

Development of hydro-meteorological reconstructions over France with the ISBA-MODCOU model

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- **Objective : to study the multi-decadal variations of the French hydrological cycle**
- **Data issues**
 - River flows :
 - Few long-term observations
 - Temporal homogeneity problems ?
 - Non-climatic anthropic influence ? (e.g. dam or pumping)
 - Other variables (evapotranspiration, soil moisture...)
 - No observations



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→ development of hydrological reconstructions

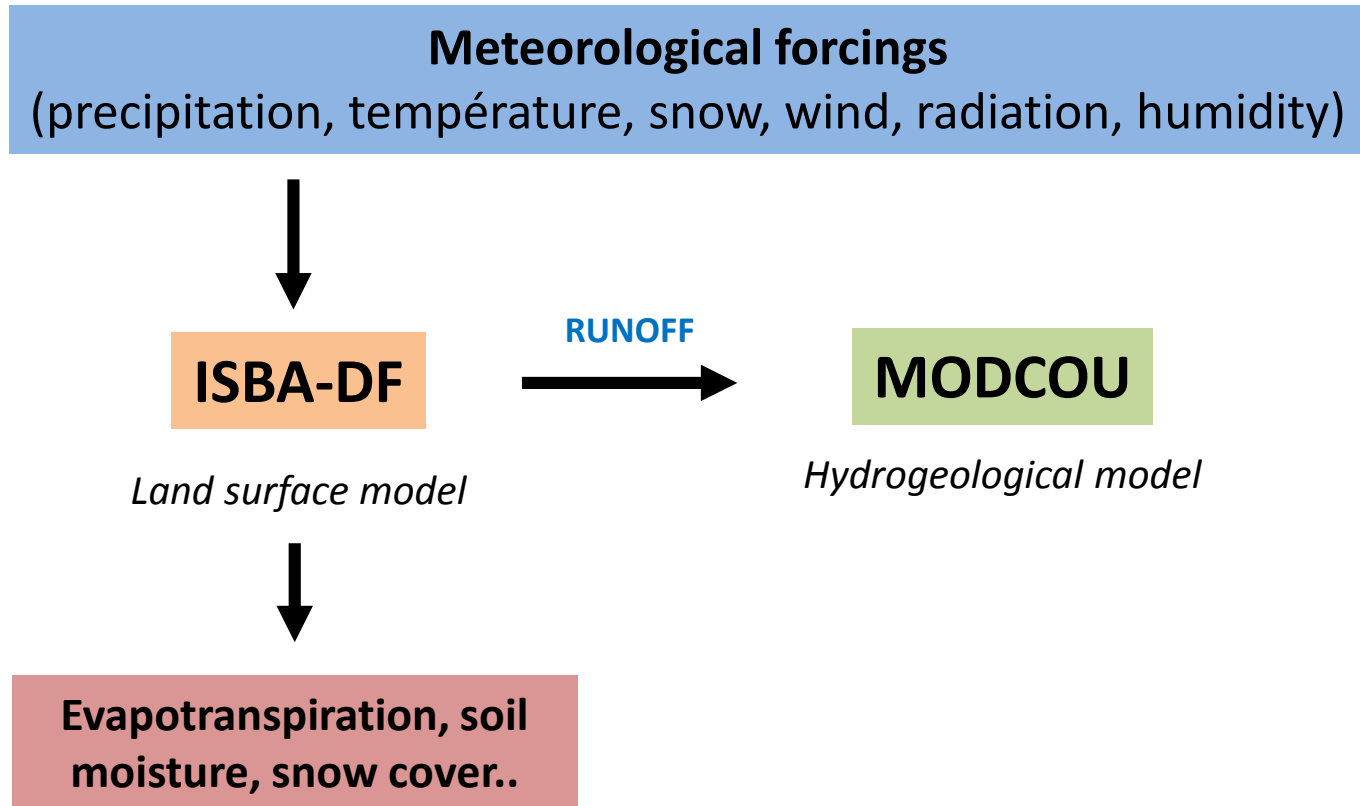
Meteorological forcings
(precipitation, temperature, snow, wind, radiation, humidity)



