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Different approaches for centralized and decentralized water system management in multiple decision makers' problems

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There is a general agreement that one of the most challenging issues related to water system management is the presence of many and often conflicting interests as well as the presence of several and independent decision makers. The traditional approach to multi-objective water systems management is a centralized management, in which an ideal central regulator coordinates the operation of the whole system, exploiting all the available information and balancing all the operating objectives. Although this approach allows to obtain Pareto-optimal solutions representing the maximum achievable benefit, it is based on assumptions which strongly limits its application in real world contexts: 1) top-down management, 2) existence of a central regulation institution, 3) complete information exchange within the system, 4) perfect economic efficiency. A bottom-up decentralized approach seems therefore to be more suitable for real case applications since different reservoir operators may maintain their independence.
In this work we tested the consequences of a change in the water management approach moving from a centralized toward a decentralized one. In particular we compared three different cases: the centralized management approach, the independent management approach where each reservoir operator takes the daily release decision maximizing (or minimizing) his operating objective independently from each other, and an intermediate approach, leading to the Nash equilibrium of the associated game, where different reservoir operators try to model the behaviours of the other operators. The three approaches are demonstrated using a test case-study composed of two reservoirs regulated for the minimization of flooding in different locations. The operating policies are computed by solving one single multi-objective optimal control problem, in the centralized management approach; multiple single-objective optimization problems, i.e. one for each operator, in the independent case; using techniques related to game theory for the description of the interaction between the two operators, in the last approach.
Computational results shows that the Pareto-optimal control policies obtained in the centralized approach dominate the control policies of both the two cases of decentralized management and that the so called price of anarchy increases moving toward the independent management approach. However, the Nash equilibrium solution seems to be the most promising alternative because it represents a good compromise in maximizing management efficiency without limiting the behaviours of the reservoir operators.