# Using a hybrid hydrological modelling approach to simulate drying patterns in 3 non-perennial European river networks

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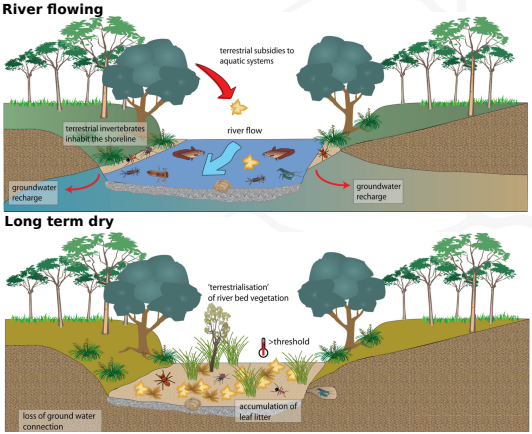
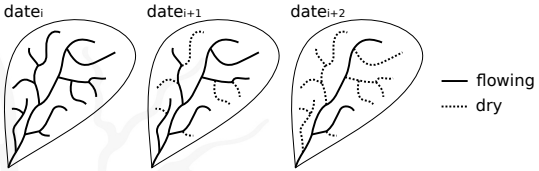
To study the impact of drying on the freshwater communities, ecologists need **spatialized long time series of flowing condition** (flowing or dry) across the river networks.




(Steward, Datry, and Langhans, 2022)



