Feature Extraction and Flow Field Visualization

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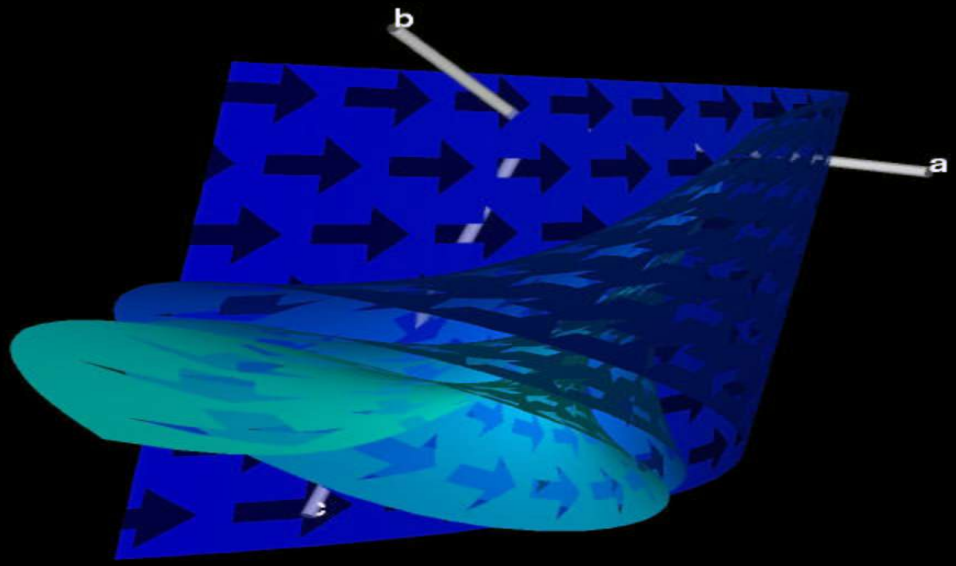

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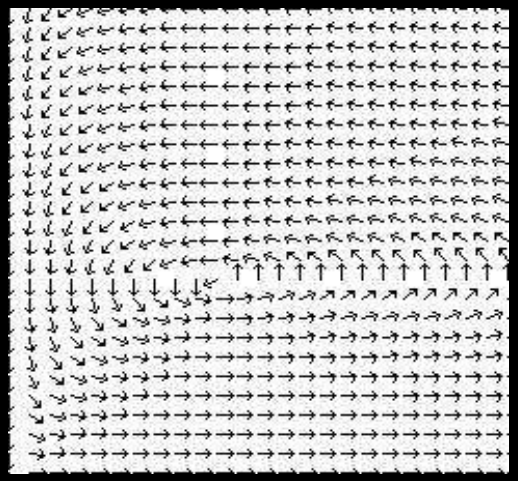
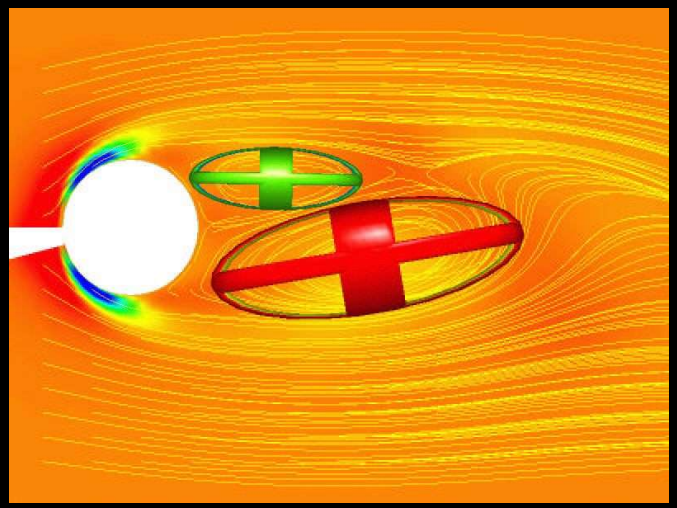
From 2D to 3D, from arrows to features

- Simple visualization of 2D flow
- Slices in 3D
- Features in 3D





- Arrows
- ...
- Features in 3D

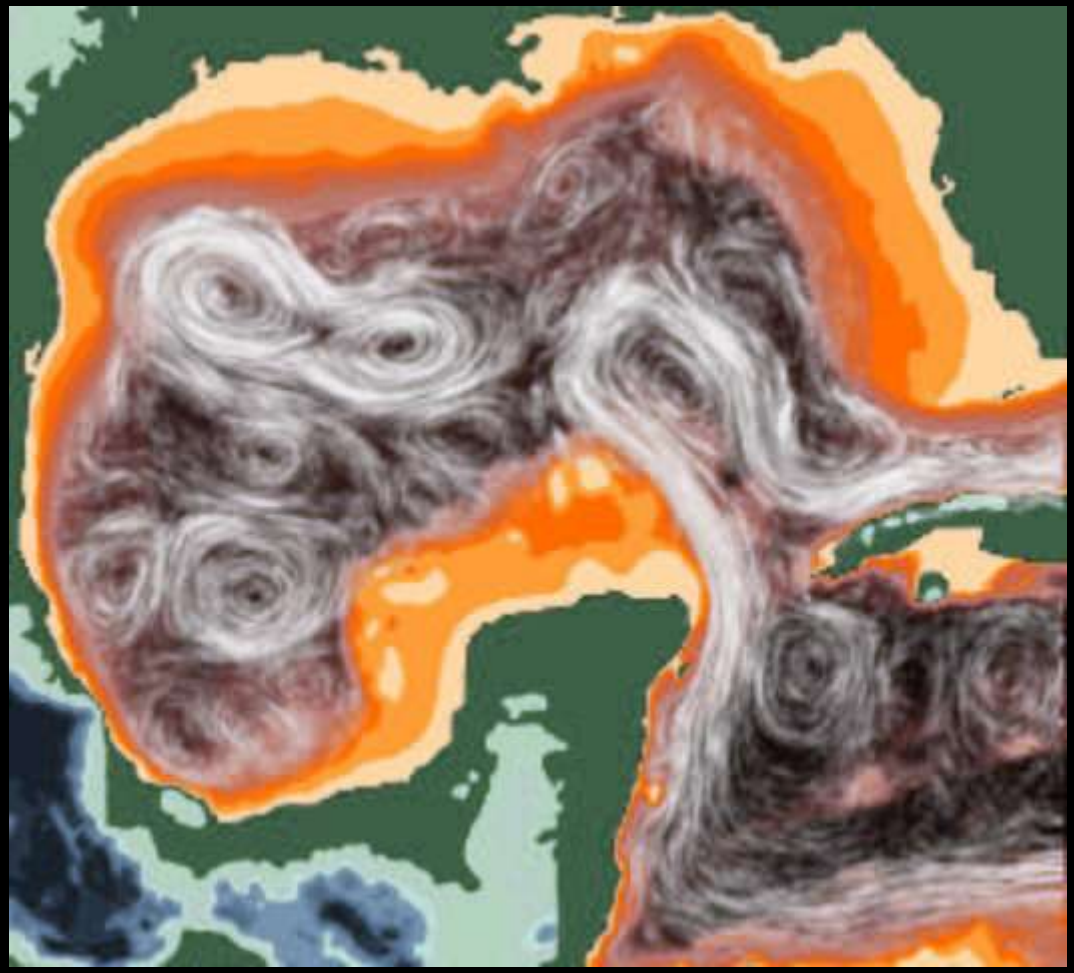
What is the flow?

