Analysing and projecting spatial drought conditions of the Seine catchment based on ocean-atmosphere oscillations over interannual and decadal scales

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“Do you want to go to the seaside?
I'm not trying to say that everybody wants to go” The Kooks

Outline

- Drought 101: the Atmosphere and Ocean Oscillation
- Statistical Downscaling

- Case study: the Seine River
  - the historical drought spatiotemporal patterns
  - the projected drought spatiotemporal patterns

- Drought management framework based on tropical sea surface temperature disturbances and atmospheric teleconnections

Droughts and oscillations

- Midlatitude droughts are affected by atmosphere-ocean oscillations
  - by the tropical disturbances, which are linked to sea-surface temperature patterns in the Pacific and Atlantic Oceans.

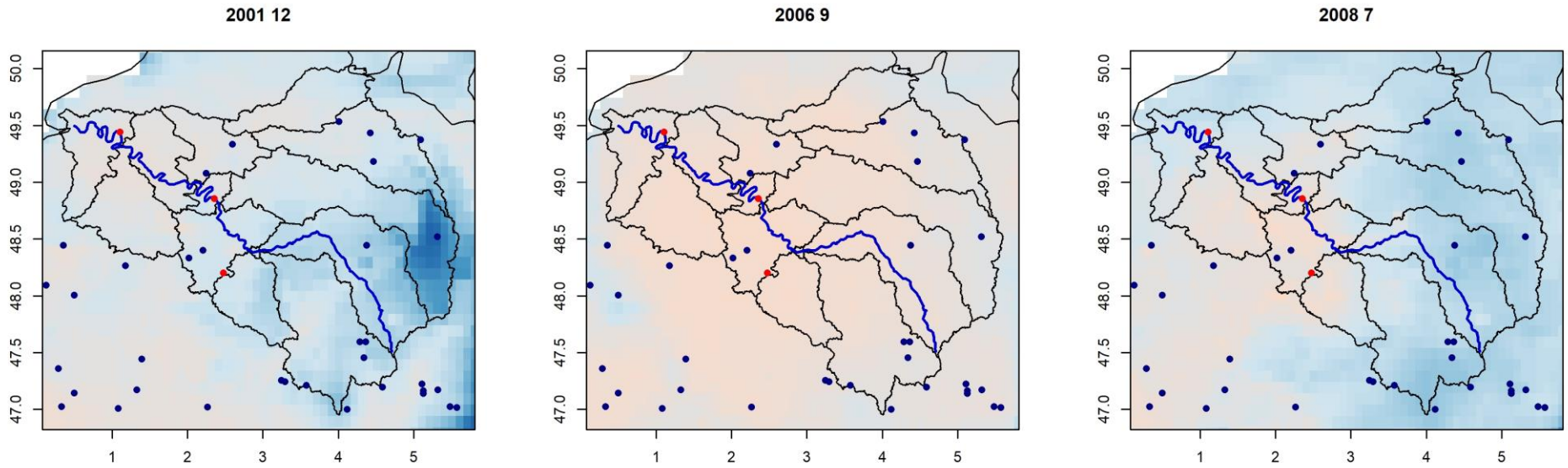
- The combined effects of these two ocean basins manifest themselves in the variation of streamflows, from land surface filtering.
  - Droughts can be considered to be the manifested accumulative effects of atmosphere-ocean oscillations on the terrestrial storage

- In this study, we use a framework to explore the effects of global sea surface temperature variations along with atmospheric teleconnection patterns, on local hydroclimatic conditions related to droughts
  - The Seine catchment, a main waterway in northern France, is used for illustration.

