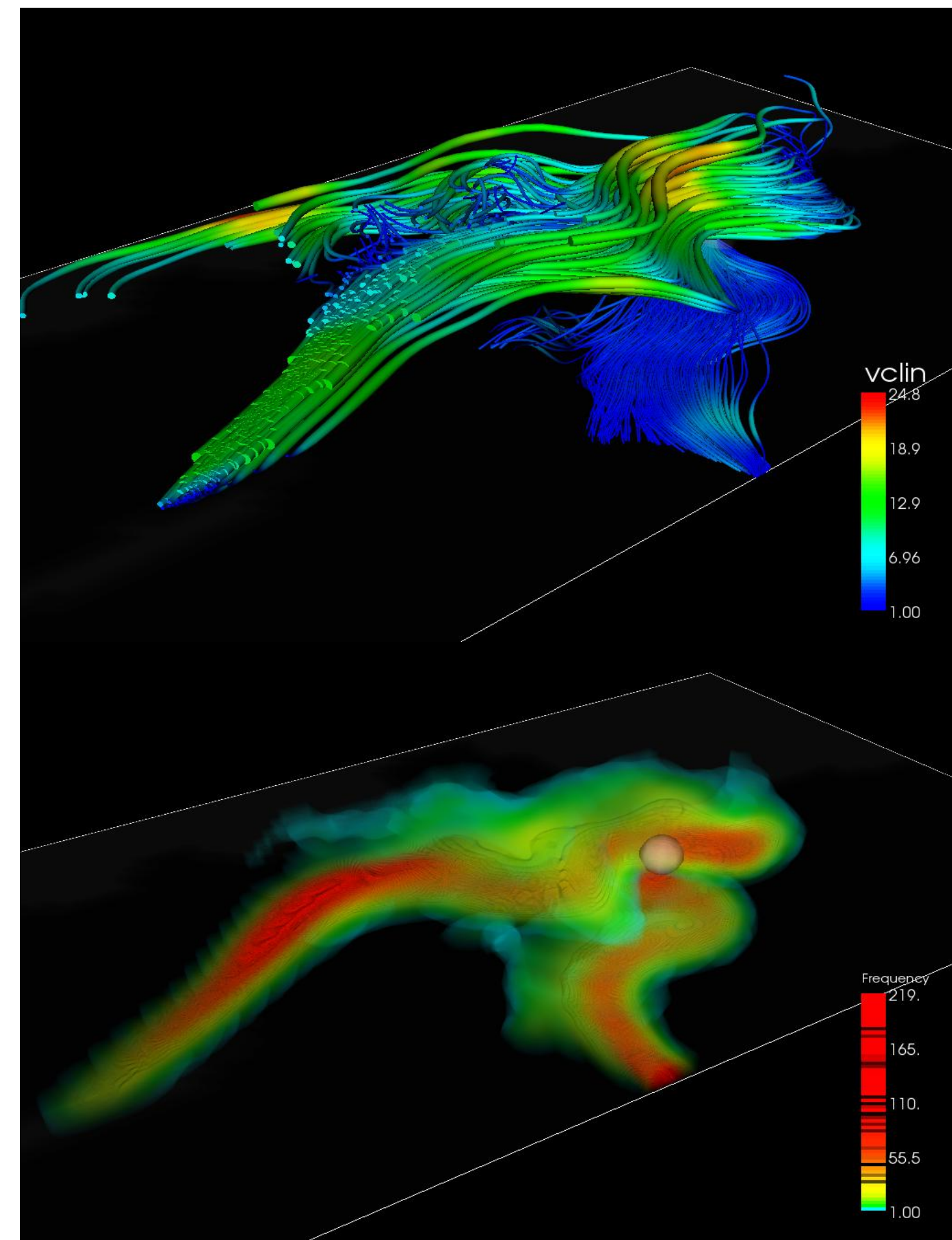


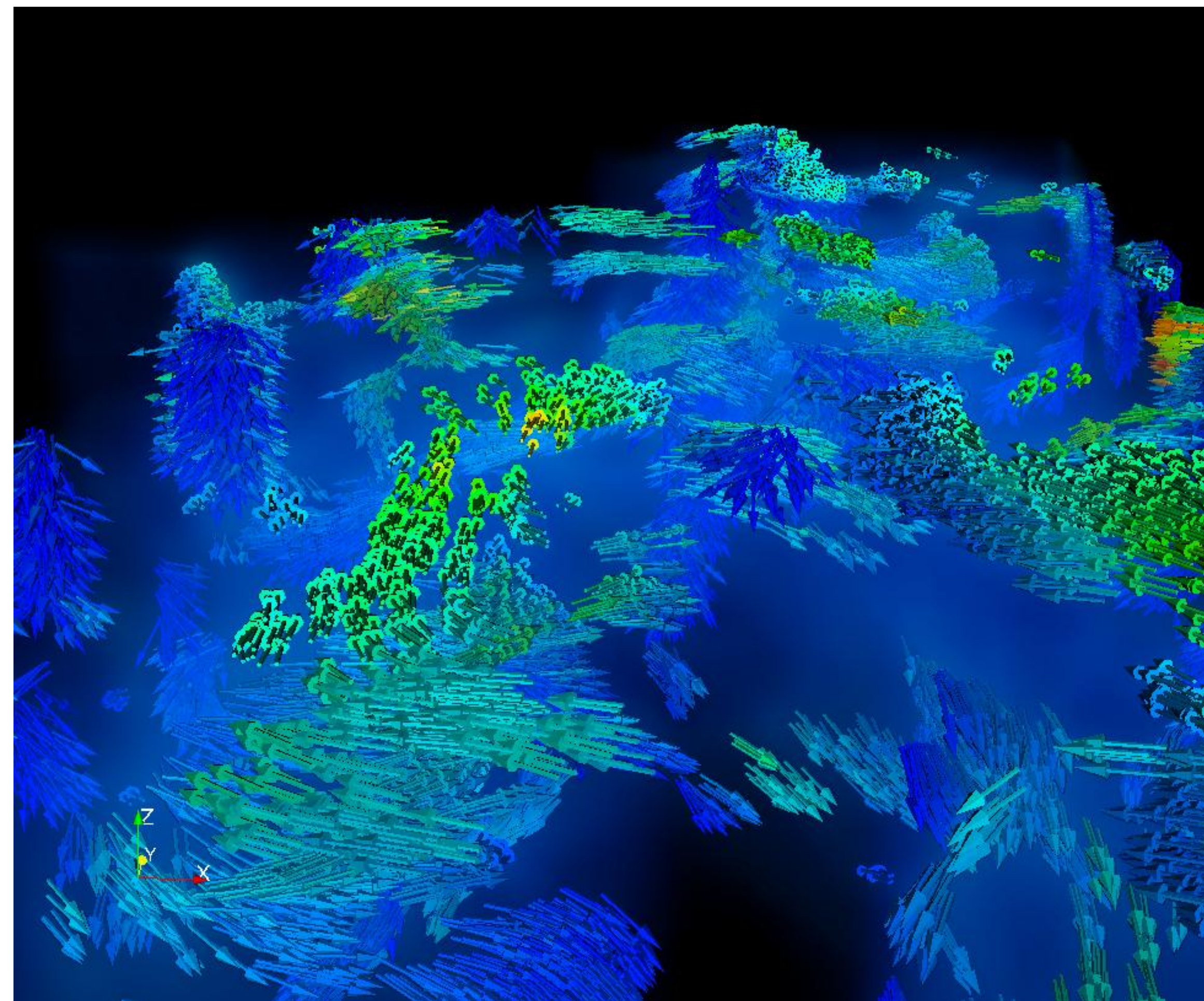
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Volume rendering with histogram equalization on the color frequency. The white sphere of the second figure at the bottom is the seed point.