- An inherent characteristic of flow data is that derivative information is given with respect to time, which is laid out across n-dimensional domain ...
- ... just a bunch of velocities, acceleration, rotation, flow convergence/divergence, ...

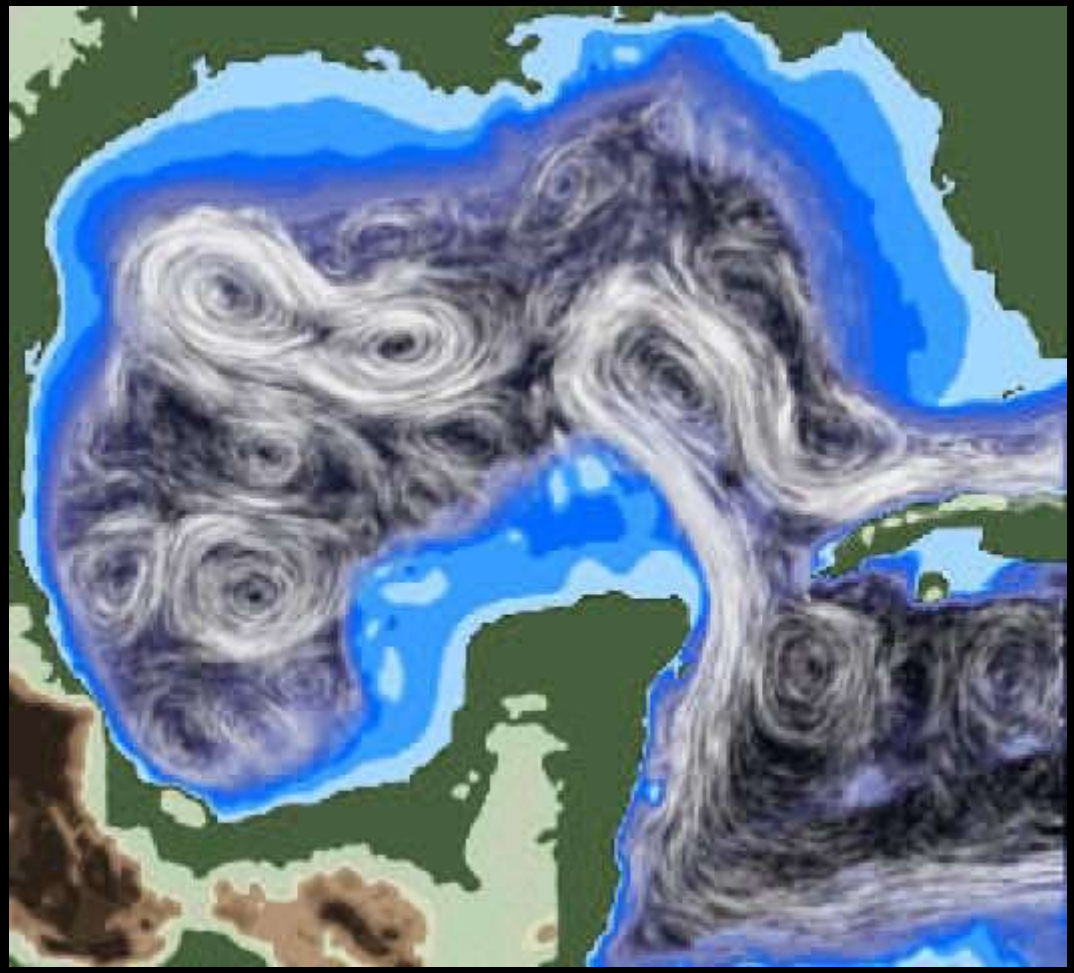
Direct visualization in 2D

- Direct mapping from data to the visual representation
- No complex conversions or extraction steps
- Very intuitive for the user – data is presented as is
- Problem with time
- Size of the domain

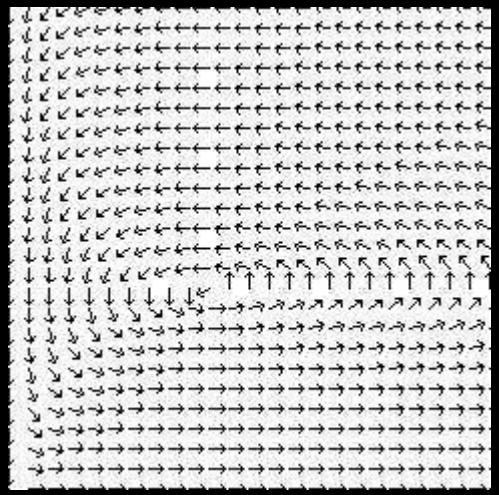
Color coding in 2D



Color coding in 2D II.

