# Responses to reviewers on: "Quantifying uncertainty in flood predictions due to river bathymetry estimation" - $2^{nd}$ round

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Dear Prof. Lixin Wang and reviewers,

We thank you so much for the second opportunity to respond to the reviewers on “Quantifying uncertainty in flood predictions due to river bathymetry estimation”. We really appreciate the time and effort that you and the reviewers spent on providing valuable recommendations to our manuscript. Similarly to the first round, please see below, in green, for our responses to the reviewers’ questions. We separated the responses into three sections for the editor and two reviewers, with an extra section to list all parts we edited to make the content more accurate, consistent, and concise. The sections and lines mentioned here are based on the track-changed manuscript version.

## 1 Editor report

Both reviewers think the manuscript was significantly improved after the revision. However, both reviewers think the manuscript requires further improvements. For example, as one reviewer pointed out, there are still opportunities to improve its clarity, justify the assumptions, validate and generalize the findings, and elaborate on the limitations. I generally concur with the reviewers’ assessment and recommend a modest revision of the manuscript.

We would like to thank the editor again for the second chance to revise our manuscript according to suggestions from the reviewers. In general, in this revision, we have improved the clarity of the uncertainty propagation process, provide further explanation on calibrations and observations, improve the visualisation, elaborate on the limitations, and enhance the result analysis. These will be presented in this response as well as the revised manuscript.

## 2 Reviewer 1

***Summary of reviewer’s comments:*** The reviewer recommended further explanation on the uncertainty propagation through the flood model in the manuscript.

***Summary of authors’ responses:*** We would like to thank you very much for showing us that we lack this information in the manuscript. We have added further explanation about this uncertainty propagation process into the revised manuscript. This addition can be seen clearly in the track-changed version in Section 2.2. at lines 143-153 and it is also be explained in detail below in Section 2.1. (question 1) in this response.

### 2.1 Question 1

***Question:*** I would like to emphasize that the flood model and its performance require a more detailed description. This component is critical, as it links the uncertainties in topographic data to those in flood predictions. As noted in the first-round revision and acknowledged by the authors, quantifying uncertainties in topographic estimation on how uncertainties in topographic estimation propagate through to the flood simulations. Therefore, the manuscript should include more information on how uncertainties in topographic estimation propagate through to the flood simulations.

***Answer:*** To add further information about the uncertainty propagation through the flood model, first, we moved the flood model description into a separate section at line 129 and named "2.2. Flood model and explanation about uncertainty propagation process". We then added the explanation about the uncertainty propagation process below at lines 143-153:

*"To further expand on the description of uncertainty propagation through the model given in Section 1, we apply the following chain for easier comprehension:*

*Estimated river bathymetric data $\longrightarrow$ riverbed elevations $\longrightarrow$ topographic data (DEM and Manning's n derived from roughness length) generated by riverbed elevations and LiDAR data $\longrightarrow$ inputs to a flood inundation model (LISFLOOD-FP in this study) $\longrightarrow$ affects flood model outputs (extents, depths, etc.)*

*As indicated in the chain above, the estimated river bathymetric data that contain errors are used to calculate the riverbed elevations (see Section 2.1). These riverbed elevations are then used to represent the river in the topographic data. These topographic data are then inputted into the flood model as a discretisation of the floodplain and channel topography to model the water flow. Here, in the flood model, the river as represented in the topographic data controls when, where, and how much the water leaves the channel and starts to flood. Hence, the flood model outputs such as the flood extents and flood depths are affected by how the river is represented. In the next section, we will describe how the river bathymetric data are estimated."*

After that, we rewrote the first paragraph of Section 2 at lines 92-98 to correctly outline this section: *"In this section, we first introduce the study site, necessary data, flood model, and explain the uncertainty propagation process. Next, we define two formulas used for river bathymetry estimation and describe a method to explore the relationships between parameters and river bathymetry from these two equations. We then show how to examine these relationships based on the river of the study site. Finally, we design a sensitivity analysis workflow to quantify the uncertainty in the flood model outputs due to errors in the river bathymetry estimations."*

## 3 Reviewer 2

***Summary of reviewer's comments:*** The reviewer recommended to improve the manuscript's clarity, justify the assumptions, validate and generalise the findings, and elaborate on the limitations. Additionally, the authors should further refine the figure and table captions to accurately describe the content of each figure or table. Apart from that, the flow and readability of the manuscript should be enhanced to make it more suitable for publication.

