PIRAGUA
OPCC

Modelling the water-system in the Pyrenean Aure-Louron Valley

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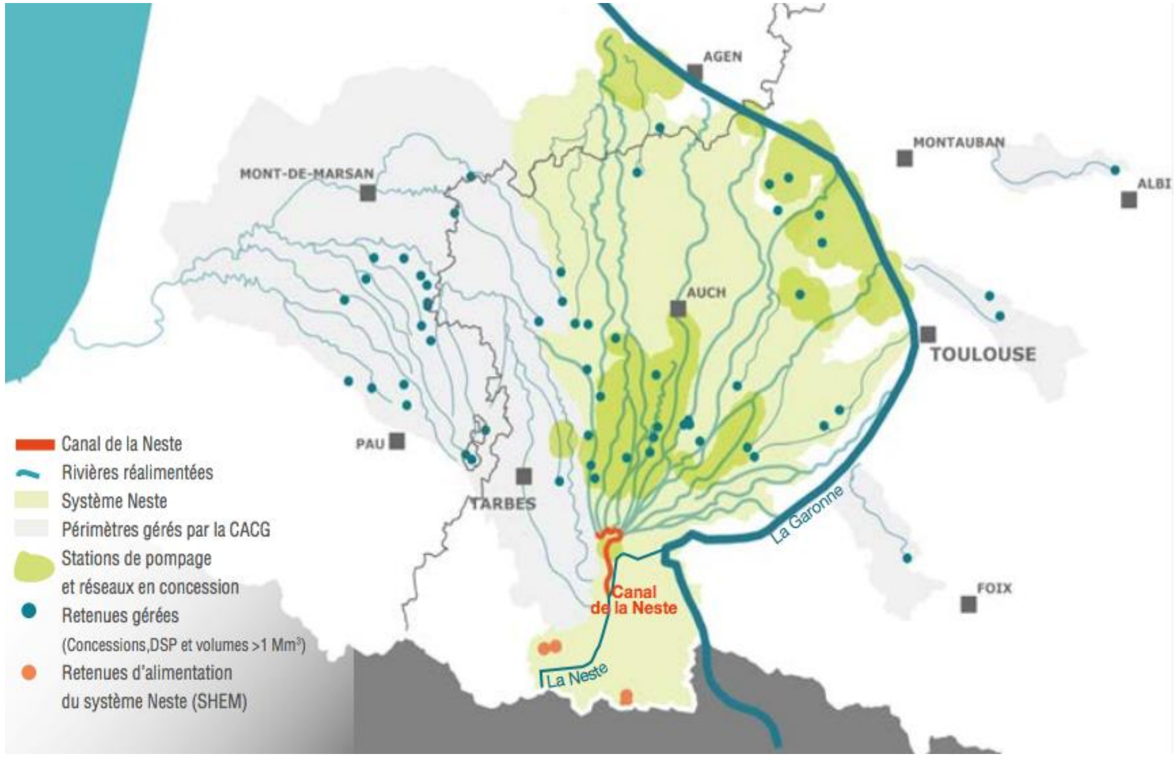
Contents