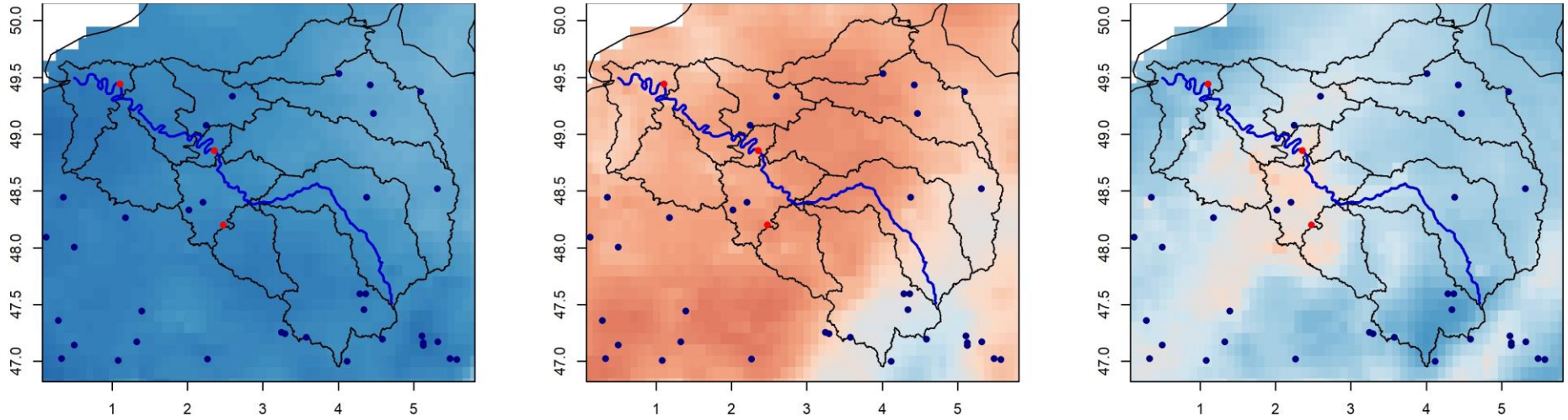
Data ERA maps for the Seine catchment

- Reanalysis
  - Streamflow
  - Drought indices
- Spatial drought variations
  - local land surface mechanisms
  - microclimates or geological processes.

