Data Centric Transfer Functions for High Dynamic Range Volume Data

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Motivation

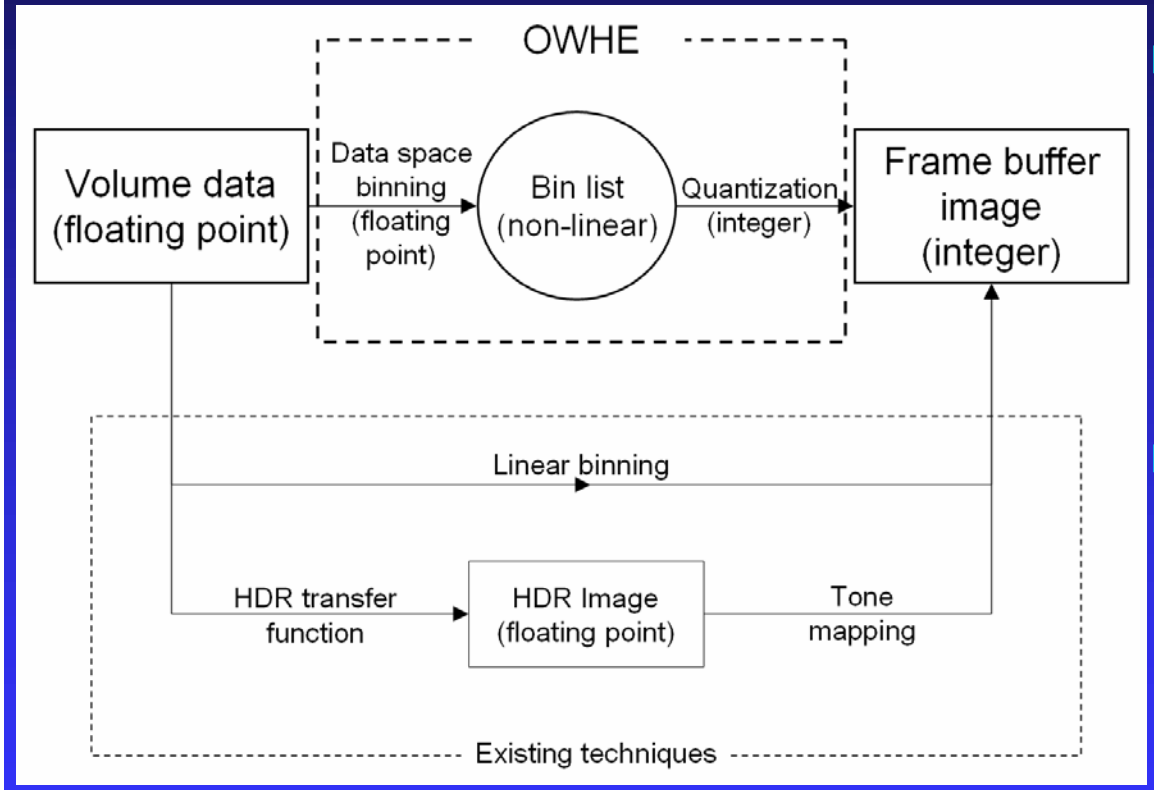
- For HDR floating point data sets, transfer function design is hard, time consuming.
- Widget based transfer function editors can be hard to understand.
- Non-linear data range display can be unintuitive.
- We use an extension of histogram equalization, along with opacity guidance provided by the user.
- Our new algorithms allow the user to minimize the effort of tuning the transfer functions.

Overview

- Concept
- Implementation
- User Interface
- Results
- Conclusions

Demo

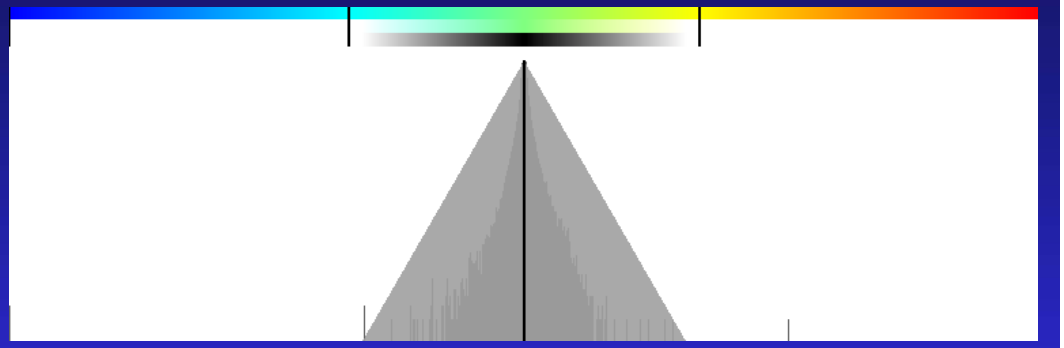
Concept of OWHE



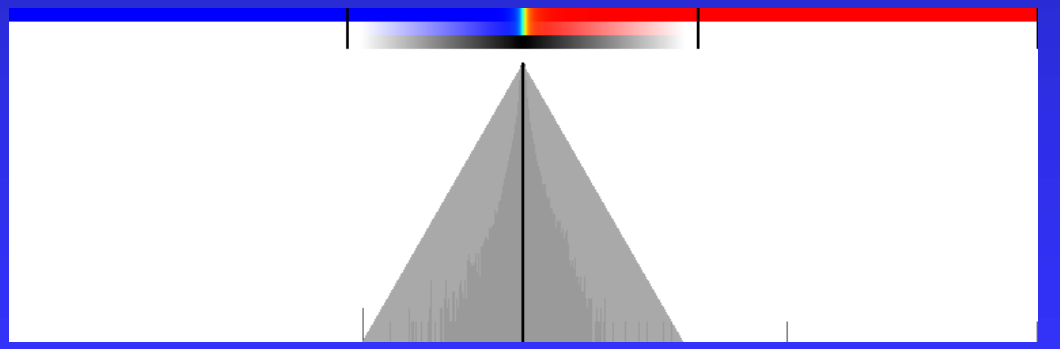
- Flowchart showing the OWHE algorithm with the existing techniques of linear binning and HDR with tone mapping.
- Our approach is shown in the box labeled OWHE, the existing techniques are shown in the dotted box below.

Linear vs. OWHE

- Data values located along horizontal axis.
- Bars at the top of each image show, from top to bottom:
  - color only
  - color and opacity
    opacity only
- Shown below: histogram, overlaid by opacity function.



