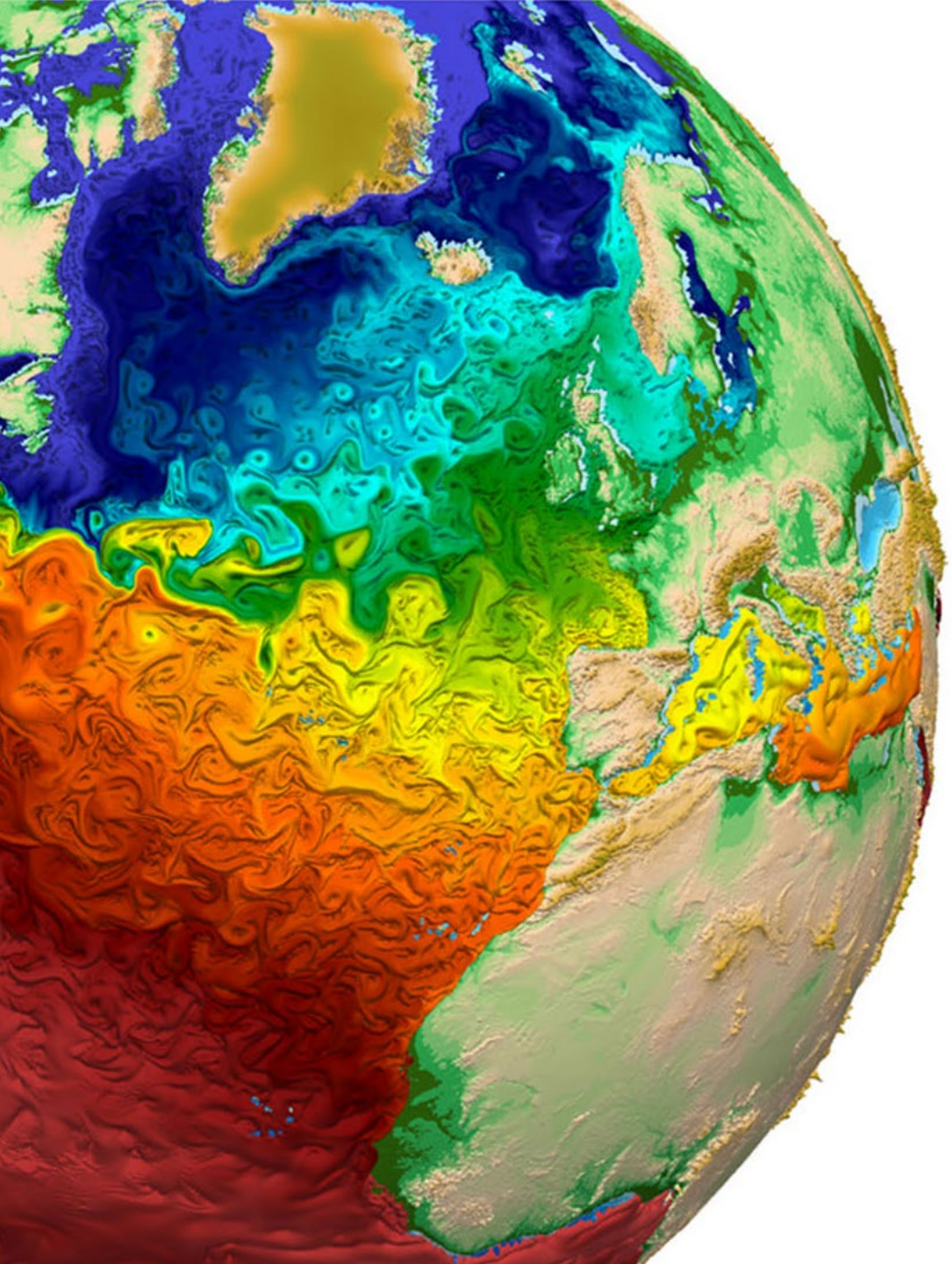

Vector Visualization

Introduction
Glyphs

Scientific Visualization

Professor Eric Shaffer

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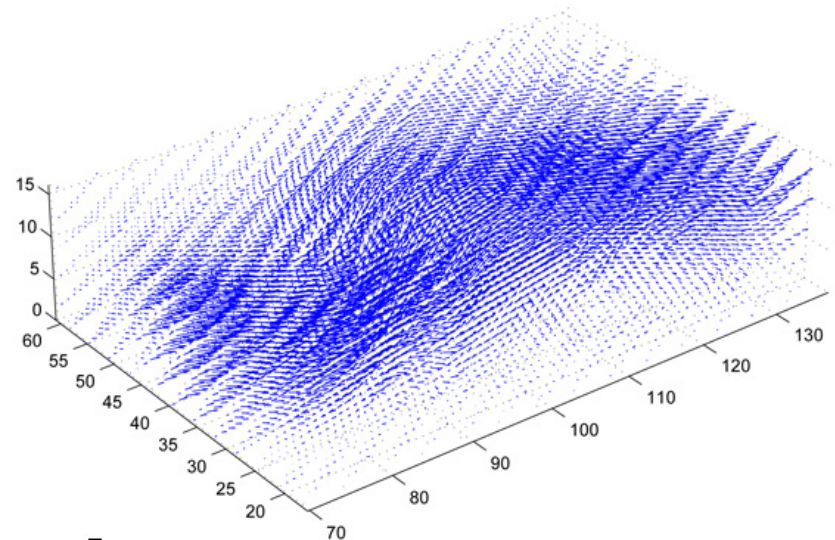
Vector Fields

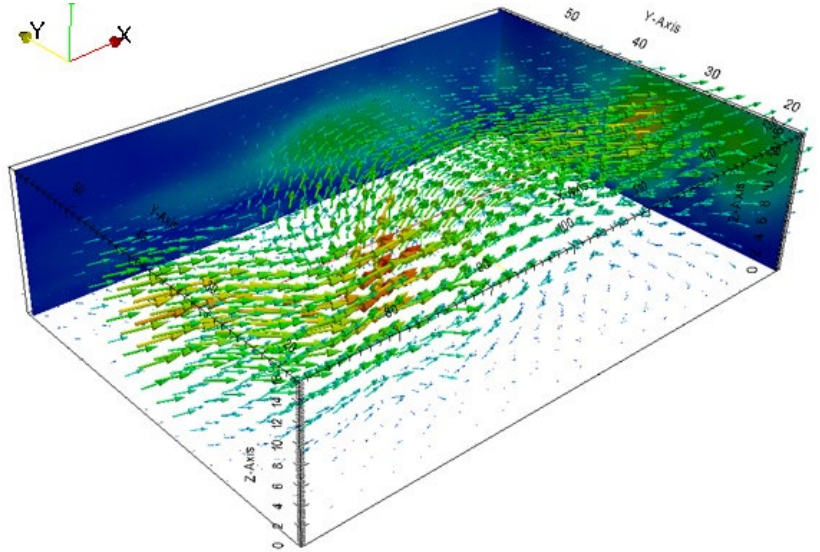
For each point in a domain we have a vector component and magnitude

- May be discretely sampled over domain