***Summary of authors' responses:*** We would like to thank you very much for showing us where we should provide further clarification, explanation, and improve the visualisations. Generally, we have added further information on the selections of formulas, observations, and explained about the calibration. Additionally, we have enhanced the result analysis along with the visualisations and clarified our limitations. Also, we have improved the flow and readability of the manuscript to highlight our findings and suggestions for future research.

### 3.1 Question 1

***Question:*** L178 ends without properly concluding the outcome of the analysis.

***Answer:*** We have rewritten and added more information for clarity at lines 199-203: *"... Although we do not know what the true errors are in these parameters, these assumed but reasonable ones from the Monte Carlo framework can still meaningfully indicate how the estimated bathymetric data can affect the flood model outputs. In future research, the measured errors can apply the framework already built in this study to compare and confirm the results.*

*Within the process of generating the simulated errors for each parameter, we spatially model the variation of the errors along the river with a Gaussian variogram ..."*

### 3.2 Question 2

We would like to divide this question into two sub-questions to answer as below:

***Question:*** Why do authors choose Uniform Flow and Conceptual Multivariate Regression only to represent river channel depth, while most models use a simpler power law equation with bankfull discharge as an independent variable to estimate it?

***Answer:*** The Conceptual Multivariate Regression (CMR) was chosen as it is developed for coarse-grained rivers - a common river type in New Zealand like the Waikane River. Additionally, since we would like to compare this equation with a more widely applicable formula that does not require river categorisation but with similar use of parameters, the Uniform Flow (UF) was selected. These rationales were mentioned and rewritten at lines 158-160: *"The CMR formula, designed for coarse-grained rivers, was selected to match with Waikanae River (Gyopari et al., 2014), and the UF formula was chosen for its similar parameters and can be widely applicable."*. Moreover, Pearson et al. (2023) has validated these formulas for the Waikanae River (as mentioned at lines 83-84) and shown that they did a reasonable job of estimating the river bathymetries.

A simpler power law equation with bankfull discharge can be a good candidate to estimate the river bathymetry. However, it would not adequately capture the complexity of the river bathymetries. In addition, the uncertainty in the flood model outputs can be overlooked due to not considering the other factors such as channel slope and width. These parameters also affect the estimated river bathymetries which will then influence the flood model outputs.

Furthermore, using only one parameter like the bankfull discharge does not seem to be adequate to develop a well-representative sensitivity analysis as well as a framework to quantify the uncertainty in flood model outputs. Instead, using formulas with more important parameters (channel slope, flow, width, etc.) which contribute to the estimated river bathymetries, like the CMR and UF, can help us to build up a more representative and widely applicable framework. This framework can then be applied not only back to simpler power law equations but also other formulas.

***Question:*** It might be better to include other estimation methods to improve the robustness of the manuscript.

***Answer:*** The main focus of this paper is to understand how the errors in the estimated river bathymetric data affect the flood model outputs rather than comparing every possible estimation method. Apart from that, different methods will have different error structures, and it is necessary to account for these errors in a sensitivity analysis. However, due to the lack of a framework for such sensitivity analysis, this paper then developed one that can be widely applied. Hence, in future research, different methods can then use this framework without building up other ones from scratch. This information has already been mentioned and rewritten at lines 418-421: *"Furthermore, the analysis framework in this research can be applied to a wide range of formula, such as those that also consider the sediment impacts, that are used to estimate river bathymetries to represent rivers in flood modelling. Future research about this can help to answer which formula constributes the most to the uncertainty in flood model outputs."*

### 3.3 Question 3

***Question:*** L225: The authors should explain the observations they have used in this study.

***Answer:*** Based on this question and Section 3.15. (question 15) in this response, we have rewritten and added further information to explain the observations we used in this study at lines 245-251: *"In our research, we went further than Nguyen et al. (2025) by validating each flood simulation - MWSE with the observed data. Due to the lack of a thorough map of measured flood levels or satellite-based water surface elevations, we used the observed flood levels under point format provided by Wallace (2010). The Root Mean Square Error (RMSE) metric was harnessed for these validations. Locations of the observed data where the flood model predicted to be dry across all the simulations were removed to ensure the RMSE focuses only on predicted flooded regions and to avoid skewing the RMSE. We then visualised the distribution of RMSEs across simulations through side-by-side boxplot for comparison."*.

