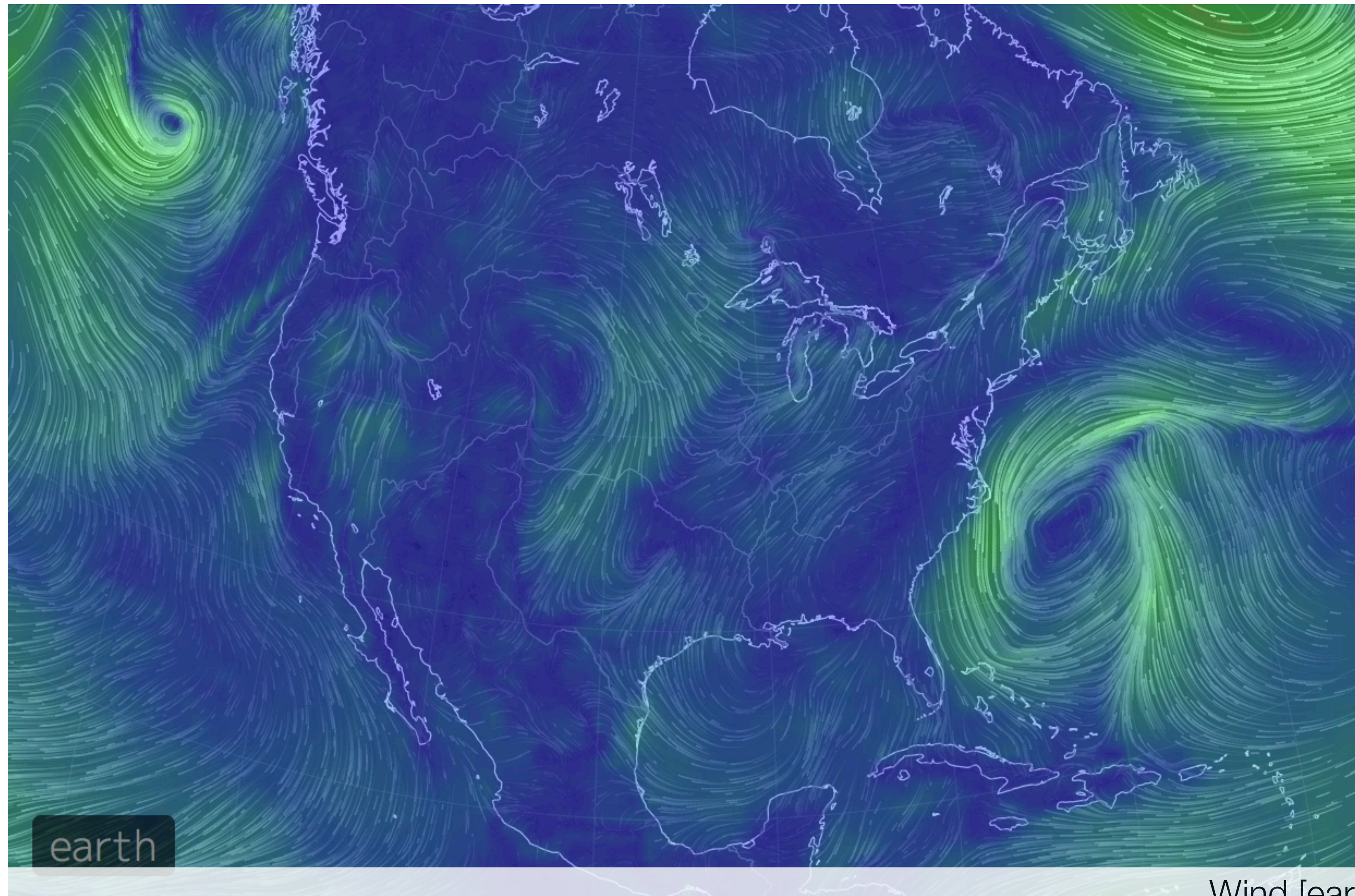


Data Visualization (CSCI 627/490)

Vector Fields & Text

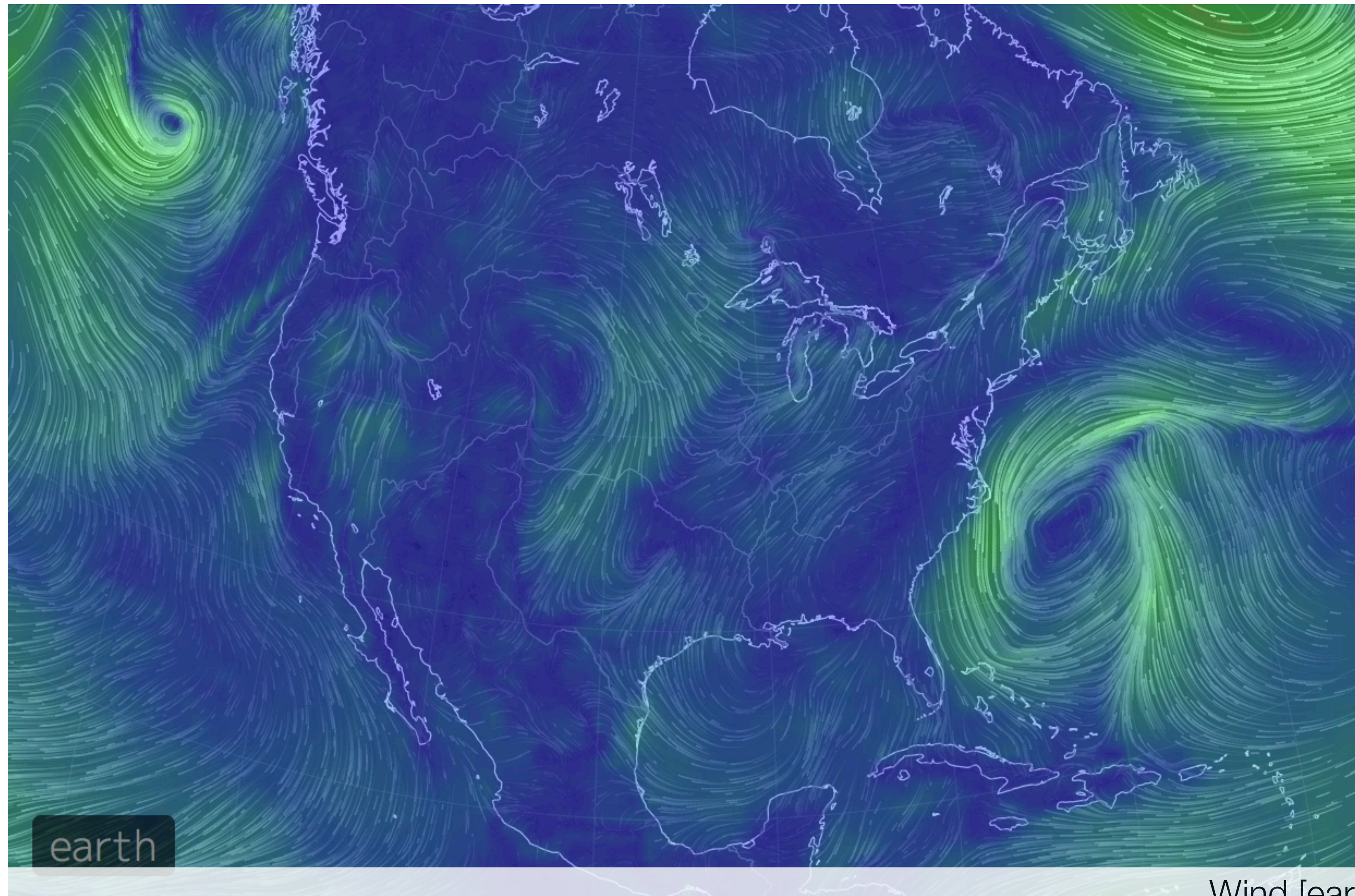
Dr. David Koop

Vector Fields



Wind [earth.nullschool.net, 2014]

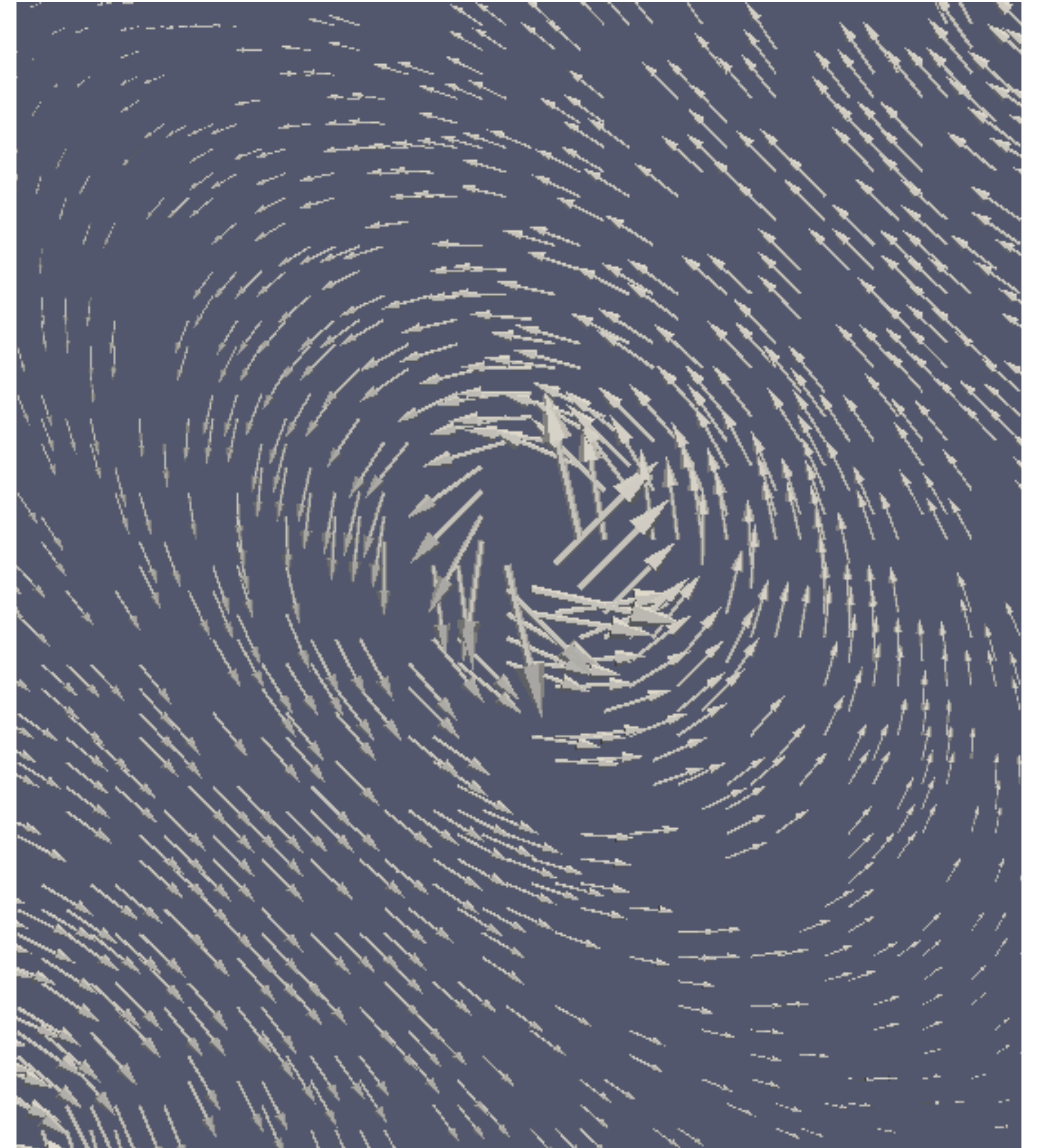
Vector Fields



Wind [earth.nullschool.net, 2014]

Glyphs

- Represent each vector with a symbol
- For vector fields, can encode direction, magnitude, scalar value
- Good:
 - Show precise local measures
 - Can encode scalar information as color
- Bad:
 - Possible sampling issues
 - Clutter (Occlusion): Can remove some points to help
 - Clutter is worse in higher dimensions

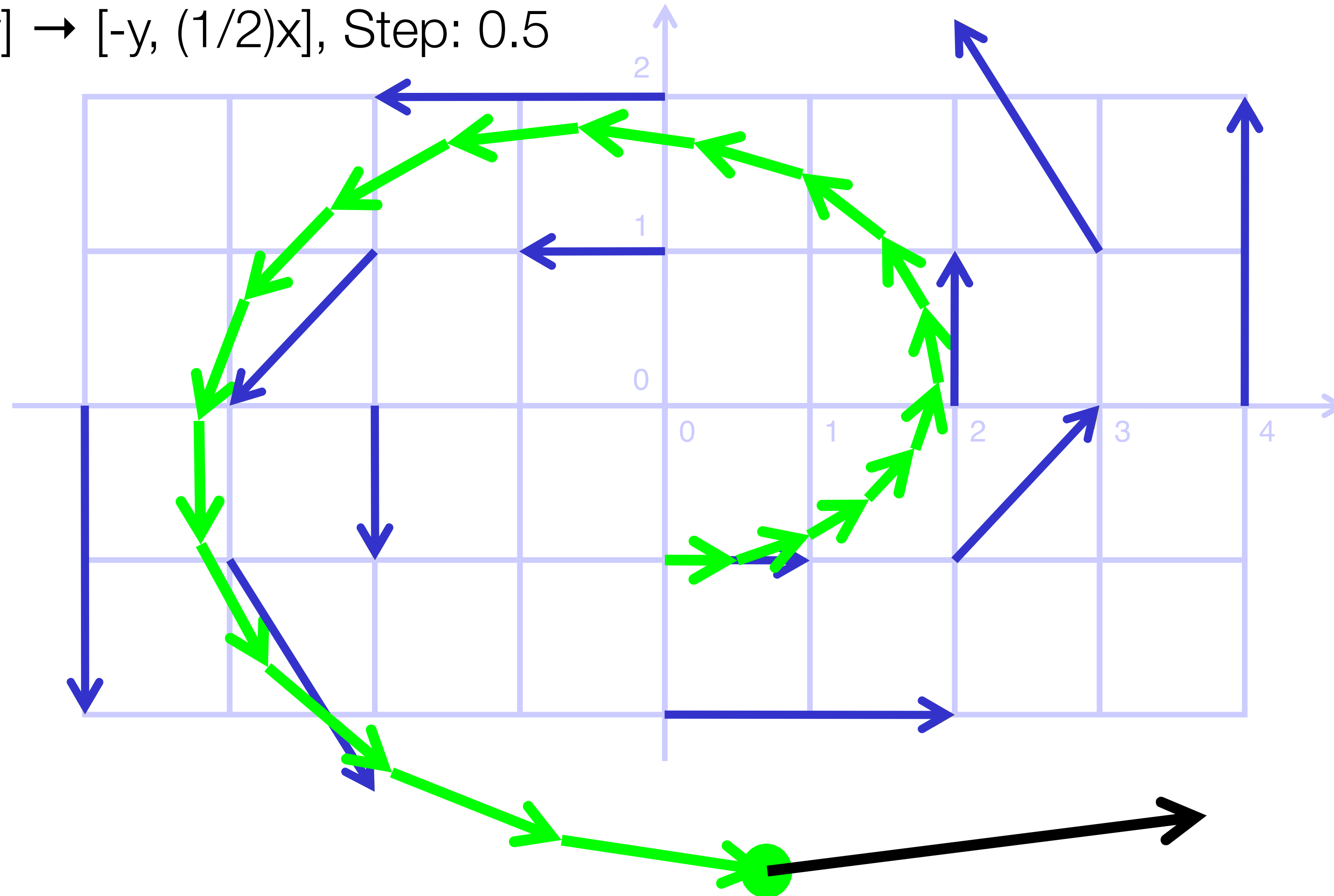


Streamlines & Variants

- Trace a line along the direction of the vectors
- Streamlines are always tangent to the vector field
- Basic Particle Tracing:
 1. Set a starting point (seed)
 2. Take a step in the direction of the vector at that point
 3. Adjust direction based on the vector where you are now
 4. Go to Step 2 and Repeat

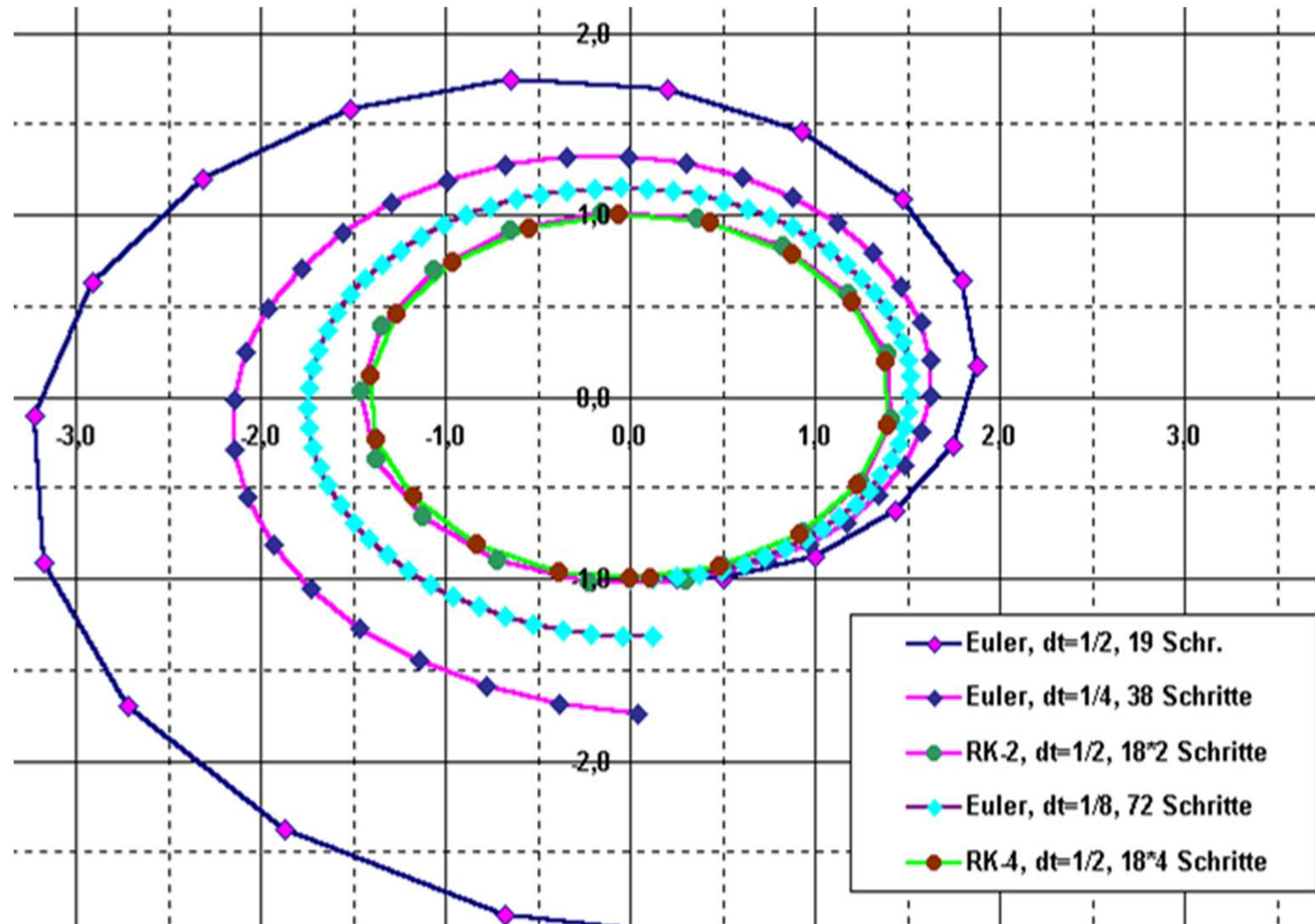
Streamlines

$[x,y] \rightarrow [-y, (1/2)x]$, Step: 0.5



[via Levine]

