Interactive comment on “Quasi-biennial oscillation of the tropical stratospheric aerosol layer” by R. Hommel et al.

Anonymous Referee #2

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The authors use a microphysical aerosol model to study the effects of QBO on stratospheric aerosol properties. This is an important topic due to changes in observed stratospheric aerosol optical depth over the past 15 years, the prolonged lifetime that stratospheric aerosols have on radiative forcing, and the lack of understanding of the natural periodic processes sustaining background aerosols. The model used by the authors is a good fit for this research, their focus on the poorly-understood impacts of QBO phase is good, and their approaching plotting anomalies in terms of the onset of QBO is illustrative. There are several minor items that should be addressed before publishing in ACP. This work is well within the scope of ACP.

General concerns:

1) I think it would be useful to compare the magnitude of the stratospheric aerosol variations due to QBO to that of seasonal variability, annual variability, and volcanic influences. For instance, how much stronger is QBO than seasonal or annual (e.g. tape recorder) variations on stratospheric aerosol? Does the QBO phase impact aerosol properties more than recent volcanic eruptions in the lower stratosphere? upper stratosphere? This could be included in the abstract and some discussion and particularly the conclusions.

2) the recent SO2 observations by Hopfner et al which included the contributions of QBO phase is a very relevant comparison to your model. It would be useful to conduct a more detailed comparison between the ranges observed by Hopfner et al and your model, provide a more detailed description of this dataset in your introduction and/or section 2.2, and compare seasonal, annual and QBO-induced variability between the model and dataset.

3) There are many places in the paper where you provide qualitative terms like "strongly", "more or less", "substantially smaller", "QBO effect exceptional", "indicates to a certain extent", "heavily influenced" and "rather in-phase" etc. It would be useful to provide more quantitative terms such as x % larger or smaller in x region.

4) There are also many places in the paper with grammatical errors and typos. I’ve tried to list most of them in my specific comments but please double check other places.

5) How might contributions from aerosols that you don’t include in these simulations convolute your analyses? Please provide some discussion around that. For instance meteoritic dust contributes significantly to upper stratospheric aerosol (see Neely et al., 2011), and recent volcanic eruptions (Vernier et al 2011) and other aerosol species such as carbon (Murphy et al 2007) contribute to lower stratospheric aerosol.

6) The discussion of ozone on p16256 is confusing. Are you presenting any of your ozone results here? If not, it seems risky to compare your model’s aerosol extinction to observations of ozone and make conclusions regarding the relative changes.
7) I find it a little concerning that your section 3.4 Microphysical processes ignores coagulation and sedimentation. Aerosol microphysical processes occur together in complex ways, and for instance coagulation and sedimentation can alter the rates of condensational growth and evaporation. Perhaps you could devote some discussion as to the caveats of your approach in section 3.4.

Specific items:

Abstract: Add a dash to "QBO-induced"

Abstract: Please quantify the relationship between QBO and the anomalies. Instead of saying that the aerosol load is "predominately influenced by QBO-induced anomalies...", please state the relationship (easterly-phase causes xxx to happen). Instead of saying "large impacts are seen" quantify the percentage change from one QBO phase to the other.

p16244 line26: change "is influenced by" to "may be influenced by" (since for example Neely et al 2013 found very little contribution of Asian aerosol to the stratospheric aerosol)

p16345 line 15: Please provide more details with regards to "These problems are addressed in the current study". perhaps something along the lines of: "In this study we propose to quantify the contributions of QBO to changes in stratospheric concentrations of background aerosols and their precursors."

p16246 line 19, 21: Add English et al., 2013 citation to the sentence describing Pinatubo studies using size-resolved models, and Campbell et al 2014 to the list of citations for background aerosol.

p16248 line 19: 39 levels is somewhat coarse to capture stratospheric dynamics. Have you conducted any studies to determine whether the vertical resolution is sufficient to capture stratospheric processes?

p16249 line 20: What are prescribed "climatological" oxidant fields? Do they include the variations in stratospheric concentrations due to QBO? If not, it would be useful to quantify how much they vary between different phases of QBO, and how that might impact your model results.