### 3.4 Question 4

***Question:*** Why do Nguyen et al. (2025) exclude bathymetry from their calibration? What are the challenges of using river bathymetry as a calibration parameter, too?

***Answer:*** Since the calibration using the river bathymetry was not the focus of Nguyen et al. (2025), it was not selected. Furthermore, this process can be complicated and requires being very careful as the river bathymetry can strongly affect when and where the water leaves the river to flood. Specifically, we initially need a good estimate, then we can decide how to alter the river bathymetric data. From here, there would be many degrees of freedom for the alteration (e.g. changing depth at many locations along the river and adjusting channel shape), which adds many unnecessary extra tasks for Nguyen et al. (2025). Hence, the calibration with river bathymetry was not chosen in their paper.

### 3.5 Question 5

***Question:*** The presentation of Table 1 is a little strange. What do the “Exponents” parameters for slope, flow, and so on mean? They vary slightly from alpha and beta.

***Answer:*** We thank you so much for showing us that we lack information about this. These "exponents" are exponents of each parameter after being processed from the original $\alpha$ and $\beta$. We have added in Appendix A (lines 495-502) more information about this: *"The exponents mentioned in Section 2.2. are exponents of each parameter after being processed from the original $\alpha$ and $\beta$. Specifically, for the UF formula, with $\alpha = 2/3$ and $\beta = 1/2$, it can be processed as below:*

$$h = (\frac{nQ}{wS^{1/2}})^{\frac{1}{1+2/3}} \Leftrightarrow h = (\frac{nQ}{wS^{0.5}})^{0.6} \Leftrightarrow h = (\frac{n^{0.6}Q^{0.6}}{w^{0.6}S^{0.3}}) \quad (1)$$

*Hence, the exponents of the slope (S), bankfull flow (Q), and width (w) for the UF formula are 0.3, 0.6, and 0.6. For the CMR formula, with $\alpha = 0.745$ and $\beta = 0.305$, it can be changed as below:*

$$h = (\frac{nQ}{wS^{0.305}})^{\frac{1}{1+0.745}} \Leftrightarrow h = (\frac{nQ}{wS^{0.305}})^{0.573} \Leftrightarrow h = (\frac{n^{0.573}Q^{0.573}}{w^{0.573}S^{0.175}}) \quad (2)$$

*Hence, the exponents of the slope (S), bankfull flow (Q), and width (w) for the CMR formula are 0.175, 0.573, and 0.573.".* Apart from that, we added a note *"(see Appendix A)"* into the caption of Table 1: *"The exponents of parameters in the Conceptual Multivariate Regression and Uniform Flow formulas (see Appendix A), and the value ranges (minimum, maximum, and mean) of paramters along the Waikanae River - the river, slope, bank-full flow, width, and Manning’s n - used to explore their relationships with the river bathymetry in both formulas.".* Also, we rewrote at lines 165-167: *"The exponents and value ranges of each parameter are shown in Table 1 and some of them are explained in Appendix A."*

### 3.6 Question 6

***Question:*** Section 2.3: The authors should include their mini-analysis as supplementary material.

***Answer:*** The section now becomes Section 2.4. and we already provided the analysis in Section 3.2. However, to enhance the clarity, we added more information at lines 186-187: *"... Three scatter plots depict the relationship between the variance of each parameter and these combined river bathymetries. All of these visualisations and analysis are provided in Section 3.2. In the next section, we detail how to generate these simulated parameters and corresponding river bathymetries and examine their variations on flood predictions.".* We placed the result analysis as Section 3.2. in the manuscript to later compare with the results from the Monte Carlo framework in Section 3.3. This would help the whole analysis easier to follow and comprehend.

### 3.7 Question 7

***Question:*** What is the x-axis “distance” reference point in Figure 3? Between UF and CMR, as well as between estimated and simulated, there is no discernible difference. Perhaps displaying a zoomed-up area would improve visualization. Also, the authors should improve the figure caption to reflect what is presented. What is shown by the color range is not clear.