Streamflow

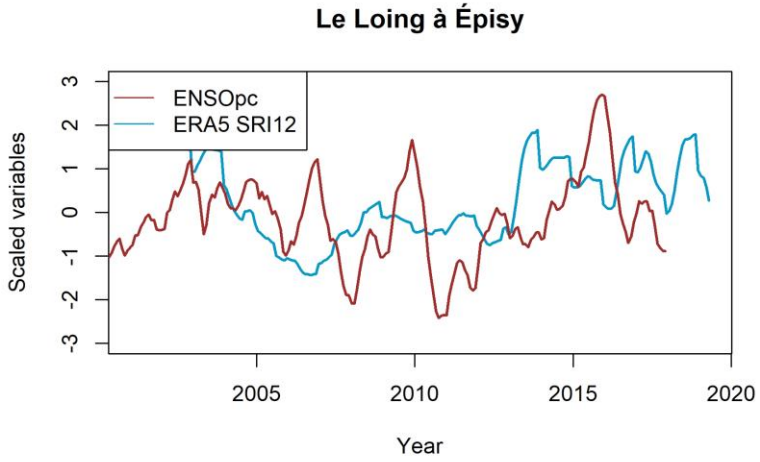


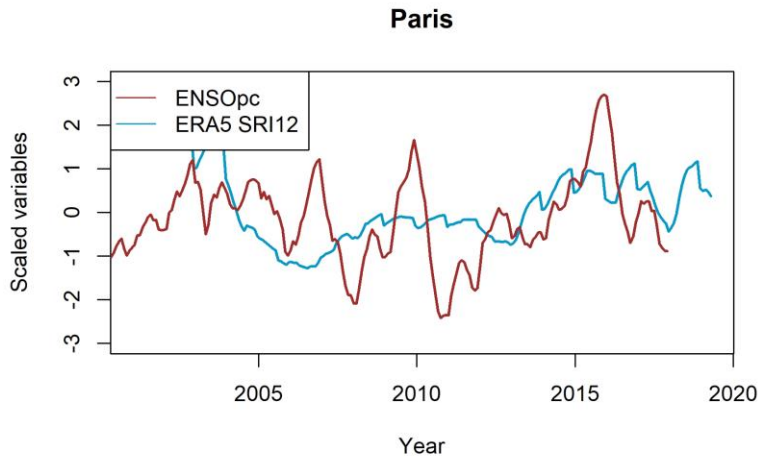
Drought Index based on streamflow

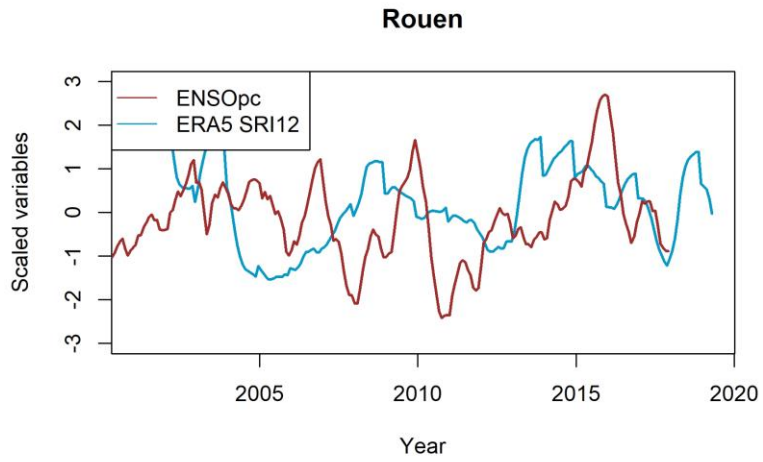


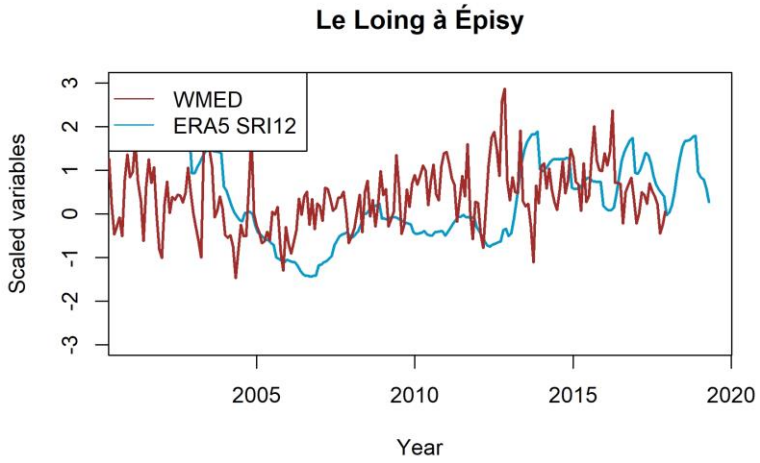
Atmosphere-Ocean Oscillation and drought indices

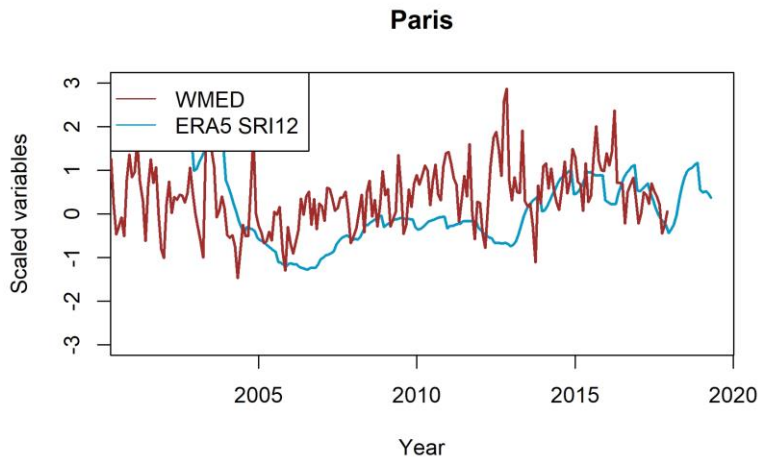
- Using the Standardized Runoff-discharge Index (SRI) to quantify hydrological drought conditions over the Seine