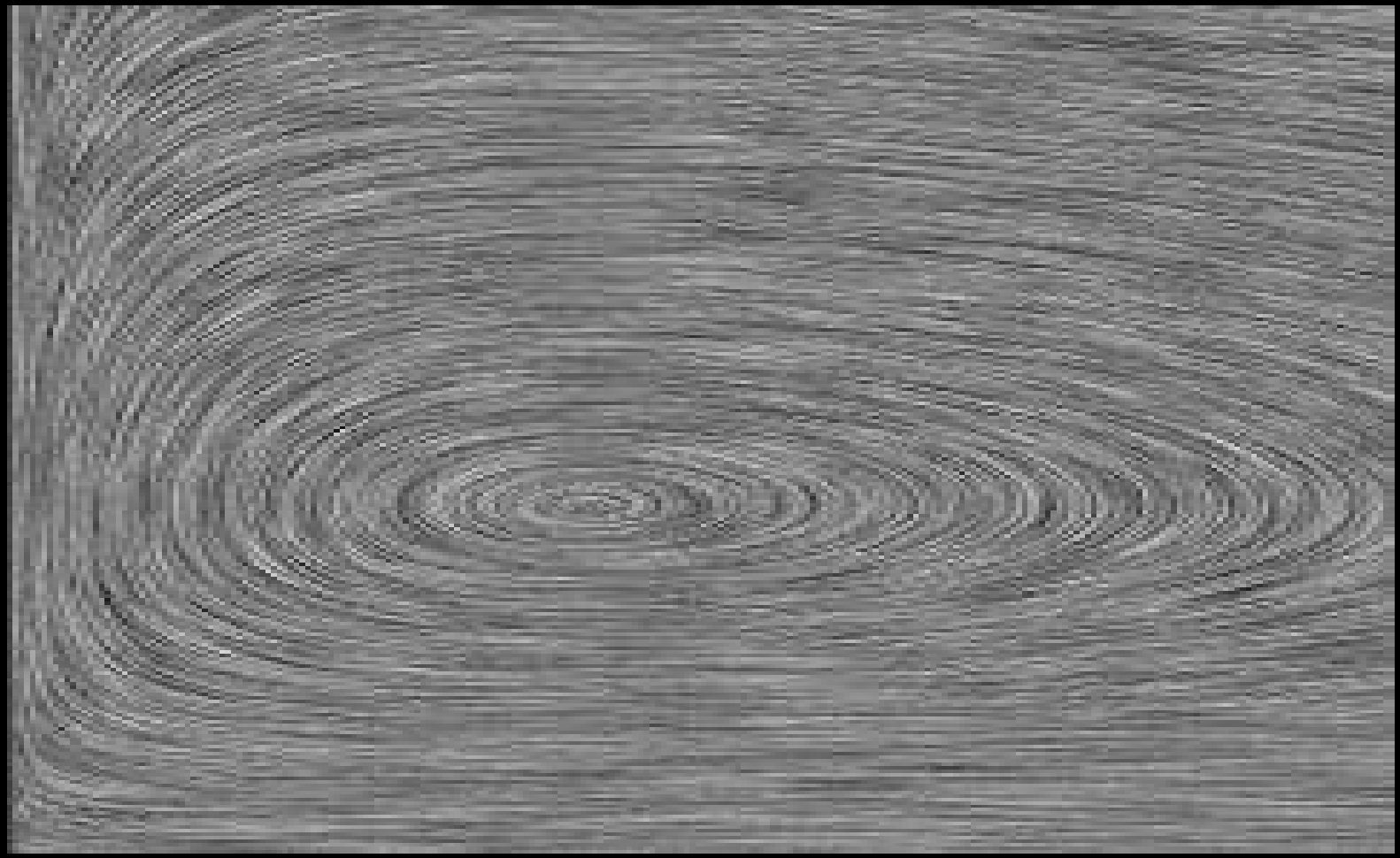


Arrows in 2D

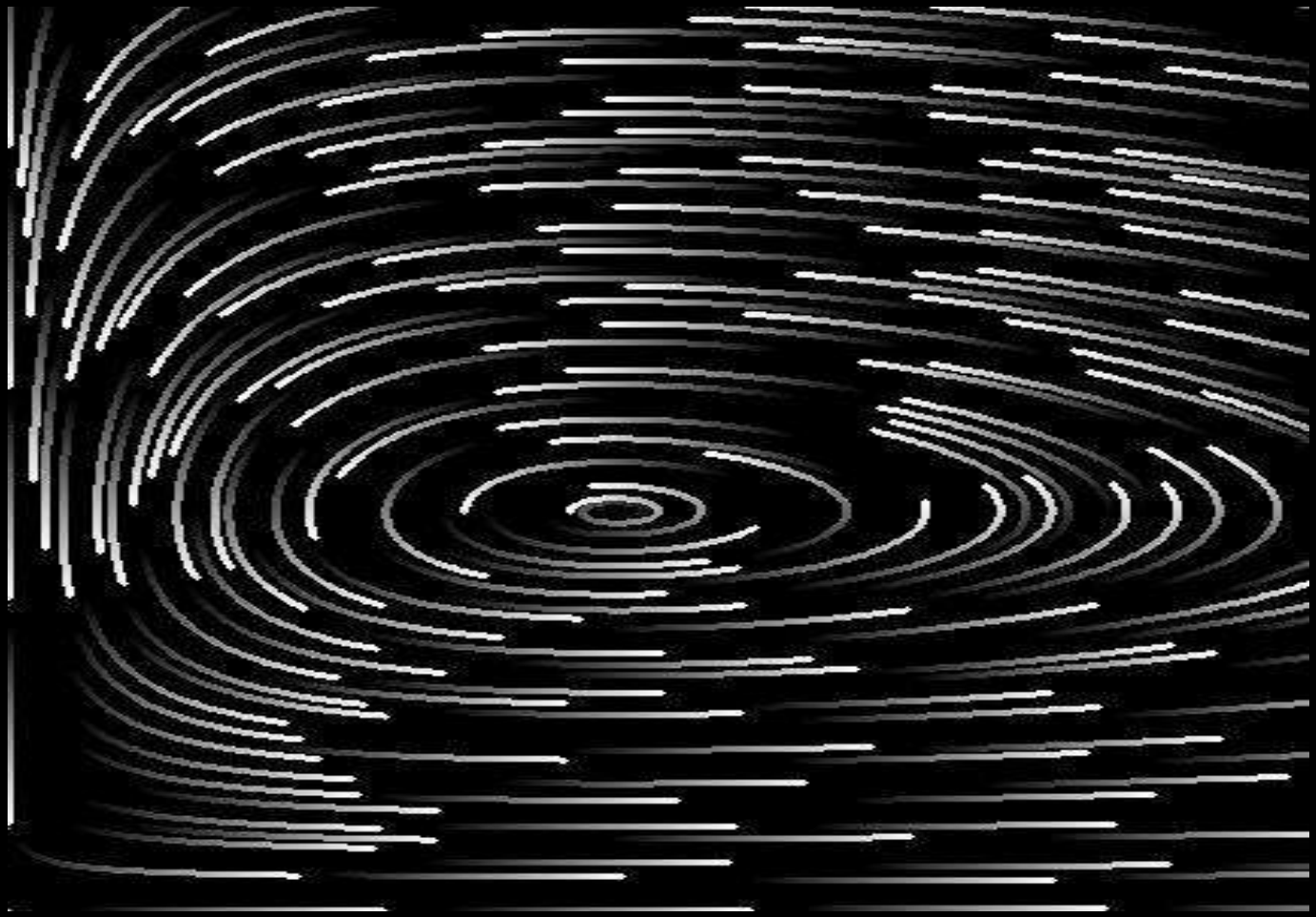


Hedgehog visualization

Line integral convolution (LIC)

