

Reviewer#3:

General comments

Climate change in the Southern Hemisphere is poorly understood, and large model biases are known to exist. Studying how climate has changed at the LGM may provide unique insights into the climate dynamics of this region. This manuscript investigates changes in temperature, precipitation, and wind over Australia at the LGM using a subset of PMIP3 and PMIP4 models and compares these changes to existing proxy data. Such a study could be helpful in improving our understanding of Australian climate.

The analysis is generally okay: the authors looked at the climate response in individual models, ensemble mean, and seasonality. However, I think the authors could have added some more in-depth analysis or discussion. One thing they can do is to expand the inter-model agreement (hatching the maps of ensemble mean could be helpful), and consider how model disagreement may affect the ensemble mean values.

[Response]: Thank you for your comments and suggestions. Stippling will be added to all MMM figures (Figure 3, 5, 8, 9, 10) to show model agreement. All other figures show individual models which allows model consistency to be evaluated by the reader.

I also think that the mechanisms for changes in temperature, precipitation, and wind are not adequately discussed. Please see my specific comments.

In addition, I think the authors should do their due diligence to acquire model output from all PMIP4 models.

In terms of presentation, the manuscript is structured logically. But the color scales for showing hydroclimatic anomalies could be improved such that the map colors are not overwhelmed by the changes at the coast to make it easier to see changes over the continent. And a better integration of data-model comparison could be achieved by showing the proxy-reconstructed changes in the map of simulated changes.

[Response]: Thank you for the suggestion. We have tried to modify the color scales of hydroclimate plots by changing to a smaller range of colorbar so that the values over land are more easily seen. However, it is difficult choose a color scale for hydroclimate figures which allows all areas to be clearly seen. We include Table 5 to show average changes over land for this reason.

Regarding the proxy-model comparison, as noted for reviewer 1, we have provided already that the sign of the change is uncertain, especially when taking into account the CO₂ effect on vegetation records, and therefore we refer to the literature but don't include any proxy records in our plots.

Specific comments

The Abstract ends abruptly by describing changes in winds, whereas here it should provide the readers with some key implications or take-home message of this paper.

[Response]: A sentence will be added to the Abstract summarising key results.

47: Ujvari et al 2018 is not an appropriate reference, as it does not talk about changes in dust at the LGM.

[Response]: Thanks. This reference will be removed.

61: Many of these referenced papers did not use PMIP4.

[Response]: This sentence will be corrected to refer to PMIP4 studies only.

66: You did not mark these regions discussed here in Figure 2. Maybe use consistent terminology here as the rest of the paper.

[Response]: Thanks for the suggestion. We will change the naming in Section 1.1 to the consistent name as the rest of the paper.

74: Reference for the fire study?

[Response]: The information comes from Rowe et al. (2020) who examined microcharcoal in the Girraween lake sediment record as an indicator of landscape fire. This sentence follows the previous sentence summarising results from Rowe et al. (2020) but we will add a second citation of the paper in this sentence.

77: You cited a wrong Denniston et al (2013) paper. The correct one is:

Denniston, R. F., Wyrwoll, K. H., Asmerom, Y., Polyak, V. J., Humphreys, W. F., Cugley, J., ... & Greaves, E. (2013). North Atlantic forcing of millennial-scale Indo-Australian monsoon dynamics during the Last Glacial period. *Quaternary Science Reviews*, 72, 159-168.

Note that in the paper you cited, the C126 speleothem shows more positive $\delta^{18}O$ and $\delta^{13}C$ values at LGM than the late Holocene, which might suggest drier glacial conditions.

[Response]: Apologies. The correct reference will now be provided, and the sentence modified to better reflect the information shown in the speleothem.

143: This statement is incorrect: Zhu et al. (2021) only assessed CESM2-CAM6, the “low top” version of CESM2, not the WACCM version.

[Response]: We apologise for the incorrect statement. We had some trouble linking the available CESM2 model simulations on ESGF with documentation and relevant publications. We will now include the CESM2-WACCM model as we now understand this model does not have an unrealistic climate sensitivity.

156: Do these different ice sheet configurations affect the Australian climate at LGM? Did you use them in your study?

[Response]: A new Table will be added which gives information of ice-sheet reconstructions for individual models. The PMIP3 models used PMIP3 ice-sheet configurations and the four PMIP4 models used in this study all used the “ICE-6G_C” ice-sheet reconstruction. There will be influences on the simulated LGM climate affected by the different ice sheet configurations between two model generations.

180: Why do you choose the first 100 years? Models need time to reach new climate equilibrations in response to external forcings. I would use the last 100 years if possible at all.

[Response]: Thanks for the suggestion. This has been justified for reviewer 1 and 2 as well. We are using the first 100 years due to the reason that the simulations public on ESGF are already in equilibrium so there will be no significant differences for whether it is the first or the last 100 years. In many cases, only 100 years were available from ESGF.

185: specify it is austral summer/winter. I also think this is where you can describe the regional climate systems in more detail. i.e., winter precipitation in the south is associated with the westerlies, summer precipitation in the north is associated with the monsoon.

[Response]: Thanks for the suggestion. We will expand the description of the regional climate systems.

241: If “land areas warm more than surrounding oceans” during DJF and SON is the case, why DJF and SON show opposite signs in temperature change over Sahul? Are there other mechanisms that could cause this change in temperature?

[Response]: The two paragraphs discussing Figure 5 will be rewritten to clarify the results. There are a number of points which required better explanation.

245-250: How do these analyses relate to your results in Figure 5? If there is enhanced cooling in SON and reduced cooling in MAM, why Fig 5 shows more cooling in MAM and less cooling in SON?

[Response]: The two paragraphs discussing Figure 5 will be rewritten to clarify the results. There are a number of points which required better explanation.

311: What is this “SST gradient”?

[Response]: The discussion refers to surface temperature gradients in the region. It will be rewritten to clarify.

395-396: This statement does not make sense. Fig 5 shows DJF cooling and SON warming over northern Australia, why does it case wetting in both seasons? What is the “response to changes in seasonal heating” and “changes in atmospheric circulation” here?

[Response]: The discussion of drivers of change in rainfall will be rewritten to clarify. New figures showing changes in 850 hPa winds in Section 3.2 will assist to show the relevant processes – due to changes in offshore/onshore circulation.

414: $p = 0.082$ suggests that the correlation is not significant or “moderate” – it is insignificant. By the way, I wonder how do changes in precipitation and the northward displacement of easterly-westerly boundary correlate.

According to your findings, what is the mechanism for changes in winds?

[Response]: Thank you, we agree this is insignificant. The whole Section 3.3.2.1 (winds) will be rewritten. The mechanism for changes in winds will be discussed with reference to other LGM westerly studies.

Technical corrections

268: You don't need a 3.2.1 subsection here

[Response]: This will be corrected.

323: Figure S4 is MMM seasonal anomalies for LGM - PI evapotranspiration, not precipitation.

[Response]: Thanks. This will be corrected.

397: to the => to the

[Response]: This will be corrected.

403: should be 3.3.2.2

[Response]: This will be corrected.