Interactive comment on “Identification of glacial melt water runoff in a karstic environment and its implication for present and future water availability” by D. Finger et al.

Anonymous Referee #4

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“Identification of glacial melt water runoff in a karstic environment and its implication for present and future water availability” by D. Finger et al. The problem of glacier-karst hydrogeology has largely been piecemeal studies, largely by the empirical investigation of field sites. Despite use of quantitative measurement and analytical tools, our understanding remains essentially qualitative. This paper therefore has an ambitious objective in attempting to further our understanding at a generalisable quantitative level, by incorporating field observations and predictive models for underground flow routing and future mass balance scenarios. Unfortunately, these ambitious aims are only met superficially. The models used are poorly developed and are not integrated into the overall study. The field work components also appear to have little overall integration.

The field work components also appear to have little overall integration. The study therefore is a useful, but essentially parochial (local) investigation of glacier-karst hydrogeology. The Glacier de la Plaine Morte is perhaps the definitive example of a glacier-karst system as the glacier largely occupies a massive closed depression. However, it is far from typical and the ice is largely stagnant. (This probably means it hosts a more stable internal drainage system than more dynamic glaciers.) I suggest that extrapolating from this unusual site (and the limited data set) to global scale is over ambitious. The generalisation that loss of alpine glacier ice will reduce late summer flow is widely recognised, and poorly supported by the analyses presented here. The “karst model” utilised in designing the tracer experiments appears to be an excellent tool, particularly valuable in the complex tectonics of the Swiss Alps. It does appear to have some limitations, however. First, the relationship between lithology, structure and hydrogeology has to be explicit. (Here it is not apparent which units and discontinuities (faults) are considered susceptible to karst permeability.) Similarly, there is no obvious inclusion of glacier ice (or talus), so the predictions are tenuous (and indeed appear to have been misleading in missing recharge from the major outlet stream). Finally, the tool's effectiveness relies on parallax-based three dimensional rendering and fails when printed on a page. It would have been much more effective to provide a clear map showing the inferred flow routes. Overall, the flow visualisation model seems a bit disappointing. The “predictions” (in text as figure 3 is unreadable) seemed to indicate various underground drainage routes. In contrast, the results seemed to show (again figure 4 is not readable) that the subglacial karst has surprisingly limited and conditional permeability (which we already know) and the tracer delivery more or less travels to the nearest spring. The dominant results of surface routing and subsequent capture on the Bernese side were not explicitly predicted by the model (as far as I can see. Although the likely capture of the surface stream to springs is fairly evident using Google Earth:to which I would add the possibility of a talus aquifer linking the Reitzliberg and Siebenbrunnen Springs). The routing model might be more effective if were used to make specific, well-illustrated and tested hypotheses. The hydroclimatic data are quite
relevant tracer test of the key focus of this research is those injections (three in all) reported cessation of surface outflow (no data are given). No tracing has been undertaken under non-overflow conditions, so the Bernese subglacial routing remains hypothetical. The lesson learned from the substantial body of work on glacier tracing is that results vary dramatically with injection conditions, location, season and runoff (diurnal and storm driven). Glacier karst tracing is expected to be even more idiosyncratic because of the likely variation in recharge opportunity at the bed. So the only relevant tracer test of the key focus of this research is those injections (three in all)
observed at Loquesse spring. The stable isotopic data are too sparse to provide much insight. Two sites have not been proven connected to glacier. The key heavy signal at Tieche is presumably a transient rain event captured at that site. I would omit this section. A glacier melt model is used to predict the future geometry of the glacier. It is not clear how a daily model is calibrated using two digital elevation models fifty years apart and validated using three years of limited accumulation and ablation data. Although it provides a crude linear trend, extrapolating this trend into the untested geometry of a closed basin seems very risky, especially when rather dire implications are drawn. It is not clear that the hydrology has been fully implemented. If the leaky closed depression model (figure 11) is used, then it seems that an increasingly large fraction of the melt would be retained in the depression and subsequently recharged. The data in this paper would seem to suggest that relatively little melt would travel north (Bern) and a greater fraction would be routed south (Valais). Overall, there are substantial weaknesses in all the components of the paper and in their integration. It is not clear that the conclusions are based on substantive analysis. This is unfortunate as the various components of the research are interesting and challenging, but lack adequate treatment in attempting to compose an integrated report. The results provided suggest that a test of underground flow predictions using dye tracing would be worth reporting. Similarly, the forward modelling looks promising. It is not clear that the results allow much advance in our understanding of glacier karst recharge. Therefore, the primary purpose of the paper is not adequately addressed. A final comment on the language: the English is good, but in places the technical usage is incorrect and possibly misleading. A editorial proof reading is advisable.

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