***Answer:*** The x axis "distance" reference point in Figure 3 is the river mouth. In other word, the x axis "distance" is the distance upstream of river mouth. We have added zoomed-in images and increased the line width of simulations to enhance the visualisation. We have rewritten the legends, figure captions, and added more information about the color range for clarity, easy comprehension, and reflect what is represented as below:

- We changed the x axis label *"Distance (m)"* to *"Distance upstream of river mouth (m)"*
- We changed the legend *"UF - Estimated bed from GeoFabrics"* to *"UF - Estimated riverbed elevations from GeoFabrics"*. Similarly, we changed the legend *"CMR - Estimated bed from GeoFabrics"* to *"CMR - Estimated riverbed elevations from GeoFabrics"*.
- We changed the legend *"UF - Simulated bed elevations"* to *"UF - Multiple simulated riverbed elevations"*. Similarly, we changed the legend *"CMR - Simulated bed elevations"* to *"CMR - Multiple simulated riverbed elevations"*.
- We changed the legend *"Observed bed elevation"* to *"Observed riverbed elevations"*.
- We rewrote the caption and added more information: *"Observed cross-sectional, best estimated (from GeoFabrics of Pearson et al. (2023)), and simulated riverbed elevations at the Waikanae River. The best estimates and simulations of riverbed elevations computed using the Uniform Flow formula are in the first column: (a) slope, (c) bank-full flow, (e) width, and (g) combined. The ones calculated using the Conceptual Multivariate Regression formula are in the second column: (b) slope, (d) bank-full flow, (f) width, and (h) combined. The color shading represents multiple simulated riverbed elevations (span of simulations)"*.
- We also changed "Distance between downstream and upstream (m)" to "Distance upstream of river mouth (m)" for x axis of Figure 5 for consistency.

### 3.8 Question 8

***Question:*** Section 2.4 should at least be divided into two sections: one for the evaluation process and another for the Monte Carlo simulation process.

***Answer:*** We thank you very much for this suggestion. We changed the title of Section 2.5 (was Section 2.4) from *"Monte Carlo simulation process"* into *"Monte Carlo framework"* and added more information at lines 189-190: *"Figure 2 shows a Monte Carlo simulation process undertaken in this study. To describe the framework in this figure, we divide this section into two subsections. The first is about simulation process and the second is about statistical analysis."*. We then divided this section into two parts as below:

- *"Section 2.5.1. Simulation process"* from line 191 to line 230.
- *"Section 2.5.2. Statistical analysis"* from line 231 to line 251.

### 3.9 Question 9

***Question:*** L236-237: But “steeper rivers” also erode more sediment. L240: Larger, wider rivers deposit more sediment into the riverbed. However, this type of phenomenon varies over time and is not represented by the model used by the authors.

***Answer:*** The formulas that consider sediment dynamics often require additional data that might not be available or beyond the scope of this study (e.g. bed composition and sediment load). Hence, in this paper, for simplicity and to focus on how the uncertainty in the river bathymetric data impacts on the flood model outputs, we selected the two hydraulic equations - the Uniform Flow and Conceptual Multivariate Regression - that do not consider the sediment effects. We have already mentioned this at lines 295-297: *"The above findings are based on the variation in the river bathymetry when a parameter is changed while others remain constant. Also, we have not considered other factors such as sediment load in this analysis. Hence, these results should not be used to fully reflect the real-world river systems."*. However, to enhance the clarity, we rewrote the lines the reviewer mentioned as below:

- Lines 259-262 (was lines 236-237): *“Physically, when the river width and flow do not vary, and the sediment effects are not considered, it is expected that in steeper sections, the water tends to flow faster and spend less time interacting with the riverbed. Therefore, its force has a smaller impact on the river bathymetry.”*
- Lines 264-266 (was line 240): *“Physically, it can be understood that, in the river sections where the river width and slope do not vary, and the sediment influences are not considered, the increased flow has greater water force, which is correlated with a higher impact on the river bathymetry than smaller flow.”*
- Apart from that, in Section 4 (Discussion) in the manuscript, we suggested further research to include formulas that consider sediment conditions when estimating the river bathymetry at lines 418-421: *“... Furthermore, the analysis framework in this research can be applied to a wide range of formulas, such as those that also consider the sediment impacts, that are used to estimate river bathymetries to represent rivers in the flood modelling. Future research about this can help to answer which formula contributes the most to the uncertainty in flood model outputs.”*

