France-wide future evolution of discharges for the next decades: a multi-RCP/GCM/hydrological model and calibration exercise

Guillaume Thirel, Madeleine Nicolas, Jules Beersma

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With the progress of models and the new definition of projection scenarios, updating our knowledge of future evolution of discharge and accounting for uncertainties is necessary.
This work presents a new insight to future discharge in France with AR5 IPCC projections.

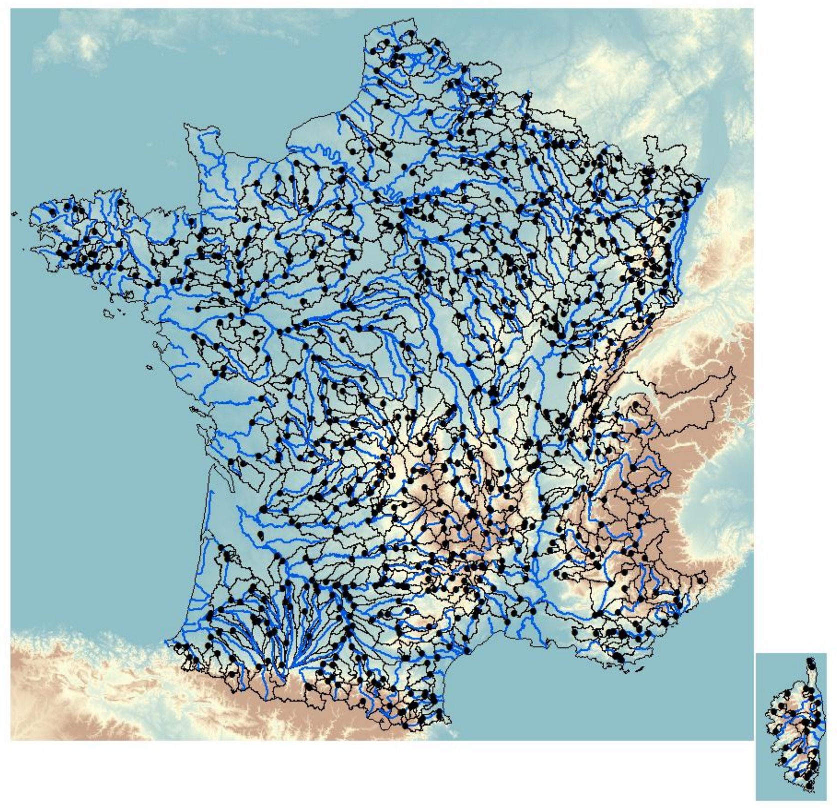


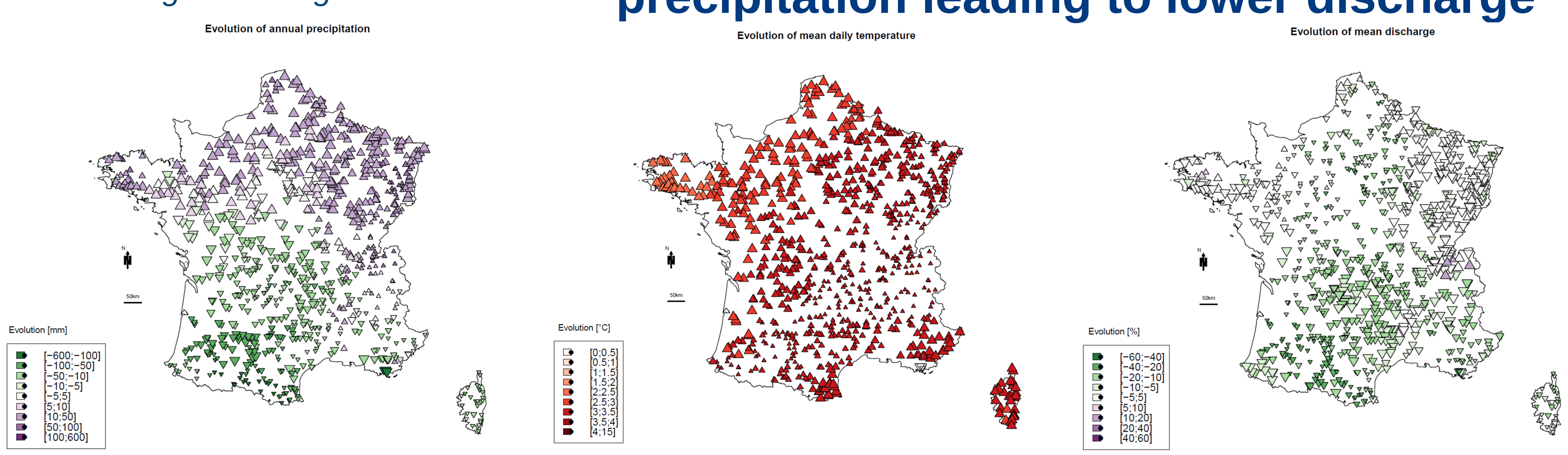
Fig. 1: Map of the 874 stations

Fig. 2: Evolution of annual precipitation, temperature and discharge of the 6 HMs between PST and FUT. The size and orientation of the triangles relate resp. to the agreement between the projections and to the sign of change.

1. Methods

We analysed 874 embedded stations over France (Fig. 1).
We used 52-year grid-based observed meteorological data.
Downscaling of GCMs' outputs for RCPs 2.6, 4.5, 6.0, 8.5 (with resp. 20, 25, 15 and 26 GCMs) is made with the Advanced Delta Change method (van Pelt et al., 2012).
