Reviewer 2

General comments

Thank you for your insightful expertise. We will address your comments point by point as below.

The work by Zhou et al. deals with the ENSO modulation of the QBO phase speed in the GISS model. This seems strongly related to the parameterized gravity wave forcing, which is not described in much detail (line 93 and following). Basic information should be provided (e.g., how convection changes the parameterized wave spectrum) and possible model-dependence of the results stressed.

Done as suggested.

The text is well-written, but there are some repetitions which could be avoided (see specific comments). For example, the data processing used for calculating ONI and the QBO could be given only once in the methods.

Done as suggested.

The observational analysis part could probably be shortened.

The revision has made clear why we should conduct this analysis.

There are several long sentences which are not very readable. It is in some cases not easy to follow the reasoning or motivation or some of the analysis, please improve the connections between paragraphs where needed.

Done as suggested.

It could be useful to provide more information on the ENSO characteristics in coupled experiments (e.g., references or number/intensity of events), briefly mentioned around line 530 and shown in the spectra plots.

Done as suggested.

Opposite results for some simulations (line 738 and following) are interesting but should be discussed further: is this suggesting a very important role for internal variability, at least in simulations?

Done as suggested.

Differences in some of the plots are small, it would be good to add some significance estimate.

Since the sample spaces consist of monthly data, we cannot know the effective sample sizes of the El Niño and La Niña sample spaces. Thus, it is a bit hard to rigorously conduct a significance test.

Specific comments

18 'gravity waves parameterized interactively' -> 'interactive GW parameterization'?

We have changed "…and its gravity wave sources parameterized interactively" into "…but with its gravity wave sources being parameterized interactively".

The propagation and dissipation of the parameterized gravity waves indeed interact with the thermal and motion fields of the model atmosphere in all CMIP5/6 models. Here, we emphasize that the generation of the parameterized gravity waves should also be dependent on the thermal and motion fields of the model atmosphere in climate models.

41 may refer at QBO zonal asymmetry

We have added the following clause ", which likely results from the zonal asymmetry of the QBO winds (Hamilton et al., 2004)".

61 all -> how many. When first introducing 'T' for truncation, please clarify what it means

Corrected.

80 using which model?

The information has been added.

114 may add a reference like Naujokat, 1986

Naujokat (1986) was cited at the end of the next sentence, i.e., in L117.

131 please add a reference, e.g. Salby, 2012

Done as suggested.

148 are you referring to the ONI for ERSST or the simulations?

Corrected.

171 I do not see why 'now', as to me this is unrelated to the previous paragraph

We have removed it.

206 I'd say that N1 and N2 do not result from calculations

Corrected.

207 you could introduce as done for A the meaning of the overbar for both quantities

Done as suggested.

344 What else could be done, since you stated that you are not considering the amplitude already?

We have removed this useless sentence.

424 To avoid confusion with capitalised psi for phase speed, please ensure the latter is uppercase elsewhere.

Here we have replaced ψ with ε.

436 Not sure to understand this sentence

Revised.

450 do you need to scale by the respective variance?

In L447-448, the preprint mentioned "both the observed and simulated QBO can be very well represented by the trajectory of $\left(PC_1(t), PC_2(t)\right)$ in a linear space spanned by the first two orthonormal EOFs."
Since EOF1 and EOF2 are orthonormal, further scaling is not needed. In other words, the variances of EOF1 and EOF2 have been absorbed into $PC_1(t)$ and $PC_2(t)$, respectively.

462 Why the focus on Coupled-NINT-Ap? Can you motivate and remind the reader about this configuration?

We have added the following sentence in the previous section: "Since coupled models encounter more difficulties in simulating the ENSO modulations of the QBO (Serva et al. 2020, see their Fig.4 for more details), we first look into the ensemble simulations from the Coupled–NINT–AP model, which incorporates the most up-to-date cloud parameterization schemes."

543 La Niña does not have a well-defined peak, suggest rephrasing

Corrected.

554 in any season? in both hemispheres?

We didn't further divide the ENSO into the cold-season-matured and the warm-season-matured ENSO as shown in Figure 1 in Rao and Ren (2014). Instead, we look at those figures from the holistic/composite point of view.