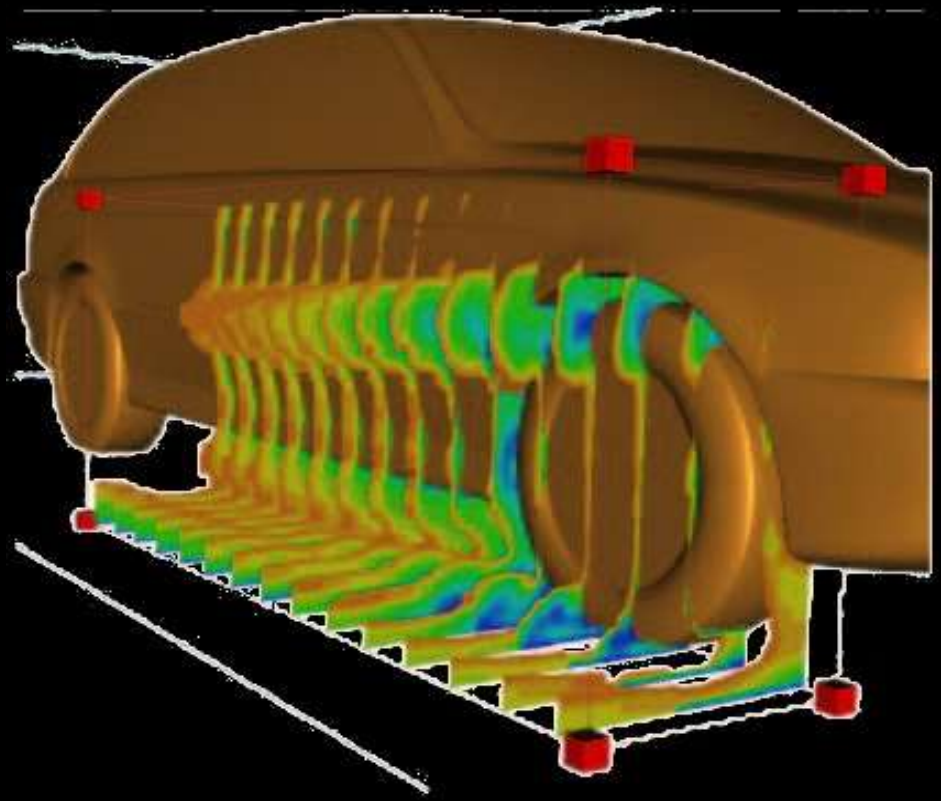


Other primitives in 2D

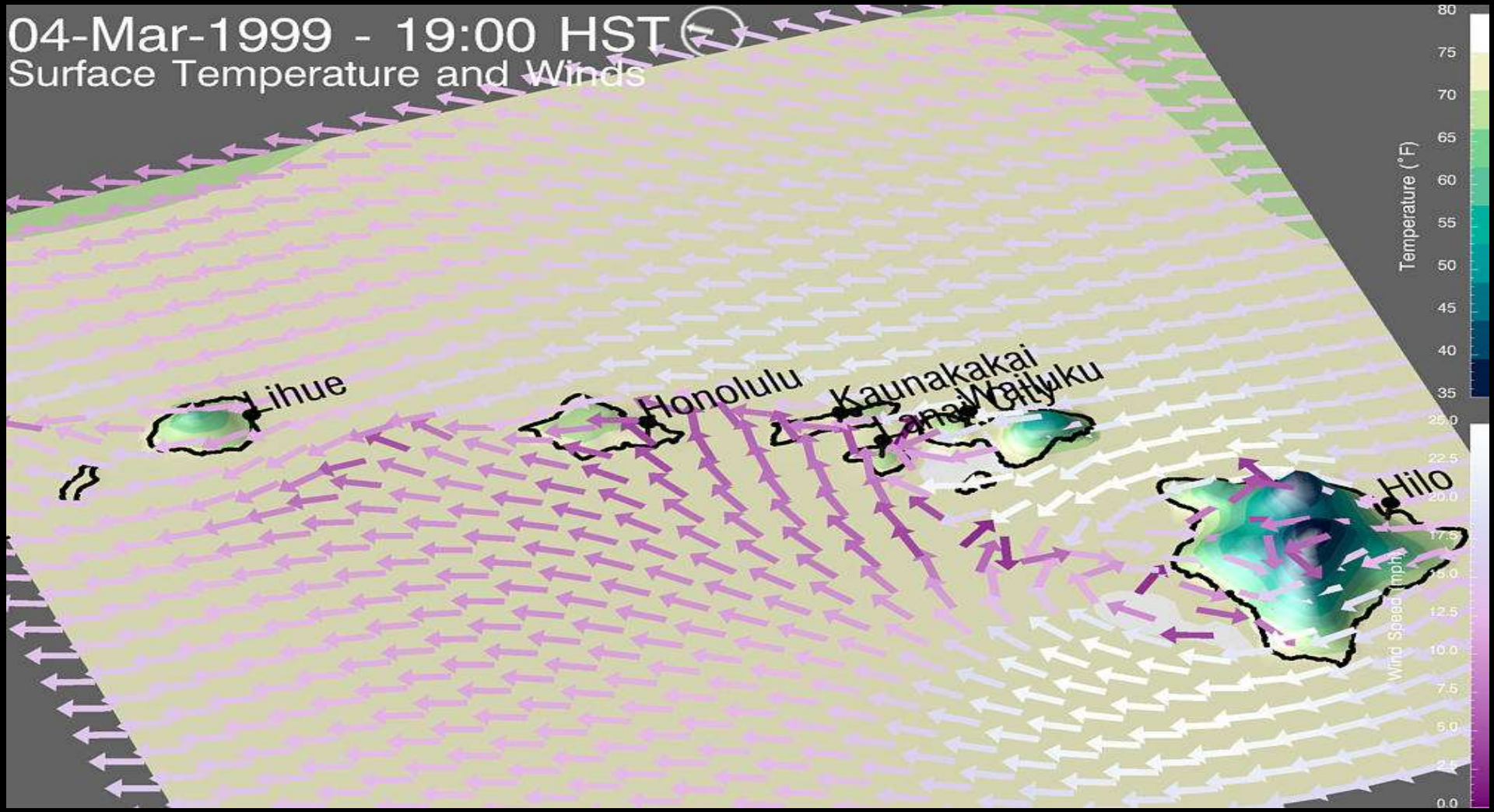


Direct flow visualization on slices or boundaries

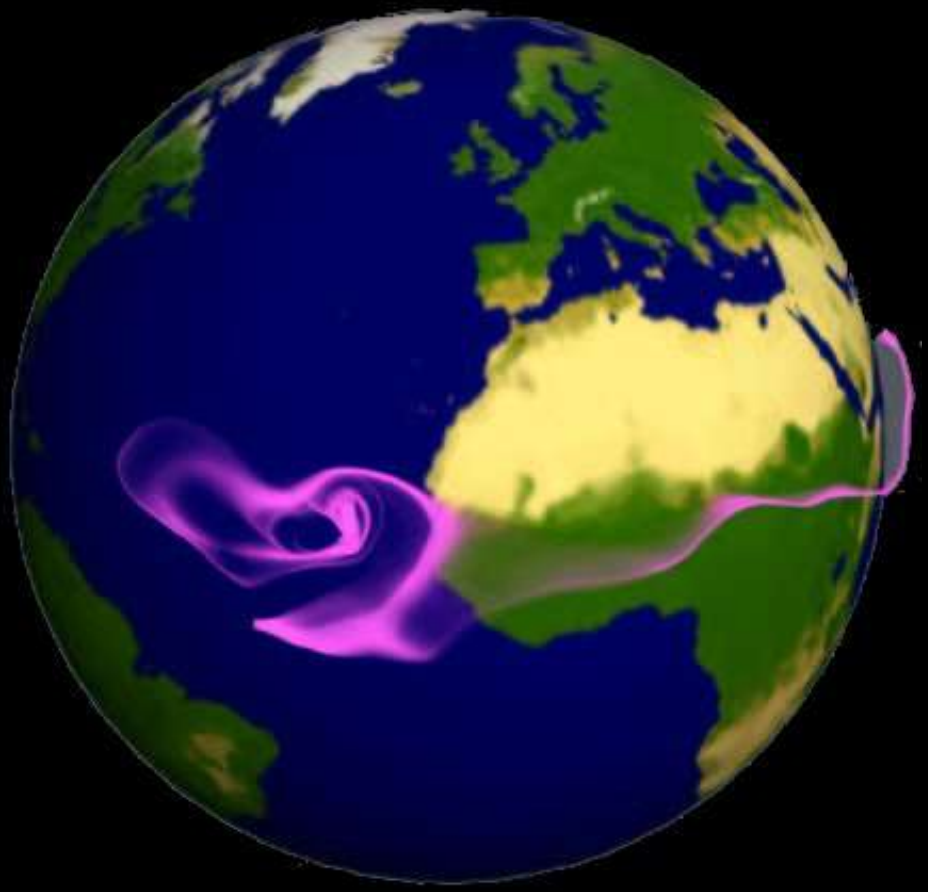
- Inter step between 2D and 3D -> 2D techniques are used



