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Comment on wcd-2022-14

Anonymous Referee #2

Referee comment on "The tropical route of quasi-biennial oscillation (QBO) teleconnections in a climate model" by Jorge L. García-Franco et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2022-14-RC2, 2022

The tropical route of QBO teleconnections in a climate model

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Recommendation: May be publishable after major revisions

The paper seeks to understand the link between the tropical stratospheric QBO and variability elsewhere in the tropical atmosphere (and on ocean SST). The tools used include observational/reanalysis output since 1979, and several preindustrial control runs from various versions of the Met Office model. This is an interesting subject and the foundation of a paper that could eventually be publishable in WCD is clearly present. Many of the arguments are not convincing in their current form however, and while I don't think these critiques are insurmountable, addressing them will require some major rethinking and rewriting.

My main criticism is that the authors argue there is a connection between the QBO and

ENSO, but the evidence provided is not strong enough (and in this reviewer's opinion the authors' claims are actually incorrect). First, the observational period covered by this paper only begins in 1979, however high-quality radiosondes have tracked the QBO since ~1953, and reliable information on the ENSO state is available even earlier. Studies that have used the entirety of the observational record have reached an opposite conclusion of that reached by the authors. Specifically, in the period before 1979, there were more easterly QBO events simultaneous with El Nino. This has been noted by at least three papers (Garfinkel and Hartmann 2007, Hu et al 2012, Domeisen et al 2019), none of which were cited in this paper. The net effect is that the observed connection between ENSO and the QBO is non-stationary, and (cherry-) picking a limited subset of the full observational record can lead to misleading (and erroneous) conclusions. Over the entirety of the observational record (at least until 2018, the last year considered by Domeisen et al 2019), the correlation was essentially zero.

Second, the modeling evidence presented by the authors for a relationship between ENSO and the QBO is also misleading and perhaps wrong. The authors consider several different simulations from one model, however Rao et al 2020 (not cited) recently considered the connection between ENSO and the QBO in ~17 different CMIP5/6 models. Rao et al found that some models simulated a connection of the same sign as that found in this paper. However other models simulated an opposite effect. Notably, the two MetOffice CMIP6 models considered by Rao et al 2020 had opposite responses (their Figure 11n and 11r). The multi-model mean effect was essentially null in Rao et al 2020. Thus, it is conceivable that the MetOffice models examined in this study do indeed simulate a connection between ENSO and the QBO, however this relationship does not appear to be generic, and future work is needed to unravel the causes of model disagreements.

The net effect of these criticisms is that I don't think it is particularly informative or meaningful to study the tropical atmospheric response to the QBO unless and until the ENSO signal has been regressed out. The authors indeed do perform such a regression, and they also additional examine ENSO neutral years only, which is great! But the analysis earlier and also later in the paper is suspect to this reviewer. Stated another way, the authors themselves note that the observed response to the QBO depends sensitively on whether neutral ENSO only is examined, so why even show the observed response before removing the ENSO influence?

My suggestion is to focus on the results where ENSO is "removed" much more or exclusively (as they do indeed contribute to the scientific discourse), and significantly shorten the rest of the paper. At the very least, the discussion of the figures 1,2, 3, 7 needs to be rewritten.

Finally, Rao et al 2020 also consider the response of OLR and precip to the QBO with the ENSO signal regressed out, and find a wide range of responses across the models. Particularly perplexing to this reviewer is that Figure 7n/8n and 7r/8r of Rao et al consider the OLR and precip response in two different versions of the Met Office models, and find if anything opposite results. The present paper focuses mainly on the higher resolution runs which were not analyzed by Rao et al, however the authors should include in the supplemental material additional figures for the other model versions for most of the figures in the paper.

Specific comments:

- My general comments mentioned four very relevant papers that appear to have not been cited. Please add them as appropriate throughout the manuscript.

- The authors attempt to remove an ENSO influence throughout by forming eQBO and wQBO composites during ENSO neutral years only. Note that this doesn't guarantee that the mean ENSO index during the wQBO and eQBO composite are actually identical.

Can the authors compute the mean of the Nino3.4 index for these composites, in order to confirm that any ENSO influence is removed?

An ENSO index can be removed also by linear regression, e.g., linearly regressing out variability associated with the Nino3.4 index, as done in figure 5. The authors seem to prefer to examine neutENSO conditions instead. There are pros and cons for both methods, and it would be worth noting in the text if results are different for either method of attempting to remove the ENSO influence.

Comments on specific lines/figures/tables (mainly on the first half of the paper, as I will likely review the revised version again):

Line 55 add Rao et al

Line 69 the the

Figure 1, 4, and 8: This figure looks fairly different from figure 8a, 8n, and 8r of Rao et al. Particularly perplexing is that 8n and 8r of Rao et al, which focus on two different versions of MetOffice models, do not agree with each nor with any of the panels here as best as I can tell. There are certainly many methodological differences between the studies (whether/how ENSO is removed, the season analyzed, historical vs. PI control), but if the results are so sensitive to these choices then the overall effect may not be particularly robust.

Line 184-185, 250-270 see my general comments about the ENSO-QBO relationship. These sentences are not representative of the entirety of the published literature or other runs of the model used in this paper.

Figure 3: please use as much as possible of the 1953-2022 period for the observational composites. I expect the resulting figure to be rather different to what is shown here, which will necessitate a rewrite of the accompanying text.

Table 1: please add the other model versions to this table

Section 3.4: Garfinkel and Hartmann 2011 (already cited) discuss changes in convective precipitation and OLR over monsoon regions and the ITCZ in response to the QBO with fixed SSTs. Note that Garfinkel and Hartmann 2011 also performed some targeted experiments in which the QBO profile nudged towards was modified (line 409).

Section 3.4: Hu et al 2012 discuss Walker circulation changes in response to the QBO.

Please include in your discussion.

Figure 11 caption discusses panels g and h, which don’t appear to exist.

Rao, J., Garfinkel, C. I., & White, I. P. (2020). How Does the Quasi-Biennial Oscillation Affect the Boreal Winter Tropospheric Circulation in CMIP5/6 Models?, Journal of Climate, 33(20), 8975-8996.

Hu, ZZ., Huang, B., Kinter, J.L. et al. Connection of the stratospheric QBO with global atmospheric general circulation and tropical SST. Part II: interdecadal variations. Clim Dyn 38, 25–43 (2012). https://doi.org/10.1007/s00382-011-1073-6

Domeisen, Daniela IV, Chaim I. Garfinkel, and Amy H. Butler. "The teleconnection of El Niño Southern Oscillation to the stratosphere." *Reviews of Geophysics* 57, no. 1 (2019): 5-47.

Garfinkel, C. Iê□¬, and D. Lê□¬ Hartmann. "Effects of the El Niño–Southern Oscillation and the quasiâ□□biennial oscillation on polar temperatures in the stratosphere." *Journal of Geophysical Research: Atmospheres* 112, no. D19 (2007).