

***Interactive comment on* “Role of external factors in the evolution of the ozone layer and stratospheric circulation in 21st century” by V. Zubov et al.**

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The manuscript by Zubov et al reports on the role of the GHG increases, ODS removal, and future changes in SST and sea ice (SI) in the evolution of ozone layer and stratospheric circulation in the 21st century. In particular, they find that the changes in SST/SI play a very important role in future ozone changes in the tropics and Northern Hemisphere extratropics. The result is interesting and, I believe, will be appreciated by the chemistry climate community. However, in some places the manuscript lacks clarity. My comments below are minor and mainly aimed at the improvement of the clarity of the presentation. Overall, I believe that the manuscript may be published in

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ACP after the points below are considered.

Comments:

P28468L20: '...some differences between the simulated results could be caused by the applied SST/SI rather than by the CCM's deficiencies.' I suggest rewriting: '...some differences between the results by different CCMs could be caused by the applied SST/SI rather than by the CCM's deficiencies.'

P28470L25: 'They operate in the atmosphere via the acceleration or suppression of the main physical and chemical processes, which play only secondary role.' Do you mean changes in timescales of the 'main physical and chemical processes'? Please rephrase this sentence.

P28470L27: 'Thus the attribution of the atmospheric changes to the external anthropogenic factors is the more important task in comparison with any other types of the attributions.' Please specify which other types of attribution you mean.

P28471L4: '...however the reasons for this uncertainty have not been clearly identified.' Please discuss here the role of the internal climate variability. Can the uncertainty in the future ozone layer be to some extent attributed to the internal climate variability?

P28471L10: 'However, it is not the case for the future SST/SI distributions taken from different models participated in IPCC AR4 assessment (IPCC, 2007) which are characterized by substantially different magnitude and pattern of the future climate change.' I think you need to acknowledge here that the use of different future SST changes allows, to some extent, sampling of the uncertainty due to atmosphere-ocean GCMs deficiencies, as well as the uncertainty due to climate variability. I agree that using different SSTs hampers CCM intercomparisons; however you need to differentiate the cases when the use of different SSTs is beneficial.

P28471L28 Could you please be more specific what is meant by 'ensemble approach' here.

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P28474L21 'Then, the last two years of the run are "recalculated" five times with the slightly (within ± 0.01 %) changed CO₂ mixing ratio to generate five ensemble members.' I do not understand this. How many years does each of the ensemble members have?

P28476L22 'The SST/SI factor has quite different effects on the zonal wind in the SH and NH which consist of the eastward wind acceleration in the middle latitudes of the SH and deceleration in the NH.' Do you mean at about 10hPa and above? Below 20hPa the situation is symmetric between the hemispheres, at least qualitatively. Please be specific here.

P28476L28 '...extending their upper flanks in vertical direction, and.' There is a full stop after 'and'. Did you finish the sentence?

P28477L15 '...the tropospheric air with rather low ozone mixing ratio and its additional accumulation over the northern extra-tropics (Fig. 3c).' Put comma between 'ratio' and 'and' to separate the different parts of the sentence.

P28477L27: I suggest rewriting the paragraph discussing the RES term. The model simulations used here are not very long and cannot capture the internal climate variability at decadal and longer time scales, which can be significant. Therefore the RES term may represent not only interactions between the different forcings, but also decadal climate variability. I'm not sure which of the two plausible effects dominate. Overall, the figure demonstrate that the RES term is very small when compared to the dominant individual terms in TEM, U and O₃, which should be the main message of the figure. It is not very clear how the RES compares to the other terms in total ozone, because the units in Fig. 5D (DU) are different from those in Figure 4 (%).

P28478L1: Which polar stratosphere is meant here – southern or northern?

P28478L10: The ozone hole occurs during austral spring while the significant differences seen in Fig. 5D are in austral summer and autumn. Please correct.

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P28478L20: 'SST/SI factor also has dominant contribution to the deceleration of the stratospheric westerly winds in the extra-tropical latitudes of the NH from 2000 to 2050 (Fig. 6a).' The location of the node separating the acceleration/deceleration regions is altitude depended. For example below 30hPa, the deceleration is only simulated in the polar latitudes north of 60N while there is an acceleration in the extratropics south of 60N. Please be more precise here.

P28479L21: Add 'by the GHG factor' to: 'The upper stratospheric westerlies are accelerated BY THE GHG FACTOR mainly in the SH.'

P28479L21: 'All these atmospheric changes are responsible for about a half of the century ozone concentration increase in the upper stratosphere and ozone decline over the Antarctic area.' There is no ozone decline over the Antarctic in the 21 century! The GHG alone would lead to a decrease in the Antarctic ozone according to Fig. 3B, but this decrease is much smaller than the increase due to the ODC removal.

P28480L13: '...in the second half of THE century'

P28480L15: '...to the relevant column ozone changes' → '...to the TOTAL column ozone changes'

P28480L19: '...rather than by model features.' → '...rather than by CCM features.'

P28480L28: The results of the sensitivity experiment with NCAR-ESM SST/SI should be reported in the Results section. I suggest moving this sentence to the Results section.

P28481L3: I think this sentence need to be rephrased, see also my comment on P28471L10. If the goal of CCM simulations is a model intercomparison then CCMs should be run with the same SST/SI. If the goal of CCM simulations is to obtain future climate projections then the use of different SST/SI is beneficial because it allows better sampling of different sources of uncertainty. If both goals are desirable (which is usually the case), then, ideally a separate set of CCM simulations should be planned,

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in which all CCMs are run with the same forcing including the SST/SI. Also, future model generations may include interactive ocean, which will likely have an effect on planning of model intercomparisons. You may want to comment on what implications your results possibly have for the evaluations of CCMs with interactive ocean.

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