

Review of “Geospatial modelling of large wood supply to rivers: a state-of-the-art model comparison in

Swiss mountain river catchments”

1. Summary

This paper presents an overview of existing modelling approaches for estimating LW supply to rivers, and a more detailed comparison of two GIS-based approaches including catchment characteristics and estimated LW supply (Steeb et al., 2019a) for 40 Swiss catchments for 50 to 150-yr return period events. The empirical potential LW volume reduction factors used in one model (EGA) were obtained from the observational dataset, reducing the contribution as model validation. In general, as the authors acknowledge, the uncertainty in both observed and modelled LW supply is large (Figure), and both modelling approaches perform similarly for LW supply estimation, with apparent overlap between the range of model results and the range of field data. The authors discuss aspects contributing to uncertainty in the modelled and observational results.

In general, the paper seems caught between two directions, on the one hand, a review paper examining the range of modelling approaches, and on the other a comparison of two GIS-based approaches through the use of a detailed observational dataset. The authors state that “the approach presented here is a useful tool to give a comprehensive overview and direct attention to areas where a more precise assessment of the LW situation is probably useful.” I appreciate that the authors acknowledge the large degree of variation in both observational and modelled results, which is interesting and presents opportunities to strengthen the contribution of this manuscript.

Do the main sources of observational uncertainty correspond to the main sources of uncertainty in both models? For each model, which steps have the highest contribution to final uncertainty? Is this broadly the same across all catchments, and could this be helped by future field observations? How does the present degree of uncertainty impact end use in hazard assessment—could this be improved if the models and observations were refined, or is the present degree of variation acceptable?

We thank the reviewer for the positive comments, suggestions, and detailed review. We addressed each of these important questions here and in the revised manuscript.

Line-by-Line comments:

Line 53: Please add references for this statement (“The main damage potential...”).

We edited the sentence as follows: “The associated damage potential of LW may depend, among other variables, on the volume of transported LW (Mazzorana et al., 2018).”

Mazzorana B, Ruiz-Villanueva V, Marchi L, Cavalli M, Gems B, Gschntzer T, Mao L, Iroumé A, Valdebenito G. 2018. Assessing and mitigating large wood-related hazards in mountain streams: recent approaches. *Journal of Flood Risk Management* 11: 207–222. DOI: 10.1111/jfr3.12316

Line 64: To improve the flow of this sentence, please incorporate the parenthetical list into a main sentence structure.

The sentence has been edited accordingly:

“The estimation of exported wood involves many uncertainties that are difficult to quantify, because LW transport happens at the end of a long process cascade, usually starting with precipitation as a trigger, followed by a flood formation and the occurrence of recruitment processes as wood suppliers, and the increased discharge as a transport medium.”

Lines 69-75: Here, additional context would be helpful to connect the model comparison and model review portions. Why focus on these two GIS-based approaches?

We provided additional information in the revised manuscript (at the end of the introduction):

“This work reviews the state-of-the-art in wood supply modelling and presents a comparison of two recent GIS-based approaches developed in the context of a research-applied project funded by the Swiss Federal Office of the Environment. The literature review provides an updated compilation of published approaches to model recruitment processes to quantify LW supply, clarifying the approaches by model type and summarizing their main characteristics, such as processes considered, and their temporal and spatial scales. We then focus on two GIS-based models that were developed based on a similar general concept, used similar input data and were applied to the same study sites. Despite their similarities, the models differ in some respects and result in somewhat different outcomes. These differences are used to stress the limitations and strengths of the two models, to compare them with other recent approaches included in the literature review and to discuss uncertainties and challenges related to the modelling of LW supply. In addition, we also consider implications for flood hazard assessment and river management.”

Lines 112-141: To contextualise model development it would be helpful to incorporate a short overview of accompanying technological advances in GIS and LiDAR enabling current model development.

We edited lines 112-115 (original ms) as follows:

“The rapid proliferation of remote sensing and the advances in computing sciences and geographic information systems (GIS; Bishop and Giardino, 2022) resulted in the development of another group of models (i.e., geospatial models). These GIS-based models allow a spatially explicit assessment of different LW recruitment processes, the identification of source areas and the estimation of LW volumes, expanding the analysis to larger areas, covering multiple (sub-)catchments.”

Bishop, M.P., Giardino, J.R. 2022. Chapter 1.01 - Technology-Driven Geomorphology: Introduction and Overview. In: Editor(s): John (Jack) F. Shroder, *Treatise on Geomorphology (Second Edition)*, Academic Press, 2022, Pages 1-17, ISBN 9780128182352, <https://doi.org/10.1016/B978-0-12-818234-5.00171-1>. (<https://www.sciencedirect.com/science/article/pii/B9780128182345001711>)

Line 163 (approx.): There is a broad range of models under comparison, making Table 1 difficult to follow. A schematic diagram illustrating different modelling approaches would be helpful, perhaps with key advantages and/or disadvantages of the scheme classes.

Thanks for the suggestion. We edited the table, and hopefully made it clearer and easier to follow.

Table 1: it would be helpful if line numbers were included and used in the text to reference specific models to easily find entries in the table. If possible could a column specifying calibration datasets and/or model validation procedures would be helpful in understanding progression of model-data comparisons and highlight areas for future work later in the text.