Linear Binning

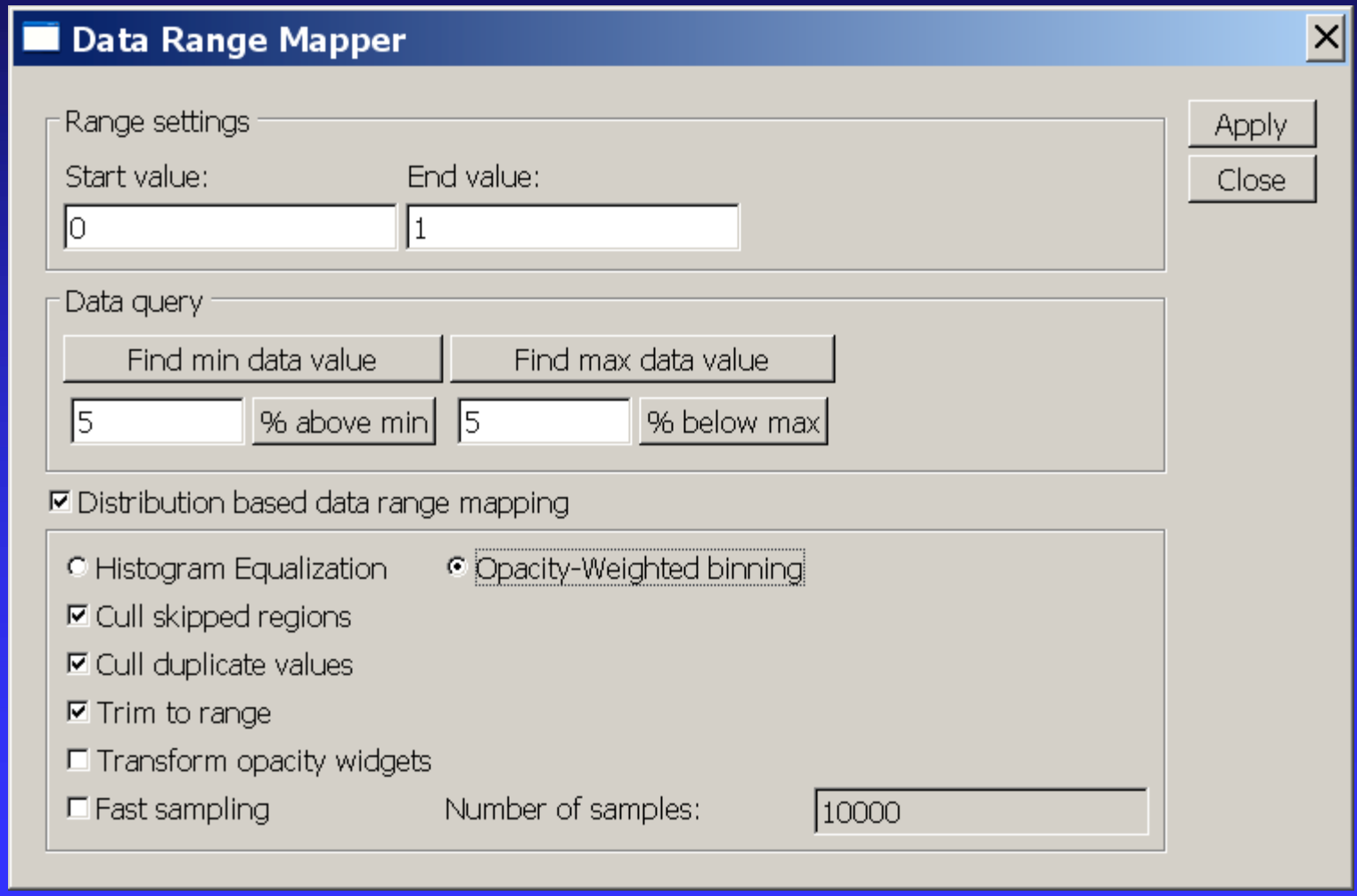


OWHE

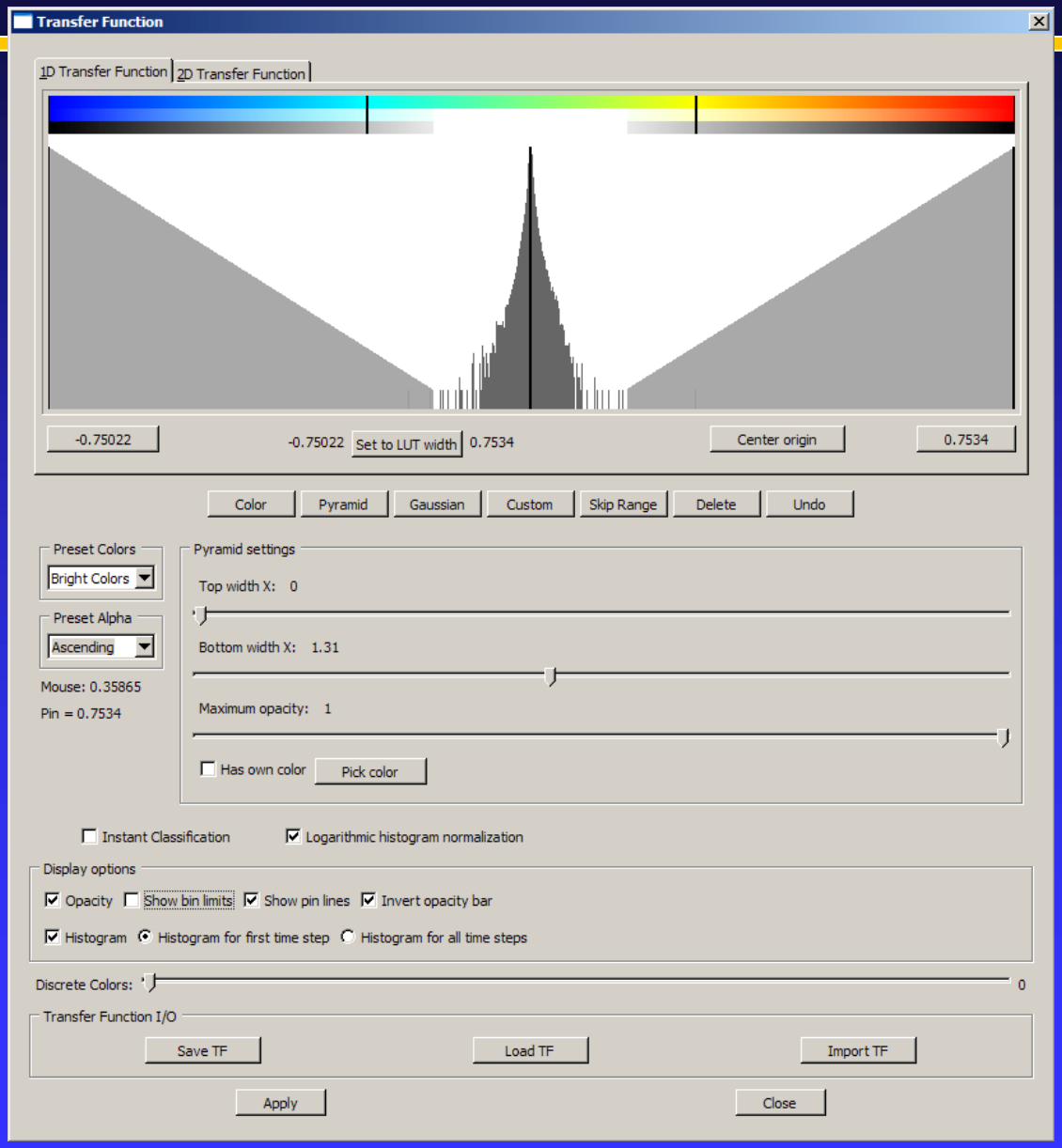
Implementation Details

- *Cull Skip regions:* Excludes regions which map zero opacity to a data range (Skip widgets) from the binning process.
- *Cull Duplicate Values:* Duplicate values in data sampling and ordering stage will be removed, so as to evenly distribute different values only. This makes a difference if the data set contains disproportionately large amounts of certain values, which are not of particular interest but should not entirely be excluded from the binning process.
- *Trim to Range:* Data range algorithm operates on can be constrained to be within a minimum and maximum value.
- *Fast Sampling:* Uses only the specified number of samples for the binning process, which speeds up the algorithm, but also makes it less accurate.

