Local and Remote Visualisation Techniques

UvA HPC cursus

Robert Belleman, UvA/IvI
Paul Melis, SURFsara
Tijs de Kler, SURFsara

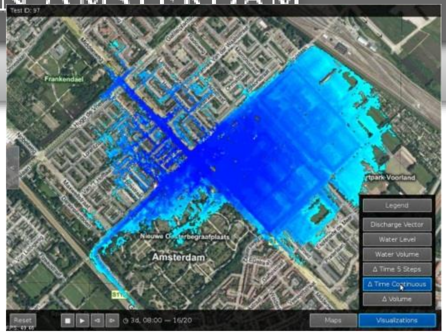
Program for today

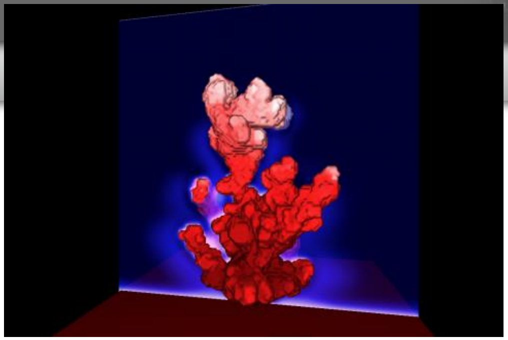
- 13:00 – 13:30: Introduction to visualization
- 13:30 – 14:30: Visualization at SURFsara, Introduction to ParaView
- 14:30 – 16:30: Hands-on: scientific visualization with ParaView
- 16:30 – 17:00: Remote Visualization

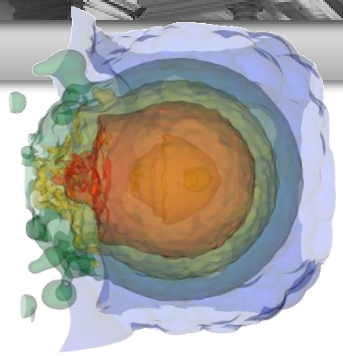
Introduction to visualization

Robert G. Belleman, PhD
Informatics Institute
University of Amsterdam

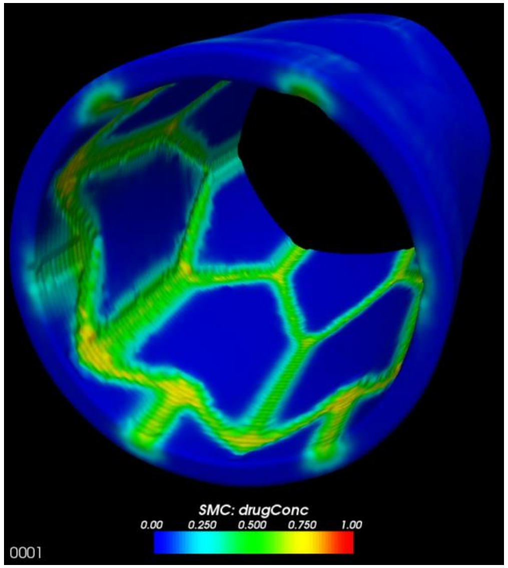
Email: R.G.Belleman@uva.nl

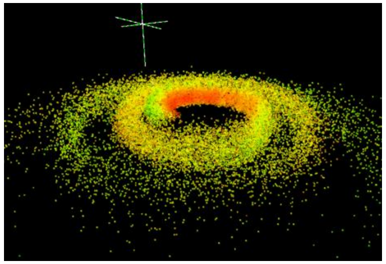


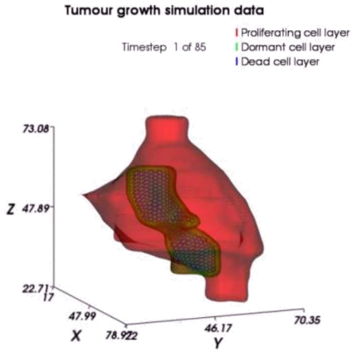


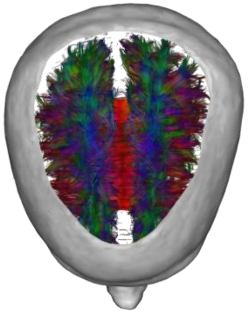


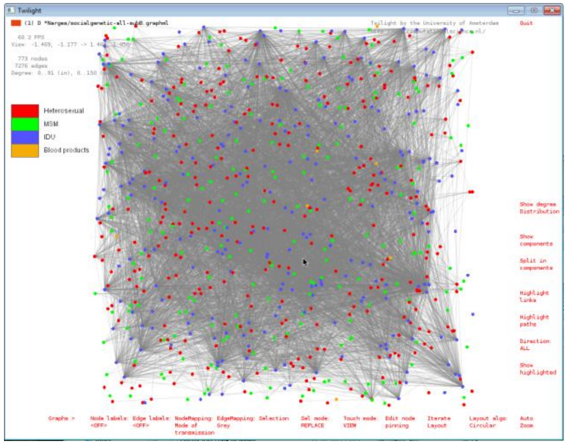
- **Scientific Visualization and Virtual Reality** team
  - part of *Computational Science* at UvA/IvI
  - close collaboration with SARA
- Research theme: **interactive visual exploration**
  - Software solutions and architectures, Problem Solving Environments, Interactive graphics devices
- Application areas: computational science
  - (astro)physics, medicine, biology, finance, architecture, computer science, …











X	Y	X	Y	X	Y	X	Y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
14,00	9,96	14,00	8,10	14,00	8,84	8,00	7,04
6,00	7,24	6,00	6,13	6,00	6,08	8,00	5,25
4,00	4,26	4,00	3,10	4,00	5,39	19,00	12,50
12,00	10,84	12,00	9,11	12,00	8,15	8,00	5,56
7,00	4,82	7,00	7,26	7,00	6,42	8,00	7,91
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

A B C D

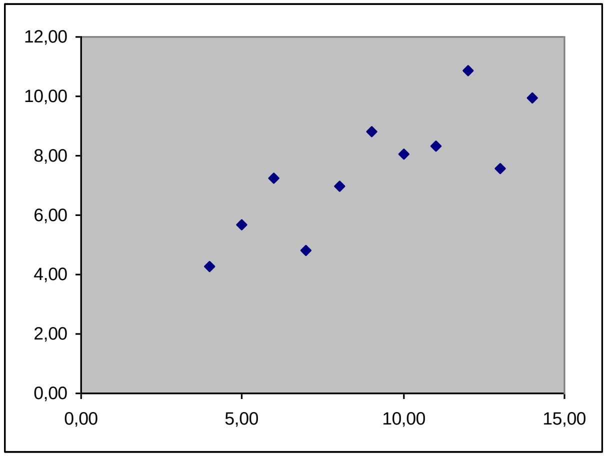
“Anscombe’s quartet”, F.J. Anscombe, “Graphs in Statistical Analysis”,
American Statistician, 27 (February 1973), 17-21.

X	Y	X	Y	X	Y	X	Y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
14,00	9,96	14,00	8,10	14,00	8,84	8,00	7,04
6,00	7,24	6,00	6,13	6,00	6,08	8,00	5,25
4,00	4,26	4,00	3,10	4,00	5,39	19,00	12,50
12,00	10,84	12,00	9,11	12,00	8,15	8,00	5,56
7,00	4,82	7,00	7,26	7,00	6,42	8,00	7,91
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

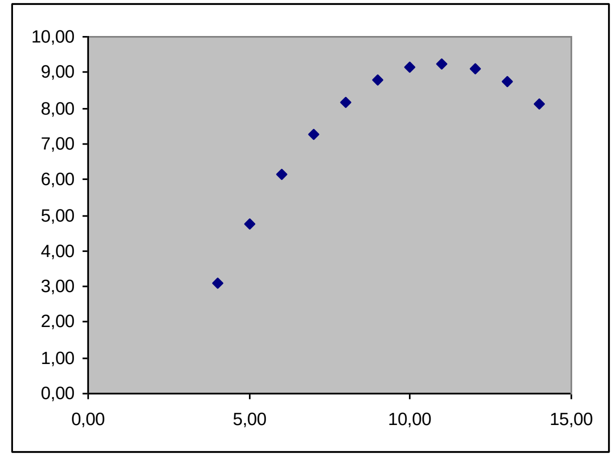
A B C D

$\mu_x = 9.00, \sigma_x = 3.32$
$\mu_y = 7.50, \sigma_y = 2.03$
linear regression: $y = \frac{1}{2}x + 3$

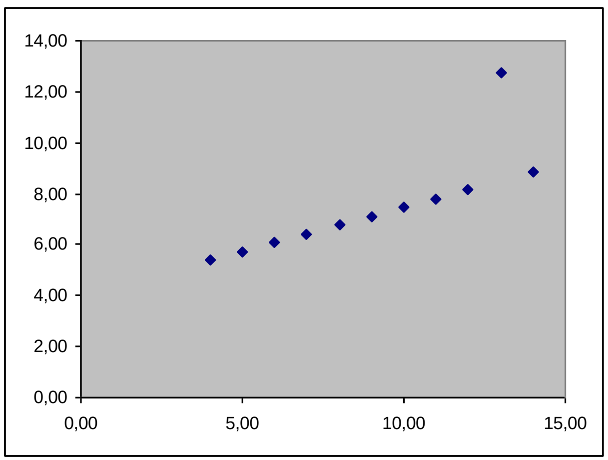
"Anscombe's quartet", F.J. Anscombe, "Graphs in Statistical Analysis", American Statistician, 27 (February 1973), 17-21.



