RESPONSE TO THE REVIEWER COMMENT OF ANONYMOUS REFEREE #2 REGARDING THE MANUSCRIPT "TEMPORAL DYNAMICS OF TREE XYLEM WATER ISOTOPES: IN-SITU MONITORING AND MODELLING"

We would like to thank the anonymous referee for the time they have taken to read our manuscript and their helpful comments to improve it. The referee has left their comments in a digital copy of the manuscript. The smaller annotations regarding orthography will be implemented in the revised version of the manuscript. We will try to summarize the points made in the additional comments (in grey italic letters) and subsequently respond to them.

Lines 100 – 102: The referee calls for a science driven motivation of the study.

We will reformulate the aim of our study into: "*The aim of this study was to investigate the temporal dynamics of xylem water isotopes of mature trees within a field experiment. Making use of the unique possibilities arising from the novel in-situ measurement approach, we wanted to test how far the commonly made assumption of equivalence between the isotopic signatures of RWU and xylem water is true for the case of mature trees.*"

Line 103: It is not clear to the referee how the hypothesis "Xylem water isotopic signatures are equivalent to the isotopic signature of root water uptake" should be tested as xylem water is the only direct gateway to root water uptake. The referee asks with which other method or approach to determining RWU the xylem method should be compared.

By reformulating our study aim, we will drop this specific hypothesis.

Line 138: The referee asks for a derivation or reference to Eq. 6

Will be answered together with the following comment…

Lines 141-142: The referee has plotted the Eq. 6 and doubts the statement that a λ value of 1 would lead to a linear decrease of root densities with distance.

We have to admit, that there is no proper way to derive Eq. 6 in the manuscript. We came up with that equation by iteratively trying out different equations until we fund one which exposed the desired behavior, i.e. an equation that can produce a concave, linear or convex decrease of predicted densities with increasing distance. Apparently, the equation that we actually used differed slightly from the formula depicted in our first manuscript. After the very observant critical referee comment, we revised our choice of the equation and ended up with the following one (behaving similar to the original one, but with a clearer origin):

$$g_r(\mathrm{r}) = 1 - \frac{B_i\left(\frac{r}{r_{max}}, \lambda, 1\right)}{B(\lambda, 1)}$$

This equation is based on the cumulative density function of the beta distribution. *B* is the beta function while B_i is the incomplete beta function. In this equation, the distance decay parameter λ behaves inversely to what we described in the initial manuscript: values smaller than one indicate a faster than linear density decrease, values bigger than one a slower than linear decrease and λ=1 leads to a linear decrease.

Fig.R1a depicts the influence of different values for the distance decay parameter λ and demonstrates the symmetric behavior of the chosen equation, where 1/ λ produces a mirrored version of the distribution that follows from λ.

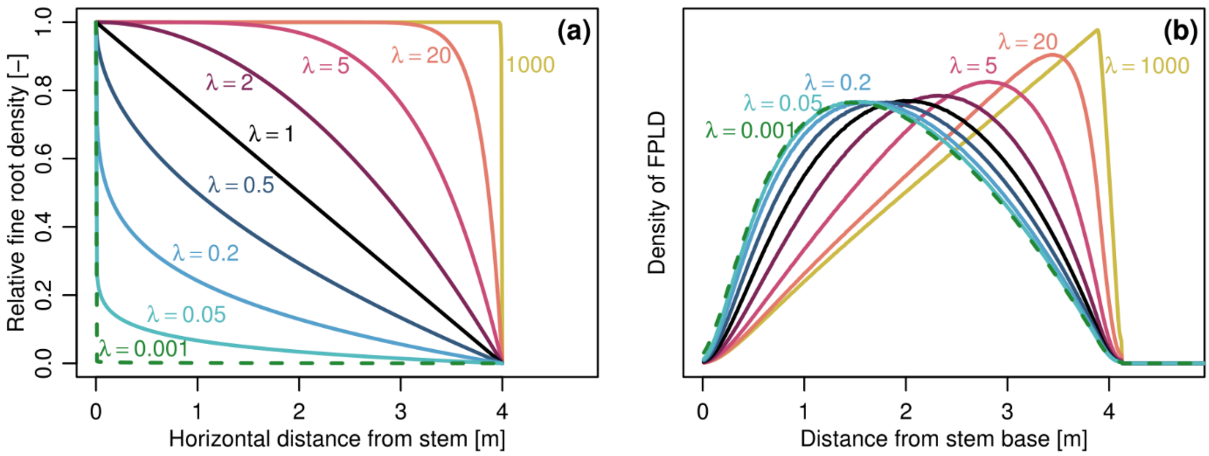

Figure R1: (a) Exemplary depiction of the horizontal fine root density distribution $g_r(r)$ for an r_{max} value of 4 m and a range of different λ values. (b) FPLDs resulting from the same $g_r(r)$ functions as depicted in subfigure (a) and a z_r value of 1 m.

