Response to RC3 Chenzhu Chen

We thank to Chunzhu Chen for their comments. *Our specific responses are given below (in blue italic) and changes in wording are indicate in normal blue script.*

Correction of the impact of changing CO_2 levels on plant-available moisture reconstructions is a significant improvement that has been previously ignored in many climate reconstructions. However, I disagree with the authors' contention that atmospheric CO_2 levels affected moisture reconstructions only in the earliest part of the records. In fact, starting around 5 ka, there is a clear difference between the corrected and uncorrected results.

In response to a comment by Chris Brierley, we have checked our calculations and found an error in the temperature inputs (please see response above). We have rectified this oversight by using the average temperature of the growing season for the α correction. We did not claim that atmospheric CO_2 levels only affected moisture reconstruction in the earliest part of the record and indeed we pointed out that the correction lead to an increase in reconstructed moisture levels during the late Holocene (line 235). Nevertheless, it is true that the largest difference between the corrected and uncorrected reconstructions occurs when CO2 levels are lowest. At 12ka, for example, the difference is nearly 0.2 whereas in the late Holocene the biggest difference is 0.08 at 4.8 ka. We have modified the text to clarify this (please see text given above).

The 7.5 degree Celsius temperature anomaly during the early Holocene appears to be very large for MTCO reconstruction. The magnitude is much larger than that of existing reconstructions and simulation results. This should be discussed further.

Although the reconstructed temperature anomaly is larger than in the previous reconstructions, the change in the TRACE-21K-II simulation is ca 5° and it is ca 3°in the LOVECLIM simulation. This suggest that our reconstructed change is not implausible. We attribute the discrepancies between our reconstruction and existing datasets primarily to methodological differences. We have modified the discussion to make this clearer as follows:

We have shown that winter temperatures increased sharply between 10.3 and 9.3 ka, but then continued to increase at a more gradual rate through the Holocene. The increase of ca 7.5°C is of the same order of magnitude to the increase shown in the TRACE-21K-II simulation (ca. 5°C) and in the LOVECLIM simulation (3°C). This increasing trend is also seen in the Mauri et al. (2015) reconstructions of MTCO (Figure 9), although the change from the early Holocene to the present is much smaller (ca 0.5–1°C) in these reconstructions than in our reconstructions and Mauri et al. (2015) do not show marked cooling around 11 ka. Nevertheless, the consistency between the two reconstructions and between our reconstruction and the simulated changes in MTCO supports the idea that these trends are a response to orbital forcing during the Holocene.

It is understandable that the fossil pollen dataset (EMBSeCBIO; 20E-62E, 29N-49N) has a smaller spatial scale than the modern training dataset (20W-62E, 29N -75N), but it is difficult to understand why model outputs have a very different spatial range (EMBSeCBIO? 20W-55W, 29N-49N).

This issue was raised by Chris Brierley. Please see response above.

The manuscript includes simulation results from multiple models, but the explanation for the consistency, and especially the inconsistencies, between climate reconstruction and modeling needs to be strengthened. This study does not focus on simulations, but the results are presented in three separate figures. I recommend arranging the curves on a single large figure and, if necessary, including a figure to clearly compare the simulations and reconstructions.

As we explain in responses to comments from the other reviewers, it is difficult to put the model results on a single figure or to combine these results with the reconstructions because of the differences in the magnitude of the trends. Our focus in the paper is to use the similarity in the trends, rather than in the magnitudes, to address whether that the forcings incorporated in the different simulations (orbital, greenhouse gas, ice sheets and meltwater) provide an explanation for the observed trends in the reconstructions. For the late Holocene, we also point out that the orbital forcing is insufficient to explain the trend in the reconstruction of plant available water since the models disagree on the direction of the trend. We have amplified our discussion of the similarities and differences between the simulations and reconstructions in response to comments from the other reviewers (please see changes to text above).

Figure 9 lacks a figure legend.

We have added a legend inside the plot