Reply to reviewer comments 2 (RC2):

Witkowski et al. reconstructed the temperature and deposition environment at a site in Yunnan, China, using multiple biomarkers. Their reconstruction indicates that the temperature at this location was similar to today at ~33 Ma, which may imply that its altitude might have reached similar height to today. Because this site is in the southeastern margin of the Tibetan Plateau, the results may be of value to people who study the evolution of the Tibetan Plateau.

The part of manuscript that is related to biomarkers is well written but the part related to climate modeling is quite poor. Lots of information are missing. I could not find even a single relevant figure which made it difficult to understand how the experiments were setup. The results of the climate modeling were not used in a meaningful way either, making me wonder why bother carrying out that many model simulations. Detailed questions and comments are listed below.

We thank the reviewer for their positive comments and their constructive feedback. We respond to each comment below in bold text. Line numbers refer to the "track changes" version of the manuscript.

1. A figure is certainly needed in order for the readers to understand how the model experiments were set up. For example, what do they mean by a constant valley or plateau (near line 195)? What do the corresponding results tell us?

We have added a figure (Fig. 5) to demonstrate the different between the valley (2.5km) and plateau (4.5km). We have also specified this more clearly throughout the section. See section 2.2.5, "Topographic changes were also considered across the Priabonian to Rupelian based on hypotheses posed by Spicer et al., 2020 (and references therein), either as a) a constant valley at 2.5 km elevation, b) a constant plateau at 4.5 km elevation, or c) a change from a valley at 2.5 km to a plateau at 4.5 km." We have also added some guiding text in the caption in Table 1, "Tibetan topography is configured at different elevations to determine the impacts this may have one the broader climate system, here showing as only a valley at 2.5 km, as only a plateau at 4.5 km, or as a change from valley to plateau from 2.5 to 4.5 km."

2. Since the model results show that there should be a large change of annual mean temperature (~6 °C) when CO_2 is changed from 4x to 2x, shouldn't they indicate that the section does not include the Eocene-Oligocene Transition (EOT)?

Based on our age model, the section should include the EOT. Although the model indicates that a CO_2 change from 4x to 2x should result in 6C cooling, we do not see that in the data recorded at this site. We have added an explanation of why there might be a difference in the model versus biomarker data on Line 439-444, namely that, "This difference is likely due to spatial resolution of the model (large homogenous grids) versus the biomarker data (specific details on a basin scale); the model cannot capture the complex topography that may influence the climate at this site."

3. In my opinion, the results are insufficient to claim that the altitude of the site had reached present-day value based on only the surface temperature. Many other factors could impact on the temperature of a local region. For example, did the latitude of the site change much between the Early Oligocene and PI? Was there a large change in the temperature of South China Sea? Was the region more cloudy during the Early Oligocene than in PI?

The biomarkers and palaeobotany proxies record the temperature that the organisms/assemblages experience in their lifetime, so the reviewer is correct that these methods leave room for alternative factors that could impact our understanding of the temperature at the section (i.e., the altitude was lower, but it was cloudier). However, this explanation seems unlikely given the agreement of the models and supporting proxy data which we have now included more explicitly in this section, ~Line 494, "An alternative explanation may be that there are complicating factors that impact temperature for the biomarker and palaeobotany proxies e.g., cloud coverage. However, this seems less likely given the proxy agreement with the model results. This coupled atmosphere-ocean general

circulation paleoclimate model includes paleo-rotations (latitude/longitude), changes in globally dynamic temperatures (e.g., SST changes from the South China Sea), and changes in cloud coverage and precipitation. In addition, there is supporting evidence from moist enthalpy from CLAMP and oxygen isotopes from carbonate nodules that topography of the eastern margin of Tibet was established immediately prior to and during the basin development (e.g., He et al., 2022).”

4. Some of the co-authors had published climate evolution for the past 100 million years, it should be convenient to look at how the temperature at this site had changed during the past 30 million years. Similar data were also published by Li et al. (2022, Scientific Data, https://doi.org/10.1038/s41597-022-01490-4).

In this manuscript, we are focused on how this specific site changed during this tectonically and climatically dynamic time in Earth history, and how this specific site fits into our understanding on local, regional, and global scales. By looking at changes in temperature at a specific location, we can gain both spatial and temporal resolution that models are not capable of reaching, given they run at geologic stage level and at 300 km spatial grids. In return, the model offers context that a single site cannot. That is why it is so valuable to combine modelling and data, as we have done here.

5. The authors may also look at how the precipitation changed at the site from the early to middle Oligocene from the two datasets mentioned above since it is directly related to their reconstruction regarding the deposition environment.

We have added a paragraph to Sec. 3.6 on precipitation to discuss the results from the model and CLAMP with our interpretation of the sedimentation and organic geochemistry, all of which support a significant hydrological shift from the Priabonian into the Chattian.

Minor comments

WMMT and CMMT are not defined, are they the temperatures for the warmest and coldest month or the average of a few months. While at lines 445-446, the dry or wet months are defined.

We have defined CMMT and WMMT for the coldest/warmest month mean temperature for CLAMP, as well as adding 3CMMT and 3WMMT for the three consecutive coldest/warmest month mean temperature for the model.

L190: downscaled -> upscaled?

Different scientific communities use this term differently; the modelling community generally use “downscaled” to describe going from a low-resolution (more course representation) to higher resolution (more detail). To avoid confusion, we’ve removed the phrasing altogether and replaced with “…at low (3.75° x 2.5°) and scaled to the high model resolution (0.5° x 0.5°)…”

L397: increases -> varies? Otherwise, I do not understand why the precipitation always increases.

We have added ~Line 408, “…mean annual precipitation (MAP) increases between 150-200 mm/yr from the Priabonian into the Chattian but is not significantly impacted by different pCO2 values (e.g., from 4x to 2x pre-industrial pCO2 or no change in pCO2) nor topographic configurations in the model conditions. This suggests MAP was impacted by global changes across this boundary e.g., the opening of ocean gateways (e.g., Drake Passage; creation of the Antarctic Circumpolar Current), the massive expansion of the Antarctic icesheet, and broad reorganisation of the global climate system (Westerhold et al., 2020).”

L445: what are the modelled precipitation?

The resulting modelled precipitation can be seen in both Table 1 under change in mean annual precipitation (delta MAP), and in Table 2 under MAP (mm/yr).

L449: where -> were

Changed.

Figs. 4-6, in all three figures, the Chrons C12n are located above C11n, inconsistent with Fig. 2.

We have revised the figures to add the age model, based on the comments of Reviewer 1.