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The Cryosphere
Discussions

Interactive comment on "Seasonal Variability in In-situ Supraglacial Streamflow and Drivers in Southwest Greenland in 2016" *by* Rohi Muthyala et al.

Anonymous Referee #2

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The authors use a suite of in-situ supraglacial streamflow observations to detail diurnal and seasonal variability in streamflow at the 660 catchment in southwest Greenland. Their analysis shows surface energy flux drivers of surface melt to shift in importance over the timeseries, and that the timing of daily maximum discharge evolves over the season. The authors give a solid introduction and discussion of the existing observations of supraglacial streamflow, and do a thorough job clearly describing the data sets they collected and how they've applied terrestrial hydrology methods to analyze observations of ice-sheet supraglacial hydrology. The figures are largely clear, with a few suggestions listed in the line-by-line comments below.

Prior to publication, however, the authors should work to improve the clarity of their discussion on the seasonal evolution in the timing of daily maximum discharge. In the abstract, a "changing effective catchment area" is listed as a main driver of changes in peak flow timing, but this driver is not fully communicated or supported in the discussion and conclusion sections. Mechanisms driving the direction of the change in lag between solar noon and the timing of daily maximum discharge (i.e., gradually decreasing from three to one hour over the season, and then increasing back to 3 hours at the end of the observation period) are not clearly discussed. The authors mention changes in the weathering crust may be important for both "expansion and contraction" (L396) of the effective catchment area, but give no directionality to this statement (Does the change to the weathering crust they envisage lead to a decrease or expansion of the effective catchment area? Would this result in a longer or shorter lag time?). A clearer communication of the physical changes to the weathering crust and the effects of these changes on the lag and effective catchment area is needed.

If the authors can strengthen their discussion on lag evolution over the season, address the minor comments below, and tighten up the figures, the paper represents a solid effort in conducting and analyzing field observations of supraglacial streamflow, and will be of interest to TC readers.

Minor comments:

L13: Suggest referring to the 46 discharge measurements as "discrete measurements" throughout the manuscript, with "discrete measurements" being in contrast to "continuous" (5-minute) measurements.

L15: Suggest "of supraglacial discharge that captures both…"

L20: Include the baseline percentage contribution to the energy budget from longwave radiation, sensible heat flux, and latent heat flux, and not just the percentage increase of these contributions (as you have for shortwave radiation in the sentence prior). Otherwise, hard for the reader to understand what a percentage increases in these minor fluxes means in terms of the total energy flux.

L24: Suggest deleting “throughout the melt season”

L25: Suggest: “how widespread rapid shifts in the timing of peak discharge are across. . .”

L33: Suggest remove citations to studies on Antarctic supraglacial hydrology (Bell et al., 2017; Kingslake et al., 2017), as these references do not address the subject of the clause: “surface melting also influences ice sheet basal properties”.

L39: Suggest “melt season” instead of “melting season” throughout (e.g., L45).

L42: Suggest “often terminate in moulins, wherein meltwater moves through and beneath. . .”

L56: Did you mean to say “time lag decreases” here? As the network contracts, time lag decreases and discharge decreases. This would go with your findings in the abstract on effective catchment area decreasing resulting in a shorter lag.

L61: Suggest delete “thereby surface runoff”

L64: What about “Lesser drivers are. . .” instead of “Additional drivers are. . .”.

L72: Two commas not needed around Gleason reference

Figure 1: Plot the stream that presumably runs from the discharge station to the moulin. Also suggest coloring stream by stream order.

L112: Suggest “46 discrete discharge measurements” instead of “occasional”.

Figure 2: Include approximate scale bars for all panels. An approximate vertical scale bar would improve reader understanding of Figure 2a. Remember that only a few privileged individuals have seen these streams in the field, and many will not have an innate sense of the vertical or horizontal scale.

Figure 3: Keep all units in meters. All other figures are in meters.

Clean up legends for the standard deviation bounds. Would “95% CI” be a clearer legend name here than “2 x stdev”?

The data in Figure 3a is clipped by the top y-axis limit. Show all data.

Maintain the same aspect ratio and axes limits across panels a and b. As presented with differing axes limits and aspect ratios, the panels cannot be compared by eye.

Are these stream cross-sections for the wetted perimeter? If yes, say so. If not, where is the approximate water line (or range in water line)?

L141: Confusion. Should the reference to Figure 4 go here: “The rating curve (Fig. 4; Q=. . ., R2=. . .) was. . .” instead of after the second sentence in this paragraph? As written, the reference to Figure 4 for “hourly discharge data” does not make sense. Hourly discharge data is in Figure 5a, no?

L143: Suggest include the “Therefore, . . .” sentence in the previous paragraph. Make the new paragraph begin at “Four uncertainty estimates. . .”

L144: Suggest “were calculated as percentage uncertainties (see. . .”

L144: Suggest “discrete” instead of “individual”

L144–145: Give the uncertainty variable namesâĂŤUME, URC, Xdm, and Uin(?)âĂŤin the first sentence where you introduce the four uncertainty estimates.

L146: Are these 95% CI uncertainties?

Figure 4: In legend, indicate whether the “observations of stage and discharge” plotted here are hourly or 5-minute discharge data.