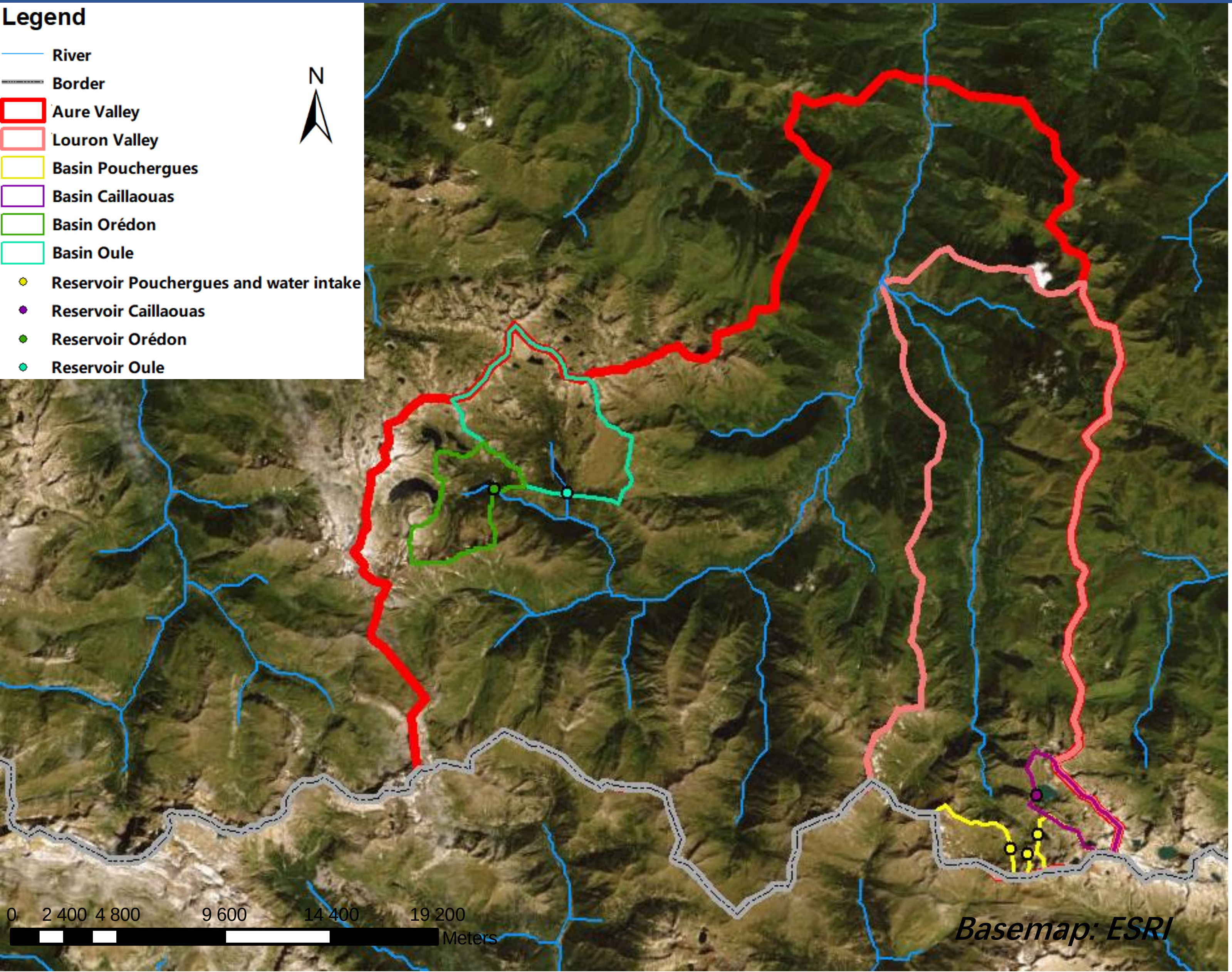
Introduction

- The Interreg PIRAGUA project (*www.opcc-ctp.org/en/piragua*)
  - **Objective:** to improve the adaptation of Pyrenean territories to climate change
  - **My contribution:** vulnerability assessment of reservoir water system under global change
- Motivation
  - Hydropower remains the largest renewable energy in France complementing the consumption peak
  - The complexity of global change compromises the sustainability of current water use
  - A robust representation of water system is necessary for vulnerability assessment



