Response to Anonymous Referee #1

Below, we provide a point-by-point response to each comment. The reviewer's comments are shown in black italics, our responses in blue, and the proposed revised text in red (*Reviewer comment*, Response, Revised text).

Anonymous Referee #1:
The study by Lin et al. presents three new oxygen-18 tree ring cellulose chronologies (d18Otrc) from the Eastern European Plain. The authors present an investigation of the climate signal in the d18Otrc, identifying the regional differences in the hydroclimate response of d18Otrc, including a comparison to the climate signal in traditional tree ring width (TRW) records. The main conclusion is that d18Otrc from the Eastern European Plain is a superior hydroclimate proxy compared to TRW records, and that long-term records for this region can provide important climate constraints for hydroclimate reconstructions and provide context for current and future climate change.
The manuscript is well-written with clearly defined scientific objectives, and the evaluation of the d18Otrc is well designed with extensive testing with reference data ranging from meteorological station data (Temp., precip.), gridded climate data sets (Temp., Rh, …), and output from an isotope enabled climate model (ECHAM5-wiso). References to existing literature is present where appropriate, and references are generally up-to-date, including background information in the introduction and theoretical considerations about the climate signal in d18Otrc and the role of tree physiology.
In conclusion, I consider the study by Lin et al. to be mature and close to be ready for publication after minor revisions taking into account the comments below.
We thank the reviewer for the positive and encouraging assessment of our manuscript. We have carefully considered all comments and suggestions and will revise the manuscript accordingly, as detailed in our responses below.

Specific comments.
Comments 1: *The authors compare to the climate signal in TRW, but there hardly any mention about maximum late wood density (MXD), which is commonly considered to have a stronger link to climate. Please explain why or add a discussion related to this.*
Response 1: Thank you for your comment. We agree that maximum latewood density (MXD) is an important tree-ring climate proxy, particularly in temperature-limited high-latitude and high-elevation regions, where its warm-season temperature response is often stronger than that of tree-ring width (TRW) (Frank and Esper, 2005; Björklund et al., 2019). In contrast, the main focus of the present study is to evaluate the hydroclimatic information recorded by tree-ring proxies. Compared with MXD, TRW chronologies and their climatic responses have been more extensively studied across the East European Plain, and the spatial differences in TRW climate signals along the latitudinal gradient are relatively well established. Previous studies have shown that the dominant climatic controls on TRW vary clearly along this gradient: TRW in the north is mainly limited by summer temperature, the central region is jointly influenced by temperature and moisture conditions, whereas the south gradually shifts toward warm-season moisture limitation (Matskovsky, 2016; Dolgova et al., 2022; Kuznetsova and Solomina, 2022). Therefore, TRW provides a suitable basis for consistent site-to-site comparisons along the latitudinal transect.

In addition, TRW chronologies have already been developed for all three study sites. Therefore, the main aim of this study is to evaluate the complementary hydroclimatic information provided by the newly developed $\delta^{18}O_{TRC}$ chronologies relative to the existing TRW records from the same sites, rather than to compare $\delta^{18}O_{TRC}$ with all available tree-ring proxies. We agree that MXD can provide important complementary information, particularly on warm-season temperature variability. Therefore, we have added a discussion of MXD and quantitative wood anatomy (QWA) as complementary proxies, as detailed below.

Added text in the Discussion (after original Line 439): The contrasting climate responses of $\delta^{18}O_{TRC}$ and TRW observed in this study indicate that different tree-ring proxies record complementary climatic information. Previous studies have shown that, in temperature-limited environments, maximum latewood density (MXD) and some quantitative wood-anatomical traits generally exhibit stronger warm-season temperature signals than TRW and have been widely used to reconstruct warm-season temperature variability (Björklund et al., 2019, 2023). By contrast, stable carbon and oxygen isotopes can provide complementary information on tree physiological responses and hydroclimatic processes (McCarroll and Loader, 2004). Therefore, future multiproxy studies combining TRW, MXD, quantitative wood anatomy, and stable carbon and oxygen isotopes across the East European Plain could help more effectively disentangle regional temperature and moisture signals.

Comments 2: *Similarly, quantitative wood anatomy (QWA) analysis shows stronger climate signal than TRW and MXD (e.g., Björklund et al., 2023). Could QWA be a way to extract more climate information for your Eastern European Plain sites?*

Response 2: Thank you for your comment. We agree that quantitative wood anatomy (QWA) can provide climatic information at the cellular scale. Particularly in temperature-limited high-latitude environments, some wood-anatomical traits can exhibit stronger warm-season temperature signals than TRW and MXD and therefore have considerable potential for temperature reconstruction (Björklund et al., 2023). QWA could thus provide additional climatic information for the East European Plain, especially regarding warm-season temperature variability, whereas the main focus of the present study is to evaluate the hydroclimatic information recorded by tree-ring proxies.

As noted in Response 1, the present study primarily compares the newly developed $\delta^{18}O_{TRC}$ chronologies with the existing TRW chronologies from the same sites to evaluate the complementary hydroclimatic information provided by $\delta^{18}O_{TRC}$. We have therefore added a discussion highlighting the potential of future multiproxy studies combining QWA, MXD, TRW, and tree-ring stable isotopes to provide more comprehensive information on regional temperature and moisture variability. The corresponding added text is provided in Response 1.

Comments 3: *The three different sites show different seasonality in the relations to climate parameters. Can you provide explanations for this? For example, spring ground water recharge from snow melt at the northern site which could account for the lagged winter signal recorded in d18Otrc, or is regional differences in auto-correlation of climate parameters/weather patterns enough to result in spurious significant correlations (for example due to large scale winter variability (NAO/EA/SCA patterns, Comas-Bru & Hernández, 2018))?*

Response 3: Thank you for this comment. In addition to recording summer hydroclimatic signals, $\delta^{18}O_{TRC}$ at all three sites also shows relationships with temperature during the previous cold season and the current spring, although the strongest response windows differ among sites. The northern site shows its strongest relationship with maximum temperature from March to September of the current year, whereas the central and southern sites show their strongest relationships with mean temperature from the previous October to the current September.

