

## Review of

*Role of discrete water recharge from supraglacial drainage systems in modeling patterns of subglacial conduits in Arctic glaciers*

by Decaux et al.

## General comments

This manuscript presents calculated locations and water fluxes through subglacial channels under two Svalbard glaciers. It compares a "spatially uniform recharge" scenario, in which melt and rain water is allowed to enter the subglacial system locally, to a "discrete recharge" scenario, in which the water may only enter at identified moulin or crevasse locations. The study finds better agreement between modeled and observed locations of subglacial outflow when the "discrete recharge" scenario is used.

The result is important and reflects conclusions of other recent work that couples surface hydrologic networks to subglacial hydrology models (e.g., Banwell et al. (2013), Gulley et al. (2012), Bartholomew et al. (2011), to name just a few).

The manuscript too frequently overstates claims, makes assumptions without evidence, lacks presentation of field (or remote sensing) observations that support or refute their predicted subglacial conduit locations and fluxes, and suffers from an imprecise writing style. If these shortcomings can be addressed, it could merit publication in *The Cryosphere*.

## Specific comments

P1 L6-8 Most current subglacial hydrology models DO include heterogeneous recharge. Unweighted hydropotential flow accumulation calculations are still regularly performed, but I would no longer consider this the "standard model". I suggest rephrasing this sentence accordingly.

P1 L15, 18 The results are generalized to "Arctic tidewater glacierS" and "land-terminating glacierS", yet only one of each type was studied, without placing them into any context of being typical or atypical of other Arctic glaciers. This generalization needs to be either supported or removed.

P1 L20 The predicted conduits are not compared to observations; therefore, "more realistic results" here is not supported.

P1 L20-21 The meaning of this sentence is unclear and should be removed or reworded.

P2 L33-34 "no [model] has used a real representation of the supraglacial drainage system" is patently false. Banwell et al. (2013), Colgan et al. (2011), Mayaud et al. (2014), Bougamont et al. (2014) are studies that have done this.

P3 L1-20 This three-paragraph summary of the manuscript does not belong in the Introduction. If you must outline your paper here, limit yourself to 3-4 sentences at the most.

P3 L23 This statement needs citation.

P3 L32 Ryser et al. (2013) is a natural citation for this statement.

P5 L14-19 This section on the unsuccessful application of automated stream detection algorithm should either be enhanced – stating more detail about the broadband overlap in reflectance, possibly including a comparison of debris-covered and relatively debris-free regions – or removed.

P7 L1 What is the origin of  $\Delta_P = 19\%$ ? This should be cited and briefly explained.

P7 L4 All the subscript in this equation make it difficult to read. You could consider using  $Q_0$  for the amount of precipitation at your AWS station, since it is sited at roughly 0 meters a.s.l.

P8 L4 Errors in  $\Delta_P = 19\%$  are not accounted for here. I suspect these will be larger than errors in  $h$  or  $Q_{PPS}$  due to expected substantial meteorological variations between rainfall events. It may be difficult to know and quantify such errors, so at the very least this additional uncertainty should be commented on.

P8 L7 Usually errors are added in quadrature.

P9 L17 - P10 L8 Five scenarios are described, but results from only two scenarios (#2 and #5) are presented. I suggest removing the other three scenarios, which will simplify the presentation.

P9 L22-24 I would not refer to Scenario #2 as “spatially uniform recharge” since water input is allowed to vary spatially according to local production at the surface (Figure 3). Instead, you might call it a “local recharge” scenario, or something like that, to describe the lack of surface meltwater routing.

P10 L16-18 Artesian features (which is a more precise way to say “geyser-like spouts of water”) suggest  $k > 1$ . Although rather nonstandard, you might consider adding  $k > 1$  for Werenskioldbreen; Everett et al. (2016) have done this for a Greenland glacier.

P10 L26-27 Are the locations of the main subglacial channels somehow seeded by the authors in their model? Presumably they originate at locations of concentrated recharge, but this sentence suggests they might be baked into the model. Clarify.

P11 A new subsection to include methods of field or remote observations of subglacial conduits needs to be added.

P12 L2 Subsection heading: What does “Changes” refer to – changes over time, space, due to model scenario, etc.? Clarify.

P13 A new subsection discussing the goodness of fit of field observations to the predicted subglacial conduit locations and fluxes needs to be added. Relevant parts of the “authors’ personal unpublished maps” must be included here.

P14 L13 How does the current approach and the results differ from those of P alli et al (2003)?

P17 L21 The assumption that observations from these two glaciers in 1990, 2010, and 2011 can be “extrapolated to the entire Arctic” is terribly overblown.

P17 L24-26 Here it is noted that “few changes” were found between 1990-2010, yet in the Results

section (4.1), “several changes” were noted, grouped into four broad classes. This inconsistency must be addressed before you can claim that your results will be valid on decadal timescales.

P18 L6, L25 These water volumes are very precise. At least one significant figure should be dropped, if not two.

P18 L18-20 The subglacial channels mentioned here are not generally “well known”; any data used to identify such channels needs to be included in the manuscript.

P19 L14-18 Why is this important?

P20 L7-8 This assumption is not adequately supported.

P20 L15-16 This was not tested or shown in the study. The subglacial flow accumulation algorithm was run on glacier geometry (surface DEM) dating to 2015. Flow accumulation at other time periods was not assessed.

P20 L28 There is no reason that I know of that subglacial channels cannot form underneath an accumulation zone.

P21 L4-8 This statement directly contradicts that on P20 L15-16 (which, as I noted above, has its own issues). Regardless of which may be true, they are not constrained by this study. If Grabiec et al. (2017) have results that would support one of these statements, they should be described here and then folded into these points.

P20-21 The conclusion section is far too long. It does not need two paragraphs to restate results, and it certainly should not refer to specific figures. I would start by deleting the first three paragraphs, then winnowing the final three paragraphs into 10-15 lines.

Figure 6: The two caves should be noted on these maps as well (red dots would be sufficient).

Appendix: I do not think these figures are necessary.

### **Technical corrections**

P2 L20 Mistakenly written “heterogeneous” instead of “homogeneous”

P2 L28-30 This is true for temperate glaciers

P2 L31 Smith et al. (2015) would be ideal to cite in support of this sentence

P6 L15 “spatialized” is not a word

P6 L27 WGMS should be written out and a citation added

P10 L22 Specify “supraglacial” drainage catchment structure

P10 L25 Specify that this refers to  $k$

P12 L22 Specify “more” consistent “than the 1990-2010 pair”; they are not fully consistent, just

more consistent than the 1990-2010 comparison

P19 L21 Absent a crevasse, moulin, conduit, or hydrofracture, this statement can be true; as written, it is not true

P19 L29, P20 L1 Use of the word “satisfying”: it is not appropriate to describe emotions associated with obtaining certain results

P19 L34 If  $k \leq 1$ , then the subglacial system is never “overpressurized”

P20 L11 I find a factor of 3 here, not an order of magnitude.

P21 L9-11 Specify “on these glaciers” at the end of this sentence. The method is not new, but its application to Hansbreen and Werenskioldbreen is.