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Informing water supply operations with basin-customized drought indexes under changing climate

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Drought management is largely studied in the literature, yet most of the traditional drought indexes fail in detecting critical events in highly regulated systems. In this study, we contribute FRIDA (FRamework for Index-based Drought Analysis), a novel framework for designing basin-customized drought indexes via feature extraction techniques. These techniques automatically combine the existing information about the water availability in the system as to reproduce in the most effective way a representative target variable for the drought condition (e.g., water deficit). Specifically, we use the Wrapper for Quasi Equally Informative Subset Selection (W-QEISS), which relies on a multi-objective evolutionary algorithm to find Pareto-efficient subsets of variables by maximizing the wrapper accuracy, minimizing the number of selected variables (cardinality), and optimizing relevance and redundancy of the subset.

The proposed FRIDA methodology is demonstrated on the case study of Lake Como (Italy), a multipurpose regulated lake primarily operated for water supply and flood protection. In the absence of an institutional drought monitoring system, we constructed the combined index using all the hydrological variables from the existing monitoring system as well as the most common drought indicators at multiple time aggregations. Seasonality, temperature, and a combined indicator accounting for rain and snow melt constitute the drivers set of droughts in the Como lake basin.

The designed FRIDA index is used to directly inform the lake operations on drought events occurrence. Numerical results show that this strategy has the potential for improving the reliability of the water supply to the downstream irrigation districts. Finally, we reiterated FRIDA on middle-to-long term hydroclimatic projections to study how current drought drivers' roles and interactions will evolve under a changing climate, (e.g., as snow loses priority due to a diminishing winter snowpack reserve) and, ultimately, to infer future drought trends in the south of the Alps.