

## ***Interactive comment on “Variability of surface climate in simulations of past and future” by Kira Rehfeld et al.***

### **Anonymous Referee #1**

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Review of “Variability of surface climate in simulations of past and future” by Rehfeld et al. for consideration in Earth System Dynamics

### Overall Comments

The analysis seeks to quantify changes in variability in both temperature and precipitation as a function of the baseline climate state by using simulations from a broad range of climate experiments. The manuscript is well written and logically organized. The core scientific objectives are well articulated. The approach and simulations used are appropriate for the science questions posed. The figures are well-designed generally and nicely illustrate some new and useful results.

My main concerns relate to the summaries provided for the results and the manner

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in which the authors gloss over some of what I find to be the the key findings. I also suggest a reconsideration of the figure layouts to more strongly align with the structure of the text (Figs 2,3).

Specific Comments - I recommend splitting the abstract into two paragraphs to make the summary clearer - one for what is done and one for what is found. - p1\_10: based on Fig 2, I'm not sure that I find this summary of a decrease in variance for increasing temperature to be true, particularly over land. For example if I am interpreting them correctly, Figs 2g/h show strong positive increases, particularly over land from 40N-S where they are associated with significant impacts. There are various statements in the text that seem at odds with the passage as well (e.g. p12\_24-30). Would it make sense to parse this statement a bit more to relate clearly to specific results and distinguish between regions of coherent change that contrast (i.e. land/ocean). - p1\_14: is "dominating rainfall variability" appropriate - do they explain the vast majority of variance? across what timescales? - p2\_8: the sentence seems to suggest that internal variability is distinct from natural variability? - p2\_21: scale linearly? - wording seems to suggest so - p2\_30: isn't there also evidence for increases in variability on some timescales? such as ENSO teleconnections? - p3\_8: Precipitation changes are also strongly linked inversely to temperature. Wouldn't this therefore be a source of increased temperature variability? There is associated literature on the topic that should be discussed and cited. - p7: For many of these experiments, multiple ensemble members are available. I don't see mention of how many members are used? If only 1, that should be made explicit on page 3. If more than 1, that too should be made explicit and the approach for avoiding overweighting individual models should be described. Despite the additional work, there does seem to be merit in consideration of all available members to address various questions on the role of noise in the results - some listed below. - p8\_10: It seems sufficient to merely cite the CVDP rather than each script invoked by it since the CVDP documentation covers this. - p12\_14: again referencing the work here that has been done on temperature precipitation relationships seems appropriate. - p12\_30: I don't think the global pattern correlation tells the key components of the story. From

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40N-40S it seems clear that the PCs are positive. - p13: The caption for Fig 2 should be explicit regarding whether it is the global mean temperature change that is used to compute the ratio or the regional change. - a number of the CVDP variable names are used - which are long and likely not familiar for many readers. I'd recommend creating acronyms for these so that they can be shortened and are more intuitive. - Fig 4: how do you estimate your degrees of freedom in computing P-values? There is mention of 500-DOF in discussion of LGM but that is clearly excessive given the strong mutual dependencies across models, no? Perhaps a more stringent estimate is warranted? - I have a general suggestion regarding the structure of the figures. Since the text is structured to discuss T/P of each experiment why organize the figures to show only T for all experiments and then P for all experiments. Particularly given the mutual relationships that exist, I find merit in having one figure of 4 panels for each experiment - for a total of 4 figures of 4 panels rather than 2 figures of 8. - Fig 4: what is the contribution of internal variability versus model structural contrasts to the scatter in each panel? can multiple ensemble members, where available, be used to estimate a contribution range? I think this would provide key context for interpreting the figure. - Figure 5: I imagine the "W" in the titles corresponds to West? If so I'd spell it out to avoid confusion with "Wet". Also what justifies the selection of the regions? They are much smaller than the climate zones they are intended to represent. Their small size suggests they may be particularly subject to internal variability rather than structural differences across models or experiments. - Figure 6: I suspect that the global mean again masks some important regional effects. How might the results change for land between 40N-S? - p12\_13: what is meant by "meridional atmospheric gradient modes of variability"? Is this referring back to results in Section 3.4? Might make this reference more explicit. - p17\_11: Is the lack of consistency the result of the choice of such small regions? - p17: There doesn't seem to be any rationale for the organization of paragraphs. Perhaps make one for each region? - p17: After reading Section 3.4 I don't seem to have much of an understanding of the robustness from past to future climate - the stated goal of the section. - p19\_5: Why combine land/ocean regions? I think a

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distinction should be made, particularly for 40N-S. - p22\_14: What is meant by a reduced ENSO? reduced variance in Niño3.4 SSTs? - p22\_22: “mean strengtHS”? Note that much of the analysis examined changes in generic variance and then changes in the indices themselves. What is left out is the change in teleconnection strength. Shouldn't this be considered? and isn't it perhaps more important than the changes in the indices themselves? - p22/23: Perhaps cite the figures and panels that support each statement as such references are at times unclear. Some figures seem to clearly contradict the statements made.

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