Reviewer #2

General Comments: There has been a significant amount of recent work done on capturing processes influencing moulin hydrographs on sub-diurnal timescales. Going forward with these approaches will require significant investment of resources, particularly if field-derived empirical parameters are needed to calibrate supraglacial hydrology models. Underlying this work is an assumption that moulin discharge variability at sub-diurnal timescales might impact the evolution of inter- and sub-glacial hydrological networks, and thus ice dynamics. If this is the case, then supraglacial hydrological processes necessitate further investment to be properly constrained at fine temporal and spatial scales. However, the impact of supraglacial discharge variability on subglacial hydrology has not yet been investigated, and it is therefore not clear if, where, and what specific investments are needed. In this context, this paper makes two major contributions:

1) This paper is a first attempt to investigate the extent to which moulin hydrographs matter for subglacial channel evolution and effective pressure on diurnal timescales.

2) This paper evaluates three different contemporary approaches to estimating daily moulin hydrographs and evaluates the consequences of each with respect to modelled evolution of subglacial channel evolution and effective pressure.

This paper therefore constitutes an original and valuable contribution to ongoing research on supraglacial hydrology.

1. ("The paper could be improved by clarity and specificity around the methods used and the objectives of the paper. Suggestions in this respect are provided below and in the accompanying annotated PDF. My comments focus primarily on the supraglacial hydrology components of the study.”)

Reply: We have better clarified the methods and the objective of the paper, as requested. We agree with the reviewer that the methods should “be made clearer for a glaciology (rather than a hydrology) readership” since the objective of the paper is to illustrate the impact of surface meltwater routing on subglacial effective pressure rather than to directly compare the three surface meltwater routing methods. We have carefully revised the supraglacial hydrology components of the study, as requested. We have also included Table S1, which simply explains the benefits of using different routing models.

2. (“Specific comments: Title: Only one of the models is a routing model. Consider saying ‘inter-comparison of moulin hydrograph estimations’ or something similar. Throughout: The use of ‘routing models’ seems inaccurate. Only one (the SRLF) approach is a flow routing approach. The other two (RWF and SUH) do not route flow. A different word choice would be preferable. A ‘comparison of hourly moulin discharge models’, or something similar…..”)

Reply: We suggest that the three models (SUH, RWF, and SRLF) are all routing models. A routing model does not need to explicitly determine how meltwater produced on a cell is routed to its downstream cell(s) in a catchment, which is the aim of spatially-distributed routing models. In contrast, a routing model can be lumped and only determines how surface meltwater produced in the catchment is temporally routed to the catchment outlet.

Unit hydrograph (UH) is designed for this purpose. UH is a transfer function that models catchment runoff response to rainfall (melt in our case) events for some unit duration and unit depth of effective water input. In this study, all the three models (SUH, RWF, and SRLF) exhibit their UHs and consequently can temporally route surface meltwater to the catchment outlet and yield moulin discharge hydrographs. From this perspective, we suggest that they are all routing models.

Moreover, RWF and SRLF actually work very similarly. SRLF uses Manning's open-channel equation to calculate meltwater flow velocity for each cell of a catchment, while RWF uses constant hillslope and open-channel flow velocities calibrated from field measurements to determine each cell's flow velocity. As such, RWF and SRLF both generate a velocity raster. Then, integrating velocity with flow path distance calculated from DEM, meltwater transport time from each cell to the catchment outlet can be determined and the transport time distribution yields UH. In short, the primary difference between RWF and SRLF is the way they determine flow velocity for each cell.

We have added Table S1 to summarize the benefits of using different routing models and better illustrated the three routing models in the methods and data section.

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)

3. ("Introduction: In general, I do not find that the introduction sets up the objectives of the paper very well. It does not provide sufficient information to set up a methods comparison,

but also only emphasizes the subglacial channel evolution at the end – like an afterthought. I suggest the following changes: - You need to be clearer in your introduction that this is not a methodological paper per se – as you say later in the paper, you cannot say which method performs better due to a lack of empirical evidence. You can only speculate on the modelled (not observed) hydrological implications of the three different methods. This needs to come across more strongly.")