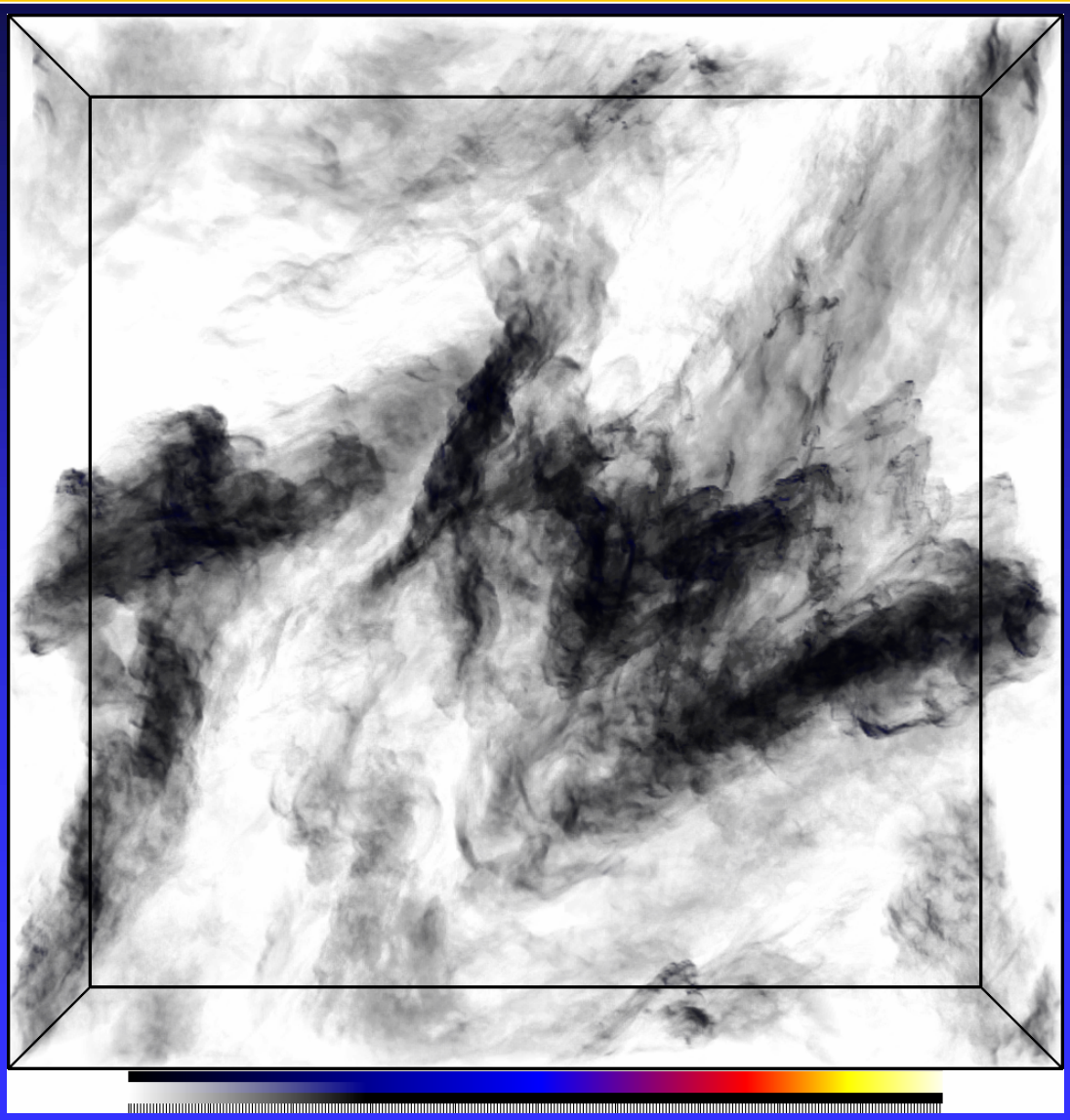
Data Range Mapper



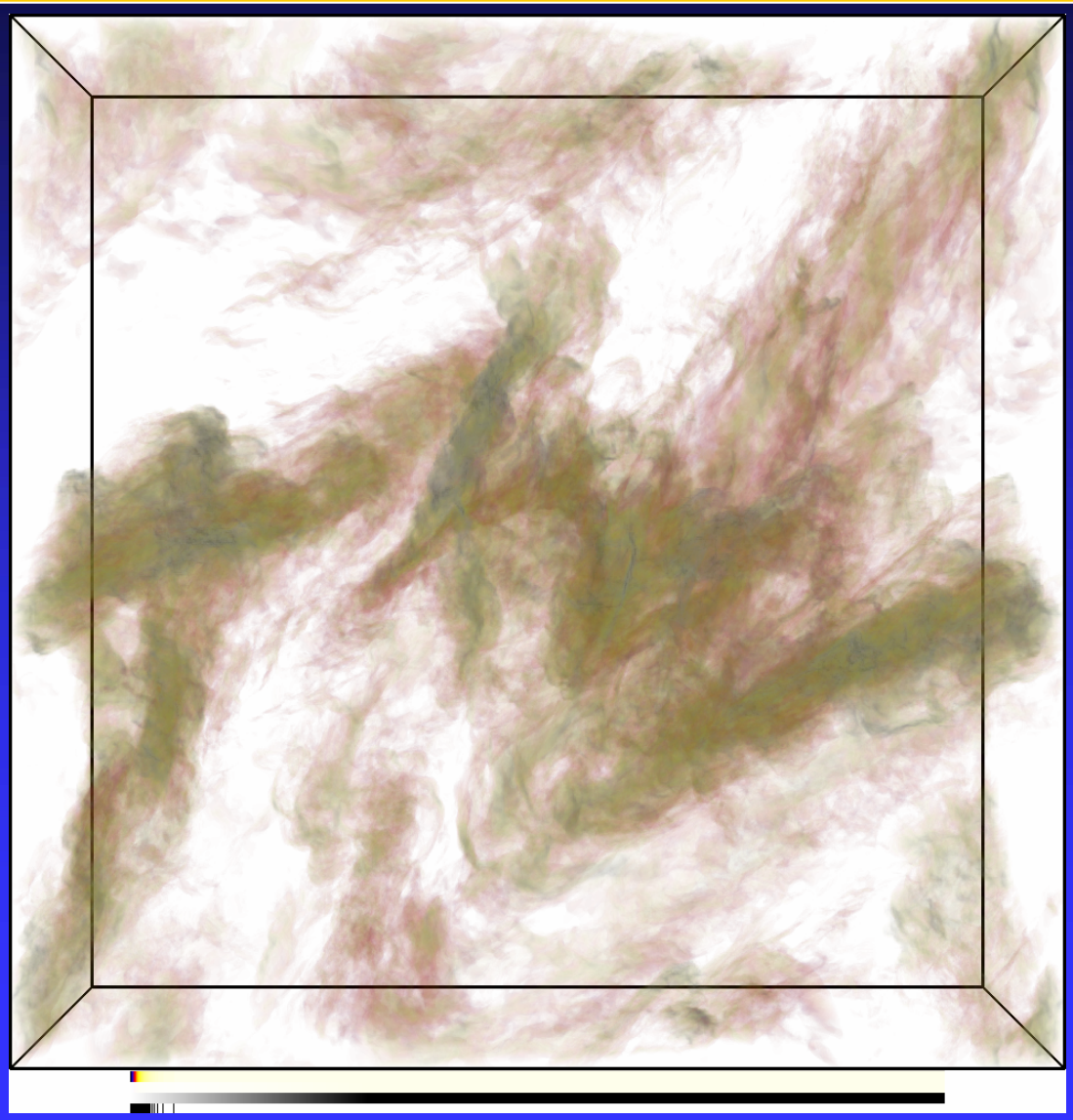
