

# Visualizing Numerical Flow Simulations of Karst Aquifers

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# Content

- Problem and actors
- Project and collaborations
- Visualization objects
- Benefits of the concept
- Architecture
- Application to hydrogeology
- Current research and results

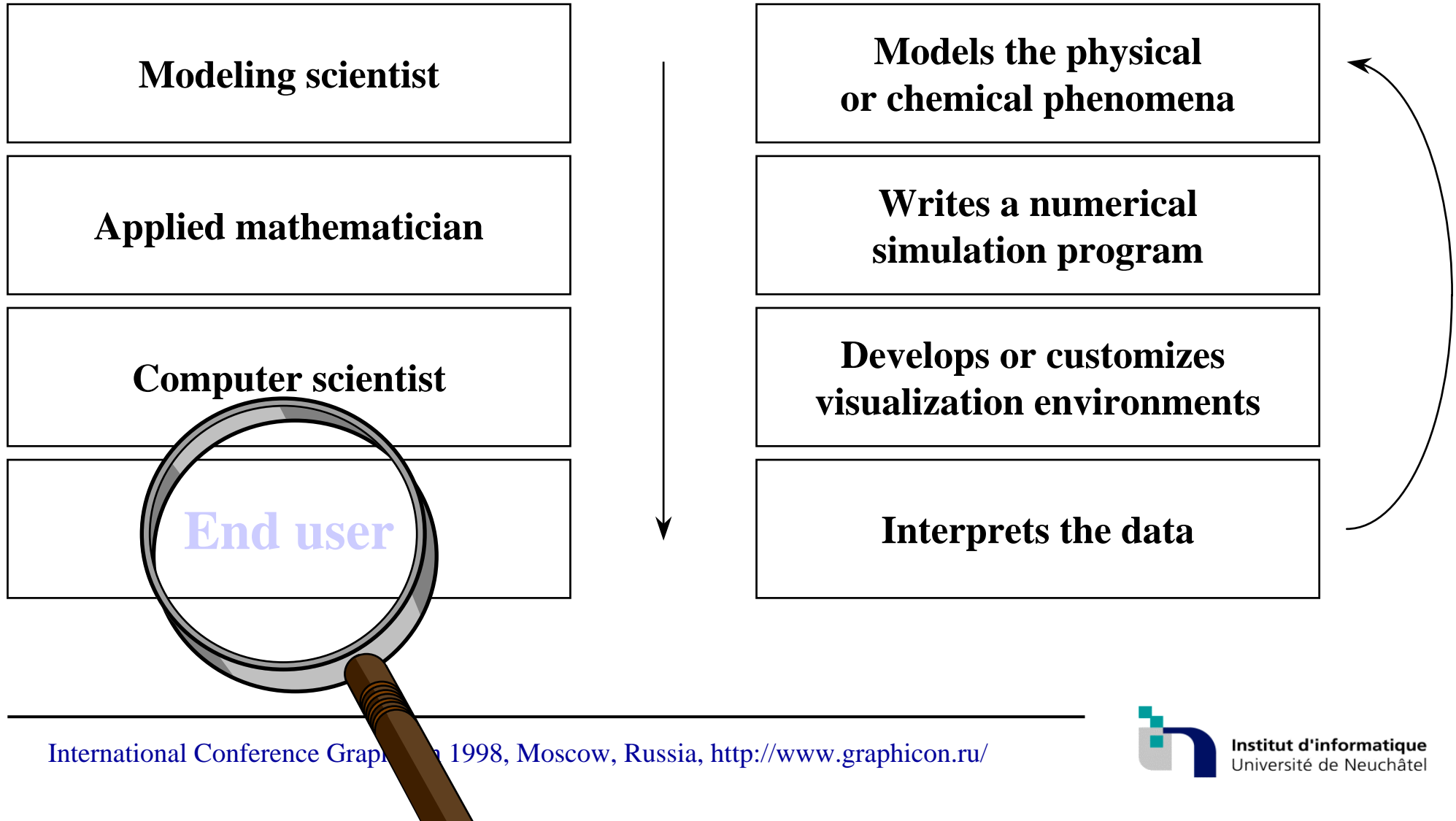
# The problem

- Fields and other objects depending on time
- Wide range of domains of interest
- No universal and foreseeable representation
- Exploration of huge datasets ( $> 1$  GB)
- Mix of common used and specific tools
- User interaction
- « Microscopic » customizations have high impact

