Closure to "Reverse Flood Routing in Rivers Using Linear and Nonlinear Muskingum Models" by Meisam Badfar, Reza Barati, Emrah Dogan, and Gokmen Tayfur

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The writers thank the discussers for their great interest in the reverse flood routing in rivers using linear and nonlinear Muskingum models presented in the original paper. The discussers suggested several ideas for modifying the structure of the proposed method. Some ideas are useful, and other ideas have adverse implications for model calibration and prediction. The writers would like to take this opportunity to thank the editors for facilitating this information exchange that will help advance the research on the reverse flood routing and enrich its practical applications.

Linear versus Nonlinear Relationship of the Storage with the Weighted Inflow and Outflow of a Flood Hydrograph

The writers agree with the discussers that an appropriate Muskingum storage equation for a river reach should be selected based on the relationship between the storage and weighted flow as is well known by considering previous studies for forward (direct) flood routing (e.g., Yoon and Padmanabhan 1993; Das 2004; Chu and Chang 2009; Chu 2009; Barati 2012, 2013; Karahan et al. 2013; Orouji et al. 2014; Easa et al. 2014; Gąsiorowski and Szymkiewicz 2020; Vatankhah 2021). However, this issue was not studied for reverse flood routing of Muskingum models, and therefore it was considered in the original paper. Moreover, there is no quantitative criterion for selecting an appropriate storage relationship for a given river reach, which should be studied in future research.

Wrong Values of *K* and *X*

For this issue, we checked the results again, and the previous results were confirmed. However, it should be noted that the initial calculated inflow is considered to be the same as the corresponding value of observed *inflow*, while we stated in the original paper (Step 2 of the "Fourth-Order Runge-Kutta Method" section) that "... to be the same as the initial observed *outflow*" (emphasis added). The discussers used the fourth-order Runge-Kutta method (FORK) model to estimate the optimal parameters of the linear Muskingum model and the results are presented in Table 1 of the discussion. The results of statistics of the original research presented in this table are incorrect and differ from the results of the original research. In addition, the routing parameters of the discussion were used in the developed model, and it was observed that different results of statistics could be obtained. The results are listed in Table 1 of this closure. For example, the value of the sum of square error (SSE) for the triangular flood data was reported as 299 by the discussers, while when we used their parameters in our model, the value of SSE obtained was 4,968. Similarly, the value of SSE for the double-peak flood data was reported as 848 by the discussers, whereas when we used their parameters in our model, the value of SSE obtained was 45,167. Sum of absolute difference (SAD), difference between the peak (DBP), and difference between the time to the peak (DBTP) values were also different, as can be seen from Table 1. The routed hydrographs of triangular and double-peak flood data are compared in Figs. 1 and 2, respectively. As is clear from the results, the computational hydrographs in original paper are more accurate than those presented in the discussion.

K in Different Tables Has Different Units

The writers agree with the discussers that routing parameter *K* has different units in different considered case studies in the original paper because of different units of time step of the measured observed hydrographs. Moreover, the unit of the *K* parameter is different for various Muskingum storage equations, as discussed in previous studies (Barati 2011; Vatankhah 2021).

Table 1. Performance of the linear storage model with FORK for the triangular and double-peak flood data

Muskingum parameter	Triangular flood		Double-peak flood	
	Original paper	Discussion	Original paper	Discussion
K	26.3223	15.0868	26.7943	11.6668
X	0.2646	0.4053	0.1961	0.3446
SSE	**280**	4,968	**967**	45,167
SAD	**89**	410	**124**	815
DBT	**3**	12	**7.6**	32
DBTP	**0**	1	**0**	3

Note: Bold values indicate the minimum value (better performance) among different approaches.

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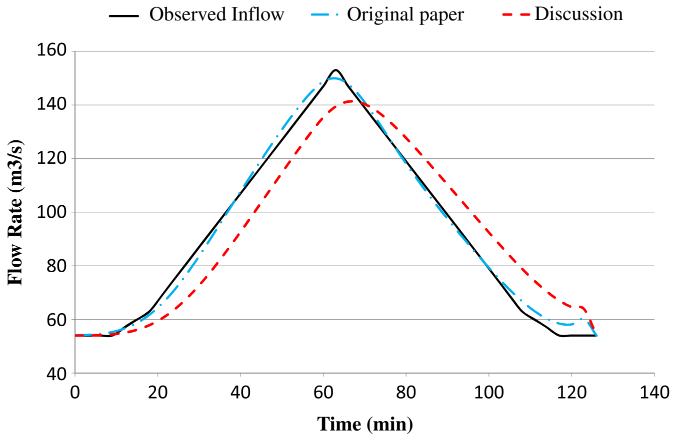

Fig. 1. Comparison of routed upstream hydrographs of the original paper and the discussion for triangular flood data.

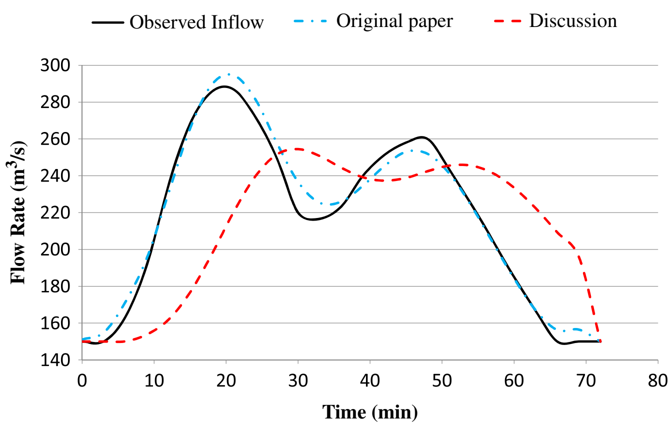

Fig. 2. Comparison of routed upstream hydrographs of the original paper and the discussion for double-peak flood data.

Application of the Euler Method and FORK Scheme

The writers agree with the discussers that the selection of an appropriate numerical solution scheme is an important issue in the flood routing process. As mentioned in the original paper, Badfar (2015) performed a comparative analysis among various explicit numerical schemes for the application in reverse flood routing, and the Euler method and fourth-order Runge-Kutta method were selected based on his analysis and used in the original paper.

Assuming Initial Inflow Is Equal to Initial Observed Inflow

As stated previously, we assumed the initial calculated inflow to be the same as the corresponding value of observed *inflow*—not *outflow*. However, in the original paper we stated that we assumed the initial calculated inflow to be equal to the initial observed *outflow*, inadvertently. However, Chow (1959), for forward (direct) flood routing, mentioned that if the value of the initial outflow at the beginning of the first routing period is assumed, the error involved in that assumption will not be magnified enough to produce appreciable effect on the result (Barati 2015). Therefore, the issue is not a critical point to the flood routing process.

Future Directions

Three important issues can be considered in future research of *reverse flood routing*: (1) comparison of the performance of the hydraulic flood routing methods (Akbari and Barati 2012; Barati et al. 2012) with hydrologic models; (2) presentation of a quantitative criterion for selecting the appropriate storage relationship for a given river reach; and (3) development of flood routing models to calculate transition lost in seasonal rivers.

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