Dear Editors and Reviewers:

Thank you for your letter and for the reviewers' comments concerning our manuscript entitled "Effects of spatial resolution of digital terrain obtained by drone on mountainous urban fluvial flood modelling" (No.: EGUSPHERE-2024-404). Those comments are all valuable and very helpful for revising and improving our paper. We have studied comments carefully and have made correction which we hope meet with approval. The main corrections in the paper and the responds to reviewer's comments are as following:

Author Comments to Referee #1
Responses to the general review comments of Referee #1:

1. "Improve language and grammar. The text is not always easy to read. Use ChatGPT, Google gemini or similar to improve your text, it will make the paper more accessible and impactful."

Response: Thanks very much for taking your time to review our manuscript. We have carefully checked and improved the English writing in the revised manuscript, and we believe the readers could understand our work more clearly.

2. "Authors have used photogrammetry techniques to derive the DEM from drone-borne imagery. Another option would be drone-borne lidar. I think the paper would benefit from a short summary of these available options, pros and cons of each option and a few references illustrating those."

Response: Thank you for your kind suggestion. We fully agree to include a brief summary of other DEM acquisition methods based on drones, and this content has been added to the introduction in lines 67-73.

3."A key step for hydraulic modeling purposes is generating the terrain model from the surface model, i.e. DSM to DTM conversion. Main factors in this are buildings and vegetation. The article explains that buildings were not removed, which I agree with – how was vegetation handled?"

Response: Thank you for your insightful comments. We processed the DSM using the PCI Geomatica software. The reason for choosing PCI Geomatica is that it allows for manual local editing of the DSM, which is a better choice for our study area as the vegetation zones are relatively small and scattered. Compared to applying global filtering to the entire study area, local processing is more suitable. The specific processing method involves using various filters available in PCI Geomatica, such as Terrain filters, Pit and Bump Filters, Median filters, and Clamp filters, along with manual touch-up edits to filter the designated vegetation areas. PCI Geomatica can also take into account the slope of the local terrain and apply directional filtering to more accurately remove vegetation and other non-ground features.

We have added the specific steps for filtering performed using PCI Geomatica and clarified which filters were used in this study in lines 171-194, and a new visualization of the results has been attached (Fig. 3).

4."As pointed out in the paper, submerged topography cannot be derived from photogrammetric DEMs. However, there are options to get bathymetric information from UAS, including green lidar, water penetrating radar and sonar. Those recent advances could be briefly summarized in the paper."

Response: Thanks for your professional suggestions. During our research, we also discussed the current progress in obtaining water depth information and underwater topography using drones with experts in drone surveying. Some conclusions were given at that time, such as the fact that the performance of green LiDAR is highly dependent on water clarity, and integrating green LiDAR data with other datasets (e.g., traditional LiDAR or sonar) may be complex.

We have added this missing research progress explanation and references in lines 197-205.

5."A key result of the paper is to show how the quality of flood simulations depends on the DEM resolution. It is perhaps not surprising that quality increases with increasing resolution. One key factor that limits what is possible, at least for larger domains, is CPU time and computing resources. It would thus be informative to see those parameters for the different model runs at different spatial resolution."

Response: Thank you for raising this important point. CPU time and computing resources are important information in this study, as improving computational efficiency is one of the research significances of this paper.

We have added the hardware information of all the computers used for simulations and the computation time for processing data at different resolutions in lines 244-253. Two new table about computational time for floodplain mapping and hardware specifications have been added (Table 2 and Table 4).

6."Authors introduce and calculate quantitative terrain indicators called topographic features here. They show that these indicators depend on the spatial resolution of the DEM and that the mismatch between the features calculated at native and coarsened resolution increases with decreasing resolution. Further, they argue that degradation of the terrain indicators with decreasing resolution is similar to the degradation of the flood simulation results with decreasing resolution. It would be good to analyze this further: What is the correlation between different topographic features and skill of the flood simulation? Are there specific thresholds for the feature mismatches, exceedance of which would cause the skill of the flood simulation to decrease? Are these findings site-independent and transferable?"

Response: We would like to thank the reviewer for these constructive comments.This study uses the statement "the accuracy of terrain undulation representation varies with different resolutions, thereby affecting the accuracy of flood simulation" to qualitatively describe the correlation between various terrain features and flood simulation techniques. How these factors are specifically related is a question we have been seeking to resolve. We believe this connection is related to the equations used for calculating two-dimensional unsteady flow in hydraulic models. Various topographic features are directly linked to the terrain gradient terms in the hydraulic equations, influencing changes in water momentum, flow velocity, and direction. This requires further in-depth research and discussion in our future work.

