Review: **Contribution of Rock Glacier Discharge to Late-Summer and Fall Streamflow in the Uinta Mountains, Utah, USA**

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Summary: This manuscript presents a field study designed to investigate the contribution of rock glaciers to the streamflow regime of a 50 km2 mountainous watershed in the Uinta mountain range, in the Colorado Rockies. Water samples were collected over a summer-fall season, by means of automated samplers located at the outlet of two rock glaciers, a groundwater spring, and the stream channel. Additional samples of snow (grab), snowmelt and rain were obtained. All samples were analyzed for stable water isotopes and for dissolved solids. Through a diverse set of graphical analyses, plus an end-member mixing method, the manuscript makes a case for a conceptual model of sources contributions to streamflow and attempts to quantify the importance of rock glacier ice melt to river flow, which amounts to 25% according to the author's estimate during this summer season.

General comments: this is a well written and nicely presented work, which has the potential of becoming a welcome addition to the body of literature. The study area, methods and results are presented, by and large, in a systematic and coherent way. The figures are of good quality, although the look of the tables could be improved. In terms of the analysis, this paper is affected by a common problem, which is to properly characterize the chemical and isotopic composition of seasonal snow. The number of snow samples is very limited, which is understandable given the difficulties of carrying out field work in mountainous areas. However, there's documented evidence of the spatial and temporal variability of snow (and, importantly, snowmelt) isotopic composition. This variability can hamper the possibility of portraying a clear-cut picture of streamflow sources, but the authors neglect to explicitly discuss this source of uncertainty. I suggest they review, for example, the following references:

Cable J, Ogle K, Williams D. 2011. Contribution of glacier meltwater to streamflow in the Wind River Range, Wyoming, inferred via a Bayesian mixing model applied to isotopic measurements. Hydrol. Process. 25 (14): 2228–2236. DOI:10.1002/hyp.7982

Ladouche B, Probst A, Viville D, Idir S, Baqué D, Loubet M, Probst J-L, Bariac T. 2001. Hydrograph separation using isotopic, chemical and hydrological approaches (Strengbach catchment, France). J. Hydrol. 242(3–4): 255–274. DOI:10.1016/S0022-1694(00)00391-7

Laudon H, Slaymaker O. 1997. Hydrograph separation using stable isotopes, silica and electrical conductivity: an alpine example. J. Hydrol. 201(1-4): 82–101. DOI:10.1016/S0022-1694(97)00030-9

Rodriguez, M., Ohlanders, N., Pellicciotti, F., Williams, M.W. and McPhee, J., 2016. Estimating runoff from a glacierized catchment using natural tracers in the semi-arid Andes cordillera. *Hydrological processes*, *30*(20), pp.3609-3626.

The discussion section includes an estimation of % contribution to streamflow, and an analysis of the degree of imbalance of the rock glaciers with current climate. It is argued that observed subsidence could be a result of 1 to 10 years of ice melt, given rock glacier outlet flow estimates. Although this is an intriguing concept, too little information is provided to sustain this calculation, and it feels as if it was added at the last minute to the manuscript. I suggest fleshing this analysis out or deleting it altogether.

Specific Comments:

L77. Probably you mean that no *clean glaciers*, remain in the Uintas.

Fig1. This figure could be complemented with a layer showing the delineation of known rock glaciers in the basin. Is the Spring sampler upstream of the Stream sampler? it is not clear from the figure.

L90. Replace “samples” with “samplers”.

L107-109. Were these data loggers active for this research? if so, their location should be shown in Figure 1.

L115. This range of flow is 1 to 2 orders of magnitude larger than the discharge from RG-1. Why might this be? Before, you say that both glaciers are “600 m long and 100 m wide”. Can you be more specific and provide surface area estimates for each rock glacier?

Methods section. Please provide accuracy estimates for isotopic signatures based on the analytical procedures and instruments employed.

L151. Replace “was” with “were”.

Figure 3. Why are samples from RG1 not shown in this figure? I can’t see a mention to this in the text.

Table 2. RG1 samples seem to be less depleted than those from RG2. Is this difference significant?

Figure 4. Why are snow, rain and melt samples not plotted in this graph? the number of samples in these cases is very low, but nonetheless it would be interesting to see where they fall in the graph.

Figure 5. Why are symbols for RG2 in July different?

Figure 6. It makes little sense to plot snow values as an average, with so few samples. Better just plot the individual samples in the graph. Same with snowmelt.

L250. The technique is called “principal” component analysis. Please review and correct throughout the text.

Figure 9. It would be nice to try and discriminate the water samples among stream, spring and rock glaciers. Maybe you could select major ions and plot in this graph as well.

L311. This inference might be correct, but I think that it is unsupported by the available data, which is very scarce in terms of snow and snowmelt isotopic composition.

Snow at different altitudes can have a large spread in the isotopic signal, and melt can favor preferential elution, which muddles the picture when trying to link stream and snow samples.

L318 and elsewhere: please use a more direct time referencing to help the reader follow your analysis. Talk in terms of specific months, at the very least.

L318. low values of what?

L333. these large reservoirs have not been described previously in the text (except for one lake). They should be mentioned in the study area description and their storage volume at least approximately quantified.

Figure 10. In this end-member mixing analysis, error bars should be provided, moreover considering the very low number of snow samples.

L384. “Thus these samples…” Yes, but may not necessarily be a valid representation of snow MELT at this time, or of basin-wide snow composition, because of preferential elution and spatial (elevation-dependent) isotopic signatures of accumulated snow. The authors must discuss this source of uncertainty and incorporate somehow in their estimates.

L389-395. the fact that this potential bias in the data (originated by the road) is brought up this late in the paper seems problematic to me. Are these data included in all the previous analysis? Why? should this data be discarded altogether?

L403. The authors should discuss why this significant estimated contribution from RG is not reflected in the stream isotopic composition time series, which remains stable although there’s a strong trend in the RG series (figure 6).

L413. but you also estimated 15 l/min for one of the glaciers. So, the rate of ice melt is hugely uncertain! Although this surface depression analysis is interesting, the way it is presented here feels rushed and somewhat contrived. The authors should expand: what is the total area of RG mapped in this basin? what is the range of glacier ice available? etc.

Figure 12. I’m afraid that I can’t see the depression the authors refer to. This data should be presented much earlier, in the data section, and not in the discussion section.

L428. Based on only one sample of snowmelt water, it is tenuous to make strong statements about snowmelt similarity or influence on streamflow throughout the season. This is a major problem of the material presented here, and should be discussed by the authors.