Anonymous referee #2

R: We thank the anonymous referee #2 for the time and effort in reviewing our manuscript (cp-2020-39). The comments, suggestions, critics and feedback raised in the review are highly appreciated as they help us to clarify our statements and to improve the quality of our manuscript. Below you will find a point by point response (*reviewer*, response) regarding the suggestions and concerns raised throughout the review process.

Summary

The authors investigate delta18O tree ring records of 26 site distributed over Europe for the last 400 years. They claim that they were able to identify a connection of the leading mode of variability of this data to El Nino Southern Oscillation. They speculate that this connection is only found in the last 130 years and thus the connection is not stable in time. The second mode of the data is suggested to reconstruct regional summer atmospheric circulation. Finally, the author team claim that delta18O tree ring records can be used to reconstruct atmospheric circulation.

General comments

The topic would certainly be of high interests. However, the authors fail to convincingly show evidence for their main claims listed in the summary. Therefore, I recommend to reject the manuscript.

Major comments

1. At several places in the manuscript the authors claim that their analysis suggests "the relationship between ENSO and the European climate may not stable over time". The connection is only found for the instrumental period after 1850 CE. I think the first order interpretation is that the reconstruction of ENSO might be not perfect, as normally the reconstruction methods are trained in the last 100 to 150 years. So differences between the training periods and the period before are a hint that the reconstruction might be not successful. So, from your analysis you cannot conclude that you have identified non stationarity of teleconnections.

R: We thank the reviewer for this comment. It stresses that we have to put further work into the manuscript clarifying our results and interpretations as we are not intending to say that we have identified a non-stationarity teleconnection. We only say that the correlations and coincidence rates are weakening, which indicates that the relationship between PC1 of the δ18Ocel network and ENSO might not be stable over time. Therefore, we can only suggest that the relationship between ENSO and the European climate may be not stable over time which is supported also by other studies based on proxy data (e.g. Rimbu et al., 2003). The idea of a unstable relationship is also supported by the results from studies based on instrumental data (e.g. Fraedrich, 1994; Fraedrich and Müller, 1992; Pozo-Vázquez et al., 2005) or studies based on ocean-atmosphere coupled models (e.g. Raible et al., 2004; Deser et al., 2006; Brönnimann et al., 2007) The fact that the relationship between climate variables and ENSO is not stable over time has been also recognized in tree-ring studies in other regions, e.g. South Amerika (Álvarez et al., 2015). Nevertheless, we are aware of the fact that further research is necessary to make a confident statement.

It is true that reconstructed ENSO indices before instrumental period are not perfect which could be the cause of decrease in the correlations between our PC1 and these indices before 1850s. However, it is also true, that 1850s represent the end of Little Ice Age (LIA) period, when ENSO properties and its teleconnections changed significantly. Modeling studies (e.g. Henke et al., 2017) report an increased frequency of El Nino during LIA due to southern displacement of ITCZ. Although the reviewer hypothesis could be true, also our interpretation that decreasing in the correlation between our PC1 and reconstructed ENSO indices is due to changes in ENSO teleconnections over Europe could be true.

We agree with the reviewer that a comparison with ENSO reconstruction which are trained within the last 150 years can be problematic, since every reconstruction has its own uncertainties and limits. Confident statements are only possible for the time from 1850 onwards, since instrumental measurements of different climate variables are available. However, the usage of climate reconstructions is the only possibility to test and analyze the teleconnection before 1850 because no observational data is available. Overall, we tested the relationship with three different reconstructions for two different time ranges, where the sample density of isotope network is relatively high and the correlation is getting weaker over time (Li et al., 2011; Li et al., 2013; Dätwyler et al., 2019) which is shown in Table 1. Not only the correlation between the first component of the $\delta^{18}O_{cel}$ network and the ENSO reconstructions is getting weaker, also the correlation between different ENSO reconstructions is getting weaker in the 18th century which was shown for specific periods in Dätwyler et al. (2019). They suggest that is based on changes of the ENSO teleconnections, because they found a consistent teleconnection pattern that is different to the known teleconnection pattern of ENSO in the instrumental period (Dätwyler et al., 2019). Based on this argumentation and comment of the reviewer, we will write more carefully about the stationarity of teleconnections and the stability in the revised version of the manuscript.

	LI ET AL. 2011	**LI ET AL. 2013**	**DÄTWYLER ET AL. 2019**
1750-1849	r=0.121 p-value=0.231	r=-0.008 p-value=0.936	r=-0.078 p-value=0.442
1850-1949	r=0.223 p-value=0.026	r=0.303 p-value=0.002	r=0.296 p-value=0.003

Table 1: Correlation between the first component of the $\delta^{18}O_{cel}$ network with three different ENSO reconstructions for two different time periods.

