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Advancing reservoir operation description in physically based hydrological models

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Last decades have seen significant advances in our capacity of characterizing and reproducing hydrological processes within physically based models. Yet, when the human component is considered (e.g. reservoirs, water distribution systems), the associated decisions are generally modeled with very simplistic rules, which might underperform in reproducing the actual operators' behaviour on a daily or sub-daily basis. For example, reservoir operations are usually described by a target-level rule curve, which represents the level that the reservoir should track during normal operating conditions. The associated release decision is determined by the current state of the reservoir relative to the rule curve. This modeling approach can reasonably reproduce the seasonal water volume shift due to reservoir operation. Still, it cannot capture more complex decision making processes in response, e.g., to the fluctuations of energy prices and demands, the temporal unavailability of power plants or varying amount of snow accumulated in the basin. In this work, we link a physically explicit hydrological model with detailed hydropower behavioural models describing the decision making process by the dam operator. In particular, we consider two categories of behavioural models: explicit or rule-based behavioural models, where reservoir operating rules are empirically inferred from observational data, and implicit or optimization based behavioural models, where, following a normative economic approach, the decision maker is represented as a rational agent maximising a utility function. We compare these two alternate modelling approaches on the real-world water system of Lake Como catchment in the Italian Alps. The water system is characterized by the presence of 18 artificial hydropower reservoirs generating almost 13% of the Italian hydropower production. Results show to which extent the hydrological regime in the catchment is affected by different behavioural models and reservoir operating strategies.