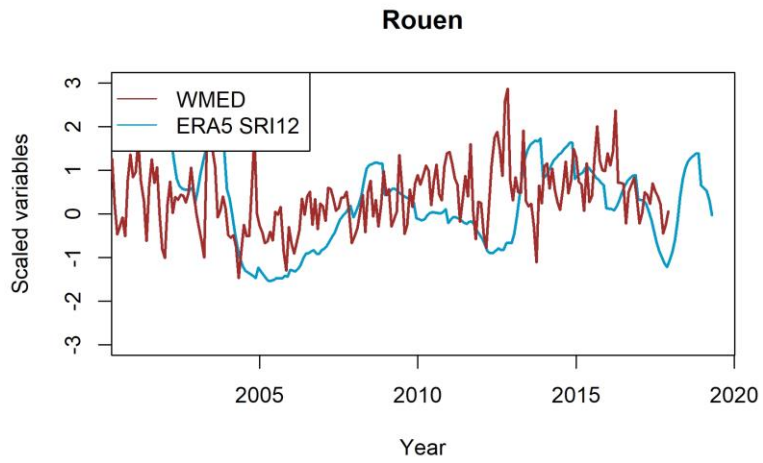






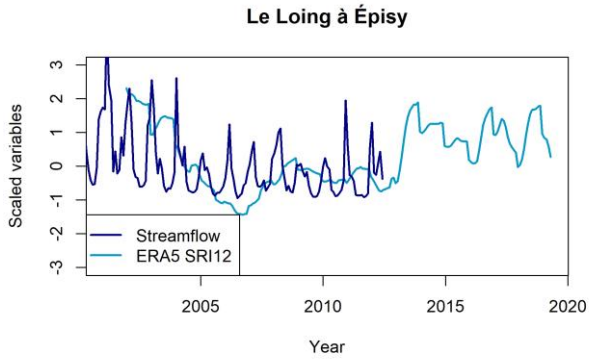


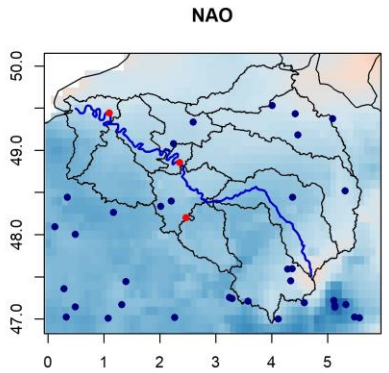


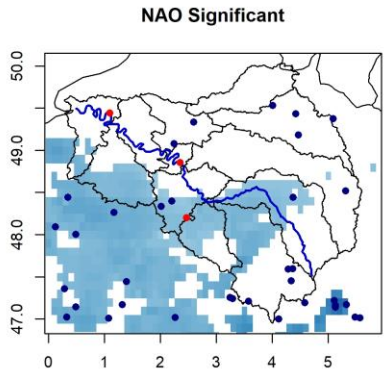


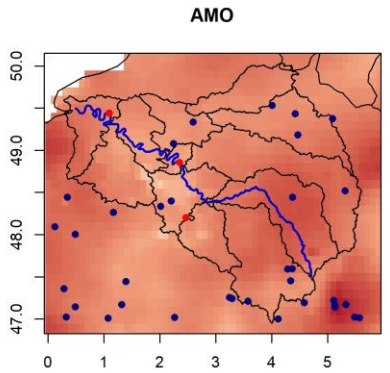
Atmosphere-Ocean Oscillation and drought indices

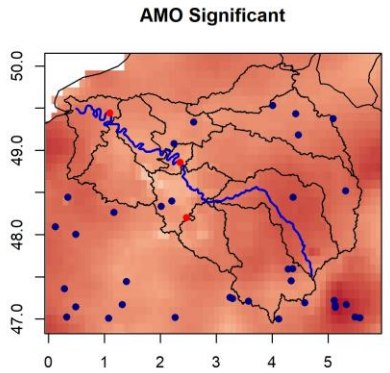
- The Seine downstream: the El Nino Southern Oscillation (ENSO) is a significant forcing variable.
- Over almost the whole Seine River basin: the Atlantic Multidecadal Oscillation (AMO) and the West Mediterranean Sea (WMED) indices was significant.