Higher-Order Interpolation Comparison



[via Levine]

Projects

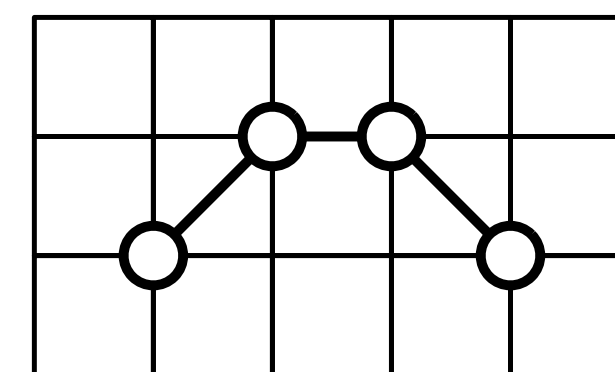
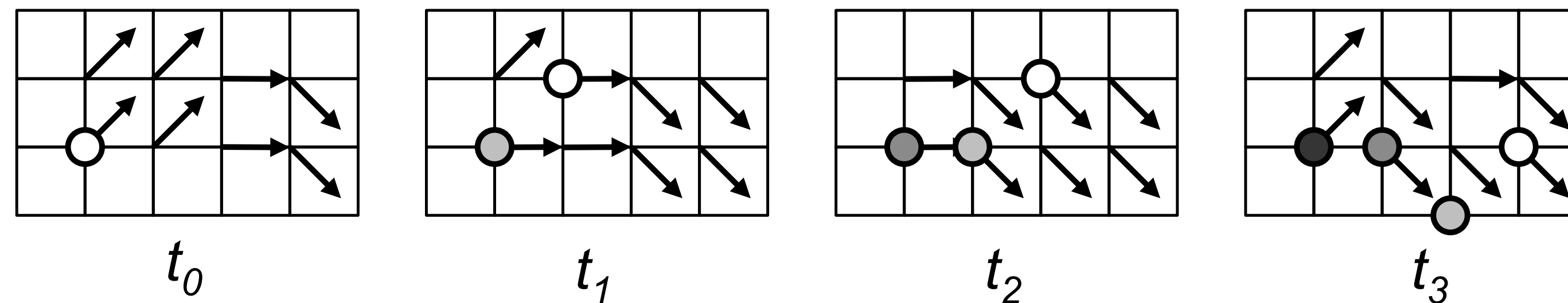
- Keep working on implementation
- Be creative, don't copy
- Think about interaction
- Presentations on the last day of class (Dec. 3)
 - Plan to use Blackboard. Please let me know if you know of tech. issues
 - Upload to Blackboard beforehand in case of technical issues

Final Exam

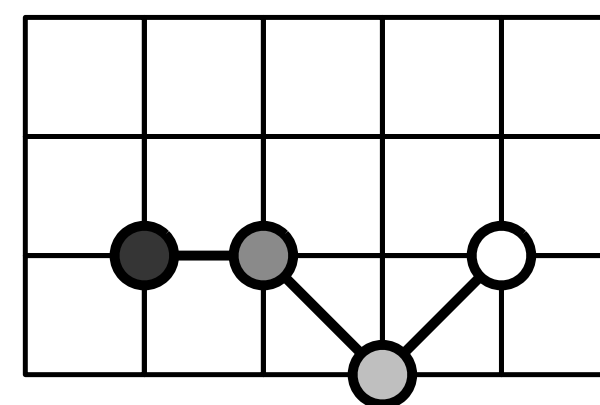
- December 10, 2020, 10-11:50am
- Covers all topics but emphasizes second half of the course
- Similar format as Midterm (multiple choice, free response)
- 627 Students will have a extra questions related to the research papers
- Review next Tuesday: Bring Questions

Streamlines & Variants

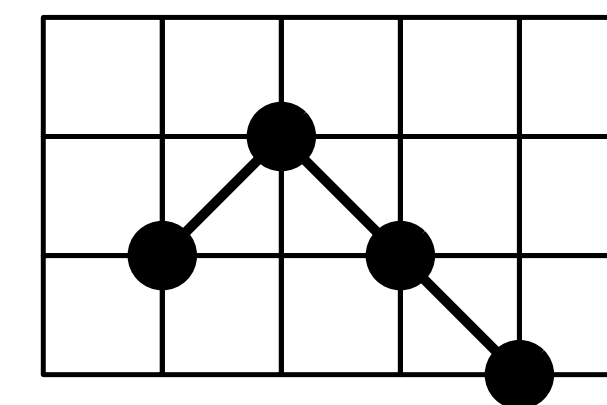
- Steady vs. **Unsteady** flows
 - In unsteady flows, the vector field **changes** over time
- Variants: **Pathlines** and **Streaklines**



pathline



streakline

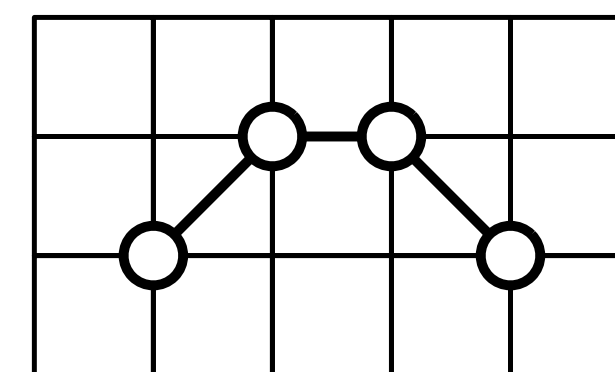
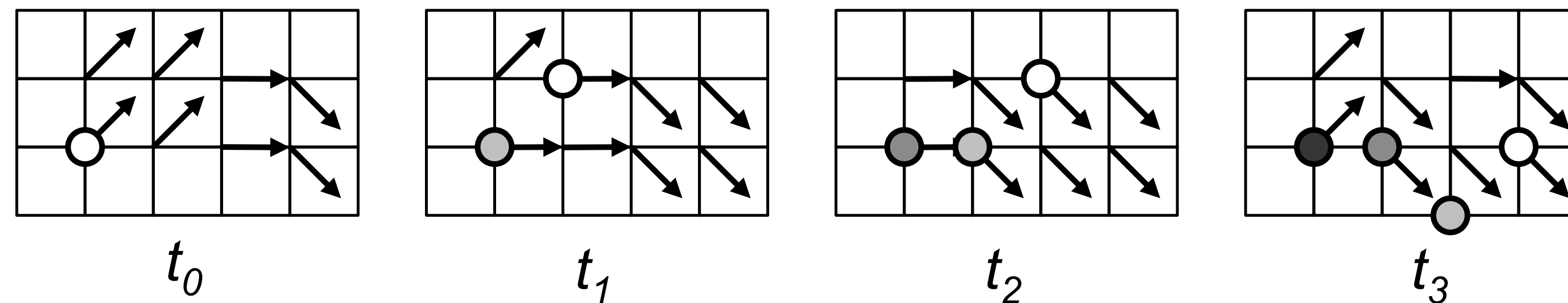


streamline for t_3

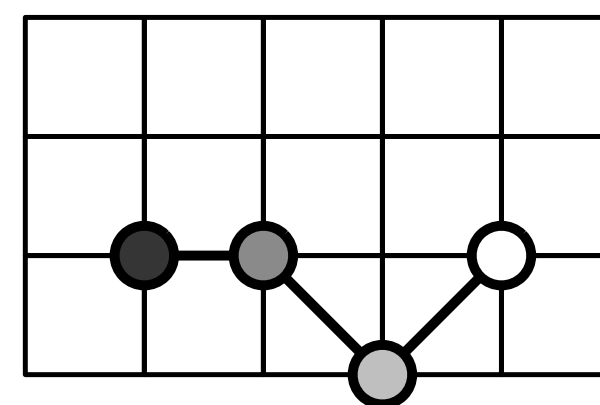
[T. Möller]

Streamlines & Variants

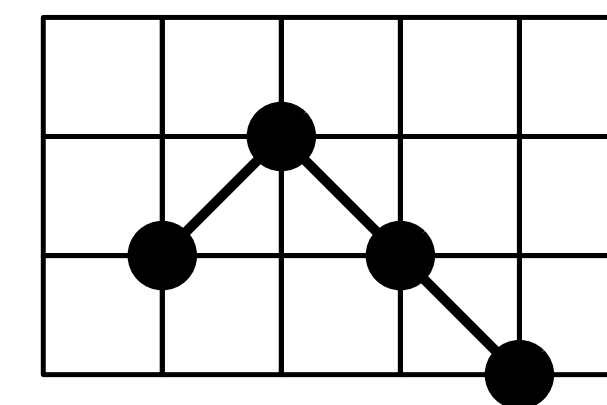
- Steady vs. **Unsteady** flows
 - In unsteady flows, the vector field **changes** over time
- Variants: **Pathlines** and **Streaklines**



pathline



streakline

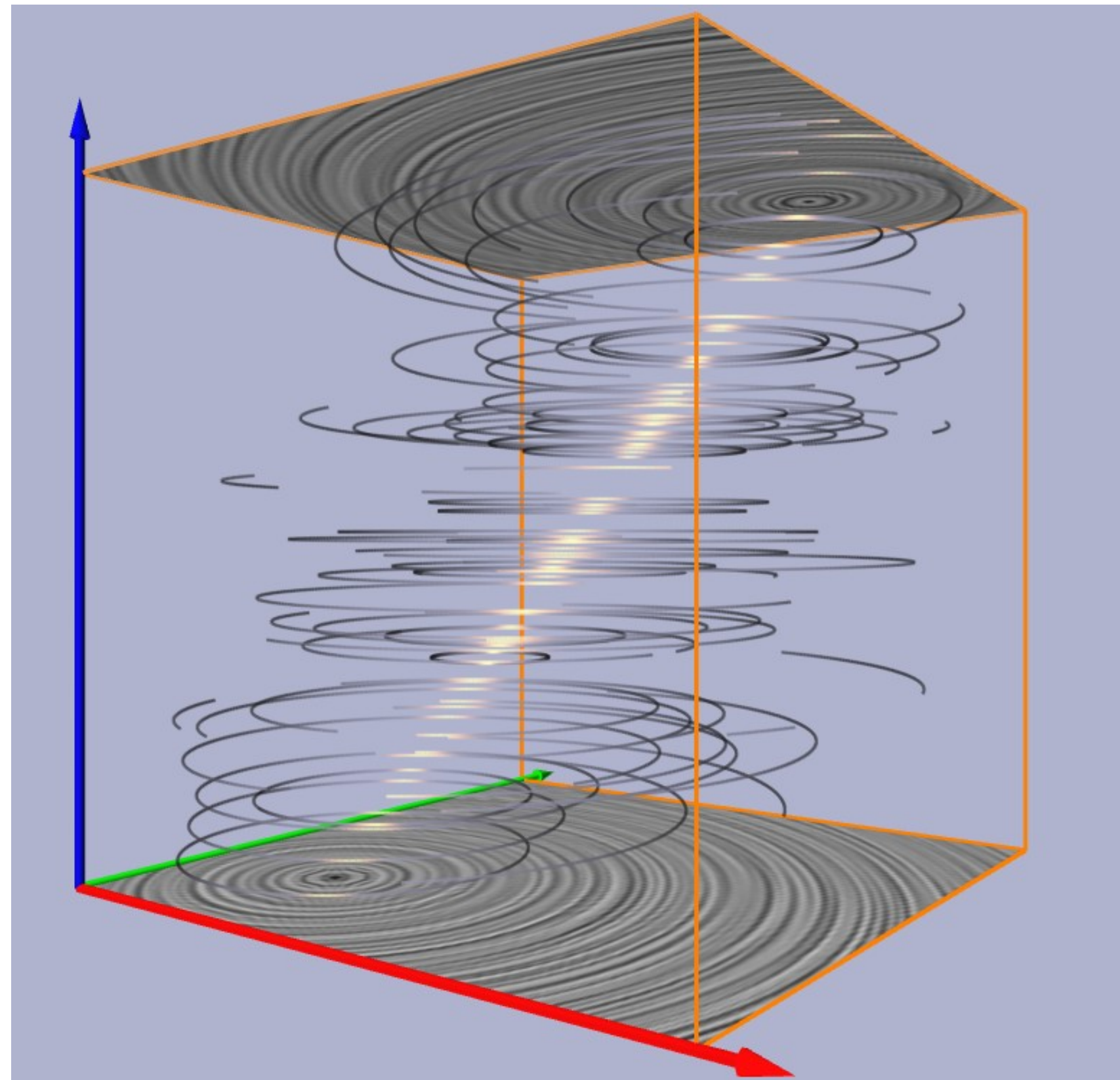


streamline for t_3

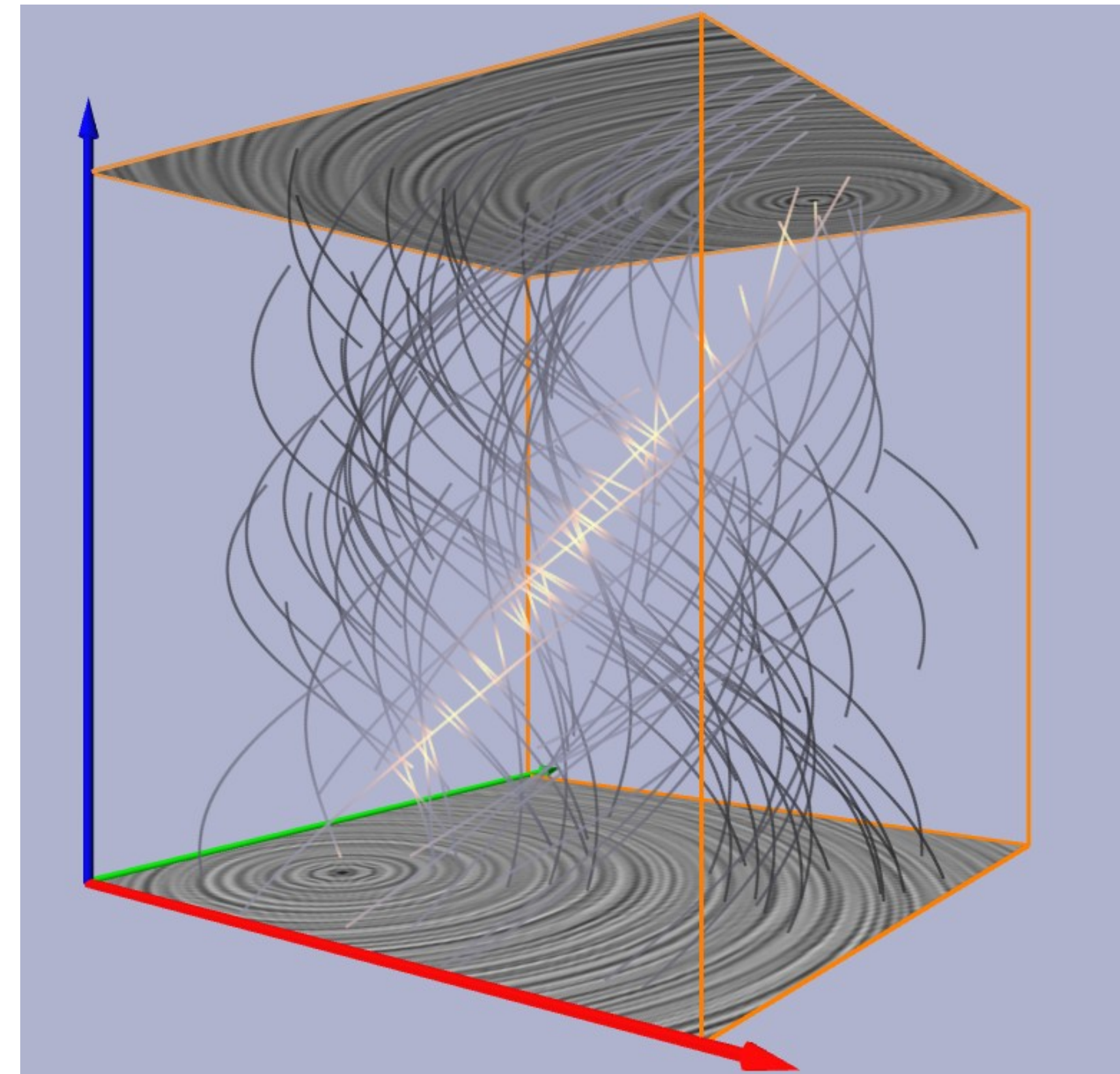
[T. Möller]

All are identical in steady flows!

