Calibration of simulation platforms including highly interweaved processes: the MAELIA multi-agent platform

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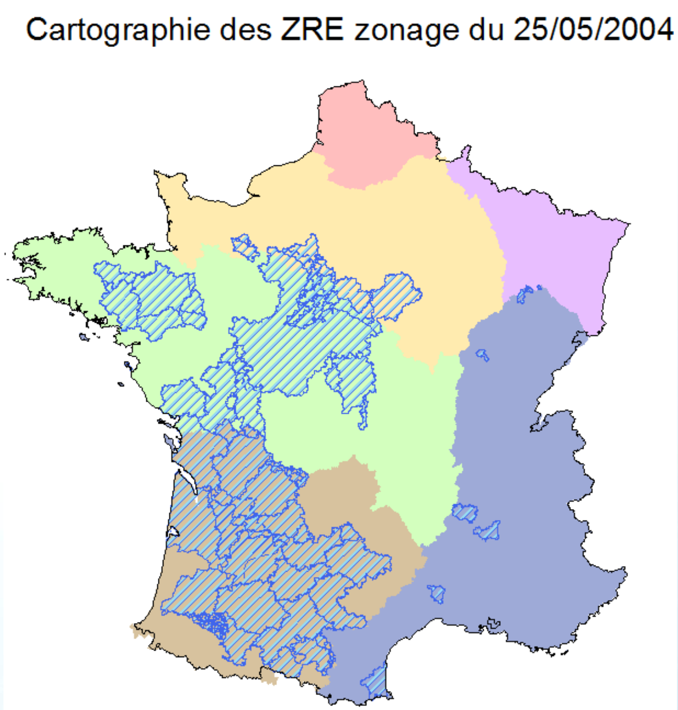
Outline

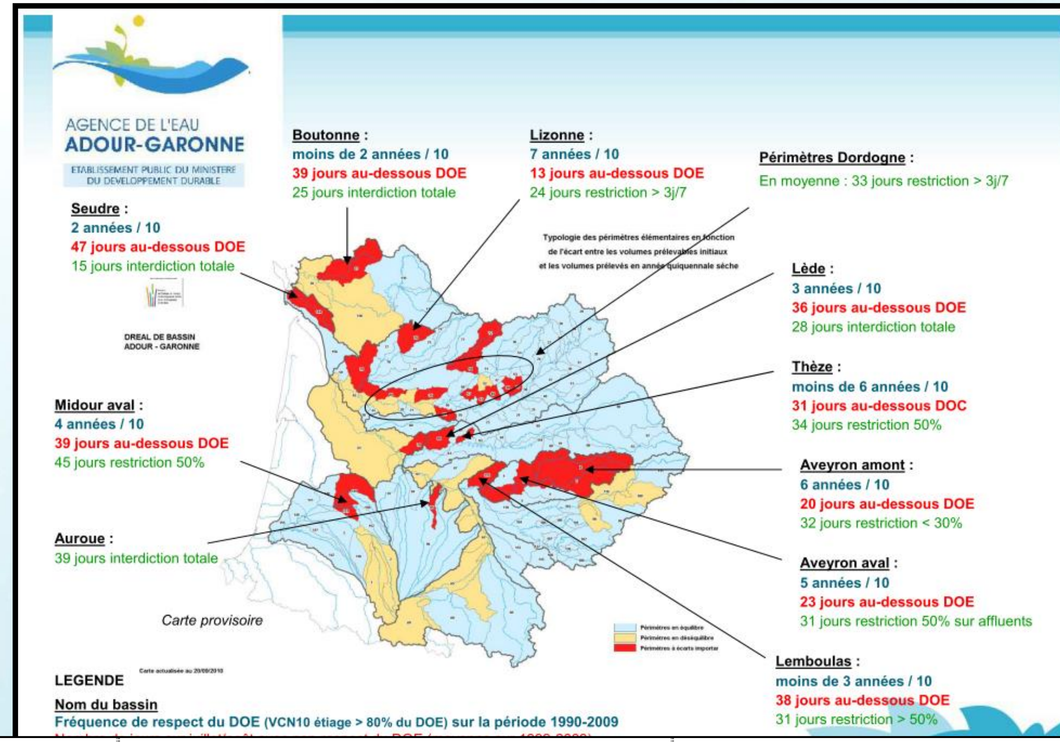
- Introduction
- The calibration process
- Calibration
- Results
- Conclusion

