Response to Editor

We would like to thank the editor for their thoughtful views and valuable comments. Below is our response to each of the comment. The point-to-point responses are below with the editor's comments in **BLACK**, our responses in **BLUE**, and change in the manuscript in **GREEN**.

1. L. 199: "differences in the photochemistry schemes" -> also radiative heating schemes.

Response: Thanks for the suggestion.

We modified the original sentence to consider radiation scheme, which includes both radiative heating and cooling scheme.

We replace the original sentence with the sentence below (P10 lines 198-200):

"…and differences in the photochemistry and radiation schemes of the models explain the different sensitivities of ozone to temperature change across models…"

2. L. 206-210: stronger tropical upwelling also means less ozone poor tropospheric air gets to the lower stratosphere.

Response: Thanks for pointing it out!

We have modified the sentence as follows (P10 lines 207-208):

"The stronger upwelling results in enhanced transport of ozone out of the tropical pipe and ozone-poor air from the troposphere to the LS, leading (locally) to a decrease."

3. L. 218-219 – this sentence in the current form still implies that models project a weakening of NH polar vortex under climate change, which is not true (see e.g. Karpechko et al., 2022). Please rephrase to "a weaker NH polar vortex correlates with an increase of ozone in the Arctic", to similar.

Response: Thanks for the suggestion!

We have modified the sentence as follows (P12 line 219):

"…for most models, a weaker NH polar vortex correlates with an increase of ozone in the Arctic."

4. L. 221 "the heating from more ozone" – but we're talking about DJF and there is no sunlight in the Arctic in DJF, and so any radiative impacts of Arctic ozone (if at all) would have to come from LW cooling.

Response: Thanks for the comment! It is a good point.

The reason that we focus on LW heating is due to the correlation of the weakening of zonal wind with the increase of ozone response shown in Figure 3. We also elaborate more to discuss about the dominant role that LW cooling can play.

We modified the sentence and added a new sentence as follows (P12 lines 223-224):

"Also, the heating from more ozone could partly contribute to polar warming and weakening of the polar vortex throughout the extended winter season, and there is more ozone in the surf zone available to be transported into the polar region. Conversely, during the deep winter months, LW cooling effect from ozone anomalies can be dominant at the polar-most latitudes."

5. Please make sure that from Section 3.1.2 onwards, the numbering of figures in the Appendix (as indicated by Fig. Bx) is corrected and incremented by 1 throughout the rest of the manuscript (as new Fig. B2 was added but the subsequent figures are not correctly referenced now).

Response: Thanks for catching that! We have revised accordingly.

6. L. 243: "Climatological differences" -> "Climatological responses"

Response: Thanks for the suggestion! We have revised accordingly.

7. L. 244: add "under higher GHGs" (or similar) at the end of the sentence.

Response: Thanks for the suggestion! We have revised accordingly.

8. L. 245: "climatological spread of the two variables" -> "differences in the responses in the two variables" (or else, currently unclear in the present form)

Response: Thanks for the suggestion!

We have revised as follows (P13 lines 246-248):

"…we don't find a consistent relationship in the inter-model differences in the responses in the two variables…"

9. Section 3.2. Please define TCO, TRO3, USO3 and LSO3.

Responses: Thanks for the suggestion. We have revised accordingly.

10. L 253 "a high bias" – you mean it's an outlier? Because we can't see it's a bias as we don't know what the 'correct' value is in this case, we can only say the other models show either near zero or negative responses.

Response: Thanks for pointing it out!

We have modified the sentence as follows (P15 lines 253-255):

"In the tropics, the multi-model uncertainty is smaller, though UKESM1-0-LL and SOCOL-MPIOM show a more negative TCO response and GISS-E2-1-G_p3 is an outlier in the opposite direction."

11. L. 271. It might be worth stating which experiment has higher CO2 around year 140, or if they both have similar CO2 levels at that time.

Response: Thanks for the suggestion.

The two experiments have similar CO2 level at year 140, and we have clarified that in the text as follows (P16 lines 273-275):

"…we can see the lag of the response since the tropical TCO response around year 140, when the CO2 level in 1pctCO2 reaches that in 4CO2, is smaller than the equilibrated value from 4CO2."

12. L. 285 – 286. It's not obvious to me that the 'full' response in models in the NH midlatitude lower stratosphere is necessarily a warming. To me it looks like the temperature response in the mid-latitude LS is as uncertain as in the high latitude LS.

Response: Thanks for pointing it out!

We have edited the sentence to make it more precise (P17-18 Lines 289-291):

"In the LS, we find a slight warming in the NH middle and high-latitudes, contributing to the total temperature response in this region, competing with a similar level of cooling from CO2, which results in differences in the sign of the total temperature response across models."

