Dear Reviewer #1,

We highly appreciated your review and constructive comments for our manuscript. We provide our responses to your queries below.

Kind regards, all authors

Comment #1: *The paper speaks about a very interesting study of UH concepts of runoff generation in river basins. The authors have successfully compared the performances of four types of UHs e.g SUH, DUH, TDUH (DUH with time-varying rainfall intensity); and TDUH (DUH with time-varying rainfall intensity & soil moisture). The approach has practical application if soil moisture conditions and the observed rainfall intensity are known and a set of IUHs are already developed using the past rainfall and flood events. The accuracy of the methodology is well established, hence acceptable. However, the reviewer raises the following points for clarification and, if incorporated into the manuscript, the quality of the paper will improve a lot.*

Response:

We appreciate you for taking the time to review our paper and provide some insightful discussion points to improve the transparency and clarity of our work. We will make the following adjustments to the manuscript based on your suggestions.

Comment #2: *Section 1 (Line 100). IA? Explain.*

Response:

This is a typo. And "*IA*" will be corrected as "*A*" in the revised version.

Comment #3: *The Author uses equations (1), (2) & (3) for velocity computation from grid cells in the case of DUH, TDUH (DUH with rainfall intensity) and the present method considering both the rainfall intensity and soil moisture content (may be referred as TDUH-MC) respectively. Subsequently, all computations for the UH or flood hydrographs have been attempted. The paper also speaks about the traditional SUH of the two test catchments about which the author has not spoken. Please explain. Or is it Clark's approach of determining the IUH considering the time-area histogram and the attenuation of this time-area hydrograph using a linear reservoir that represents channel storage effects?*

Response:

Thank you for your comments.

I) This is a good suggestion and the TDUH method considering both the rainfall intensity and soil moisture content will be expressed as TDUH-MC method in the revised manuscript.

II) The details of SUH determinations will be added to the revised manuscript in Section 3. The Nash instantaneous unit hydrograph model (Nash, 1957) was used to derive the synthetic IUH in this study. In the Nash IUH model, a catchment is assumed to be made up of a series of *n* identical linear reservoirs each with the same storage constant *K*, which is given by

$$h(t) = \frac{e^{-\frac{t}{k}}}{k\Gamma(n)}\left[\frac{t}{k}\right]^{n-1}$$

where $h(t)$ is the IUH of the Nash model, $\Gamma(n)$ is the Gamma function. Using the method of moments, the model parameters *n* and *k* can be determined as (Singh, 1988; Chow et al., 1988):

$$M_1(Q) - M_1(I) = nk$$

$$M_2(Q) - 2M_1(I)M_1(Q) + M_2(I) = nk^2(n-1)$$

where M_1 and M_2 are the first and the second moments of the quantities within parentheses. For some watersheds without observed rainfall and runoff data, Nash established experimental relations between watershed physical properties and the IUH parameters and presented a synthetic IUH (Singh, 1988).

The added sentences are as follows:

"*Specifically, the DUH, TDUH and TDUH-MC were derived according to the methods in Section 2.2. The Nash instantaneous unit hydrograph model (Nash, 1957) was used to derive the synthetic IUH in this study. In the Nash IUH model, a catchment is assumed to be made up of a series of n identical linear reservoirs each with the same storage constant K. The magnitude of n and K is estimated based on an observed excess rainfall hyetograph and corresponding direct runoff hydrograph using the method of moments, the details can be found in* (*Singh, 1988; Chow et al., 1988*). *The parameters n of the Qin River basin and Longhu River basin are 4 and 3, and parameters k are 3.4 and 2.1 respectively.*"

References:

Nash, J. E.: The form of the instantaneous unit hydrograph. International Association of Science and Hydrology, 45(3):114-121, 1957.

Singh V.P.: Hydrologic Systems, Rainfall–Runoff Modeling, vol. I, Prentice-Hall, Englewood Cliffs, 1988.

Chow V. T., Maidment D. R., Mays L. W.: Applied Hydrology, McGraw-Hill, New York, 1988.

Comment #4: *The author has commented on the assumptions of Bunster et al. (2019) regarding the watershed equilibrium condition prior to the end of excess rainfall pulse*

(Line 138-148). Under saturated conditions and the routing velocity-at-maximum condition, the time to peak becomes shorter, peak is higher. How the slower travel time (line 145-146) will ensure shorter time to peak and higher peak may be justified/corrected?

