5 REASONS

NOT TO USE NUMERICAL MODELS IN WATER RESOURCES MANAGEMENT

Francesca Pianosi, University of Bristol

3 things I am not going to talk about

1. Water is an essential resource
2. Water resources are under increasing pressure
3. We need novel approaches to water resources management

1 question I would rather discuss

Can numerical models help to improve water resources management?

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5 REASONS

NOT TO USE NUMERICAL MODELS IN WATER RESOURCES MANAGEMENT

Francesca Pianosi, University of Bristol

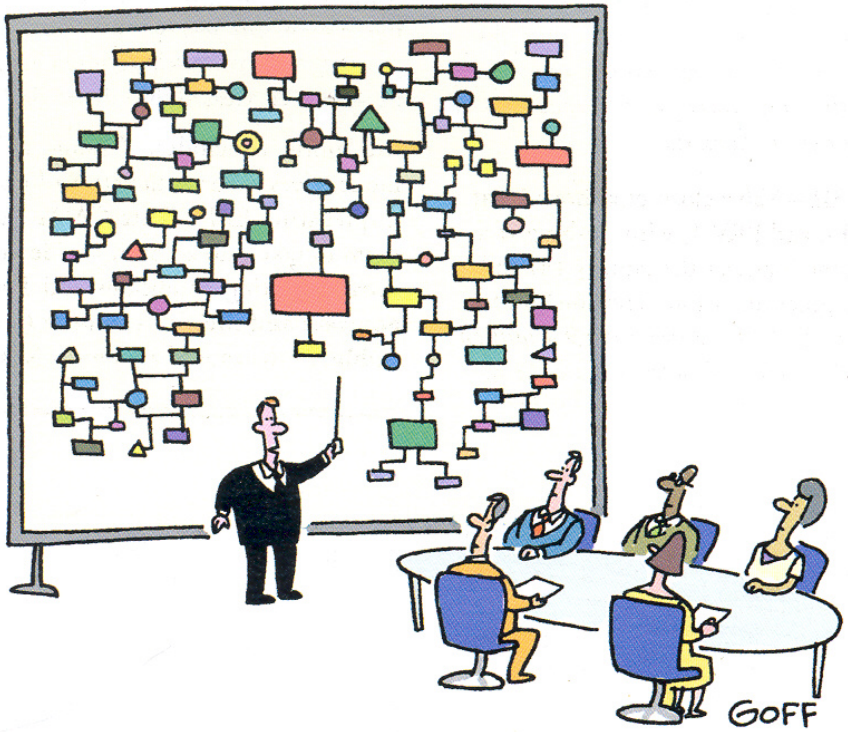
4 REASONS

NOT TO USE NUMERICAL MODELS IN WATER RESOURCES MANAGEMENT

Francesca Pianosi, University of Bristol

REASON #1

The models we use are so complex that
we have no idea what is really happening in there

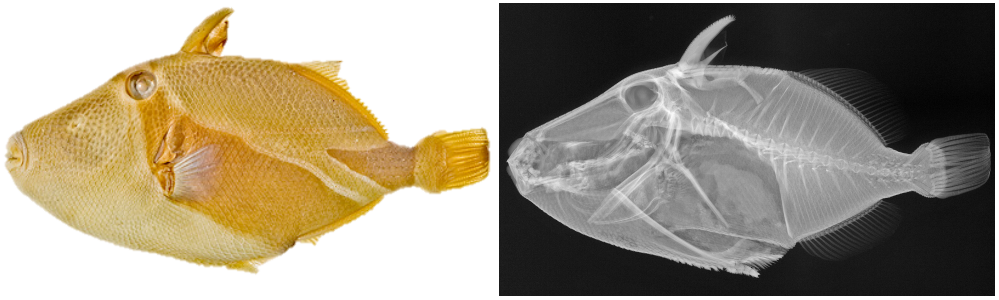


As we use increasingly complex models we need formal, structured approaches to support model calibration, verification and diagnostic evaluation

→ Sensitivity Analysis (SA) is a set of statistical techniques that provide such a structured approach

WHAT
does the model predict?

WHY
does it predict so?



X-Ray Vision: Fish Inside out: www.mnh.si.edu/exhibits/x-ray-vision/

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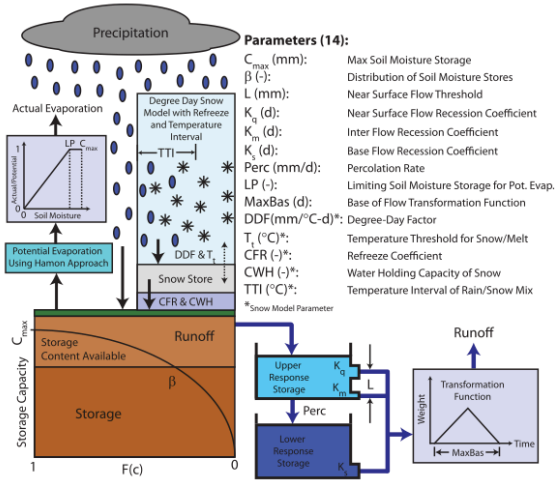
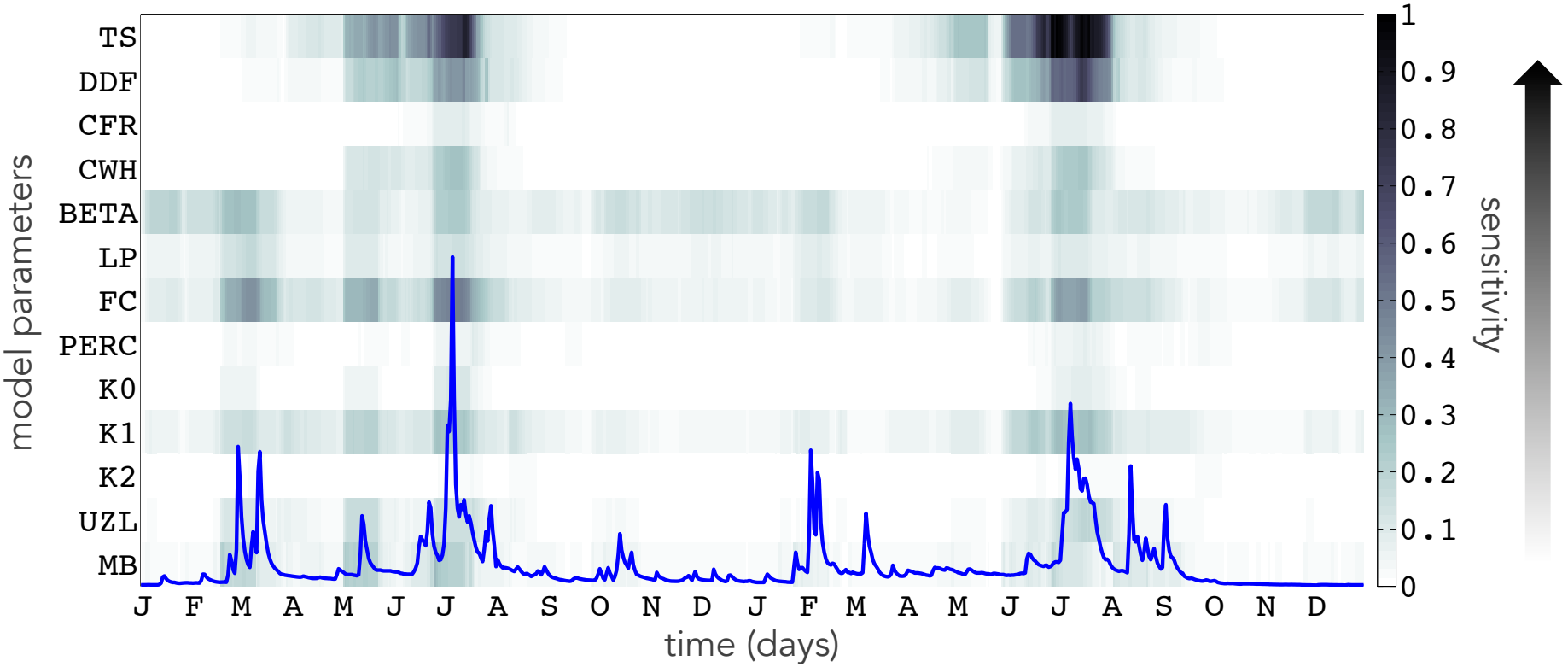
Application example to hydrological model

Sensitivity of model performance
to variations in the 13 model parameters
[model: HBV+snow accounting as in Kollat et al 2012 *WRR*]





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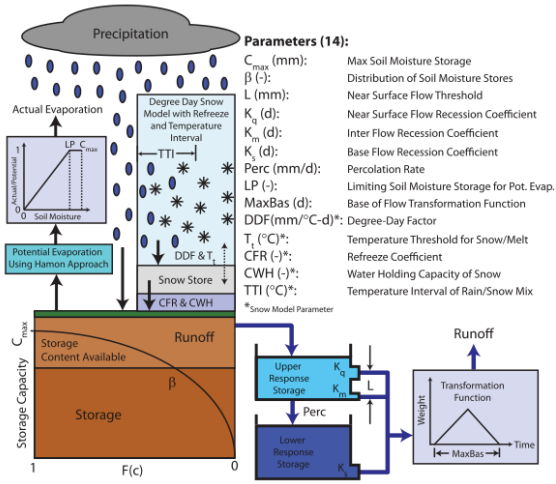

