Robust Decision-Making Under Deep Uncertainty: Hydro-economic Multi-model Ensemble in Water Resource Management

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01 Previous Review and Motivation

1. Review findings on uncertainty analysis
2. Importance of addressing input, parameter, and structural uncertainty
3. Innovation in using a multi-model ensemble

Study motivation:

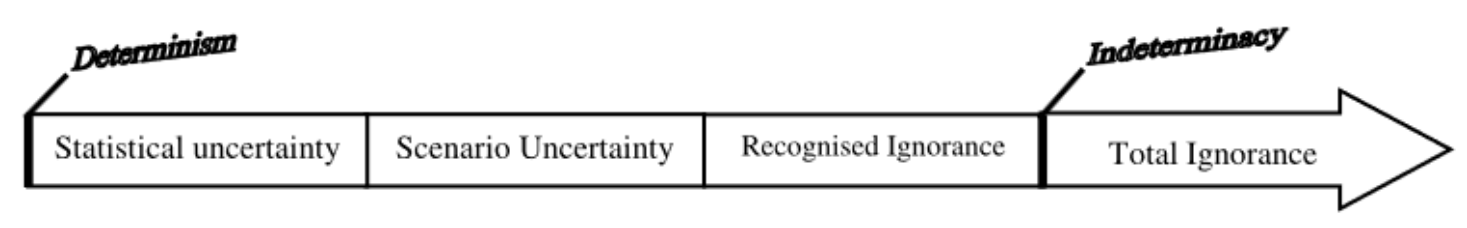
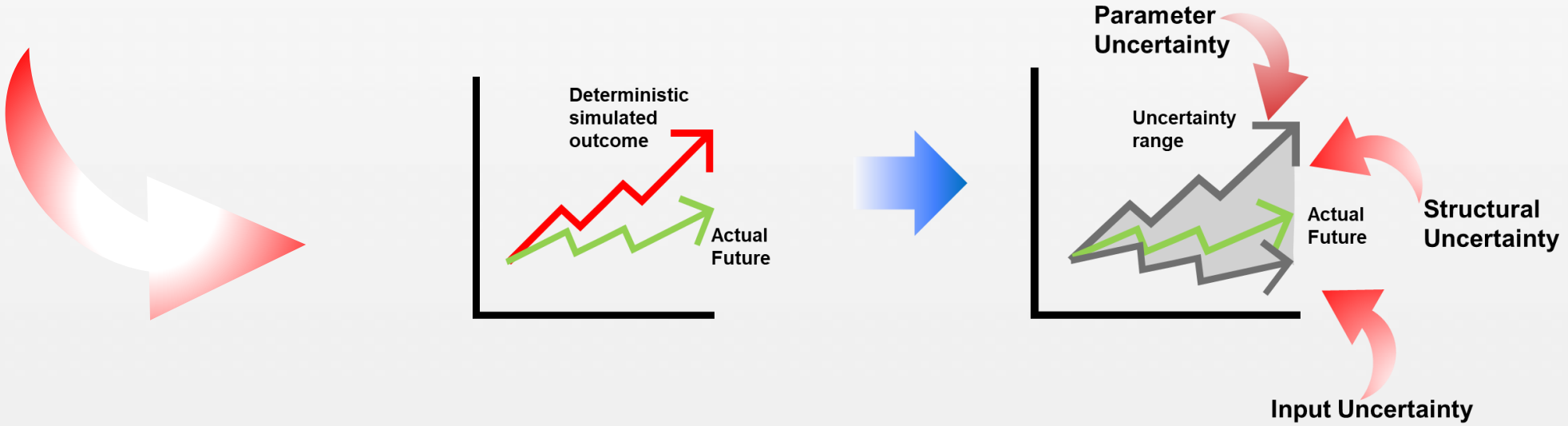


Figure from Walker et al, 2003



Findings:

1) Lack of parameter and structural uncertainties within models' quantification – Existing analysis are partial.

2) Inexistent structural uncertainties assessment between models:

Recommendations:

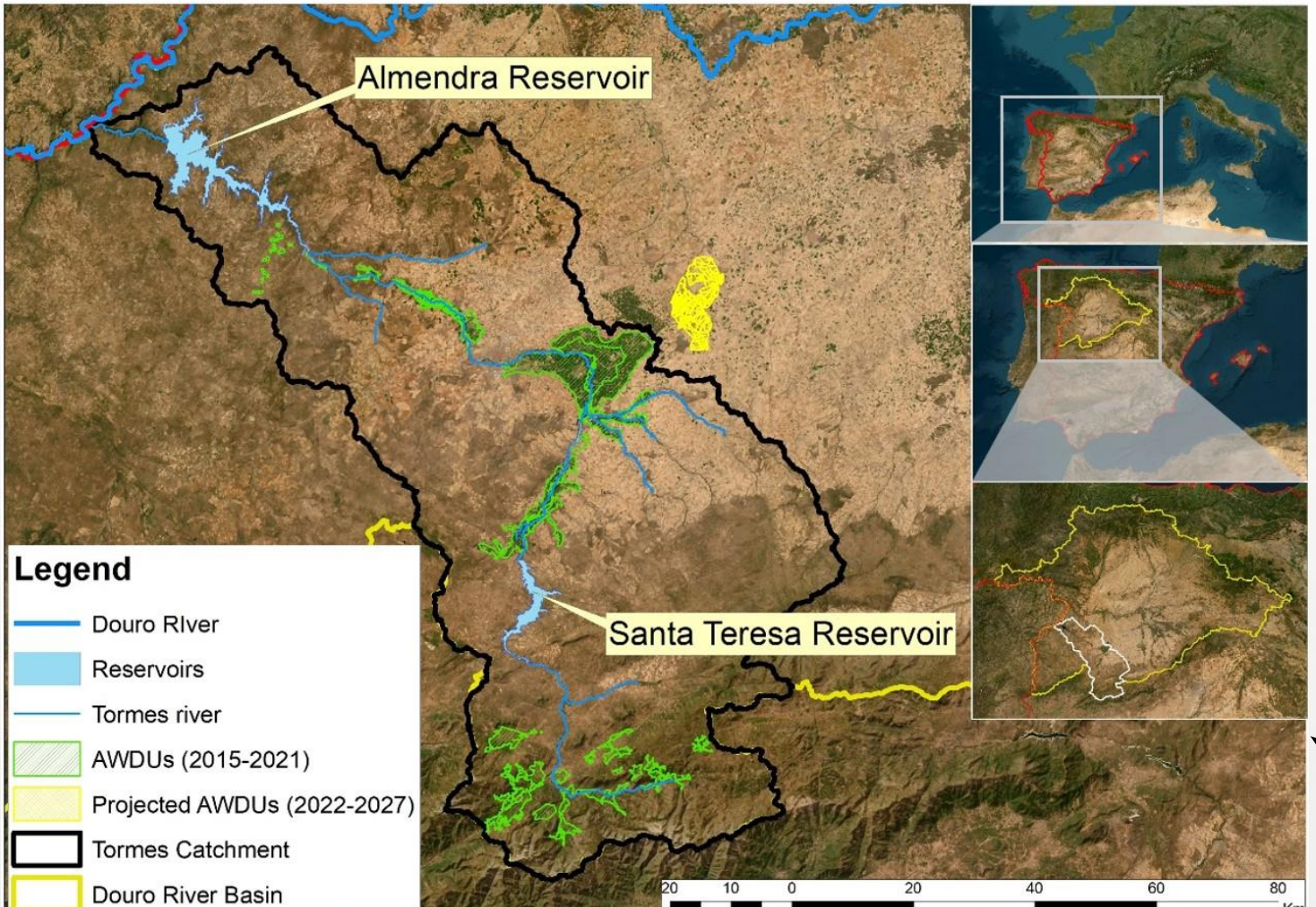
- *Expand uncertainty analyses to explore a wider range of input and parameter values.*
- *Investigate alternative coupling setups to understand their impact on modeling outcomes by using Multi-model ensemble experiments to quantify uncertainties.*

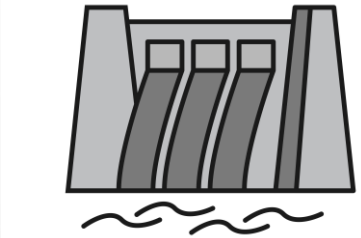
02 Study Area

1. Description of the Tormes River Basin

02 Study Area

Tormes Catchment – Douro River Basin, Spanish side.



