

Review of

Tropical circulation and associated precipitation response under idealized global warming simulations

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General

The authors examine changes in precipitation and in the large-scale tropical overturning circulation in models participating in tipping points intercomparison project (TIPMIP). A general weakening and widening of the Hadley circulation is seen, consistent with previous works based on observed and other model intercomparison projects (MIPs). Despite the weakening of the Hadley cell, precipitation intensifies in its rising branch and decreases in the subtropics. The ITCZ is similarly seen to intensify, but also contract, and generally shift toward the winter hemisphere (i.e., weaker seasonal excursions following the Sun). The analysis of precipitation uses a novel approach where the meridional boundaries of the analysis region are defined relative to the mean value, and can therefore change across regions.

The results are well communicated and the analysis is for the most part, solid. However, it is not clear to me what novelty this analysis bring to the topic. Specifically, there are numerous works, and even several reviews on the response of the tropical rain belt (or more generally, the hydrological cycle) to global warming. Documenting how TIPMIP models perform in that respect is useful, but very incremental. The fact the TIPMIP consists of only 7 models makes this analysis even more anecdotal. Moreover, the authors generally do not sufficiently describe how their results relate to similar analyses of other MIPs, and to known precipitation and equatorial warming biases. My understanding is that the whole purpose of TIPMIP was to have ramp-up and ramp-down experiments, so that the asymmetries between warming and cooling may be evaluated. Using only the warming component of TIPMIP to me seems as not properly utilizing TIPMIP. Therefore, due to this lack of novelty, the neglect of model biases and their potential influence on the response, and the lack of delineation from previous works, I recommend rejection with an invitation to resubmit an improved version of this text.

Comments

1. **Reference to previous works.** The findings of the present analysis reproduce similar finding in analyses of other MIPs (e.g., Lionello et al. 2024, Ma et al. 2018). These, however, are scarcely cited in the text. Aside for the problematic lack of referencing, the novel results of the present analysis, if any, are not clear. A single reference is mentioned in the Conclusions (Hu et al., which is also not properly cited in the references), and with no context.
2. **Sensitivity to biases.** Systematic tropical precipitation biases in modern climate models are well known. Given that the simulations considered here involve specific global warming targets, there clearly would be a thermodynamic component. See comment related to how to correct for that in relation to Fig.1. Similarly, models generally show equatorial warming while over the past decades, the equatorial central Pacific has cooled. This is important context that should be provided when interpreting the results.
3. **Utilization of TIPMIP.** It is not clear to me why the authors do not also analyze the ramp-down simulations. Given that there has been so much work on the response of the tropical rain belt

to global warming, one clear novelty that TIPMIP may provide is in contrasting the ramp-up and ramp-down simulations. For example, if such differences exist, they would inform us on state dependence and would be helpful in disentangling dynamic and thermodynamic responses (cf. Kug et al. 2022).

Comments by line number

- 25–27 The subtropical convergence zones, such as the SPCZ, SACZ are regional features closely related to storms and adjacent monsoonal regions. Hence, they are not necessarily related to the ITCZ — which is specifically associated with the tropical meridional overturning circulation. Counting these as ‘extensions’ of the ITCZ is an error in my opinion. Please change the phrasing or provide support for this idea.
- 41 It would be appropriate to also cite here Byrne and Scheider 2016a
- Fig. 1 Some information on the precipitation bias in the models would be critical here. Given that the experiments are specifically designed to change the global mean temperature by 2 and 4 °C, there would be a thermodynamic component to the change in precipitation that is entirely due to biases. See Adam et al. 2023 for how to correct for that.
- 213–233 How do these regional responses agree with previous analyses of the sensitivity of the tropical rain belt to global warming (e.g., Mamalakis et al. 2020)?
- 234–244 In recent decades the central Pacific has been cooling, in contrast with projected warming by most climate models (e.g., Seager et al. 2019). The response to equatorial warming may therefore be spurious.
- 250–254 In order for Figs. 3 and 4 to be associated with the mean meridional overturning circulation, you would need to remove the component of the vertical wind associated with zonal overturning circulations (see Schwendike et al. 2014)
- 335 Hu et al. is a review. One of several. Please provide context on what is in agreement here.

References

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