Reply: We have included the following statement in the Introduction: "Notably, this study cannot, in good faith, focus on method comparison, nor determine the 'best' (i.e., best able to reproduce a real-world moulin hydrograph) due to the lack of calibration and validation data. Owing to this limitation, the goal of this study is to assess differences among the three meltwater routing models, rather than revealing which model most realistically simulates surface meltwater routing on the ice surface. By using the outputs from all three as meltwater inputs to drive the SHAKTI subglacial model, we characterize the impact of their differences on subglacial effective pressure, and, more generally, the importance of routing supraglacial runoff on subglacial conditions." Moreover, we have further emphasized this fact in the discussion and is generally discussed in section 4.5 (Future research directions).

4. ("The differences between the three approaches as well as the assumptions and limitations of each needs to be made clearer for a glaciology (rather than a hydrology) readership. The limitations of the empirically-derived RWF and SUH also need to be made clear, particularly the temporal limitations of the original field-derived moulin hydrograph measurement. As is, a comparison of these three approaches is only useful for conditions similar to those under which the SUH and RWF approaches are calibrated – this needs to be made clear.")

Reply: We have better explained the three approaches and made them clearer for the glaciology readership, including the addition of Table S1. The limitations of the empirically-derived RWF and SUH have been made clearer, as requested.

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 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 it may be problematic to apply over larger space and longer time. A second independent, long-term moulin hydrograph will help to address this problem.

5. ("Because the comparison between the approaches is inherently limited due to the temporally-limited nature of the field moulin discharge measurements in the SUH and RWF, I think it would be useful in the introduction to put more emphasis on the goal of the paper as an exercise in examining (modelled) subglacial effective pressure sensitivity to diurnal hydrographs, rather than explicitly a comparison of moulin discharge estimate approaches. I

would consider a bolder introductory statement around Page 2, Line 17 that frames the paper as a (preliminary) investigation of the extent to which moulin hydrograph estimates matter for affecting modelled subglacial hydrology and effective pressures.”)

Reply: We have included two modifications to the introduction to emphasize the importance of the supraglacial system on subglacial hydrology. First, the current lack of representation of the surface meltwater routing leads to an insufficient understanding of surface-to-bed meltwater connections and ice dynamics, particularly on diurnal timescales. Therefore, constraints on IDC discharge can provide critical boundary conditions for studies of the subglacial hydrologic system. Second, by using the outputs from all three as meltwater inputs to drive the SHAKTI subglacial model, we have characterized the impact of their differences on subglacial effective pressure, and, more generally, the importance of routing supraglacial runoff on subglacial conditions. We have also emphasized the subglacial results in the last line of the abstract. We thoroughly discuss the implications of these different surface meltwater routing models on subglacial hydrology in section 4.2.

6. (“Last paragraph of introduction. I think there needs to be more explanation of what you are hoping to achieve with using the SHAKTI model. I think you need to be explicit that there is no objective away to compare the three moulin hydrograph methods, and the differences between them only matter in a glaciological sense if they significantly impact subglacial hydrology and effective pressure. You therefore run what is loosely a sensitivity test using SHAKTI to assess the modelled impacts of each approach. Although this comes out later in the paper, you need more framing of this consideration in the introduction.”)

Reply: See our reply to your comment 3. We have revised the last paragraph of introduction to better illustrate the objective of this study, as requested and explicitly indicate our goals with the lines: “By using the outputs from all three routing models as meltwater inputs to drive the SHAKTI subglacial model, we seek to characterize the impact of differences in surface routing on subglacial pressures and evolution, particularly over diurnal timescales. More generally, these results can demonstrate the extent to which the choice of surface meltwater routing algorithms can alter modelled subglacial conditions.”

7. (“Study area and datasets: More specific justification of the chosen study IDCs is needed. They are approximately similar sizes to the IDC used in the Smith et al. (2017) measured moulin hydrographs, which should be pointed out, and they also appear to exclude large supraglacial lakes, which is likely to affect the comparison of the SRLF approach with the RWF and SUH approach. This should be noted in the study area description and in the discussion.”)