Source: CACG

Case study: site description



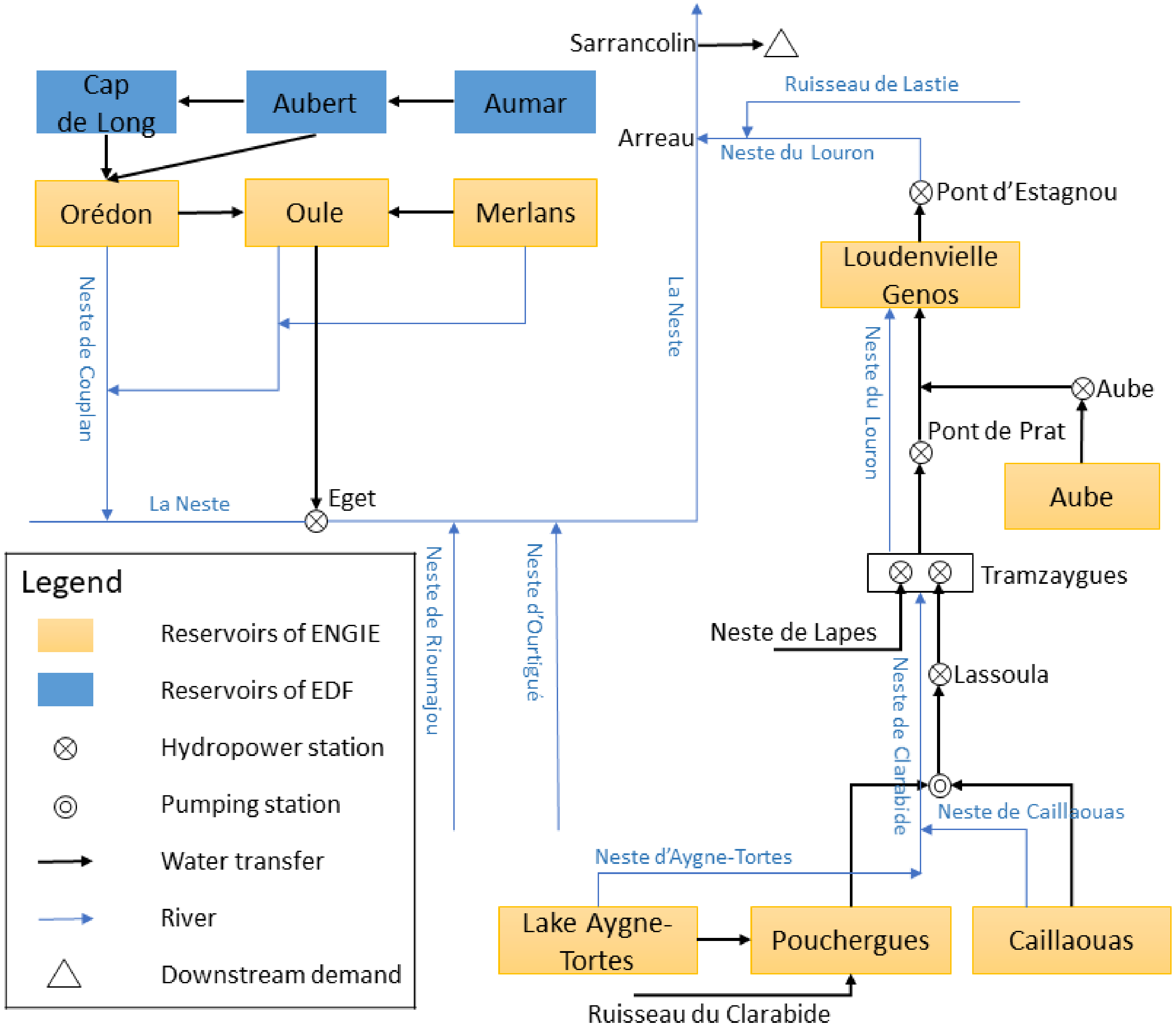
Location

In the central French Pyrenees

Two hydropower systems

- Eget (installed power 33 MW): Oule + Orédon reservoir 16.6 + 7.3 Mm^3
- Lassoula (installed power 40 MW): Caillaouas + Pouchergues reservoir 25.4 + 0.83 Mm^3

Case study: water system in the Aure-Louron Valley



Coordinated management of the two systems to meet the two main water demands:

- **Hydropower production**

1 power plant in Eget

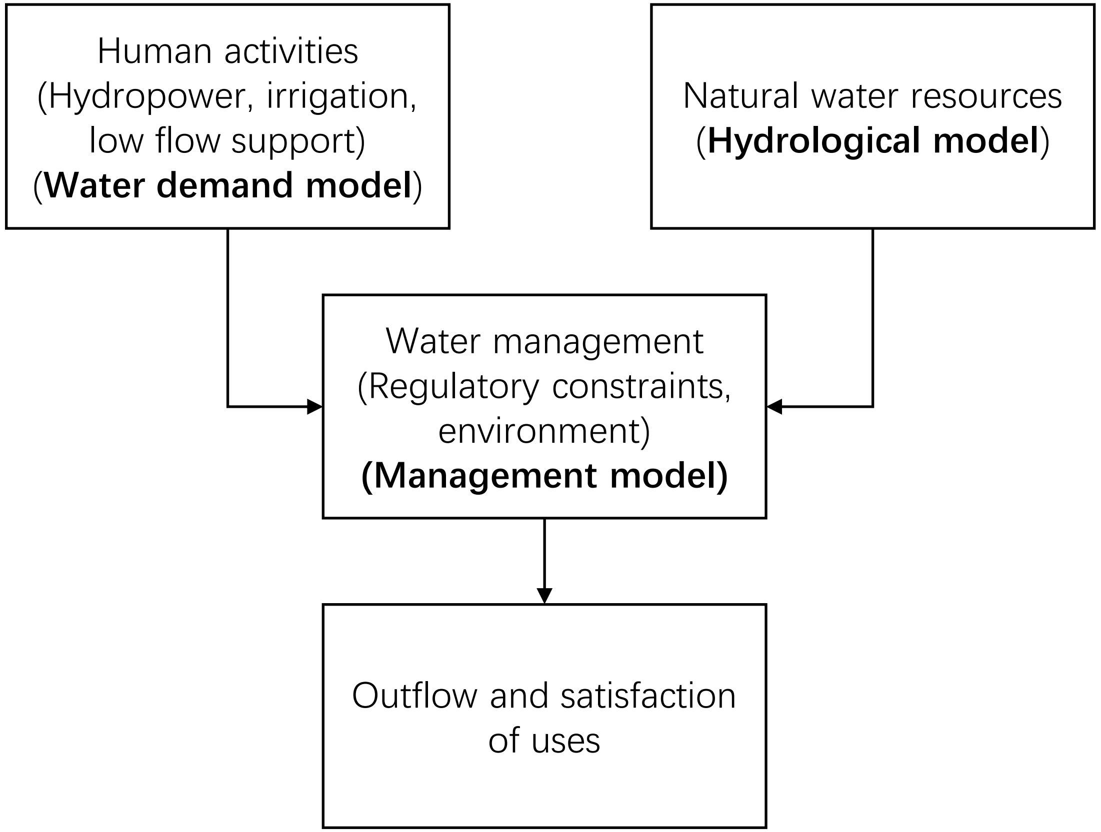
4 cascading power plants in Lassoula

- **Downstream water use**

The two systems are committed to providing a maximum of 48 Mm^3/year to downstream water demand, including the needs for irrigation, low flow support and drinking water

