Hydrology and Earth System Sciences
Discussions

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Comment on hess-2021-512

Anonymous Referee #3

Referee comment on "Quantifying the glacial meltwater contribution to streams in mountainous regions using highly resolved stable water isotope measurements" by Philipp Wanner et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-512-RC3, 2021

Summary of the paper:

This article estimates the role of glacial meltwater in generating stream discharge in three Alpine catchments located in the Central Swiss Alps. Stable water isotopes (^{2}H, ^{18}O) are used to quantify the proportion of streamflow generated from ice melt vs rainfall while electrical conductivity measurements are qualitatively used to understand the dominant hydrologic processes. The article concludes that ice melt is the dominant driver of streamflow generation in August and September and propose that due to climate change, glacial coverage will reduce which might adversely impact streamflow generation during this period of the year. The article then estimates annual glacial melt discharge in these three catchments and propose a power law relationship between minimum annual glacial meltwater discharge and the glaciated area, which can potentially be extrapolated to catchments with known glaciated areas.

The paper is well written but lacks significantly in terms of robustness of the methods used and the inferences made thereafter. The key problem that I see is one missing end-member which is “*groundwater*” that has not been considered in this article. In Alpine environments, groundwater has a significant role is sustaining streamflow during low flow periods in August-October period. In this particular case study, I think groundwater is significantly contributing to streamwater generation during August-September period as can be inferred from the high EC values during that part of the year (Figure 6C). If this period was completely dominated by ice melt originating from glaciers, EC values would be much lower and similar to that observed in the June-July period in Steinwasser catchment when snowmelt was dominating streamwater recharge (Figure 6C). As Steinwasser is the only catchment which has a longer timeseries of EC values, we can see that snowmelt was probably dominating stream recharge in June, July (low EC values) and then groundwater kicked-in in late August which is why EC values increased significantly.

As the article has only relied on stable isotope measurements, this distinction is missing. I want to see if the results would be similar if the end member mixing exercise was undertaken with EC values and not stable water isotopic ratios. This also makes sense because electrical conductivity is largely a conservative tracer.

In terms of mechanism, I think there might be significant subsurface storage that is getting recharged by snowmelt and ice melt (hence very depleted) and this storage is then recharging the stream during August September period. If this mechanism is indeed true, then the underlying hypothesis that rapidly retreating glaciers will lead to very low flows in August September period will not be true as groundwater can be recharged via rainfall, snowmelt and ice melt. I would like to hear the authors' perspective on this and if this was considered as a possible hypothesis.

Variability in the isotopic ratio of ice melt (originating from the glacier) is very low and might not be very realistic. This is probably due to very limited ice sampling (only sampled two times in August and September, L418). Hence, the distinction in isotopic ratio of ice melt and snowmelt might be more of a function of sampling bias rather than any underlying hydrologic process.

Other major comments

L521-523: I find it very surprising that the ice melt contributes to ~25% of total discharge in Giglibach when the extent of glacial coverage is only 8%. On the other hand, the extent of glacial coverage is as high as 28% in Steinwasser but the contribution of glacial melt to total discharge is only slightly higher at ~29%. Are these estimates reasonable or to put it differently, have these kinds of number been reported at any other place where despite very high glacial coverage (>3x for Steinwasser compared to Giglibach), contribution to annual stream discharge only increases slightly.

L377: Groundwater might also be a significant contributor to stream recharge. I propose the authors to explore this hypothesis.

L381-385: If snow and glacial meltwater show lower EC compared, then August and September discharge cannot be explained by glacial meltwater as EC values are high across catchments.

L418: Two samples is very few to make any meaningful statistical judgement

L420-423: Details about Gaussian error propagation has not been explained anywhere in the article. Additionally, ±2% uncertainty bound seems to be very small. This might be due to small sample size.

L483-486: Has this been reported for the first time? I am not familiar with this literature, are there other studies which have reported similar results? In that case, it might be good to include relevant references.

L544-545: Using temporally high resolution isotope measurements leading to superior quantification of glacial meltwater hasn't been shown in this article.

Minor comments:

L284: It should read as "… in the ablation compared to the accumulation period …"

L285: It might be clearer if its written as "… which has a heavier isotopic signature compared to the snow that fell during the accumulation period…"

L538: Should be ". This is of major importance .."

Figures:

Figure 1: Incorrect figure caption, Wendenwasser is shown in grey and not pink.

Figure 5: Should also include snowmelt isotopic ratios here to make the comparison between snowmelt and ice melt easier. Is this any reason to believe that both will have different isotopic signature?

Figure 6: In subplots B, C and D there is a lot of whitespace due to very large y-axis bounds. For e.g. there are no discharge measurements below 0.1 m^3/s, so showing y-axis values up to 0.01 m^3/s is not necessary. Similar is the case for EC values < 10. I will suggest the authors to consider using tighter y-axis bounds so that the underlying data variability is more clearly visible.

Figure 6A: Is the unit mm or mm/hr?

Figure 7: I will suggest adding uncertainty bounds in this figure. Also, is 90%+ glacial melt contribution (Figure 7A) a plausible estimate at the end of July in a catchment which is only 6% glaciated?

Figure 7 caption: Should be ".. glacial melt water contribution to the three .."