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M3O: a Matlab toolbox for designing Multi-Objective Optimal Operations of water reservoir systems

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Abstract: Water reservoir operations have huge potential for contributing positively to the development of different sectors, as well as for reducing the vulnerabilities of water systems caused by changing hydro-climatic and socio-economic forcing. Despite the problem of optimally designing operating policies for water storages has been extensively studied, many state-of-the-art methods are generally distributed as commercial software, thus constraining the possibility of exploring or modifying these tools for customized applications. This motivates the search for advanced, flexible, and open tools supporting the design of operating policies capable of meeting the multiple competing demands associated to the operations of water storages. In this work, we present the Multi-Objective Optimal Operations (M3O) Matlab toolbox, which allows users to explore several state-of-the-art methods for designing Pareto optimal (or approximate) operating policies for managing water reservoir systems. The current version of the toolbox includes Deterministic and Stochastic Dynamic Programming, Implicit Stochastic Optimization, Sampling Stochastic Dynamic Programming, fitted Q-iteration, Evolutionary Multi-Objective Direct Policy Search, and Model Predictive Control. We demonstrate the potential of M3O on a case study application represented by the optimal operations of Lake Como, a regulated lake where the operator has to balance flood protection and water supply. The application of different methods on the same case study contributes a step-forward with respect to traditional literature review papers as the availability of the source code, along with the possibility of cross-comparing the results on the same problem, allows a better understanding of pros and cons of each approach. At the same time, M3O is implemented in a modular structure, which allows practitioners, researchers, and students to easily customize, and possibly further develop, the implemented case study and policy design methods, according to their specific requirements.

Keywords: optimal reservoir operations, multi-objective optimization, water resources management, Matlab toolbox