# The challenge

To prevent complexity from  
impeding usability

# Actors

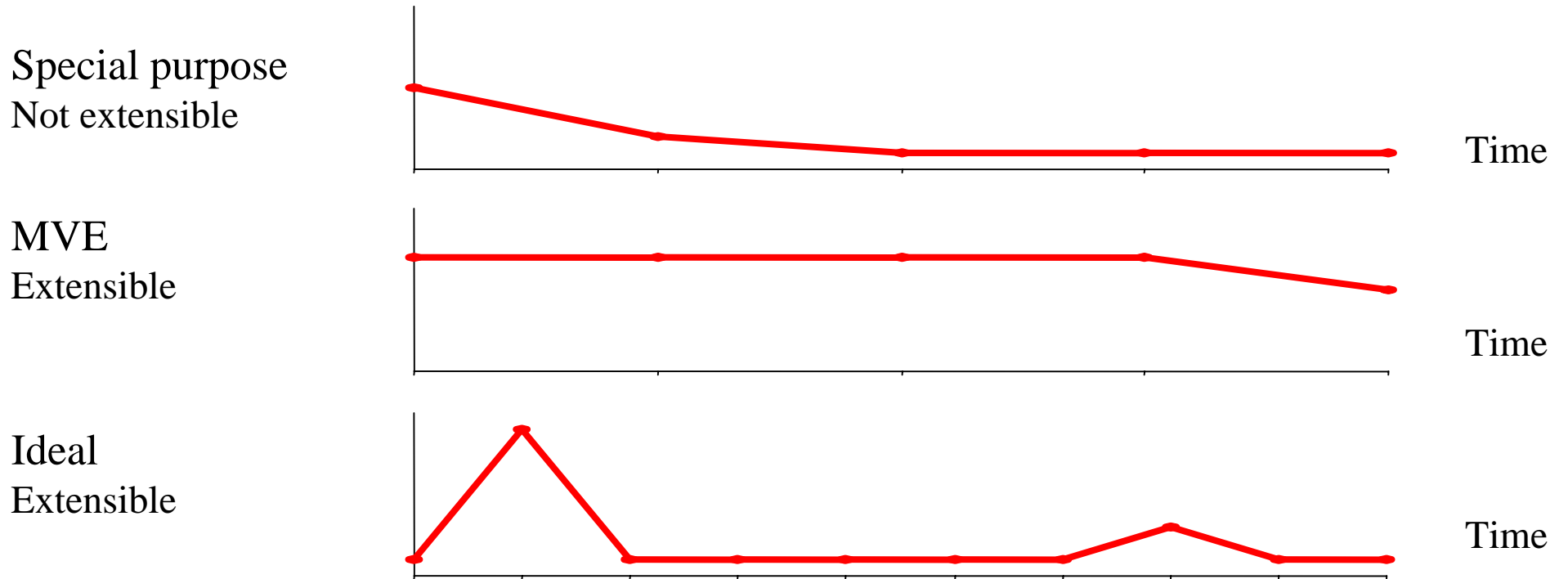


# Existing systems

- MVE (AVS, IBM Data Explorer)
  - generality  $\Rightarrow$  difficult to master
  - static because of dataflow
- Special purpose environments (Fieldview, Scian)
  - too specific
  - hardly extensible
- Libraries with toolkit (OpenGL, OpenInventor, VTK)
  - far outside reach

# Division of labor

Computer scientist interventions



# Project

Collaboration on natural science problems

- oceanography, hydrogeology

To build an end user oriented platform

- intuitive tools (probe, tracer, isosurface ...)