### 3.10 Question 10

***Question:*** L264-266: This is common knowledge and redundant.

***Answer:*** We have removed this common knowledge at lines 289-291: *" ... a steeper or wider river typically becomes shallower, while an increase in the flow corresponds to a deeper river. Moreover, ..."*, and rewrote into: *"Overall, the variation in the river width corresponds to the largest variability in the river bathymetry followed by variations in the river flow and slope. Besides, ..."*

### 3.11 Question 11

***Question:*** L280: Why are there smaller depths in smaller slopes (Figure 5c)? Is it near the coast?

***Answer:*** To explain, in this area near the coast, the river depths are more correlated to the rise of the river width than the decrease of the river slope. We have explained and rewritten about this at lines 334-342 as below:

*"Furthermore, in the downstream reach, given the flat terrain, the increase in width outweighs the decrease in slope. Mathematically, the slope and width are in the denominator of both formulas, indicating their inverse relationships with the river bathymetries. Moreover, the slope drop (within 80 %) and its exponents (0.3 and 0.175 for the UF and CMR formulas) are much smaller than the width increase (within 400 %) and its exponents (0.6 and 0.573 for the UF and CMR formulas). Consequently, the river bathymetries are affected by the increase in the river width than the decrease in the slope. Besides, as mentioned in Section 3.1, when the width starts increasing and the slope keeps decreasing, the river bathymetries of both formulas first converge, then diverge, with the UF bathymetries eventually exceeding the CMR bathymetries."*

### 3.12 Question 12

***Question:*** Figure 5: It is better to indicate the panel number (a, b, c, ...) closer to the plot or inside the axes. Overall, the description of Figure 5 in the text is vague and hard to follow (L276-306).

***Answer:*** We have moved the panel numbers (a), (b), (c) closer to the plots to be consistent with other panel numbers. We did not put them inside the axes as they will overlap with some information. We have also rewritten and added more information in the description of Figure 5 at lines 301-342 (was lines 276-306) for clarity and easily following as below:

*"In this section, we first analyse Fig. 5 by dividing the distance between Waikanae River Treatment Plant gauge (upstream) and the coast into two parts - from the river upstream to 1000 m downstream (upstream reach) and from 1000 m downstream to the coast (downstream reach). Based on this, we focus on analysing the upstream reach of the slope (first row of Fig. 5), flow (second row), width (third row), and combined (forth and fifth rows) datasets. We then compare the two formulas in the upstream reach and then in the downstream reach. After this, Fig. 6 will be examined.*

*For the slope dataset, Fig. 5a-b indicate that, in the upstream reach, the Waikanae river becomes gentler when it also deepens. In this case, despite variability of other parameters (i.e. river width and flow) along the river, the relationship between slope and bathymetry still aligns with findings in Section 3.1. Their simulations also follow this trend as seen in Fig. 5c.*

*For the flow dataset, in the upstream reach of Fig. 5d-e, when the Waikanae River becomes deeper, its flow shows only a slight increase, from 145.3 to 146.2 cumecs, with the highest value remaining constant for the next 6000 m downstream. This implies that the bathymetry along this river is not strongly correlated with the bank-full flow. However, in Fig. 5f, the simulated rivers slightly deepen when the simulated flow increases. This pattern is still consistent with observations from Section 3.1, even though other simulated parameters (i.e. river width and slope) vary along the river.*

*For the width dataset, in Fig. 5g-h, in the upstream reach, the Waikanae River width resembles a reversed version of its bathymetry, showing an inverse relationship. In this situation, in spite of variations of other parameters (i.e. river slope and flow), the relationship of the river width and bathymetry still follows the results found in Section 3.1. Their simulations also indicate this trend in Fig. 5i.*

*For the combined dataset, Fig. 5j-m show the same patterns as what we found above when analysing each parameter dataset. Specifically, in the upstream reach, the simulated bathymetries and bank-full flows are not strongly correlated with each other.*

*Apart from that, the simulated river slopes decrease as the simulated bathymetries increase. Finally, the shapes of the simulated river widths are reserved versions of the simulated river bathymetries, showing their inverse relationship.*

