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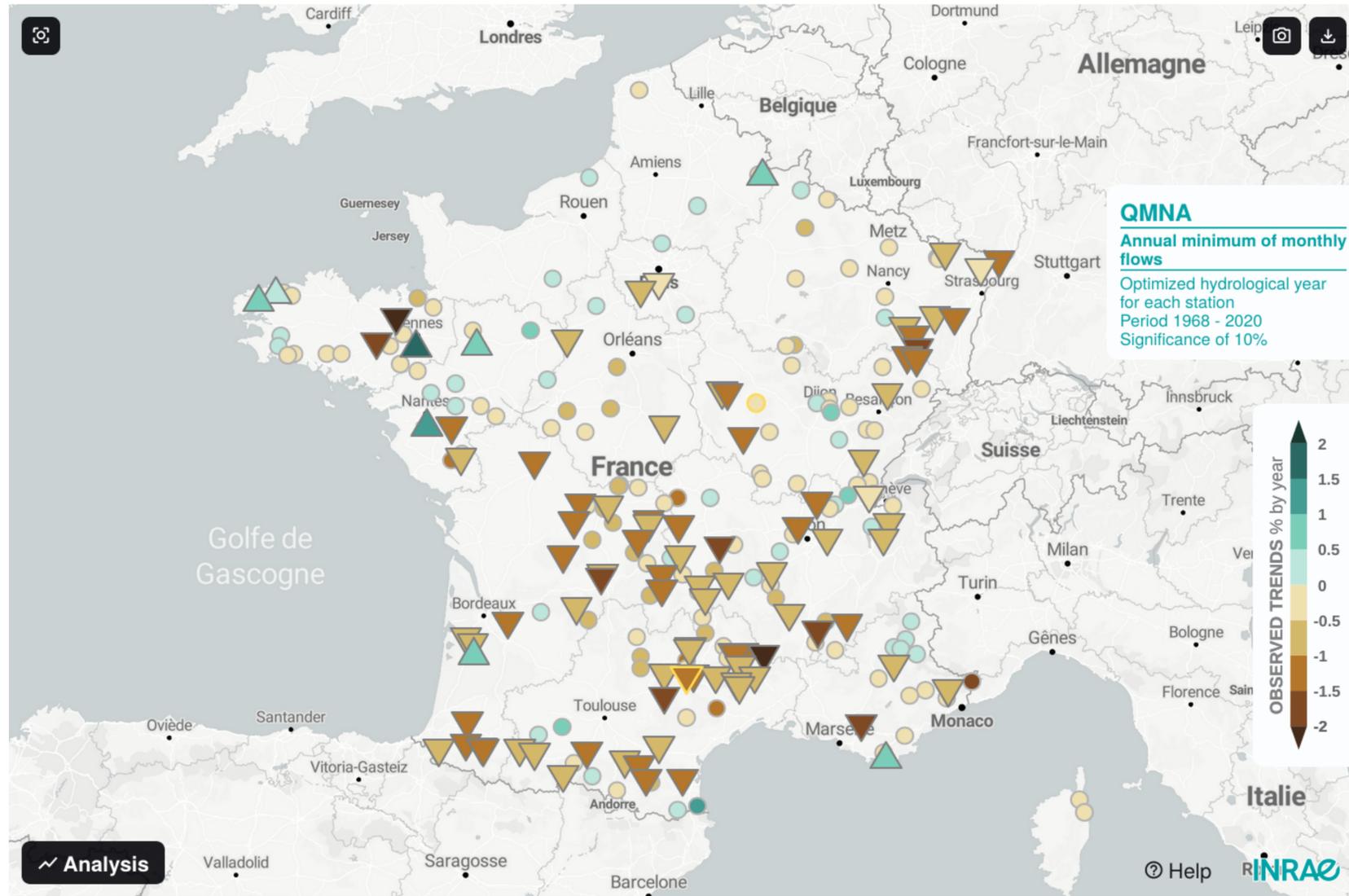
# MAKAHO : An interactive cartographic Tool for Trend Analysis of hydrological extremes in France

