The authors would like to thank the reviewer for your time and effort in reviewing our manuscript entitled "QBOi El Nino Southern Oscillation experiments: Teleconnections of the QBO". Above all, the authors are deeply grateful for the many insights gained by reading the papers recommended by the reviewers. We will incorporate his/her valuable comments and suggestions on how our proposed revised manuscript will address your concerns. Our reviewer responses and revision plan are shown in blue text whereas reviewer's comments are shown in black. Individual responses are as follows.

Black: Reviewers comments

Blue: Authors response to the reviewer

To Reviewer 1:

RC1: 'Comment on egusphere-2025-1148', Anonymous Referee #1, 21 Apr 2025

This study uses ERA5 data and a multi-model ensemble of APARC QBOi models to investigate how QBO teleconnections are modulated by ENSO. To separate the QBO and ENSO signals, simulations were conducted with annually-repeating prescribed SSTs corresponding to idealized El Nino or La Nina conditions. Models are unable to represent the observed (ERA5) enhanced Holton-Tan effect during La Nina, where QBO W favors a stronger NH winter polar vortex. Models are also unable to represent the observed increase in SSWs during El Nino. Overall, the polar vortex responses to the QBO are much weaker than to ENSO in the models. In addition, the equatorward shift of the boreal winter Pacific subtropical jet (APJ) observed during QBO W in not seen in the models. In the tropics, the model experiments do not show a robust or coherent QBO influence on precipitation. It was further found that QBO effects on the Walker circulation exhibit a complex dependence on season, longitude, and phase of ENSO. They that suggested that weakness of the QBO polar vortex coupling in the models might arise from systematically weak QBO amplitudes at lower levels in the equatorial stratosphere, polar vortex biases in winter, and inadequate representation of stratospheric-troposphere coupling, while an inadequate representation of QBO effects in the tropical troposphere might arise from the systematically weak QBO amplitudes at lower levels, precipitation bias, and inadequate representation of the Walker circulation in these models. This paper documents the results of a considerable effort in the QBOi community, with well-organization presentation and choice of figures. The narrative provides an authoritative interpretation of the detail and status of observed and modeled QBO/ENSO influences on the extratropics. I recommend publishing with minor revision.

R1-1. Idealized time mean La Nina and El Nino states. Would the model results be noticeably different for a time-varying ENSO (then binned by ENSO phase), versus two perpetual ENSO phases? It seems possible that the two-state method represents an upper bound on possible effects.

In the context of tropical teleconnections, the two-state method versus a time-varying method might result in different model responses. In the tropics, a continuous ENSO state creates a different set of climatologies for the ITCZ, the Walker circulation, etc., which affect the way intraseasonal variability behaves in the model. Whether the two-state method is an upper bound on possible effects is less clear, since the evidence is not conclusive on why tropical precipitation responds to the QBO, but it is a fair hypothesis that needs to be tested.

In the extratropics, QBO teleconnections are largely affected by tropical circulation and ENSO states, by means of subtropical jets, PNA pattern responses, stratospheric circulation including QBO itself, etc. Thus, the two-state method versus a time-varying method might result in different model responses in the extratropical teleconnections, too.

R1-2. l216-217, Fig. 13: This is a kind of discretized time-height section. It is similar to Reed et al.'s original 1961 figure which shows a time-height section of zonal wind. The Hovmoller diagram was originally defined to be the variation of geopotential height or another quantity near 60N as a function of longitude and time. It was generalized to mean a longitude-time diagram, which is usually used to indicate wave propagation. You have a table with dependence on season and altitude and you are not discussing wave propagation in longitude. Please use the phrase "season-altitude variation" instead of Hovmoller diagram to indicate what you are showing.

Thanks for this helpful clarification. We agree that "season-altitude variation" more accurately describes the content of Fig. 13, as our analysis does not involve wave propagation in longitude. We will revise the text accordingly to replace "Hovmöller diagram" with "season-altitude variation".

R1-3. l221-226: "when the QBO phase is not defined by the preferred 70 hPa level" ? does this mean that there are other ways to define it or that sometimes the 70 hPa level index isn't well defined? In this discussion of how multiple indices affect significance calculations, please give a sense of the meaning and outcome. For example, If you use more than one index definition at different levels, perhaps one might ascribe reduced significance to a result, but in your method it appears that alpha is reduced, therefore implying greater significance. A little more information would be helpful for understanding this paragraph.

