

#Review2

Summary: This study links calibrated Muskingum parameters to effective channel cross section parameters. The paper uses the well-known equivalence of the Muskingum-Cunge lumped routing approach and the diffusive wave approximation of the de Saint-Venant equations. I see little novelty in the material presented here and also have some concerns regarding the methodology, pls see comments below. I do not recommend acceptance of this paper in its current form.

Review comments:

1. The basic idea of this paper is that calibrated Muskingum parameters for a river reach can be translated into effective river cross sections. However, the equivalence between the diffusive wave approximation of the de Saint-Venant equations and the Muskingum-Cunge model is well understood and not new.

Response:

We sincerely thank the reviewer for this comment. We agree that the Muskingum method and the Saint-Venant equations are not new formulations. The primary contribution of this study is not to reinvent these established equations, but to propose a novel, explicit linkage between them.

As a traditional hydrological approach, the Muskingum method is highly efficient but does not involve hydrodynamic calculations, thereby providing limited insight into internal hydrodynamic conditions within the river channel. Our proposed method serves as a bridge, transforming this purely hydrological method into a hydrodynamic modeling framework.

As we explained in lines 51-57 of the original manuscript, the distinction between standard Muskingum parameters and the need to represent river reaches with distinct flow characteristics motivated this transformation.

2. The purpose of the effective river cross sections is unclear. Normally, the motivation for using hydraulic instead of lumped routing is interest in continuous water levels along the river (e.g. for flood risk assessment). However, the approach presented here will generate average, reach-scale cross sections, which will only reproduce large-scale behavior not detailed small-scale backwater effects etc. I believe the water levels produced with this approach will essentially be equivalent to water levels derived from reach-scale rating curves, thus making the hydraulic routing model obsolete.

Response:

We sincerely thank the reviewer for this critical and insightful comment. We fully agree that the CERC method produces an idealized and generalized equivalent river channel. Because it is designed to capture reach-scale storage capacity rather than precise local bathymetry, we frankly acknowledge that while the simulated discharge at the outlet is highly accurate, the absolute values of internal variables like water level and flow velocity may carry uncertainties and might not be perfectly precise at every local point.

However, we respectfully disagree that this generalization makes the hydrodynamic model obsolete or merely equivalent to a reach-scale rating curve. A stage-discharge rating curve is an empirical, static relationship that is strictly limited to specific gauged cross-sections and inherently fails to capture the internal kinematic behavior of flow. In contrast, the 1-D hydrodynamic model using CERCXs solves the Saint-Venant equations, enabling the continuous simulation of flow variables at any arbitrary cross-section along the entire routing path. This allows the model to capture crucial spatiotemporal trends of flood wave propagation. For example, Section 4.4 and Figure 8 explicitly demonstrate the continuous temporal evolution flow velocities across eight different un-gauged cross-sections, dynamic behaviors that a simple rating curve simply cannot reproduce.

Furthermore, establishing this parameterized physical cross-section provides a foundational framework for modeling complex systems. Unlike static rating curves, the CERC framework can be easily adjusted to match measured cross-sections by incorporating even limited actual field data, thereby enabling more accurate simulations of localized hydrodynamic effects in the future.

3. Methodology: International readership is used to Muskingum and Muskingum-Cunge algorithms. It would be useful to align your description with these standard algorithms. Is your nonlinear Muskingum model equivalent to Muskingum-Cunge? While that seems to be the case for the parameterization of X (eq 7), the parameterization of K (eq 6) is different. In Muskingum-Cunge, parameter K (i.e. reach length divided by wave speed) decreases with increasing discharge (wave speed increases), while in your approach (eq 6) it seems that you assume increasing K with increasing discharge. This seems counter-intuitive at first sight and needs more explanation/motivation. Any deviation from standard Muskingum-Cunge should be carefully explained and motivated.

Response:

We sincerely appreciate the reviewer's careful scrutiny of our methodology and the

insightful comparison with the standard Muskingum-Cunge (M-C) algorithm. We fully agree with the physical intuition that in standard M-C routing, the parameter K typically decreases with increasing discharge because of the increased wave speed. We would like to clarify that our nonlinear parameterization in Equation 6 ($K = k_s \cdot Q + k_0$) does not inherently assume an increasing with increasing K discharge.