**and**

- extensible with specific tools



# Objects

Exploration and interaction based on objects

- creation - deletion
- selection
- hide - show
- copy - cut - paste
- modification of properties

⇒ Visualization objects

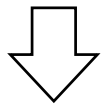
# Visualization objects

**AVO** (abstract vis. object), Haber and McNabb, 1990

« An imaginary object with some extent in space and time»  
whose « attribute fields might include geometry, color,  
surface texture, ... »

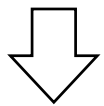
# Visualization objects

**AVO : abstract visualization object**



« a function which applies part of the data on a geometrical object with certain parameters »

**CVO : concrete visualization object**



« a 3D object which exists in the conceptual world of the user »

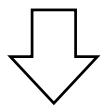
**RVO : rendered visualization object**

« an approximation of the CVO which is manipulated by the graphical system »

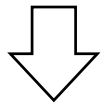
# Visualization objects

Example : an isosurface

AVO : isosurface whose source is a scalar field and parameter  
threshold



CVO : isosurface of the temperature field for the value 16°C



RVO : the polyhedron which is projected onto the screen

# Creation and combination

Time : 12:00

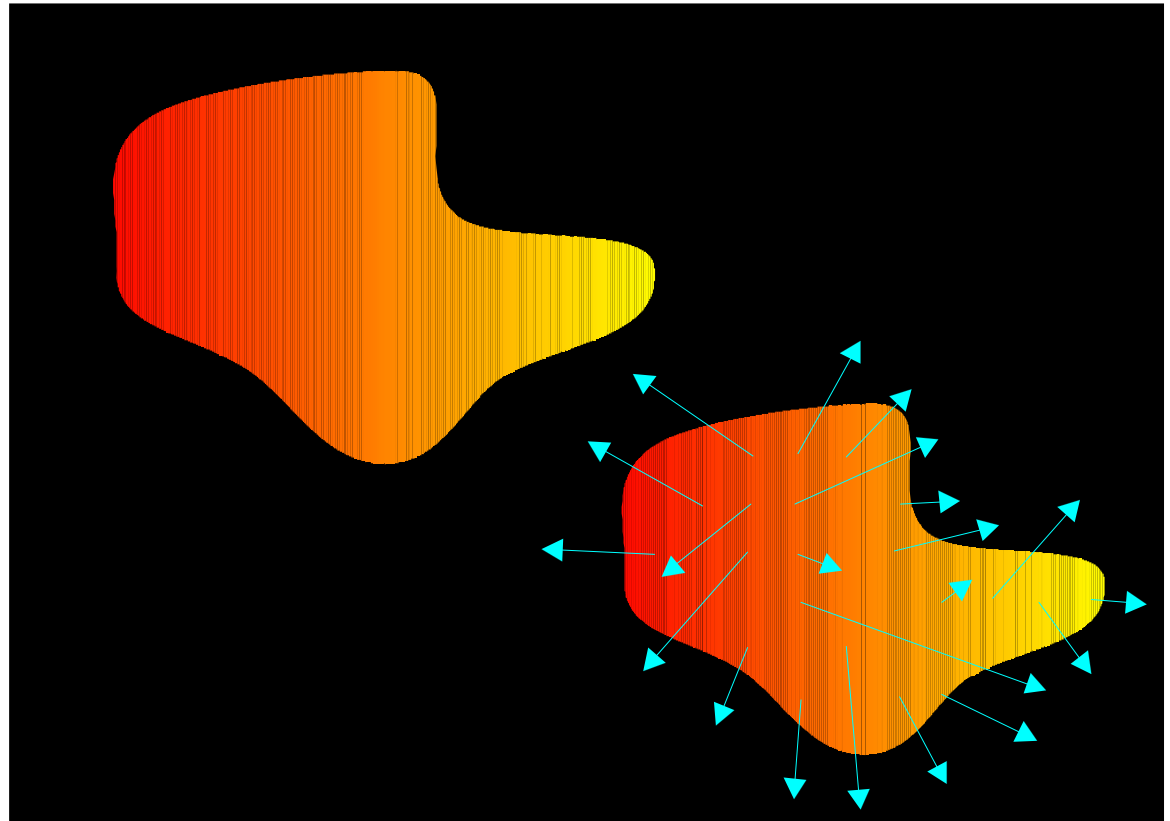
Isosurface

Source : Temperature

Threshold : 16

Coloring : Salinity

Colormap : Standard



# Modification of properties

Time : 12:00

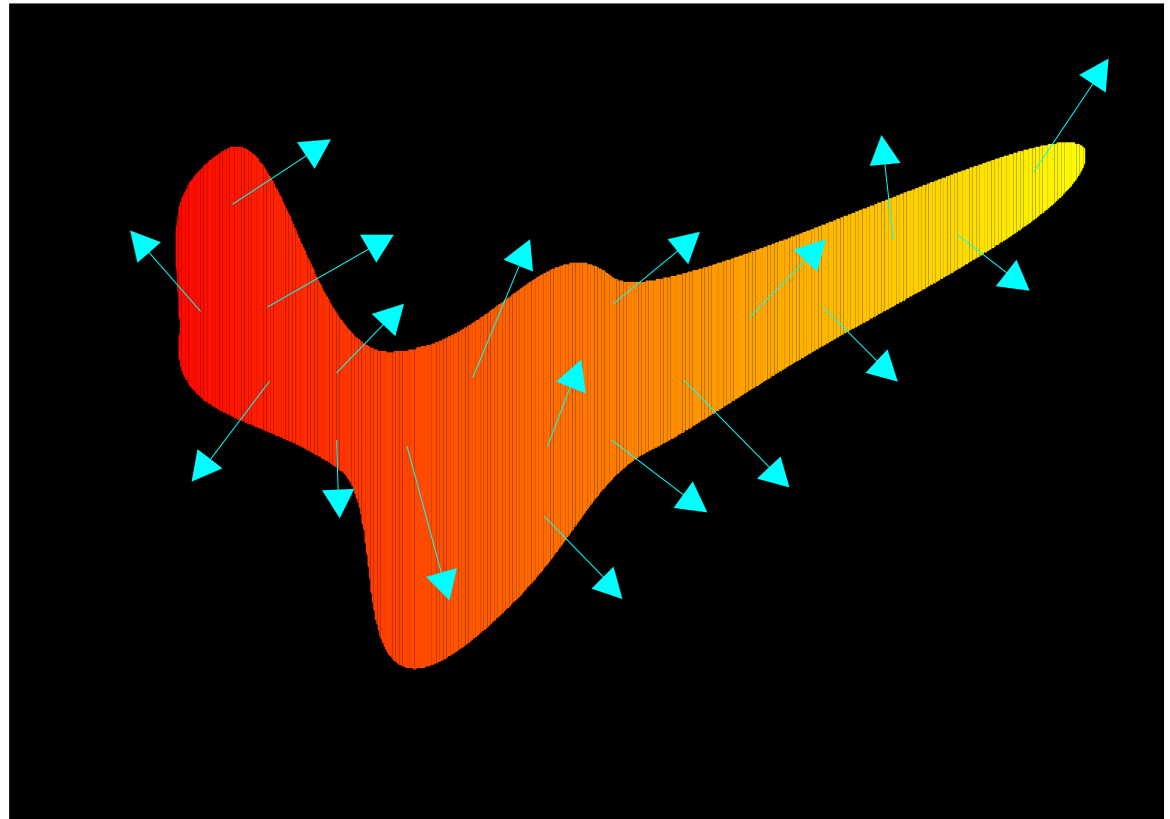
Isosurface

Source : Temperature

Threshold : 25

Coloring : Salinity

Colormap : Standard



# Copy through time and space

Time : 12:05

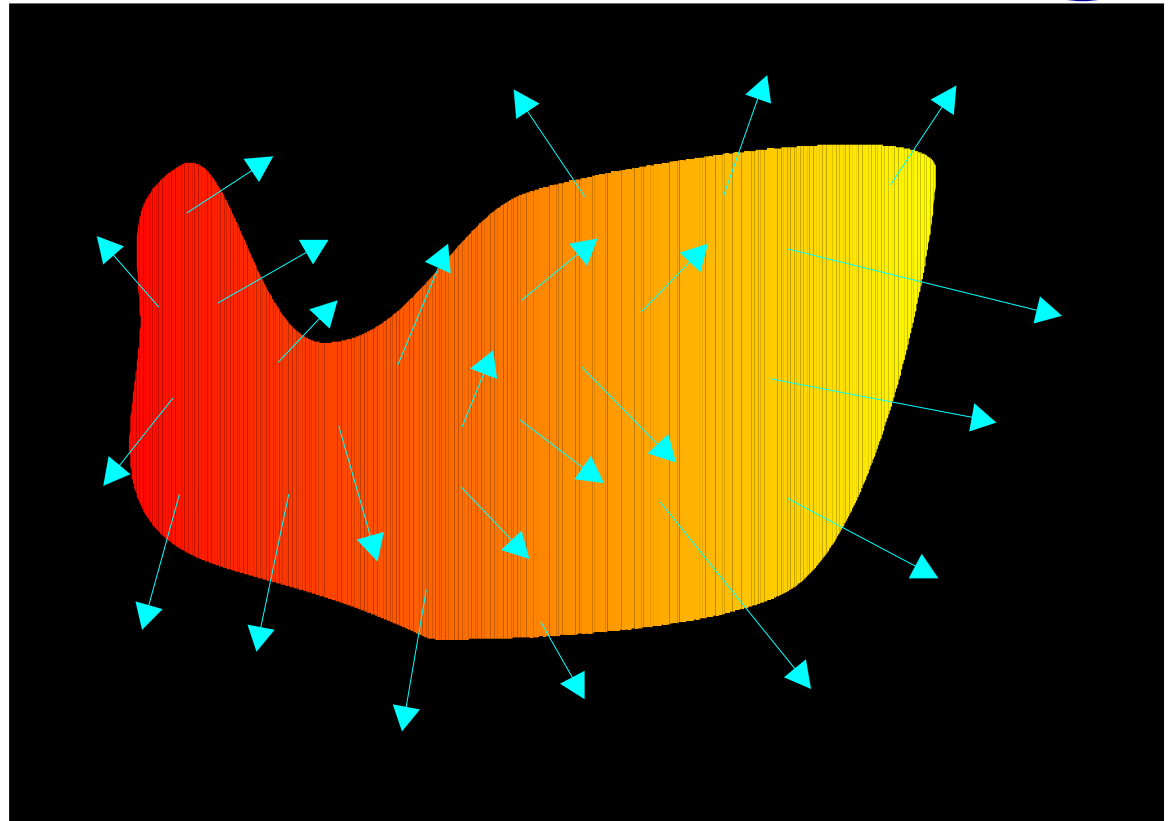
Isosurface

Source : Temperature

Threshold : 25

Coloring : Salinity

Colormap : Standard



# Benefits

## End user

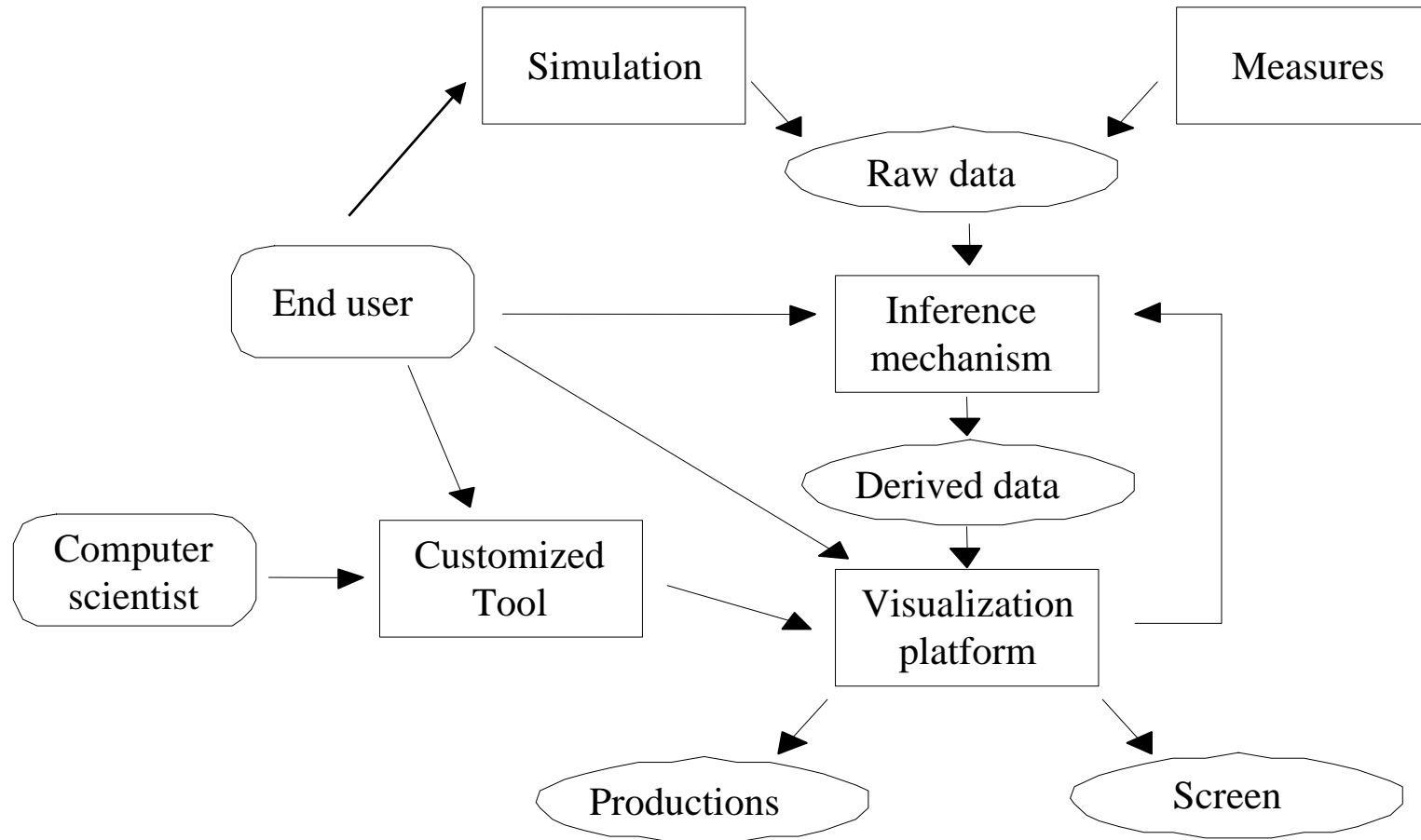
- intuitive tools applied to different sources (data) and different parameters (time, precise regions of interest)