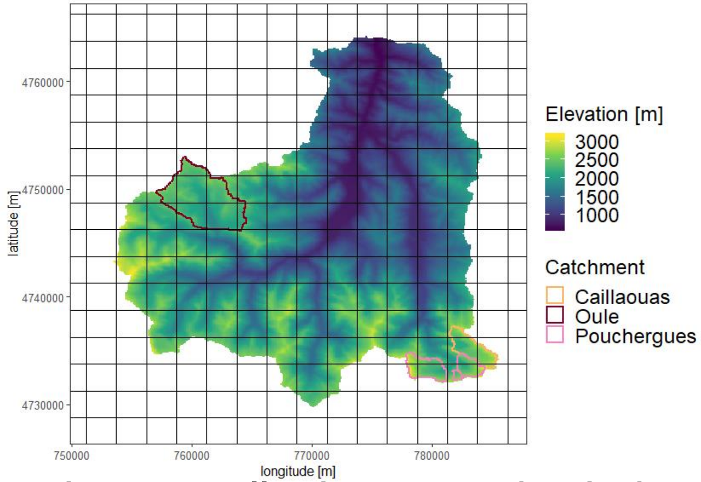
Methodology: modelling framework

Modelling chain: integration of the human interactions with water resources within hydrological modelling (Montanari et al., 2013)

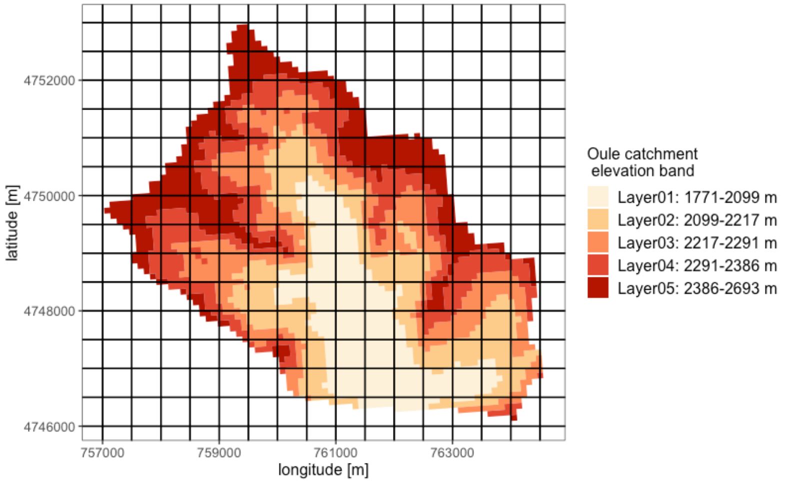


Hydrological model
Rainfall-runoff model **GR6J** (Pushpalatha et al., 2011) coupled with a semi-distributed snow module **Cemaneige** (Riboust et al., 2019)
Water demand model
Energy demand: a linear model linking HDD (Heating Degree Day) (Spinoni, 2018) with historical production data from SHEM **Downstream demand**: in progress and in communication with CACG
Management model
Preliminary trial based on linear programming optimization method in a deterministic way

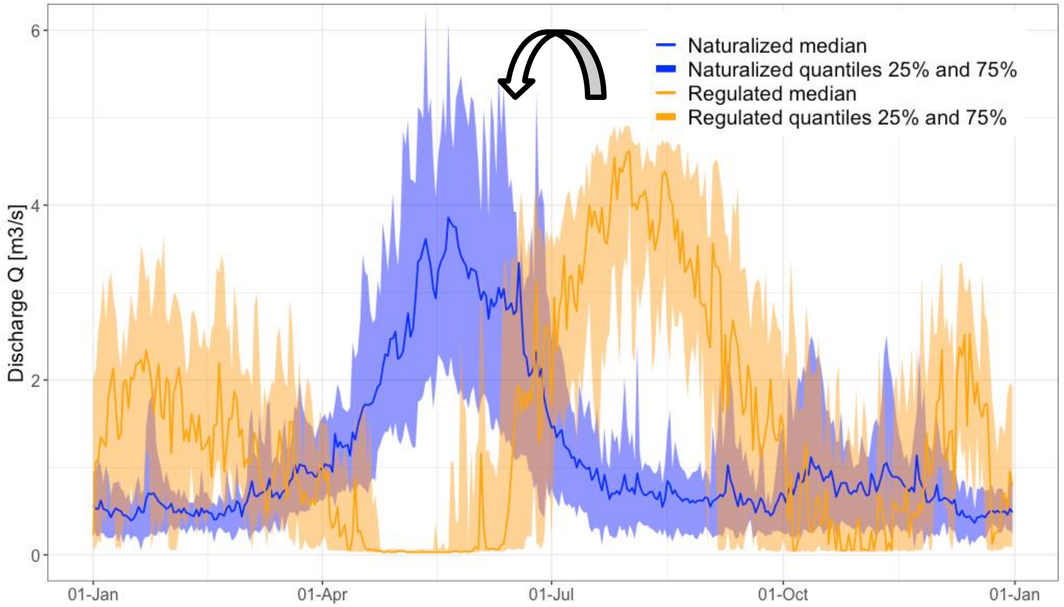
Materials



The Aure Valley in SAFRAN (2.5 km)



