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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Net influence of an internally-generated QBO on modelled stratospheric climate and chemistry" *by* M. M. Hurwitz et al.

**M. M. Hurwitz et al.**

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We thank Reviewer #3 for his/her comments. We have revised the manuscript accordingly. Our responses directly follow each comment.

M. M. Hurwitz and co-authors August 2013

> My major concern is that the authors seem to imply that the QBO is "doing something to the high latitudes". They skip the interesting and important point of how, for example, planetary wave propagation is changing, where resolved and unresolved waves dissipate and why transport barriers are changing. It would be nice to show the non-

orographic wave drag and to discuss changes in the propagation characteristics of planetary waves (amplitudes / phases), “communicating” the equatorial changes to high latitudes.

Please see our response to Reviewer #1 regarding QBO-related changes in planetary wave activity.

Using aerosol distributions, Trepte and Hitchman (1992) found that the strength of the sub–tropical mixing barriers is controlled by the phase of the QBO. Sub–tropical aerosol gradients were reduced when the phase of the lower stratospheric QBO was westerly, implying enhanced sub–tropical mixing, due to changes in the critical zero-wind lines and thus changes in wave propagation. We would expect weakened sub–tropical transport barriers and enhanced mixing in the Q simulation relative to the N simulation, due to the relative westerly shift in tropical lower stratospheric zonal winds. We use the distribution of stratospheric N2O, increased poleward transport (v*) and enhanced sub–tropical variability to infer increased mixing and weakening of the sub–tropical transport barriers in our simulations.

Trepte, C. R., and Hitchman, M. H.: Tropical stratospheric circulation deduced from satellite aerosol data, Nature, 355, 626–628, 1992.

> The title mentions a “net influence” and I am still not quite sure what this is. Certainly the tropical variance should increase, and the mean will change, so presumably Figure 2 is showing the “net influence”. Maybe this wording could be avoided?

Please see our response to Reviewer #1’s comment.

> The paper focuses on the Q-N differences (Q/N ratios). MERRA is shown once, but I find it very hard to decode the model biases and how they change between Q and N. Maybe the authors could consider a slightly more detailed discussion of the general model biases with respect to the reanalysis data? This would help the reader to understand the basic behaviour (improvements?) of biases and planetary wave



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propagation better (which will hopefully be mentioned in the next paper version).

We agree. In the revised manuscript, we show both the N simulation and Q simulation means compared with observational datasets (Figures 3, 5 and 6). These additional panels help readers visualise the model biases in the simulation without a QBO (N), and the relative improvements in model performance in the Q simulation, e.g., improvements in tropical zonal winds (Figures 3a and 3b). Panels showing the Q – N differences highlight the net influence of the modelled QBO on the stratospheric mean climate.

> P13502, L15: I don't understand the point about water vapour. It seems counter intuitive and doesn't mention the role of temperature changes. Please clarify!

We have removed the comment about changes in water vapour, as we agree this could be confusing to readers.

> P13503, L21: capital "S"

We have revised this sentence as follows: "Mean N2O differences between 10 and 40 degrees latitude serve. . ." because this diagnostic is applied the same way in both hemispheres.

> P13504, L16: Which month? Is the Holton-Tan relationship always there? Why not discuss the planetary waves and show the HT relationship explicitly?

A new figure (Figure 9) shows correlations between equatorial zonal winds and extra–tropical zonal winds at 50 hPa, as a function of month, in both MERRA and in the Q simulation. Strong, positive correlations $\sim 60^{\circ}$ latitude indicate months when the Holton–Tan relation is present. Though the seasonality differs, both MERRA and the Q simulation show the presence of the Holton–Tan relation in winter.

> Is the change in tropical age-of-air significant (Figure 9)?

Yes. Though small, increases in tropical age–of–air in the Q simulation relative to the



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N simulation are statistically significant; see revised Figure 5c.

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