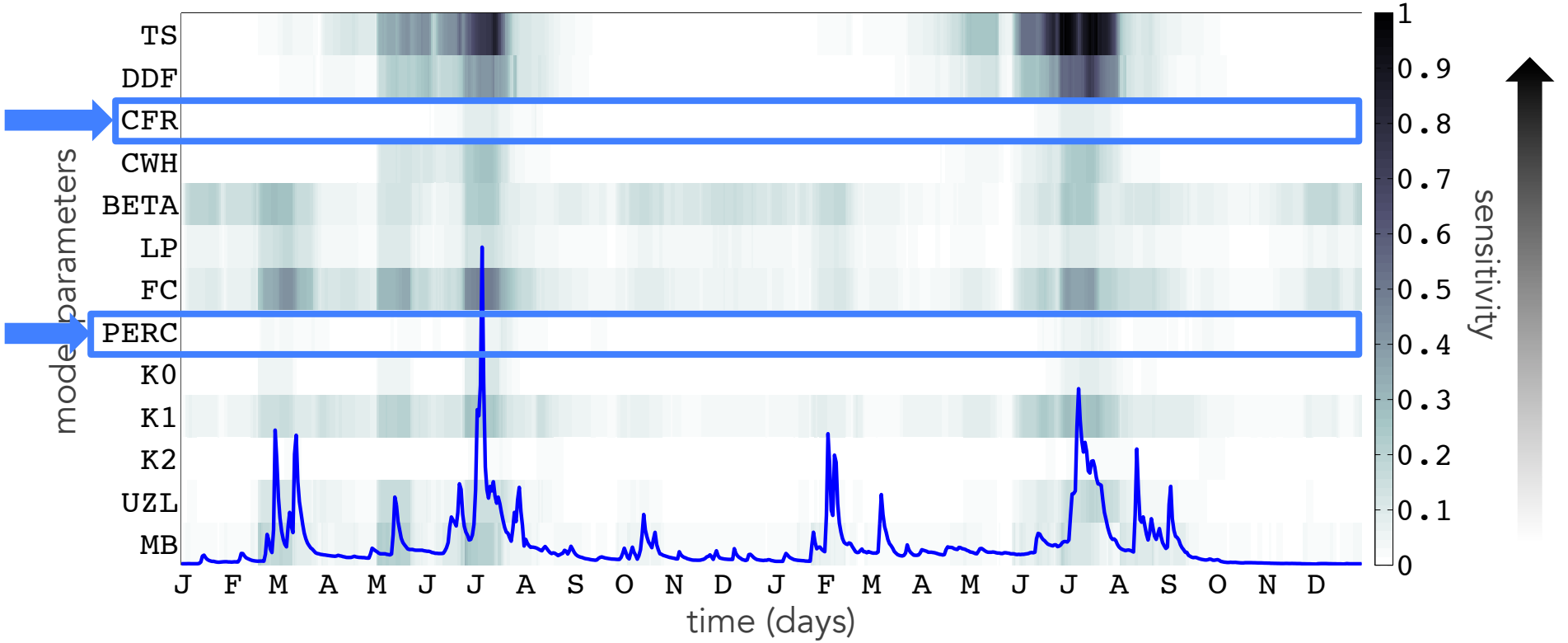

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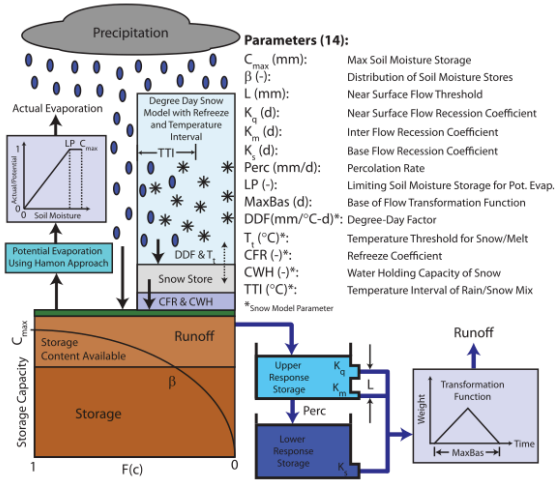

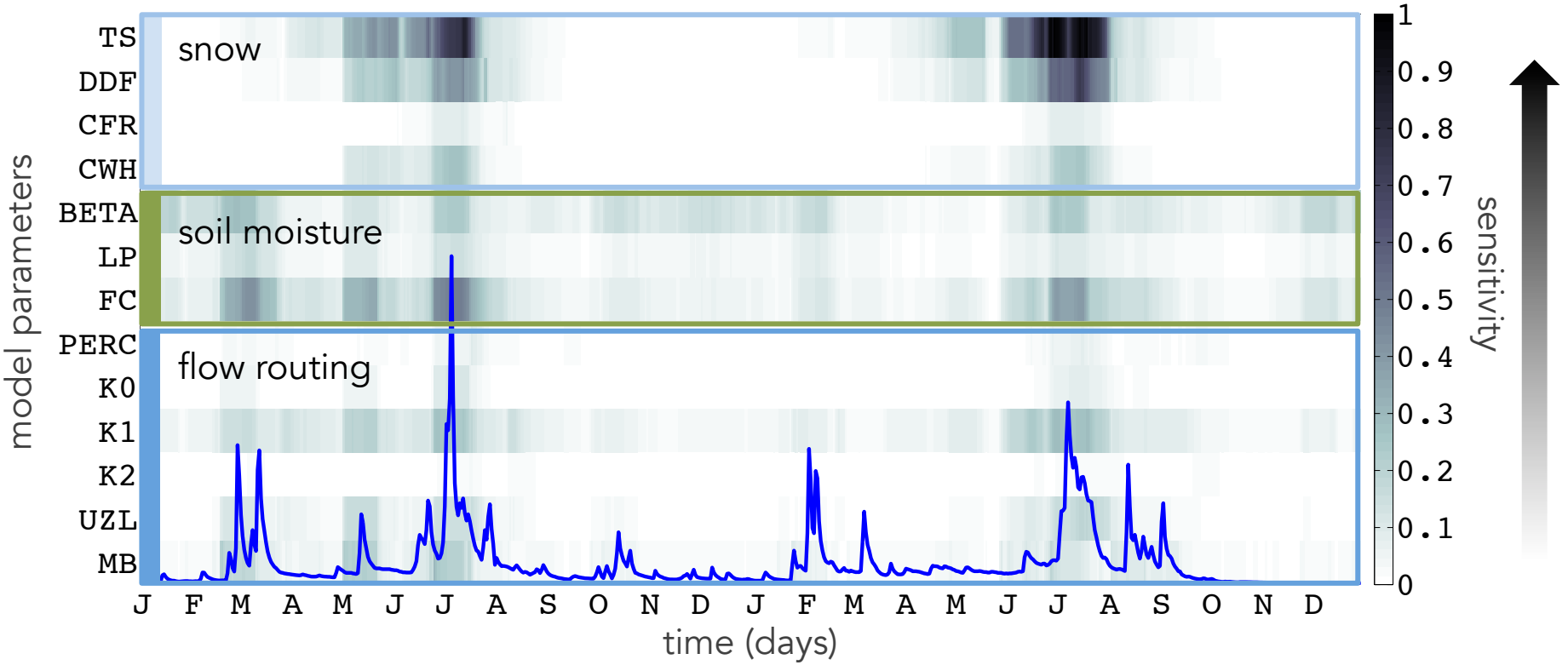

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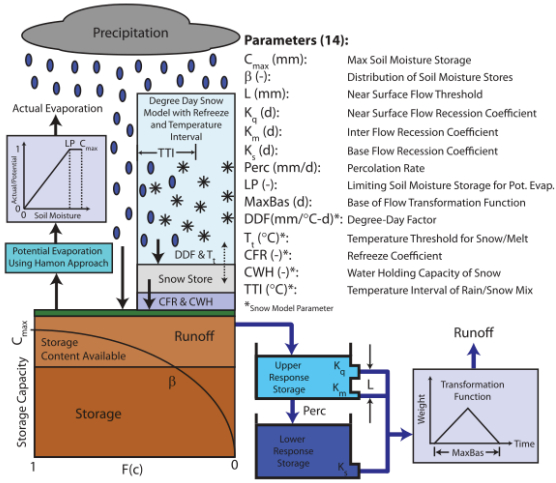

