

## ***Interactive comment on “Identifying residence times and streamflow generation processes using $\delta^{18}\text{O}$ and $\delta^2\text{H}$ in meso-scale catchments in the Abay/Upper Blue Nile, Ethiopia” by S. Tekleab et al.***

### **Anonymous Referee #1**

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#### General Comments:

This paper is written to provide a base line for the use of stable water isotopes in Ethiopian catchments. It describes patterns of the isotopic composition of the incoming precipitation as well as looking at how this pattern is altered on its way through the catchment before it reappears in springs and streams. Furthermore, the authors use stable isotopes as tools to separate pre-event from event water and to determine mean residence times.

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The style and focus of the manuscript is rather descriptive more than analytic, which is not a problem to begin with. However, at some points in the paper the interpretation of the collected data leaves something to be desired, e.g. when the different water lines are discussed, when the precipitation amount effect is discussed, when different moisture sources are discussed, when hydrological differences between the catchments are discussed. Also, the results of the hydrograph separation and the residence times deserve some more interpretation, especially with respect to streamflow generation processes (which are prominent in the title).

Throughout the paper there are some orthographic problems - especially concerning plurals and articles: The ‘s’ at the end of plural words is often left out or the verb forms of singular and plural are mixed up. Additionally, determined or undetermined articles are often omitted which makes reading very cumbersome. What most diminishes the paper’s readability is, however, the use of nested sentences. The authors often try to fit three sentences into one wrapping multiple thoughts into one phrase instead of writing them down one after the other. That makes some of the sentences incomprehensible. Therefore, to begin with, I recommend a thorough review of language and style.

Overall, the paper is interesting and valuable for the regional hydrology of Ethiopia. Still, it could be even more valuable to the general public if the sections on residence times and streamflow generation processes would be extended.

#### Specific Comments:

##### Title:

The identification of residence times is only a very small part of the paper at the very end (section 4.4). I am not sure whether this justifies the current title.

##### Abstract:

p. 34, l. 15: I would recommend that the authors choose one of the terms (main rainy or summer, little rainy or spring, dry or winter) and stick with it throughout the whole

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manuscript. So far, the terms are used interchangeably and this adds some confusion here and there.

p. 34, l. 19-21 and l. 24-28: You talk about residence times at the end of one paragraph (19-21), then you start a new one talking about hydrograph separation (22-24) and then you go back to residence times (24-28). Better finish the residence time part before reporting on hydrograph separations.

p. 35, l. 1: Does 'suggest' mean that these catchment management measures are ongoing or recommended?

Introduction:

p. 35, l. 21: What is the East African meteoric water? Some details about its origins and characteristics would be helpful for comparison.

p. 35, l. 23- p. 36, l. 2: Sentence structure is awkward and unclear.

p. 36, l. 3: Why do you use 'nevertheless' here?

p. 36, l. 20: You should mention the fact that time-invariant residence times are naturally unlikely to exist in real-world catchments and that there is quite some newer literature (in the last 2-3 years) that tries to tackle these assumptions by introducing methods to determine time-variable residence times (Botter, Hrachowitz, Heidebuechel, van der Velde).

p. 39, l. 9: What about evaporation within the bottle? A 10 liters canister leaves a large air-filled volume.

p. 41, l. 3-6: This method is unclear. Please rephrase.

p. 41, l. 20: Using the weighted mean isotopic composition of precipitation is problematic. Since the isotopic composition of precipitation events within a month can vary widely from event to event, I would recommend using a different end-member for every event and only accumulate the event/pre-event fractions afterwards. This could

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change your results significantly and still would give you a much more robust estimation of these fractions.

p. 43, l. 3: This is the one and only time you mention 'transit time' in your manuscript. I see that you assume that residence time and transit time are the same, but still I would stick with one of the terms.

p. 44, l. 4: Maybe rather name this section 'Meteoric water lines' or just 'Water lines' instead of 'Meteoric water', since you will be discussing more 'meteoric water' in the following section.

p. 44, l. 9: Please discuss the effect of evaporation of falling rain drops for the deviation.

p. 44, l. 13-16: Unclear, please rephrase.

p. 44, l. 22: 'heavy delta18O values' is technically incorrect. Use a consistent terminology regarding isotopes. For example: 'enriched in the heavy isotope' or 'less negative delta18O values' instead of 'higher delta18O values'.

p. 45, l. 8: entails?

p. 45, l. 8: Do not write: 'decrease the isotopic composition'. That does not mean anything.

p. 45, l. 8-12: Do you have any clue why the 3000 m station always has less negative values than the 2400 m station? This is contrary to what you say in this paragraph and you should discuss it.

