**Reply to Reviewer #3**

We appreciate the helpful comments and suggestions by Reviewer #3.

**Reviewer #3**

The manuscript presents a diverse water isotope (δ18O) data set from three different glacierized catchments in Greenland. Streamwater isotopic composition from samples collected between 2000 and 2009 are analyzed using isotopic hydrograph separation and isotope data collected from snow and ice samples. The paper is overall well written (although a few minor typos still need to be corrected). The study provides a nice compilation of different isotope data sets and the combined results section provide an interesting discussion of potential mechanisms responsible for the observed diurnal or spatiotemporal differences in the isotopic signals. The authors provided an excellent literature review and did a very good job supporting data interpretations and discussion of results with previous studies.

**AUTHORS:** Thank you.

1) My main recommendation to the authors that the manuscript needs a clearer structure and a more information in the methods section that make it easier for the reader to understand what calculations were done to estimate the different hydrograph components and how uncertain these estimates are. It is understandable that due to the challenging research environment many samples have been collected in an opportunistic way (e.g., one time stream sample). Nevertheless the work that is presented would gain value if sources of uncertainty were discussed and presented in the methods and result section. In the results section the actual results of the hydrograph separation get a little lost because there is no clear distinction between the description of the site characteristics, the end-members (e.g. snow or ice isotopic composition) and the interpretation of results. Perhaps instead of grouping the results section into the three watersheds the authors should rather consider structuring the results section into first a presentation of the input data (e.g. end-member composition across sites), the hydrograph separation results, discussion of uncertainties, comparison of hypothesized processes across sites and a separate discussion that is focusing on the comparison of findings with previous investigations as defined in the objectives.

**AUTHORS:** Thank you for your helpful recommendations. We have restructured the manuscript as suggested. The Methods section has been amended to improve the clarity. The results of the multi-sampling tests have been moved to the Methods section, so that

the instrumental uncertainty, the sampling uncertainty and the uncertainty of the runoff measurements are presented in the same section. We have followed your suggested structure of the Results and Discussion sections; with the exception that we have places the discussion of uncertainties in the Discussion section.

Specific comments

2) Abstract Line 10: “specific water component” is not very specific. Could this be narrowed down to a list of the actual water sources that were discussed in the results section?

**AUTHORS:** We have rewritten the Abstract to avoid this poor phrasing.

3) Page 5849, last paragraph: Melting snow samples at room temperature causes a much stronger fractionation and concentration of lighter isotopes in the headspace than melting the snow slowly in a fridge. In addition, depending on the ratio of snow sample to bottle volume the resulting headspace in the melting process can be of variable volume for each sample again causing variable fractionation between melted snow samples. This effect needs to be determined (e.g. comparison of the isotopic value of two snow samples collected from the same location/layer, one melted at room temperature, the other melted in the fridge) and the uncertainty associated with this effect considered in the isotopic hydrograph separation.

**AUTHORS:** Kinetic effects during the melting of samples have absolutely no influence on the uncertainty beyond the instrumental uncertainty. The reason is that the amount of water molecules in the liquid phase is several orders of magnitude higher than the amount of water molecules in the headspace. Hence, it does not matter whether the melting was conducted at 5C or 20C.

This can be exemplified by the following rough calculations: Assume that we have 20 ml water equivalent snow in a 40 ml bottle (a 1:1 volume ratio between air and water), then melting at 5C and 20C will have water vapor pressures of 10 HPa and 20 HPa, respectively. Hence, in the bottle there will be 0.02 l (*c*. 1 mol) of liquid water and 0.02 l * 20 HPa/1013 HPa = 0.0004 l water vapor at 20C. 0.0004 l water vapor is equal to 0.0004 l/24l/mol = 1.6 e-5 mol. Thus, in the bottle the molar ratio between water and water vapor is 60000:1 at 20C. At 5C, the ratio is 120000:1.

4) Page 5850, line 1: Correct “wter isotope”.

**AUTHORS:** Typo fixed.

5) Page 5851, line 3: I find it strange to use the German word for glacier in as glacier name (e.g. Mittivakkat Gletscher).