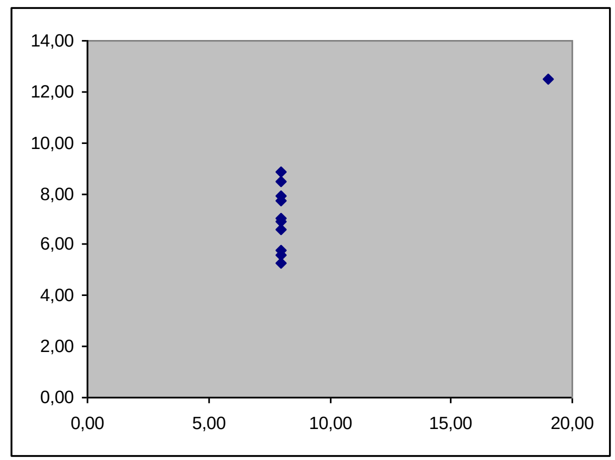
A



B



C



D

“Anscombe’s quartet”, F.J. Anscombe, “Graphs in Statistical Analysis”, American Statistician, 27 (February 1973), 17-21.

Visualization taxonomy

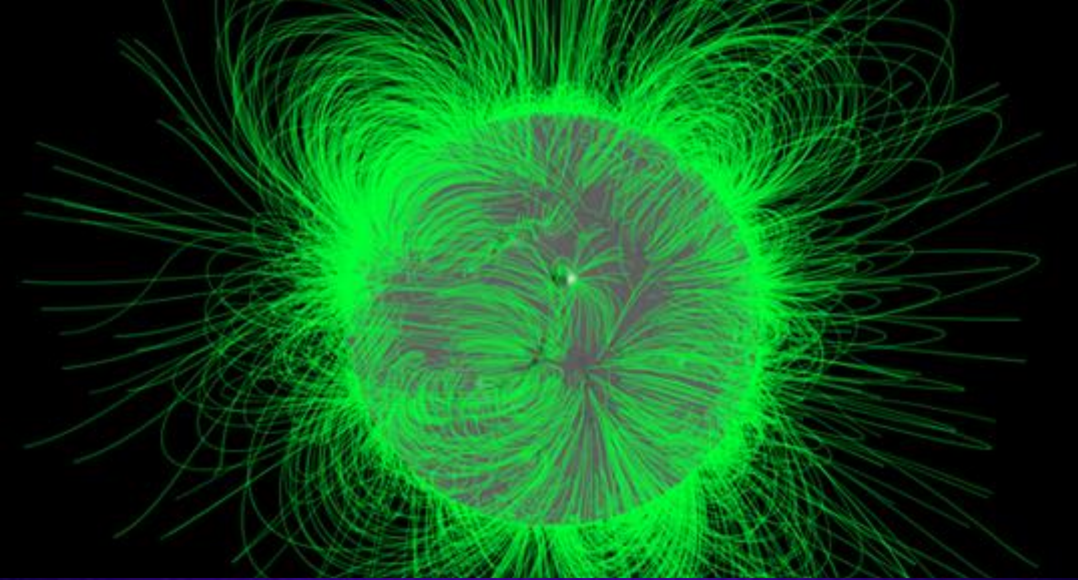
- Scientific visualization ("scivis" or "datavis")
  - Data with an implicit or explicit geometric structure
    - Measurements, results from simulations or experiments
- Information visualization ("infovis" or "infographics")
  - Data with an abstract structure
    - Relations, graphs and networks
- Visual analytics
  - Interactive environments for the detection of the expected and discovery of the unexpected

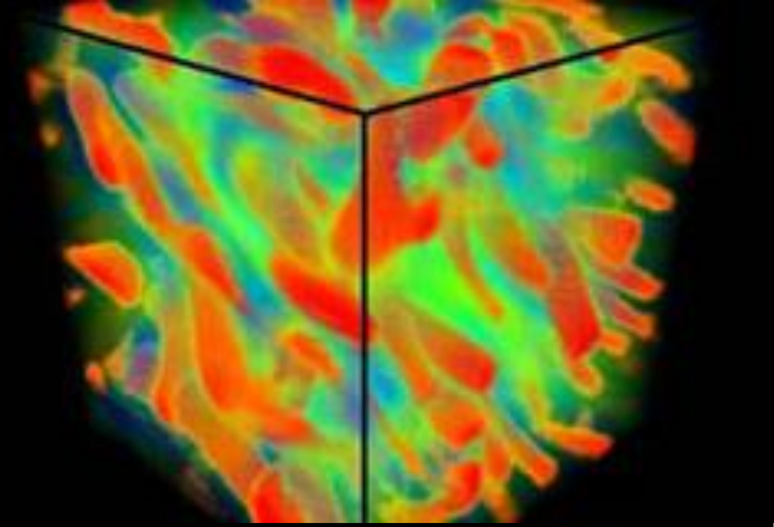
Scientific visualization

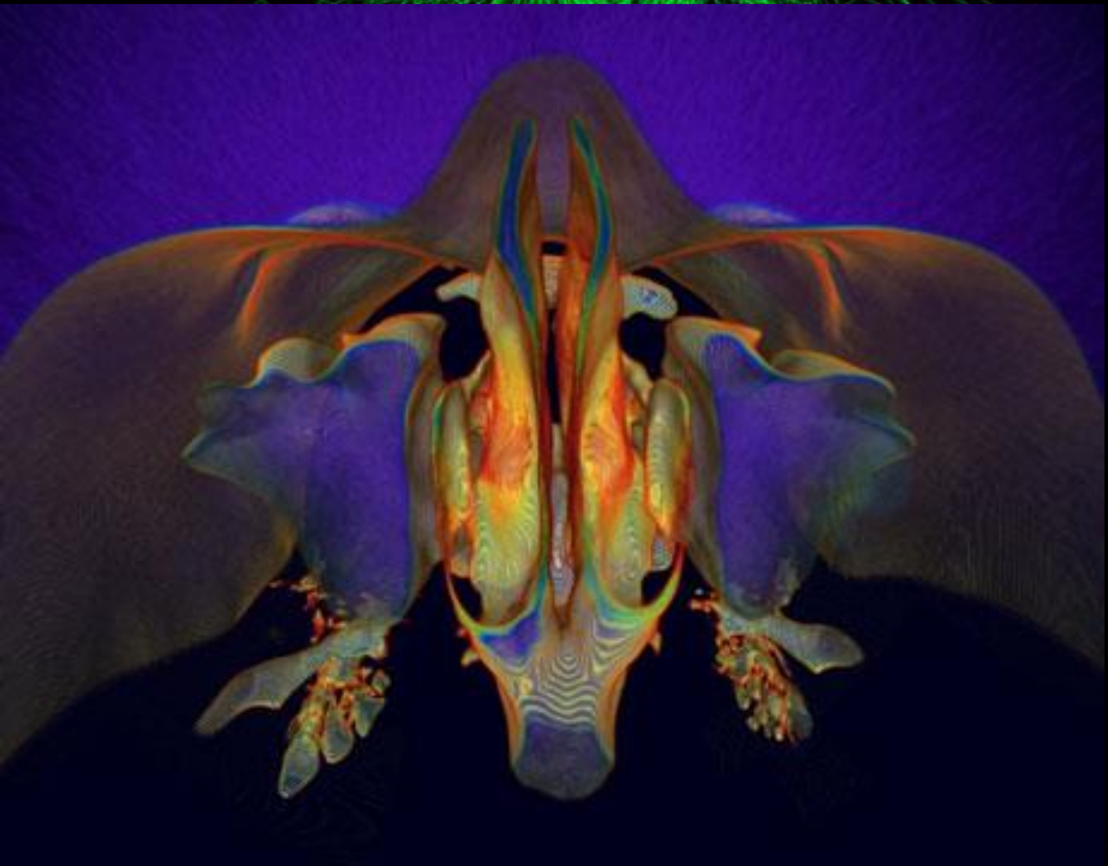
- Scientific visualization deals with all aspects that are connected with the visual representation of data sets from scientific experiments or simulations to achieve a deeper understanding or a simpler representation of complex phenomena.

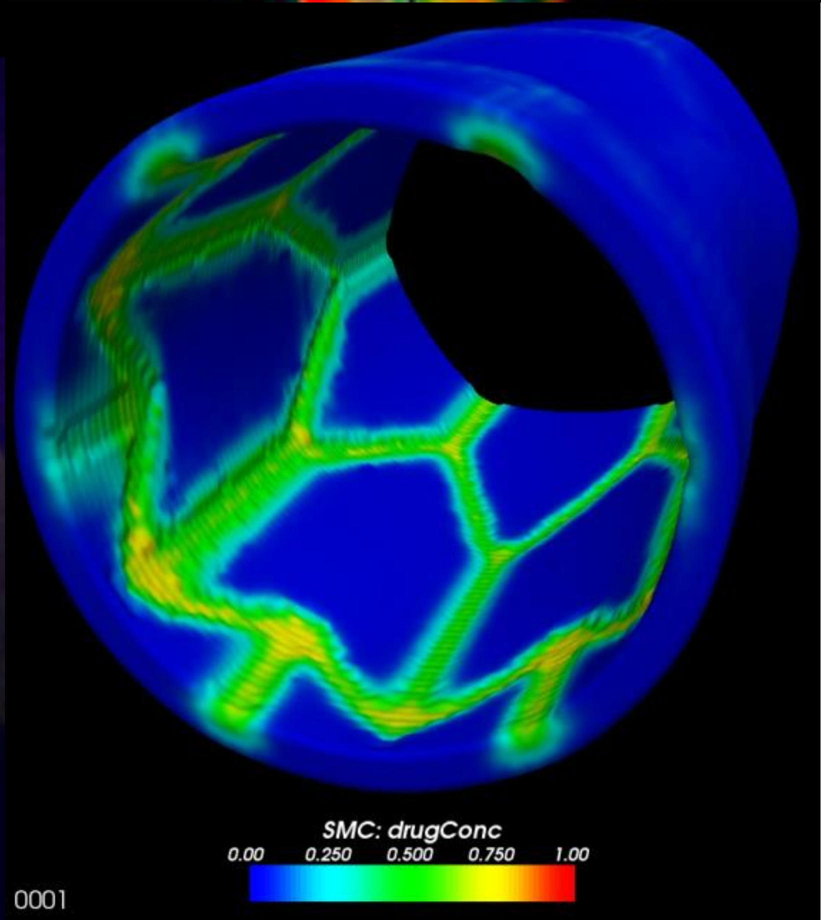
Martin Rotard, Daniel Weiskopf, and Thomas Ertl, *Curriculum for a Course on Scientific Visualization*, Eurographics / ACM SIGGRAPH Workshop on Computer Graphics Education (2004)