Widget-Based Transfer Function Editor



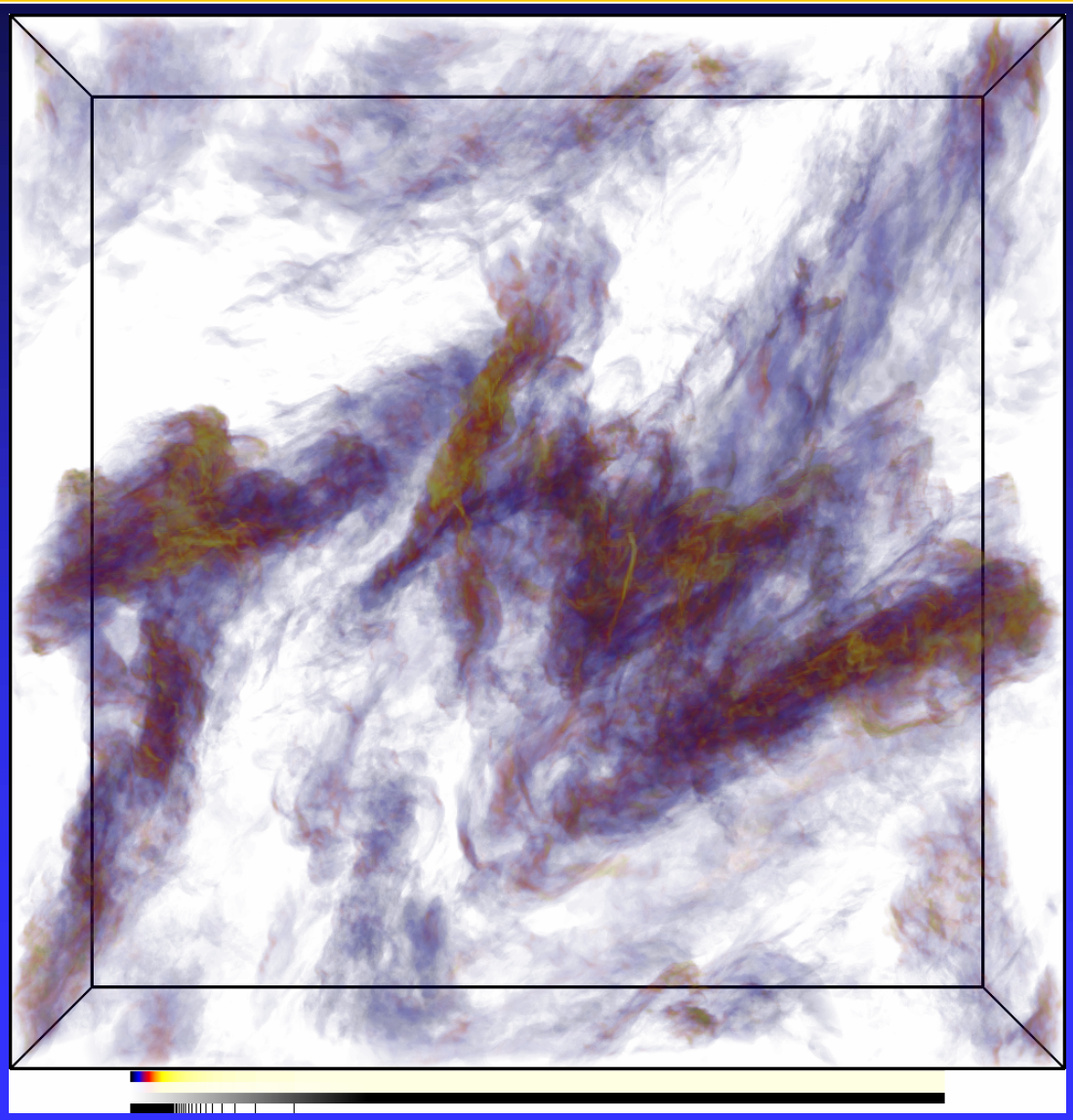
Enzo - Linear