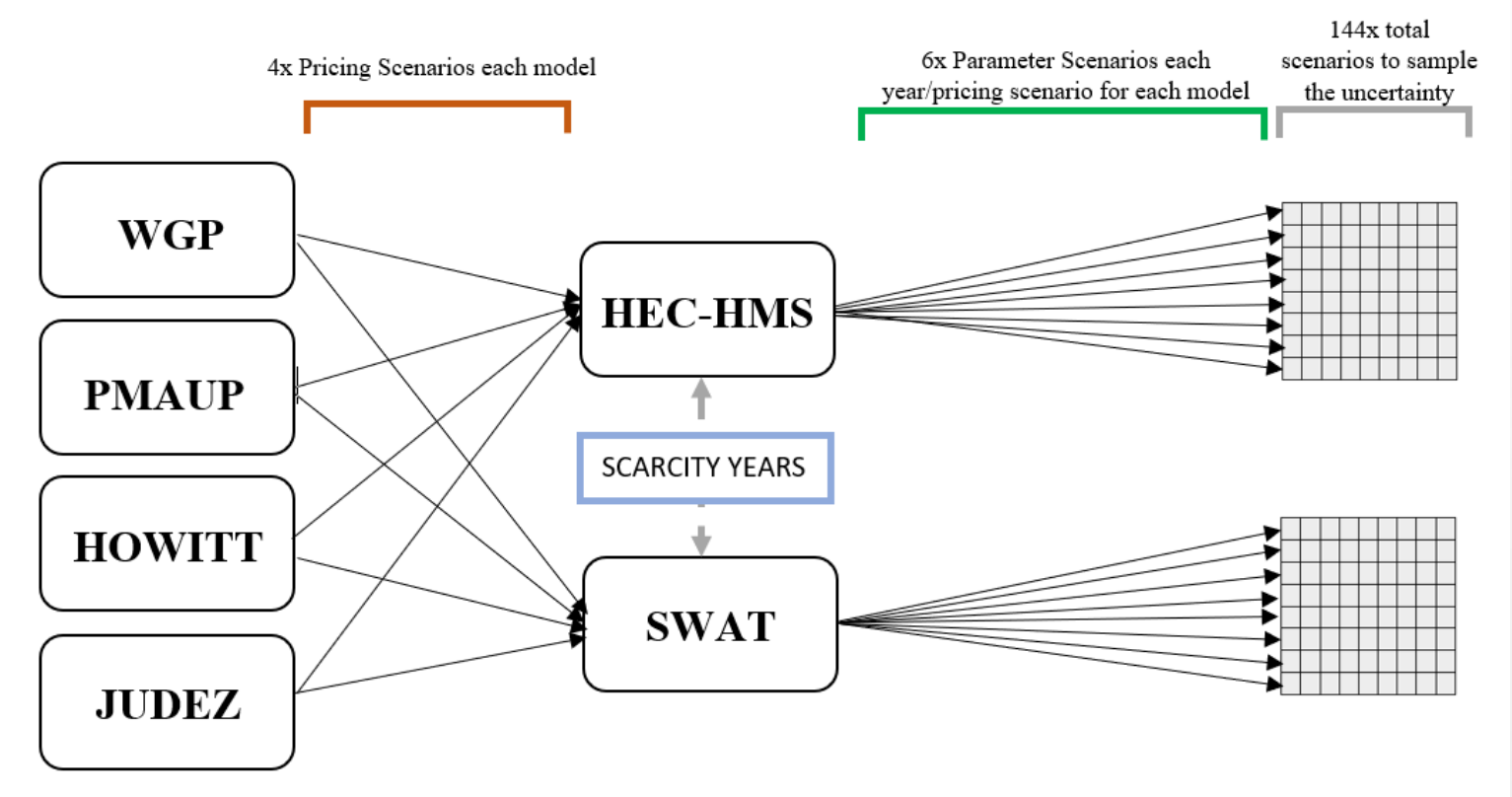


Santa Teresa Reservoir = 496 Hm³

03 Methodology

1. Methodology Overview
2. Hydrological Models Configuration
3. Models integration
4. Input Uncertainty, Parameter Uncertainty, Structural Uncertainty

Methodology overview



Hydrological Models configuration: SWAT (2012 versión)

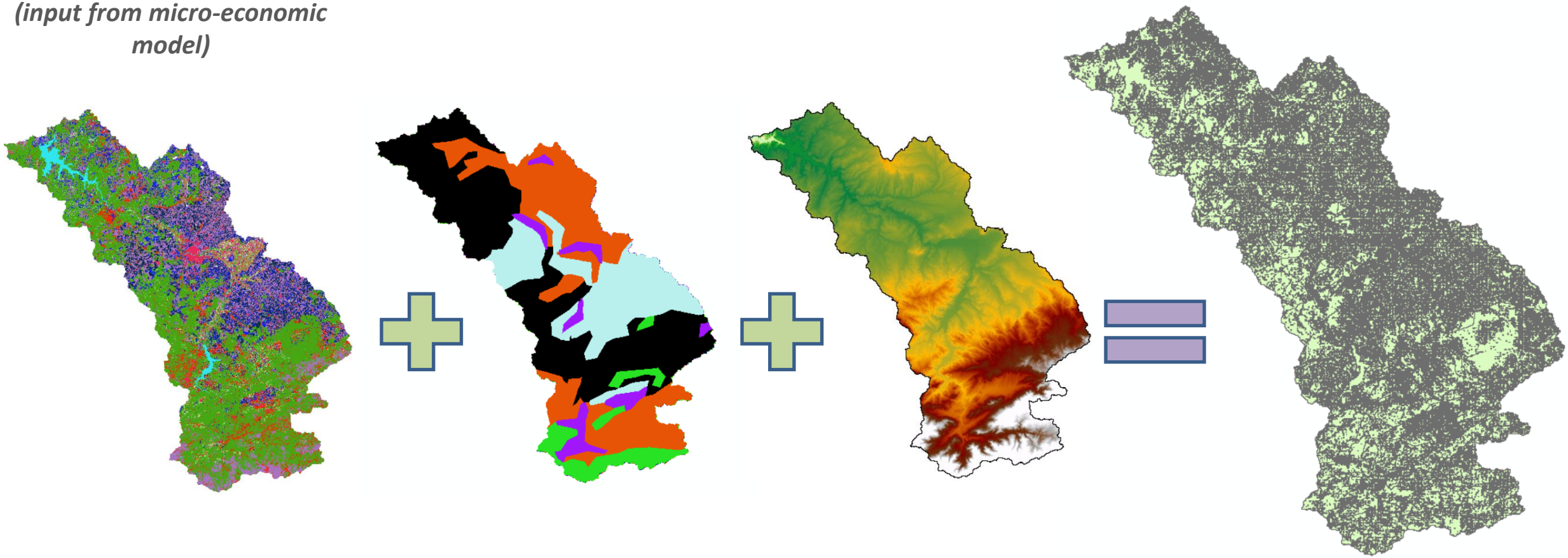
Land Use

(input from micro-economic model)

