Visualizing Numerical Flow Simulations of Karst Aquifers

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International Conference Graphicon 1998, Moscow, Russia, http://www.graphicon.ru/

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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

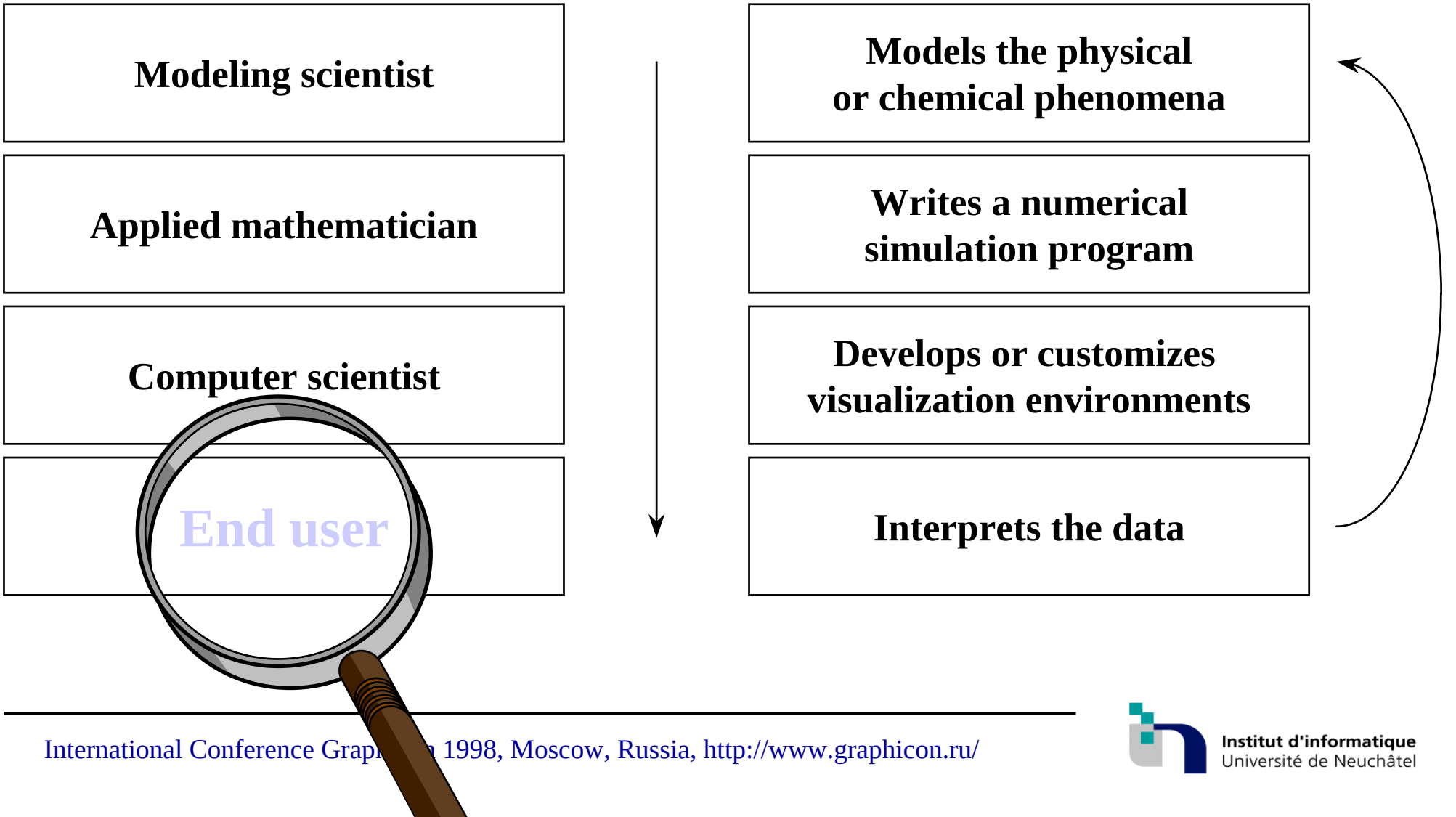
The problem

- 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 specifical tools
- User interaction
- « Microscopic » customizations have high impact

