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Hydrology and Earth System Sciences Discussions

Interactive comment on "Relating stable isotope and geochemical data to conclude on water residence times in four small alpine headwater catchments with differing vegetation cover" *by* M. H. Mueller et al.

Anonymous Referee #2

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General Comments:

This paper aims to add to the ongoing discussion on catchment response controls, specifically on the influence of vegetation cover on mean transit times. This is an important aspect that has not been discussed very much in detail before. Still, after reading the manuscript, it appears that the paper deals mostly with other topics and the vegetation effect is only a side note. In a similar manner the geochemical data is presented but not used sufficiently to support the arguments on transit times. Overall,

there are too many topics that the authors try to address but mostly in a superficial way leaving out important information in too many places and not integrating the pieces into a consistent story.

Some of the modeling concepts are not clear either. For example the use of base flow samples. I'm not sure whether the term 'base flow' in this paper refers to streamflow, because there is no explanation on how base flow was sampled or distinguished from storm flow. Also, I was trying to make sense of the synthetic experiment but could not see the value in reducing the summer precipitation input and adjusting the transfer function in the convolution model to match the output isotopic signal that was produced by different input fluxes.

To sum it up, I think the paper needs some streamlining and a consistent story. The authors should concentrate more on explaining important details of the methods they use, clearly stating assumptions and hypotheses. In order to do this they need to consider more of the newer literature that has been published on transit time modeling (in the last 3 years).

Specific Comments:

p. 11006, l. 19: 'the geological and topographical situation': You have not mentioned this before. Could you be a little more specific here?

p. 11006, l. 24: Residence time and transit time are not the same! The first one is describing the age distribution of all the water in a catchment, the second one is characterizing a specific precipitation event and the time that the water from this specific event needs to transit through a catchment. Please refer to McDonnell et al. 2010 (in your references already) or Hrachowitz et al. (currently under review in HESS) and change your terminology.

p. 11007, l. 2: . . .calculated via 'time series of' stable isotopes. . .

p. 11007, l. 3: The variation of the isotopic signature is not solely dependent on varying

temperatures (can be caused by varying storm tracks, precipitation event volumes, etc.).

p. 11007, l. 20: You mean that more freely draining soils cause more mixing of new incoming water with older groundwater (instead of soils that create more subsurface, macropore and overland flow).

p. 11008, l. 1: Runoff generation processes can be altered 'in what way'? Please give more details.

p. 11008, l. 6: This sentence is unclear.

p. 11008, l. 9: 'They' refers to Clark and Fritz or Darling and Bath?

p. 11008, l. 9: So Darling and Bath did not find this effect in their study? They just hypothesized about it?

p. 11008, l. 13: Again, you just state that there were changes, but you don't tell what they changes were. You need to summarize these studies in your introduction better, also including their results as they relate to your study.

p. 11008, l. 16: You hypothesize that there will be changes but you don't tell which changes in what direction.

p. 11008, l. 21: What do you mean by 'scale dependency'? Which scale?

p. 11010, l. 19: How did you sample only stream base flow if you had a fixed sampling every 14 days? How did you distinguish base flow conditions from event conditions?

p. 11010, l. 23: Did you melt the whole snow column to measure water isotopes? Did you also measure water isotopes from naturally occurring snow melt (as input to the flow system)? The two methods could potentially yield significantly different isotope values...

p. 11012, l. 1: I recommend calling this transit time modeling. I understand that you

are assuming the system to be in steady-state and hence transit time = residence time; still the term transit time would better reflect what you want to express in the paper.

p. 11018, l. 12: This is the first time you mention the Reuss river and later the wetland site. You should introduce them in the study site description.

p. 11018, l. 26: Enriched in what? In the heavy or in the light isotope?

p. 11018, l. 27: I don't understand this. Almost all water in the water cycle is of meteoric origin. Maybe you want to say that the subsurface/overland flow derives mainly from precipitation that has not traveled via deeper flow paths?

p. 11019, l. 8: Do you mean 'less negative' values? Please be more precise with the isotope nomenclature.

p. 11019, l. 9: Why was it more pronounced in the modeled data?

p. 11019, l. 16: Better write: 'The model estimates the same mean water...', because it is very apparent that the real mean has to be longer just from looking at the data.

p. 11019, l. 21: The real problem is that you assume that the mean transit time is time-invariant although it has been shown that it varies from season to season and from event to event. You should acknowledge that and refer to papers of (Botter et al. 2011, van der Velde et al. 2010, Heidbüchel et al. 2012, Hrachowitz et al. 2010).

p. 11020, l. 3: This is no justification for including snow melt samples if you are looking for base flow mean transit times.

