Reviewer #1

General comments: This study focuses on different ways of treating the supraglacial drainage of water at the surface of ice sheets. The region of interest studied here is Russell Glacier in South West Greenland. The authors presents an inter-comparison of three different surface routing models and compare their results to the output of a Regional Climate Model (RCM). The different inputs are further compared through by using them as the forcing quantity provided to a subglacial drainage model. The conclusion of the study are that the use of a supraglacial drainage system allows to get a better representations of the lag of the water input to the moulins. Some sensitivity among models also allow to quantify the impact of the Digital Elevation Model resolution on the drainage characteristics.

1. ("This study provides an interesting insight into the differences that arise from the use of different supraglacial drainage model. However, my impression is that this study should be further refined in order to be more understandable and provide a usable tool for the community. I find that the presentation of the different models and their results is lacking detail and clarity. Moreover I am concerned by the choice that were made with regards to the boundary condition that are applied to the subglacial hydrology model. Details of my concerns and potential improvement are given bellow section by section.")

Reply: Thanks for the comment. We have: (1) reorganized the results and the discussion sections to make the study more understandable; (2) better clarified the three surface meltwater routing models in the methods and data section; (3) rerun the subglacial hydrology simulations with a more realistic downstream boundary condition (50% of overburden pressure); (4) revised the main figures of this study to make them more readable; and (5) published all the model codes online (https://doi.org/10.6084/m9.figshare.11635932.v1). We think the revised manuscript is much easier to follow and the three routing models will be usable tools for the community.

2. ("1.1 Abstract: The abstract is quite hard to read due to the accumulation of acronyms. Where possible I would urge the authors to refrain from using acronyms in this part of the papers. It might be beneficial to simplify the abstract to make it more accessible to readers which might afterwards gather the details of the study in the rest of the paper. As an example, the author could state that they compare three surface meltwater routing models at this point 1 without specifying those models, the list of variables line 21 (page 1) could be omitted and replaced by "key variables".)

Reply: We have simplified the abstract, as requested. Most acronyms have been deleted. We suggest that the full names of the three routing models are necessary because they are used to explain the results. The revised abstract is as follows:

"Each summer, large volumes of surface meltwater flow over the Greenland Ice Sheet surface and drain through moulins to the ice sheet bed, and impact subglacial hydrology and ice flow dynamics. Runoff modulations, or routing delays due to ice sheet surface conditions, thus propagate to englacial and subglacial hydrologic systems and require accurate assessment to correctly estimate subglacial effective pressures and short-term lags between surface meltwater production and ice velocity. This study compares hourly supraglacial moulin discharge simulations from three surface meltwater routing models, (1) synthetic unit hydrograph, (2) surface routing and lake filling, and (3) rescaled width function, for four internally drained catchments located on the southwestern Greenland ice sheet surface. Using surface runoff from the Modèle Atmosphérique Régionale regional climate model (RCM), simulated variables used for surface meltwater routing are compared among the three routing models. For each catchment, simulated moulin hydrographs are used as input to the SHAKTI subglacial hydrologic model to simulate corresponding subglacial effective pressure variations in the vicinity of a single moulin. Two routing models, surface routing and lake filling and rescaled width function, which require the use of a digital elevation model (DEM), are assessed for the impact of DEM spatial resolution on simulated moulin hydrographs. Surface routing and lake filling is sensitive to DEM spatial resolution, whereas rescaled width function is not. Our results indicate the three surface meltwater routing models perform differently in simulating moulin peak discharge and time to peak, with rescaled width function simulating slower, smaller peak moulin discharges than synthetic unit hydrograph or surface routing and lake filling. We also demonstrate that the seasonal evolution of supraglacial stream/river networks can be readily accommodated by rescaled width function but not synthetic unit hydrograph or surface routing and lake filling models. Overall, all three models produce more realistic supraglacial discharges than simply using RCM runoff outputs without an applied routing scheme; however, there are significant differences in supraglacial discharge generated by the three models tested. This variability among surface meltwater routing models is reflected in SHAKTI subglacial hydrology simulations, yielding substantially different diurnal effective pressure amplitudes depending on the applied surface meltwater routing model; however, the temporal mean effective pressure is relatively consistent across models."

3. ("1.2 Introduction: The introduction gives a succinct outlook on the motivations of the study. This could be developed further to point out the current lack of representation of the supraglacial drainage system and the necessity to have a better representation of this system. The description starting on line 20 (page 2) would be better in a method section of the paper. Moreover, some terms defined in the introduction (such as Unit Hydrograph or Internally Drained Catchments) might not be familiar to the Cryosphere community and the author should consider defining those in more details.")

Reply: The current lack of representation of the surface meltwater routing leads to an insufficient understanding of surface-to-bed meltwater connections and ice dynamics, as the reviewer pointed out. Additional new text has been added to better highlight this point, as requested.