The Oule catchment in MODIS (0.5 km)



Naturalized inflow vs Regulated flow of the Oule catchment

Hydrological model

Forcing data: SAFRAN with a dedicated Pyrenean 2.5 km resolution (Vidal et al., 2010); Catchment characteristics (surface and hypsometry)
Calibration data: naturalized inflow (Falgon, 2014) and gap-filled MODIS observations (Gascoin et al., 2015) in 5 equi-surface elevation bands

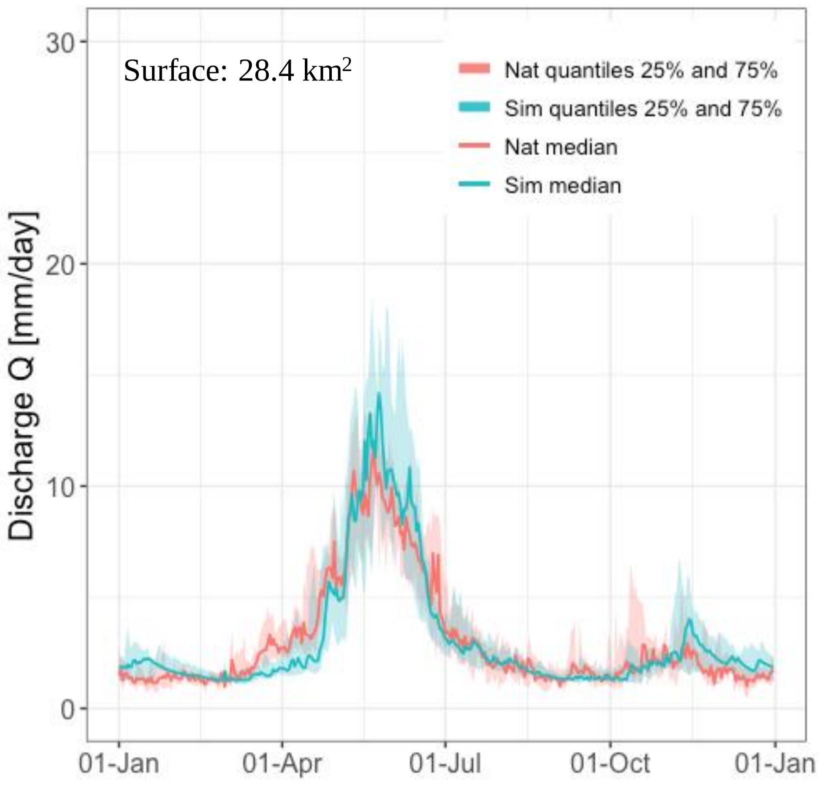
Energy demand model

Data: France temperature calculated from SAFRAN with a 8 km resolution (Vidal et al., 2010); Reservoir operation data

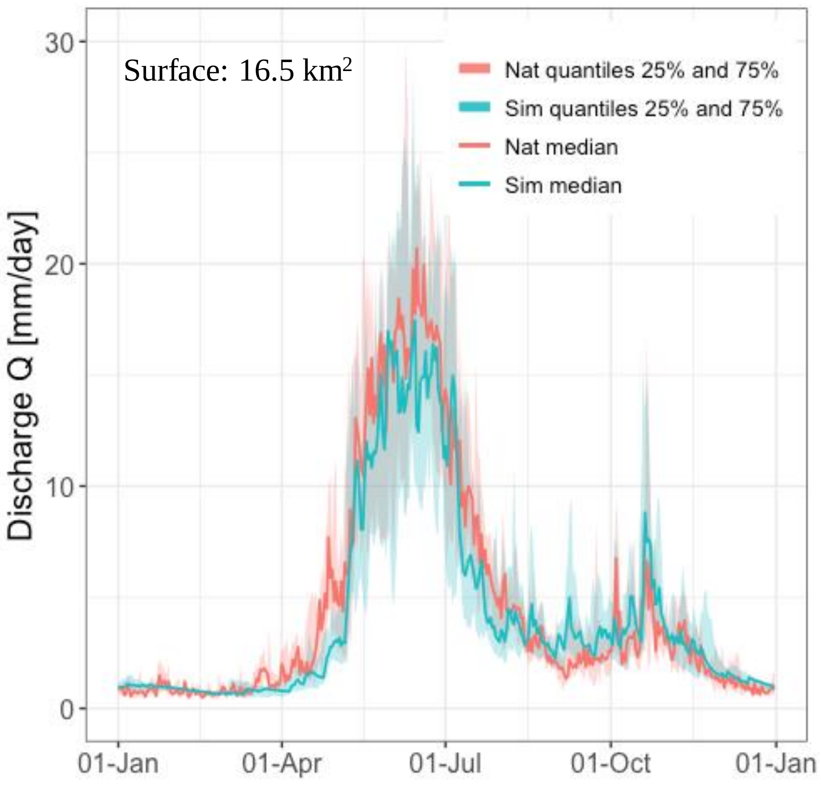
Management model

Materials: Current reservoir management rules; Reservoir characteristics (Volume, water-power efficiency)