**AUTHORS:** "Gletscher" is also the former Danish word for glacier, and the name "Mittivakkat Gletscher" is widely used by the local population and in international scientific literature. We have chosen not to use the new name "Mittivakkat Gletsjer", as the word "Gletsjer" has not yet been implemented in scientific literature. This may change in the future. A manuscript by Bjørk et al. containing the official names of Greenlandic glaciers is currently under review for The Cryosphere. Here, Mittivakkat Gletscher is used as an example of a widely used informal name.

6) Page 5851, line 11: Here it would make sense to restate the elevation range of the catchment or glacier in parentheses.

**AUTHORS:** Following the Reviewer's advice, we now restate the elevation range of Mittivakkat Gletscher.

7) Page 5852, line 10: Replace "where" in "30 May 2008 where a rainfall event" with "when".

**AUTHORS:** The sentence has been amended to "… 30 May 2008 when a rainfall event …"

8) Page 5852, line 28: Awkward phrasing. ". . .the runoff suddenly remained constant, coinciding with an air temperature increase and a change in 18O from decreasing to. . .".

**AUTHORS:** The sentence has been rephrased.

9) Page 5853, line 12 ff.: I would find it interesting if the snowmelt/ice melt dynamics would be explored more in depth using the diurnal variation of the isotope signal. Could it be that as snowmelt is increasing over the day, subsequently the snowmelt volume passing through the glacier is increasing as well causing melting of the englacial conduits due to

the heat of fusion introduced with the snowmelt. It would be interesting to see of rates of conduit enlargement could be correlated to observed increases in ice meltwater contributions.

**AUTHORS:** We agree with the Reviewer that a study coupling snowmelt and ice melt dynamics, energy balance components, glacier hydrology and isotope dynamics will be interesting. While a theoretical model study is possible, it will be difficult to validate the model output. For instance, it will be difficult to estimate the amount of englacial melting of conduits caused by heat of fusion from snowmelt and separate this contribution to runoff from contributions to runoff caused by other ice melting processes. However, as the application of advanced runoff modelling is beyond the scope of this study, we focus our interpretation of diurnal variations on (1) the proportional contributions of snowmelt, ice melt and rainwater, and (2) the use of $\delta^{18}O$ variation to gain insights into the configuration of the subglacial drainage system.

10) Page 5857, line 25: You mention the interannual mean δ18O was -24.17±0.20‰ while at the same time you provide information that this value was only calculated over the July-Aug. period. I would say “interannual” is the wrong term here since clearly you didn’t take samples every month over one year. This needs to be corrected. In addition, I would suggest adding information throughout the manuscript on how many samples these mean values are based (e.g. n=7).

**AUTHORS:** This part on Watson River has been removed from the manuscript (see our reply to Reviewer #2 point 13).

11) Page 5858, line 19: Insert “was” before “. . .derived from mixed proglacial snowmelt and ice-marginal ice melt.”.

**AUTHORS:** This part on Watson River has been removed from the manuscript.

12) Page 5861, line 24: “An alternative explanation may be that snowmelt only constituted so small a proportion of the meltwater in the late melt season that backscattering rendered water source discrimination impossible.” This sentence is not clear.

**AUTHORS:** The sentence has been rephrased and now reads: “An alternative explanation may be that snowmelt only constituted so small a proportion of the total runoff in the late melt season that discrimination between snowmelt and ice melt was impossible.”

13) Page 5862, line 12: Plural! “. . .phenomenon on large glacier with lateral tributary. . .”.

**AUTHORS:** The sentence has been rephrased and now reads: “Hence, it therefore remains unknown whether a high spatial variability in $\delta^{18}O$ is a common phenomenon or related to specific circumstances such as surge activity or presence of tributary glaciers.

14) Figure 2: This figure is hard to read. I would suggest using a topographic depiction instead of a Lands

**AUTHORS:** We are sorry about the poor quality of Figure 2. The figure was intended as a high quality figure covering two pages. The figure has been amended.