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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Net effect of the QBO in a chemistry climate model" *by* H. J. Punge and M. A. Giorgetta

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The authors thank referee 3 for the comments and careful reading.

Reply to general comments:

- The reviewer states that the study has not "led to any new information about the QBO and its influence at mid and high latitudes". Indeed, the novelty of the article is to quantify deficiencies models with no QBO may have compared to models with QBO, rather than revealing new aspects of the phenomenon QBO. While many studies exist on the QBO signals at specific QBO phases, or on biases of models without QBO compared to simulations including the QBO at a specific QBO phases, we do not know any study that investigates the long term biases of models without QBO, as presented here.

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- The reviewer writes that "it's unfortunate that the control run does not include the same drivers of variability as the QBO run". We agree on this in principle. However we think that the issue is dealt with adequately in the article and the conclusion that the experiments are still suitable for the examination of the QBO net effect is justified. Therefore we think the benefits of a further model run are minor and it's not worthwhile given the extensive computational resources required for these runs.

- Regarding interactive chemistry, we refer to the discussion of this issue in the reply to review 1. Although feedback from chemistry is likely important for modelling the stratospheric circulation, we do not think it is essential for modelling of the net effect of the QBO.

In reply to the specific comments, we would like to state the following:

(1) P12118, L2-7
It will be made clear that the statement is mainly valid for the tropics.

(2) P12120, L 16
We did not focus on this question, and do not think these asymmetries are important. However, in principle, hemispheric asymmetries in the forcing of the QBO, e.g. orographic or convective gravity waves, may be reflected in the QBO.

(3) P12120, L18-29
As explained later on, P12128, L27- P12129, L3, in fact only 15 years of the model runs are used for the comparison.

(4) P12121, L 19
We refer to the mean flow from the summer towards the winter hemisphere in the mesosphere.

(5) P12122, L20-22
It seems that ENSO affects tropical tropopause and lower stratosphere temperatures only in the absence of the QBO and hence the impact of the QBO is more important

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here. We do not understand this effect at this point, but still found it worth reporting. Possibly, the QBO impact hinders an ENSO-triggered feedback process in this region, e.g. a tracer-radiative feedback.

(6) P12123, L 6-15
Yes, six year averages 1992-1998 are shown also for the model runs.
No, HALOE data was not used for ERA-40.
The vertical profile of ozone in ERA-40 was derived from SBUV/SBUV2 observations, which have a rather coarse vertical resolution and focus on the middle and upper stratosphere. This may partly explain the slight underestimation of the O3 maximum just below 10 hPa in ERA-40. The differences between QBO and nonQBO runs in Fig. 3 are in agreement with the differences found for the full 15 year period in Fig. 12, which are significant based on Student's t-test.

(7) P12123, L25-29
We think that the model generally overestimates the impact of Pinatubo on equatorial ozone; hence the effect is more clearly distinguished in the model than in the HALOE record, where mixing ratios do seem to be slightly higher until 1993. (Note also that no HALOE ozone data are shown below 50 hPa before 1992, i.e. in the domain of the sulfate aerosol plume that formed in the lower stratosphere after the Pinatubo eruption.)

(8) P12424, L4-5
Yes, the signals in upper and lower stratosphere are indeed in opposite phase in the nonQBO run. They do however not show the QBO-specific delay. The QBO signal in ozone in ERA-40 is not very good, as vertically resolved long term ozone observations are scarce and few data have been assimilated. We consider omitting it for the final draft.

(9) P12127, L1-4
Indeed, upwelling and NO2 anomalies are of opposite phase. This will be clarified in the final draft.

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(10) P12127, L19-29
The purpose of Figure 6 was to show the effect of the QBO distinctly for opposite phases at the same season or calendar month. Criteria for choosing September 95 and 96 were (a) exactly opposite QBO phases in succeeding years and (b) pronounced QBO phase at 10 hPa. These constraints limit the number of candidates strongly.

(11) P12131, L19
Citation will be added.

(12) P12136, L1-10
The issue is discussed in the context of the ozone net effect in the upper tropical stratosphere because the differences in the forcing are unimportant for the other results of the study. The net effects in the experiments for the 2000 8211; 2019 period, which do not have these differences are very similar to those for the past, but omitted for compactness. The differences in the forcing were also described and discussed in Section 2, P12120, L18 to P12121, L4.

(13) P12136, L16
BDC is the acronym for the Brewer-Dobson circulation. This will be clarified in the final draft.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12115, 2008.