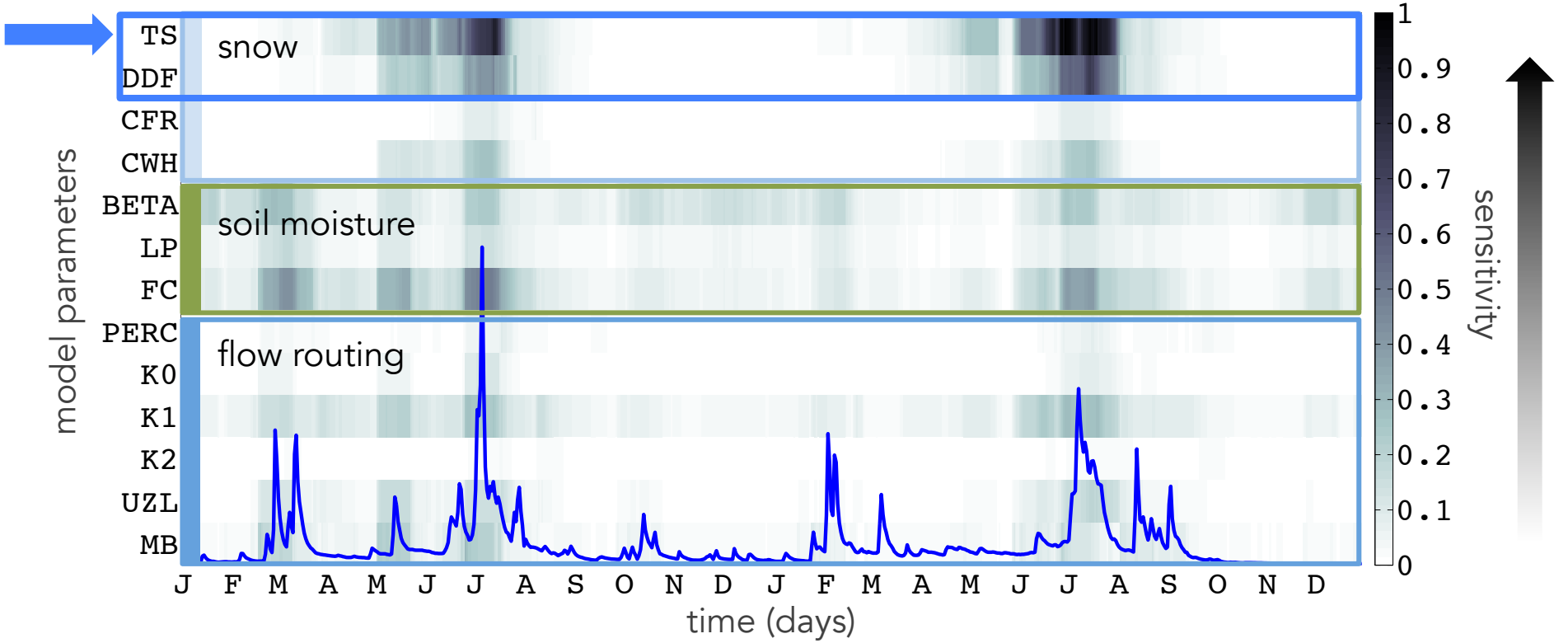

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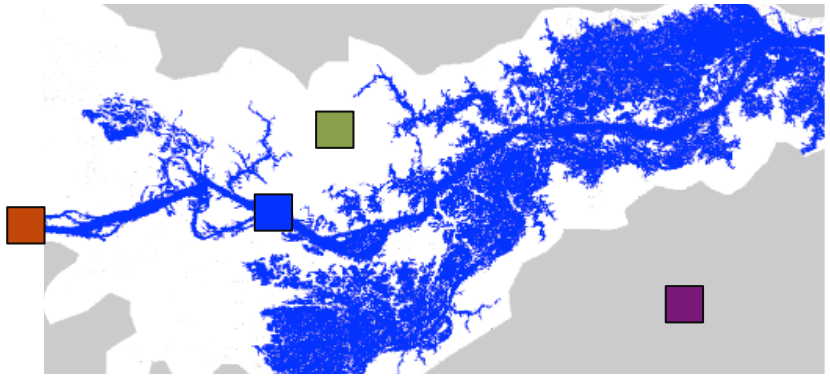
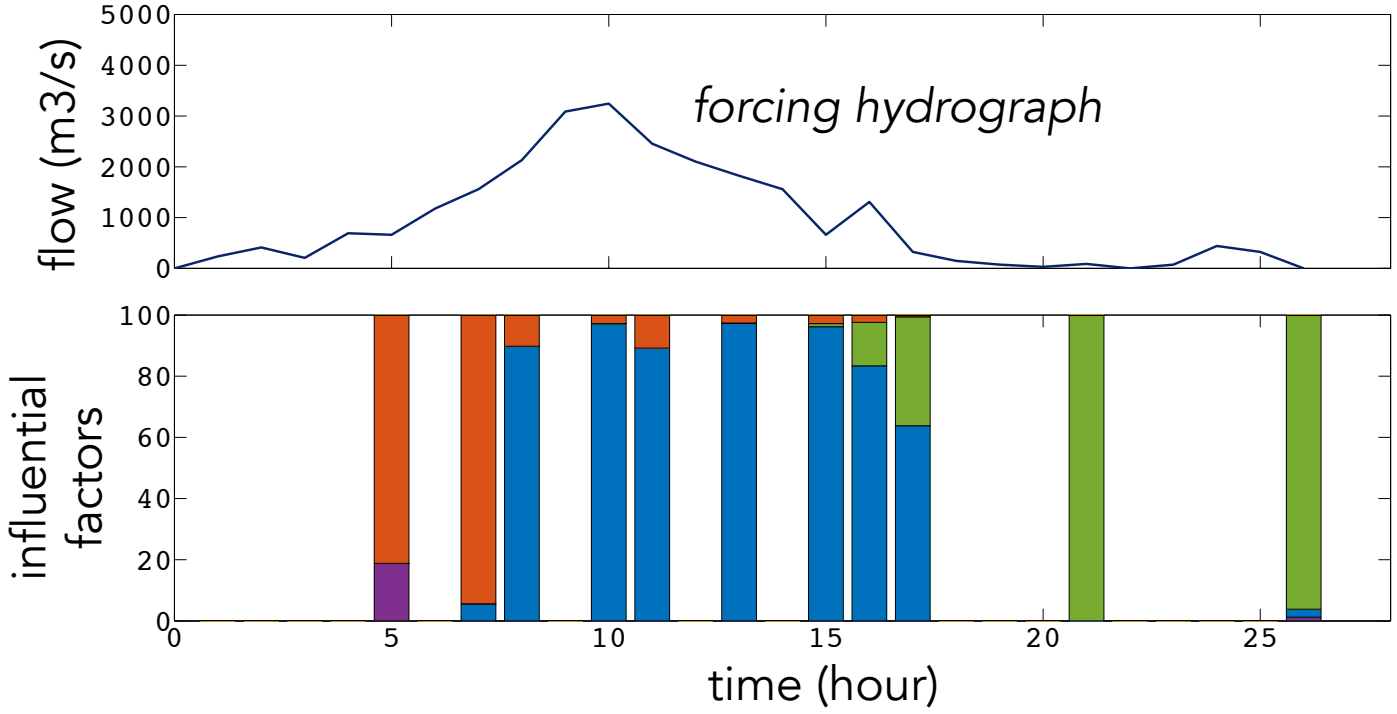
Application example to flood inundation model



James Savage et al., *in progress*

floodplain friction | channel friction | forcing hydrograph | spatial resolution



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EGU presentation on Sensitivity Analysis

Wed, 15 – 11:45 - Session NH1.6 - Room G6 - EGU2015-13145
The application of Global Sensitivity Analysis to quantify the dominant input factors for hydraulic model simulations by James Savage et al.

Wed, 15 – Session NP1.3/HS2.3.16 - Blue Posters - EGU2015-2218
Global Sensitivity Analysis of Environmental Models: Convergence, Robustness and Validation by Fanny Sarrazin et al.

Fri, 17 – Session NH3.11 – Blue Posters - EGU2015-6555
Robustness for slope stability modelling under deep uncertainty
by Susana Almeida et al.

Mon, 13 – 13:30 – Session HS3.3 – PICO Session - EGU2015-1356
SAFE(R): A Matlab/Octave Toolbox (and R Package) for Global Sensitivity Analysis

bristol.ac.uk/cabot/resources/safe-toolbox/
Pianosi et al. *EMS* in press

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We use increasingly complex
and 'non-intuitive' models
+
Increasing availability of data types
adds up to model complexity

However

We have more and more sophisticate methods
to investigate model behaviour
and
We have ever growing computing power
to put those methods into practice

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REASON #2

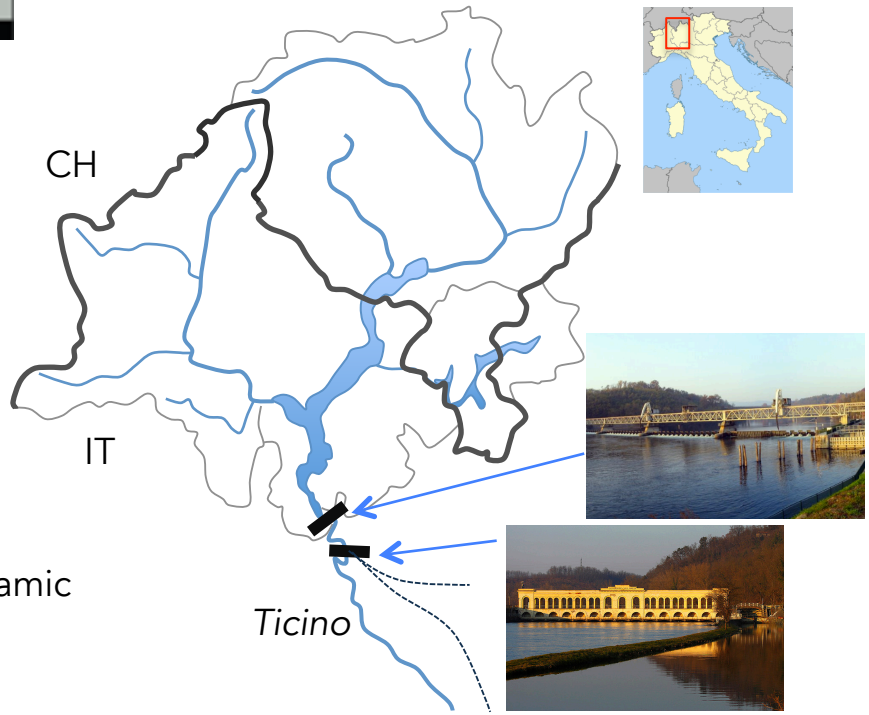
Water resource management problems
involve multiple, conflicting sectors

