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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.

K. Schwarz et al.

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We thank referee 3 for an overall constructive criticism and hope that with some suggested re-arrangements of the manuscript it can be considered as publishable. The ANSWER:s to the comments are marked with “ANSWER:”

COMMENT: Practically the same paper titled: “New aspects of Storage and Transport through Stable Isotopes in Precipitation, Cave Seepage and Groundwater in a South German Karst System” was submitted to the Journal of Hydrology in March 2007 and finally reject. However, the review included a lot of practical comments, which could help to improve the manuscript, the authors’ limited their present work only to reduce the manuscript. So, I would like to repeat some comments already known for the authors.

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Interactive Discussion

Discussion Paper

ANSWER: This manuscript evolved as part of a larger study on the atmospheric deposition of persistent organic pollutants at the catchment scale with their accumulation into, and leaching from soils as well as their transport to groundwater and to the spring. Surprisingly, the water isotopes indicated that preferential transport in fast conduits is not important in this system otherwise we would observe the seasonality found in the precipitation. This in turn has for instance important implications for aerial deposition of unpolar pollutants such as PAHs that –if at all—are transported by particles in seepage water coming for instance from vertical shafts. We therefore still think this manuscript is worth publishing to outline further research needs in this area.

ANSWER: While we fully admit that the data set cannot be used for quantification of recharge rates or mixing, it still helps to show that most of the homogenisation of the water masses takes place in the unsaturated zone and that fast conduits play a minor role in the discharge of the Blautopf. We think that prove of this fact is publishable.

COMMENT: General comments Although the subject matter of this manuscript is of potential interest to the readership, the manuscript fell short of expectations regarding development of new concepts or conceptual model supported by field data.

ANSWER: For an isotope study these data are quite detailed given the cost and effort of isotope analyses. Even if more isotope data would be collected, it remains questionable if results or conclusions would be different or if they would enable quantification of recharge rates or underground mixing and contribution of the fast conduit system to the Blautopf discharge. In the next version of the manuscript we will list all isotope data collected ($>$ 200) and point out that higher sampling frequencies in caves was not always possible fore safety reasons.

COMMENT: Unfortunately, the application of isotope data is very poor, limited to the qualitative speculation, and is not supported by any quantitative consideration.

ANSWER: Quantitative considerations are for instance possible if significant differences in the isotopic composition can be used for mass balance calculations. However,

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as the cave dip water as well as the Blautopf Spring water are both almost identical (within their errors of detection) to the weighted average of the annual precipitation no such mass balance calculations are possible.

ANSWER: We could observe a minor seasonality in the cave drip waters with the most positive values around February / March. With the most positive precipitation values around July, this could indicate the infiltration time to the caves of about half a year (or even longer if more than one season is passed). However, this seasonality is masked and lies within the errors of detection of the method (2 sigma of d18O measurements of 0.4) so that only a very careful interpretation can be made.

COMMENT: In my view, the main problem of this paper is that its content is "in between" a research paper and a case study; therefore it is neither a good research paper nor a good case study because in both cases details are very limited and discussion and conclusions poorly supported by field data.

ANSWER: As any other field study, also this work was limited in time effort and sampling frequency. In this case, sampling in caves was not possible at any time of the year due to safety considerations particularly when they are prone to flooding. Even more samples would probably not have changed the fact that both the spring and the cave drip water are completely buffered and mixed.

COMMENT: As a research paper, this study brings nothing new (contrary to what the title says) and does not even apply some new concepts developed recently; the field data are far from complete both in space and time: where are for instance the data of caves HWS and SH? Weekly samples are too few to really understand the dynamics of transport in karst system especially in the case of recharge events; it is not clear how the conceptual model (figure 5) relates to field data;

ANSWER: The intention of the title was not to introduce something entirely new. Admittedly, the title can still be misleading. Our suggestion for an improved title is “Mixing and Transport water in a large Karst Catchment: From Precipitation

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via Seepage Water to the Spring”

ANSWER: Note that the total number of oxygen isotope measurements alone is over 200. However we did not show them all because they seem too similar to each other. Also HWS and SH samples were not presented in the data set as they have been sampled on a less regular basis, but their results essentially indicate the same as the LTH. This has perhaps not been made clear enough in the manuscript. We will list all samples in the next version of the manuscripts together with sampling dates.

COMMENT: no any modeling is developed to strengthen the discussion.

ANSWER: This manuscript did not have the intention to present a modeling study. It relays some field observations that show how the water is completely mixed already in the vadose zone. Given the assumption that karst systems are often fast responsive, this is a result that seems worth publishing.

COMMENT: As a case study paper, the geological and hydrogeological settings should be developed with maps and detailed information; it would be necessary to describe other hydrogeological information available for the catchment (such as tracing experiments, diffuse vs. concentrated recharge, flow direction, spring functioning, connection with adjacent basins, etc...) Among these other field data, it would then be possible to present the isotopic data of this paper to describe the recharge processes (and the adequacy of the mean recharge elevation calculated with isotopes with the one known from the delineated catchment).

