

Response to Reviewers:

Reviewer 1:

This manuscript analyzes the influence of variabilities in hydrograph input on the dynamics and impact areas of debris flows. The work covers an essential aspect of debris flow research, and represents a substantial step forward when it comes to our ability to analyze the uncertainties of debris flow simulation results, a highly important aspect when using such results for risk management purposes.

The manuscript is very well written, structured, and illustrated. I would certainly like to see this work published. I have no major comments, but I would like to place two minor, though still important, suggestions:

- Whereas it is fine to have Fig. A-1 in the Appendix, I strongly recommend do add a work flow figure to the main text, relating the different steps done with the different hydrographs (triangular, Swiss/Austrian sites, BC sites) for different purposes. In my opinion, this would substantially enhance the clarity of the concept.
- In order to enhance clarity for the readers, I also suggest to add a reference to Section 3 at the beginning of section 2.4, and to briefly mention the names of the three debris flow sites used. When reading this part of the manuscript for the first time, I had some difficulty to follow the logics (even though everything was clear when I read it for the second time).

Thank you for the supportive comments and constructive review.

To address the first bullet point, we have moved Figure A-1 from the Appendix to the main body of the text (it is Figure 3 now). The flow chart has also been revised to more clearly show the distinction between the processes for the generation of the triangular and scaled hydrographs.

To address the second bullet point: Excellent suggestion. A sentence has been added to the paragraph stating: "The three sites are Lattenbach, Austria, Dorfbach, Switzerland, and Spreitgraben, Switzerland, described in detail in Section 3."

Reviewer 2:

The paper by Mitchell et al. investigates how the variability of input hydrographs affects the outcome of debris-flow modeling. Results show a large variation in simulated flow depths and velocities, also reflecting in the variability of the affected areas. This study represents a significant advance in debris-flow research and opens the door to applications in the field of risk management. Using field observations and monitoring data can improve our capability to model the potential variability of debris-flow impact. The paper already is in good shape and I recommend publication after minor revisions. Here follow my remarks and suggestions, best regards.

Lines 35-46: well said.

Thank you, we think the fact our models are not as complex as reality is an important point to have in mind when interpreting results.

Lines 47-54: again, well said. Maybe, you can also mention one additional point related to rainfall distribution. The actual area contributing to debris-flow initiation is often considerably smaller than the whole basin (e.g., Berti et al., 2020; Coviello et al., 2021).

Thank you. The following sentence has been added: "The proportion of the catchment area contributing to a debris flow event may also vary substantially, from isolated sediment sources subjected to a "firehose effect" triggering mechanism (e.g., Berti et al., 2020), to much more diffuse sources leading to debris-flow initiation in only part of a catchment area (Coviello et al., 2021)."

Line 82: the word "model" is repeated, please check the wording.

Good observation, the first instance is redundant and was removed from the manuscript.

Section 2 Methodology: few sentences summarizing the different steps would be useful to understand the work flow from the beginning.

Good suggestion. We have added the following statement to contextualize the methodology section: "To explore the effects of inflow hydrograph shape on simulated runout, we first investigated a simple model and progressively added complexity. In this section, we describe the runout model used, the simple synthetic topography used to test triangular hydrographs, and complex hydrographs derived from records of real events. Finally, we applied the complex hydrographs to cases with natural terrain. This approach allows us to examine the interplay between inflow conditions, flow resistance and simulation outputs."

Line 90: "we used a model based on... Lagrangian model that...", please check the wording.

To remove the two models in one sentence, the start of the sentence was modified to read: "In this study, we modified Dan3D..."

Lines 182-184: why did you select a value $c = 0.2$ to define the upper peak-discharge limit of this second test?

This value was selected from an analysis of the real event hydrographs, as shown in Figure 3 (now Figure 4). The examination of the hydrographs is now mentioned in the manuscript, as follows, when the selection of c is first introduced: "The c value we selected is an upper envelope value from the real event hydrographs compiled in this study (Section 3)."

Figure 6: the figure is ok but the five lines above it already contains the key message. Does the reader need a colored 3D plot presenting the variation of Froude number to understand the story? In my opinion, this figure can be moved to the appendix or supplement.

Good point, the figure has been moved to the Appendix, and only the text explaining the Froude number evaluation remains in the main text.

Line 391: "the red outline on the impact..." the line is yellow, am I right? In the caption, please refer to panels using (a), (b), etc.

You are correct, the outline is yellow. Apologies for the confusion. References to the specific panels have been added to the caption.

Lines 408-415: everything is fine, maybe I would just add one sentence to clarify if your results are consistent with other studies investigating the impact of topography and flow resistance parameters on the modeled discharge.

Thanks very much for this comment. The authors are not aware of other studies that have specifically investigated the influence of these parameters on modeled discharge. Other numerical runoff modelling studies have found that simulated deposition areas and flow depths are influenced by DEM resolution and resistance parameters (e.g., Arattano et al., 2006; Schraml et al., 2015; Zhao & Kowalski, 2020), however these did not specifically investigate discharge, so we prefer to leave the text as is.

Lines 416-427: good discussion. I am wondering if a figure with a concept illustration of a simplified channel summarizing the two cases (in two panels?) could be useful: case (1) if channel slope $> f$ value, then the downstream estimate peak discharge can be used as it is; case (2) if channel slope $< f$ value, then higher inflow peak discharge is probably needed.

Thank you for the suggestion. We have decided to make an explicit link back to Figure 5 (Figure 4 in the original manuscript), as opposed to creating a new figure. The following text has been added: For example, the peak discharge for all cases shown in Figure 5 (a) and (b) where the local channel slope is greater than the f value, the modelled discharge is approximately equal to the inflow peak discharge. Further in the simulation, the peak discharge is attenuated significantly where the local channel slope is less than the f value, Figure 5 (e), relative to the inflow hydrograph and the case where the local channel slope is still greater than the f value (Figure 5 (d)).

Section 5: here, you move to British Columbia, Canada, and test the methodology described in the previous sections on two debris-flow fans (Currie D and Neff Creek). This is ok but I would suggest adding a couple of introductory sentences to this section just to avoid that it sounds somehow disconnected from the previous ones.

Thank you for this suggestion. The following statement has been added to make the link from the previous section to the case histories: "In the previous section, we detailed how variations in flow resistance and inflow conditions affected debris-flow depths and velocities using an idealized synthetic topography. In this section, we apply the scaled, real hydrograph inputs to the much more complex topography of two natural debris flow sites in southwestern British Columbia, Canada."

Data availability: given the Copernicus data policy, consider making hydrograph data available through an official repository.

Excellent suggestion, the data is currently under review with the Pangaea repository.

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