Six hydrological models (HMs) calibrated with Nash-Sutcliffe on square root of discharge were used: GR4J, GR5J, GR6J, TOPMO, MORD6, HBV0. Nash(Q) and Nash(log(Q)) also used in Fig. 4 for GR4J only.
Results are aggregated for all RCPs, GCMs and HMs except if specified. We present relative or absolute changes between the 52-yr historical period (PST) and that period transformed to the future based on the 2071-2100 time slice (FUT).

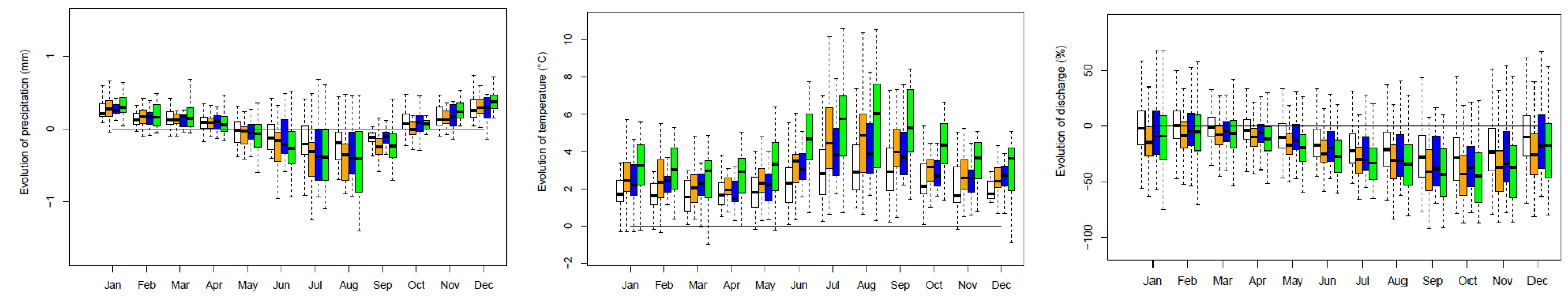
2. A warming climate and contrasted precipitation leading to lower discharge



Unsurprisingly mean discharges should be decreasing on most of France except in the North-East. Precipitation seasonal variations (not shown) are high with a decrease in summer, and an increase in winter.

3. Sources of uncertainties

Fig. 3: Evolution of monthly precipitation, temperature and discharge of the 6 HMs for the 4 RCPs (RCP2.5 in white, RCP4.5 in orange, RCP6.0 in blue, RCP8.5 in green) for the River Seine at Paris between PST and FUT.



RCPs are shown to impact the intensities but not the sign of changes (Fig. 3).