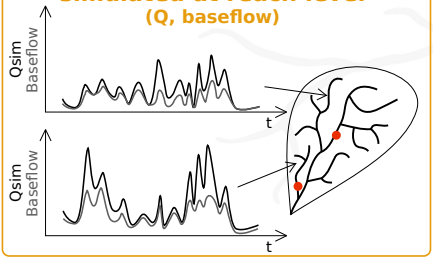

**Objective: Developping a spatialized flow condition model to meet ecological challenges**

## Modelling method

Climate data
Geophysical data

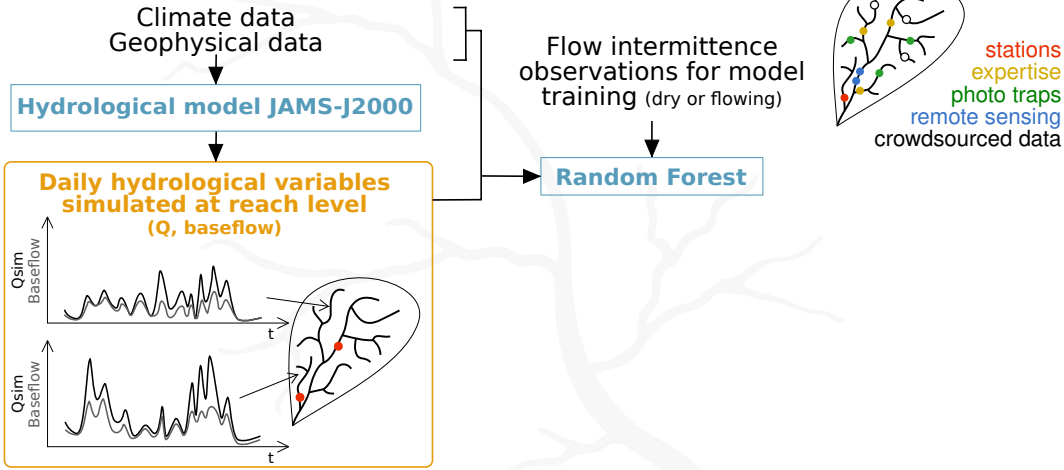
**Hydrological model JAMS-J2000**

**Daily hydrological variables simulated at reach level**
**(Q, baseflow)**




- Gauging stations for calibration

## Modelling method

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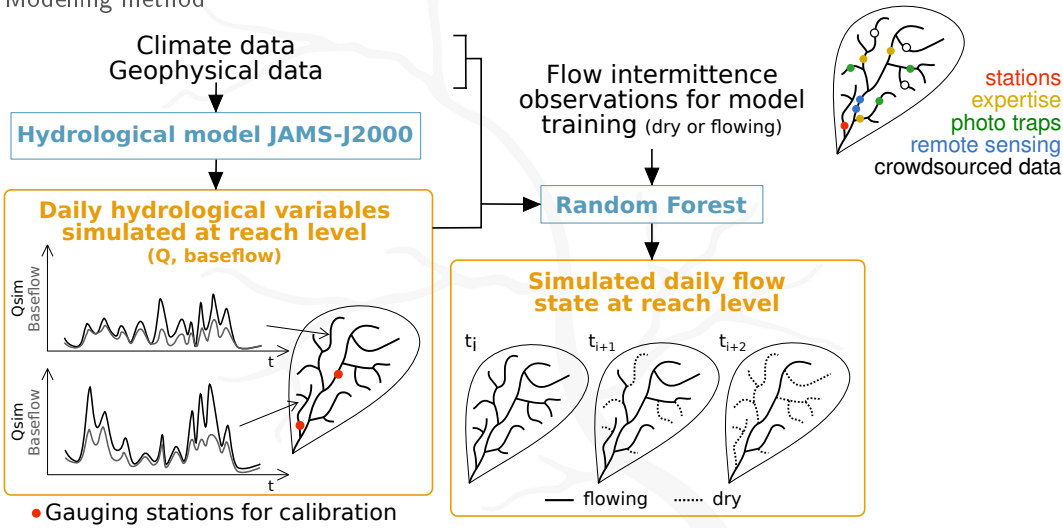
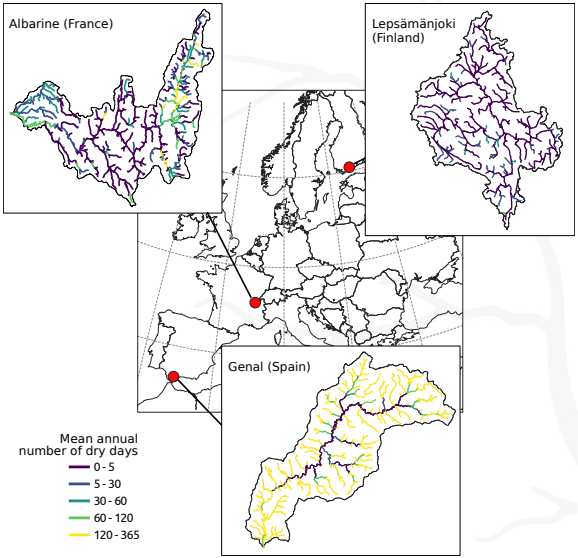
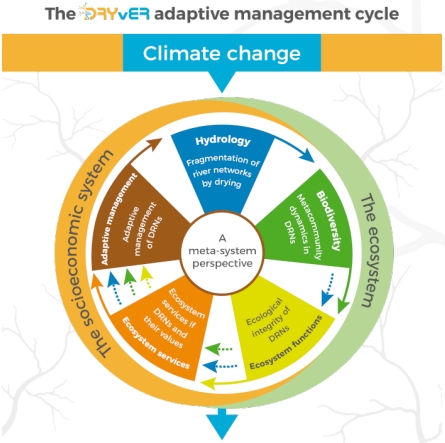





Analysis of the

- model's performance
- spatio-temporel patterns of drying in the river networks
- sensitivity to the size of the training data
- sensitivity to the type of training data

This study is part of a multi-disciplinary project **DRYvER on drying rivers and climate change** (Datry et al., 2021)



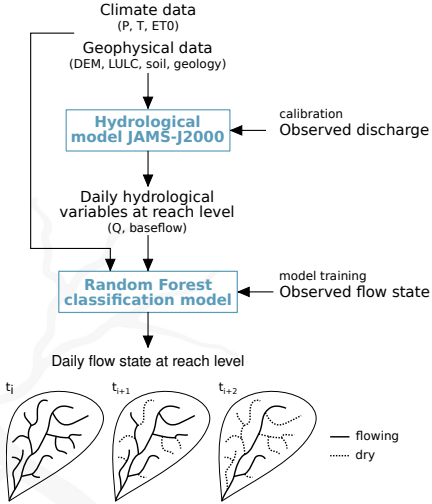

**Adaptive management of drying river networks**

Objectives of the project:

- Studying the impact of climate change on drying river networks
- Evaluating the consequences of drying on biodiversity and ecosystems

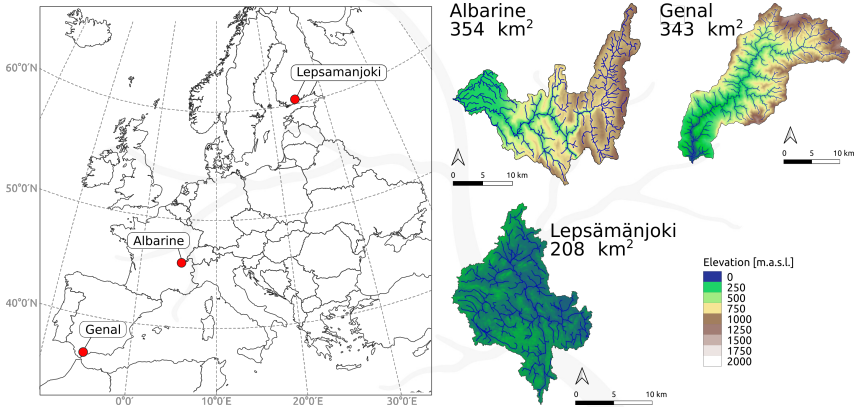
Objectives of this study

- Developping a **flow intermittence model** using a **hybrid approach**: coupling between a distributed hydrological model JAMS-J2000 and a Random Forest model (RF)
- Analyzing the **spatio-temporal patterns of drying** in 3 European drying river networks
- Analyzing the **impact of the amount and type of observed data used to train the RF model** on the simulated patterns of drying

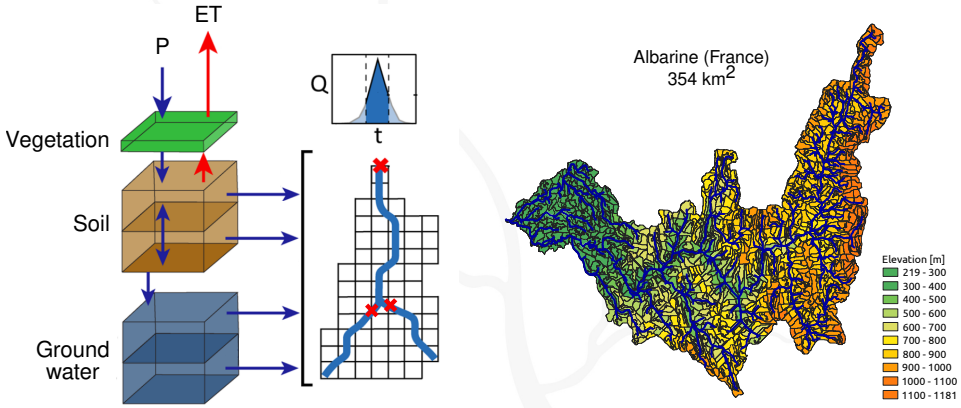


# Study area

This study focuses on **3 European drying river networks** with constrasting climates and causes of drying (climatic droughts, geology, water abstraction).