Regarding whether there is a specific threshold for feature mismatch, this is also a question we aim to address in this study. Our original research plan was to design a scoring system based on topographic attribute metrics, improving the statistical topographic attribute metrics into a comprehensive evaluation index. We would then use finer resolution intervals to comprehensively score the accuracy of terrain undulation representation under different resolutions, while also incorporating flood inundation simulation accuracy and computational cost into the evaluation system. This would not only facilitate discussion on whether a specific threshold exists but also help discover how these methods apply in different regions. We are currently making efforts to find suitable improvement methods.

Responses to the minor comments of Referee #1:

1.Avoid acronyms in abstract or write out before first use (DSM)

Response: Thank you for pointing out the problem, we have modified the abbreviation in line 12.

2.Line 17: Replace "within" with "better than"
Response: Thanks for your comment.We have revised the expression int line 17.

3.Line 18-20: Please rephrase sentence "However…. flood depth". Unclear
Response: Thanks for your comment.We have revised the expression in lines 19-20 .

4.Line 29: El Nino is not induced by global warming – rephrase
Response: Thank you for pointing out this important expression error, we have corrected the expression in lines 29-31.

5.Line 50: Be consistent with the terms DSM, DEM and DTM. DTM is the main input to flood models.
Response: We fully agree with the reviewer's opinion. We are sorry for the confusion in our expression regarding DSM and DTM. In most past studies, DTM (which focuses only on the natural terrain without surface features like trees or buildings) was used as the input for hydraulic models. However, in this study, since it involves flood inundation simulation, we retained the riverside buildings while processing the DSM obtained from the drone (DSM includes all surface objects), and only filtered out noise points from vegetation, water surfaces, and roads. As a result, the terrain data is in a state between DSM and DTM. After discussion and considering other reviewers' suggestions, we have decided that it is more appropriate to define the terrain data we used as DTM.

We have made the necessary revisions to the corresponding expressions about DTM and added specific explanations of DSM and DTM in lines 171-175. Additionally, we have included the visualization of DTM generation from DSM using PCI Geomatica (Fig.3).

6.Line 141: There are drone-borne bathymetry options (https://doi.org/10.5194/hess-22-4165-2018, https://doi.org/10.1016/j.jhydrol.2022.128789)
Response: We greatly appreciate the reviewer for providing the references. We have carefully read them and included additional explanations regarding UAV-based bathymetry in lines 197-205, and added these references.

7.Line 204: Which model parameters?
Response: The parameters adjusted in the hydraulic model are the Manning's roughness coefficient, and we have modified the expression in lines 285-287.

8.Fig 7: Legend items are mis-spelled
Response: We sincerely appreciate the reviewer for pointing out the spelling errors. We have corrected the expressions in the figure legend accordingly. The new figure is Fig. 9.

9.Fig 9: Provide units for y-axis (absolute error)
Response: We are grateful to the reviewer for pointing out this issue. We have revised the result figures for the indicators that include units accordingly. The new figure is Fig. 11.

We sincerely appreciate the reviewer's comments on the details of the manuscript, especially for pointing out some errors and confusions in the expressions. We will carefully revise the relevant content in the next version of the manuscript. Once again, thank you for taking the time to review our paper and providing such valuable feedback.

Author Comments to Referee#2
Responses to the general review comments of Referee #2 :

1. "Being the topography one crucial element of the paper there is a need to define once in the text the definition of dsm and dtm, their differences and which one of them is used in the model. The post processing of the dsm should be detailed in order to make it clear and reproducible. The authors should move from spelling the name of the software used to spelling the single steps of the procedure (and the main algorithms) they used. Is there any computation of levees lines, special topographic features/lines, artificial depressions filling?"

Response: Thank you for your insightful comments. Sorry for the confusion in our expression regarding DSM and DTM. In most past studies, DTM (which focuses only on the natural terrain without surface features like trees or buildings) was used as the input for hydraulic models. However, in this study, since it involves flood inundation simulation, we retained the riverside buildings while processing the DSM obtained from the drone (DSM includes all surface objects), and only filtered out noise points from vegetation, water surfaces, and roads. As a result, the terrain data is in a state between DSM and DTM. After discussion and considering other reviewers' suggestions, we have decided that it is more appropriate to define the terrain data we used as DTM. We have supplemented the relevant modifications and explanations in the section on processing drone imagery in lines 171-175 .