The definitions of Unit Hydrograph and Internally Drained Catchments have been added, as requested. Internally drained catchments (IDCs) are "hydrologic units on the GrIS surface that collect and drain meltwater through supraglacial stream/river networks to terminal moulins or lakes" (Yang and Smith, 2016). Unit hydrograph (UH) is "a transfer function that is widely used for modeling catchment runoff response to rainfall events for some unit duration and unit depth of effective water input" (Smith et al., 2017). A new section has been added to better define unit hydrograph in more details, as requested.

The description starting on line 20 (page 2) introduces the three routing models and their different assumptions and data requirements. We suggest that it may be useful to explain these three models clearly in the introduction section.

4. ("I don't completely agree with the statement starting on line 10 (page 2) to my knowledge supraglacial meltwater routing is usually simplified in subglacial hydrology models (e.g. Banwell et al., 2016; de Fleurian et al., 2016) it would be interesting to have some citation here that present studies directly using an RCM as their water input. I am not sure that the citation to Flowers et al. (2018) is relevant in this context or I missed the point of the author here. Further down, the citation to Bartholomew et al. (2011) seemed to be misplaced here as this specific study treats about observations rather than modelling.")

Reply: Flowers (2018) is a review of Greenland hydrology, which discusses some important issues in surface-to-bed meltwater connection. We agree with the reviewer that Flowers (2018) may not be appropriate to state that "surface meltwater routing is either simplified or simply ignored" so it has been deleted, as requested. Reviewer 2 made the same comment. We agree that Bartholomew et al. (2011) is primarily "about observations" so have removed this citation. We have listed several studies (see Table S1) that use RCM runoff as water input, as requested.

5. ("1.3 Study area and data source: This section is missing a major information as the study area is actually never named. The Russell glacier region will be familiar to most of the reader interested of the subject but mention of it should still appear in the paper. My opinion is that this section should be merged into a section 3 (Methods and Data). Regarding the content of the present section it is not clear to me how and why the IDCs that are presented in this section were generated and why those specific IDCs have been chosen.")

Reply: Section 2 (Study area and data sources) has been merged into Section 3 (Methods and Data) as suggested. The Russell Glacier region has been added to better introduce the study area, as requested.

We have better explained the reasons to select the four IDCs, as requested: "They are distributed at approximately 200 m elevation intervals in order to span the elevational range of most well-developed IDCs found in the Russell Glacier region and the variable surface melt conditions of this region. Large supraglacial lakes are absent in these four IDCs and surface meltwater is all routed to the moulin at the catchment outlet. As such, surface runoff produced in each IDC should equal to the moulin discharge. A moulin discharge hydrograph collected at Rio Behar catchment (IDC2 in our study), southwestern GrIS (67.049346N, 49.025809W) for 72 h from 20 to 23 July 2015 was used to calibrate parameters of SUH and RWF models. It is problematic to apply these empirically-derived parameters over large spaces and long times. Therefore, the four IDCs distributed in a relatively small region were selected and the areas of IDC1, IDC3, and IDC4 are similar to the Rio Behar catchment (IDC2)."

6. ("1.4 Methods: The description of the different models here is quite brief and some more

details could be provided. Particularly it would be interesting to have a better overview of the advantages and drawbacks of each models. The paragraph starting line 15 (page 5) would fit better in the introduction of the study rather than here. Subsections 3.5 and 3.6 refer to the sensitivity studies that where performed for some of the model, it could be beneficial to transfer those sections into the descriptions of the relevant models. That would outline the advantages and potential drawbacks of the models and would clarify the overall setup of the experiments.")

Reply: Overview of the advantages and drawbacks of each model has been provided in the introduction section and a new table (Table S1) has been added to better compare the three routing models. We have further illustrated the advantages and drawbacks of these models through the manuscript. RWF can mimic seasonal evolution of supraglacial stream/river networks by varying the partitioning of hillslope versus open-channel zones. SRLF, in contrast, assumes the bare ice surface has a stable response to the surface melt and uses static meltwater routing velocities to build the UH. SUH relies on C_p and C_t to build the UH. If we can have a moulin hydrograph during the entire melt season, we can calculate multi-temporal C_p and C_t using variable time-to-peak (t_p), peak discharge (h_p), and main-stem stream length (L), thus creating multi-temporal UHs. Unfortunately, we do not have such measurements at present so SUH cannot mimic variable hydrologic response of a catchment to surface melt.

Table S1. A brief summarization of surface meltwater routing models.

