

Response to Editor

Title: QBOi El Niño–Southern Oscillation experiments: Teleconnections of the QBO

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10 The authors appreciate the Editor's extensive efforts in reviewing our manuscript. We incorporate your valuable comments and suggestions on our revised manuscript. Our Editor's responses and revision are shown in "blue text", whereas Editor's comments and **suggested changes** are shown "in black" and "in bold red", respectively. Individual responses to the Editor are as follows. (All line numbers refer to the third revision, not current fourth revision.)

Co-editor decision: Publish subject to minor revisions (review by editor), 24 Sep 2025
by David Battisti
15 Supplement to the public justification (visible to the public if the article is accepted and published) (pdf):
egusphere-2025-1148-comments-to-author.pdf
Public justification (visible to the public if the article is accepted and published):

Dear Prof. Naoe and co-authors:

20 Thank you for your third revision on the manuscript (WCD 2025-1148). I appreciate that you and your co-authors have corrected the grammar and presented a manuscript that is now clear of ambiguities due to language problems. In doing so, I was able to find a few minor (but important) issues that should be easy to address quickly. I am recommending minor revisions to allow you to make these modifications (or to argue why certain modifications are not appropriate).

Please feel free to contact me if you have questions.

Regards, David

25 → We appreciate the Editor's positive assessment of our revised manuscript. We carefully considered each of the remaining comments and revised the manuscript where appropriate.

Note: all line numbers refer to the revised text, not the Author tracked changes. Text appearing in the revised manuscript is in
30 italics; my suggested changes are in red.

- As stated on lines 303-304, “no model reproduces the observed strength of the Holton-Tan relationship between the phase of the QBO and the strength of the polar vortex across all three experiments”. That is true, but I don’t think it goes far enough. Following that sentence, I suggest you insert the following sentence: **“From Fig. 2, only three models reproduce the observed relationship in the CTL and EN experiments, and only one model reproduces the observed relationship in the LN experiment.”**

→ We insert this sentence as follows:

L304: “... across all three experiments (CTL, EN, and LN). From Figure 2, only three models reproduce the observed relationship in CTL and EN, and only one model (MRI-ESM2.0) reproduces the observed relationship in LN. Only The two models in CTL (MRI-ESM2.0 and WACCM) exhibit responses within half the observed amplitude ~~in CTL~~. The one model Furthermore, only in LN (MRI-ESM2.0) exhibits a stronger QBO impact on the vortex ~~in LN~~...”

- Lines 305-306: the correlation between U60 and Ueq50 in LN observations is positive (and statistically different from zero), while in the GISS model LN experiment is zero, so I don’t think it is fair to say this is a good fit compared to observations. So I would remove GISS from the list on line 306 and change to read **“In LN three models...”**

→ We revise the sentence as follows:

L304: “... In LN, ~~three~~**four** models (ECHAM5sh, ~~GISS~~, MIROC-AGCM, and MRI-ESM2.0) better reproduce the observed response, ...”

- Change lines 38-39 in the Abstract to reflect the above results. Change “... respectively). In LN, four out of nine models reproduce the observed Holton-Tan relationship within half of the observed amplitude.” to read “... respectively). In LN, four out of nine models reproduce the observed Holton-Tan relationship within half of the observed amplitude.” to read **“The strength of the Holton-Tan relationship between the phase of the QBO and the strength of the polar vortex seen in observations is reproduced in fewer than three models under ENSO neutral conditions and by one model under EN conditions. In LN, three out of nine models reproduce the observed Holton-Tan relationship, but with less than half of the observed amplitude.”**

→ We reflect this point to add sentences in the Abstract:

L38-39: “... representing idealized El Niño and La Niña conditions (the QBOi EN and LN experiments, respectively), and results are compared with the QBOi control experiment (CTL) under ENSO-neutral conditions. The strength of the Holton-Tan relationship between the phase of the QBO and the strength of the polar vortex seen in observations is reproduced in fewer

than three models in CTL and by one model in EN. In LN, ~~threefour~~ out of nine models reproduce the observed Holton–Tan relationship, but within less than half of the observed amplitude.”

