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Modeling the water-energy nexus under changing energy market and climate conditions: a case study in the Italian Alps

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Climate change and growing population are expected to severely affect freshwater availability by the end of 21th century. Many river basins, especially in the Mediterranean region, are likely to become more prone to periods of reduced water supply, risking considerable impacts on the society, the environment, and the economy, thus emphasizing the need to rethink the way water resources are distributed, managed, and used at the regional and river basin scale. This paradigm shift will be essential to cope with the undergoing global change, characterized by growing water demands and by increasingly uncertain hydrologic regimes. Most of the literature traditionally focused on predicting the impacts of climate change on water resources, while our understanding of the human footprint on the hydrological cycle is limited. For example, changes in the operation of the Alpine hydropower reservoirs induced by socio-economic drivers (e.g., development of renewable energy) have been already observed over the last few years and have produced relevant impacts on multiple water uses due to the altered distribution of water volumes in time and space. Modeling human decisions as well as the links between society and environmental systems becomes key to develop reliable projections on the co-evolution of the coupled human-water systems and deliver robust adaptation strategies.

This work contributes a preliminary model-based analysis of the behaviour of hydropower operators under changing energy market and climate conditions. The proposed approach is developed for the San Giacomo-Cancano reservoir system located in the Lake Como catchment. The identification of the current operating policy is supported by input variable selection methods to select the most relevant hydrological and market based drivers to explain the observed release time series. The identified model is then simulated under a set of future scenarios, accounting for both climate and socio-economic change (e.g., expansion of the electric vehicle sector, load balancing from renewable energy), to eventually estimate the impacts on the multi-sector services involved (i.e. hydropower, flood protection, irrigation supply). Preliminary results show that the magnitude of the socio-economic change impacts is comparable with the one induced by climate change.