Response to both reviewers

Our responses are given in normal blue font and proposed changes to the text are given in *blue italics*. References to line numbers refer to the revised manuscript.

As suggested by the reviewers, we have moved two figures and one table from Supplementary to the main text, and renumbered the figures and tables accordingly.

Response to Reviewer 1

1. One of the main goals of the paper is to use the recently developed fxTWA-PLS method (Liu et al., 2020). Using this method provides new knowledge in the area of quantitative paleoclimate reconstructions, and therefore, it is one of the main points why the paper is worth publishing. However, since this is a new method and very few pollen records have used this methodology (as far as I know: Liu et al., 2020; Wei et al., 2020; Prentice et al., 2022), more information should be included. For example, the authors mention that the WAPLS suffers from the tendency to compress the reconstructions towards the central part of the sampled climate range (Line 87-88) but they do not mention that the WAPLS is robust to spatial autocorrelation (Telford et al., 2005). Has this method been demonstrated to be robust to spatial autocorrelation?
Since fxTWA-PLS is a modification to WA-PLS, it is robust to spatial autocorrelation as we showed in our previous paper. Furthermore, the cross-validation excludes spatially correlated pseudo sites. We agree that we should make this clearer in the text. We have modified the text at line 111-113 in the revised text without tracked changes as follows:

The modified version further reduces the biases at the extremes of the sampled climate range, while retaining the desirable properties of WA-PLS in terms of robustness to spatial autocorrelation (fxTWA-PLS: Liu et al., 2020).

2. With respect to fossil pollen records, the authors did a great work compiling a large number of sites, using different data sources such as the European Pollen Database (EPD), Pangaea and even contacting directly with the authors from the original studies ("Author" in the excel file "Iberia_pollen_records_v3_0307.xlsx"). However, the authors should have also checked the relatively new and opened ACER database (Sánchez-Goñi et al., 2017), which provides high-resolution global-scale fossil pollen data. Did the authors check the high-resolution Spanish pollen records from this database? In addition, other new high-resolution Holocene Iberian pollen records should have also been included in the paper, such as lake Medina or Padul (both in southern Spain), especially when the number of fossil pollen records in the southern Iberian Peninsula is not as good as in the north, which could lead to uncertainties in the reconstructions and interpretations (as you mentioned in Lines 350-354).
The ACER database focuses on records covering D-O cycle and some of the records included are truncated before the Holocene, our period of interest. The database contains 3 terrestrial sites from Iberia: Navarres, Abric Romani, Lake Banyoles. Navarres and Banyoles are both included in our compilation. Abric Romani is an archaeological site and not suitable for the purpose of climate reconstruction. The new high-resolution data from Padul is not publicly available as the author is still working on these records. The Medina record has numerous hiatuses and we were advised not to use this record by one of the authors of the 2020 paper. This is also, presumably, the reason that Medina was only used for lake level reconstructions (and not for climate reconstructions) by Ilvonen et al. (2022). Thus, our data set is currently the most comprehensive one available for Iberia.

3. As we know, the pollen-based quantitative reconstructions are controlled by the modern pollen training dataset, and thus by the modern pollen vegetation. Although the MTCO reconstructions appear to be consistent with climate model simulations and consequence of insolation forcing (Lines 233-237), I wonder whether the MTCO reconstructions are completely reliable. Looking at the statistical performance of the MTCO (R^2 0.75 for Component 4, Table 1), the MTCO reconstructions should be reliable. However, the reconstructed MTCO anomalies at individual sites (Fig. 3) do not show a clear E-W trend (neither at low nor high altitude). This seems to be a consequence of the recent MTCO variability over a NW-SE (or E-W) transect (Figure 2), which shows no clear E-W changes in temperature. Actually, the MTCO in Figure 2 seems to be related with elevation changes in Iberia, with the lowest temperatures in Pyrenees, Central and Iberian Mountain chains, etc. Although the winter temperature can influence the vegetation at high-altitudes, at low elevations it is well known (you have also pointed it out in the Discussion) that the vegetation in the Iberian Peninsula is strongly influenced and controlled by the precipitation and moisture availability, and not by the winter temperature. The authors have pointed out a similar problem in the Discussion with the MTWA (Lines 260-268). Therefore, taking into account the issues related with the influence of the MTCO (and even MTWA) in the Iberian vegetation, at least at low-altitudes, the authors should consider whether including the MTCO is correct from a scientific point of view.