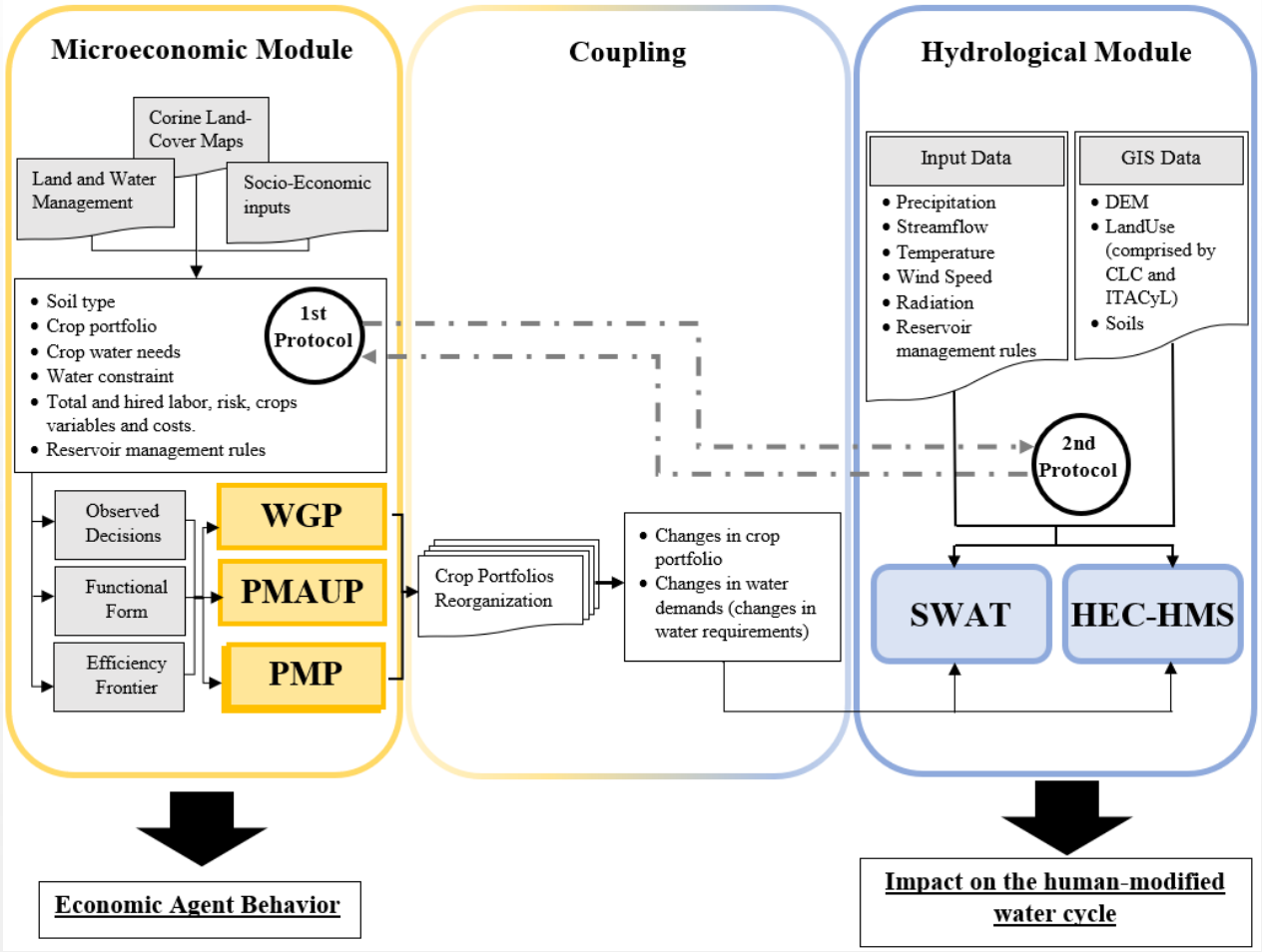
Soils

Slope

Hydro-Economic Response Units ("HERU")



Models integration: Coupling



Uncertainty Analysis – How it was addressed?

- *Input uncertainty: pricing scenarios.*
  - *3x pricing on water demand scenarios per each micro-economic model were accounted for the human-side (micro-economic models): 0.01€, 0.02€, and 0.03€ -> 12x total input scenarios triggering 12 different crop-portfolios.*

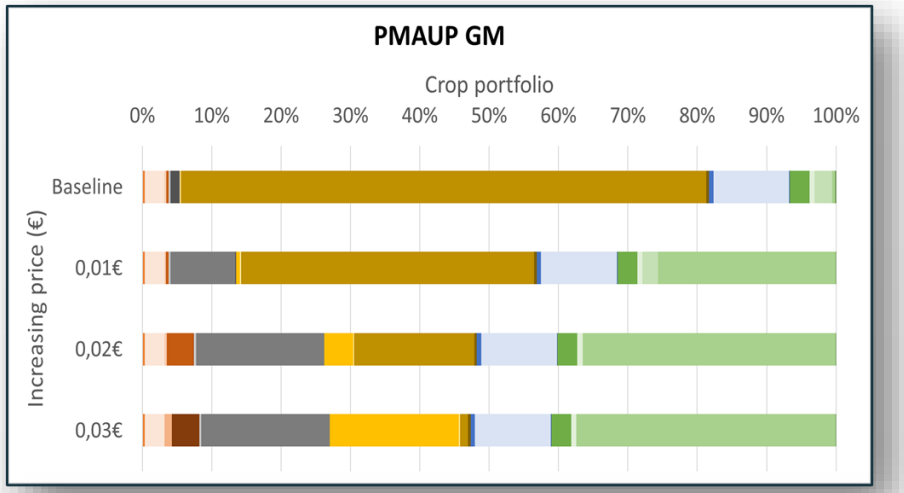
- *Parameter uncertainty: Sensitivity Analysis.*
  - *Parameters such as Infiltration, Time Lag, and Soil Storage were strategically varied in the hydrological HEC-HMS simulations in addition to the Sensitivity Analysis developed in SWAT-CUP.*

