Dear Dr. Naoe and colleagues:

Both Anonymous referees have posted their comments on your manuscript (WCD 2024-1148). As per WCD policy, you are now to post a response on how you will address the referee's comments – after which I will make a decision on the manuscript.

Both reviewers have made excellent comments on the manuscript and call for revisions (one major, one minor). To provide guidance in revising the manuscript so that it is acceptable for publication in WCD, below I itemize the issues that I expect will be addressed in a revised manuscript. I will also post these on the WCD page for the manuscript.

Both anonymous reviewers feel this is a worthwhile manuscript for publication in WCD, and I agree. The opening paragraph by Reviewer #1 has a very succinct summary of the paper, followed by 8 bulleted points that contain either comments or suggestions. I strongly recommend you address all the comments, and adopt all the suggestions. In particular, the reviewer notes that the text is not sufficiently critical of the model results concerning the impact of the QBO on the polar vortex (Figs. 1 and 2), stating: "only ECCAM5, WACCM and MRI are reasonably correct for neutral ENSO, but none get El Nino right. Maybe ECCAM5 and MRI get LaNina right (relative to ERA5)." I agree: only two of the models get within ½ the amplitude of the observed for the ENSO neutral case (MRI and WACCM), and only the MRI model also shows a stronger impact on the QBO on the vortex under La Nina conditions than under El Nino conditions (but even that model has the wrong sign response for El Nino conditions). The reviewer also asks for more clarification on the text on lines 221-226, and clarification on the statistical significance when multiple indices are used in the identification of the QBO. Reviewer #1's suggestion "to include more in-text references to figure panels being discussed" would really help the reader.

Reviewer #2 also has excellent major comments and I strongly recommend you address them in your revised manuscript. In particular, Reviewer #2 asks for more discussion and analysis of why almost all the models do not reproduce three of the four teleconnections examined, and I agree. In some cases, further analysis may be required to support these discussions (e.g., is there a relationship between the model biases in the strength of the simulated QBO (in either neutral, El Niño and La Niña conditions) and the strength of the polar vortex response? Is there a relationship between the model biases in the strength of the polar vortex and the polar vortex response? Is there a relationship between biases in the extratropical stratospheric winds and the weakness in the impact of the QBO phase on the polar vortex?).

Reviewer #2 also notes that previous work suggested that a measure of the efficacy of a model to reproduce QBO's impact on the polar vortex (the Holton-Tan effect) seen in observations is sensitive to the level that is used as an index of the QBO, and that model differences in the QBO justify the use of model-specific indices. Please address this point in your revised manuscript. Also, if you did choose levels to define the QBO that were model-specific, would the QBOs simulated by the models still be only half as strong as that observed (as documented in Fig. 3)? Would that still be the leading candidate for the weak relationships between the QBO phase, ENSO phase and polar vortex?

Finally, Reviewer #2 asked why a different analysis procedure was used to examine the relationship between the QBO phase and the Walker circulation than that used to examine the other three teleconnections and whether the teleconnections were stronger for the Walker circulation simply because optimal pressure levels and seasons were chosen. I am not to bothered by this because, to be frank, the evidence presented in this section is pretty damning. Contrary to the description in the text, the observed relationship between the Walker circulation and the phase of the QBO shown is not well reproduced by most of the models for either La Nina or El Niño conditions. For La Nina conditions (Fig. 11), the anomalies in the zonal winds over the Pacific show a slightly westward shifted Walker circulation, whereas the models b,d,g,h and i shows a weakened Walker circulation (in phase anomalies of the opposite sign as the climatology aloft) and model e shows only easterly anomalies everywhere. The agreement during El Nino conditions is even worse (Fig. 12). [By the way, please note the contour interval for the anomalies in these figures. They seem to be much coarser than the discretized colorbars.] Stepping back a bit, I wonder whether the relationship between the QBO phase and the Walker circulation is poor because the band to define (5S-5N) the Walker circulation may be too narrow; 10S to 10N would better capture the zonal wind anomalies associated with the Walker circulation. Based on Fig. 17.17 of Wallace et al (2023), I expect this isn't the answer -- but it might be worth checking.

Minor comments:

Does the GPCP bar in panel 9b stop the top of the plot, or does it run off scale? Why isn't there an error bar on this bar?

In Fig. 10, is the temperature also the zonal mean over the western Equatorial Pacific, or is it a zonal mean?

Lines 777-790: These statements are inconsistent with the published papers, dating back as far as Hoerling et al. (1987). Atmosphere general circulation models DO robustly reproduce the nonlinearity in the atmospheric response to warm and cold ENSO phases, given El Niño and La Niña SST anomalies. Also, given the very weak relationship between the QBO phase, the ENSO phase, and the tropical anomalies shown in this study, it is unlikely that weaker ENSO events or ENSO events with less dramatic changes in the location of tropical convection than used in this study would yield further insights.

References

Hoerling, M. P., Kumar, A., & Zhong, M. (1997). El Niño, La Niña, and the nonlinearity of their teleconnections. *Journal of Climate*, **10**(8), 1769–1786. **https://doi.org/10.1175/1520-0442(1997)010<1769:ENOLNA>2.0.CO;2**

Wallace et al, "The Atmospheric General Circulation", Cambridge University Press, 2023.