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Comment on acp-2022-397

Anonymous Referee #2

Referee comment on "Effects of Arctic ozone on the stratospheric spring onset and its surface impact" by Marina Friedel et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-397-RC2, 2022

Effects of Arctic ozone on the stratospheric spring onset and its

surface response

By Friedel et al , ACP

Friedel et al investigate the connection between stratospheric ozone anomalies, the final warming or breakdown of the stratospheric polar vortex, and subsequent surface impacts. The key novelty of this work is that the authors compare simulations in which the radiative scheme reads in vs. ignores daily variability driven by the dynamics of each particular winter, and hence are able to isolate key feedbacks between ozone and dynamics. These simulations are performed for two different models, which enhances the robustness of their conclusions

The foundations of a paper that could be published in ACP are clearly present, and two of the three subsections in the results section are generally convincing. The last is still incomplete however, as described below. However, this last subsection can be improved with additional analysis of already existing simulations, and hence the required revisions should be relatively straightforward to perform. After these are addressed this paper should be publishable.

Major comments:

- The authors pose the question “2) Is there a significant influence of ozone on the surface response to FSWs?;” on line 67, but I don’t think section 3.2 answers this question fully. Section 3.1 convincingly demonstrates that FSWs are indeed modified by ozone, however this conclusion is not reflected in the methodology the authors then use in section 3.2.

Section 3.1 demonstrates that the CLIM experiments simulate a narrower PDF of dynamical variability in the polar vortex, with a narrower distribution of FSW dates. Hence, by selecting the top 25% and bottom 25% of ozone anomalies, and then studying the surface impacts, the authors are baking in a larger dynamical stratospheric perturbation in INT-3D than in the CLIM runs, and hence it is obvious (at least to me) that the surface impacts would be larger in INT-3D than in CLIM (e.g. Harari et al 2019) with the present methodology.

In order to isolate an ozone impact on surface climate, the methodology should be different. In addition to (or instead of) the current Figures 4 and 5, can the authors try compositing years with ozone anomalies of, say, between +20 to +40 DU vs. -20 to -40DU in both CLIM and INT-3D, and then study whether the difference in surface response between the high and low ozone years depends on how ozone is treated? This would more carefully isolate the role of ozone anomalies for surface impacts, and isolate whether the surface impact is via ozone affecting dynamics vs. ozone affecting tropospheric processes directly. That is, does a given strengthed ozone anomaly lead to the same surface impact regardless of whether ozone is interactive, or is the interactive ozone crucial?

2. The discussion section should include a more thorough comparison of the results from this paper to those of Friedel et al 2022 in Nature Geo. Specifically, it is perplexing (at least to this reviewer) that the NatureGeo paper found that low ozone has a surface impact, while the present paper finds low ozone has little surface impact when viewed through the lens of final warmings (lines 265 to 271 and figure 5). As best as I can tell the identical simulations are analyzed in both, and the authorship list is essentially the same as well. Does that imply that low ozone has a surface impact but FSW distorts this impact somehow? The authors need to help the reader sort out this conundrum.

Minor comments:

- There are a few recent papers showing that include interannual or intraseasonal ozone variability in a model helps improve forecast skill for the Southern Hemisphere (Oh et al 2022, Hendon et al 2020). I realize this study is focused on the NH, however these papers should be included and discussed.
- Line 70 "Finally"-> "Next" (this isn't the final item yet)
- Line 300 "In summary" is an odd way to begin a sentence before the results are actually shown. Maybe instead, "Briefly, we will demonstrate that …"
- Line 352 What about the upper stratosphere, especially in WACCM? Why is the radiative heating anomaly opposite? More generally, it would be nice if the authors could show all terms in the TEM thermodynamic budget in order to understand better how the differences arise. However the paper is publishable even without such additional analysis.

Harari, Ohad, Chaim I. Garfinkel, Shlomi Ziskin Ziv, Olaf Morgenstern, Guang Zeng, Simone Tilmes, Douglas Kinnison et al. "Influence of Arctic stratospheric ozone on surface climate in CCMI models." *Atmospheric Chemistry and Physics* 19, no. 14 (2019): 9253-9268.

Hendon, H. H., Eâ□□P. Lim, and S. Abhik. "Impact of interannual ozone variations on the downward coupling of the 2002 Southern Hemisphere stratospheric warming." *Journal of Geophysical Research: Atmospheres* 125, no. 16 (2020): e2020JD032952.

Oh J., S-W Son, J. Choi, E-P. Lim, C I. Garfinkel, H. Hendon, Y. Kim, H-S. Kang, Impact of Stratospheric Ozone on the Subseasonal Prediction in the Southern Hemisphere Spring, Progress in Earth and Planetary Science, doi: 10.1186/s40645-022-00485-4.