**Hydrogeology of an alpine rockfall aquifer system and its role in flood attenuation and maintaining baseflow**

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**Summary:** The paper reports on an interesting study. The presentation of related work and its comparison with the results of the study should be expanded.

**General comments:**

1) At the end of chapter one I missed a short review of related literature (Alpine aquifers) leading to open questions which might be answered in the paper and thus tying the general ideas at the beginning of the chapter to the concrete goals presented in the last paragraph of the chapter.

2) There are different definitions of the term discharge response:
   - p. 6807 L. 27: discharge response = ratio between direct discharge and precipitation intensity (Onda et al. 2006, Zillgens et al. 2007)
   - p. 6814 L. 13: „The discharge response is calculated by dividing the amount of direct discharge ($Q_P - Q_I$) by the precipitation intensity ($P_{peak}$), a unit conversion factor and the catchment area (A) (Blume et al. 2007)".
   - p. 6829, Tab. 2: „discharge response: ratio between direct discharge ($Q_P - Q_I$) and precipitation ($P_{peak} \cdot A$)"

   In Tab. 2 peak rainfall is given in mm (with the comment: „note that the maximum resolution of sum of precipitation is 6 h), which might be called maximum precipitation intensity (mm/6h). Thus the definition at p. 6807 L. 27 should be adapted (maximum precipitation intensity).
   Direct discharge is a well-known term und describes the difference of event discharge and base flow, summed up over time, resulting in a volume [m³]. I recommend to use another word for the difference of initial discharge [m³/s] and peak discharge [m³/s] in order to avoid misunderstandings.
   The unit conversion factor is mentioned only once. Catchment area misses in the first definition.
   I could not find any explanations in the cited literature (searching for the term discharge response). I would recommend to harmonize the definition of discharge response at all parts of the paper.

3) It would be interesting to get some distinct information on the grain sizes of the investigated aquifer. Of course, the description (e.g. coarse grained delta sediments, fine limnic sediments) gives a good impression of the composition of the sediments, and of course rockfall and alluvial sediments are very heterogeneous, thus it is difficult to give information on the percentages of gravel, sand, silt and clay of the two rockfall and the two alluvial aquifers. However, concrete numbers could help to compare the results of this study with others.

4) Data from 2002-2011 are available (chapter 3.2). Though obviously incomplete (p. 6814, first paragraph), it would be interesting to get mean values for the whole measurement period, for example to get to know, if the conditions described for 2006 (begin of snowmelt in April, characteristic discharge maximum of about 7 m³/s) represent mean

values or outliers within the time period 2002 - 2011.
It is well argued why hydrographs from 2006 and 2011 were chosen. Nevertheless a view to the data of 2005 would be very interesting due to the extreme flood event in August.

5) Chapter 4: results and discussions: I would recommend to extend the comparison between the results of the presented study and results published in literature by other working groups. In the present version, the study presents very interesting results. Their benefit would increase significantly, if they would be related to the results of similar studies as demanded by McDonnell (2003).

6) "Alpine" can start with a capital letter (Alpine – belonging to the Alps) or a small letter (alpine in the sense of situated at high elevation). Botanists associate a special altitudinal belt with the word „alpine". Thus it might be clearer to use „Alpine" instead of „alpine" to avoid confusions.

7) (e.g. p. 6809 L. 9) : „Geography and Geology" are scientific disciplines. Although the words „geography and geology" are commonly used in this context (description of a catchment), it would be more correct if the heading would be called „geographical and geological settings". The same is valid for hydrology, hydrogeology and lithologies.

8) The extreme event in 2006 is mentioned several times. Although the "hard facts" may be extracted from table 2, it would help to get some more information on why this event was extreme. Especially: What is the difference between the event 7 Aug 2006 and 7 Aug 2011? Both rainfall events lasted 12 h, both had high precipitation sums, but discharge response is only extraordinary high on 7 Aug 2006. Do you have any information on the temperature of these events (snow!)?