Here , we don't mean the ENSO teleconnections/effects on a global scale. Since we are dealing with the ENSO modulation of the QBO, we view those figures in a very narrow sense that is described in the *Wikipedia* as follows:
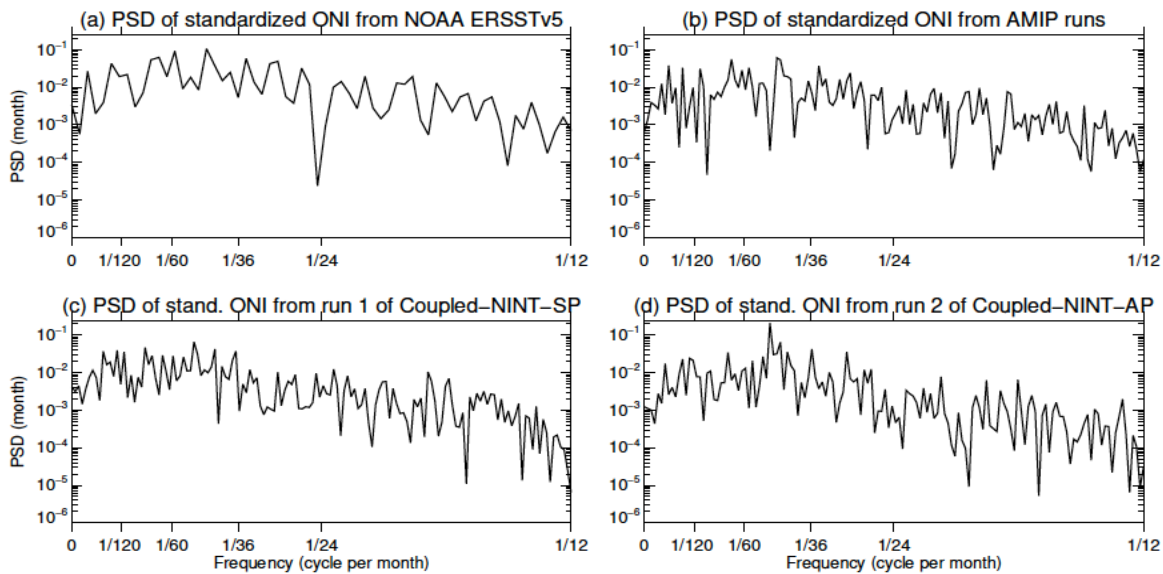El Niño–Southern Oscillation (ENSO) is an irregular periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean…
The spatio-temporal complexity of the ENSO was detailed in Timmermann (2018) and is beyond the scope of the manuscript.

588 please explain why you discuss this now. ERA5 should be introduced in the Methods section.

Corrected.

1311 figure could be improved by using logarithmic ordinate and/or putting spectra in a single plot

(a) PSD of standardized ONI from NOAA ERSSTv5
(b) PSD of standardized ONI from AMIP runs
(c) PSD of stand. ONI from run 1 of Coupled–NINT–SP
(d) PSD of stand. ONI from run 2 of Coupled–NINT–AP

The above figure uses logarithmic ordinate. It doesn't help us to contrast the ratios of signal to noise between various pair of panels. In addition, when we use various colored lines to put spectra in a single plot, some overlapping of the lines makes it difficult to visualize them.
Thus, we decided to use the original format.

Technical corrections

133 NOAA undefined

NOAA was defined in L123 in the preprint.

143 CDC=CPC?

Corrected.

209 repeated v and t

The repeated v and t have been removed.

221 be consistent in the use of lowercase psi

For consistency, we denote ψ' as the monthly QBO phase speed. Then we average ψ' over the time span (i.e., the number of months) of each ENSO event and denote Ψ' as the mean QBO phase speed during an ENSO event.

267 Why 'according'? Unclear

https://www.merriam-webster.com lists the meaning of "according to" as
1: in conformity with
2: as stated or attested by
3: depending on

By "according to" we mean "depending on".

288 NCCS undefined

Corrected.

338 'baseline'

This part has been moved into a new section "Data, models, and methods".

434 'Andrews'

Corrected.

441 maybe 'configuration'?

Corrected.

632 'nether'?

Corrected.

688 'Earth'

Corrected.

1146 more shades in Fig 5 right would be better?
     Or maybe using the same levels to ease comparison

The contour intervals are halved in all panels in Fig. 5 so that more shades in the right ones could show up.

1275 the varying levels across plots should be fixed

Contour levels across plots are identical. We simply added the maximum and minimum values in each panel as extra annotations to give more information.

Additional references

Naujokat, 1986 https://journals.ametsoc.org/view/journals/atsc/43/17/1520-0469_1986_043_1873_auotoq_2_0_co_2.xml

Salby, 2012 https://doi.org/10.1017/CBO9781139005265

References

Rao, J. and Ren, R.: Statistical characteristics of ENSO events in CMIP5 models. Atmos. Oceanic Sci. Lett., 7, 546–552, https://doi.org/10.3878/AOSL20140055, 2014.

Taguchi, M.: Observed connection of the stratospheric quasi-biennial oscillation with El Niño–Southern Oscillation in radiosonde data, J. Geophys. Res., 115, D18120, https://doi.org/10.1029/2010JD014325, 2010.

Timmermann, A., An, S.-I., Kug, J.-S., Jin, F.-F., Cai, W., Capotondi, A., Cobb, K. M., Lengaigne, M., McPhaden, M. J., Stuecker, M. F., Stein, K., Wittenberg, A. T., Yun, K.-S., Bayr, T., Chen, H.-C., Chikamoto, Y., Dewitte, B., Dommenget, D., Grothe, P., Guilyardi, E., Ham, Y.-G., Hayashi, M., Ineson, S., Kang, D., Kim, S., Kim, W., Lee, J.-Y., Li, T., Luo, J.-J., McGregor, S., Planton, Y., Power, S., Rashid, H., Ren, H.-L., Santoso, A., Takahashi, K., Todd, A., Wang, G., Wang, G., Xie, R., Yang, W.-H., Yeh, S.-W., Yoon, J., Zeller, E., and Zhang, X.: El Niño–Southern Oscillation complexity, Nature, 559, 535–545, https://doi.org/10.1038/s41586-018-0252-6, 2018.