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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Spatially resolved information on karst conduit flow from in-cave dye-tracing" *by* U. Lauber et al.

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We thank Malcolm Field for classifying our paper as an "excellent manuscript" and for his constructive comments that will contribute to further improve its quality. All comments concerning language will be taken into account and are not discussed in the response letter. We will send the revised manuscript to a native speaker (a geoscientist) prior to resubmission, so all language issues will be resolved. Most of the scientific and technical comments seem to be related to unclear formulations / language problem, which will be improved in the revised manuscript. Here are our answers on the specific review comments:

Page 11312, Line 5 – I know what is meant by the term "black box" and I suspect most

readers will have some concept of the meaning. However, it might be appropriate to be more explicit to ensure that readers know exactly what is meant by the term "black box." Wikipedia defines black box as "In science and engineering, a black box is a device, system or object which can be viewed in terms of its input, output and transfer characteristics without any knowledge of its internal workings."

Reply: We appreciate the approach to make scientific papers intelligible for all readers. However, we believe that the term and concept of a black box model is generally known in hydrology and earth sciences. Therefore, we prefer to leave it as it is, also to keep the abstract short and concise.

Page 11316, Line 27 – You mention that velocities were calculated "on the basis of peak transit times" but you do not explain why. I know that it has been argued that peak time is more "robust" than mean time, but the robustness has never been properly defined. (In this context, robust is supposed to negate the effects of long tails in the breakthrough curves, but robust is a statistical terms with a very specific definition.) Peak velocity will nearly always slightly overestimate actual transit velocity so you should explain your reasoning if you are going to use peak velocity.

Reply: All BTCs were evaluated using the ADM or 2RNE model that delivers mean transit times, mean flow velocities, dispersion etc. (summarized in Table 1). Peak times were used to quantify flow velocities between individual sampling sites, as illustrated in Fig. 6 and 7. The tails of the BTCs are rather short so that the difference between peak and mean velocities are small. Peaks times neither depend on analytical detection limits nor on any assumptions concerning transport processes. To avoid misunderstandings, we will use the term "straightforward" instead of "robust".

Page 11317, Lines 4-5 – The ADM and CXTFIT calculate mean velocity so how do you equate the model calculations with your use of peak velocity.

Reply: For all breakthrough curves, we have determined times of first detection, peak times and mean transit times. Based on this, we have calculated maximum, peak and

mean flow velocities between the 4 injection sites and the 4 sampling sites. All results are summarized in Table 1. However, as described above, we have used only peak times to quantify the (peak) velocities between the individual sampling sites along a flow line in the conduit system, shown in Figures 6 and 7. We will clarify this approach in the revised manuscript.

Page 11317, Line 11 – You report an RMSE of 0.931, but Table 1 lists this value as a coefficient of determination. The RMSE and coefficient of determination are not the same thing even though they represent the same type of statistical measure. Please correct your wording in the correct location.

Reply: The wording will be corrected: it should read coefficient of determination (R2).

Page 11319, Lines 7-9 – The sentences that read "Due ... tracer." and "Maximum ... 45 m h−1." do not read well. I suggest "The rainfall event caused spring discharge to increase to 1.25 m3 s−1 after peak 1 resulting in additional dilution of the tracer." "Maximum flow velocity from IP-4 to SP-4 was 53 m h−1, and mean flow velocity for the first peak was 45 m h−1." (NOTE: mean flow velocity and peak time are not synonymous âĂŤplease resolve this discrepancy. Also, maximum flow velocity has little theoretical or physical meaning because it is entirely based on sampling frequency and the sensitivity of the instruments used for analysis.)

Reply: Yes, we know that mean and peak flow velocities are no synonymous and we will clarify this in the revised manuscript. Mean flow times / velocities were determined using CXTFIT, while times of first detection and peak times were directly obtained from the BTCs. It is true that the time of first detection and, thus, the calculated "maximum" velocity depend on the detection limit of the analytical instruments (i.e. they are not "robust" parameters). Nevertheless, we believe that these results are relevant, mainly in the context of contaminant hydrogeology, because in the case of an accidental contaminant release in the catchment, people will ask: When will the contaminant first reach the spring? We will better explain this aspect in the revised manuscript.