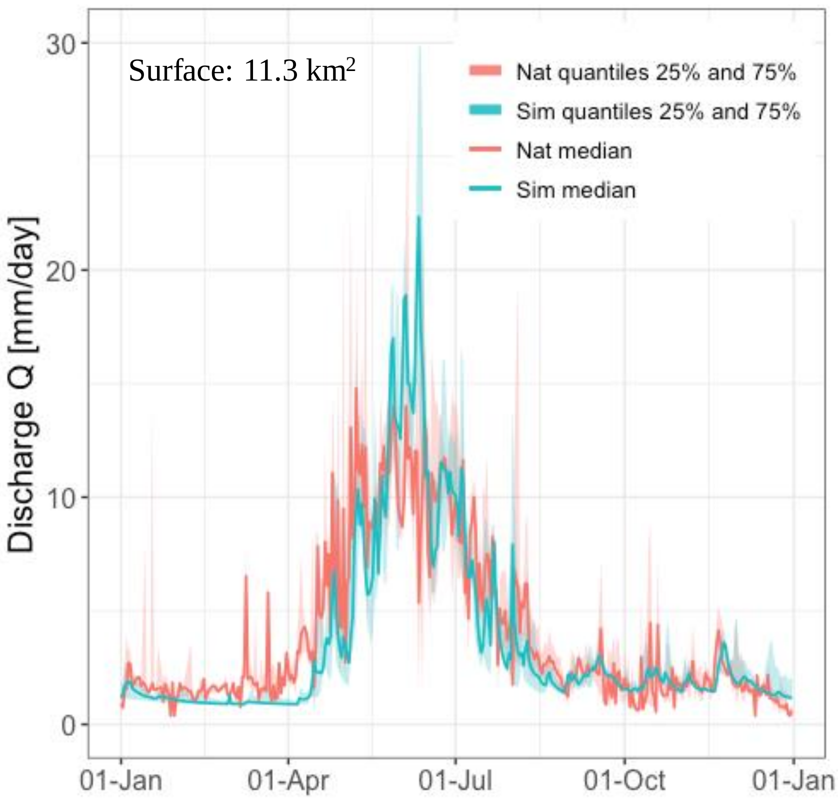
Results: hydrological modelling



Oule: 2001-2014



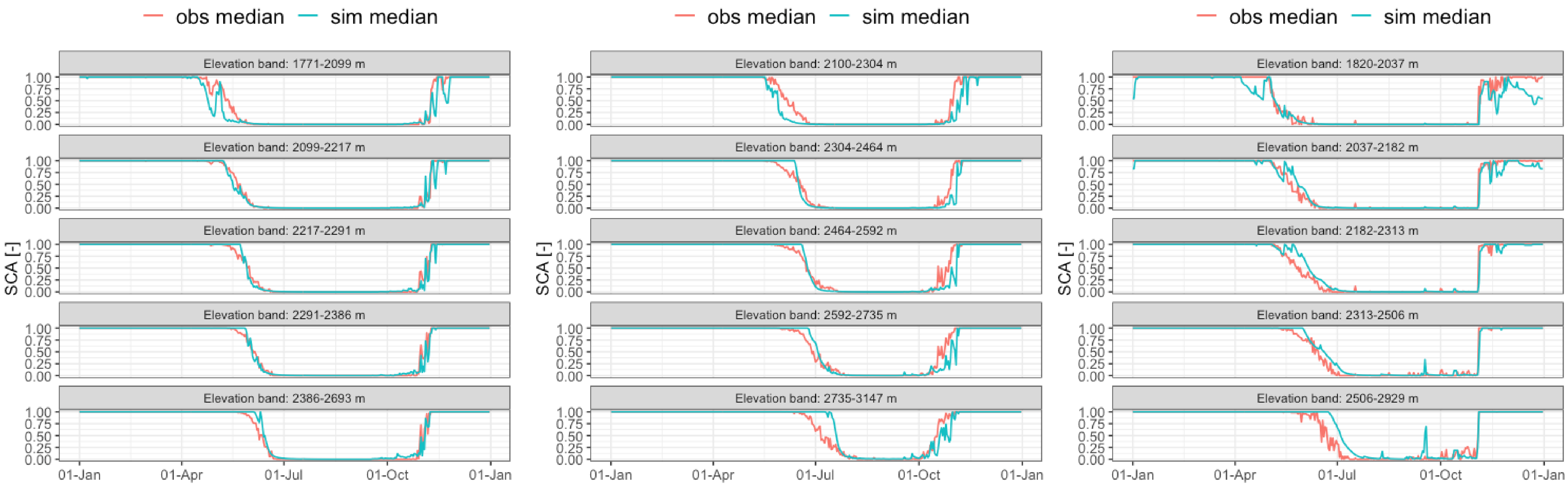
Lassoula (Pouchergues + Caillaouas): 2001-2014



