

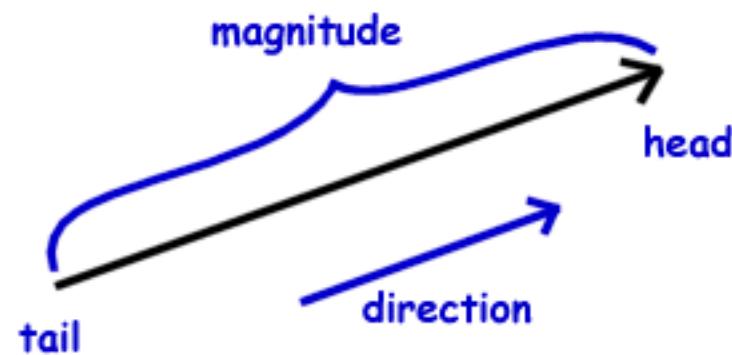


Module #13c: **Vector Field Visualization**



Vector Visualization

- Data set is given by a vector component and its magnitude
 - often results from study of fluid flow or by looking at derivatives (rate of change) of some quantity



- How can we visualize vector data?



Vector Visualization - Techniques

- Hedgehogs/glyphs
- Particle tracing
- stream-, streak-, time- & path-lines
- stream-ribbon, stream-surfaces, stream-polygons, stream-tube
- hyper-streamlines
- Line Integral Convolution



Flow Visualization

- Gaseous flow:
 - development of cars, aircraft, spacecraft
 - design of machines - turbines, combustion engines
- Liquid Flow:
 - naval applications - ship design
 - civil engineering - harbor design, coastal protection
- Chemistry - fluid flow in reactor tanks
- Medicine - blood vessels, SPECT, fMRI



Flow Visualization (2)

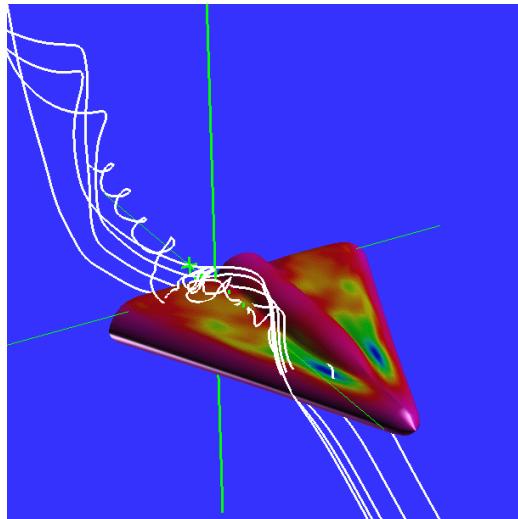
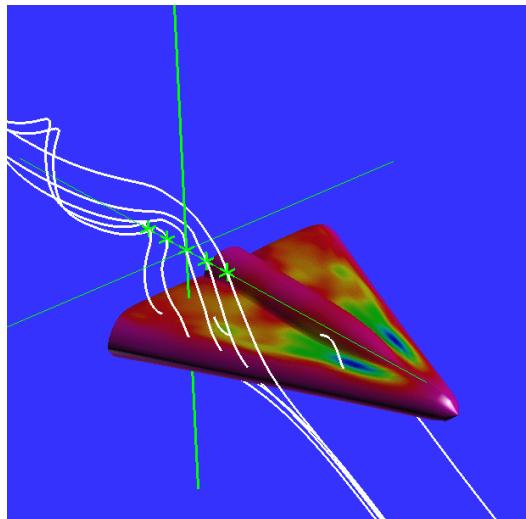
- What is the problem definition?
- Given (typically):
 - physical **position (vector)**
 - pressure (scalar),
 - density (scalar),
 - **velocity (vector)**,
 - entropy (scalar)
- steady flow - vector field stays constant
- unsteady - vector field changes with time



Streamline

- Basic idea: visualizing the flow directions by releasing particles and calculating a series of particle positions based on the vector field -- streamline

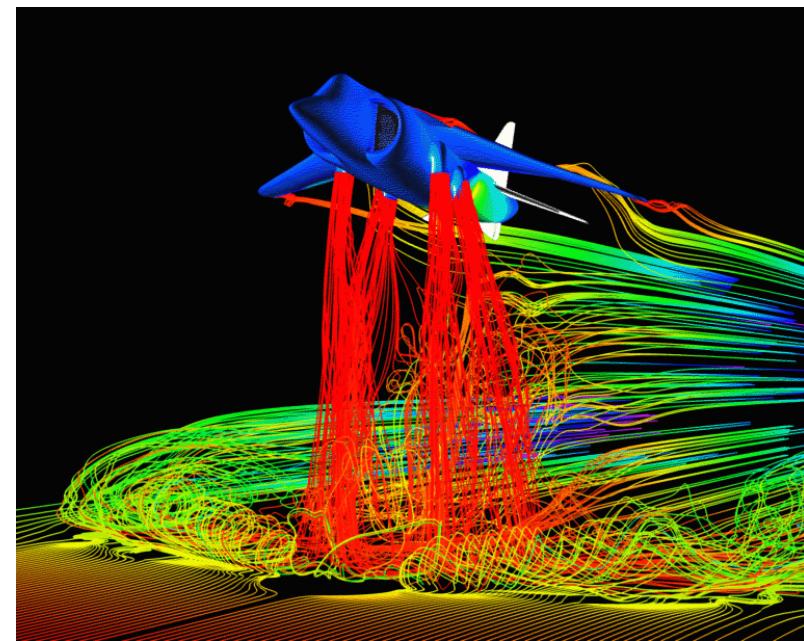
$$\frac{d\bar{x}}{ds} = v(\bar{x}, t_0) \quad \text{or} \quad \bar{x} = \bar{x}(s) + \int \bar{v} ds$$





Streamlines (cont' d)

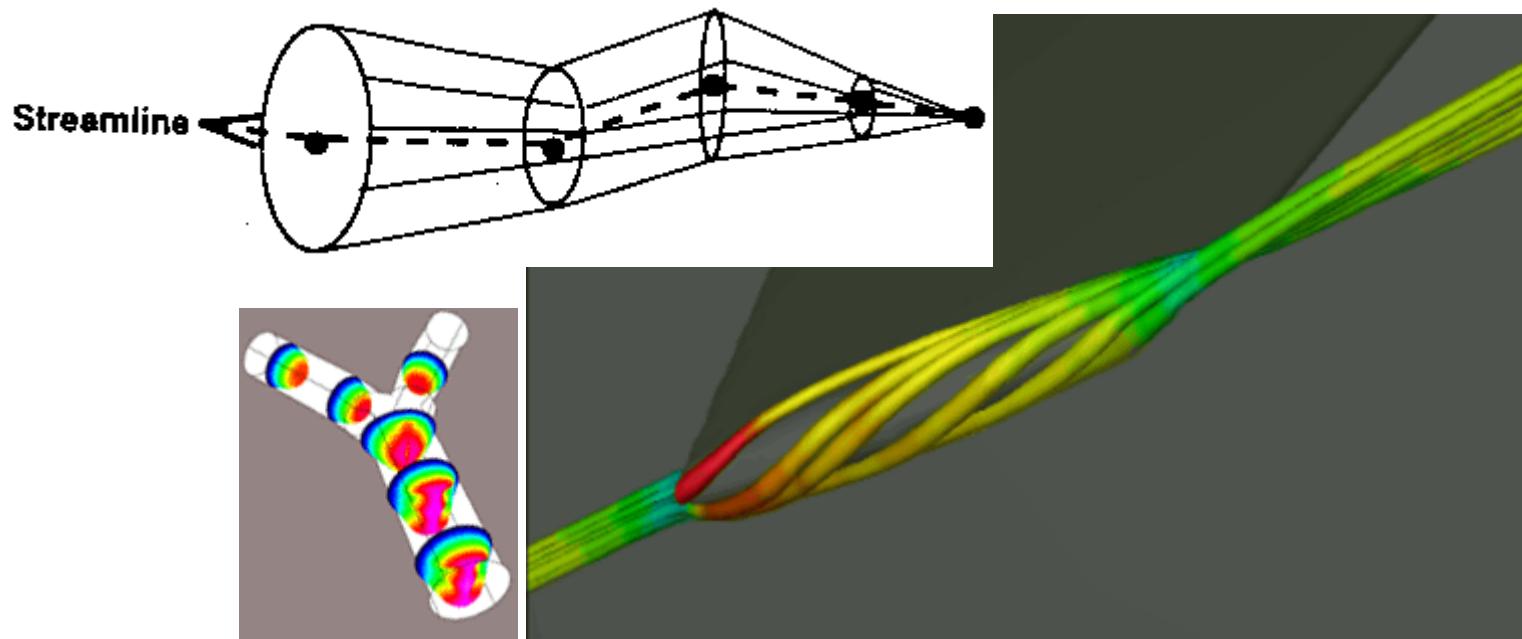
- Displaying streamlines is a local technique because you can only visualize the flow directions initiated from one or a few particles
- When the number of streamlines is increased, the scene becomes cluttered
- You need to know where to drop the particle seeds
- Streamline computation is expensive





Stream-tube

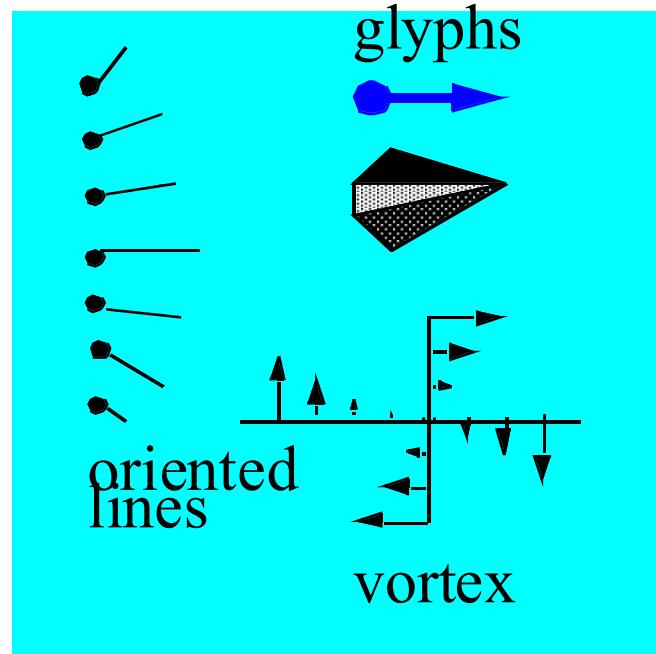
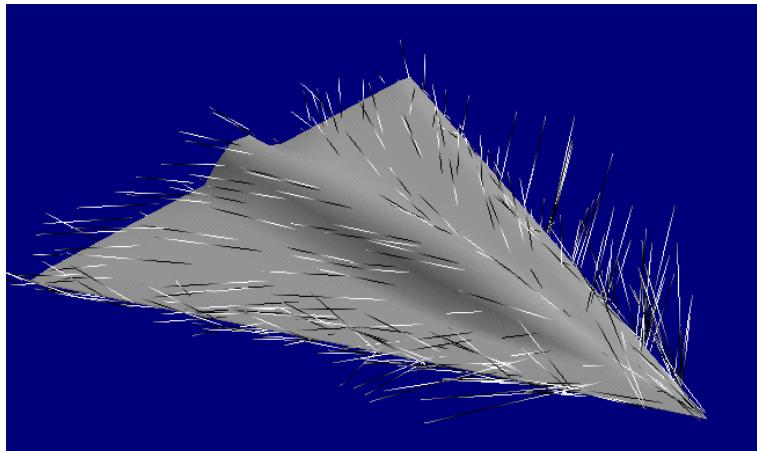
- Generate a stream-line and connect circular crossflow sections along the stream-line





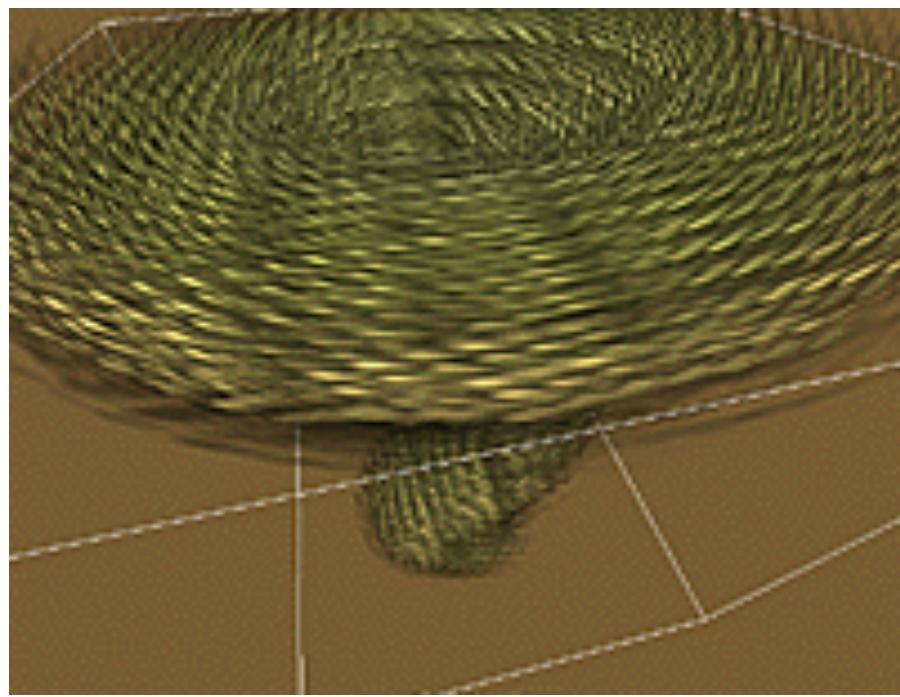
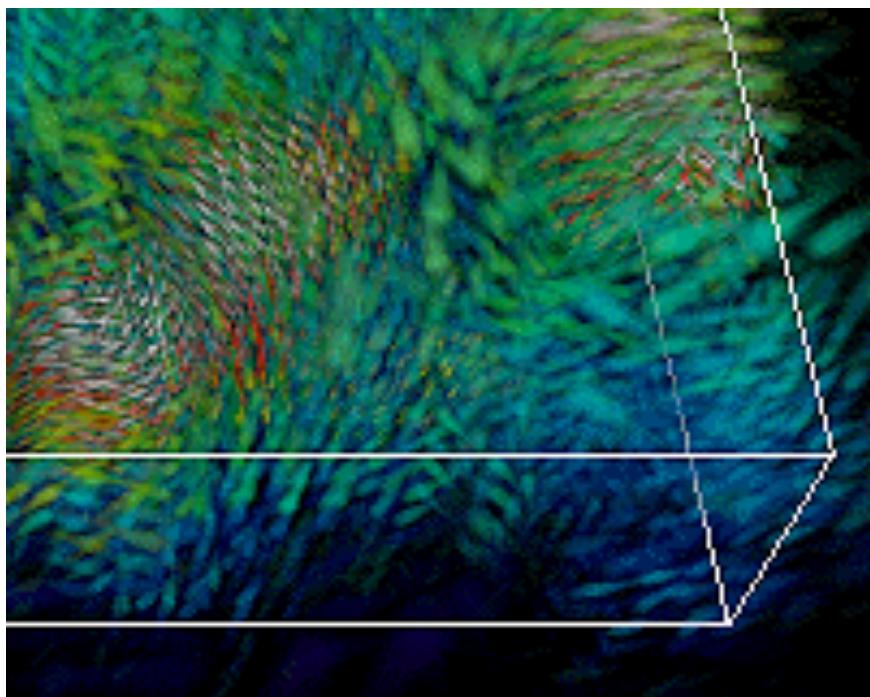
Mappings - Hedgehogs, Glyphs

- Put “icons” at certain places in the flow
 - e.g. arrows - represent direction & magnitude
- other primitives are possible



