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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "Drivers of changes in stratospheric and tropospheric ozone between year 2000 and 2100" *by* A. Banerjee et al.

**Anonymous Referee #1**

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In this paper, the authors have explored the sensitivity of stratospheric and tropospheric ozone, and tropospheric ozone budget to future climate change, reductions in ozone depleting substances, and non-methane tropospheric ozone precursor emissions using an interactive stratospheric and tropospheric chemistry-climate model. The results of this study highlight the importance of stratospheric chemistry and dynamics for determining tropospheric ozone burden under different climate change, ODS and precursor emission scenarios. The paper adds to the body of work on the importance of stratosphere-troposphere exchange for tropospheric ozone by performing an in-depth analysis of the tropospheric ozone budget terms. Overall, the analysis is rigorous and the paper is well-written. I recommend the acceptance of this paper by ACP after the following comments have been addressed:



Page 30647, Line 28: A reference to van Vuuren et al., (2011) would be appropriate here.

Page 30648, Line 25: Reference to Revell et al. (2015) would be appropriate here. Same for Line 20 on page 30649.

Page 30650: Do lightning NOx emissions change in any of the perturbation simulations? Since lightning NOx is conventionally tied to model convection and therefore climate, I would imagine that it is responding to climate change in $\Delta$CC simulations.

Page 30652: As described by the authors, any ozone molecule above the thermal tropopause is tagged as "stratospheric", however, it is quite possible that ozone produced in the troposphere can potentially land in the stratosphere due to deep convection in the troposphere, particularly in the tropics. It would be helpful if authors could provide insight into how their definition of O3S and the tropopause might impact the conclusions of this study.

Page 30652, Line 16: Reference to Eyring et al. (2013) with results from the latest CMIP5 simulations would be appropriate here.

Page 30653, Line 15: The authors mention tropical upper tropospheric increases in ozone are driven by lightning NOx – are lightning NOx emissions allowed to respond to climate change?

Page 30654, Lines 13-16: It is not clear if the authors found the model to produce reductions in the abundance of ClONO2 reservoir in the ODS experiment. A supplemental plot of modeled changes in ClONO2 would be helpful here.

Page 30656, Lines 23-24: References are needed after "theory and previous model studies".

Page 30657, Lines 13-15: I think it would be useful to provide ACCMIP ozone budget numbers for comparison with the caveat that the budget terms were calculated using 6 models while ozone burden and methane lifetime are calculated using output from $\sim$15

ACCMIP models. Particularly, because many ACCMIP models included interactive stratospheric chemistry.

Page 30658, Lines 22-24: Ozone depositional loss increases for CC4.5 and ODS simulations while it increases for CC8.5. Perhaps the authors could comment on how changes in loss processes (chemical plus dry deposition) affect ozone burden.

Page 30659, Line 3: Insert "tropospheric" between higher ozone.

Page 30659, Lines 4-5: Refer to Table 2 and/or Figure 4 here.

Page 30659, Lines 7-17: I don't think this is a fair comparison as these models used different assumptions for climate and emissions changes.

Page 30663, Lines 10-11: The reference to Figure 6 without getting into details of the diversity in STE across the perturbation experiments is conspicuously standing out here. I think this sentence could be removed as the figure is discussed in in section 4.5.2.

Page 30663, Lines 26-27: A citation is needed here.

Page 30664, Lines 10-12: Suggest rephrasing to "Figure 8 shows absolute changes in O3S and O3 between Base. . .."

Page 30671: Lines 5-6: A citation would be helpful here.

Figure 2: Add "Tropical" to y axis title.

Figure 8: For easy comparison, it would help to use the same color scale for (a) and (b), and (e) and (f). Also, the size of this plot should be increased as the colorbar labels are difficult to read.

References: Revell, L. E., Tummon, F., Stenke, A., Sukhodolov, T., Coulon, A., Rozanov, E., Garny, H., Grewe, V., and Peter, T.: Drivers of the tropospheric ozone budget throughout the 21st century under the medium-high climate scenario RCP 6.0,



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van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., Hurtt, G. C., Kram, T., Krey, V., Lamarque, J.-F., Masui, T., Meinshausen, M., Nakicenovic, N., Smith, S. J., and Rose, S. K.: The representative concentration pathways: an overview, Clim. Change, 109, 5–31, doi:10.1007/s10584-011-0148-z, 2011.

Eyring, V., Cionni, I., Arblaster, J., Sedlacek, J., Perlwitz, J., Young, P. J., Bekki, S., Bergmann, D., Cameron-Smith, P., Collins, W., Faluvegi, G., Gottschaldt, K.-D., Horowitz, L., Kinnison, D., Lamarque, J.-F., Marsh, D. R., Saint-Martin, D., Shindell, D., Sudo, K., Szopa, S. and Watanabe, S.: Long-term changes in tropospheric and stratospheric ozone and associated climate impacts in CMIP5 simulations, JGR, 10.1002/jgrd.50316, 2013.

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Interactive comment on Atmos. Chem. Phys. Discuss., 15, 30645, 2015.