Dear editors:

Thank you very much for your letter and for the respected reviewers' comments concerning our manuscript entitled "An improved dynamic bidirectional coupled hydrologic-hydrodynamic model for efficient flood inundation prediction" (ID: egusphere-2023-1106). Those comments that the respected editor proposed are all valuable and very helpful for revising and improving our paper, as well as important guiding significance to our research. We have studied comments carefully and have revised the article which we hope meet with approval. There were new lines and page numbers in the revised manuscript. All the changes were marked using red bold in the revised manuscript. We also responded point by point to the reviewers' comments as listed below, along with a clear indication of the revision. Hope these will make it more acceptable for publication.

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 manuscript, we considered thoughtfully what you have advised.

1. Comment: Regarding the mesh generation approach, the authors have opted for a strategy that maintains fine resolutions over the river channel while utilizing coarse resolutions for slope lands. While this approach may have been chosen to optimize computational resources, it raises questions about its suitability for flood modeling, particularly given the traditional emphasis on floodplain inundation processes. The distinction between the proposed d∞ mesh generation method and adaptive mesh generation methods, which typically focus on flow status or topographic differences, warrants clarification. Additionally, the authors should elaborate on their decision to prioritize river flow over floodplain inundation processes, as this choice may impact the comprehensiveness and applicability of the modeling framework.

Response to comment: Thank you very much for your valuable comments. Adaptive mesh refinement (AMR) dynamically adapts the grid resolution during the simulation, refining the grid locally based on domain characteristics or flow conditions. AMR is commonly employed in scenarios where flow characteristics exhibit abrupt variations, such as aerodynamic shock waves, hydraulic jumps, and tsunami waves. Capturing discontinuous solutions necessitates local grid refinement, with the location of refinement dynamically adapting to the position of the discontinuities. Consequently, AMR are indispensable. However, AMR needs to segment and merge the grid elements repeatedly during the calculation, which can be time-consuming and offset the calculation time saved by the optimized grid. Besides, the mesh generation and flood simulation were compiled in the same code base, which increased the computation cost and time.

Flow characteristic variations arising from abrupt geometric changes in the computational domain can be captured using static local refinement grids, provided that the extent of these changes is limited. This approach offers computational time savings. In flood simulations, inundation regions are typically situated in low-lying 2D regions. The outer boundary of the inundation regions can be determined using DEM or calculating by hydrologic models. The D∞ algorithm was employed to preemptively estimate the extent of these areas, providing enhanced computational efficiency relative to AMR and obviating the uncertainty and complexity associated with manual subdivision of the computational domain.

We have introduced the distinction between the proposed D∞ mesh generation method and adaptive mesh generation methods in the revised manuscript (lines 194 to 213). Besides, we have also detailed the applicability and disadvantages of the AMR in introduction of the revised manuscript (lines 98 to 114).

The 1D rivers and 2D inundation regions are prone to flood disasters. In the proposed model, both the 1D rivers and 2D inundation regions were discretized using fine grids, while the coarse grids were used to divide the remain regions. We have elaborated it in the revised manuscript from lines 180 to 186, as follows:

Generally, the river drainage networks present low slopes and hydraulic conveyance, which is subject to flooding. Areas prone to waterlogging, characterized by persistent water saturation, frequently occur adjacent to rivers. The dynamics of inundation in these low-lying zones constitute a central aspect of our investigation. Therefore, these areas should be discretized using fine grids to represent the flooding process in high resolution. However, in the slope lands, fine grids were not required and coarse grids were used to improve computational efficiency.

2. Comment: Concerning the efficiency of the improved model (as highlighted in the title), a more extensive demonstration of its efficiency is needed, especially considering the limited area coverage presented in the current results. While the model may indeed offer computational advantages, its effectiveness across larger spatial extents remains unclear. To address this concern, the authors should consider incorporating real-world case studies for model validation, showcasing the model's performance under varying environmental conditions. Furthermore, including the spatial distribution of flood inundation and comparing model outputs with remote sensing-derived flood extent data would enhance the validation process and ensure the model meets the requirements of practical flood modeling applications.

Response to comment: Thank you for reading this article carefully and making valuable suggestions. In the Section 3.3 of the revised manuscript, we have simulated the flood processes in a natural watershed, Goodwin watershed. We have verified the numerical accuracy and computational efficiency of the proposed model. The simulated discharge hydrographs were compared with the measured data. In the revised manuscript, we have showed the spatial distribution of flood inundation, as shown in Figure 12. And the computational efficiency was also detailed from lines 594 to 622.

In line with reviewer recommendations, we are endeavoring to apply the model to flood control in real-world. Our research team is currently engaged in flood control projects funded by the Asian Development Bank (ADB), Loan 3485-PRC: Flood control and Environmental Improvement Project in Kongmu River watershed, Xinyu city, Jiangxi province, China. The proposed M-DBCM is currently being applied to elucidate the effects of reservoir and gate operation, as well as sponge city facilities, on mitigating flood disasters. The M-DBCM has demonstrated superior accuracy in simulating flood inundation in low-lying areas outside the river channel, a capability that is lacking in existing models. Given that the simulation of the Kongmu River watershed pertains to a real-world flood control project, its progress is contingent upon the pace of engineering design. Moreover, the design of flood control infrastructure, including embankments and sponge city facilities, within the Kongmu River watershed has undergone multiple revisions. Consequently, the demands for data collection and processing are comparatively high. Substantial work remains before the model simulation results are ready for publication in academic journals.