Model	Meltwater Routing	Applicable on bare ice surfaces		Applicable on snow surfaces	Parameter dependency	DEM dependency	Case study
		Hillslope	Open-Channel				
Instantaneous RCM runoff	No	-	-	Yes	No	No	(McGrath et al., 2011; Bartholomew et al., 2012; Rennermalm et al., 2013; Fitzpatrick et al., 2014)
Snyder Synthetic Unit Hydrograph (SUH)	Yes	-	-	Yes, but model parameters should be recalibrated	C_p, C_t are calibrated using a field-measured moulin hydrograph	No	(Smith et al., 2017)
Surface Routing and Lake Filling (SRLF)	Yes	No	Yes	Yes	No	DEM is required to calculate meltwater flow velocities for all catchment cells	(Arnold et al., 1998; Willis et al., 2002; Banwell et al., 2012; Banwell et al., 2013; Arnold et al., 2014; Banwell et al., 2016; de Fleurian et al., 2016; Koziol and Arnold, 2018)
Rescaled Width Function (RWF)	Yes	Yes	Yes	Yes, but model parameters should be recalibrated	Hillslope and open-channel flow velocities (v_h and v_c) are calibrated using a field-measured moulin hydrograph	High-resolution (<10 m) DEM is required to calculate hillslope flow path length	(Yang et al., 2018)

Moreover, SUH and RWF both rely on several empirically parameters (C_p and C_t for SUH, and v_h and v_c for RWF) calibrated from a moulin hydrograph measured at the Rio Behar catchment, southwest GrIS during a very short time period (72 hours), July 2015 (Smith et al., 2017). In contrast, SRLF is more solid and applicable over large spaces and long times. because it only relies on DEM to calculate meltwater flow velocities (Banwell et al., 2012). In this study, we assume these empirically parameters are transferable over space and time but this assumption needs further validation. It may hold for ice sheet surface with similar hydrologic and glaciological environments but is problematic to apply over large regions and long times due to evolving ice surface characteristics. Multiple independent, long-term moulin hydrographs will help eliminate the need for this assumption.

The paragraph starting line 15 (page 5) has been removed to the introduction section, as requested.

Subsections 3.5 and 3.6 are not sensitivity studies as the reviewer suggested. In contrast, they are both important topics in terrestrial hydrology and this study attempts to expand these two topics to ice sheet hydrology. Zhang and Montgomery (1994) is a classic study investigating the impact of DEM spatial resolution on terrestrial stream flow and we followed their method to investigate the impact of DEM spatial resolution on surface meltwater routing. The temporal evolution of stream/river networks on stream flow is a state-of-the-art topic and attracts growing attention in terrestrial hydrology. For example, a recent study shows that the extension and retraction of the terrestrial stream network can substantially change the mean travel time and the shape of the travel time distribution (van Meerveld et al., 2019), similar to the finding of our study. Therefore, we suggest that these analyses are partially independent of routing models and should have their own subsections.

van Meerveld, H. J. I., Kirchner, J. W., Vis, M. J. P., Assendelft, R. S., and Seibert, J.: Expansion and contraction of the flowing stream network alter hillslope flowpath lengths and the shape of the travel time distribution, Hydrol. Earth Syst. Sci., 23, 4825-4834, 2019.

Zhang, W., and Montgomery, D. R.: Digital elevation model grid size, landscape representation, and hydrologic simulations, Water Resour. Res., 30, 1019-1028, 1994.

7. ("From the references that were provided in the paper regarding the SRLF model I understand that this model is routing water with different equations if it sits on snow or on bare ice. From the model description given here it seems that only the bare ice formulation was used. Is that so? If yes the reasons for this choice should be explained.")

Reply: Yes, only the bare ice formulation of the SRLF model was used. The parameters of SUH and RWF routing models were calibrated using field-measured moulin discharge on bare ice (Smith et al., 2017; Yang et al., 2018). Therefore, to make these meltwater routing models comparable, we only discussed the situation of meltwater routing on the bare ice surface. This point has been better explained in the revised manuscript, as requested.

8. ("As stated above my main concern with this study is the way in which the subglacial

hydrology model is set-up. In my opinion the boundary condition that is given for the left edge of the domain is not realistic, I do not think that we expect to find water pressure at the atmospheric pressure anywhere under the ice sheet. A more sensible choice would be to set the water pressure at a given fraction of the overburden pressure. A change of boundary condition would need to perform new simulations but I would expect a good argumentation on the choice of the present boundary condition if it is to be kept. I also do not understand why the slopes of the bed and surface, and velocities are not taken from the values of the IDCs as is done for the ice thickness. As it stands now I have a hard time trusting the results from the subglacial hydrology model as it seems that the downstream boundary that is currently set is exerting an important control on the whole domain. I would also note that the Figure 2 related to this section is not very informative and could probably be omitted.")

Reply: Thank you for the recommendation to use a more realistic boundary condition for the moulin input-forced subglacial hydrology simulations in the interior of the ice sheet. We have rerun all SHAKTI simulations using a downstream boundary condition with water pressure corresponding to 50% of ice overburden pressure. The new simulations also use mean surface slope calculated for each catchment drainage (used for both surface and bed slopes, maintaining a uniform slab of ice for the 1 km square domain), as well as sliding velocity corresponding to 100% of the mean annual observed surface velocity in each drainage catchment. The mean slopes and surface velocities are included in Table S2. Figure 2 was originally included to show the model discretization and clearly indicates the moulin location at the bed, but we have removed it, as suggested.

Table S2. Summary of four study catchments.