- Often results from study of fluid flow or
- Or by looking at derivatives (rate of change) of some scalar quantity

No visual intuition for what a vector field should look like

Many visualization techniques proposed





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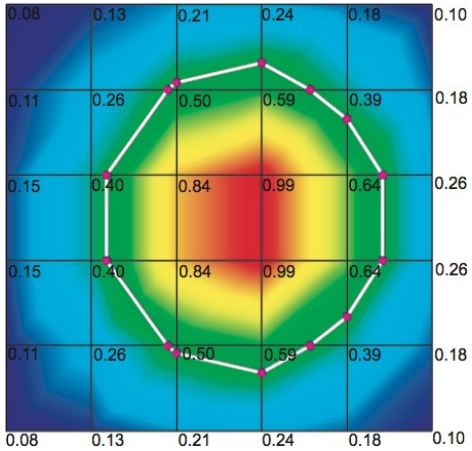
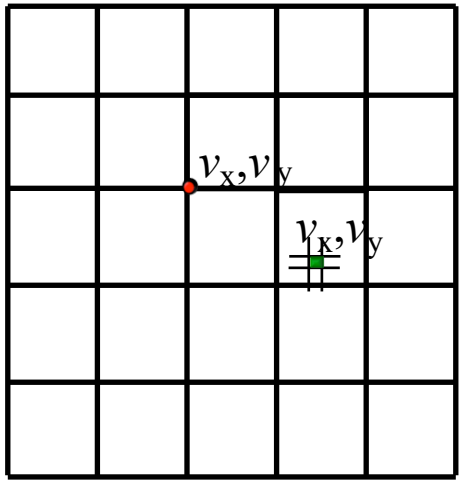
Vector Fields

