Reviewer 3

This study combines state-of-the-art model simulations of past climates and future warming to evaluate ENSO activity throughout a wide range of climate states. The authors find that the sensitivity of ENSO to the background climate is nonlinear and tied to the climatological position of the tropical Pacific convection centers, the ITCZ and SPCZ. Results of this study provide a comprehensive mechanism of how tropical Pacific mean state modulates ENSO activity.
I find this is a novel and interesting study and the analysis is basically sound. Nevertheless, as previously mentioned by the other two reviewers, the writing can be further refined so that the paper will be more readable.
Please see my specific comments below.

We thank the Reviewer for their constructive comments, which helped improve our manuscript. Below we answer the reviewer's comments and include in purple some excerpts of modified text to be included in the revised manuscript.

1. As seen in the dispersion diagrams and discussed in the manuscript, abrupt 4xCO2 simulation results show strong equatorward shift of convection centers, which is distinct from the past climates. I was wondering how the location of convection centers and ENSO-convection centers relationship change in other less aggressive CO2 emission scenarios. It will be helpful to show these results since "across climate states" is mentioned in the title of this study.

We thank the Reviewer for this suggestion. We have added data from simulations ssp126 l averaged over years 2250-2300, when the climate is closer to an equilibrium state. For completeness, we have also added results from the ssp370 scenario ("most likely scenario") in Appendix, averaged over years 2051-2100. These simulations show that ENSO variability significantly increases (95% level) in both scenarios, though with larger spread in ssp370.

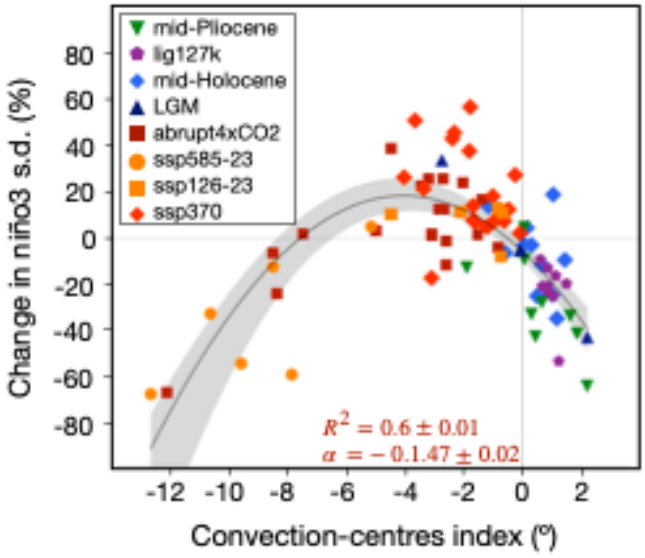

Figure R2.1 – Relationship between the convection-centres index and the change in niño3 amplitude, measured by its standard deviation (s.d). The solid black line indicates the quadratic fit based on the

least squares method. Banding indicates 95% confidence interval based on a 1000-sample bootstrap. The mean displacement of the convection centers boreal spring-summer is considered (i.e., encompassing developing and mature ENSO phases). R2 indicates the coefficient of determination and *a* the nonlinear coefficient of the quadratic regression model. Error estimates for R2 and alpha we calculated as one standard deviation of 1000 bootstrap realizations. The convection center index is, by definition, positive for poleward movements of the Convergence Zones referenced at the model's piControl position.

2. It's interesting to see that the left branch of the quadratic regression curve is due to mid-Pliocene scatters in Fig. 3c. In contrast, there are scatters mainly from the abrupt 4xCO2 simulations at the left branch of the quadratic regression curve in Fig. 3b. Could you provide some explanation/discussion on the reason of this? In addition, why there are not many abrupt 4xCO2 scatters in Fig. 3c?

We thank the Reviewer for noticing this. This was a typo. Symbols for 4xCO2 and Pliocene simulation were reversed in this figure. This has now been corrected.

3. Fig. 1: It would be helpful if the color bars in Fig. 1a-1d could be revised to make positive values in warm colors (yellow and red) and negative values in cold colors (blue).

We opted for centering the warm and cold colors in the average warming over the tropical Pacific because cold colors align with regions of stronger winds and vice-versa, in agreement with changes expected from the wind-evaporation-SST feedback. Thus, representing how wind intensity affects the zonal SST gradient in the equatorial Pacific. Also, as nearly all the simulations used in our study represent warmer climates than the pre-industrial control. Therefore, most of the changes in SST are positive and thus fewer colors (yellow and red) would not highlight the patterns.

Technical corrections:

We thank the Reviewer for noting these technical corrections. As the text has been modified, the location of these corrections has changed, but we carefully checked our manuscript to address them.

Line 30: Central El Niño events -> Central Pacific El Niño events
Line 58: ~129 116 thousand years ago -> ~129-116 thousand years ago
Line 77: CO2to -> CO2 to
Line 167: Figure 2a -> Figure 2b
Line 176: Figure 2b -> Figure 2d
Line 477: boreal spring-summer -> austral spring-summer