INRAE

Assessing flow intermittence in France under climate change

Aurélien BEAUFORT [1], Quentin BOTTET [1],
Guillaume THIREL [2] & Eric SAUQUET [1]

[1] INRAE, RiverLy, Lyon, France
[2] INRAE, Hycar, Antony, France

EGU2020: Sharing Geoscience Online 4-8 May 2020

Introduction

- Globally, in the future, flow intermittence in summer should increase where climate is projected to be driest; conversely, flow intermittence in winter should reduce where no-flow conditions are due to freezing

- Few impact studies of climate change on European intermittent rivers due to:
  - the difficulties for hydrological models to simulate no-flow events
  - the reduced number of gauged basins with intermittent flow regime

- Besides climate influences, intermittence characteristics are strongly influenced by processes operating at small scales, such as groundwater-surface water interactions and transmission losses (e.g. Beaufort et al., 2019, Costigan et al. 2017). Using global hydrological models is thus certainly hazardous to assess changes in flow intermittence characteristics (e.g. Döll and Schmied, 2012)

Beaufort, A., Carreau, J., & Sauquet, E. (2019). A classification approach to reconstruct local daily drying dynamics at headwater streams. Hydrological Processes, 33, 1896– 1912.

Costigan et al. (2017). Chapter 2.2 – Flow regimes in intermittent rivers and ephemeral streams. In: "Datry T., Bonada N. & Boulton A.J. (Eds.), Intermittent Rivers and Ephemeral Streams. Ecology and Management", Academic Press (pp. 51–78).

Döll, P., & Schmied, H. M. (2012). How is the impact of climate change on river flow regimes related to the impact on mean annual runoff? A global-scale analysis. Environ. Res. Lett., 7, 014037.

Introduction

- De Girolamo et al. (2017) have calibrated and applied the SWAT model forced by three regional climate projections to a temporary river system in southern Italy and results point out a longer period with no-flow conditions during the period 2030–2059 compared to the recent past period 1980–2009

- Cipriani et al. (2014) have used two rainfall-runoff models to simulate no-flow events of an intermittent river in south-eastern France and the consequences in terms of biodiversity. Results suggest that, by 2050, (1) no-flow events could be more frequent, (2) durations of no-flow event are expected to increase, and (3) the consequence could be a loss of approximately two taxa

- **Here, a modelling framework supported by field observations** performed on a large number of French headwater streams **is developed and applied to assess the probability of drying in headwater streams at the regional scale (RPoD) under climate change**

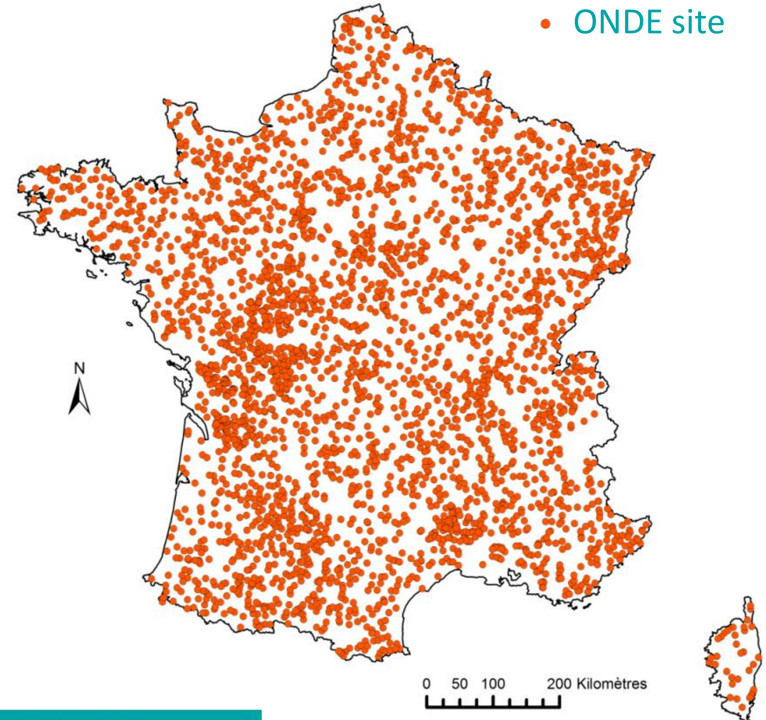
Cipriani et al. (2014). Impact of climate change on aquatic ecosystems along the Asse River Network. In: FRIEND-Water 2014, Hydrology in a Changing World: Environmental and Human Dimensions, February 2014, Hanoi, Vietnam (IAHS Publ. 36X, 2014), 463-468.
De Girolamo et al. (2017). Hydrology under climate change in a temporary river system: Potential impact on water balance and flow regime. River Research and Applications, 33, 1219– 1232.