ANSWER: Most of the hydrological settings are described in the references cited (cf. Villinger). On the other hand, it is not entirely clear what the manuscript would gain from other field data as requested. For instance, the literature search on tracer experiments in this catchment gave no results. To reconstruct flow directions, one would either need tracer data with a time component (i.e. tritium) or enough piezometers to construct a groundwater table plan. Both are currently not available.

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ANSWER: The possibility of a connection with adjacent basins is an interesting point if cave systems are spread beyond the surface area of the catchment. Since the isotope data lie on the meteoric water line, we can at least show that the Blautopf Spring has been fed by local recharge. This means that the local recharge of the catchment is indeed responsible for the Blautopf discharge. Alternatively, if caves extent to adjacent catchments, they have received recharge of similar isotopic composition. A reasoning like this can be outlined in the manuscript.

COMMENT: If a research paper has to be published, it seems to me that more data (rainfall isotopes at different locations, soil water isotopes), short term sampling on a flood event, quantification of the flow and consequently of the isotopic fluxes. These additional data could bring interesting information that could improve existing soil-epikarst conceptual models.

ANSWER: The points raised for a proper research manuscript are highly interesting but extent beyond the scope of this study. We offer to clearly outline in the conclusion that this is neither a full research manuscript, nor has it the full data set for modelling to produce a plausible model itself. If we then proceed to list the measures suggested by the referee for a full research manuscript, would the referee agree to accept it as a study that provides a base for further studies?

COMMENT: The form of the paper should be improved: it is important to clearly explain each con- clusion based on field observations and present a conceptual model that tight all these conclusions together. The literature should be used when it is really necessary: to introduce the topic with a state of the art review (this is done but should be better presented i.e. showing the different existing models of karst aquifers, karst aquifer recharge), and at the end of the discussion (in this paper references are spread throughout the discussion section which makes the reading difficult). References are not always cited with the proper form.

ANSWER: We will clear the introduction and reduce references in the discussion sec-

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tion. The three summarised conclusions are based on the field observations of the isotopes. The similarity of the isotope data point at a well-mixed system and further show that mixing takes place in the unsaturated zone. Figure 5 is admittedly not a concept model but provides an overview of the various flow systems in the karst system studied. The importance of the flow systems will be outlined in the text more clearly and in the diagram.

ANSWER: If any references were not cited in the proper form they will of course be adjusted.

COMMENT: Detailed comments In the Blautopf spring one should expect the mean transit time of water in the order of magnitude 15-20 years. So it is evident that the stable isotope signal is washed out, as observed. Similarly, the flow through the unsaturated zone having app. 150 m thickness yields, by the recharge of 0.5 m/year, the transit time larger than 4 years. So, it is clear that the stable isotope variations measured in the caves are also nearly completely damped.

ANSWER: We agree, but the isotope data set presents a method to prove this point. Besides, such long residence times are not always an undeniable truth in karst systems. With cave and fast conduits often being connected in more direct pathways to the surface, much faster transit times of the water could have been expected.

COMMENT: The only scientific purpose of the presented research could be the estimation of the portions of fast flow (1) through the unsaturated zone to the caves and (2) to the spring. Considering these two points the question appears: why in such heterogeneous system during the observation period of 80 weeks, the authors collect so little water samples.

ANSWER: Although we would have liked to collect and analyse more water samples the sampling frequency was limited mainly by security concerns. After strong precipitation and snowmelt events it is not safe to enter caves. Of course we cannot prove that more detailed sampling schemes in time and space would provide better conclusions

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or a data set fit for calculations but we can raise this point in the conclusions.

COMMENT: Figure 3a shows that the input signal (precipitation), most important for any evaluations, was collected once per month or even less frequently (Why there is not sampling datums in the Table 1?

ANSWER: The sampling frequency of precipitation was generally more often than once per month and based on events and the dates will now be added to table1.

COMMENT: Why there is not common time axis for three parts of figure 3?).

ANSWER: True. The middle figure has a wrong time axis. As this figure reveals no new trends, we suggest to remove it and enlarge Fig. 3a.

COMMENT: Practically, all quantitative results are taken from the literature and the own yield of the authors is missed. Why there is not any trial to quantify the results?

ANSWER: A calculation of proportions such as summer recharge to winter discharge would be possible if we could find output isotopic compositions that arrive with a time delay to the input. However this could not be found as the isotope signal is already too buffered in the cave.

ANSWER: It is clear that with the given results, we can only afford to provide a qualitative conclusion. This can lead to further suggestions how to derive at quantitative results.

COMMENT: The English should be improved: avoid the use of "we", "this nicely fits" is not appropriate; some sentences can be understood but are not written correctly

ANSWER: While none of the authors is a native English speaker, the English has been accepted in most of their other publications. Nonetheless, to avoid any linguistic discussion we will ask a native speaker to correct the English before re-submission.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 1267, 2008.