L







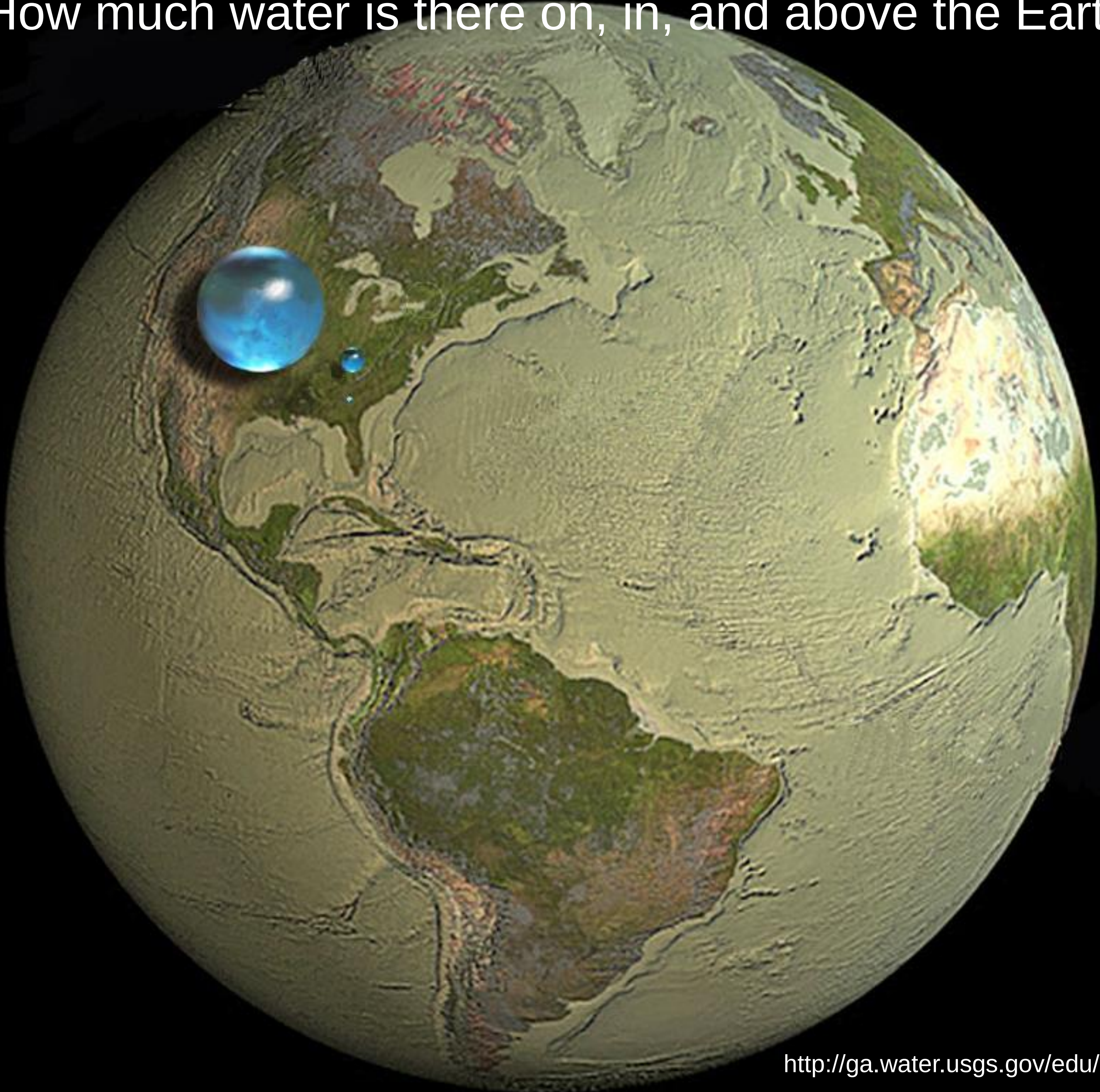

SMC: drugConc
0.00 0.250 0.500 0.750 1.00
0001

Information visualization

- In information visualization, the graphical models may represent abstract concepts and relationships that do not necessarily have a counterpart in the physical world.

Maria Cristina Ferreira de Oliveira, Haim Levkowitz, [doi.ieeecomputersociety.org/10.1109/TVCG.2003.1207445 From Visual Data Exploration to Visual Data Mining: A Survey], IEEE Transactions on Visualization and Computer Graphics, vol. 9, no. 3, pp. 378-394, July-September, 2003.

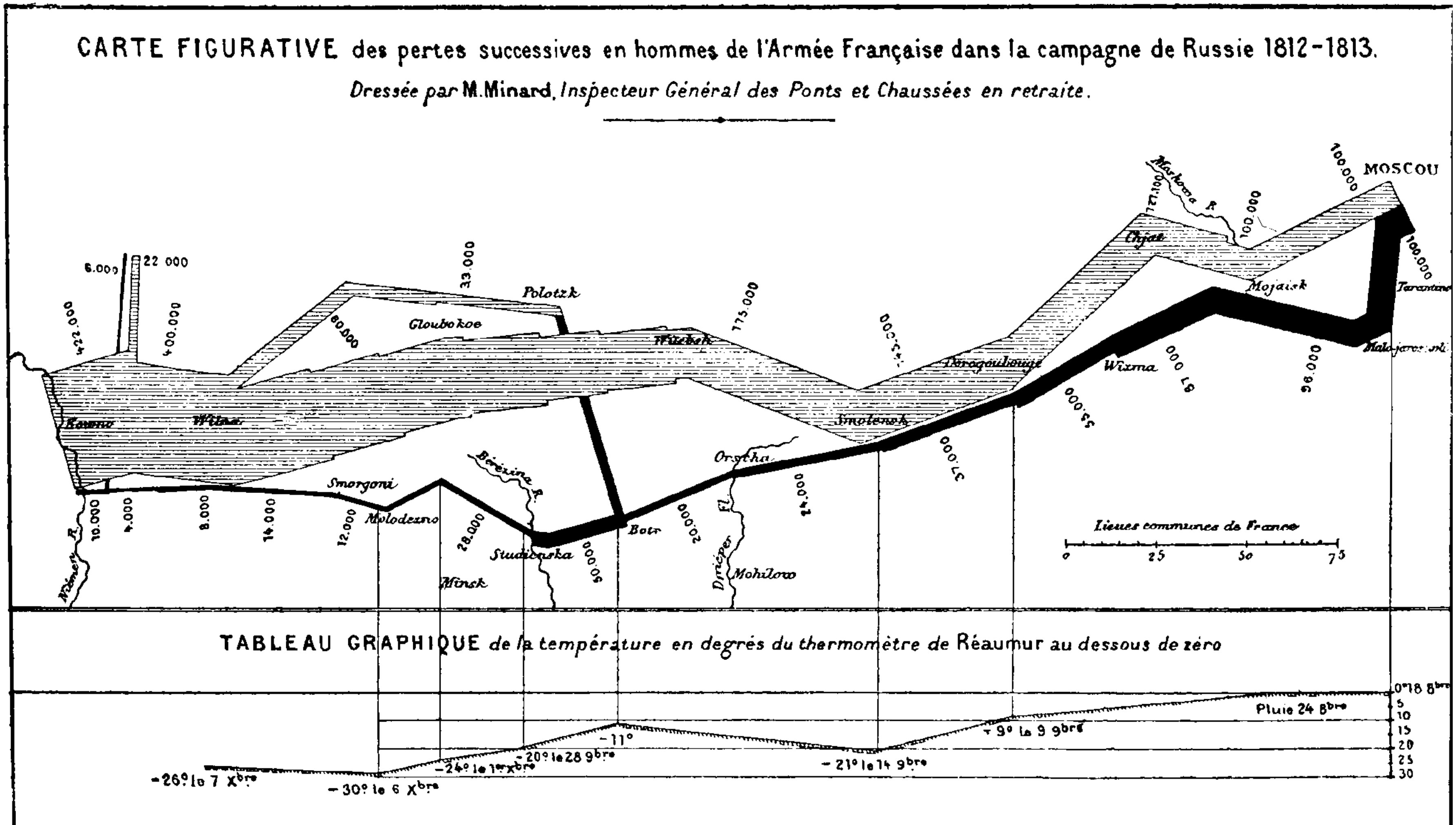
How much water is there on, in, and above the Earth?



