Reviewer #1:

First of all, sincerely thank you very much for your valuable comments. All your suggestions are very important and have important guiding significance for our writing and research. When revising the article, we considered thoughtfully what you have advised.

1. Comment: The paper presents an interesting approach of coupling hydrologic and hydrodynamic models to improve computational efficiency while maintaining numerical accuracy. However, to demonstrate the superiority of the proposed approach, it is essential to conduct a thorough comparison with state-of-the-art individual hydrology and hydrodynamic models. This will help highlight the advantages and necessity of the coupled modelling approach. It's crucial to show how the proposed method outperforms existing models in terms of both efficiency and accuracy.

In the introduction, the authors should focus more on recent progress in coupled hydrology-hydrodynamic models, especially with respect to their proposed coupling method, which seems different from the common coupling methods. Additionally, a detailed explanation of the non-uniform grid generation should be provided to give readers a better understanding of its significance in the proposed approach.

Response to comment: Thank you very much for your valuable comments. The coupling model can be divided into two types: external (one-way) and internal (two-way) coupling models (see Figure 1).

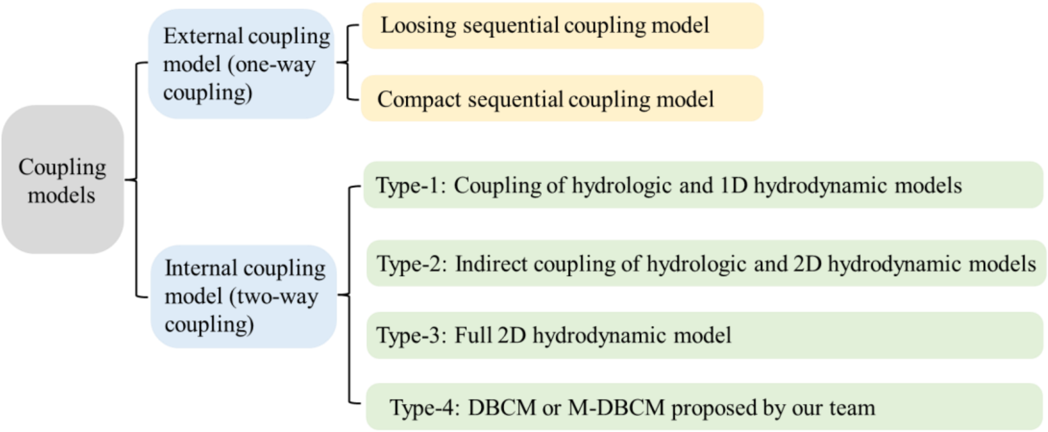

Figure 1 Classifications of coupled hydrologic and hydrodynamic models

One-way coupling model utilizes hydrographs obtained from hydrologic models as an input for hydrodynamic models, providing a one-way transition. Usually, the hydrologic model is run first and independently from the hydrodynamic model. External coupling models are powerful tools for watershed flood simulation, in particular large spatial and temporal scale, due to its convenience in model construction. However, the location of the boundary points limits the influence of the upland runoff to downstream waters. The runoff generation on both sides of the river is transferred to limited points upstream of the main stream or tributaries of the river network, resulting in an error in the peak flow rate of the boundary points. Since the flow information is transferred in one-way from hydrologic to hydrodynamic models, the external coupling cannot capture the mutual interaction between runoff production and flood inundation.

Moreover, mass conservation of water through the coupling interface cannot be guaranteed.

Two-way coupling models were further divided into four types: the coupling of hydrologic and 1D hydrodynamic models; the indirect coupling of hydrologic and 2D hydrodynamic models; full 2D hydrodynamic models, and the DBCM and M-DCBM proposed by our team. The characteristics and applications of different coupling models for flood simulation were detailed as follows.

(1) The hydrologic and 1D hydrodynamic models are calculated synchronously in time in the coupled hydrologic and 1D hydrodynamic models. The flow discharge rate obtained from the hydrologic model is treated as mass source of the 1D hydrodynamic model, while the water depth calculated in 1D hydrodynamic model is fed back to hydrologic model. The coupling of the Mike SHE and Mike11 is a typical example of coupling of hydrologic and 1D hydrodynamic models. The coupling of hydrologic and 1D hydrodynamic models lacks ability to accurately simulate flood inundation process in 2D regions, such as lakes, reservoirs, complex flows and estuaries where 2D or 3D computations are required.