Streamlines vs. Pathlines



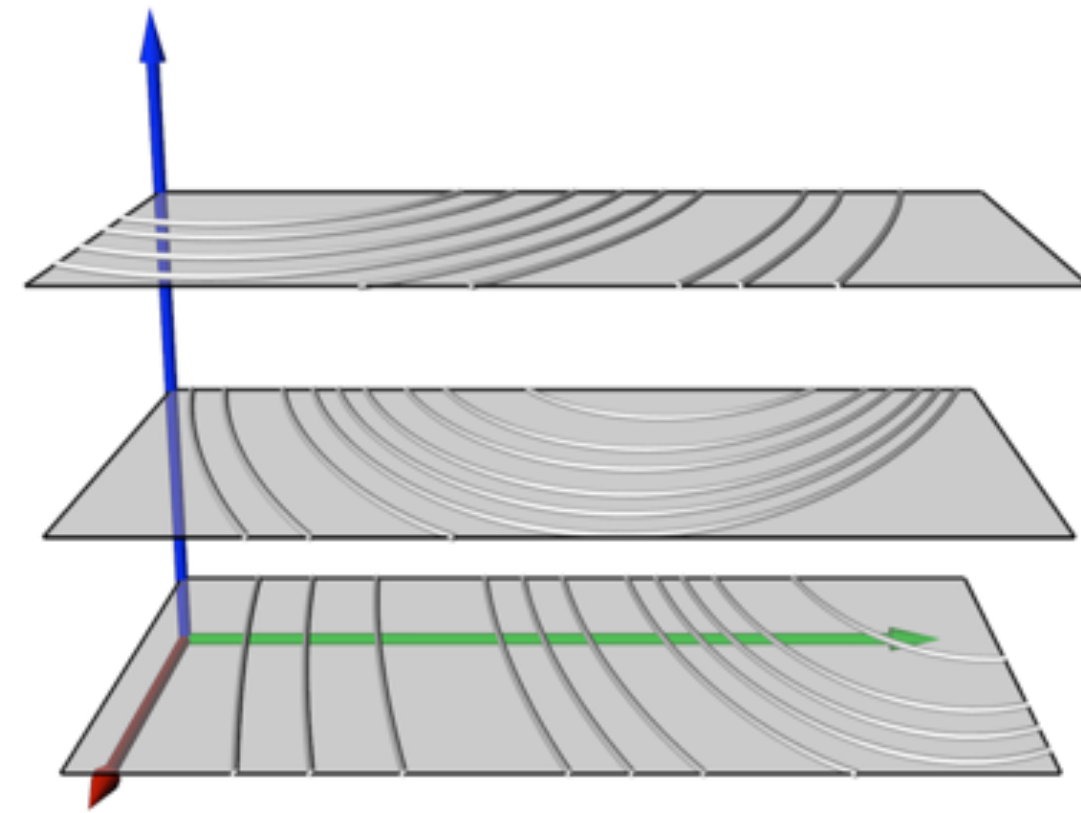
Streamlines



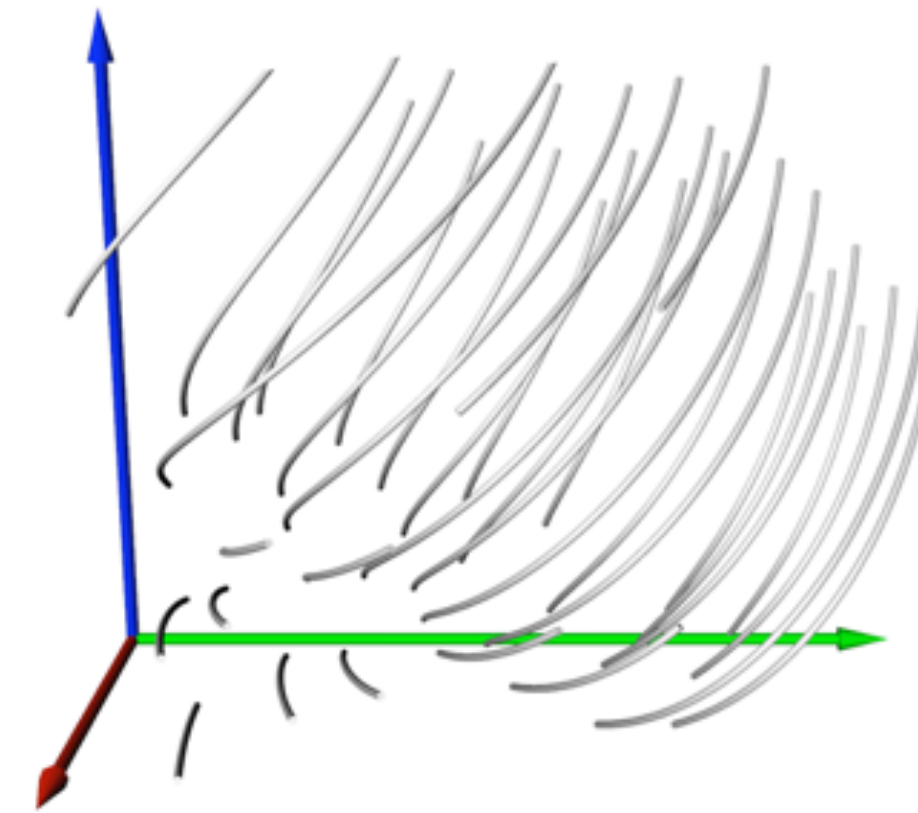
Pathlines

[Weinkauff & Theisel, 2010]

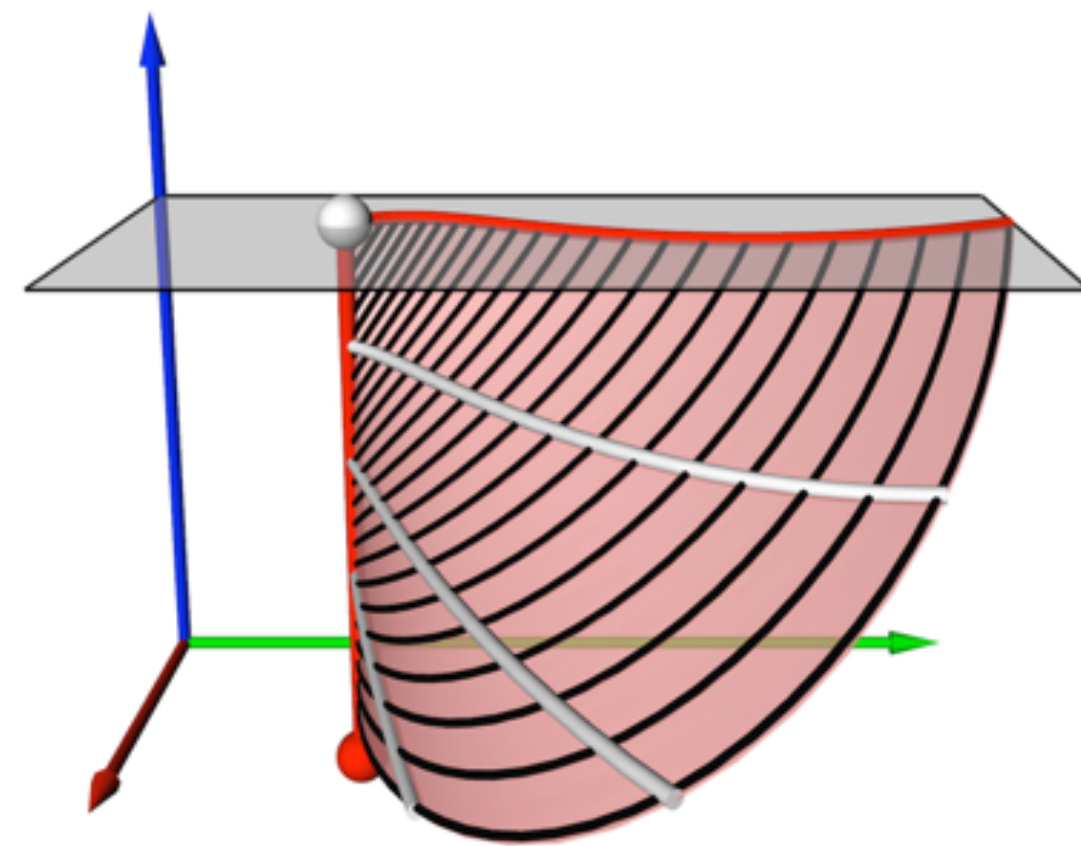
Streaklines and timelines



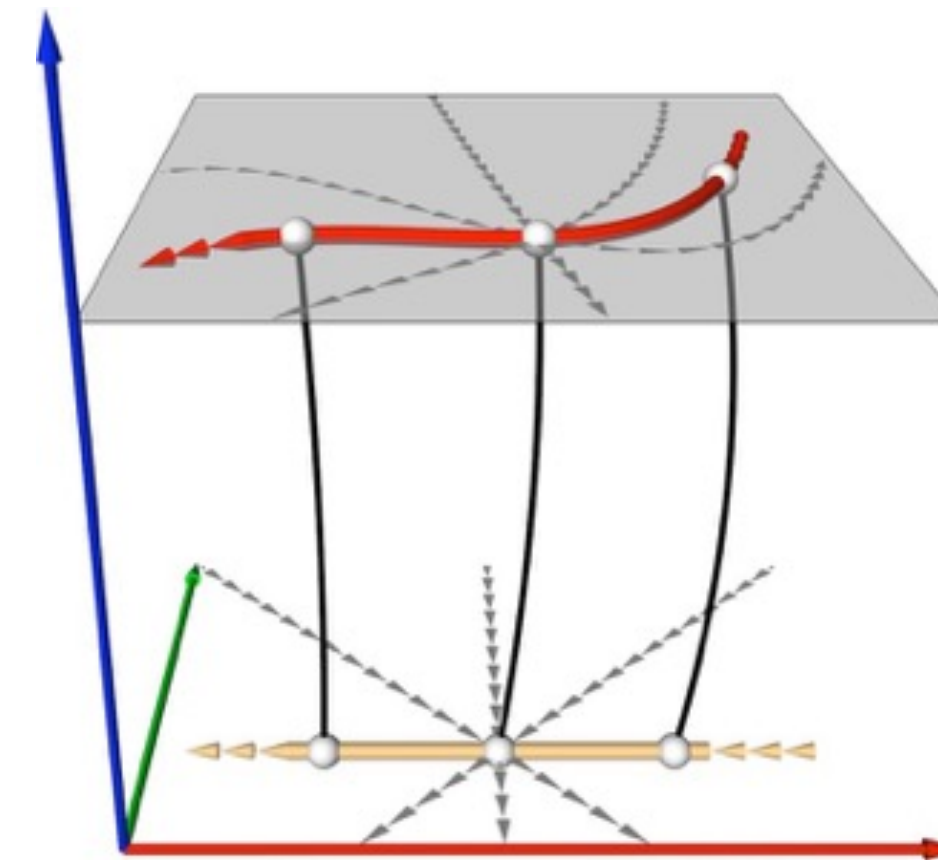
streamlines



pathlines



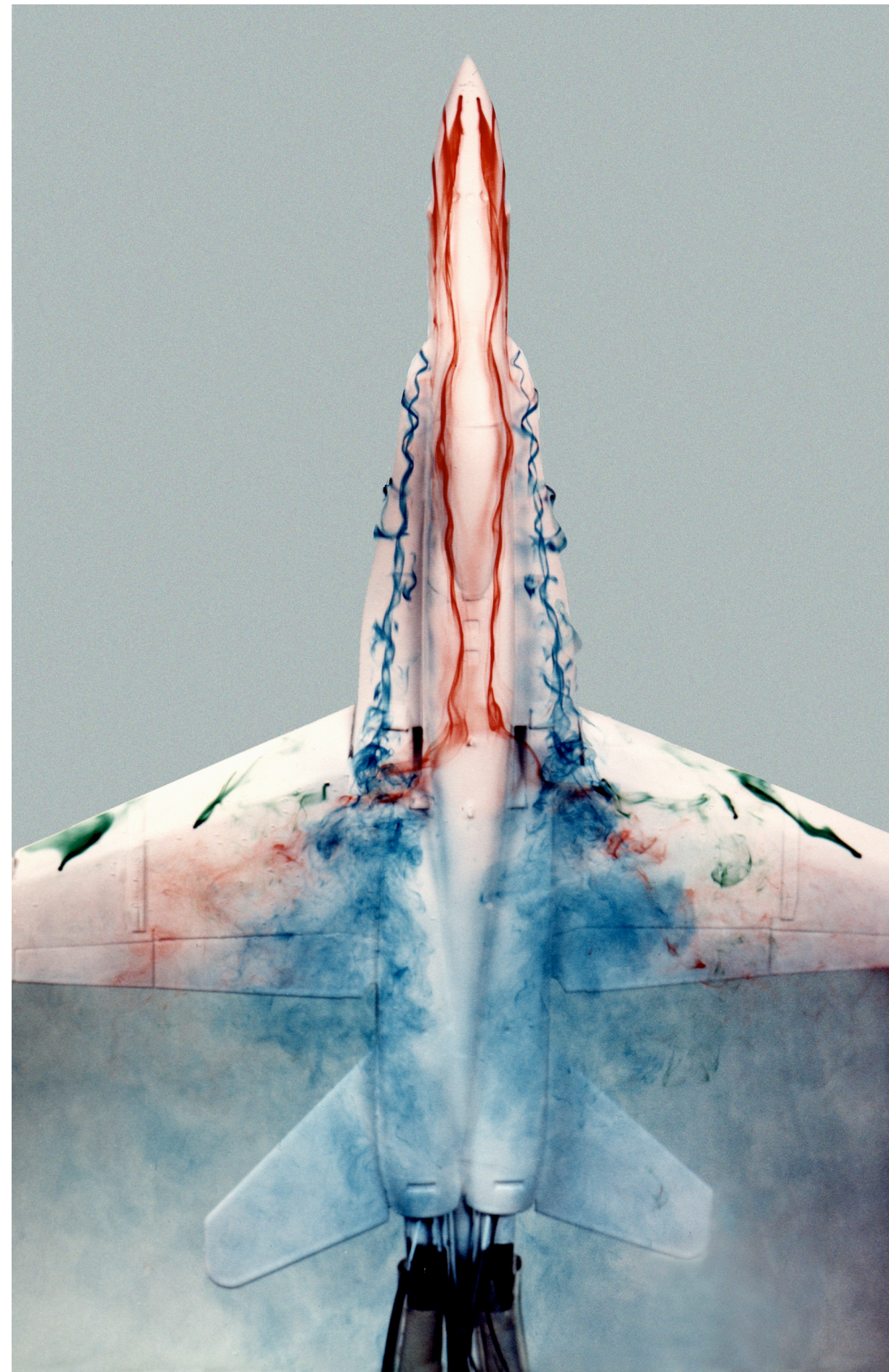
streaklines



timelines

[via Levine]