*Between two formulas, in the upstream reach of Fig. 5b, e, h, and j, the river bathymetries estimated by the UF are lower than the CMR formula mainly due to the difference in the friction and its exponent, as explained in Section 3.1. However, in the downstream reach, both formulas generate shallower rivers in which the UF bathymetries are greater than the CMR bathymetries. This is where the river slope decreases 80 % from about 0.001 m/m to about 0.0002 m/m. Simultaneously, its width increases up to 400 % from approximately 20 m to around 100 m.*

*Furthermore, in the downstream reach, given the flat terrain, the increase in width outweighs the decrease in slope. Mathematically, the slope and width are in the denominator of both formulas, indicating their inverse relationships with the river bathymetries. Moreover, the slope drop (within 80 %) and its exponents (0.3 and 0.175 for the UF and CMR formulas) are much smaller than the width increase (within 400 %) and its exponents (0.6 and 0.573 for the UF and CMR formulas). Consequently, the river bathymetries are affected by the increase in the river width than the decrease in the slope. Besides, as mentioned in Section 3.1, when the width starts increasing and the slope keeps decreasing, the river bathymetries of both formulas first converge, then diverge, with the UF bathymetries eventually exceeding the CMR bathymetries."*

Accordingly, we also rewrote lines 350-351: *"Overall, in the upstream reach, despite a slight rise in the simulated bathymetries when the simulated flow increase, they are not strongly correlated with each other."* and line 355: *"In the downstream reach, the river becomes shallower when it widens with a mild drop in the slope."*.

### 3.13 Question 13

***Question:*** L307-322 and Figure 6c,d: What is the reason for the abrupt change in Cov of flow in the downstream of the river in Figure 6c,d?

***Answer:*** The flow values were provided for each segment along the river. In this project, between the downstream (river mouth) and upstream (where the Waikanae Water Treatment Plant gauge is), there are three flow values representing for three segments along the selected section of the river. They are 145.196, 145.978, and 146.194 cumecs, and the CoV of the bathymetry of these segments are 3.969, 4.315, and 4.351% for UF formula, and 3.792, 4.123, and 4.156% for CMR formula. The flow difference between the first and second segments is larger than the one between the second and third segments, and thus the differences in CoV values of the bathymetric data between these segments also follow a similar trend. This leads to the abrupt change in color as we can see in Fig. 6c-d.

### 3.14 Question 14

***Question:*** Figure 6: The authors should show meaningful values in the color bars. It is worthwhile to include the 1000 m mark in this figure.

***Answer:*** We have added the 1000 m mark in the Figure 6. Also, for each dataset, the coefficient of variation (CoV) values in the color bars show the variations in the simulated bathymetries. Apart from that, each row in the Figure 6 represents for the parameter that has its errors added, and each column represents for the formula used to calculate the bathymetry. This informtation has been described in the caption: *“Variations in the simulated Waikanae River bathymetries due to associated error distributions in parameters: the Conceptual Multivariate Regression formula - (a) slope, (c) bank-full flow, (e) width, and (g) combined; the Uniform Flow formula - (b) slope, (d) bank-full flow, (f) width, and (h) combined.”*.

Based on this figure, by comparing the ranges of CoV values between each row we can see that the variation in the simulated bathymetries increases between the slope, flow, and width datasets. This has been mentioned at line 345: *“In both formulas, the ranges of coefficients of variations increases between the slope, flow, and width datasets.”*. Between two formulas, we can see that the first column (Conceptual Multivariate Regression formula) has darker colors than the second column (Uniform Flow formula). In other words, the variations in simulated bathymetries using the Conceptual Multivariate Regression formula is smaller than using the Uniform Flow formula. This has also been mentioned at lines 347-348: *“Moreover, the colors of the UF-formula river bathymetries are darker than those of the CMR-formula ones. This demonstrates the UF-formula bathymetries exhibit larger variability than those from the CMR formula.”*.

To make it clearer, the labels of the colorbars are changed as below:

- We changed *"Coefficient of variation of SLOPE (%)"* into *"Coefficient of variation of simulated bathymetries of SLOPE dataset (%)"*
- We changed *"Coefficient of variation of FLOW (%)"* into *"Coefficient of variation of simulated bathymetries of FLOW dataset (%)"*
- We changed *"Coefficient of variation of WIDTH (%)"* into *"Coefficient of variation of simulated bathymetries of WIDTH dataset (%)"*
- We changed *"Coefficient of variation of COMBINED parameters (%)"* into *"Coefficient of variation of simulated bathymetries of COMBINED dataset (%)"*

### 3.15 Question 15

***Question:*** Why did authors not use observed water levels to better understand the changes in river bathymetry? Using observed or satellite-based water surface elevations would help authors to understand the effect of the estimates.