(2) In order to overcome the lack of 2D hydrodynamic simulation in type-1, the coupling of hydrologic, 1D and 2D hydrodynamic models is proposed. In this coupling type, the runoff first flows into 1D rivers, and then discharge into the 2D inundation regions, such as lakes or reservoirs. The hydrologic model was coupled with 1D hydrodynamic model, and the 1D hydrodynamic model was coupled with 2D hydrodynamic model. This coupling type is an indirect coupling of hydrologic and 2D hydrodynamic models. For instance, Mike SHE and Mike11 are coupled to form Mike Urban, and Mike11 and Mike21 are dynamically coupled to form Mike Flood. The indirect coupling of hydrologic and 2D hydrodynamic models applied to simulate rainfall-runoff have been reported in many kinds of literature (http://doi.org/10.2166/wst.2017.504;http://doi.org/10.1016/j.jhydrol.2018.07.069; http://doi.org/10.1061/(ASCE)HY.1943-7900.0000485). Compared with type-1, this coupling type has satisfactory and acceptable accuracy and is widely used. However, in these models, the hydrologic model is not directly linked with 2D hydrodynamic model, which is inconsistent with the natural flood processes. In reality, runoff from the uplands may be simultaneously discharged into both 1D channel and 2D inundations, and the hydrologic and 2D hydrodynamic models should be linked directly. Direct dynamic coupling of hydrologic and 2D hydrodynamic model can reflect the flood process more truly. The dynamic bidirectional coupling of the hydrologic and the local 2D hydrodynamic models has been paid much attention.

(3) In this coupling type, only the runoff generation is calculated by the hydrologic model and considered as source term of the continuity equation of 2D hydrodynamic model, and then both the overland flow migration and inundation processes are all calculated by 2D hydrodynamic model. This coupling type is also called full 2D hydrodynamic model (HM2D). The HM2D can be used to simulate the complex flow patterns and achieve satisfactory results. In HEC-RAS (version 6.4), the flood process in 1D rivers was calculated using 1D hydrodynamic model, whereas the 2D diffusion wave equations (DWE) or shallow water equations (SWE) were solved in 2D regions.

The 1D hydrodynamic model was coupled with the 2D DWE or SWE. The HEC-RAS was also considered as the HM2D, since the 2D DWE or SWE were solved in the entire 2D regions. As the 2D hydrodynamic equations need to be solved in the entire watershed, the HM2D are still computationally prohibitive for large-scale applications, especially in regions where high-resolution representation of complicated topographic features are necessary. Therefore, the HM2D is typically applied to small and medium-sized watershed.

(4) The DBCM joins the hydrologic and hydrodynamic models into a single modelling framework by combing their code, where the governing equations of hydrologic and hydrodynamic models are reformulated and synchronously solved in a single code base. The information exchange between both portions of the code is performed internally within the same source code and does not involve the exchange of external input and output files. The hydrologic and 2D hydrodynamic model are coupled by a coupling moving interface (CMI), and the inundation and non-inundation regions change with the accumulation of rainfall, which is more consistent with the natural flood process. The DBCM framework was presented in the paper (http://doi.org/10.5194/nhes-21-497-2021). The classification, performance, applications and challenges of different coupling models were detailed by Shen and Jiang (2023). If you want to learn more about this, you can review it in https://doi.org/10.1007/s11069-023-06047-1.

To further improve the computational efficiency, we developed the M-DBCM (https://doi.org/10.3390/w13233454). In the original M-DBCM, the multi-grids were used to divide the computational domain, and the task consists of the following steps:

First, the areas prone to flooding disasters was identified based on two methods. A hydrologic model was used to simulate the flood disasters based on the coarse grids to determine the areas prone to flood disasters. Besides, the areas prone to flood disasters was also identified based on experience. Second, the areas prone to flooding disasters were divided using finer grids, whereas the others were discretized using coarse grids. The grid generation methods were detailed in Shen et al. (2021), if you want to learn more about this, you can review it in Shen et al. (2021) (https://doi.org/10.3390/w13233454). One limitation is that the grids need to be generated manually, which is highly subjective and uncertain. Therefore, we revised and improved the grid generation method, which is presented in Section 2.1 of the manuscript.