We think that we may have confused the reviewer by stating that there is no spatial differentiation between western and eastern Iberia in the changes in winter temperature (line 182-184 in the first revision without tracked changes). We do not expect MTCO to show a west-east trend. Winter temperatures today generally increase from north to south, although are also affected by elevation. Changing winter insolation over the Holocene should not affect this pattern. Although, the vegetation of Iberia is strongly influenced by moisture availability, nevertheless winter temperature affects the distribution of woody species because of the necessity to have physiological mechanisms to resist frost damage which could have been important in the early Holocene. Given that we obtain a reasonable R^2 for MTCO, as pointed out by the reviewer, and that the VIFs for our reconstruction show that our reconstructions of all three climate variables are independent, we feel that it is perfectly correct from a scientific point of view to include MTCO here. However, we have modified the text to ensure that other readers are not confused by our statement about the lack of east-west differences as follows:

The composite curve also shows a general increase in winter temperatures through time (Fig. 4a), consistent with the trend in winter insolation (Fig. 4d). The composite curve shows that it was ca 4°C cooler than today at 11.5 ka and conditions remained cooler than present until ca 2.5 ka. Winter temperatures today increase from north to south and are also affected by elevation; these patterns are still present in the Holocene reconstructions, but there is no spatial differentiation between western and eastern Iberia in the anomalies (Table 4, SI Fig. S2). The similarity of the changes compared to present geographically is consistent with the idea that the changes in winter temperature are driven by changes in winter insolation.

4. The authors have briefly compared their moisture reconstruction with speleothem records from the Iberian region (Lines 310-320). Since the study is based on pollen records, it would also be interesting to compare and discuss similarities/differences with other Iberian pollen records showing humidity changes throughout the Holocene period. In particular, comparing the results with other recent pollen-based quantitative moisture index or precipitation reconstructions from the Iberian Peninsula (e.g., Ilvonen et al., 2022) would show a more complete picture of the quantitative precipitation/humidity changes in the region and would definitely improve the Discussion section.

Ilvonen et al. (2022) provide pollen-based reconstructions of mean annual and summer and winter precipitation from 8 sites in Iberia, using WAPLS and a Bayesian modelling approach. The training

data set that is confined to samples from Spain, which may explain the somewhat limited variability shown by these records for most of the Holocene. They draw attention to a distinction between northern sites and southern sites in terms of hydroclimate trends but they do not specifically address the idea that the west-east gradient in moisture was reduced. Nevertheless, the increased precipitation during the early to mid-Holocene that they claim is characteristic of both northern and southern sites is largely caused by increases in the sites in the eastern part of Iberia, specifically San Rafael, Navarres, and Qintanar. With the exception of Monte Areo (which shows an increase for a short period), the sites in the western part of the peninsula either show little change or in some cases a decrease in precipitation (Zalamar, El Maillo). There are only a few other pollen-based reconstructions of moisture changes from Iberia, specifically precipitation reconstructions from Padul and Villarquemado (Camuera et al., 2022, also Garcia-Alex et al., 2021) and moisture index from Villarquemada (Wei et al., 2021). These sites are also in the east of the peninsula, thus the increased moisture recorded there during the early to mid-Holocene is also consistent with our reconstructions. Although it is difficult to compare changes in precipitation directly with changes in plant-available moisture, we have added a brief description of these reconstructions and pointed out they support our conclusion of a reduced west-east gradient during the early to mid-Holocene as follows:

There are comparatively few pollen-based reconstructions of moisture changes during the Holocene from Iberia. Records from Padul show increased mean annual and winter precipitation during the early and mid-Holocene (Garcia-Alex et al., 2021; Camuera et al., 2022). Reconstructions of mean annual and winter precipitation (Camuera et al., 2022) and the ratio of annual precipitation to annual potential evapotranspiration (Wei et al., 2021) also show wetter conditions at this time at El Cañizar de Villarquemado. Both of these sites lie in the eastern part of the Iberian Peninsula, so these reconstructions are consistent with our interpretation of wetter conditions in this region during the interval between 9.5 and 3.5 ka. Ilvonen et al. (2022) provide pollen-based reconstructions of mean annual, summer and winter precipitation from 8 sites in Iberia, using WAPLS and a Bayesian modelling approach. Although they focus on the contrasting pattern of hydroclimate evolution between northern and southern Iberia, the three easternmost sites (San Rafael, Navarres, and Qintanar de la Sierra) show much wetter conditions during the early to mid-Holocene. With the exception of the record from Monte Areo, the records from further west are relatively complacent and indeed two sites (Zalamar, El Maillo) show decreased precipitation between 8 and 4 ka. Thus, these records are consistent with our interpretation that the west-east gradient of moisture was reduced between 9.5 and 4.5 ka.

Speleothem oxygen-isotope data from the Iberian Peninsula also provide support for our pollen-based reconstructions of changes in the west-east gradient of moisture through the Holocene. .....

We have added the following references:

Camuera, J., Ramos-Román, M. J., Jiménez-Moreno, G., García-Alix, A., Ilvonen, L., Ruha, L., Gil-Romera, G., González-Sampériz, P. and Seppä, H.: Past 200 kyr hydroclimate variability in the western Mediterranean and its connection to the African Humid Periods, Sci. Rep., 12(1), 9050, doi:10.1038/s41598-022-12047-1, 2022.

García-Alix, A., Camuera, J., Ramos-Román, M. J., Toney, J. L., Sachse, D., Schefuß, E., Jiménez-Moreno, G., Jiménez-Espejo, F. J., López-Avilés, A., Anderson, R. S. and Yanes, Y.: Paleohydrological dynamics in the Western Mediterranean during the last glacial cycle, Glob. Planet. Change, 202, 103527, doi:https://doi.org/10.1016/j.gloplacha.2021.103527, 2021.

Ilvonen, L., López-Sáez, J. A., Holmström, L., Alba-Sánchez, F., Pérez-Díaz, S., Carrión, J. S.,

Ramos-Román, M. J., Camuera, J., Jiménez-Moreno, G., Ruha, L. and Seppä, H.: Spatial and temporal patterns of Holocene precipitation change in the Iberian Peninsula, Boreas, doi:https://doi.org/10.1111/bor.12586, 2022.

5. The authors have included a paragraph about the impact of CO2 on plant physiological processes and how this affects the reconstructions. However, as the paper deals with Holocene records, they have not included any reconstruction that takes into account the effect of the CO2. I agree with that, but then: what is the purpose of including this paragraph? The authors should avoid taking about a methodology that has not been used in this paper. I suggest removing this paragraph or, they could briefly explain that the variability of CO2 during the Holocene is very low, and therefore, the effect of the CO2 has not been taken into account for the moisture reconstructions (in contrast to other reconstructions, such as Wei et al., 2021).

We included this paragraph because the direct impacts of changing CO_2 are significant on longer timescales, as we have shown, and we wanted to make clear why it is unnecessary to do this in the current case. Specifically, as we state (line 322-334 in the first revision without tracked changes) the impact of the relatively small change in CO_2 over the Holocene is within the uncertainties of our reconstructions. However, we agree with the reviewer that this paragraph is long and rather belabours the point, so we have rewritten it more succinctly as follows:

Pollen data are widely used for the quantitative reconstruction of past climates (see discussion in Bartlein et al., 2011), but reconstructions of moisture indices are also affected by changes in water-use efficiency caused by the impact of changing atmospheric CO_2 levels on plant physiology (Farquhar, 1997; Gerhart and Ward, 2010; Prentice et al., 2017; Prentice and Harrison, 2009). This has been shown to be important on glacial-interglacial timescales, when intervals of lower-than-present CO_2 result in vegetation appearing to reflect drier conditions than were experienced in reality (Prentice et al., 2011, 2017; Wei et al., 2021). We do not account for this CO_2 effect in our reconstructions of α because the change in CO_2 over the Holocene was only 40 ppm. This change relative to modern levels has only a small impact on the reconstructions (Prentice et al., 2022) and is sufficiently small to be within the reconstruction uncertainties. Furthermore, accounting for changes in CO_2 would not affect the reconstructed west-east gradient through time.