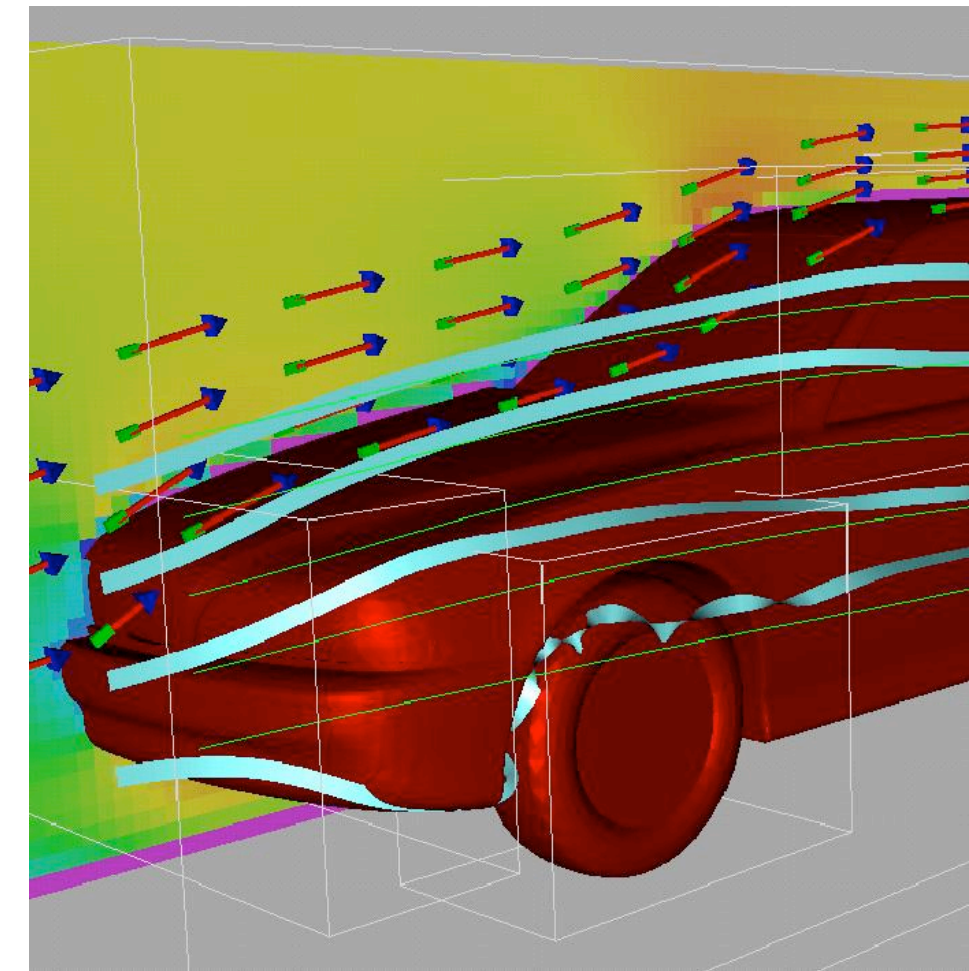
Streamline Variants



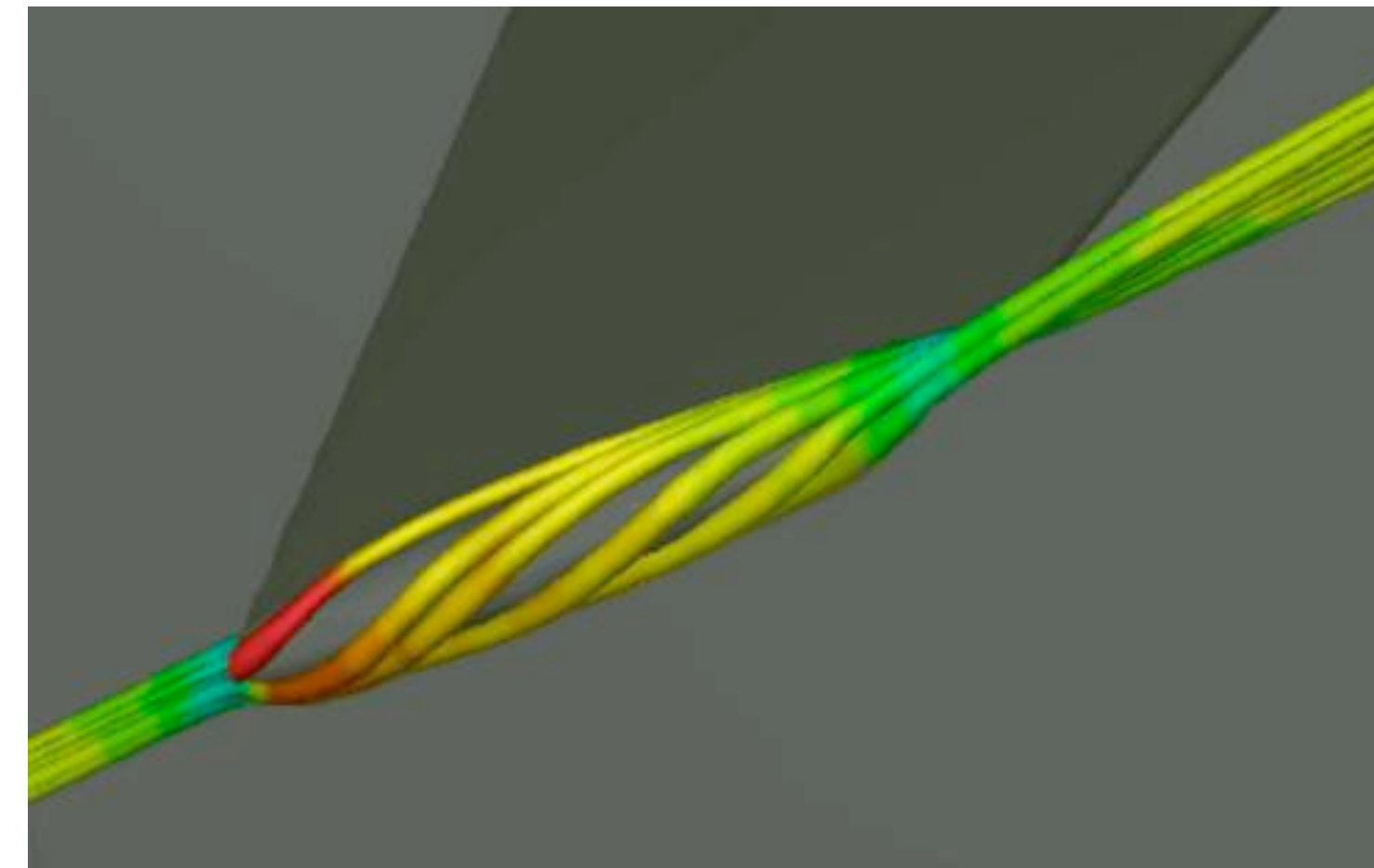
NASA Dryden Flight Research Center Photo Collection
<http://www.dfrc.nasa.gov/gallery/photo/index.html>
NASA Photo: ECN-33298-03 Date: 1985

1/48-scale model of an F-18 aircraft in Flow Visualization Facility (FVF)

Streaklines [NASA]

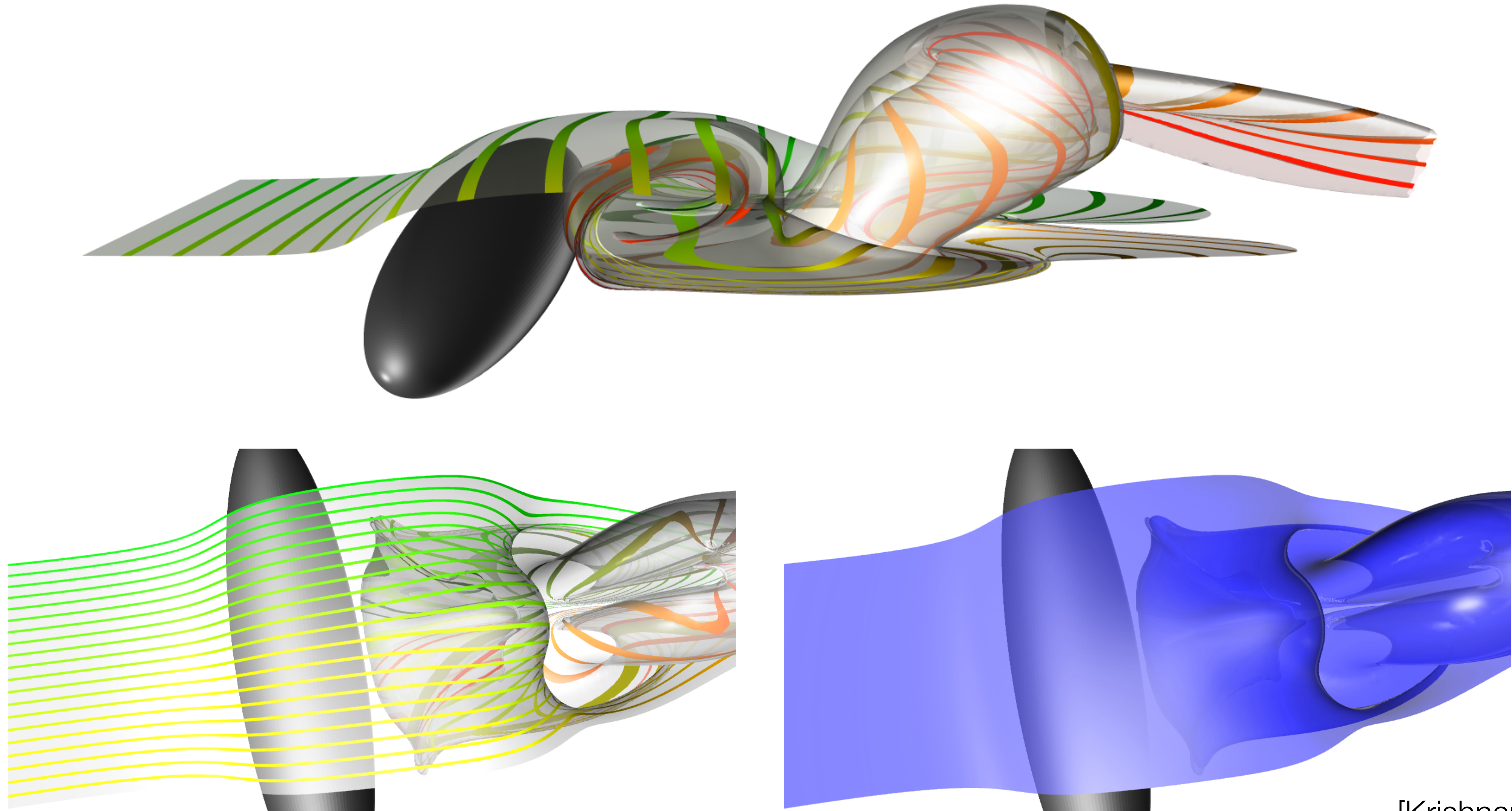


Stream Ribbons [Weiskopf/Machiraju/Möller]



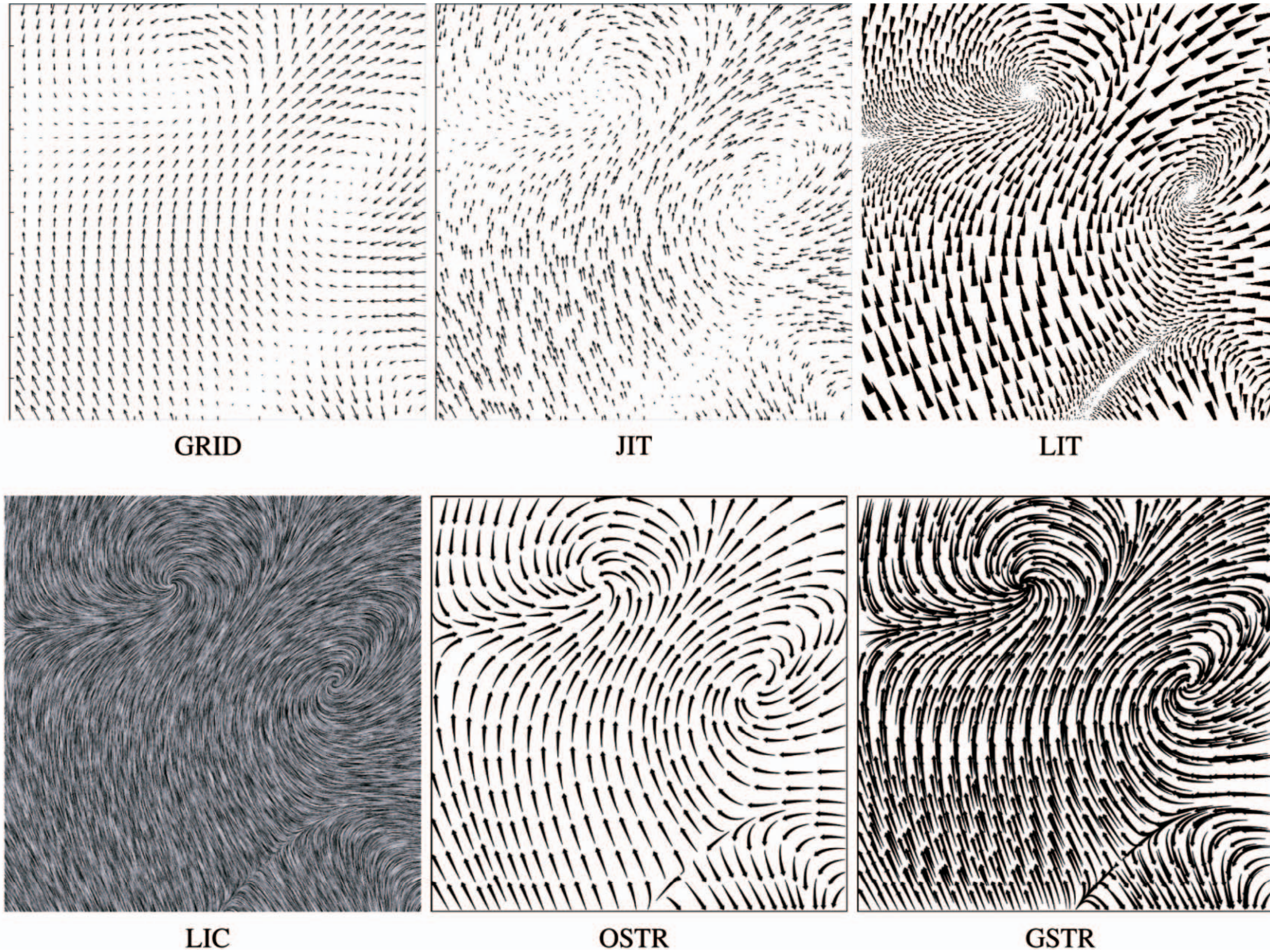
Stream Tubes [Weiskopf/Machiraju/Möller]

Streak Surfaces



[Krishnan et al., 2009]

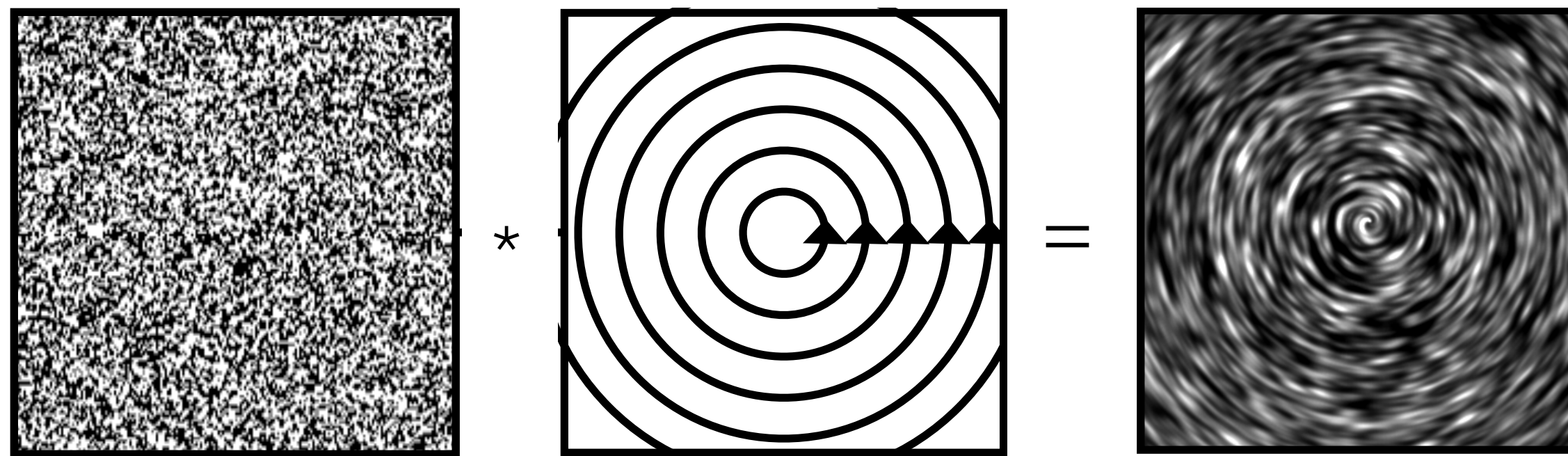
2D Vector Field Visualization Techniques



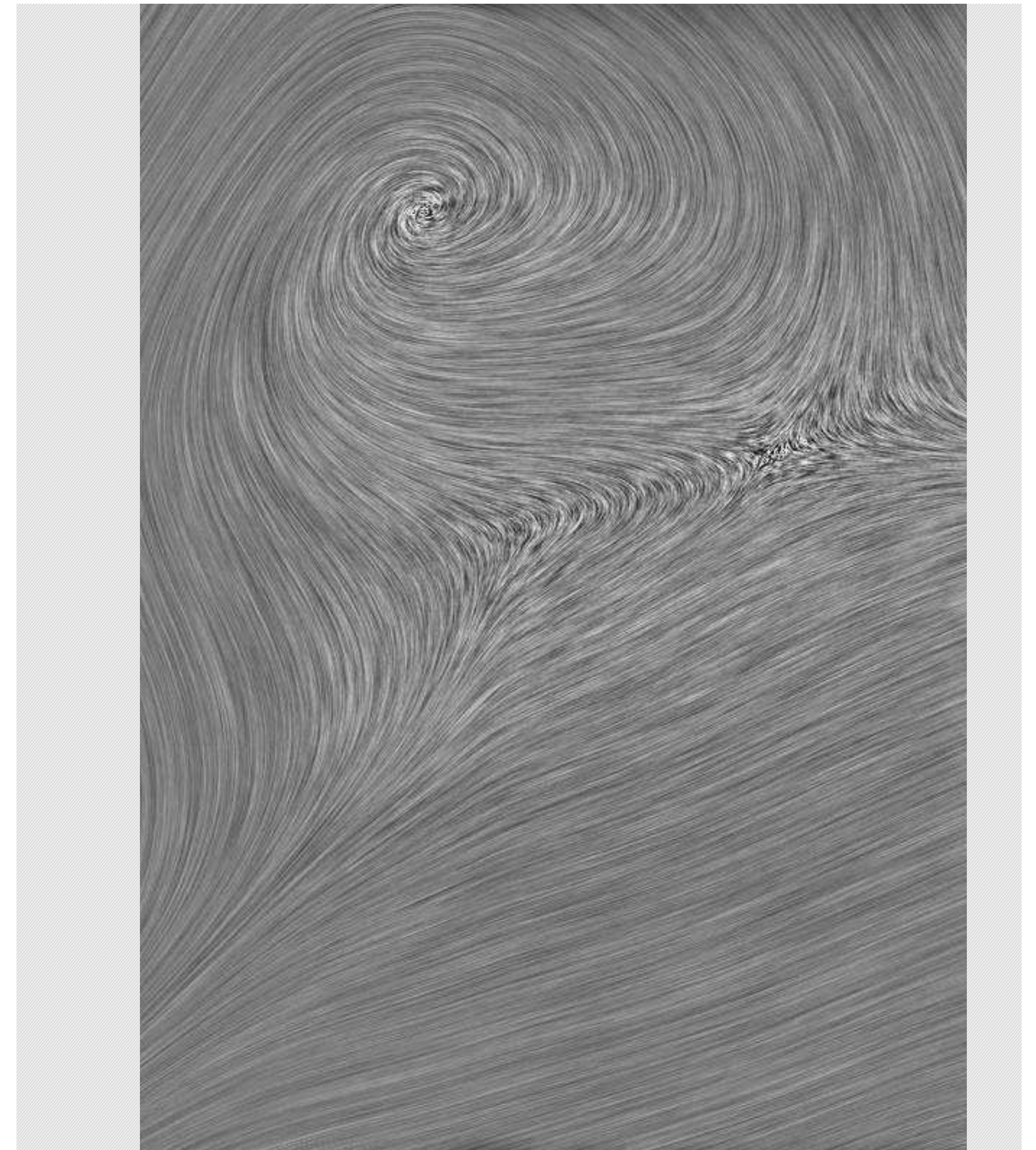
[Laidlaw et al., 2005]