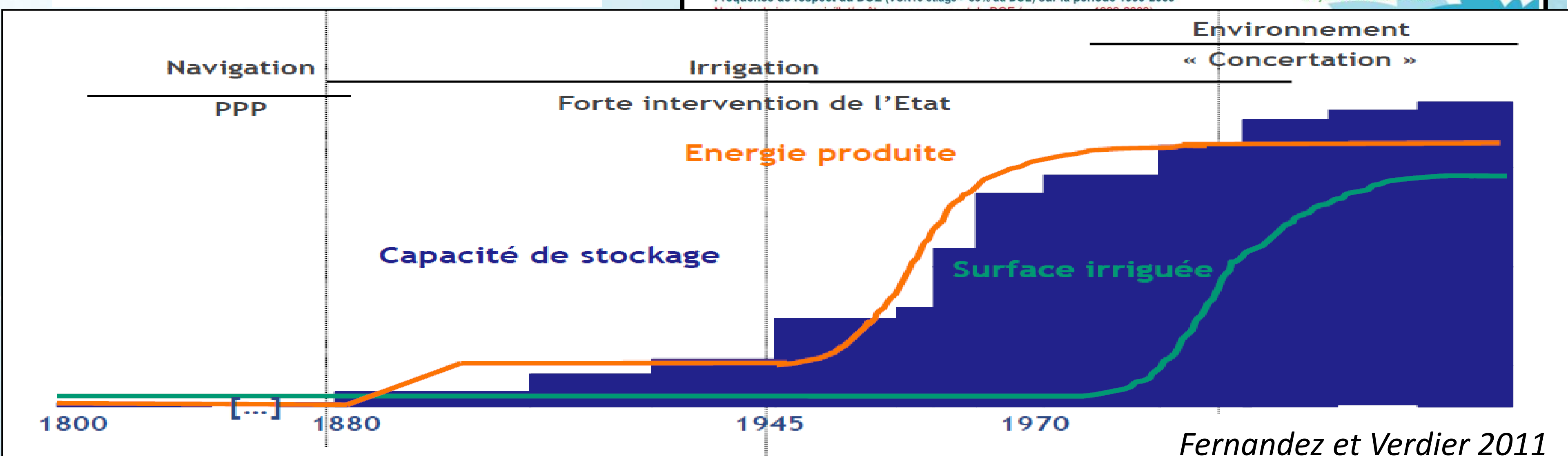
I. Introduction

1) The Context
2) The MAELIA model
3) The calibration issue

Context: the quantitative water management

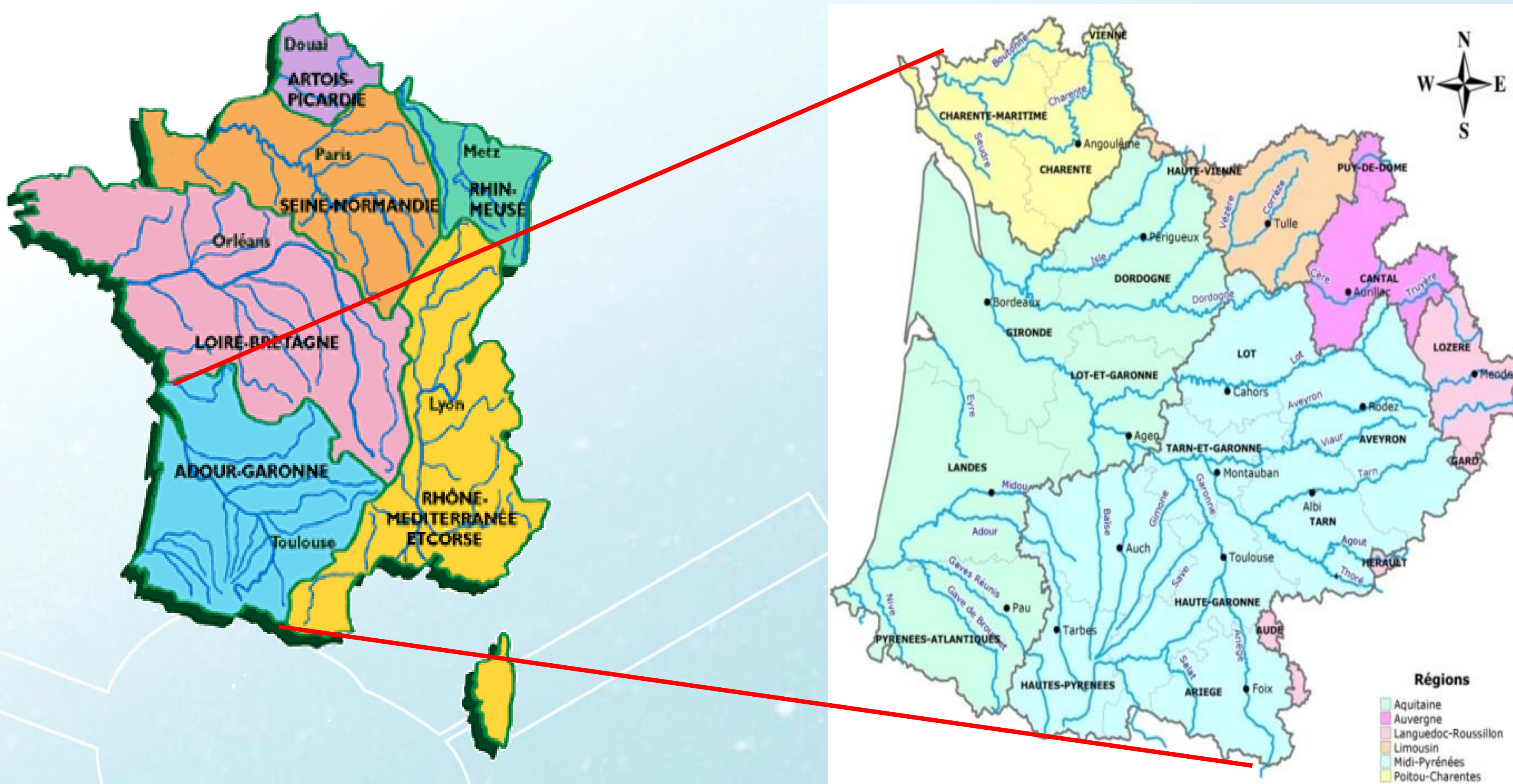






Fernandez et Verdier 2011

The MAELIA case-study: the Adour-Garonne bassin



Patrick Taillandier

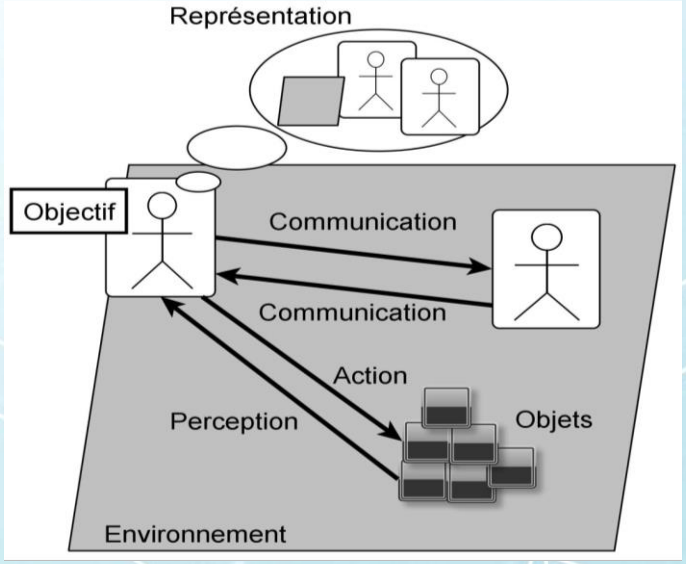
1. Context: management of water scarcity

