Climate change, water availability and agricultural water demand projections at basin scale: will the scissor effect cut the yields?

The Mediterranean is a critical region in terms of the impact of climate change on water resources management. Water use for irrigation is prevalent in this region, and a particularly significant rise in temperatures has already led to a significant increase in plant water demand, which, combined with an increase in irrigated areas, leads to increased water demand at basin scale. At the same time, changes in precipitation and evapotranspiration cause a decrease in renewable water resources (Sauquet et al. 2024).

This scissor effect questions the adaptation measures to adopt. Stakeholders and decision-makers in the field of agricultural production and water resources management need prospecting tools to project the impact of their policies in the context of climate change. However, there are large uncertainties in the projections of resources and needs.

Climate change impact studies generally examine several socio-economic scenario trajectories (SSPs) to which greenhouse gas emission trajectories (RCPs) are associated. From these RCPs, global-scale climate models (GCMs) are developed, scaled down by regional climate models (RCMs), whose data are then debiased by various statistical techniques. The Explore2 project has carried out a study of climate and hydrological trends in France (Sauquet, 2024) using this methodology, providing projections for renewable water resources. The differences observed between the results of different models, for different parameterizations forced by different climate scenarios (GCM+RCM+debias) lead to difficulty in understanding the latter, particularly in the context of communication to stakeholders who have to make long-term decisions about planning (water allocation, development of new infrastructures, changes in crops…). Evin et al (2021) have developed a method to determine how much of the uncertainty is due to each of these components (RCP, GCM, RCM, debiasing, model, parameterization) and to identify trends solely from the RCPs independently of the biases in the chain of models used. This method has been successfully applied by Lemaitre-Basset et al. (2021) to hydrological model outputs on the Hérault river. To date, no such study has been published for the projection of agricultural water needs, although the uncertainties may be even larger considering the possible evolutions of cropping strategies, adding to the uncertainty of climate drivers.

The aim of the project is to explore the uncertainty in agricultural water use projections. A preliminary study was conducted in 2024 by calculating theoretical needs in hydric comfort conditions, with a simplified crop model. To go further, it is necessary to consider not only hydric comfort (unlimited water resources), but also limited water resources (availability constrained by actual flow) due to scissor effect. The influence of the model and its parameterisation should be considered too.

For this project, indicators will have to be identified first (about water needs and yield), and calculated thanks to a set of selected crop and water balance models. The approach of Evin et al. (2021) will be used to quantify the relative uncertainties of each component.

The approach will be conducted on river catchments of the Mediterranean basin, selected for the importance of climate change impact on water resources and demand.

Activities :

- data collection from open-access databases (using tools developed in 2025 by the research team); modeling, with tools coded in R (contribution to the development of a R-package);
- analysis of simulation results with statistical tools.

The project will be supervised by David Dorchies (UMR G-eau, INRAE, specialist in hydroinformatics) and Gilles Belaud (UMR G-eau, professor at IA, specialist in agricultural water management).

Specific skills developed during the project:

- using and analysing climate projections, databases (soil, climate, crops)
- programming with R
- increasing knowledge in hydrological and crop modeling

References

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