6. I strongly recommend including the CCA plots (not only the numerical results as in the Table 2) in order to observe the relationship between the climatic variables and the pollen data. The Variance Inflation Factor (VIF) analysis is used to demonstrate that the climatic variables are independent from each other. Your VIF results suggest that the collinearity between variables is not high, and therefore, variables seem to be independent from each other. However, the authors should better explain the VIF analysis. There is no single mention about the VIF analysis in Methods. In the current version of the paper, the methodology should be improved and these issues/questions should be clarified in the main text. Since the current version of the article is short, the authors could further clarify the methodology.

We have now included the CCA plots in Supplementary Materials (Fig. S11) and an explanation of the VIF analysis, at line 161-164 in the revised text without tracked changes, as follows:

Variance inflation factor (VIF) scores are calculated for both the modern climates and the climates reconstructed from fossil pollen records, in order to avoid multicollinearity problems and thus guarantee the climate variables (MTCO, MTWA, α) used here represent independent features of the pollen records.

7. Line 49: Add other references about new Iberian Holocene records related with changes in moisture conditions (e.g., Schröder et al., 2020; Ramos-Roman et al., 2018).

We have now added the references:

However, much of the evidence for Holocene climates of the Iberian Peninsula is based on qualitative interpretations of vegetation changes, generally interpreted as reflecting changes in moisture availability (Morellón et al., 2018; Ramos-Román et al., 2018; Schröder et al., 2019).

Reference:
Schröder, T., López-Sáez, J. A., van't Hoff, J. and Reicherter, K.: Unravelling the Holocene environmental history of south-western Iberia through a palynological study of Lake Medina sediments, The Holocene, 30(1), 13–22, doi:10.1177/0959683619865590, 2019.

Ramos-Román, M. J., Jiménez-Moreno, G., Camuera, J., García-Alix, A., Anderson, R., Jiménez-Espejo, F., Sachse, D., Jaime, T., Carrión, J., Webster, C. and Yanes, Y.: Millennial-scale cyclical environment and climate variability during the Holocene in the western Mediterranean region deduced from a new multi-proxy analysis from the Padul record (Sierra Nevada, Spain), Glob. Planet. Change, 168, doi:10.1016/j.gloplacha.2018.06.003, 2018.

8. Lines 113-118: You should specify which taxa have been removed.
We have now provided a list in Table S1 the taxa that have been removed because they are obligate aquatics, insectivorous species, introduced species, and taxa that only occur in cultivation.

9. Line 131: "a modified code from SPLASH…"
We have rewritten the sentence:
… MI was calculated for each pollen site using a modified code from SPLASH v1.0…

10. Line 140: Remove the Doi number. Include the citation: Harrison et al. (2022)
We have now rewritten the sentence:
The fossil pollen data from the Iberian Peninsula were compiled by Shen et al. (2021) and the data set was obtained from Harrison et al. (2022).

11. Line 173: "The variance inflation factor (VIF) scores…"
We have now rewritten the sentence:
The variance inflation factor (VIF) scores are all less than 6, …

12. Lines 173-174: Add reference.
We have added a reference for this, specifically:
Allison, P. D.: Multiple Regression: A Primer, Pine Forge Press., 1994.

13. Figure 2: Figure caption: use acronyms for "m above sea level", for example "m a.s.l.".
We have made this change.

14. Figure 4: You must include the references for the insolation values. Where are insolation values taken from?
We have now added a sentence to describe the source of the insolation values at line 158-160 in the revised text without tracked changes:

Summer insolation and winter insolation are also calculated using the PAST software based on the age and latitude of each sample (Hammer et al., 2001).

Reference:
Hammer, O., Harper, D. and Ryan, P.: PAST: Paleontological statistics software package for education and data analysis, Palaeontol. Electron., 4, 1–9, 2001.

15. Table 2: The methodology related to this table needs to be better explained. For example, include in Methods the reason for using the VIF analysis.
We have now added in Methods the reason for using the VIF analysis in the Methods section. Please see response to C6 for revised text.

