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What impacts of climate change on surface water in France by 2070? Results of the Explore2070 project in metropolitan France and overseas departments

Sébastien Chazot⁽¹⁾, Mathilde Chauveau^{(1),(2)}, Julian David⁽¹⁾, Charles Perrin⁽²⁾, Pierre-Yves Bourgin⁽²⁾,
Eric Sauquet⁽³⁾, Jean-Philippe Vidal⁽³⁾, Nathalie Rouchy⁽⁴⁾,
Xavier de Lacaze⁽⁵⁾, Pascal Maugis⁽⁶⁾

⁽¹⁾ BRLi, Nîmes ; ⁽²⁾ Irstea (formerly Cemagref), UR HBAN, Antony ; ⁽³⁾ Irstea (formerly Cemagref), UR HHLY, Lyon ;
⁽⁴⁾ Météo-France, Toulouse ; ⁽⁵⁾ DEB/DGALN, MEDDTL, La Défense ; ⁽⁶⁾ ONEMA, Vincennes

Context and objectives

Water availability and water management will be the focus of most of the adaptation measures that will be taken in the next decades to face the consequences of climate change. These measures will have to account for the socio-economic evolutions, in terms of population size, town and country planning, as well as public policies (agriculture, energy, transports, etc.). It is therefore essential for decision makers and managers to be able to quantify the possible socio-economic evolutions together with the evolution of water resources and their temporal and spatial variability.

In this context, the Explore2070 project aimed at evaluating the possible impacts of future climate and socio-economic changes on water bodies (surface water, groundwater and coastal water) and biodiversity, in metropolitan France and overseas departments (Guadeloupe, Martinique, French Guyana, and Réunion Island). The project was managed by the French Ministry of Ecology (MEDDTL) and gathered several consultancies and research institutes to establish a general overview of the expected evolutions by 2070. Through both the extent and the variety of the project's objectives, Explore2070 will provide answers to many questions raised by managers and better evaluate the stakes related to these evolutions.

In the following, we present the work done specifically to quantify the evolution of surface water. The general modelling approach, the type of results and the way uncertainties were quantified are detailed. Uncertainty quantification is essential to help decision making in an uncertain future

Methodology

The quantification of climate change impacts on surface water has already been studied in various projects, in France and elsewhere, at different spatial and temporal scales and with various quantitative objectives: on water resources, low flows, floods, etc. Within the Explore2070 project, a modelling suite was established to uniformly process the French territory, with a specific attention to the quantification of uncertainties associated to climatic and hydrological projections. The modelling suite mainly focused on the quantitative evolution of water resources. The possible evolutions of stream water temperature were also evaluated on a number of target stations.

A multi-model approach was selected to better estimate the uncertainties associated with the various steps of the modelling process. The outputs of 7 GCMs corresponding to the SRES A1B gas emission scenario and downscaled at an 8-km spatial resolution were used to drive two hydrological models (Isba-Modcou, a physically-based model and GR4J, a lumped empirical model). Flow simulations were obtained on more than 1000 gauging stations spread over the territory and representative of the French hydro-climatic diversity. These stations were chosen at first to account for a number of stakes (low-flow monitoring, flood defence, nodal points of water management schemes, large cities, etc.). In the overseas departments, a similar (though simpler due to limited data availability) modelling suite provided projections on the main catchments. Last, more detailed analyses were made on a few target basins representative of important stakes (Seine, Orb-Hérault and Garonne river basins), for which naturalized flows were available. These analyses gave a more reliable estimation of the evolution of natural resources.

Results

The analysis of results was based on an ensemble of hydro-climatic descriptors used to synthesize the evolution of air temperature and precipitation on the climatic side, and the evolution of water resources, low flows and floods on the hydrological side. These indicators were chosen in order to be easy to use by stakeholders and to ease the dissemination of the project's results in the managers' community. The evolutions were quantified between the simulations in present conditions (1961-1990 period) and in future conditions (2046-2065).

For each studied catchment, a synthetic sheet (see example in Figure 1) was built to summarize the possible evolutions (on the basis of 7 projections for each of the 2 hydrological models). Besides, maps were produced to better evaluate regional trends and spatial evolution patterns (see example in Figure 2). In all these representations, the uncertainty associated with projections was quantified, based both on the evaluation of the reliability of the modelling suite and on the spread of results.

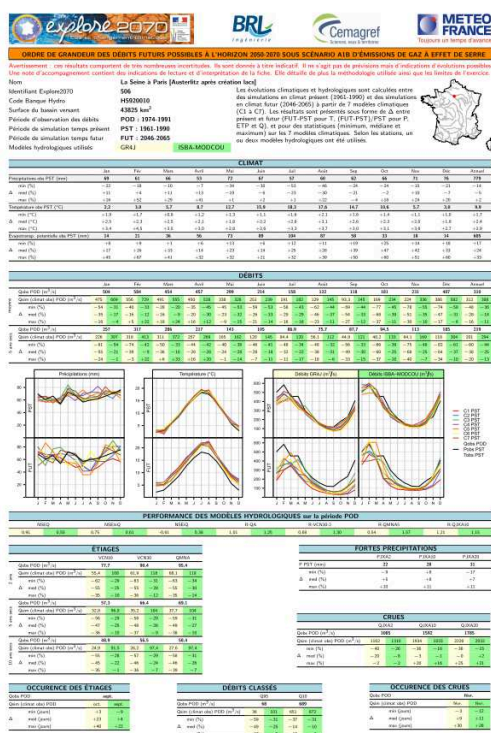


Figure 1 : Example of synthetic sheet of results

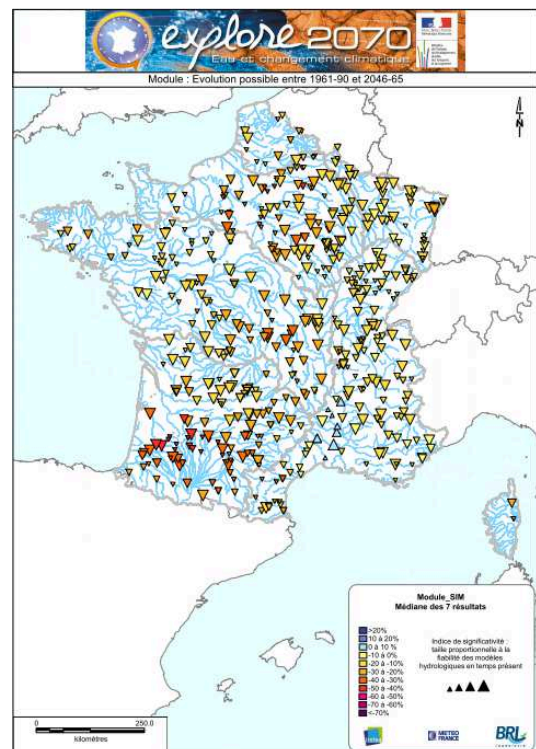


Figure 2 : Map of the evolution of mean flow (Isba-Modcou model)

Results show a significant and generalized decrease of water resources at the scale of France with more severe low flows in a majority of basins. The evolutions for floods are more heterogeneous.

Conclusions and perspectives

The Explore2070 project exhaustively evaluated the projected trends in surface water in metropolitan France and overseas departments by 2070. Results should help decision makers to better elaborate adaptation strategies that will be necessary to cope with the strong evolutions in water resources. The last phase of the project will provide proposals to derive such strategies.