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:** While the DBCM is currently not available as an open-source model package, a comparative analysis with widely used software is essential in the presentation of the model results. This will elucidate the advantages of the proposed coupling mechanism, which claims to align more consistently with natural flood disasters. Additionally, it is crucial to demonstrate the computational efficiency and accuracy gains compared with state-of-the-art models.

**Response to comment:** Thank you very much for your valuable comments. In the Introduction, the advantage, disadvantage and applicability of existing coupling models were detailed. And therefore, the benefit of the DBCM was highlight compared to other coupled models.

Considering the length of the manuscript, we have removed the case in Section 3.2 of the original manuscript, and added another example in the revised manuscript. In this example, the full 2D hydrodynamic model (HM2D) and coupled Mike SHE and Mike 11 were also used to simulate the surface flow to verify the performance of the proposed IM-DBCM. If you want to learn more about this, you can review it in the Section 3.2 of the revised manuscript, which were also remarked using red bold.

Besides, we have also compared the computational efficiency of the IM-DBCM with the HM2D (see Figure 11), which was shown in the Section 3.3 in the revised manuscript.

**2. Comment:** Section 2.3.1: In the context of the hydrological model, a comprehensive consideration of the water balance is paramount. It is imperative to elucidate the methodology employed for estimating evaporation, infiltration, and ground water dynamics. Also, how land cover and soil moisture texture impact the hydrological

processes.
**Response to comment:** Thank you for reading this article carefully and making valuable suggestions. In the hydrologic model applied to IM-DBCM, only the surface flow processes, i.e., runoff generation and routing, are calculated. The runoff generation was equal to the rainfall intensity minus infiltration and evaporation rate, and the infiltration rate was calculated using Green-Ampt.

In a flash flood, surface flow is the most important factor to be considered, interflow, and underground runoff can be neglected due to the short rainfall and calculation duration (Hou et al., 2018; Li et al., 2021). However, a complete hydrologic model should include surface flow, interflow, and underground runoff. Regarding the surface hydrologic model, the ignored interflow and underground runoff processes likely lead to underestimations in flood simulation, especially for long-term simulations. In future works, the interflow and underground runoff could be calculated in the hydrologic model.

The aforementioned issues are discussed in the Conclusions section of the revised manuscript (lines 626-630), which are also highlighted in red bold. Furthermore, we noted that only surface runoff was simulated in the hydrologic model (Section 2.3.1 of the revised manuscript, lines 289-291).

References:
Hou, J., Wang, R., Liang, Q., Li, Z., Huang, M.S., Hinkelmann, R. (2018). Efficient surface water flow simulation on static cartesian grid with local refinement according to key topographic features. Computers & Fluids, 176, 117-134 https://doi.org/10.1016/j.compfluid.2018.03.024

Li, Z., Chen, M.Y., Gao, S., Luo, X.Y., Gourley, J.J., Kirstetter, P., Yang, T.T., Kolar, R., McGovern, A., Wen, Y.X., Rao, B., Yami, T., Hong, Y. (2021). CREST-IMAP v1.0: a fully coupled hydrologic-hydraulic modeling framework dedicated to flood inundation mapping and prediction. Environmental Modelling and Software, 141(1), 105051. http://doi.org/10.1016/j.envsoft.2021.105051

**3. Comment:** Evaluation of discharge exchange at the coarse-fine resolution interface is crucial. Specifically, when surface runoff transitions from a coarse grid to a fine grid, potential instability issues should be thoroughly examined. Though interpolation method is applied, will the possible sharp increase in discharge at the coarse-fine grid interface cause instability?
**Response to comment:** We acknowledge and fully understand your concerns. In the IM-DBCM, the multi-grids were used to discrete the computational domain. It may reduce numerical accuracy at the coarse-fine grid interface, compared to the model using fine grids discrete computational domains. The accuracy and stability of interpolation formats have been discussed in existing literature. For example, the Holly-Preissmann scheme employs values of the dependent variable and its derivatives to achieve high-order spatial interpolation (Holly and Preissman, 1978; Holly and Cunge, 1979). This approach avoided interpolation errors that exceed the maximum or minimum values.

In aerodynamic and hydrodynamic simulations, the nonlinear partial differential nature of the Navier-Stokes or shallow water equations often leads to flow discontinuity, such as shock waves, hydraulic jumps, or tsunami waves. These phenomena result in abrupt spatial variations in the flow state. Linear interpolation of variables between coarse and fine grids can smooth out discontinuous solutions, resulting in substantial errors.

However, in the IM-DBCM proposed in this study, two types of connecting interfaces are presented, which divide the computing domain into three parts (see Figure 3 in the revised manuscript). The first part represents the coarse-grid areas, where the hydrologic model is used to simulate rainfall-runoff. The other two parts are located in the fine-grid areas. The regions between VII and CMI are defined as intermediate transition zones, where the hydrologic model is used to simulate the flooding process. These transition zones facilitate the application of different time steps in different grid cell sizes to improve computational efficiency. On both sides of the interface between coarse and fine grids, the hydrologic model was used to simulate the flood process. In the hydrologic model applied to the IM-DBCM, the Manning equation is employed to simulate surface runoff processes. As a linear partial differential equation, the Manning equation lacks a nonlinear convection term. Consequently, the flow state undergoes relatively smooth changes without exhibiting discontinuous solutions. Linear interpolation is applied to interpolate variables between coarse and fine grids, with the interpolated values falling within the range defined by the maximum and minimum values of the interval. This interpolation ensures that the result lies between these bounds, precluding the occurrence of increased flow at the interface of coarse and fine grid transitions.