http://ga.water.usgs.gov/edu/earthhowmuch.html

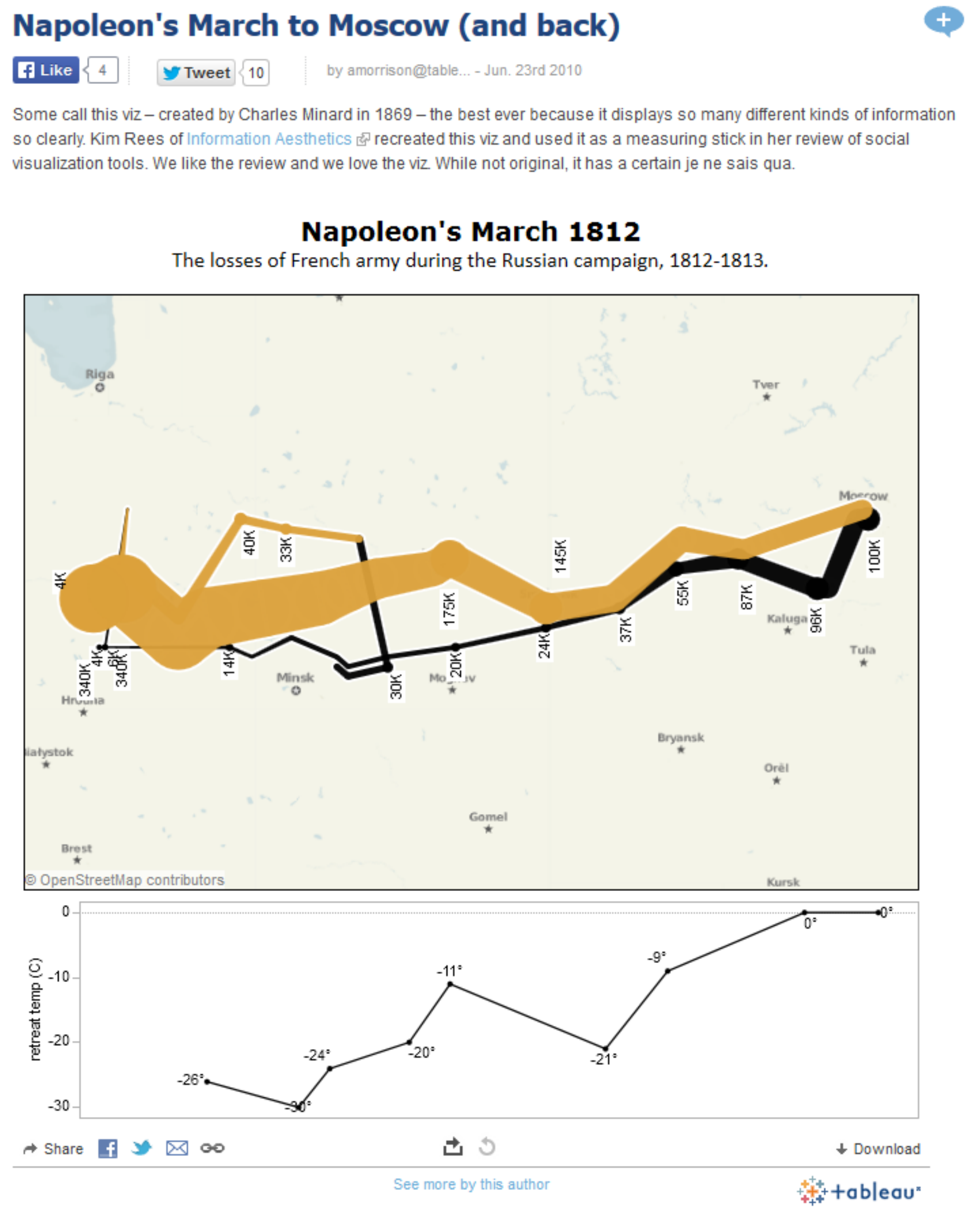
Information visualization

Charles Minard, 1869

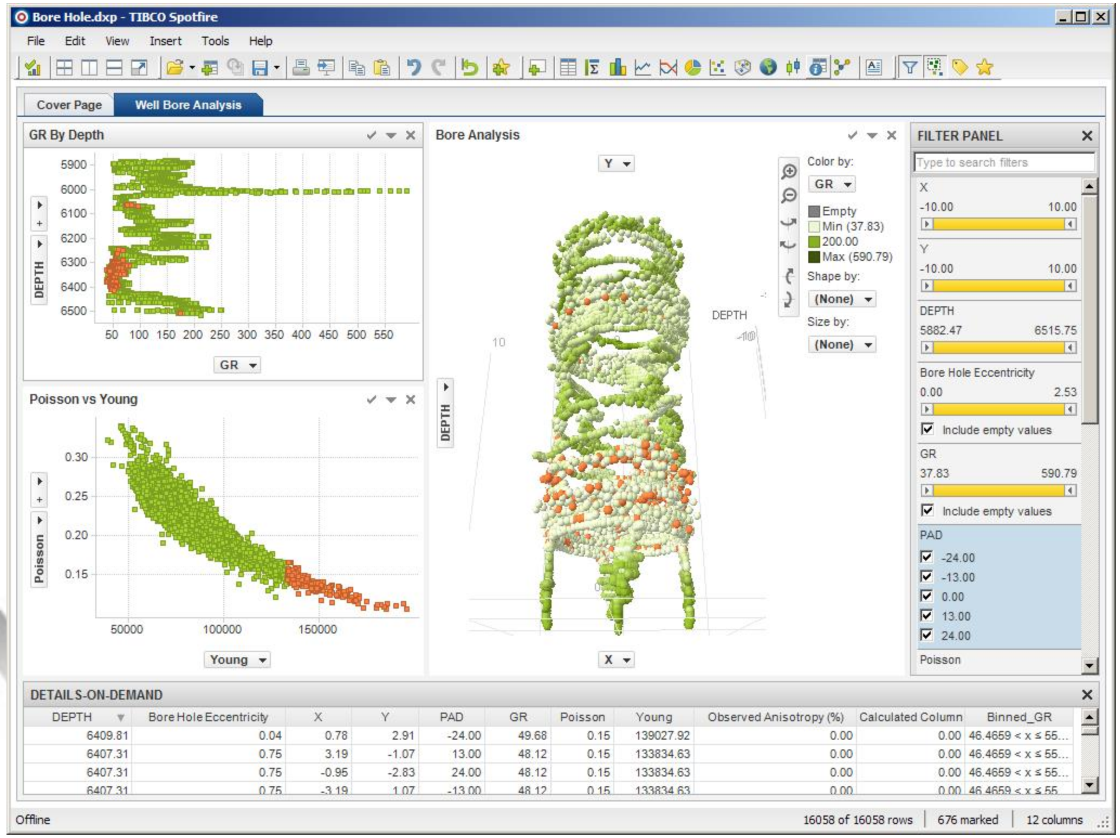


Xbre = December   9bre = November   8bre = October

Software: Tableau

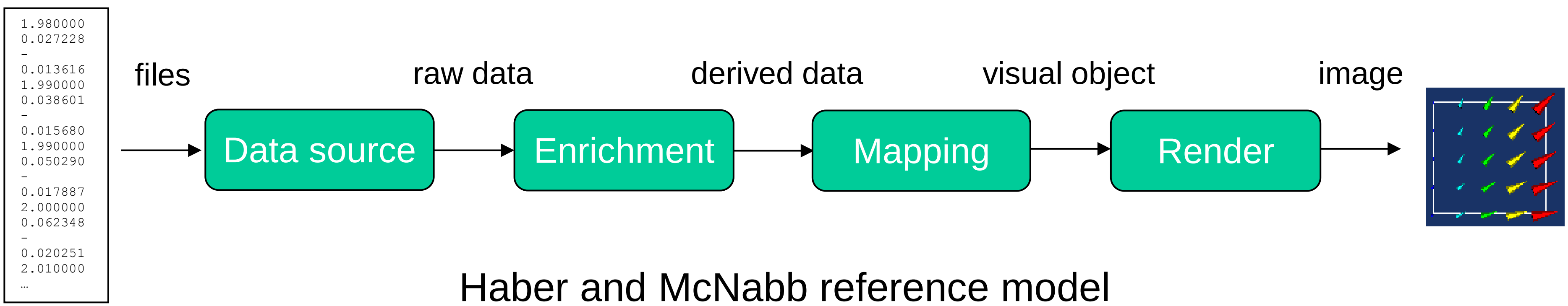


Software: Spotfire



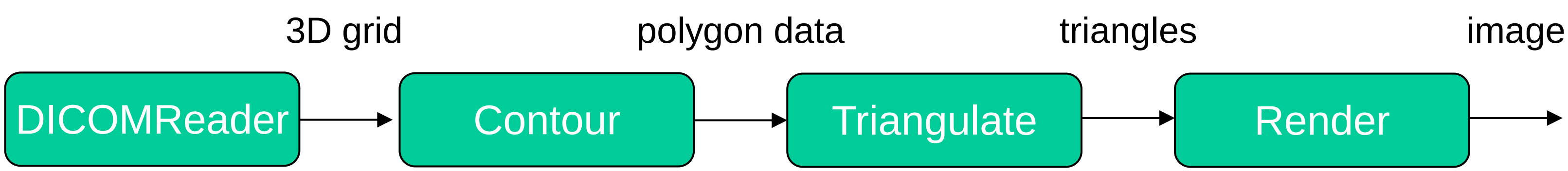
DIY Software: D3.js

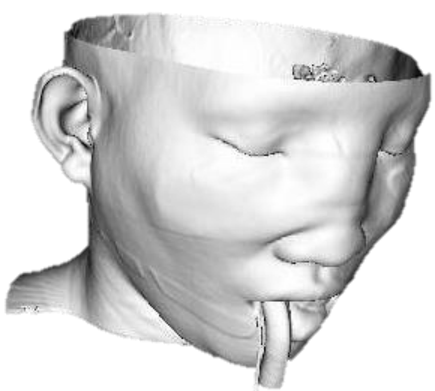
The scientific visualization pipeline



Haber and McNabb reference model

Example:
extracting a contour from medical data

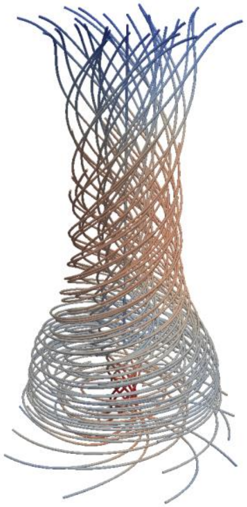




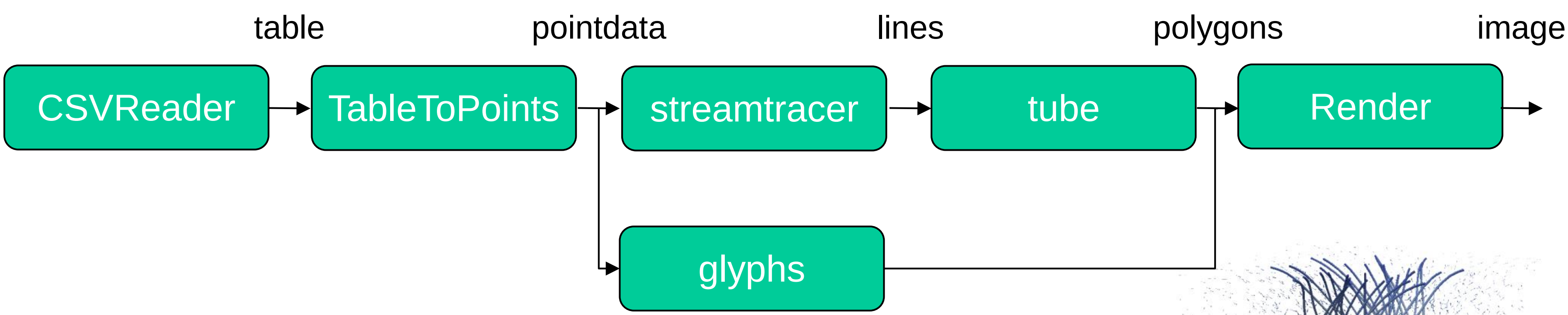
Example:
visualizing flow data with streamlines

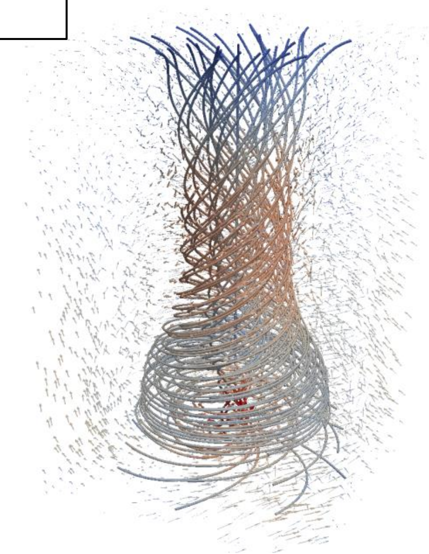