- manipulation of geometrical objects
- control of visual clutter
- fully customized and interactive environment
- production of 3D models for presentation (VRML objects)

## Computer scientist

- generalization of most widely used techniques
- abstraction  $\Rightarrow$  new tools  $\Rightarrow$  reuse



# ZoomIn Architecture



# Application

- Implementation of a new AVO
  - inheritance from abstract class AVO
  - declaration of parameters (CVO)
  - method to build RVO using OpenInventor
  - to compile and link the code into a shared library
- Implementation of a new dataset

# Hydrogeology

## Karst Aquifers

- velocity field  $\Rightarrow$  3D conical glyphs
- turbulence  $\Rightarrow$  isosurface
- instantaneous tracer concentration  $\Rightarrow$  cutting plane
- tracer concentration through time  $\Rightarrow$  graph glyph
- vortices  $\Rightarrow$  streamlines
- bathymetry

6 AVOs  $\Rightarrow$  3 weeks / man

# Experiences

- Lake of Neuchâtel, Gulf of Lion (France)
  - 5 AVOs + 1 dataset during prototype implementation
- Cave of Milandre - karst aquifers
  - 3 AVOs + 1 dataset  $\Leftrightarrow$  3 weeks / man
- Gulf of Thermaikos (Greece)
  - No AVO and dataset

# Current research

- Development and integration of new tools
  - **interactive particles tracer**
  - **distribution probe**
- Optimization of data server, expression evaluator
- Distributed creation of RVO

<http://iiun.unine.ch/ZoomIn/>

# Data server

- key problem, difficult
- powerful object databases and query language.
- to abstract data query and consider it as a separate problem from visualization
  - every source (file, network, oodb, memory)
  - solve interpolation and multiresolution problems

# Data server

- solution retained
  - the platform provides an interface
  - the computer scientist an implementation
- entities
  - fields (assumed continuous in time and space)
  - user defined objects
- expression evaluator
  - combine the quantities

