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Estimation of Muskingum parameter by meta-heuristic algorithms

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The Muskingum model is a hydrologic flood routing method in which the accuracy of the parameter estimation affects the routed hydrograph, especially in both the value and time of the flood peak. Meta-heuristic algorithms are good candidates to determine optimal/near-optimal parameters in the Muskingum model. In this paper, two meta-heuristic algorithms – the simulated annealing (SA) algorithm and the shuffled frog leaping algorithm (SFLA) – are applied and compared in two benchmark and real case studies, considering the sum of the squared deviation (SSQ) between observed and routed outflows and the sum of the absolute value of deviation (SAD) between observed and routed outflow as the objective functions, and deviation of value and occurrence time of the routed flood peak (DPO and DPOT) as the important parameters on the routed flood hydrograph. Results show that the SFLA improves (decreases) the SSQ and SAD by 0·03% and 0·39% in the benchmark problem, and by 3·59% and 2·03% in the real case study, respectively, compared to reported results using various optimisation algorithms. In addition, the SFLA improves (decreases) the DPO of the routed hydrograph in the benchmark problem by 56·67% compared to the best (minimum) result using the Tung method.

1. Introduction

Flood is a natural phenomenon that can cause considerable damage in urban, industrial and agricultural regions. To prevent such damage, it is necessary to identify flood characteristics, especially the value and time of the flood peak. Hydrologic and hydraulic flood routing are two approaches to route floods through river channels. Hydraulic methods, which are based on numerical and mathematical techniques, entail complex and time-consuming processes to determine an appropriate solution. In contrast, most of the hydrologic methods consist of simple processes, such as the continuity equation, to calculate an appropriate solution.

During the past two decades, meta-heuristic algorithms capable of determining an appropriate solution to various types of mathematical problems have been widely used in the field of water resources management. Various meta-heuristic algorithms have been used to solve the non-linear form of the Muskingum model. Mohan (1997) proposed a genetic algorithm (GA) to determine the optimal parameters of two non-linear forms of the Muskingum flood routing model. Results showed that the GA provided a better, or at least as good, solution as that of the non-linear technique. Kim *et al.* (2001) developed a meta-heuristic algorithm, harmony search (HS), to estimate non-linear parameters in the Muskingum model, using two objectives

(*a*) sum of the squared deviation (SSQ)
(*b*) absolute value of deviation (SAD).

Results showed that the HS algorithm produced better solutions with lower values of SSQ and SAD compared to previous studies (Kim *et al.*, 2001; Mohan, 1997). Chu and Chang (2009)