Reply: 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 (Yang and Smith, 2016). Large supraglacial lakes are absent in these four IDCs (Figure 1) and surface meltwater is all routed to the moulin at the catchment outlet. As such, surface runoff produced in each IDC equals to the moulin discharge (Smith et al., 2017). 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 key parameters of SUH and RWF models. It is problematic to apply these empirically-derived parameters over large spaces and long times (Yang et al., 2018). 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)."

We have better illustrated the limitations of SUH and RWF in the discussion section, as requested: "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 larger space and longer time. A second independent, long-term moulin hydrograph will help to address this problem."

8. ("Methods: Overall, the methods seem written for hydrologists, not for glaciologists. More information is needed in this section to make it useful to its readers.")

Reply: We have better introduced the three routing models from a perspective of glaciologists. A new section has been added to explain Unit Hydrograph and its application for calculating moulin discharge. Additional new text has been added to better explain Snyder Synthetic Unit Hydrograph, Surface Routing and Lake Filling, and Rescaled Width Function, as requested.

9. ("Presumably, July 2015 was chosen for the MAR runoff simulations because that is coincident with the field-collection of the moulin discharge hydrograph. This should be made clear, so that the constraints on the method are obvious to readers.")

Reply: Yes, July 2015 runoffs were derived to be coincident with the field-collection of the moulin discharge hydrograph. Additional new text has been added to explain this point, as requested.

10. ("If this paper is to be a useful methodological resource for glacier hydrologists, a more complete comparison of the three approaches is needed. Perhaps a table would be useful in comparing the three methods – this table could keep track of the references, acronyms, assumptions, limitations, etc…")

Reply: Thanks for this great comment. We have added a new table (Table S1) to better compare the three routing models, as suggested (see our reply to your comment 2).

11. ("Section 3.6 – your explanation of a 'dynamic' Ac is not clear, or perhaps I have missed it. In Figure 3, it looks like you tested all five of the different Ac values independently over the whole time span, but then there is also a 'dynamic Ac'. Is a 'dynamic' Ac one that evolves according to your six five-day RWF-UHs? Be sure to call that 'dynamic' here.")

Reply: Yes, we tested all five of the different A_c values independently over the whole time span and then a 'dynamic' A_c one evolves according to the six five-day RWF-UHs, as the reviewer pointed out. We have added a new sentence "Each RWF UH was conducted to calculate moulin discharge for five days and the resultant moulin discharge is termed as dynamic A_c discharge" to better explain dynamic A_c, as requested.

12. ("Results: the figures for this section are confusing. They need to be pulled apart to be more readable, and the legends and captions need better information.")

Reply: We have carefully revised the figures to make them more readable, as requested. See our reply to your following comments.

13. ("Figure 3 is too confusing with this many panels, and the result is that the lines are too small to make out the subtle differences due to the different variables. I suggest taking the third column (effective pressure) out and putting it in its own figure, as it is a distinct part of the results and discussion. You could then make the main figure slightly larger, and show with a title on the legend in (g) and (j) that the different series refer to g) the DEM resolution and j) the channel initiation threshold (proxy for time).")

Reply: We have taken the third column (effective pressure) and put it in its own figure, as the reviewer suggested (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. We have added a title "DEM resolution" to Figure 3c and 3e, and a title "Ac" 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. We have better explained "the channel initiation threshold (proxy for time)" in the caption of Figure 3.