Line Integral Convolution

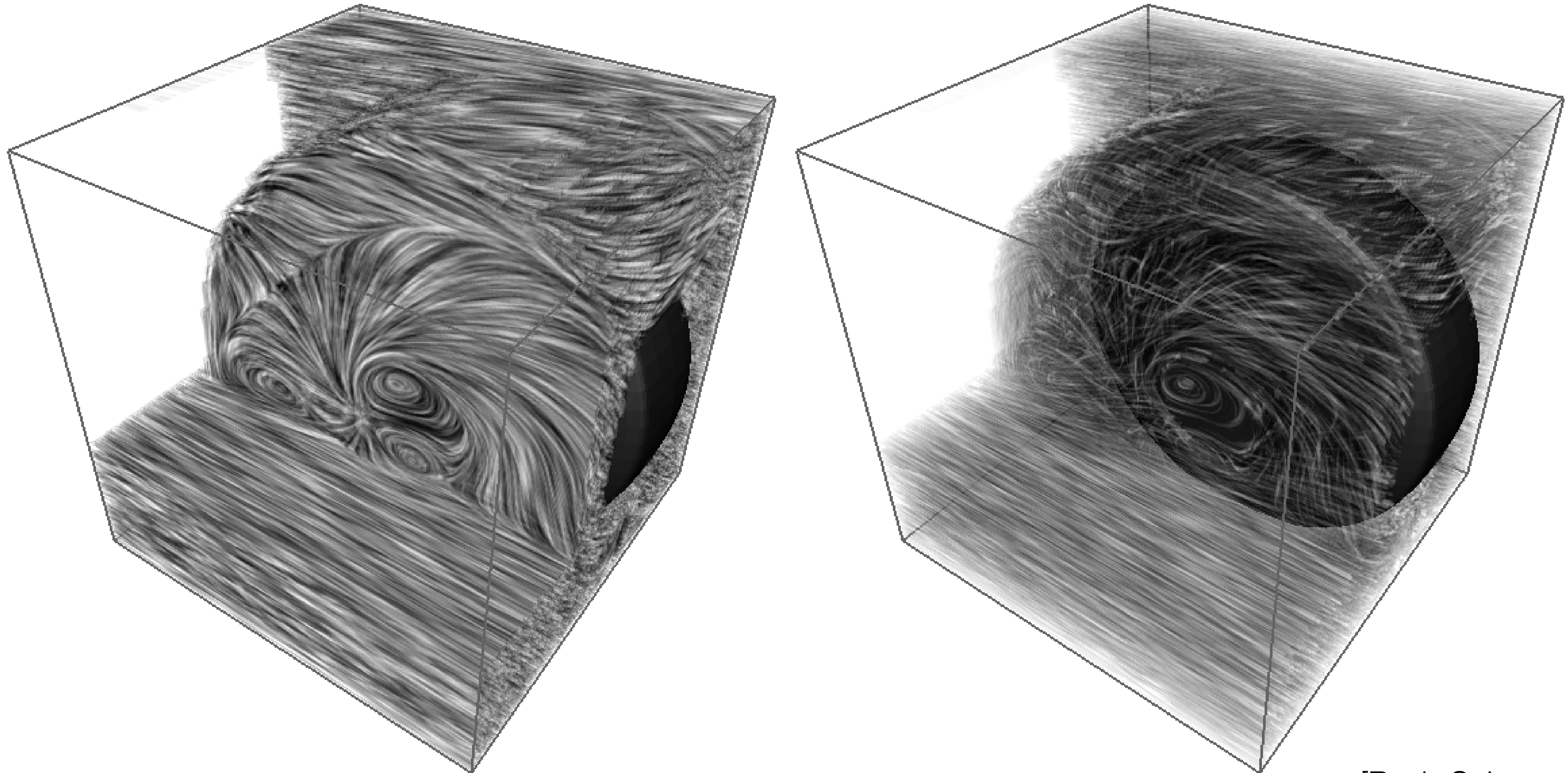
- Goal: provide a global view of a steady vector field while avoiding issues with clutter, seeds, etc.
- Remember convolution?
- Start with random noise texture
- Smear according to the vector field
- Need structured data



[Weiskopf/Machiraju/Möller]



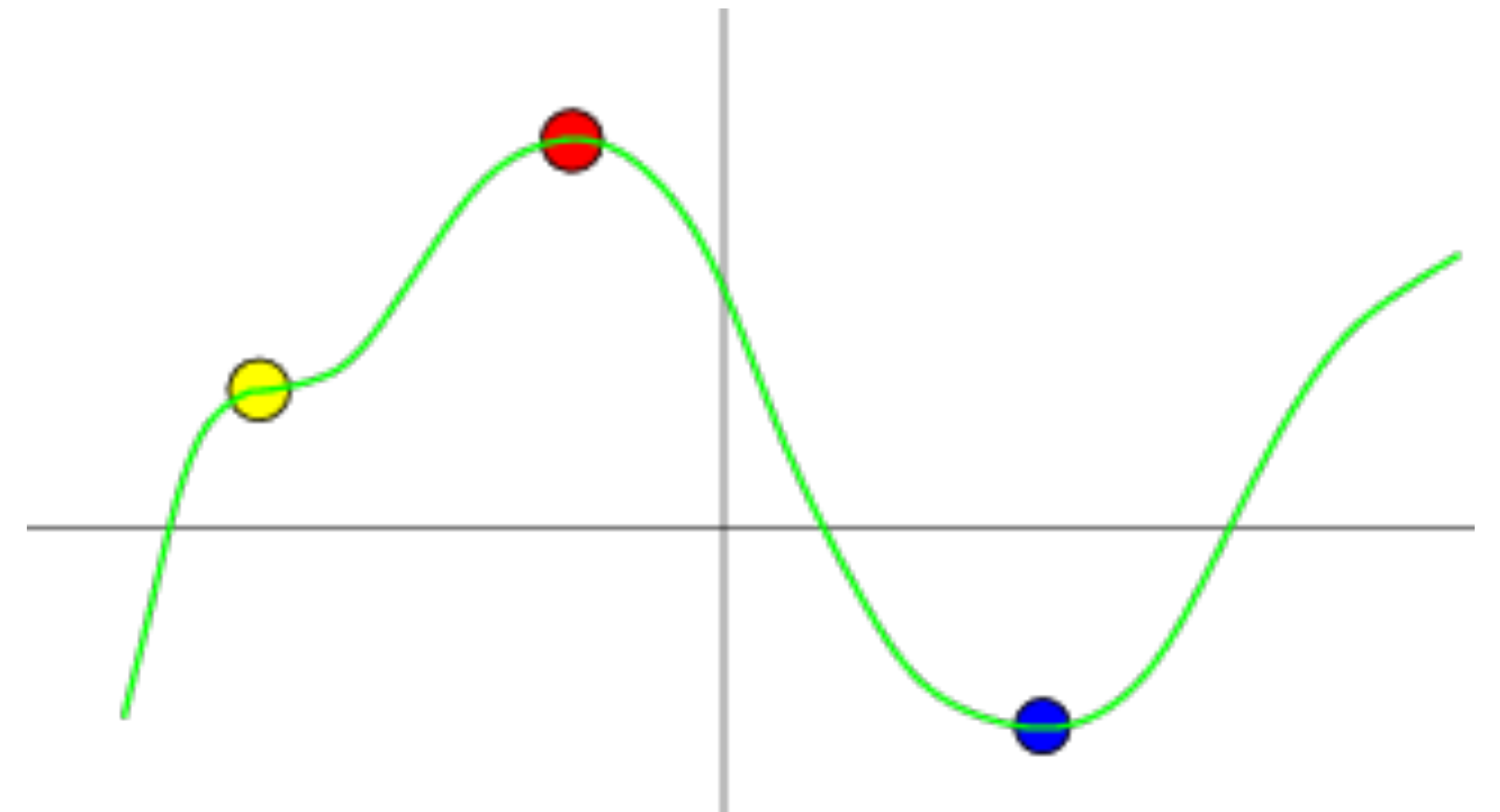
3D LIC



[Rezk-Salama et al., 1999]

Critical Points

- Remember finding min/max for functions?
- Want to understand the general structure of a field, not the exact values
- Find critical points, understand there is a general trend in between
- How?
 - Derivative for functions
 - For fields...gradients

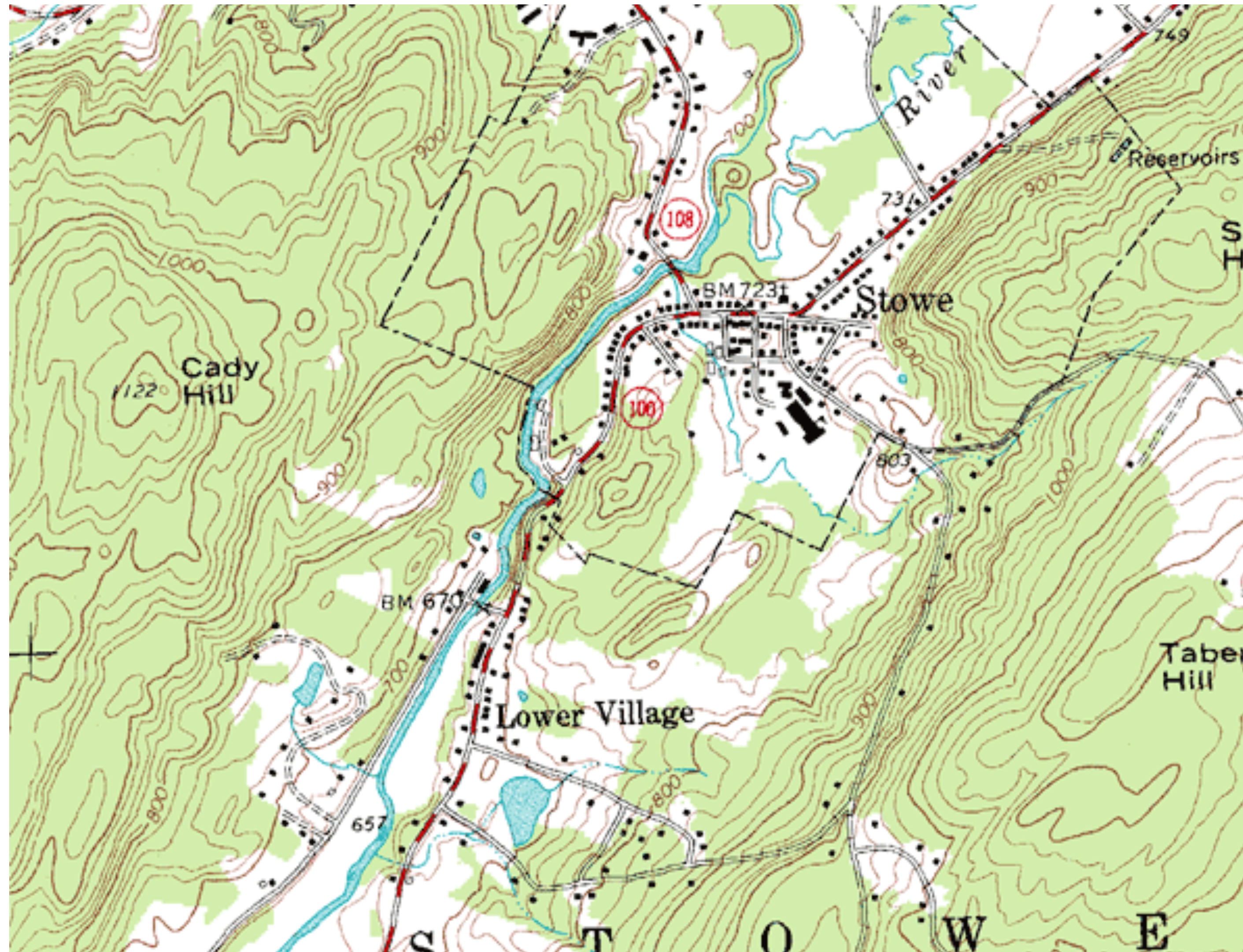


[DQ Nykamp, [MathInsight](#)]

Topology

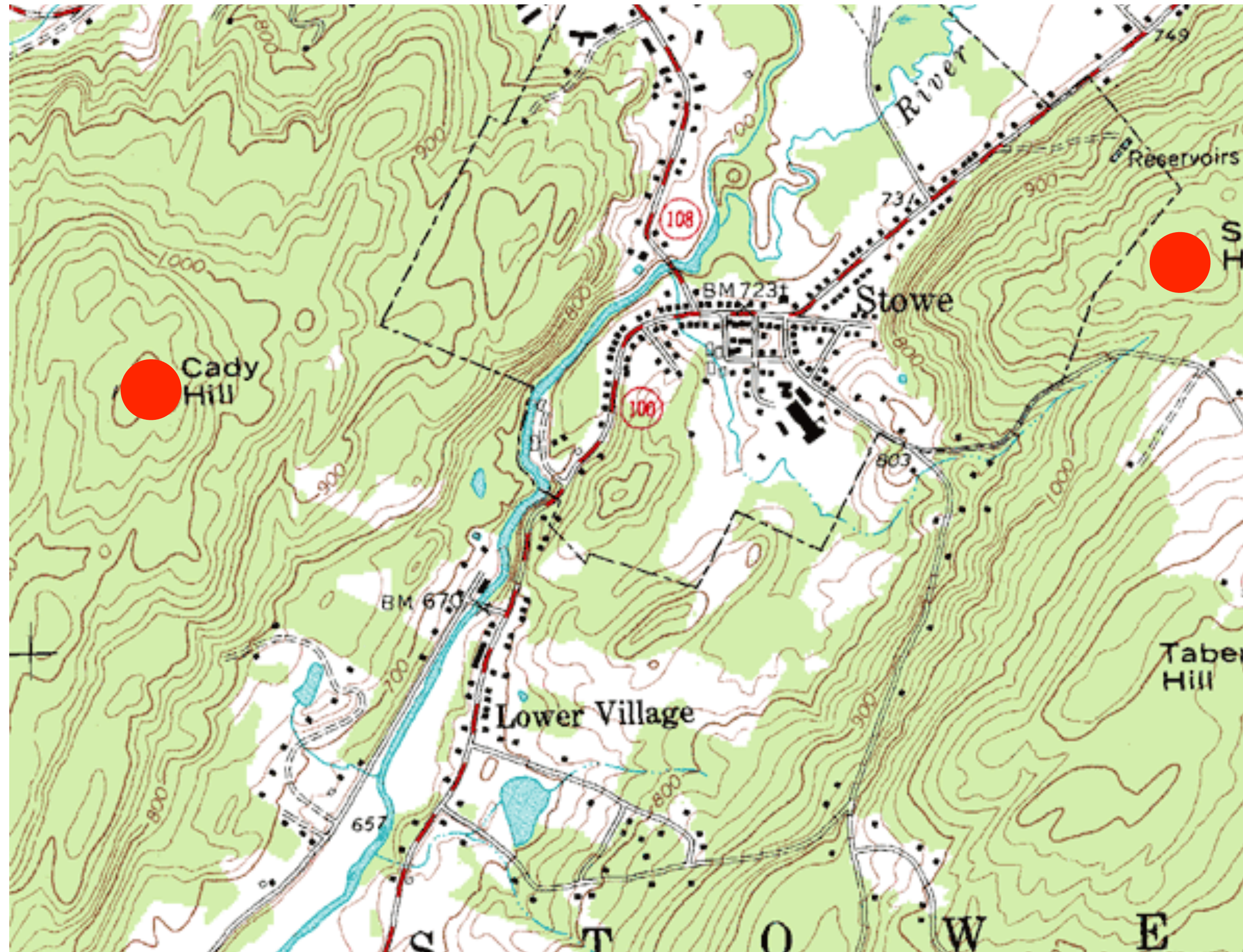
- The general shape of data
- Visualizations that can be "stretched" to resemble each other are topologically equivalent
- Technically, continuous transformations don't change anything
- Connect critical points to obtain a general picture of the data
- Can talk about topology in both scalar and vector fields

2D Scalar Field Topology



[Wikipedia]

2D Scalar Field Topology



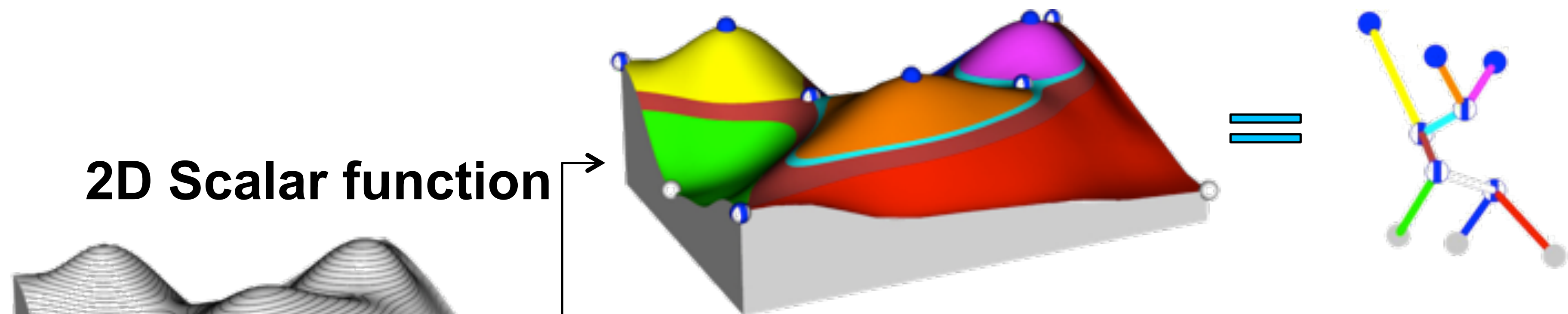
[Wikipedia]

Scalar Field Topology

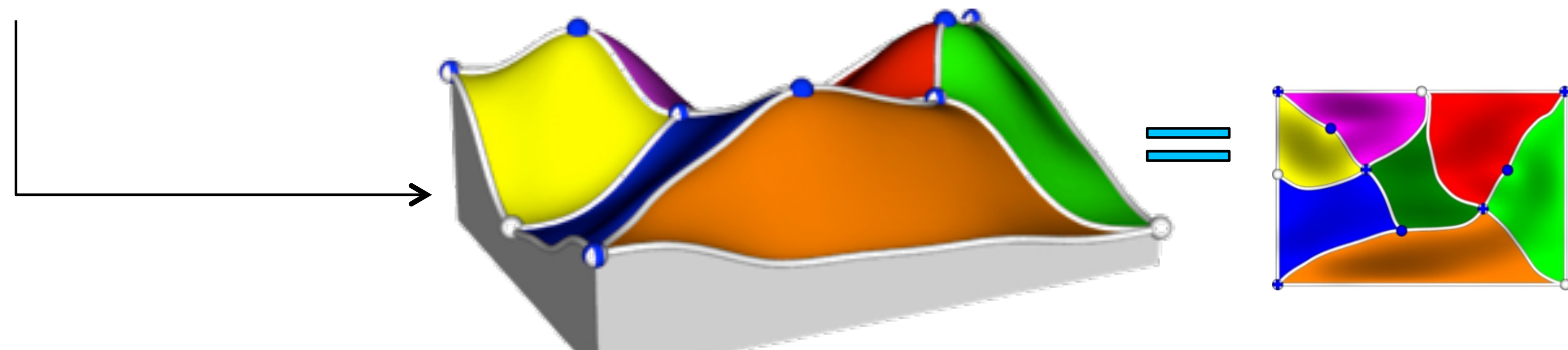
- Examine the gradient (changes between points on the grid) of the scalar field
- Where the gradient is zero, we have critical points (max, min, saddle)
- Can build Reeb Graph, Contour Tree, or Morse-Smale Complex from this information to show the topology (with some reasonable assumptions about how the scalar field looks)