In order to show how stable the connection between the sea surface temperature (SST) of the tropics and the first mode of $\delta^{18}O_{cel}$ is, we have computed stability maps of the correlation between these two quantities. The stability map is a tool which is primarily used for streamflow predictions to identify stable teleconnection (for more details see Ionita et al. (2008), Lohmann et al. (2005) or Rimbu et al. (2005)). SST anomalies from the Extended Reconstructed Sea Surface Temperature (ERSST) v5 dataset (Huang et al., 2017) have been correlated with the first mode of $\delta^{18}O_{cel}$ in a moving window of 21 years. The correlation is considered to be stable for those grid points where anomalies are significantly correlated at the 90% level ($r = 0.25$) for more than 80% of the 21-yr windows, covering the period 1850–2005. This is shown in Figure 1. The results from the stability maps analysis will be also integrated in the revised version of the manuscript.

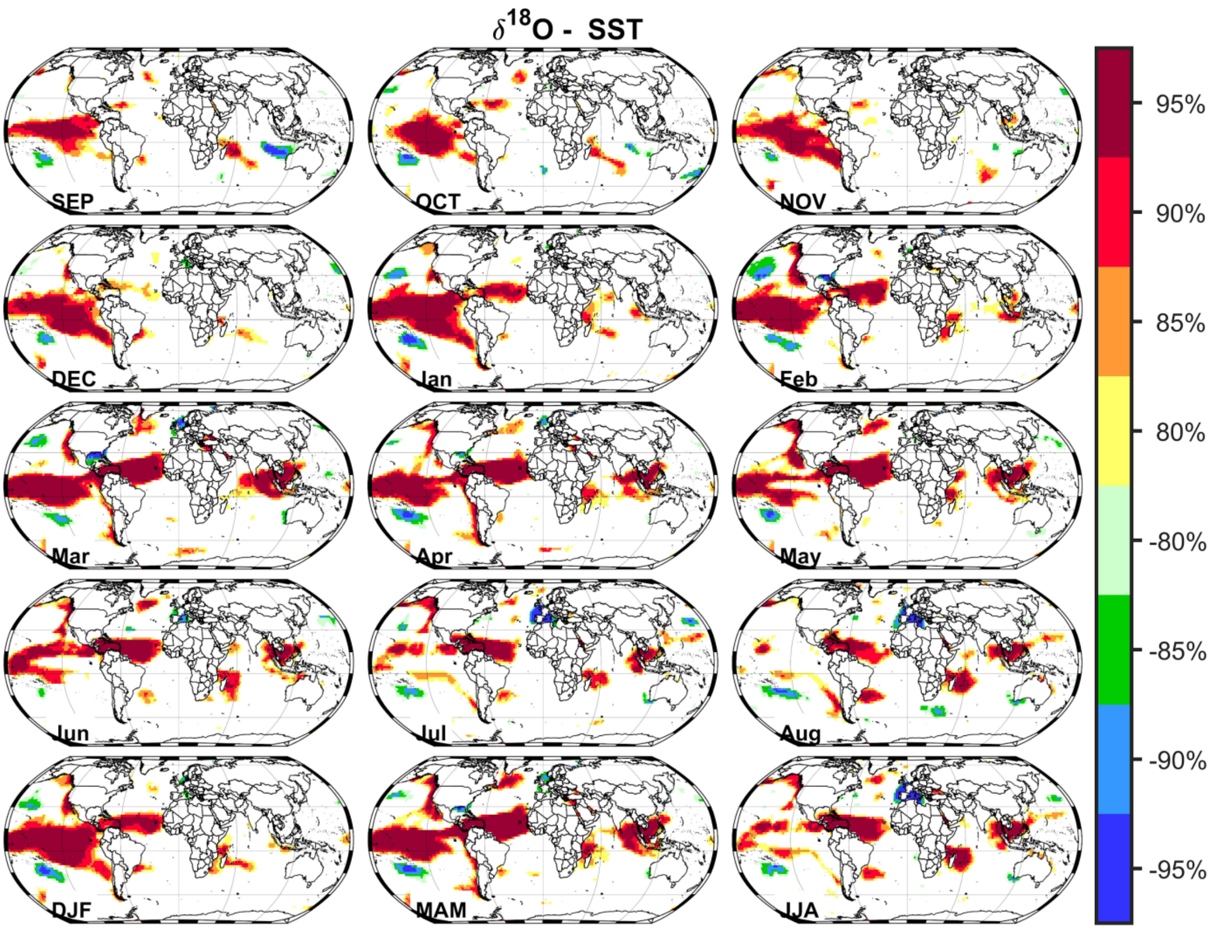

Figure 1: Stability maps for the correlation between SST anomalies (Huang et al., 2017) and the first mode of $\delta^{18}O_{cel}$. The color bar indicates how many years are characterized by a significant correlation (at the 90% level) in a 21-yr window, covering the period 1850–2005. Positive correlations are shown from yellowish to reddish and negative correlations from greenish to blueish.