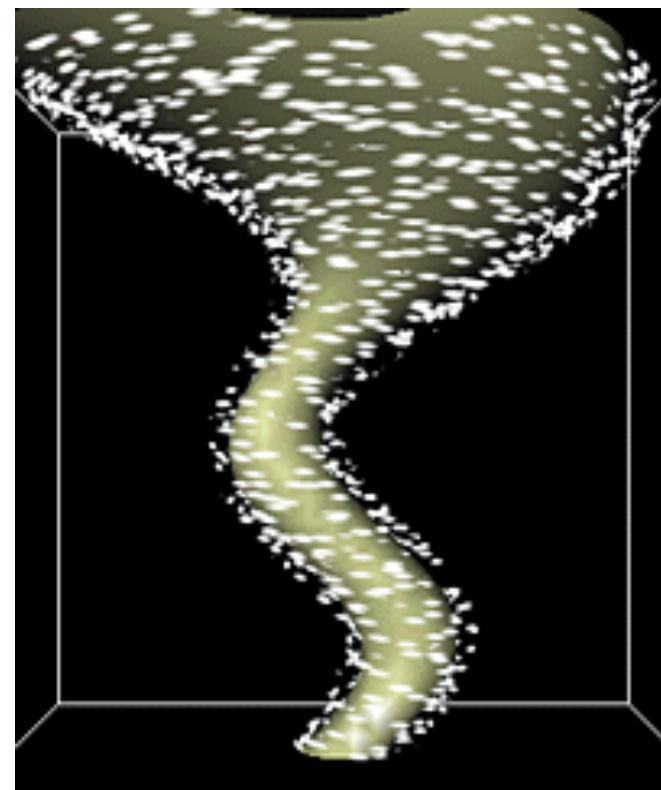
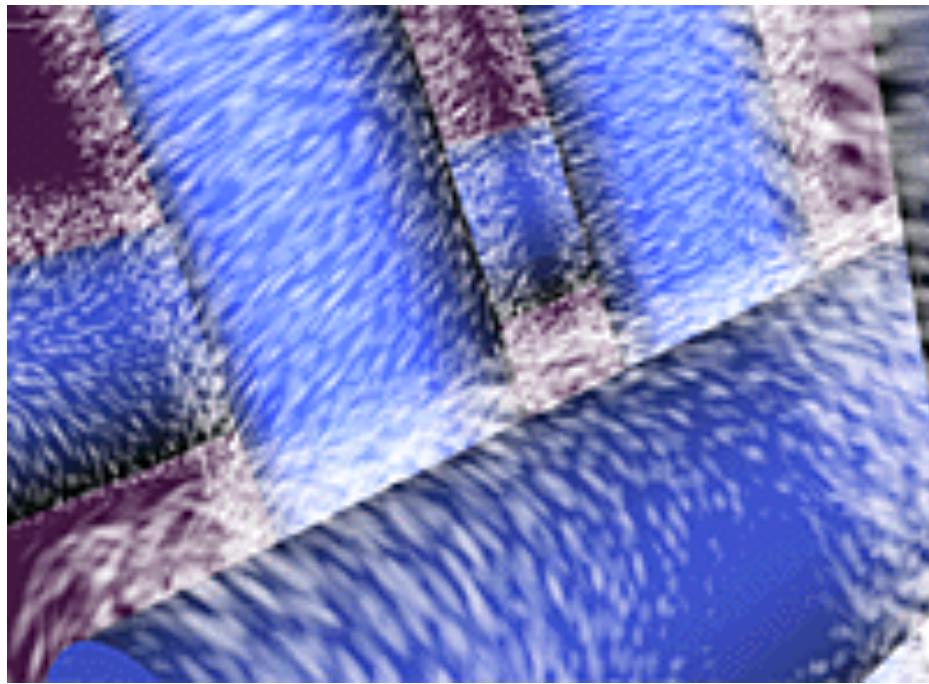


More global techniques



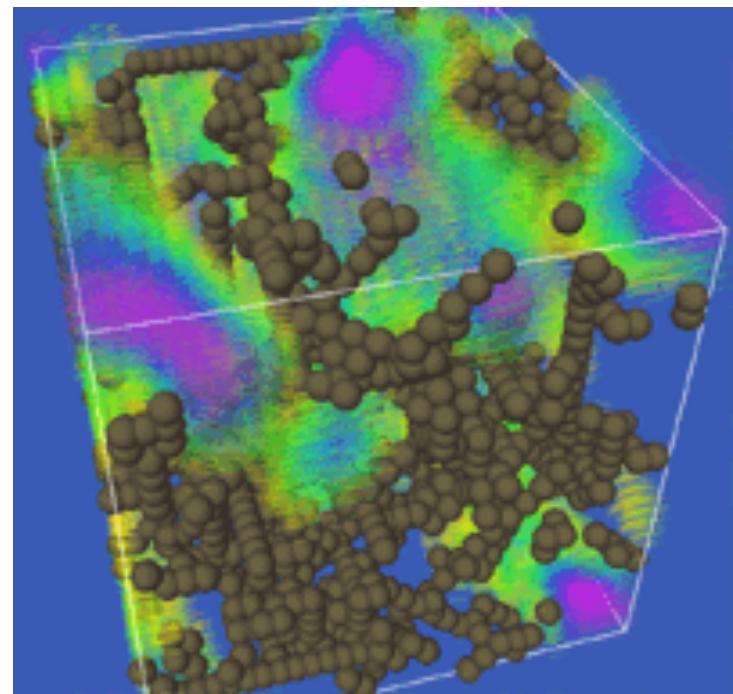
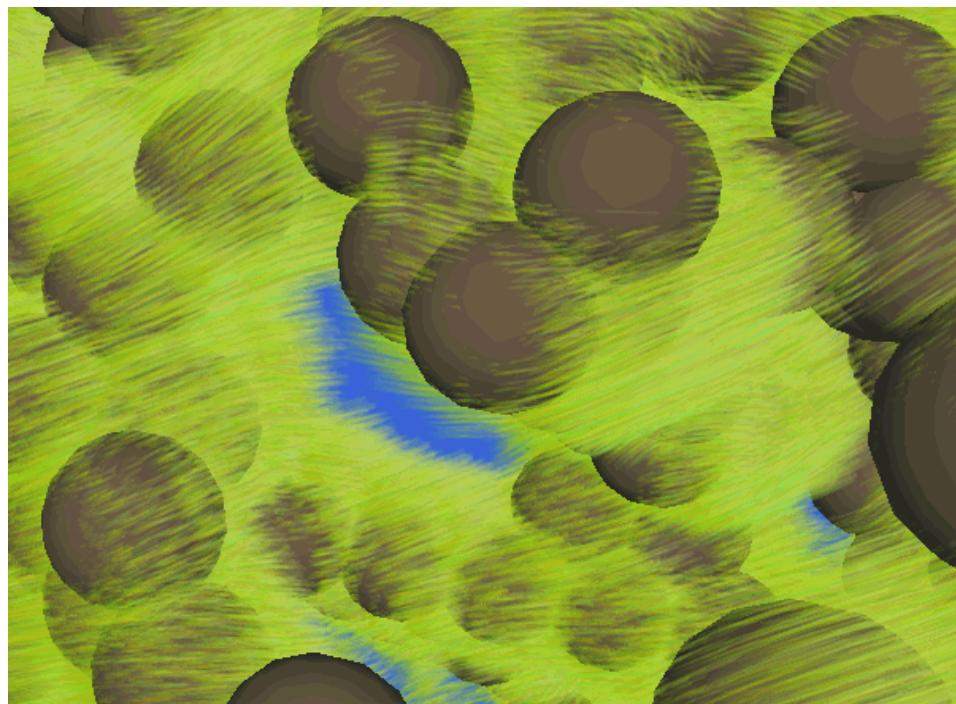