The challenge

To prevent complexity from impeding usability

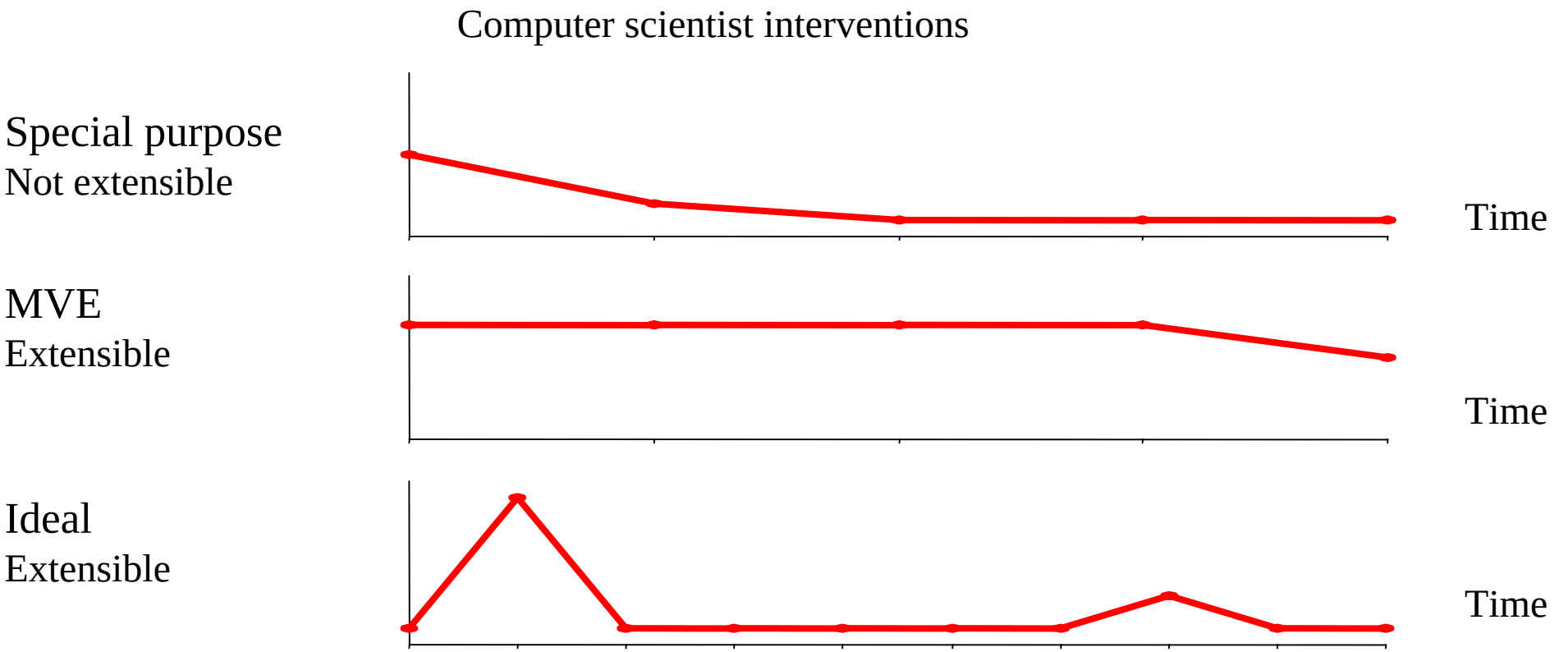
Actors


Modeling scientist
Applied mathematician
Computer scientist
End user
Models the physical or chemical phenomena
Writes a numerical simulation program
Develops or customizes visualization environments
Interprets the data

Existing systems

- MVE (AVS, IBM Data Explorer)
  - generality ⇨ 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



Project

Collaboration on natural science problems

– oceanography, hydrogeology

To build an end user oriented platform

– intuitive tools (probe, tracer, isosurface …)

and

– extensible with specifical 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 »