- **Increase of the frequency of low water crisis** in the recent years in the Adour-Garonne basin.
- During low water period (May-Octobre), irrigation = 75% of water withdrawal

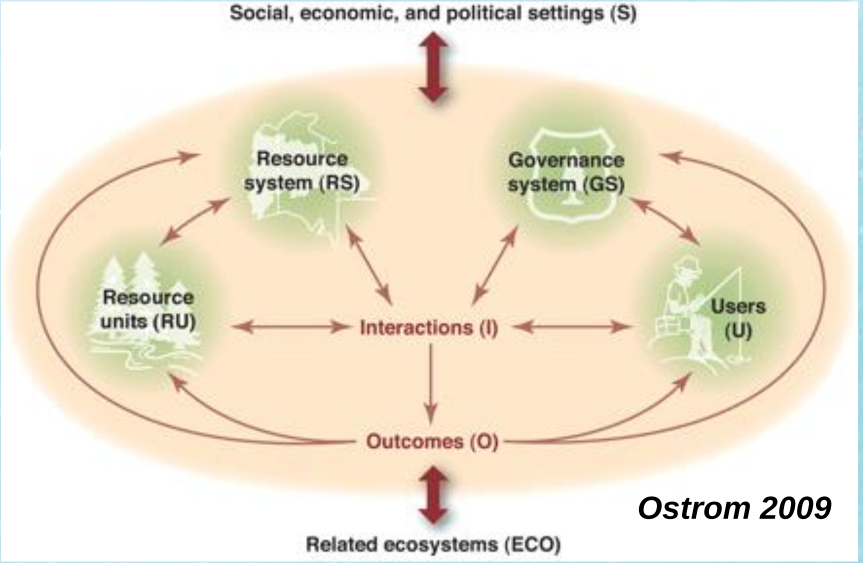
- Concerns related to **climate change**
  - How to maintain the aquatic ecosystem and the farmers' activity ?

2. The MAELIA model

A generic platform for modelling and simulating socio-agro-hydrosystems to develop rules for sustainable water management during low-flow period, at watershed scale



Ferber, 1995



Ostrom 2009

2. The MAELIA model

Ecological processes

- **Soil-crop model**
- **Hydrologic model**

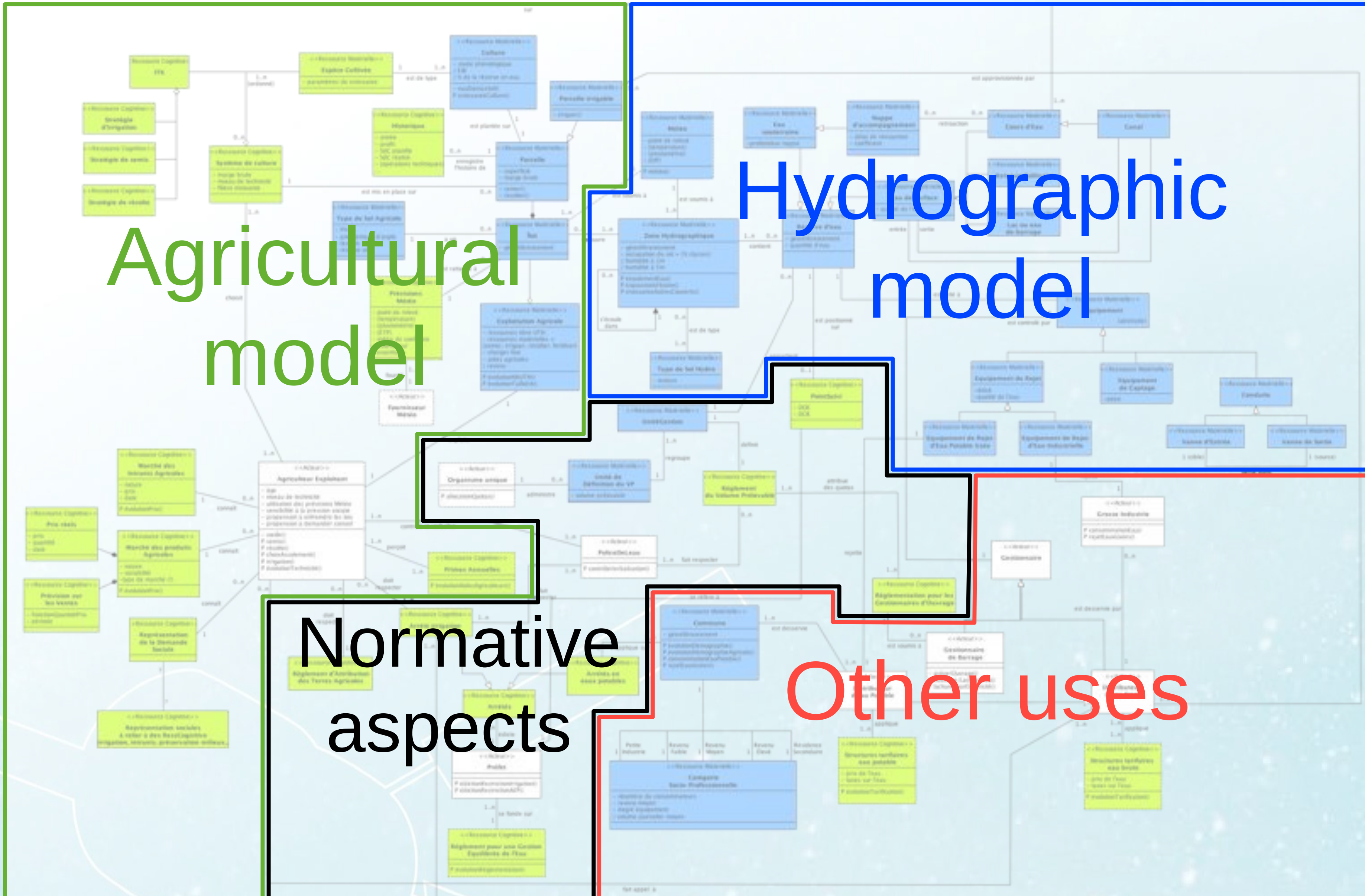
Socio-economic processes (phenomena)