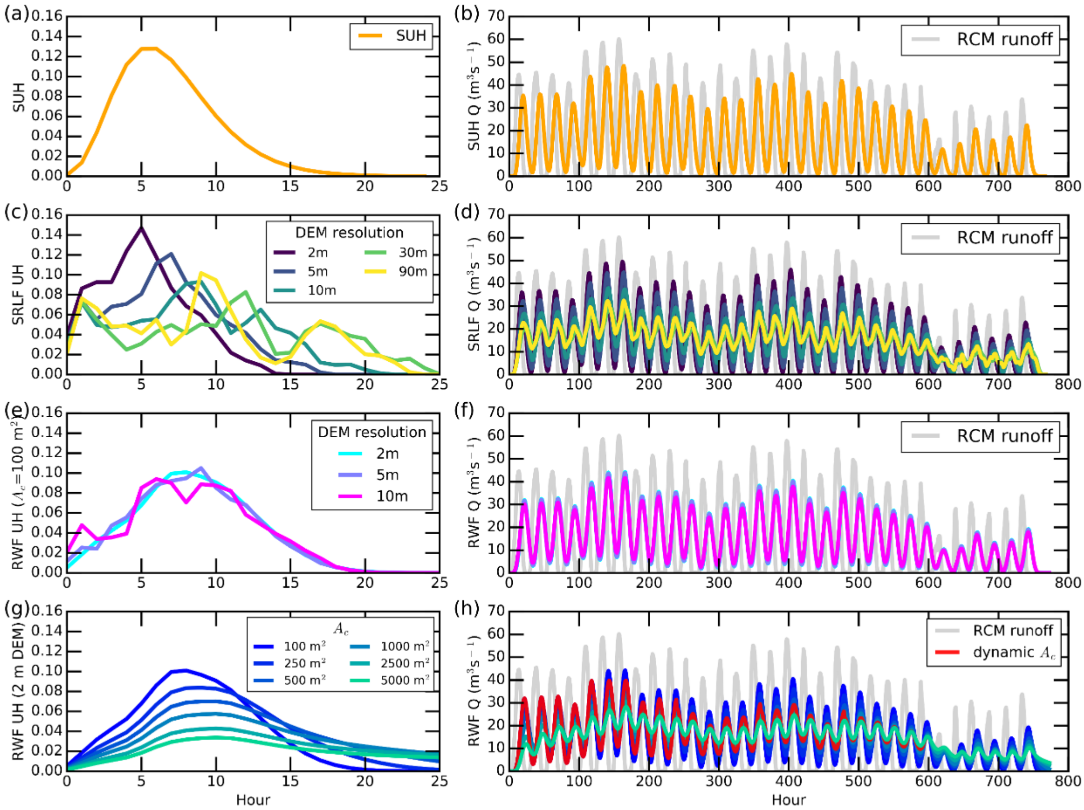

Figure S1. Presentation of Unit Hydrographs (UHs) (column 1) and moulin discharges (column 2) of IDC1 during July 2015, as simulated by three supraglacial routing models (SUH, SRLF, and RWF). A_c is the cumulative contributing area required to initiate a supraglacial meltwater channel and dynamic A_c 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.