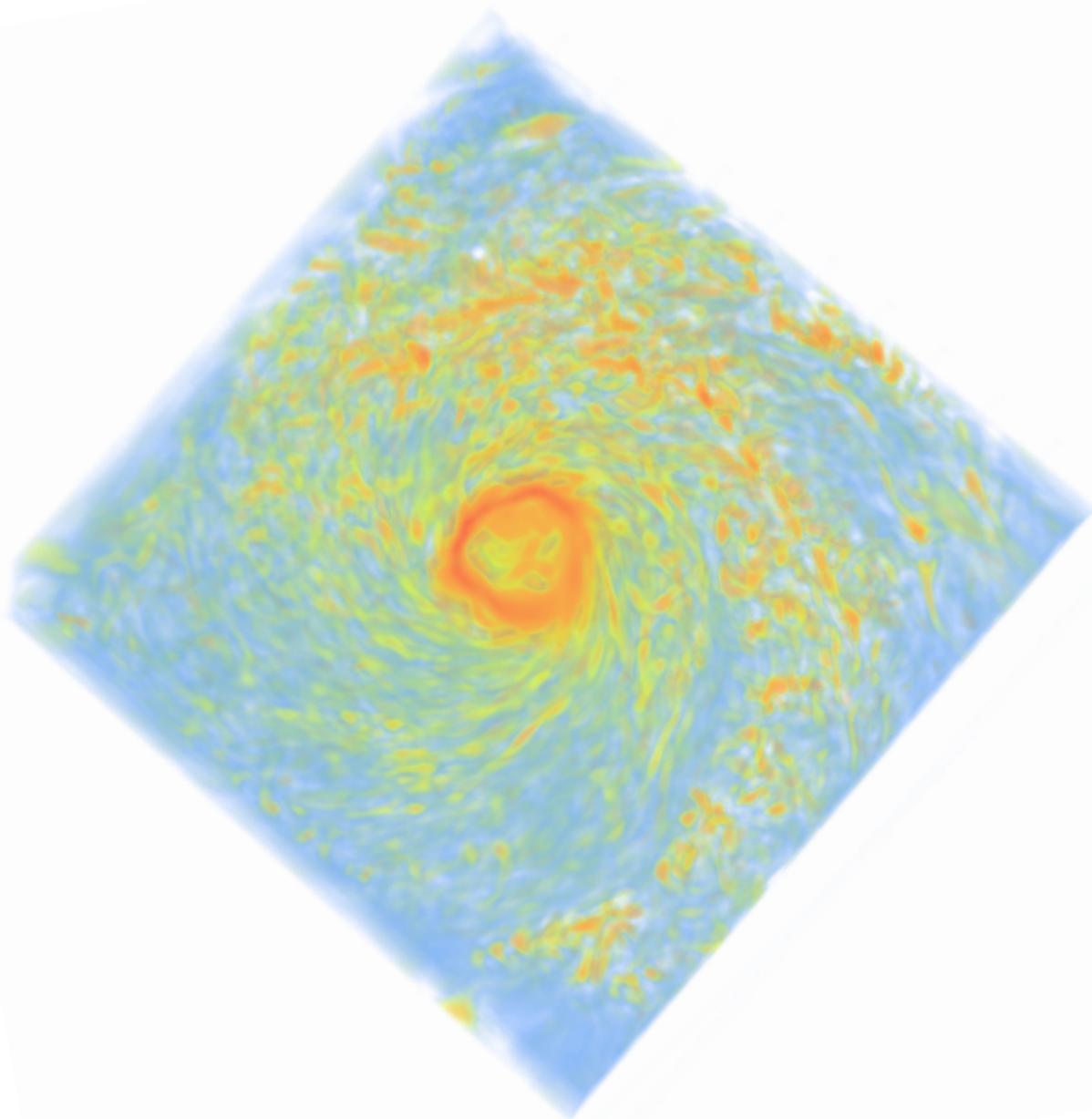
Spot Noise

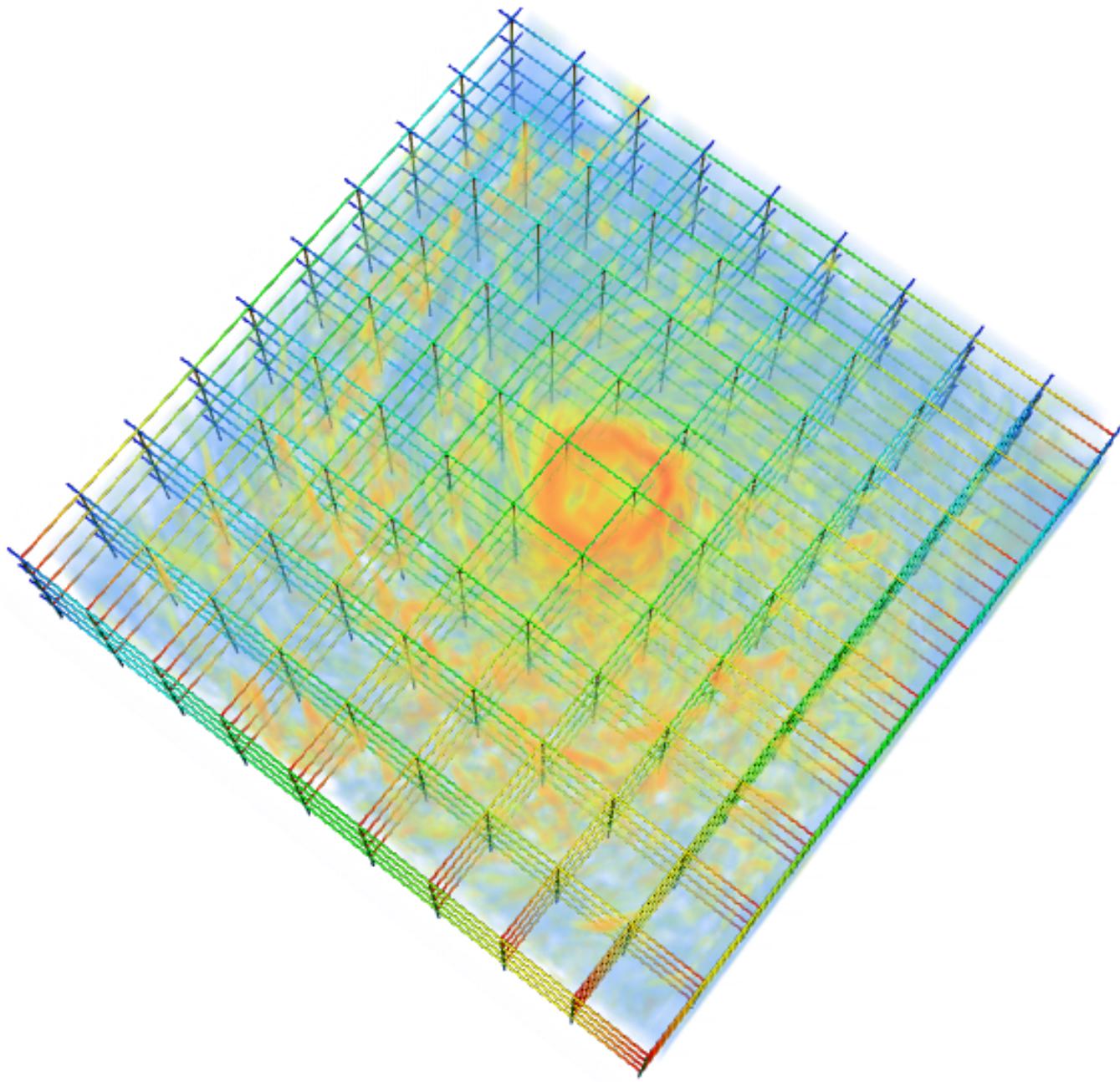


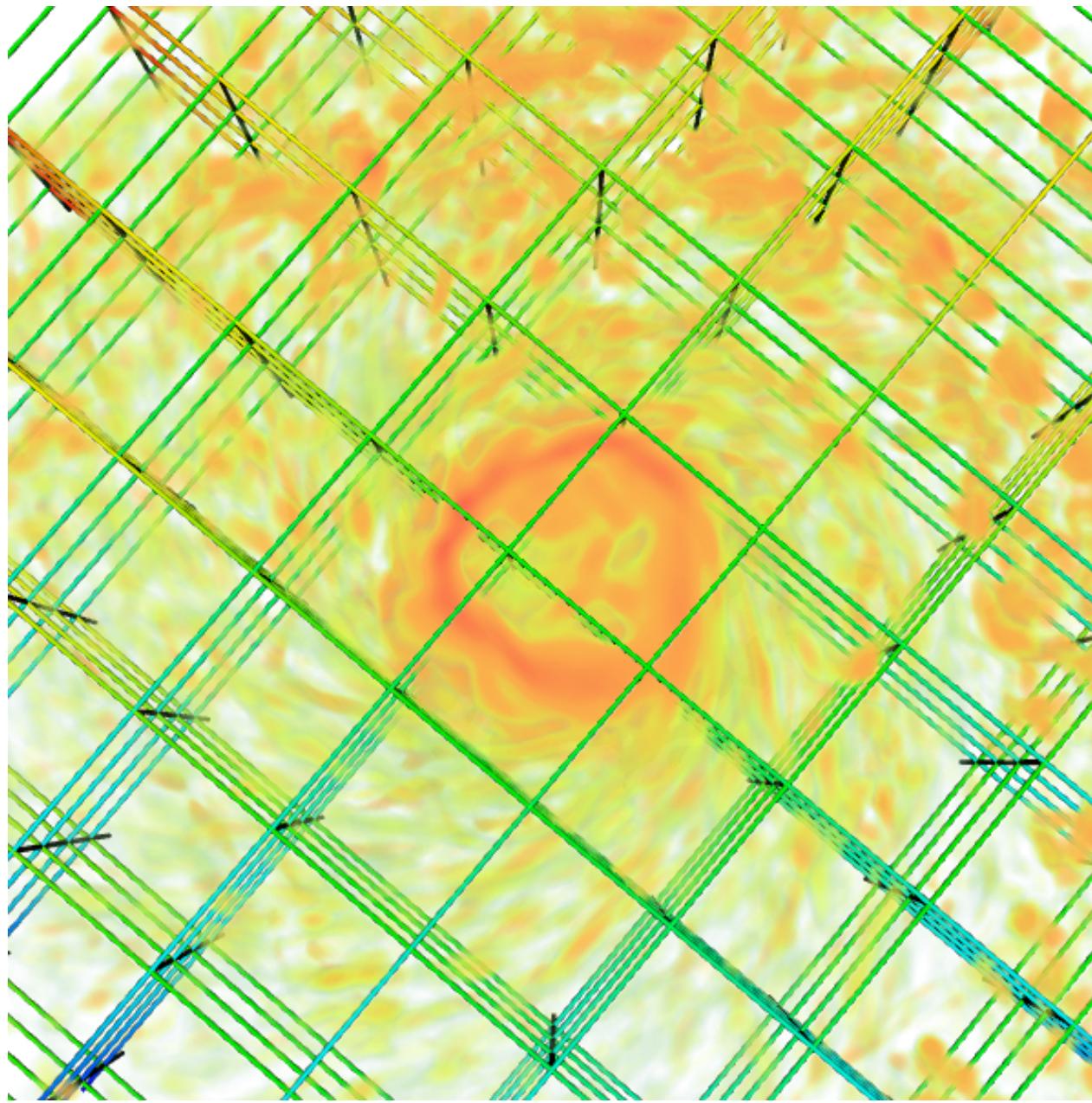


Line bundles



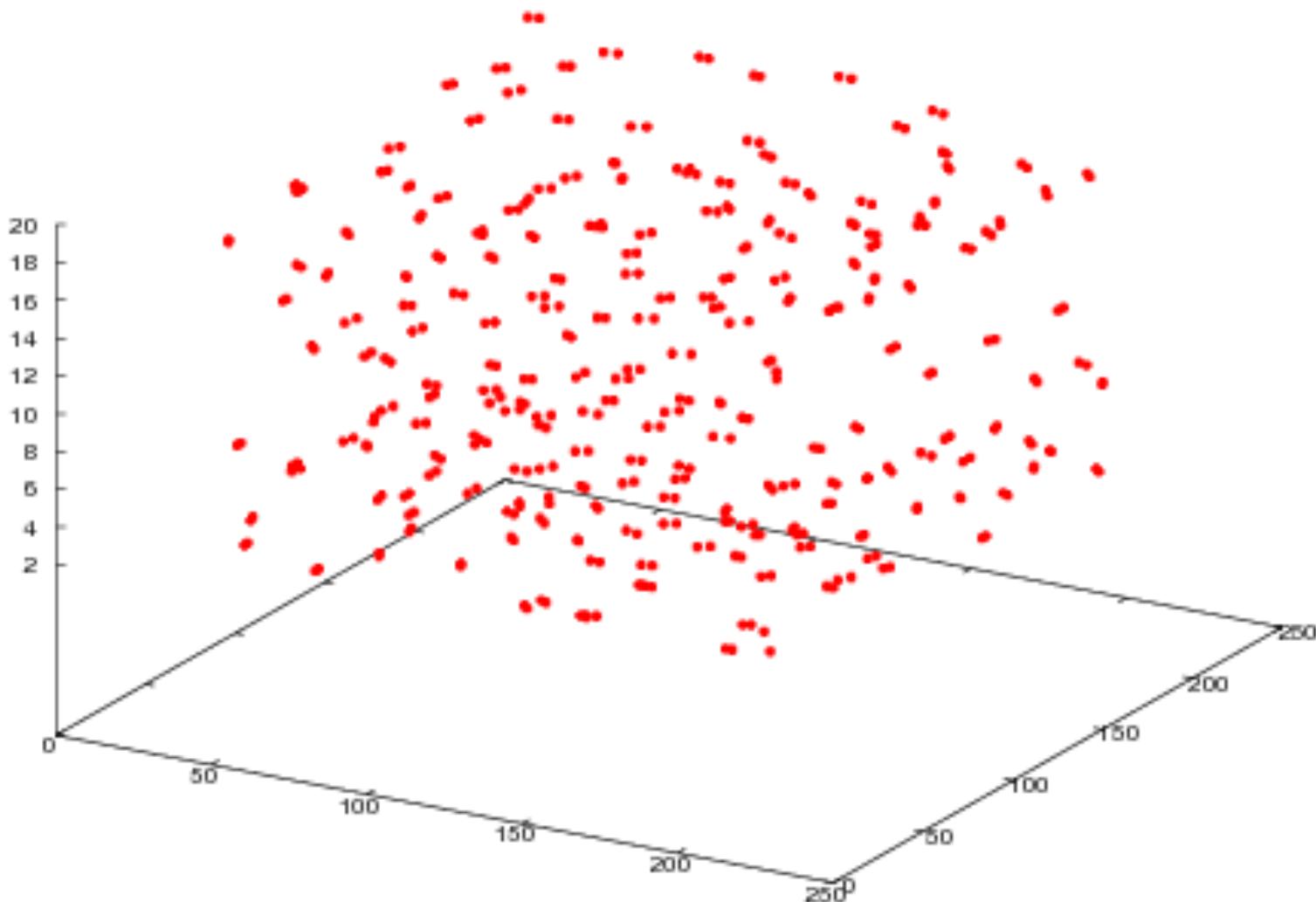


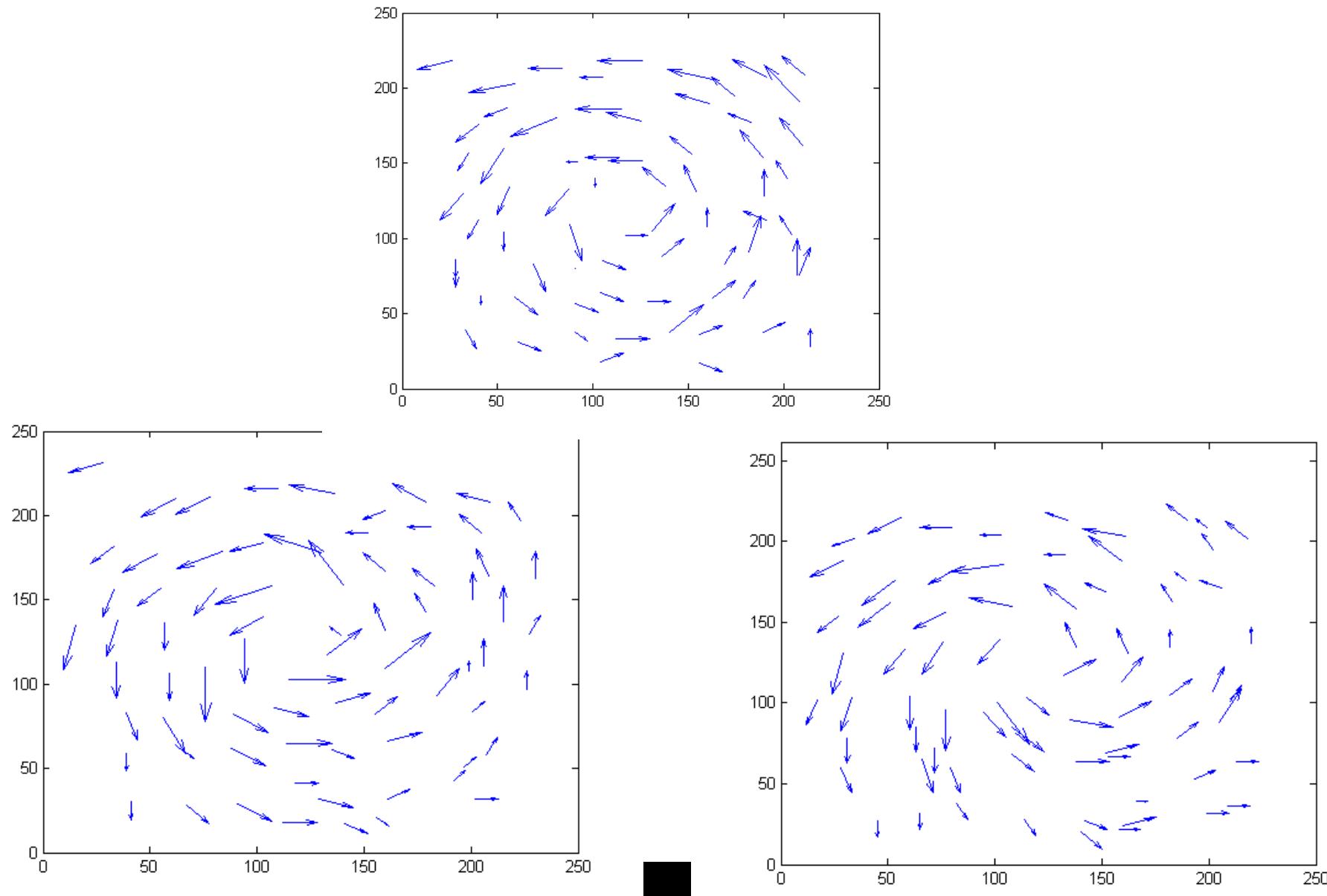




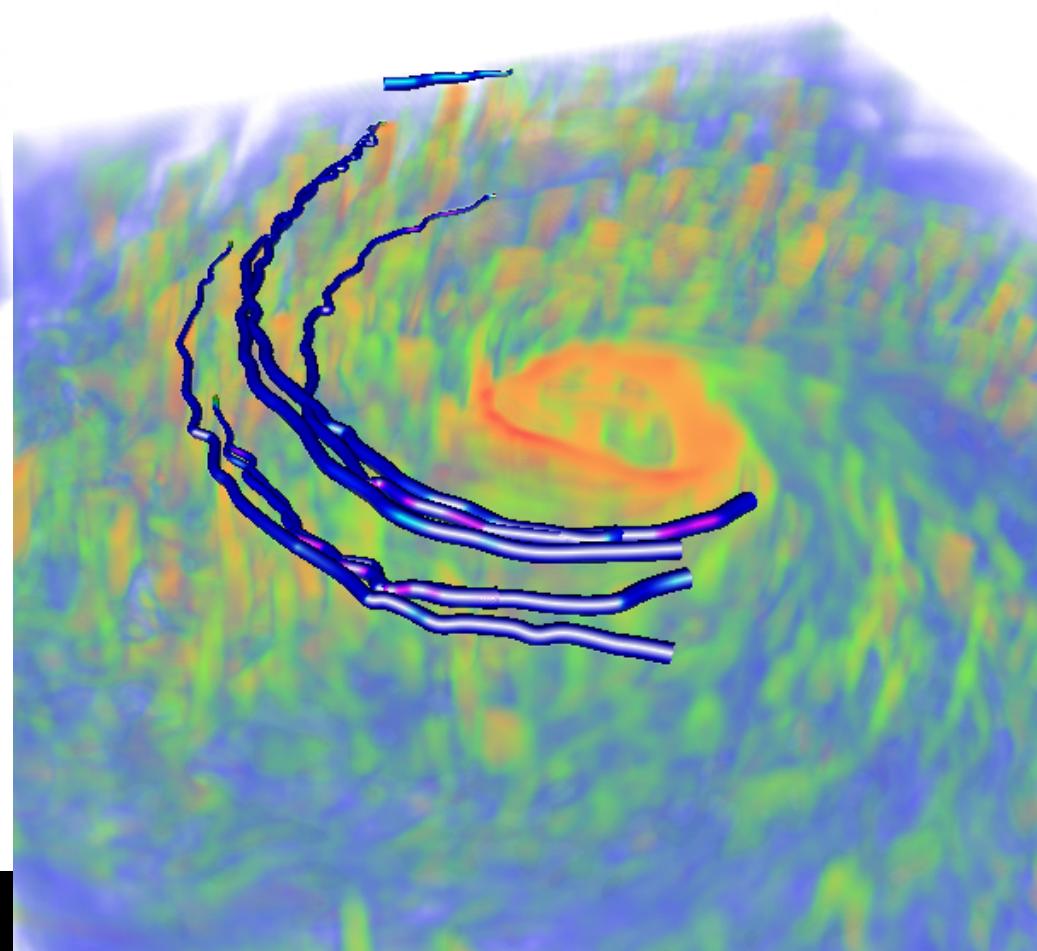
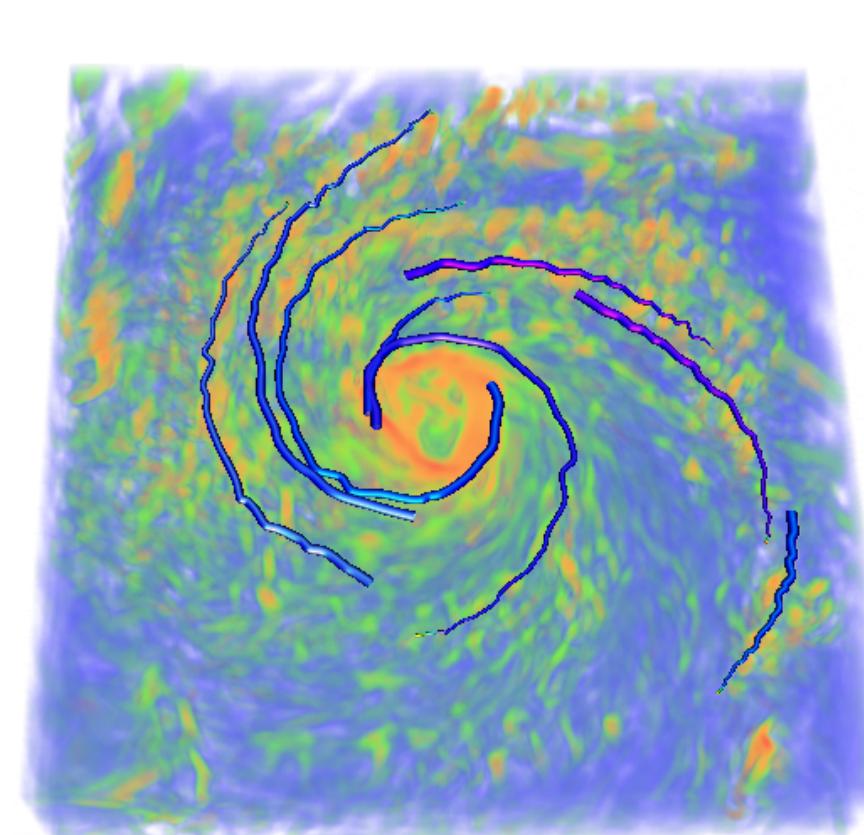
Tracked Points