- **Demographic changes** (INSEE, municipality level)
- **Land Cover changes** (Corine Land Cover database)
- **Drinking Water Consumption**
- **Industrial Water Consumption**

Human activities (Decision process)

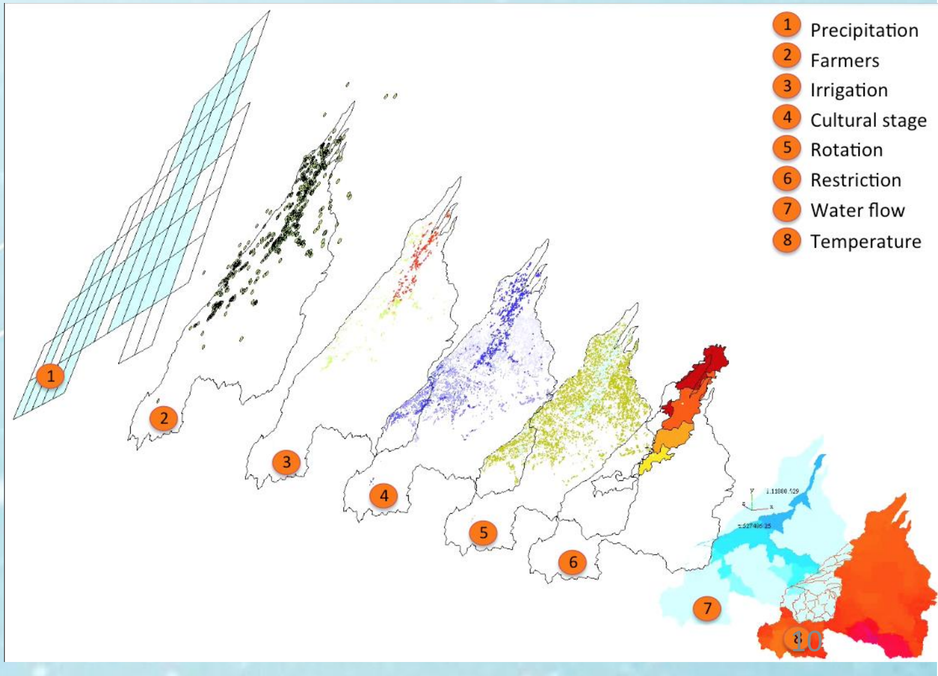
- **Farmer decision**
  - crop allocation plan
  - crop management
- **State services decision:**
  - decree of water-use restrictions (severity & spatial extension)
- **Dam Manager decision:**
  - water releases

Actor Resource Diagram (static model)



2. The MAELIA model

- Modular
- Mainly deterministic
- Multi-scale
- Daily time step



3. The calibration issue

- How to calibrate such a model?
  - Modular
  - Spatialized
  - High level of interaction between processes (e.g. irrigation)
  - High non linearity (threshold effect)
  - Computation time constraints (~5H for 10 years)