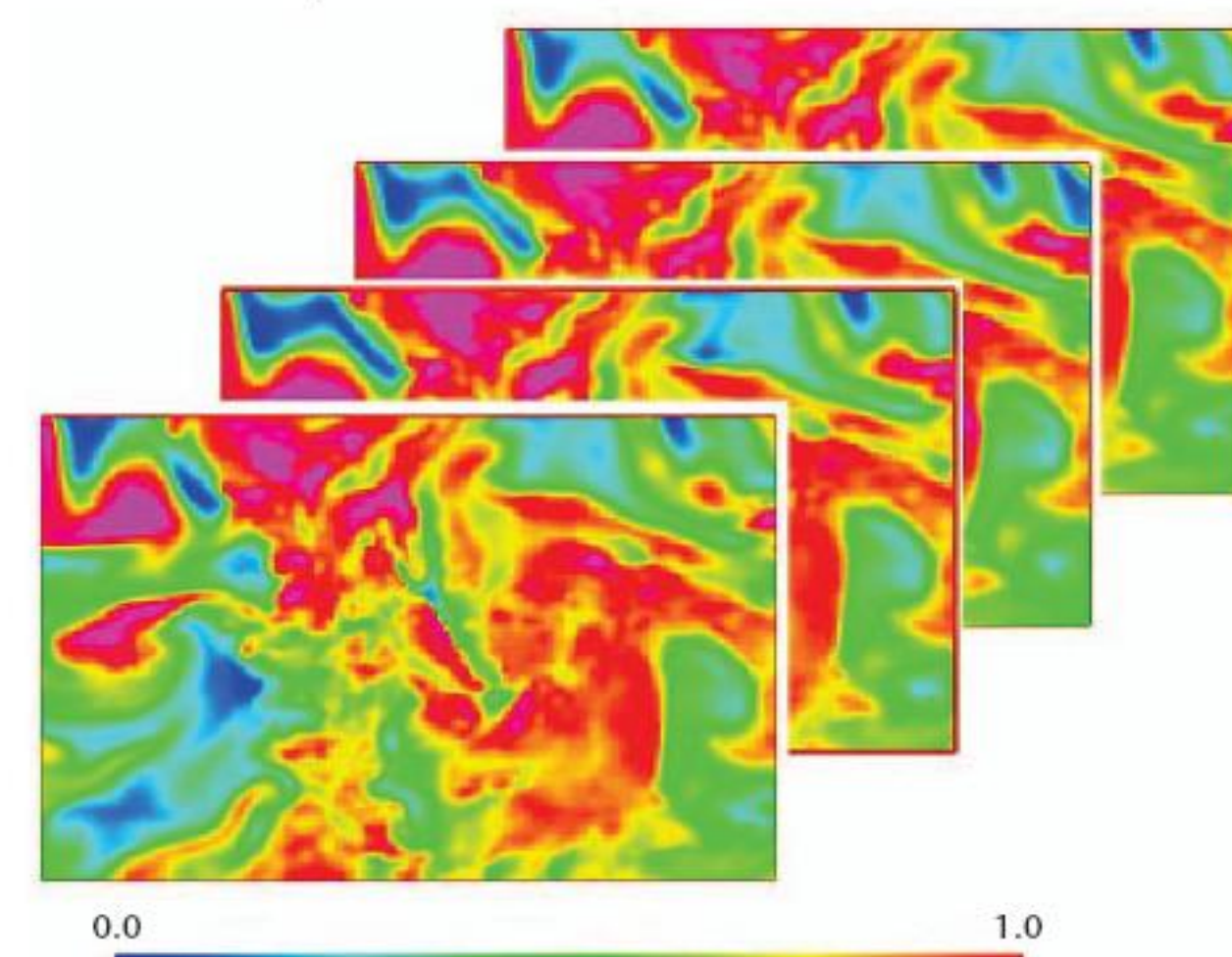
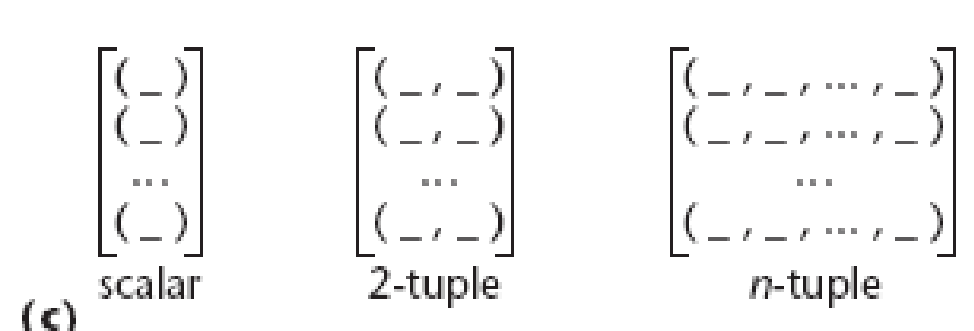
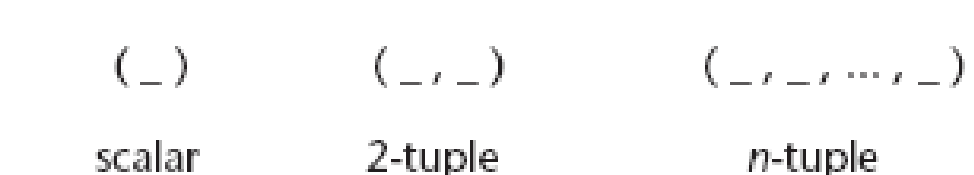
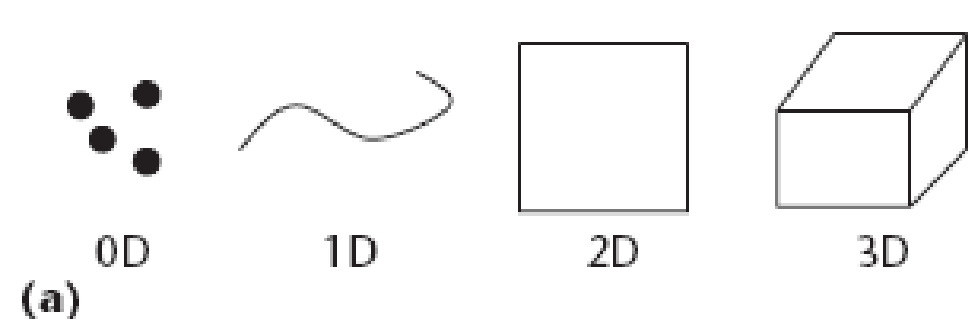
Red regions correspond to places with high traffic of highly correlated streamlines.