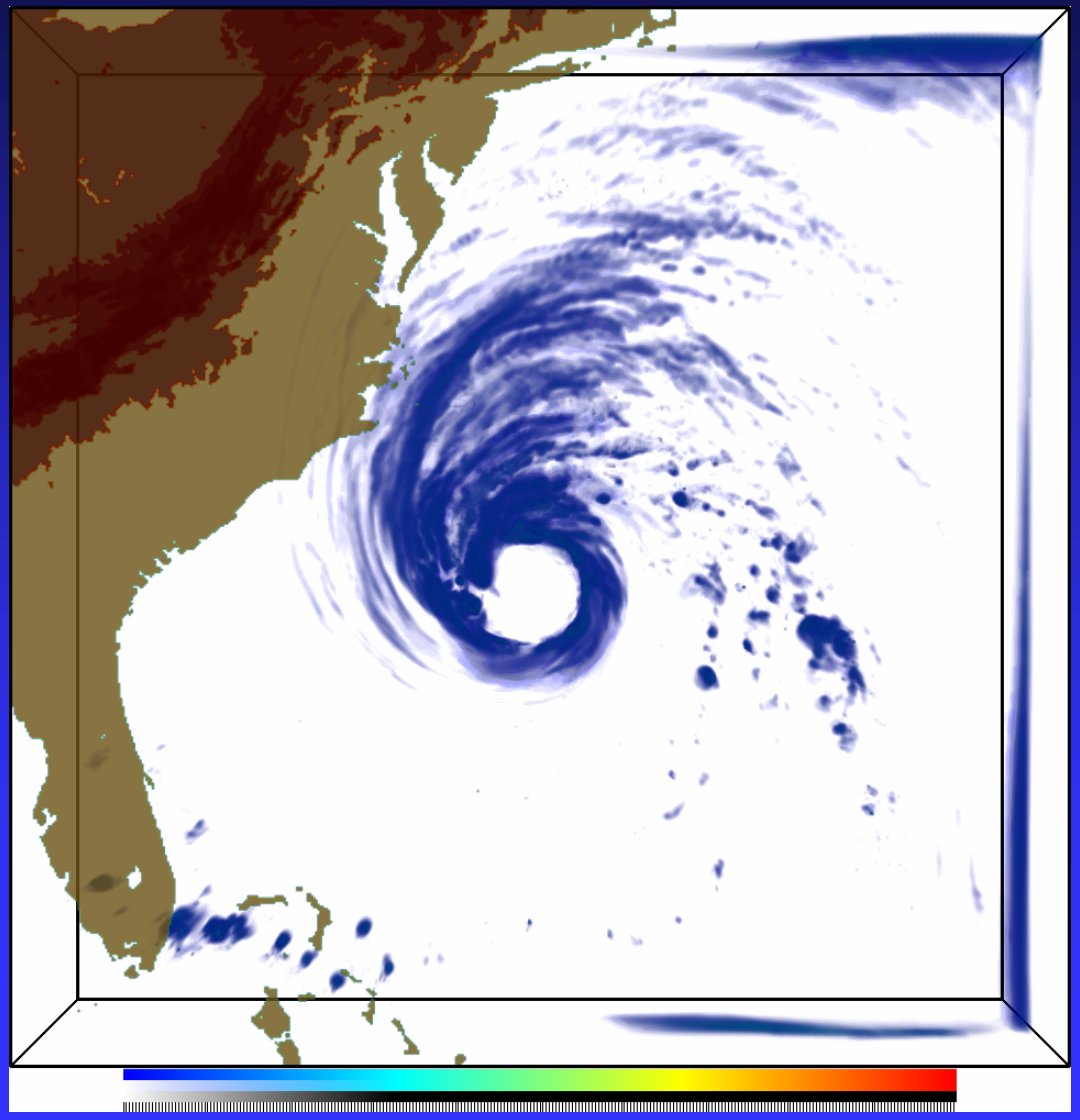
Enzo – Histogram Equalization