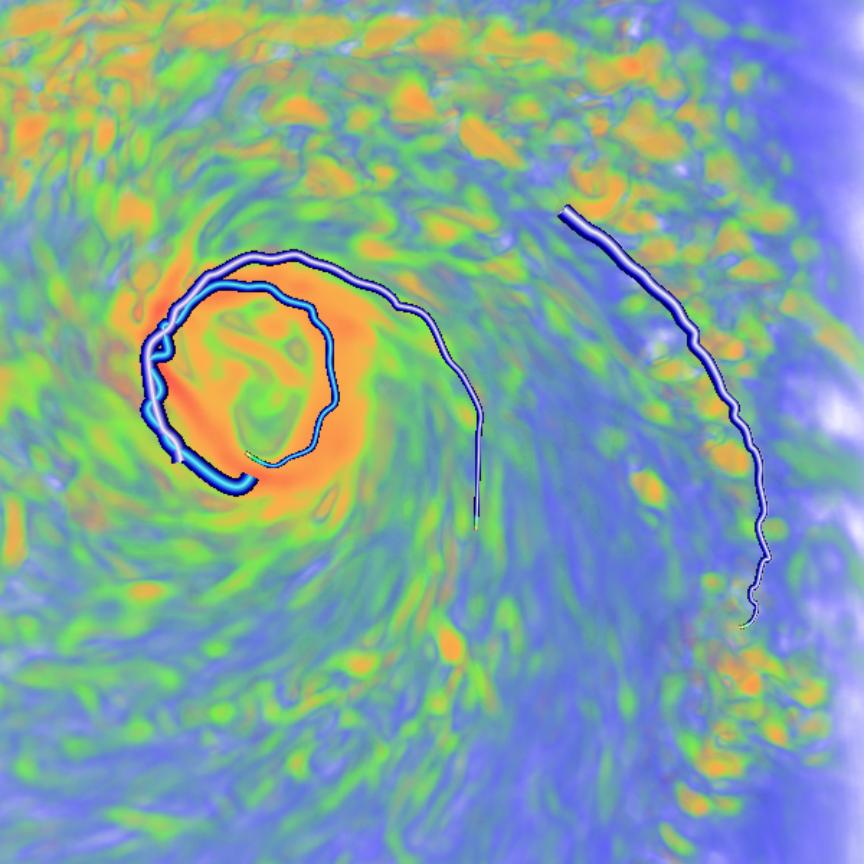
Tracked 3D Points



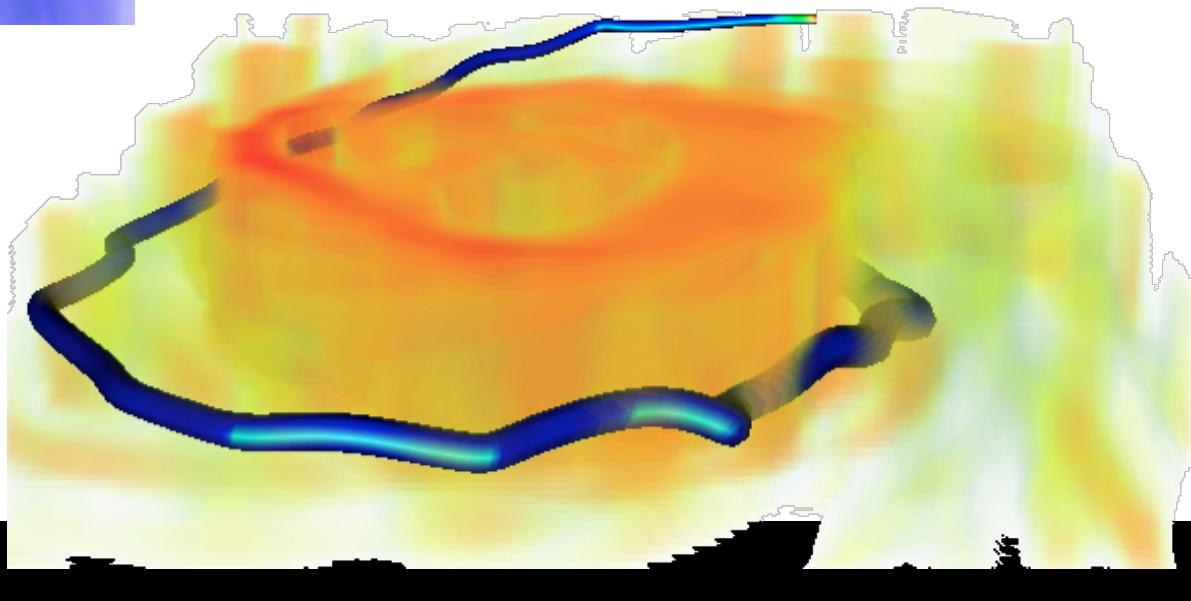


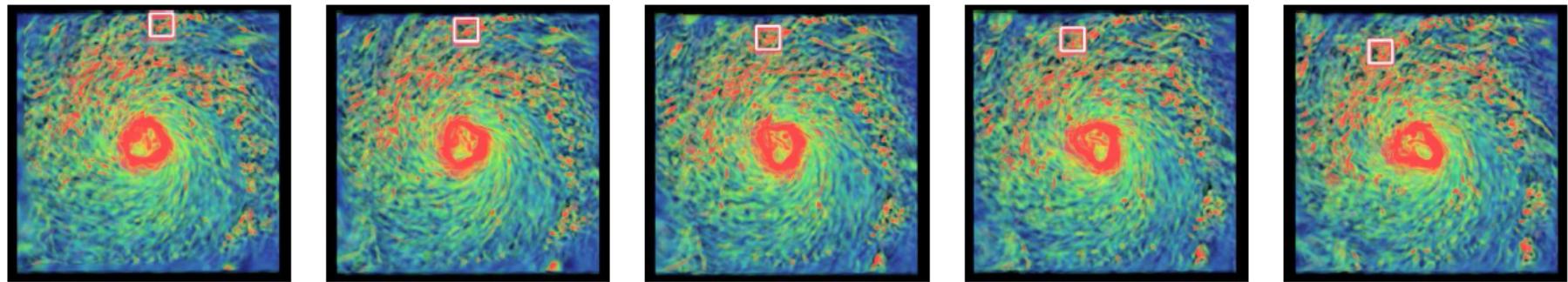
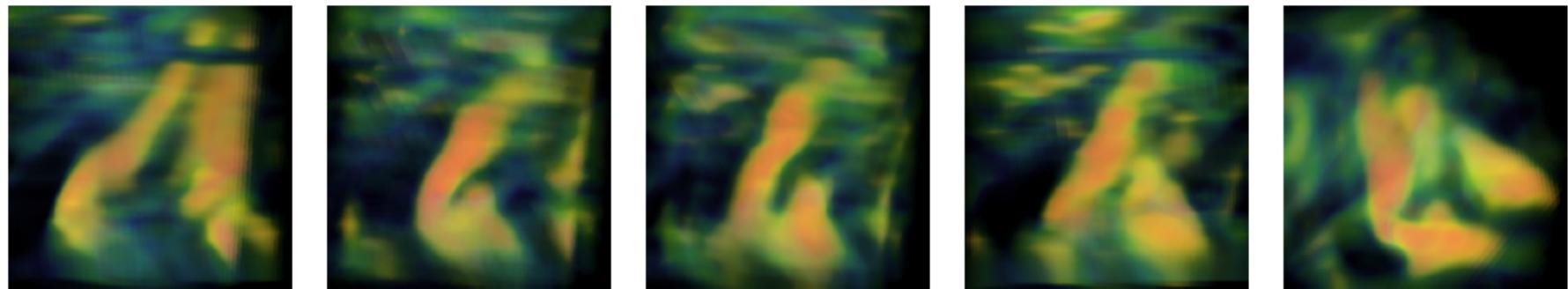
Results





What about changes
within specific features?





