Response Letter:

Reviewer(s)' Comments to Author:
Comments to the Author
MS#: hess-2023-91

Title: Root water uptake patterns are controlled by tree species interactions and soil water variability

The manuscript provides valuable insights for quantifying the role of throughfall patterns on root water uptake patterns and the drive factor of root water uptake patterns. It is of great significance to understand the effects of throughfall patterns on subsurface water dynamics and the interaction between plant-soil-water systems in forest ecosystems. The study seems interesting Overall, I would recommend this manuscript for publication in HESS after some redivision. The comments and suggestions as follow:

Thank you very much for reading the manuscript carefully and providing your feedback to improve it. We have tried to understand the essence of each comment and make propositions how to accommodate them in the revision.

In the introduction section,

The research methods of root water uptake patterns should be introduced so that we can better understand the subsequent analysis.

We understand, also from later comments, that the methodology on the root water uptake should at least be very briefly mentioned in the introduction. We will do so shortly, mentioning the water balance method and also comparing it to the other methods such as stable water isotope signatures.

Further statements on the effect of throughfall patterns on the variation of soil moisture should be added. For example, some previous studies showed that the weak and short-term influence of throughfall patterns on the soil moisture patterns. However, when the proportion of throughfall is greater, whether this relationship will change.

We are not entirely sure, whether we understand what the reviewer means. We believe the reviewer refers to a potential contradiction between previous results and the research question here, which we ask whether throughfall patterns affect root water uptake. The latter implies that throughfall patterns are retained in the soil in the first place, but previous research shows that this is rarely the case (Metzger et al., 2017). Yet this is an important point. Our research question was motivated by previous research on other sites (Zhu et al., 2021; Metzger et al., 2017; Coenders-Gerrits et al., 2013), and we wanted to address it directly. In addition, we see in a recent paper, (Fischer et al., 2023), that the throughfall patterns leave a slight imprint on the soil water content even after drainage, although other drivers are much stronger. We will add some sentences to the introduction to give more background on this point.

The influence of abiotic factors on water use patterns should also be mentioned.

Thank you for reminding us. We will add a few sentences to mention the effect of abiotic factors on root water uptake which will also improve the communication of the results

regarding abiotic factors that were included in the linear mixed effects model, such as soil bulk density, field capacity etc.

In the Materials and methods section,

What you mean" We measured gross precipitation and throughfall on rainless days"? It is confusing how you can measure total rainfall when there is no rain.

Yes, we understand now that the expression is confusing. What we meant to say is that we read out the collectors during a precipitation-free period. For the weekly sampling we sometimes shifted the days, to catch a rain-free period. We will revise the sentence as follows.

"Gross precipitation and throughfall was read out on days without rain. Thus, the sampling interval ranged between six and eight days depending on the occurrence of rain events."

In 2.4 section, what indicators are used to reflect root water uptake?

We are not sure, what the reviewer means. We derived root water uptake directly from the high-resolution measurements of volumetric soil water content (section 2.4). We checked whether the decrease of soil water storage during daylight hours was larger than that during the night. If this was the case, this decrease was taken as root water uptake. The method was introduced by (Guderle and Hildebrandt, 2015) and shown to perform well on high resolution weighted lysimeters (Guderle et al., 2018).

We will revise the first sentence of the section to improve communication:

"We estimated root water uptake using the multi-step, multi-layer regression method (MSML), which is a water balance method and derives evapotranspiration from diurnal differences in soil water content (Guderle and Hildebrandt, 2015; Guderle et al., 2018)."

How to integrate the water uptake pattern of a single site to the plot scale?

We are not sure we understand what the reviewer means. Probably there is a misunderstanding regarding the scale at which the root water uptake was calculated. Here we do not calculate the root water uptake on the plot or subplot scale but at the microsite scale. We have not attempted any upscaling. In this paper, we are interested in the differences between microsites, i.e., spatial patterns, which are characterized by the soil moisture sensor locations. We then analyze whether microsite root water uptake is higher or lower compared to the other sites using the spatial deviation from the mean (see Line 219-223, at section 2.3.3) We consider including a short explanation in the model section (2.5) that root water uptake was characterized by the sensor location so as not to mislead the reader about the spatial scale.

In the Discussion section:

L454-455: What exactly does root activity mean? How does this study prove that root activity does not alter canopy-attributed heterogeneity in drainage pathways?

We agree that the sentence is vaguely formulated and lacks a clear explanation leading to the question marks as the reviewer pointed out. We will revise the sentences by describing and including exclusive description of the root activity to address these questions.

In the cited study (Guswa, 2012) in the corresponding lines, root activity refers to transpiration, root compensation, and hydraulic redistribution. Guswa (2012), employed numerical experiments to investigate the competing effects of canopy and root processes at the patch scale on water balance, recharge localization, spatial and temporal variability of soil moisture, and the upscaled relationship between mean soil moisture and transpiration. In this study, the water balance and upscaled fluxes were shown to be relatively insensitive to horizontal variability.

How do you prove that bulk density of the monitored soil layer did not affect local water uptake?

This study focused on the effect of soil bulk density on root water uptake, but other soil properties, such as texture and organic matter, affect soil structure and aggregate characteristics, which will indirectly affect water transport in soil and thus affect the water use pattern of plants.

This comment touches on two points (1) how do we see that soil bulk density had no effect (2) even is soil bulk density was not relevant, other soil properties (not measured) may have been.

Regarding (1) we have a clear answer: Soil bulk density did not come out as a significant variable during model selection, and we therefore conclude that it was not an important driver in our setting.

Regarding (2) unfortunately, we do not have measurements of soil organic matter and soil texture at all locations (which really would have been a valuable but equally time-intensive dataset). Therefore, statistically speaking both may have influenced the uptake without us noticing and may be hidden in the random factors. However, from the soil physics perspective soil bulk density is dependent strongly both on texture and soil organic carbon and integrates these two soil properties, because they affect aggregation and soil structure. Therefore, we think that an effect of either texture or soil organic matter would have resulted in soil bulk density being significant, unless they compensate each other, which is unexpected. Note however, that the field capacity was significant and arguably influenced by aggregation as well. Therefore, some signal of soil properties may be contained there. We will add few sentences to the discussion.

Trees with different ages have different physiological structures, such as root system and leaf characteristics, which will affect the water use pattern of plants. The effects of different tree ages on the water use pattern of plants should be discussed.

Agreed. We can add a short section on how our results may have been driven by the demography of the surrounding stand.

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