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Estimating the economic value of forecasting systems using hydroeconomic stochastic programming in the Jucar River System (Spain)

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Stochastic programming algorithms are able to combine inflow forecasting systems with water resources optimization models taking explicitly into account inflow uncertainty. In case of using a hydroeconomic approach, monetary gains associated with alternative forecasting systems can be compared to rank their suitability according to added economic value. In here we present an assessment of the economic value of several forecasting systems including tools and datasets at the pan-European scale, at the local scale and combinations of both. This analysis has been applied to the Jucar River System (Spain). The economic value is estimated using a hydroeconomic Stochastic Dual Dynamic Programming (SDDP) approach, combined with 1-month leadtime forecasts in a rolling horizon, in line with its frequency of update.

Forecasting systems used are: 1) average monthly values of hydrological discharge (no-forecast situation); 2) the pan-European hydrological forecasting system developed by the Swedish Meteorological and Hydrological Institute (SMHI), based on the bias-adjusted System 4 meteorological forecasts from the European Centre of Medium-Range Weather Forecasts (ECMWF) used as input to the E-HYPE hydrological model, post-processed using fuzzy logic to adjust forecasts to the local hydrological conditions; 3) the meteorological forecasting service SEAS5 from ECMWF, bias-adjusted to the local meteorology using fuzzy logic and combined with locally-adjusted hydrological models; and 4) a locally-adjusted stochastic model ARMA 1,1. Additional alternatives considered are: 5) a scenario with a 1-month perfect forecast; and 6) a scenario with a perfect forecast of the whole analysis period (deterministic programming).

Case study is the Jucar River System in Spain, characterized by Mediterranean hydrology, intensive use of water in agriculture, the existence of large reservoirs and complex decision-making processes. The SDDP problem is solved to obtain future benefit functions for each month of the year. Then, a forward-moving optimal control problem is solved, for the 1998-2012 period (including a drought period between 2005 and 2008), optimizing the current plus future benefits for each forecasting system.

Results show that SEAS5 meteorological forecasts combined with local hydrological models offer the best performance among forecasting systems, overwhelming the no-forecast situation by 2.71 M€year and the second best forecast, the ARMA 1,1; by 0.31 M€year. The best forecasting system is able to fill 76% of the economic gap between no forecasts and 1-month perfect forecasts. E-HYPE forecasts, on the other hand, show a lower economic performance than the other two alternatives, being similar to climatology. These economic results do not agree with the comparison of forecasting skills, in which SEAS5 and ARMA 1,1 show similar scores while E-HYPE clearly outperforms climatology. SEAS5 outperforms ARMA 1,1 in benefit levels due to its better accuracy during the worst part of the drought period (year 2007), in which accurate forecasts are distinctly valuable. E-HYPE performance suffers from being less accurate for the same year.

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