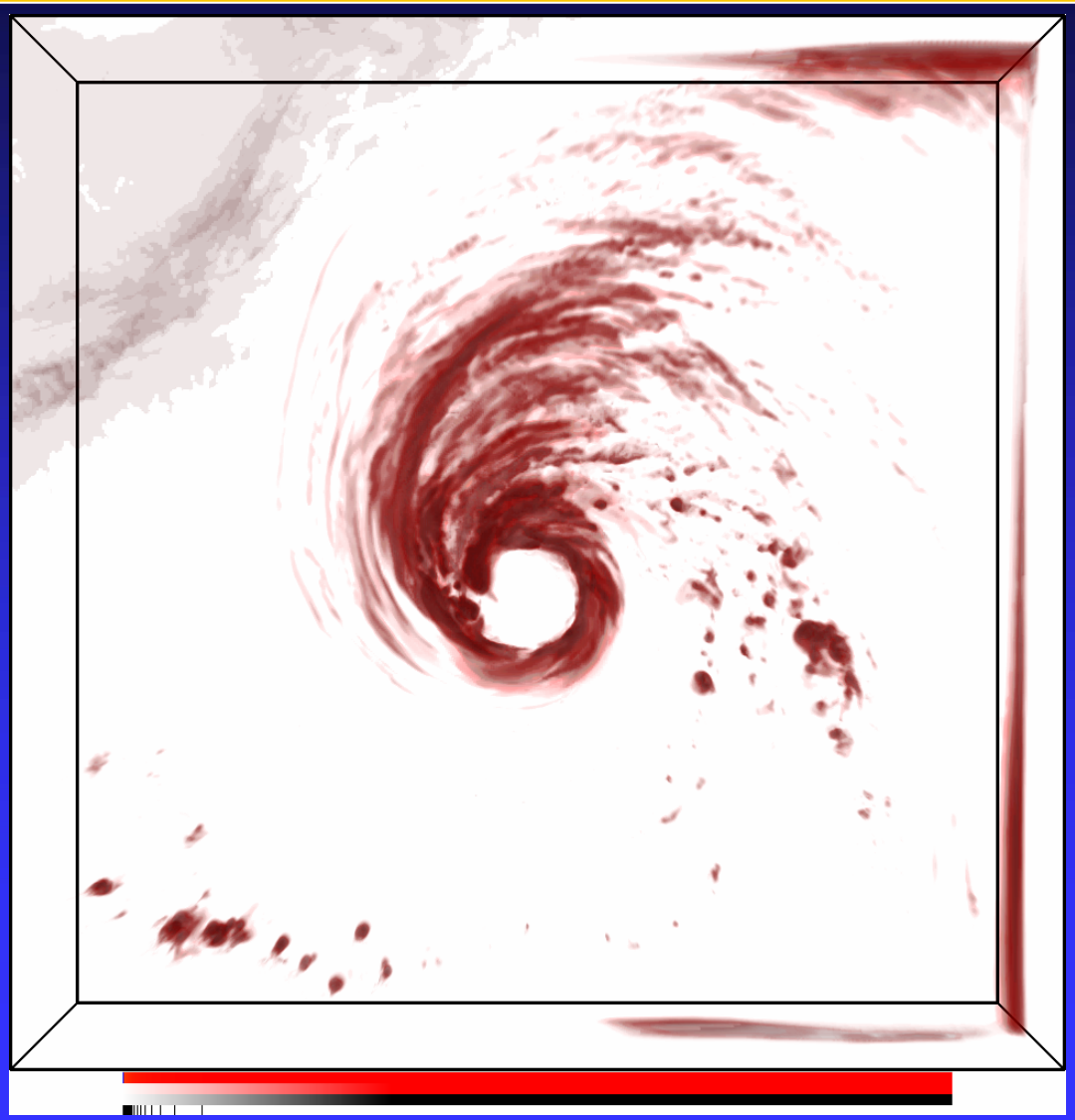
Enzo - OWHE



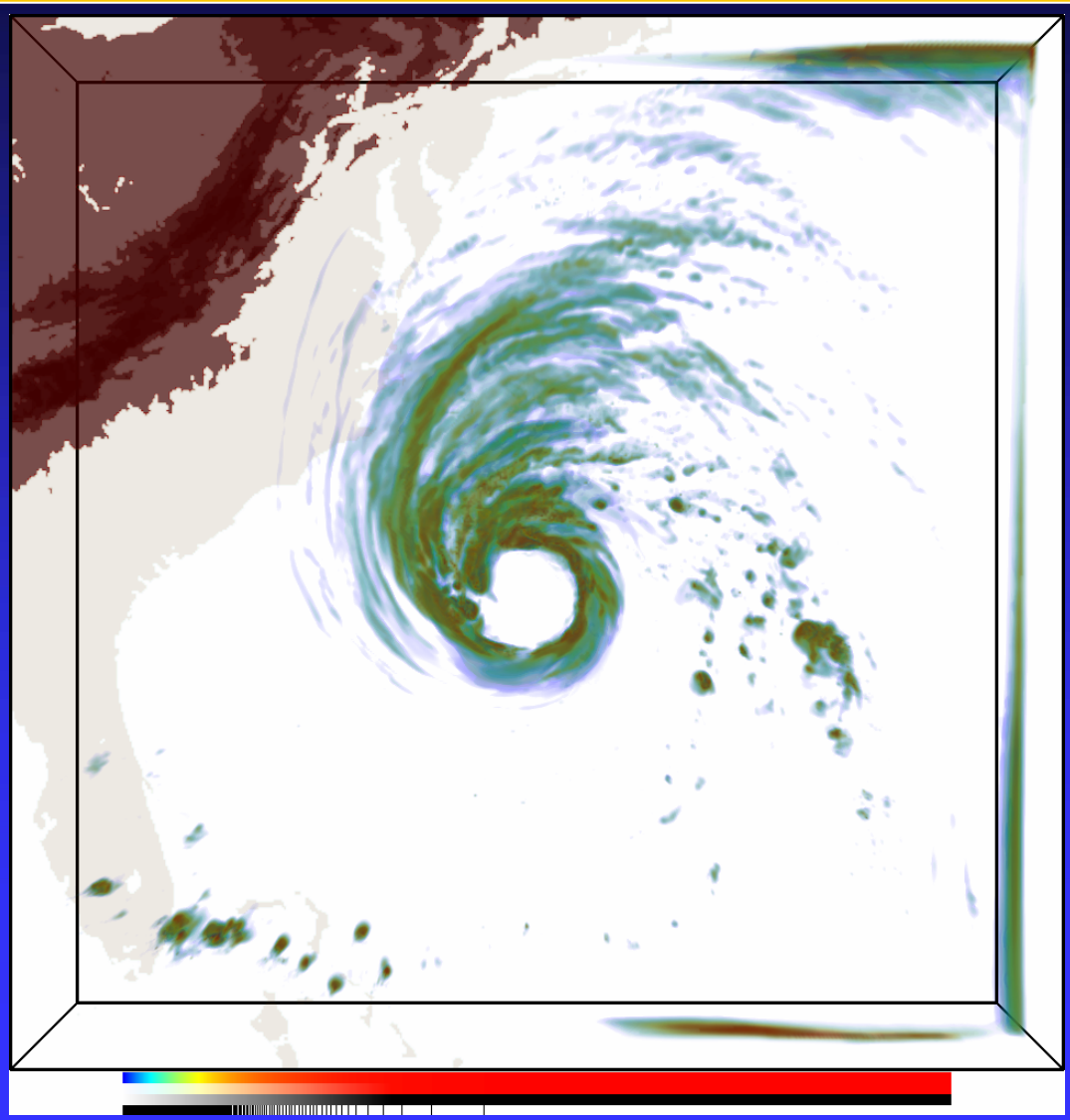
Hurricane Isabel - Linear



