Discussion of "Optimization of Fuzzified Hedging Rules for Multipurpose and Multireservoir Systems" by Iman Ahmadianfar, Arash Adib, and Mehrdad Taghian

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Because optimization approaches produce near-optimal or optimal solutions (Garousi-Nejad et al. 2015), the present use of these approaches is significant in all aspects of water engineering and management. Optimization approaches have been performed for various issues, such as water allocation (Moradi-Jalal et al. 2007; Noory et al. 2012; Ashofteh et al. 2013, 2015b), aquifer systems (Bozorg-Haddad and Mariño 2011), sedimentation management (Shokri et al. 2013), structural rehabilitation of urban drainage networks (Sebti et al. 2014), spillways design (Bozorg-Haddad et al. 2010), reservoir operation (Fallah-Mehdipour et al. 2011), levee layouts and design (Bozorg-Haddad et al. 2015), and design-operation of pumped-storage and hydropower systems (Bozorg-Haddad et al. 2014). A few of these papers have conducted optimization approaches in extraction of hedging rules for reservoir system.

Ahmadianfar et al. (2016) developed a monthly simulation model linked to an evolutionary algorithm. The model was applied to the multireservoir system in Iran using the multiobjective particle swarm optimization (MOPSO) algorithm. Objective functions were minimization of flow and agriculture demands. The results showed that performance of MOPSO was acceptable in extraction of hedging rules.

The discussers would like to acknowledge the authors for applying the MOPSO algorithm for optimizing fuzzified hedging rules within the field of water engineering. Because the MOPSO algorithm is associated with randomly produced solutions (Fallah-Mehdipour et al. 2011, 2012; Noory et al. 2012), the discussers aim to add some points that can improve the results of optimization approaches.

In the "System Constraints" section of the original paper, Eq. (27) indicates the process of calculation for the spill volume from a reservoir at the end of period t (Sp_t^j). It is better to involve evaporation loss volume of reservoir j at period t (E_t^j) in Eq. (27) of the original paper, as follows:

$$Sp_t^j = \begin{cases} S_t^j + Q_t^j - S_{\max}^j - E_t^j & \text{if } (S_t^j + Q_t^j - E_t^j) > S_{\max}^j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

In addition, it is possible that in some periods the reservoir release from reservoir j at period t (R_t^j) becomes greater than the planned water demand in the same period, and thus it can be considered as a constraint in the optimization model. Therefore it may be appropriate to add the mentioned constraint to the System Constraints section.

The particle swarm optimization (PSO) algorithm is modeled on a bird migration pattern (Fallah-Mehdipour et al. 2012). In this pattern, each bird improves its movement toward food. Each bird (i.e., single solution) is presented as a particle and a set of the birds (set of solutions) is recognized as a swarm. In the process of solving the algorithm, random solutions are produced. Then the objective function for each solution is calculated. Next, the best position of a bird moving toward the food and the bird with the smallest distance from the food are determined. In the next step, the velocity of particle in mentioned process is calculated. Thus movement of each solution is denoted in the decision space by a velocity vector. The resulting particle position is used to calculate new objective functions. This process continues until the stop criteria are satisfied. Because the number of objective functions in the MOPSO is more than one, the movement in the decision space toward each objective should be adopted.

The process of solution by MOPSO (as an evolutionary algorithm) for various runs is different. It is obvious that achieving the best solution with only a single run is not adequate. This was previously investigated by Ashofteh and Bozorg-Haddad (2015a) and Ashofteh (2016) in other evolutionary algorithms for solving water resources problems.

Thus the MOPSO algorithm should be run several times to dominate the uncertainties related to the random essence of evolutionary algorithms (Deb 2001). The set of solutions resulting from the process then can be assessed by using the statistical criteria from each run (Ashofteh 2016).

Different solutions for supplying minimum flow can be caused by the various supplies for agriculture demands. In the original paper, the Pareto front was extracted by the MOPSO algorithm by only a single run. To achieve optimal hedging rules, extraction of several solutions from different runs is significant.

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