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Economics on reservoir operation

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Even a single reservoir system is a primary coupled hydrologic-socioeconomic systems characterized by the interactions of natural inflow variability & uncertainty and storage and release demand for human purposes. Thus such systems are embedded with integrated hydrologic and economic relationships. This paper discusses the economics involved in the operation of reservoir systems in the context of hydrologic uncertainty, as well as engineering constraints (e.g., storage capacity.)

Reservoir operation is complicated by inflow uncertainty; however microeconomic theory on resource allocation is inherent to reservoir operation decisions. This paper illustrates the role of economics from the following aspects, 1) the marginal value principle for hedging rule policies (HRP) considering the uncertainty of inflow in the future period; 2) an explicit economic interpretation of three typical constraints for reservoir operations: mass balance, reservoir capacity and minimum flow requirement, based on the derivation of the changes between the present and future marginal values caused by each of the three types of constraints; 3) the economic value of inflow forecast under a certain level of uncertainty and with a certain length (i.e. forecast horizon.)

The application of the economic insights from these aspects is further discussed, which includes: a) New algorithm design for dynamic optimization under HRP, which specifies the starting and ending water availability for hedging, the range of hedging under inflow uncertainty, water demand and evaporation loss. b) Derivation and explanation of optimality conditions for standard operation policies (SOP) and HRP based on the status of constraints. Specifically when all non-negative constraints and storage constraints are non-binding, HR results in optimal reservoir operation following the marginal benefit (MB) principle (the MB is equal over the two stages); while if any of the non-negative release or storage constraints is binding, in general SOP results in the optimal solution except some special cases. Furthermore, uncertainty complicates the effects of the various constraints but in general higher uncertainty level in the future makes HR more favorable since water needs to be reserved to defense the risk caused by the uncertainty. 3) Incorporation of forecast for real-time optimization of reservoir operation, which shows the complicating effect of forecast uncertainty and forecast horizon. Increasing horizon provides more information for decision making in a long time framework but with increasing uncertainty, and then there exists an effective forecast horizon (EFH), beyond which the forecast horizon increase will not contribute to reservoir operation efficiency.

Finally the extension of the economics on reservoir systems to more complex water resources systems such as multiple-reservoir systems and river basin systems will be discussed.