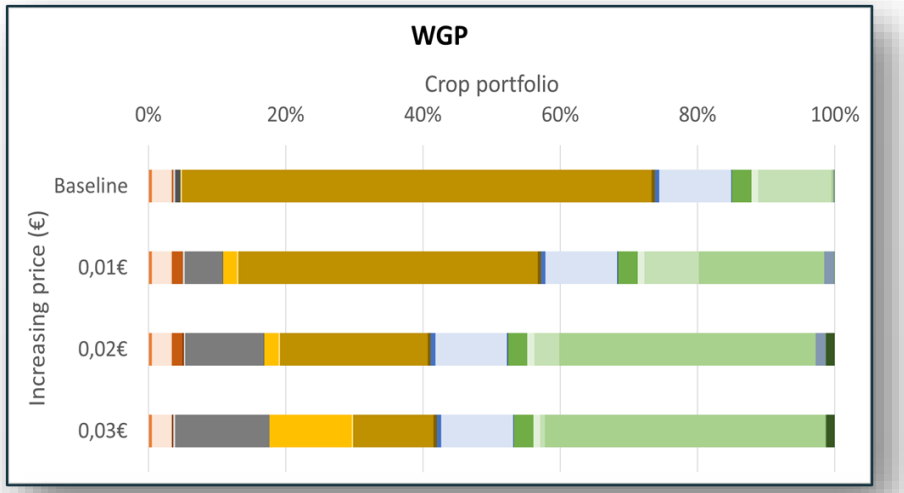
- *Structural uncertainty between models: different coupling approaches.*
  - *Different methodology to couple micro-economic outputs with the hydrological models: using SWAT's ecological module and developing an ecological module from scratch for HEC-HMS.*

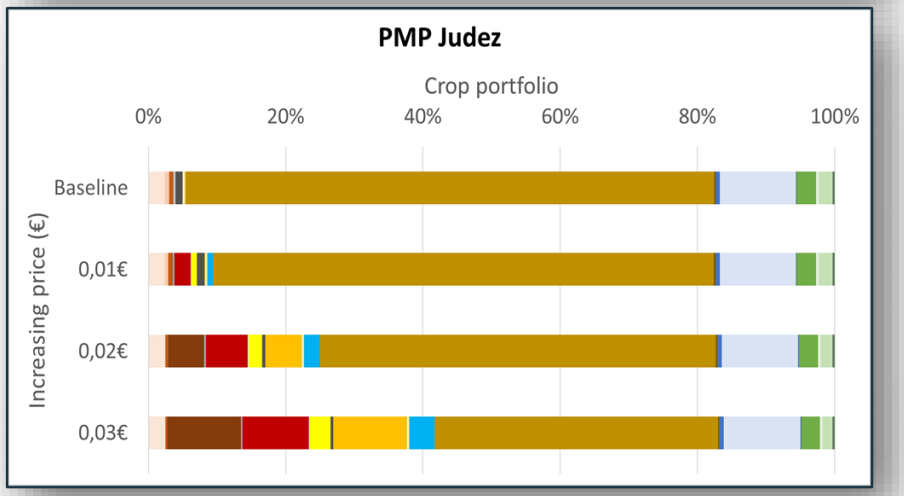
04 Results

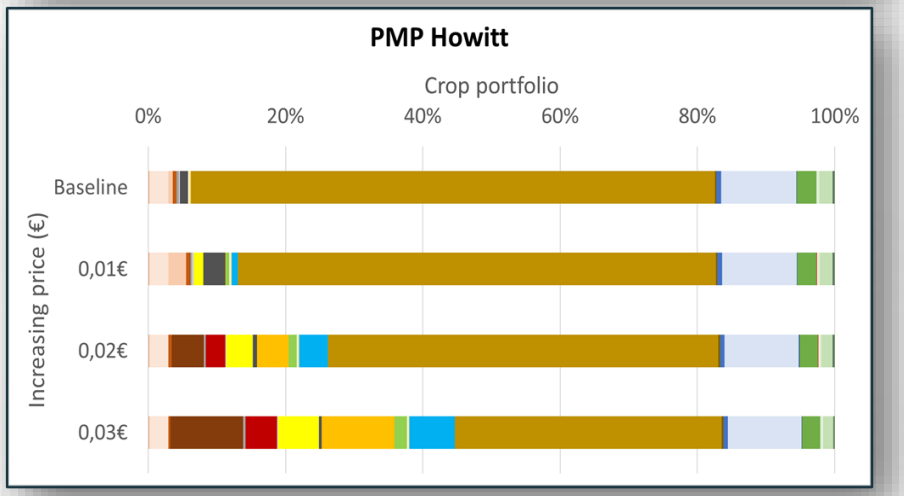
1. Micro-economic results
2. Hydrological results
3. Comparison of Results

