

Response to Referee #2 (in blue)

Recommendation: Minor revision

General comments:

Many numerical studies have demonstrated the importance of fine resolution in modelling the climate system, but at the current time, fine resolution and long-term integrations are competing requirements for climate simulations due to limited computational resources. With these demands and limitations, the variable-resolution approach is an attractive method to conduct high-resolution simulations within a global lower-resolution model. In this study, the authors overview the E3SM version 2 with the regionally refined technique, and presented the evaluation of climate simulations. Results show that the regionally refined technique can provide improved simulations over regional scales. This manuscript would be suitable for publication after revision.

Thank you, and that is our main purpose to document the fully coupled E3SMv2 NARRM results.

In section 4, model results are validated at the global scale in terms of global air temperature increase and climate sensitivities. Precipitation simulation skill is an important aspect. I suggest the authors to add a figure to show the comparison of global annual mean precipitation.

Thanks for the suggestion. We added in Section 4 the description of the global annual mean precipitation results (Fig. A3), which show that NARRM and LR have very similar global patterns.

Besides, I found that although the variable-resolution method indeed improves many aspects in modeling the regional climate, but the systematic biases in the lower-resolution model are not reduced. The authors may give more explain about this point in the manuscript.

As much as we would love to, NARRM is not expected to reduce the systematic biases compared to the LR model as the same low-resolution grids still cover most of the global area in NARRM.

Minor comments:

Table 2. Need to indicate the meaning of the numbers in the brackets.

The numbers in the brackets indicate the simulation year numbers. We revised the table caption to clarify this. Thanks.

Figure 8. Need to indicate the observational minimum-maximum range in the legend.

Revised the figure legend to show the minimum and maximum numbers of observations.

Figure 11. In the ERA5 reanalysis, I think there are also uncertainties in the precipitation. Could you please add an observational benchmark?

Figure 11 mainly shows that the precipitation patterns are better captured by NARRM relative to LR in mountain areas. While we acknowledge that uncertainties exist in the ERA5 precipitation data, such uncertainties should not change this main point and hence we think ERA5 is a reasonable reference in this context.