Therefore there is no possibility
to take rational ('optimal') decisions

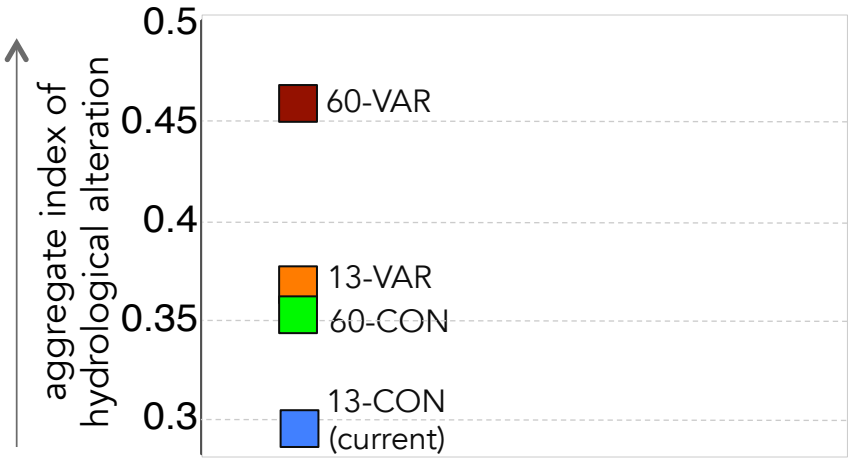
Example from Ticino River, Italy

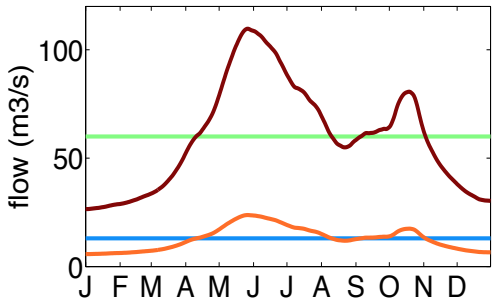
How to redefine the
Minimum Environmental Flow
for the river?

Bizzi et al. 2012 *JoH*



Indicators of Hydrological Alteration - Stochastic Dynamic Programming - Multi-Criteria Analysis





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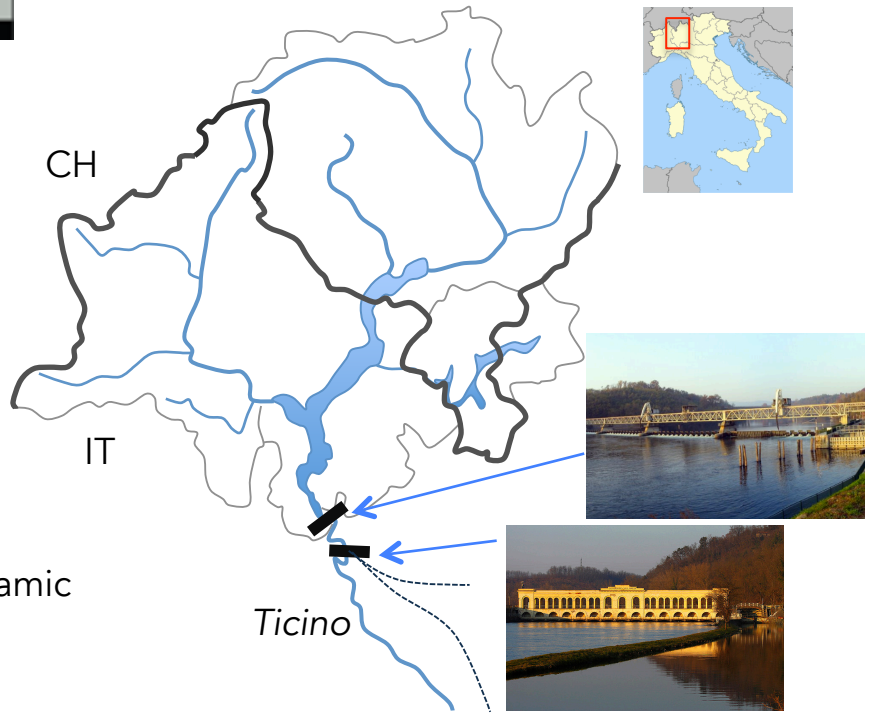

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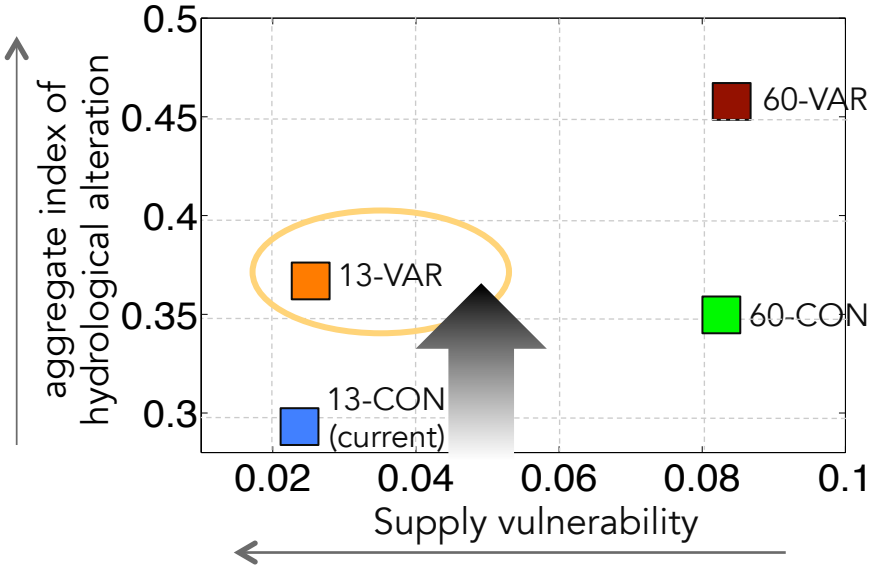