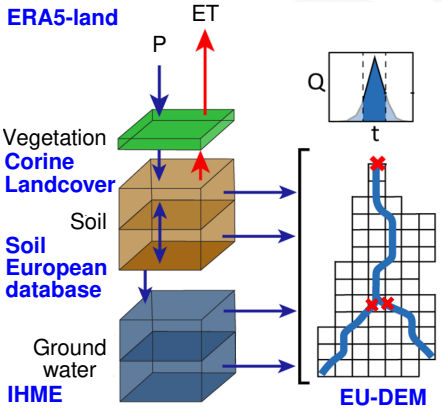


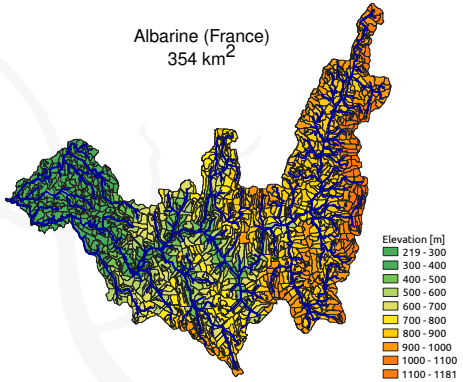
## Distributed hydrological model J2000 (Krause, 2002)



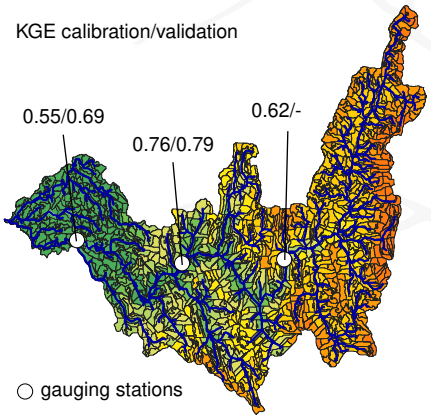

The J2000 model is spatially discretized in Hydrological Response Units (HRUs). It simulates the hydrological processes on the HRUs and then routes the flow components between the HRUs and along the river network.

## Distributed hydrological model J2000 - Harmonized input datasets for the 6 basins

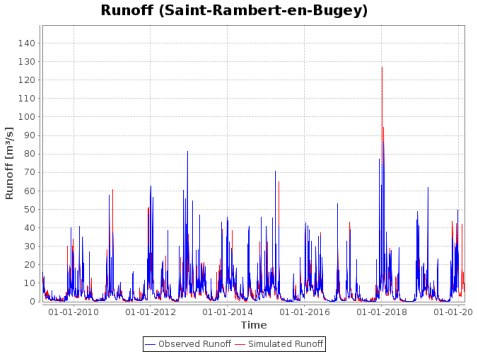


The J2000 model is calibrated using a **multi gauges** and **multi-objective** calibration with a focus on low flows.




Albarine river basin




Simulated and observed daity discharge for the validation period at the Saint-Rambert gauging station in the Albarine river basin

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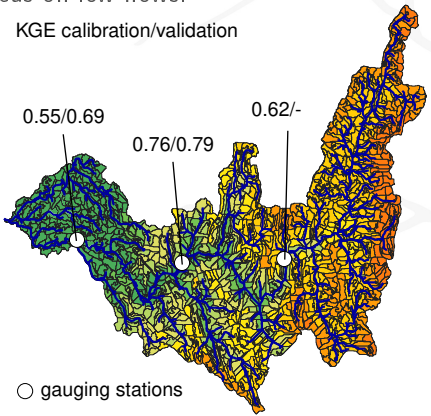