13. L. 300 "LW flux changes largely corresponds to the temperature adjustments in the LS and is consistent with the ozone changes" – While changes in T (caused by O3) definitely lead to changes in LW, changes in O3 themselves also lead to changes in LW (so not just by changing T but also by more/less LW absorption and re-radiation).

Response: Thanks for pointing it out!

We have added a sentence to discuss the effect of ozone response on LW flux (P19 lines 305-306):

"The ozone changes determine the temperature adjustment and modulate the LW flux by increasing the local LW absorption and emission."

14. L. 309-310. Might be worth pointing out also that it's the tropical response that dominates the global mean response, and that is always negative (unlike in the mid/high latitudes)

Response: Thanks for the suggestion!

We have modified the sentence as follows (P19 lines 314-315):

"The net flux change is the sum of that of LW and SW, and is negative in the tropics and positive in the extratropics, with the LW generally dominating over the SW forcing. Due to the large area of the tropics, the global mean net RF is negative in all models…"

15. L.360-361: "The strengthening of zonal wind in the tropical US is due to the expansion of the weakened polar vortex as discussed in Section 3.1.1." – I'm confused by both what strengthening of the zonal wind in tropical US and also what expansion of the weakened polar vortex. Please either clarify or delete this sentence.

Response: Thanks for pointing it out!

We have clarified that in the following sentence (P23 lines 366-367):

"The positive zonal wind anomalies in the tropical US could be related to the expansion of the polar vortex area due to its weakening, as discussed in Section 3.1.1."

16. L. 405-406: "increase of Arctic ozone is partly due to weaker westerlies, and thus more in-mixing of ozone rich air into the polar region". I disagree. First, as I said earlier, models don't show any consistent sign of projected changes in the strength of Arctic polar vortex under climate change (Karpechko et al., 2022), with some

showing jet strengthening, some showing jet weakening, and some not showing any change at all (this is seen also in your Fig. 11). Second, any changes in Arctic polar vortex would really only matter in winter (and maybe late autumn and early spring). What determines the year-round polar ozone increase under higher CO2 is strengthening of the BDC, and the resulting enhanced transport of ozone rich air from the production region (tropics) to mid and higher latitudes, plus the overall increase in O3 in mid/upper stratosphere from GHG-induced cooling. Please change.

Response: Thanks for the suggestion.

We have modified the sentence as follows (P26 lines 411-414):

"In the lower stratosphere, there is a decrease of ozone dominated by stronger upwelling, while in the middle and high latitudes, the ozone anomalies are positive, because of the combination of increased transport by BDC and overall higher ozone abundance due to cooling from CO2. Additionally, the weakening of westerlies also leads to more in-mixing of ozone-rich air into the polar region during winter."

17. L. 407. Please say this is true for the multi-model mean, and that individual models can show both positive, negative or near zero changes.

Response: Thanks for the suggestion.

We have modified the sentence as follows (P26 lines 415-416):

"In the multi-model mean sense, the total column ozone response is negligible in the tropics because of the cancellation between decreases in the lower stratosphere and increases in the upper stratosphere."

18. L. 409. “which is related to the different response of zonal wind in the models”. As above, the main driver of these differences is different response of BDC in these models, not zonal wind (although zonal wind response would obviously have some influence too, but it will be smaller, especially in the Artcic, than BDC)

Response: Thanks for pointing it out!

We have modified the sentence as follows (P26 lines 416-418):

“Total column ozone increases at high latitudes, but with a larger inter-model discrepancy compared to the tropics, which is related to the differences in the response of residual ozone transport in the models and, to some extent, uncertainty in the polar vortex response.”

19. L. 418-420. Again, I disagree with this sentence as currently written, as it implies that the models project weakening of the polar vortex under increased CO2, which is not true. What the results show is that the inclusion of ozone feedback leads to a more easterly response of the stratospheric polar vortex in both hemispheres. Please correct.

Response: Thanks for pointing it out!

We have modified the sentence as follows (P27 lines 426-429):

“These temperature changes cause the weakening of the stratospheric polar vortex during boreal winter, with this signal extending to the troposphere. Compared to the model uncertainty in the total response of polar vortex to increased CO2，the models are more consistent in terms of the sign of the response.”

20. L. 428 “it might worth” -> “it highlights the need for”. It might worth is way too weak given the whole paper demonstrates why is it so important to include ozone.

Response: Thanks for the suggestion. We have revised accordingly.

21. L. 433. “and weaker westerlies in polar region”. Please delete as this not true (as stated above).

Response: Thanks for the suggestion. We have revised accordingly.

22. L. 444: might be worth adding “direct” to “radiative effect of ozone response”

Response: Thanks for the suggestion. We have revised accordingly.

23. Figure B2 – swap panel order, JJA should come before SON

Response: Thanks for the suggestion. We have revised accordingly.