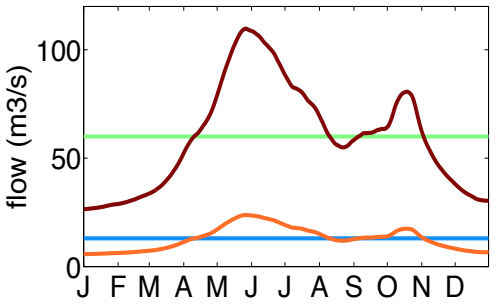

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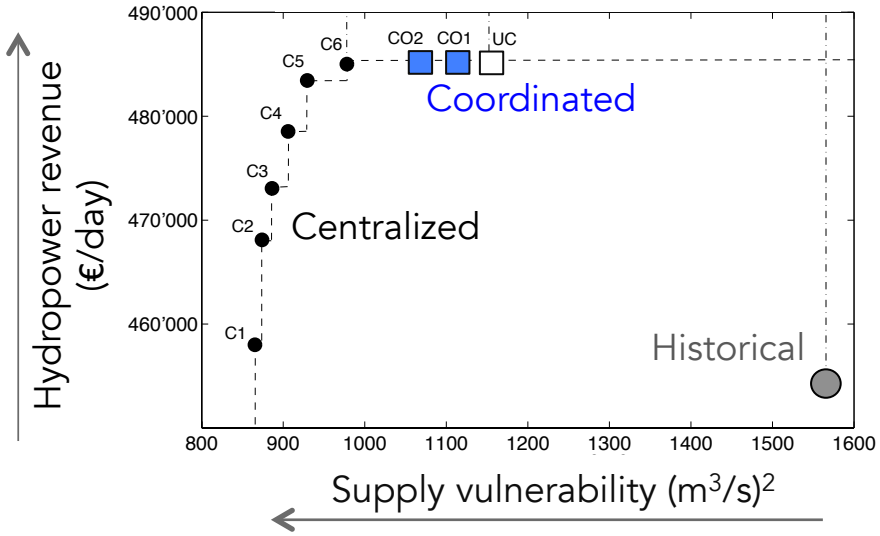
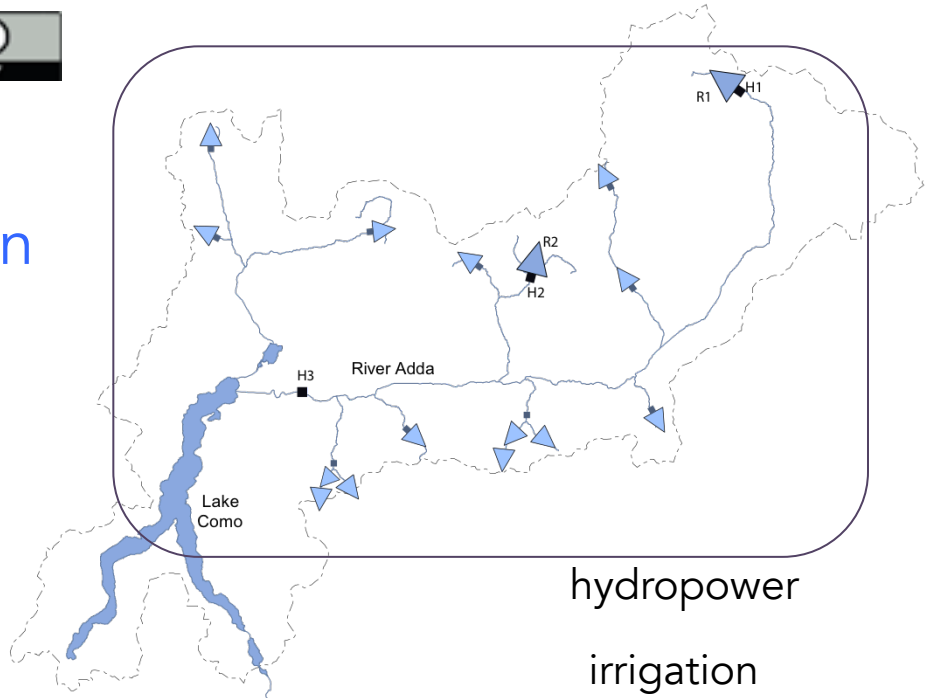
Example from Lake Como basin

How to mitigate the conflict between upstream and downstream users?

Anghileri et al. 2013 *JWRPM*

Multi-objective optimization of system operation under different institutional setups





hydropower

irrigation

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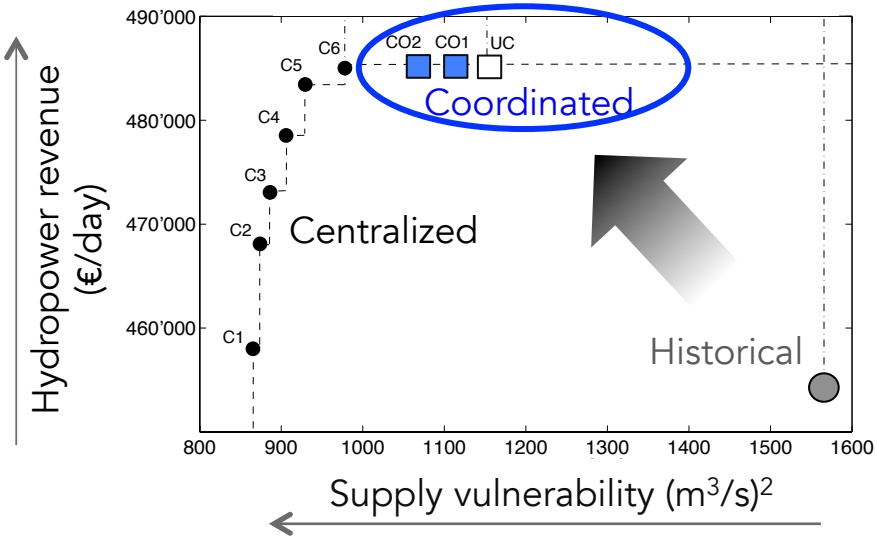

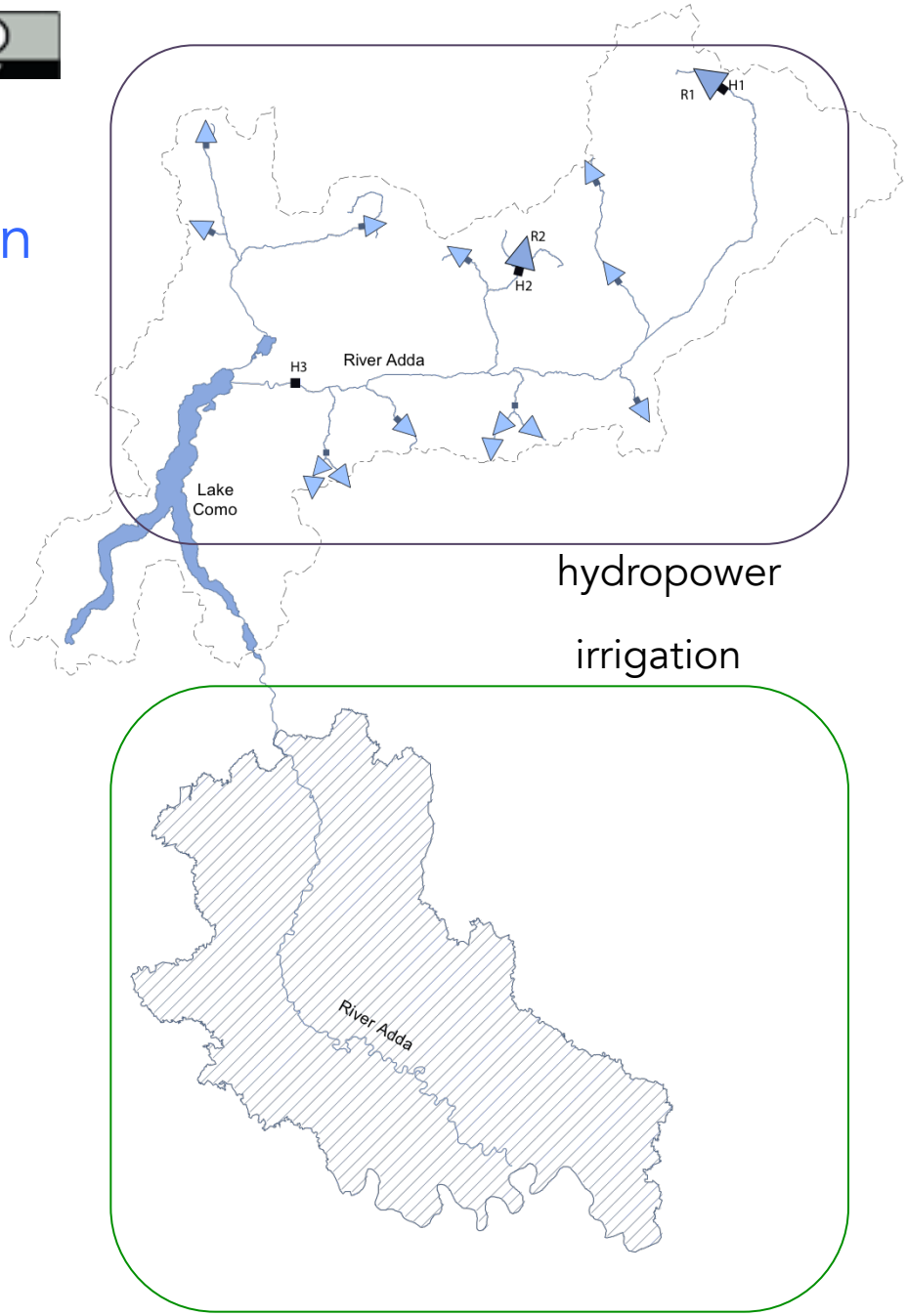

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Multi-Criteria Analysis and Multi-Objective Optimization
provide the framework
to analyze tradeoffs between conflicting criteria
and to design Pareto-optimal solutions

Sometimes win-win solutions can be found

In all cases, MCA and MOO help supporting
the investigation of tradeoffs
and therefore increase transparency of decisions

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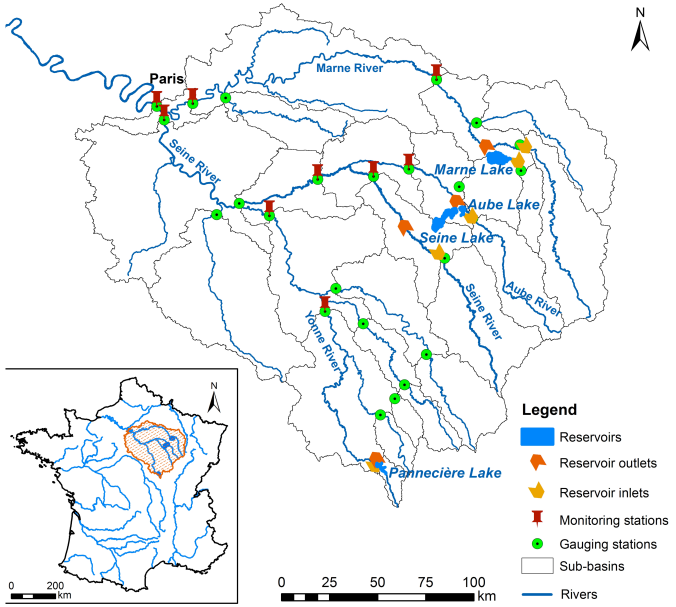
REASON #3

Model predictions are uncertain
and it is not possible to make good decisions
based on uncertain predictions

Example from 4-reservoirs system in the Seine river basin, France

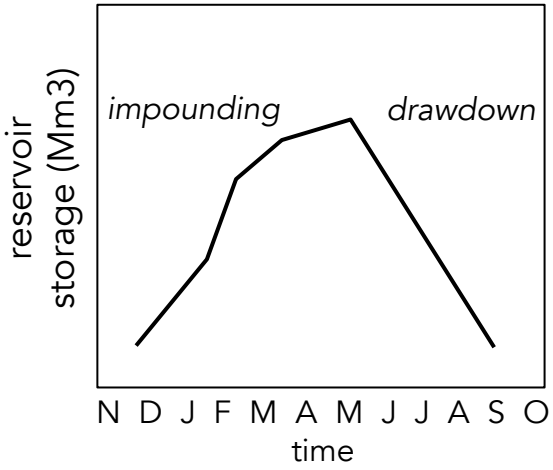
How much can we improve the efficiency of existing infrastructure by making the best use of model forecasts?