The specific processing method of DSM involves using various filters available in PCI Geomatica software, such as Terrain filters, Pit and Bump Filters, Median filters, and Clamp filters, along with manual touch-up edits to filter the designated vegetation areas.The specific process of handling DSM in this study is indeed important for the readers. Previously, we did not provide detailed explanations due to space constraints. We have added the specific steps for filtering performed using PCI Geomatica and clarified which filters were used in this study in lines 171-194, and a new visualization of the results has been attached (Fig. 3).

When using HEC-RAS for hydraulic simulation, we did not set additional levee lines or other special topographic features/lines, because, unlike traditional low-resolution DEMs, the 6 cm resolution DTM can accurately and realistically reflect terrain obstacles (such as levees and highlands). This was also verified during the cross-section processing and subsequent simulations in HEC-RAS. As for the artificial depressions filling, we handled it using Pit and Bump Filters during the DTM processing.

2. "The authors often acknowledge the fact that the study area is mountainous and urbanized. However there is not reference, no discussion and no comparison against studies that include physical processes such as sediment transport and turbidity in the flood modeling as well as concerning the urban drainage network. What the assumptions used, and the hypothesis made by the authors concerning these (neglected) concepts? I believe this should be clarified and offer interesting points to be discusses."

Response: Thanks for your professional suggestions. We apologize for not providing a more detailed explanation regarding the impact of sediment transport and urban drainage networks in the manuscript. The reason we did not consider the influence of sediment transport in this study is due to the fact that the research area is located immediately downstream of a large reservoir, which intercepts sediment and results in the release of clear water. Additionally, we referred to the situation in many flood-prone mountainous riverside cities, where—except for extremely underdeveloped areas—reservoirs or other water-retaining structures are typically built upstream to mitigate the effects of flood disasters. These structures also reduce the downstream impact of sediment transport, even during flood discharges, as they provide a degree of sediment interception. Furthermore, since our research focuses on the main urban river section most affected by floods, without considering the broader flood propagation, we concluded that sediment transport has a limited impact on the flood simulation in our study.

As for the impact of urban drainage networks, as mentioned in the introduction of the manuscript, unlike plain cities where urban flooding is mainly caused by impervious surfaces and drainage networks, riverside cities in mountainous areas have impervious roads and various buildings constructed along significantly sloped terrains. During heavy rainfall, runoff rapidly converges towards the lowest areas of the river channel, making it difficult for significant urban flooding to occur. Additionally, flash floods in such areas are dominated by fluvial flood, with the inundation range gradually spreading along both sides of the river. The main human and economic damages occur close to the riverbanks. The rapid rise and fall characteristics of flash floods mean that the processes of flood initiation, peak passage, and recession could all be completed before the urban drainage network in mountainous cities has any significant impact. The main factors influencing flood propagation in such areas are the downstream channel's flow capacity and upstream inflow variations, with the influence of the urban drainage network being relatively minor in comparison to these factors.

We have added the corresponding explanation in lines 147-154, and we would like to once again thank you for pointing out these key issues.

3."The validation procedure is not clear. Two concepts should be clarified: i) inundation points: the authors should spell out if they are points, cross sections, groups of flooded pixels. Are they flooded by a single or multiple flood events? Are those measured localized data? ii) the authors use the 6cm simulation as benchmark, but no spatial error metrics are presented over the analyzed domain. This is crucial for having an overall model assessment with varying resolution and not only at the 6 points."

Response: Thank you for raising these important points. We sincerely apologize for the lack of clarity in the validation procedure. In fact, the term "inundation point" refers to a specific location indicating the flood boundary, which in reality is a flood boundary line. This line represents the position that the flood reaches when the water flow attains a certain value. These six flood boundary locations were selected by the local flood management department as key flood warning and observation points. During the flood season, staff members are stationed at these points to observe conditions and oversee evacuation procedures.

The flood boundary lines for each location were derived from historical observations over multiple flood events, which are summarized in the form of red lines (as shown in the field investigation photos in Figure 5). This data was provided by the technical staff of the Dazhou Hydrological and Water Resources Survey Centre (one of the co-authors of this study). During our field investigation, we also verified these lines through the inspection of historical flood traces and interviews with local residents.

We have made revisions and added supplementary explanations in lines 137-146.

