Response to comments by Anonymous Referee #2

We thank Referee #2 for reviewing our paper, the positive feedback on the visualization of the presented data and that the study will be a good addition to the soil water isotope literature

We will first comment on each of the major issues raised by Referee #2 and further respond to each comment by Referee #2 below.

General comments

The authors studied the influence of vegetation on water fluxes in the upper soil compartment of the Scottish Highlands by means of stable water isotopes. Soil samples were taken eleven times over the course of a year and analyzed for their isotopic composition using the direct equilibration method. The authors nicely visualized their results. However, they should consider cutting down the number of figures. I think the paper length should also be reduced by at least five pages, which would help focus on the most important points.

Response: We will revise the manuscript with a special focus on repetition of results and discussion to shorten the manuscript. We will take out the Figure 8 of the original manuscript, since also Referee #1 was commenting on the difficulty to understand it. However, Referee #1 asked for a more detailed description of the direct-equilibration method, which will add a few paragraphs to the manuscript.

There are many repetitions, which unnecessarily blow up the manuscript. What did the authors really expect to find?

Response: *We refer to the literature reviews by Evaristo et al. (2015) and Sprenger et al. (2016) who showed that northern environments have not yet been widely studied regarding their soil water isotope dynamics. Especially the intensity of evaporation fractionation was the main question, since surface waters in an adjacent peatland drainage network showed kinetic a fractionation signal (Sprenger et al. 2017b), but soil water with suction lysimeters in the same experimental catchment showed only limited fractionation (Geris et al. 2015). We therefore believe that the presented results are not just of limited interest to the particular study site, but are more widely and generally relevant for stable isotope dynamics in soils of humid northern environments that have not yet been well studied.*

I think there could also be a more compelling title that illustrates immediately to the potential reader what exactly the paper is about. The title should focus more on the actual findings as the manuscript does not present atmospheric data or detailed data on vegetation (e.g. rooting depth and density) anyway.

Response: We consider changing the title to "Soil water stable isotope reveal evaporation dynamics at the soil-plant-atmosphere interface of the critical zone" in order to clarify what compartment was measured. However, we present rooting depth for the heather and present and discuss the atmospheric driver of the isotope dynamics of the soil water.

The authors pose three research questions. In my opinion, these questions could be more precise. In particular, the third research question cannot really be answered by the results – especially not the atmospheric component.

Response: We will change the research questions as follows to be more specific:

How do precipitation input and the soil water storage mix and affect the soil water isotope dynamics over time?

How can one infer soil evaporation dynamics in the field from soil water isotopic fractionation?

How do soil characteristics, vegetation cover and aspect drive evaporation fractionation dynamics?

With regard to the soil samplings, I would not consider the sampling strategy as high frequent, especially against the background of portable laser spectroscopes which can indeed measure water isotopic composition in-situ with high frequency.

Response: Despite the new possibilities that come with in-situ measurements of pore water stable isotopes, only the recently published study by Oerter, Bowen (2017) applied it to cover almost one year limited to one particular location. However, for the most part, experimental studies used the high frequency sampling with in-situ stable isotope analysis short term investigations covering only a few days (Volkmann et al. 2016; Beyer et al. 2016). Our motivation of the experimental set up was to cover the dynamics that occur within an entire year, capturing seasonal variability at a number of dominant landscape units. We will include the discussion above in the introduction of the revised manuscript.

The authors describe the soil texture of the upper 20 cm as mainly loamy sand. A table, which com- piles all soil properties, would be helpful at this point. Soil properties have been shown to affect the extraction method's isotope results. Do the authors have data on the soil mineralogy (clay mineral composition)? The applied direct equilibration has several downsides: It is less precise for more clayey soils and soils with low water content; storage time is also an issue as it can lead to evaporative water loss through the bag (How long were the bags stored prior to analysis in the present study?) Furthermore, soil organic matter content has been proven to have an effect on gained isotope results. The authors should consider these aspects when discussing their data.

Response: Please see Table 1 for a detailed list of the soil properties. You see that the clay content was generally very low for the studied soils. As referred to in the manuscript, we have tested our method for soil water isotope analysis for its sensitivity of CO2 emissions during the equilibration period of 2 days. The results have been published elsewhere (Sprenger et al. 2017a). This is why we do not pick up this issue in the discussion. We will include in the methods section comments that the conditions at the study site (low clay content and generally high volumetric water content) are in favor of the applied direct-equilibraiton method. We will further mention that the analysis was done within one week after the sampling and that the evaporation losses through the bag can be neglected. A test between different bags (as reported by Sprenger et al. (2015)) showed that the used bag (Weber packaging) loosed less than 0.15% of its stored water over 30 days (details www.hydro.uni-freiburg.de/publ/pubpics/post229).