As it can be inferred from Figure 1 (below), one of the largest locations with stable correlations is located in the tropical Pacific. Stable correlations are shown from September (last year) to June which also supports our result that $\delta^{18}O_{cel}$ is able to capture a multi-seasonal signal and that the first mode of $\delta^{18}O_{cel}$ is sensitive for ENSO variability. With the help of these maps, it is also possible to track the development of the correlation over time. During July and August, the pattern dissolves in the tropical Pacific whereas a stable negative correlation is shown around Europe. Based on these results, we suggest that the relation between the first mode of $\delta^{18}O_{cel}$ and the SST in the tropical Pacific/Atlantic in winter and spring is stable in the period from 1850 to 2005. We will add the shown figure in the appendix of the revised version of the manuscript and we will discuss why $\delta^{18}O_{cel}$ is able to capture this stable teleconnection.

2. The conclusion that the analysis shows that "We infer that the investigation of large- scale atmospheric circulation patterns and related teleconnections far beyond instrumental records can be done with oxygen isotopic signature derived from tree rings." is not convincingly demonstrated. There is only 2 line in the introduction which gives a hint why this should be possible, i.e., fractionation happens during the transport from source to sink areas. Most of the studies however try to reconstruct temperature and precipitation when using delta18O as delta18O is first order temperature dependent. The authors also nicely discuss that fractionation processes are also relevant within the tree. Then, at the different sites the water can be transported form different source regions during the seasonal cycle, e.g., North Atlantic versus Mediterranean, or long distance transport versus local water recycling. Moreover, seasonality plays an important role, so mostly tree ring records are interpreted to record growing season signals and not winter signals. So given all these uncertainties how can the transport aspect (which is related to the atmospheric circulation) survive?

R: We agree with the reviewer that transport can lead to uncertainties. The earth system is interconnected and includes many factors that make it hard to identify a single cause. Nevertheless, we think that the aforementioned statement of the reviewer is somehow mixes up several points. First of all, the source of oxygen isotopes in cellulose is mostly the water from the atmosphere. Through precipitation, the soil gets enriched with water and depending on the length and depth of the root system, a tree uses surface water or water from groundwater reservoirs for photosynthesis processes. Therefore, $\delta^{18}O_{cel}$ is coupled to the hydrological cycle on Earth. This cycle is strongly dependent on large-scale atmospheric circulation, since large-scale flows determine the path of clouds, precipitation patterns and the distribution of water vapor in the atmosphere. Also, the mentioned water transport from different source regions is related to large-scale atmospheric circulation. Synoptic patterns and associated indices (e.g. cyclone and anticyclone activity, air pressure) have also been reconstructed from $\delta^{18}O_{cel}$, with stronger correlations revealed during extreme years or periods (e.g. Saurer et al., 2012). $\delta^{18}O_{cel}$ is related to the $\delta^{18}O$ of the precipitation source via soil water. $\delta^{18}O$ of soil water constitutes the $\delta^{18}O$ input to the arboreal system and represents an average $\delta^{18}O$ over several precipitation events modified by partial evaporation from the soil (depending on soil texture and porosity) and by a possible time lag, depending on rooting depth (Saurer et al., 2012). $\delta^{18}O_{cel}$ is further dependent on two tree-internal processes: evaporative ^{18}O-enrichment of leaf or needle water via transpiration, as well as biochemical fractionations and isotopic exchange of $\delta^{18}O$ with trunk water during cellulose biosynthesis (e.g. Barbour, 2007; Kahmen et al., 2011; Roden et al., 2000; Saurer et al., 2012; Treydte et al., 2014). Fractionations occurring at leaf level, are partly reset by isotopic exchange between sugar oxygen and stem water during cellulose synthesis in the trunk allowing the soil water isotopic signal to be largely preserved in the tree-ring cellulose (e.g. Gessler et al., 2014 and citations therein).

The seasonality is essential since trees store the climate signal within the $\delta^{18}O_{cel}$ ratio during the growing season. One of the key messages of the manuscript is that winter climate signals can be stored which is shown by significant correlation plots (Figure 6). We argue that this is possible through hydrological feedback processes (e.g. via the soil moisture content). The fact that trees are able to store a winter signal is not new and was published for example by Treydte et al. (2006) and Treydte et al. (2014).

With the knowledge about the physical climate processes (the hydrological cycle) and the understanding of the theory behind the fractionation of $\delta^{18}O_{cel}$ ratio, we feel that the points mentioned by the reviewer are not uncertainties. They are part of the climate system and essential for the understanding of climate proxies.

3. For the first EOF I have a different interpretation, which takes into account the fact that temperature play the dominant role in delta18O. What we see is a monopole structure. The authors claim to see a link to ENSO. I hypothesize that the link is simply due to the fact that ENSO has a global impact on the global mean temperature. So, due to an El Nino event, the Earth warms and thus also the North Atlantic and the Mediterranean (visible in the composite plots). Warmer source regions affect the fractionation of delta18O without any change of the circulation we see in the sink regions (at the tree sites) a uniform signal.