p. 11020, l. 24: The reasoning is unclear.

p. 11021, l. 23: Enrichment of what?

p. 11021, l. 27: But the input to the system is the snow that melts from the snow pack. That snow melt water is generally much enriched in the lighter isotope and only later during the snowmelt becomes more enriched in the heavier isotope. So your

reasoning, that there is only little change in the snow pack isotopic signature does not address the real problem of input characterization.

p. 11022, l. 13: This cannot work because isotope values are not only related to air temperatures. You should rather repeat the measured time series a couple of times.

p. 11022, l. 16: How did you use that measured record to reduce input uncertainties?

p. 11023, l. 7: Unambiguously, really? There is always uncertainty and Figure 5 shows that there is little difference between 50 and 80 weeks for three of the catchments although there is only one minimum value.

p. 11023, l. 10: Is this a common goodness-of-fit measure? Why not use the Nash-Sutcliffe Efficiency, it would also provide information on whether your modeling is better than using an average value.

p. 11023, l. 21: I don't understand this sensitivity analysis. You reduced the precipitation input and assumed that the output signal remains unchanged. Then you adjust the transfer function so that it again produces the observed output (that was created by different input). What information do you gain by doing this? I would expect that the output signal would change too, if the input signal was changed.

p. 11025, l. 1 - 22: You could remove the whole geochemistry section. It is a little confuse and doesn't add to the story.

p. 11026, l. 26: What do you mean by 'If we compare these results with the time series of the Reuss river. . .'. Compare them in which way, please give more details.

p. 11027, l. 24: If you use mean water transit time and mean discharge you will only get an average mobile catchment storage. However, the storage is likely variable and at certain times potentially much larger.

p. 11027, l. 26: How exactly did you estimate the volume of rocks? Please give more details.

p. 11027, l. 27: An equation that shows how you used Darcy's law to estimate porosity would be helpful.

p. 11028, l. 2: The values you are giving (3.46x10-4 to 4.09x10-2) are not within the range of values given by Frick and Himmelsbach (7.4x10-3 and 1.3x10-3). It's the other way around.

p. 11028, l. 26: This is the first time you mention that you expect karst formation at you test sites.

Table 1: The correct English term for the German word 'Exposition' is 'aspect'.

Table 3: The values you are presenting here are probably very uncertain, so don't add two decimal places.

Figure 1: Is it Ursern or Urseren Valley?

Figure 7: You can remove this figure. Since there are no significant correlations anywhere, you can simply state that in the text.

Figure 8: The same applies for this figure.

Technical Corrections:

p. 11006, l. 14: either "catchments' outlets" or "catchment outlets"

p. 11008, l. 12: Better write '. . .Stumpp et al. (2009b and 2012). . .'

p. 11008, l. 20: Stable isotope(s) values.

p. 11014, l. 15: 'melted' is the past participle of 'to melt'.

p. 11016, l. 12: represent's'

p. 11018, l. 2: . . .values 'are' reflecting. . .

p. 11018, l. 22: . . .stored water(s). . .

p. 11018, l. 28: . . .these waters represent(s). . .

p. 11019, l. 27: Months are spelled with capital letters.

p. 11024, l. 10: extenT

p. 11024, l. 19: . . .higher than can BE expected. . .'

p. 11029, l. 14: A 'time' is missing.

References:

Botter G., E. Bertuzzo, and A. Rinaldo (2011), Catchment residence and travel time distributions: The master equation. Geophys. Res. Lett., 38, L11403, doi:10.1029/2011GL047666.

Heidbüchel, I., P. A. Troch, S. W. Lyon, and M. Weiler (2012), The master transit time distribution of variable flow systems, Water Resour. Res., 48, W06520, doi:10.1029/2011WR011293.

Hrachowitz, M., H. Savenije, T. A. Bogaard, D. Tetzlaff, and C. Soulsby (2012), What can flux tracking teach us about water age distributions and their temporal dynamics?, Hydrol. Earth Syst. Sci. Discuss., 9, 11363-11435, doi:10.5194/hessd-9-11363-2012.

Hrachowitz M., C. Soulsby, D. Tetzlaff, I.A. Malcolm, and G. Schoups (2010), Gamma distribution models for transit time estimation in catchments: Physical interpretation of parameters and implications for time-variant transit time assessment. Water Resour. Res., 46, W10536, doi:10.1029/2010WR009148.

van der Velde Y., G.H. de Rooij, J.C. Rozemeijer, F.C. van Geer, and H.P. Broers (2010), Nitrate response of a lowland catchment: On the relation between stream concentration and travel time distribution dynamics. Water Resour. Res., 46, W11534, doi:10.1029/2010WR009105.

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