During the data collection process for flood simulation, hydrological monitoring stations may experience data loss due to damage or deterioration over time. Efforts are currently underway to address this issue as well. Future work will involve the continued collection of data and information. The model will be employed in diverse scenarios to comprehensively evaluate its performance. In addition, as recommended by the reviewer, a comparison between model outputs and flood extent data obtained from remote sensing could be undertaken.

The proposed model has a relatively short timeframe, typically spanning two to three years. The widespread promotion and application, like Mike series, necessitate a protracted timeframe. Our ultimate objective is to disseminate our research findings through scientific publications, thereby broadening the accessibility and comprehension of the proposed model to a wider audience. Engaging with distinguished international experts and scholars, we strive to continually refine and enhance our models. We eagerly anticipate your continued provision of insightful feedback.

For detailed information regarding the computational efficiency of the model, we have proposed a parameter to quantitatively evaluate the computational efficiency of the M-DBCM (Shen and Jiang, 2023, http://doi.org/10.2166/hydro.2023.131), We defined the evaluation parameter as the ratio of the simulation time of the M-DBCM to that of the full 2D hydrodynamic model (HM2D), as shown in Eq. (1):

$$C=\frac{(1+\alpha_0)t_1+t_2}{t_0}=\frac{(1+\alpha_0)\alpha\frac{A_1}{\Delta x_1^2}\left(\frac{T_{end}}{\Delta t_1}\right)+\beta\frac{A-A_1}{\Delta x_2^2}\left(\frac{T_{end}}{\Delta t_2}\right)}{\alpha\frac{A}{\Delta x_1^2}\left(\frac{T_{end}}{\Delta t_1}\right)} \tag{1}$$

where C is the assessment parameter to evaluate computational efficiency of M-DBCM; t_1, t_2 are the computation time on fine and coarse grids, respectively (s); t_0 is the computation time of HM2D (s); Δx_1, Δx_2 are the size of fine and coarse grids (m); Δt_1, Δt_2 are the time step on fine and coarse girds (s); A_1, A_2 are the area of coarse and fine grids, respectively; T_{end} is simulation time (s); α and β are the runtime of hydrodynamic and hydrologic models at one calculation node (s), which is depended on computer power and numerical model complexity. Since the hydrodynamic model is expressed by nonlinear hyperbolic equation and hydrologic model is expressed by linear equation, the calculation of the hydrodynamic model is more complicated than that of the hydrologic model, which results $\frac{\beta}{\alpha} < 1$.

The time step ratio of coarse grids to fine grids is equal to the size ratio of coarse grids to fine grids, as follows:

$$\frac{\Delta t_2}{\Delta t_1} = \frac{\Delta x_2}{\Delta x_1} \tag{2}$$

Based on Eq. (2), Eq. (1) can be rewritten as:

$$C = \frac{A_1}{A} + \frac{\beta}{\alpha}\left(\frac{\Delta x_1}{\Delta x_2}\right)^3 \frac{A - A_1}{A} \tag{3}$$

Define $n = \frac{A_2}{A}$ $(0 < n \leq 1)$, $\Delta t_2 = k\Delta t_1$ $(k \geq 1)$, Eq. (3) becomes

$$C = (1-n) + \frac{\beta}{\alpha}\frac{1}{k^3}n \tag{4}$$

From Eq. (4), the computational efficiency of M-DBCM is not only related to the size ratio of coarse to fine grids, but the area ratio of coarse grids to entire domain. If the area of coarse-grid regions are much greater than that of the fine-grid regions, that is, $n \to 1$, the assessment parameter becomes $C \propto \frac{\beta}{\alpha}\frac{1}{k^3}$. It is indicated that the computational efficiency of M-DBCM exponentially improves with the increasing of the area ratio of the coarse grids to entire domain, as shown in Figure 3(a). If the size of coarse grids is much more than that of fine grids, that is, $k \to \infty$, the assessment parameter becomes $C \propto (1-n)$. It is stated that the computational efficiency of M-DBCM improves linearly with the increasing of the size ratio of the coarse to fine grids, as shown in Figure 3(b).

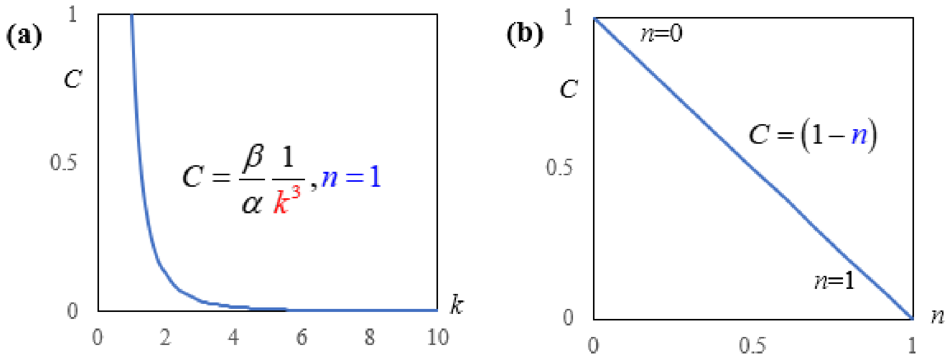

Figure 3 The relationship between the evaluation parameter and the n and k:(a) the relationship

between the evaluation parameter and n; (b) the relationship between the evaluation parameter and k