Catchment ID		**IDC1**	**IDC2**	**IDC3**	**IDC4**
Area (km^2)		53.0	66.9	57.3	58.5
Mean Elevation (m)		1054	1248	1473	1646
Mean surface slope (m/m)		0.018	0.020	0.008	0.008
Mean bed elevation (m)		207	309	247	222
Mean bed slope (m/m)		0.050	0.075	0.036	0.022
Mean ice thickness (m)		847	939	1226	1424
Mean ice flow velocity (m/a)		116	99	98	73
Distance to ice edge (km)		25	40	70	100
Peak discharge time	RCM	13-15	13-15	13-14	13-14
	SUH	19-20	20-21	19-20	19-20
	SRLF 2m, 5m, 10m, 30m, 90m	18-19, 20-21, 21-22, 22-23, 22-23	18-19, 19-20, 21-22, 21-22, 21-22	17-18, 18-19, 20-21, 22-23, 22-23	17-18, 19-20, 23, 23, 23
	RWF	22-23	21-22	20-21	21-22

9. ("1.5 Results: In general I find the presentation of the results quite hard to follow. This might come from the structure that was chosen by the author, from the presentation of the figures or both. I also wonder why only the results from IDC 1 are presented, it appears from the supplementary figures that the results from the four IDCs are quite similar but this should be stated. I also expect that changing the boundary conditions and parameters of the subglacial hydrology model may alter those results. Regarding the presentation of the results, it would be clearer to me if the author would describe first the results of the inter-comparison itself before delving into the sensitivity studies that were performed on DEM resolution and the value of Ac. Comparing the results to a given reference might also help

with the clarity of the text.")

Reply: The structure of the results section has been reorganized, as requested. The revised results section includes: 4.1 Simulations of supraglacial moulin discharge, 4.2 Simulations of subglacial effective pressure, 4.3 Long-term evolution of moulin discharge simulations, and 4.4 Effects of DEM spatial resolution on surface meltwater routing. The sub-sections of discussion have been changed accordingly. We agree with the reviewer that the new structure is much easier to follow. The results from the four IDCs are quite similar as the reviewer pointed out. We have explicitly stated this point, as requested: "The three UHs (i.e., SUH, SRLF UH, and RWF UH) and their routed moulin discharges for the four IDCs are presented in the supplement; the resultant patterns of moulin hydrographs are similar so we use IDC1 to illustrate our results here."

As you might expect, the modifications to the subglacial hydrology simulations to include the more realistic boundary condition, surface slopes, and sliding velocities do change the magnitude of the resulting effective pressures (now lower than with the atmospheric pressure boundary condition used in the initial submission). The text has been updated to describe the new results, and the overall behavior and findings of the study remain consistent.

10. ("I generally find the presented figures a bit too busy and so hard to read. Figure 3 is described a lot throughout the manuscript but the size of some panels make it hard to read. As for the text having specific figures for the inter-comparison and the sensitivity study might help to lighten the figures. Figure 4, 6 and 7 however are not described in the Results part and should be included there.")

Reply: To make Figure 3 more readable, we have taken the third column (subglacial effective pressure) and put it in its own figure, as it is a distinct part of the results and discussion (Figures S1 and S2). We have made Figure 3 larger and reshaped the width ratio between the first column (UH) and the second column (moulin discharge) from 1:1 to 1:1.5 to better represent the diurnal moulin discharge (Figure S1). We have added a title "DEM resolution" to Figure 3c and 3e, and a title "A_c" to Figure 3g, changed the x-axis labels of Figure 3e and 3g into "RWF UH (A_c = 100 m^2) and "RWF UH (2 m DEM), respectively, and added legend "RCM runoff" to Figure 3b, 3d, and 3f to make the figure easy to follow. Figure 4 has been removed as suggested. Figures 6 and 7 have been updated and better explained in the main text, as requested (Figures S3 and S4).

Moreover, we cannot obtain the "optimal simulations for SRLF and RWF" because determining DEM spatial resolutions or cumulative area thresholds are important topics in surface hydrology rather than sensitivity analysis (see our reply to your comment 6). Therefore, we prefer to plot variable simulations together and believe necessary legends make all the sub-figures understandable. However, we agree with the reviewer that a less busy figure will be easier to follow. Therefore, we only plot simulation results using 2 m DEM in Figure S4.