Volume rendering with vectors at the red regions (threshold >= 250).

Characteristics of Multivalued Data

- Definition:** Multivalued data are where you have multiple values about the same variable in a repeated measurements.



1 Illustration and comparison between (a) multidimensional, (b) multivariate (at each location), and (c) multivalued (at each location) data.

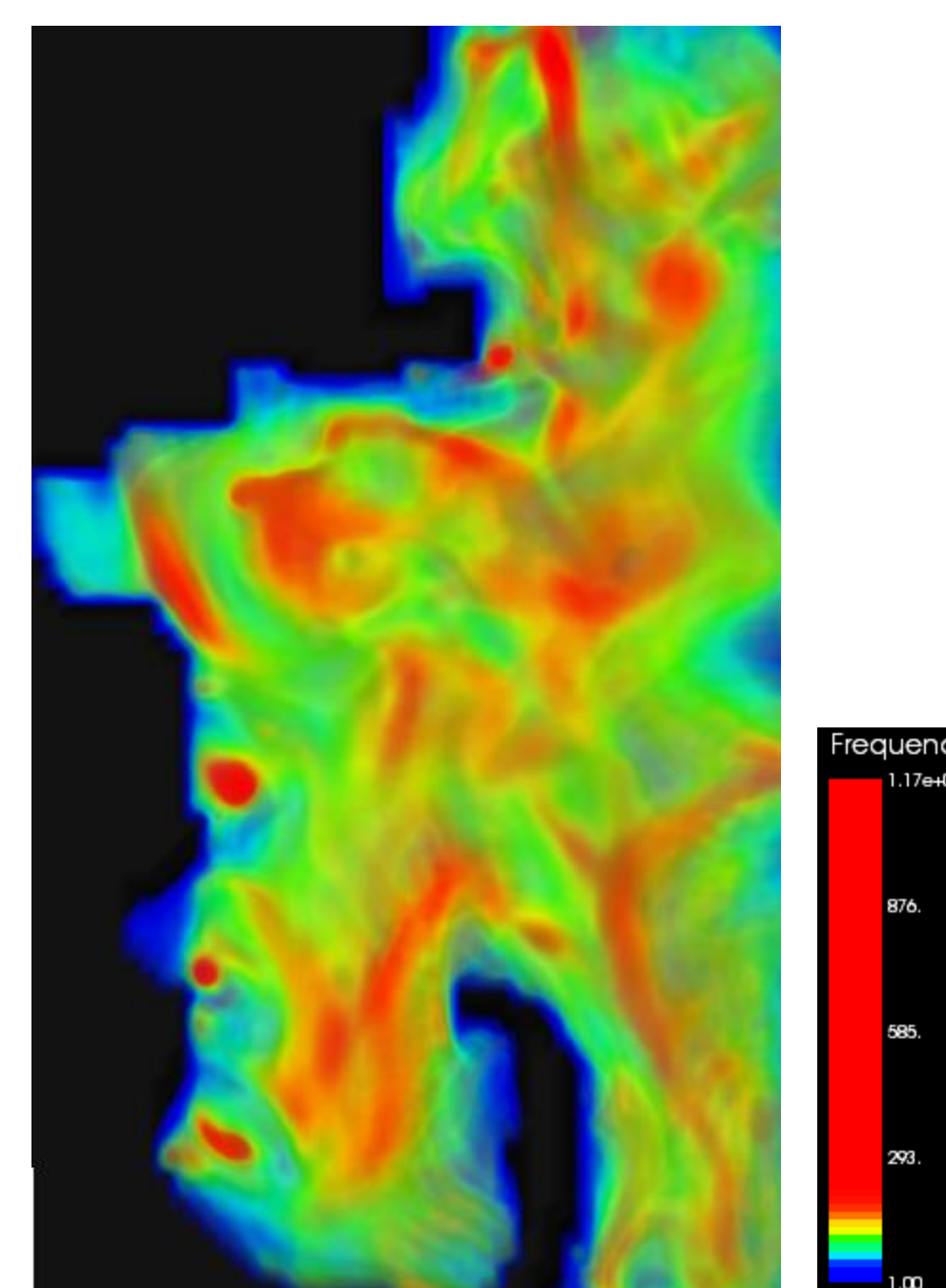
2 Individual realizations of a 2D time-varying multivariate weather forecast data set covering the continental US. Each time frame has multiple forecasts for each variable. Here, we show four different realizations or forecast scenarios of the humidity field for the first time frame. The values fall within [0, 1] and are colored using the standard rainbow color map.

- Challenge:** Lack of current comprehensive visualization tools for the probabilistic or uncertain nature of the multivalued data.
- Research:** Investigate probabilistic streamlines using different ways of combining vector distributions.

Massachusetts Bay Data

- 4D field that contains a time evolution of baroclinic velocity; its total dimensions are 600 instances of 53x90x16 volumes.