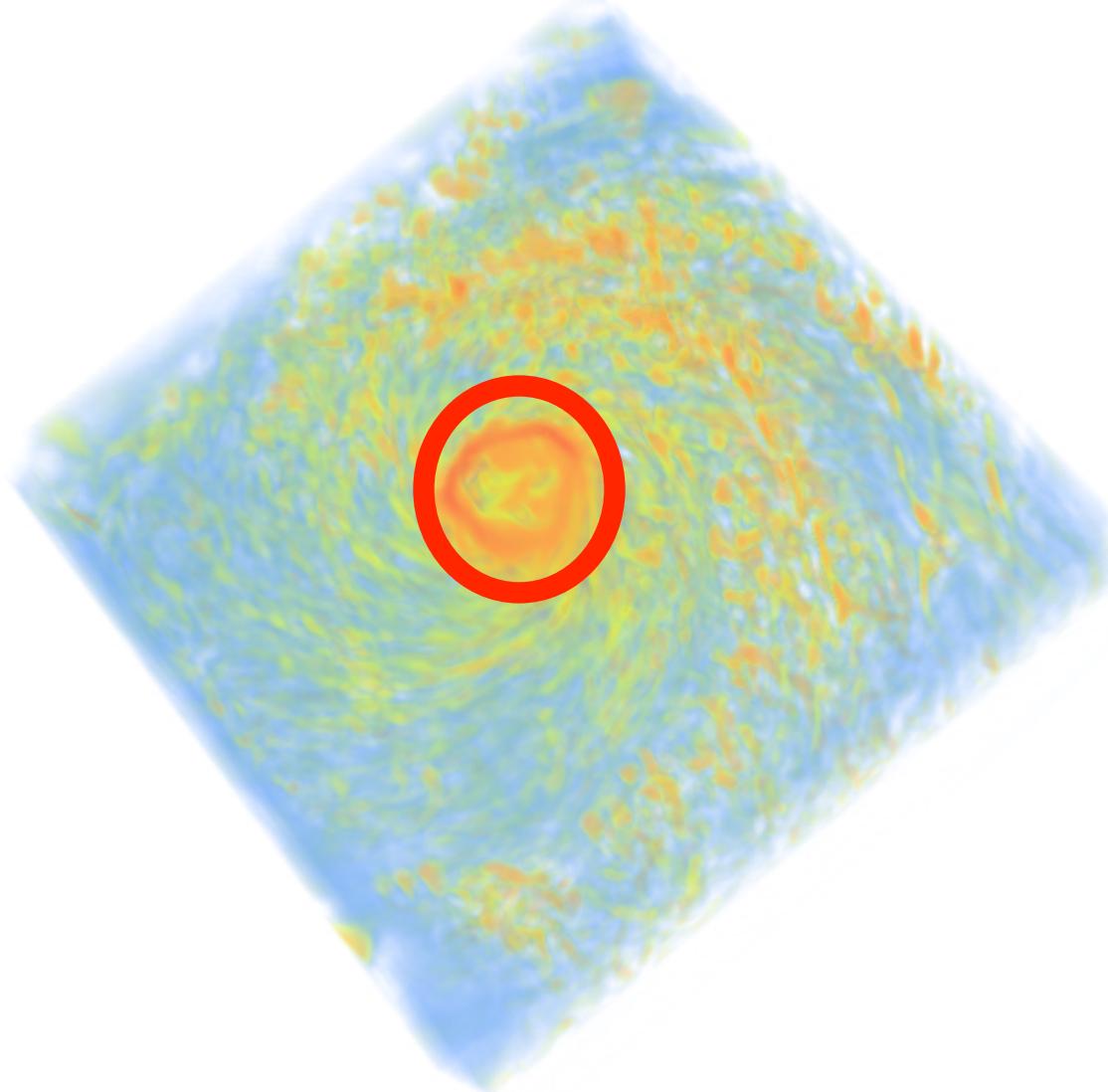
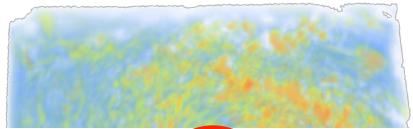
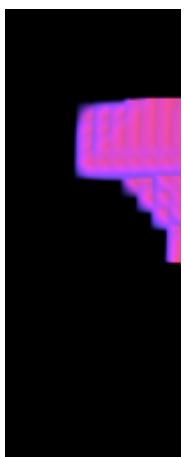
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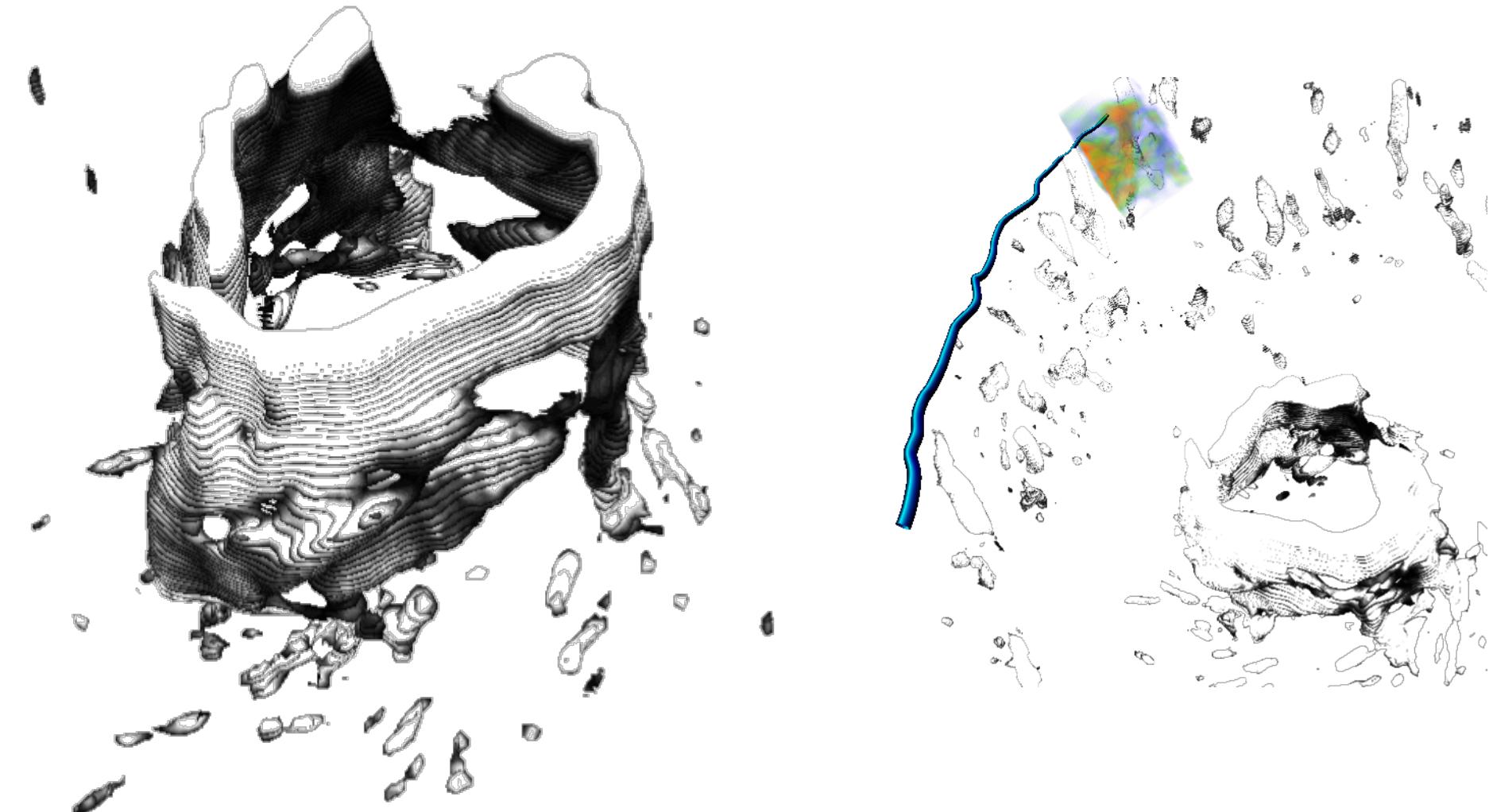
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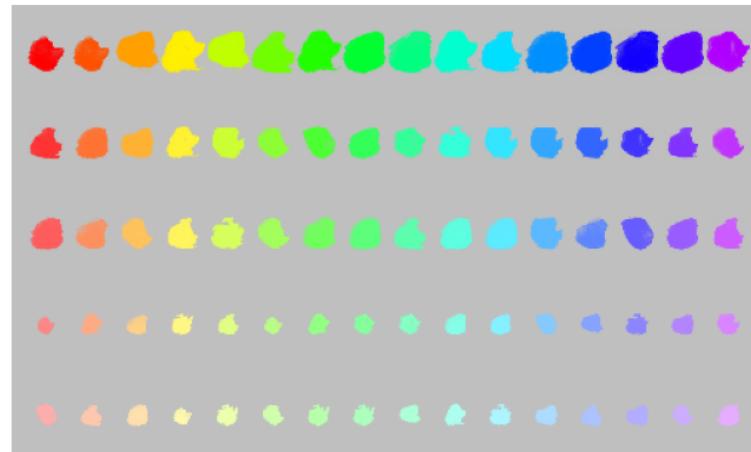
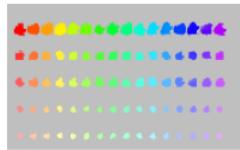
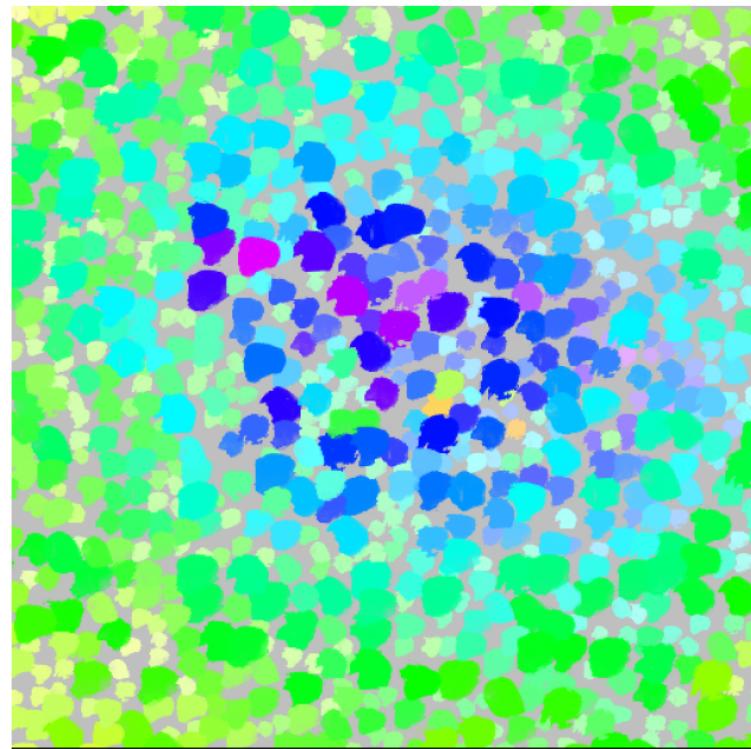
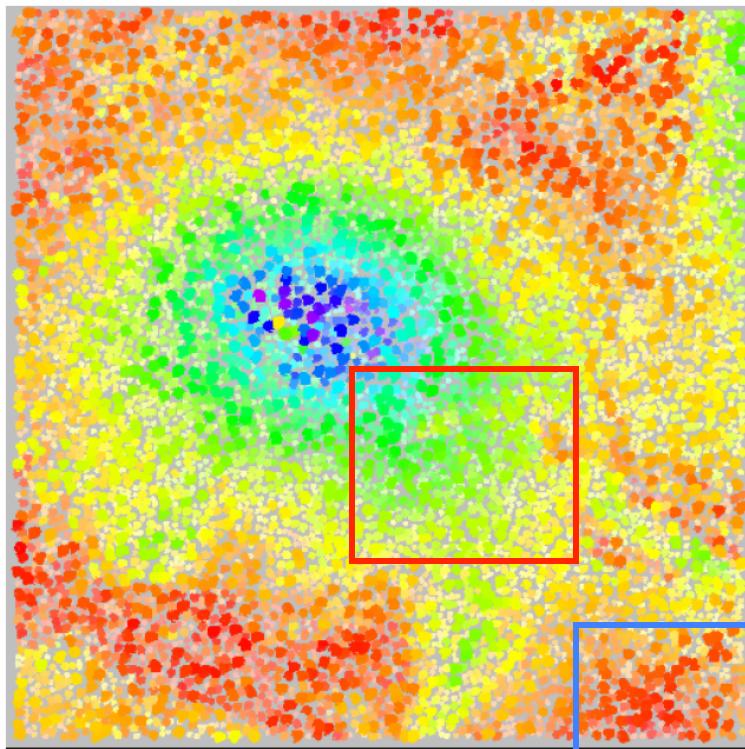
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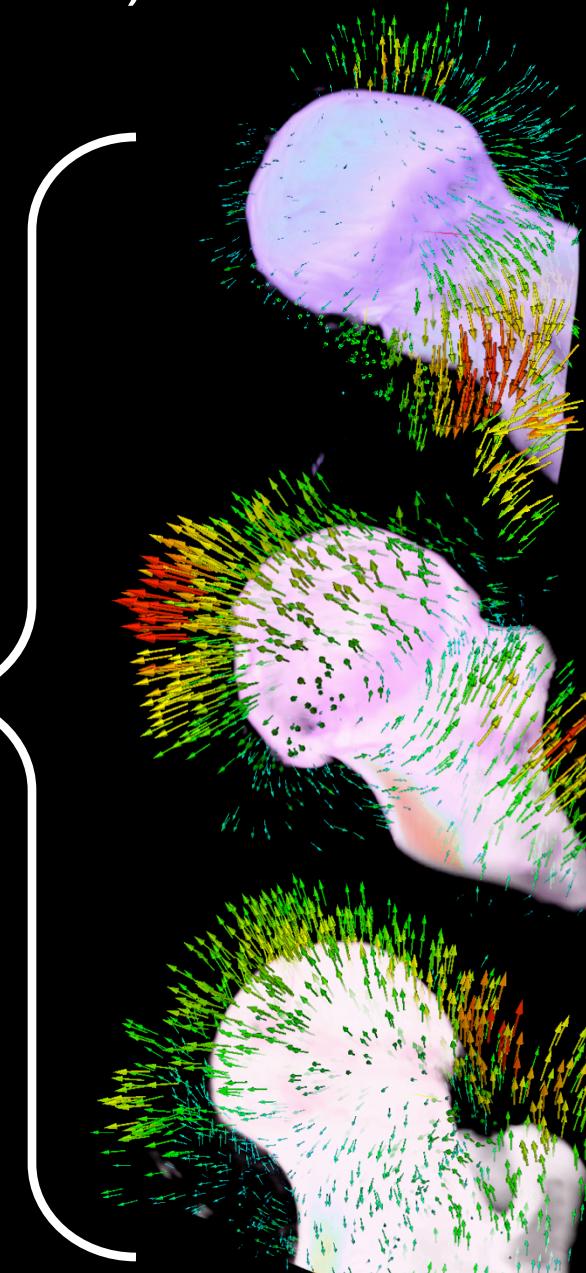
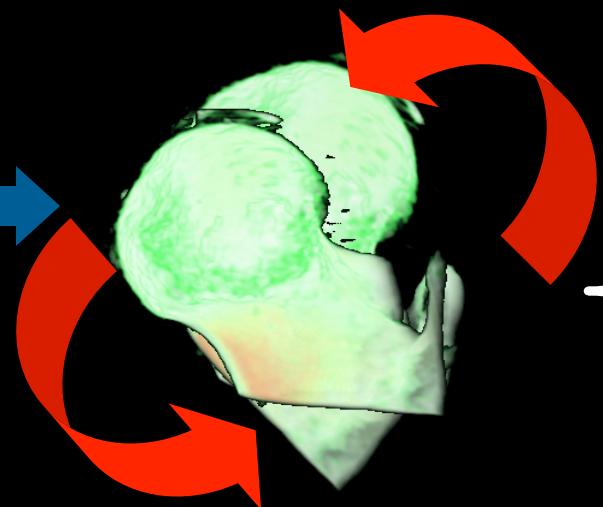
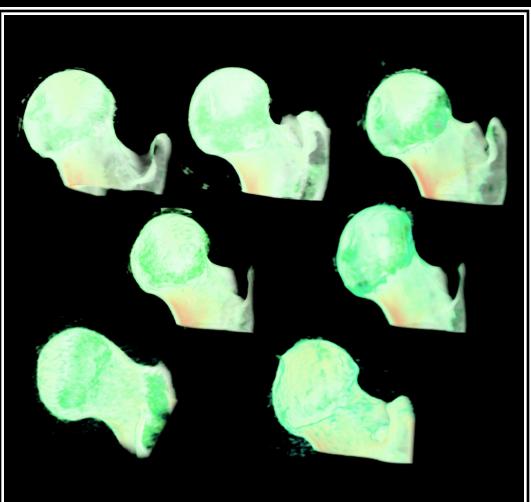
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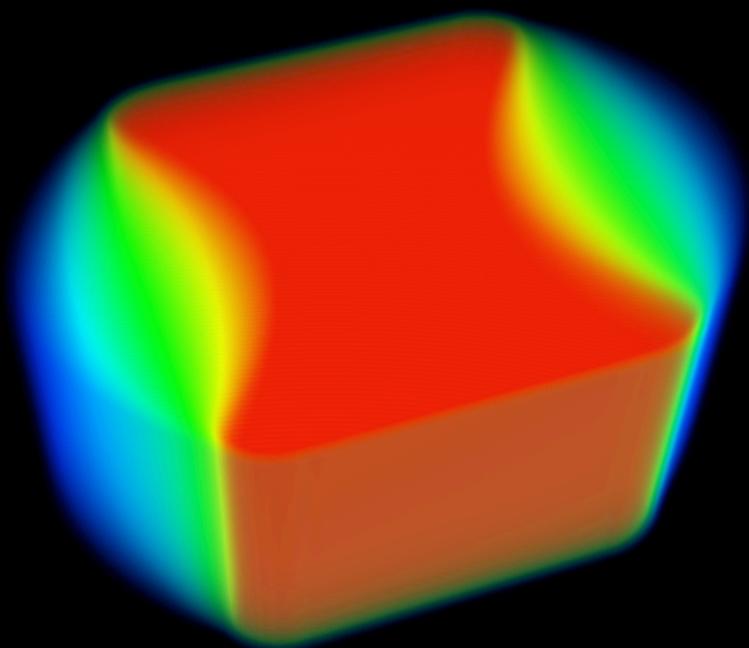
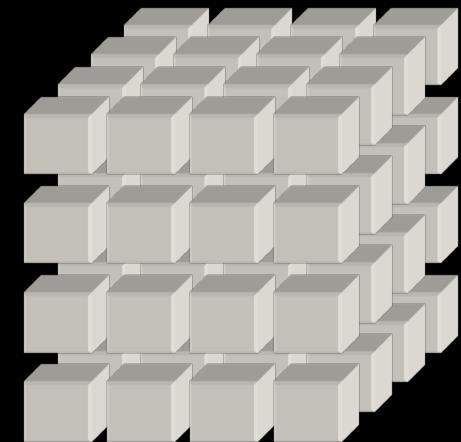
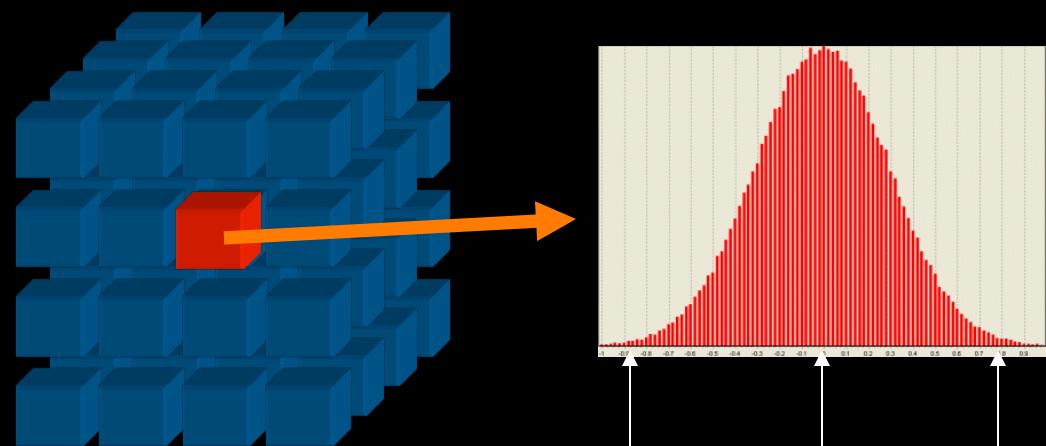




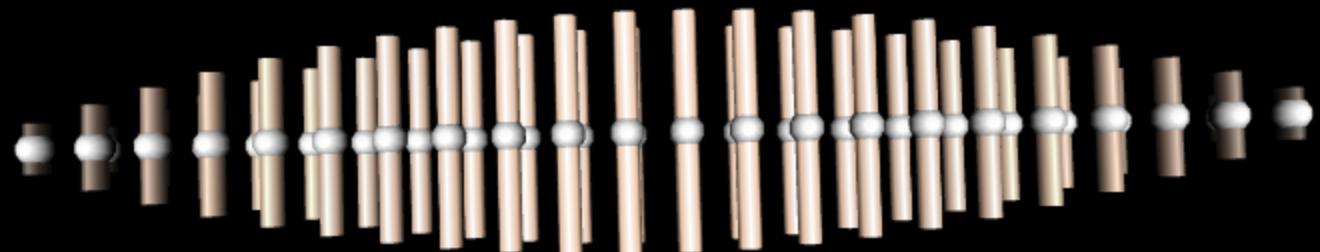
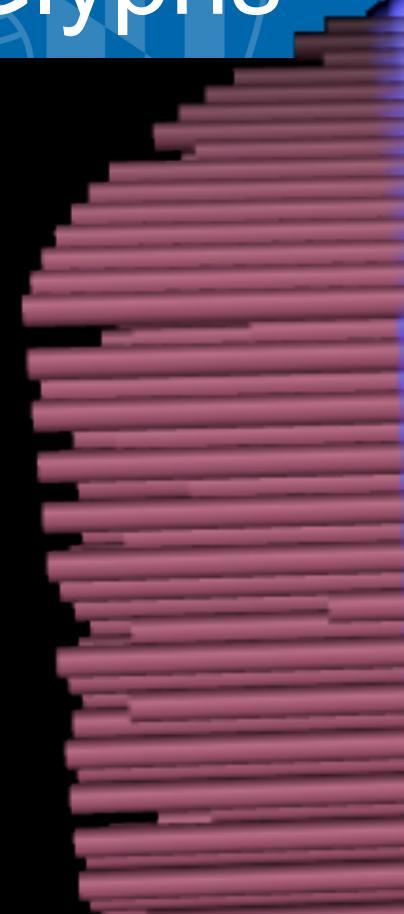
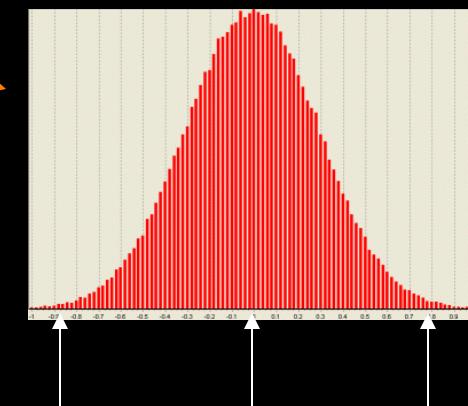
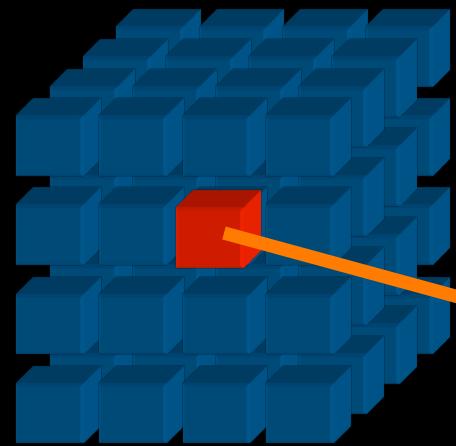
Statistical Deformation Models (SDMs)