2. Comment: The modelling performance is highly influenced by the underlying mesh generation. Even with advanced adaptive methods using meter-scale data, there can be uncertainties impacting the modelling performance. It is recommended that the authors perform an uncertainty analysis on the mesh generation process to understand its potential effects on the model results.

Response to comment: Thank you for reading this article carefully and making valuable suggestions. There were many mesh generation methods, such as adaptive mesh refinement, static non-uniform grids, and the modelling performance is highly influenced by the underlying mesh generation. In Section 3.2 of the manuscript, cases with different ratios of coarse to fine grids were developed. The computational efficiency and accuracy of different grid generations were evaluated. In future works, we can combine different mesh generation methods, such as the adaptive mesh refinement with the M-DBCM to study the influence of the gird generation on the simulation results. Besides, sensitivity analysis will also be performed to discuss the impact of parameters (such as Manning coefficient, the grid generation, ratio of coarse to fine grids) on the simulation results. Thank you for reading this article carefully and making valuable suggestions, which have important guiding significance for our writing and scientific research work.

3. Comment: The paper mentions the use of a coarse grid. What is the resolution of a coarse grid? What is the ratio between find grid resolution and coarse grid resolution? Will the coarse grid resolution/ratio have a large impact on modelling performance? Understanding the impact of this coarse grid resolution/ratio on the modelling performance is crucial.

Response to comment: In the proposed M-DBCM, the size of a coarse grid is an integer multiple of that of a fine grid. The fine grids were first used to divide the areas prone to the flood disasters, and then the coarse girds were used to discretize other areas. As the size of the fine grids varies in different computational domain, the size of coarse grids is also different. In a computational domain, compared with the fine grids, a grid with a larger size is referred to as a coarse grid.

The computational accuracy and efficiency were influenced by the ratio of coarse to fine grids, which was presented in the Section 3.2. Besides, the influence of the ratio of coarse to fine grids on the computational efficiency was detailed by Shen and Jiang (2023). If you want to learn more about this, you can review it in this paper (http://doi.org/10.2166/hydro.2023.131)

4. Comment: Providing a detailed description of the hydrology and hydrodynamic components, especially on their treatment of flow variables (e.g., discharge, depth), would greatly enhance readers' understanding of the coupling process at the interface. This information is vital to evaluate the robustness of the proposed coupling approach.

Response to comment: In hydrologic model, a 2D nonlinear reservoir model, including water balance and Manning equations, was used to simulate rainfall-runoff, and the governing equations were listed from Eqs. (7) to (11) in the manuscript. The shallow water equations were solved in hydrodynamic model. Since the shallow water equations were commonly used in most models, we did not detail the hydrodynamic model taking into account the length of the manuscript.

The Finite volume method of conservation scheme was used to discretize the governing equations of hydrologic and hydrodynamic model. A Harten-Lax-van Leer contact (HLLC) approximate Riemann solver was used to calculate the fluxes through the cell interface (see Figure 2).

The governing equations of hydrologic and hydrodynamic models are discretized on structured grids (see Figure 2). The hydrologic model is rational for the continuous non-inundation regions, and hydrodynamic model is rational for the continuous inundation regions. However, since discontinuity existed at the coupling moving interface (CMI), the single hydrologic or hydrodynamic models were not acceptable, which was a challenge for the model calculation. It is necessary to apply suitable numerical schemes to calculate the fluxes through the CMI.