Line 157: The referee wants to know, how we accounted for diffusion and or dispersion of the isotopic signal in the xylem especially during periods of low or no sap flow.

We did not explicitly account for diffusion and dispersion.

Lines 236-239: The referee asks for more information regarding the materials used to build the probes.

We will include more information in the description of the probe design and add the utilized materials.

Line 256: The referee asks for a reference to the Arduino microcontroller platform

We will add a reference to an introductory article on the topic.

Line 291: The referee wants to know why the sap flow measurements have been discontinued in early August

The data logger for the sap flow probes was needed more urgently for another project.

Line 300: The referee wants to know how comparable the four soil moisture profiles were.

As can be expected from a skeleton rich loamy-clayey soil, there were some differences between the single profiles. We will add the information that the used soil moisture data was averaged across the four depth profiles.

Line 337: The referee asks about an estimate of the validity of our assumption of a constant boundary condition for the isotopic signatures in a depth of 2 m

As already mentioned, we did not have any measurements below the specified depths and our boundary conditions are just assumptions that needed to be made one way or another in order to interpolate our measurement data. Regarding the shallow soil and rooting depths (our optimized RWU model suggest that 95% of all fine roots are found above a depth of 90 cm), which were largely covered by our actual observations, we do not think that the chosen hypothetical values at 2-m depth were overly critical for the final outcome of the study.

Line 534: The referee asks whether we tested our assumption of water vapor saturation within the probe head and compared measurements to theoretical values.

Volkmann and Weiler (2014) have tested that for this kind of probe in soil and Marshall et al. (2020) have computed a very fast saturation of added dry air within tree xylem. We have supported our assumption with references.

Lines 535 to 537: The referee wants to know which safety measure we had to avoid sampling from an unsaturated probe head.

We did not have any safety measures to avoid sampling from an unsaturated probe head. But Gaj et al. (2016) have used similar soil probes within much dryer soils in the Namib Desert and their comparisons to destructively obtained samples did not indicate any problems that might be caused by sampling from an unsaturated probe head.

In a yet unpublished experiment, where a similar setup with soil probes placed very close to the soil surface (at 2.5, 5.0, 7.5 and 10 cm depth) ran from April to November 2020, all measurements plotted very close to the meteoric water line. This means that even in those parts of the soil that can be expected to become rather dry we did not observe any obviously conspicuous behavior of the probes at any time throughout a whole summer.

Lines 540 – 541: The referee deems it inevitable to devise a calibration procedure that considers temperatures at each WIP head to make full use of the sub-daily temperature artefacts left in our current calibration procedure.

We would argue that this kind of enhanced calibration procedure is definitely desirable, but as our measurements show, this kind of measurement setup also may provide valuable insights with a basic calibration procedure, especially in connection with isotopic labeling, but also within the range of natural abundances (i.e. ^{18}O during our experiment).

Line 548: The referee asks how the fact that the root distance decay parameter λ could not be identified affected our model results.

As can be seen in Fig R1b, the effective FPLDs for small values of λ do not differ much. A λ value of 1/1000 produces more or less the same FPLD as a λ value of 1/20. Even the FPLD resulting from a λ value of 1/5 is still very similar. Actually, ever smaller – in the original manuscript with the old version of the equation for $g_r(r)$ bigger – values for λ lead to slightly better fits. However, at a certain point towards extreme values of λ rounding errors do occur and the quality of the fits deteriorates.

The idea behind the whole approach was to constrain the FPLD by a reasonable assumption on a (potentially measurable) horizontal distribution of fine roots. Eventually, we came to the conclusion, that the tracer inferred FPLD underlies influences (such as dispersion) which cannot be traced back to macroscopically observable characteristics of the root xylem.

Lines 564-565: The referee asks how diffusion/dispersion have been accounted for.

We did not explicitly account for diffusion and dispersion, but as mentioned in Lines 581 – 586, the fitted parametric distributions based on Eq. 22 (h_{F1} and h_{F2} in Fig 7c) most certainly are implicitly accounting for dispersion effects.

Lines 567-568 and 572-573: The referee asks whether diffusion/dispersion could be used to explain the observed discrepancies between sap flux measurements and observed tracer velocities.

First of all, we could attribute a good part of the observed discrepancy to our lacking wounding correction of v_{sap}, but even with such a correction, as John Marshal pointed out in his comment, Steppe et al. (2010) have shown that sap flux sensors based on the heat pulse dissipation method tend to underestimate actual velocities.

Diffusion might become more important during periods of very low or even stagnant sap flow, but the mean sap flow velocities during our experiment probably were too high for unaccounted diffusion to cause observable discrepancies.

References:

Volkmann, T. H. M. and Weiler, M.: Continual in situ monitoring of pore water stable isotopes in the subsurface, Hydrology and Earth System Sciences, 18, 1819–1833, https://doi.org/10.5194/hess-18-1819-2014, 2014.

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