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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 #1

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

The paper aims to investigate the importance of vegetation cover on water residence times and geochemical response in runoff. For this, 4 micro catchments are sampled and compared.

Major comments: I think this is an interesting study showing with interesting data. However, am not convinced that the conclusions drawn from the data / findings presented in the best way - at this stage. I think the focus / main message of this paper could / should be different. For example, I don't think one can draw any conclusion whether catchment size has or has not an influence on transit times if all sampled catchments are less than 1 km2. Secondly, a clear landscape / environment context is missing. What I mean by this is that its crucial to put all case studies you cite from the literature into a correct context – what scales were investigated, what landscape evolution took place – as this is crucial to be able to contextualise the actual catchment response. Thirdly, I am also not convinced that just 4 sites really allow any conclusion to be drawn regarding "correlations". Particularly, as most "relations" reported are extremely weak.

I also get the impression too many results and messages are presented rather than focussing on one "take home" message based on a clear "story".

Using isotopic and geochemical tracers in conjunction is nothing new – and it is not clearly presented what the novel contribution of this paper is.

In my opinion, this study's most interesting results are in terms of the snow sampling, fractionation etc. So, as a suggestion, I wonder whether the paper (title etc) should rather focus on "Importance of snow, fractionation and vegetation on isotope dynamics in mountainous microcatchments" or something along these lines. I would also show the high resolution snow sampling (if it was conducted). There are not many studies on isotope measurements in snow – so that in itself would be an interesting result.

All aspects of uncertainty are also ignored. There is such a wealth of literature out there now on transit times, transit times distribution, and time-variant transit times which need to be at least discussed. Some kind of error and uncertainty assessment is necessary (even if its as error bars or Standard deviations). There are limitations to using "mean transit times" – MTTs are still an incredible useful concept but need to be presented correctly.

I would also suggest that an overall aim of the paper and specific objectives are formulated.

Figure 3 is quite important – but very difficult to read. I would firstly suggest to include discharge and precipitation time series – to allow contextualisation (pre-ebent and event conditions etc). Secondly, I would probably present this as a panel figure, i.e. one plot for each of the 4 sites, but same axes to allow comparison.

I had difficulties to interpret some of the results – simply because I couldn't read some of the figures very well.

Overall, I would recommend streamlining this m/s. Decide clearly what is the focus and main findings of this study (land use effects? Environmental change? Vegetation and evapotranspiration? Fractionation? Snow effects?). Following this, please focus the introduction and discussion section on the chosen topic or issue. As the m/s stands at the moment, the authors tried to cover a lot of topics, and by doing so missing out on some of the most relevant, recent international literature and discussions.

Specific comments:

Abstract: The abstract as it stands is unclear. There are no findings reported about influence of vegetation on transit times.

Introduction:

I think the authors would benefit from reading "Kendall, C., McDonnell, J. J. (eds) (1998). Isotope Tracers in Catchment Hydrology. Elsevier Science Publishers. 816p." which is an excellent introduction into isotope hydrology.

p. 11006, l.24 change "circulating" to "residing"

p. 11007: This whole section on example studies and previous findings needs clear contextualisation. For example, the "role of landscape structure and topography as controlling factors..." is not "still debated" rather different studies at different spatial

scales and – most importantly – landscapes with different evolution (e.g. "young" topographically very active landscapes vs ancient landscapes....) showed different findings, i.e. controlling factors. This is very important to be clear about this. Second example: l19: "They argued that they found more freely draining soils..." should be "In such ancient, formerly glaciated landscapes free-draining soils are usually found at steeper hillslopes..."

p. 11008: the section on land use effects on runoff generation is a bit basic – and just textbook knowledge. I think if you want to introduce issues on land use and its effects on runoff generation processes you should cite some more of the recent state of the art literature.

p. 11008: Please formulate clear objectives.

Section 2: Were discharge and precipitation (amount) measured? I suggest to add these data – and also show e.g. in Fig. 3.

