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Assessing the Water-Energy-Food nexus on the Jucar river system using hydrometeorological forecasting and stochastic hydro-economic programming

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Multipurpose water systems are subject to complex trade-offs among competing water uses, which could eventually have a significant potential for conflict. Hence these interlinkages should be properly identified to estimate the impact of changing allocation rules and avoid the trigger of undesirable outcomes. Concretely, forecast-based water allocation requires to assess the outputs of hydrometeorological forecasting within a sectoral context (e.g. urban, agriculture, energy) and contrast it with the current statu-quo. In this regard, stochastic hydro-economic modelling is an efficient approach to compare multipurpose water allocation rules using a common monetary unit, explicitly considering inflow uncertainty and exploiting the potential of hydrometeorological forecasting systems.

Here, we analyse the economic impacts caused by the implementation of forecast-based allocation rules on the Jucar river system in Spain. The economic revenues are calculated by combining Stochastic Dual Dynamic Programming (SDDP) with Model Predictive Control (MPC) forced with hydrometeorological forecasts. The following forecasting systems have been considered: (1) the current system operating rules forced by historical observations, (2) SMHI's pan-European E-HYPE hydrological forecasting system forced with bias-adjusted ECMWF System 4 seasonal meteorological forecasts and post-processed using fuzzy logic to adjust forecasts to the local hydrological conditions, (3) five seasonal meteorological forecasting systems from the Copernicus Climate Change Service (ECMWF SEAS5, UKMO GloSEA5, MétéoFrance System 6, DWD GCFS and CMCC SPS3), bias-adjusted using linear scaling and further combined with locally-adjusted hydrological models, and (4) an ensemble system based on local observations of past river discharge.

Results show that the forecast-based allocation rules derived from SDDP and MPC improve the revenues obtained by the current policies forced by historical observations (which is the best scenario achievable without modifying the current operation). This indicates that combining stochastic modelling with seasonal forecasts improves water allocation performance without requiring a particular forecasting system. Although the agricultural benefits depend on the

forecasting system considered, hydropower's increases of economic returns are almost the same regardless of the forecast product. This means that hydropower revenues are mainly driven by the fact that forecast-based policies are adopted instead of using a particular forecasting service. Our results show that both uses (i.e. agriculture and hydropower) can simultaneously benefit from forecast-based operating rules, offering opportunities for collaboration to increase the regional water use efficiency.

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