Scalar Field Topology

Reeb Graph/Contour Tree/Merge Tree



Morse-Smale Complex



[via Levine]

Vector Field Topology

- Instead of “guessing” correct seed points for streamlines to understand the field, try to identify structure (topology) of the field

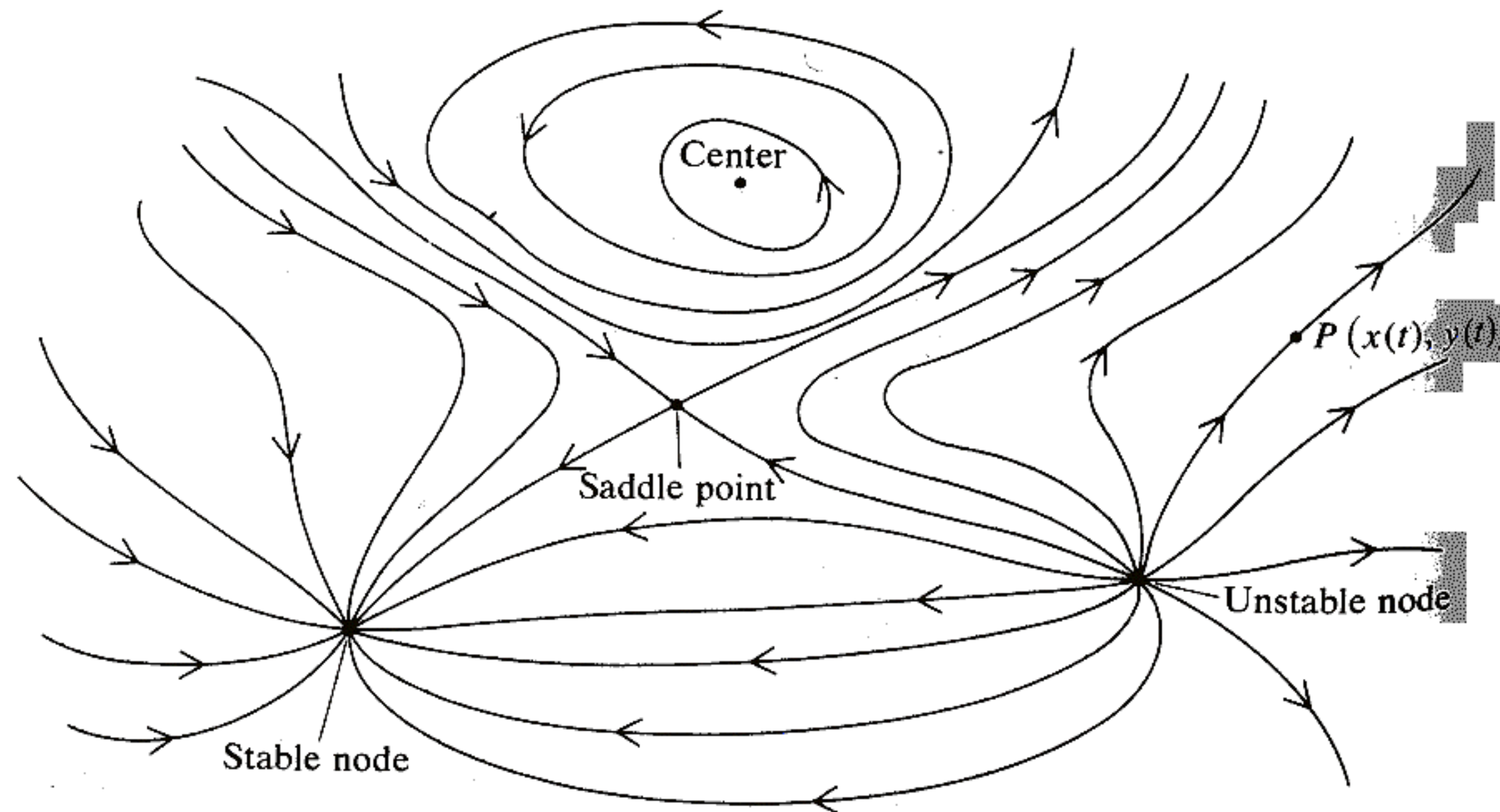
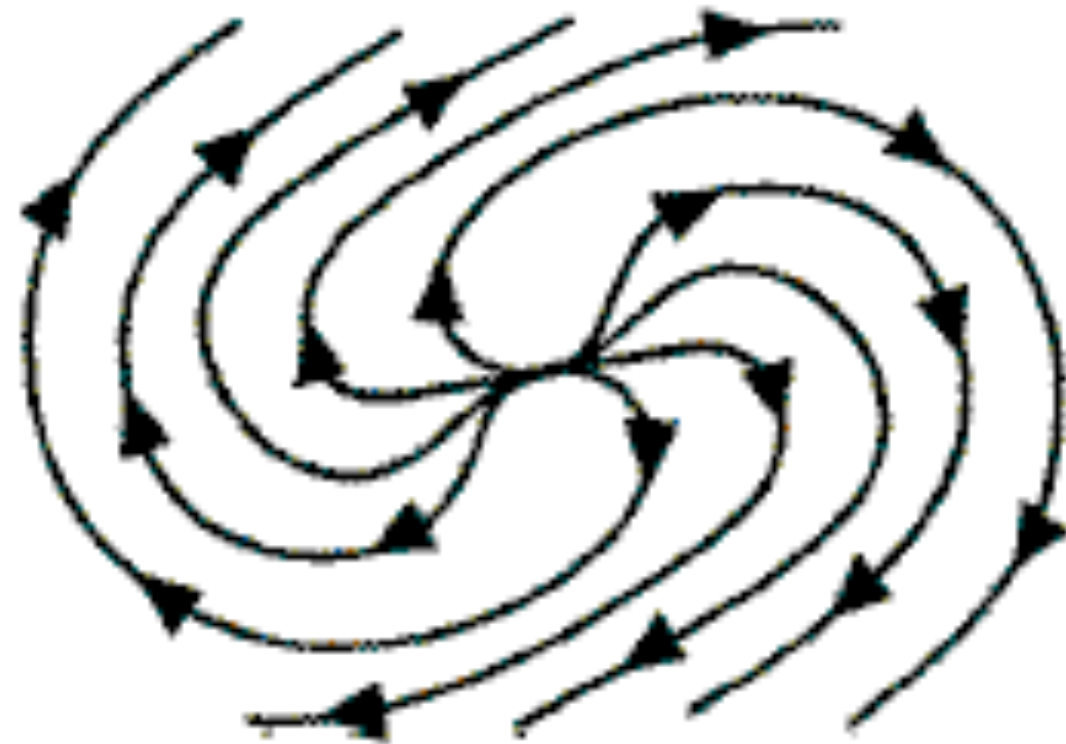


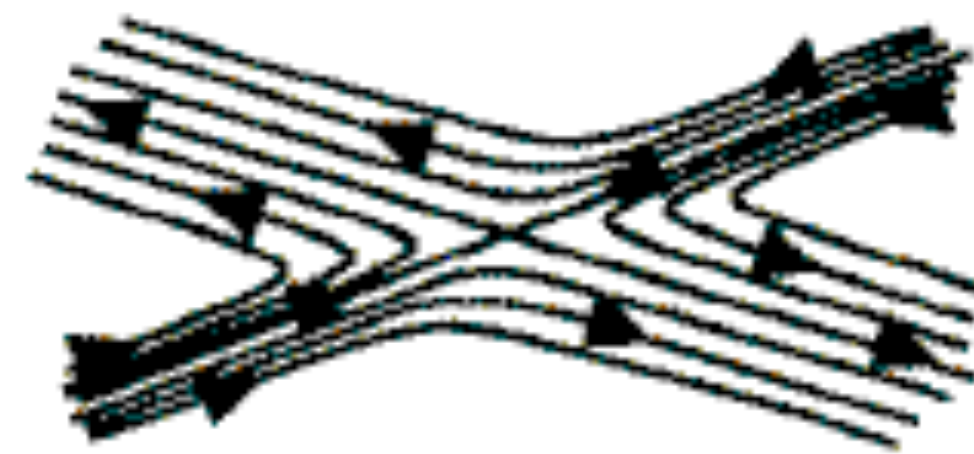
Figure 7.1 A phase portrait.

[M. Henle]

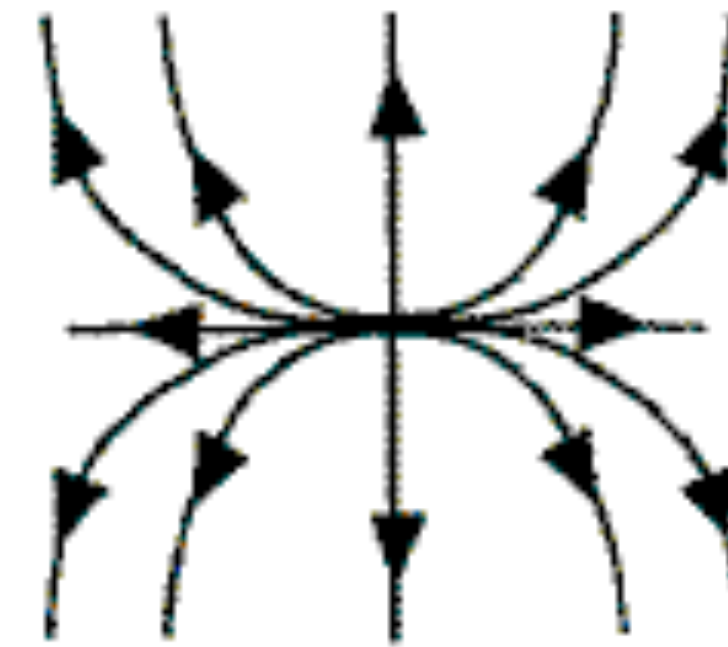
Critical Points



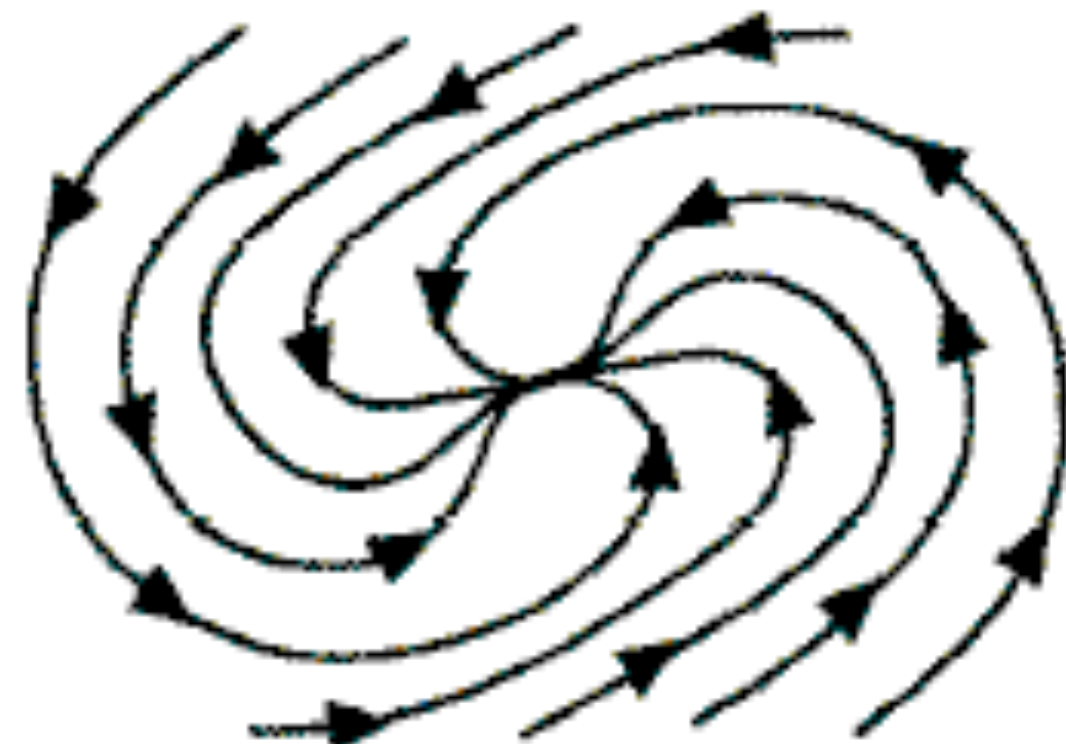
Repelling Focus
 $R_1, R_2 > 0$
 $I_1, I_2 \neq 0$



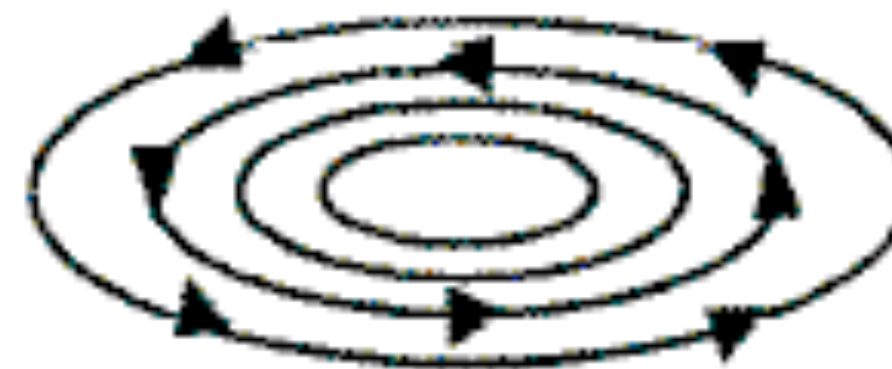
Saddle Point
 $R_1 \cdot R_2 < 0$
 $I_1, I_2 = 0$



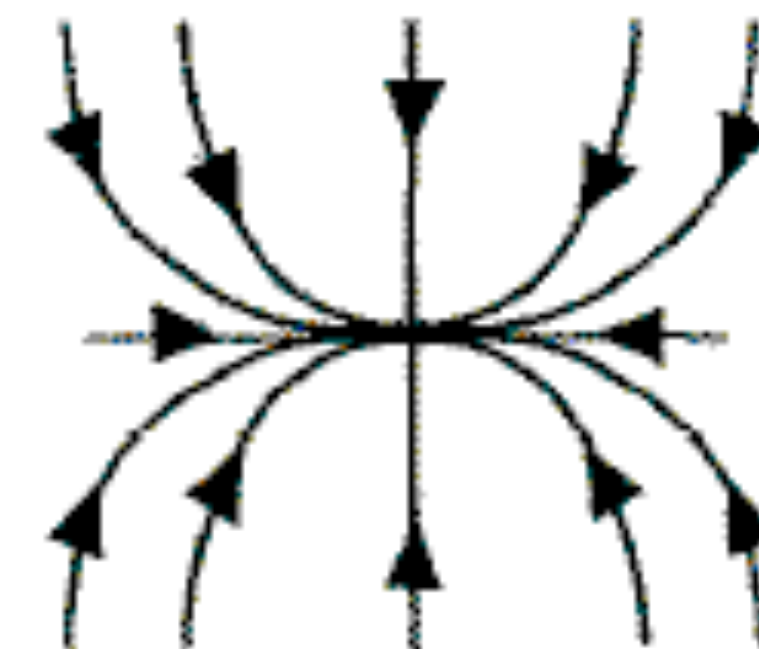
Repelling Node
 $R_1, R_2 > 0$
 $I_1, I_2 = 0$