Orédon: 2014-2018

- Generally, the Oule and the Lassoula catchments are well simulated
- The simulation of the Orédon catchment is less performed due to the length and quality of naturalized inflow

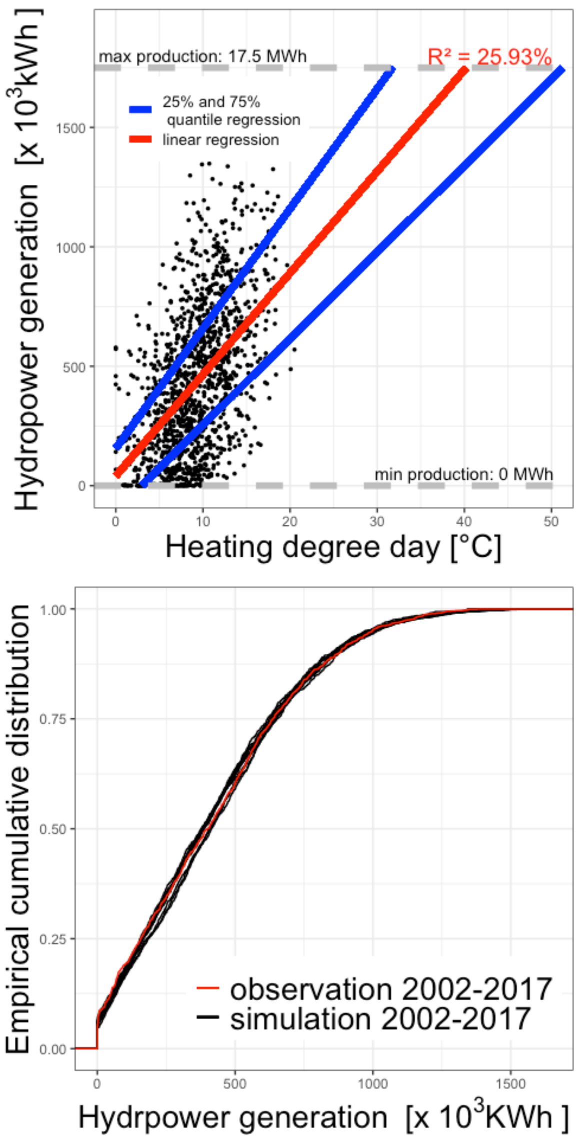
Results: hydrological modelling



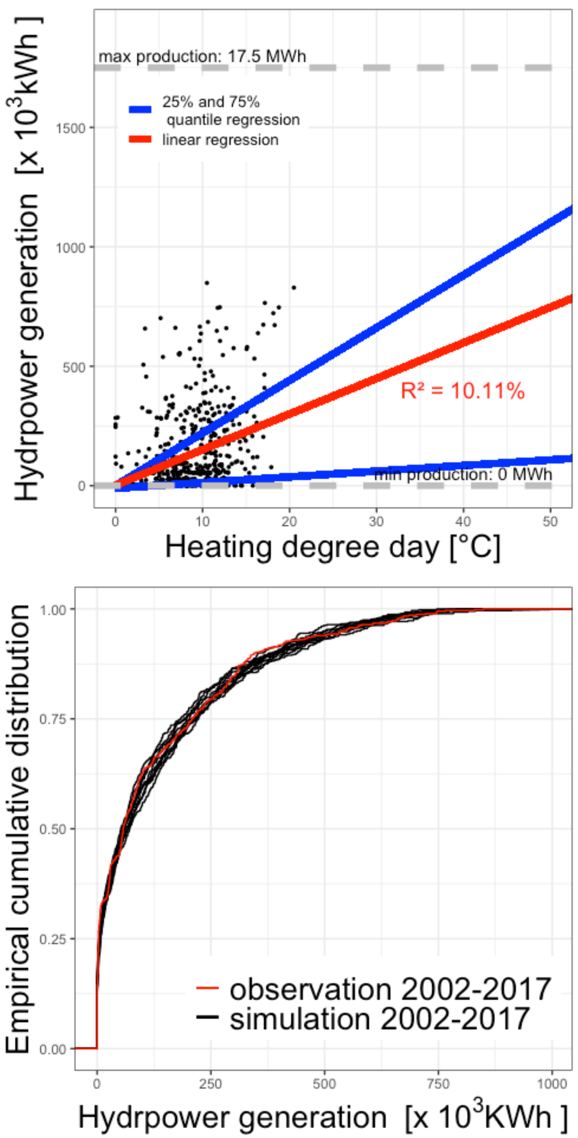
Oule: 2001-2014 **Lassoula (Pouchergues + Caillaouas): 2001-2014** **Orédon: 2014-2018**

- Snow is a dominant factor in these catchments
- A robust representation of snow cover area (SCA) along with discharge is essential for hydropower estimation