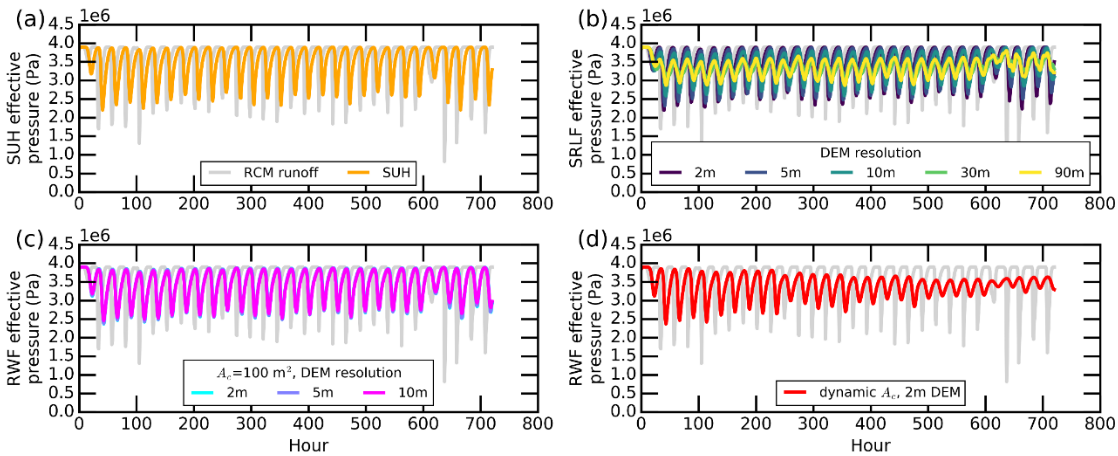

Figure S2. Effective pressures for IDC1 simulated by SHAKTI, with inputs to the subglacial system via a single moulin prescribed by the moulin discharges (shown in Figure S1) calculated by the various routing models. The effective pressure shown here is the spatial mean for the entire 1-km square domain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

14. ("Figure 4 is not discussed in the results section. Some discussion should be provided in the 'long-term evolution' section, or it should be removed.")

Reply: We agree Figure 4 is not closely related with the main topic of this study so we have removed it, as suggested.

15. ("Figure 3k – how is that there is so much smaller discharge for 5000m2 than there is for 100m2? With a higher Ac, there should be less efficient routing, lower peak Q and a flatter hydrograph but still, presumably, similar discharge. This distinction is not clear from the figure, perhaps because the lines are so compressed and the 'flashiness' of the hydrographs is not clear. Perhaps an inset figure would be helpful.")

Reply: A_c = 5000 m^2, as the reviewer pointed out, yields lower peak Q and a flatter hydrograph than A_c = 100 m^2 but it also yields higher minimum Q. Therefore, the daily Q values calculated from A_c = 5000 m^2 and A_c = 100 m^2 are similar.

16. ("Discussion: Overall, I think this section is too critical of SRLF and not critical enough of SUH and RWF. Some discussion of the limitations of the latter two is needed, namely: the chosen study catchments do not appear to have lakes, and those methods may not perform adequately in catchments with lakes, at different times of year and in different snow/ice/ surface slope conditions than those in which the field-measurements of the moulin hydrograph (Smith 2017) were collected.")

Reply: SRLF is the first model to route surface meltwater on the Greenland Ice Sheet. We think it is very successful. The SRLF model employs Darcy's law to route surface meltwater flow through snow and Manning's open-channel flow equation to route meltwater flow over bare-ice surfaces (Arnold et al., 1998). SRLF has been applied to simulate supraglacial lake growth and to drive subglacial hydrological evolution during several entire melt seasons (Banwell et al., 2012; Banwell et al., 2013; Arnold et al., 2014; Banwell et al., 2016). In this study, we focus on its bare-ice part to make it comparable with the SUH and RWF because the coefficients of these two models were calibrated using a field-measured moulin hydrograph on bare ice surface (Smith et al., 2017; Yang et al., 2018). It may 'hurt' the full ability of SRLF model as the reviewer pointed out.

To address this problem, we have: (1) better introduced SRLF model in the methods and data section, and (2) better discussed the limitations of SUH and RWF as requested. We have illustrated the limitations of SUH and RWF in detail in our previous studies (Smith et al., 2017; Yang et al., 2017) so we have only illustrated their limitations when comparing with SRLF and driving subglacial hydrology.

17. ("More discussion of the limitations of SHAKTI would be helpful. You should be clear that SHAKTI is used to provide preliminary insight into the possible importance of accurately capturing the details of an hourly moulin hydrograph, and that many complexities are not captured by this model.")

Reply: The limitations of SHAKTI itself are enumerated in Sommers et al. (2018). We have included a statement indicating the limitations of the model runs themselves in the results section: "The subglacial model domain and duration were chosen to illustrate the impact of the chosen supraglacial routing model on local subglacial hydrology in the vicinity of a moulin input at the bed. As such, our results cannot necessarily be extrapolated to infer large-scale or seasonal evolution of the subglacial hydrologic system in response to different surface forcings; however, the results do provide insight into the potential diurnal sensitivity of the subglacial system to changes in supraglacial meltwater routing and the associated modification of the discharge hydrograph."