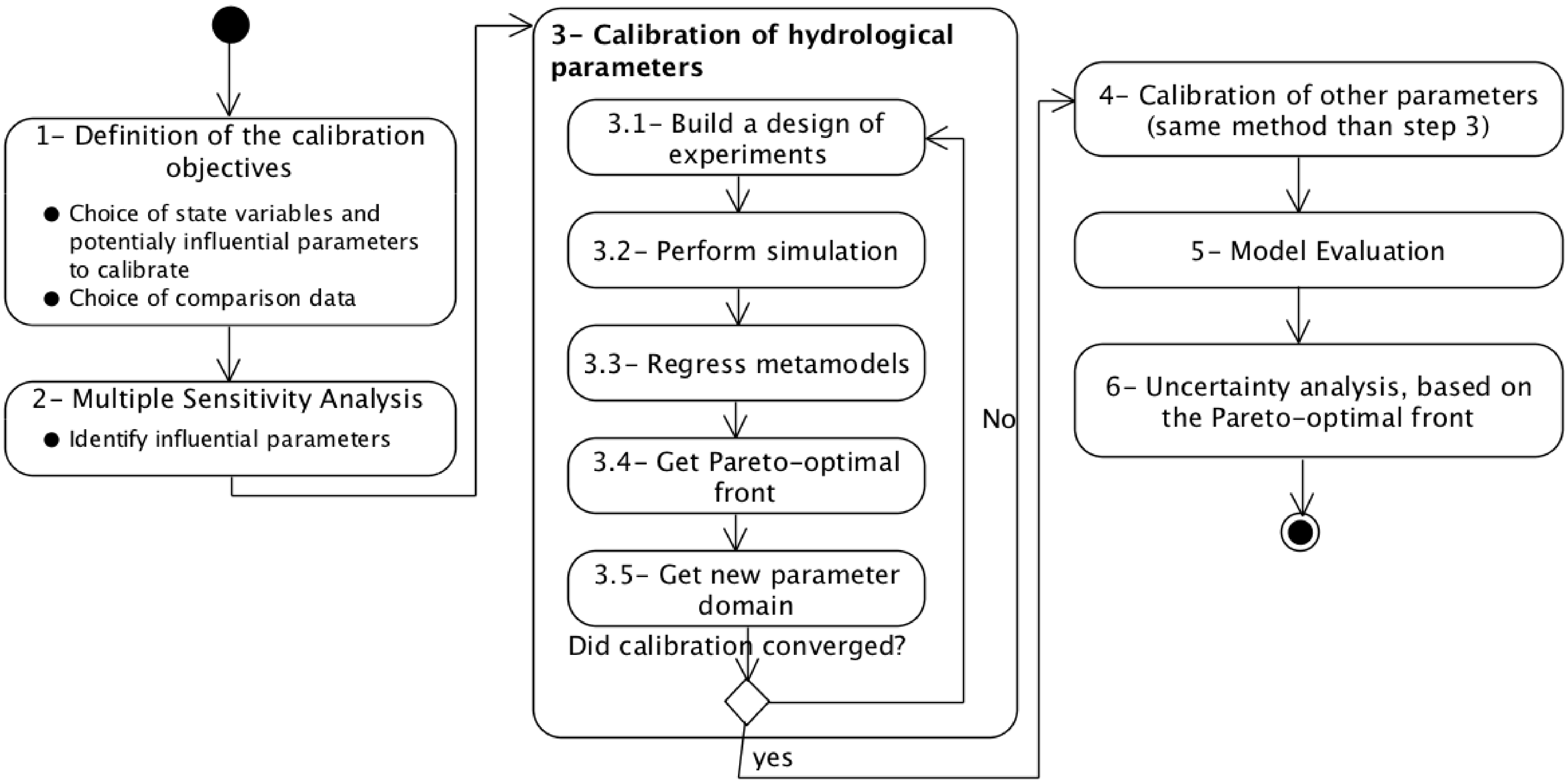
II. The calibration process

1) The aims
2) The different steps
3) The optimisation method

1. The aims

- Reproduce
  - Dynamics during scarcity water period (duration during alarm thresholds)
  - Quantities (flows) in low water period
  - Anthropic effects (irrigation, dam supply, crop management)

2. The different steps



2. The different steps

- Aims definition (=> variables, parameters and data)
  - Unaffected data 1970-2008
  - Real data 2000-2012

- The sensitivity analysis (=> influential parameter)
  - Morris method (LHS-OAT)
  - Model with or without some modules

2. The different steps

❖ The sensitivity analysis: a key step of model exploration

- To get influential parameters
- Check model stability => partial code validation
- Verify where, when and how parameters are influential

=> Go back to modelling step

- Missing processes
- Forcing data precision (e.g. number of altitude classes)

2. The different steps

- Hydrological parameters calibration
  - Model without withdrawal (irrigation, channels)
  - Unaffected data 1980-2000
- Farmer and dam agents calibration
  - Full model
  - Real flow data 2000-2005
- Evaluation and uncertainty analysis
  - Unaffected data 2001-2008
  - Real flow data 2006-2012

3. The choice of the optimization method

- Multi-criteria optimization
  - 4 numerical criteria
  - 16 (over 33) hydrological influential parameters

- Computation time constraint
  - Simulation for the full model over 10 years:
    - ~5 H and 6 Go of RAM
    - => High performance computing, Design of Experiment (DoE) and metamodels

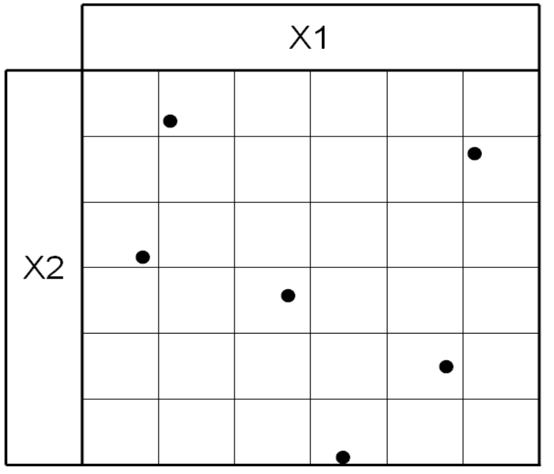
- Get a parameter distribution

3. The optimization method

❖ MAM : Multi-Point Approximation Method

1. We build a first DoE (Design of Experiments)
2. We regress metamodels
3. We search for optimums (Pareto front)

1



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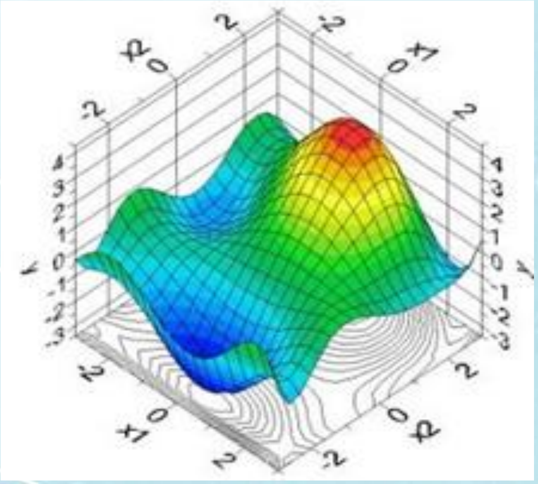