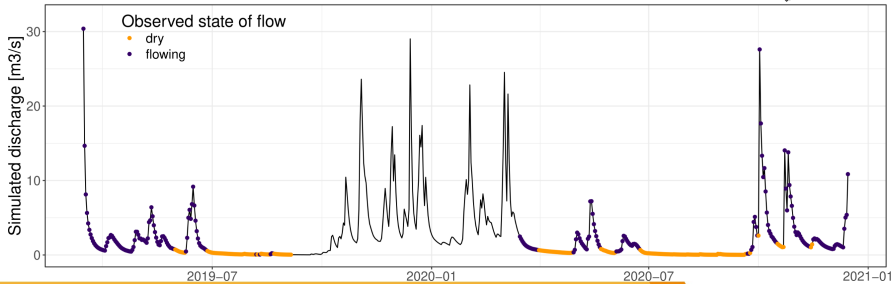

Albarine river basin

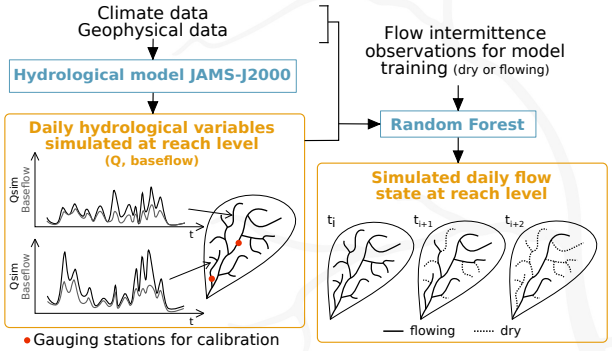
Calibration and validation results in the 2 other river basins

| Basin | KGE calib. | KGE valid. |
|---|---|---|
| Genal (ES) | 0.75 | 0.76 |
| Lepsämänjoki (FI) | 0.74 | 0.81 |

# Streamflow simulation at the reach scale

J2000 model enables to simulate the daily discharges at the reach scale.
However when the simulated discharge is compared to the observed state of flow (from an photo trap from 2018 to 2021), it shows that J2000 does not accurately simulates zero-flow periods (in orange).





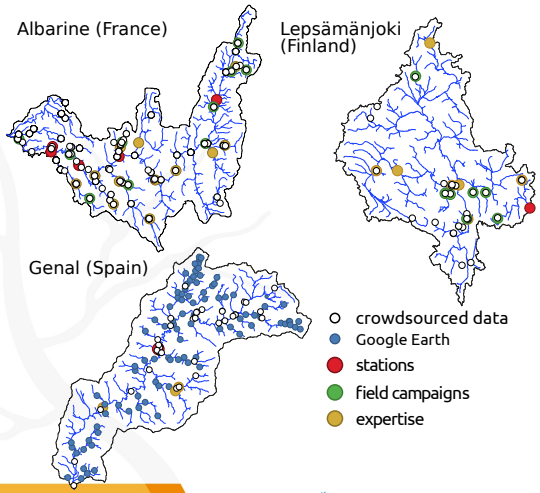

(Mimeau et al., 2024)

For this reason, J2000 is coupled to a **Random Forest** algorithm (RF), which from 20 covariates enables to **predict the daily state of flow in every reach**. There are 3 categories of covariates:

- daily **climate data** at the basin scale (P, T, ET during the previous days)
- **reaches characteristics** (drainage area, slope, types of geology, soils and landuse)
- daily **simulated discharge and groundwater contribution** at the reach scale

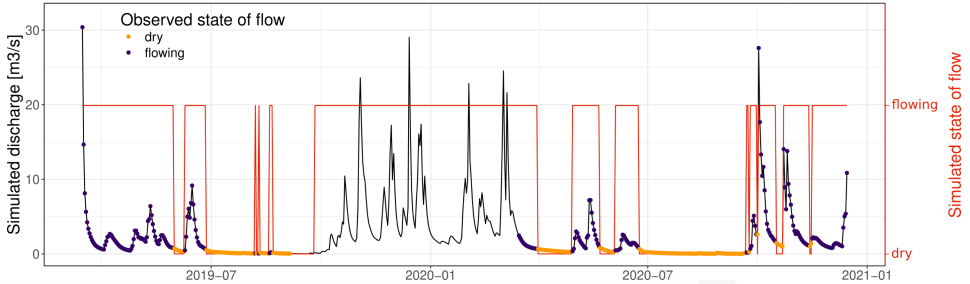
Flow intermittence observations used to train the RF were collected between 2005 and 2021 from heterogeneous datasets

- **Stations**: long time series (> 10 years), but few gauges in the DRNs
- **Field campaigns (phototraps)**: rather long time series (between 3 months and 2 years), around 10 monitored reaches in the DRNs
- **Crowdsourced data (DryRivers and CrowdWater smartphone Apps)**: very good spatial coverage but no temporal monitoring (Truchy et al., 2023)
- **Google Earth data**: very good spatial coverage and good temporal coverage (> 10 years) but only possible with scare vegetation
- **Expertise data**: ites that are not monitored but well known for having a perennial flow regime