Orthogonal components

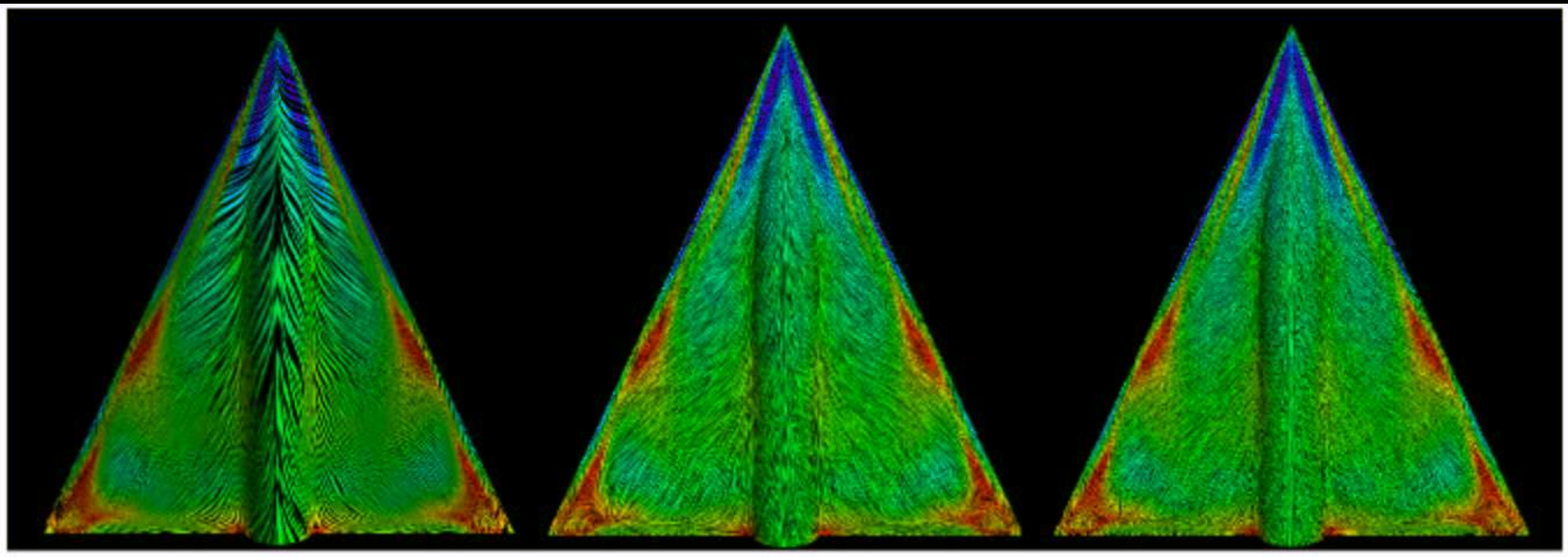


3D, hurray



Arrows in 3D

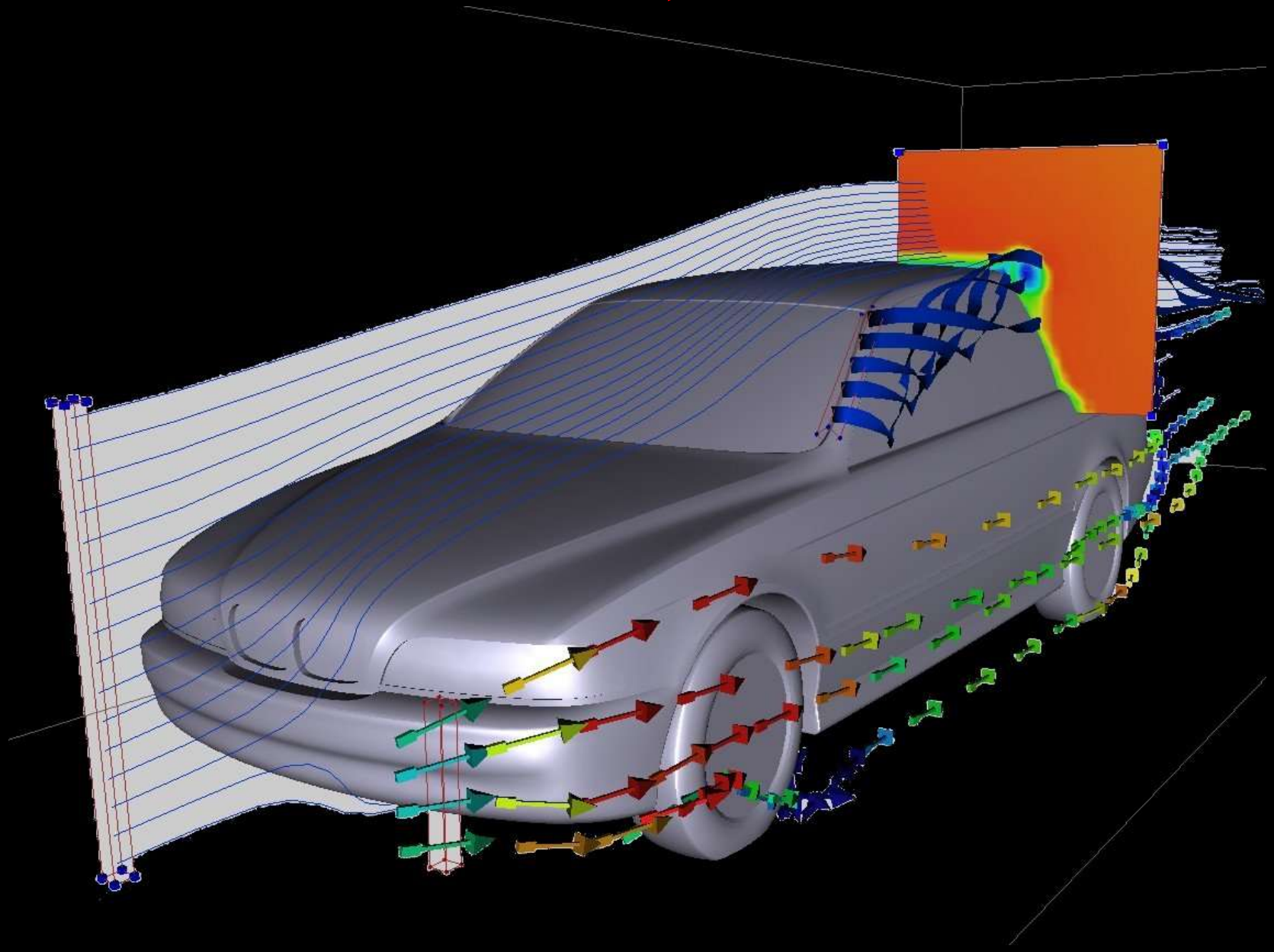
Linear Integral Convolution in 3D



Visualization using Integral Objects

- Streamlets
- Streamlines
- Pathline (particle trace)
- Timeline
- Streakline

Streamribbons, streamtubes



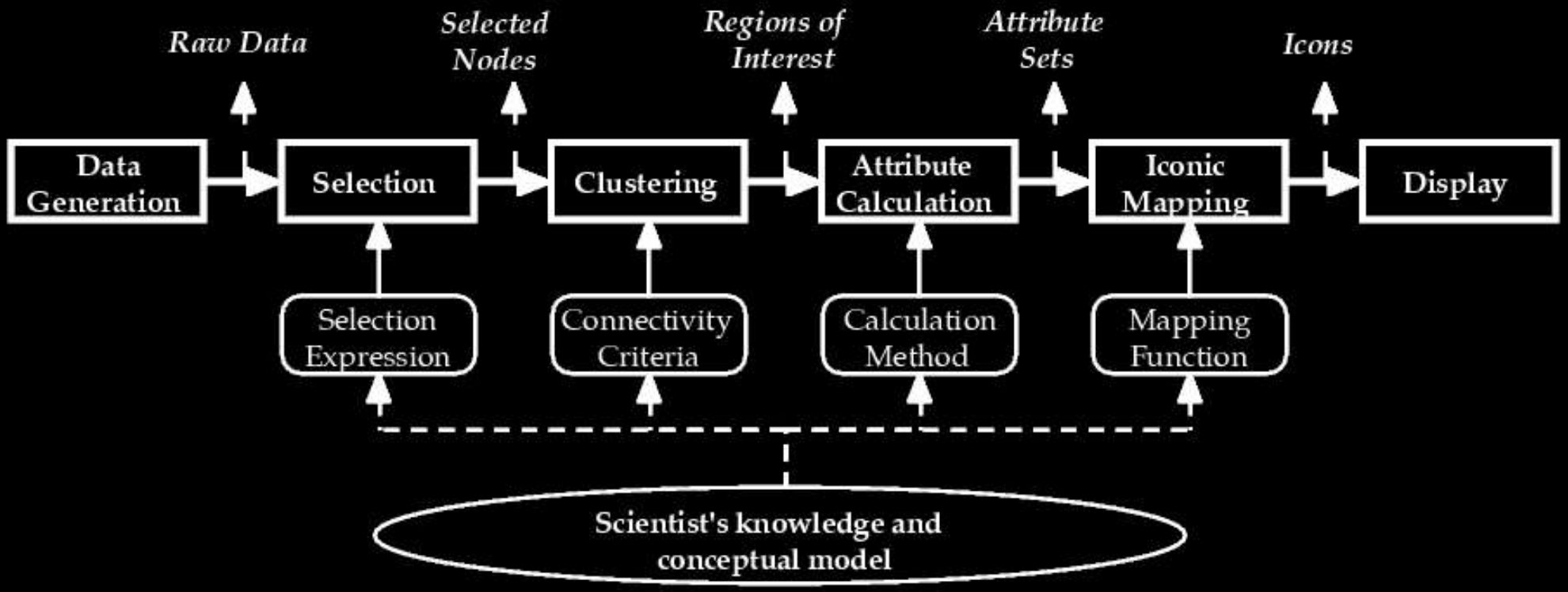
Features extraction

- Flow is no more described by it's values, but by it's features
