

Interactive comment on “On the Climate Sensitivity and Historical Warming Evolution in Recent Coupled Model Ensembles” by Clare Marie Flynn and Thorsten Mauritsen

Anonymous Referee #2

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Review for Flynn & Mauritsen

This manuscript analyzes differences in the climate sensitivity and transient climate response (TCR) between the CMIP5 and CMIP6 models. After showing that the increases in climate sensitivity and TCR of the CMIP6 models relative to the CMIP5 models is statistically significant, the authors aim to explain the underlying reasons for the increases. They conclude that the increase in climate sensitivity is likely related to changes in mixed-phase clouds and they suggest that TCR increased due to exaggerated warming after the 1970s.

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In my opinion, the manuscript addresses an important and interesting topic, however, after Section 3 (which addresses the possibility that the increases in climate sensitivity and TCR may be due to chance), I find that the manuscript is only scratching the surface of several complex topics, though I do feel that it is going in the right direction and it points out several important issues. I also find that the text is not very detailed, and there are too many figures that don't directly address the "why"s to a satisfactory degree in my opinion. Overall, I think the manuscript could benefit from a clearer "punchline" that is backed by solid analysis. Furthermore, the results for the analysis of climate sensitivity related to cloud feedbacks has already been noted in more detail by a recent publication by Zelinka et al. (2020) (not cited in the references), that looked at a similar number of models. I would recommend that the authors look for a clearer "punch line" for this paper, and to do a more in-depth analysis on it before this paper can be accepted for publication. Perhaps they could focus on and expand the analysis of the increase of TCR, or on the clear-sky feedbacks, for example.

Specific comments:

- I realize that Zelinka et al. (2020) was first published online on Jan. 3, 2020, but I think it's important for the authors to differentiate their work from this paper now that it has been published. First, how do the authors reconcile the fact that Zelinka et al. (2020) actually find that the increase in ECS in the CMIP6 models is statistically *insignificant*? Second, Zelinka et al. (2020) went further and performed a cloud feedback analysis of the CMIP5 and CMIP6 models. They found that besides the cloud optical depth feedback, the cloud amount feedback also played a large role in the increase in climate sensitivity. The authors "speculate" the possibility of cloud optical depth playing a central role in the increased climate sensitivity via mixed-phase cloud processes, but apparently Zelinka et al. (2020) had shown that cloud fraction changes play just as strong a role.

- What I'm left wondering is *why* aerosol cooling is stronger for the pre-1970 period but compensated for with greater post-1970 warming in CMIP6?
- Section 2.1: Why was an attempt to account for annual fluctuations applied to piControl but not for abrupt4xCO2?

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