To examine whether these cross-seasonal signals could be caused by interseasonal temperature covariance, we further calculated the correlations between June–August mean temperature and mean temperature during the previous October–November and the current March–April (Table R1). The results show that only at the northern site was summer temperature significantly correlated with spring temperature ($r = 0.38$, $p < 0.01$), whereas all other correlations were not significant. Therefore, interseasonal temperature covariance may partly explain the extended spring–summer response window at the northern site, but cannot fully explain the preceding cold-season and spring temperature signals observed across all three sites.

As suggested by the reviewer, the preceding cold-season signal may also be related to the delayed influence of snow accumulation and snowmelt on tree source water. Cold-season precipitation can be stored as snow and subsequently enter soil water or shallow water reservoirs during spring snowmelt, where it may remain available for tree uptake during the growing season. A similar mechanism has been proposed to explain winter signals in Greenland tree-ring $\delta^{18}O$ records (Xu et al., 2021). However, because our study lacks direct observations of snowpack, soil-water isotopes, and xylem-water isotopes, this mechanism can only be considered a possible explanation.

We also examined the relationships between the three $\delta^{18}O_{TRC}$ chronologies and the North Atlantic Oscillation (NAO), East Atlantic (EA), and Scandinavian (SCAND) indices (Figure R1). These indices were obtained **from** the KNMI Climate Explorer. The results show no significant relationships at any of the three sites during the previous October–November. During March–April, only isolated significant relationships were observed, including a negative correlation between $\delta^{18}O_{TRC}$ and SCAND at the central site and a positive correlation between $\delta^{18}O_{TRC}$ and EA at the southern site. These relationships lack consistent spatial and seasonal patterns. Therefore, there is currently no clear evidence that NAO, EA, or SCAND provides a common explanation for the preceding cold-season and spring signals across the three sites.

Overall, neither interseasonal temperature covariance nor direct statistical relationships with large-scale circulation patterns are sufficient to explain the cross-seasonal temperature relationships observed across the three sites. Snowmelt and antecedent water storage may represent a possible mechanism, but the available data do not allow reliable attribution. We therefore provide these additional analyses in response to the reviewer's comment, but given the lack of a clear conclusion and the focus of this study on summer hydroclimate variability, we do not further elaborate on these possible mechanisms in the Discussion.

Table R1: Correlations between summer mean temperature and mean temperature during the previous October–November and the current March–April at the three study sites.

Site	JJA vs. previous Oct–Nov	JJA vs. Mar–Apr
Northern (1950-2021)	0.05 ($p > 0.05$)	0.38 ($p < 0.01$)
Central (1950-2020)	0.002 ($p > 0.05$)	0.16 ($p > 0.05$)
Southern (1950-2014)	0.24 ($p > 0.05$)	0.14 ($p > 0.05$)

JJA denotes June–August, previous Oct–Nov denotes October–November of the previous year, and Mar–Apr denotes March–April of the current year.

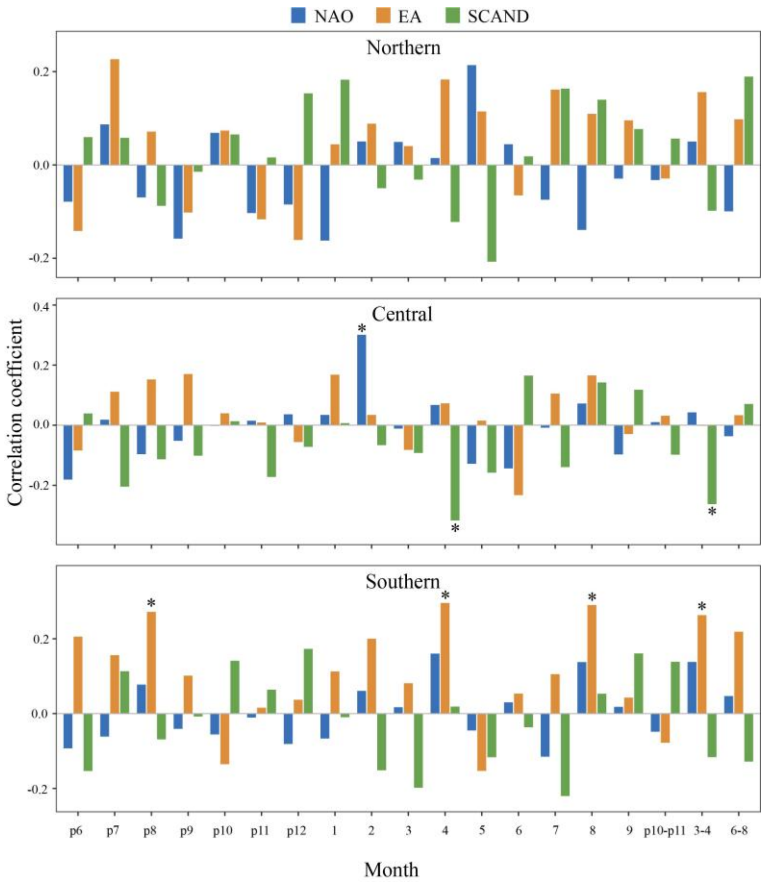

Figure R1: Correlations between the $\delta^{18}O_{TRC}$ chronologies and the NAO, EA, and SCAND indices at the three study sites. Asterisks indicate statistically significant correlations at $p < 0.05$.

References

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