Attracting Focus
 $R_1, R_2 < 0$
 $I_1, I_2 \neq 0$



Center
 $R_1, R_2 = 0$
 $I_1, I_2 \neq 0$



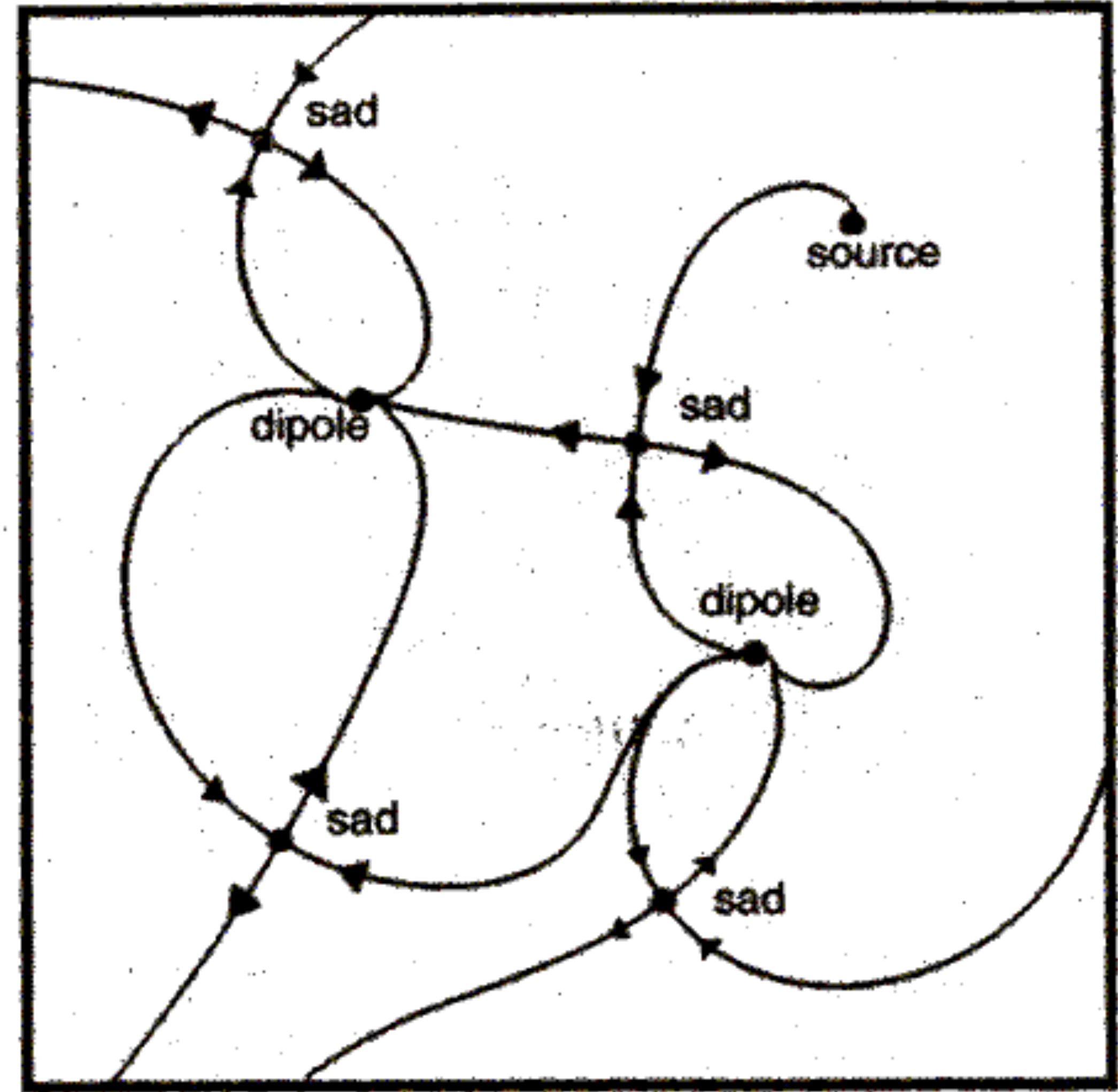
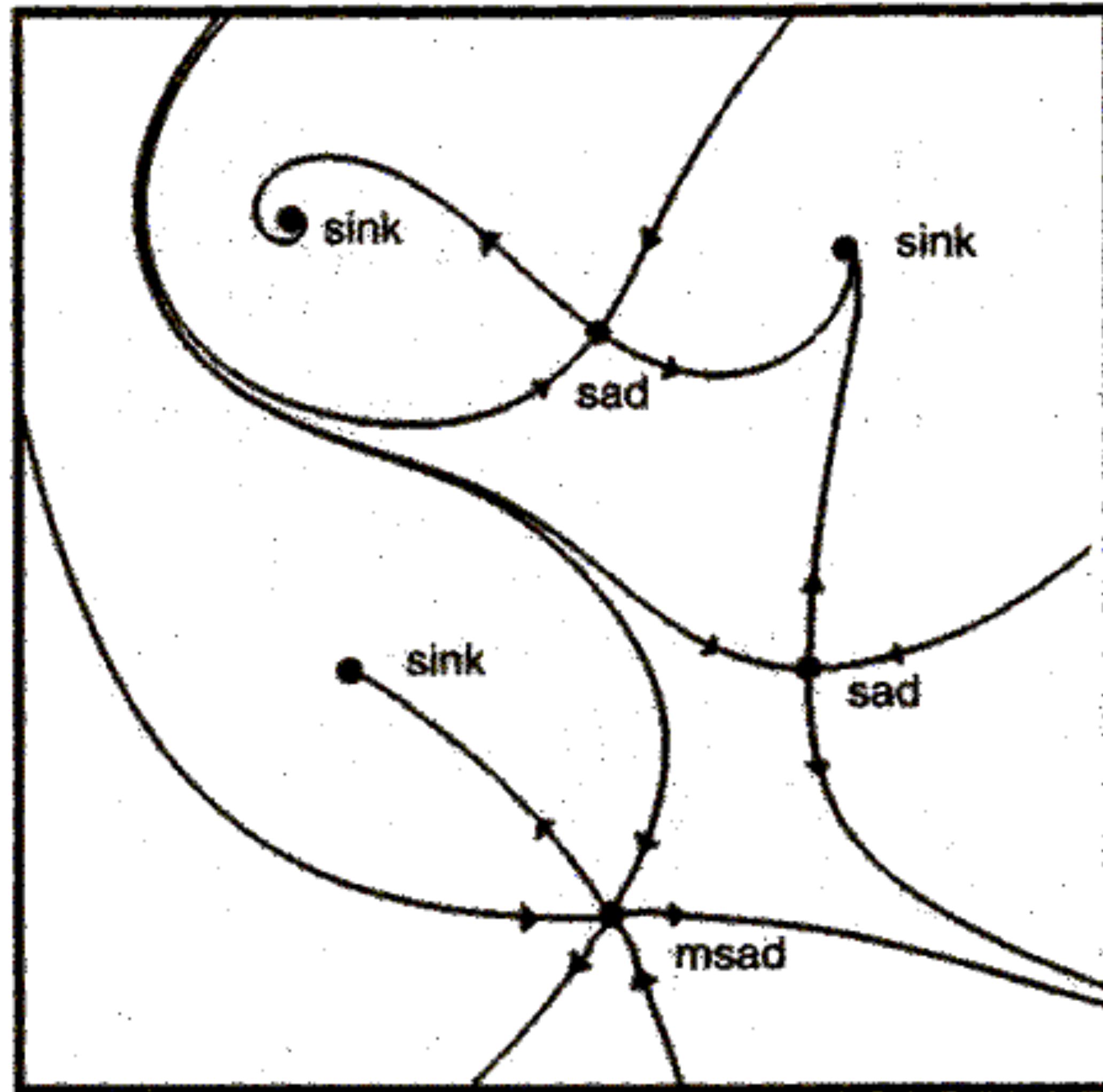
Attracting Node
 $R_1, R_2 < 0$
 $I_1, I_2 = 0$

[Helman & Hesselink]

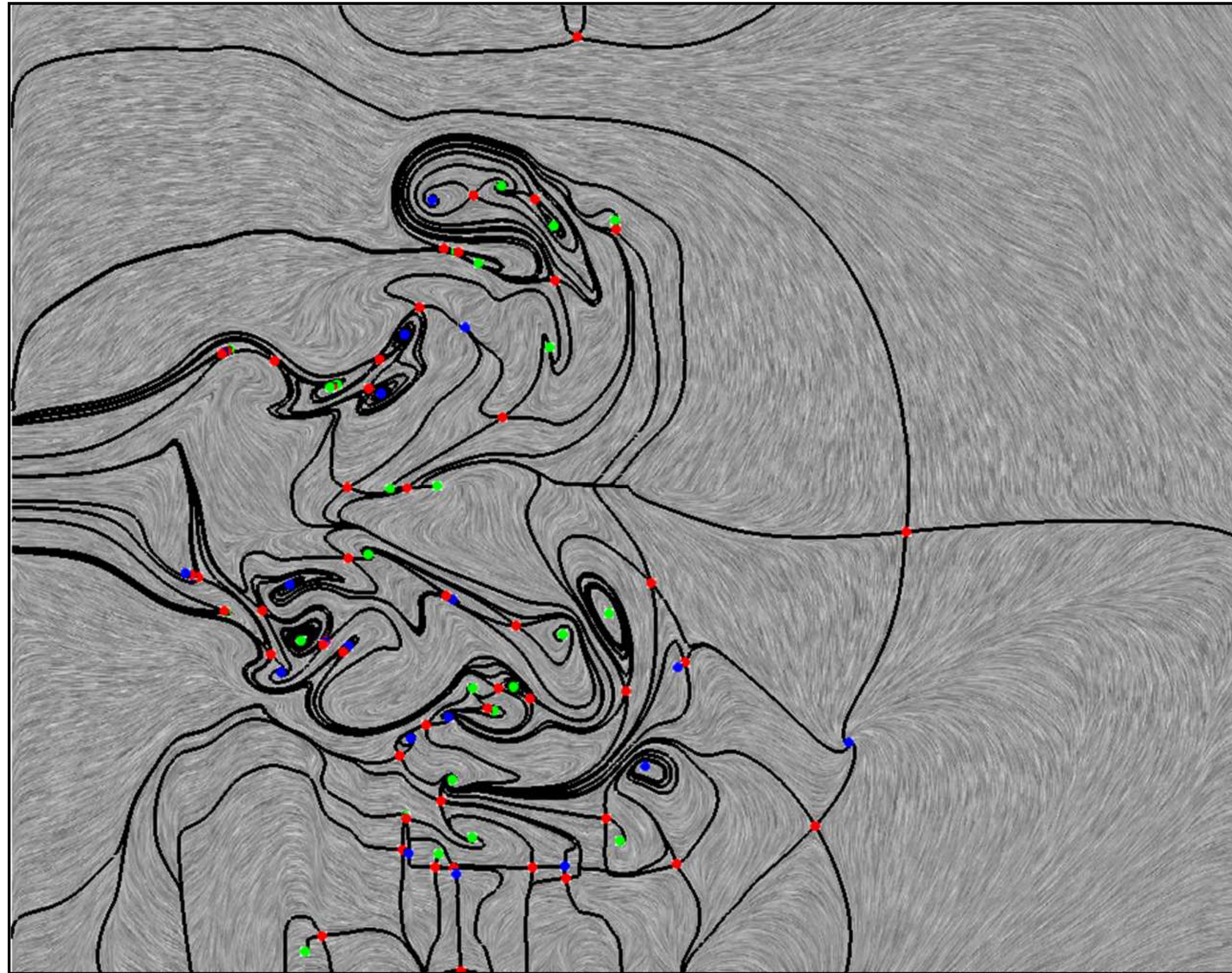
Critical Points

- Critical Points
 - Find where the vector field vanishes (the zero vector or undefined)
 - Attracting Nodes (Sinks), Repelling Nodes (Sources), Attracting Foci, Repelling Foci, Saddles, Centers
- How to find such points?
 - Can use a similar idea to Marching Cubes
 - Use the eigenvalues of the Jacobian matrix to classify

Topological Skeleton



More Examples



[Levine]

Text

Text Visualization

- Why visualize text? Text is already visual, right?
- How much text? What granularity? (What is an item?)
 - Single string
 - Words/lines
 - One document
 - Multiple documents (corpus)
- Considerations:
 - Legibility
 - Variable length
 - Locality
 - Occurrence

Data Sources

- Literature: books, poetry
- Social Media: tweets, posts
- Web: Pages, posts, emails
- Code

Tag Cloud (One Document)

- Derived data: number of occurrences of words
- Channel: Font size
- Potential problem: Think about ink...



[Scray, CC-BY-SA-3.0]

Read

ALICE'S ADVENTURES IN WONDERLAND

Lewis Carroll

THE MILLENNIUM FULCRUM EDITION 3.0

CHAPTER I

Down the Rabbit-Hole

Alice was beginning to get very tired of sitting by her sister on the bank, and of having nothing to do: once or twice she had peeped into the book her sister was reading, but it had no pictures or conversations in it, 'and what is the use of a book,' thought Alice 'without pictures or conversation?'

So she was considering in her own mind (as well as she could, for the hot day made her feel very sleepy and stupid), whether the pleasure of making a daisy-chain would be worth the trouble of getting up and picking the daisies, when suddenly a white Rabbit with pink eyes ran close by her.

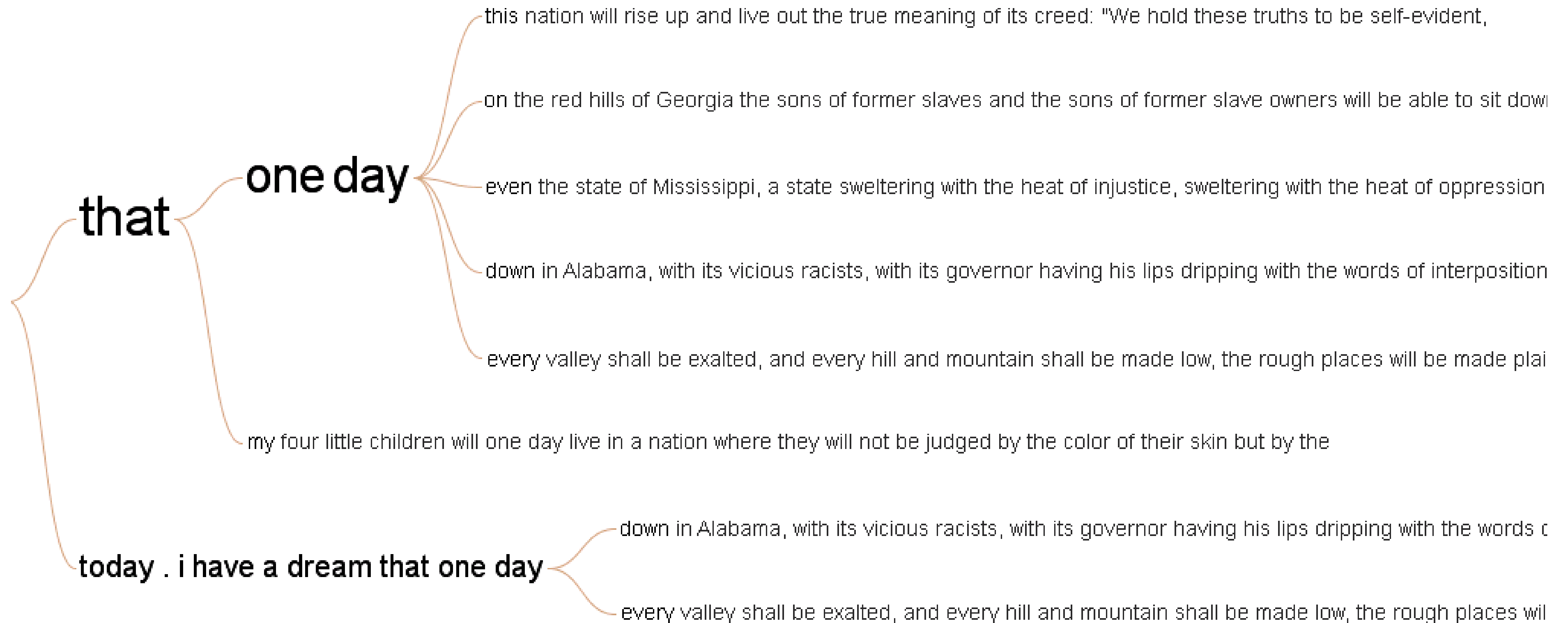
There was nothing so VERY remarkable in that; nor did Alice think it so VERY much out of the way to hear the Rabbit say to itself, 'Oh dear! Oh dear! I shall be late!' (when she thought it over afterwards, it occurred to her that she ought to have

signify frigate hole rat celebration pleasure a...
 manufacture bat slipped label pool she'll adv...
 ears of mail hungrily forward lock burn Dinah...
 and as a pledge to her pardon position save woman they'll...
 submit two letter takes sensation whatever ye English take...
 an hour in a rate dear as small spread take bottle...
 and sleepy shawnders sunny hunting sent animal cake...
 a sorry crested headed other will know as large...
 d take a thing and way down a hole...
 use nothing in a little herself...
 began thought... get...
 turn... know...
 Alice...
 time...
 a low...
 antermptuous...
 tweak...
 chose...
 Miss...
 bowed nose tiptoe waistake feeble height...
 sleep...
 decided...
 couple baby...
 should...
 mushroom wood sky...
 Caterpillar...
 addressed...
 em...
 solemn...
 Mind...
 curls...
 whisker...
 smoke...
 beneath...
 false...
 ar...
 br...

TextArc

- Three rules:
 - Show the entire text in an ellipse around the page: line-by-line and word-by-word
 - Like tag clouds, use larger font-size and brighter text for frequent words
 - Central words move to the middle (links to its mentions)

Word Tree (One Document)

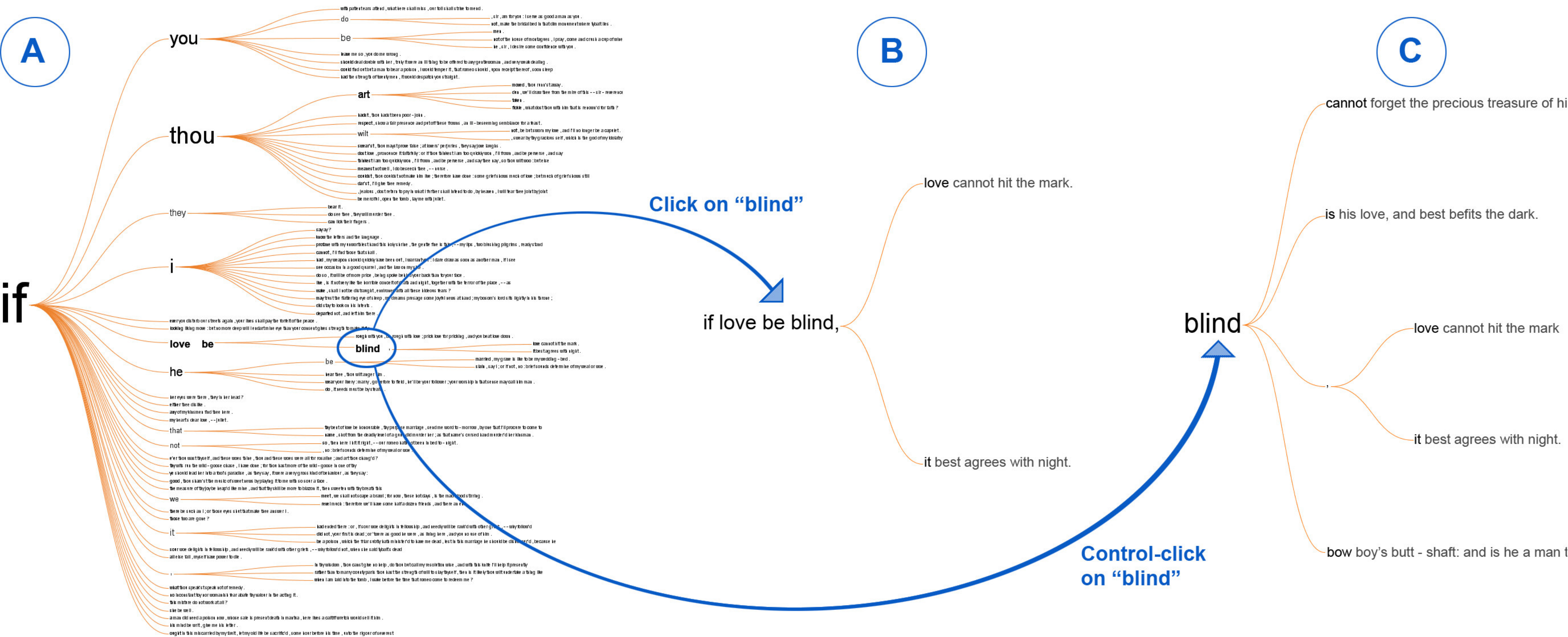


[Wattenberg & Viegas, 2007]