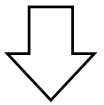
RVO : **rendered visualization object**

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

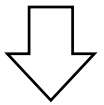
Visualization objects

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

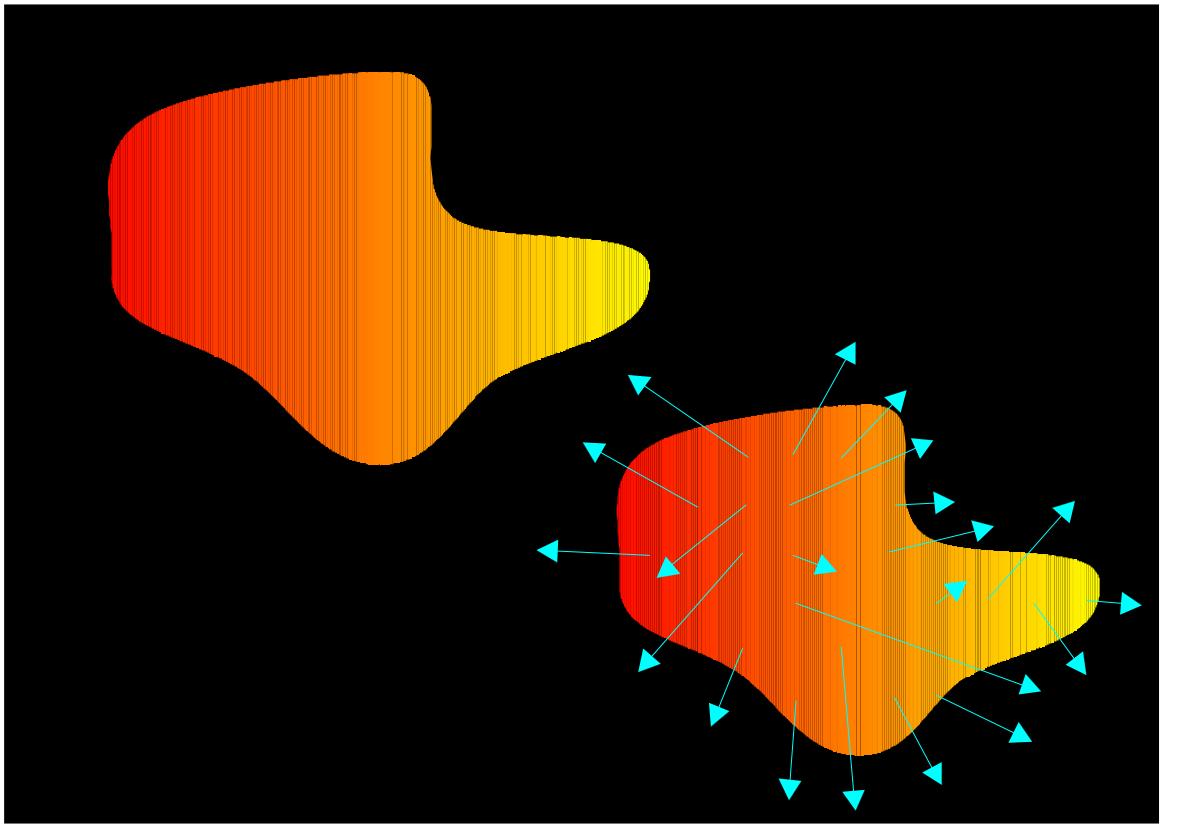


RVO : the polyhedron which is projected onto the screen

Creation and combination

Time : 12:00

Isosurface	
Source :	Temperature
Threshold :	16
Coloring :	Salinity
Colormap :	Standard



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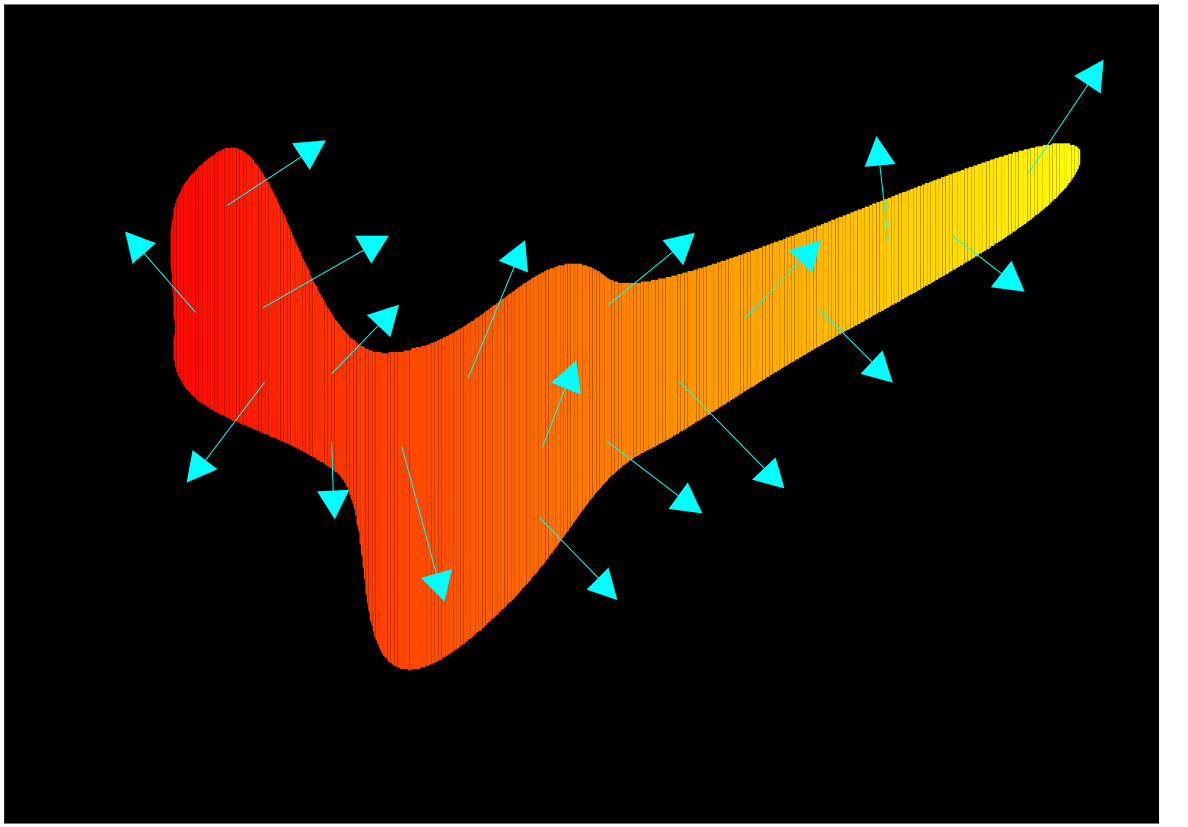
Modification of properties