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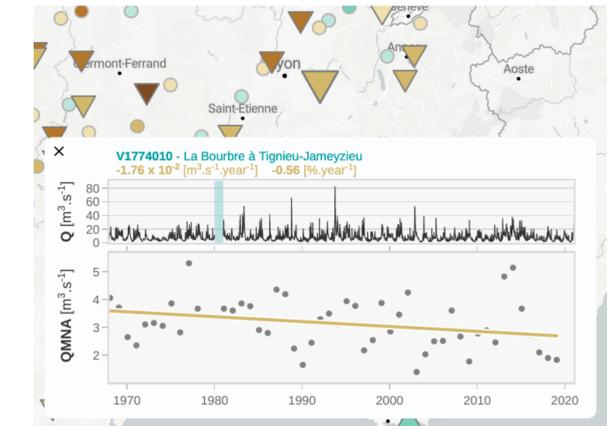
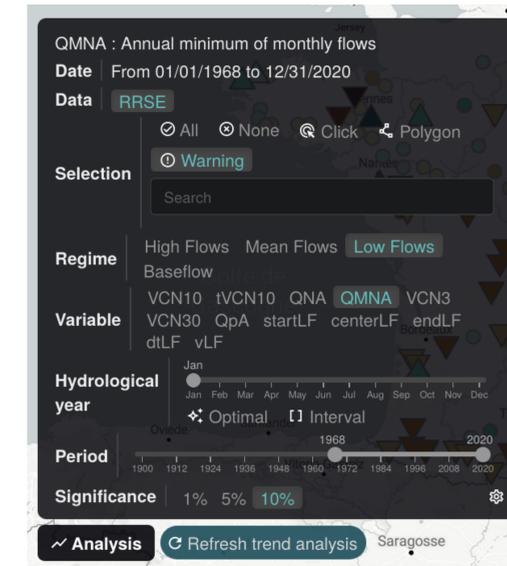
<https://makaho.sk8.inrae.fr>



## Interface

Calculations are performed **on the fly**, allowing greater customisation of analyses. Users can choose between nearly **50 variables** organized by hydrological topics.

The definition of the **hydrological year** is fully customizable and an optimal hydrological year is proposed based on hydrological considerations about the variable. The **analysis period** can be adjusted as well as the **significance level** of the Mann-Kendall test.



A click on a station displays the **time series** for the variable of interest.

## Data processing



[git@super-lou/EXstat](mailto:git@super-lou/EXstat)

The daily discharge series are stored in the form of a table and are entirely processed by the **EXstat** R package. Initially, the aggregation of daily data into an annual variable is carried out following parameterization files standardized by the **CARD** project. Trend analysis is then performed on the resulting annual variable. MAKAHO thus is an interface with the EXstat package.

## Tech stack



Web interface and data management



Interactive map



Aggregation process based on dplyr



Shiny web hosting by SK8 INRAE project

**MAKAHO** (MAnn-Kendall Analysis of Hydrological Observations) is an interactive cartographic visualization system designed to **examine trends in hydrometric observations** from the **232 stations** belonging to the French Reference Hydrometric Network (*Giuntoli et al., 2013*). These stations show a **high measurement quality**, time series with a historical depth of over 40 years, and they crucially gauge near-natural catchments. The statistical test used for trend detection is a variant of the **Mann-Kendall test** accounting for first-order autocorrelation. The trend slope is provided by the **Theil-Sen estimator**.

Giuntoli, I., Renard, B., Vidal, J.-P., and Bard, A. (2013). Low flows in France and their relationship to large-scale climate indices. *Journal of Hydrology*, 482:105–118. <https://doi.org/10.1016/j.jhydrol.2012.12.038>

## Key results

- > Between 1968 and 2020, the hydrological situation in France exhibited a **marked contrast** between the **northern upward trends** and the **southern downward trends** in mean discharge.
- > Nearly **10 % of stations** show an **upward significant trend** in the **annual maximum daily streamflow** at the 90 % confidence level with an average increase of 13 % per decade. Almost all of these stations are located in the northern part of the country.
- > Mainly located in the south, around **40 % of stations** show a **decreasing trend** in the **annual minimum monthly discharge**, with an average intensity of about 11 % per decade.
- > The **duration of low flows** has **significantly increased in all the country** with an average of more than **10 days per decade**, reaching almost a month in extreme cases in the southwest.

## Datasheets

Each hydrometric station has **technical sheets** summarizing all trend analysis results for a selection of variables. These datasheets are directly downloadable from the website.