	table	pointdata	lines	polygons	image

CSVReader → TableToPoints → streamtracer → tube → Render →

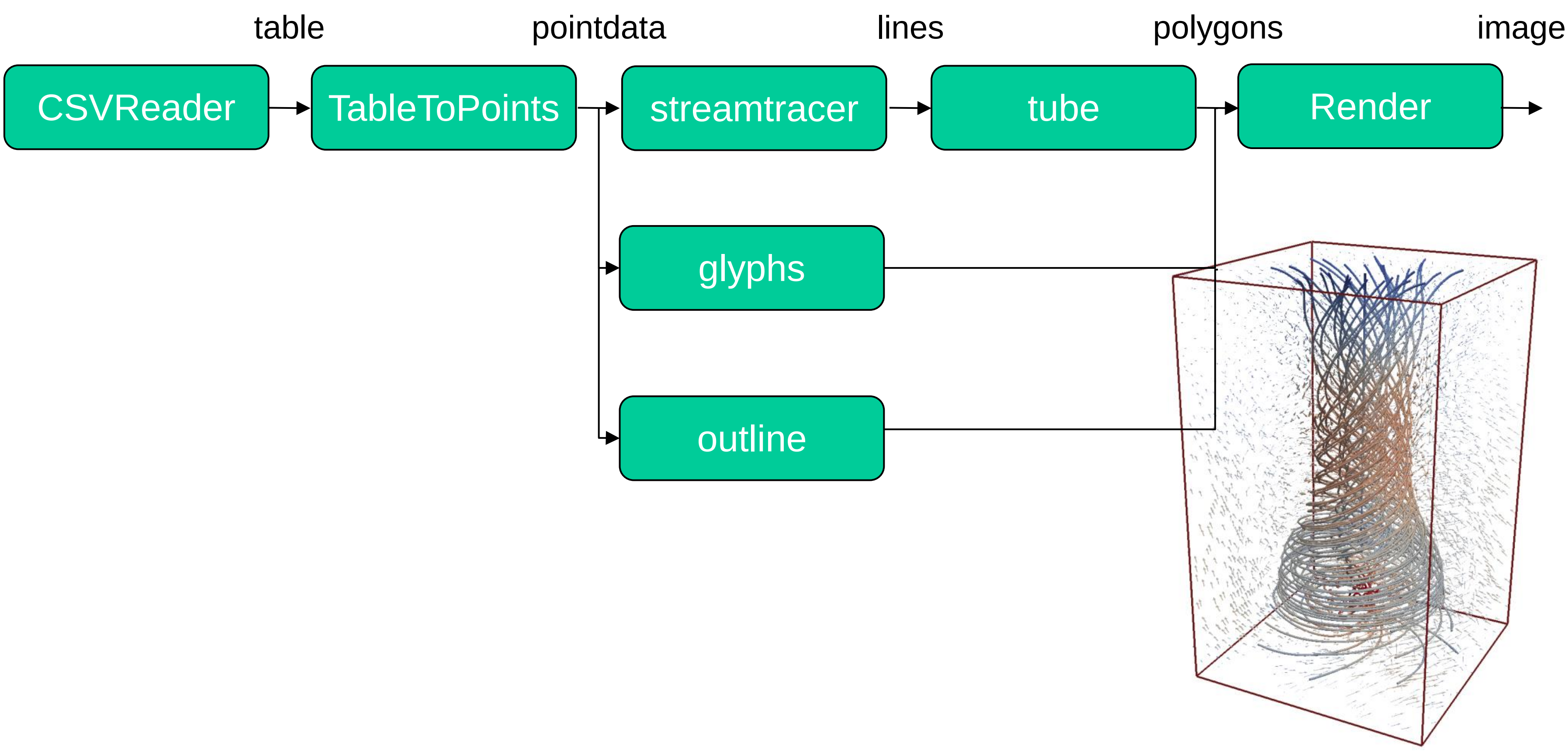


Example: visualizing flow data with streamlines





Example:
visualizing flow data with streamlines



Pipeline creation

- Filters are connected together to form a “visualization pipeline” or “dataflow network”
- The input port of a filter may only be connected to the output port(s) of (an)other filter(s) if the port types are “similar"

Pipeline behaviour

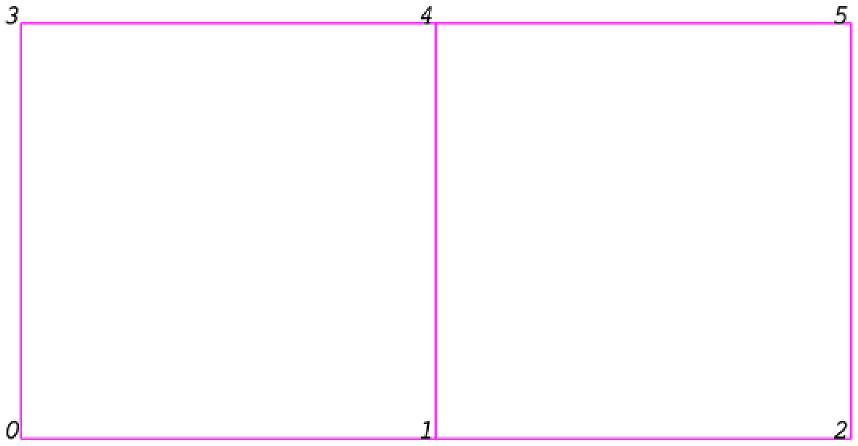
- Filters in a pipeline only execute when necessary
  - When data at the input has changed, or a parameter
- Data flows downstream, update checks go upstream