p16249 line 28: why does it take 6 years to reach steady state? stratospheric lifetime is typically a year or 2.

p16250 line 4: Describe the specific "aerosol forcing data set" you are referring to. Extinctions? SAD?

p16250 line 10: I’ve seen the new SAGE 2 referred to as “v7” not “vn7”

p16251 line 1: change “to” to “too”

p16251 lines 19-25: these two sentences aren’t very clear, and the grammar could be improved.

p16253 line 16: “extra-tropically” is mis-spelled

p16253 lines 14+: this paragraph could use more citations.
I realize this is somewhat standard practice, but I and others find the (parentheses) describing opposite trends confusing. There are a few instances of "nicely seen" that should be reworded, possibly to "clearly shown". Change "east" to "easterly". "Wavelength" is one word. It is important to take what into account? Condensational growth? Is this more important that coagulation? It seems that several microphysical properties are important. Please quantify "strongly depends". For instance something like "including particles smaller than xx nm increases SAD by xx %". I don't believe that larger particles evaporate at higher rates than small particles. As large particles start to evaporate they become small particles. Please clarify. Change "more or less" to a quantifiable term e.g. "which varies by only +/- x %". Do you mean greater than 0.005 um instead of less than? Remove the comma after "region". "Datasets" is one word. How does your modeled SAD compare to SAGE when you cutoff particle size smaller than the detection limit of SAGE? Negatively biased to what kind of observations – satellite or aircraft? Satellite observations have known biases as you've stated but aircraft observations are more reliable. "Infer with effect" grammar could be improved. This sentence uses the word "anomaly" yet fig 8g is not an anomaly. The paragraph discussing nucleation should probably go before the current preceding paragraph which discusses other microphysics. References. Nucleation mode does not prove BHN occurs as other processes such as ion-mediated nucleation may occur. Perhaps state that it suggests BHN is occurring. "More and more inhibit" grammar could be improved, and the following sentence starting with "However", the grammar and sentence structure could be improved. Also, before this sentence you could state what happens "below this layer". "Vapour contents" is not a common way to describe the thermodynamics. Perhaps use the words "supersaturation of h2so4 and water, which depends on temperature and vapor concentration...". Improve grammar for "tends to zero". Improve grammar for "QBO east shear". What do you mean by "can amount to 50%"? Under which circumstances? What are the units of time-averaged molecule concentration transferred? Seems like time should be on the denominator, but this is not noted in Fig. 9. Does warmer T also explain the changes in saturation vapor pressure above 20 hPa?
"imposes" mis-spelled
remove comma after "mentioned"
could the temperature biases affect modeled nucleation and
growth in addition to evaporation as you've noted?
how does QBO "interfere" with the annual cycle?

improve grammar of "regularly base"
add Campbell et al 2014 citation.
A more direct comparison between your model SO2 and Hopfner et al would be useful. How do each SO2 vary between QBO phases? how do so2 annual and seasonal variations compare?
this reasoning is not clear to me. To me, aerosols in the lower stratosphere seem strongly driven by transport from upper troposphere, but aerosols in the middle stratosphere are more driven by OCS oxidation. Please clarify your reasoning.
add "and so2 measurements (Hopfner et al 2013)."
change to "easterly phase"
the assumption that condensation and evaporation occur concur-
rently seems risky. I would suggest that you analyze your instantaneous model output to determine whether this is true, or change your discussion of it.

Several figure captions need superscripts for units
Fig 1: caption has a duplicate "zonal mean zonal"
Why is there a sharp gradient in ERA-interim at 15 hPa?
I thought your control simulation had prevailing easterly winds? why are there some non-dotted lines (e.g. westerlies)? Also "Ratio" is mis-spelled in the title
add "(a)"
suggest you change lower panel description to "50 nm <= R < 2.6 um" for consistency
Add "modelled" to caption description. and to other figure captions where appropriate to clarify that this your model output.

shouldn't there be a unit of time in the denominator?

References

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 16243, 2014.