How many sigma are you plotting with URC? Suggest keep the 95% CI language from Figure 3.

L159: Suggest “we compared coincident depth profiles (Fig. 3) and velocity measurements”

L159: Are these velocity measurements ever shown? Show across flow profiles of stream velocity, which you “measured at each 0.2 m interval at 60% of the depth” alongside the stream cross-section depth profiles in Figure 3 or as a stand-alone new figure.

L162Âň–3: Suggest giving 2 sigma values that will better align with the 95% CI given in L164.

L177: Suggest “discharge Q.”

L184: State the elevation of KAN–L in comparison to the study site.

L185: State what variables are used from the KAN–L station.

L190: Suggest: “to calculate surface energy balance components of net. . .”

L194: Give a citation for the Monin-Obukhow similarity theory.

L196: Reference Figure 1.

L198: That’s a lot of handheld GPS points!

L199: A change in catchment size was not observed, but how does this align with the change in effective catchment area implicated in the abstract? Include a quantification of the time-varying effective catchment area.

L200: State the uncertainty in meters.

L204: Are these repeat visits all during the melt season? As written, the visits could have occurred in the winter as well.

L218–224: The sentence ordering in this section is confusing. Suggest stepping through the description of the timeseries linearly here.

L219: Suggest “Between the second and third episodes, . . .”

L222: Suggest “melt episodes, which have large. . .”

L223: Suggest “amplitude from 0.64 m3s-1 on 21 July to 0.33 m3s-1 on 13 August.”

Figure 5: Make all of these panels the same width. Stack them vertically so the eye can travel vertically down the figure to compare the timeseries, just as you have done in Figure 6.

L228: Does the mean daily discharge go all the way to zero? The lowest value in Figure 6a seems to be ∼0.02 m3s-1. Suggest defining/describing what zero means when given as the lower bound here. Suggest keeping the same number of places past the decimal when reporting values in text.

Figure 6: Calculate total heat flux/energy from components in panel b, and then plot total heat flux/energy as the right y-axis on panel a.

Figure 7: Note days that are not “clear sky” with vertical bars. State the proportion cloud cover cut off to designate a day as not being “clear sky”.

Figure 8: Suggest “melt season”.

L273: How different is the time lag on non clear-sky days?

L278: Suggest “shifts back to initial season conditions of a 3 hour time lag in early August.”

L282: Suggest “above the ice surface. . .”

Figure 9: Include the 2 to 3 clear-sky days between melt episodes 1 and 2 in mid-June on panel a to present the entire 62-day timeseries. Plot the time of daily maximum discharge for non clear-sky days with a different symbol in panel a. Would be interesting to see if the times on non clear-sky days are random, and this would further support your choice of investigating the seasonal evolution of lag only on clear-sky days.

In the panel b legend, do you mean “Daily mean air temperature” ?

L300. Give the 660 catchment size here, so the reader can better compare with the results from other studies that follow.

L304: Does zero discharge mean a dry stream bed at portions of the day? Observations taken outside of the melt season? Suggest defining/describing what zero means when given as the lower bound in a range.

L307: Is this time local time? Suggest stating at the beginning of the paragraph that all times given will be given in the local time of the study sites.

L309: Quantify and give how many times larger the Holmes (1955) catchment is compared to the 660 catchment.

L316: Suggest "In addition to diurnal variability, . . ."

Table 1: Suggest "660 Catchment (this study)" in the bottom row.

Table 1: Again, what do the zeros in discharge signify for the different studies? A dry stream bed for a portion of a day, or taking observations outside of the melt season?

L341: Suggest new paragraph at "For the 660 catchment,. . .", as you are now switching from comparing the total area of the catchment between studies, to the evolution of the catchment over time at 660.

L343: What does Mernild et al. (2006) attribute the change in lag to, and is this supported by your findings at catchment 660? Is it the change in effective catchment area you mention in the abstract? Add a few sentences on this here.

L348: The last sentence shifts back to effective catchment area (poor vs efficient network) as the reason for a shifting time of daily maximum discharge. But the sentence immediately prior discusses changes to the weathering crust. Suggest working through these points more carefully to clearly describe how a decrease in effective catchment area leads to shorter lag times, and how the weathering crust plays into this decrease in effective catchment area. Add citations for the L346 statements on how changes to the weathering crust under colder conditions would affect lag times. Does Yang et al.

(2018) include weathering crust in their model? State this explicitly for readers who have not read Yang et al. (2018).

Table A2: Are all of these reported at 95% CI, or just the final row? Suggest keep everything at 95% CI and state that in the table caption.

L394: Split these ideas into two sentences: (1) a drop from 3 to 1 hours in lag due to a decrease in effective catchment area; and (2) back to 3 hours due to a sudden drop in air temperature that delays melt from leaving the weathering crust.

L396: "expansion and contraction" Doesn't the increase in lag suggest this is an effective expansion of the stream network? A clearer communication of the physical changes to the weathering crust and the effects of these changes on the lag is needed.

L399: Change "notice" to "observe".

L434: "All uncertainties are expressed at the 95% confidence interval." ← This is the sentence that would be very helpful to have early on in the main text Methods section. In general, a consistent level of reporting for the uncertainties is needed to allow the reader to easily compare uncertainties across measurements.

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