The bilinear interpolation scheme employed for the spatial discretization of variables has been preliminarily validated through numerical examples, demonstrating its numerical stability and validity. The reviewers' suggestions provide invaluable guidance for enhancing the quality of this paper. Future research directions include exploring the relationship between various spatial interpolation schemes and simulation errors for different types of partial differential equations.

We have clarified the performance of the bilinear interpolation applied to the IM-DBCM in the revised manuscript, from lines 268 to 277.

References:

Holly F M, Preissman A. Accurate Calculation of Transport in Two Dimensions. (1978). Journal of Hydraulics Division, 103:1259-1277.

Holly F M, Cunge J. Coupled Dynamic Streamflow-Temperature Models Discussion. (1979) Journal of Hydraulics Division, 104: 316-318.

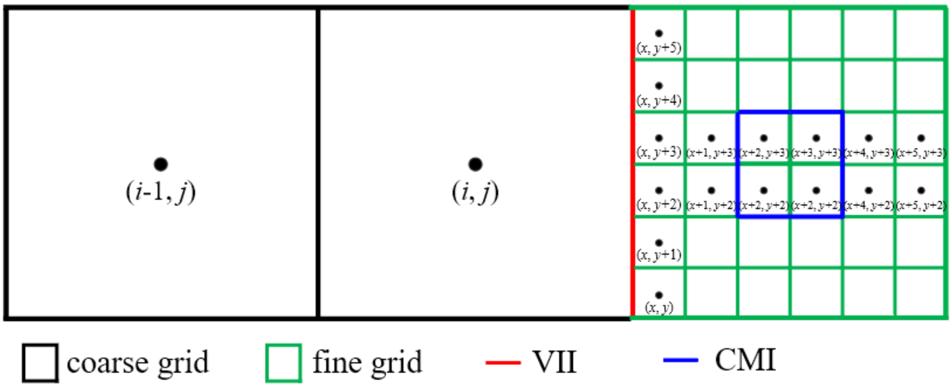


Figure 3 in the revised manuscript. Schematic diagram of grid generation, where *i* and *j* are the coordinates of coarse grid; *x* and *y* are the coordinates of fine grid; VII is the Variable Interpolation Interface and CMI is the Coupling Moving Interface

**4. Comment:** Concerning the mesh generation controlled by the D∞ algorithm, there is a suspicion that the mesh might be limited to a static structured nonuniform format, controlled by only the DEM features without consideration of the flow characteristics. It would be beneficial to clarify whether an adaptive mesh generation approach is employed, allowing the mesh to dynamically adjust over time in response to changing flow conditions. Such clarification would contribute to a more nuanced understanding of the model's spatial discretization strategy.

**Response to comment:** Thank you very much for your valuable comments. Initially, Adaptive Mesh Refinement (AMR) was applied to the DBCM (Yu 2019), but has since been replaced with static mesh due to the high computational cost and complexity of the AMR. Static structured non-uniform grids were used to discretize the computational domain based on the D∞ algorithm. The grid generation can be considered as a model preprocess, which is the foundation of flood simulation and can influence both computational accuracy and efficiency. In the watershed, when heavy rainfall occurs, the extent of the inundation regions can be primarily determined. Our focus is on flood dynamics in inundation regions. Therefore, a static grid can meet the requirements. For example, the Mike and SWMM models also employ static grids to discretize 2D inundation regions and have gained widespread usage.

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. Static non-uniform grids have increasingly received attention in recent years, which simplified grid generation procedure compared with AMR.

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. For example, the Mike series model employs static grids to delineate the boundaries of 2D low-lying waterlogged areas (Thompson et al., 2004). Given that the extent of these areas can be estimated in advance, static grids offer enhanced computational efficiency. The impact of employing hydrodynamic or hydrological models on the overall calculation results is minimal due to the shallow water depths and relatively low flow velocities at the boundary between the inundation and non-inundation regions. Consequently, static multi-grids are employed in flood inundation calculations in the proposed model. This approach involves coarse and fine grid discretization, followed by interpolation. It has been demonstrated to yield satisfactory results.

However, the structured grids were used to divide the computational domain based on D∞ algorithm. But the finite volume numerical scheme can be implemented on both structured and unstructured grids. In the future works, maybe the non-structure grids can be used to divide the computational domain based on D∞ algorithm.

We have compared and analyzed the performance of static non-uniform grids and AMR in Introduction (from lines 98 to 119). We have also clarified the grid technology applied to the proposed model in the revised manuscript from lines 148 to 149.

References:

Yu, W.: Research on Coupling Model of Hydrological and Hydraulics Based on Adaptive Grid. Ph.D. Thesis, Tsinghua University, Beijing, China, 2019.

Thompson, J.R., SoRenson, H.R., Gavin, H., Refsgaard, A.: Application of the coupled MIKE SHE/MIKE 11 modelling system to a lowland wet grassland in southeast England. Journal of Hydrology, 293(1-4): 151-179. 2004. http://doi.org/10.1016/j.jhydrol.2004.01.017

**5. Comment:** Given that the model is currently confined to your research group, it is advisable to articulate a broader research purpose, both in the introduction and the method section. This will provide a more comprehensive understanding of the main contributions that the DBCM brings to the field of flood modelling.

**Response to comment:** Many thanks for your suggestions. In the first paragraph of the introduction, we have explained the necessity of developing the coupling models. And next, we introduced the shortcomings of existing coupling models. Finally, we present the purpose and importance of the model we intend to develop. We aim to develop a model that can improve the computational efficiency while maintaining simulation accuracy. In the Conclusions, we have verified that the performance of the proposed model, which can be used for rapid flood prediction and management.

However, 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.