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# Determining effective forecast horizons for multi-purpose reservoirs with short- and long-term operating objectives

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Real-time control of multi-purpose reservoirs can benefit significantly from hydro-meteorological forecast products. Because of their reliability, the most used forecasts range on time scales from hours to few days and are suitable for short-term operation targets such as flood control. In recent years, hydro-meteorological forecasts have become more accurate and reliable on longer time scales, which are more relevant to long-term reservoir operation targets such as water supply. While the forecast quality of such products has been studied extensively, the forecast value, i.e. the operational effectiveness of using forecasts to support water management, has been only relatively explored. It is comparatively easy to identify the most effective forecasting information needed to design reservoir operation rules for flood control but it is not straightforward to identify which forecast variable and lead time is needed to define effective hedging rules for operational targets with slow dynamics such as water supply. The task is even more complex when multiple targets, with diverse 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 analyze the relationship between operational forecast value and streamflow forecast horizon for different multi-purpose reservoir trade-offs. We use the Information Selection and Assessment (ISA) framework to identify the most effective forecast variables and horizons for informing multi-objective reservoir operation over short- and long-term temporal scales. The ISA framework is an automatic iterative procedure to discriminate the information with the highest potential to improve multi-objective reservoir operating performance. Forecast variables and horizons are selected using a feature selection technique. The technique determines the most informative combination in a multi-variate regression model to the optimal reservoir releases based on perfect information at a fixed objective trade-off. The improved reservoir operation is evaluated against optimal reservoir operation conditioned upon perfect information on future disturbances and basic reservoir operation using only the day of the year and the reservoir level. Different objective trade-offs are selected for analyzing resulting differences in improved reservoir operation and selected forecast variables and horizons. For comparison, the effective streamflow forecast horizon determined by the ISA framework is benchmarked against the performances obtained with a deterministic model predictive control (MPC) optimization scheme. Both the ISA framework and the MPC optimization scheme are applied to the real-world case study of Lake Como, Italy, using perfect streamflow forecast information. The principal operation targets for Lake Como are flood control and downstream water supply which makes its operation a suitable case study. Results provide critical feedback to reservoir operators on the use of long-term streamflow forecasts and to the hydro-meteorological forecasting community with respect to the forecast horizon needed from reliable streamflow forecasts.