Outlines

- Material and methods
- Results
- Conclusions

Material and methods

- Field observation states from the ONDE network (https://onde.eaufrance.fr)
  - 3300 sites with Strahler order < 5 visually inspected once a month between April and October since 2012
  - One of the following flow states assigned at each observation:



No-flow

Flowing

No flow

Dry

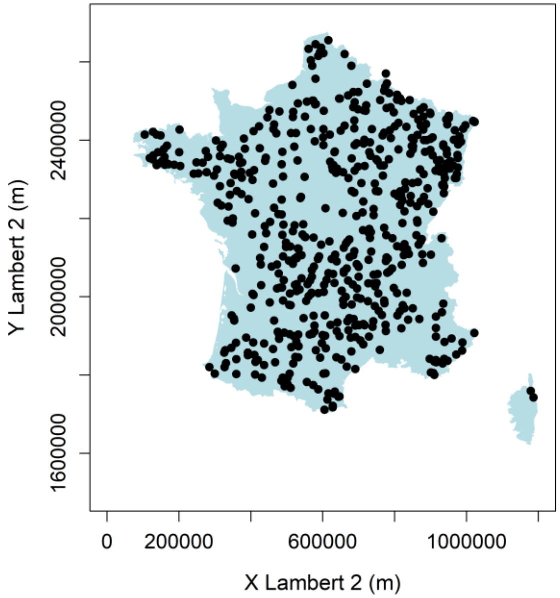
Material and methods

- Meteorological forcing datasets from the Safran French near-surface reanalysis data (Vidal et al., 2010)

- An ensemble of 26 high-resolution projections derived from GCM simulations under RCP2.6 and RCP8.5 emission scenarios, applying an advanced delta change approach (van Pelt et al., 2012)

- Discharge data of 568 gauging stations (●) extracted from the French HYDRO database (http://hydro.eaufrance.fr/)

- A total of 22 large regions homogeneous in terms of climate, topography and geological features (Wasson et al., 2002)



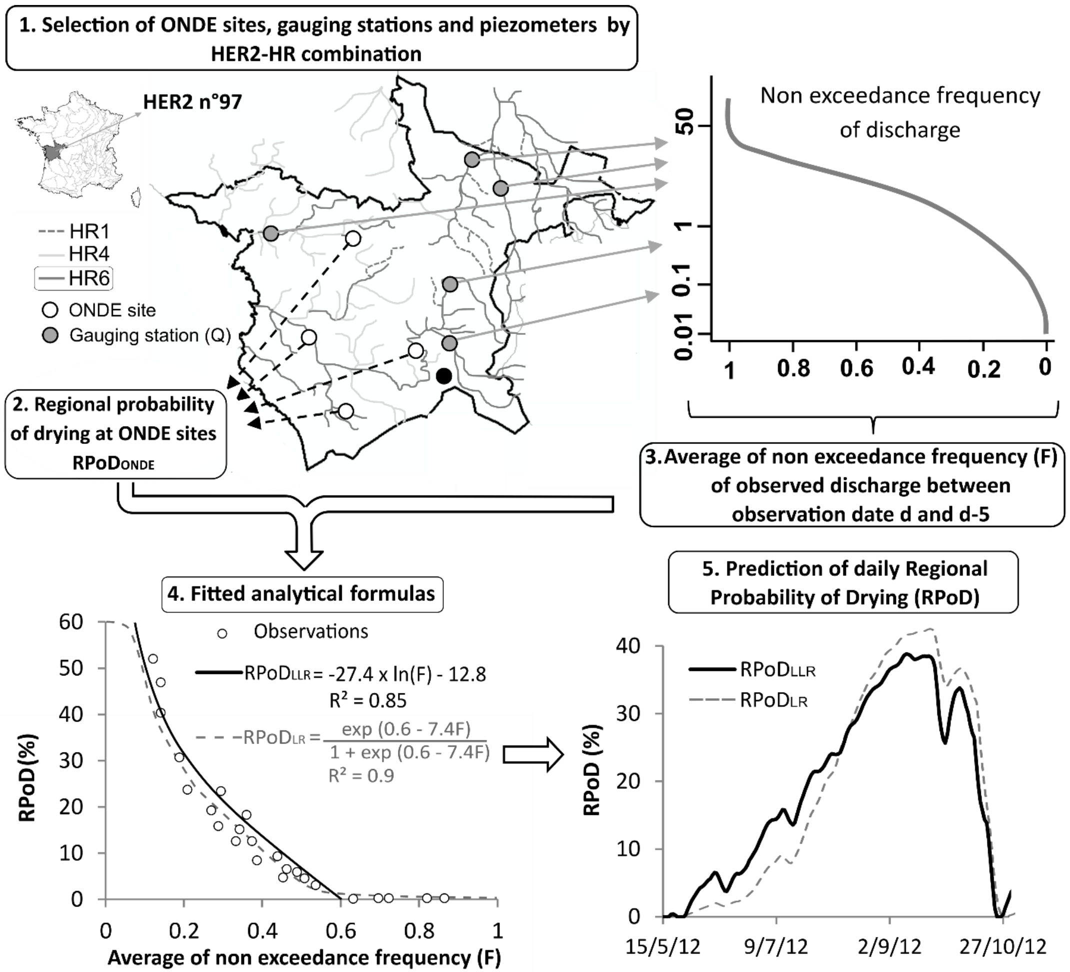
Vidal et al. (2010). A 50-year high-resolution atmospheric reanalysis over France with the Safran system. Int. J. Climatol., 30, 1627–1644.