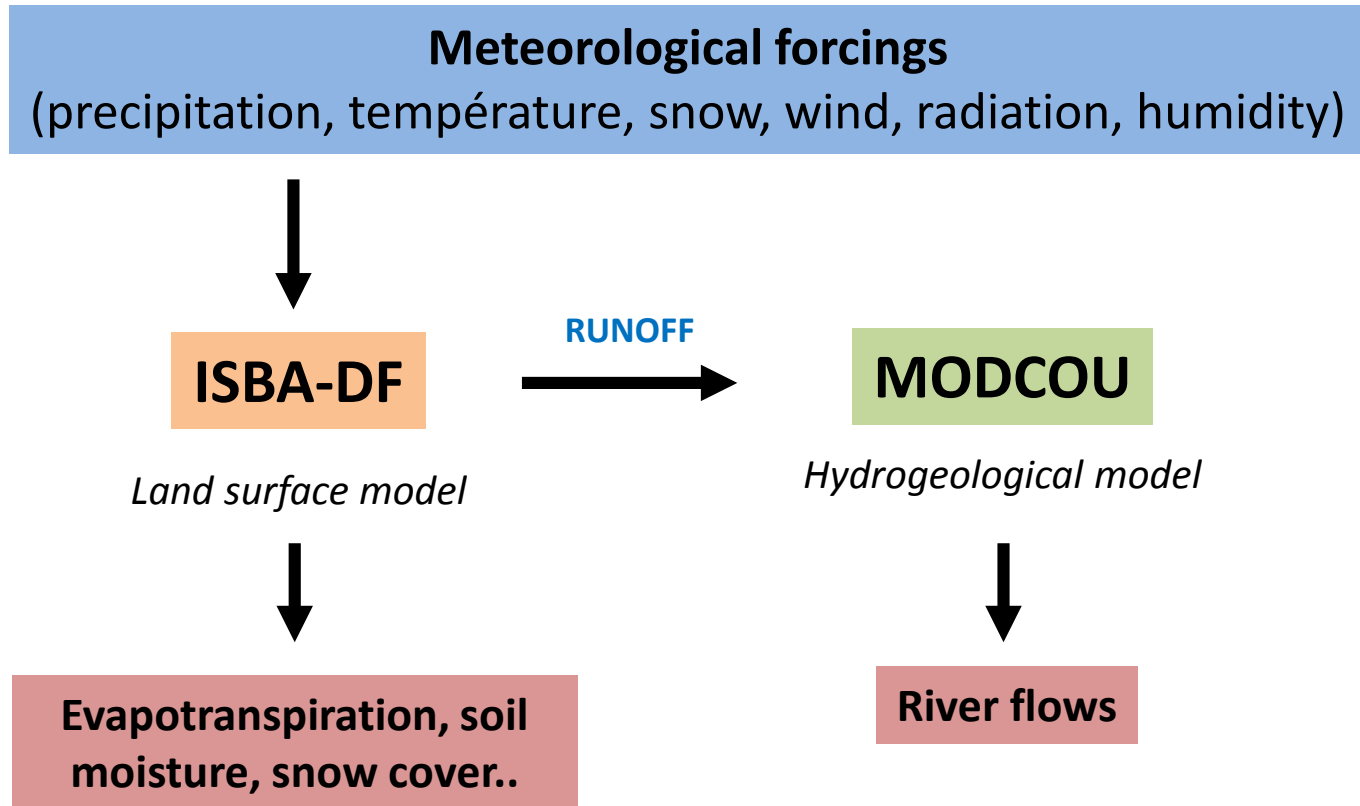
ISBA-DF

Land surface model

Habets et al, 2008



Habets et al, 2008



Habets et al, 2008

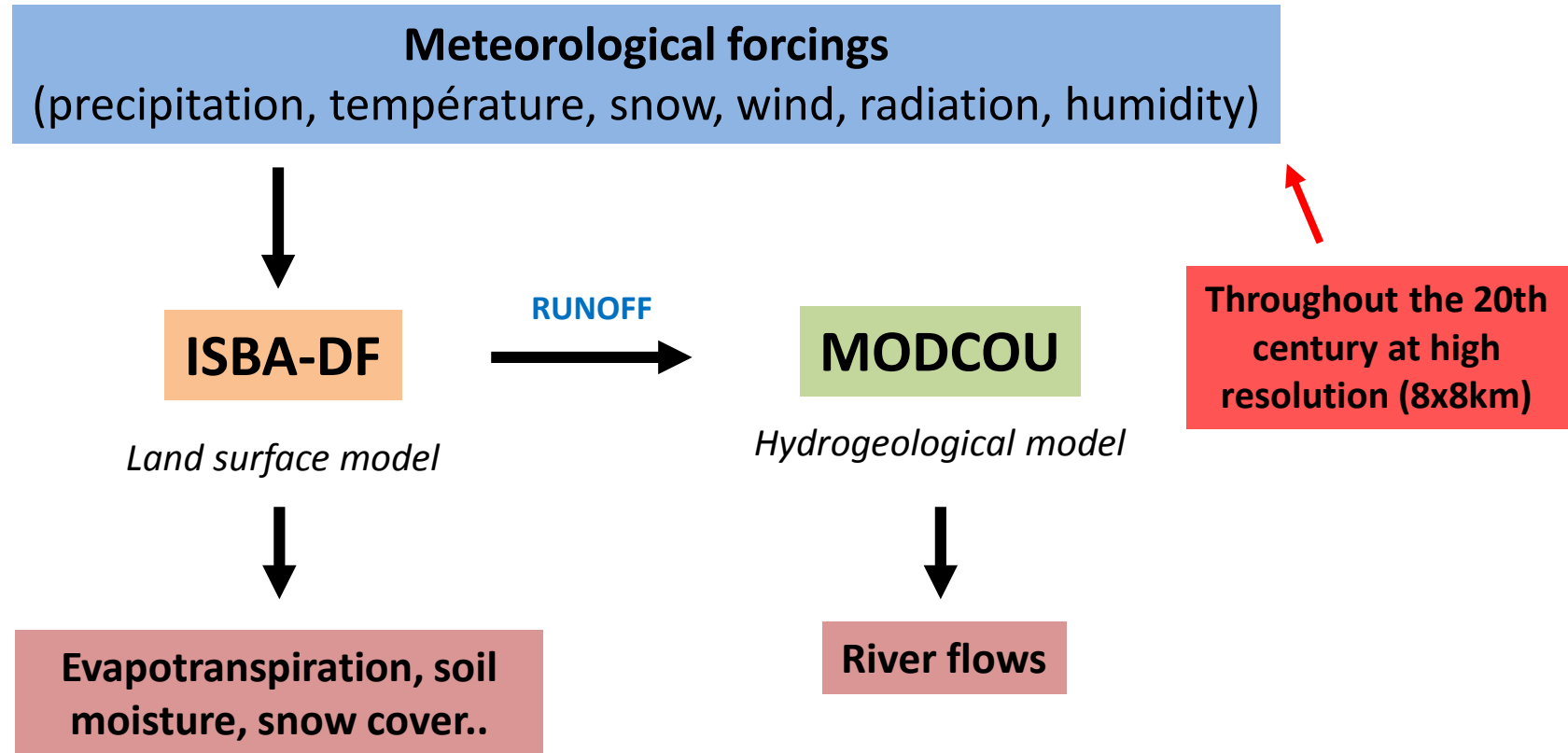
Interest of this hydrometeorological system:

- A lot of hydrological cycle variables available
- Only river flows calibration → concentration time in MODCOU (\approx daily time scale)
 - No river flows calibration at longer time scale
 - Dam or pumping no taken into account

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→ Independance between observed and simulated river flows



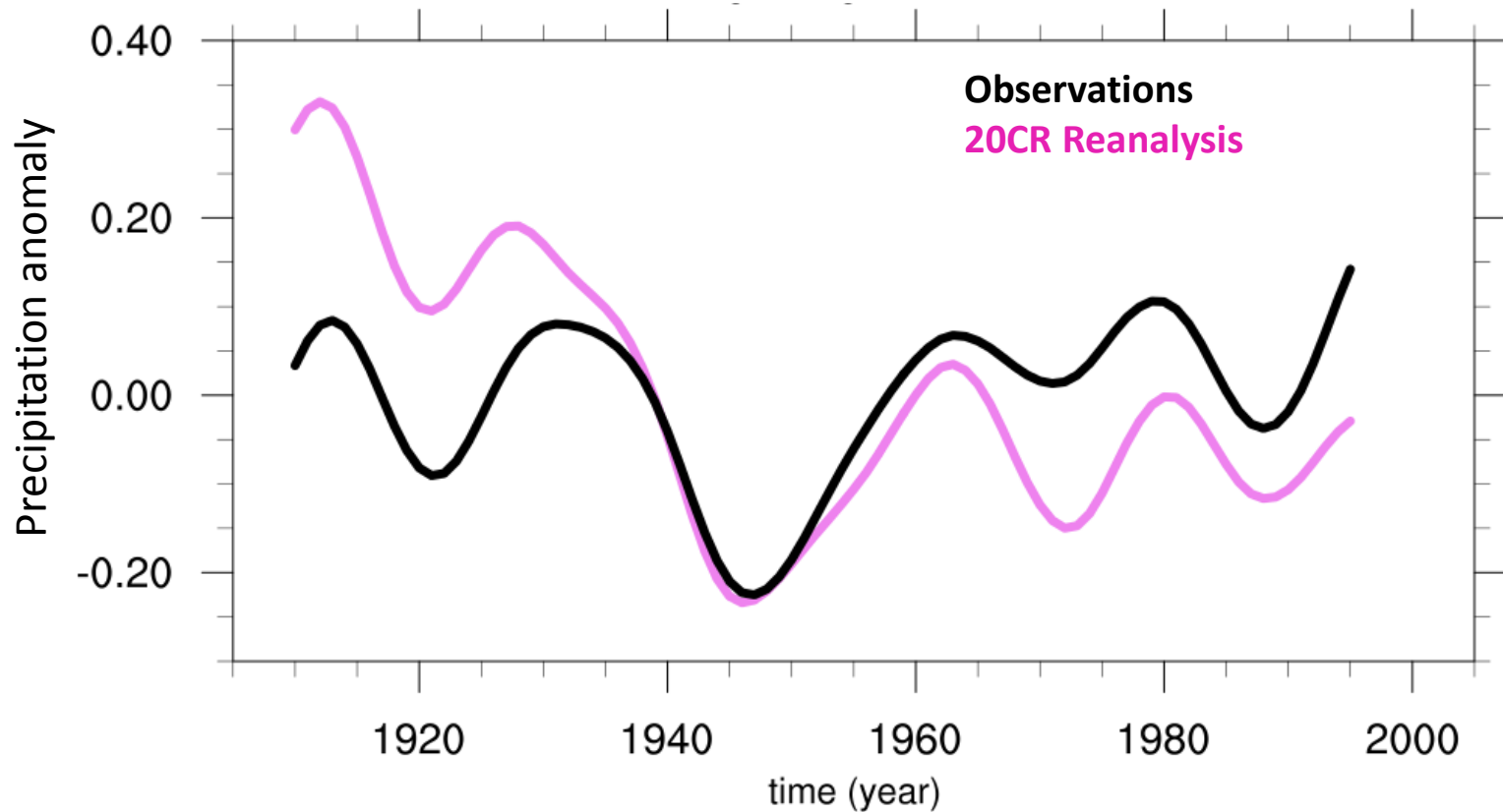
Habets et al, 2008

Analog method:

- **Hypothesis:** large scale climate state of day d1 \approx large scale climate state of day dn \rightarrow Local variables of day d1 \approx Local variables of day dn
- **Data:**
 - \rightarrow Large scale: 20CR and ERA20C reanalyses
 - \rightarrow Local scale: SAFRAN analysis (8x8km grid)
- **Predictors:** slp, tas, qfx850, hus850, TTI

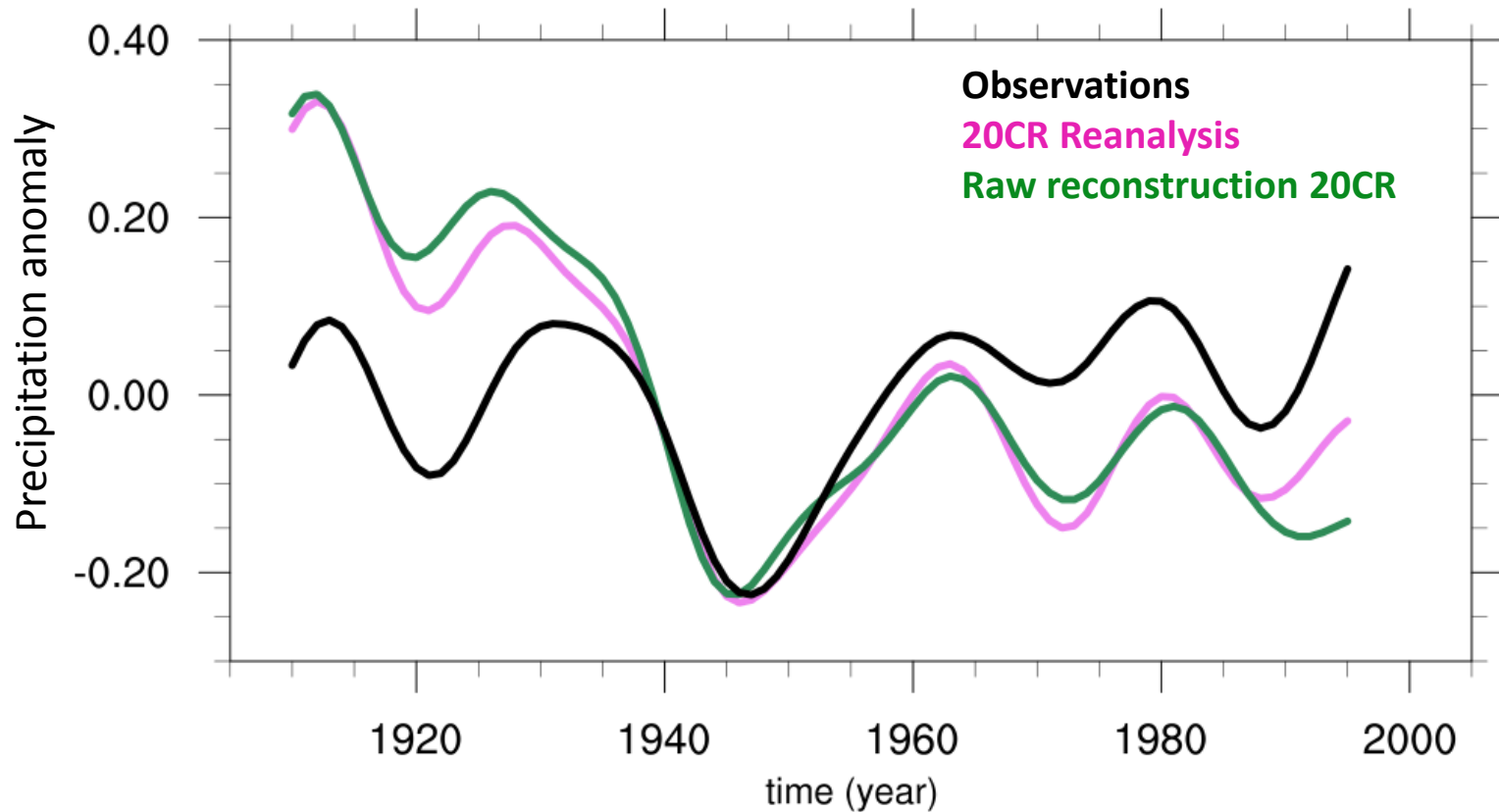
Dayon et al. 2015

Unrealistic trends can be present in the reanalyses



Low-pass filtered annual series of precipitation anomaly over France (21 years)

The reconstructions quality depends of the reanalysis



Low-pass filtered annual series of precipitation anomaly over France (21 years)



- **Problems:**

- Unrealistic trends and/or low frequency variations in the reanalyses
- Also seen in our raw reconstructions

Idea:

→ To use homogenised observations → to correct unrealistic trends and improve temporal variability

Concept:

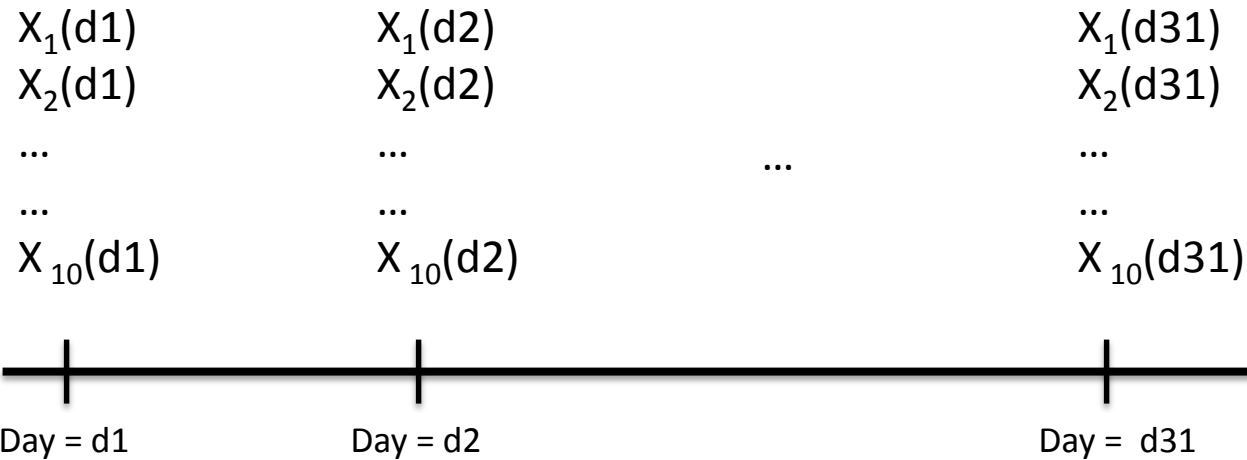
- Creation of a set of possible trajectories and selection of the closest to the observations
- Analog method = stochastic method → the k best analogs can be selected each day

Observations:

- Long-term monthly homogenized observations (Météo-France)
- Precipitation and temperature