p. 45, l. 13: What relationship did you find? Describe it with words - that makes reading and understanding much easier.

p. 46, l. 10: Again, some more details on these 'multiple moisture sources' and the 'local meteorological processes' would be helpful.

p. 46, l. 12-27: This needs better structure to make it clearer to the reader. Also, you

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see opposing trends in the spring with FC becoming more negative and YW becoming more positive.

p. 47, l. 8: But you said that the amount effect is more important than the temperature effect. Unless higher elevations also receive more precipitation, it is hard to tell whether the recharge areas for the springs are located at different altitudes.

p. 47, l. 9: What is the 'mean isotopic variation'?

p. 48, l. 20-24: But neither the Atlantic Ocean nor the Mediterranean Sea is on the map shown in Figure 10.

p. 49, l. 15: What do you mean by 'reveals the variation in catchment storage'? Please elaborate.

p. 49, l. 15-17: If you mention this water balance study here, it would be good to relate some of its results to the results from this isotope study.

p. 49, l. 18-28: This paragraph is unclear. Please rephrase.

p. 50, l. 11-16: Unclear. Please rephrase.

p. 50, l. 20: What are these 'visual observations'?

p. 51, l. 12-17: This nested sentence is unclear. Please rephrase.

p. 51, l. 18- p. 52, l. 13: The section on uncertainty analysis should be rewritten. It contains nested sentences and lacks clarity. What does it mean when you say that 'This lower average uncertainty term accounted for  $\pm 0.46$  for Chemoga...'?  $\pm 0.46$  of what exactly? Uncertainty, variability, error? From which sources does the error in hydrograph separation originate? Can you give some more information?

p. 53, l. 9-11: Direct comparisons with other similar meso-scale catchments are definitely possible and also scientifically interesting. Especially when different climatic settings, soil types, geologies and land cover properties change the residence times.

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p. 53, l. 20: What are these local meteorological settings?

Figures:

Figure 1: A different color scheme with less extreme colors would be better for the elevation map. Also use bolder labels in general and different sizes (or fonts) for the catchment names.

Figure 3: The order of the legend entries is mixed up. Group all the springs and streams together and move the water lines to the end. Maybe add three trend lines for Q, S and P and remove the black marker outlines. You could also order the marker colors by elevation and give the LMWL a different color than the one from Addis Ababa.

Figure 5: For easier comparisons you could make just 2 panels – one with all the 18O data and the other with all the 2H data.

Figure 11: This is very small. Maybe insert a window where you zoom into one of the rainy seasons to show some detail.

Technical Corrections:

p. 34, l. 12: Sudd or Sud?

p. 34, l. 13: 'likely' or 'potential'?

p. 34, l. 16: 'affected by the amount effect' sounds awkward.

p. 34, l. 12: 'to a lesser extent'

p. 35, l. 19: affected

p. 36, l. 7: 'utility' and 'use' are mixed up in this sentence.

p. 36, l. 17: missing parentheses for the citation.

p. 36, l. 28: '...in the two adjacent meso-scale headwater...'

p. 37, l. 3: '...tributaries of the Abay/Upper Blue Nile,...' (without basin)

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- p. 37, l. 14: '...oats and potato...'
- p. 38, l. 5: 2011 not 2001!
- p. 38, l. 10-11: You use 'over the same period' twice here.
- p. 39, l. 7: remove 'locally'
- p. 41, l. 8: '...neither as surface nor as subsurface...'
- p. 41, l. 15: 'At the same time...'
- p. 45, l. 26: It should read '...+ 2.093T +...'
- p. 46, l. 5: '...presents...'
- p. 48, l. 1: 'shows that' instead of 'reflects'.
- p. 48, l. 9: Delete 'results of the'.
- p. 49, l. 8: Delete 'While'.
- p. 50, l. 4: '...reveals that the...'
- p. 50, l. 18: 'This implies that the new water component is generated via surface...'
- p. 50, l. 23: '...high percentage ... is due to the low infiltration'
- p. 51, l. 9-12: 'Although the application of the method to semi-arid catchments in Africa is limited ... the outcome from this research also suggests that...'
- p. 52, l. 21: Delete 'results of'.
- p. 52, l. 26: agriculturally.
- p. 53, l. 6: Delete 'quantification of'.
- p. 54, l. 8: '...were used for the first time...'

References:

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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 (2013), What can flux tracking teach us about water age distribution patterns and their temporal dynamics?, *Hydrol. Earth Syst. Sci.*, 17, 533-564, doi:10.5194/hess-17-533-2013.

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Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 10, 10333, 2013.

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