

Evolution of the French hydrological cycle during the last century

R.BONNET, supervisors: J.BOÉ, L.TERRAY

Context

The few long-term observations available show that **multidecadal variability** is large on French river flows [1]

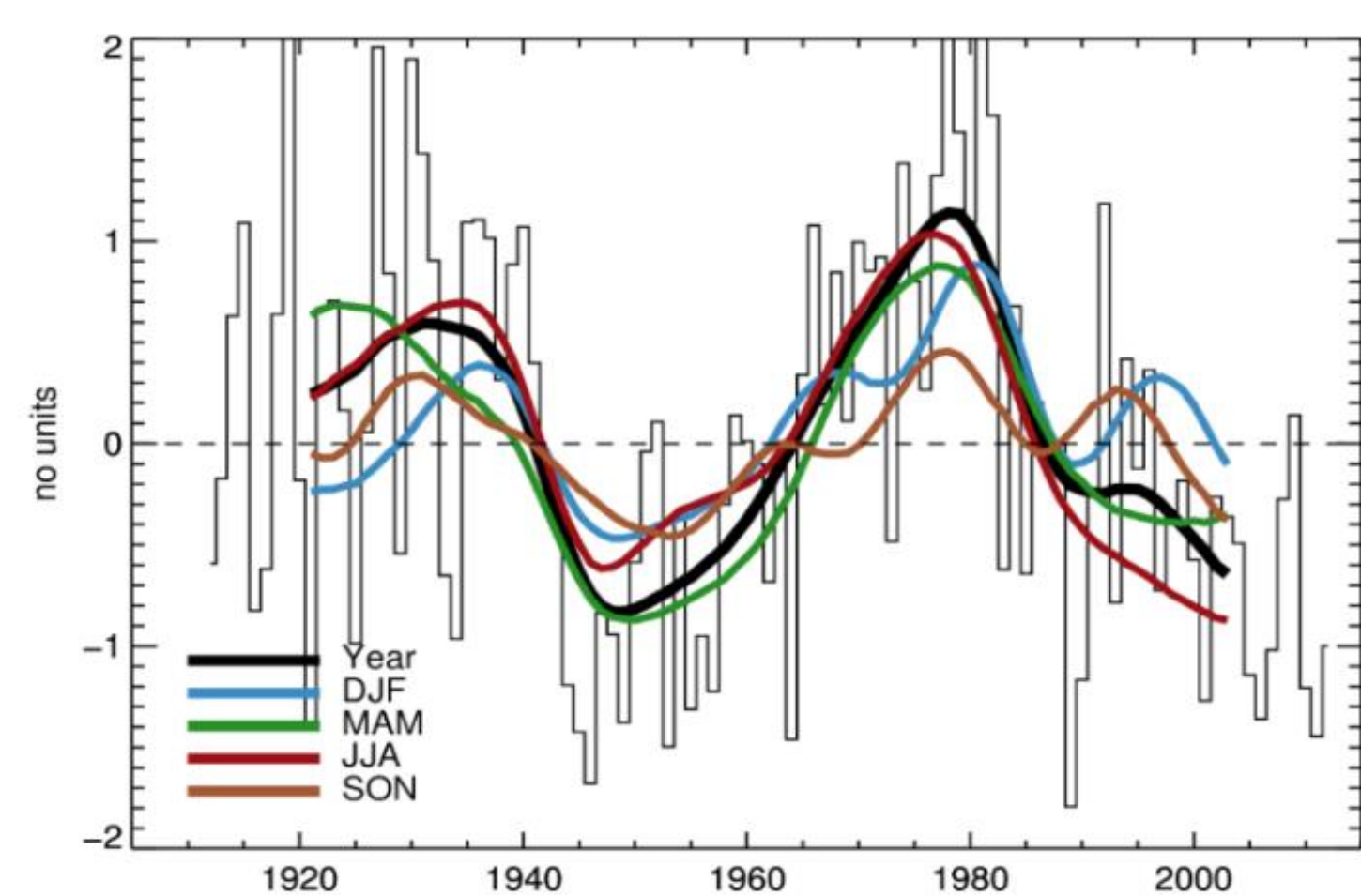


Figure 1: Standardized river flow at the Gave d'Ossau (Pyrenees) [1]