Response to reviewer 2

1. Introduction is better, papers are now cited (Tarroso et al); the paper of Davis et al., 2003 is still lacking.
We have now added the Davis et al. paper, as follows:
Iberia was also included in the quantitative pollen-based reconstructions of European climate through the Holocene in Mauri et al. (2015), which is an update of Davis et al. (2003).

Reference:
Davis, B. A. S., Brewer, S., Stevenson, A. C. and Guiot, J.: The temperature of Europe during the Holocene reconstructed from pollen data, Quat. Sci. Rev., 22(15), 1701–1716, doi:https://doi.org/10.1016/S0277-3791(03)00173-2, 2003.

Please see response to C10 for detailed explanation.

2. line 73: contradiction better than contra-distinction;
We have now modified the sentence:
…, either for the Iberian Peninsula as a whole or for individual sub-regions, in contradiction to the other reconstructions.

3. line 80 and in the text: update the ref Shen et al 2021 as Shen et al 2022 Clim. Past, 18, 1189–1201, https://doi.org/10.5194/cp-18-1189-2022, 2022
We have now updated the reference:
Shen, Y., Sweeney, L., Liu, M., Lopez Saez, J. A., Pérez-Díaz, S., Luelmo-Lautenschlaeger, R., Gil-Romera, G., Hoefer, D., Jiménez-Moreno, G., Schneider, H., Prentice, I. C. and Harrison, S. P.: Reconstructing burnt area during the Holocene: an Iberian case study, Clim. Past, 18, 1189–1201, doi:10.5194/cp-2021-36, 2022.

4. Lines 84-87: “These analyses allow us to confirm that the west-east gradient in moisture was less steep during the mid-Holocene and indicate the importance of changes in atmospheric circulation in explaining observed patterns of climate change across the region”. This sentence is a result, avoid it in the introduction.
We have now changed the sentence to:

These analyses allow us to investigate whether the west-east gradient in moisture was less steep during the mid-Holocene and explore what controls the patterns of climate change across the region.

5. Line 78: The terms pollen and transfer function are required here; better as: Here, using pollen-inferred transfer functions, we re-examine the trends in summer and winter temperature…
We have now modified the sentence:

Here, using pollen-inferred transfer functions, we re-examine the trends in summer and winter temperature and plant-available moisture through the Holocene across Iberia, …

6. Line 92, could also add Salonen et al 2019?
We have modified this sentence to include a mention to machine-learning techniques and included the Salonen et al. (2019) reference.
Machine-learning and Bayesian approaches have also been applied to derive climate reconstructions from pollen assemblages (Peyron et al., 1998; Salonen et al., 2019).

We have also added the new reference:
Salonen, J. S., Korpela, M., Williams, J. W. and Luoto, M.: Machine-learning based reconstructions of primary and secondary climate variables from North American and European fossil pollen data, Sci. Rep., 9(1), 15805, doi:10.1038/s41598-019-52293-4, 2019.

7. Line 103: add a brief sentence on the recent RForest and BRT new methods (Salonen papers). BRT is a nice and powerful tool to provide robust climate reconstructions
Our aim here is to provide a motivation for our use of a modified version of fxTWA-PLS, rather than review alternative methods of climate reconstruction. However, we have added a reference to the Salonen et al. (2019) paper at the beginning of this section (see response to Comment 6 above)

8. Line 238: Mid-Holocene not Middle
We have now changed "middle Holocene" to "mid-Holocene".

9. Line 300: add the ref for the transient output
We have now added the references for the individual transient simulations, and a reference to some analysis papers that use all of these simulations.
Our reconstructed trend in winter temperature is consistent with the changes in insolation forcing at this latitude during the Holocene, and is also consistent with transient climate model simulations (Braconnot et al., 2019; Carré et al., 2021; Dallmeyer et al., 2020; Parker et al., 2021) of the winter temperature response to changing insolation forcing over the late Holocene in this region (Fig. 8, SI Fig. S8).