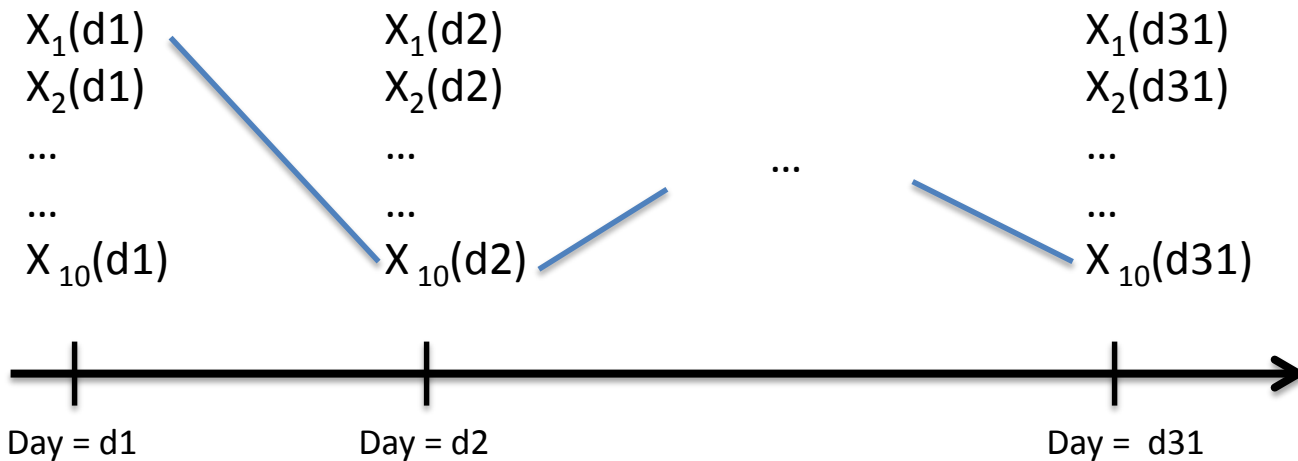
Observationally constrained downscaling

- 10 best analogs selected each day



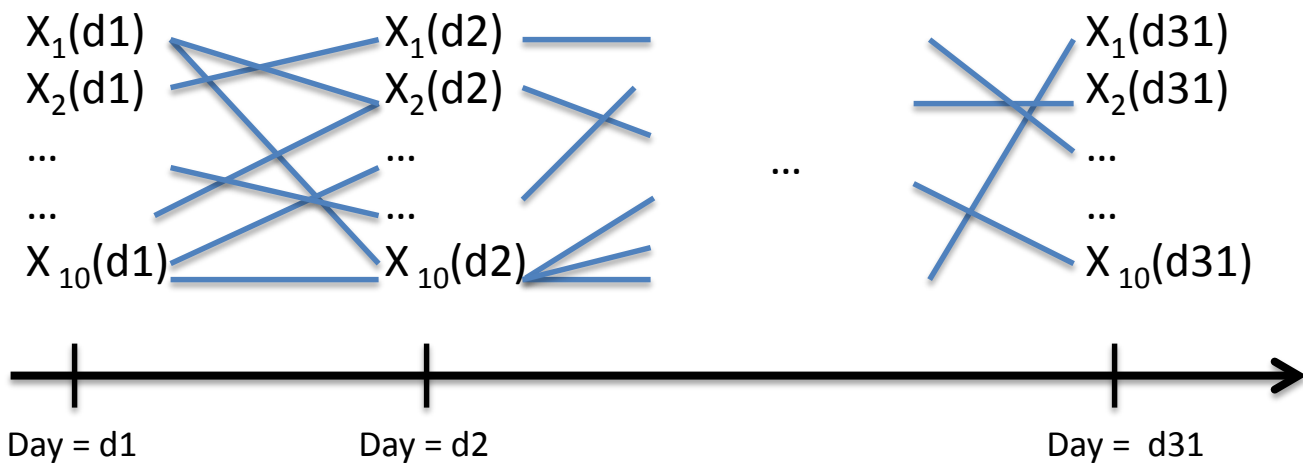
Observationally constrained downscaling

- 10 best analogs selected each day
- Each day \rightarrow one of the 10 best analog is randomly chosen

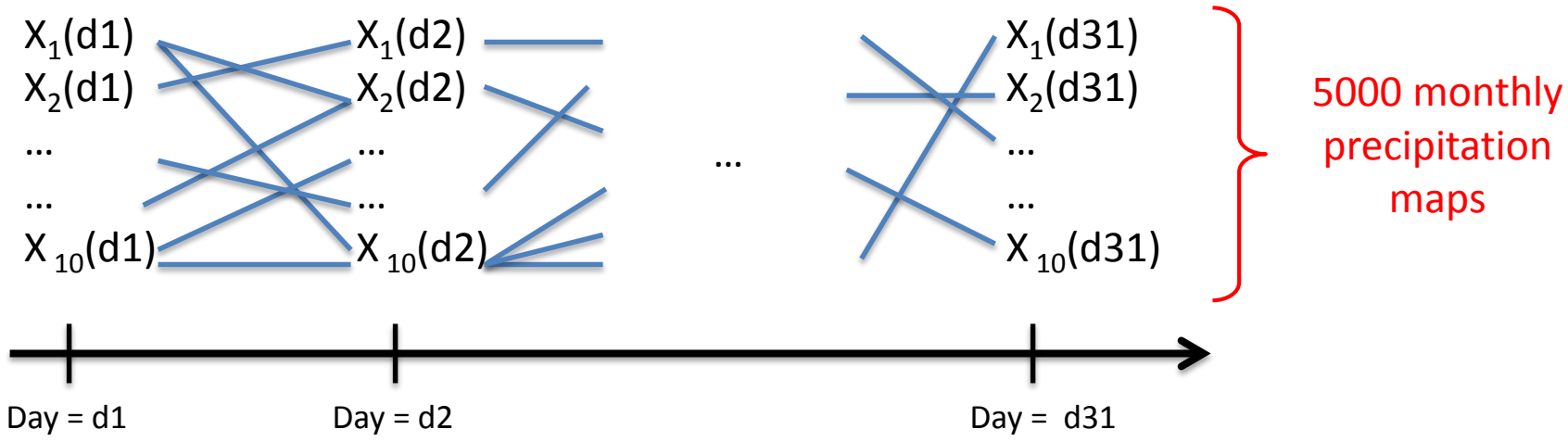


Observationally constrained downscaling

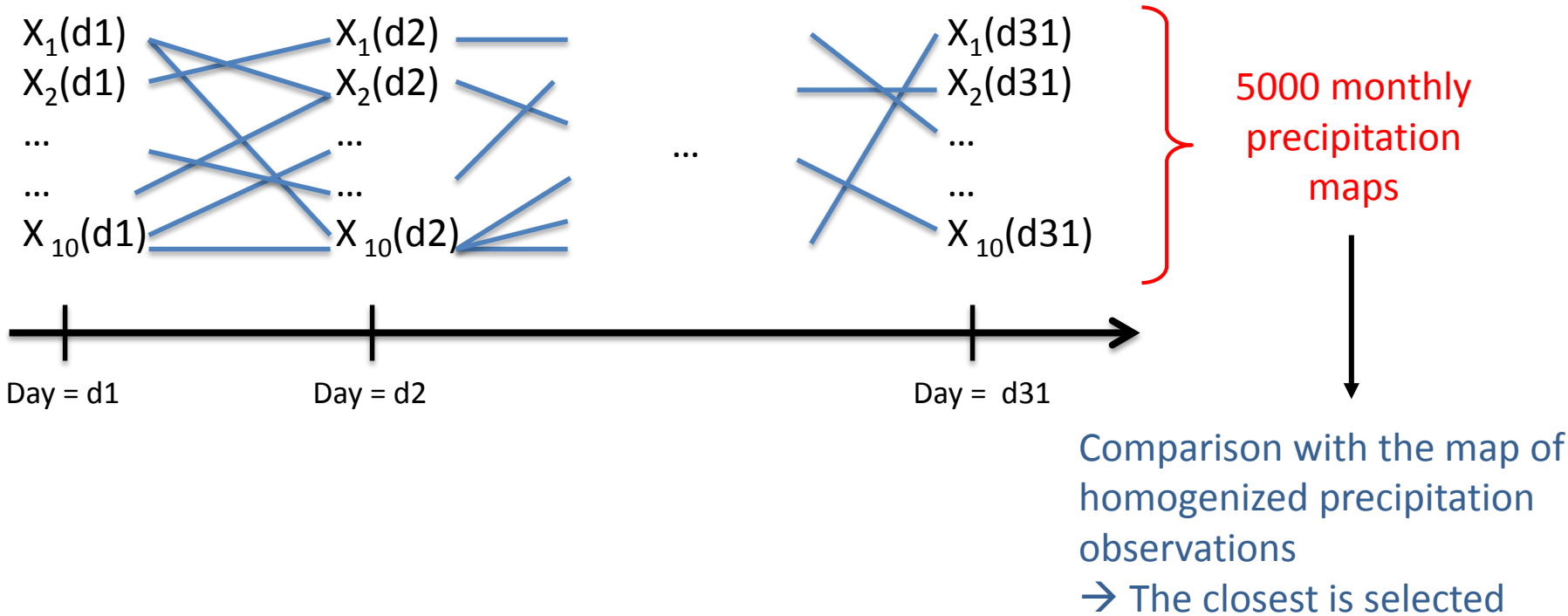
- 10 best analogs selected each day
- Each day \rightarrow one of the 10 best analog is randomly chosen
- This process is repeated 5000 times \rightarrow 5000 analog series