***Answer:*** We agree with the reviewer that the observed or satellite-based water surface elevations would help to further understand the effects of the estimated river bathymetry. However, we do not have this data, and thus we used the other available observed data as mentioned in the paper - the observed flood levels under point format. As mentioned in Section 3.3 (question 3) in this response, we have added this information at lines 245-251: *"In our research, we went further than Nguyen et al. (2025) by validating each flood simulation - MWSE with the observed data. Due to the lack of a thorough map of measured flood levels or satellite-based water surface elevations, we used the observed flood levels under point format provided by Wallace (2010). The Root Mean Square Error (RMSE) metric was harnessed for these validations. Locations of the observed data where the flood model predicted to be dry across all the simulations were removed to ensure the RMSE focuses only on* *predicted flooded regions and to avoid skewing the RMSE. We then visualised the distribution of RMSEs across simulations through side-by-side boxplot for comparison."*

### 3.16 Question 16

***Question:*** L360: The authors should clarify how the RMSEs were calculated.

***Answer:*** We haved described how the RMSEs were calculated in Section 2.5.2. at lines 245-251 (also as mentioned in Section 3.3 and 3.15 (questions 3 and 15) in this response): *"In our research, we went further than Nguyen et al. (2025) by validating each flood simulation - MWSE with the observed data. Due to the lack of a thorough map of measured flood levels or satellite-based water surface elevations, we used the observed flood levels under point format provided by Wallace (2010). The Root Mean Square Error (RMSE) metric was harnessed for these validations. Locations of the observed data where the flood model predicted to be dry across all the simulations were removed to ensure the RMSE focuses only on predicted flooded regions and to avoid skewing the RMSE. We then visualised the distribution of RMSEs across simulations through side-by-side boxplot for comparison."*.

To make it clearer, we have added a note in the caption of Figure 11: *"RMSE distributions for predicted flood levels of eight datasets (slope-, flow-, width-, and combination-CMR and -UF datasets) compared to the January-2005 observed flood levels. The RMSEs were calculated using the method described in Section 2.5.2."*

### 3.17 Question 17

***Question:*** L412-413: Then a question arises: why and where is the current method useful?

***Answer:*** For situations where we lack the river bathymetric data and cannot collect or measure them for flood modelling, this study with its Monte Carlo assessment helps to show the sensitivity and understanding of the limitations and uncertainties involved. This has been rewritten and added at lines 410-421 as below:

*"Our research went a step further than previous studies (Durand et al., 2008; Lee et al., 2018; Moramarco et al., 2019; Kechnit et al., 2024) to quantify the uncertainty in flood predictions due to the errors in the estimated river bathymetry. In this research, we applied the Monte Carlo method to generate a large number of simulations to capture the typical variability in the flood predictions and included spatial variability in our method. Moreover, we not only considered associated error distributions in parameters collectively, but we also performed a sensitivity analysis to assess the impact of each parameter. Hence, for situations where we lack the river bathymetric data and cannot collect or measure them for flood modelling, the formulas in this study can be used with the Monte Carlo assessment here that shows the sensitivity and understanding of the limitations and uncertainties involved. Furthermore, the analysis framework in this research can be applied to a wide range of formulas, such as those that also consider the sediment impacts, that are used to estimate river bathymetries to represent rivers in the flood modelling. Future research about this can help to answer which formula contributes the most to the uncertainty in flood model outputs."*

Besides, in sensitivity analyses, the Monte Carlo framework allows the physical concepts to be used, so we can compare the impacts of flood model inputs on the flood model outputs. In contrast, other methods like machine learning models can only learn the relationships between the predictors and the outputs to make the predictions. They do not include the physical concepts to thoroughly explain the uncertainty propagation in flood models. Therefore, in such situations, the Monte Carlo framework should be applied.

For other cases, especially in flood risk management, where the uncertainty should be included but normally excluded, due to its computational expense (i.e. requirements of a large amount of simulations). Hence, a more computationally efficient method such as machine learning models should be considered. However, to develop such machine learning models, the Monte Carlo framework still plays an important role to produce the data for training and testing processes. Additionally, the framework can also serve as a reference to benchmark the machine learning models.