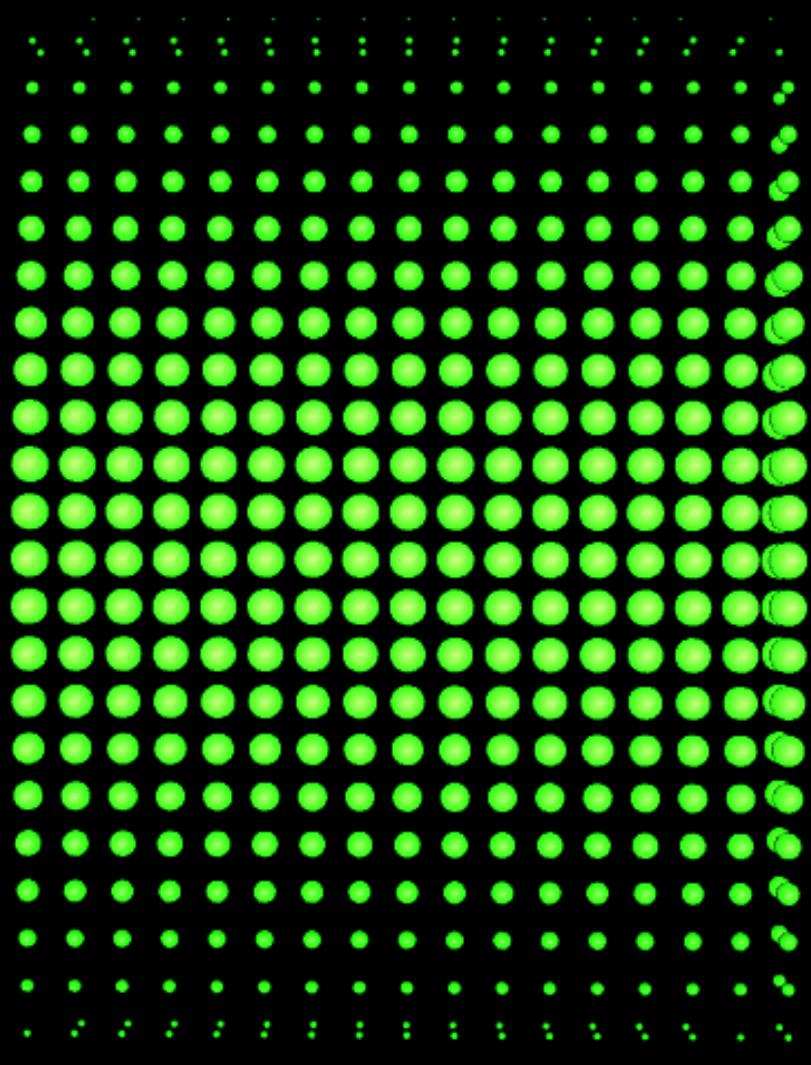
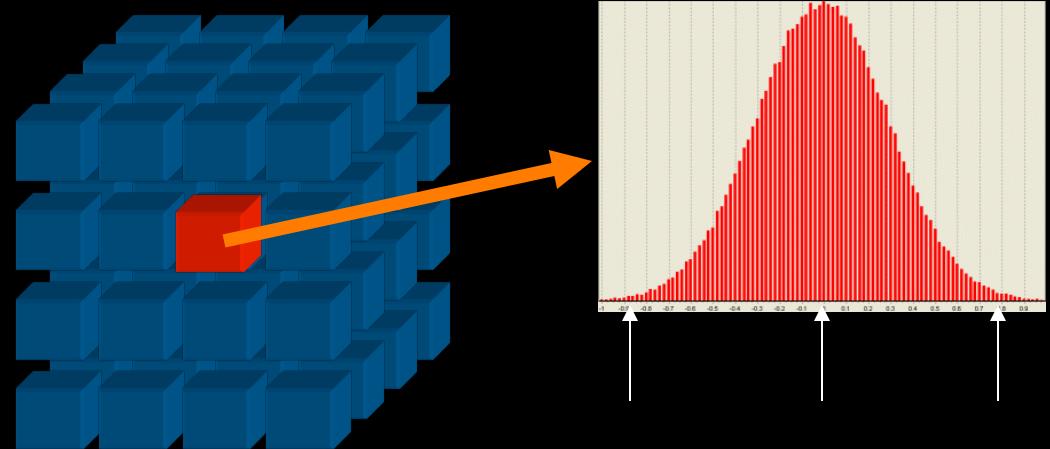


