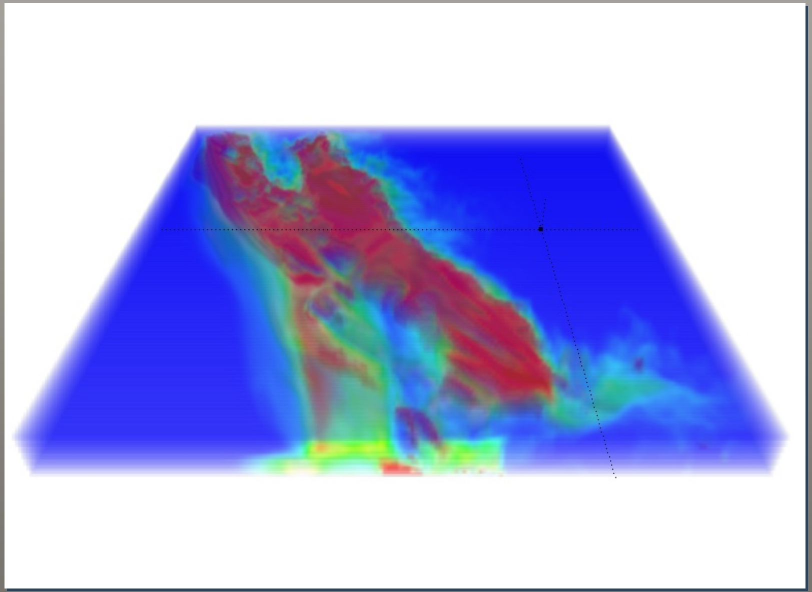

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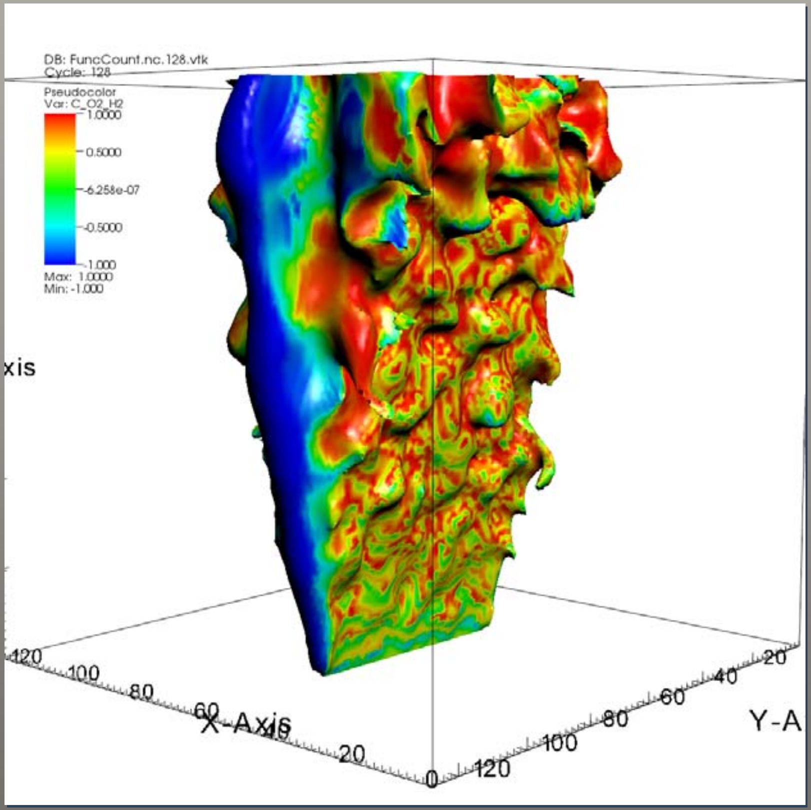
Variable Interactions in Multi-Dimensional Data

- Complexity, Spatial
  - Uses queries to extract data from a large-scale data set
  - Mapping correlations between variables on isotherms give an indication of variable interaction



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QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