Time : 12:00

Isosurface

Source : Temperature
Threshold : 25
Coloring : Salinity
Colormap : Standard



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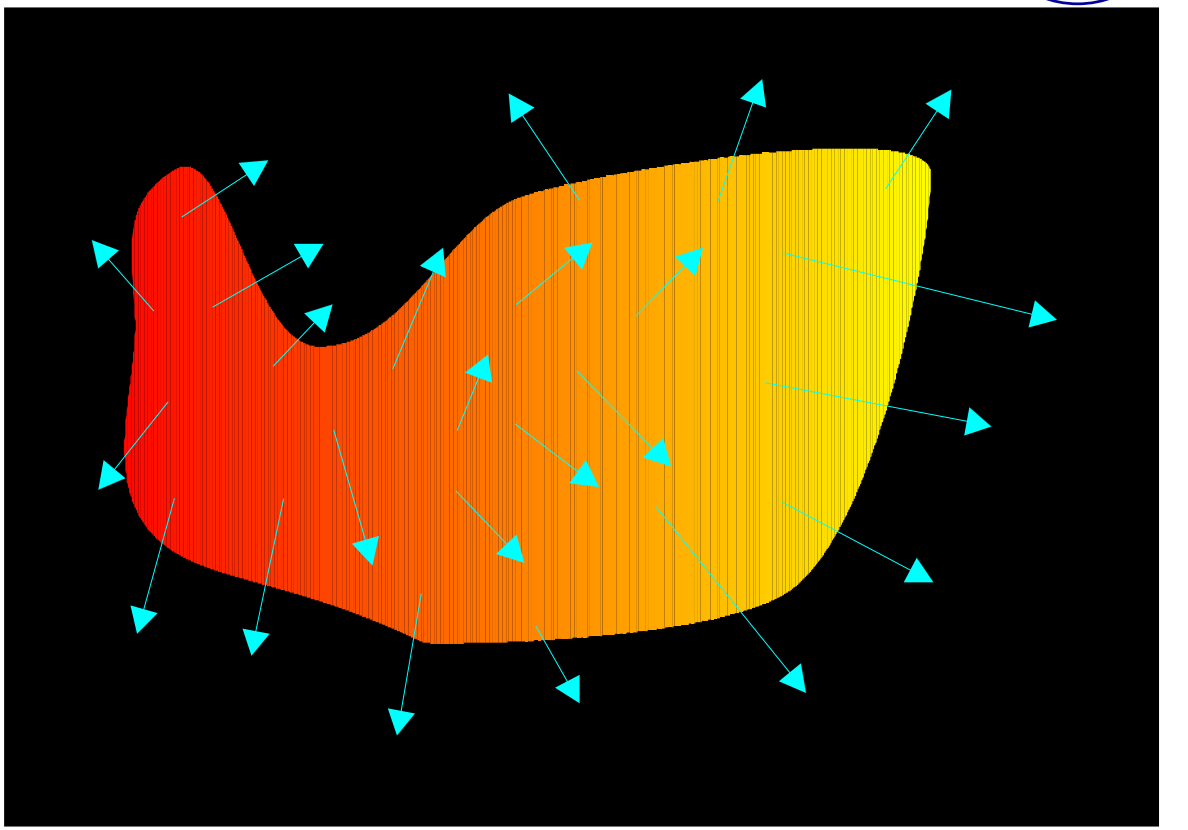
Copy through time and space