Observations of the hydrological variables are **very scarce**

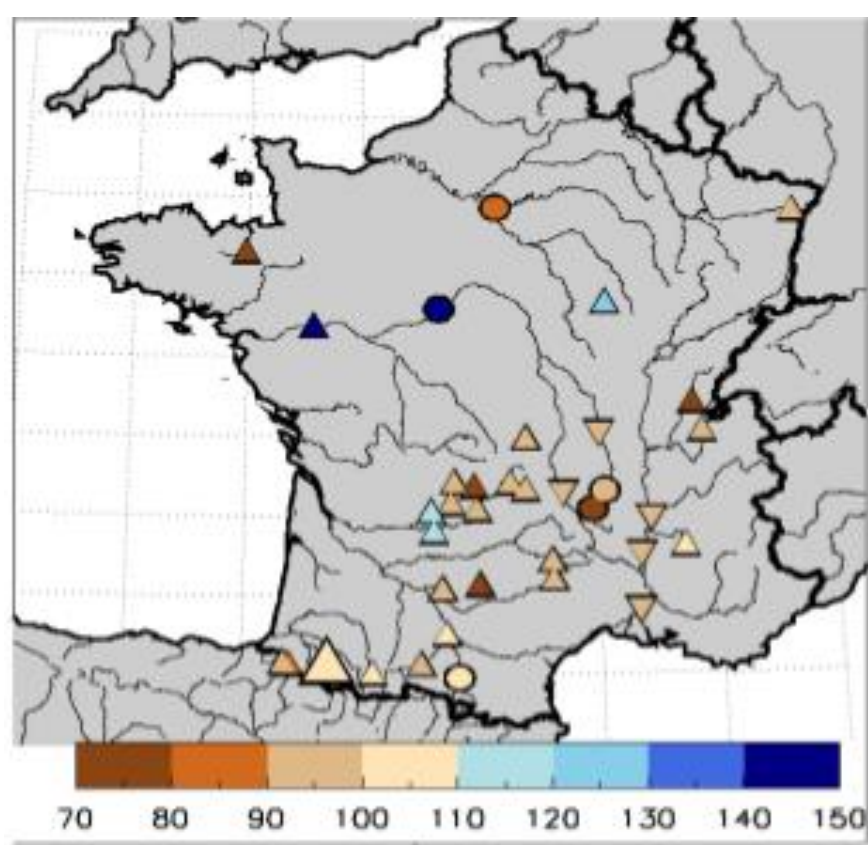
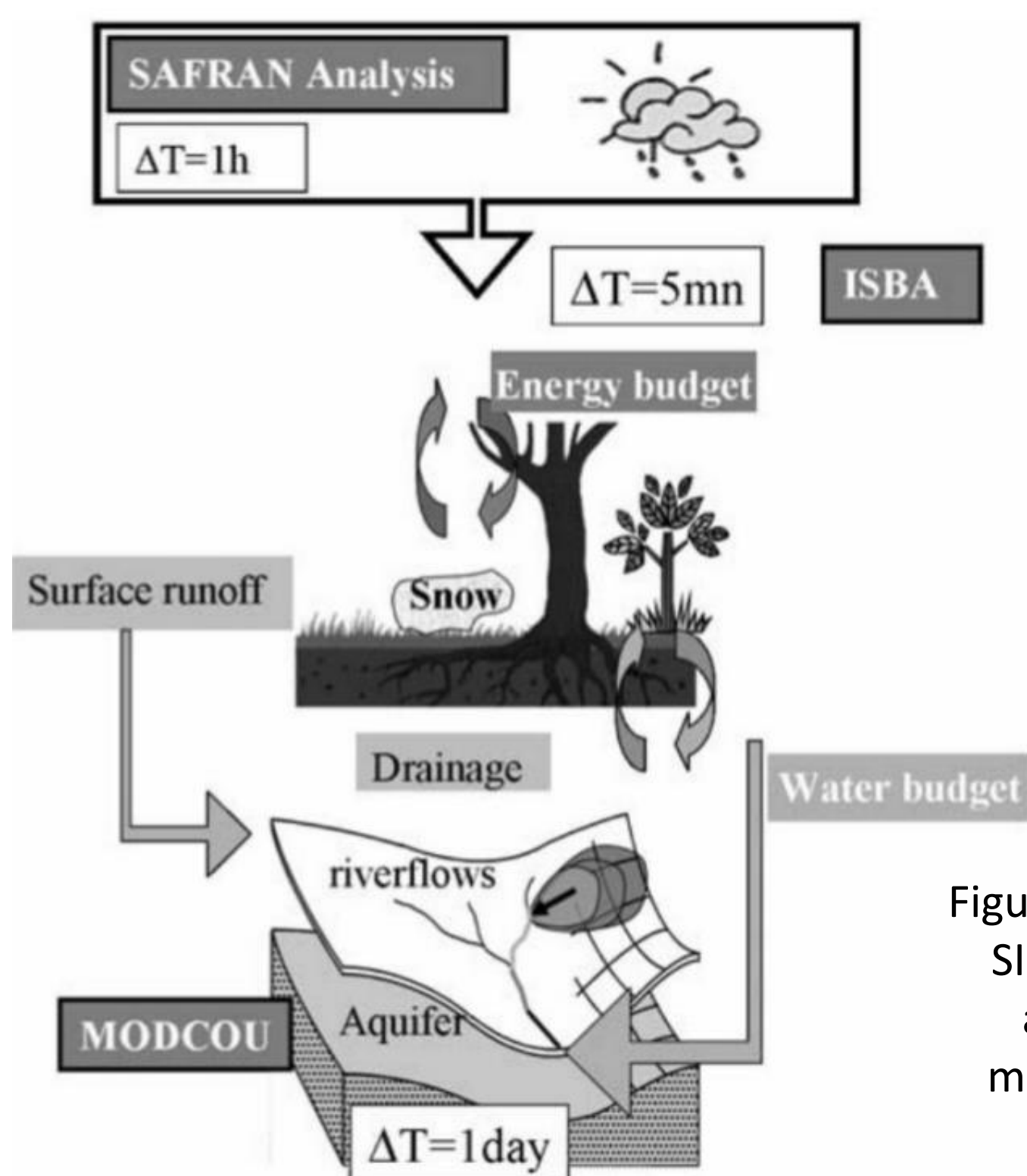


