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Automated identification of streamflow forecast variable and lead time in multipurpose water systems

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Real-time water resources system operation can remarkably benefit from hydro-meteorological forecast products. Depending on the operating targets, whether they are associated to fast (e.g. flood) or slow (e.g. crop growth) system dynamics, either short-term or long-term forecasts might be more effective in anticipating the future system evolution and prompting adequate decisions. While it is comparatively easy to identify the most effective forecasting information needed to optimize fast targets, it is not straightforward to identify which forecast variable and lead time is needed to define effective hedging rules for slow dynamics targets such as agricultural water supply. This task is even more complex when multiple targets, with mixed slow and fast dynamics, are considered at the same time. In these cases, the relative importance of different pieces of information, e.g. magnitude and timing of peak flow rate and accumulated inflow on different time lags, may vary depending on the season or the hydrological conditions.

In this work, we propose a procedure to automatically select the most informative pieces of information (i.e. variable and lead time) for water resources systems with multiple objectives characterized by mixed fast and slow dynamics. We use the Information Selection and Assessment (ISA) framework to identify the most effective forecast variables and horizons. The ISA framework is an automatic, iterative, machine-learning procedure to discriminate the information with the highest potential to improve the operating performance of any controlled system. The improved system operation is then designed using Multi-Objective Direct Policy Search and evaluated against optimal reservoir operation conditioned upon perfect information on future disturbances.

The methodology is demonstrated onto the real-world case study of regulated Lake Como, Italy, operated on a daily basis to supply water to irrigated agriculture, while controlling floods on the lake shores. ECMWF System 4 seasonal ensemble reforecasts of temperature and precipitation are used as input to Topkapi-ETH model, a spatially distributed and physically based hydrological model, in order to produce realistic streamflow forecasts.

Results show that the methodology successfully indicates streamflow forecast variables and lead-times that improve reservoir operation with respect to fast or slow operating targets. This information provides practical decision support for the use of streamflow forecasts for improved multi-objective reservoir operation.