Review of 'Hadley cell expansion in CMIP6 models'

by Kevin M. Grise and Sean M. Davis

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Recommendation: Minor Revision

Reviewer Name: Penelope Maher

1 Summary of the Review

The manuscript documents contrasts trends in the Hadley cell edge in current generation CMIP6 models, the previous generation CMIP5 models and multiple reanalysis products. This results are new, novel and will be of broad interest to the community. Put simply the manuscript is superb and I very little reservation in recommending this for publication with only a few minor changes. The manuscript is skillfully written and clearly communicated. I particularly liked the perfectly simple and concise title, an excellent and well motivated introduction, and plots of a consistently high quality and common style. The manuscript also has a nice balance of both the NH and SH perspectives.

I would be happy to review the paper a second time should it be neeed.

2 Minor Comments

1. In the introduction the focus is very much Hadley cell edge rather than tropical edge. So I was a bit surprised then to see the EDJ metric used in the analysis. I think a more general description of Hadley cell edge vs tropical edge metrics is then needed in the introduction. Then bring this through to your second last paragraph in the introduction that describes the aims of the paper.

2. My interpretation for the use of the EDJ is that your taking advantage of the correlations between the HC edge and the EDJ in order to get longitudinal variability. Can you explain why you used this approach over say a local HC method (eg Schwendike et al. (2014) or your own study Staten et al. (2019))? Is this to avoid adding more metrics (ie consistent with TropD and the idea that fewer/better methods are the goal) or is it that you have concerns about the local methods accuracy/applicability?

3. Introduction: In addition to the papers already cited, there are a number of excellent papers on Hadley cell expansion from Chris Lucus and Hanh Nguyen at the Bureau of Meteorology which could also be cited here. I am thinking papers such as Nguyen et al. (2012, 2015, 2018) Lucas et al. (2012, 2013); Lucas and Nguyen (2015). I am not suggesting you cite them all, but one or two would be good.

4. The introduction would benefit from a brief discussion that the Hadley cell latitude (middle atmosphere mass stream function zero crossing latitude) is thought to be the most reliable measure of tropical expansion (this is touched on briefly in L45 but I think this could be expanded a little). I think there should also be mention to other tropical edge metrics (STJ, EDJ, OLR, P-E etc) which are used within the literature already cited, and include the relationships with the jets (strength and position) in terms of tropical edge metrics and relationships with the HC position Ceppi and Hartmann (2012); Menzel et al. (2019); Maher et al. (2019).

3 Editorial comments

3.1 Introduction

1. L21: I found 'indicate' awkward in this sentence. I suggest rearranging to the following or similar: ' The poleward expansion of the Hadley circulation is one of the most robust aspects of the atmospheric general circulations response to a warming climate in global circulation models.'

2. The acronyms CMIP, SH and NH are already written in full in the abstract so I do not think you need to define them again in the introduction.

3.2 Data and Methods

1. L79-90: I think this would be easier to read directly from Table S1/S2 rather than list in the paragraph. I would then move move the tables from the supplementary into the manuscript. Instead of 'x' you could add the time window of the data, add a column for the reference for each model, add a column for indicating if CMIP5 or 6 (then you only need 1 table) and include the horizontal resolution of the model. This would probably then be a landscape whole page table which is common for CMIP papers. These are simply suggestions, proceed as you wish.

2. L107-112: I would also use a table for the reanalysis data sets.

3. It would be mentioning in this section the method used to test significance (it is stated in each of the plots already).

3.3 Dynamical sensitivity of CMIP6 models

1. Fig 1 (and S1): I think this plot would look better and take up less space if it were 1 row and 2 column (ie side by side). I found the asterisk (and in later plots the circles) hard to interpret (are they in S1 too?). I think open and filled circles for the ensemble mean might communicate this clearer or have a lighter and darker versions of black/red. Likewise for Fig 4

2. Was the goal of Fig 2-3 on focusing on the NH only to draw out the differences seen in Fig 1 for JJA in NH?

3.4 Hadley cell expansion over the historical period

1. Fig 5: The legends are a little small and repeated. Suggest making larger and only having one (perhaps at the top or bottom of the panel). Might also help to add 'ensemble mean' for the purple line in the top panels of each sub-plot.

2. L238: only 3 out of the models 'greatly exceed' historical and AMIP runs. Suggest mentioning the reanalysis models by name or putting in the clause 'some of the reanalysis greatly exceed'.

3. Fig 6-7: I can't really tell one model from another. I am not sure this level of detail is helpful as I found these plots a little overwhelming. The ensemble mean bars are also easily lost in the scatter. This is my personal opinion and the authors can change or not change these figures as they wish.

4. What is happening in Fig c-d bottom panels for the reanalysis between 1990-2000 – is this the PDO?

3.5 21st century trends

1. Suggest starting this section with 'The' so that the 5 and 21 are separated.

3.6 Supplementary

1. The first page would benefit from adding a title of the paper and stating it is the supplementary material (minimum) or adding title page (if you wish).

References

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