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- Line 241, change to read “... of the statistical test α is adjusted ...”

→ We insert this symbol as follows:

L241: “In this method, the significance level of the statistical test α is adjusted by dividing it by m , ...”

70

- Fig. 1, titles on panels c, f and j should probably read **CTL49EN39LN39**, **CTL69EN81LN81**, and **CTL87EN99LN99**, respectively.

→ You are right. Something was missing in the titles on these panels. We revise this figure.

75

- The sentence on lines 354-356 (In summary, **across** all three experiments, models generally show.... observed response.) is still ambiguous. If this statement is meant to say “In summary, for **each** experiment, models generally show ...”, then it isn’t supported by Figs. 2 (or 3): for the EN experiment, Fig. 2, five of nine models produce the opposite response to that in observations. I would change this sentence to read “In summary, **across the CNT and LN experiments**, models generally show.... observed response.)”

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→ We revise the sentence as you suggested:

L354-356: “In summary, across the CTL and LN ~~all three~~ experiments, models generally show ...the observed response.”

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- Line 412, change to read “... also show later final warming dates in LN ...” to read “... also show **median final warming dates that are later** in LN ...”

→ We revise the sentence as you suggested:

L412: “GISS and MRI-ESM2.0 also show median ~~later~~ final warming dates that are later in LN compared with EN, consistent with the observed response (Fig. 4c).”

90

- Line 414, change “fail to show earlier final warming dates” to read “**show later final warming dates**”

→ We revise the sentence as you suggested:

95 L414: “In contrast, five models (EC-EARTH, ECHAM5sh, LMDZ, MIROC-AGCM, and MIROC-ESM) ~~fail to~~ show
later~~earlier~~ final warming dates in EN, opposite to the observed response. “

- Line 445, change “... on the APJ. Only ...” to read “... on the **Asian-Pacific subtropical jet (APJ)**. Only ...” so the reader
100 doesn’t have to search 10 pages back to recall what APJ means.

→ We spell out APJ here as follows:

L445: “... by ENSO, focusing on the Asia-Pacific subtropical jet (APJ). Only ...“

105 - Line 548, change to read “... precipitation response **to the phase of the QBO** across models or experiments.”

→ We revise the sentence as you suggested:

L304: “ In summary, there is no robust or consistent precipitation response to the phase of the QBO across models or
experiments.“

110 - Line 642, change to read “... expect models **that have** larger TTL ...”

→ We revise the sentence as you suggested:

L642: “One might expect models ~~that havewith~~ larger TTL temperature signals or static stability to also show stronger
precipitation signals.“

115

- Line 650, change to read “.. underestimate **QBO TTL** temperature anomalies ...” because zonal wind, in itself, isn’t the zero-
order control on convection.

→ We revise the sentence as you suggested:

120 L649-651: “Overall, the QBOi models underestimate QBO ~~wind amplitudes in the lower stratosphere (Bushell et al., 2022)~~
~~and thus show weak~~ TTL temperature anomalies (Serva et al., 2022), which may explain their weak precipitation signals.“

- Lines 735-736, change "...exhibit a tropospheric signal characterized by upper-level (100 hPa) westerly and lower-level (700 hPa) easterly anomalies during various seasons from May to November. This pattern suggests ..." to read **"...exhibit a tropospheric signal characterized by upper-level (100 hPa) westerly anomalies during various seasons from June to November, while about half of the models and the observations show lower level (700 hPa) easterly anomalies. This pattern suggests ..."**

→ We revise the sentence as you suggested:

130 L734-736: "Across all three experiments, nearly all models, along with ERA5, exhibit a tropospheric signal characterized by upper-level (100 hPa) westerly ~~and lower-level (700 hPa) easterly~~ anomalies during various seasons from May to November, while about half of the models and the observations show lower level (700 hPa) easterly anomalies. This pattern suggests ..."