R: The climate over the European region has a rather peculiar variability, and in most of the cases the first EOF is monopolar, especially if we consider mostly the central and western part of Europe in the analysis (like in our isotope network). This is valid for precipitation, temperature and even for drought indices. As we discussed in the first point raised by the reviewer, we disagree that the relationship with ENSO is purely by chance given the tests of statistical significance. The fact that PC1 correlates significantly with the SST from the tropical Pacific in winter and this signal is transmitted to the tropical Atlantic in spring and central Atlantic in summer is part of the natural cycle of ENSO. The ENSO anomalies (either El Niño or La Niña) develop in winter and it needs 3-6 months to see a signal in the European climate. This lagged relationship is typical for many ENSO related teleconnections. This long transition from the tropical Pacific to central North Atlantic affects in turn the large-scale atmospheric circulation and as a consequence the climate over Europe, especially in spring and summer. We do not agree with the idea that just because we have El Niño or La Niña the earth will be either warm or colder. ENSO dynamics are more complicated than this and the signal from ENSO to the $\delta^{18}O$ is transmitted mainly via the large-scale atmospheric circulation.

On the composite maps the ENSO teleconnection patterns are clearly emphasized. This means that there is not only a thermodynamical influence on $\delta^{18}O$, that is variation of global temperature with ENSO, playing a role, but also ENSO related teleconnections impact on European climate is important.

4. There are problems with the data (see comment below Section 2.2, L132-140, L145) ignored which might be influential to the analysis.

R: In the revised version of the manuscript we will make a better description of Section 2.2 so it is clearer for the reader which data are used. We will add the source of the data also in the figure caption, for each figure (where needed). Please see our detailed answers and argumentation to the aforementioned comment below.

Minor comments

L18: What is meant by "reflects a multi-seasonal climatic signal."? ENSO works on timescales of 3 to 7 years.

R: Quote from the submitted manuscript (L17-18): "The first mode of $\delta^{18}O$ variability is associated with anomaly patterns of the El Niño-Southern Oscillation (ENSO) and reflects a multi-seasonal climatic signal". So, the last part of the sentence is connected to the first mode of $\delta^{18}O$ which means that the first mode of $\delta^{18}O$ variability reflects a multi-seasonal climatic signal. The multi-seasonal climatic signal stored in $\delta^{18}O$ is essential to capture El Niño/La Niña events and the related ENSO variability.

L20: "out of phase variability": I would interpret this in the time and not in space as the authors. Just say the 2. EOF is a dipole pattern with centers over northwestern and southeastern Europe.

R: Thank you for the suggestion. We will rewrite it in the revised version of the manuscript.

L47-50: Hard to read.

R: We will rewrite the mentioned section.

L53: please change to "leaf water clearly affects"

R: We will change it in the new version of the manuscript.

L55: I disagree with this statement, see major comments 2 and 3.

R: In this point, we disagree with the reviewer. Please have a look above for our argumentation.

L56: What is meant by "resulting long-term perspective"? Where does it result from?

R: Thanks to the reviewer for highlighting this. We mean the long-term perspective that results from the usage of $\delta^{18}O_{cel}$ as a climate proxy. We will rewrite the sentence to make it clearer.

L84: Created -> generated

R: We will change it.

L88: Please include a space between number and unit throughout the manuscript.

R: Good point. We will improve it in the new version of the manuscript.

L91: What is SMOW?

R: It should be VSMOW (Vienna Standard Mean Ocean Water). We will rewrite it.

Section 2.1: Which method is used to get the delta18O samples from trees. This is relevant as studies show that the method (pooling or not pooling) makes a huge difference Hangartner et al. Methods to merge overlapping tree-ring isotope series to generate multi-centennial chronologies CHEMICAL GEOLOGY Volume: âAR 294 Pages: âAR 127-134 Published: âAR FEB 10 2012

R: We agree with the reviewer that further information about the sampling method is very important. According to Treydte et. al (2007a, b), all tree rings from the same year were pooled prior to cellulose for the majority of sites. We will add this in Section 2.1 in the revised version of the manuscript.

Section 2.2: Again if is unclear what the authors are using. Is it the ensemble mean of 20CR or an individual ensemble member. Please note that the 20CR is only constraint with sea level pressure (SLP) data so no sea surface temperatures (SST) are used which are relevant for ENSO. My guess is that the authors use the ensemble mean. This is problematic as in the early part of the reanalysis the constraint (via SLP) is rather weak leading variance deflation and thus can have a strong impact on the analysis (so it is normally recommended to use all individual ensemble members). As said, the other problem is that ENSO might not be realistically included in the first part of the reanalysis.