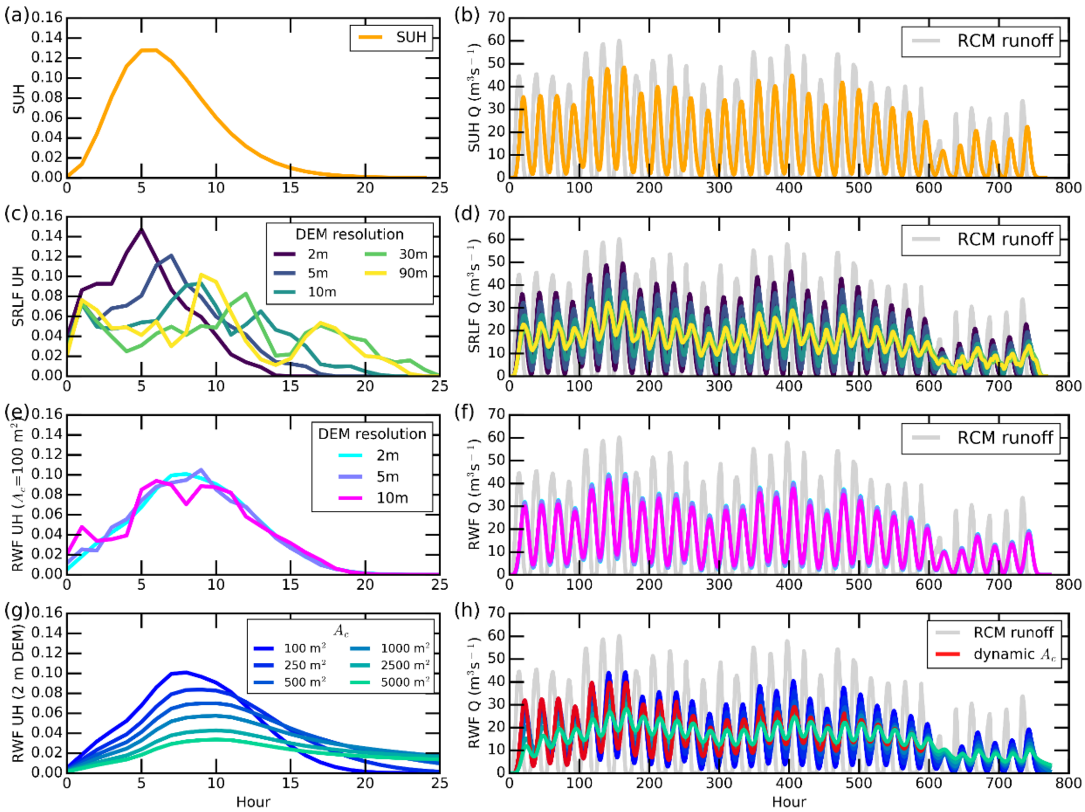

Figure S1. Presentation of Unit Hydrographs (UHs) (column 1) and moulin discharges (column 2) of IDC1 during July 2015, as simulated by three supraglacial routing models (SUH, SRLF, and RWF). A_c is the cumulative contributing area required to initiate a supraglacial meltwater channel and dynamic A_c values are used as proxy for time to simulate the temporal evolution of supraglacial stream/river networks. Simultaneous RCM runoff (grey line) is shown to indicate the effect of surface meltwater routing process on moulin discharge.

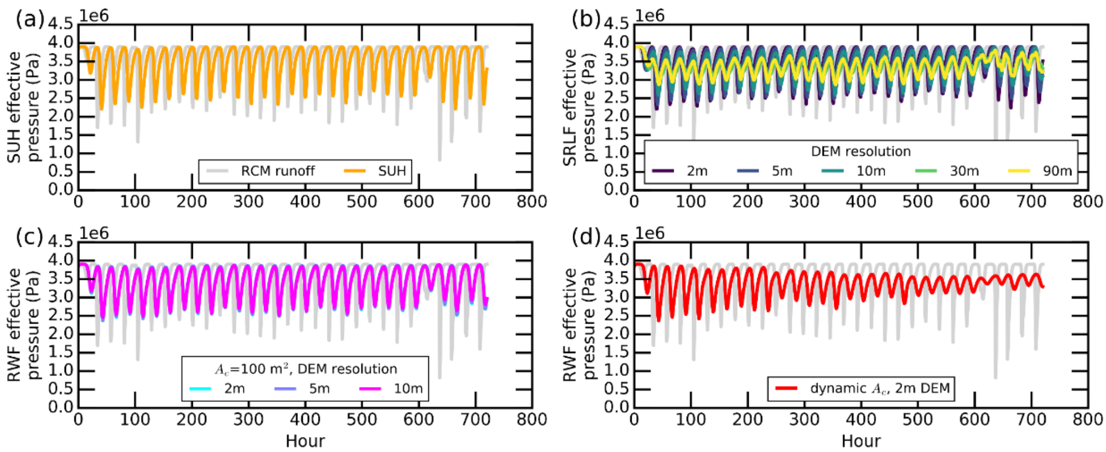

Figure S2. Effective pressures for IDC1 simulated by SHAKTI, with inputs to the subglacial system via a single moulin prescribed by the moulin discharges (shown in Figure S1) calculated by the various routing models. The effective pressure shown here is the spatial mean for the entire 1-km square domain which contains the moulin input at its center.