- Examples of features:
  - vortex
  - shock wave
  - separation line
  - attachment line
- Huge data size reduction

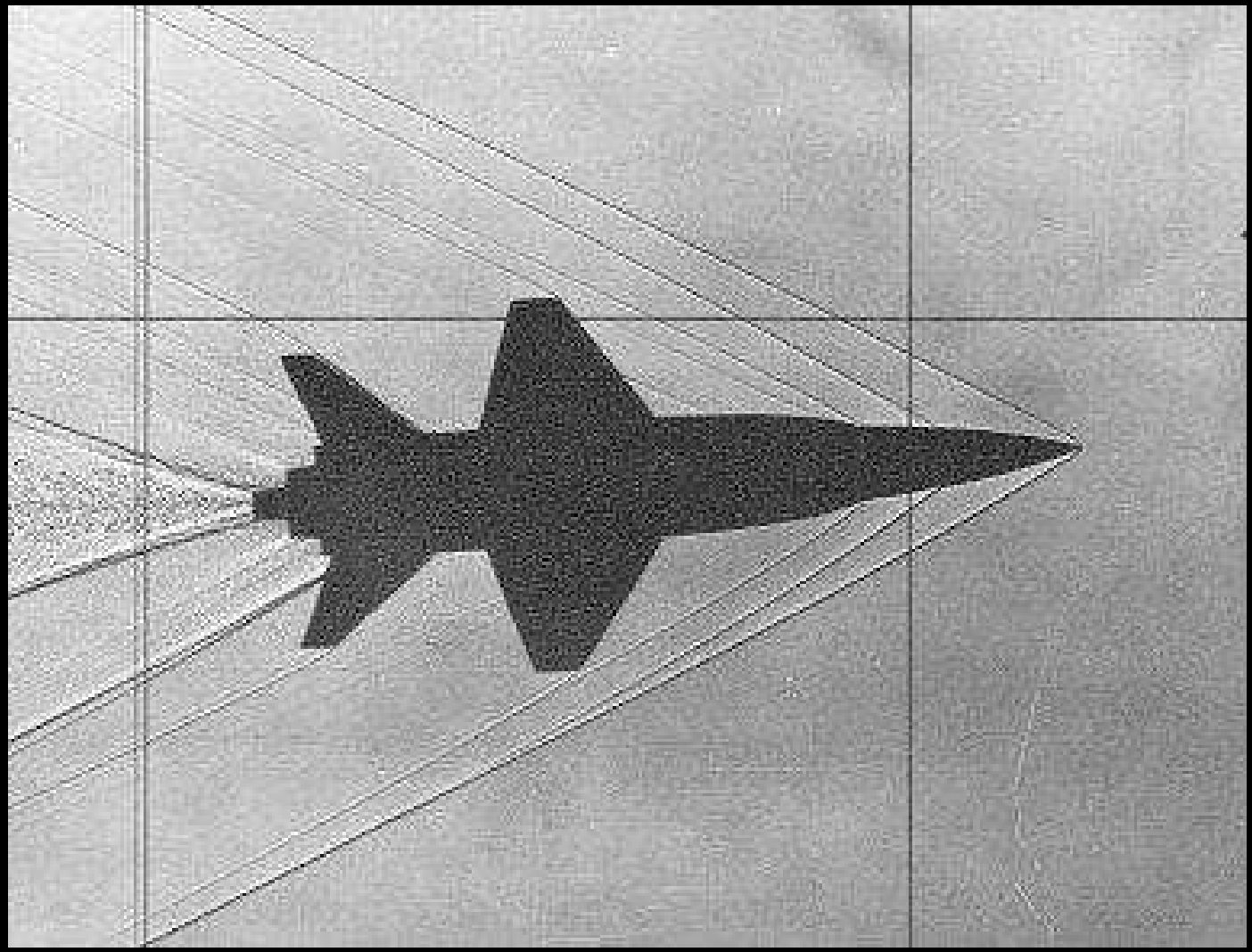
Image processing based feature extraction

- Originally developed for analysis of 2D and 3D image data, usually represented as scalar (grayscale) values on a regular rectangular grid
- Feature may be distinguished by range of data values (like in medical images)
- Edge detection
- Segmentation