R: The argumentation that 20CR (V2c) is not using SST is not correct since the SST dataset from 18 members of Simple Ocean Data Assimilation with Sparse Input version 2 (SODAsi.2, Giese et al., 2016) are used as SST boundary condition (the high latitudes (>60°) were corrected to COBE-SST2 (Hirahara et al. 2014)). Furthermore, the sea ice cover (SIC) reconstruction of Hirahara et al. (2014) are also used as boundary condition (for more details see https://www.psl.noaa.gov/data/gridded/data.20thC_ReanV2c.html). Therefore, the SST and SIC are influencing the atmosphere (Compo et al, 2011) and therefore, ENSO activity is represented in 20CR (V2c).

In our study, we used the ensemble mean of 20CR (V2c). The ensemble spread is definitely bigger at the beginning compared to the end. In our opinion, this is not the reason why we will not use the ensemble mean especially if we focus on around 150 years of the reanalysis. Furthermore, the advantage of our study is that we are focusing on the climate in Europe. For this continent the effect of large ensemble spread at the beginning of 20CR (V2c) is relatively minor compared to other continents since a lot of observations are available from the beginning of the observation period.

Section 2.3: too short and not clear why the simulations are used and how the simulations are generated. The reader needs to understand which model is used and how, just references is not enough.

R: We thank the reviewer for the comment. We will extend the section and explain the nudged model simulations in more detail in the revised version of the manuscript.

Section 2.4: It reads like EOF and PCA are different analysis, but actually they are not. The method of empirical orthogonal function (EOF) analysis is a decomposition of a data set in terms of orthogonal basis functions determined from this data. Thus it is the same as geographically weighted PCAs.

R: We identify the dominant pattern of $\delta^{18}O_{cel}$ variability using Empirical Orthogonal Function (EOF) analysis (von Storch and Zwiers, 1999). This helps to eliminate the noise from the data and identify the climatic signal (etc.).

The concept of the Principal Component Analysis (PCA) was firstly described by Pearson (1902) and Hotteling (1935) and used for the first time by Lorenz (1959) for climatological research (Storch & Zwiers, 1999). The general aim of the PCA is to find a new set of axes which explains the most part of the variability within the dataset. This is done by rotating the initial data onto axes which are orthogonal to each other (Schönwiese, 2013). For this purpose, a vector is necessary which indicates the direction of the new coordinate axis which is called eigenvector. This type of vector doesn't change its direction by a rotation. Therefore, the eigenvectors are used as a transformation matrix for the input high dimensional datasets onto the new axis. To indicate if a rotation maximizes the explained variance, every eigenvector has a corresponding eigenvalue. The corresponding eigenvalue is a kind of stretch factor for the eigenvectors. A huge eigenvalue indicates that the eigenvector has to be strongly stretched to map high variabilities within the dataset which can be explained with the new set of axes. Therefore, the eigenvalue (λ) is equal to the variance of the time series ($\vec{X}$) from matrix M which got rotated by the corresponding eigenvector ($\vec{e}$) (Equation 1).

$$Var(\langle \vec{X}, \vec{e} \rangle) = \lambda \quad (1)$$

To find a first set of eigenvalues and eigenvectors, the data is rotated until an axis can be defined which explains the highest variance. Storch & Zwiers (1999) described this with the effort of minimizing ϵ_1 respectively to maximize $Var(\langle \vec{X}, \vec{e}^1 \rangle)$(Equation 2).

$$\epsilon_1 = Var(\vec{X}) - Var(\langle \vec{X}, \vec{e}^1 \rangle) \quad (2)$$

Finally, the rotated data forms the first component. Like in a traditional coordinate system, it is possible to calculate a new axis which is orthogonal to the first one. Therefore, the second component is formed by an orthogonal rotation around the axis of the first component. The total number of components is given by the absolute number of time series. To compute the time series for the first component, the e.g. first value of all input time series is multiplied with the individual eigenvector and afterwards, summed up over all time series for each year. This process forms the time series of a principle component which has the same temporal coverage as the input time series.

Especially a separate analysis of the eigenvectors of $\overrightarrow{X}$ is commonly used. This analysis is known as Empirical Orthogonal Functions (EOF) and the goal of it is to identify spatially coherent climate patterns which explain a significant part of the variance for a specific region (this is shown and used for example in Ionita et al. (2008)). Therefore, the largest part of the variance can be explained by the pattern of the leading EOF.

L132-140: How many tree ring records cover the entire period with no gaps? How sensitive it the analysis to filling the gaps? How many cycles are needed to reach convergence? What if you use only the tree ring records which cover the entire period?

R: The temporal coverage is listed in Line 100-102. "Here, we use the extended ISONET+ product with the longest chronologies covering a period from 1600 to 2005. The highest data density is available for the period 1850-1998 with 26 time series available for further analysis. 12 time series cover the entire period of 400 years." The 12 time series, which are mentioned at the end, cover the entire period. Our goal is to use all time series of the ISONET+ product and therefore, we have to fill the gaps. If we calculate the EOFs and PCs for the period 1850 to 1998 the spatial and temporal correlation to the EOFs and PCs is very high. If we remove samples in the period 1850 to 1998, also the PCs and EOFs are changing because the input variability of the network is changing. The results are similar patterns, but the temporal and spatial correlation is varying. For a comparison, the reader is referred to the publication of the used isotope network of Treydte et al (2007b).