van Pelt et al. (2012). Future changes in extreme precipitation in the Rhine basin based on global and regional climate model simulations. Hydrol. Earth Syst. Sci., 16, 4517–4530.

Wasson et al. (2002). Typology and reference conditions for surface water bodies in France: the hydro-ecoregion approach. TemaNord, 37–41.

Material and methods

Modelling the risk of intermittence (regional approach) developed by Beaufort et al. (2018)



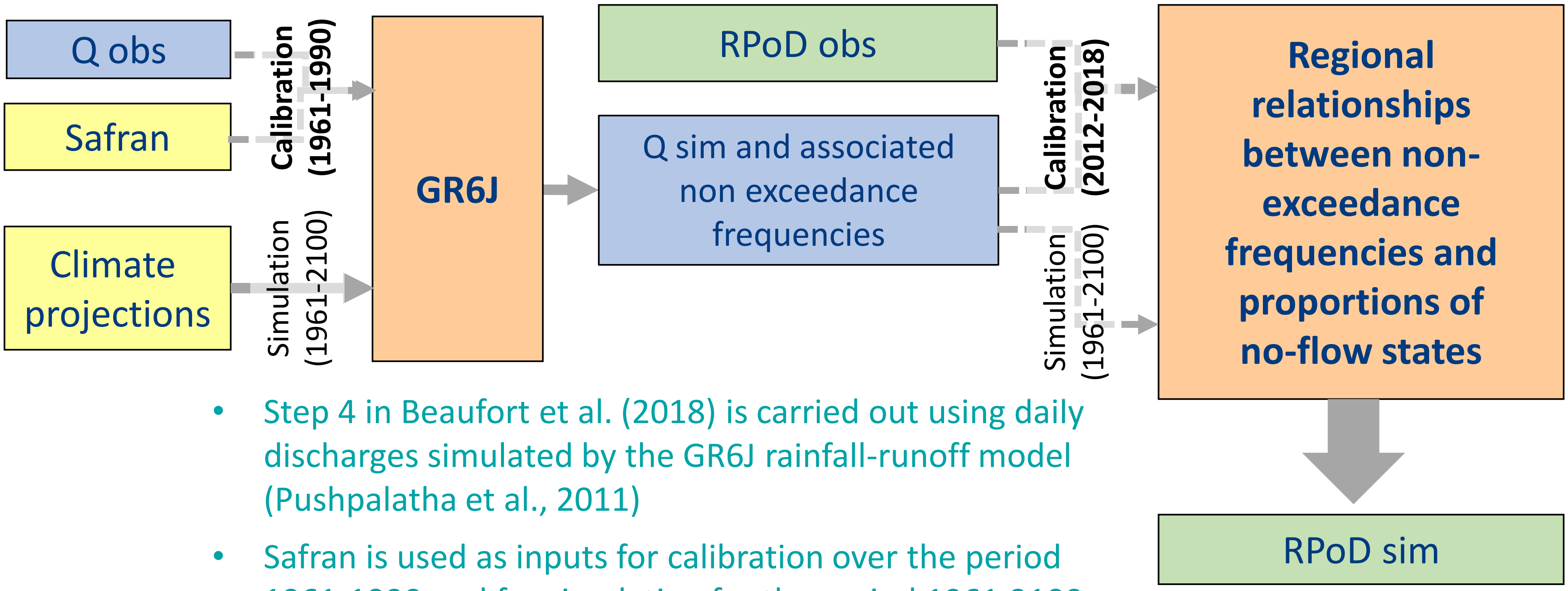
The observed regional probabilities of drying of headwater streams (RPoD) are given by the daily proportions of no-flow states observed at ONDE sites within the region

