Chapter 4 General Review of Calibration Process of Nonlinear Muskingum Model and Its Optimization by Up-to-Date Methods

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ABSTRACT

Nonlinear Muskingum method is a very efficient tool in flood routing implementation. It is possible to estimate an outflow hydrograph by a given inflow hydrograph of a flood at a specific point of the river channel. However, it turns out an optimization problem at the stage of employing this method, and it becomes important to reach the optimal model parameters so as to obtain precise outflow hydrograph estimations. Hence, it was decided to utilize five up-to-date optimization algorithms, namely, vortex search algorithm (VSA), gases brownian motion algorithm (GBMO), water cycle algorithm (WCA), flower pollination algorithm (FPA), and colliding bodies optimization (CBO). The algorithms were integrated with the nonlinear Muskingum model so as to estimate the outflow hydrograph of Wilson data, and it was deduced that WCA, FPA, and VSA perform relatively better than the models employed in the other researches before.

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INTRODUCTION

Flood routing techniques are user-friendly tools in estimation of downstream hydrograph by given upstream hydrograph and practically utilized in engineering issues such as designing flood control facilities and used for warning the people living in the flood regions in order to prevent them from loss of life and property as well. They are separated into two categories as hydraulic and hydrological models. Hydraulic models are built upon Saint Venant equations in which principle of mass and momentum conservation are taken into consideration. The use of momentum conservation principle introduces the flood routing processes into tedious struggle. Moreover, hydraulic models require thorough data measurement of multiple variables in the related river reach (Papaioannou et al., 2017). In view of these conditions, the hydrological methods such as Muskingum model are sufficient such that linear reservoir concept based on only principle of mass conservation is taken into consideration (Barati, 2011).

Floods are natural hazards which come to existence frequently around the world such that they have disastrous effects on human life, animals, agricultural fields, etc. Hence, it is crucial to implement planning studies about flood risk managements and vulnerability. The studies about flood risk managements deal with flood hazard prediction, its effects on human society and how to minimize flood risk (Schanze, 2006; Nikoo et al., 2016). In this respect, the methods such as flood routing specifies characteristics of a river channel by modeling the temporally or spatially varying flood wave. The flow rate is measured at a cross-section of the channel and it is predicted at an outlet point. Thus, this method enables decision makers to take measure right after a storm which may give rise to flood events. In the literature, Muskingum model is one of the well-known flood routing methods frequently used in the literature.

The linear Muskingum model in which only streamflow measurement data are utilized is the most frequently used method in natural channels and rivers among all hydrolgical models with regard to its ease of use. The model is presumed to capture the river characteristics in the routing process by means of its inherent parameters. A linear storage-discharge relationship is set up in the linear Muskingum model, however, it is highly possible to experience the linear Muskingum model to be insufficient in many flood events. That is, the nonlinear structure of streamflow with respect to time gives rise to inadequacy in estimation of outflow by linear model. Hence, a nonlinear Muskingum model in which a nonlinear storage-discharge relationship is involved in the process is more appropriate to use at this stage. Following the