Ficchì et al., JWRPM, under review

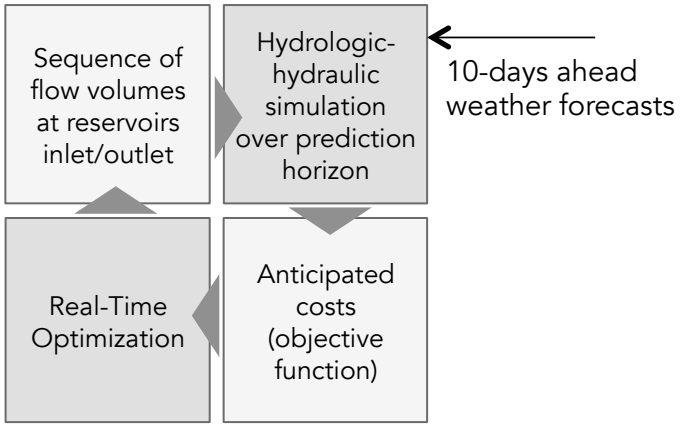


www.uni-kassel.de/fb14/wasserbau/CLIMAWARE/home/home.html

Rule Curves approach



Forecasts-based approach



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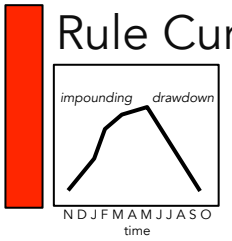
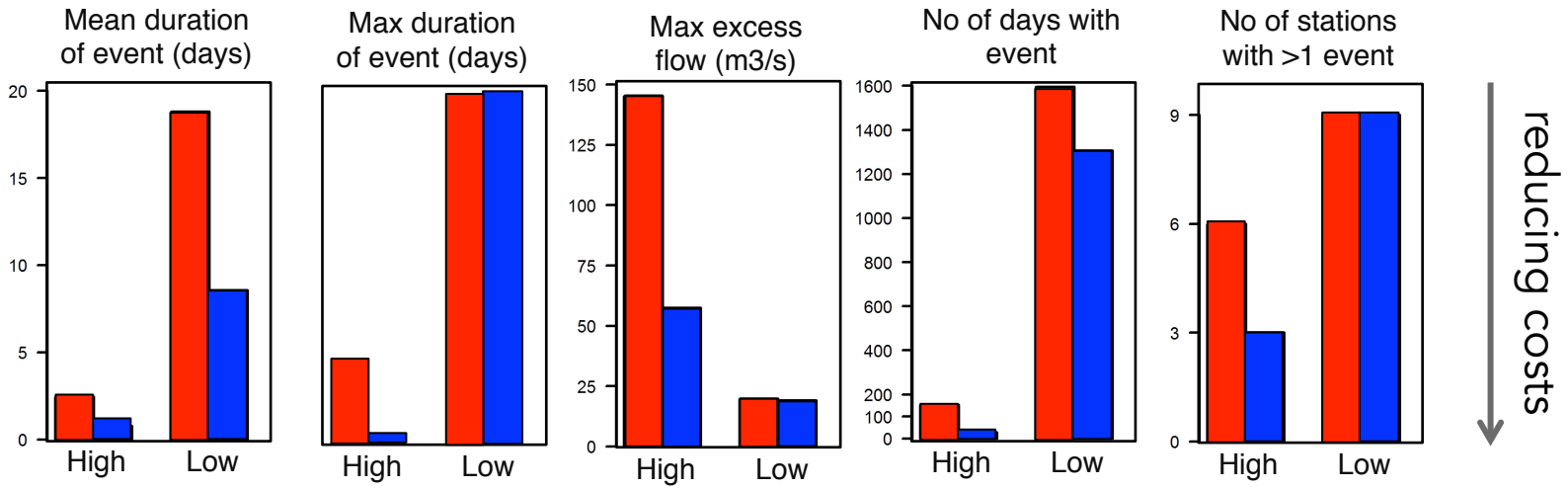
Step 1: Assessing the potential of Real-Time Optimisation



Simulation over 15-year period (01/08/1973-01/11/1988)



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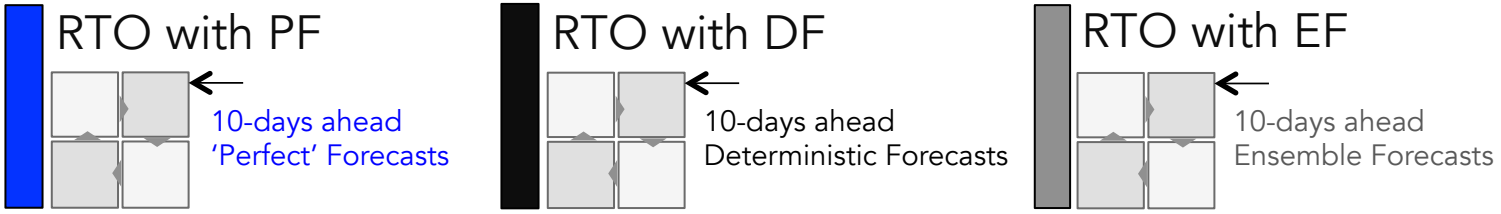
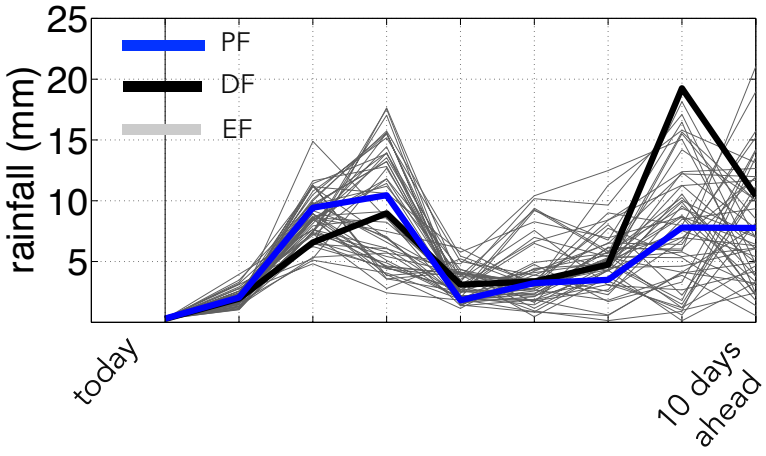
Step 2: Assessing the value of available forecasts for Real-Time Optimisation



from European Centre for Medium-Range Weather Forecasts (ECMWF)