Beaufort et al. (2018). Extrapolating regional probability of drying of headwater streams using discrete observations and gauging networks. Hydrology and Earth System Sciences, 22(5), 3033–3051.

Material and methods

Modelling the risk of intermittence (regional approach) developed by Beaufort et al. (2018)

- For each region and each regional climate projection:

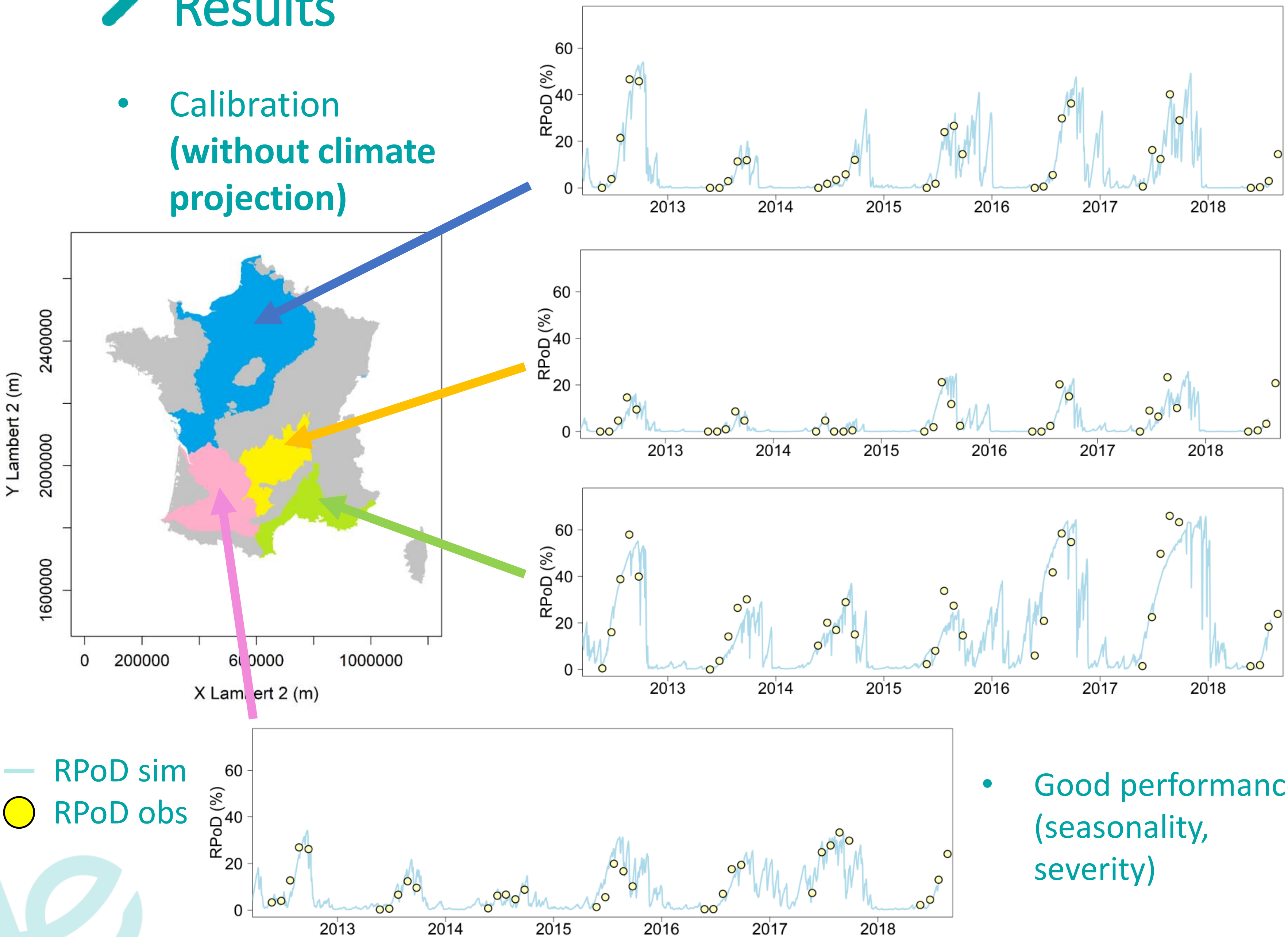


- Step 4 in Beaufort et al. (2018) is carried out using daily discharges simulated by the GR6J rainfall-runoff model (Pushpalatha et al., 2011)