To enhance the clarity, lines 453-458 are rewritten: *"On the other hand, although applying the Monte Carlo framework to quantify this uncertainty is fully comprehensive, its requirement of a large amount of simulations can be seen as a computationally expensive problem. Due to this, the uncertainty quantification is not normally considered in the flood risk management. Hence, a more computational efficient method is essential. The machine learning approach, well-known for its more effective process to obtain the comparable results, is a good candidate which needs further investigation."*

### 3.18 Question 18

***Question:*** Conclusion: The authors should improve the conclusion to present their findings and recommendations clearly and objectively, presenting them vaguely will substantially reduce the value of the manuscript.

***Answer:*** We thank you very much for this suggestion to protect the value of our manuscript. We have rewritten the conclusion for clarity and easy comprehension at lines 460-492 as below:

*"Our research focused on quantifying the uncertainty in flood predictions due to the errors in parameters used to estimate the river bathymetries. We applied LISFLOOD-FP flood model within a Monte Carlo method to generate multiple flood simulations for the January-2005 Waikanae River flood event for analysis. We performed a sensitivity analysis on three estimated parameters (river slope, flow, and width) and two formulas (the UF and CMR formulas) to assess their error impacts on the flood predictions individually and collectively through the estimated river bathymetries.*

*We found that, among three parameters, the uncertainty in flood model outputs, when the errors were added into the river width, is higher than when the errors were added into the river flow, followed by the river slope. The combination of all of them was found to have the highest uncertainty. Between two formulas, the uncertainty in the flood predictions, especially in the flood depths and extents, when using the UF formula for estimating the river bathymetric data, is larger than using the CMR formula.*

*It is recommended that, instead of developing from scratch, the Monte Carlo framework used for the sensitivity analysis in this research should be applied to benchmark various formulas used to estimate the river bathymetries to represent rivers in flood modelling. Further study is necessary to confirm the broad applicability of the UF formula without river categorisation. Moreover, based on our results, the data collection process should focus on measuring the parameters (river width and flow) that have more significant impacts on the flood predictions if the resources are limited. Additionally, further investigations should also include the river Manning's n, and $\alpha$ and $\beta$ coefficients to perform a thorough sensitivity analysis.*

*Apart from that, we suggested another study to be implemented on many rivers with different features. In addition, further research should consider how different realistic sources of errors affect the flood predictions. Also, the impacts of grid resolution on the estimated river bathymetry and on the flood predictions should be focused in future study. Currently, to cover such uncertainty, a freeboard is often used, but it fails to cover the variation in the flood extent, and thus a further study is recommended to improve its effectiveness. Lastly, there is a need for simpler and faster methods than the Monte Carlo framework such as machine learning approaches to be included in flood risk management."*

## 4 Extra changes

We have edited some parts as below to make the content more accurate, consistent, and concise:

- We rewrote lines 130-134: *"In this study, LISFLOOD-FP (Bates et al., 2010; Neal et al., 2018), a 2D hydrodynamic model, was used to simulate the January-2005 flood event because it is well known for its computational efficiency and highly accurate flood model outputs (Nguyen et al., 2025). Also, it was calibrated for the Waikanae River in Nguyen et al. (2025). The DEM and Manning's n values, along with the flow information and tidal data mentioned above were used as input into this model."*
- We changed the minimum values along the river of parameter flow (Q) from 145.3 (cumec) to 145.2 (cumec) in Table 1 for correction.
- We rewrote lines 170-177 for more clarity: *"Before Monte Carlo simulation process, we explore the relationship between these parameters and the river bathymetries estimated by the UF and CMR formulas. At first, the mean value over the entire river section of each parameter is calculated as seen in Table 1. We then increase the mean value of each parameter, except for the river Manning's n, from 50% to 200% while keeping other parameters constant. This method allows us to observe how the river bathymetries from the two formulas are affected when a parameter is varied. The result analysis of this part is mentioned in Section 3.1."*.
- We changed the red color of *"errors"* into black color in Table 2.
- We rewrote lines 235-236: *"However, different to Nguyen et al. (2025), mMWDs and sdMWDs were not considered in the research due to no useful information."*