

## ***Interactive comment on “Multidecadal Variations of the Effects of the Quasi-Biennial Oscillation on the Climate System” by Stefan Brönnimann et al.***

### **Anonymous Referee #2**

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Review on the manuscript “Multiple variations of the effects of the Quasi-Biennial Oscillation on the climate system” by Stefan et al.

The manuscript is motivated by the fact that the tropospheric impact of the Quasi-Biennial Oscillation is previously found to be weak, despite the dominance of the QBO in the equatorial stratosphere at interannual timescale, along with the known mechanisms by which the QBO influences the troposphere and the surface. The main objective of the study hence is to clarify the QBO connection to the surface by utilizing over 100 year long reconstructed and simulated data. The reconstructed data, which is mostly carried over from a previous study, goes back to 1908, and the QBO-forced model simulations extends even further back to 1600. Reanalysis data, such as ERA-20C and ERA-interim, is additionally used as well in the study. The analysis result primarily replies on the composites for two QBO phases.

Overall, it is appreciable that the study provides an attempt examining the question in long observational data and simulations. The composite analyses for QBO phases during chosen two sub-periods of the data conclude that the tropospheric impact of the QBO is small and appears intermittently. However, I feel that the conclusion could be more carefully drawn, as suggested below. In addition, despite the question itself is interesting, the manuscript is quite difficult to read, which limits the contribution of the study. For example, descriptions are missing for the use of data and the statistical significance test, while the historical background on observation is quite lengthy. Also, I find there are too many jumps back and forth to follow their analysis and figures. Lastly, figures and tables are not explained clearly.

Sec. 2: Although detailed information on data used in QBO reconstruction and tropospheric climate is described, it is very difficult to follow which one goes to which period and which exact period is used for the study. A table or schematics showing types of observations and period used in reconstruction will be certainly helpful to readers.

Model: Indicate the vertical resolution between 300hPa - 50 hPa, which would be important for the QBO to influence the tropical convection.

The composite is done for QBO phases. The phases are defined by the sign of the wind without the information on the amplitude. Has the amplitude been considered? For instance, sampling only when QBO index exceeds certain threshold may reduce discrepancy between the sub-periods and between the datasets.

I.14, p.2: It is puzzling that the paragraph starts that the impact of QBO on the troposphere is weak, but the main context of the paragraph supports the tropospheric signal of the QBO.

I.13, p.8: Figure 2 must be for 1979 and onward, and one of the purposes of the plot is to show the pattern of the H-T effect. But the results from other datasets often do not support the H-T mechanism. To better visualize why this is the case, I recommend to examine the patterns in other datasets as well, such as REC+NNR, 20CRv2c, and the

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model simulations. This can tell use about the following: Z100 does not tell us about tropical response, which should be consistent with ERA-interim by construction. Extratropical Z100 response of REC+NNR for 1957-2014 is consistent with ERA-interim and the H-T effect. Some model simulations also support this picture. However, it is not the case for 20CRv2c.

I.19, p.8: Please indicate pressure levels in Fig. 2. Absence of this hinders comparison with Table 1. Statistical significance will be very useful.

Table 1: Please define REC+NNR. Also add period 1979-2014 and ERA-interim result; this period is shown in Figs. 2 and 5. Lastly, it is difficult to picture what is going on based on the mean pictures of the two sub-periods. Temporal variation would be certainly useful to understand each data. For example, running correlations between QBO index and Z100 may be able to tell us about the discrepancy between data. At least all the data are expected be consistent for the latest decades, say after 1979 and onward. One may be able to trace back where the discrepancy is started.

Figure 3: Another row using REC+NNR can be a useful reference as REC+NNR better compares with the simulations based on Table 1.

Model simulations in Fig. 4 provide a nice visualization that the impact of QBO is weak. However, some metrics can be useful to summarize the result. For example, what are the correlations among models? Also, the authors probably have tested different windows for the moving average. What is the reason of choosing 30 years? It should be tested to indicate robustness of their result to the choice of the window.

Figure 5: Statistical significance test especially for the vertical motion is required.

Figure 6: Fig. S10 shows just one row. Besides it appears there is almost no significant areas, which is not clear in the text. I feel that Figure 6 is misleading as if there is strong QBO signal.