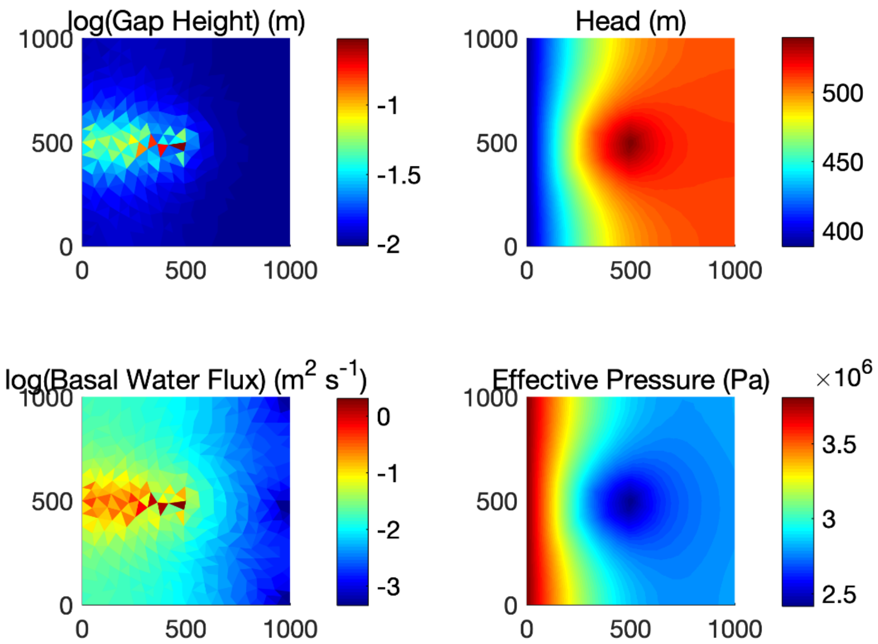

Figure S3. Snapshots of subglacial hydrology fields on day 23 in IDC1 using the SUH routing method to drive moulin input (see full animation of channel evolution and fluctuation in the supplement). An efficient channelized drainage pathway develops from the moulin location at the center of the domain to the outflow at the left, characterized by higher gap height, water flux, effective pressure, and lower hydraulic head than its surroundings perpendicular to flow.

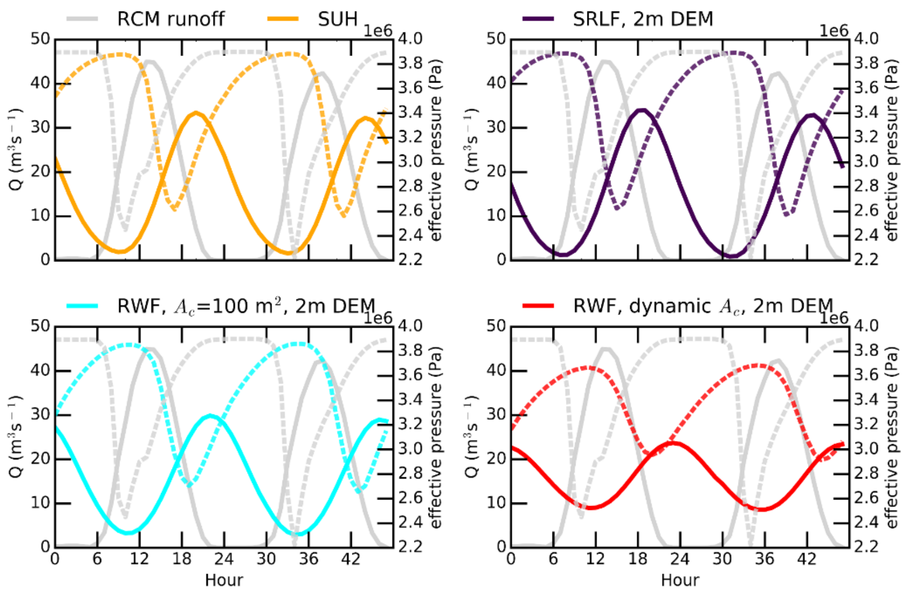

Figure S4. The average two-day cycle of moulin discharge (Q) for IDC1 during July 2015. The daily minimum input in supraglacial moulin discharge (solid lines) corresponds generally to maximum effective pressure (dashed lines), and is followed within 8-9 hours by the daily minimum effective pressure (maximum subglacial water pressure). This suggests that the system shuts down due to creep with low meltwater input, and becomes highly pressurized as meltwater input increases again. As the new water inputs are accommodated, efficient pathways reform and effective pressure increases (subglacial water pressure decreases).

11. ("Lastly I have not seen any information with regard to the sampling of the effective pressure that is discussed, is it an average value or this value is taken at a specific point?")

Reply: The effective pressure that was described in the initial submission corresponded to the value at the moulin location on the bed (i.e. the head of the channel that forms to the downstream boundary). This description may have been inadvertently removed in the initial manuscript submission (our apologies). In the revised manuscript, we have altered the figures and discussion to focus instead on the mean effective pressure for the entire domain. While the spatial mean effective pressure variations are not as dramatic as seen at the moulin location itself, we feel this gives a more informative view of effective pressure behavior in the vicinity of a moulin, which is potentially more useful from an application perspective.