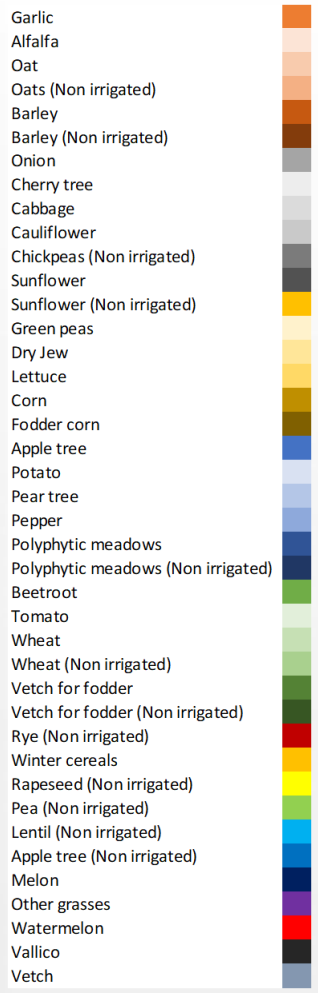
Micro-economic results







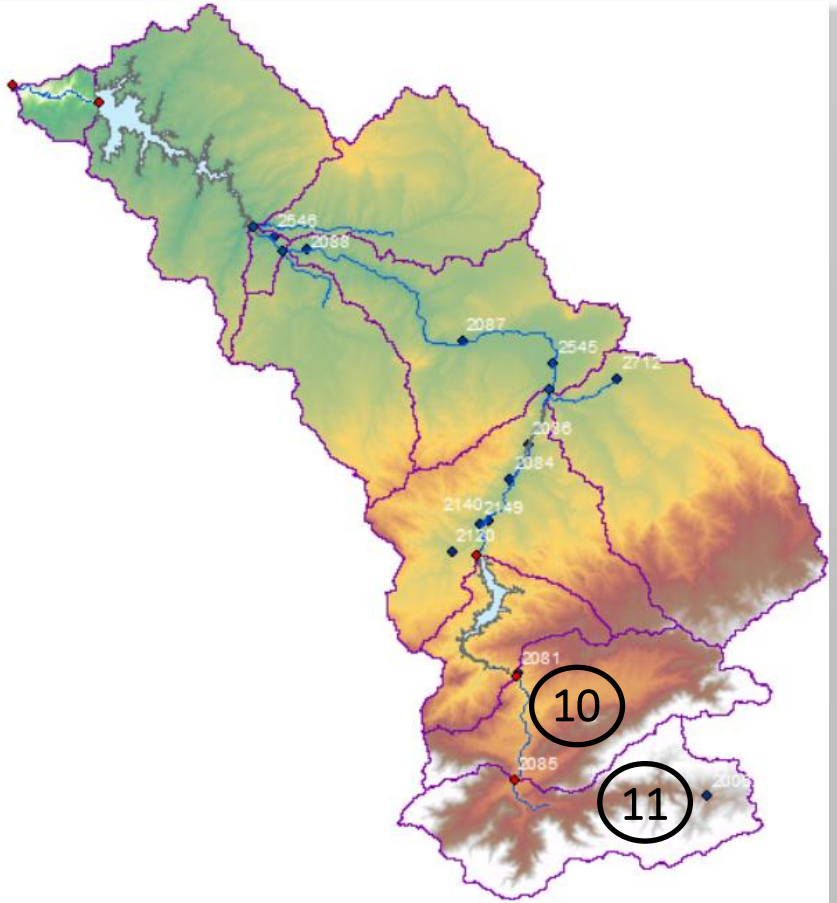




Changes in land use, obtained as a response of the economic agents to water price increasing.

Hydrological results

SWAT-CUP Calibration:

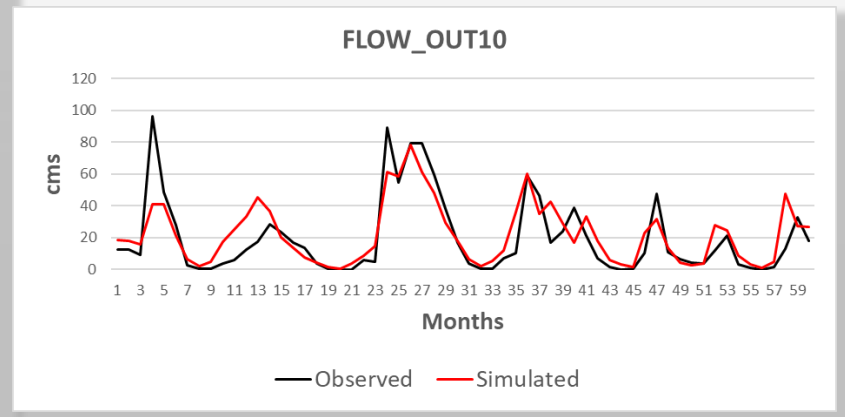


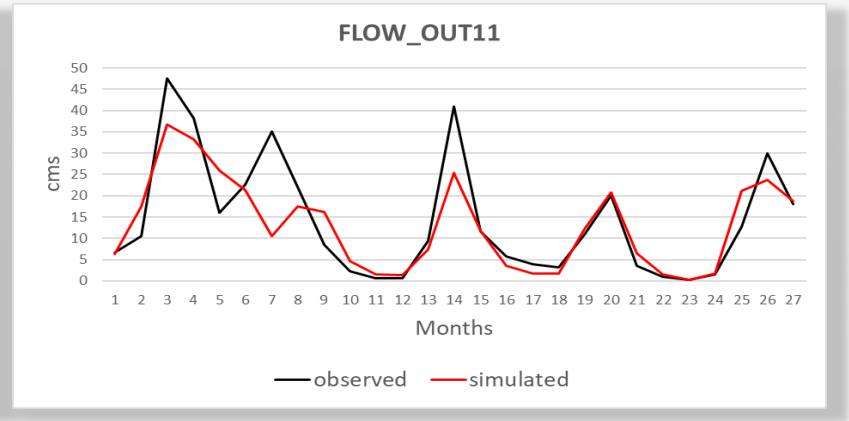
Monthly calibration: 2000 - 2010

Point	*NSE*	*R2*	*KGE*
FLOW_OUT_10	*0.69*	*0.69*	*0.70*
FLOW_OUT_11	*0.72*	*0.74*	*0.72*

Monthly validation: 2010 - 2013

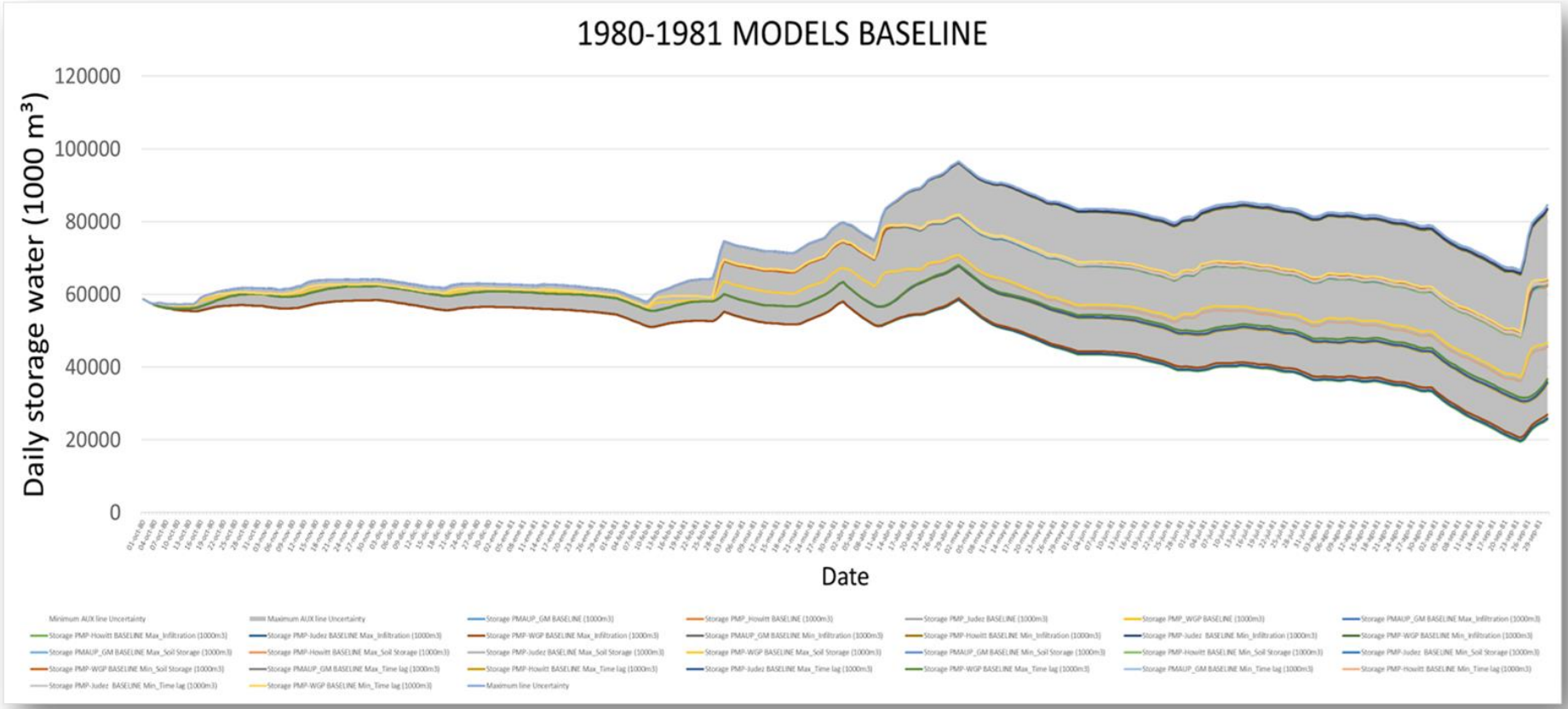
Point	*NSE*	*R2*	*KGE*
FLOW_OUT_10	*0.67*	*0.68*	*0.69*
FLOW_OUT_11	*0.68*	*0.70*	*0.70*





Hydrological results

Hydrological Model (SWAT)