Data model

- Data sets are represented by a *mesh* and *attributes*

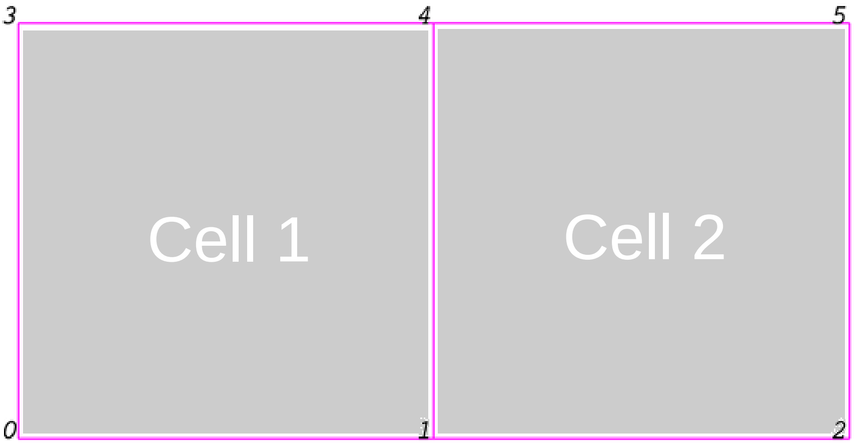
Data model

- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)



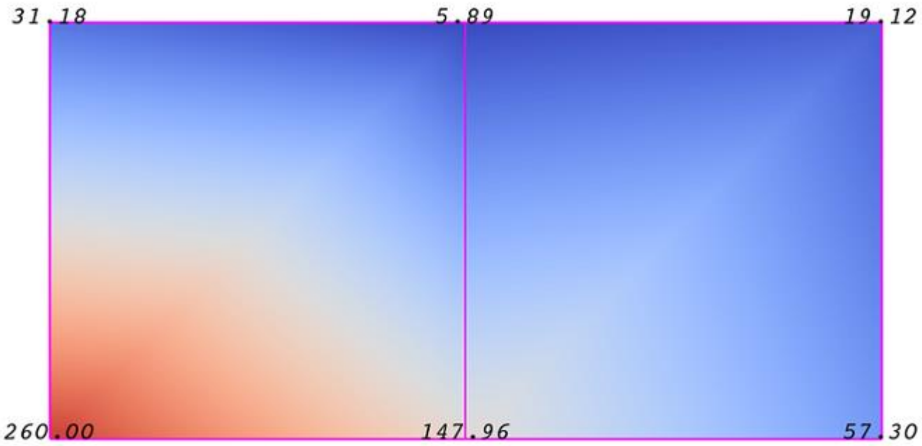
Data model

- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)
- Collections of vertices form cells (regions, zones)



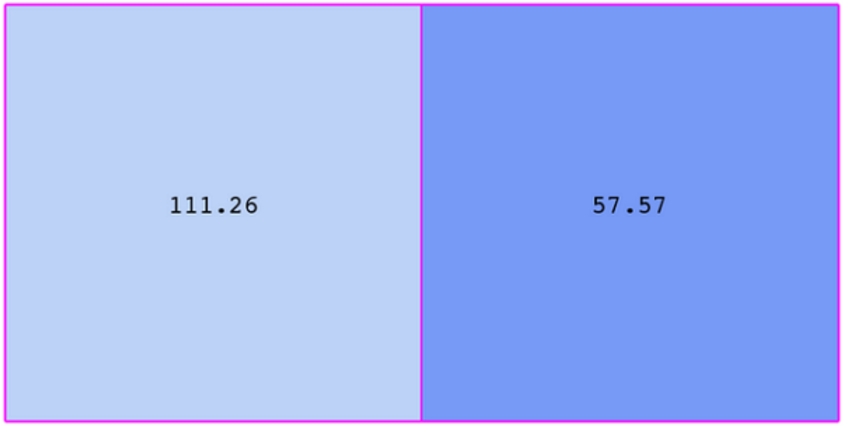
Data model

- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)
- Collections of vertices form cells (regions, zones)
- Vertices can have attributes

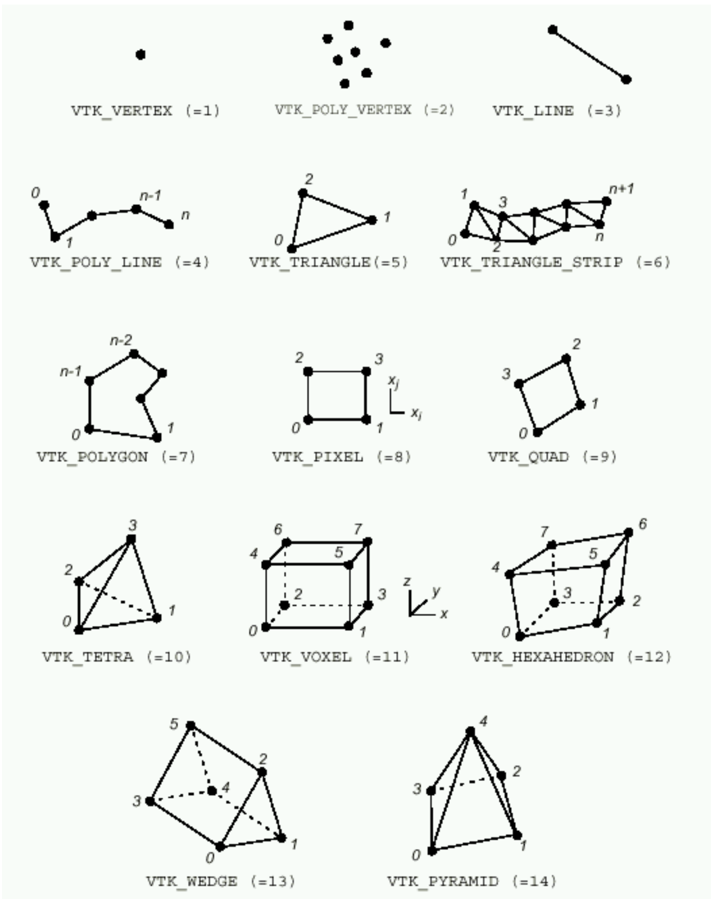


Data model

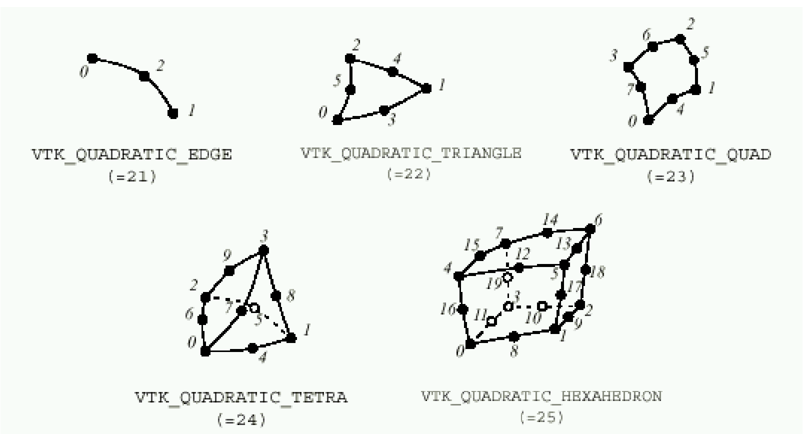
- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)
- Collections of vertices form cells (regions, zones)
- Vertices can have attributes
- Cells can have attributes



Cell types



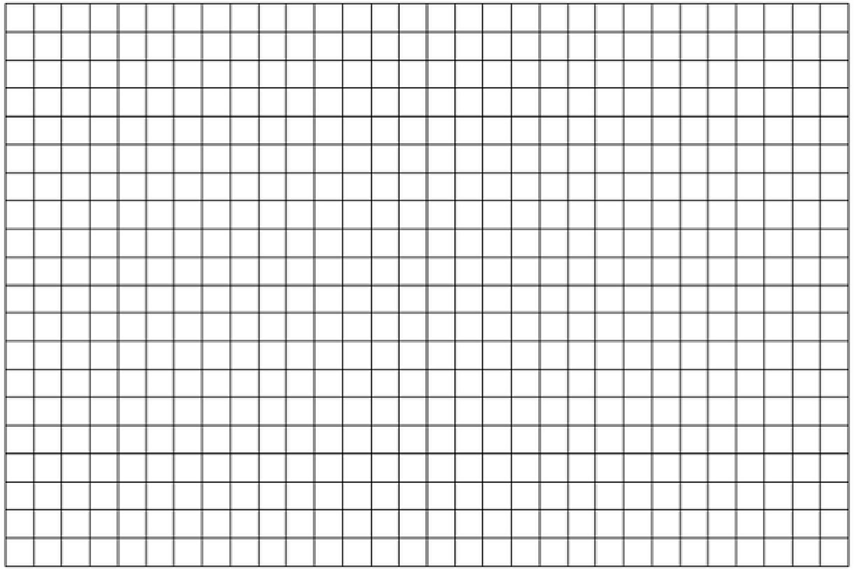
Linear cell types



Non-linear cell types

Uniform Rectilinear Grid (image data)

Implicit topology and point coordinates, all cells of same type.



