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Interactive comment on "Exploring precipitation pattern scaling methodologies and robustness among CMIP5 models" *by* Ben Kravitz et al.

Anonymous Referee #2

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The submitted manuscripts compares several methods for the pattern scaling of precipitation across time periods and scenarios. They compare a regression based approach, an epoch difference and a 'physically' approach. I cannot recommend this paper for publication because of two significant errors in the methodology, combined with a manuscript which is too long, without a clear structure.

Firstly, the 'physically-based' approach, which is based on the work of Lau (2013), is very likely incorrectly applied. In Figure 4, which is basically a test of whether the methods are able to reconstruct an in-sample pattern of precipitation using the same ensemble and time period as a test response pattern as was used to produce the pattern itself. In this case, the method produces errors an order of magnitude greater than the other approaches - which suggests that there is an error in application. If there is no error, this huge discrepancy requires an explanation.

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Discussion paper

However, even taking this into account, there is little logic that this approach is 'physically-based' at all. The precipitation rates are binned by different monthly rain rates, averaged over the ensemble and recombined into a single pattern. If a single pattern is being scaled - the ability to treat differently rain rates in different regimes has already been lost. The entire concept is not clearly defensible.

The separation of response patterns into CO2 and non-CO2 components could potentially be useful, but the implementation is flawed. The authors assume in Figure 14 that the non-CO2 response pattern is given by the difference between the RCP8.5 and 1pctCO2 patterns. This is not correct.

Assume there is a 'pure CO2' precipitation response which can be measured from the 1pctCO2 simulation:

$$B_{CO2} = \Delta P_{1pctCO2} / \Delta T_{1pctCO2}$$

If we assume things are linear, the precipitation response in RCP8.5 is this pure CO2 response, multiplied by the pure CO2 warming, plus a non-CO2 response:

$$\Delta P_{RCP85} = \Delta T_{RCP85,CO2} B_{CO2} + \Delta T_{RCP85,nonCO2} B_{nonCO2}$$

so - by solving this, we get the B_{nonCO2} pattern and could reconstruct the ΔP_{RCP85} exactly.

However, it's still not clear that CO2/nonCO2 is the correct way to break this problem down. The nonCO2 component is a broadly mix of aerosols, and other greenhouse gases (CH4, N2O etc). These two groups can have opposite effects on global mean temperature - potentially making $\Delta T_{RCP85,nonCO2}$ near zero and making the above equation ill-posed.

Furthermore, CH4 and aerosols have very different precipitation response fingerprints. RCP8.5 and RCP2.6 have very similar aerosol forcings, but very different CH4 trajectories, so the nonCO2 pattern appropriate for RCP8.5 would be very different than that for RCP2.6.

A far more logical decomposition would be between GHG and nonGHG forcing. The authors could solve this by treating the 1pctCO2 response as the GHG response pattern, and then in RCP8.5 calculating the effective CO2 concentration using the emission factors for each of the non CO2 gases, and then computing the $\Delta T_{RCP85,GHG}$ as before using effCO2 rather than CO2 itself.

The general formulation of the rest of the paper, and the treatment of the other two pattern scaling approaches, is broadly correct - but the presentation is often frustratingly vague. It is often not made clear what is in sample, and what is being tested. In Figure 8, are the same models being used to make the patterns and the test the errors? In Figure 11, is it 1pctCO2 or RCP85 being reconstructed?

The authors should correct the major errors above and restructure the paper to ensure concise and clear communication before resubmission.

Lau, W. K.-M., Wu, H.-T., and Kim, K.-M.: A canonical response of precipitation characteristics to global warming from CMIP5 models, Geophys. Res. Lett., 40, 3163–3169, doi:10.1002/grl.50420, 2013.

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