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Hydrology and Earth System Sciences Discussions

Interactive comment on "Storage and transport in cave seepage- and groundwater in a South German karst system" *by* K. Schwarz et al.

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General comments:

This manuscript presents stable isotope data of precipitation, seepage water in caves, and spring water in a karst catchment (Blautopf spring, Schwäbische Alb, South Germany). The investigation is focused on characterizing slow flow and mixing processes rather than fast responses of the karst system. Although the results are probably not ground-breaking, I think the data may provide useful insight into the functioning of recharge processes in karst systems. Thus, the study can be of general interest. However, the presentation of the results and the discussion are fairly superficial and need improvement. In particular, more details about the sampling locations (e.g., depth below land surface) and the sampling times (only during drought periods or some samples

soon after heavy rainfall / snowmelt?) must be provided and used for interpreting the results. In addition, results from similar investigations in another spring catchment of same karst area (Gallusquelle catchment) are available and should be compared to the results from this study. It is further irritating that several references cited in the text are missing in the references section. While this can easily be corrected, it leaves the impression that the manuscript was not prepared with care.

Specific comments:

1. Abstract, p. 1268, l. 15-19: I think the last two sentences of the abstract, which are very general, are not fully supported by the results. Perhaps they can be replaced by more specific statements (or the discussion in the manuscript can be changed to demonstrate that these general conclusions are valid).

2. Introduction, p. 1268, l. 26 - p. 1269, l. 3: The three compartments defined by Mangin (1974) do not correspond to the conceptual model elsewhere considered in the manuscript. The conceptual model presented here ignores soil and vadose zone, which are several times addressed in the discussion of the results. Thus, a more appropriate conceptual model should be introduced here.

3. Introduction, p. 1269, l. 11-14: 'Tracer tests are useful tools particularly for investigation of flow dynamics in karst . . . They were able to reveal information about the fast conduit system.' I do not think that the first statement is appropriate; if a tracer is injected before or during a storm event, it may provide information about the dynamics, but this is not very typical. Thus, emphasis should be placed on the second statement.

4. Introduction, p. 1269, l. 14-15: ' . . . conduit system. However, the latter usually presents only a small part of the subsurface water balance.' Obviously, the conduit system cannot *be* part of a water balance. The conduit system is a small part of the total subsurface porosity. Alternatively, one could say that direct recharge into the conduit system is a small part of the subsurface water balance. But note that the conduit system probably provides the major contribution to the discharge.

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5. p. 1272, l. 3-15: Please add the depth below land surface to the description of the sampling locations. If available, you may add further information that might be useful for the data interpretation, e.g., information about the rock porosity (estimate of total porosity, types of porosity, matrix vs. fractures, etc.), the land surface (hill slope, dry valley, doline?), or the soil characteristics (the average soil thickness is mentioned, but are there any differences between the sampling locations?). In addition, you should explain how the sampling times were chosen: Did you try to sample after recharge events; did you prefer drought periods or was there a fixed schedule independent of the hydrologic situation?

6. p. 1274, l. 21-22: ' . . . known for fast response to strong precipitation events, however even at this subsurface location no strong seasonality in the O-18 signal was found.' Why would you expect a seasonality resulting from fast responses to storm events? It would be rather of interest to see whether there were short-term responses to storm events at this location. Obviously, the study was not designed to address this issue, but still the graphs shown in Fig. 3 suggest that short-term responses to storm events were observed. Unfortunately, it is unclear to which sampling location the data belong. Perhaps it would be useful to show the graphs of all locations and to discuss the differences (if there are any).

7. p. 1275, l. 10-15: It is quite interesting that you (in agreement with Bauer and Selg, 2006) found that O-18 in spring and cave waters equals the weighted average of O-18 in precipitation. Since recharge occurs preferably in winter and spring one might have expected a shift towards lower values in spring and cave waters. However, a closer look at Fig. 3 reveals that O-18 is low only from November to February and starts to increase above the average already in March. If the recharge period extends beyond March it appears to be reasonable that a precipitation-weighted average is close to the recharge-weighted average. Wouldn't it be possible to calculate a recharge-weighted average? To my knowledge, the geological survey has established a recharge model on a daily basis that could be used for that purpose. It is further interesting to compare

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your results to those by Sauter (1992): On p. 95, Sauter presents a graph showing that O-18 at the Gallusquelle showed a tendency to lower values with decreasing spring dicharges; on p.89 and p. 94, he suggests that this is due to the mobilization of old winter recharge that was stored in lower aquifer zones and only released from storage during low-flow conditions. I wonder whether this is a peculiarity of the Gallusquelle catchment or rather an effect of extreme low-flow conditions. Thus, you may want to speculate about geologic differences between the two catchments and about differences of the hydrologic situations represented by the two time series. A further note: Obviously, the cave seepage water and the spring water sampled are several years old. How far is it justified to compare the O-18 values of today's precipitation with those of these old waters? At least it would be useful to know whether the year under consideration was an average hydrologic year.

8. p. 1275, l. 15-18: ' . . . similar buffering was found . . . ' - is this in spring waters or seepage to caves? Please provide more details.

9. p. 1275, l. 29 - p.1276, l. 1: ' . . . travel times . . . '. Although it is not possible to calculate exact travel times, rough estimates could be made (e.g., recharge divided by porosity yields an estimate of seepage rate). Very recently, Geyer (2008; Dissertation at the University of Göttingen, Germany) derived some estimates for the Gallusquelle catchment based on the analyzes of tritium data and other environmental isotopes. Obviously, this was not accessible at the time when the manuscript was written, but you might be able to get a copy of it now.

10. p. 1276, l. 8-9: ' . . . given the thickness of the vadose zone . . . a considerable storage can be assumed for the epikarst.' I do not think that there is a straightforward relationship between thickness of the vadose zone and epikarst storage. Please explain your reasoning in more detail or drop this statement.

11. p. 1276, l. 15: This appears to be the hydraulic conductivity of the porous matrix (e.g. measured in a lab experiment). It is not correct and of little help to present this

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value simply as 'average hydraulic conductivities'. Measurements at field scale yield much higher values. A detailed discussion of hydraulic conductivities and their scale-dependency (referring to the Gallusquelle catchment) is provided by Sauter (1992; available at http://tobias-lib.ub.uni-tuebingen.de/volltexte/2005/2039/)

12. p. 1276, l. 16-17: 'The base flow preferentially enables gravimetrical flow of more easily mobilized water.' What exactly is the meaning of this sentence? Perhaps it would be helpful to include in Fig. 5 arrows that illustrate how the conduits receive water under baseflow conditions and after storm events. I guess that under low-flow conditions the porous matrix is increasingly drained (via the fracture system and the conduits), which appears to be in contradiction to your statement. 13. p. 1276, l. 22/23: ' . . . heavy precipitation events . . . ' - this is one example where it would be helpful if information about the sampling times were provided and if short-term responses apparent in the data were discussed in more detail. 14. p. 1276, l. 25-30: I would like to add that similar percentages were found by Sauter (1992) in the Gallusquelle spring water.

Technical corrections:

1. Abstract, p. 1268, l. 2: ' . . . access waters . . . ' probably should read ' . . . access to waters . . . '.

2. Introduction, p. 1268, l. 23: ' . . . 25

3. References: Einsiedl (2005), Einsiedl and Mayer (2005), Nordhoff (2005), Worthington et al. (2002) are cited in the text but missing in the references section (perhaps others are missing too - I have not checked all the citations).

4. Caption of Fig. 3: 'Tiefenhhle' should read 'Tiefenhöhle'.

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