Regarding the issue of missing spatial error metrics, we fully agree with the reviewer's opinion. For the entire study area, we only used inundation area and average inundation depth as evaluation metrics, which are indeed insufficient for a comprehensive assessment of the model.

We have added a spatial and statistical comparison analysis of the simulation results at different resolutions with the benchmark (6 cm DTM) in Section 3.2.1(lines 300-315), and have redrawn the result figure (Fig. 8).

Responses to the minor comments of Referee #2 :

1.Figure 1: Inundation points and the corresponding text are not readable from the insert of Figure 1 please use a different color

Response: We appreciate the reviewer for pointing out this issue. We have revised the colors of the inundation points in Figure 1 accordingly.

2.Table 1: serial number is not a number but a letter please be consistent in the table description and in the text.

Response: Thank for your suggestion. We have corrected the erroneous statements in Table 1.

3.Line 88: simulation errors: errors or dissimilarities, if errors please clarify how these errors are computed, against what type of ground truth?

Response: Thanks for your comment. We have supplemented the calculation methods for the errors and the types of ground truth used for comparison, along with the corresponding references in lines 97-100 .

4.Line 116: please clarify what is the meaning of "typycal" and what are these main feautures

Response: Thanks for your comment. We have provided additional explanations for the features of typical mountainous riverside cities, including geographical location, topography, and urban distribution in lines 129-132.

5.Line 116: According to the 2022 Flood Control Plan of Xuanhan: I wonder if the domain was already used in the According to the 2022 Flood Control Plan of Xuanhan and if inundation maps are available in the plan or by local authorities over the same study area. This will provide an independent validation of the method used in this paper, which move from 6 points to spatial assessment.

Response: Thanks for your comment.Relevant explanations can be found in the response to the third major comment above, and we have also added additional clarifications in the manuscript in lines 137-146.

6.Line 118: what is a warning points, how is this defined? in a location/a cross section, an area of pixels well defined where inundation was observed? if yes, what about the surrounding of the 6 points?

Response: Thanks for your comment. Similar to the previous response, we have added additional clarifications in lines 137-146 of the manuscript.

7.Line 121: please be more explicit on how did you select the flood event (if it was only one or more than one); is this measured or simulated? if simulated by which kind of model? how about initial hydrological/hydraulic conditions that generated this event?

Response: Thanks for your comment. We used observational data from the major flood event in 2005, and we have revised the unclear expression in lines 144-146.

8.Line 134: can you better define the PCI Geomatica, which tools algorithm did you apply for obtain the filtered maps? Can you describe them in order to achieve reproducible research?

Response: Thanks for your comment.Relevant explanations can be found in the response to the first major comment above, and We have added the specific steps for filtering performed using PCI Geomatica and clarified which filters were used in this study in lines 171-194, and a new visualization of the results has been attached (Fig. 3).

9.Line 137: carried out using the highest quality settings: can you please specify what does it means? which

processes are involved in the "high quality" and how "high" is defined?

Response: Thanks for your comment.The term "high quality" refers to an option in DJI's drone imaging processing software, DJI Terra. High-quality processing signifies the generation of denser and more refined point cloud data, utilizing advanced noise filtering techniques, among others. This approach places higher demands on both image quality and computational hardware. We have provided corresponding explanations in lines 166-169.

10.Line 148: processing tool RAS Mapper: which tools algorithm did you apply for obtain the filtered maps? Can you describe them in order to achieve reproducible research?

Response: Thanks for your comment.One of the major problems in hydraulic modeling is that terrain data does not often include the actual terrain underneath the water surface in the channel region. RAS Mapper can now be used to create a terrain model of the channel region from the HEC-RAS cross sections and the Cross Section Interpolation Surface. This terrain model can then be combined with the general surface terrain model (that does not accurately depict the terrain below the water surface) to create an improved terrain model for hydraulic modeling and mapping. We have added the relevant content in lines 208-213.

11.Line 150: a table could be useful where the authors clearly mention all the input, the parameters for setting the model simulations, and all the output. This should clarify the procedure and eventually the study reproducibility, which is crucial in research.

Response: Thanks for your comment.We have added a new table (Tabel 3) in the manuscript that contains all the inputs, the parameters used for setting up the model simulations, and all the outputs.

12.Lines 156-162 please clarify the meaning, the units, and values of the variables presented

Response: Thanks for your comment.We have supplemented the meaning, units, and values of the variables presented in lines 225-229

13.Line 162 radius: please space is missing

Response: Thanks for your comment.We have corrected the missing spaces.