135 - Delete the two sentences on lines 783-785 ("The observed the observations.") because it is irrelevant to what follows in this paragraph.

→ We delete these sentences as you suggested:

140 L783-786: ~~"The observed correlation coefficients between the 50 hPa equatorial zonal wind and the strength of the polar vortex at stratospheric altitudes during DJF exhibit considerable uncertainty (Fig. 1a). The models show less uncertainty because of their larger sample sizes (Fig. 1). Some models reproduce weaker correlations for a specific ENSO experiment, consistent with the observations. The Holton-Tan relationship ..."~~

- Lines 808-809, change to read "... show weaker responses. **Hence**, neither the ..."

145 → We revise the sentence as you suggested:

L808-809: "... show weaker responses. Hence, ~~This means that~~ neither the QBO amplitude ..."

150 - Line 811, change to read **"The impact of the QBO on the troposphere** is examined, focusing"

→ We revise the sentence as you suggested:

L811: "The ~~impact~~tropical pathway of the QBO ~~teleconnection modulated by ENSO~~on the troposphere is examined, focusing on tropical precipitation (Figs. 8–10) and the Walker circulation (Figs. 11–13). "

155

- Line 812, change to read "... to the QBO **phase** in the ..."

→ We revise the sentence as you suggested:

L815: "The precipitation response to the QBO phase in these experiments varies by model, region, and ENSO phase, ..."

160

- Line 820, change to read "... is strongest in **observations** over the..."

→ We revise the sentence as you suggested:

L304: "The QBO teleconnection to the Walker circulation is strongest in reanalysesobservations over the Indian Ocean–Maritime Continent region ..."

165

- Line 829-830. I am not sure what is being argued here. Yes, the SST forcing (common to all the models) constrains the circulation in the equatorial (lon-height) plane, and so each model has a very similar mean state that is being acted upon by the QBO. Hence, one might expect the QBO W minus QBO E response to look the same across the models for the same experiment. But the SST for the LN experiment is different from the SST for the EN experiment, and so the mean state that QBO acts upon in the LN experiment is different from that in the EN experiment. And yet, the QBO W minus QBO E response is very similar in the LN and EL experiments (compare the colored contours in Fig. 11 to those in Fig. 12). This implies that the impact of the QBO phase is not terribly sensitive to changes in the SST. Also, on Line 831-2, it is stated that precipitation may be less constrained by the experimental setup but we know that tropical Pacific precipitation is heavily constrained by the SST, which is common to all models for each experiment. Altogether, I find this paragraph confusing or even troublesome, and so I would drop it.

175

→ We delete this paragraph as you suggested:

~~L304: "One possible explanation for the more coherent Walker circulation response is that the zonal circulation in the SST-forced simulations is sufficiently similar across models—owing to the SST forcing—that the responses remain relatively consistent. In contrast, other aspects of the response, such as the tropical precipitation, the polar vortex, and the subtropical jet, may be less constrained by the experimental setup. It is also plausible that the mechanisms driving the Walker cell response are better represented in these models. Given the relatively large static stability anomaly shown in the results (Fig. 10), one could reasonably suspect that this mechanism is strong enough in the models to produce a consistent response in the Walker circulation."~~

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- Line 858, change "... vortex coupling arise from consistently weak QBO amplitudes at lower levels in the equatorial stratosphere biases..." to read "vortex coupling **arises** from consistently weak QBO amplitudes at lower levels in the equatorial **stratosphere, biases**..."

→ We revise the sentence as you suggested:

190 L857-860: "In the extratropical stratosphere, previous studies using QBOi models have suggested that the systematic weakness of the QBO–polar vortex coupling arises from consistently weak QBO amplitudes at lower levels in the equatorial stratosphere, biases in the wintertime polar vortex, and inadequate representation of stratosphere–troposphere coupling (Bushell et al., 2022; Richter et al., 2022; Anstey et al., 2022c). "