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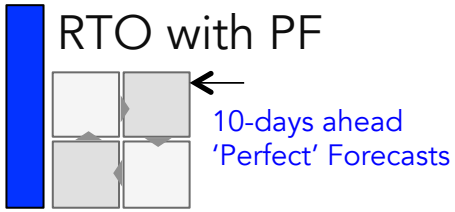
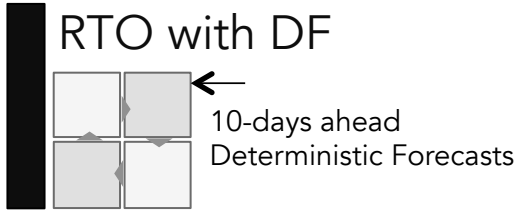
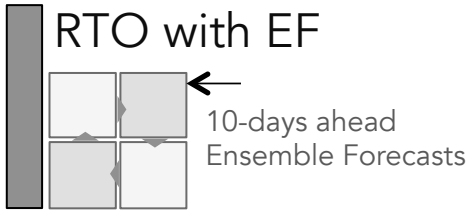
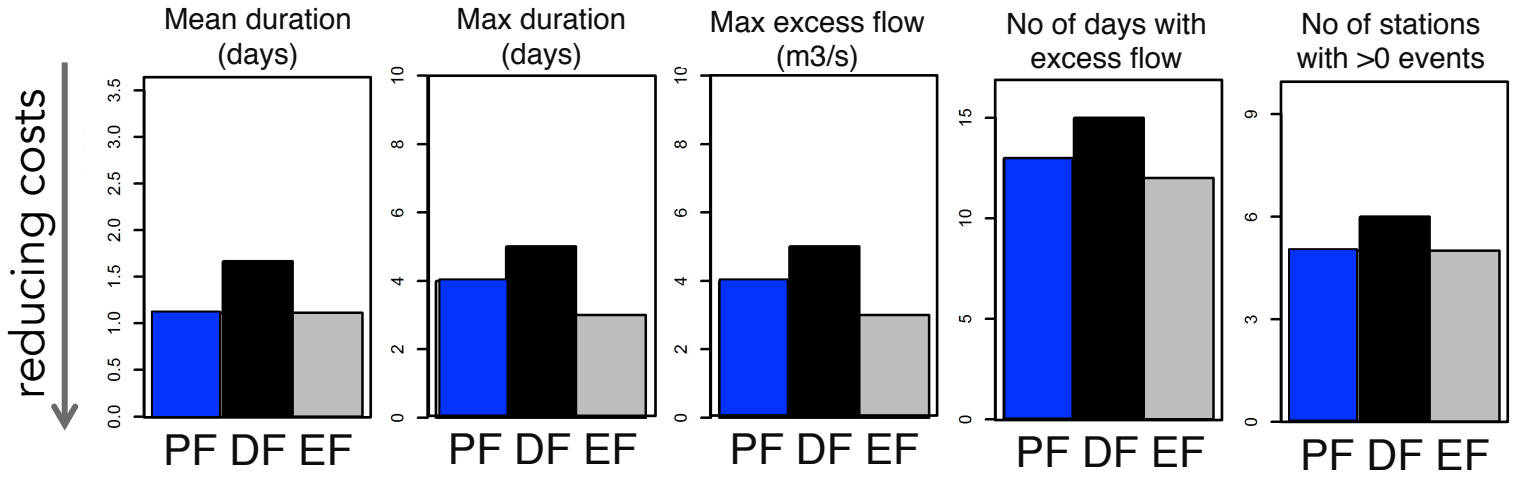






Simulation over flood event in February, 2007



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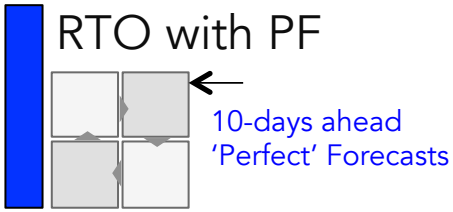

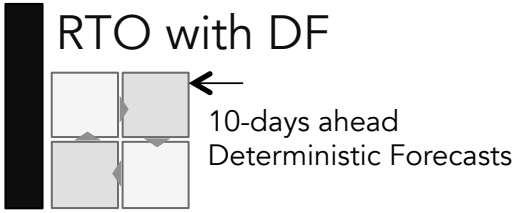

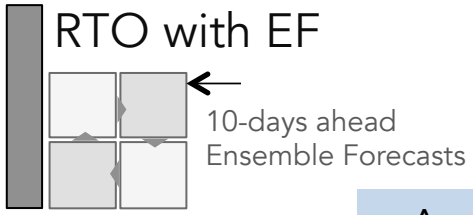

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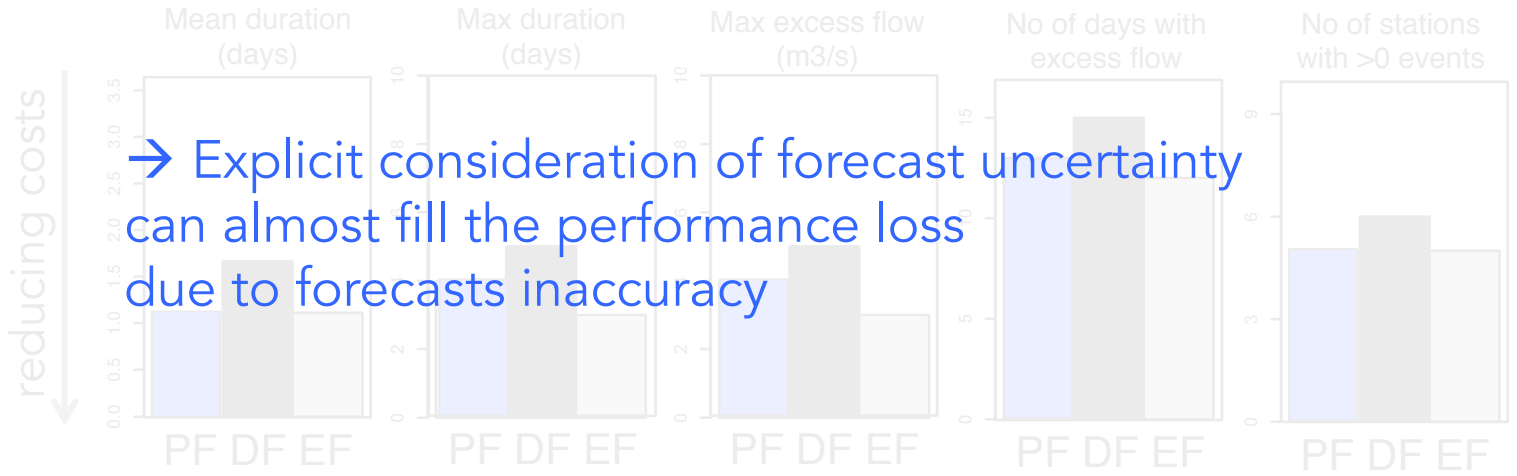
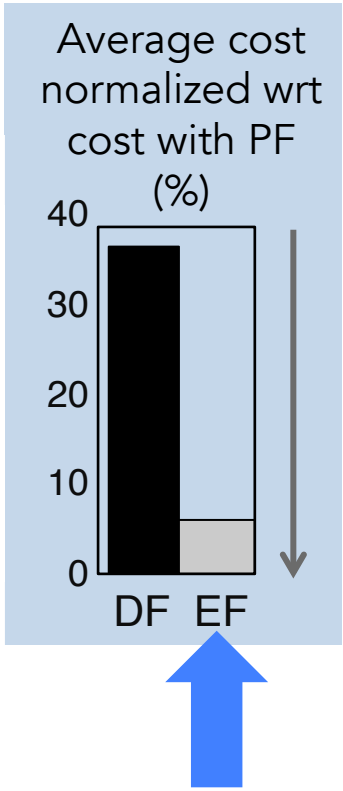


→ Explicit consideration of forecast uncertainty can almost fill the performance loss due to forecasts inaccuracy



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Although uncertain, model predictions
can still have value for decision-making

Explicit consideration of uncertainty in decision
(optimisation) methods help making better decisions

Combining prediction models and decision theory
provides a new way to look at models:
from focusing on accuracy in predictions
to focusing on value for decision-making

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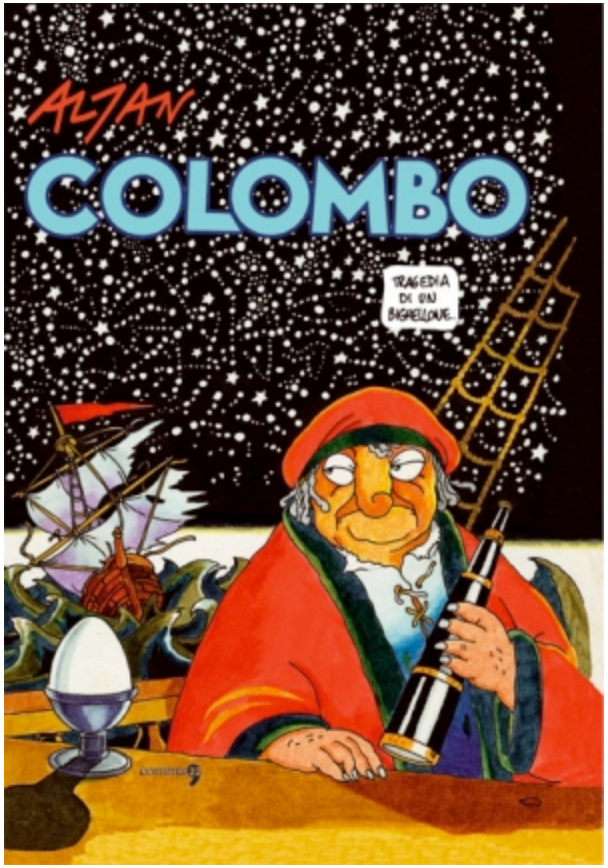
REASON #4

Models are a simplification of the real world,
and their predictions are just the reflection
of their underlying assumptions

Therefore we cannot trust and implement the decision
that a model suggests is ‘best’

Model results are certainly wrong…

But does this really matter?



