Construction of a hydrological model coupling farm dams and irrigation to estimate the cumulative impact on a regional scale

Nathan Pellerin[1], Flora Branger[1], Jean Philippe Vidal[1], Louise Mimeau[1], Ninon Brown[1].

[1]INRAE Riverly, 5 rue de la Doua, 69100 Villeurbanne

Introduction

Gaminon farm dam in the Yzeron catchment, FRANCE (photo C. Houpert)

Context

- Crop irrigation **increases yields** and **guarantees** harvests during droughts or heatwaves.
- **Intensification in frequency** and in **intensity** of extreme climate events increases the vulnerability of agricultural systems (IPCC, 2023).
- **Farm dams** are presented as a solution for adapting to climate change to guarantee irrigation supply during the low-flow period.
- Strong **pressure to increase** the number of farm dams in France.

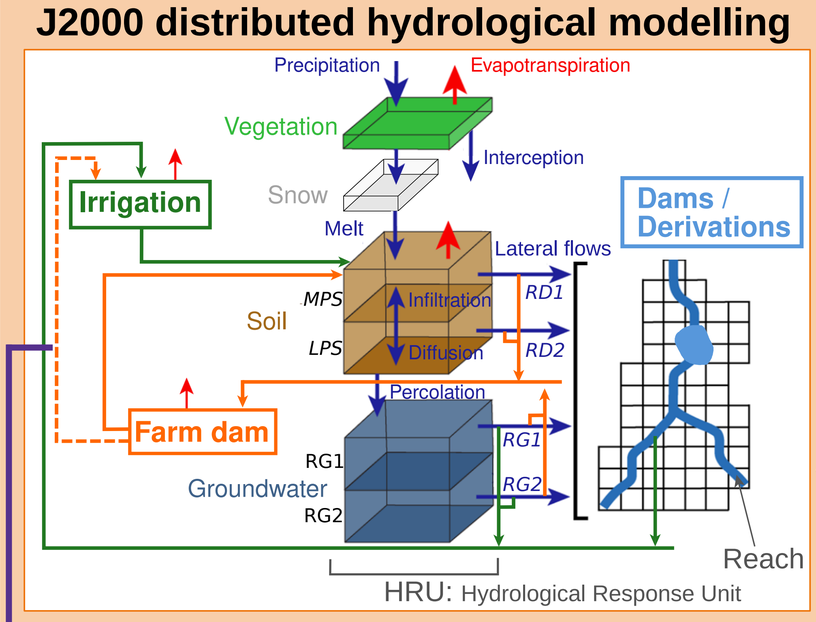
What would be the hydroecological impact ?

Objectives

- To couple irrigation and farm dam in a spatially distributed hydrological model, which in the long term will make it possible to study cumulative impacts of farm dams in large catchments.
- To assess the physical realism of this coupling on a test sub-catchment by analysing simulated water fluxes and storages for different configurations of irrigation.

Methods

J2000 distributed hydrological modelling



J2000 model (adapted from Watson et al., 2021) with water uses (Branger et al. 2024)

Irrigation – Farm dam coupling

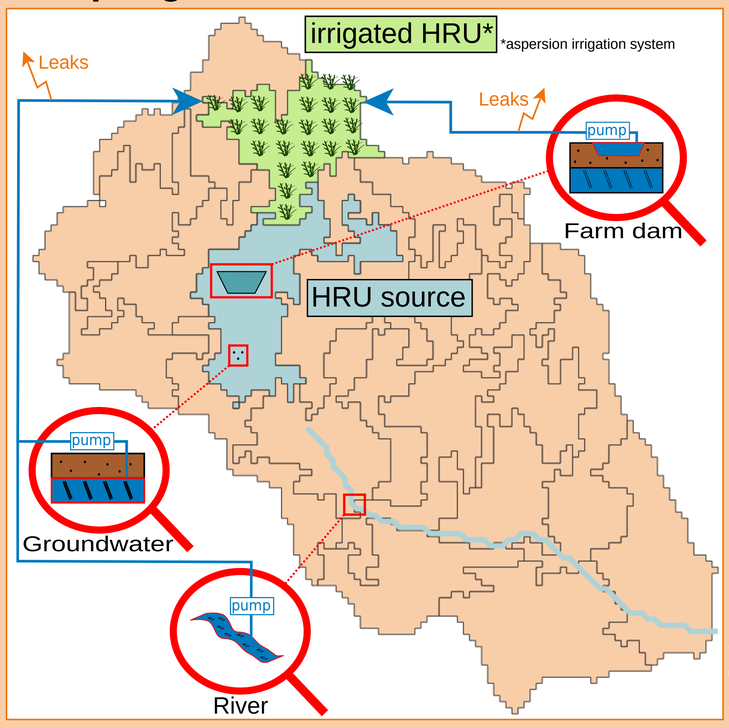
Plant **demand** → Water **extraction** (6 configurations) → Water **application** (aspersion)