- Safran is used as inputs for calibration over the period 1961-1990 and for simulation for the period 1961-2100
- Non-exceedance probabilities deduced from simulated discharges are calculated considering the whole period 1961-2100

Pushpalatha et al. (2011). A downward structural sensitivity analysis of hydrological models to improve low-flow simulation, J. Hydrol., 411, 66–76.

Results

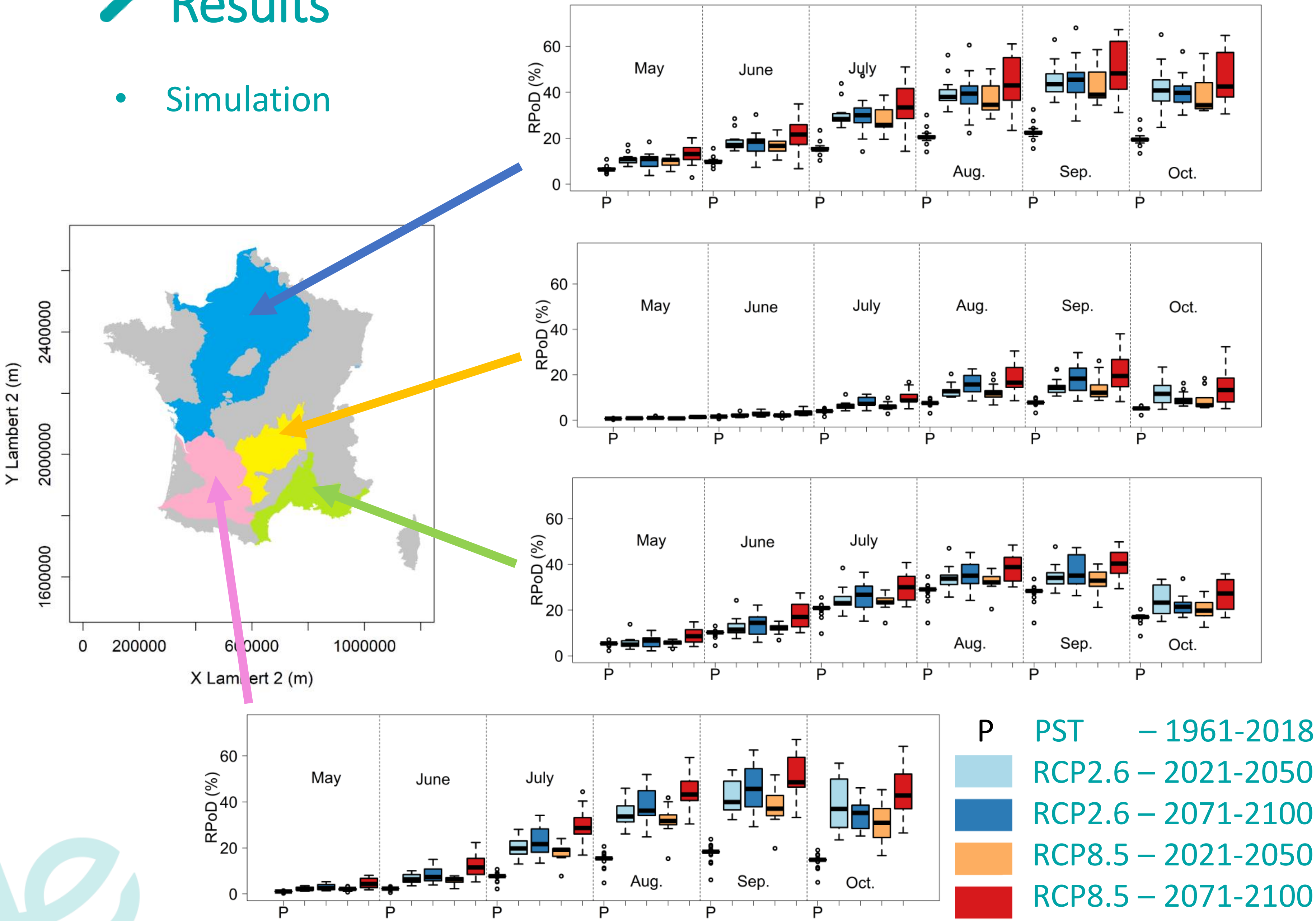
- Calibration **(without climate projection)**