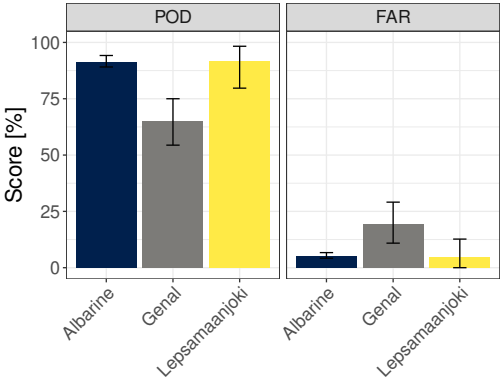
# Performance of the RF model

The coupling with the RF model enables to accurately predict the periods with zero-flows in this reach of the Albarine basin (RF prediction in red).



# Performance of the RF model

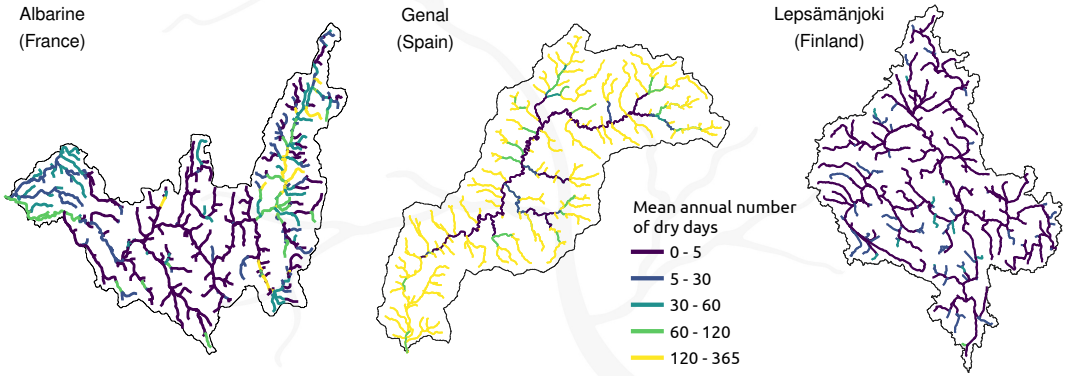
To evaluate the model, the RF is trained with 75% of the observed data 20 times and then tested on the remaining 25%.




**POD**: Probability of prediction of a drying event
**FAR**: False alarm ratio (drying event wrongly predicted)

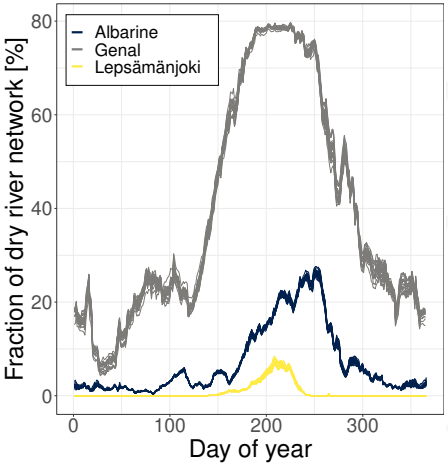
The RF predicts accurately the drying events in the Albarine and Lepsämänjoki basins, but shows a lower performance in the Genal basin.

# Spatial patterns of flow intermittence (2005-2021)




The simulated spatial patterns of drying were validated by local teams.

