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Integrating operation design into infrastructure planning to foster robustness of planned water systems

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Over the past years, many studies have looked at the planning and management of water infrastructure systems as two separate problems, where the dynamic component (i.e. operations) is considered only after the static problem (i.e. planning) has been resolved. Most recent works have started to investigate planning and management as two strictly interconnected faces of the same problem, where the former is solved jointly with the latter in an integrated framework. This brings advantages to multi-purpose water reservoir systems, where several optimal operating strategies exist and similar system designs might perform differently on the long term depending on the considered short-term operating tradeoff. An operationally robust design will be therefore one performing well across multiple feasible tradeoff operating policies.

This work aims at studying the interaction between short-term operating strategies and their impacts on long-term structural decisions, when long-lived infrastructures with complex ecological impacts and multi-sectoral demands to satisfy (i.e. reservoirs) are considered. A parametric reinforcement learning approach is adopted for nesting optimization and control yielding to both optimal reservoir design and optimal operational policies for water reservoir systems.

The method is demonstrated on a synthetic reservoir that must be designed and operated for ensuring reliable water supply to downstream users. At first, the optimal design capacity derived is compared with the 'no-fail storage' computed through Rippl, a capacity design function that returns the minimum storage needed to satisfy specified water demands without allowing supply shortfall. Then, the optimal reservoir volume is used to simulate the simplified case study under other operating objectives than water supply, in order to assess whether and how the system performance changes. The more robust the infrastructural design, the smaller the difference between the performances of different operating strategies.