Review of “Understanding the model uncertainty of future changes in extreme precipitation events”

In this paper, the authors analyse changes in Rx1day precipitation across 23 climate models, including 4 models with 10+ ensemble members. They uncover sources of internal and inter-model uncertainty in Rx1day through a dynamical-thermodynamic decomposition, and analyse the extent to which various simplifying approximations to their decomposition can give equivalent results. They complement this with an analysis of local temperature anomalies, and reveal that inter-model uncertainties in thermodynamic changes are dominated by a shift in the seasonality of Rx1day.

This is a really fantastic paper. The authors’ methodological framework is excellently suited to the task they approach, allowing them to obtain a clean conceptual synthesis of the multi-model ensemble they analyse. I found it very enlightening, and have been pleased to review it. I do have a small number of comments aimed at clarifying certain aspects of the methodology and contextualising the findings, and so I am recommending minor revisions overall.

- The paper is laid out in a Nature-like format with methods in an appendix at the end. I would prefer to see these as Section 2. The various “(see methods)” comments in later sections could then be removed.

- I would like to see a slightly clearer presentation of what exactly you show in Figure 5. Based on the discussion from L165 to L178 I do not feel confident I can write down the formula for what you’ve computed. This could be added into the methods, and referred to in the Figure discussion.

- In Equation 1 can you explicitly specify the meaning of theta_star?

- You refer to Figure 7 before Figure 6

- The evaluation of how well simpler, vertically integrated variables can reproduce the full scaling is a very valuable aspect of the paper. It would have been interesting to see a full decomposition of Eq. 1 in this line, and I’m just curious as to why you didn’t take that approach here. The scaling of Eq. 1 decomposes fully into 6 terms: contributions from the vertical mean and vertical deviation of the dynamical, thernodynamic and nonlinear eddy trends. I suppose from that alone you would be able to see that the vertical deviation terms are small?

- In a similar vein, do you know how much of the difference between Rx1day changes and the diagnostic scaling do you think may be a result of time-evolving precipitation efficiency? Modelling Pe = [E_0+E_1*dT]*{omega dq/dp}, then (ΔPe,true - ΔPe,diagnostic)/Pe,diagnostic = E_1. Have you previously assessed if including such a second-order term explains much of Fig. 1c? Obviously you’re interested in the linear scaling here, but there are interesting implications to whether the difference is actually just for the numerical reasons you discuss or from some nonlinearity in the response.

- In the conclusion could you briefly discuss/speculate how synoptic/large-scale dynamics might connect to some of your core results? To me it seems plausible that some of the seasonal shifts you see might be at least partly related to alterations in shoulder-season synoptic activity, for example. To the casual reader, it would be easy to misinterpret what your dynamic and thermodynamic terms represent and conclude that a predominately thermodynamic contribution to uncertainty means only small-scale processes are uncertain.

- Also, could you speculate/comment in the conclusion as to how you think model resolution may impact your decomposition? I wonder how models with explicitly resolved mesoscale convective systems or tropical deep convection might look different/similar? Just to help add interpretative context.