Christopher Columbus
(1451-1506)

francesca.pianosi@bristol.ac.uk

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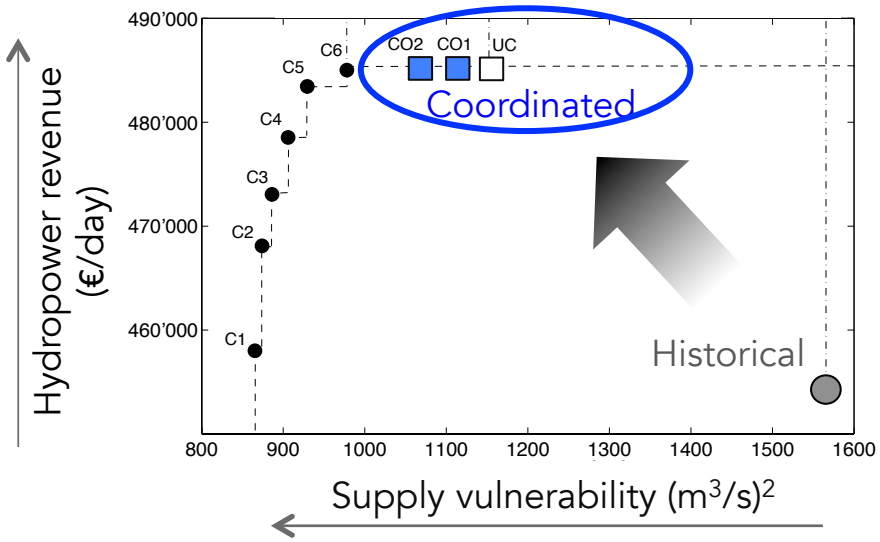

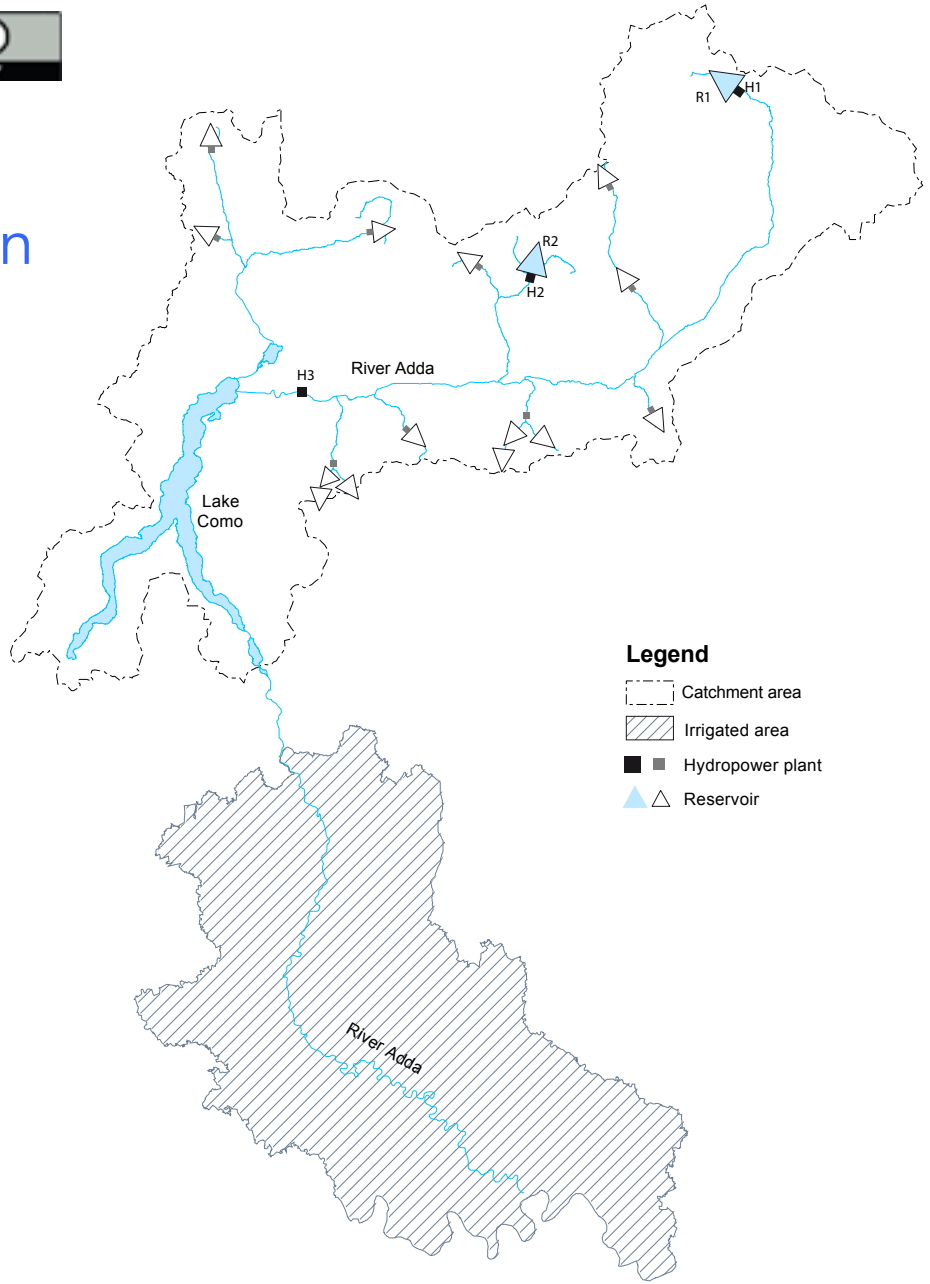

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Modeling exercises are an opportunity for us to

- *think about our understanding of a problem,*
- *bring expertise and knowledge together,*
- *organize knowledge in a structured way,*
- *discover unexpected behaviours or connections,*
- *reduce uncertainty about the problem,*
- *identify knowledge gaps,*
- *raise new questions,*
- *...*

The main outcome of the modeling exercise
is the learning process
induced by the model construction (?)

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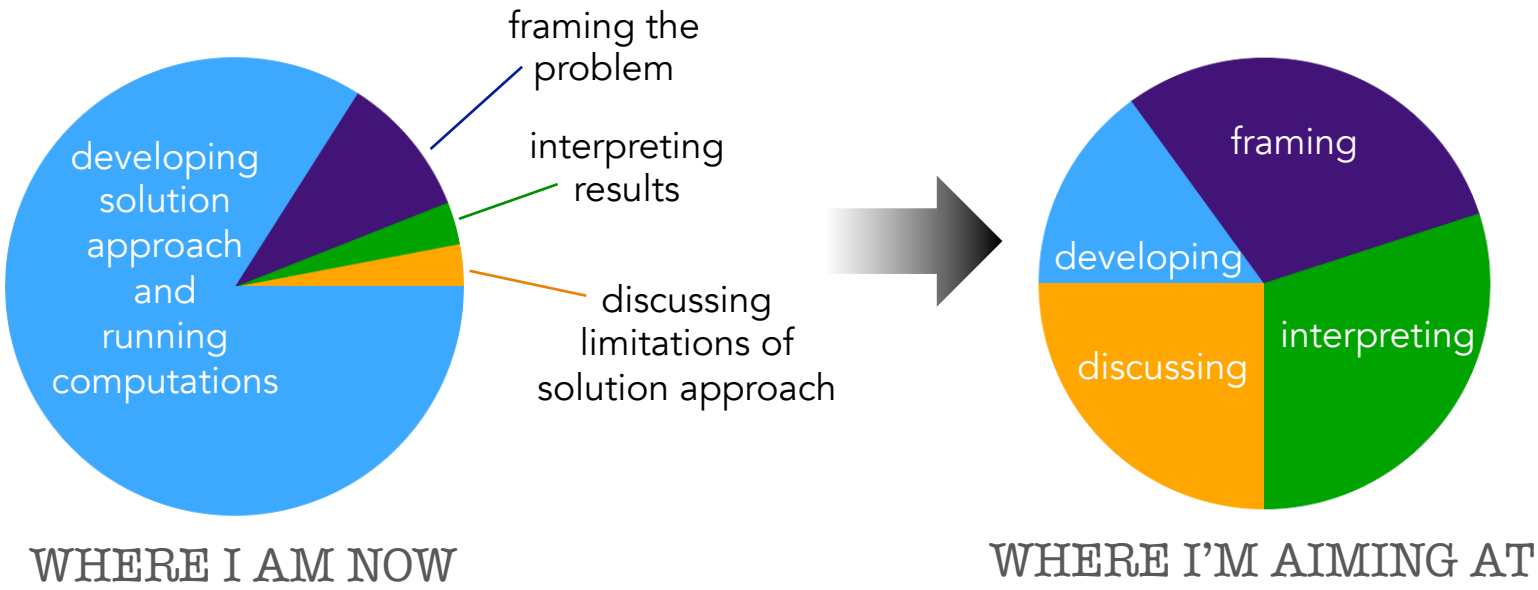
CONCLUSIONS

3

things I would do differently of my research so far

Spend more time on:

1. understanding problem context, formulation, previous works, etc.
2. interpreting numerical results and their broader implications
3. discussing limitations of the proposed solution approach



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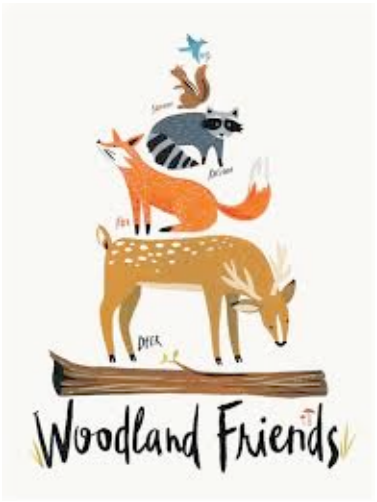
THANK YOU

SEE THE GLASS HALF FULL
AND
CARRY ON SAILING



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