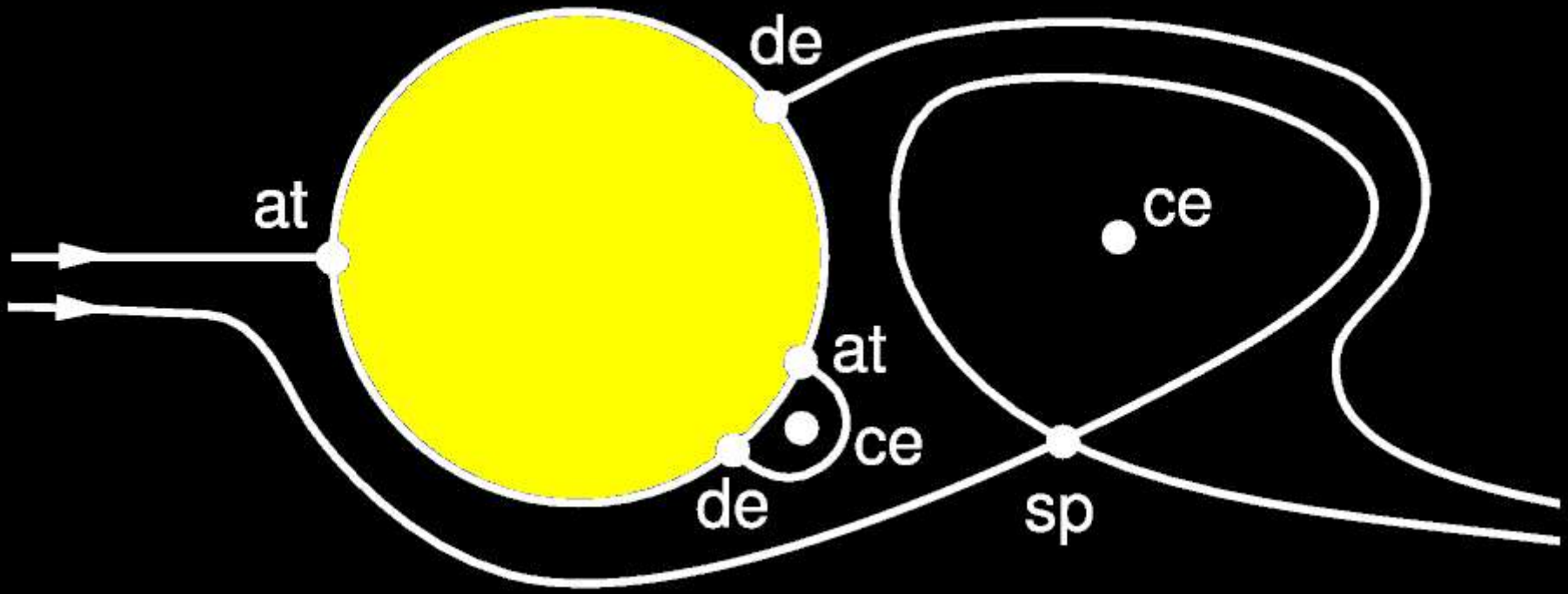
Selective visualization pipeline



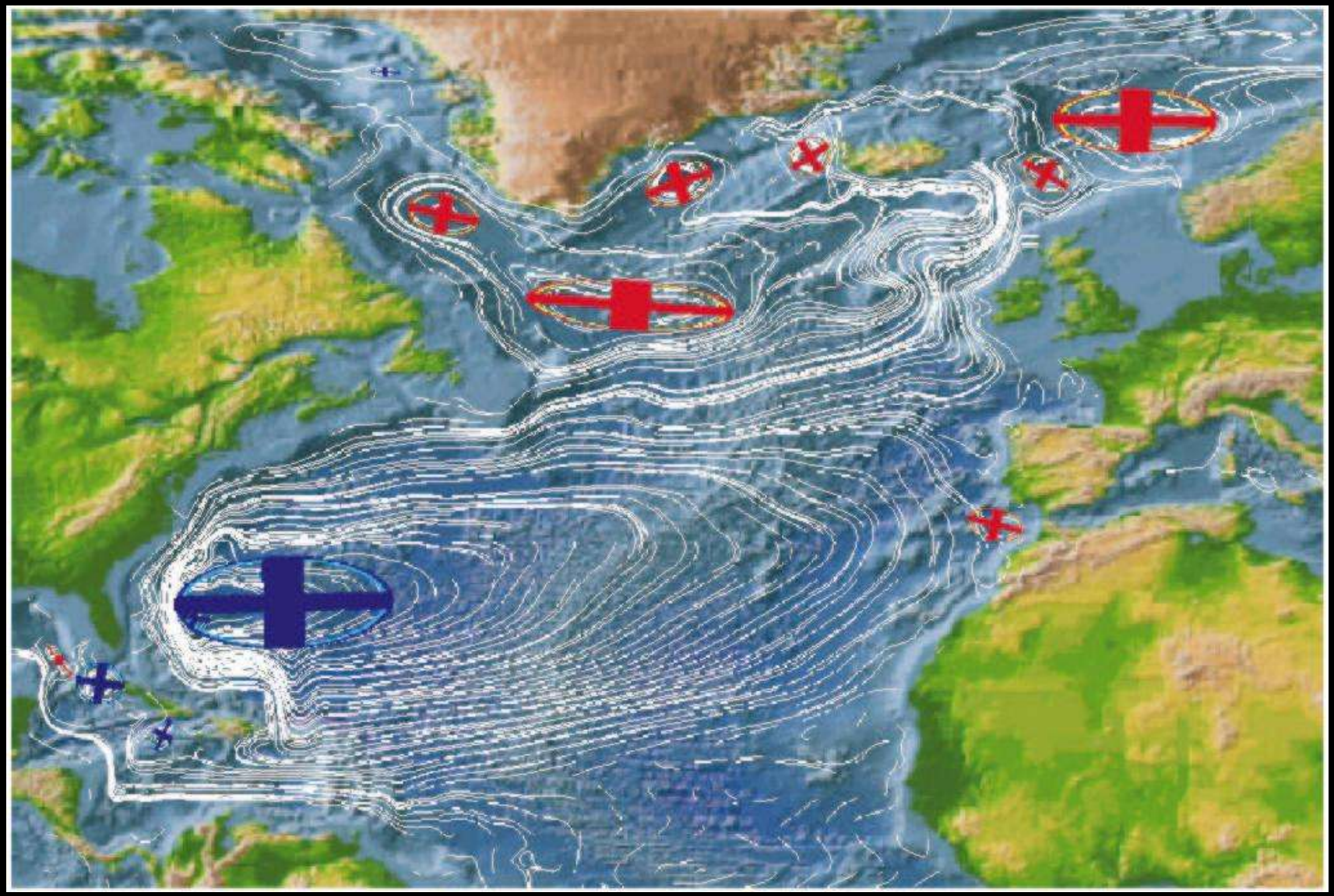
Shock waves



Attachment and separation lines



Vortex

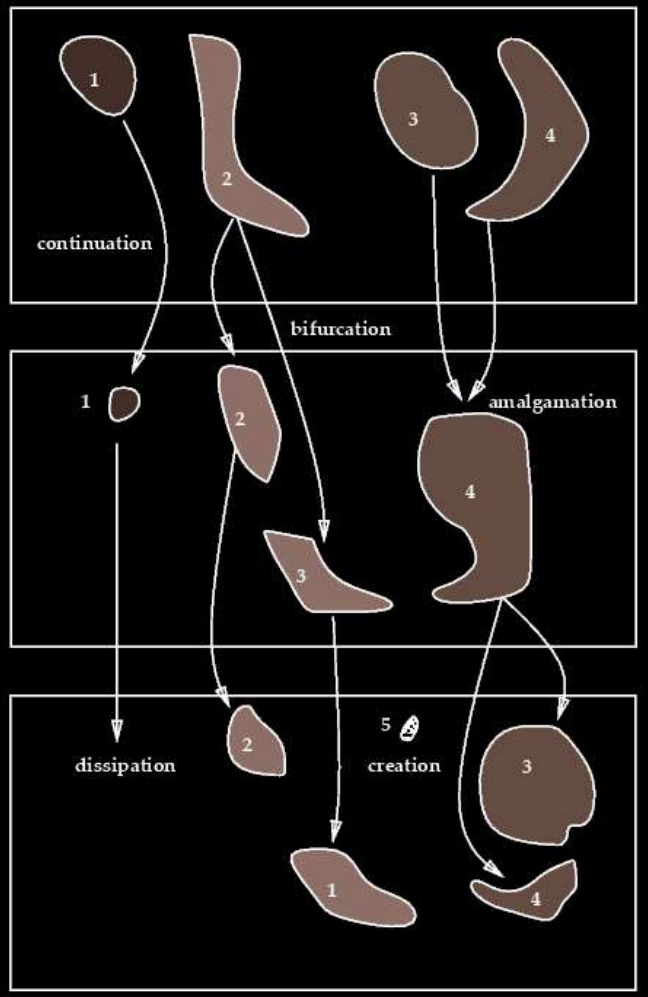


Feature tracking

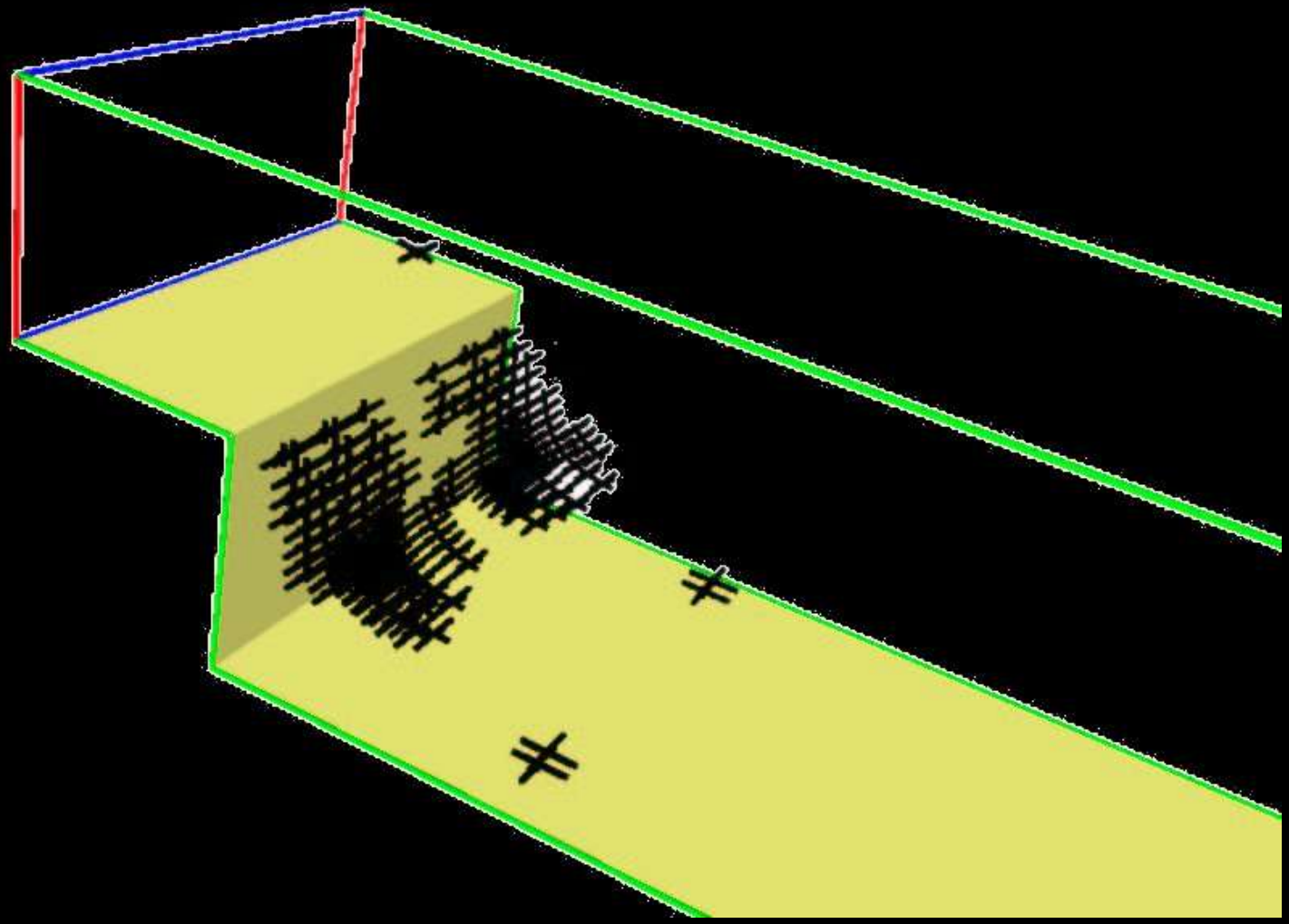