Word Tree

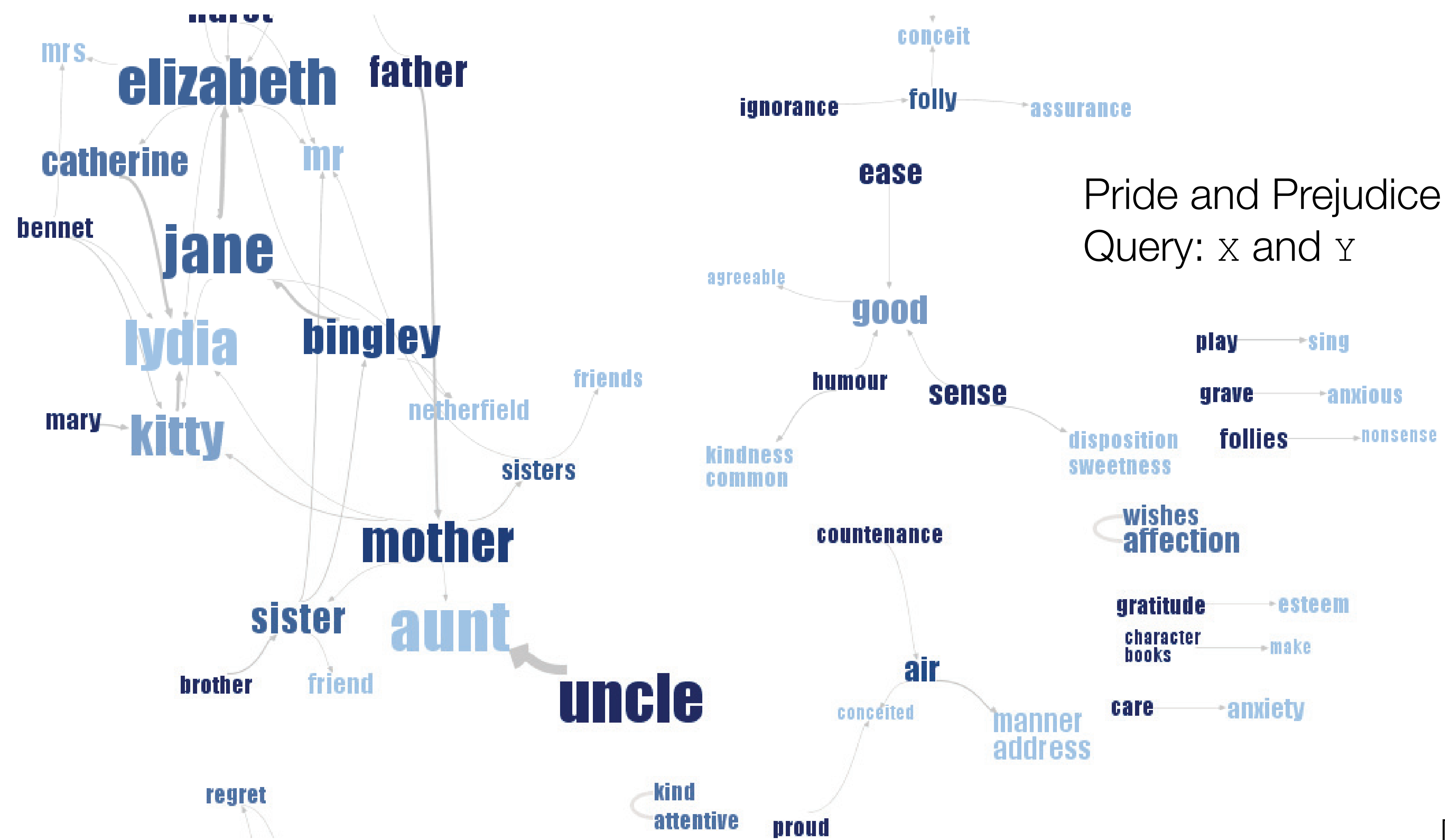
- A "Visual Concordance"
- Shows phrasing, relationships between words
- Starting point is a single word or snippet
- Branches to show common words/phrases that follow
- Goal is to show context: "keyword-in-context"

Interaction in Word Tree



[Wattenberg & Viegas, 2007]

Phrase Nets



Pride and Prejudice
Query: x and y

[van Ham, 2009]

Words are more than just character sequences

Fed Drapes

Clark Coolidge

FELL ~~FAR~~ BUT THE BARN (came) up & ~~smacked~~ me

Who're you, bleeding? Fled.

Blat in back of a Vistrola Car

is so red is such that sun

fell in the rushes & pen bear appear

the white wrong numeral on the wall

can't take it off with the clock

down with the clock it ...

way

on the board - couch with brass, kindergarten clench joints

backed violet rip into the gas valve

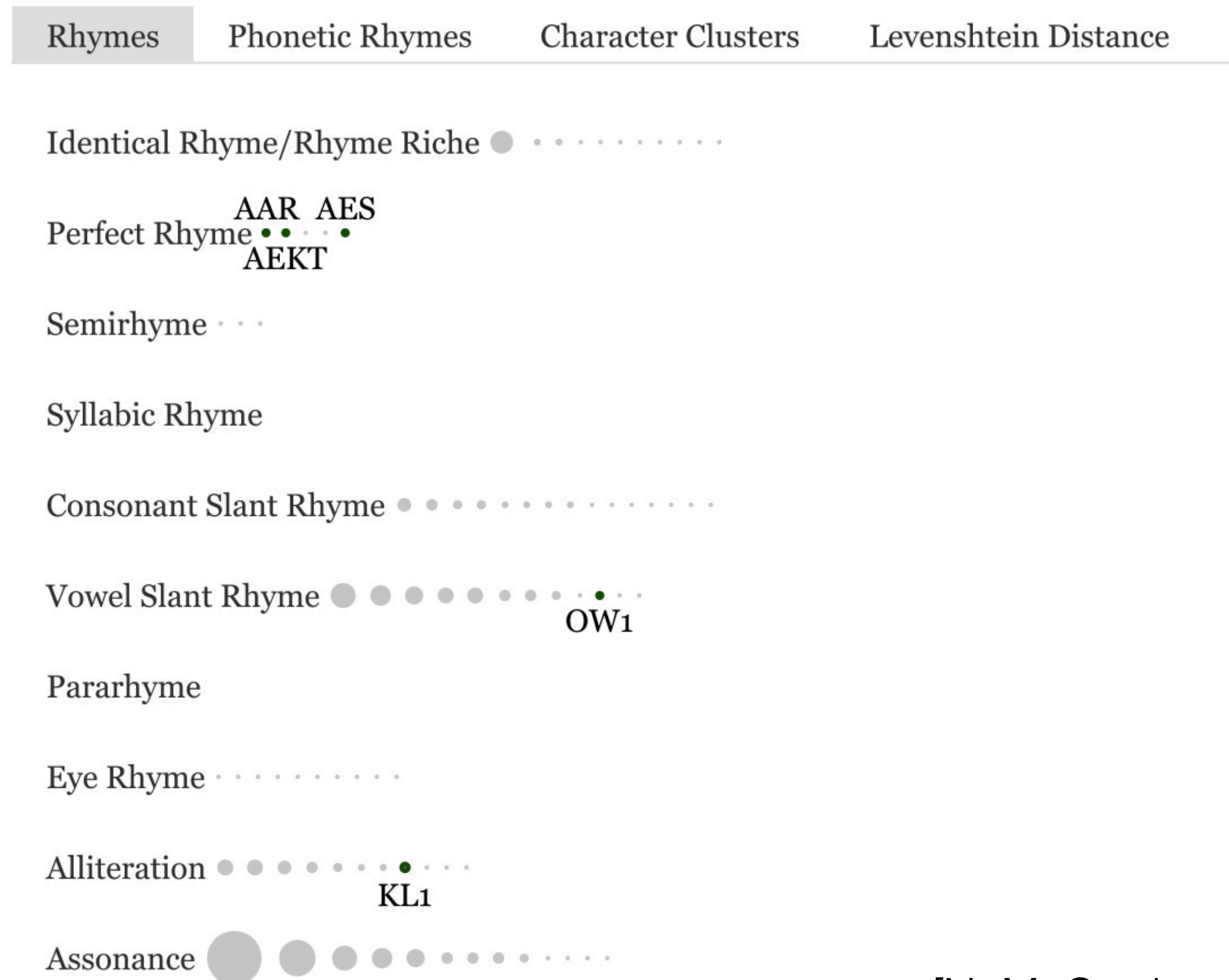
it hemmed & snowed

the wrong way

remnant face

rubber

the pucker



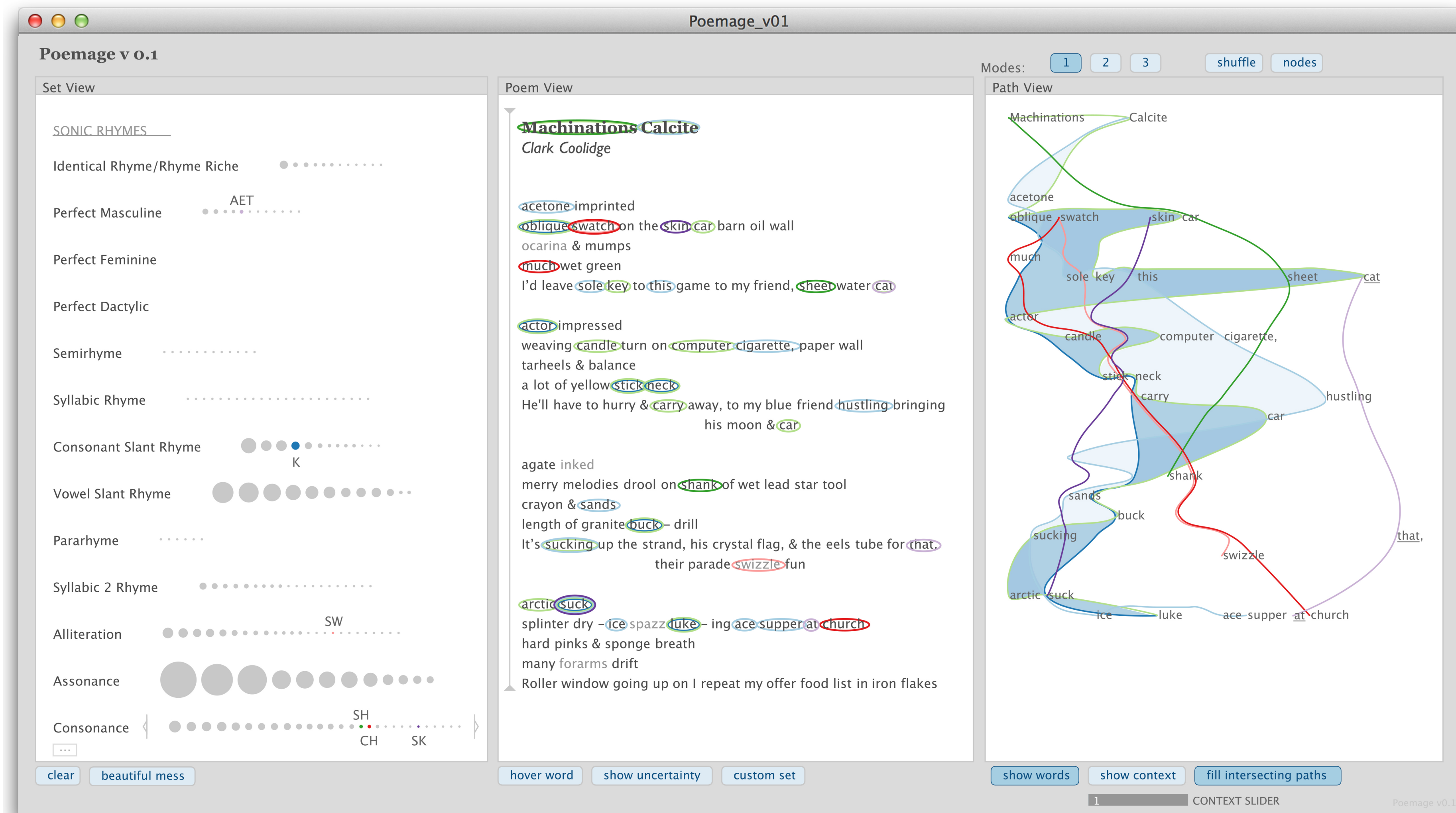
[N. McCurdy et al., 2015]

Poemage

- Support close reading—in-depth reading to generate as much productive meaning as possible
- Search for poetic devices: affect, imagery, pun, metaphor
- Sound and linguistic devices → Rhyming
 - Identical: pare/pair
 - Perfect: picky/tricky
 - Assonance & consonance: blue/estuaries, shell/chiffon
 - Eye rhyme: cough/bough
- Support exploration: scholars do not want computers to "solve" poems

[N. McCurdy et al., 2015]

Interface



[N. McCurdy et al., 2015]

Comparing Documents

- Word choice/usage
- Relationships
- Phrasing

Tag Cloud (Two Documents)

State of the Union Address, 2002 vs. 2011

act afghanistan allies
american attack best budget
camps children citizens coalition
congress continue corps country create
danger depend destruction develop economy encourage
enemies evil extend fight free freedom
government health help history home homeland
hope increase islamic jobs join lives mass
military moment months nation opportunity
peace people police power protect rebuild
regimes resolve retirement security
spending states tax terror
terrorists thank thousands
together tonight training true united
war ways weapons women
work workers world

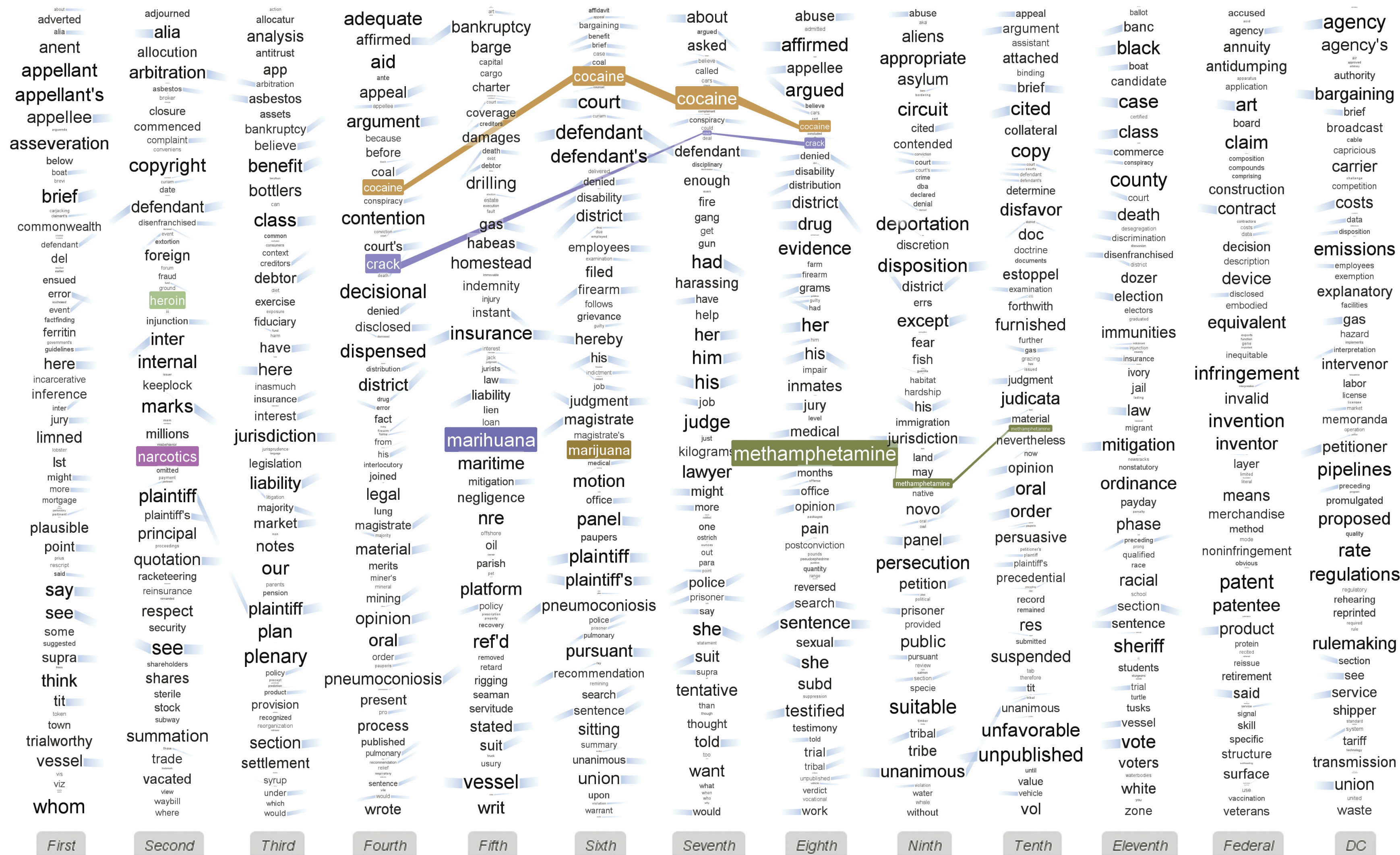
President Bush, January 29, 2002

afghan ago already american behind
believe best better building business
care century challenge chance change child children clean
college company compete congress country
create cuts deficit democrats different don done
dream economy education energy family
future generation give goal
government health help home idea
innovation internet invest jobs laughter law
life live money nation passed
people percent possible projects race reform
republicans research responsibility schools
spending states step students success
support sure tax teachers technology things together
tonight troops willing win work workers
world years

President Obama, January 25, 2011

[Pyrsmis, CC-BY-SA-3.0]

Parallel Tag Clouds (Multiple Documents)



[Collins et al., 2009]

Jigsaw (Multiple Documents)

Visual Analytics Support for Intelligence Analysis Case Study: The 9/11 Report

Carsten Görg
Youn-ah Kang
Zhicheng Liu
John Stasko



Information Interfaces Group
Georgia Institute of Technology

[<http://www.cc.gatech.edu/gvu/ii/jigsaw/>]

Jigsaw (Multiple Documents)

Visual Analytics Support for Intelligence Analysis Case Study: The 9/11 Report

Carsten Görg
Youn-ah Kang
Zhicheng Liu
John Stasko



Information Interfaces Group
Georgia Institute of Technology

[<http://www.cc.gatech.edu/gvu/ii/jigsaw/>]