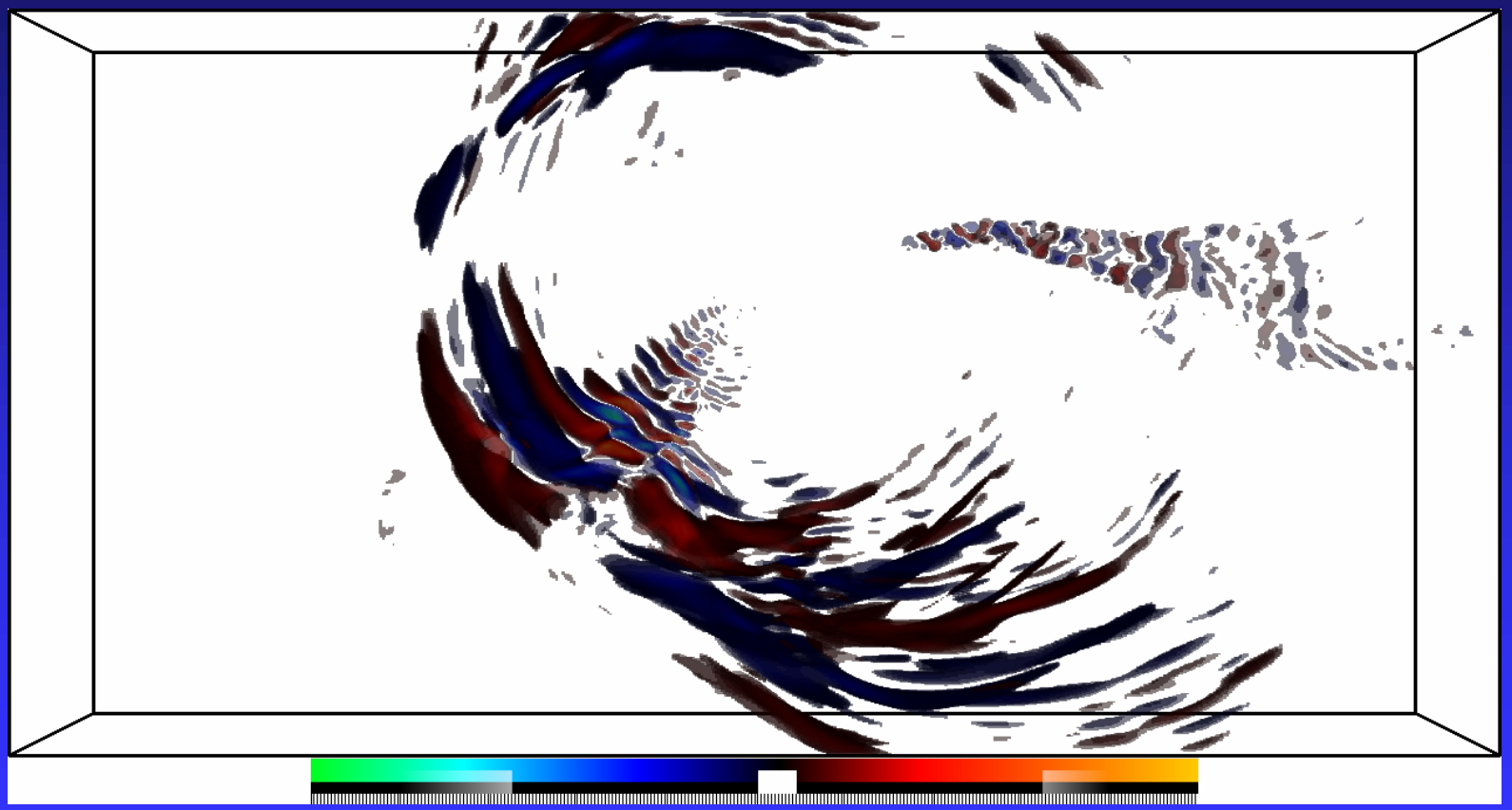
Hurricane Isabel – Histogram Equalization



