Dear Prof. Guo,

We greatly appreciate the very positive evaluation of our work by Reviewer #2 and thank them for taking another good look at our paper.

Below we reply to each point they raise and indicate how we intend to revise the manuscript.

Sincerely, also on behalf of all co-authors,

Chris Fokkema

Fokkema et al. reported orbitally resolved SSTs and associated data from a tropical Atlantic site. They first confirmed that the Eocene "hyperthermal" events are present in the tropical ocean. Then, these TEX86-based SSTs were used together with benthic foram d18O to constrain Polar Amplification in the ice-free greenhouse world. They identified a persistent PA factor that appears to be robust across different archives, proxy calibrations, and timescales. They concluded that feedback other than ice-albedo, probably involving the carbon cycle, was in play. This is a solid study with a large number of measurements used to provide robust paleoenvironmental reconstructions, while considering potential caveats (such as upwelling at the studied site and different calibrations of TEX86). These results were used to strengthen the series of studies conducted recently by the authors and other folks to constrain PA over different periods of the Cenozoic. I actually reviewed an earlier version of this manuscript for a different journal and don't have many remaining comments. I suggest publication after minor revisions.

Author response: We thank the reviewer for their feedback and their positive assessment of the changes made to an earlier version of the manuscript.

The only thing I can think of is to use this opportunity to expand a little bit more on the discussion of feedback mechanisms operating on orbital timescales in the early Cenozoic. This should be feasible given the expertise of the climate dynamics in the author's team. What could be important but currently missing in the model?

Author response: While the data-model mismatch does not necessarily imply that the models miss a feedback (i.e., a certain feedback is not included at all), there are multiple feedback mechanisms in the models that still carry large uncertainties. There is a chance that the importance of some of these processes are systematically under- or overestimated, which could result in a (slight) mismatch such as we observe.

We will extend on this in the discussion section, where we will highlight which processes might not be accurately represented in Eocene climate modeling and can cause such as mismatch. This will include cloud feedbacks, which play an important role in polar amplification (Taylor et al., 2013 (*JoC*); Vavrus, 2004 (*JoC*); England and Feldl, 2024 (*JoC*), have large uncertainties in global climate models (Zelinka et al., 2022 (*JGRA*)) and may not be well-simulated in paleoclimate modeling. Several studies have shown that early Eocene high-latitude warmth can be well simulated by changing cloud properties (Sagoo et al., 2013 (*PTRS)*; Zhu et al., 2019 (*Sci. Adv.*). In addition, we will discuss ocean heat transport, which influences polar amplification in ice-free climates (England and Feldl, 2024 (*JoC)*). Ocean heat transport in models is sensitive to changes in background conditions, as oceanic gateways, orbital parameters and CO_2 concentrations (Huber and Nof., 2006 (*PPP*).

Also, any thought experiment on the potential drivers of these carbon cycle changes on orbital cycles (I know we still haven't really figured out the late Pleistocene G-IG CO2 changes, but what are the potential ways to balance the carbon budget of the Eocene?

Author response: The distinct negative ^{13}C-depleted carbon isotope signature of all hyperthermals of the early Eocene (and in particular the PETM) has led previous workers to the hypothesis of periodic release of ^{13}C depleted carbon into the ocean-atmosphere system, presumably from an organic reservoir, with proposed reservoirs including methane hydrates and terrestrial organic carbon pools (peatlands, permafrost).

We can conclude that the mechanisms responsible for the eccentricity-forced GMSST variability was likely the same as for the (seemingly superimposed) hyperthermals: the slope of open ocean benthic $\delta^{18}O$ versus $\delta^{13}C$ during the hyperthermals and during the background variations (including multiple 100-kyr eccentricity scale variations) is equal (Lauretano et al. 2015 (*CotP*). We will include this in a brief speculative statement in a section at the discussion on carbon cycle feedbacks.

What factors could be more important in the greenhouse world than the Pleistocene)?

Author response: The largest difference between the early Eocene situation compared to the Pleistocene is the absence of (sea)ice and snow at the poles, dominantly resulting in a large albedo difference between the Pleistocene G-IG and Eocene greenhouse world. Furthermore, factors like the much warmer background temperatures and higher sea level during the early Eocene presumably affected the importance of surface carbon reservoirs and thereby (orbitally forced) carbon cycle feedback mechanisms. Some of these feedbacks may have been more sensitive in the Pleistocene (e.g., likely more permafrost in the Pleistocene) and others in the Eocene situation (e.g., the sea floor was warmer and therefore the gas hydrate stability zone was smaller, and (high-latitude) peat deposits may have been larger). We will expand on this in the relevant discussion section.

References in Author response:

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