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The Cryosphere Discussions

Interactive comment on "Hypsometric amplification and routing moderation of Greenland ice sheet meltwater release" *by* Dirk van As et al.

Anonymous Referee #2

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General comments

This study examines how routing of melttwater from the surface of the ice sheet delays meltwater on its way to the river outlet at the fjord. A unique time series of river discharge data measured at the Watson River is used to quantify the meltwater output. To quantify ice sheet runoff, a three automated weather stations along an elevation gradient are use to force a surface mass balance model. The authors quantify that meltwater routing can delay outflow with up to a week at the highest elevations.They find a good match between ice sheet runoff and proglacial river discharge suggesting that meltwater retention is insignificant at larger scales.

This paper is an important contribution to the literature about Greenland ice sheet runoff and meltwater losses. I urge the authors to provide a more convincing analysis

of about the impact of rainfall on modeled runoff (see specific point 8). Other than that, most comments are suggestions to clarify the paper for readers. The work is very interesting and the paper will get a wide readership.

Specific comments

1. Regarding the rating curves (section 2.1). A more in-depth discussion about the previous ratings curves are needed. Were they created with some of the 90% of the float discharge measurements that now are discarded? Explain why they are so different. 2. Clarify what uncertainties are considered in the uncertainty estimates made with each the three discharge methods. 3. Regarding the gap filling method (section 2.2). Consider referring to the positive degree-day melt model as a motivation for using temperature for gap filling. Also, please provide the correlation/coefficient of determination and/or RMSE for fit between the observations and the temperature-based model. 4. Alternatively, forego the temperature based gapfilling method all together. The paper would be simplified if the SMB model output with runoff delays would be used for gap filling the river discharge time series rather than the temperature based model. The advantage of the SMB model is that it physically based. This hinges upon that the runoff delay can be developed without the gap-filled time series 5. Regarding testing the SMB model performance (section 2.3). It would be good to quantify the difference between model estimates and the in situ ablation and accumulating data. 6. Specify the uncertainties in the catchment delineation method and discuss the implications on the results and conclusions. For example, consider work by Ben Hudson about how DEM uncertainty propagate to catchment delineation (see ref by Carroll et al.) 7. It is unclear how science question 1 is examined in section 3.2. The section appears to quantify the effect of the factor three inter-annual variability on hypsometric amplification, but does not appear explain it. It is a difficult section to follow so it may be in there, but difficult to follow. Consider rewriting. 8. The analysis about rainfall events and their impact on ice sheet meltwater production presented in the discussion warrants some deeper analysis. First, provide a more comprehensive identification of these events

and how often they coincide with rainfall events. Second, to prove your argument that the temporal mismatch between the red and black lines in Figure 7 can be explained by rainfall events, run the SMB and routing model without precipitation. The mismatch should then be reduced.

Technical comments and clarifications

P2.L1: Clarify what you mean with “similar methods”

P2.L8: “did not quantify [it’s effect] as we do here”

P3.L22: Rephrase. I think you are using one method (rating curve) to relate state and discharge, but three different methods to measure discharge.

P3. L29: Explain a bit more about how was the cross section area was determined. Particularly, why couldn’t the area be determined for over 90% of the float discharge data.

P5. L10: Consider rewriting this. Pressure transduces may be installed through winter if protected from freezing with anti-freeze liquid.

P5.L26. Clarify if this is plus/minus 70 percent, or plus/minus 45 percent.

P5.27: Rephrase, this is unclear. Will you get back to these equations to revise them and update the river discharge dataset?

P5.L31-33: Confusing. Please rephrase.

P6.L4: Clarify how the model has been improved since van As et al. 2012. Some modifications are clear (i.e. MODIS albedo) while it is unclear if precipitation is a new modification or was part of the old model.

P7.L3: Rewrite equation so that it calculates albedo for each of the 100 elevation bins.

P7.L11: Explain where these in situ measurements originate from. Are they from the AWS stations or the K-transect?

P7. L24. Rewrite as this can be misunderstood. Meltwater run over the surface in ice sheet stream networks. However, Yang et al shows how these networks ends in moulins far from the margin and is routed subglacially from there.

P8. L30. Consider naming M, runoff to distinguish between meltwater production and runoff, given that not all meltwater reach the river.

P10. L15. Clarify what the Zo sensitivity test is.

P10. 25: Clarify what you mean with four “equal” portions.

P10.L 28: How does the accumulation rates play a role in the calculation of the p-value. Isn’t the p-value just a function of elevation distribution?

P12. L16-27: The text about the development of englacial drainage system needs references or it should be made clear that those are speculations/hypotheses.

P12. L34. Figure 7 does not have monthly panels. . .

P13. L18. Clarify what the “long-term” ablation area refers to.

P13. L20. Clarify that these ice lenses are most likely to be in the higher elevation areas.

P14. L19. Rewrite. Some conclusions are indeed about the magnitude of discharge

P15. L20. This reads as if all the peaks are due to the combined effect of rainfall and melt. Is this true? It would be good to see the timing of the (modelled) rainfall events . P16.L8. This can’t be seen in Figure 7. The delayed runoff agrees pretty well with the observations throughout the whole season.

Comments on figures

Figure 1: Show the entire catchment.

Figure 4. The x-axis shows 10 day smoothed temperature, right? Please clarify.

Figure 8: put the line about p=0 in the caption. Having it in the legend suggest that it is a line represented in the plot

Figure 9: Be consistent and use day of year or real dates, but not both

Reference

Carroll, D., Sutherland, D. A., Hudson, B., Moon, T., Catania, G. A., Shroyer, E. L., ... van den Broeke, M. R. (2016). The impact of glacier geometry on meltwater plume structure and submarine melt in Greenland fjords. Geophysical Research Letters, 9739–9748. https://doi.org/10.1002/2016GL070170

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