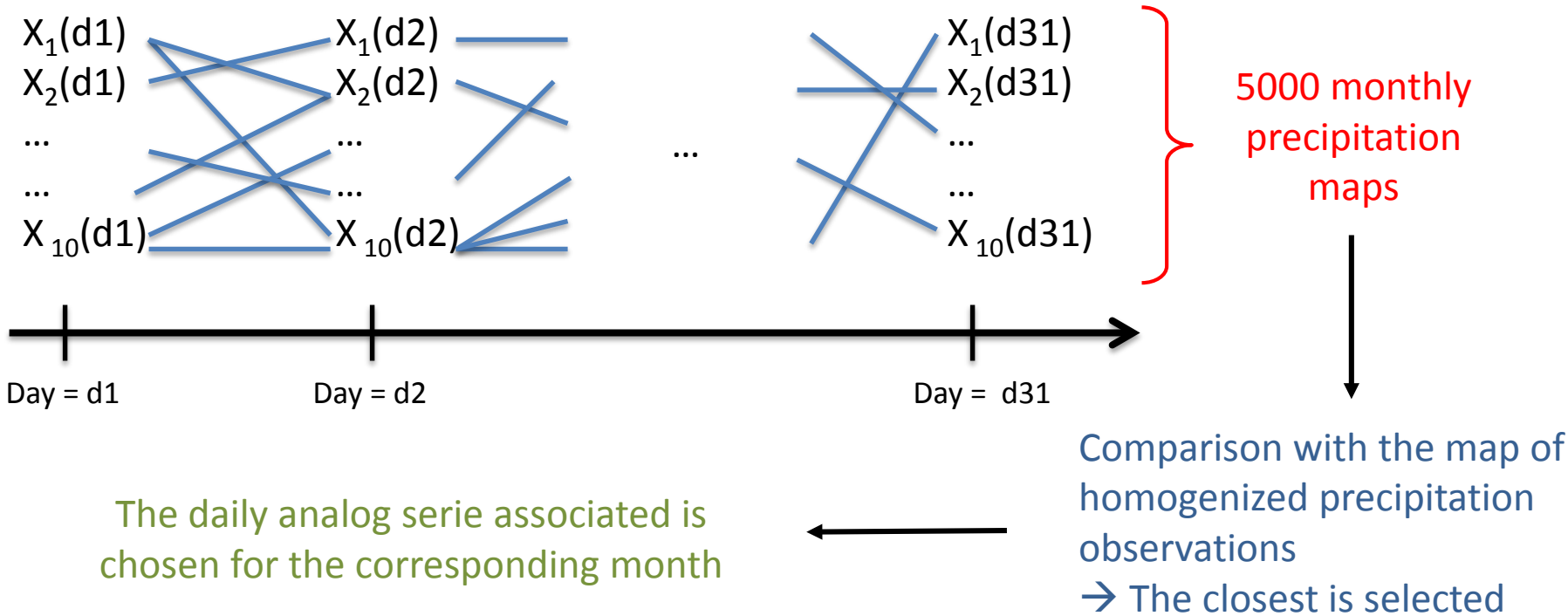
Observationally constrained downscaling



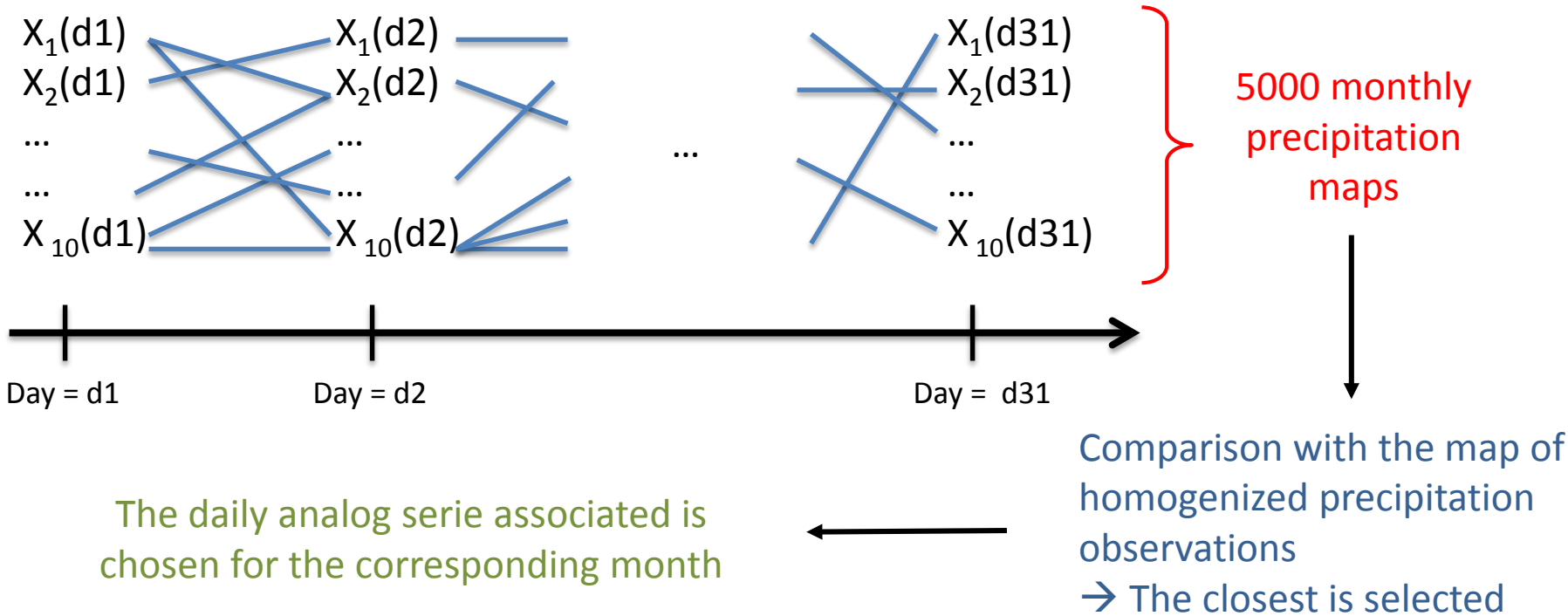
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Observationally constrained downscaling