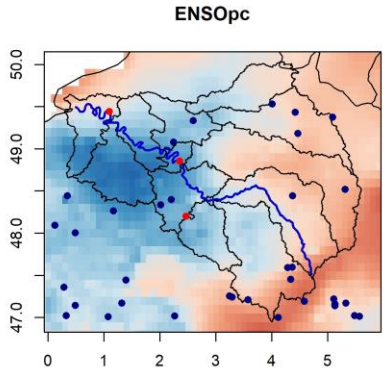


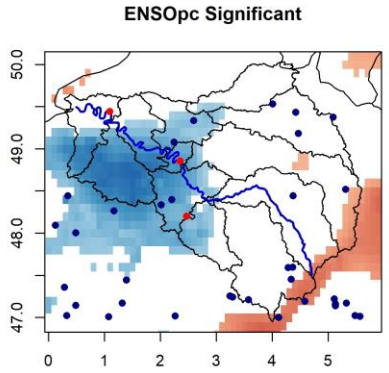


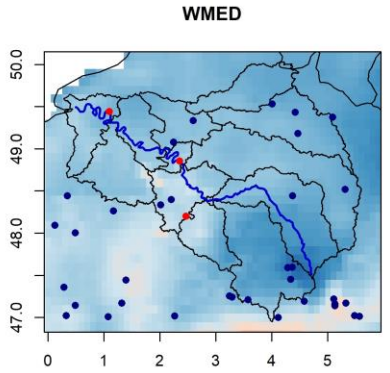


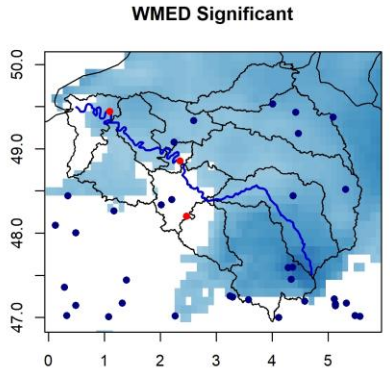






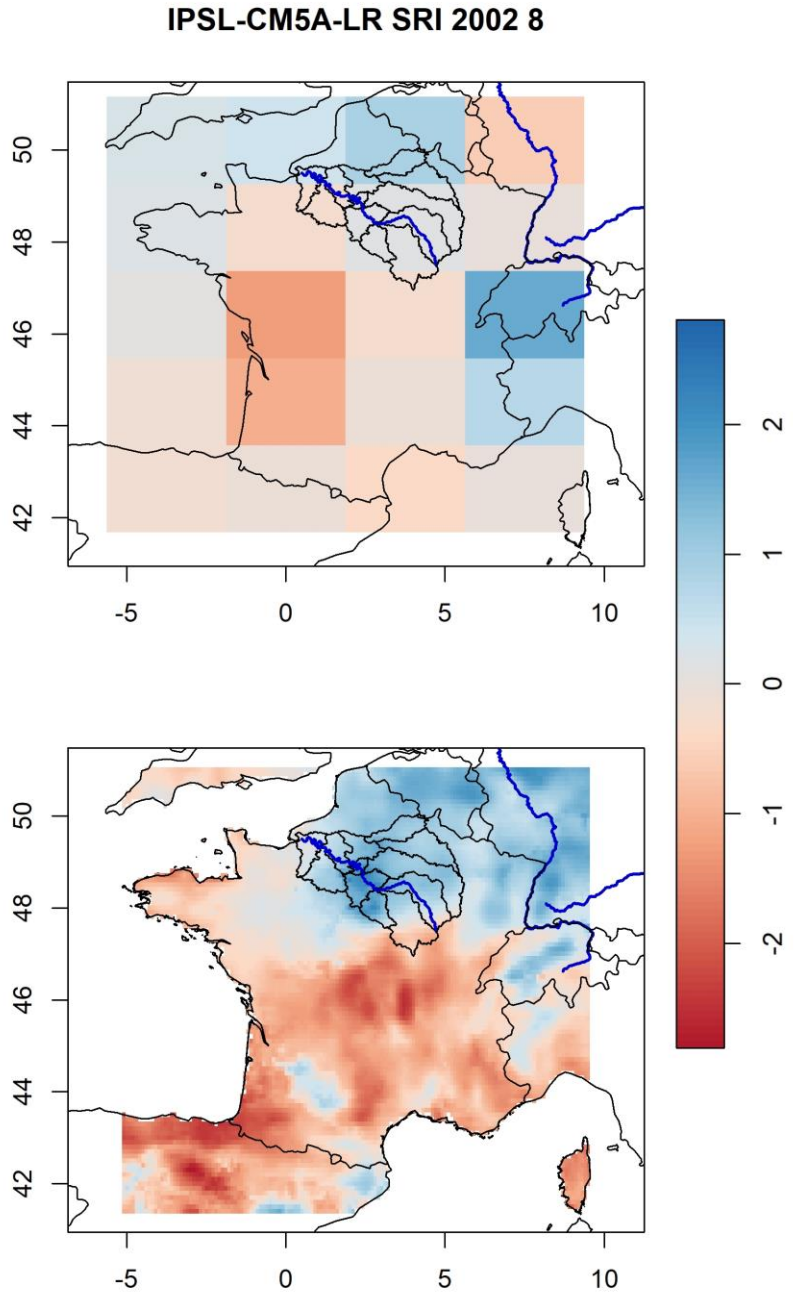






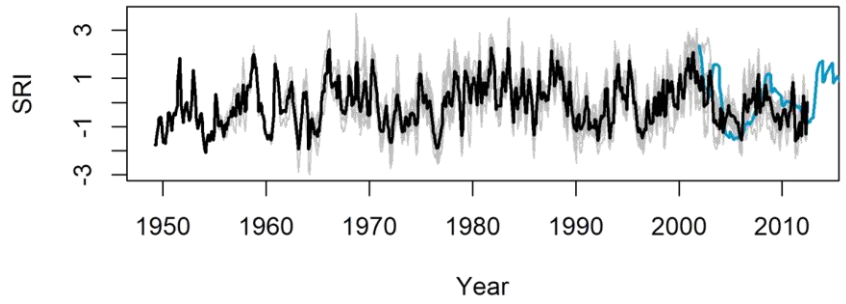
Spatial Downscaling

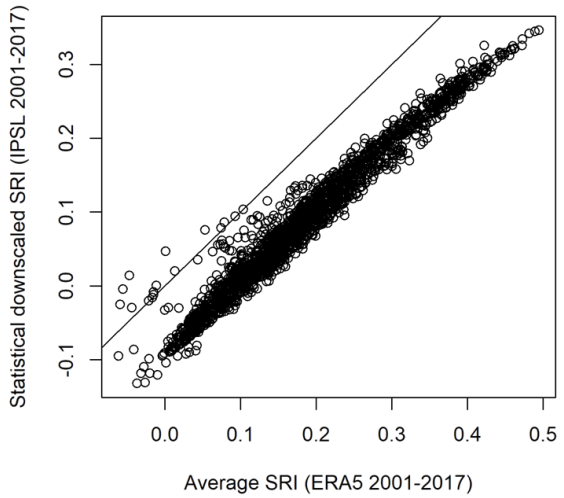
- In general, during the negative phase of AMO and the positive phase of ENSO, the sea surface temperature of the North Atlantic Ocean is low.
- Droughts are likely to occur at the Seine during the negative phase of AMO, because the cold North Atlantic Ocean has less evaporation and provides less moisture to France.
- Based on these results, a statistical downscaling model is developed to relate SRI to atmospheric and oceanic oscillation indices, which are derived from the Institut Pierre Simon Laplace climate model (IPSL-CM5) outputs.