Rather, k_s is an empirical coefficient that is typically negative, thereby maintaining complete physical consistency with the standard M-C logic. For instance, as explicitly demonstrated in Table 1 for the Huayuankou-Jiahetan reach, the calibrated K value for the first layer with a lower characteristic discharge ($Q_1 = 5000 \text{ m}^3/\text{s}$) is 15, whereas the K value for the the second layer with a higher characteristic discharge ($Q_2 = 20000 \text{ m}^3/\text{s}$) decreases to 13.5. This confirms that our practical application perfectly aligns with the physical behavior expected by the reviewer. The general linear equation was utilized merely to provide a flexible framework for empirical calibration. To avoid any further confusion, we have revised the methodological description following Equation 6 in the manuscript to explicitly state that the coefficient k_s is generally negative, reflecting the physical reality of decreasing travel time with higher flow rates.

4. Methodology: Equation 12: Variable H is not explained. I assume that this is water surface elevation (WSE) or water level. The formulation $f(H)$ then correctly describes that flow cross-sectional area depends on WSE, according to the chosen geometry assumption (rectangular, triangular, etc.). However, hydraulic radius R is written without WSE dependence. Is this just a mistake or do you assume constant hydraulic radius? In reality, R will definitely be $R(H)$.

Response:

We are very grateful to the reviewer for pointing out this notational ambiguity. We apologize for the oversight of not explicitly defining H immediately near Equation 12. As the reviewer correctly assumed, H represents the water depth (or bankfull depth) in our formulation. Furthermore, we completely agree that the hydraulic radius is physically and mathematically dependent on the water depth. The notation R was used purely as a shorthand for $R(H)$ in the manuscript. In our actual mathematical derivations and model implementation, the hydraulic radius is strictly treated as a function of H . This is clearly evidenced by our inclusion of the derivative of the hydraulic radius with respect to H (denoted as R') in Equation 14, as well as the explicit functional relationships defined for each cross-sectional geometry in Appendix A. To eliminate any potential confusion, we would revise the manuscript to

explicitly define H upon its first use and updated the notation in Equation 12 and the surrounding text to $R(H)$.

5. It should be clearly stated that the translation from Muskingum parameters to geometry (which is a direct consequence of the equivalence of Muskingum-Cunge and diffusive-wave approx. of de Saint-Venant) can only be done for given/known hydraulic roughness (n). However hydraulic roughness values are usually not available. Usually, Manning numbers are obtained from inverse modeling, i.e. fitting observed water levels for given geometry and discharge. This is a well-known parameter trade-off in hydraulic modeling, which stems from the fact that conveyance is a function of both geometry and hydraulic roughness. The impacts of both on conveyance cannot be separated based on water levels only.

Response:

We are highly appreciative of the reviewer for highlighting this fundamental principle of open-channel hydraulics. We completely agree that channel conveyance is a combined function of geometry and hydraulic roughness, leading to a well-known parameter trade-off where their individual impacts cannot be easily isolated using water level data alone. Consequently, we acknowledge that the Conceptual Equivalent River Channel (CERC) derived in our study represents a specific hydraulic pairing based on an assumed roughness n , rather than a unique, absolute physical reality. Fortunately, we anticipated this inherent equifinality and explicitly addressed it through a comprehensive parameter sensitivity analysis in Section 5 of our original manuscript. By varying the roughness coefficient n from 0.01 to 0.06, we demonstrated that while the inferred morphological parameters (such as channel slope i_0 , width B , and depth H) are indeed highly sensitive to the choice of n , the overall discharge routing performance remains remarkably robust, maintaining a Nash-Sutcliffe efficiency (NS) consistently above 0.97 across all tested roughness conditions. This proves that the CERC framework effectively preserves the essential "equivalent conveyance and storage" required for accurate flood routing, even when the exact roughness is unknown. To fully address your concern, we would add a dedicated statement in both the Methodology and Discussion sections of the revised manuscript, explicitly acknowledging this parameter trade-off.