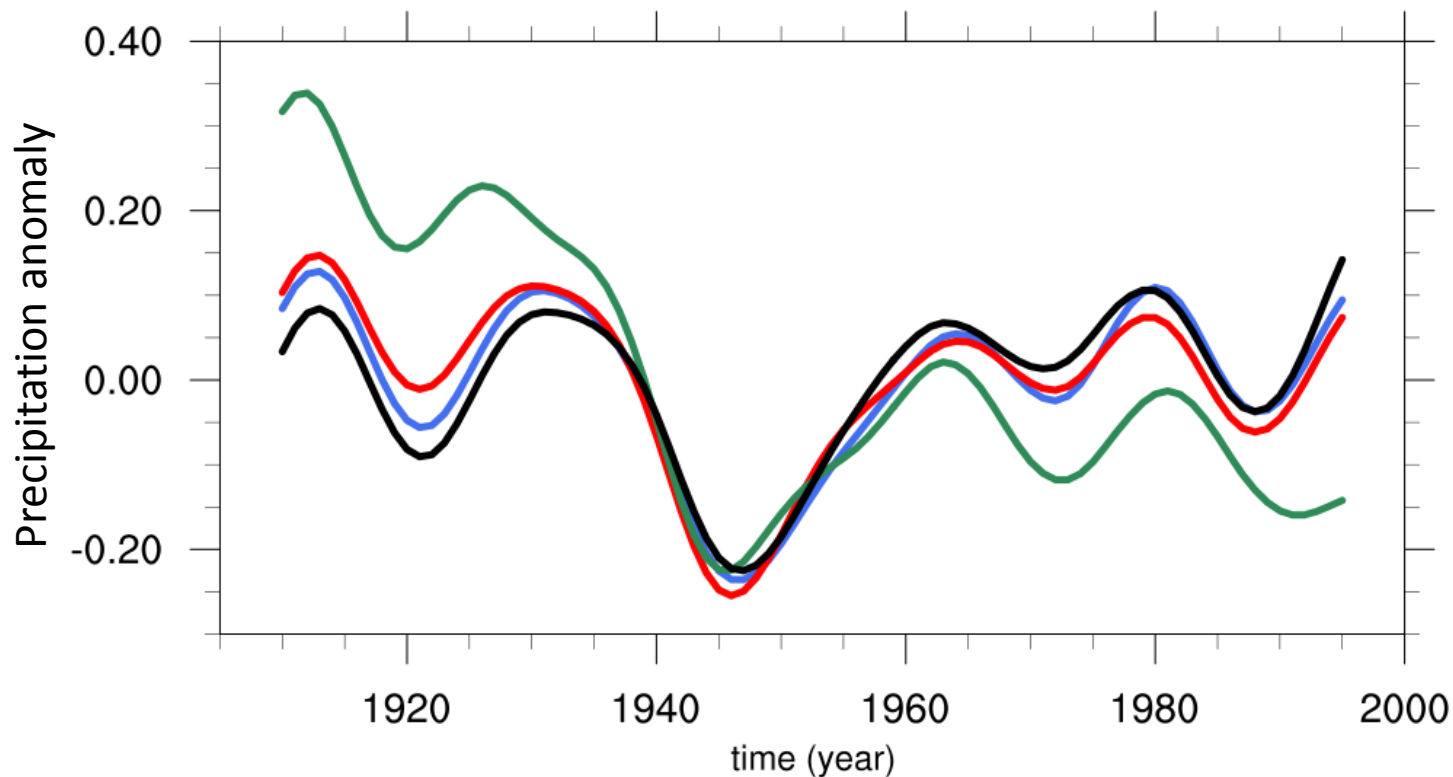


2 types of constraints:

- Constraint by precipitation
- Constraint by precipitation and temperature

Impact on precipitation reconstructions

No more unrealistic trend



Observations

Raw reconstruction 20CR

Reconstruction 20CR constrained by Pr

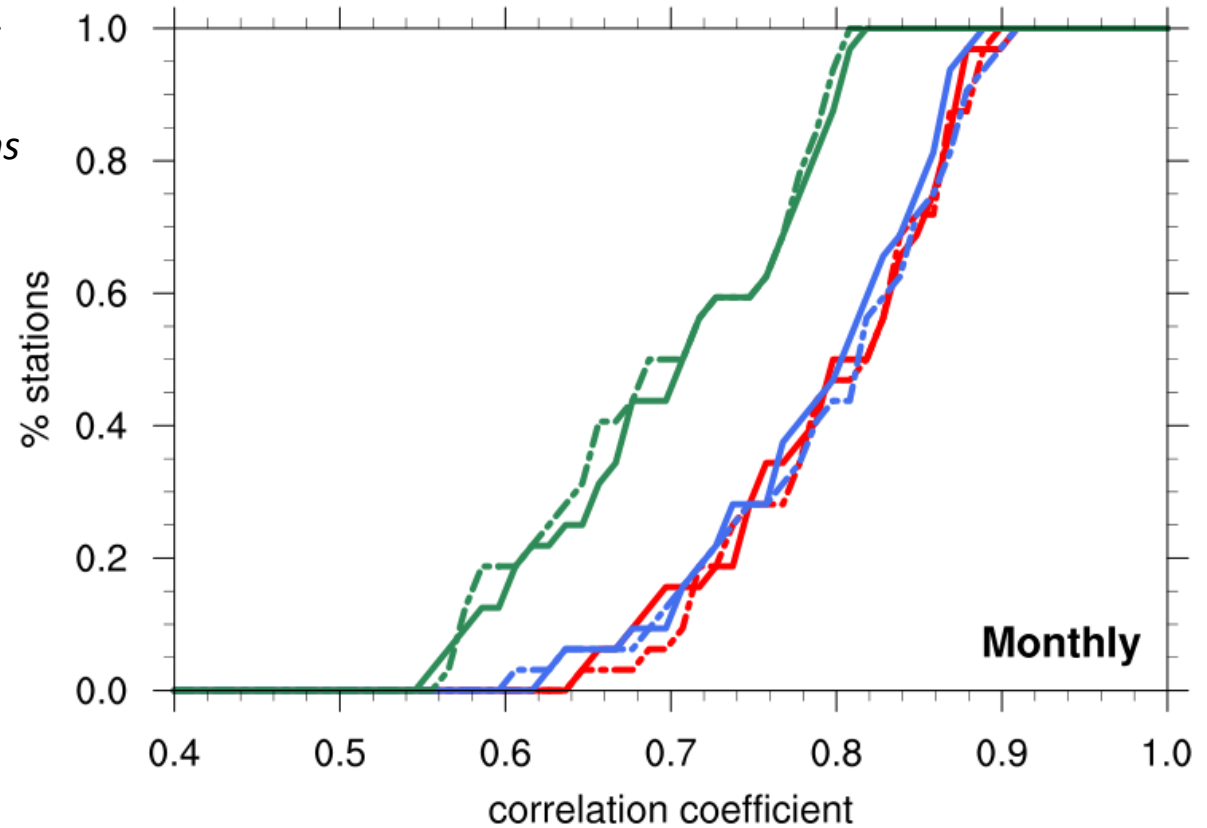
Reconstruction 20CR constrained by Pr and Tas

Low-pass filtered annual series of precipitation anomaly over France (21 years)

Impact on river flows reconstructions

Cumulative density function of monthly correlations between observations and reconstructions (deseasonalized)

River flows (over at least 70 years)