Input data

- vector field $v : D \rightarrow \mathbf{R}^n$
- domain D 2D planar surfaces, 2D surfaces embedded in 3D, 3D volumes
- for typical scientific application: n=2 (fields tangent to 2D surfaces) or
  n=3 (volumetric fields)

Challenging compared with scalar visualization





Scalar visualization

- challenge is to map D to 2D screen
- after that, we have 1 pixel per scalar value

Vector visualization

- challenge is to map D to 2D screen
- after that, we have 1 pixel for 2 or 3 scalar values!

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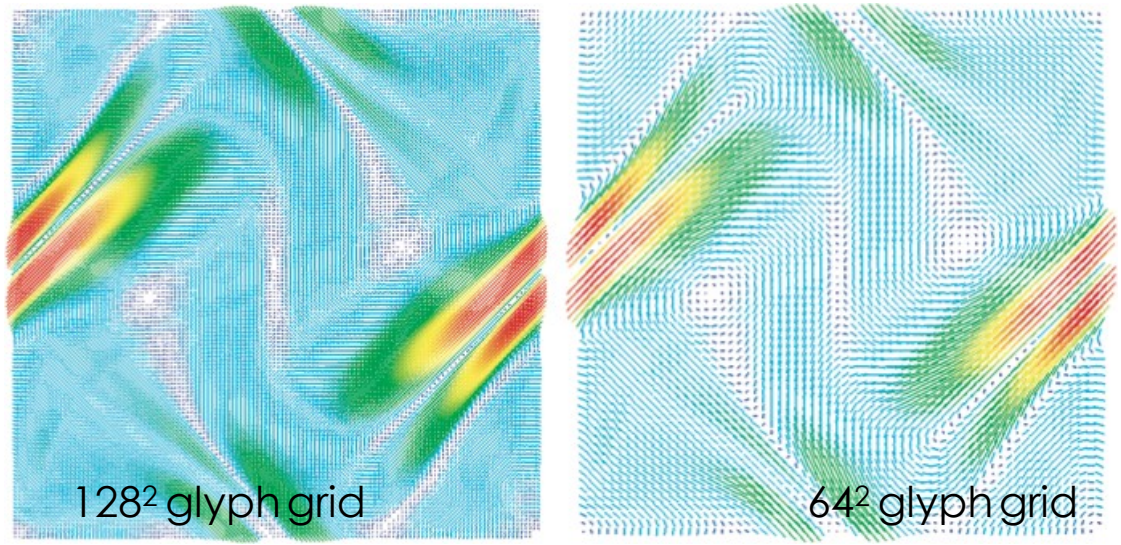
Glyphs

Icons, or signs, for visualizing vector fields

- placed by (sub)sampling the dataset domain
- attributes (scale, color, orientation) map vector data at sample points

Simplest glyph: Line segment (hedgehog plots)

- for every sample point $x \in D$
  - draw line $(x, x + k\mathbf{v}(x))$
  - optionally color map $||\mathbf{v}||$ onto it



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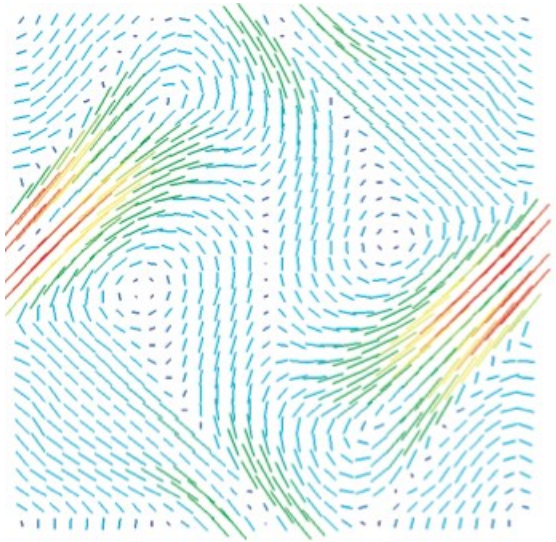
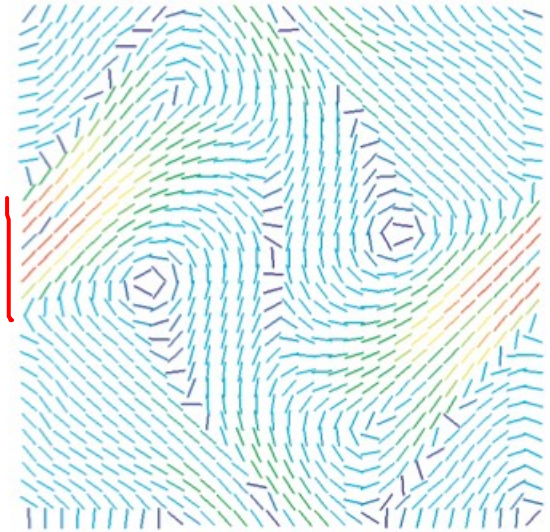
Glyphs