Properties:

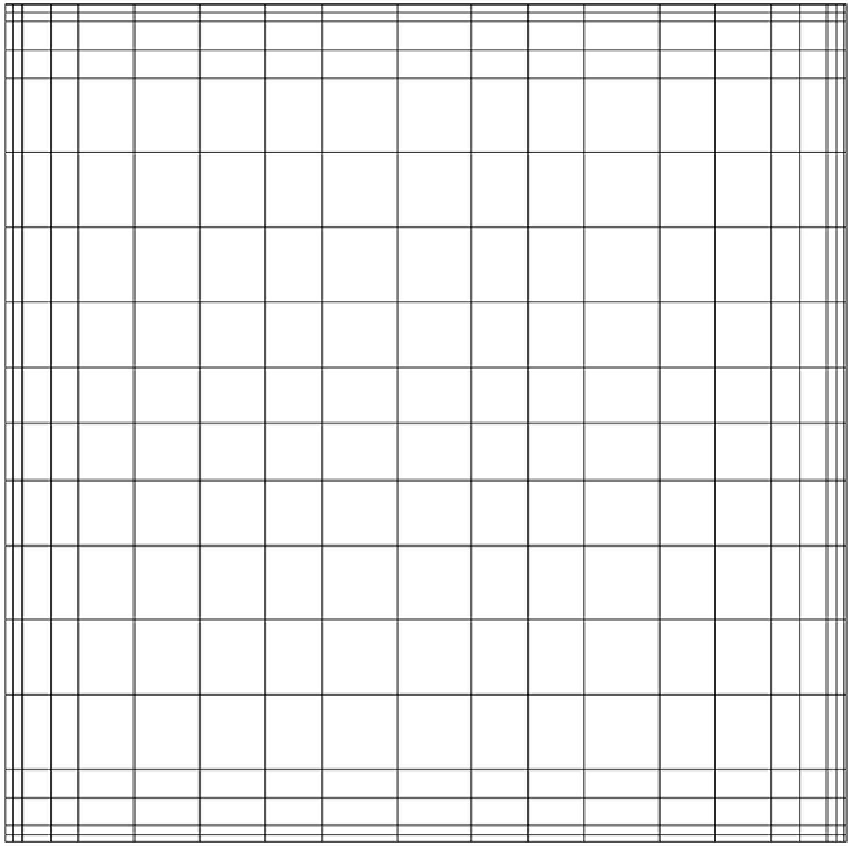
- Extent: min/max indices
- Origin
- Spacing

Examples:

- Images (JPEG, PNG, TIFF, etc)
- (Bio-)medical data (CT, MRI, CLSM, etc)

Rectilinear grid

Implicit topology, semi-implicit point coordinates, all cells of same type.



Properties:

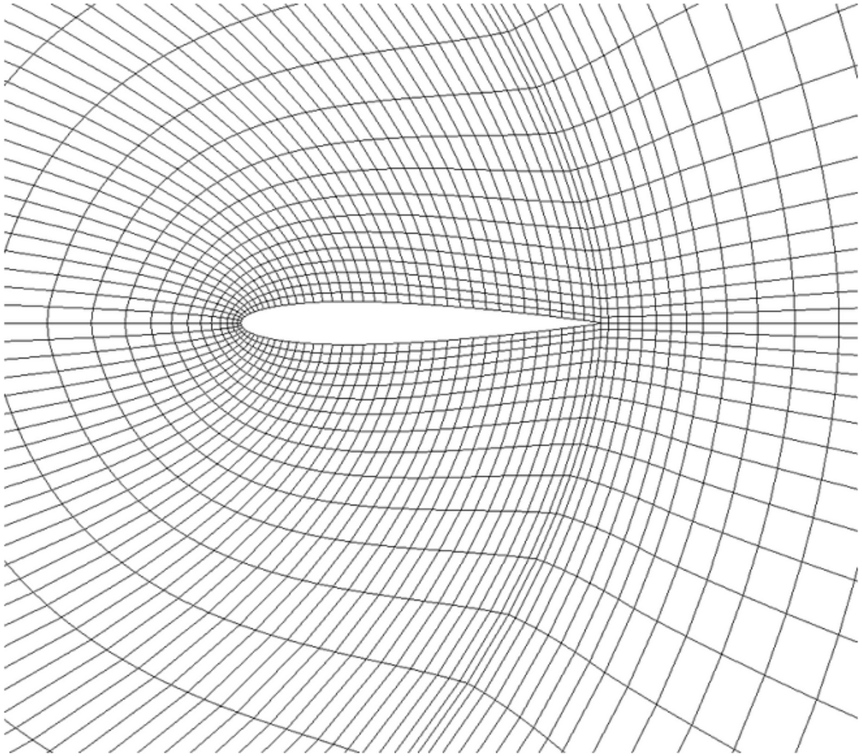
- Extent: min/max indices
- Vertex coordinates

Examples:

- Data structure in simulations with non-uniform density

Curvilinear Grid

Implicit topology, explicit point coordinates, all cells of same type.



Properties:

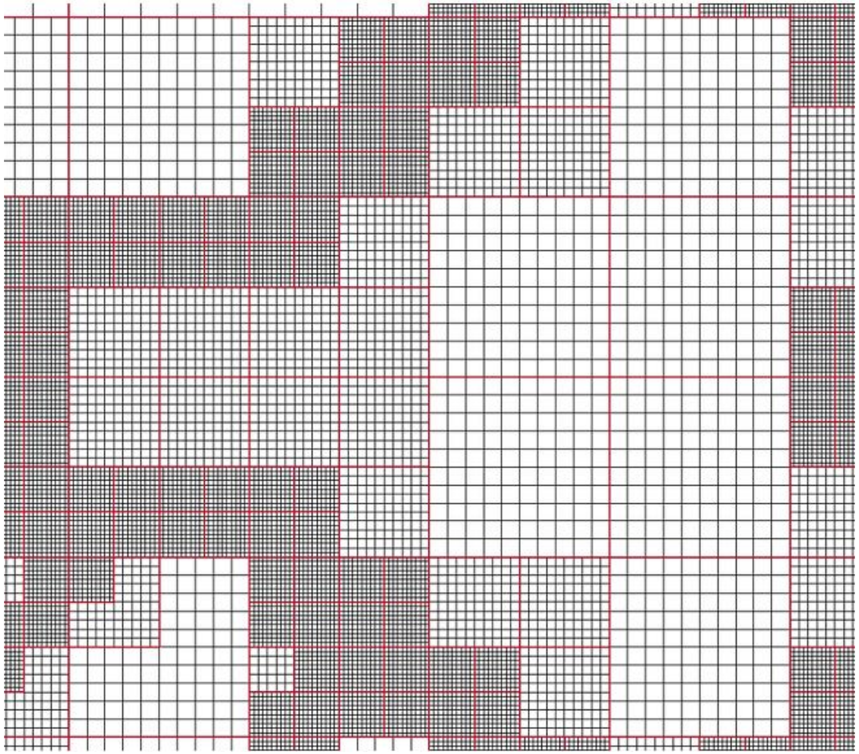
- Extent: min/max indices
- Vertex coordinates

Examples:

- Data structure in simulations with non-uniform density on non-rectangular domain

Adaptive Mesh Refinement (AMR)

Collection of non-uniform rectilinear grids (a.k.a. Berger-Oliger mesh).



Examples:

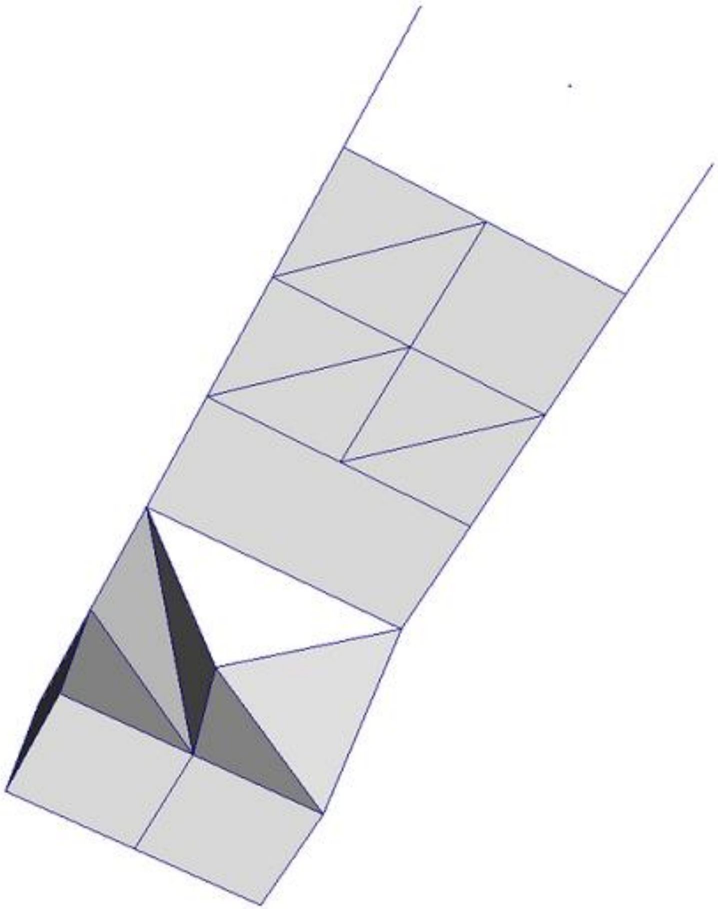
- Data structure in simulations with irregular non-uniform density

Unstructured grid

Explicit topology, explicit point coordinates, all possible cell types.

Examples:

- Finite Element/Volume Models
- CAD/CAM

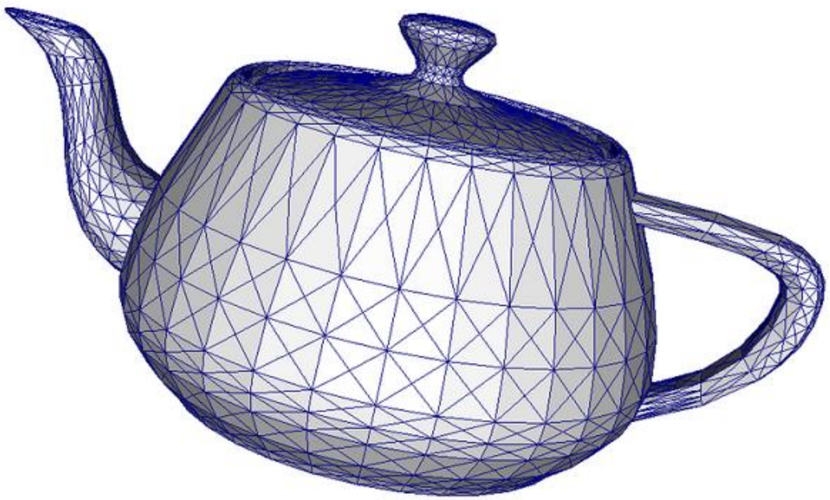


Polygon data

Explicit topology, explicit point coordinates, restricted cell types (vertices, lines, polygons).