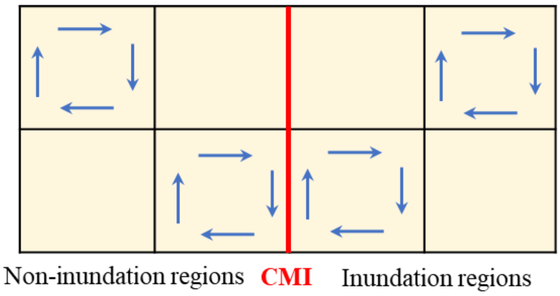

Figure 2 Model calculation at inundation regions, non-inundation regions and CMI

A pair of characteristic waves was used to determine the fluxes calculation methods through the CMI. The characteristic waves were calculated as follows:

$$S_L = u_{i,j} - \sqrt{gh_{i,j}} \tag{1}$$

$$S_R = u_{i+1,j} - \sqrt{gh_{i+1,j}} \tag{2}$$

where S_L and S_R are the characteristic waves; *u* is the flow velocity (m/s); *h* is the water depth (m); subscript (*i*, *j*) and (*i*+1, *j*) refer to the cells in non-inundation and inundation regions, respectively.

If $S_R > 0$ and $S_L > 0$, the fluxes through the CMI were calculated by the hydrologic model, and the CMI may move toward the non-inundation regions. Therefore, the non-inundation regions shrunk, whereas the inundation regions expanded. Only mass conservation through the CMI can be considered in this situation.

If $S_L < 0 < S_R$, the fluxes were calculated by both hydrologic and hydrodynamic models, and the CMI remained unchanged.

If $S_L < 0$ and $S_R < 0$, the fluxes are calculated by the hydrodynamic model, and the CMI may move toward inundation regions. Therefore, the inundation regions shrunk, whereas the non-inundation regions expanded. Both the mass and momentum conservation through the coupling boundary were obtained in the latter two situations. The couplings were detailed in Jiang et al. (2021) (http://doi.org/10.5194/nhes-21-497-2021) and Shen et al. (2021) (https://doi.org/10.3390/w13233454).

5. Comment: The paper uses small test cases to evaluate the modelling efficiency. However, it is important to validate the model's performance on larger scales, to ensure its practical applicability. Even the hydrodynamic models working on ~10m-30m can be configured for model run covering an area of several hundred kilometers and quite efficiently.

Response to comment: The proposed model in the manuscript has high computational efficiency compared with full 2D hydrodynamic model. The computational domain was divided using grids with different sizes. The areas prone to flood disaster were divided into fine grids, while other areas were discretized into coarse grids. The hydrologic model was applied to coarse grids, whereas the hydrodynamic model was only solved in local fine grids. Different time steps were accepted in coarse and fine grids. However, the uniform fine grids were used to divide the computational domain in full 2D hydrodynamic model, and the 2D hydrodynamic model was solved in entire computational domain. The performance of the M-DBCM was evaluated by Shen and Jiang (2023). If you want to learn more about this, you can review it in http://doi.org/10.2166/hydro.2023.131

Shen and Jiang (2023) also showed that the larger the computational domain, the more pronounced the improvement in computational efficiency of the model. However, the main drawback of the proposed M-DBCM is the applications, due to the difficulty of the data collection including input data, observation data. In future works, we will apply the proposed M-DCBM to watersheds of different sizes. We sincerely hope we have the opportunity to continue our cooperation and publish our study in this journal. Thank you for reading this article carefully and making valuable suggestions, which have important guiding significance for our writing and scientific research work.

6. Comment: The choice of using Fortran for coupling the two modelling components, while the SWMM model is written in C++, raises questions about the rationale behind this decision. The authors should provide a clear explanation for this choice, considering factors like compatibility, performance, and ease of implementation.

Response to comment: C++ and Fortran are widely used in scientific research. There were many differences between C++ and Fortran. C++ is widely used in various domains such as system-level programming, game development, and graphical user interface development. Its flexibility and performance make it a versatile programming language. Fortran is primarily used in scientific computing, numerical simulation, and engineering calculations. It has rich libraries and optimization tools specifically designed for mathematical and scientific computations.

Our team started developing the coupled hydrologic-hydrodynamic model five years ago, when we have a software solving the hydrodynamic model based on Fortran language. It is convenient to develop the coupled hydrologic-hydrodynamic model based on the existing code. Therefore, we developed the coupled model based on Fortran language. We still use Fortran language to ensure continuity in the work of developing model.

However, since the C++ has more advantages than Fortran and is more widely used, we will develop the coupled model based on C++ in future works. It is thus more convenient to discuss the proposed model with other researchers. Thank you for reading this article carefully and making valuable suggestions, which have important guiding significance for our writing and scientific research work.