- Good performance (seasonality, severity)

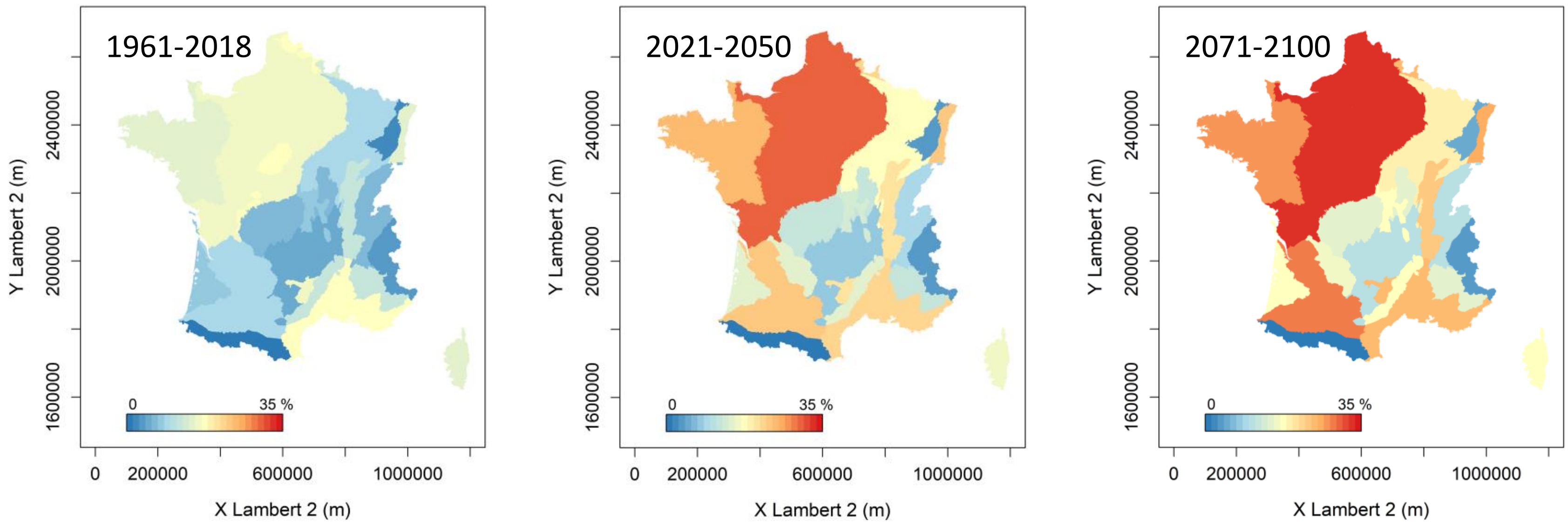
Results

- Simulation



Conclusions

- Results for the two 30-year periods 2021-2050 and 2071-2100 show an increase in flow intermittence in headwaters with time. The mean RPod over the period May–October is 12% at the national scale under the current climate, compared to 20% and 23% on average all RCPs together for the periods 2021-2050 and 2071-2100, respectively



- The changes are significant in regions with historically high probability of drying. No change is detected in the Alps (debatable result due to low performance of the models for predicting RPoD, intermittence due mostly to freezing, and sparse ONDE network in this area)

Thanks for your attention!

Contact: eric.sauquet at inrae.fr

#shareEGU20