Figure 2: Long observation stations in function of their length (year) [1]

Hydrological simulations are used to study the multi-decadal variability of the hydrological variables and understand the mechanisms behind it.

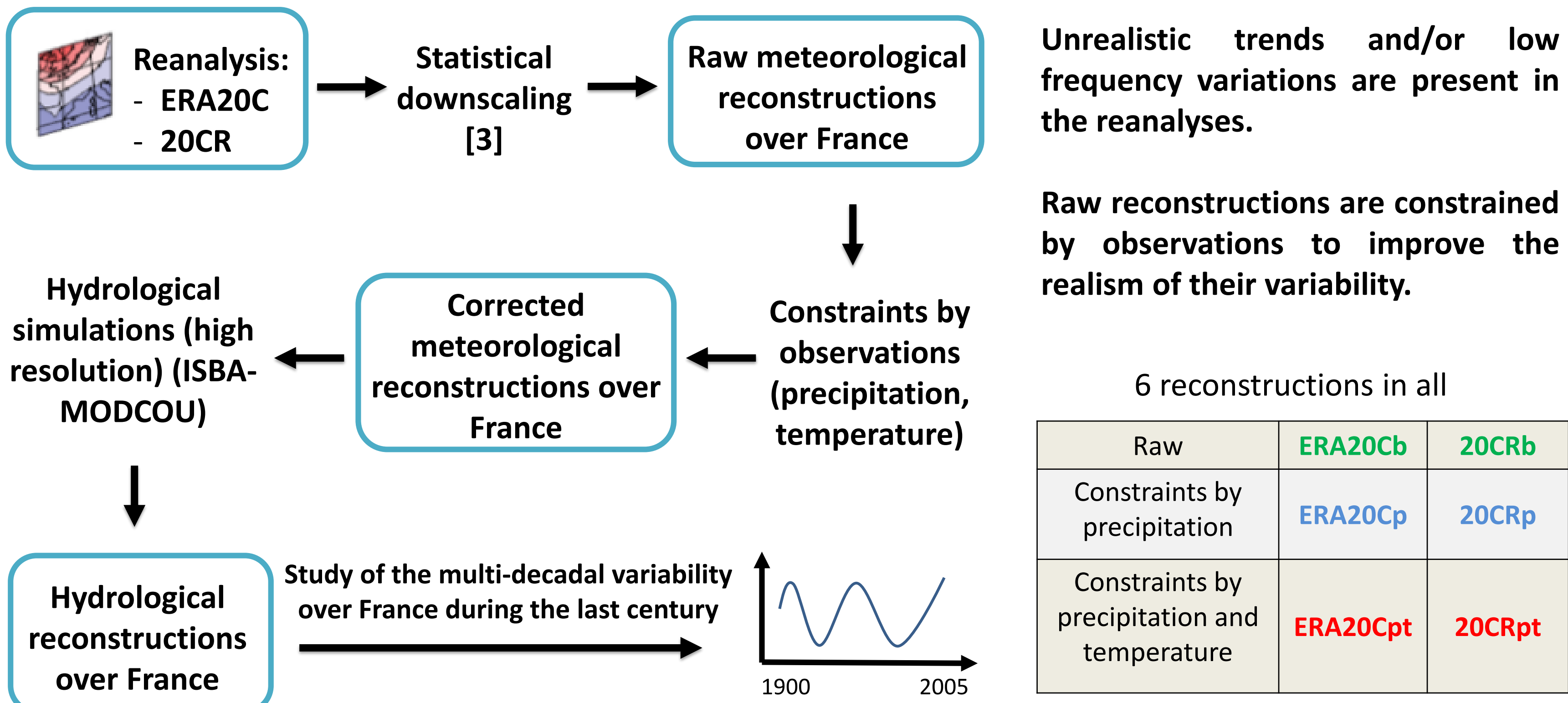
SAFRAN-ISBA-MODCOU



As the SAFRAN analysis is just available for the 1959-2012 period, a method is used to **reconstruct the meteorological forcing** during the entire 20th century [3].

Figure 3: hydrometeorological model SIM with his 3 modules: SAFRAN atmospheric analysis, surface modèle Isba and hydrogéologique model Modcou [2]

Method



Unrealistic trends and/or low frequency variations are present in the reanalyses.

Raw reconstructions are constrained by observations to improve the realism of their variability.

6 reconstructions in all

Raw	ERA20Cb	20CRb
Constraints by precipitation	ERA20Cp	20CRp
Constraints by precipitation and temperature	ERA20Cpt	20CRpt