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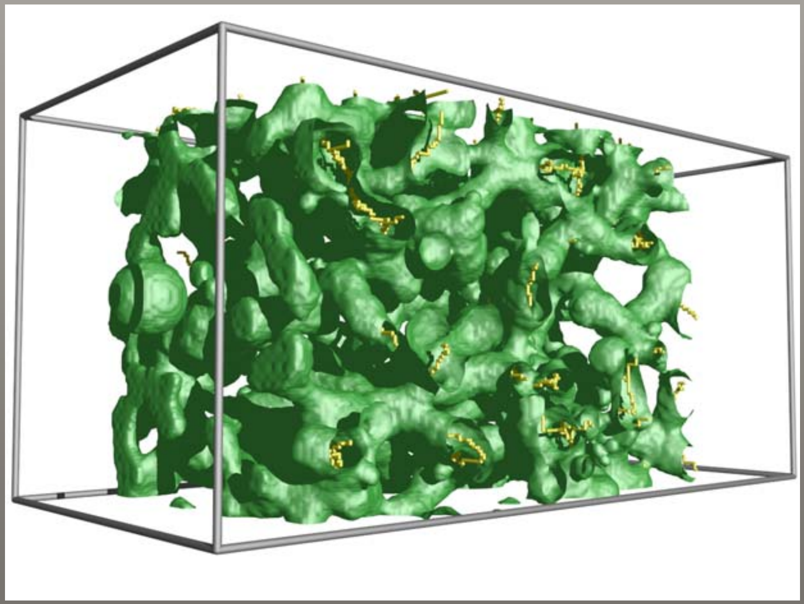
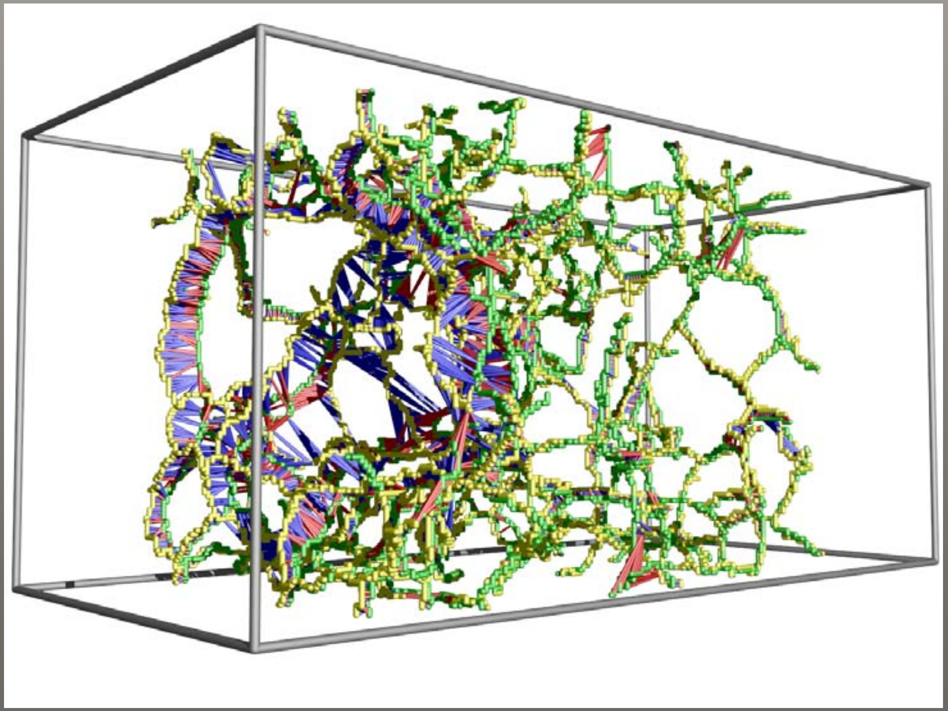
Topology

- Spatial, Complexity





A. Gyulassai (UC Davis)
Valerio Pascucci (LLNL)
Mark Duchaineau (LLNL)

…don’t have time to talk about…

- Expanding derived data set generators to include statistical operators
- Uncertainty Visualization
- Embedded Boundaries
- Multi-dimensional Visualization Techniques
- Visual comparison methods
- Real-time ray tracer
- Many more…

Conclusions

- Remember!
  - Extreme Scale implies expansion along several axes
    - Increase in spatial resolution
    - Increase in complexity
    - Increase in temporal resolution
    - Increase in ensemble testing
  - Each of these challenges requires different solutions and technologies.

We need your help!!!!

- Our work derives from scientific problems.
- Visualization now implies “exploration”
- Integration of visualization and analytics into modern petascale problems will create the modern analysis techniques of the future.

Thank You

Ken Joy

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