

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1  
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## Comment on hess-2022-133

Anonymous Referee #1

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Referee comment on "Assessing the influence of lake and watershed attributes on snowmelt bypass at thermokarst lakes" by Evan J. Wilcox et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-133-RC1>, 2022

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This study by Wilcox et al. uses established stable isotope tracers of lake hydrological processes in an innovative way in order to assess snowmelt bypass and retention in multiple representative open-drainage thermokarst lakes. A key result of the study is that the spring freshet replaces a larger fraction of lake water in shallower lakes, while this replacement does not appear to depend on catchment characteristics. The isotope tracers also allowed the authors to identify contributions of different meltwater sources (snowpack or rain / thawing active layer), which is an important result given the impact of meltwater provenance on lake biogeochemistry.

### General comments

In the introduction, the reader would be aided by a broader discussion of the rationale of the study. Why would one expect the snowmelt bypass to be a function of lake and watershed characteristics? Which characteristics are important and why? And what will this information enable us to do next?

It may be worthwhile to briefly discuss evidence that smaller lakes and basins ( $\leq 1$  ha) can be flushed entirely with meltwater in a matter of days (Jansen et al., 2019; Cortés and MacIntyre, 2020). This process likely affects a majority of Arctic lakes and ponds, which tend to be very small, and a brief discussion of the literature would extend the findings of this paper.

Uncertainty about the isotopic end members: Figure 5c indicates that considerable uncertainty exists about the mean isotopic composition of rain and the snow pack and thus  $\delta P$ . This implies that omitting one or several of the rain or snow samples from the analysis – or including additional samples – could significantly change the results and their interpretation. How would the uncertainty about  $\delta_{rain}$ ,  $\delta_{snow}$  and  $\delta P$  affect the

uncertainty about the estimates of  $\delta^*$ ,  $\delta I$  and % lake water replaced? I strongly recommend that the authors compute the error propagation for the quantities affected, or conduct a sensitivity analysis.

Assumption of mixing: the computation of the percentage of lake water replaced by freshet requires that the lakes be fully mixed during sampling immediately after ice-off. However, some (shallow) arctic and boreal lakes have been shown to mix incompletely in spring, especially when thermal stratification is strengthened by chemical stratification, or prior to wind mixing just after ice-off (Vachon et al., 2019; Wiltse et al., 2020; Cortés and MacIntyre, 2020). I think it is important that the authors provide evidence that the lakes were fully mixed during sampling on June 15 2018, for example by showing temperature profile observations at the time of sampling in a representative lake along the transect, or by applying a simple 1D hydrodynamic model such as FLake (<http://www.flake.igb-berlin.de/>).

Data sources: in accordance with the HESS data policy, please provide a statement of where the stable isotope measurements and meteorological observations used in the study can be accessed.

Specific comments:

L13: "limited vertical mixing conditions that lead to this relationship are present at all ice-covered lakes": is this true for all lakes? Exceptions that come to mind include shallow lakes that freeze to the bottom, or are subject to radiatively-driven convection that mixes the water column prior to snowmelt.

L41-42: "cannot mix with the deeper, warmer, and denser lake waters": but in small lakes, snowmelt can displace these waters, for example to an outflow or to a different basin (Jansen et al., 2019, Cortés & MacIntyre, 2020).

L54: "up to 25% of the landscape": by surface area? Please specify.

L56: "isotope methods": what is meant here? Please specify.

L75: "1981-2010 climate normals": please provide a source for this data.

L83 and Figure 3: since this information is provided before the methods, for context it would be helpful to list the data source of the meteorological observations.

L102: how many replicate bottles were collected? How many replicate measurements were performed of each sample?

L102: please specify the container material, as long-term storage in some polyethylene containers can cause isotopic fractionation (Spangenberg, 2012).

L103: what is the manufacturer and model of the laser spectrometer used? How was the instrument calibrated?

L105: this equation appears to be erroneous: the 'x1000' factor is unnecessary when also using the per mil notation. See Coplen, 2011, p. 2554-2555.

L108: how were the analytical uncertainties determined?

L124: "The average difference obtained using the two isotopes in the estimate of the percentage of lake volume replaced by runoff was minimal (1.8%)." Was the difference between isotopes negligible in all lakes? Please provide, in addition to this average number of 1.8%, a minimum and maximum value.

L131: why were the pre-melt source isotopic signatures ( $\delta^{18}O_I$  Ice-Corrected and  $\delta^2H_I$  Ice-Corrected in Table 2) also corrected for freezing fractionation? Is this because  $\delta I$  was estimated by drawing a line from  $\delta^*$  through  $\delta L_{corrected}$ ?

L177: "higher isotope composition": unclear what this means.

L199: "The presence of a uniformly thick layer of freshet beneath lake likely": rephrase

L200: Figure 6 does not show that the freshet layer is uniformly thick. To support this claim, it would be helpful to have a (supplementary) table that shows the computed layer thicknesses for each lake.

L204: "Shallower lakes likely had colder lakebed temperatures": is there a study that shows this is true for thermokarst lakes?

L238: "as minimal hydrological activity occurs over the winter months at arctic lakes" I assume what is meant by "hydrological activity" are water flows from land to lake, but please specify.

L254: In this section I think it may be worthwhile to also briefly discuss the impact of the timing of snowmelt and ice-out on freshet retention and its ecological implications (Dugan, 2021; Hrycik et al., 2021). For example, what happens when the ice goes out before all the snow has melted?

L325: "and calculated for  $\delta^{18}\text{O}$  as:" shouldn't this read "and calculated for  $\delta^2\text{H}$  as:"?

Figures 1 and 7: the coloured temperature gradient does not show in my preprint copy of the manuscript.

Figure 5a,b: please define  $\delta\text{SSL}$ . Also, the dashed LEL line from  $\delta^*$  to  $\delta\text{P}$  appears to curve so as to fit through the point  $\delta\text{SSL}$ . Is this correct?

Table 1: since snow and ice thickness are variable properties, they seem out of place in a table that lists the lake location and morphometry. Consider moving these two variables to a separate table that includes the sampling date.

Table 2: "Pre-Snowmelt Lake Water (01-05-2018)", were all samples collected on this date? Also, for clarity and consistency, consider using  $\delta\text{L}$  and  $\delta\text{I}$  in the column headers and provide a brief definition in the table caption.

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