Review of “Comparison of past and future simulations of ENSO in CMIP5/PMIP3 and CMIP6/PMIP4 models” by Brown et al.

Recommendation: Major revisions

Summary: This study investigates the change in ENSO amplitude, ENSO related precipitation changes and ENSO teleconnections in a multi model ensemble of CMIP5/6 and PMIP3/4 models in past and future climate states. While the models agree quite well in ENSO Holocene and LIG, the they disagree strongly in LGM, 1pctCO2 and 4xCO2.

Overall opinion: This is an interesting and well structured study. The results are well elaborated and convincing. My major concern is the presentation of some SST Figures, as relative SST highlights in many cases the relation between SST change and precipitation/atmospheric circulation changes much better (see major point). A more detailed discussion of the presented results to the changes in the Walker Circulation would also allow a deeper insight into the cause of the precipitation and ENSO amplitude changes.

Major comments:

Introduction: You don’t say anything about ENSO in the Interglacial. Please add.

Fig. 1: As for the tropical circulation the relative SST reveals the relation to precipitation and atmospheric circulation much better, please show the relative SST bias in Fig. 1c-f) and give the area mean temperature in the header (Johnson and Xie 2010; Johnson and Kosaka 2016; Bayr et al. 2018; Izumo et al. 2019).

Fig. 6: As for Fig. 1 I would strongly suggest to show the relative SST change (and area mean SST change in the header), as this indicates the change in Walker Circulation (Bayr et al. 2014, 2020), which would be helpful to understand the precipitation change and ENSO amplitude change. Further, the change of Walker Circulation under different global mean temperatures is partly driven by the overall (homogeneous) warming (weakening under warmer and strengthening under colder mean climate, (Held and Soden 2006; Vecchi et al. 2006; DiNezio et al. 2011) and partly by the inhomogeneous warming (depends on the change of the SST gradient, Bayr and Dommenget 2013; Bayr et al. 2014). The best would be a more detailed analysis of the Walker Circulation changes to understand the ENSO amplitude change and precipitation change. But maybe you already get a clearer picture, when looking at the relative SST change.

Fig. 8 & 9: can you please show the multi model ensemble mean for each subfigure and the spread around as box plot.

Fig. 13: Please give the correlation values for each scatter plot. Further, I suggest to also look on how the wind-SST feedback changes in the scenarios, as from my experience and the study of (Vijayeta and Dommenget 2018) the change in the wind-SST feedback explain a large part of ENSO amplitude change. The change in wind-SST feedback is strongly influenced by the change in the Walker Circulation (Bayr et al. 2018, 2020).

Minor comments:

75: mid-Holocene – please give the years BP

120: “was replaced by the Central Pacific-type El Niño” When? At the beginning of 21st century? Please make clearer.

132: You should also cite here (Latif and Keenlyside 2009).

Fig. 1 & 2: What is the stippling? It is not mentioned in the figure caption.

255: “The Intertropical Convergence Zone (ITCZ) is generally shifted to the north”. But also the rising branch of the Walker Circulation is shifted to the west (Bayr et al. 2018, 2020). This weakens the atmospheric feedbacks and hampers simulated ENSO dynamics. This should be discussed somewhere in the paper.

429: “must consist of several processes.” An other explanation is the nonlinear behavior of ENSO amplitude and SST gradient/thermocline slope as shown in Fig. 6 in (Hu et al. 2013).

460: “increase of the negative feedback by the mean current thermal advection” Another possible factor can be an increase of the negative heat flux damping as found in (Prigent et al. 2020) for the Atlantic Nino reduction since the year 2000.

498: you should also mention here the bias ENSO dynamics due to the error compensation of the underestimated wind-SST and heat flux-SST feedback (Bayr et al. 2019) and weaker oceanic response (Kim et al. 2014).

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