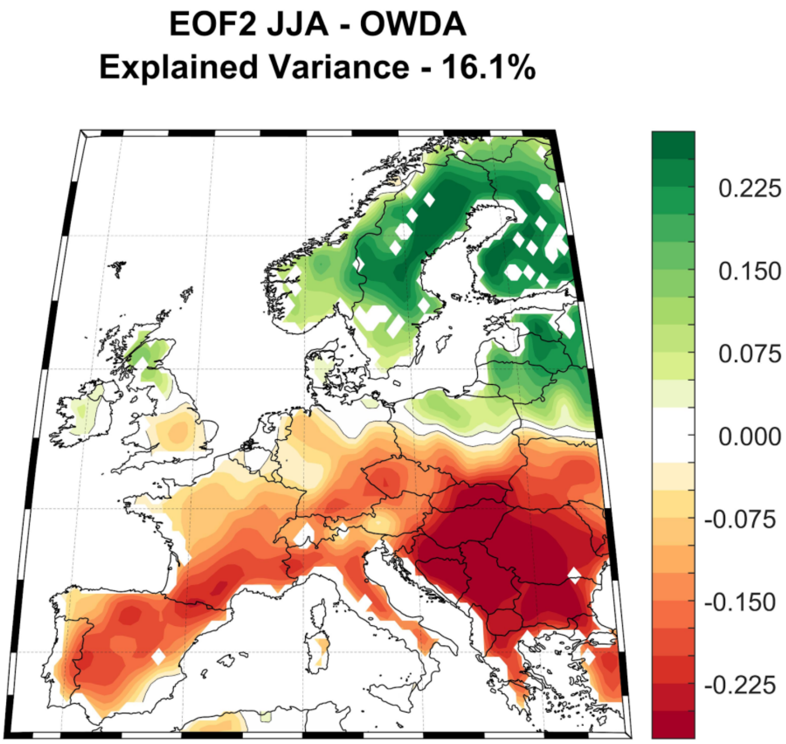

Figure 2: The EOF for the second component of the OWDA (Cook et al., 2015) for JJA which explains 16.1% of the variance.

To test if our results are influenced by the gap filling method, we tested the correlation with the reconstruction with summer wetness and dryness reconstruction from the Old World Drought Atlas (OWDA) which was developed by Cook et al. (2015). At first, we investigated the correlation between the first 4 PCs for JJA with the PC1 of the isotope network for the period 1850 to 2005, where we have closely the highest sample density. The highest correlation is detected with the PC2 (EOF plot below) of Cook et al. (2015). The component is explaining 16.1% of the variance (very similar to the explained variance of the first component of the isotope network) and the correlation is characterized by Pearson's R=0.43 and p-value=3.1e^-08. If we test the correlation for the entire period 1600 to 2005, it would be expected that the correlation is strongly changing in the case that the filling algorithm is influencing the representation of climate signals. In our study, the correlation is only slightly changing to Pearson's R=0.39 (p-value=4.2e^-16) which indicates that the influence of the filling algorithm on the results is not so strong, because climate signals are presented in a similar manner as in comparison for the period with a high sample coverage. Nevertheless, we have to consider the uncertainties based on the used gap filling method, especially for the first decades where the sample density is low. Therefore, the interpretation of the first decades need to be handled with care, and statements should be regarded as less robust.

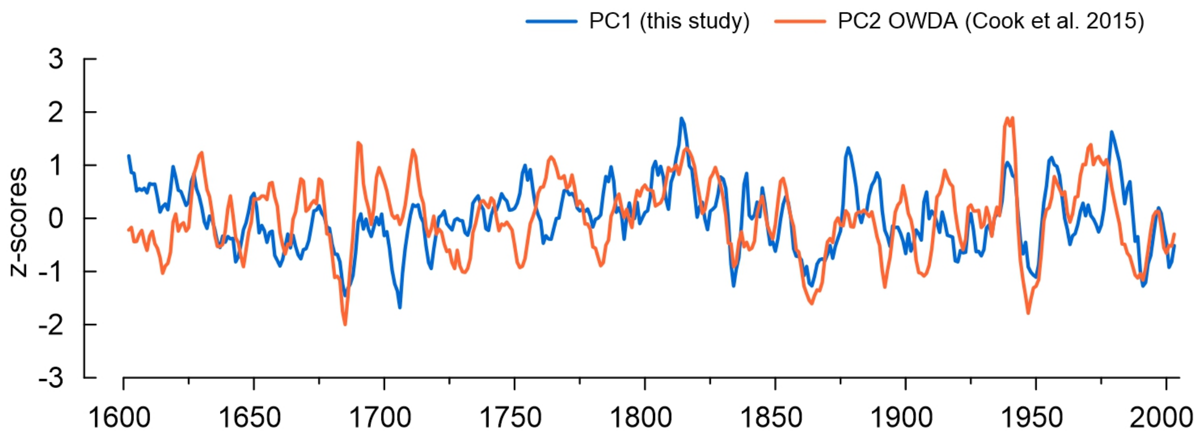

Figure 3: Comparison of the time series of the first component of our study and the second component of the OWDA (Cook et al., 2015) for JJA.