- Correspondence problem
  - Region correspondence
  - Attributes correspondence
- Prediction, verification

Events

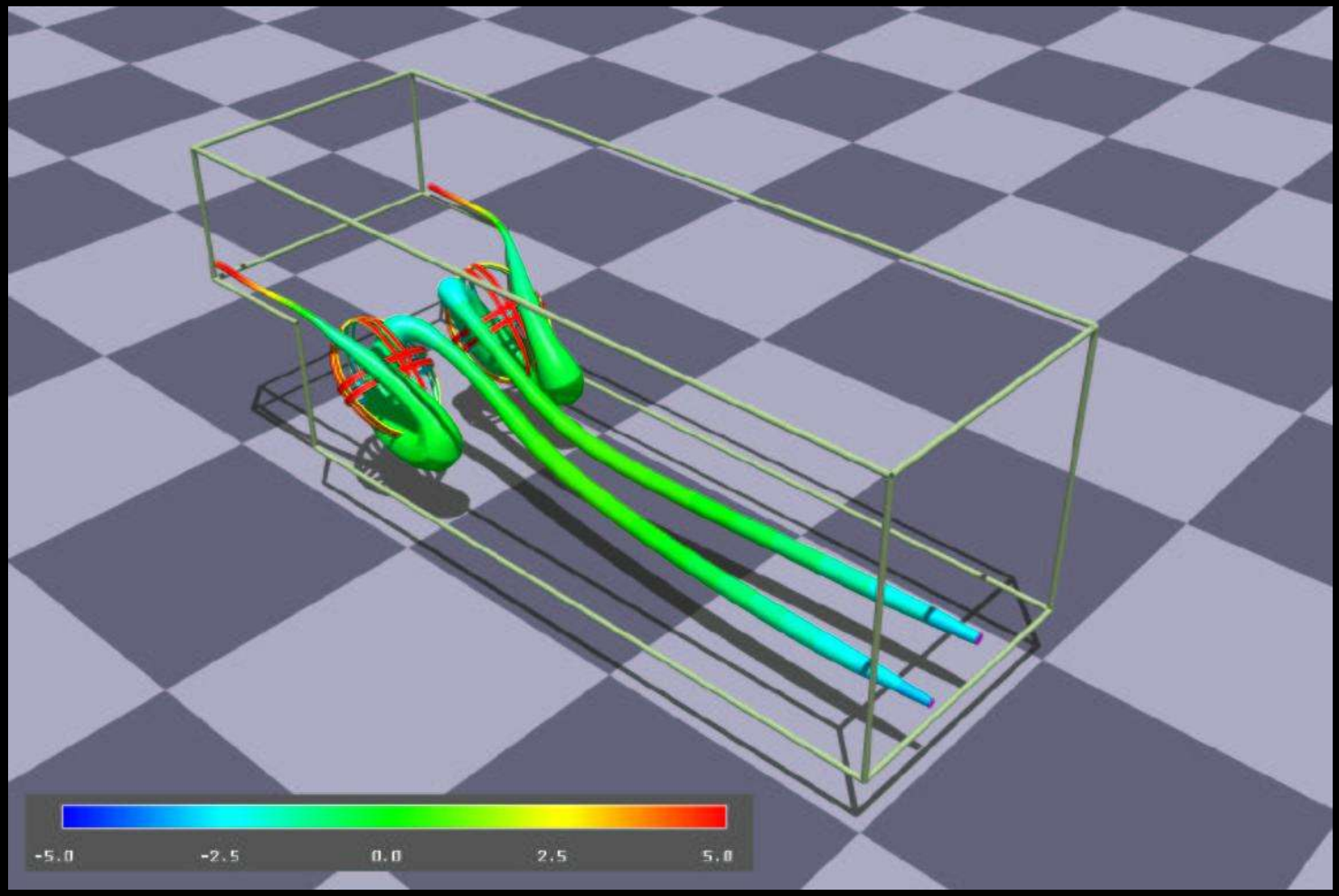
- Birth
- Death
- Split
- Merge
- Entry
- Exit



Features visualization – Binary data



Features visualization
- seeding points



Conclusion