Examples:

- Game models (OBJ, STL, PLY)
- Molecule models (PDB)



Software

- Often domain-specific
- Almost all based on visualization pipeline / dataflow concept

Commercial:

- AVS (Advanced Visual Systems)
- IRIS Explorer
- Amira
- Matlab, Mathematica, IDL
- Spotfire
- …

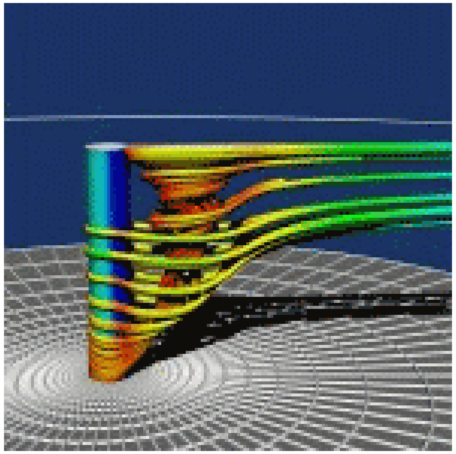
Public domain:

- VTK
- ParaView
- VolView
- VisIt
- DeVIDE
- MeVisLab
- SCIRun
- Gephi
- Cytoscape
- R
- …

The Visualization Toolkit (VTK)

VTK is:

- open source visualization library
  - C++ library with > 1500 classes
  - Language “bindings” to Java, Python, Tcl, Ruby
- works on Unix/Linux, Windows, MacOS
- object-oriented design



VTK provides:

- *Visualization* methods to turn data into geometry
- *Graphics* model to turn geometry into images (OpenGL)
- *Image processing* methods

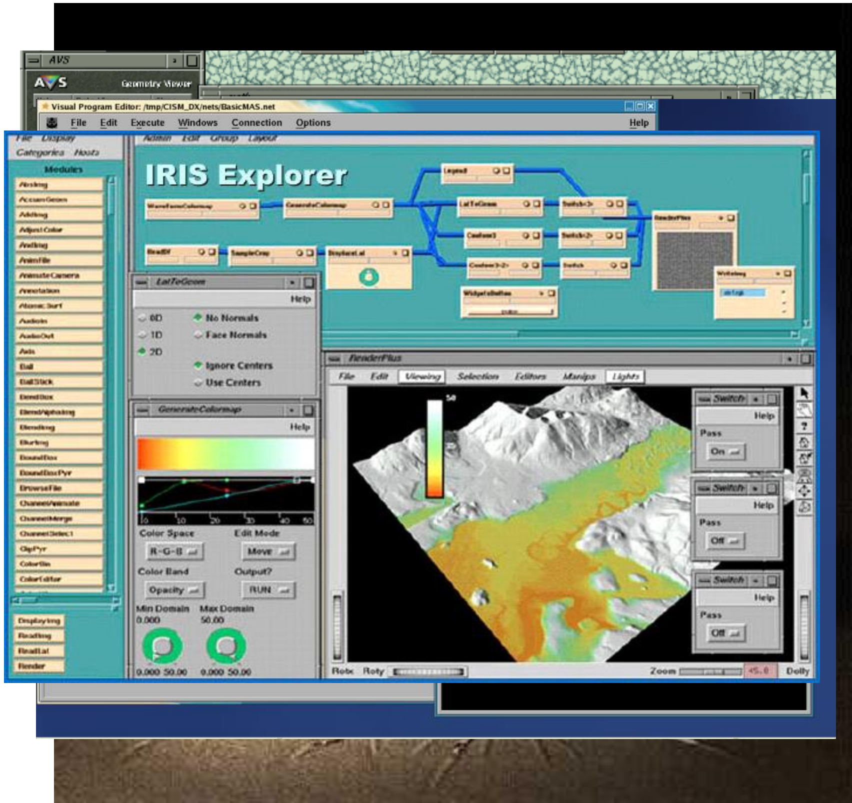
The Visualization Toolkit (VTK)

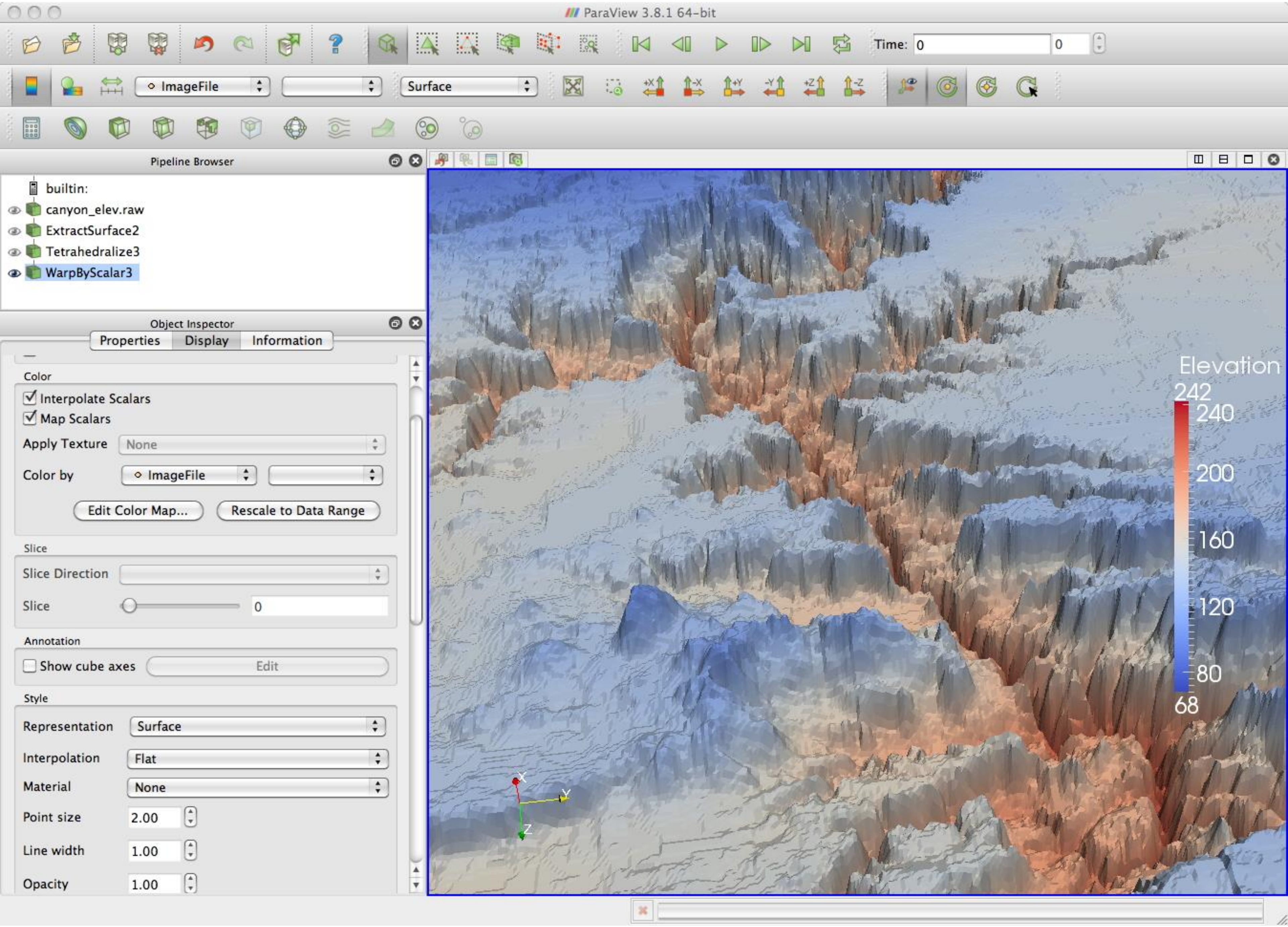
VTK is *not*:

- VTK is *not* a programming language
- VTK is *not* an application
  - No drag-and-drop "visual program editor" as with AVS, Iris Explorer, OpenDX, etc.
  - You have to *program*

More info:

- http://www.vtk.org/
- http://www.paraview.org/




ParaView 3.8.1 64-bit
Time: 0
ImageFile
Surface
Pipeline Browser
builtin:
canyon_elev.raw
ExtractSurface2
Tetrahedralize3
WarpByScalar3
Object Inspector
Properties
Display
Information
Color
Interpolate Scalars
Map Scalars
Apply Texture
None
Color by
ImageFile
Edit Color Map...
Rescale to Data Range
Slice
Slice Direction
Slice
0
Annotation
Show cube axes
Edit
Style
Representation
Surface
Interpolation
Flat
Material
None
Point size
2.00
Line width
1.00
Opacity
1.00
Elevation
242
240
200
160
120
80
68

UNIVERSITEIT VAN AMSTERDAM

Robert G. Belleman, PhD
Informatics Institute
Universiteit van Amsterdam

Science Park 904
1098 XH Amsterdam

Email: R.G.Belleman@uva.nl