L142: This is certainly not extreme.

R: The detection of extremes by using the standard deviation is often used in climate science. There are many other definitions of extremes. We decided to use the standard deviation as an approximation given the available degrees of freedom. These extremes may not be extremely rare but certainly unusual and different from the mean.

L145: I would say that the authors misuse the composite analysis by focusing on the linear response. If they would like to analyze the linear response, a simple correlation analysis is enough. The beauty of the composite analysis is that you can easily show non-linear effects, but only if you make the difference between the mean above the threshold with the long term mean and in a second plot the mean below the negative threshold and the long term mean. This was done by Fraedrich 1992 mentioned in the manuscript. He highlighted the nonlinearity of the ENSO response over Europe and thus is in contradiction to the linear relationship suggested here.

R: We think that this point is a misunderstanding of our idea because we used the composite maps to learn more about the linear response. It is not our aim to test relation for non-linearities. The reference of Fraedrich (1992) is used to highlight the uncertainties and show the reader that the shown relationship in the results cannot be seen as linear. In the revised version of the manuscript we will replace the figures with new figures in which we show both the high (PC1 > 1 standard deviation) and low high (PC1 < -1 standard deviation) composite maps. There are cases in which the high and low composite maps show different results, thus indicating non-linearity between the variables analyzed, but in our case the high and low composite maps are similar (in terms of structure), that is why we have shown just the difference map. But in order to be clearer in our description and analysis, we will add both the high and low composite maps.

L150: Event Coincidence Analysis needs to be explained.

R: Thank you for the comment. We will extend the explanation and also the entire "Material and Method" section.

L177-179: If this is the case one could speculate that EOF2 showing a North South patterns just resemble this latitudinal effect.

R: In this comment, two essentials were mixed up. First of all, the latitudinal effect was found by Daansgard (1964) and is defined as a steady shift of the isotope values from the equator to the poles. The reason for this is that temperature changes within different seasons and varies over the latitudes. According to Daansgard (1964) and Gat (2010), the mean annual temperature and the $\delta^{18}O$ in the atmosphere are strongly correlated. For a documentation of several effects on the $\delta^{18}O$ ratio, e.g. the continental effect, we refer to the publication of Gat (2010).
The latitudinal effect is important for the $\delta^{18}O_{cel}$ ratio at each site (Figure 1 of the submitted manuscript), because it is one factor which influences the source values ($\delta^{18}O_{precipitation}$, $\delta^{18}O_{soilwater}$). In contrast, the latitudinal effect cannot explain the (climate) variability which is investigated and represented by the PCA and EOF technique in our study. The climate variability is determined by several other quantities which cannot be explained by a simple latitudinal position, e.g. large-scale atmospheric flows. Based on that argumentation, we disagree with the speculation of the reviewer.

L195: I do not see this is there a typo and the authors mean PC1?

R: Thank you for the comment. We will rewrite it to: The time series of the second component (PC2) is characterized by an underlying positive trend from the mid of the 19th century onwards.

L200-210: Avoid using the bracket with e.g. (cold). This makes the text unreadable. Just say what you show in Fig. 4.

R: This is the standard way how composite maps are described. It is necessary to add the brackets since both tails of the distribution function are combined and represented in these maps. Therefore, we have to write this additional information to clearly represent both extremes. To make it more understandable, we will add an explanation of how composite maps are working.

L208: I do not see a AO pattern, again the reference to Fraedrich are incorrect as they claim that ENSO has a nonlinear response behavior over Europe.

R: It is true that there is some asymmetry between El Niño and La Niña teleconnection patterns over Europe. However, the analysis of long-term data reveals that El Niño (La Niña) conditions in the tropical Pacific are associated with a negative (positive) phase of the North Atlantic Oscillation in the North Atlantic region during winter. The composite pattern represented in the Figure reflects this ENSO-NAO relationship, although the pattern is not identical with the AO/NAO.

L225: Why drought we see a positive precipitation anomaly?

R: We think that your comment is a misunderstanding of our composite map. As mentioned above both extremes of the distribution are represented by the composite map. This is also the reason why we use the brackets for the explanation. We will add an explanation on how to read the composite maps.

Section3.4: What do we learn from this? What is shown and why? This section is unclear and to my feeling can be removed.

