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Conjunctive Management of Surface and Groundwater Resources under Uncertainty: A Retrospective Optimization Approach

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Abstract : Conjunctive management of surface and groundwater resources is a challenging task due to the spatial and temporal variability nature of hydrology as well as hydrogeology of the water storage systems. Surface water-groundwater hydrogeology is highly uncertain; thus it is imperative that this uncertainty is explicitly accounted for, when managing water resources. Various methodologies have been developed and applied by researchers in an attempt to account for the uncertainty. For example, simulation-optimization models are often used for conjunctive water resources management. However, direct application of such an approach in which all realizations are considered at each iteration of the optimization process leads to a very expensive optimization in terms of computational time, particularly when the number of realizations is large. The aim of this paper, therefore, is to introduce and apply an efficient approach referred to as Retrospective Optimization Approximation (ROA) that can be used for optimizing conjunctive use of surface water and groundwater over a multiple hydrogeological model simulations. This work is based on stochastic simulation-optimization framework using a recently emerged technique of sample average approximation (SAA) which is a sampling based method implemented within the Retrospective Optimization Approximation (ROA) approach. The ROA approach solves and evaluates a sequence of generated optimization sub-problems in an increasing number of realizations (sample size). Response matrix technique was used for linking simulation model with optimization procedure. The k-means clustering sampling technique was used to map the realizations. The methodology is demonstrated through the application to a hypothetical example. In the example, the optimization sub-problems generated were solved and analysed using “Active-Set” core optimizer implemented under MATLAB 2014a environment. Through k-means clustering sampling technique, the ROA – Active Set procedure was able to arrive at a (nearly) converged maximum expected total optimal conjunctive water use withdrawal rate within a relatively few number of iterations (6 to 7 iterations). Results indicate that the ROA approach is a promising technique for optimizing conjunctive water use of surface water and groundwater withdrawal rates under hydrogeological uncertainty.

Keywords : conjunctive water management, retrospective optimization approximation approach, sample average approximation, uncertainty
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