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Stochastic dynamic programming based on copula functions to guide the operation of reservoirs

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Stochastic dynamic programming (SDP) has been widely used to derive operating policies for reservoirs considering streamflow uncertainties. However, there are two aspects the previous study does not pay enough attention. On the one hand, the transition probability matrix is usually based on observed or synthetic streamflow series in which the probability is replaced with the frequency. Consequently, the precision of the transition probability matrix depends critically on the representativeness and size of the sample or the reliability of the synthetic streamflow series. The transition probability matrix can be distorted in the case that the observation occurs by chance or the synthetic streamflow series can not well characterize the original data. On the other hand, the value function in the last stage is ignored in most previous studies. That is to say, there is no difference in future value no matter where the ending water storage of the last period is. This is obviously conflicting with the actual situation. To overcome these two shortcomings, we proposed a stochastic optimization model for hydropower generation reservoirs, in which 1) the transition probability matrix was calculated based on copula functions; and 2) the value function of the last period was calculated by stepwise iteration. Firstly, the marginal distribution of stochastic inflow in each period was built and the joint distributions of adjacent periods were obtained using the three members of the Archimedean copulas, based on which the conditional probability formula was derived. Then, the value in the last period was calculated by a simple recursive equation with the proposed stepwise iteration method and the value function was fitted with a linear regression model. These improvements were incorporated into the classic SDP and applied to the case study in Ertan reservoir, China. The results show that the transition probability matrix can be more easily and accurately obtained by the proposed copula function based method than conventional methods based on the observed or synthetic streamflow series, and the reservoir operation benefit can also be increased.