We have added the following references:
Braconnot, P., Crétat, J., Marti, O., Balkanski, Y., Caubel, A., Cozic, A., Foujols, M.-A. and Sanogo, S.: Impact of multiscale variability on last 6,000 years Indian and West African monsoon rain, Geophys. Res. Lett., 46(23), 14021–14029, doi:https://doi.org/10.1029/2019GL084797, 2019.

Carré, M., Braconnot, P., Elliot, M., d'Agostino, R., Schurer, A., Shi, X., Marti, O., Lohmann, G., Jungclaus, J., Cheddadi, R., Abdelkader di Carlo, I., Cardich, J., Ochoa, D., Salas Gismondi, R., Pérez, A., Romero, P. E., Turcq, B., Corrège, T. and Harrison, S. P.: High-resolution marine data and transient simulations support orbital forcing of ENSO amplitude since the mid-Holocene, Quat. Sci. Rev., 268, 107125, doi:https://doi.org/10.1016/j.quascirev.2021.107125, 2021.

Dallmeyer, A., Claussen, M., Lorenz, S. J. and Shanahan, T.: The end of the African humid period as seen by a transient comprehensive Earth system model simulation of the last 8000 years, , doi:10.5194/cp-2019-86, 2020.

Parker, S. E., Harrison, S. P. and Braconnot, P.: Speleothem records of monsoon interannual-interdecadal variability through the Holocene, Environ. Res. Commun., 3(12), 121002, doi:10.1088/2515-7620/ac3eaa, 2021.

10. Line 311: "The differences between the three data sets probably reflect differences in the number of records used, but the lack of coherency points to there not being a strong, regionally

coherent signal of summer temperature changes during the Holocene". I think that the differences are also probably linked to the method used (MAT with PFT for Mauri et al. and Davis et al, PDF for Tarroso et al. and improved WAPLS for your study). Please add a sentence on that.
It is possible that the differences are related to the methods used, but we cannot demonstrate this, whereas it is clear that there are differences and spatial biases in the number of records used. The key point here is that whereas there is broad agreement between different data sets about the changes in winter temperature, there is little agreement in terms of summer temperature. We argue that this reflects the absence of a strong, regionally coherent signal of summer temperature changes. We have modified the sentence to make the point of our argument clearer as follows:

The differences between the three data sets could reflect differences in the reconstruction methods, or differences in the number of records used and in the geographic sampling. However, given the fact that all three data sets show similar trends in winter temperature, the lack of coherency between the data sets for MTWA points to there not being a strong, regionally coherent signal of summer temperature changes during the Holocene.

What about the results from Davis et al., 2003? Did you compare with your results? I think their reconstruction of MTWA indicate cooler conditions in south west Mediterranean during mid-Holocene.
We did not explicitly compare our results to Davis et al. (2003) because the Mauri et al. (2015) paper is an update of Davis et al. (2003), and as Mauri et al. (2015) explicitly states it was made "using the same methodology, but with a greatly expanded fossil and surface-sample dataset and more rigorous quality-control". Thus, they argue that the newer results are more reliable than the earlier work.

11. Line 412: human impact: this part is still too short. Human impact on pollen data is probably the most important problem on climate reconstruction during the mid to late Holocene. Even if archeological evidences are not found, human societies may influence vegetation for the Bronze age, especially in Mediterranean regions. So please, add more sentences on this topic. (Did you find NPP or specific pollen taxa related to human impact in your dataset). What about fires and its possible impact on vegetation?
The degree of human influence on land-use in Iberia is still a matter of debate, with some authors arguing for evidence of human influence on the vegetation at particular sites and no evidence at others. Archaeological evidence indicates that the Neolithic transition in Iberia was non-synchronous across the region and occurred over a period of several thousand years, which makes it unlikely that anthropogenic signals would produce coherent patterns of vegetation change through time. There is also an issue about the methods used to identify anthropogenic land-use change. The presence of fungal spores associated with animal faeces has been used to identify the presence of domesticated animals at individual archaeological sites in but can also indicate non-domesticates and has not been investigated systematically across multiple sites. Evidence of land-use changes based on increases in weed plants, which has also been used to identify human impact in particular sites in Iberia, are unreliable because they can also reflect non-anthropogenic disturbance. The most reliable evidence of anthropogenic land use changes is the presence of cereals. However, with the exception of rye which is wind pollinated, most cereals do not release pollen until they are threshed and this means that they are generally poorly represented in pollen diagrams. Indeed, the latest reconstructions of changes in the abundance of cereals across Europe (Githumbi et al., 2022) shows that it was not until ca 1000 years ago that cereal pollen was present in more sites in the Iberian Peninsula than absent. Change in fire regime have also been attributed to human activities in Iberia. However, our recent analyses of fire history across Iberia (Sweeney et al., 2022) shows no relationship between the timing of first agriculture in different parts of the Peninsula and changes in fire regime, nor between intervals of rapid population growth and fire. It is clear that a more