Likelihood Volumes

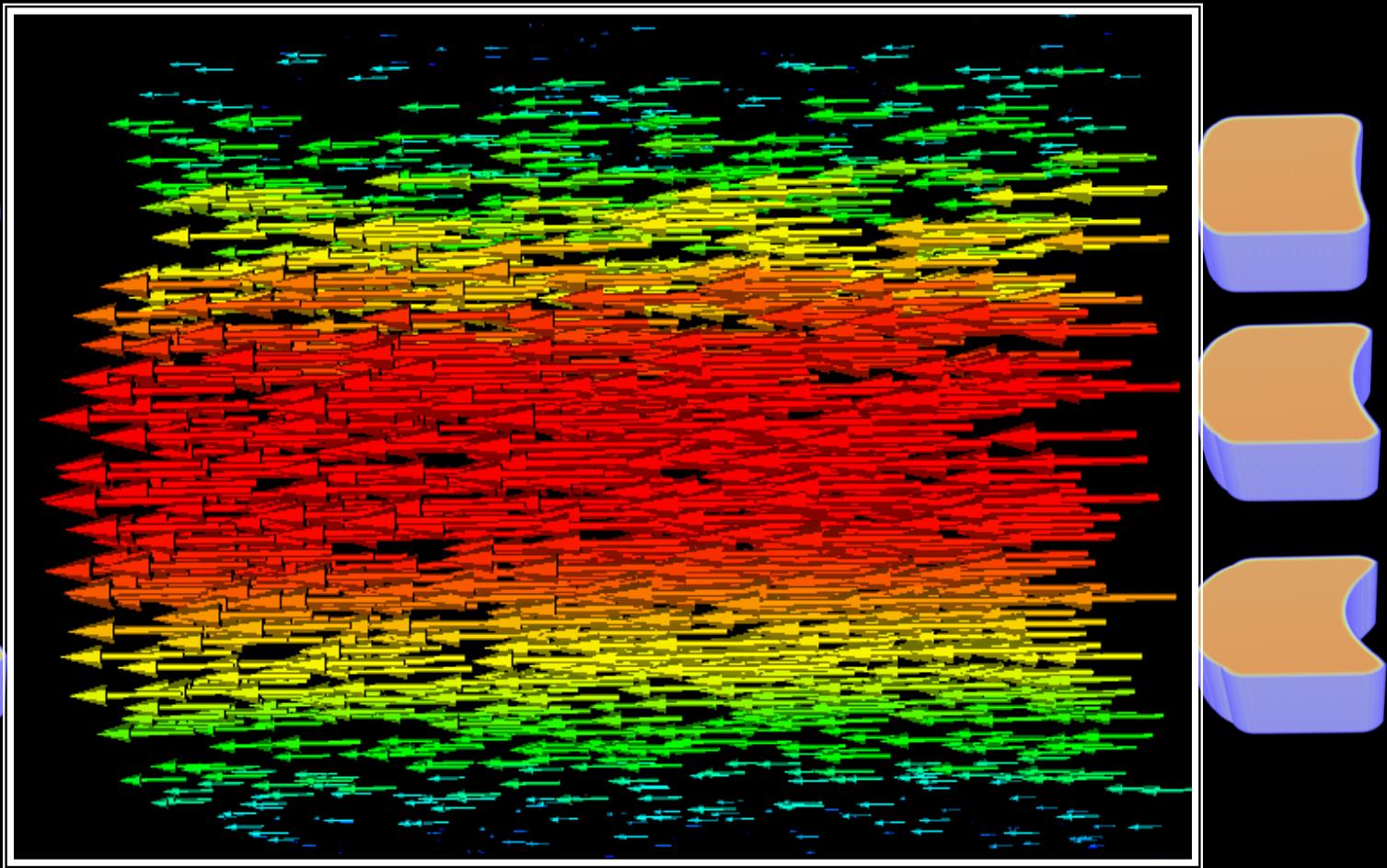


Line-based Glyphs

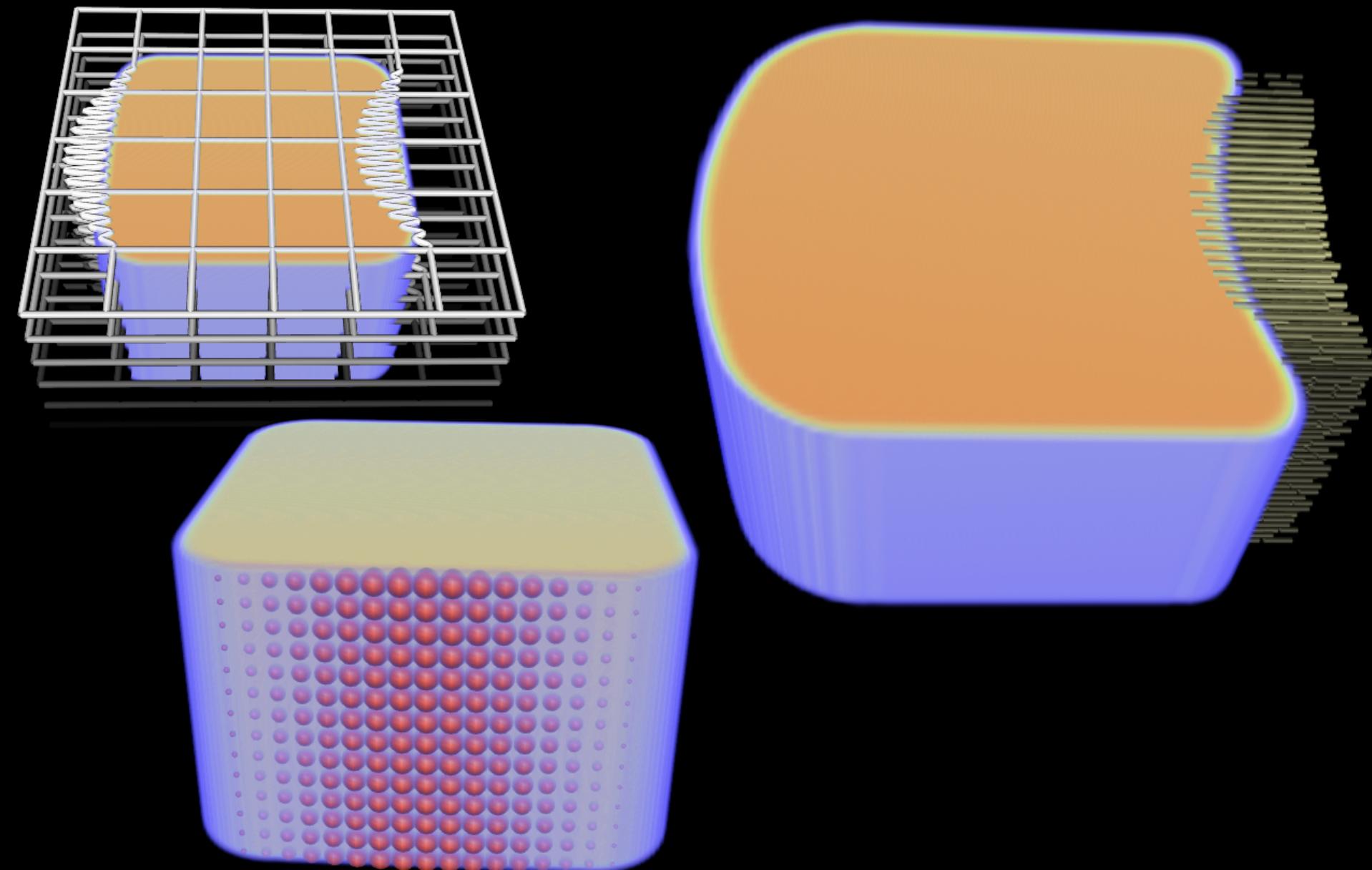




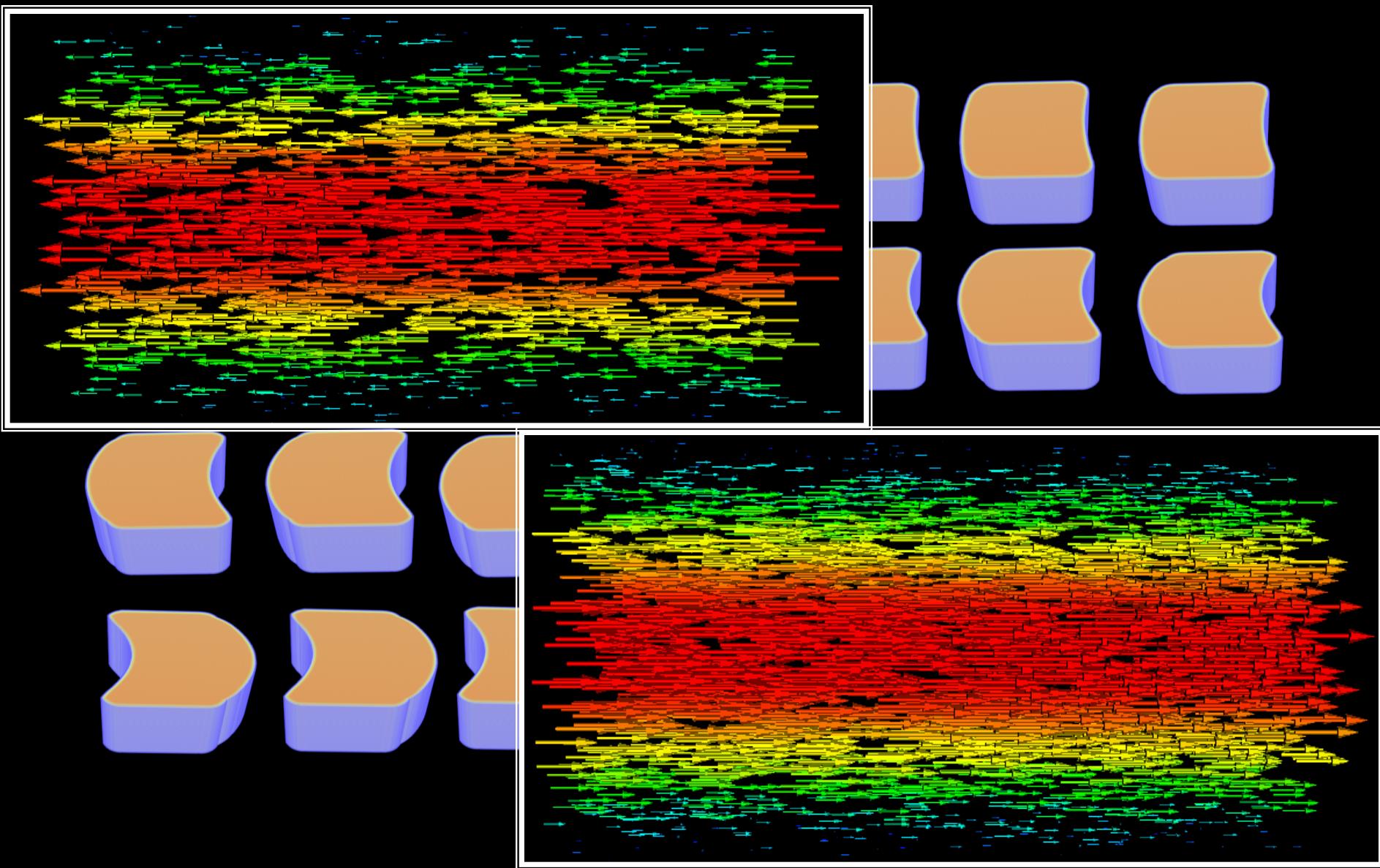
Results – Synthetic #1



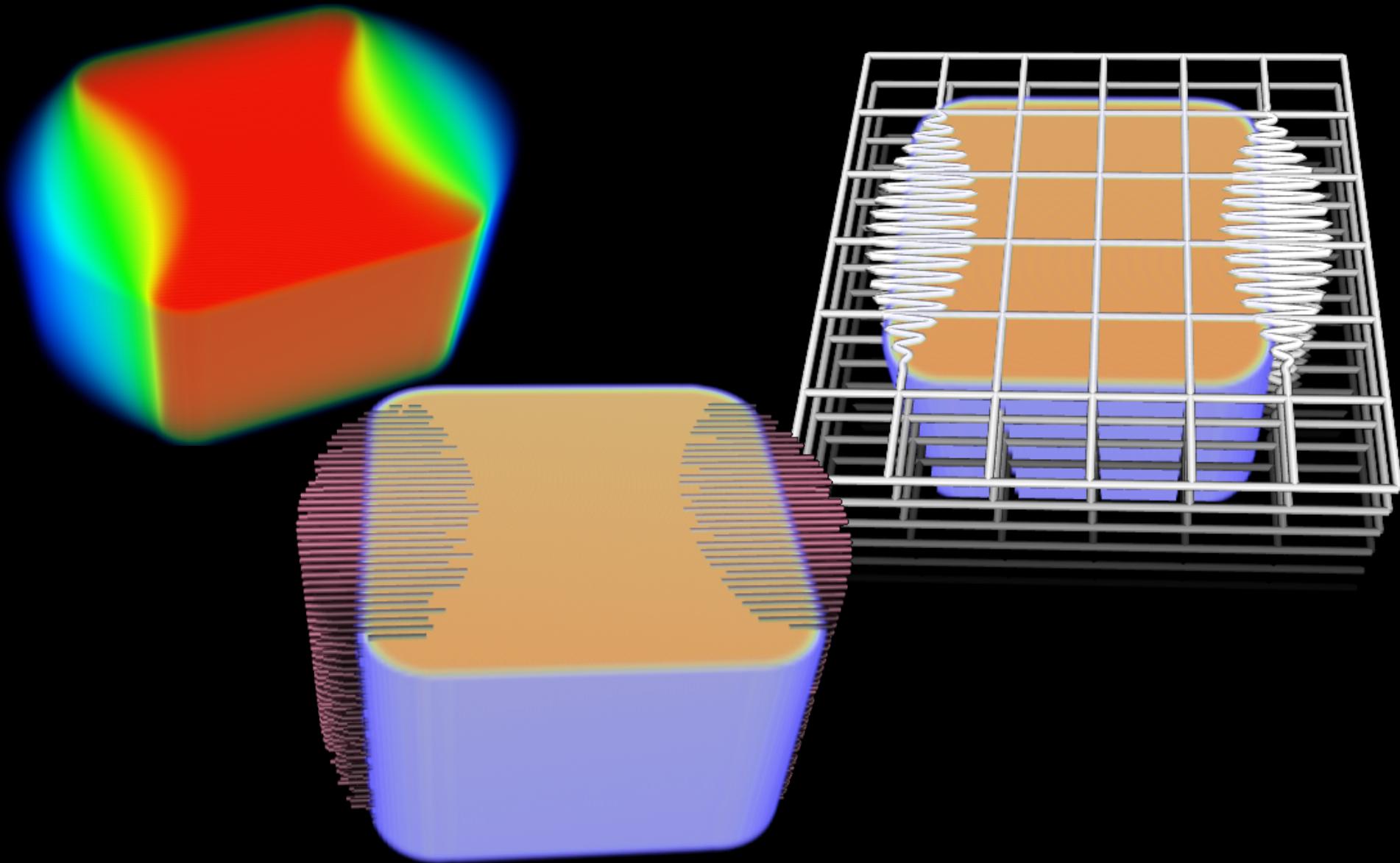
Results – Synthetic #1



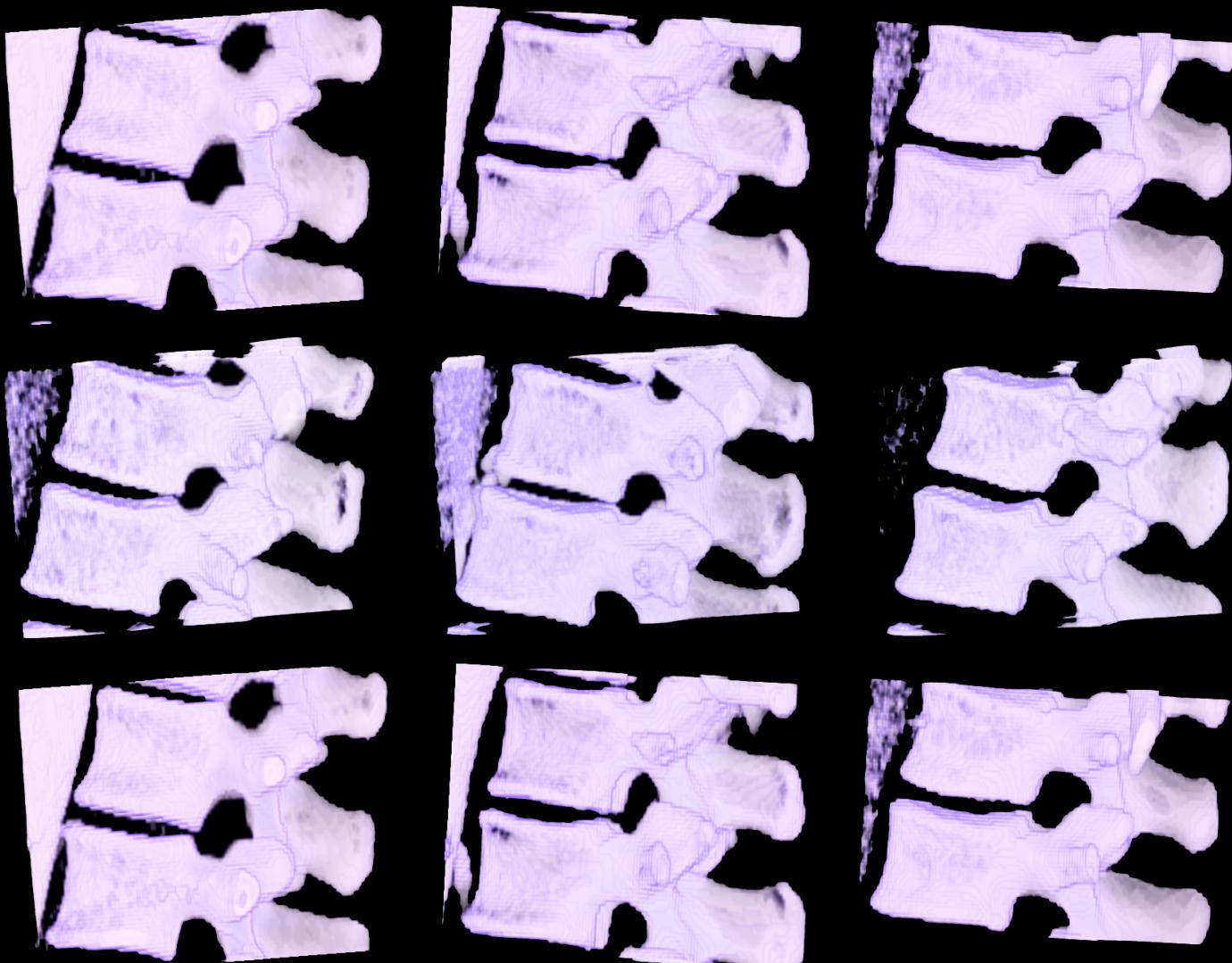
Results – Synthetic #2



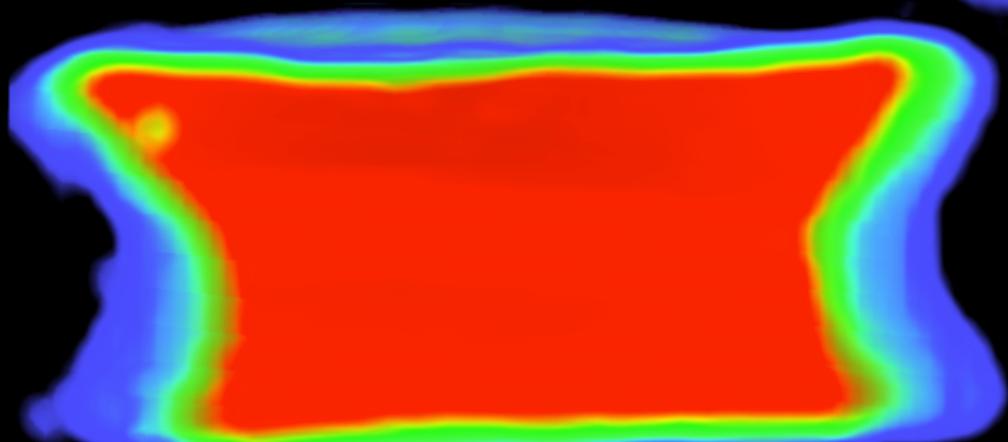
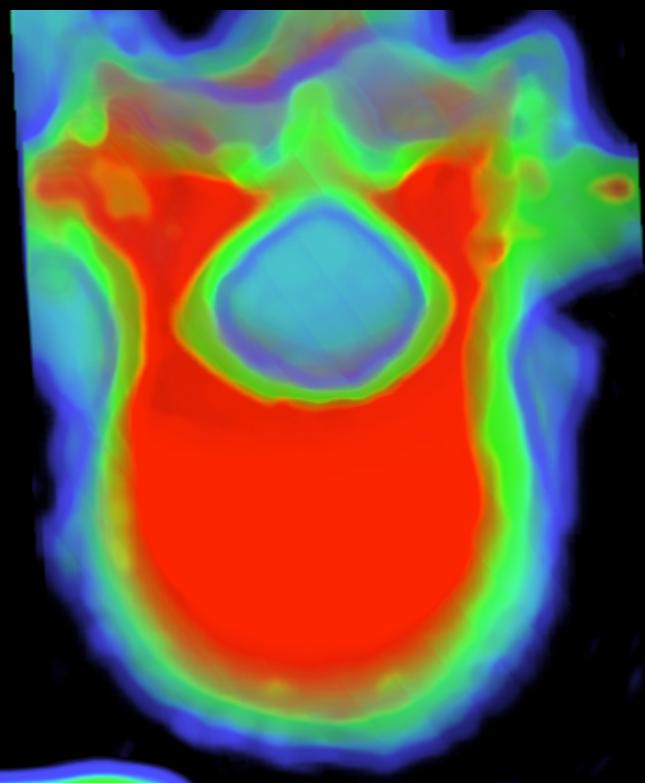
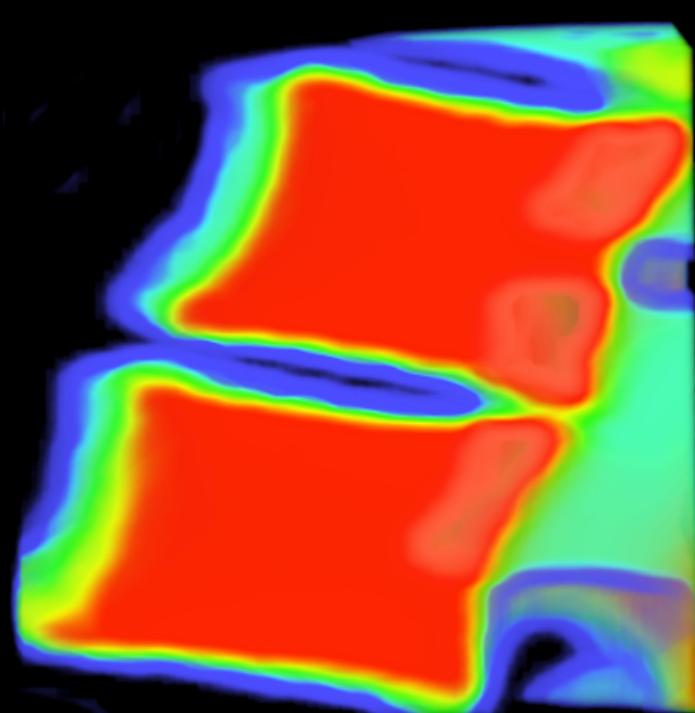
Results – Synthetic #2



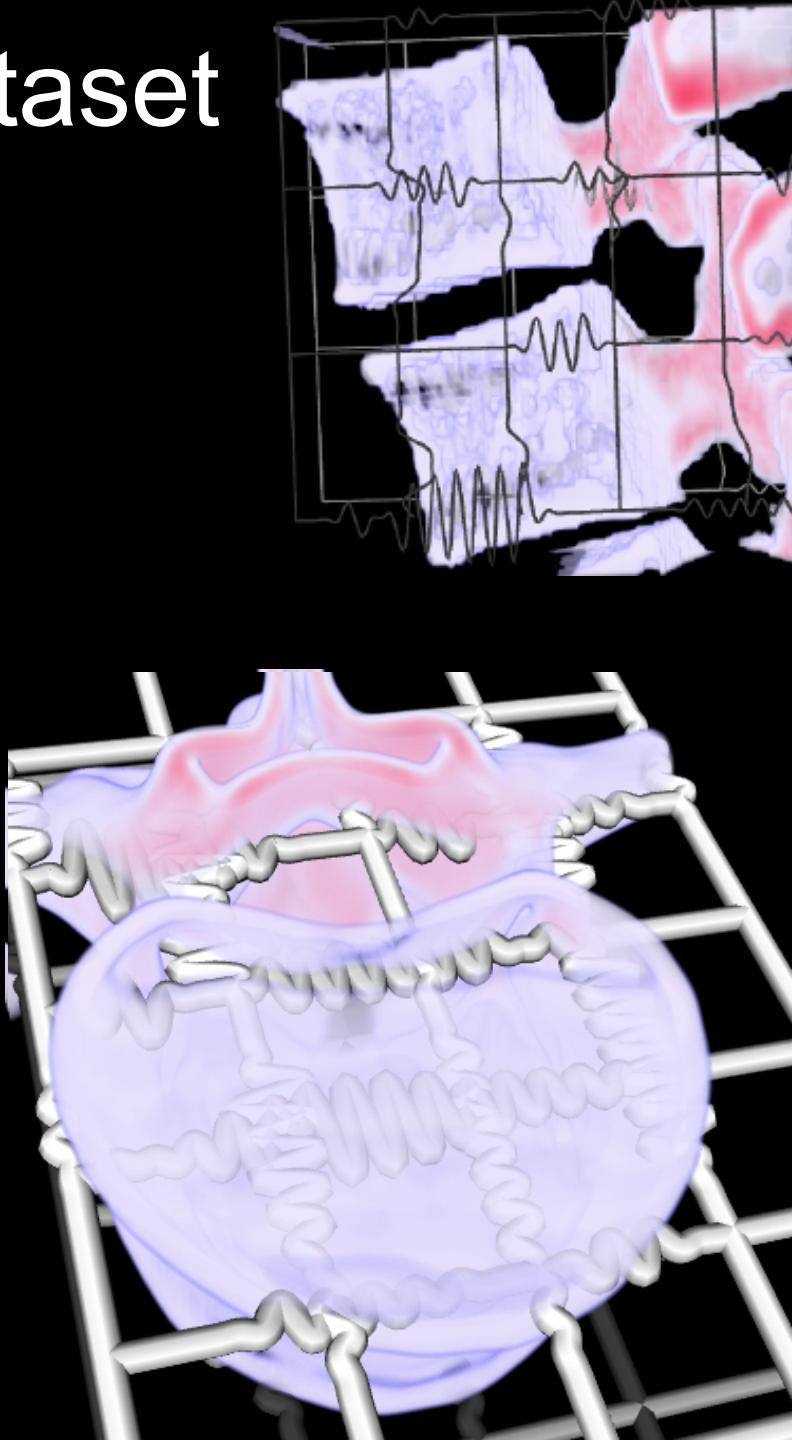
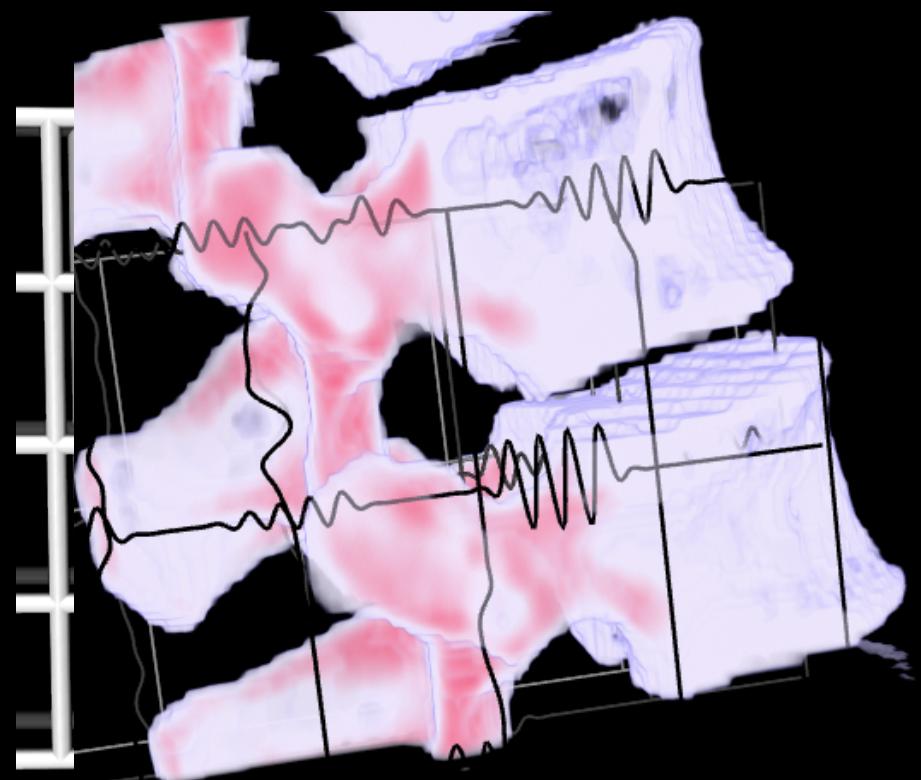
Lumbar Dataset