Page 11319, Lines 19-21 – You state "Results from charcoal bags make it possible to further constrain the location of the connecting conduit ..." which is problematic. First, what results!? You don't report the results. Second, if you are basing any of your velocities calculations on the results of charcoal bags then your calculations are in error. Third, assuming that your velocity calculations and your basic assessments of flow trajectories and connects are based on water samples (which I believe to be the case) then what was the purpose of the charcoal bags, which are never as reliable or scientifically valid as water samples.

Reply: Yes, the reviewer is right: Charcoal bags do not deliver fully quantitative information, but only "positive" or "negative" detections. Therefore, all quantitative results presented in our paper (transit times, flow velocities, transport parameters, etc.) are based on results from water samples and field fluorimeters. Results from charcoal bags helped to better resolve the spatial flow pattern, in particular the location of the confluence between the two caves. We will clarify this in the revised version.

Page 11320, Line 8 – No matching reference is provided for the citation to Worthington and Ford, 2009.

Reply: The citation will be inserted in the manuscript.

Page 11320, Line 18 – Use of the permil symbol, e.g., "40 0/00" (40 per 1000) isn't very commonly used. You may want to think about another way of describing the gradient.

Reply: Hydraulic gradients can be expresses as %, ‰ or as a fraction of 1. For example: 40 ‰ = 4 % = 0.04. We do not have any specific preference and are ready to change the way of describing the gradient if the reviewer or the editors tell us what is the preferred notation.

Page 11320, Lines 26-27 – The sentence that reads "This gives rise to impoundment in the phreatic zone and the formation of underground lakes in the nearby epiphreatic cave passages." needs explaining. Please elaborate.

Reply: Indeed, this is an unclear formulation. In this sentence we refer to tailback of water / backwater near the spring. The language will be improved with the help of a native speaker.

Page 11321, Line 23 – The sentence that reads “Dispersion . . . partly different.” makes no sense to me. I have no idea what partly different means; either the dispersions coefficients were different or they were the same. Did you mean to imply that they were similar?

Reply: Actually, this expression is not clear. Dispersion coefficients vary within the cave sections, but some dispersion coefficients are also quite similar (IP-1 and IP-3). We will improve this in the revised manuscript.

Page 11322, Lines 14-17 – The sentence that reads “It seems . . . karstified zones.” needs explaining and/or clarification; it makes little sense as written. How do an extreme karstified zones and a major influence (IP-4) cause a little increase in dispersivity (IP-3) with less karstified zones? What constitutes “extreme karstified zones” and what constitutes “less karstified zones.”

Reply: Yes, the reviewer is right, this needs clarification. By using the expression “extreme karstified zones” we refer to zones where open, sub-vertical karst shafts are present, whereas the expression “less karstified zones” refers to zones without such shafts. We will make this more clearly in the revised manuscript.

Page 11323, Line 20 – Change “single cave passages” to “two individual cave passages prior to their confluence”

Reply: Yes, we will do so, thanks.

Page 11323, Line 25 – The statement “Dispersion is highly variable due to flow velocities.” needs explaining and clarification. By “flow velocities” do you mean low-flow velocities, high-flow velocities, or variable-flow velocities? How do flow velocities cause highly variable dispersions?

Reply: Yes, we will give some more explanation. By this statement we refer to the heterogeneous distribution of flow velocities within the cave systems, which also cause the heterogeneous distribution of dispersion coefficients. We will clarify this in the revised manuscript.

References

Reply: Thanks, we will include the DOI-numbers.

Page 11327, Table 1 – In the table caption change “without/with” to “with/without”

Reply: We agree that “with/without” reads more fluently. However, velocities calculated without considering tortuosity are smaller than those with tortuosity. In this sense “without/with” means “minimum/maximum” values, which is a more logical order than “maximum/minimum”. Therefore, we prefer not to change the table caption.

Page 11329, Fig. 2 – Consider changing “dry cave passages” in the caption to “vadose passages” Move “mapping of caves by Arge Blautopf and Arge Blaukarst” to the Acknowledgements or just delete because these two people have already been acknowledged (this latter statement should never appear in figure or table captions in scientific manuscripts).

Reply: Thanks, this will be changed.

Pages 11333 and 11334, Figs. 6 and 7 – These two figures are really significant and would benefit from more comprehensive captions. Every figure and table in any scientific publication should be able to stand on its own (i.e., without the benefit of descriptions in the manuscript text) so I think that you should add more detail to the two captions.

Reply: More information will be added to the captions.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 11311, 2013.