R: Our goal with the model output is to test the correlation between $\delta^{18}O_{cel}$ and $\delta^{18}O_{P}/\delta^{18}O_{SW}$ to identify if the water, which is used during the photosynthesis processes, has a multi-seasonal isotopic signature. If yes (as shown in our plots), it is an explanation how $\delta^{18}O_{cel}$ is able to capture the ENSO signal. The results are interesting because a significant ENSO influence of the European climate has been identified for the winter (Fraedrich and Müller, 1992; Fraedrich, 1994; Pozo-Vazquez et al., 2005; Brönnimann et al., 2004; Brönnimann et al., 2007) and spring season (Brönnimann et al., 2007; Lloyd-Hughes and Saunders, 2002; Helama et al., 2009). Since the climate information is predominantly stored in $\delta^{18}O_{cel}$ in the summer season in Europe, we suggest that our results are an indicator that $\delta^{18}O_{cel}$ is able to capture multi-seasonal climate signals through hydrological processes (soil moisture and soil water content) and therefore can capture a winter/spring climate signal. We agree with the reviewer that it is not clearly written in the manuscript. Therefore, we will add an extended explanation of the used dataset and results. Also, the findings will be compared with other studies and discussed in the revised version of the manuscript.

L250: section 3.5

R: We will correct it in the new version of the manuscript.

L251-252: This sentence is a repetition.

R: It is a short repetition of the results of the PCA. We will remove it in the next version of the manuscript.

L260 -263: You need to show this with more proxies. Note that dry conditions are not droughts!

R: Thank you for the comment. We will be very sensitive with usage of the term "drought" in the next version of the manuscript. Furthermore, the comparison with more proxies is a really good idea. Based on the complexity of this topic, this would be another big study and a topic for the future work in this field. In our study, we want to show primarily the results of the analysis of the $\delta^{18}O_{cel}$ isotope network.

L263-265: Given your study you cannot conclude this. The authors study certainly is inadequate to reconstruct blocking so this statement is not supported by the authors analysis.

R: We agree with the reviewer and we will remove this part from the manuscript.

L269-70: Please change to ". . . signal still dominates".

R: We will rewrite it.

Figures: Statistical significance is not tested (or not shown).

R: We think that the comment is relevant for Figure 4 and 5. To show the significance for the SST variable, we have attached the composite maps with a separation between high and low events. The SST and Z500 composite map with significance will be part of the new appendix of the revised version of the manuscript. In the revised version of the manuscript we will replace each figure with figures with the statistical significance.

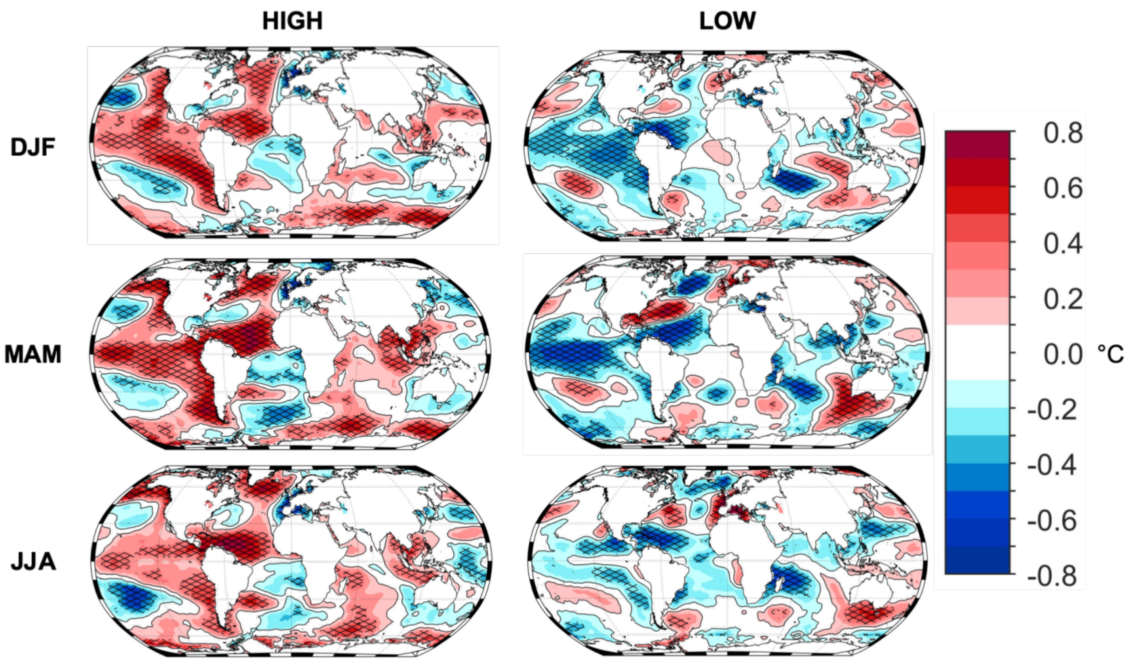

Figure 4: High and low SST composite maps for the first component of the $\delta^{18}O_{cel}$ network. The significance is shown where a black grid is shown in front of the color. The ERSST (Huang et al., 2017) is used in this figure.

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