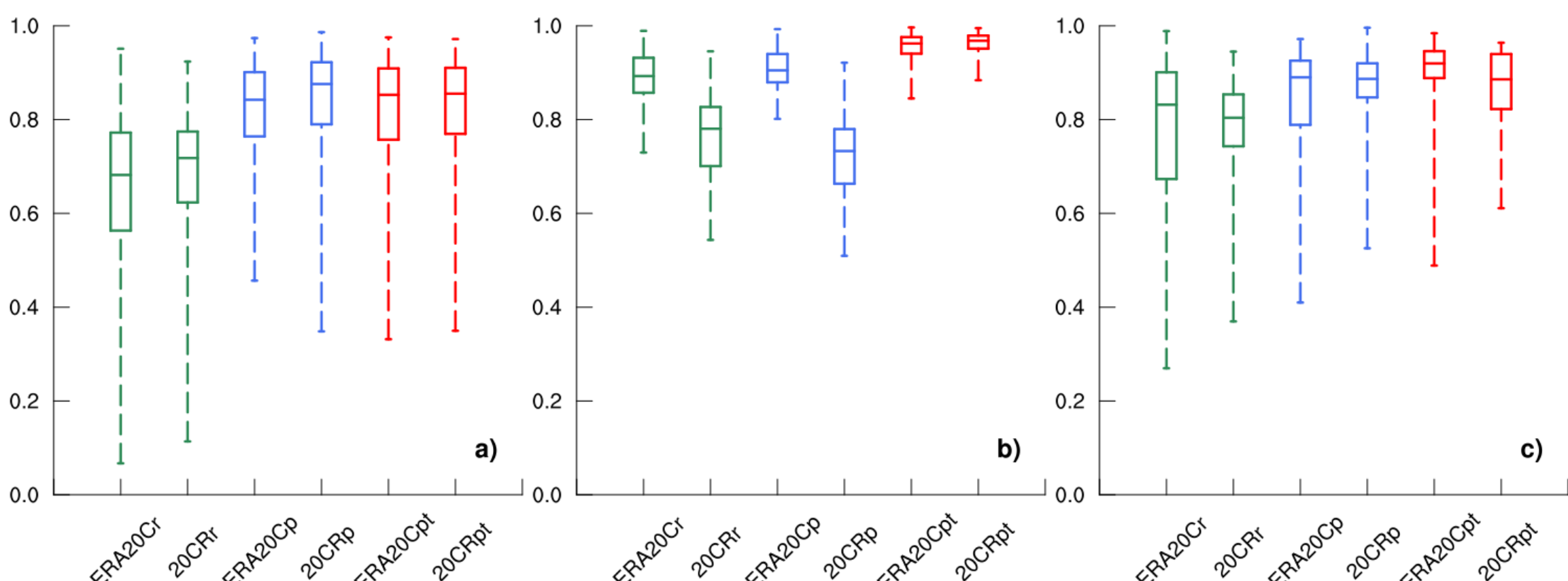