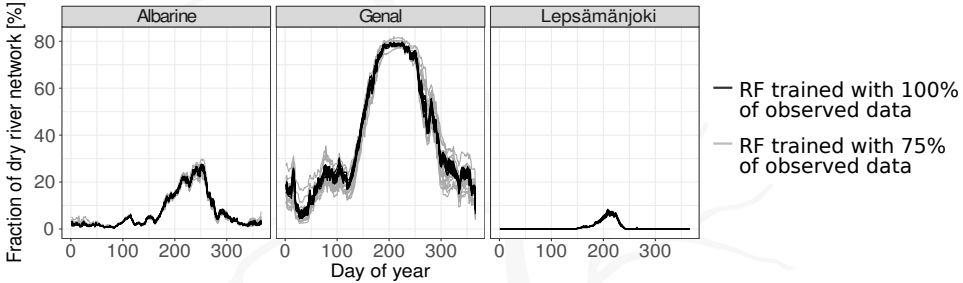
# Seasonal patterns of flow intermittence (2005-2021)




Contrasted drying patterns in the 3 river basins:

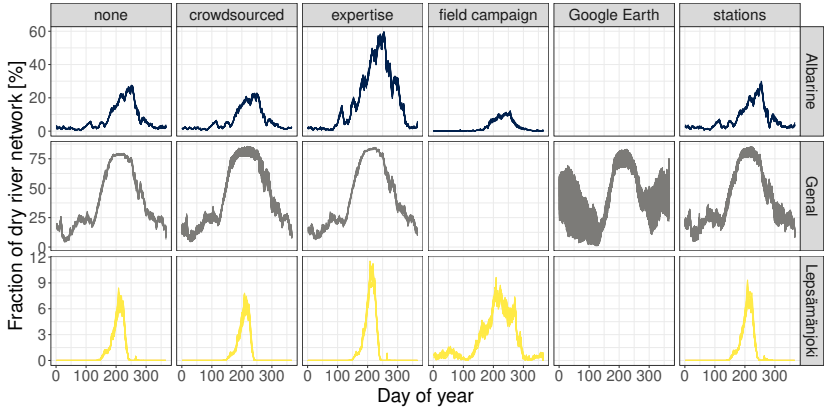
- drying in the Albarine caused by the infiltration of the river in morainic deposits
- intense drying in Genal, especially downstream due to abstraction for irrigation,
- little drying in Lepsämänjoki except in small reaches

Sensibility of the simulated seasonal pattern of drying to the size of the training dataset




For the Lepsämänjoki basin there is no visible impact of reducing the training dataset on the predicted flow intermittence. In the Albarine and Genal basins, the results show that the uncertainty increases particularly during the winter season, when there are fewer observations.

Sensitivity of the different types of observed flow intermittence data on the seasonal pattern of drying. First column: the RF is trained with all data. Other columns: one type of data is removed from the training sample.




The model is particularly sensitive to the expertise, field campaign and Google Earth observed data.

## Conclusions

- **Coupling a distributed hydrological model with a Random Forest algorithm** allowed to simulate zero-flows and reproduce flow intermittence patterns in the 3 studied river networks
- **Combining different sources of flow intermittence observations** enables to reduce the uncertainty in the modelling of flow intermittence

# References

Datry, T. et al. (2021). "Securing Biodiversity, Functional Integrity, and Ecosystem Services in Drying River Networks (DRYvER)". In: *Research Ideas and Outcomes*. DOI: 10.3897/rio.7.e77750.

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Steward, A. L., T. Datry, and S. D. Langhans (2022). "The terrestrial and semi-aquatic invertebrates of intermittent rivers and ephemeral streams". In: *Biological Reviews* 97.4, pp. 1408–1425.

Truchy, A. et al. (2023). "Citizen scientists can help advance the science and management of intermittent rivers and ephemeral streams". In: *BioScience* 73.7, pp. 513–521.

# Thank you for your attention !

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Other EGU24 presentations related to the **DRYvER** project:

- EGU24-12911 HS2.1.1 Künne et al. Flow intermittence patterns in European river networks under climate change: Assessing temporal and spatial changes.
  Fri, 19 Apr, 08:47–08:49 (CEST) PICO spot A | PICOA11
- EGU24-3816 HS2.5.1 Abbasi and Döll Quantifying the potential impacts of climate change on streamflow intermittence in Europe.
  Fri, 19 Apr, 14:45–14:55 (CEST) Room C

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