Thank you for this thoughtful comment. The analysis in the Walker Section initially used a consistent QBO definition and target season across all models. Specifically, we define the QBO using the zonal-mean zonal wind at 70 hPa during JJA. Figure R1-1 shows the initial results for LN experiment and other figures will be included in the revised supplementary material for consistency. With this uniform framework, we identify a coherent signal, but we want to enhance this signal and capture the strongest response in each model. To do so, we allow for slight adjustments in the QBO definition (70 or 85 hPa and JJA or SON) and in the target season (ranging from May to November), when necessary. These adjustments aim to capture the most robust response while maintaining a physically consistent framework. We have clarified this process in the revised text. Importantly, when a model's QBO definition differs from the standard (70 hPa during JJA), we account for the increased flexibility by applying a Bonferroni correction. This reduces the significance threshold (alpha) from 0.05 to 0.025 or lower, depending on the number of alternative definitions tested. The significance threshold (also called the significance level) determines the p-value below which the null hypothesis is rejected. If the p-value is smaller than α, we reject the null hypothesis and consider the result statistically significant. We will clarify this point in the revised version of Section 2.

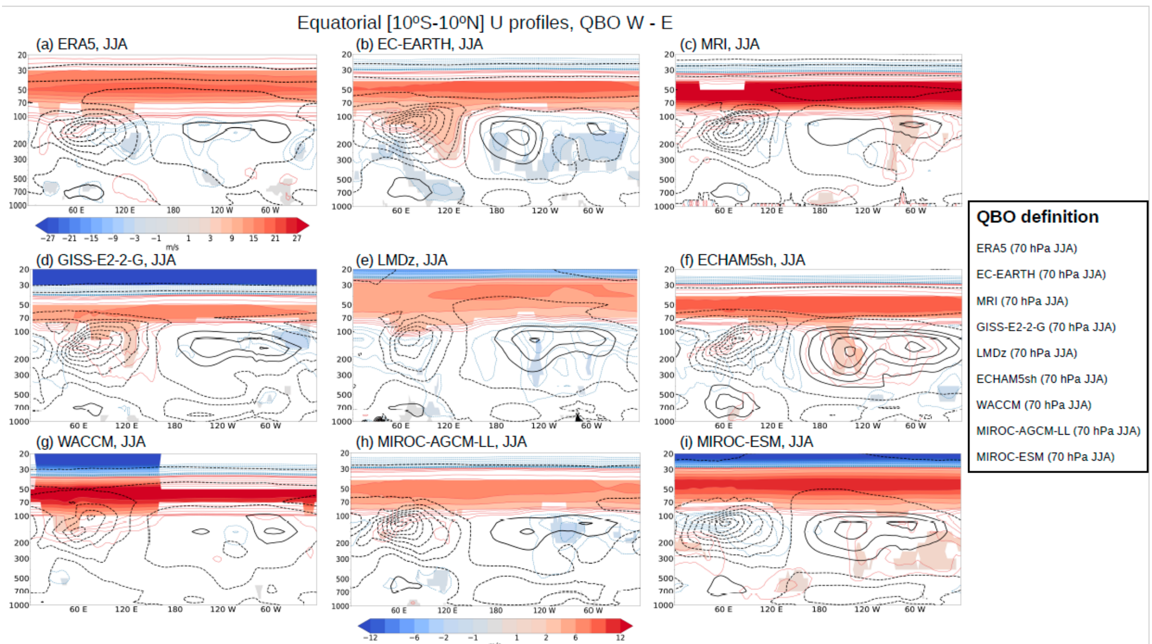

Figure R1-1. Climatology (black contours) and QBO Westerly (W) minus Easterly (E) differences (shading and colored contours) in equatorial zonal wind profiles, averaged over 10° S-10° N, from the LN experiment for the QBOi models. Black contours are drawn at 4 m s-1 intervals, and colored contour follow the same scale as the shading, as indicated in the color bar. The target season is JJA for all models, with the QBO phase defined at 70 hPa during JJA. Only statistically significant zonal wind differences at the 95% confidence level are shaded.

(Figures for CTL and EN experiments will be added in the supplementary material.)

R1-4. Fig.1: It looks like 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).

Thank you very much for your suggestions to note that the text is not sufficiently critical of the model results concerning the impact of the QBO on the polar vortex (Fig. 1). We will revise the text to add these points and delete an unnecessary description.

R1-5. Fig. 2: Only MRI seems to represent the basic sense of the ERA5 signal.

Again, in the revised text, we will add critical points of the model results and delete an unnecessary description.