32^2 glyph grid



32^2 glyph grid, no line scaling

MHD simulation
256^2 grid

Observations:

- more samples: more data points depicted, but more potential clutter
- fewer samples: fewer data points depicted, but higher clarity
- more line scaling: easier to see high-speed areas, but more clutter
- less line scaling: less clutter, but harder to perceive directions

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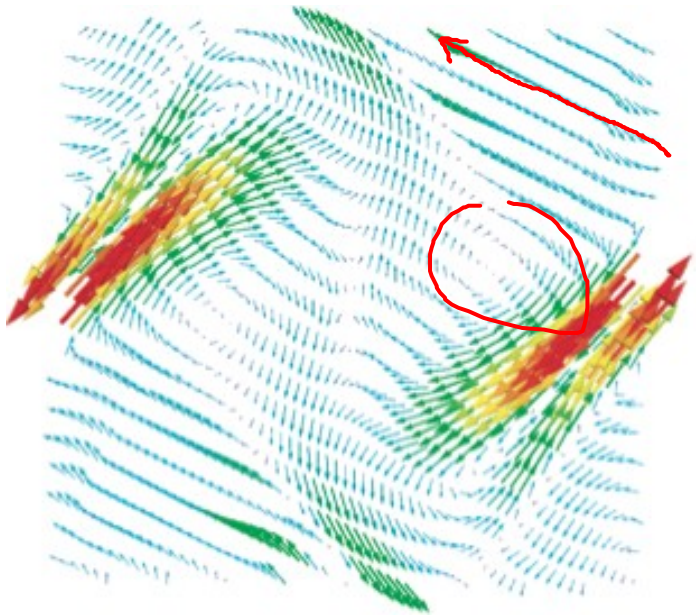
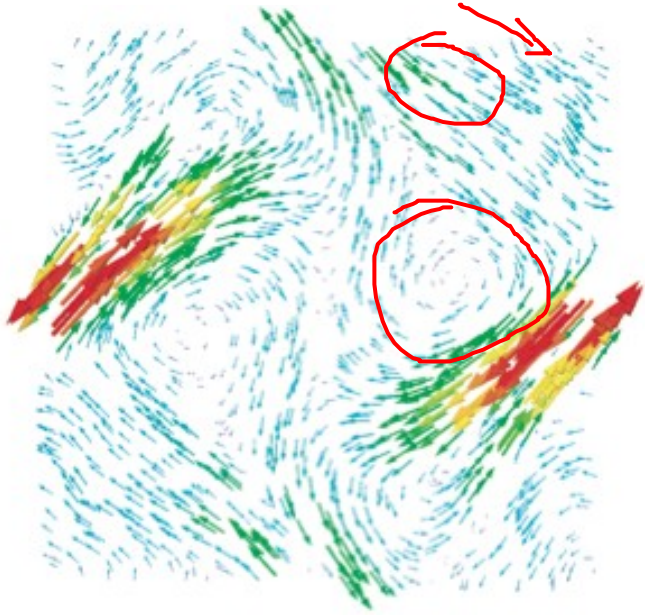
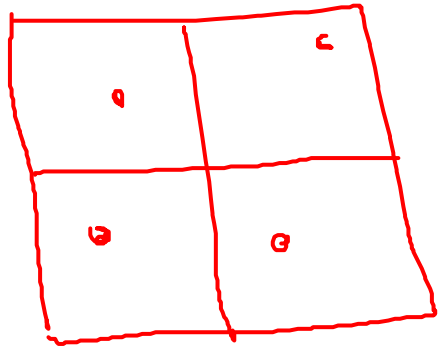
Glyphs



samples on a rotated grid



random samples, quasi-uniform density



How to choose sample points

- avoid uniform grids!
- random sampling: generally OK

What false impressions does the left plot convey w.r.t. the right plot?

