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Hydrology and Earth System Sciences Discussions

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.

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The manuscript deals with karst aquifers partly recharged from snow and ice melting in Swiss Alps. The observed increase in air temperature since the last decades lets the authors forecast a strong decrease and even the dying of the glacier. Because groundwater partly recharged by ice melting is used for supplying an important skiing resort both for domestic use and artificial snow, it looks essential to evaluate the change in seasonal flow at the springs in the context of global climate change. This is a topic of broad interest which fits well with the aim of the journal.

The authors finely introduce the main issue and present the study site. They detail the

methods and data. Their results concern climatological and hydrological observations, tracer experiments, karst model results, isotopic composition, and, as a synthesis, the present and future of runoff, downstream the glacier. At last, before concluding, they discuss the results in two directions, theoretical (validation of the karst model) and practical (implications of the findings for future water resources).

General comments

This is a really interesting, but complicated issue, seldom considered, for two reasons: (i) combining glacial and karst hydrology looks to be a difficult challenge; and (ii) generally there is no practical interest what does not push scientists to work on. So the bibliography is relatively scarce. All the more reason to try to make a review as comprehensive as possible! I regret to tell that the authors seem to ignore a large part of the literature about karst and glacial hydrology. I think that they could give to their work a broader scope than in its present state.

Glacial hydrology presents characteristics very close to karst hydrology to such an extent that the best synthesis on glacial hydrology was written by two karst specialists, A. Eraso and M. Pulina.

- Eraso A. and Pulina M. 2011. Cuevas en hielo y rios bajo los glaciares. McGraw Hill, 2^{nd} ed., 280 p. (and GLACKMA, 3^{rd} ed., 300 p.). See http://www.glackma.es/

- Works of the International Committee "Glacier caves and karst in Polar Regions" (GLACKIPR) created in 1989 in Budapest, during the 10^{th} International Congress of Speleology. They were published in symposium proceedings, the first one in 1990 in Madrid, Spain, and the 8^{th} in 2007 in Katowice, Poland.

C.C. Smart is probably the pioneer of subglacial karst hydrology. I agree that his PhD was unpublished, but he published some interesting papers which could have helped the authors in a better presentation of the relations between the glacier and the underneath karst and in a more generalized approach.

- Smart C.C. 1983. Hydrology of glacierised alpine karst. PhD, McMaster University, 343 p.

- Smart C.C. 1983. The hydrology of the Castelguard Karst, Columbia Icefields, Alberta, Canada. Arctic and Alpine Research, 15 (4): 471-486.

- Smart C.C. 1997. Hydrogeology of glacial and subglacial karst aquifers: Small River, British Columbia, Canada. Proc. 6^{th} Conference on Limestone Hydrology and Fissured Media, La Chaux-de-Fonds, Switzerland, p. 315-318.

I also suggest to read the following references:

- Ford D.C. and Williams P.W. 2007. Karst hydrogeology and geomorphology. Wiley, 562 p. See especially 10.3. The cold extreme: karst development in glaciated terrains, p. 410-421.

- Lauritzen S.E. 1984. Evidence of subglacial karstification in Glomdal, Svartisen. Norsk Geografisk Tidesskrift, 38 (3-4): 169-170.

- Lauritzen S.E. 1986. Kvithola at Fauske, northern Norway: an example of ice-contact speleogenesis. Norsk Geografisk Tidesskrift, 66: 153-161.

These references could help the authors in presenting in a better way the functioning of subglacial karst hydrology, and particularly the hydraulic connection through glacier "moulins" between the seasonal flows at the surface of the glacier and the karst sinkholes below it. This is clear from figure 11, but unclear at all in the 1^{st} paragraph of 2.3 Hydrology, characteristic (i). This is a particularly important point which needs to be detailed, because some tracing tests combine glacial and karst flows and the contribution of glacial water looks important during summer melting.

Furthermore the manuscript is sometimes confusing, difficult to follow. I make some suggestions in order to help the authors in improving their manuscript.

First, this Chapter 2.3 Hydrology should give as an introduction the different flow types

described in karst and glacial hydrology, from the literature. Then the paragraph could be re-written for instance in that way:

"Discharge from snow and ice melt, as well as rainfall runoff is characterized by different mechanisms depending on field characteristics in the Plaine Morte area: (i) water storage in the glacier and the snow fields, (ii) rapid subsurface flow under gravel covered soil, (iii) low flow in fertile agricultural soil, (iv) retention in natural swamps, (v) storage in natural and artificial lakes, (vi) seasonal streams running on the glacier, partly swallowed in "moulins" and crevices connected to sinkholes underneath the glacier, and (vii) a well-developed karst system which drains melt water to karstic springs at lower elevations."

In this aim, Chapter 2.2 Geologic setting should be re-named Geology and hydrogeology settings.

Chapter 3 "Methods and data" is quite surprising. What is named "Karst model" (Subchapter 3.1), and defined as one of the tools used for studying the hydrology, is in fact a 3-D representation of the geology in which the flow paths inferred from tracing tests are indicated. This hydrogeological model (see fig. 3, which is not really easy to read) is an interpretation, synthetizing geological, hydrogeological and tracing data. It can't be presented before tracing results. I think that it should be considered in Chapter 5 "Discussion" with sub-chapter 4.3 "Karst model results" all included in sub-chapter 5.1 "Hydrogeological model", and not in "Methods and data", because it is an interpretation of all hydrogeological data.

Sub-chapter 3.2 regards all climatic (not meteorological, which is related to weather forecast) and hydrological data.

In Chapter 4, may tracing test data help in interpreting the observed differences in isotopic compositions of the springs, as a result of different contribution from ice melting? Did you try to compare the results of the glacier melt modelling to the observed flows? I think that they could help in testing some of the assumptions of the models

(hydrogeological functioning and glacier melting).

In Chapter 6 “Conclusions” point 1 is interesting, because this is not really said in the text. In fact the interpretation of tracing test data (sub-chapter 4.2) should have explained that the tests show that the flows are typical of karst conduits, from the surface of the glacier to the springs.

Despite I am not a native English speaker, I think that the English writing should be revised, although the paper is understandable as it is.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 2743, 2013.