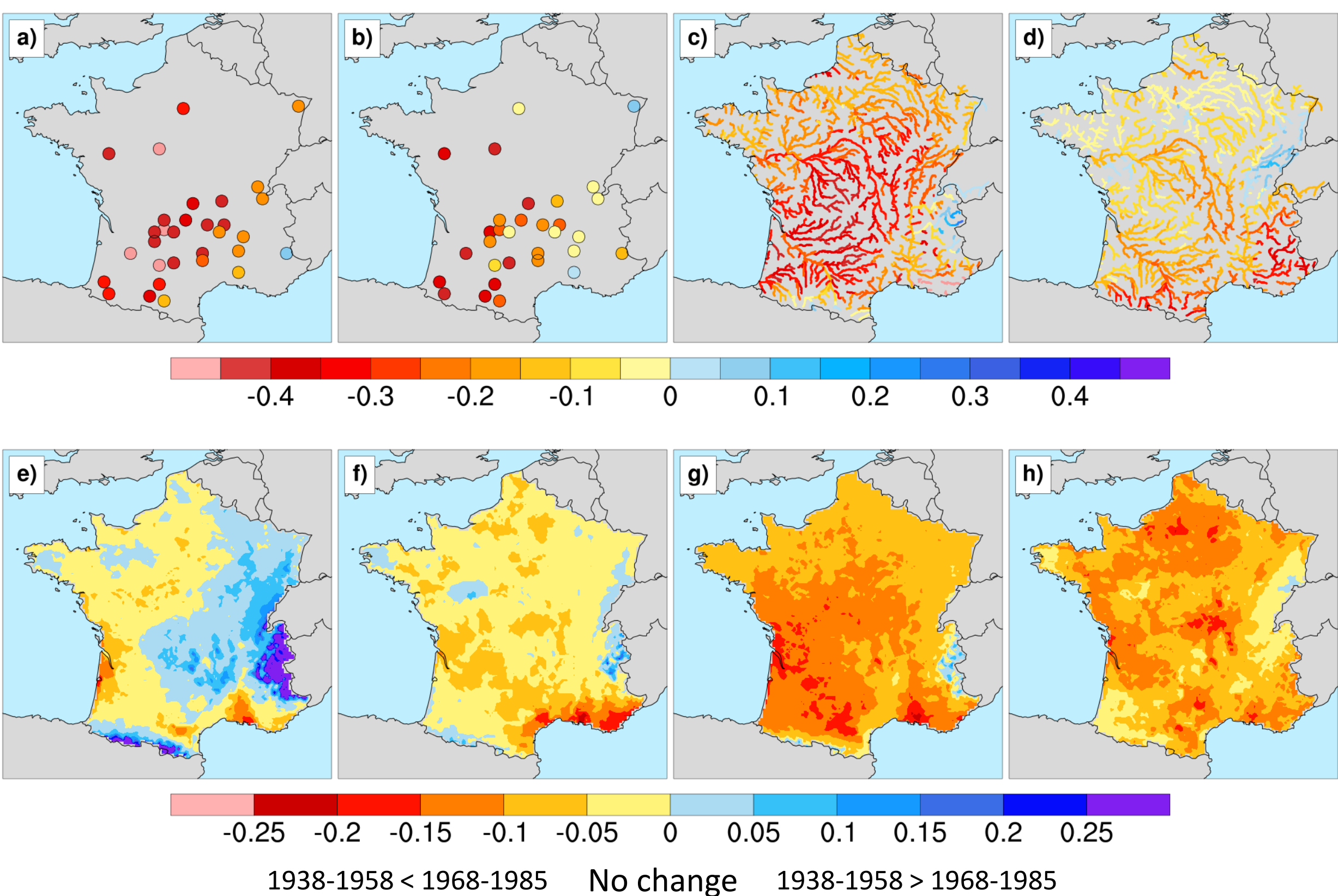