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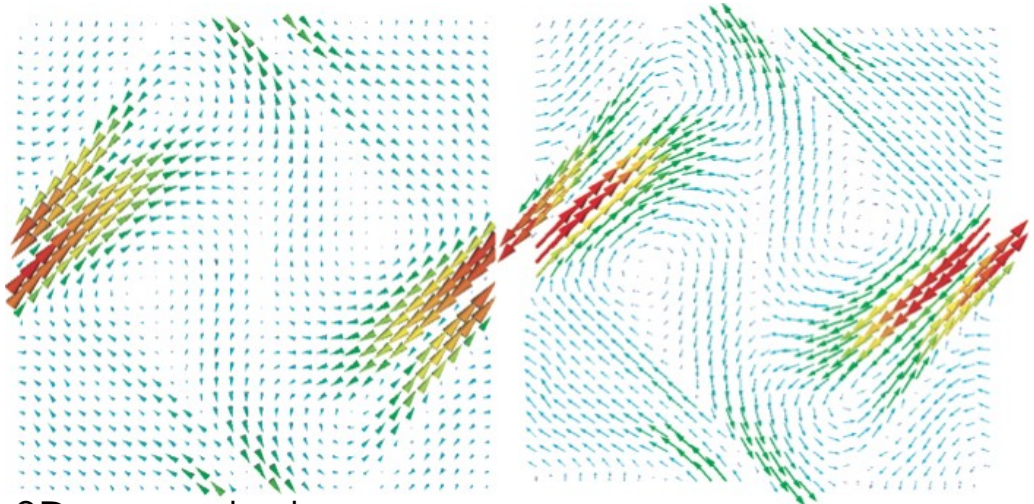
Glyphs



3D cone glyphs

3D arrow glyphs

Variants

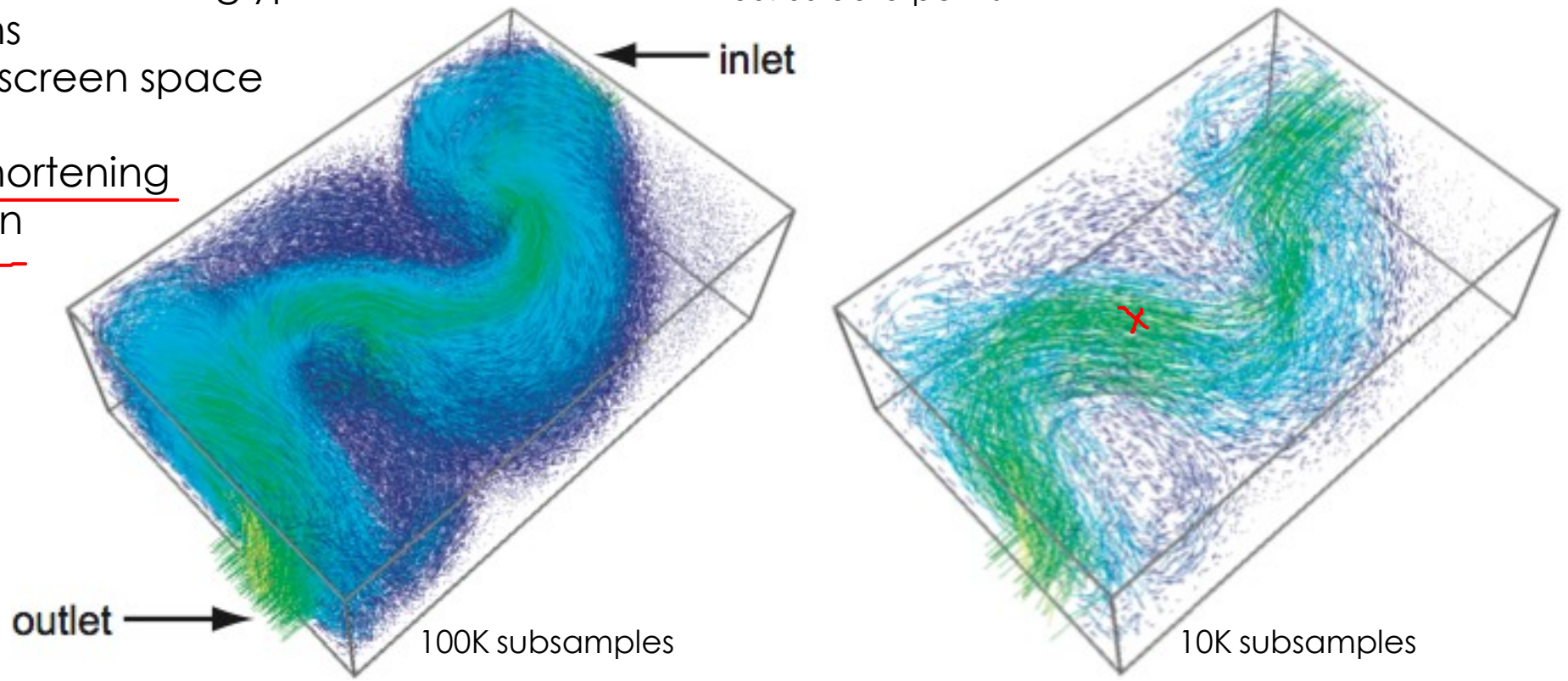
- cones, arrows, …
  - show *orientation* better than lines
  - but take more space to render
  - shading: good visual cue to separate (overlapping) glyphs