The choice of the calibration function may be essential for intermittent rivers (Fig. 4).
The climatic conditions of the calibration period significantly impact the intensities of changes (Fig. 5).
The effect of the sources of uncertainties are very dependent on the basin, period of the year, and studied index.

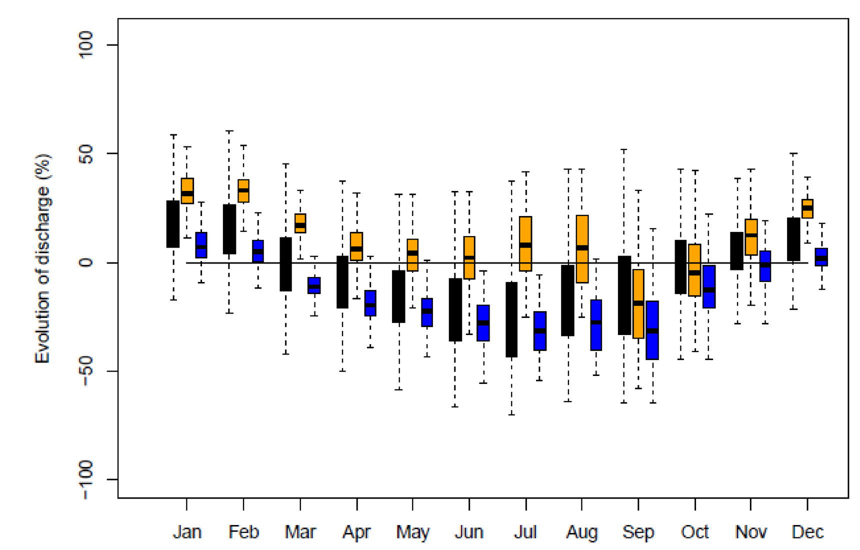


Fig. 4: Evolution of discharge between PST and FUT with GR4J and calibration function: Nash(SQRT(Q)) (black), Nash(Q) (orange), Nash(log(Q)) (blue) for the River Ardèche at Pont-de-Labeaume,

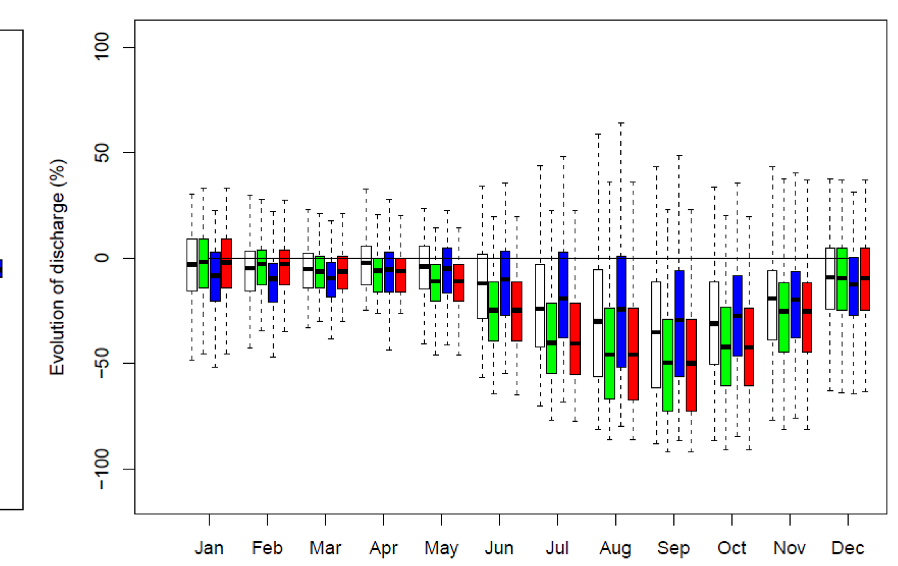


Fig. 5: Evolution of discharge between PST and FUT for GR4J with calibration period: dry (white), wet (green), cold (blue), warm (red) for the River Ill at Alkirch.

4. Conclusions

While the evolution of discharges are in agreement with those obtained in AR4-based studies (e.g. Chauveau et al., 2013), we show that sources of uncertainties due to hydrological modelling exist and should not be neglected. Still, these sources are barely tested or evoked even in recent impact studies.

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