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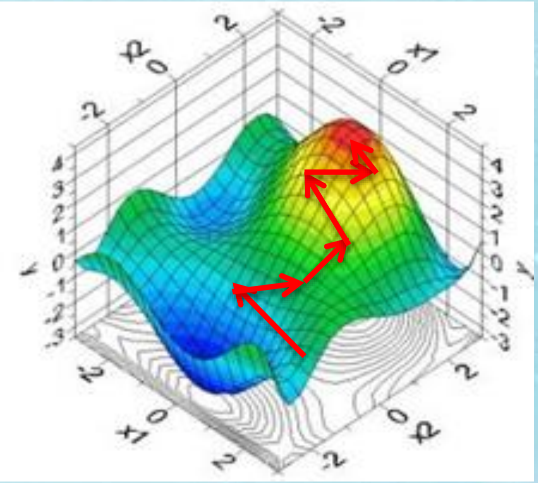
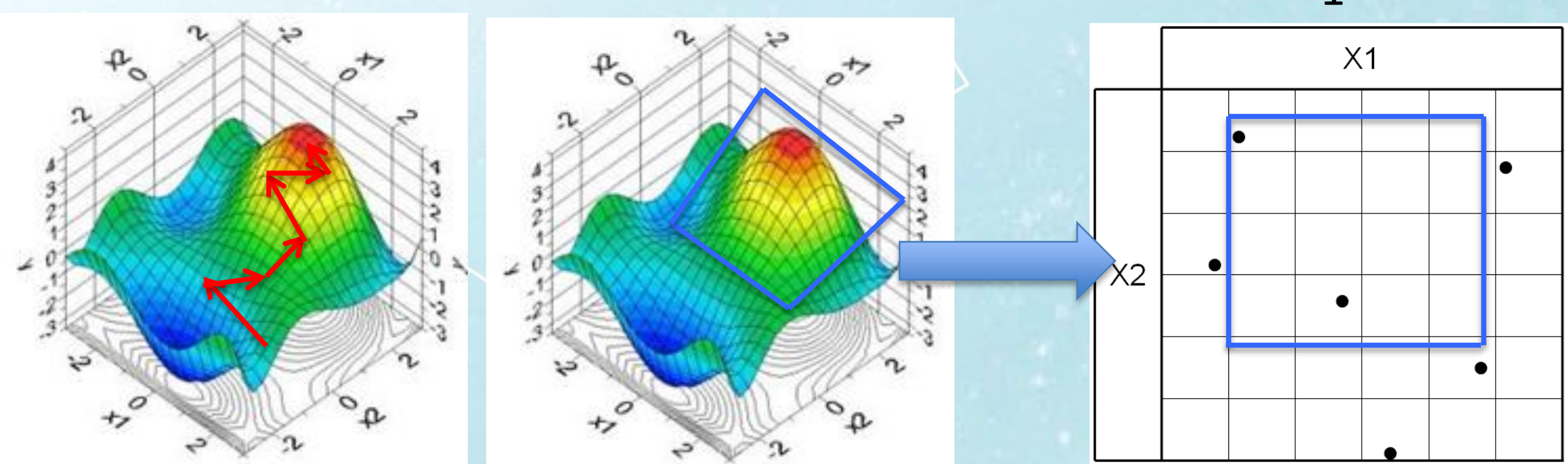


3. The optimization method

- MAM : Multi-Point Approximation Method
  3. We search for optimums (Pareto front)
  4. We deduce a new research area
  5. We iterate => update of response surfaces

3 4 1’

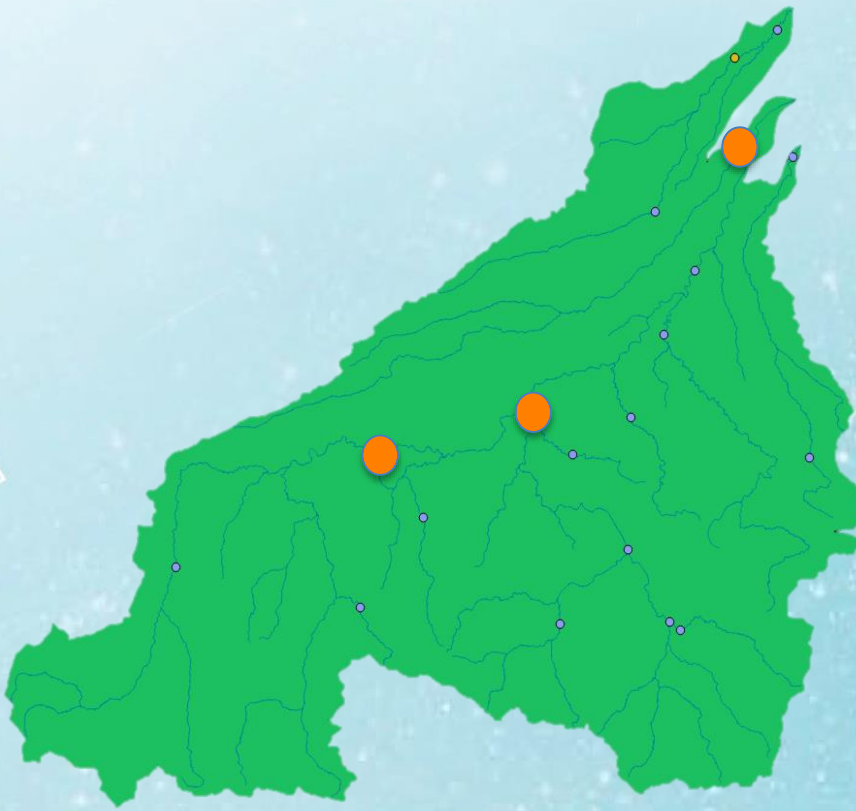


III. Calibration

1) Data
2) Numerical criteria
3) Implementation

1. Data

- Comparison data:
  - Unaffected data 1975-2008
    - Roquefort
    - Valentine
    - Portet
- Calibration 1980-2000
  - 1977-1979 initialisation
- Evaluation 2001-2008



2. Numerical criteria

- One to reproduce value and dynamic of water flow

- 3 criteria on low water period dates
  - Length of scarcity period
  - Starting date of scarcity period
  - Ending date of scarcity period

3. Implementation

- Design of Experiment (DoE) : LHS of size 160

- 3 response surfaces / criteria
  - Kriging
  - 3 types de covariance
  - Weighing of response surfaces based on prediction efficiency (resampling technics)