3D Glyphs

Same idea/technique as 2D vector glyphs

- 3D additional problems
  - more data, same screen space
  - occlusion
  - perspective foreshortening
  - viewpoint selection

128x85x42 volume field
456960 data points



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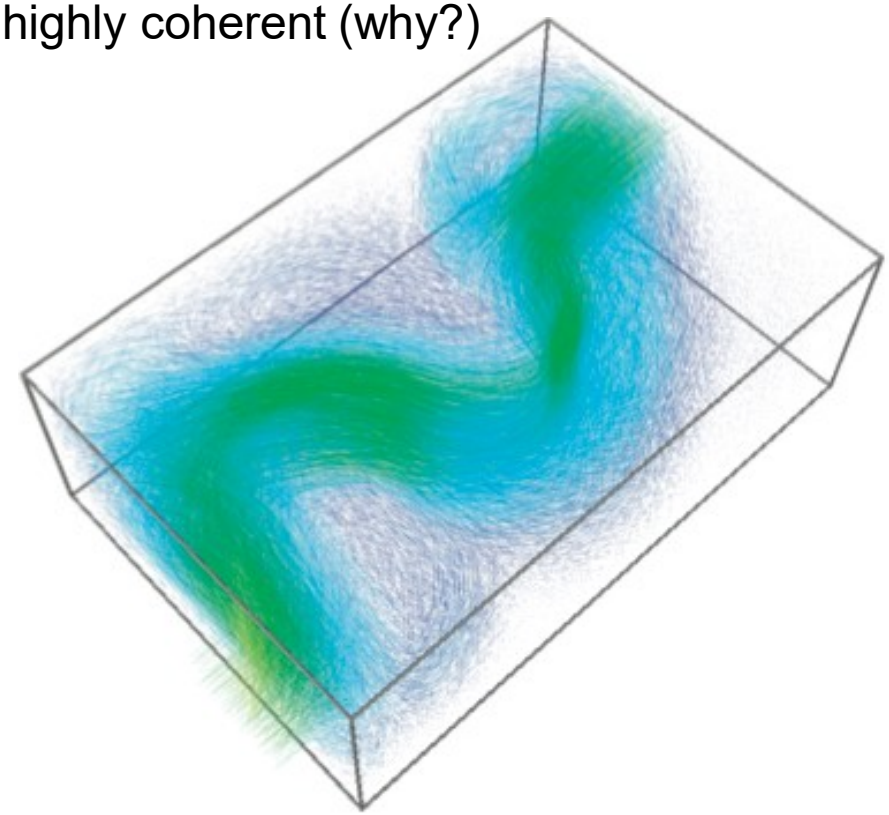
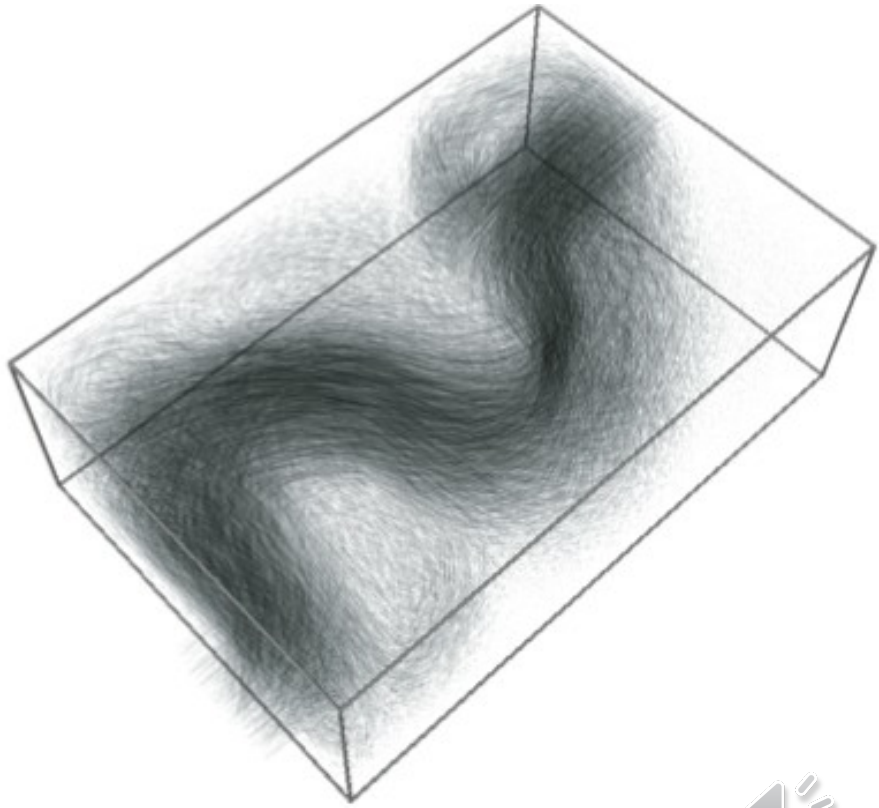
Glyphs in 3D