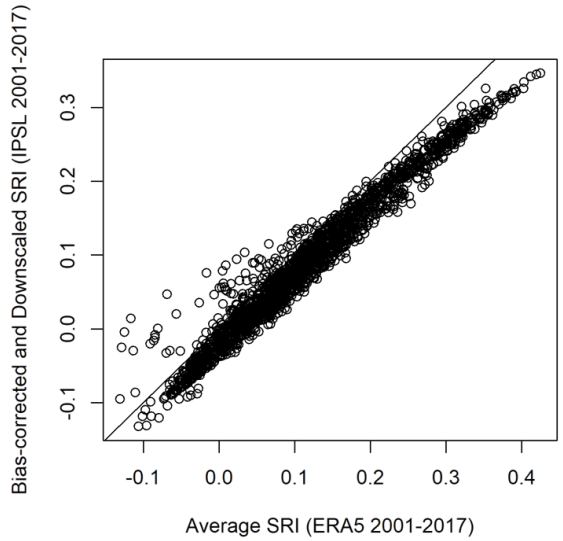


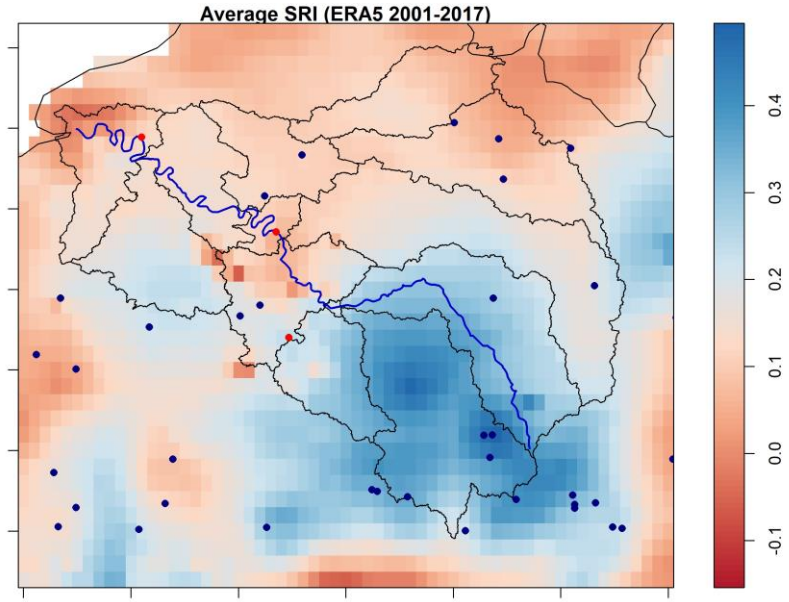
Downscaling Performance

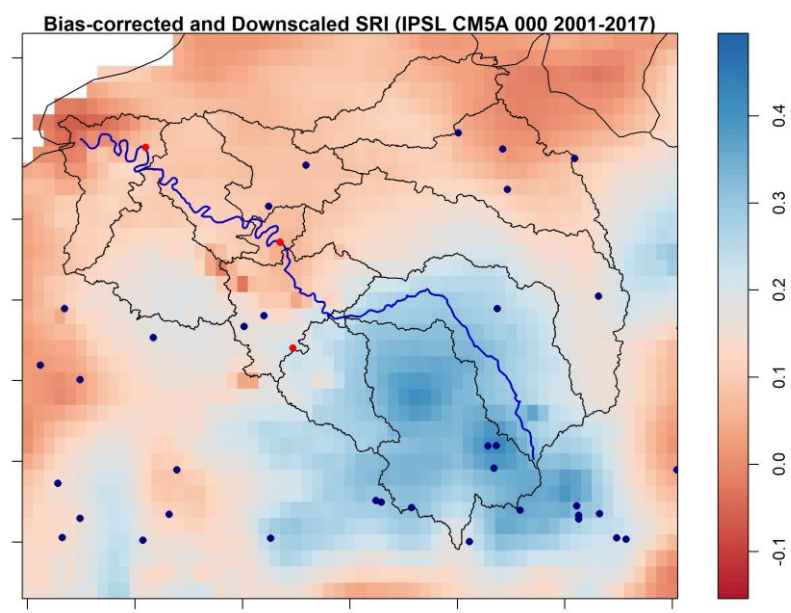
- Bias correction

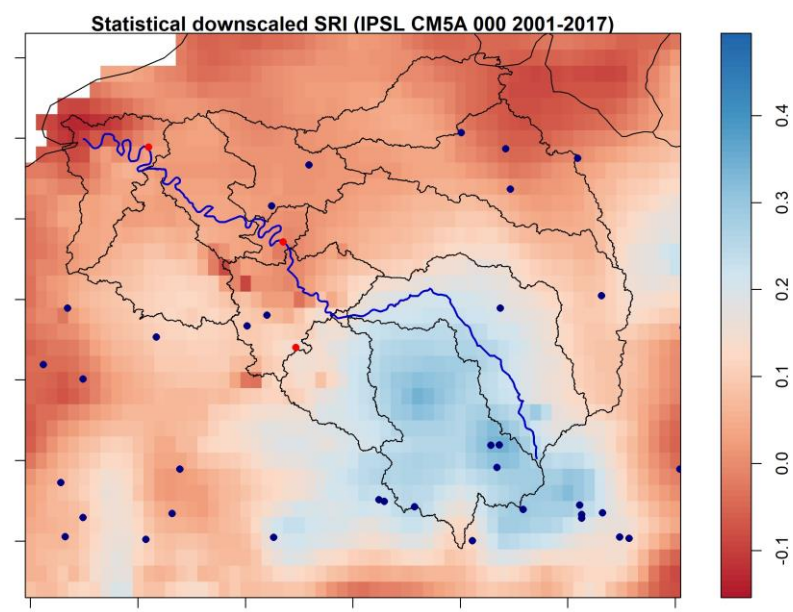








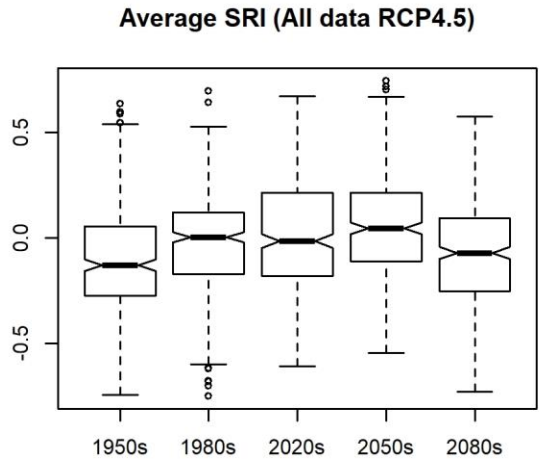


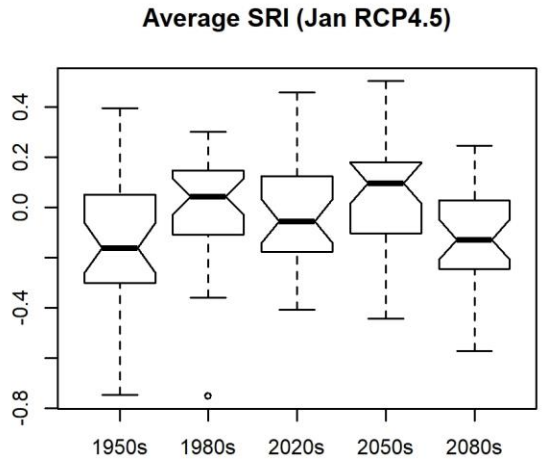


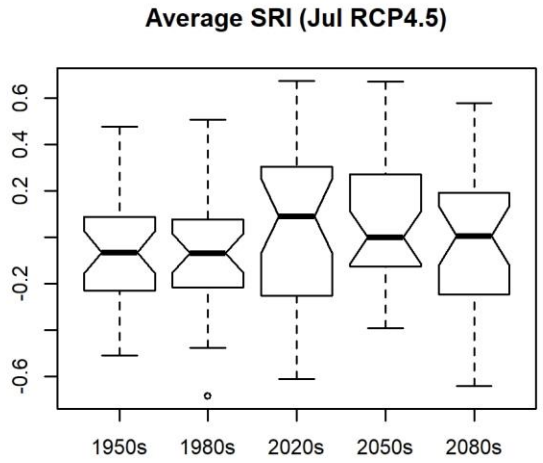
Future drought projections

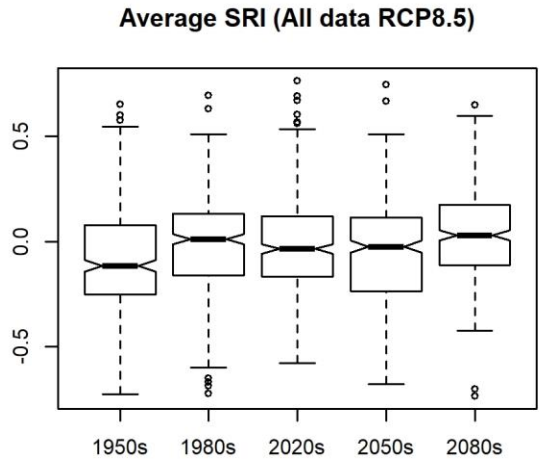
- Using this statistical downscaling model and scenarios of Representative Concentration Pathways (RCP4.5 and RCP8.5), the drought conditions of the Seine are projected for the mid- and long-term future (2050s and 2080s).