Raw reconstructions

Reconstructions constrained by Pr

Reconstructions constrained by Pr and Tas

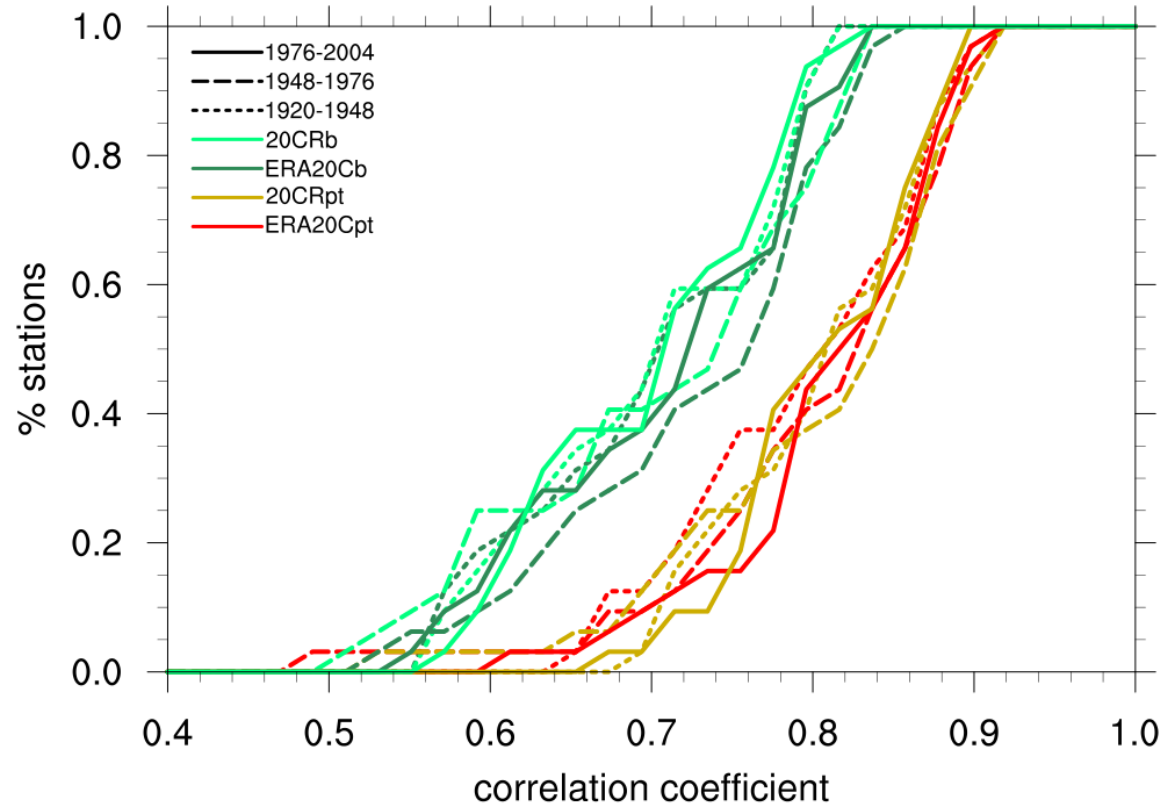
NOAA-20CR

ECMWF-ERA20C

—————

River flows (over at least 70 years)

Cumulative density function of monthly correlations between observations and reconstructions (deseasonalized)



1976-2004 ———
1948-1976 - - - -
1920-1948 ·····

Raw reconstruction (ERA20C)

Raw reconstruction (20CR)

Reconstruction constrained by Pr and Tas (ERA20C)

Reconstruction constrained by Pr and Tas (20CR)



Constraint by observations:

- ✓ Better representation of trends and temporal variability
- ✓ Reduction of biases (not shown)

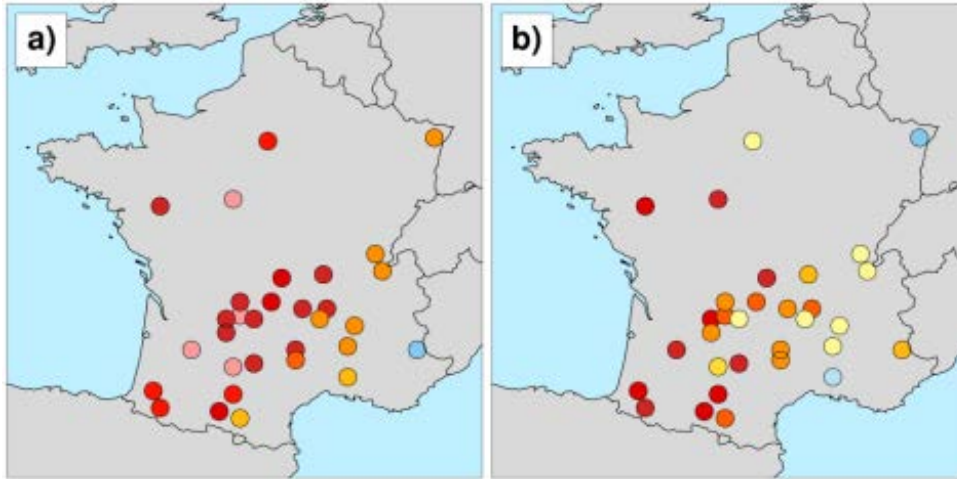
Reconstructions constrained by observations → good dataset to study the multi-decadal variability of the hydrological cycle

First application: relative change in river flows

Spring

Summer

OBSERVATIONS



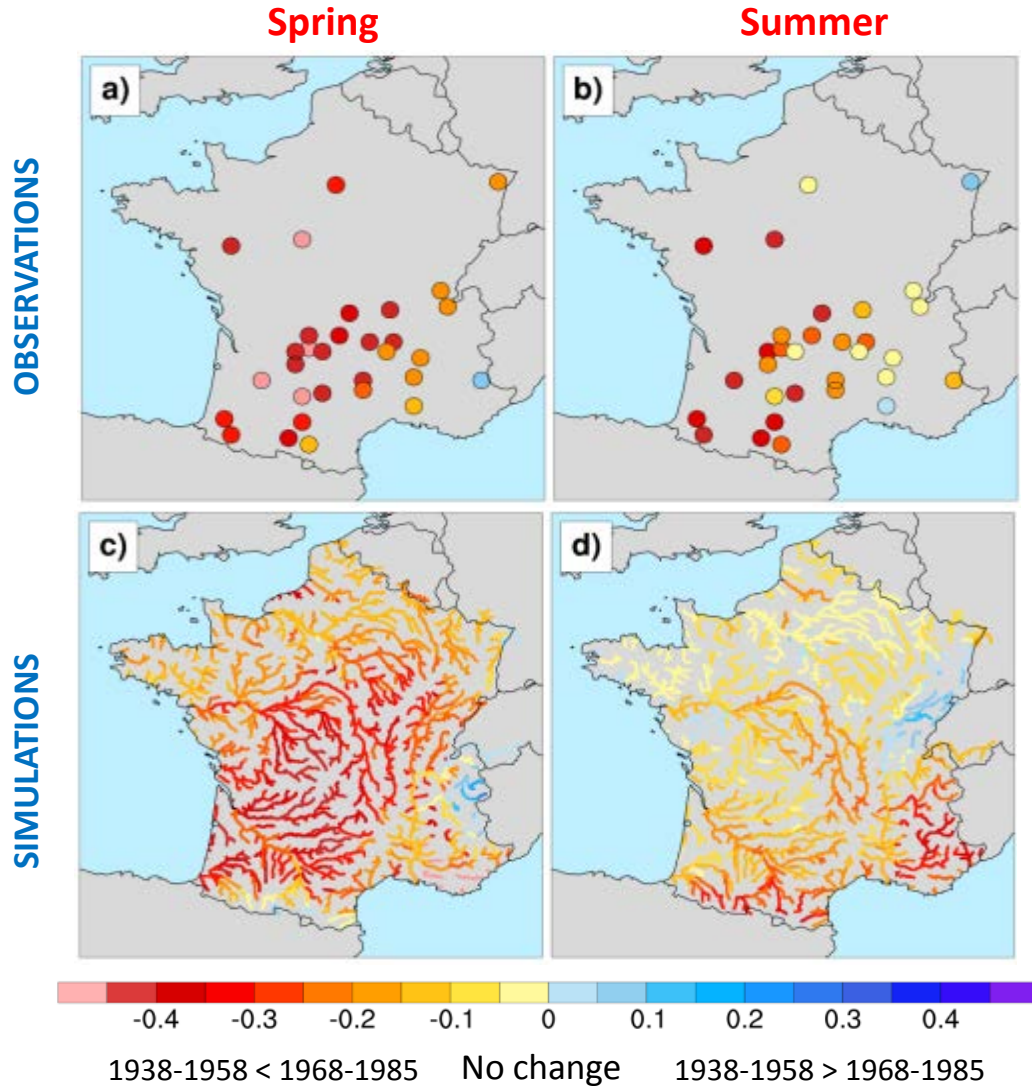
Relative change of detrended annual river flows between 1938-1958 and 1965-1985.