R1-6. Fig. 4 caption: suggest adding information to the effect of "La Nina, CTL, and El Nino, from left to right", to orient the reader about the order of the triplets, and maybe move to near the beginning of the caption.

Thank you very much for your suggestion. We will move this description to near the beginning of the caption and change the order of the triplets as the reader is easy to identify them.

R1-7. l356: suggest refer to (Fig. 4c). In this paragraph, and at times elsewhere, it might be beneficial to include more in-text references to figure panels being discussed.

Thank you very much for the suggestion from Reviewer #1 and the Editor. We will revise the text to include more in-text references to figure panels being discussed.

R1-8. l387, 150W-150E: How sensitive are results in Figs. 6 and 7 to the choice of longitude band?
Thanks for the suggestion. We test the sensitivity of the QBO-APJ connection to the choice of longitudinal domain: (a) 150°E–150°W, as used in the original manuscript, (b) 130°E–120°W, as used in Anstey et al. (2022), and (c) 120°–180°E, as used in Park et al. (2022) (Figs. R1-2a–c, respectively). The domain adopted by Anstey et al. (2022) spans a broader longitudinal range than that used in this study, while the domain of Park et al. (2022) focuses on a region upstream of the jet core.
Although a few models exhibit domain-dependent responses, the results are overall insensitive to the choice of longitudinal domain.

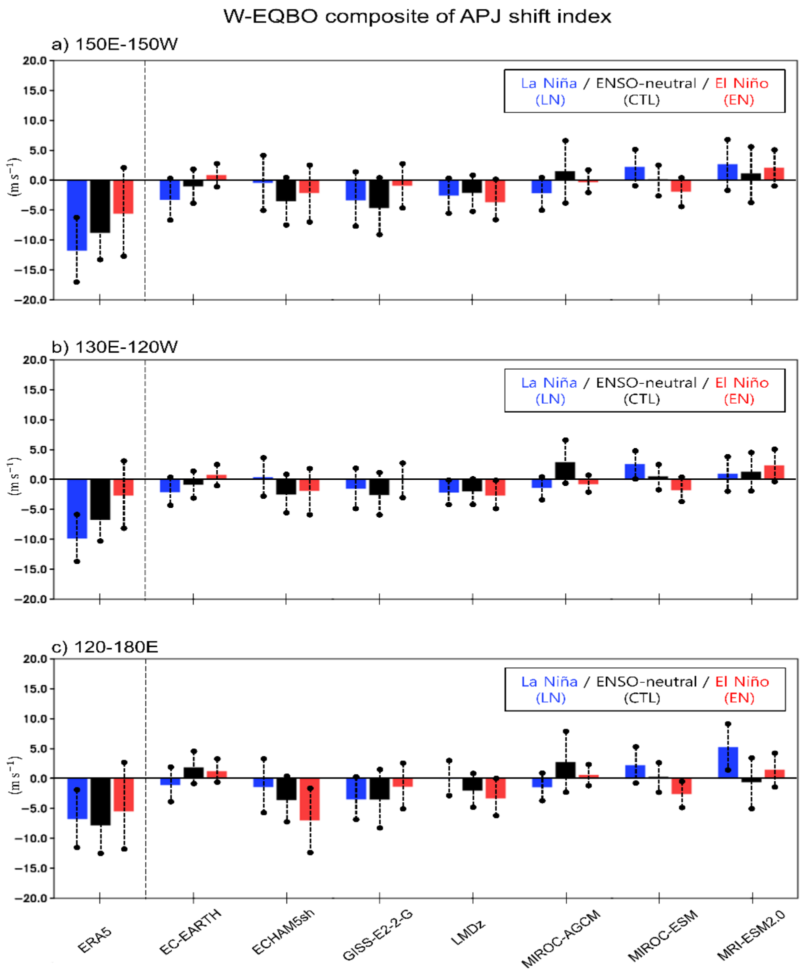

Fig. R1-2. Sensitivity of the QBO-APJ connection to the longitudinal domain.

Anstey, J. A., Simpson, I. R., Richter, J. H., Naoe, H., Taguchi, M., Serva, F., ... & Yukimoto, S. (2022). Teleconnections of the quasi‐biennial oscillation in a multi‐model ensemble of QBO‐resolving models. Quarterly Journal of the Royal Meteorological Society, 148(744), 1568-1592.

Park, C. H., Son, S. W., Lim, Y., & Choi, J. (2022). Quasi‐biennial oscillation‐related surface air temperature change over the western North Pacific in late winter. International Journal of Climatology, 42(8), 4351-4359.