**NHESS**

**Ref: NHESS-2022-297**

**Title: Numerical model derived intensity-duration thresholds for early warning of rainfall-induced debris flows in a Himalayan catchment**

## Response to Editor

| Ref. | Comment | Reply |
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| 1 | Dear Authors,<br><br>Thank you very much for delicately incorporating all the suggestions by the first reviewers. The second round's reviewers think you have addressed all the issues, which I agree with. However, sharing the concern of the 1st reviewer, I believe some figures could be improved for clarity for the final publication.<br><br>Reviewer 1 has some minor concerns justifying some aspects of the manuscript and regarding Figures 11 and 12. Please improve the figures and the manuscript following the reviewer's suggestions. I also believe the text size (e.g., in the legend) in Figures 2, 10, and 11 is tiny to follow.<br><br>Once the figures meet NHESS standards, I will accept the article for publication.<br>Kind regards<br>Ugur Öztürk | Dear Editor Dr. Ugur Öztürk,<br><br>Thank you for valuable feedback and for acknowledging the revisions made in response to first-round reviewers' suggestions. We appreciate your consideration.<br><br>We have carefully addressed the concerns raised by you and the reviewer regarding Figures, ensuring that the improvement contributes to the clarity of the manuscript.<br><br>Additionally, we have also addressed the concerns about the text size in Figure 2,10, and 11 to comply with NHESS standards.<br><br>We hope these revisions meet the NHESS standards.<br><br>Kind regards.<br>Authors of NHESS-2022-297. |

## Response to Reviewers

| Ref. | Comment | Reply |
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| 1 | **General comments by Referee in Report #1**<br><br>The manuscript under review is promising and caters to a very important issue, particularly, looking at the use of forecasted hourly rainfall data to simulate debris flows for early warning. This is also pertinent in areas where there is a dearth of data required to develop early warning systems, so a procedure that use synthetic data, but which is carefully validated is quite beneficial. Furthermore, this procedure can be useful in regions lacking historical rainfall data, which is rightly pointed out by the authors. The initial version of the manuscript indeed lacked relevant supporting literature, and the research objectives were not clearly articulated in the introduction; however, these shortcomings have been effectively addressed in the revised version. The Results and Discussion sections have been enhanced through an expanded presentation of the findings. Additionally, the manuscript commendably extends the application of rainfall intensity-duration thresholds, with a focus on Kedarnath, India, as observed in the revised version. | Thank you for your careful consideration and very detailed evaluation of our manuscript.<br><br>We sincerely appreciate your time to provide constructive as well as critical comments on the manuscript, analysis, technical aspects and writing of this research article.<br><br>We thank you for your encouragement towards the intriguing idea of this manuscript and identifying it within the scientific scope of NHESS.<br><br>Please see our detailed responses below to each of your comments sectionized in the order. |
| 2 | **Review by Another Referee in Report #2** | Thank you for your careful consideration and evaluation of our manuscript. We sincerely thank the referee for having checklisted the manuscript excellent in scientific significance, good in scientific and presentation quality. |

Comments on Manuscript:

| Ref. | Comment | Reply |
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| 1 | I note significant improvements in the figures, following recommendations from Referees 1 and 2.<br><br>Nonetheless, I am confused by Figure 11. Despite captions indicating segments (a) through (i), only two sub-plots, labeled (a) and (b), are present, depicting varying cumulative rainfall intensities. This discrepancy suggests either an error in the figure, necessitating nine subsections, or a required revision of the caption. The previous version included nine subplots, which have been altered in the current version without updating the caption accordingly. Please update it accordingly. | We deeply appreciate your thoughtful review and thorough evaluation of our manuscript.<br><br>Thank you for your careful observation and comment. We have updated the Figure 11 caption for better understanding. |
| 2 | Overall, the study exhibits robust scientific rigor, and the utilization of numerically synthesized data to model rainfall-threshold forecasts is commendable. However, I have some reservations regarding the numerical analysis and the resultant mapping of debris flow extents. Focusing on Figure 10 (a), while there is a notable correlation between the simulated debris flows of 2013 and actual events, numerous potential 'false positives' are apparent away from the river channel peripheries. It does prompt a question: could these be attributed to alternative debris flow mechanisms, such as those originating on hillslopes? | Thank you for your critical evaluation of the results and thoughtful questions. We think you are right. The model predicts the actual debris flow extents with an accuracy of 63 percent. However, the false positives are 37 percent. Those are spread over hillslopes away from river channels. We also believe the reason for this could be the different debris flow mechanisms which the model could not simulate satisfactorily.<br><br>Thank you again for this very important observation.<br><br>We explained the same in line 210 – 212 on page 13 in the revised manuscript. |
| 3 | Despite these observations, the revisions undertaken, coupled with feedback from previous referees, indicate that the manuscript has successfully addressed key concerns. I would recommend to accept the manuscript, provided the suggested (small) revisions are made. I present a synopsis of the overall changes made by the reviewers: | Thank you for your kind comment and in detail exploring the major revisions made to the manuscript. We hope to have addressed the minor comments made by you as stated in the above and below responses. |
| 4 | Methods Section:- Detailed information about the analysis and calibration details for the debris flow model have been included, and this was important for reproducibility and validation of the methods used, addressing a significant gap in the original manuscript. | Thank you for noting the crucial addition of detailed analysis and calibration information in the Methods section, addressing a significant gap for reproducibility. |
| 5 | Validation and Calibration of Models:- The authors have now validated the Weather Research and Forecasting (WRF) model outputs with ground-based and satellite-derived precipitation data. | Thank you for acknowledging our enhanced model validation, incorporating diverse precipitation data sources, and justifying the empirical approach for debris flow volume estimation. |

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| | They have also conducted a sensitivity analysis and used different empirical equations for debris flow volume estimation, which was a good step up from the previous single empirical equation based on the Taiwanese case. | |
| 6 | Overall Structure and Presentation:- The authors have restructured the manuscript for better flow, clarity, and logical consistency. This includes adjusting the positioning of certain sections and adding necessary explanations and justifications for their modelling choices. | Thank you for acknowledging the positive impact of our manuscript's restructuring on flow, clarity, and logical consistency. We remain committed to continuous improvement |

Minor Comments:

| **Ref.** | **Comment** | **Reply** |
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| 1 | Line 110: Although the referring to statistical thresholds holding physical explanations are true, it would be nice to see a reference citing/explaining this. | Thanks for the suggestion. We have added the relevant reference for better understanding.<br>Please see page 11 line 162 in the revised manuscript. |
| 2 | Line 230: In the examples of US, Italy, and Japan, please provide the relevant literature for reference. | Thanks, we have included the references in page 15 Line 240 – 241 in the revised manuscript. |
| 3 | Figure 12: In the legend, I do not see the year of publication for Lakhera et al. Are they referring to the same 2020 study that is mentioned in the caption? | Thank you. Yes, we are referring to the same 2020 study mentioned in the caption. We have modified Figure 12 and included the year of publication. Please see revised Figure 12 on page 15 in the revised manuscript. |