thorough analysis of the evidence for human impacts on vegetation, based on a comprehensive analysis of various sources of data, is required in order to provide a better understanding of how this might impact the pollen-based climate reconstructions for Iberia, but this is beyond the scope of the present paper. Nevertheless, we are happy to provide more discussion of this issue and have expanded the text in the Discussions as follows:

A more serious issue for our reconstructions may be the extent to which the vegetation cover of Iberia was substantially modified by human activities during the Holocene. Archaeological evidence shows that the introduction of agriculture during the Neolithic transition occurred ca 7.6 ka in some southern and eastern areas of the Iberian Peninsula but spread slowly and farming first occurred only around 6 ka in the northwest (Drake et al., 2017; Fyfe et al., 2019; Zapata et al., 2004). Anthropogenic changes in land use have been detected at a number of sites, based on pollen evidence of increases in weeds or the presence of cereals (e.g. Abel-Schaad and López-Sáez, 2013; Cortés Sánchez et al., 2012; López-Merino et al., 2010; Mighall et al., 2006; Peña-Chocarro et al., 2005) or the presence of fungal spores associated with animal faeces which has been used to identify the presence of domesticated animals (e.g. López-Sáez and López-Merino, 2007; Revelles et al., 2018). The presence of cereals is the most reliable source of data on human activities, but most cereals only release pollen during threshing and thus are not found in abundance in pollen diagrams from natural (as opposed to archaeological) sites (Trondman et al., 2015). Indeed, it is only after ca 1 ka that the number of sites which record cereal pollen exceeds the number of sites at which cereals are not represented (Githumbi et al., 2022). Thus, while anthropogenic activities may have been important at the local scale and particularly in the later Holocene (e.g. Connor et al., 2019; Fyfe et al., 2019; Githumbi et al., 2022), most of the sites used for our reconstructions are not associated with archaeological evidence of agriculture or substantial landscape modification. Furthermore, the consistency of the reconstructed changes in climate across sites provides support for these being largely a reflection of regional climate changes rather than human activities.

We have added the following additional references:

Cortés Sánchez, M., Jiménez Espejo, F. J., Simón Vallejo, M. D., Gibaja Bao, J. F., Carvalho, A. F., Martinez-Ruiz, F., Gamiz, M. R., Flores, J.-A., Paytan, A., López Sáez, J. A., Peña-Chocarro, L., Carrión, J. S., Morales Muñiz, A., Roselló Izquierdo, E., Riquelme Cantal, J. A., Dean, R. M., Salgueiro, E., Martínez Sánchez, R. M., De la Rubia de Gracia, J. J., Lozano Francisco, M. C., Vera Peláez, J. L., Rodríguez, L. L. and Bicho, N. F.: The Mesolithic–Neolithic transition in southern Iberia, Quat. Res., 77(2), 221–234, doi:https://doi.org/10.1016/j.yqres.2011.12.003, 2012.

Drake, B. L., Blanco-González, A. and Lillios, K. T.: Regional Demographic Dynamics in the Neolithic Transition in Iberia: Results from Summed Calibrated Date Analysis, J. Archaeol. Method Theory, 24(3), 796–812, doi:10.1007/s10816-016-9286-y, 2017.