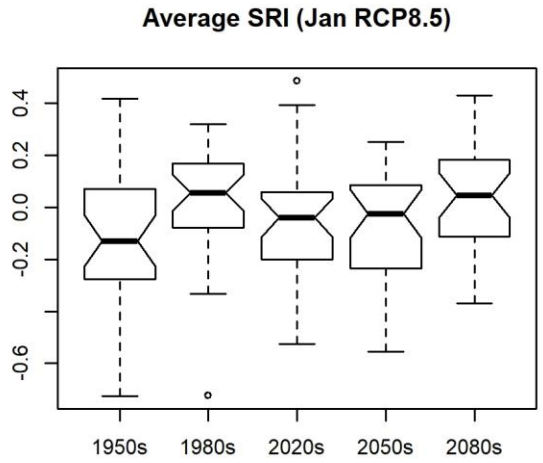
- Drought can increase and decrease depends on scenarios

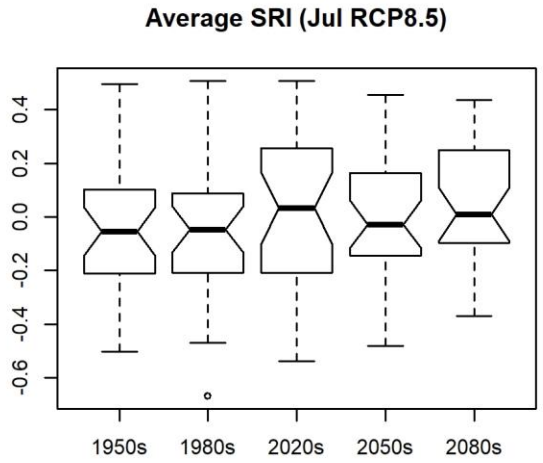












Wrapping up

- A downscaling framework has been demonstrated in this presentation, for analysing and projecting spatial drought conditions

- In the Seine, the Atlantic Multidecadal Oscillation (AMO), ENSO and the West Mediterranean Sea (WMED) can modulate drought conditions in the basin.

- Using these relationships between oscillations and droughts, water management measures can be designed based on tropical sea surface temperature disturbances and atmospheric teleconnections from the predictions of the climate models