- **G : Groundwater**
- **R : Reach**
- **F : Farm dam**
- **RG : Reach* + Groundwater**
- **RF : Reach* + Farm dam**
- **FG : Farm dam* + Groundwater**

(* priority extraction source)

Steps for calculating irrigation

Coupling verification



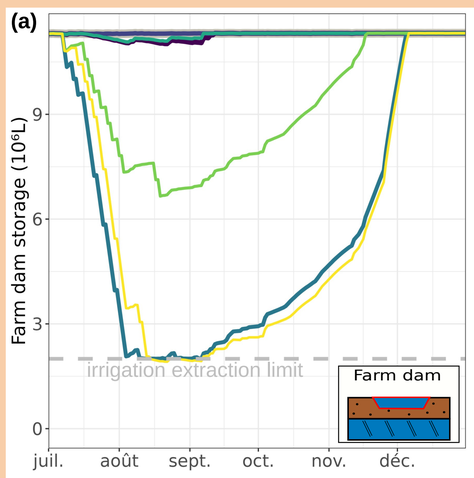
Test sub-catchment:
54 km², 19 HRUs, 1 reach

Farm dam ( ):
- S = 3800 m²
- h = 3 m
- Natural in-filling through interception of lateral flows

Simulation period: 1990-2010
Focus on summer 1995

Irrigation / Farm dam coupling applied to the test sub-catchment

Results



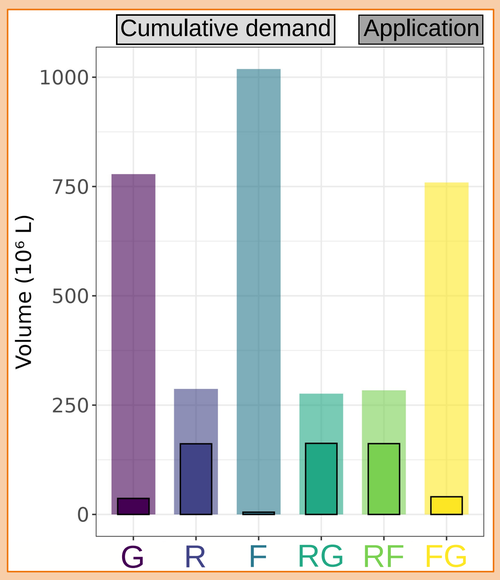
Simulated farm dam (a), groundwater (b) and channel storage (c) for the 6 extraction configurations during summer 1995

Irrigation impact on water storages for the 6 extraction configurations

- Irrigation has a significant impact on storages, and the impact varies depending on the configuration.
- Water extraction leads to the emptying of the smallest storages (i.e. farm dam and groundwater for this case study).
- Farm dams are indirectly impacted by groundwater extractions. Streamflow extraction reduces farm dam extraction (RF).

Cumulative irrigation demand vs applied volume

- Difficulty in meeting water demand, particularly when extracting from groundwater or farm dams (G, F, FG) due to different storage capacity of reservoirs.
- Difference between the irrigation demand and the applied volume when extracting from river (R, RG and RF) is due to the irrigation network efficiency parameter (leakage).



Comparison between irrigation demand and applied volume for the 6 configurations, cumulated over the summer 1995

Conclusion

- The coupling between irrigation and farm dams in a hydrological model has been implemented to investigate the impact of extraction configurations on catchment hydrology.
- The model represents water storage processes with **physically realistic behaviour**.

Perspectives

- **Exploring the hydrological response** to farm dams across a range of climates, agricultural practices and types of farm dams, thanks to a classification mixing physiographic and agriculture features.

References

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