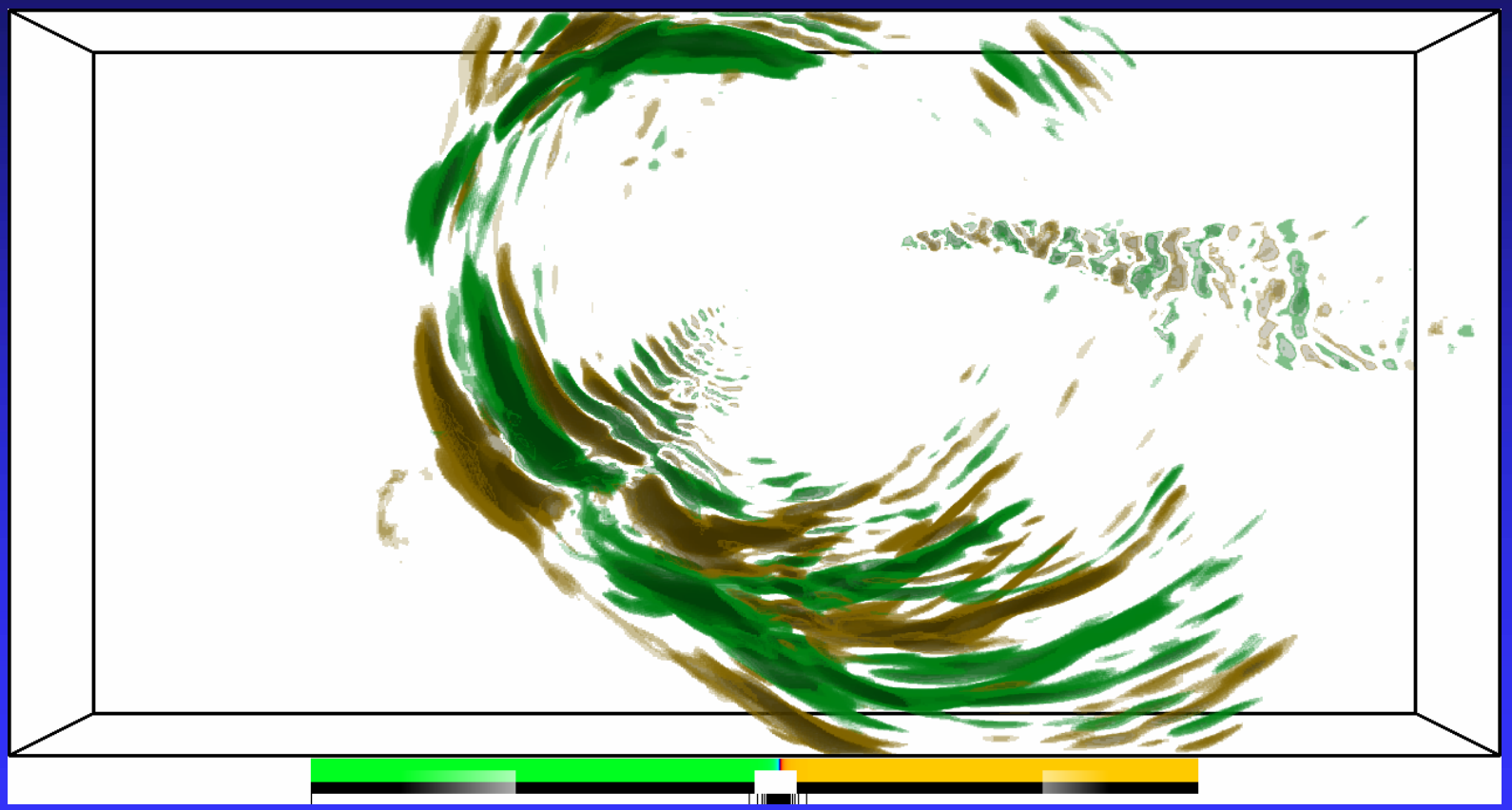
Hurricane Isabel - OWHE



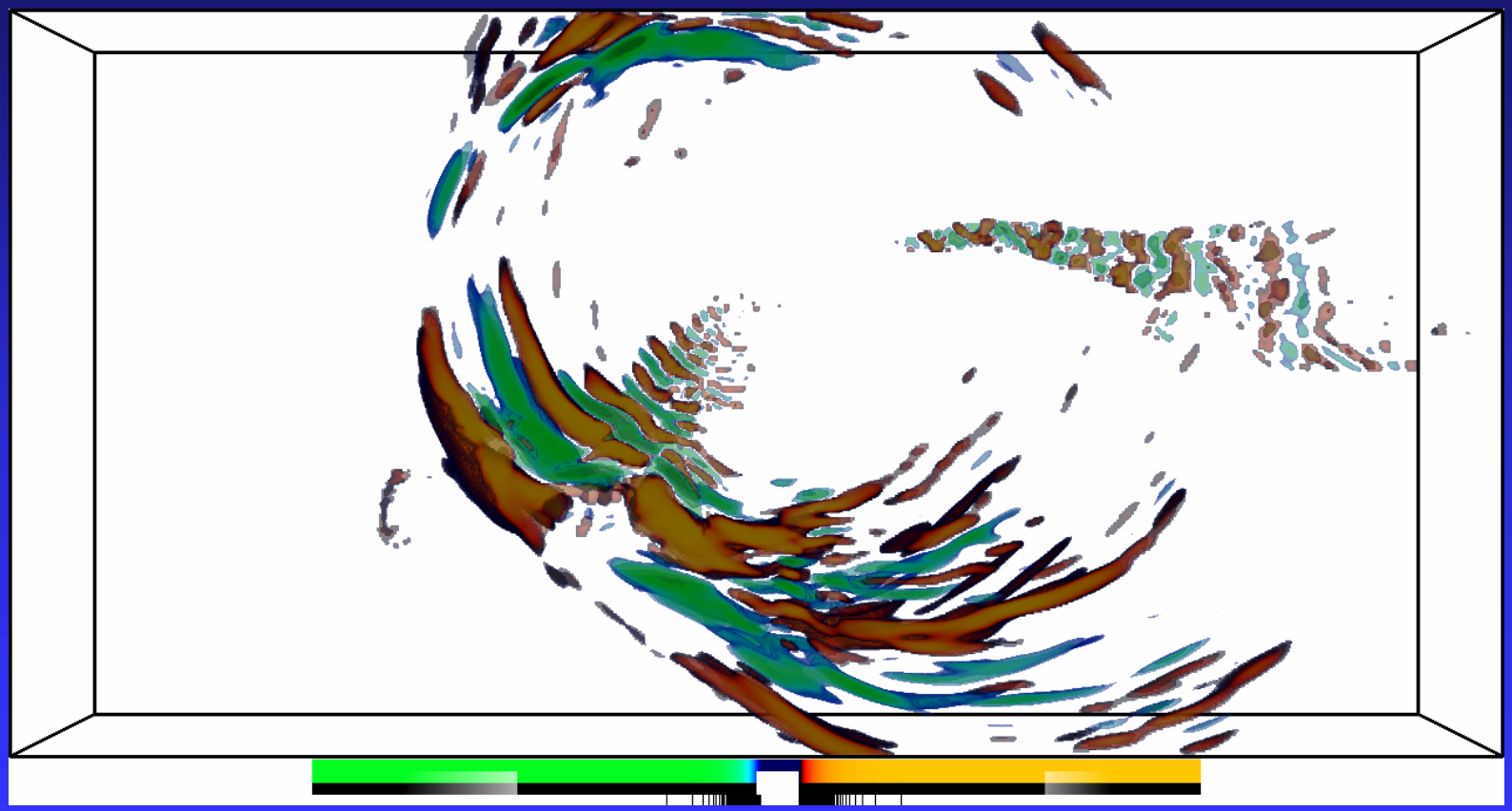
Terashake - Linear



Terashake – Histogram Equalization



Terashake - OWHE



Conclusions

- The main contributions of this paper are:
  - 1. OpacityWeighted Histogram Equalization (OWHE) as the basis for transfer function design.
  - 2. Efficient utilization of the available color space, thus yielding a more detailed visualization of structures in data sets.
  - 3. Real-time interaction with a simple and intuitive user interface to access the algorithm’s parameters.