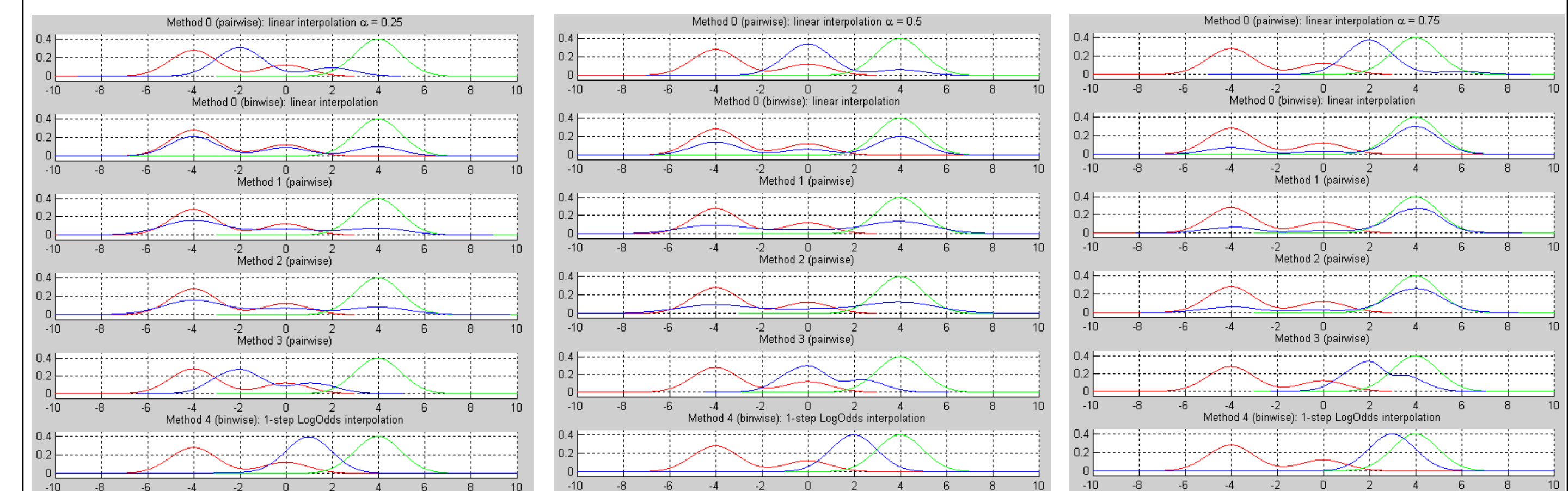
Visualizations of Streamline Frequency Volume



- We trace streamlines from seed points and count how many streamlines pass through a cell.
- Seeding the whole volume and using at least 25 instances (out of the 600 instances) of the flow fields, we created a streamline frequency volume that counts how many streamlines passed through a cell.
- This volume represents the streamline traffic and also the likelihood that a streamline would pass through a cell. This is shown in the volume rendering above.

Interpolation Strategies

- The velocity at each location is a multivalued vector. There are multiple possible trajectories resulting in different streamline paths.
- Constructing new data distribution can be done by predicting values within the range of a discrete set of known data points needed after the completion of each integration step.
- Since many interpolation methods produce different results, we investigate six different ways of interpolating distributions. The figure below shows their behavior as we vary the interpolation coefficient α from 0 to 1.



Comparing behaviors of six different interpolation methods when a given bimodal distribution is interpolated to a unimodal distribution, and α is 0.25, 0.5, and 0.75 respectively.

$$\text{Gaussian mixture} = \text{Gaussian PDF} \times (1 - \alpha) + \text{Gaussian PDF} \times \alpha \text{ when } 0 \leq \alpha \leq 1.$$

- The interpolated PDF C (blue) is generated by two PDFs of Gaussian mixture A (red) and B (green) from six different interpolation methods including linear, 1-step LogOdds, and other probabilistic interpolations.

Contributions

- Visualizing uncertainty of multivalued flow field data is a valuable new idea.
- The streamline-based technique of visualizing multivalued flow field data and its uncertainty has been presented.

Acknowledgements

- This work is supported by ISSDM.