Reply to comments of Anonymous Referee #1

The manuscript presents a revisit to the aqueous chemistry of the superoxide anionin the atmosphere, using both a box and a global model. The focus of the study is on the impact of this newly implemented chemistry on VOCs, OVOCs, HOx, and ozone. Comparisons of the model against satellite methanol and ozone observations are shown, with updates decreasing EMAC's positive ozone bias. Overall the authors clearly demonstrate the importance of including this chemistry in global chemistry models. The science is generally presented in a clear and appropriate way and the manuscript as whole fits the remit of ACP. I would encourage publication effectively as is.

We are very grateful for this positive feedback and for seeing the potential of our contribution to the community. Please find in black the original comments and in red our replies.

Specific comments

Line 44 – A suggestion for flow of reading: Add "However" to the beginning of the sentence below.

"By not considering additional in-cloud HO2(aq) sources, Liang and Jacob (1997) underestimated O2(aq) concentrations dampening the in-cloud destruction of O3(aq)."

Done.

Line ∼ 175 – Please add a table to section 2.4 to make it easier for the reader to quickly decode the simulation acronyms used elsewhere in the text.

Thank you for this helpful comment. We added a table summarising the characteristics of the gas- and aqueous-phase mechanism used in each simulation performed, using CAABA and EMAC in this study. A reference to it has been added to Sect. 2.4.

Figure 2 caption – Consider moving expansions of families (e.g. VOCs) here and elsewhere to a table in the supplement to make the text more readable.

This is a good point. Removing the definition from the captions will make them easier to read. We think that creating a supplemental material just for this one line does not fit. Thus, we therefore created Appendix A, which includes the definition of $\sum$OVOCs. We also added references to the definition in Appendix A to Sect. 4.1.

Table 4 – Please add some reference numbers from a multi-model study such as TOAR as a column to Table 4. This enables the reader to put these numbers in context (e.g. Loss via bromine seems quite high in this model).

In the revised manuscript, we added two additional comparisons to Table 4 (now Table 5). The multi-model study from TOAR only includes the total chemical production and loss, the dry deposition, the Stratospheric-Tropospheric Exchange, and the burden. Therefore, we added an additional detailed multi-model comparison based on Sherwen et al. (2016), Hu et al. (2017), and Griffiths et al. (2020).

Table 3 and 2 – As with Table 4, is it possible to provide some context for the numbers to another model study? Few will know where these numbers are high or low without context.

In the revised manuscript, we added the detailed gas-phase OH budget from Lelieveld et al. (2016) to Table 2 (now Table 3). We are not aware of any detailed HO_2 budget from the literature. Therefore, we couldn't add any comparison to Table 3 (now Table 4).

Please expand all abbreviations/acronyms in table/figure captions or at least link to a table of these (e.g. "Scm" in Table 1).

We now refer to the newly created table summarising the characteristic of each simulation in the caption of all figures and tables.

References

Griffiths, P. T., Keeble, J., Shin, Y. M., Abraham, N. L., Archibald, A. T., and Pyle, J. A.: On the Changing Role of the Stratosphere on the Tropospheric Ozone Budget: 1979–2010, Geophysical

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Hu, L., Jacob, D. J., Liu, X., Zhang, Y., Zhang, L., Kim, P. S., Sulprizio, M. P., and Yantosca, R. M.: Global budget of tropospheric ozone: Evaluating recent model advances with satellite (OMI), aircraft (IAGOS), and ozonesonde observations, Atmospheric Environment, 167, 323–334, https://doi.org/doi.org/10.1016/j.atmosenv.2017.08.036, 2017.

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Liang, J. and Jacob, D. J.: Effect of aqueous phase cloud chemistry on tropospheric ozone, Journal of Geophysical Research: Atmospheres, 102, 5993–6001, https://doi.org/10.1029/96JD02957, 1997.

Sherwen, T., Schmidt, J. A., Evans, M. J., Carpenter, L. J., Großmann, K., Eastham, S. D., Jacob, D. J., Dix, B., Koenig, T. K., Sinreich, R., Ortega, I., Volkamer, R., Saiz-Lopez, A., Prados-Roman, C., Mahajan, A. S., and Ordóñez, C.: Global impacts of tropospheric halogens (Cl, Br, I) on oxidants and composition in GEOS-Chem, Atmospheric Chemistry and Physics, 16, 12 239–12 271, https://doi.org/10.5194/acp-16-12239-2016, 2016.