Results: energy demand



High energy demand



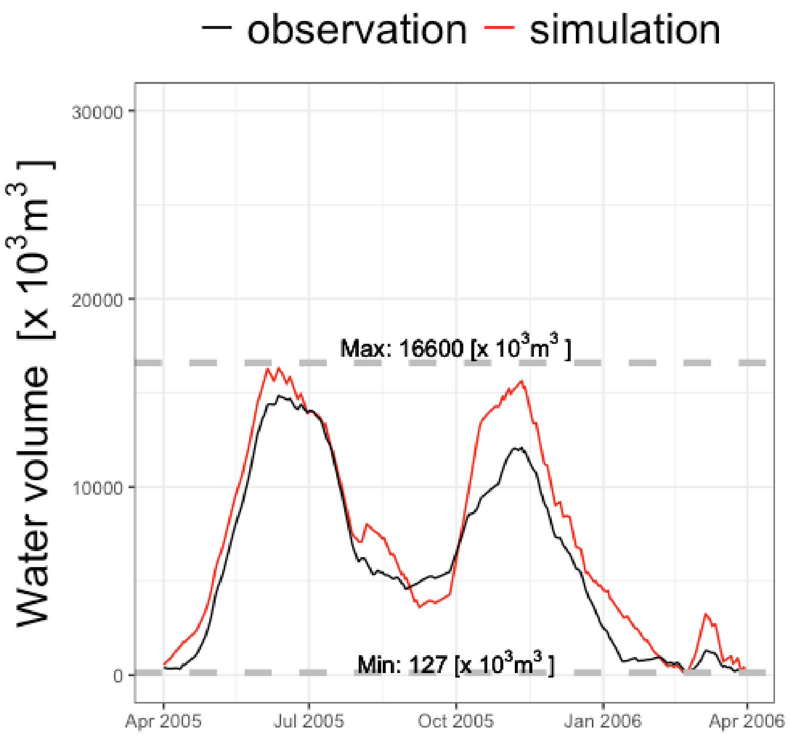
Low energy demand

- Energy demand is divided into two segments: high energy demand (weekdays) and low energy demand (weekends + Christmas)
- Heating degree day HDD drives the water release for hydropower; the higher HDD, the more energy produced

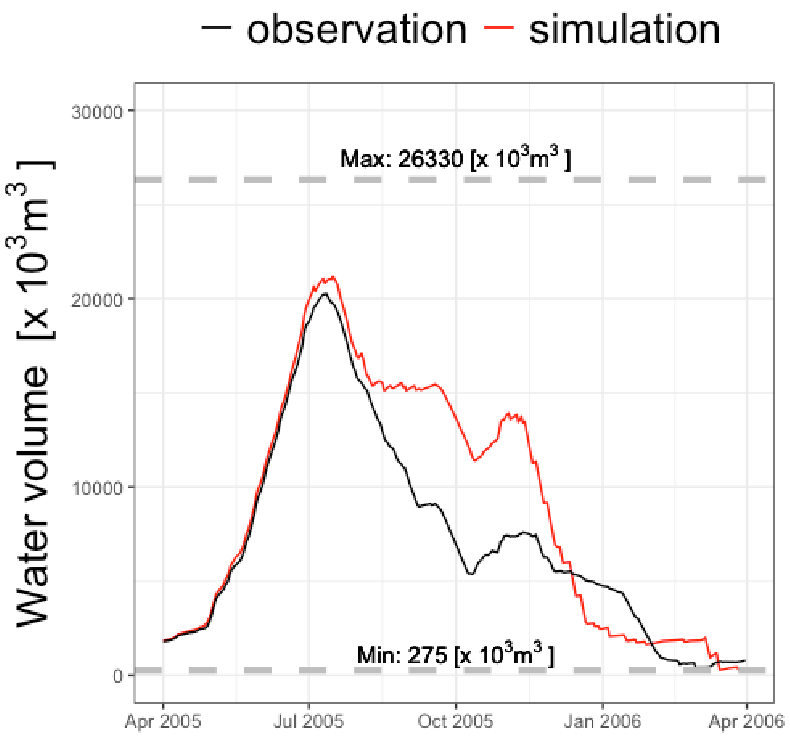
$$HDD_t = \max(\tau_{France} - T_t, 0)$$

  - τ_{France} the threshold of trigging the energy demand (15°C for France) (Hendrickx and Sauquet, 2013)
  - T_t daily France temperature
- The determination coefficient R^2 is poor as hydropower generation is highly anthropogenic
- The energy demand model is validated by comparing the empirical cumulative distribution between simulated results (10 trials) and observation values

Preliminary results: water management



Eget system (example hydrological year 2005)



Lassoula system (example hydrological year 2005)

- **Input data:** naturalized inflow, observed water demand, and observed water transfer
- The optimization process based on linear programming has an objectif of maximizing the annual benefit in a deterministic way
- Need for additional complexity in the management model

Conclusions and next steps

- The robustness of GR6J-Cemaneige to represent the water resources of case study
- The simplicity of energy demand model to capture the seasonality of energy demand
- Improvements on water management model
- Downstream water resources estimation and water demand modelling
- Vulnerability assessment with the modelling chain under various global change scenarios

- Thank you for your attention

- Questions?
- Now or at

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