Githumbi, E., Fyfe, R., Gaillard, M.-J., Trondman, A.-K., Mazier, F., Nielsen, A.-B., Poska, A., Sugita, S., Woodbridge, J., Azuara, J., Feurdean, A., Grindean, R., Lebreton, V., Marquer, L., Nebout-Combourieu, N., Stančikaitė, M., Tanţ\uau, I., Tonkov, S., Shumilovskikh, L. and data contributors, L.: European pollen-based REVEALS land-cover reconstructions for the Holocene: methodology, mapping and potentials, Earth Syst. Sci. Data, 14(4), 1581–1619, doi:10.5194/essd-14-1581-2022, 2022.

López-Merino, L., Cortizas, A. M. and López-Sáez, J. A.: Early agriculture and palaeoenvironmental history in the North of the Iberian Peninsula: a multi-proxy analysis of the Monte Areo mire (Asturias, Spain), J. Archaeol. Sci., 37(8), 1978–1988, doi:https://doi.org/10.1016/j.jas.2010.03.003, 2010.

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12. Line 425; “Thus, the finding that winter temperatures are a direct reflection of insolation forcing whereas summer temperatures are influenced by land-surface feedbacks and changes in atmospheric circulation is robust to the method used.” I agree that results are close if you use WAPLS, but if you use another method (MAT, BRT, RF, Bayesien, ANN…), results could be strongly different, so please modify your sentence.
We agree that the results might be different if we used non-regression based techniques, as indeed previous papers comparing WAPLS and other types of reconstruction method (e.g. Ilvonen et al., 2022) have shown. Here we are simply arguing that our improvements of fxTWA-PLS produce a better model but do not change our conclusions. We have modified the sentence as follows:

Thus, the finding that winter temperatures are a direct reflection of insolation forcing whereas summer temperatures are influenced by land-surface feedbacks and changes in atmospheric circulation is robust to the version of fxTWA-PLS used.

13. Conclusion: too short, you can improve it!
We tried to keep the conclusion short to emphasise the key findings about the Holocene climate of Iberia. However, we are happy to expand this and have rewritten the text as follows:

We have developed an improved version of fxWA-PLS which further reduces compression bias and provides robust climate reconstructions. We have used this technique with a large pollen data set representing 117 sites across the Iberian Peninsula to make quantitative reconstructions of summer and winter temperature and an index of plant-available moisture through the Holocene. We show that there was a gradual increase in winter temperature through the Holocene and that this trend

broadly follows the changes in orbital forcing. Summer temperatures, however, do not follow the changes in orbital forcing but appear to be influenced by land-surface feedbacks associated with changes in moisture. We show that the west-east gradient in moisture was considerably less pronounced during the mid-Holocene (8~4 ka), implying a significant increase in moisture advection into the continental interior resulting from changes in circulation. Our reconstructions of temperature changes are broadly consistent with previous reconstructions, but are more solidly based because of the increased site coverage. Our reconstructions of changes in the west-east gradient of moisture during the early part of the Holocene are also consistent with previous reconstructions, although this change is not simulated by state-of-the-art climate models, implying that there are still issues to resolve the associated land-surface feedbacks in these models. Our work provides an improved foundation for documenting and understanding the Holocene palaeoclimates of Iberia.

14. For figures, I already asked to include the synthesis figures (S8 and S9) in the text and not in supplementary material. This has not been done. Most of the discussion is based on these figures: it must be included in the text. I ask the editor to carefully check this point before acceptation of the manuscript.

In our previous response we explained that we did not think these figures were central to the paper since our goal was to compare the reconstructions rather than the methodologies. We were concerned that, as we already have 9 display items, adding two new figures and a new table (see C15 below) would be rather too much. However, since the editor seems to be happy to have 12 display items, we have now moved figure S8 and S9 into the main text and numbered them accordingly. Figure S8 and S9 are now Figure 7 and 8 in the revised version.

15. For tables, pollen data must be better taken into account in the text. I already kindly asked to include Table S1 in the text as table 1. The description of the data sources of fossil pollen used to reconstruct the climate in the Iberian Peninsula must be included directly here in the text and not in supplementary material. This has not been done. I insist because we need to check easily the pollen sites, the chronological frame… I ask the editor to carefully check this point before acceptation of the manuscript.

We have now moved Table S1 into the main text and renumbered the Tables accordingly. Table S1 is now Table 1 in the revised version.