Reviewer#1:

The knowledge of the characteristics and mechanism for the climate change over Australian regions in LGM is still not enough. This study investigated the climate changes at the LGM over the Australian region, in terms of temperature, precipitation, moisture balance and wind, based on the output from PMIP3 and PMIP4 simulations. The work might contribute to our understanding of the hydrological change of Australia in ice ages. The following are my comments and reviews for the authors' consideration.

Comments:

1. The uncertainties of model simulations and reconstructions are important information for model-data comparison. It would be better to evaluate the model consistence since there was large model spread. Specifically, the authors could further provide the percentage of model ensembles consistent on of the signal of their multiple model ensembles mean value.

[Response]: Thanks. 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.

For the reconstruction, the background information of proxy used here and their uncertainty could be listed in a table. The information of the LGM climate getting wetter or drier and in which parts of Australia based on proxies is still not clear, even though the authors cited others' work in line 459-463. It would be easier to read and make comparison if were there reconstructed data mapped on the plots of model results.

[Response]: Thank you for your suggestion. We emphasize that this study is not concerned specifically with detailed data-model comparison of LGM hydroclimate in Australia. Our principal reason for avoiding a quantitative data-model comparison with proxy climate reconstructions of the Australian LGM is that the Australian proxy-based LGM palaeoclimate literature typically has provided qualitative reconstructions, ('drier', 'much drier', 'somewhat drier') and that, where quantitative reconstructions have been provided, they have uniformly been based on comparison of LGM plant distributions with modern plant distributions, or comparison of the LGM occurrence of mobile sand dunes with their modern distribution, respectively. These comparisons, however, have ignored the plant physiological effects of low atmospheric CO_2, which is increasingly recognised as a problem that should not be ignored (Scheff et al., 2017; Prentice et al., 2022). In brief, C3 plants perceive an LGM world with low (180 ppm) CO_2, as much 'drier' than today, so that model simulations with dynamic vegetation typically show widespread forest reduction, even when holding temperature and precipitation at modern values. Moreover, it is increasingly suspected (e.g. Scheff et al., 2017; Roderick et al., 2015) that greater LGM dustiness and dune-mobilisation are secondary effects from reduced plant productivity, via landscape destabilisation.

For these reasons, we believe it is misleading to describe or list the published LGM hydroclimatic reconstructions in detail. We believe it will be clearer, to explain in summary form the recently-recognised problems associated with understanding LGM hydroclimate, as described above; and treat the published reconstructions collectively, at the level of a literature, rather than as individual reconstructions.

1. Usually, modeling community use surface air temperature (SAT) instead of surface temperature (ts) to investigate the temperature change, and to explain the related change of circulation and/or precipitation.

[Response]: Thank you for that. We will redo all temperature analysis for surface air temperature (tas).

2. The climate proxy from 28 to 18 ka is compared with the LGM simulations at 21ka (Line 55-56). This may also contribute to the model-data inconsistence considering the extended date of proxy. For example, the variability of climate proxy during 28 and 18 ka may switch between drier or wetter condition than pre-industry and thus make the complexity of model-data comparison. This point could discussed further when necessary

[Response]: Thank you for the suggestion. We have checked the dates of the proxy records, this range can be narrowed to 24-18 ka, which is consistent with many studies of LGM climate (e.g. Clark et al., 2009).

3. As pointed out by the authors, the sst gradients and related circulation change could explain the precipitation change (Line 309-311). Thus the analysis of sst change (which roughly equals to the ts value over ocean) and model-data comparison of sst could improve the knowledge of the LGM climate change over Australia.

[Response]: Thank you for the suggestion. We will add a Supplementary Figure showing the SST change over a larger domain extending across the Pacific and Indian Oceans to allow discussion of SST changes linked with Australian precipitation change. Further analysis of the dynamical links between SST and precipitation are beyond the scope of the current study.

Line by line comments

Line 42. "Many regions", could be pointed in details.

[Response]: This sentence will be rewritten to provide more detail of vegetation changes based on proxies and biome models, with citation of Prentice et al. (2011) as the appropriate source: "There was a large reduction in area covered by boreal and temperate forests in northern mid- to high latitudes, expanded lowland tundra in Eurasia, expansion of savanna and grasslands at the margin of Amazon tropical forests and replacement of some areas of tropical forest in Africa, China and Southeast Asia with savanna, woodland and grassland (Prentice et al., 2011)."

Reference:

Prentice, I. C., Harrison, S. P., & Bartlein, P. J. (2011). Global vegetation and terrestrial carbon cycle changes after the last ice age. New Phytologist, 189(4), 988–998. https://doi.org/10.1111/j.1469-8137.2010.03620.x.

Line 92-100. The reconstructed evidence of moisture or hydrocliamte could be compared with model simulations in the section of discussions.

[Response]: Thank you for your suggestion. We already have some discussion in Section 4.2 but will expand this.

Line 155-157. There were three different ice sheet reconstructions. Thus it's necessary to clarify the information of ice sheet configuration of the four models from PMIP4.

[Response]: Thank you for your comment. 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 (differences between the two LGM ice-sheet reconstructions in Kageyama et al., 2017), this will be discussed in Section 2.1.

Table 2. In term of vegetation of PMIP4, were there any model using the dynamic vegetation? Please check and make it clear.

[Response]: Only PMIP4 AWI-ESM-1-1-LR model is using dynamic vegetation. This will be noted in the text in Section 2.1.

Line 180-182. Usually models use the last 100 years, instead of the first 100 years, to do analysis. Were there any big differences between those two choices?

[Response]: Thank you for your comment and sorry for the confusion with the wording of the sentence. We will clarify why we choose the first 100 years of the model run with the new table described above.

Most climate models used in this study only have 100-year length of simulation based on the number of years of data available on the ESGF (Earth System Grid Federation). According to Kageyama et al. (2017), the models have been spun up until equilibrium following the PMIP protocols (refer to Kageyama et al. (2017) for details of the spin-up). At least 100-year data from the equilibrium part of the simulation is required to store on the ESGF (Kageyama et al., 2017). Therefore, the data stored on the ESGF has already been in equilibrium and it does not matter anymore whether it is the first or the last 100 years. There will be no significant differences.

Line 213-214. The difference between the analyses in the paper with Kageyama et al. may lies in the choice of ts, instead of SAT. Please check.

[Response]: Thank you for the comment. Yes Kageyama et al. (2021) used surface air temperature instead of ts. We will change all of our temperature analysis to surface air temperature (tas) to allow a clearer comparison between our study and previous work.