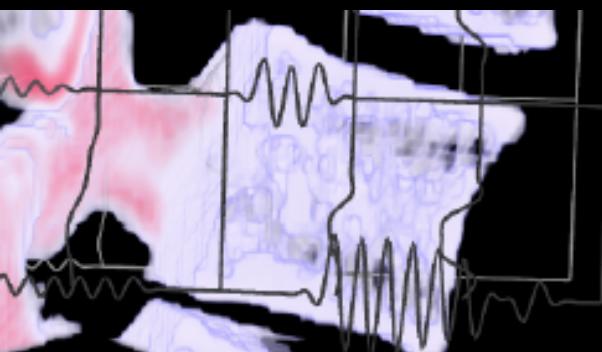
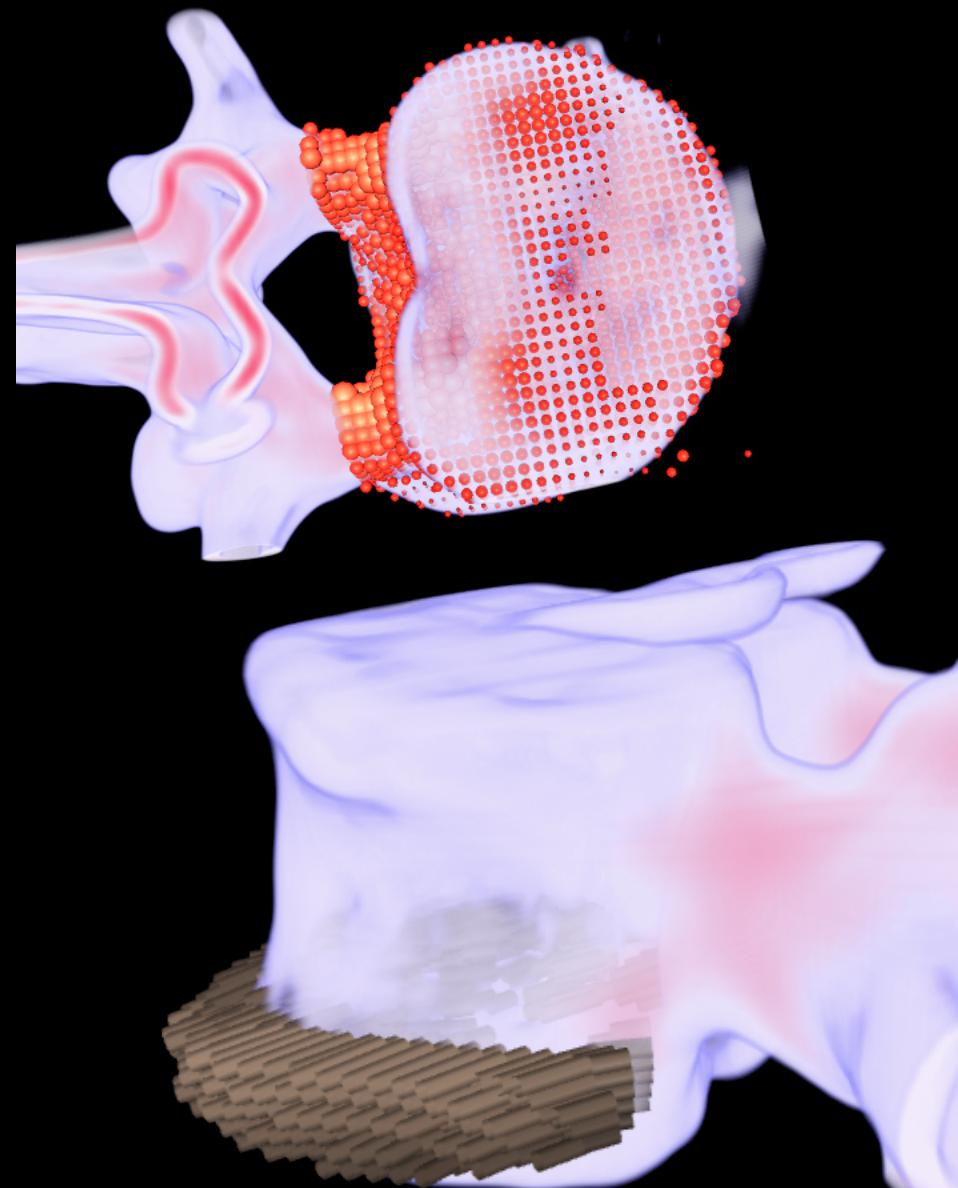
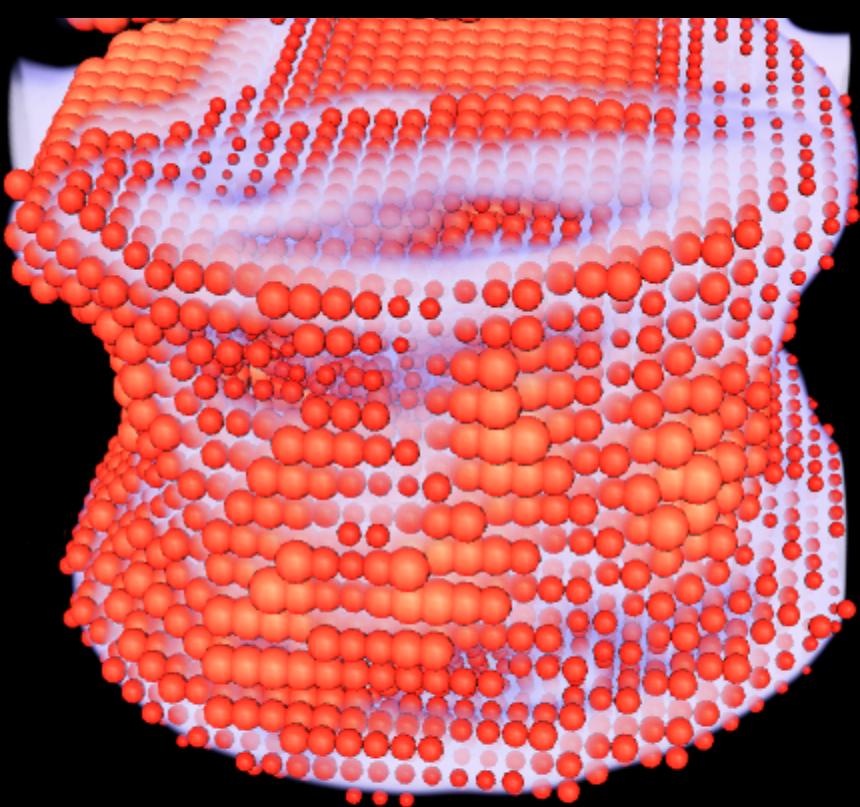
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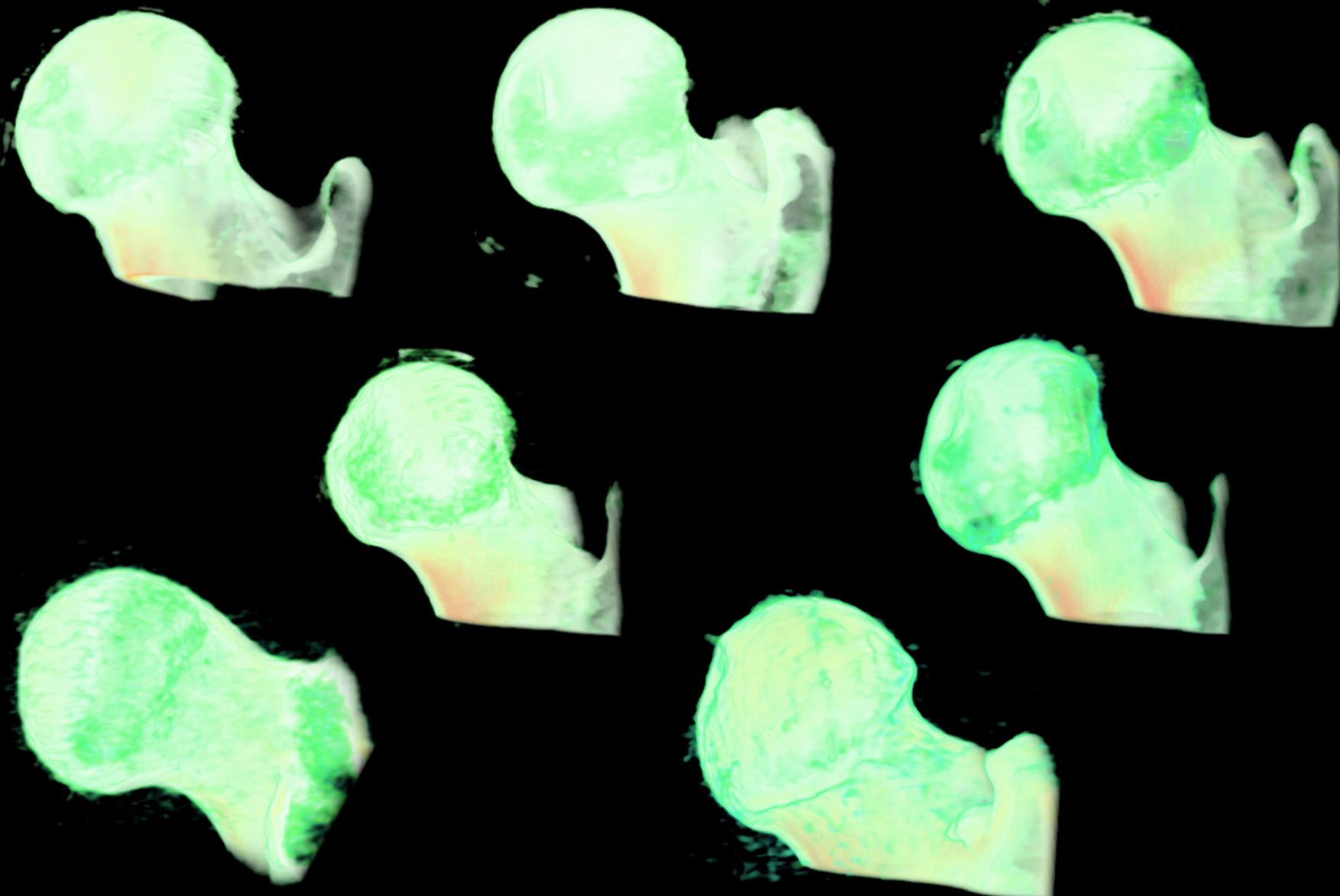
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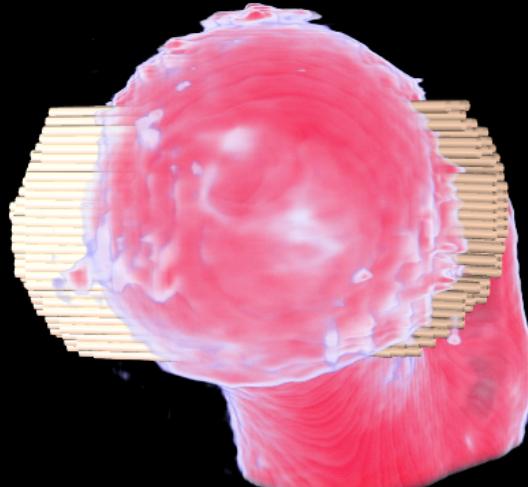
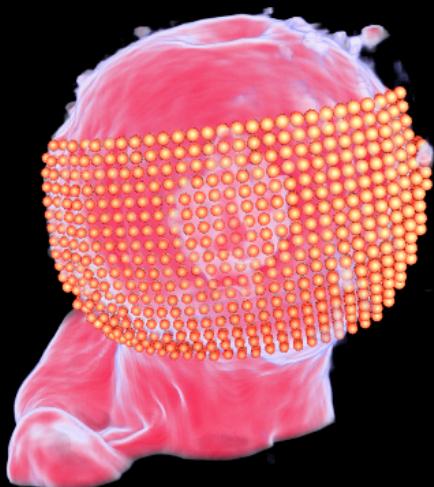
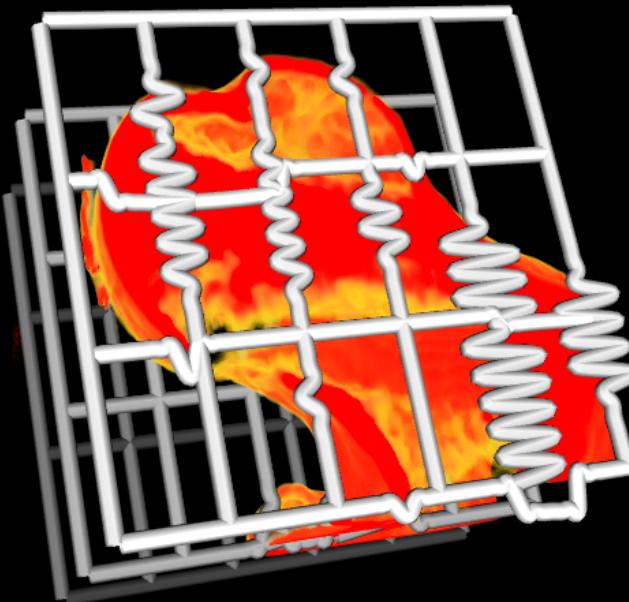
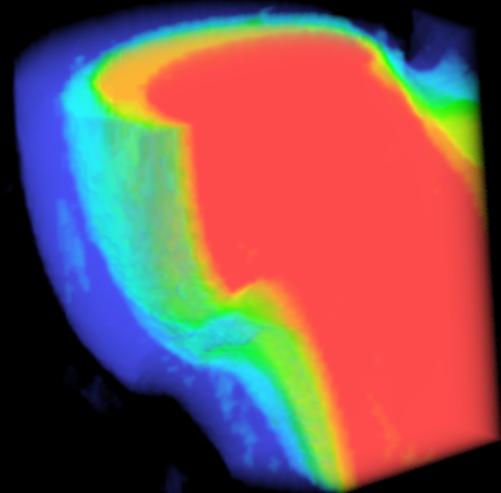
Lumbar Dataset



Femoral Head Dataset



Femoral Head Dataset





Conclusion

- Vector field visualization important to illustrate multiple attributes within volume data
- Consider combining different visualization techniques