Response letter to referee 2

General comment of referee 2

This paper describes a study of lignin δ^2H measurements from an Alpine site in Central Europe. Lignin isotope studies complement existing studies based on cellulose, because they it is formed in the xylem and thus less affected by enriched leaf water. The study explores some of the potential influences of the δ^2H_{LM} that can lead to variation between individual trees at the same site, and attempts an air temperature reconstruction for Western Europe. Comparison to an observed temperature record appears promising (with uncertainties). The study is generally well written. I have several comments that could lead to a more comprehensive discussion of some of the findings. I suggest acceptance of the manuscript subject to minor revisions.

General response to referee 2

We appreciate the time and effort Referee #2 has spent on reviewing our manuscript. Below, we address each comment separately and highlighted as follows: *Referee comments* → **Response** → **Changes**. Line referencing refers to the originally submitted manuscript.

Response to main comments of Reviewer 2

1. *In the introduction, the deficiencies of cellulose isotope measurements are discussed. It would be very useful to compare your results with any existing isotope record from cellulose in the region.*

Response: We fully agree that a comparison of the stable isotope signatures from both compounds would be useful. However, to the best of our knowledge, there is no tree-ring chronology of cellulose isotope measurements from the region available with a matching age coverage that would allow a meaningful comparison with our δ^2H_{LM} chronology. We note that high-altitude $\delta^2H_{cellulose}$ or $\delta^{18}O_{cellulose}$ chronologies from the Alps are available in the literature. However, we consider stable isotope chronologies from such sites as not suitable for a comparison with the Hohenpeißenberg δ^2H_{LM} chronology due to potential additional affects on stable water isotopes, such as the altitude effect.
Changes: Unless the referee is aware of any suitable cellulose chronology that we could consider for such a comparison, we suggest no changes.

2. *The groundwater influence is now mostly discussed as a hypothetical factor. It seems unlikely that the groundwater stable isotope composition would vary systematically across the sites at a distance of up to 1 km.*
3. *There are some studies on the isotope composition of runoff, precipitation and water vapour in alpine/subalpine catchments which could enlighten the discussion of the results (Fischer et al. 2017 and references therein, Aemisegger et al., 2014).*

Combined response: We agree that local variabilities in groundwater δ^2H values are an important control on the δ^2H_{precip}-δ^2H_{LM} relationship and can - with the help of other studies - be involved more explicitly in our discussion. However, the suggested studies rather focus on the spatial variability of δ^2H_{precip} values of single or few precipitation events (Aemisegger et al., 2014; Fischer et al., 2017). Since we show strong evidence that δ^2H_{LM} values rather reflect an annual mean of local δ^2H_{precip} (cf.

Fig. 6a), we consider it more suitable to include studies that investigated spatial δ^2H variability of soil water. For instance, the recent study of Goldsmith et al. (2019) analyzed soil water δ^2H values across an 1 ha large temperate forest in central Switzerland (720 m.a.s.l.). They further investigated δ^2H values of water extracted from *Fagus sylvatica* branches from the same area and concluded that the trees primarily used water from deeper soil layers (40 – 50 cm), which showed δ^2H differences of up to 21 ‰. Consequently, there is further evidence that the maximum difference in mean δ^2H_{LM} values among our sampled trees (21 ‰) results from systematic δ^2H differences in soil water. **Changes:** We will integrate the findings of Goldsmith et al. (2019) in our discussion of spatial variability of δ^2H_{precip} and δ^2H_{LM} values.

4. The soil properties and hydrology could be discussed more explicitly. What is the role of snow melt in the local hydrology? What is the soil type, is there permafrost?

Response: Please see the response above regarding the extended discussion of the hydrology and soil properties. Snow falls almost exclusively in December, January and February at Hohenpeißenberg. The study area consists of eutric cambisols and has no permafrost. Adding this information appears helpful although the main aim of this study was to investigate (for the first time) the relationship between instrumental δ^2H_{precip} and δ^2H_{LM} tree-ring series at annual resolution. The potential influences of varying soil properties or hydrology among the micro-sites on the δ^2H_{precip}-δ^2H_{LM} relationship in space and time require a different study design, such as applied by Goldsmith et al. (2019). Even though these are essential aspects for future studies, they are considered to be beyond the scope of this paper. **Changes:** The requested information regarding snow fall, soil type and absence of permafrost will be added to Section '2. Study site and local climate'.

5. The correlation presented in Fig. 7 seems less stable through time than the discussion suggests. The early part is not correlated with the local influences whereas the latter is. Does the same correlation pattern appear for these time slots when you use observed temperature? That way you could reinforce that a climatic signal is picked up, otherwise you would have an indication that the correlation with the isotope measurements is not stable through time.

Response: We estimated temporal variance in correlation between local temperatures (using the 'shifted' annual average) and the δ^2H_{LM} chronology for two 50 years periods. This comparison yields significance for the recent period of 1966-2015 ($r = 0.64$, $p<0.01$) and insignificance for the earlier period 1916-1965 ($r = 0.24$; $p > 0.1$). Hence, the temporal inconsistency in the relationship between local temperature and δ^2H_{LM} agrees with the observed eastward expansion of areas of highest correlation over time (cf. Fig 7b and c). **Changes:** We will add the correlation coefficients mentioned above in Section '4. Results and Discussion'. As mentioned in SC1 to referee #1, we agree that the observed relationship between (large-scale) averaged surface air temperatures and the δ^2H_{LM} chronology indicates inconsistency over time. Even though this current drawback was mentioned and shown in the intital submission (cf. line 322-328 and Fig. 7b and c), a revised manucript requires further highlighting and guidance on how to address this issue in future studies.

6. It would be helpful to show some selected correlations between δ2HLM and δ2Hprecip that are summarized now in Fig. 6 in detail, such as for the annual mean, spring and summer.

Response: Agreed. **Changes:** We will produce new figures showing selected δ^2H_{LM}-δ^2H_{precip} correlations including the annual mean, shifted annual mean, spring and summer. We will include these in the Supplemental section.

7. I am used to ordering multiple references that go with one sentence be by time, rather than alphabetically.

Response: The *Climate of the Past* citation style orders multiple references alphabetically. **Changes:** None.

Aemisegger, F., Pfahl, S., Sodemann, H., Lehner, I., Seneviratne, S. I. and Wernli, H.: Deuterium excess as a proxy for continental moisture recycling and plant transpiration, Atmos. Chem. Phys., 14(8), 4029–4054, doi:10.5194/acp-14-4029-2014, 2014.

Fischer, B. M. C., van Meerveld, H. J. (Ilja. and Seibert, J.: Spatial variability in the isotopic composition of rainfall in a small headwater catchment and its effect on hydrograph separation, J. Hydrol., 547, 755–769, doi:10.1016/j.jhydrol.2017.01.045, 2017.

Goldsmith, G. R., Allen, S. T., Braun, S., Engbersen, N., González-Quijano, C. R., Kirchner, J. W. and Siegwolf, R. T. W.: Spatial variation in throughfall, soil, and plant water isotopes in a temperate forest, Ecohydrology, 12(2), doi:10.1002/eco.2059, 2019.