Second review of "Disentangling the chemistry and transport impacts of the Quasi-Biennial Oscillation on stratospheric ozone" by Xie et al.

The authors have provided extensive responses to the reviewer comments and have revised their manuscript accordingly. The revision is easier to follow.

Much of the description of the analysis is comprehensive and carefully presented. My recommendation is that this work may be eventually publishable if the authors revise the manuscript to be very clear about what is new from their work and what message the community should learn from this investigation. In particular, the title, abstract, and introduction would benefit from major revision to focus attention on what new can be learned from the model simulations and analysis. As can be seen from the major comments below, I was still confused about the main thrust of the investigation and about how the linear model is used.

Major comments

1. The manuscript still does not do an adequate job of setting up the goals of the project so the reader is left wondering what is the point of evaluating the linear ozone model. Is the eventual goal to use this linear model in interactive runs or is it primarily for purpose of diagnosing ozone? The paper shows that the model with a nudged QBO and expanded range of chemical families (version 3) reproduces ozone reasonably well. The impact of ozone changes due to the QBO on stratospheric or climate variables is not presented and so the manuscript does not make a case for including Linoz as a component of an interactive model. The analysis seems mainly to demonstrate that this simplified model can reproduce results from more comprehensive studies showing that transport of ozone, transport of NOy, and temperature dependence of ozone photochemistry are the dominant processes in the response to the QBO in different vertical regions. The manuscript does not describe any new insights into the chemistry or the impact of the ozone changes on the QBO, rather, it demonstrates that their linear model is able to capture these
2. Unfortunately, even after several times reading through, I'm not sure I was able to follow some basic aspects of the model description. This makes it very difficult to evaluate the results. At line 65-66, "In this study, we use the interactive stratospheric chemistry module in E3SM (Linoz: 65 Mclinden et al., 2000; Hsu and Prather, 2009) as an off-line model …" indicates the Linoz is used offline. But then at line 77-78 "Our primary modeling tool is the Department of Energy (DOE) Energy Exascale Earth 77 Model version 2 (E3SMv2, Golaz et al., 2022) with interactive stratospheric ozone …". And at line 99-100 "Stratospheric ozone in E3SMv2 is calculated interactively through transport and the chemical Linoz module". Then at line 467-468, "the use of the offline Linoz model…" Perhaps part of the problem is the use of the term "interactive" since any potential ozone impact on the QBO is weakened or cancelled by the dynamical nudging.

Other comments

1. Please make it clear what you mean by "phase asymmetry" (e.g. line 74, line 179, etc.). Based on further reading in the manuscript and familiarity with the observations, it appears you mean the difference in the length of time and evolution of the wind change with pressure between the easterly and westerly phases. This should be defined at the outset so the reader is not wondering what asymmetry you are referring to.

2. (l. 326-327) Sentence beginning “This indicates …”. Since the response of column ozone is mainly driven by the winds in the lower stratosphere, this discrepancy likely indicates that the internally generated QBO is too weak there.
3. (l. 349-356) What are you trying to say here? The figure indicates poor response of ozone in the simulation with internally generated QBO. What is the “improved representation” that is referred to?
4. Is anything additional learned from the convoluted calculation of the ozone that CESM2 would have if it used Linoz?

Editorial comments

1. (l. 394) “the no response” -> “the lack of response”
2. (l. 427) What does “colder/warmer” mean? It’s either one or the other.
3. (l. 469) “with the with the”