12. ("1.6 Discussion and Conclusion: The discussion of the manuscript is clear, it would however take advantage of the alterations suggested above for the Result section. Particularly describing all the figure in more details in the result section would help during the discussion. I also expect that the changes required above regarding the subglacial hydrology model might have a significant impact on the results and should be taken into account in the discussion.")

Reply: The discussion section has been reorganized, as requested. The revised discussion section includes: 5.1 Implications of surface meltwater routing method inter-comparison, 5.2 Influence on diurnal subglacial pressure variations, 5.3 Influence of seasonal supraglacial drainage evolution on meltwater routing, 5.4 Impact of DEM resolution on supraglacial meltwater routing, and 5.5 Future research directions of surface-to-bed meltwater connection. We have better described all the figures in the results section, as requested (see our reply to your comment 10).

As described above, the subglacial hydrology simulations have been rerun with more appropriate/realistic boundary conditions, slopes, and sliding velocities. As noted, these changes do influence the magnitude of resulting effective pressures, but not the overall behavior and differences between routing methods. The text has been updated to reflect the new results.

13. ("I have noted a few minor concern on this section which are listed in the Specific comments bellow. Specific comments. Below is a list of more specific comments throughout the manuscript given with line and page number: Page 1, Line 16: "ice surface" can be replaced by "ice sheet surface".")

Reply: Changed as requested.

14. ("Line 17: "climatological melt" should be replaced by "surface meltwater".")

Reply: Changed as requested.

15. ("Line 21: MAR abbreviation is not defined here.")

Reply: Changed as requested.

16. ("Line 23: "input" can be replaced by "used as input"")

Reply: Changed as requested.

17. ("Page 2, Line 2: Surface melt is not restricted to the ablation zone but occur in the accumulation zone too.")

Reply: "across the ablation zone of" has been replaced by "on".

18. ("Line 3: "Greenland ice surface" should be "Greenland ice sheet")

Reply: Changed as requested.

19. ("Line 3: "can be" should be "is"")

Reply: Changed as requested.

20. ("Line 14: Bartholomew et al. (2011) does not seem to be a fitting citation here as this paper treats of observations.")

Reply: Bartholomew et al. (2011) has been deleted, as requested.

21. ("Page 3, Line 3: "to discern", to is missing")

Reply: "to" has been added, as requested.

22. ("Page 4, Line 13: The parameters Cp and Ct should be explained.")

Reply: C_p and C_t are two parameters depending on "units and drainage-basin characteristics". This has been explained, as requested.

23. ("Line 13: "time-to-peak in" reads strangely.")

Reply: "in" has been deleted.

24. ("Line 15: I am not sure that the citations are needed here an interested reader will find those in Smith et al. (2017)")

Reply: These two citations have been deleted, as requested.

25. (“Page 5, Equation 2: t; tc and th are not described in the text.”)

Reply: t_h is the hillslope travel time and t_c is the channel travel time. This has been explained, as requested.

26. (“Line 16: Replace “research” by “study”.”)

Reply: Changed as requested.

27. (“Page 6, Line 6: The contributing area (Ac) should be introduced and discussed in the model description.”)

Reply: Cumulative contributing area (A_c) defines the surface area needed to initiate open channel flow. Larger A_c values will yield smaller open-channel zones because larger contributing interfluve areas are required to form open channels. Additional new text has been added to explain A_c, as requested.

28. (“Line 15: “compute” rather than “derive”.”)

Reply: Changed as requested.

29. (“Line 19: “framework” could be omitted.”)

Reply: Changed as requested.

30. (“Page 7, Line 6: “climate model” can be skipped here.”)

Reply: Changed as requested.

31. (“Line 7: The times given here do not agree with the one that are present on Figure 3. The author should choose which are the more relevant and keep them throughout.”)

Reply: The peak discharge time 13:00-15:00 is shown in Table 1 rather than Figure 3. This point has been better explained, as requested.

32. (“Line 16: I don't agree with the statement on the smoothness of the UHs. From the figure it seems that the UHs from SUH are actually the smoothest of all.”)

Reply: We mean the RWF UH is flatter than SUH and 2 m SRLF UH because its peak UH value is smallest, thus distributing surface meltwater more ‘smoothly’ over time. We now think this is confusing as the reviewer pointed out so we have changed this sentence into “The peak values of RWF UHs are smaller than SUHs and 2 m SRLF UHs therefore RWF UHs temporally distribute surface meltwater most smoothly”, as requested.

33. (“Page 7, Line 2: Shouldn't it be “potential dynamism”?”)

Reply: Changed as requested.

34. (“Page 9, Line 16: Figure 7 actually shows the results from the three different models not only SUH. The comparison between the results of SHAKTI with the forcing from the RCM and the various models should be presented here to convince the reader of the advantage to use those models. As stated before, the setup of the subglacial hydrology model should be corrected to give convincing results. I am also unsure of the location where the effective pressure presented on Figure 7 is sampled from the model.”)