Response:

Thank you for your comments. This sentence will be corrected.

Change from

"This assumption of equilibrium globally or in grid cells yields slower travel times, shorter times to peak and higher peak discharges."

to

"This assumption of equilibrium globally or in grid cells yields faster travel flow velocities, smaller travel times, and higher peak discharges."

Comment #5: *Section 3. Several approaches can be adopted to compute the runoff at the basin outlet. The author has used the Muskingum method of runoff routing. Since any natural river is multiple inflows-single outflow runoff systems with different travel times from the sub-basins to reach the outlet, the author may describe the routing method steps in more detail.*

Response:

Thank you for your comments. The details about the parameters determination of the Muskingum method will be added in Section 3 of the revised manuscript. In the conventional Muskingum method, these parameters are determined by calibration using measured inflow and outflow hydrographs. In recent decades, the artificial intelligence-based optimization methods have been widely utilized in the parameter estimation of the Muskingum model (Chu et al., 2009; Moghaddam et al., 2016). In addition, the physical-based methods were also widely used for parameters estimation, such as Muskingum-Cunge method (Ponce et al., 1996).

1) For the SUH, the basin is taken as a whole. The parameters of the Muskingum methods were calibrated with those of the Xinanjinag model. The SCE-UA algorithm was used to calibrate the parameters of XAJ model. The parameters (*XE* and *KE*) of the Muskingum method have been given in Section 5.1.2.

2) For the DUH, the basin was divided into several sub-basins. Since any natural river is multiple inflows-single outflow runoff systems with different travel times from the sub-basins to reach the outlet, the Muskingum-Cunge method is suitable to be applied to ungauged watersheds. The parameters of the Muskingum-Cunge method for each sub-basin were determined based on flow and channel characteristics, such as the top width of the

river, wave celerity, reach length and reach slop, which can be expressed by (Chow, 1959; Wilson and Ruffin, 1988)

$$KE = \frac{\Delta L}{V_w}$$

$$XE = \frac{1}{2} - \frac{Q_0}{2SWV_w\Delta L}$$

where Q_0 is the reference discharge; S is dimensionless channel bottom slope; V_w is kinematic wave celerity; ΔL is routing reach length; W is water surface width.

The calibrated parameters will be given in the revised paper.

References:

Chow, V. T.: Open Channel Hydraulics, McGraw-Hill, New York, USA, 1959.

Wilson, B. N., Ruffini, J. R.: Comparison of physically based Muskingum methods. Transactions of ASAE, 31(1): 91-97, 1988.

Chu, H. J., Chang, L. C.: Applying Particle Swarm Optimization to Parameter Estimation of the Nonlinear Muskingum Model. Journal of Hydrologic Engineering, 14(9):1024-1027, 2009.

Dooge J. Linear theory of hydrologic systems. Agricultural Research Service, US Department of Agriculture, 1973.

Nash, J. E.: The form of the instantaneous unit hydrograph. International Association of Science and Hydrology, 45(3):114-121, 1957.

Moghaddam, A., Behmanesh, J., Farsijani, A.: Parameters estimation for the new four-parameter nonlinear Muskingum model using the particle swarm optimization, Water Resour. Manage., 30 (7), pp. 2143-2160, 2016.

Ponce, V. M., Lohani, A. K., Scheyhing, C.: Analytical verification of Muskingum-Cunge routing. Journal of Hydrology, 174(3-4): 235-241, 1996.

Comment #6: *Section 5.1.1 (Line 377-382). In the model calibration process, SUH derived from historical rainfall-runoff data was used for flow routing in the model calibration process. But different rainfall-runoff events associated with different soil moisture conditions will give rise to various shapes of UH. The author may throw some more light on the suggested routing model calibration in this Section.*

Response:

Thank you for your comments. We realized that the initial condition is crucial for the UH derivation, and the shapes of the UH depend on the spatial and temporal distribution of rainfall and antecedent soil moisture.