Section 2.3. I am not sure whether the authors are familiar with all the recent literature on transit time modelling, and uncertainties linked to transit time model parametrisation. E.g. Kirchner et al., 2001; Hrachowitz et al. 2010; Botter et al. 2008; Godsey et al., 2010; Hrachowitz et al., 2011 etc.

How did you consider and incorporate uncertainty in your data and model structure?

Section 3 results:

p/ 11017: "The isotope signal was reflected in the streamwater..." please show this clearly in a figure – thats an interesting finding.

p. 11017, l. 25: "data not shown" – I think it would be valuable for this study to show these data. In this context, please also consider other studies on high resolution tracer data (e.g. Birkel et al., 2012)

p. 11019, l. 10 "This can be either due to heavy rain..." see my comment about Figure

3: the reader needs to see the time series of discharge and precip to actually be able to draw his/her own conclusions.

L 14, same page: “drier periods...” again, are these drier conditions shown anywhere?

l. 15-20: how can it be that the residence times are the same in Wallenboden and Chaemleten, when isotopic signatures is much more damped in Wallenboden? Is something wrong with your model parameters?

Sections on evapotranspiration: pls read papers Brooks J R et al. 2010. Ecohydrologic separation of water between trees and streams in a Mediterranean climate, Nat. Geosci., 3, 101–104, doi:10.1038/ngeo722; and Muñoz-Villers LE, McDonnell JJ. 2012. Runoff generation in a steep, tropical montane cloud forest catchment on permeable volcanic substrate, Wat. Resour. Res., 48, W09528, doi:10.1029/2011WR011316.

I am aware that the climate in these catchments is totally different to your sites, however, differences in seasonality might have similar effects on fractionation etc. You should be at least aware about these recent findings.

Section 3.23. Please see recent literature on time variant transit times.

Section 3.24: large parts of this section could come in methods – rather than results.

p. 11026, l. 14... or you have to conclude that these indices are simply not relevant at scales of $\sim$0.5 km2 and less.

Section 3.4.2 this section seems a bit out of context. If main findings (following the title) are on vegetation effects – how does link?

p. 11028, l. 17-19: try to avoid such "listing" of a number of papers. Rather cite these studies regarding specific issues (as again, all of them were conducted in very different landscape context, at different scales etc).

Please conclude your discussion section with a clear statement of the wider implica-

tions of your findings.

Recommended literature:

Birkel C, Soulsby C, Tetzlaff D, Dunn SM, Spezia L. (2012) High-frequency storm event isotope sampling reveals time-variant transit time distributions and influence of diurnal cycles. Hydrological Processes. DOI: 10.1002/hyp.8210.

Botter, F., F. Peratoner, M. Putti, A. Zuliani, R. Zonta, A. Rinaldo, and M. Marani (2008), Observation and modeling of catchment scale solute transport in the hydrologic response: A tracer study, Water Resour.Res., 44, W05409, doi:10.1029/2007WR006611.

The first chapter by Buttle in “Kendall, C., McDonnell, J. J. (eds) (1998). Isotope Tracers in Catchment Hydrology. Elsevier Science Publishers. 816p”

Kirchner, J. W., X. Feng, and C. Neal (2001), CatchmentâĂŘscale advection and dispersion as a mechanism for fractal scaling in stream tracer concentrations, J. Hydrol., 254, 82–101, doi:10.1016/S0022-1694(01) 00487-5.

Hrachowitz M et al. (2010) Physical interpretation of parameters in the gamma distribution: implications for time-variant transit time assessment in catchments. Water Resources Research, doi:10.1029/2010WR009148.

Hrachowitz M et al. 2011. Sensitivity of mean transit time estimates to model conditioning and data availability. Hydrological Processes 25: 980–990. DOI: 10.1002/hyp.7922.

Rodhe, A., L. Nyberg, and K. Bishop (1996), Transit times for water in a small till catchment from a step shift in the oxygen 18 content of the water input, Water Resour. Res., 32, 3497–3511, doi:10.1029/95WR01806.

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