Reply: In the original manuscript, the effective pressure was sampled from the location on the bed where the meltwater is input (i.e. the “moulin location” on the bed). Similar behavior is seen by examination of the mean effective pressure instead, however, and we have altered the revised manuscript to focus on this quantity (see our reply to your comment 11).

35. (“Line 30: The study from Chandler et al. (2013) actually shows subglacial travel time. I don't see how this reference fits here.”)

Reply: Chandler et al. (2013) focused on subglacial travel time, as the reviewer pointed out but also reported peak supraglacial river discharge time for an IDC at southwest GrIS (moulin site L41 in their study) during 29 June to 7 July 2011. Thereby, we suggest that this reference fits here.

36. (“Page 10, Line 18: Should be “bare ice”.”)

Reply: Changed as requested.

37. (“Figure 2: I don't think that Figure 2 is necessary and it could be skipped.”)

Reply: Figure 2 has been deleted, as requested.

38. (“Figure 3: This figure is quite hard to read as it holds a lot of information. I would suggest to plot on this figure only the optimal simulations for SRLF and RWF which would allow an easier and more fair inter-comparison of the models. Another solution might be to split the figure to present the inter-comparison on a specific figure and the sensitivity studies on others. Finally, a zoom on some relevant period for the discharge and effective pressure would help the comparison of the different models. I also noticed a discrepancy here between the times given in the first column and the one of the text. It would be advantageous to introduce the RCM instantaneous runoff in the first column for ease of comparison.”)

Reply: We have revised Figure 3 based on your and Reviewer 2's comments. See our reply to your comment 10.

Figure 7 shows the average two-day cycle of moulin discharge (Q) for IDC1 during July 2015 derived from Figure 3. As such, Figure 7 is "a zoom on some relevant period" as the reviewer suggested. We have better illustrated Figure 7 to compare different routing models, as requested: "A magnified example of this timing is seen in Figure 7, which presents the average two-day cycle of moulin discharge input using the three routing models overlaid with effective pressure in IDC1. All three routing models achieve minimum moulin discharges around 09:00-11:00 and minimum effective pressures around 17:00-19:00, yielding a time lag of 8-9 hours; in contrast, the RCM instantaneous runoff without routing achieves minimum moulin discharge around 00:00 and minimum effective pressure around 10:00. The timing of effective pressure produced using RCM instantaneous runoff is visibly different than with the routing methods; interestingly, the timing of minimum effective pressure simulated by the RCM instantaneous runoff is very close (~ 1 hour) to that of maximum effective pressure simulated by the routing models."

39. ("Figure 4: Figure four is barely described in the text, it should either be better described or completely omitted.")

Reply: Figure 4 shows scatter plots of RWF-routed moulin diurnal discharge range (difference between maximum and minimum moulin discharge) vs. those modeled from RCM instantaneous runoff, SUH routing, and SRLF routing. We now think it is not closely related with the main topic of this study so we have deleted it, as suggested.

40. ("Figure 5: Ac is given here in km2, it should be given in m2 for consistency with the rest of the manuscript. The caption here could be shortened to its descriptive part.")

Reply: The area unit has been changed into "m^2" and the caption has been shortened, as requested (Figure S5).

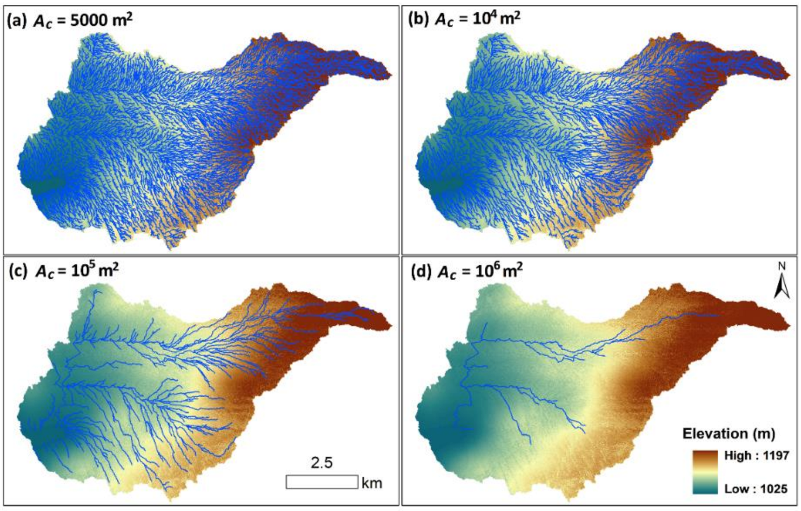

Figure S5. Variable supraglacial stream/river network for IDC1, as simulated by applying variable accumulative area threshold (Ac) values to ArcticDEM.

41. ("Figure 7: As for Figure 3 this figure is quite busy and should be simplified. The caption here is not adequate with some description missing and some discussion points that could be stripped.")

Reply: Figure 7 has been simplified and better explained, as requested. See our reply to your comment 10.

42. ("References: dois are missing from the references")

Reply: DOIs have been added, as requested.

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