In the updated manuscript, we have rerun the SHAKTI simulations with more realistic boundary conditions, surface slopes, and sliding velocities for each catchment to better represent actual effective pressures that may be found in the vicinity of a moulin in each region. The reviewer is correct that this is a simple exploration of the influence of different surface meltwater methods on subglacial pressures, but we hope that it provides a view into these connections and may serve as inspiration and motivation for more detailed studies involving simulations of multiple catchments with multiple realistic moulin inputs, topography, etc. In terms of capturing complexities of the subglacial drainage system, even with these small-scale simulations, the SHAKTI model does realistically represent realistic flow and pressure regimes, and evolving geometry under the ice in the vicinity of a moulin.

Technical corrections: Please see specific in-text comments in the attached annotated PDF. Please also note the supplement to this comment:

18. ("P2, line 12, Flowers, 2018, I would drop this reference as you provide specific references in the next sentence.")

Reply: This reference has been deleted, as requested.

19. ("P2, line 31, "field-measured moulin hydrograph", more information needed. Be clear that this is based on one moulin for one moment in time - make the limitations clear.)

Reply: The field-measured moulin hydrograph was collected at Rio Behar catchment, southwestern GrIS (67.049346N, 49.025809W) for 72 h from 20 to 23 July 2015. Although Smith et al. (2017) demonstrated coefficient transferability using two other independently field-measured moulin hydrographs, the two calibrated coefficients are collected at "one moulin for one moment in time" as the reviewer pointed out so they may still be limited to apply over longer time and larger areas. Additionally new text have been added to explain this point, as requested.

20. ("P3, lines 3-4, "Catchment-averaged meltwater transport velocities for each zone were then calibrated using a field-measured moulin hydrograph (Smith et al., 2017)", More information needed. Be clear that this is based on one moulin for one moment in time - make the limitations clear.)

Reply: See our reply to your comment 19.

21. ("P3, line 6, "it only requires catchment shape and area to estimate surface meltwater transport time (Smith et al., 2017)", As well as a number of important empirically-derived parameters. That should be made clear here.")

Reply: Changed as requested.

22. ("P4, line 5, "RCM runoff simulations", Avoid acronyms in the subtitles.")

Reply: This subtitle has been changed into "3.2 Regional Climate Model Runoff Simulations", as requested.

23. ("P4, line 14, "field-measured moulin hydrograph", Specify where and when this data was collected.)

Reply: This data was collected at Rio Behar catchment, southwestern Greenland Ice Sheet (67.049346N, 49.025809W) for 72 h from 20 to 23 July 2015. Additional new text has been added to explain this point.

24. ("P4, line 23, If you are going to supply the equation here, supply it for the relevant SUH equations above as well.)

Reply: The relevant SUH equations have been added, as requested.

25. ("P4, line 28, Spell this out here - it is difficult to keep track of all the acronyms.)

Reply: Changed as requested.

26. ("P5, lines 14-19, Make this its own section - at the moment, it is tucked under RWF. Alternatively, move it to the introduction or to section 3.7")

Reply: We have removed this paragraph to the introduction section, as suggested.

27. ("P6, lines 1-2, Is it possible that the empirical parameters Cp and Ct might change seasonally?)

Reply: Good point. C_p and C_t are two empirical parameters that quantify the hydrologic response of a catchment to surface melt. If we can have a moulin discharge 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 SUHs. Without such direct measurements, the parameters cannot be realistically varied in time and SUH cannot mimic variable hydrologic response of a catchment to surface melt. We have better explained this point in the Methods and Data section.

28. (“P7, line 8, I keep getting up on routing. These are not routing processes in the RWF and the SUH??”)

Reply: See our reply to your comment 2.

29. (“P7, line 14, But of course this is the catchment from which the empirical parameters are derived, so is the comparison really appropriate? At least make it clear.”)

Reply: We agree with the reviewer that this comparison is limited since we do not have a second field-measured moulin discharge hydrograph as validation data. But we suggest that this comparison at least indicates the transferability of these empirical parameters (C_p and C_t for SUH, and v_c and v_h for RWF) from the field-measured catchment to other catchments with similar areas. The limitation of the comparison has been better explained, as requested.