3. Implementation

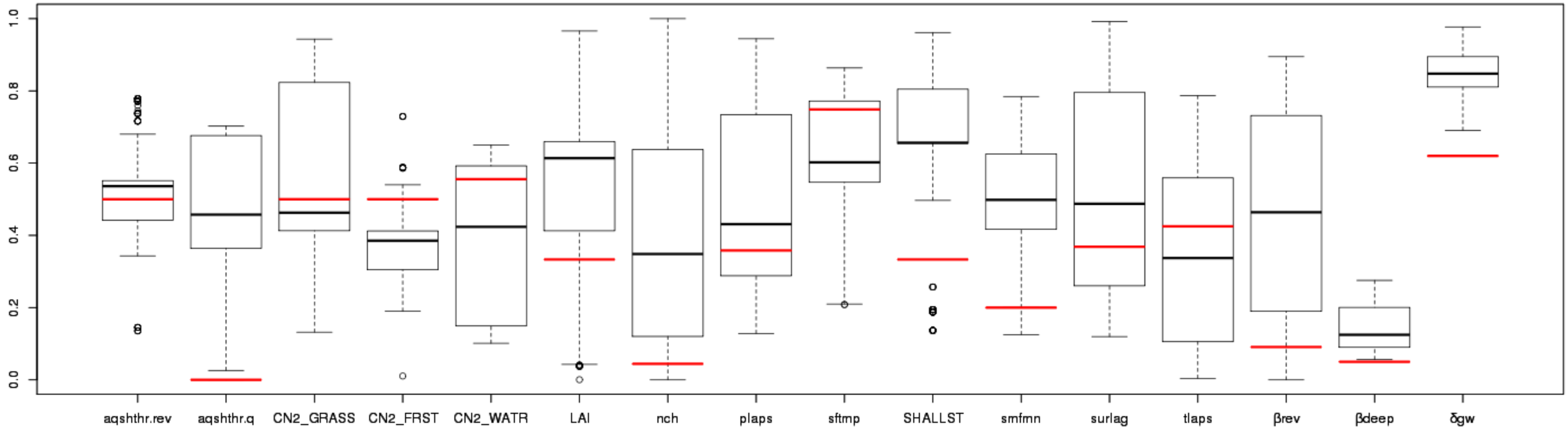
- Pareto front search
  - Gradient descent method (gradient available for Kriging)
  - Local exploration of the Pareto front
    - Random selection of one of the criteria
    - Random spatial step
  - => Until 200 points
- Computation on grid (~48H per step)

