

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

**Anonymous Referee #2**

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

General comments:

This paper describes results from a chemistry climate model (CCM). The model nudges zonal winds in the tropical stratosphere towards observations over Singapore in order to reproduce the quasi-biennial oscillation (QBO) from 1980-2000 in one simulation and does not nudge winds in another simulation (noQBO). The CCM is able to simulate the observed QBO in temperature and ozone in the QBO simulation. By comparing the QBO and noQBO results, the authors concluded that (1) vertical advection of NO<sub>x</sub> and its impact on ozone chemistry is essential for the ozone QBO, confirming previous

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theory; (2) QBO secondary meridional circulation (SMC, i.e., QBO induced changes in the mean meridional circulation) causes 4 layers of alternating reduced and increased upwelling, with consequences on temperature and ozone.

The methods are clearly outlined. The results are interesting, and are compared to many previous studies when they are available. The paper is appropriate for publication in ACP after revisions.

Specific comments:

(1) One potential problem with nudging zonal winds around the globe towards observations at a specific site is the artificial creation of vertical and meridional advection in order to maintain the continuity of mass. Because the main results are related to ozone and temperature changes due to SMC, it would seem useful to comment on whether there is any artificial advection and, if there is, its effect on the SMC relative to the real changes in upwelling and in the strength of Brewer-Dobson circulation (or QBO induced SMC). Otherwise, one is left to wonder whether the results are real phenomena or just modeling artifacts.

(2) What is the time constant used in the wind nudging? Please also give some justification for the choice of time constant. Please comment on whether the wind measurements over Singapore can accurately represent winds around the globe over the Equator.

(3) Line 24 on page 12123. It would help to see the phase shift if lines are drawn in Figure 4 that show the downward propagation of winds shown in Figure 1.

(4) Please give a brief comment on the long-term cooling trend shown in Figure 2 (effect of increasing CO<sub>2</sub> and other greenhouse gases).

(5) Lines 12-19 on page 12130. In the five points summary of SMC (in section 4), points 3-5 do not match with the figures shown in the Appendix.

(6) Line 14 on page 12131. It is not obvious why the upper stratospheric cooling is a

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consequence of the more easterly wind shear due to the modified SAO (please also define SAO in earlier text).

(7) Line 22 on page 12135. "balanced by increased photolysis rates" should be "balanced by reduced O<sub>3</sub>+O and Clx+O rates"?

(8) Line 23 on page 12139. What is the connection to temperature? Is it due to slower loss or larger production at lower temperatures?

Technical corrections:

(1) Line 13 on page 12116. "below the level of maximum ..."

(2) Line 16 on page 12116. "during summer and fall seasons in both ..."

(3) Line 18 on page 12116. "and thereby affect".

(4) Line 17 on page 12117. Insert before "Firstly": "There is growing interest in studying QBO in chemistry climate models."

(5) Line 5 on page 12118. delete "higher resolved and".

(6) Line 25 on page 12118. "stream function".

(7) Line 11 on page 12124. Delete "The" leading the paragraph.

(8) Line 18 on page 12125. "where it would be".

(9) Line 20 on page 12125. "the shift in altitude of the phase reversal"?

(10) Line 14 on page 12126. No need to give units in the main text.

(11) Line 2 on page 12131. "The pattern of warm-cold-warm-cold regions from 100 hPa to 1 hPa".

(12) Line 4 on page 12131. "in the stream function (see Figure A1a)".

(13) Line 24 on page 12131. "The cold temperature ..."

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- (14) Line 6 on page 12132. "net effects to the ozone volume".
- (15) Line 13 on page 12132. "in the upper stratosphere, especially at the Equator, seriously impacts ...."
- (16) Line 16 on page 12132. "the QBO's net effect"; delete "in Fig. 12a".
- (17) Line 25 on page 12132. "Only between 3 and 15 hPa do we find ..."
- (18) Line 27 on page 12132. "stronger upwelling"
- (19) Lines 6-7 on page 12133. move the sentence "Figure 12b shows ..." to the end of next paragraph, after "vortex area" on line 13.
- (20) Line 16 on page 12136. define BDO in earlier text.
- (21) Line 20 on page 12133. "net effect on temperature".
- (22) Line 2 on page 12135. "we have forced a QBO in zonal winds based on observations in a CCM. The resulting circulation yeilds realistic temperature and ozone fields in the model."
- (23) Line 20 on page 12135. "stronger upwelling".
- (24) Line 2 on page 12136. "differs between the two simulation."
- (25) Line 4 on page 12136. "are only present".
- (26) Line 5 on page 12136. "and may have consequences ..."
- (27) Line10 on page 12136. "to clarify this point."
- (28) Line 17 on page 12136. "between the two model runs ..."
- (29) Line 22 on page 12136. delete "however".
- (30) Line 9 on page 12137. "to additional quantities besides zonal wind".
- (31) Line 16 on page 12138. "20<sup>o</sup> and 30<sup>o</sup>"

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- (32) Figure 1. define ME4-C in legend.
- (33) Figure 4. "zonal mean ozone volume mixing ratio"
- (34) Figure 6. "Contributions of ..."
- (35) Figure 11b. x-axis labels too crowded.
- (36) use "noQBO" everywhere (replace nonQBO with noQBO).

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

## ACPD

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