Figure 4: Boxplots of the correlations between annual detrended low-pass filtered series from the reconstructions and the observations for (a) precipitation, (b) temperature and (c) river flows. For temperature and precipitation, the correlations are calculated on the 1900-2005 period using the SMR dataset. For river flows, the correlations are calculated on the longest possible period for each station. [4]

ERA20Cpt seems to be the best reconstruction

Multi-decadal variations in French hydrological cycle

Figure 5: Relative changes between the 1938-1958 and 1965-1985 periods of detrended (a-b) observed river flows, (c-d) simulated river flows, (e-f) evapotranspiration and (g-h) soil wetness index (SWI). (a-c-e-g) spring and (b-d-f-h) summer. Simulated river flows, evapotranspiration and SWI come from the ERA20Cpt reconstruction. [4]



ISBA-MODCOU is a physically-based model. The only river flow calibration is the concentration time in MODCOU (\approx daily time scale).

- No river flows calibration at longer time scale
- Dam or pumping no taken into account

→ Independence between observed and simulated river flows

- The multi-decadal variations in French river flows are mainly climate driven, as a large part is reproduced by the river flows simulations.
- Multi-decadal variations also exist for evapotranspiration and soil moisture, depend on the region.

Conclusion and perspectives

- The constraint method, associated with the downscaling, improve the reconstructions quality. Their variability and trends are closer to the observations.
- The reconstructions developed provide a good opportunity to study the low frequency variations of the hydrological cycle and the associated mechanisms.
- New simulations will be performed on two French watersheds: the Pyrenees and the Seine. The method (downscaling and constraints by observations) will be improved for each.

Bibliography

- [1] Boé, J., & Habets, F. (2014). Multi-decadal river flow variations in France. Hydrology and Earth System Sciences, 18(2), 691-708.
- [2] Habets, F., Boone, A., Champeaux, J. L., Etchevers, P., Franchisteguy, L., Leblois, E., ... & Noilhan, J. (2008). The SAFRAN-ISBA-MODCOU hydrometeorological model applied over France. Journal of Geophysical Research: Atmospheres, 113(D6).
- [3] Dayon, G., Boé, J., & Martin, E. (2015). Transferability in the future climate of a statistical downscaling method for precipitation in France. Journal of Geophysical Research: Atmospheres, 120(3), 1023-1043.
- [4] Bonnet, R., Boé, J., Dayon, G., & Martin, E., 20th-century hydro-meteorological reconstructions to study the multi-decadal variations of the water cycle over France, submitted to WRR.