The Cryosphere Discussions

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Comment on tc-2021-141

Anonymous Referee #1

Referee comment on "Long-period variability in ice-dammed glacier outburst floods due to evolving catchment geometry" by Amy Jenson et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-141-RC1, 2021

This manuscript presents a modelling study of the evolution of jökulhlaups from an ice marginal lake as the damming glacier recedes. One novel aspect is (besides the retreating glacier) that it investigates how the floods are affected by remnant ice within the lake basin, due to a tributary glacier disconnecting from the main trunk. The study conducts synthectic experiments with a coupled jökulhlaup and ice dynamics model, both sub-models are of relatively low complexity, which is suitable for the paper's aim, namely, to investigate dynamics of the system in a qualitative fashion. (As an aside: note that fully quantitative modelling of jökulhlaups is not yet possible.)

The topic of the manuscript is interesting and timely, as many new glacier lakes are expected to form under a warming climate. It is well written and is suitable for publication in The Cryosphere once the minor revisions I outline below are incorporated.

Specific comments

I am a bit confused about the importance of Q_in for the filling scenario. The authors write around line 131 that the choice of Q_in does not impact the results much (which is, by the way, opposite to the finding of Ng & al (2007, doi:10.1029/2007GL031426)). However, then in the Results (line 225) they state "This behavior is sensitive to the model parameters though, as the basin could be made to reach or even exceed flotation by selecting a larger influx Qin." This seems to me like a pretty big impact (and indeed the one I would expect). The authors should state prominently that setting Q_in (the initial channel size S0 has a similar effect) sets how full the lake will get and, consequently, the time and size of the outburst. If the authors feel adventurous, then I would suggest a plot like Fig.6b using a range of S0 (or Qin, although S0 is more arbitrary than Qin, thus I would use that).

The authors should briefly explain the difference to the Kessler&Anderson (2004, doi:10.1029/2004GL020622)-model (which is what Schoof 2020 uses) who combine a cavity with an R-channel. In particular, that model would avoid having to set an arbitrary initial channel size, albeit, by having to set an almost as arbitrary bedrock bump height. All in all, I think the model used here is totally adequate but still the difference to K&A (2004) should be stated.

I think the work on Hidden Creek lake (Kennicott Glacier) should be cited, it is one of the best studied jökulhlaups and also from an ice-marginal lake (albeit, not from a de-glacierized tributary). The generic reference would be Anderson et al (2004, doi:10.1029/2002JF000004). But it might be worth checking whether another of their papers would be more relevant.

The authors need to acknowledge that drainage by flotation probably involves other processes than just channel enlargement, the work of Flowers & al (2004, doi:10.1029/2003GL019088) springs to mind.

Discussion 4.1: here I struggled with this lengthy discussion on something which the model is not capturing, namely ice flow into the basin (lines 255-287). I agree that model limitations should be discussed but starting off the Discussion with this and in particular at this great depth I found a bit much. My suggestion is to move all the mathematics (Eq19-22) and much of the accompanying text into the Appendix and then briefly discuss the limitation in words here and refer to the Appendix for details.

Line by line comments

2: "Marginal basins can form..." as there are other ways that marginal basins form.

Introduction: I think almost all citations need an "e.g." as they are not exhaustive.

19: also cite Werder & al (2010, www.nat-hazards-earth-syst-sci.net/10/227/2010/) here (add the "e.g.")

18: there is a new study by Mölg & al (2021, doi:10.1002/esp.5193) for the Swiss Alps which should be cited here.

21: how do proglacial temperatures change rapidly during a flood? Flood water is as cold as usual proglacial water.

26: I'm pretty sure this study was "caused" by the Kienholz & al. (2020) study. Why not acknowledge that with an extra sentence or two here?

35: here Huss & al (2007) should be cited too (add the "e.g.")

38: cite Kessler&Anderson 2004 here too.

68: write "917 kg m^{-3}" and do not use "/". Check the whole manuscript.

77: write "Assuming pressurised flow, mass conservation dictates that the rate of change of conduit area is also related to the spatial gradient in discharge,"

81: write ".. always remains open (Fowler, 1999)."

84: I suggest to use another letter than "f" here as "f" is commonly used for the Darcy-Weisbach friction factor, which is the other commonly used discharge relation.

94: state some details of the numerical implementation: spatial discretisation, time stepping algorithm, and maybe other details.

136: state what kind of model it is. I think it is a "higher order" model.

166: state what the spatial discretisation is. Presumably, finite differences? Also state what time-step algorithm is used. A forward Euler step?

178: The terminology around "floation" is used inconsistently. Here it is stated "ice dam to be at flotation" on line 179 "the basin is not at flotation." This confuses me a bit... another instance is on line 214. More consistent usage would be good.

Section 2.4: a table summarising the different simulations would be very helpful.

Fig.4: also include a run here which corresponds to zero floating ice layer thickness. Probably around hw,0=225m

Fig.5 and other places: I was never quite sure how "storage capacity" was defined (i.e. with or without ice). Maybe "outburst volume" could be used in many instances instead? Either way, define what is used it more prominently than just somewhere in the Results (currently line 218).

Section 4.2: nice!

316-317: this is definitely not true in general, e.g. Huss et al 2007.

319: write "flood initiation time" or "flood initiation mechanism" (if that was meant)

Fig 8a,b not referenced in the text.

Fig 8: "Peak floating ice surface" would be clearer (if it fits).

333-334: I had to read this several times to extract the meaning. Re-word.

354: write "and thus helps"

359: write "the basing drains once it reaches floation or if it ..."

367-374: Again, I find this list of limitations too prominent for the Conclusions. If I see a list of "bullet points" in the Conclusions I expect a list of major findings and not short-comings. Maybe just make the enumeration in-line, thus something like: "In particular, we (1) assumed....; (2) treated ...; (3)...".

378: I very appreciate that the code is made available! It would be great if the README contains a better description, for instance, what scripts need to be run to produce which figures. Also, ideally, the code is archived into a permanent repository (github is not). Zenodo does this and readily integrates with github: https://zenodo.org/