30. (“P7, line 28, Is this really 'long term'? 'Temporal evolution' would be better.”)

Reply: We have changed ‘long-term’ into ‘temporal’, as suggested.

31. (“P11, line 17, Should be decreases because subglacial water pressure will increase?”)

Reply: Good catch! Changed and clarified to: effective pressure decreases, resulting in increased sliding velocities.

32. (“P21, Figure 3, Remove the 'UH' - it looks as though you are subtracting a function from a function. With this legend down here, it is not clear that the grey refers to all plots. Is only 100 and 5000m2 showed in this figure? If so, it should say so in the legend.)

Reply: ‘UH’ has been removed, as requested. The grey refers to all plots and moulin discharge hydrographs for all six cumulative area thresholds are showed in Figure 3k. We have revised Figure 3 to make it more understandable.

33. (“P22, Figure 4, This figure is not explained in text and its context is therefore not clear”)

Reply: We now think Figure 4 is not closely related with the main topic of this study so we have removed it, as suggested.

34. (“P25, Figure 7, Why are there two solid lines and two dashed lines in each? What do the grey lines mean? Are they RCM discharges?”)

Reply: Two solid lines are supraglacial moulin discharge and two dashed lines are effective pressure. The grey solid lines are RCM surface runoff and the grey dashed lines are effective pressure simulated from RCM surface runoff. All the line colors correspond with the ones in Figure 3. This point has been better explained. We have updated Figure 7 to make it more understandable (Figure S3).

The average two-day cycle is presented because the average one-day cycle cannot present complete results for all models. All the 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 (Figure S3). 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.

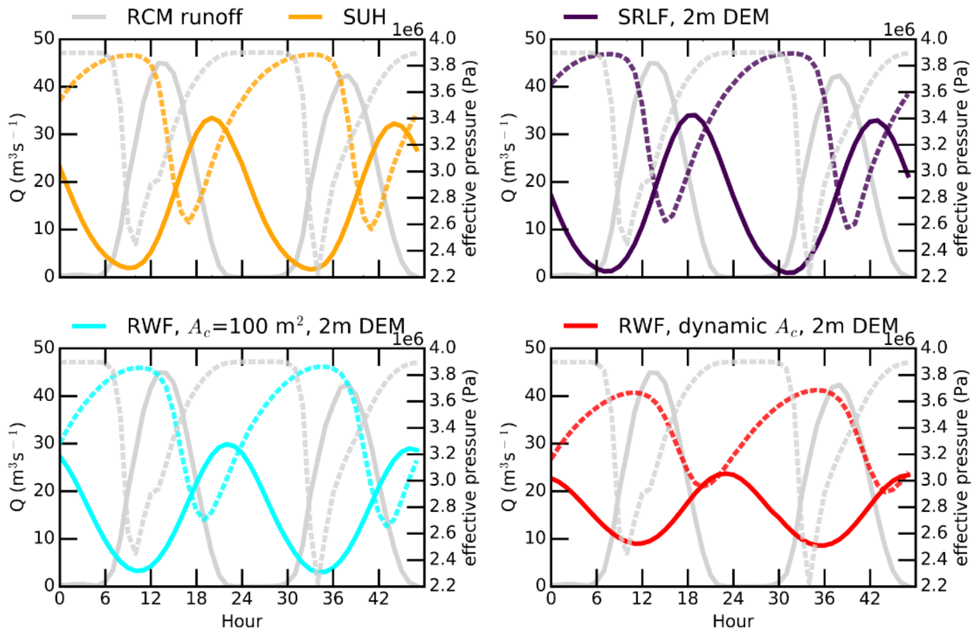

Figure S3. The average two-day cycle of moulin discharge (Q) for IDC1 during July 2015. The daily minimum input in supraglacial moulin discharge (solid lines) corresponds generally to maximum effective pressure (dashed lines), and is followed within 8-9 hours by the daily minimum effective pressure (maximum 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).

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