14.Line 173: what is a flood process: do you mean a flood hydrograph?

Response: Thanks for your comment.This refers to using the runoff time series of the selected flood events as input. We have revised the wording that caused the confusion in line 240.

15. Line 181: how and why did you use these attributes? the meaning of each of them is clear but how and why they will be used in the methodology is not clear.

Response: Thanks for your comment.These six attributes comprehensively account for the factors of elevation, terrain ruggedness, exposure, and morphometric protection, as well as flow resistance, providing a thorough evaluation of how topographic features influence hydrodynamics. For instance:

Elevation: Elevation is a critical topographic parameter affecting water flow speed, direction, and energy. It directly determines the downhill flow tendency, making it essential for flood simulation.

TPI (Topographic Position Index): TPI describes the position of a point within its surrounding terrain (e.g., hilltops or valleys). It helps determine areas where water collects or disperses, influencing flow paths and ponding locations.

TRI (Terrain Ruggedness Index): TRI measures terrain roughness, describing the degree of surface undulation. Rugged terrain can increase flow friction, affecting both flow velocity and water kinetic energy.
WEI(Wind Exposition Index): Calculates the average wind effect across all directions using an angular step. This index indirectly reflects the impact of topography on flow paths by evaluating the terrain's openness or shielding characteristics.
MPI (Morphometric Protection Index): MPI reflects the protective role of terrain against natural disasters like landslides or erosion. In hydraulic models, this index helps assess the influence of terrain on flow paths.
VRM (Vector Ruggedness Measure): VRM is another measure of terrain complexity, capturing surface variation in all directions. Complex terrain can significantly alter water flow paths and velocities, and in flood simulations, VRM assists in identifying areas where water flow might be obstructed.

We have incorporated this clarification into the Table 5.

16. Line 201-204: this is not results, it is method; still not clear what are the 6 points
Response: Thanks for your comment. We have rewritten this section and optimized the description of the inundation points in lines 279-297, and added a new result figure (Fig.7). For detailed descriptions of the inundation points, please refer to the content in lines 137-146.

17. Line 208 210: what physically happen in correspondence of these six points/cross sections? change of slope, drainage directions? roughness?
Response: Thanks for your comment. The explanation regarding the inundation points can be found in the response to the third major comment above. For detailed descriptions of the inundation points, please refer to the content in lines 137-146.

18.Figure 7: what are the dashed lines in panel b? please define them
Response: Thanks for your comment.The dashed lines are used to better depict the variations (step changes) between the simulation results at different resolutions. We have added relevant explanations in lines 336-337.

19. Line 224-225 please the sentence does not make sense, consider to revise or remove the sentence .
Response: Thanks for your comment.We have removed the sentence (line 310).

20. Line 225: "The reason for the lack of significant trends " do you mean statistically significant or only a clear pattern? please clarify
Response: Thanks for your comment.The term "not significant" here refers to the observation of a clear pattern derived solely from the bar charts in the figure, as it only involves results from six different resolutions (which provides a limited statistical sample), and there are no apparent differences in the results.

21. Line 258: remove 1 dot
Response: Thanks for your comment.We have corrected this error (line 353).

22. Line 266, please define what the numbers in table 3 mean: eventually with a formula. In the caption mean error is used but how is it computed and why average error is considered; can you add more typical measures such as rmse, absolute error, percentage bias?
Response: Thanks for your professional suggestions. We have added the specific calculation method and related

descriptions in lines 360-367. The discussion here mainly focuses on comparing the differences between the simulation results at different resolutions and the benchmark under varying flow conditions, as the six inundation points correspond to six flow values ranging from low to high (from 6000 m^3/s to 12,700 m^3/s). The simulation results at the inundation points consist primarily of a flood inundation boundary line, which covers a small area and involves relatively few data points. Therefore, we believe that using the average error for analysis provides a more intuitive comparison.

We have added a spatial and statistical comparison analysis of the simulation results at different resolutions with the benchmark (6 cm DTM) in Section 3.2.1(lines 300-315), and have redrawn the result figure (Fig. 8), including rmse, absolute error, percentage bias.

Finally, thank you very much for taking the time to review our manuscript and for providing many professional evaluations. Each comment has been extremely helpful in enhancing the professionalism and readability of the manuscript. We will carefully revise the manuscript according to your suggestions. Once again, we appreciate the valuable feedback provided by the reviewer.