IV. Results

1) The parameters
2) Evaluation
3) Discussion

1. The parameters

- step 7



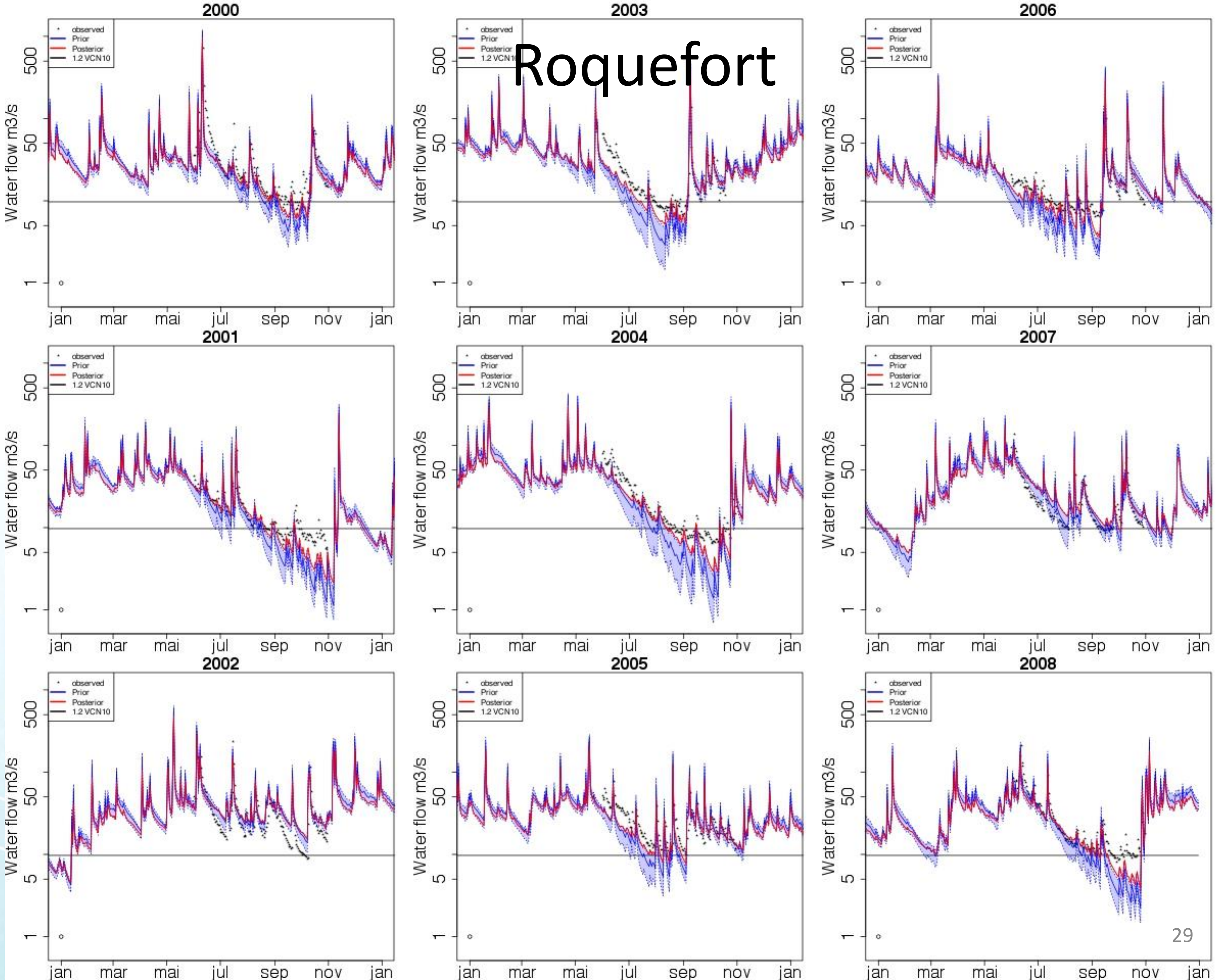
- Step N until convergence

Non uniform convergence of parameters

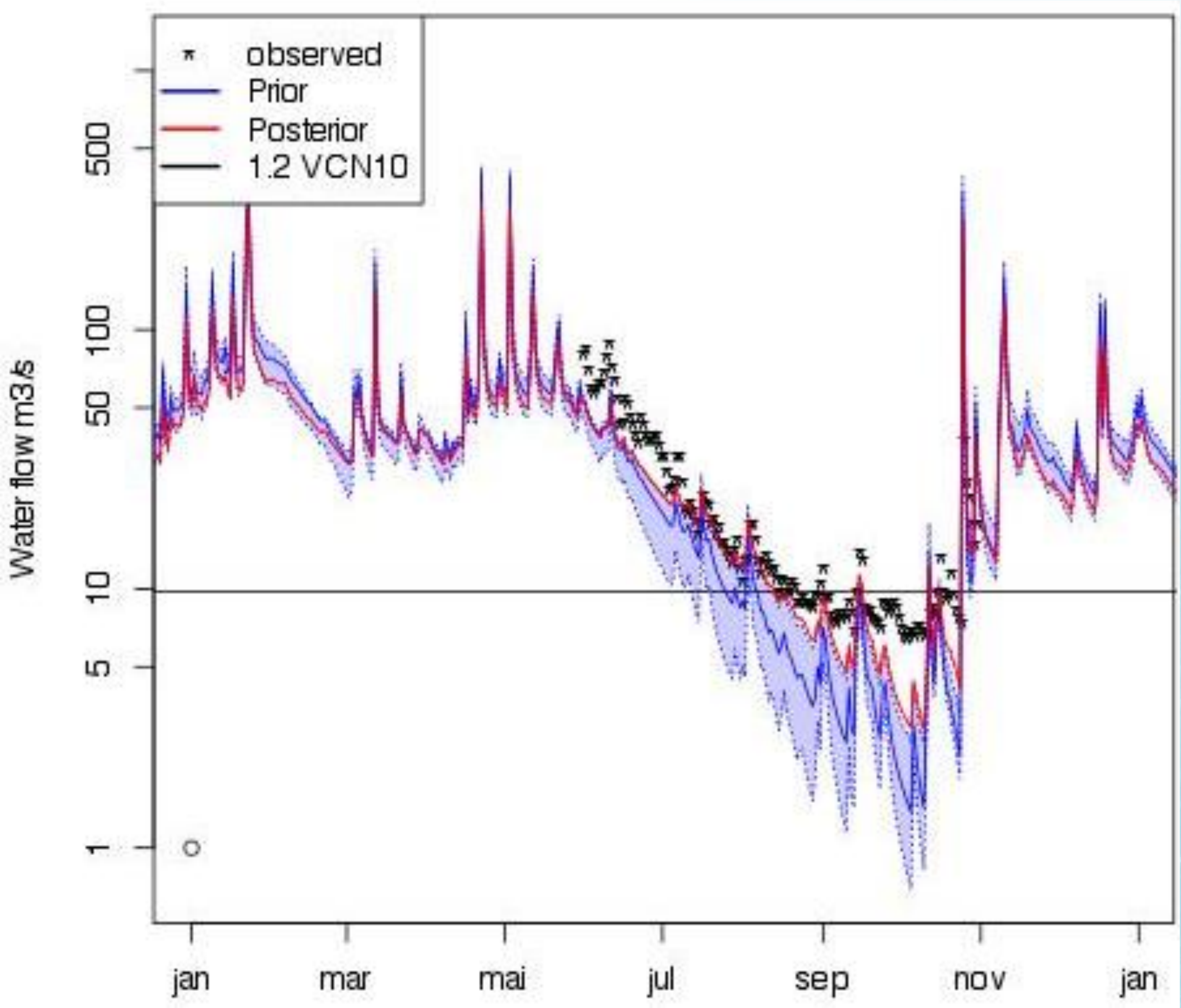
2. Evaluation

- Comparison over 2001-2008
  - "unaffected" data
  - Prior (before calibration): reference value ± 20% interval literature
  - Posterior : Pareto front distribution
  - Simple estimation of uncertainty by a LHS (not taking into account for covariance)

Roquefort


2000
2003
2006
2001
2004
2007
2002
2005
2008
observed
Prior
Posterior
1.2 VCN10
Water flow m3/s
500
50
5
1
jan
mar
mai
jul
sep
nov
jan

Roquefort 2004



3. Discussion

- Difficulty to assess uncertainties of comparison data

- Missing process in the model
    - Hill dams

- Negative correlation between criteria

3. Discussion

- Non uniform convergence of parameters
  - Not influential enough parameters? Or too high correlation

- A single parameter set for the whole area: a mistake?
  - Necessary? Enough data available / how to avoid over parameterisation? Preliminary tests are planned

V. Conclusion

Conclusion

- Still ongoing work
  - Promising results
- A generic and robust method
  - Possibility to reuse the simulations base with other criteria
  - Not specific to this area, nor to this model
- Still some methodological questions
  - Refine DoE building
  - Proof of convergence

Thank you for your attention