1938-1958 < 1968-1985 No change 1938-1958 > 1968-1985

Boé et Habets, 2014

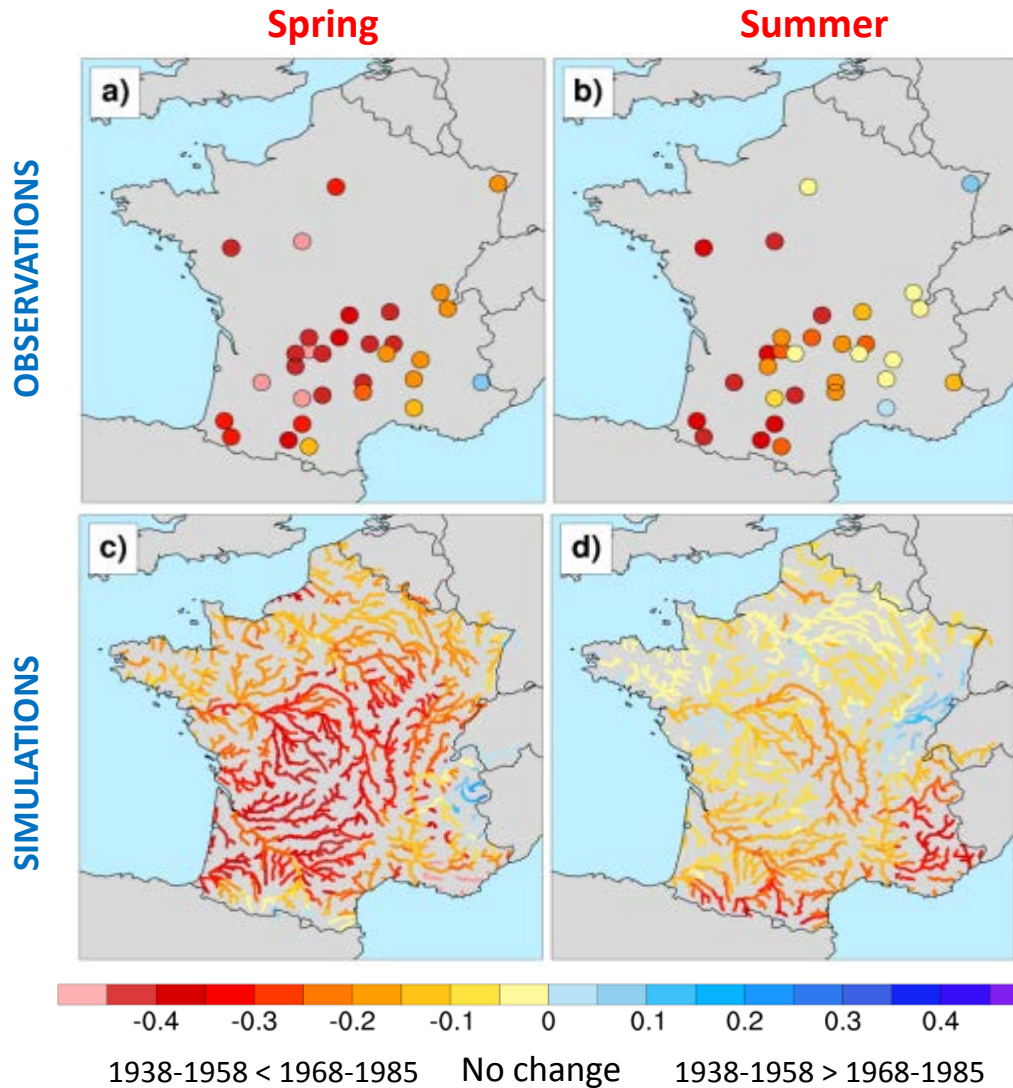
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Relative change of detrended annual river flows between 1938-1958 and 1965-1985.

**Reconstruction ERA20C
constrained by Pr and Tas**

First application: relative change in river flows

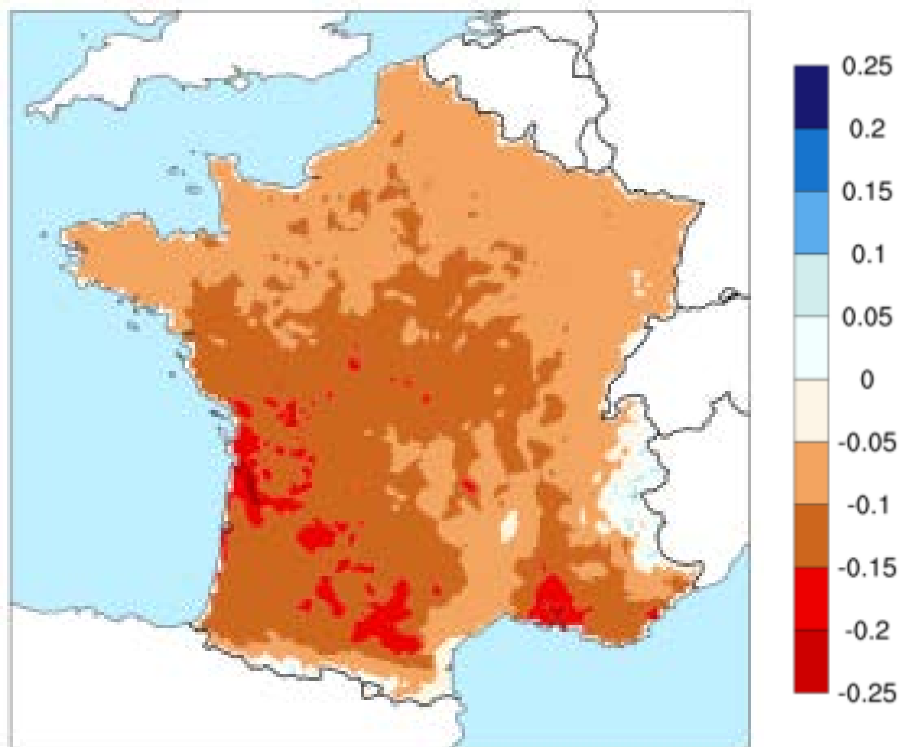


Relative change of detrended annual river flows between 1938-1958 and 1965-1985.

Multi-decadal variations in French river flows are climate driven

- Downscaling constrained by observations:
 - Improves the reconstructions quality
 - Provides an opportunity to study the low frequency variations of the hydrological cycle and the associated mechanisms

- To characterize of the multi-decadal variability of other hydrological cycle variables
- To understand the mechanisms behind these variations



Relative change of detrended annual soil moisture between 1938-1958 and 1965-1985.

**Reconstruction ERA20C constrained
by Pr and Tas**