Time : 12:05

Isosurface

Source :	Temperature
Threshold :	25
Coloring :	Salinity
Colormap :	Standard



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Benefits

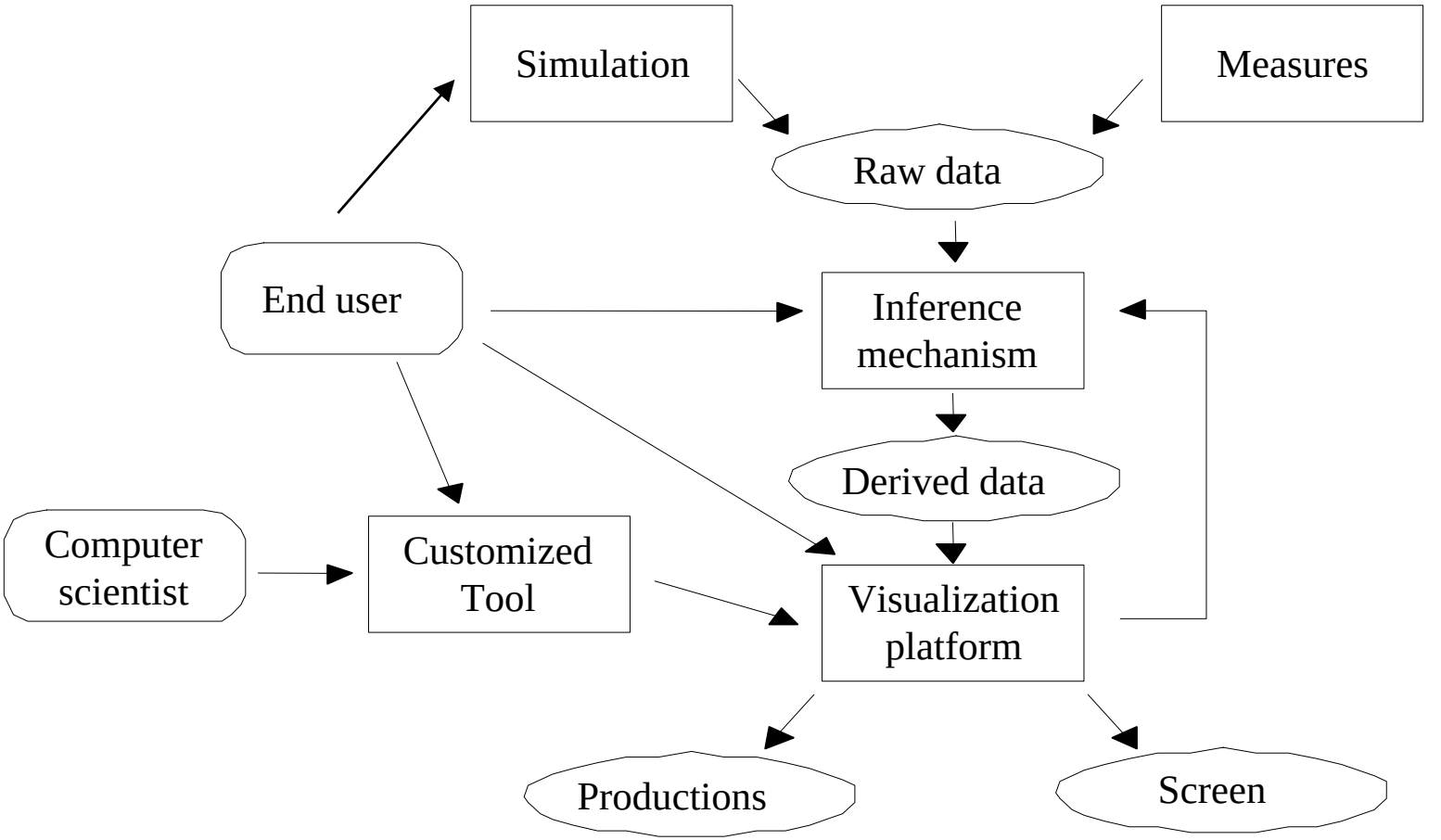
End user

- 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 ⇨ new tools ⇨ 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 ⇨ 3D conical glyphs
- turbulence ⇨ isosurface
- instantaneous tracer concentration ⇨ cutting plane
- tracer concentration through time ⇨ graph glyph
- vortices ⇨ streamlines
- bathymetry

6 AVOs ⇨ 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 ⇨ 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 langage.
- 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