The traditional UH method has little flexibility to different storm events, i.e. the unit hydrographs computed by it vary considerably from storm to storm (Rao and Delleur, 1971). This is partially because the UH methods ignore the influence of initial soil moisture conditions or antecedent soil moisture conditions (evapotranspiration and rainfall) on runoff generating processes. Several studies have shown that UH which is derived by considering antecedent soil moisture are more consistent than UH which is ignoring that (Yue and Hashino, 2000; Nourani et al., 2009). Therefore, the antecedent precipitation was calculated and was considered in this study. In order to obtain the UH, we defined excess rainfall and separated direct runoff and baseflow hydrographs in advance. The SUH used for calibration of the two case studies are average values deduced by 25 and 23 historical flood events respectively.

The added sentences are as follows:

"Several studies have shown that UH which is derived by considering antecedent soil moisture are more consistent than UH which is ignoring that (Yue and Hashino, 2000; Nourani et al., 2009). Therefore, the antecedent precipitation was calculated and was considered in this study. In order to obtain the SUH, we defined excess rainfall and separated direct runoff and baseflow hydrographs in advance. The final SUH used for calibration of the two case studies are average values deduced by 25 and 23 historical flood events respectively."

References:

Rao R. A., Delleur, J. W. The instantaneous unit hydrograph. Its calculation by the transform method and noise control by digital filtering. Technical Report No. 20, Purdue University, Water Resources Research Center, West Lafayette, IN. 1971.

Yue S, Hashino M. Unit hydrographs to model quick and slow runoff components of streamflow. Journal of Hydrology, 227(1-4): 195-206, 2000.

Nourani V, Singh V P, Delafrouz H. Three geomorphological rainfall–runoff models based on the linear reservoir concept. Catena, 76(3): 206-214, 2009.

Comment #7: *Section 5.1.2. A Table for the flood event statistics used for model calibration and validation may be inserted in this section.*

Response:

Thank you for your comments. The flood events statistics used for model calibration and validation will be added to Section 5.1.2. The average peak flow of the two basins are 1311 m^3/s and 118 m^3/s, and the average flood durations are about 50 h and 13 h, respectively.

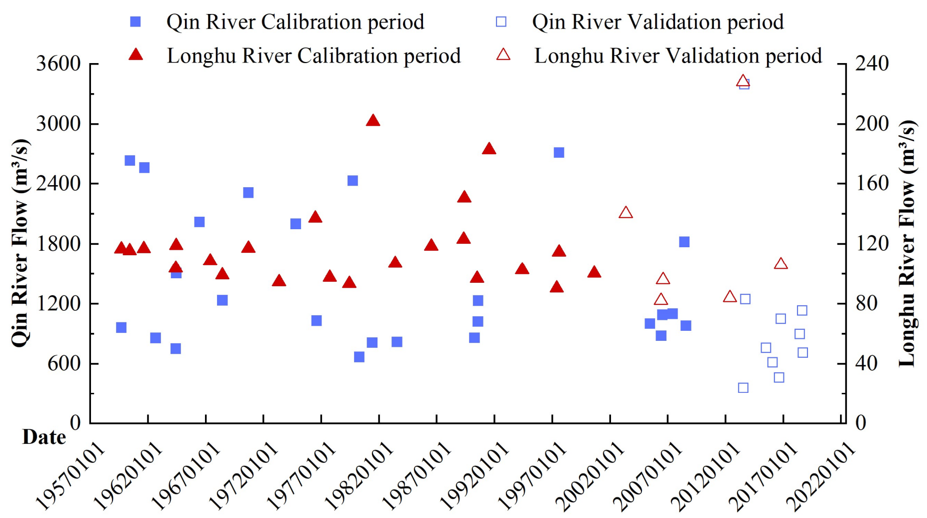

Figure 6. Flow event statistics used for model calibration and validation

Comment #8: *Section 5.2 (Line 443). Sub-basin 6 may be corrected as sub-basin 9.*

Response:

Thank you for your comments. *Sub-basin 6* will be corrected to *sub-basin 9* in the revised paper.

Comment #9: *Section 5.4 (Line 535). Is it Fig 10 or Fig 11. May be corrected accordingly.*

Response:

Thank you for your comments. *Fig 10* will be corrected to *Fig 11* in the revised paper.

Comment #10: *The paper suffers from improper sentence formation (at few places sentences are not completed), poorly written. Sentences are not properly formed. Hence needs improvement.*

Response:

Thank you for your comments. The language of the revised manuscript will be improved by a native speaker.