**Specific comments:**
**p. 6807 L. 22-24:** as far as I know Merz and Blöschl (2009) analysed event hydrographs, not spring hydrographs
**p. 6808 L. 3-6:** High topographic gradients lead to a high peak discharge due to high flow velocities, if surface flow develops. However, high topographic gradients do not necessarily lead to a high amount of surface flow. E.g. coarse talus slopes are steep, but do usually not show any surface flow, flat areas are often covered by fine-grained fluvial sediments reducing their infiltration capacity and thus producing surface flow (e.g. Löhmannsröben 2002).
**p. 6010 L. 5:** At p. 6809 L. 15 two cirques are mentioned, here „sequences of cirques": sounds as if there would be many cirques (sequentially situated).
**p. 6811, L17-18:** GS-RD is „at the downstream end of the valley" contradicts to my feeling to p.6812 L. 20: GS-RD is „at the outlet of the alluvial/rockfall aquifer system". If there is really a contradiction depends on the definition of „the downstream end of the valley" – I would say it is situated at the lower end of the Partnachklamm. Thus I would say the description of the position of GS-RD given at p.6812 L. 20 fits better.
**p. 6811, chapter 2.2:** Fig. 1 contains also SP-R3 and SP-RU which are not explained in this chapter. Although they are mentioned later on, it might be helpful to give an complete overview at this stage.
**p. 6812, L 10:** Was the sampling interval equidistant (4 h)?

**p. 6812, L. 11:** „The final samples were collected three weeks after injection“: I would prefer a sentence like „sampling was stopped three weeks after injection“ in order to stress that there was no day without sampling.
**p. 6817, L. 4:** Is it possible to identify a threshold (rainfall intensity, precipitation sum) describing the „intense or prolonged precipitation events“?
**p. 6821, L. 14:** The sentence starts with the discharge ratio (peak discharge minus initial discharge) and switches to the discharge variability which is something else (the ratio between maximum and minimum discharge according to Schmidt and Morche (2006)). Please define the term discharge variability if used! It would be better to compare discharge ratio values with each other and not with discharge variability values, although there is probably a connection between both of them.

**p. 6829 Table 2:** Event 20 May 2006: rainfall duration 6 h, peak rainfall 8 mm, but sum of precipitation until peak discharge 37 mm. If the resolution of the sum of precipitation is 6 h, I assume, that the peak rainfall of 8 mm refers to 6 h. Where do then the 37 mm come from? (Apart from this event, all events shown in Tab. S1 which last 6 h, have the same value in p sum and Peak rainfall.)

**Technical comments:**
**p. 6808 L. 3:** As can be seen from my comments, I am not an English native speaker, thus I might be wrong. However, I am not sure, if the construction „of low permeability bedrock“ is correct (better: bedrock of low permeability).
**p. 6808 L 7:** particularly instead of particular
**p. 6809 L. 18:** I would omit the first „thick“ as the thickness is anyway mentioned in the next words
**p. 6010 L. 1:** I would omit „however“ as „only“ points out the contrast already.
**p. 6811 L. 2:** Is „the headwaters Partnach stream“ gramatically correct?
**p. 6811, L. 8:** „spring“ instead of „springs“

**p. 6831 Figure 1:**
- In chapter 2.1 two cirques are mentioned. It would be helpful to see the second cirque in the figure.
- The intermittent stream southwest of Partnach karst spring crosses the topographic divide.
- (b) Zugspitzplatt cirque instead of Zugspitz cirque
- Please mention the function of the rectangle in the figure (extent of figure 2?)

**p. 6835 Figure 5:**
- The lower line leading to the arrows with question marks is not visible.
- The labels are very small.

**p. 6836 Figure 6:** The legend is missing (different kinds of arrows, dashed lines, black double points under the dashed lines). A label for the aquifer between the alluvial plains / rockfall deposits and the karst aquifer would be helpful (Quarternary sediments?).

**p. 6837 Figure 7:** Why is the tracer recovery curve for SP-R1 longer than for SP-R2?

I understood from chapter 4.2 that mean discharge was measured only during the main part of the tracer breakthrough. Wouldn't it be more honest to restrict the tracer recovery curve to this time period?

**p. 6840, Figure 10:** Legend: FIT TRF, underline: FIT-IRF

**p. 6841, Figure 11:** In the corresponding text (p. 6820) one can read about a correlation between the hydrologic flow conditions and the lag times. It would be helpful to classify the 38 events shown in Fig. 11 according to the text (high, medium and low flow conditions).

**References:**

Löhmannsröben, R. (2002): Die Bedeutung des Bodens im Zusammenhang mit der hydrologischen Regionalisierung. In: Wiener Mitteilungen Band 164: Niederschlag-Abfluss Modellierung – Simulation und Prognose, p. 201 – 213.

McDonnell, J.J. (2003): Where does water go when it rains? Moving beyond the variable source area concept of rainfall-runoff response. In: Hydrological processes 17, pp. 1869 – 1875.