Alpha blending

- extremely simple and powerful tool
- reduce *perceived* occlusion
- low-speed zones: highly transparent
- high-speed zones: opaque and highly coherent (why?)

128x85x42 volume field
456960 data points





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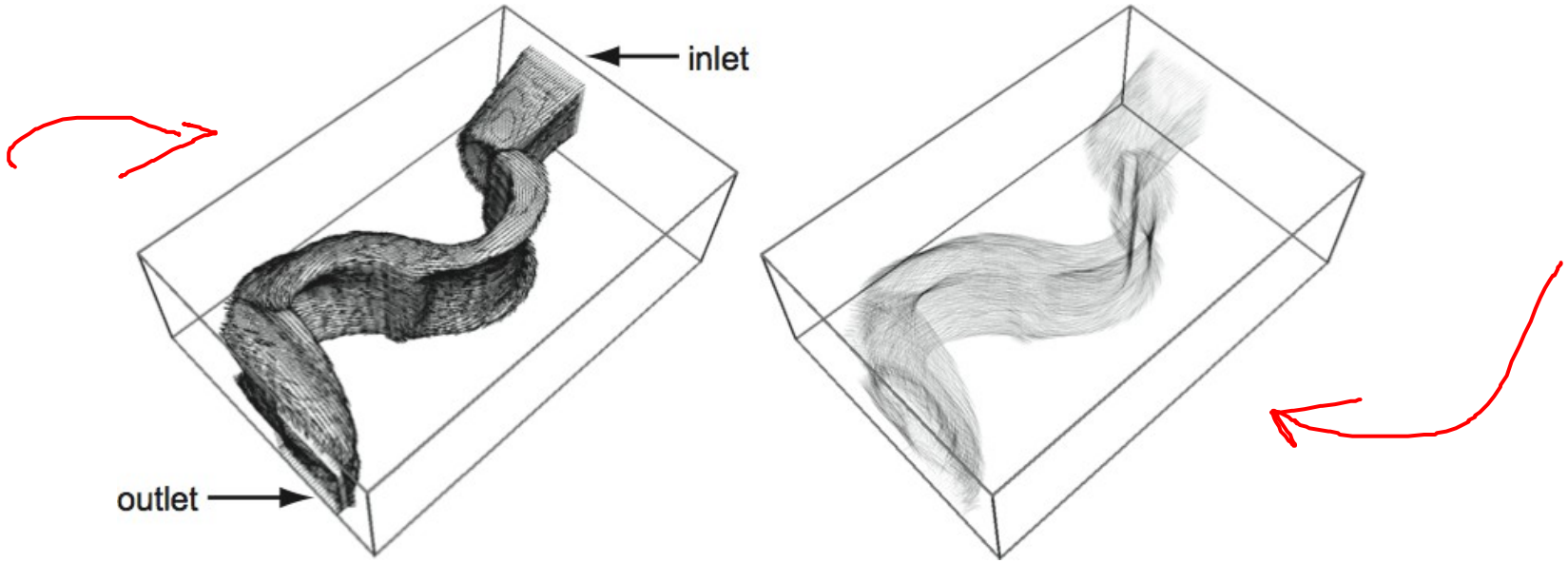
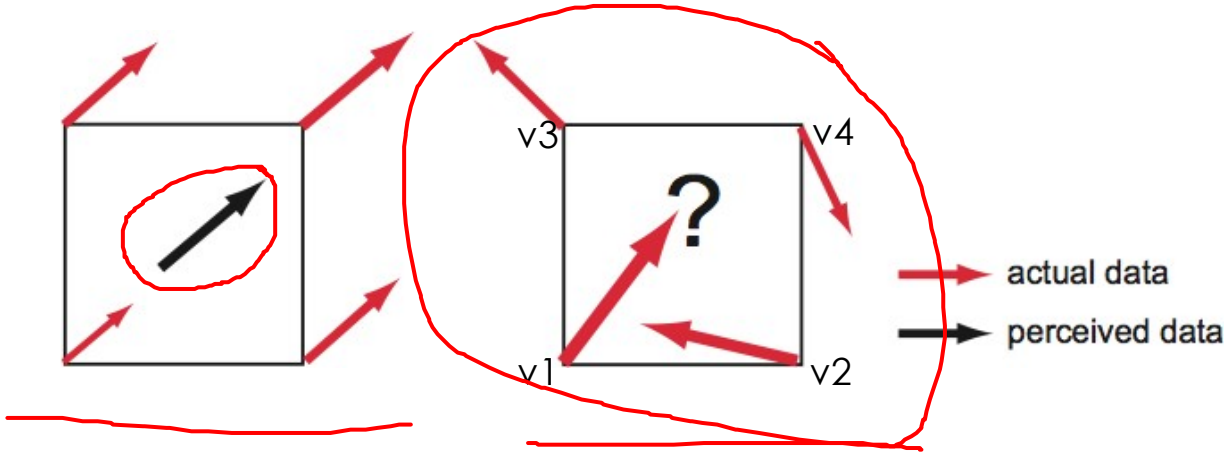
Glyphs on Surfaces

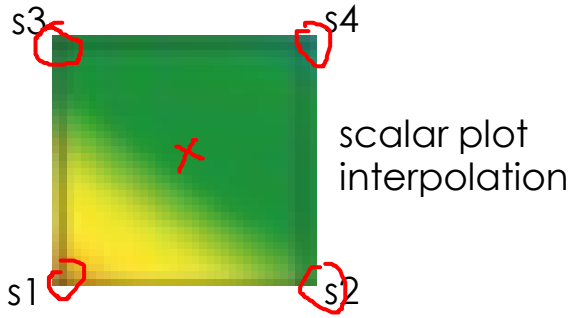


Trade-off between vector glyphs in 2D planes and in full 3D

- find interesting surface
  - e.g. **isosurface** of flow velocity
- plot 3D vector glyphs on it

Problems with Glyphs





The 'inverse mapping' proposal

- we render something…
- …so we can visually map it to some data/phenomenon

Glyph problems

- **no interpolation** in glyph space (unlike for scalar plots with color mapping!)
- a glyph takes more space than a pixel
- we (humans) aren't good at visually interpolating arrows…
- scalar plots are **dense**; glyph plots are **sparse**
  - this is why glyph positioning (sampling) is extra important

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