In sum, I think this paper will make a good addition to the soil water isotope literature, although it does not contain much novel or surprising findings. However, the authors did a great job in data analyses and presentation.

Response: Thanks for the positive feedback, however we strongly disagree that the study lacks novelty. We have not found a study that showed the soil water isotope fractionation in the field over an entire year at sites with contrasting land cover; this alone makes our study highly novel.

Specific comments

P 1 L 13: δ18O

Response: Will be changed as suggested.

P 3 L 1: Thus,. . .

Response: Will be changed as suggested.

P 4 L 14-29: Described in too much detail; consider compiling important soil data in a Table

Response: We will shorten it. Please also see the Table 1.

P 5 L 3-8: Far too detailed

Response: We will shorten it.

P 5 L 24: Not necessary to state model and serial number of the isotope analyzer

Response: We will remove it.

P 6 L 7: Not necessary to reference the python module; please change throughout the manuscript

Response: Will be changed as suggested.

P 8 L 4 –P9 L3: This whole section is again too long. Please condense

Response: We will try to condense this, but we believe that details of the applied statistical analysis are of relevance for the reader.

P 9 L 6: Different font used

Response: Will be changed as suggested.

P 11 Fig. 2: for a) I would suggest to plot the rainfall amount data inversely (top-down) and either change the scale of the axis or the size of the blue star so that they are not cut off; for b) consider including moving averages through the soil data (e.g., moving average for the top and subsoil); describe the color code of the soil data (light brown dots stand for. . .)

Response: We will change the bar plot in a way that the y-axis is inversely and adjust the axis scale to prevent cut off. We will not consider including moving averages, since the physical meaning of such a moving average is questionable, given that we do not know the soil water isotopic composition of up to 30 days between two sampling campaigns.

P 13 Fig. 4: This figure does not add much information; consider deleting this figure. Does the average precipitation input signal represent a 1-yr mean?

Response: We consider taking out this figure.

P 16 chp. 3.2.2.: Include this section in results section 3.1 as it does not add too much new information

Response: We prefer to keep the structure of the results section with a focus on temporal (3.1) and spatial (3.2) variability. The differences in depth would therefore be part of section 3.2.

P 20 chp. 3.2.4 Delete this section. There are no sig. differences in isotopic signatures when considering the aspect.

Response: We consider deleting this section.

P 20 L n134 ff: Repetition; consider deleting

Response: This section will be intensely revisited according to the comments made by Referee #1 on the evaporation estimates.

P 21 L 167-68: bypass flow, really; not so much differences over depth here

Response: We agree that it is difficult to infer from hydrometric data (here GWC) to mixing and will remove that sentence.

P 22 L 175 : Is throughfall data available for these sites to underline this statement?

Response: Yes, we will refer to the throughfall study here as follows: "The higher variability of the SW δ^2H values beneath Scots pine compared to the SW beneath heather (Figure 11) cannot be explained by differences of the throughfall isotopic signal, since they are minor for the two vegetation types (Braun 2015). The higher variability in the isotopic signal therefore indicates that flow paths are generally more variable in the forest soils."

P 24 L 260: Add Gaj et al. (2017b)

Response: Gaj et al. (2017) will be added.

P 24 L 265: This is not a new finding and not really surprising.

Response: If this is not surprising, why is it ignored in studies dealing with root water uptake pattern with the means of stable water isotopes?

P 24 L 269: The authors compare their study with results by Geris et al. (2015a) quite frequently. Is the vegetation cover comparable in both studies?

Response: Yes, here, we refer to their samples taken at site NF, but we state that in the sentence.

P 24 L 277: Debatable that the authors state to see highly dynamic isotope signals.

Response: We refer to Fig. 3 which shows that.

P 25 L 290: What exactly is the angle in your case?

Response: We will add in brackets (4°).

P 25 L 293: gramma: . . .are mainly due to. . .

Response: Will be changed as suggested.

P 26 L 318: In my opinion, the present study does not really unravel interactions occurring in the soil-plant-atmosphere continuum but adds to process understanding of water fluxes through the soil compartment.

Response: Here we simply state that the presented soil water isotope data can be used to improve hydrological models.

Publication bibliography

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Sprenger, Matthias; Tetzlaff, Doerthe; Tunaley, C.; Dick, Jonathan; Soulsby, Chris (2017b): Evaporation fractionation in a peatland drainage network affects stream water isotope composition. In *Water Resour Res* 53 (1), pp. 851–866. DOI: 10.1002/2016WR019258.

Volkmann, Till H. M.; Haberer, K.; Gessler, A.; Weiler, M. (2016): High-resolution isotope measurements resolve rapid ecohydrological dynamics at the soil-plant interface. In *New Phytol* 210 (3), pp. 839–849. DOI: 10.1111/nph.13868.