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Reconstruction of the daily drying dynamics of headwater stream in western France

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Headwater streams are generally naturally prone to flow intermittence, mainly due to their upstream position in the network and to their high reactivity to natural or human disturbances. These intermittent rivers and ephemeral streams (IRES) have recently seen a marked increase in interest, especially to assess the impact of drying dynamics on aquatic ecosystems. However, the understanding of IRES dynamics and their geographic extent remains limited because gauging stations are preferentially located along perennial rivers and, consequently, the proportion of IRES is highly underestimated.

A new source of observational data named ONDE have recently become available in France to complement discharge data from the conventional French River Flow Monitoring network. The ONDE network provides frequent discrete field observations (five inspections per year or more) of the flow states on 3 300 sites throughout France and located mostly in headwater areas. At each ONDE site, one flow states is assigned each day of observation (including "dry" condition). This study focuses on a region homogeneous in terms of geology, topography and climate located in western France (20 000 km^2) and containing 240 ONDE sites more or less impacted by flow intermittence.

The objective of this work is to reconstruct the daily drying dynamic at ONDE sites by combining available flow states observations over the period 2012-2016 with time series of discharge and groundwater level, climate indices (rainfall, evapotranspiration and air temperature) and geomorphological characteristics. Four statistical classification models are tested: (1) k-nearest neighbors model (k-NN); (2) Artificial Neural Networks model (ANN); (3) Random Forest model (RF) and (4) Least Absolute Shrinkage and Selection Operator model (LASSO). A performance analysis is carried out over the 5-year period 2012-2016 to assess their ability to simulate the daily drying dynamic at ONDE sites by cross validation. In a second step, the influence of each explanatory variable in predictions is examined and main drivers of flow intermittency are identified.

ANN, RF and LASSO models perform equally well over the period 2012-2016 with both F.score and the probability of detection (POD) > 0.7. The worst results are obtained with the k-NN model (F.score around 0.5, POD < 0.4). ANN, RF and LASSO models tend to slightly less under-estimate zero-flow conditions in comparison to ONDE observations. The main drivers controlling the drying development are in order of importance: the proportion of days with dry states observed at ONDE site between 2012 and 2016, the non-exceedance frequency of discharge and groundwater level and the antecedent rainfall. The proportion of days with dry states observed at ONDE site informs the temporariness of the streams and the additional variables controls the inter-annual variability. Finally, ANN, RF and LASSO models succeeded to reconstruct the drying dynamics locally by differentiating each stream and could be potentially used to analyze the past and future temporal variability of flow intermittence.