We included the numbering and used it in the text when needed. However, we did not add information about calibration datasets or validation procedures as that was not available in many cases. We provide the source references for further information on each case and suggest reading the original papers.

Line 171: Here as above in the Introduction, additional context on why the two GIS-based approaches were chosen for comparison and relationship to the reviewed model development would be helpful in contextualising the comparison portion of the manuscript.

We explain this in Lines 176-178 (original ms), and now also added the context in the last paragraph of the introduction.

Figure 1: The quantitative definition of ‘medium, large, very large’ events is not presented until later in the text; please could this be defined earlier (or mentioned in the figure caption) so that the figure can be easily interpreted.

We added a definition of the scenarios in the caption of Figure 1 and referred to the text that describes them in detail.

Lines 197-198: Here, more information on the calibration dataset would assist in interpreting the results. This information is currently largely presented in Section 5.3. However, the degree of variation in both the observational and modelled results is interesting and an examination of the reasons for variation and accompanying areas for future work in both approaches could be very helpful in motivating future work to fill identified research gaps.

The uncertainties and challenges related to the model calibration are discussed in detail in section 5.3. However, we added a sentence at the end of section 3.1 to give more information about the calibration dataset:

“Modelling results were validated by comparison with available empirical data documented after flood events in Switzerland (Steeb et al., 2021, 2022). This dataset documents recruited and transported quantities of large wood together with the associated catchment and flood-specific parameters, including associated recruitment processes (Table S1 in supplementary material).”

Steeb N, Rickenmann D, Rickli C, Badoux A. 2021. Large wood event database. EnviDat. <https://www.envidat.ch/dataset/large-wood-event-database>

Figure 2: This figure does not seem to add significant support to the text, especially in light of repeated reference to Supplemental Information figures. Could this figure be replaced by either Figure S1A In this section more fully present the difference between the EGA buffer and FGA fuzzy-logic approaches would be helpful here. The difference in approach is a key focus of the Results, but equations are not included and the procedure details are not yet fully brought out in the text or figures.

The wood stock raster is an important input to the models, and since it is not visualized elsewhere in the manuscript, we prefer to keep it as it is in section 3.2.3. Figure S1A is a FGA-specific graph with a level of detail that is better suited for the supplementary material, in our opinion. The methodological differences between EGA and FGA are described in detail in the following sub-sections 3.3 and 3.4, including the classification of buffer widths (no equations required).

Lines 283-286: More details of the choice of f are needed here. What range did the literature review yield? Can a more in-depth discussion of the five catchment mentioned be examined? Or, if these details are already in previous literature, please clarify.

We further specified in the text that the five calibration catchments are from the well documented 2005 flood event. In the caption of Figure 3 it is stated that the five catchments were used to calibrate the volume reduction factors from the EGA approach so that the estimated supplied wood was in the same order of magnitude as the observed values from past flood events. A reference is added to the caption for further details (Steeb et al., 2019b).

We forgo, however, to explicitly specify ranges of f values from literature in the manuscript. We doubt that this would be really helpful, since the potential recruitment areas may be defined rather differently in different studies. Direct comparison with our f values is therefore not given.

Figure 5: From Lines 355-356 I believe that the observed data corresponded to the ‘large’ event scenario. This should be made clear in the figure and figure caption, and in Table 3.

Yes, in general, the observed data correspond to the ‘large’ event scenario. We added a sentence accordingly in the caption of Figure 5 and Table 3:

"Observed refers to the reported LW volumes after flood events, in most cases equivalent to the large scenario."

Lines 404-405, and elsewhere: In general the Results would benefit from stronger quantitative comparison to contextualise results for the reader. Here, it would be helpful to discuss the variation in results in addition to mean values, and elsewhere (ex. Lines 421-424, 483, 486, and elsewhere) quantitative assessment of what constitutes “larger” and “much larger” is needed to interpret the Results.

Lines 421-424 (original ms): We added a paragraph to section 4.1 describing the variation between the models, including quantitative values. We also added values of standard deviation (SD) and root mean square error (RMSE) of the model outputs to Table 3. References are made to Table 3 and Table 4, where quantitative values are shown. The newly created Figure S6 in the supplementary material further visualizes and quantifies the comparison of EGA and FGA outputs.

Line 483 and 486 (original ms): Quantitative assessment is stated with the order of magnitude of variation.

Figure 9: Please label the lines of equality ($y=x$) in the subfigures.

It is explained in the revised caption of the figure.

Figure 10: Please explain the plotted grey lines.

This is explained in the revised caption: The grey rectangle shows the reduction factor range used for EGA computations.

Discussion: The Discussion and overall contribution of this manuscript would be strengthened through a more in-depth discussion of the observed variation in model and observational results presented in the Results (please see second paragraph of Summary). It is mentioned (ex. Lines 739-740) that the observational dataset enables comparison between catchments. Perhaps a catchment comparison case study be highlighted to help demonstrate differences in the models or variation in observational data.

We added a paragraph in section 4.3 discussing the differences in the distribution of observed vs. estimated wood supply, including reference to a new Table S3 and a new Figure S7 in the supplementary material.

A comparison case study was made during the WoodFlow research program (FOEN, 2019), and we added a reference at the end of line 740. But it would go beyond the scope of this manuscript to present the case study here.