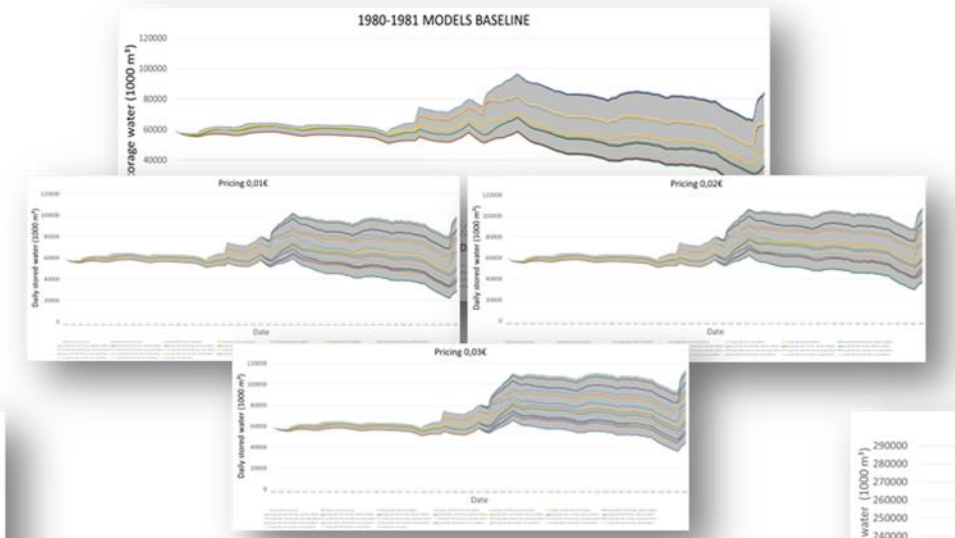


Simulations' Cascade uncertainty after the second protocol of the hydro-economic multi-model ensemble.

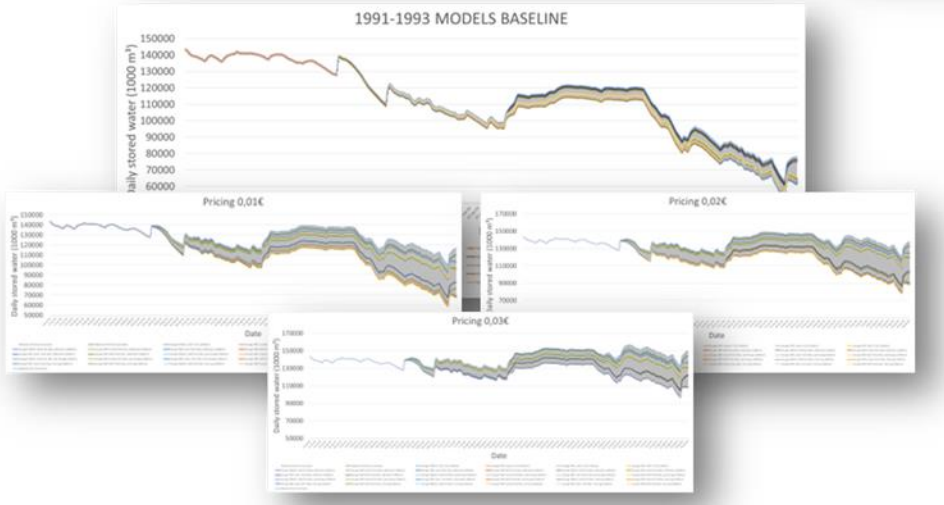
Hydrological results

Hydrological Model (SWAT)

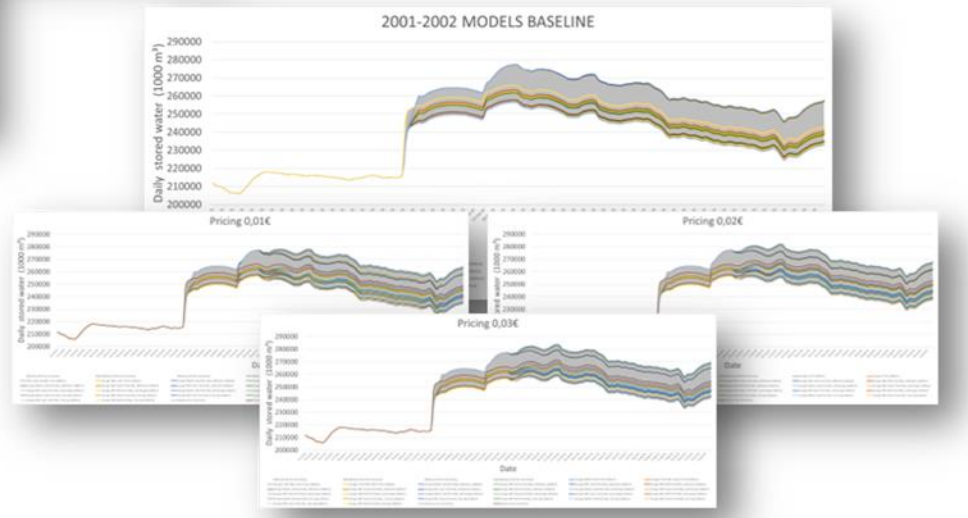
1980 - 1981



1991 - 1993



2001 - 2002



05 Conclusions

1. Key findings, relevance, and future research directions

Findings and future steps:

1) *As expected, linear programming models shown best calibration results, but their outputs reflect that they are not able to replicate non-linear behaviors properly, triggering wider uncertainties.*

2) *The absence of validation in the micro-economic models makes it challenging to evaluate the uncertainty gap.*

3) *Although this study accounts for a complete uncertainty cascading assessment, a robust and realistic global sensitivity analysis must be implemented in both water-human sides, accounting for input, parameter and structural uncertainties.*

4) *This approach aims to incorporate climatic models to enhance the input uncertainty assessment, considering not only contemporary scenarios and add also SWAT+ with gwflow module as a new hydrological model in the comparison.*

5) *Model re-calibration using not only streamflow values, but also ET values to improve the model simulations.*

THANK YOU

for your attention

TALANOA
- water -

PRIMA

TRANSCEND

European Commission
Horizon 2020
European Union funding
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