Impact of multidecadal climate variability on policy-relevant low-flow estimates over France

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Low-flow statistics support the definition of legal thresholds used for estimating environmental flows, and for designing water structures or maximum abstraction levels. This works aims at demonstrating that such low-flow estimates are highly dependent on the period chosen for calculation, as a consequence of the large multidecadal climate – and thus hydrological – variability. The basis for this analysis is the SCOPE Hydro dataset, a 25-member ensemble daily streamflow reconstruction for more than 600 near-natural catchments in France covering the period 1871-2012 (Caillouet et al., 2017).

Sparce and scarce high-quality streamflow observations before the 1960s

- French Reference Hydrometric Network: 236 stations gauging near-natural catchments, with long records, and with high-quality measurement data (Giuntoli et al., 2013)

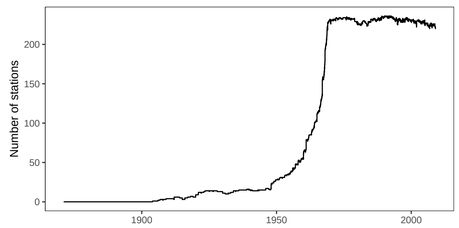

Figure 1: Evolution of the number of RHN stations with available data from 1871 onwards.

- No sufficient high-quality observations for assessing the impact of multidecadal climate variability on low-flow estimates

SCOPE Hydro: Historical daily streamflow reconstruction from 1871 onwards

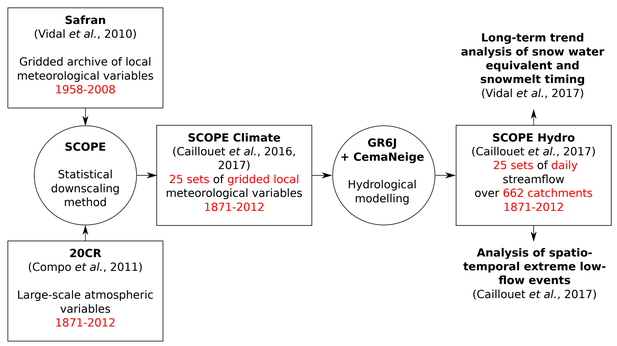

Figure 2: Hydrometeorological reconstruction scheme used to derive the SCOPE Hydro datset, and application examples.

Policy-relevant low-flow estimates: QMNA5

- QMNA5: annual monthly minimum streamflow value with a 5-year return period
- Fit on a lognormal distribution with the L-moments in a probabilistic way:
  - 1 best estimate
  - 100 replications to take account of sampling uncertainty
- Application for:
  - 236 RHN catchments
  - 7 × 20-year periods covering 1871-2010
  - 3 datasets:
    - **Observations**
    - **SCOPE Hydro** (25 time series)
    - **SAFRAN Hydro**: daily streamflow reconstructions based on hydrological modelling (GR6J+CemaNeige) driven by the SAFRAN reanalysis

Evolution of low-flow estimates for a case study catchment

Figure 3: Low-flow values estimated for the Gartempes@Folles catchment, for the 7 time periods and the 3 datasets. Filled points show best estimates for individual series, and violins show the sampling uncertainty (plus downscaling uncertainty for SCOPE Hydro)

Evolution of low-flow best estimates across France and datasets

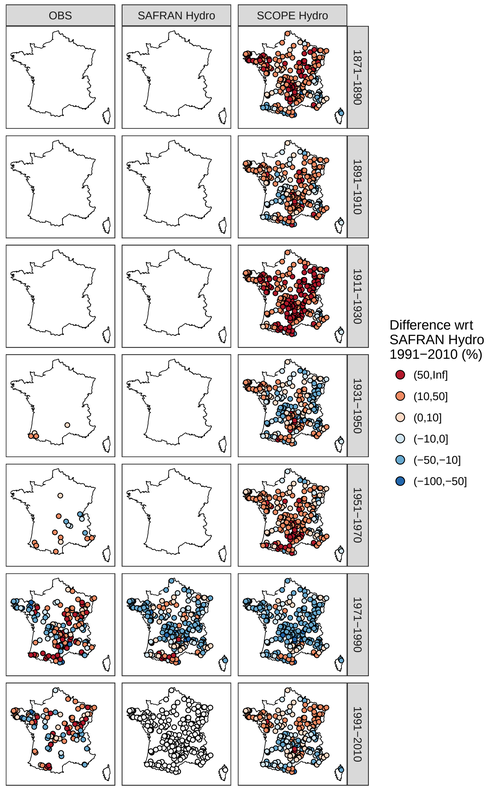

Figure 4: Evolution of low-flow best estimates for each station and each dataset, as anomalies with respect to SAFRAN Hydro values for the most recent period (1991-2010)

Are there historical time periods with statistically different low-flow estimates?

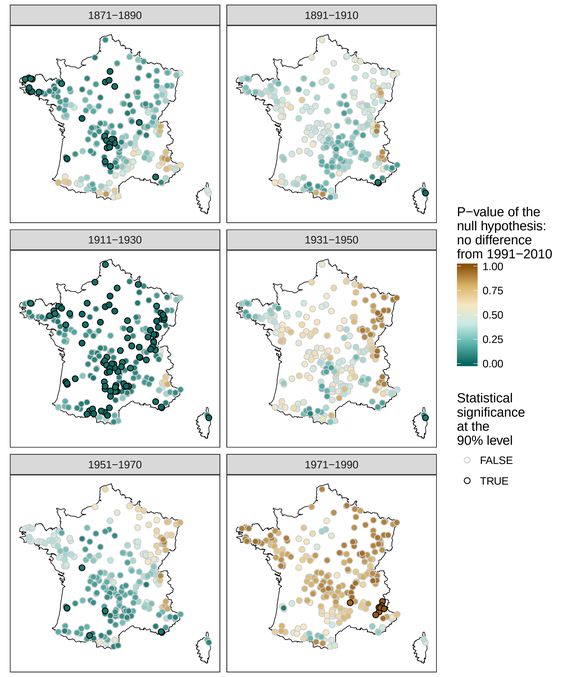

Figure 5: Statistical significance of differences of low-flow estimates with respect to those of the most recent period 1991-2010, within the SCOPE Hydro dataset. Brown colours indicate drier periods and green colours wetter periods.

- Large errors in hydrological modelling (cf. differences between OBS and SAFRAN Hydro in Fig. 4)
- Large impact of multidecadal variability on low-flow estimates with consistent patterns over France (within SCOPE Hydro, Fig. 5)
- General drying over time, with significantly wetter period 1911-1930

Results critically question current practices for estimating legal streamflow thresholds, which generally use a short and recent period for determining low-flow statistics and their associated uncertainty.

Perspectives

- Reduction of uncertainty in historical reconstructions by assimilating surface weather observations in the SCOPE Climate dataset, with an offline Ensemble Kalman Filter approach (Alexandre Devers on-going PhD thesis)
- Assessment of added value for streamflow reconstructions and especially for historical low-flow estimates

See poster "High-resolution reanalysis of precipitation over France through offline data assimilation in a downscaled ensemble meteorological reconstruction" by A. Devers et al., Hall A at board number XA.124 (Fri. 13:30-15:00)

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