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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The effect of interactive ozone chemistry on weak and strong stratospheric polar vortex events" *by* Jessica Oehrlein et al.

Anonymous Referee #2

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General Comments

This paper investigates differences in mid-winter sudden stratospheric warmings (SSWs), strong polar vortex events (SPVs), and March SSWs for timeslice simulations run with and without interactive chemistry. They find significant differences when interactive chemistry is included for mid-winter SSWs. Overall the study is clearly written and within the scope of ACP. I think the mechanisms for the differences they are seeing could be better explained, but in general I recommend the paper for publication if my comments can be addressed.

Specific Comments

Line 16: I'd be careful about the word "induce" here (maybe instead: "associated with").

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For example, Ivy et al. 2017 states that causality is difficult to determine, as ozone could just be a proxy for dynamical effects.

Line 18: greater interannual variability of what? Also, in general it's a little tricky in these first few sentences of the introduction to understand if the focus is on the role of man-made ozone depletion or on the role of ozone extremes in general (regardless of the presence of CFCs).

Line 21-22: Particularly for the NH, where it's rarely cold enough for PSCs to form, what is the relative role of heterogeneous chemistry versus decreased mixing with mid-latitude air? I would expect mixing (or lack of it) to play a significant role.

Line 62: I'm not sure what is meant by "via its interannual variation".

Line 80: It would be good to be more explicit about what else is prescribed; given that you are using year-2000 conditions, for example, how are CFCs dealt with? (are they the same fixed value in each simulation? Also, do you think you need to be in a time period of peak CFCs to see the results that you get here? If true, that seems like an important point to make, especially as ozone is now slowly recovering.

Line 81: Could some of the differences seen in the results be due to using zonally-symmetric prescribed ozone, since during SSWs in particular the flow is very asymmetric? Could this also help explain why there is a larger difference in interactive vs prescribed for SSWs compared to SPVs (where the flow is very zonal)?

Line 92-93: Might also mention that surface impacts in March could be different than in mid-winter, as the NAO itself is changing in spatial structure from its winter to summer state.

Line 99: Is there any sensitivity to your results if you use a different threshold, such as 43 m/s? If you use a non-absolute metric like NAM, can you better examine differences in Dec-Feb versus March SPVs? It would be nice to be able to compare to Ivy et al. results, for example.

Line 105, and throughout: when you use the two-sided two-sample t-test, what are the sample sizes used (is it just the number of events)? If it's the latter, this seems valid for, e.g., Figure 3. But I wonder about Figure 1 in particular where you are showing daily data; in this case, what is the sample size for CHEM vs NOCHEM and does it take into account auto-correlation of the daily time series?

Line 113-115: So, what is the mechanism for the difference using year 2000 or year 1850 conditions? Is it just that you need CFC-driven ozone depletion to affect the basic state of the polar vortex?

Line 119: this difference seems extremely small given the large internal variability of the polar stratosphere zonal winds so I'm surprised that it's significant; how is significance assessed? Does it take into account auto-correlation of daily time series?

Line 123: Given that the climatology is different in these two simulations, I wonder if it's worth also checking the statistics of a non-absolute metric like the NAM, to see if the variance/PDF of the NAM changes.

Line 125: You might mention in this paragraph how well the overall (Nov-Mar) SSW frequency compares with reanalysis, as the Dec-Feb value seems low (75/200 = 0.38).

Line 132-133: I wonder also if this is because the CP07 definition is somewhat problematic with regards to the arbitrary April 30 cutoff for SSWs. Events in March essentially only have to pass a 10-day return to westerlies criteria (before April 30) to be counted as an SSW; when stricter criterion is used to separate these events from the final warming, some of them drop out (Butler and Gerber 2018).

Line 170, 187: Is it possible to demonstrate that there is an increase in dynamical forcing? This is mentioned several times as the mechanism but it's not shown that this is true.

Line 175-180: Can you explain further the vertical/temporal structure in the shortwave heating differences (Figure 5 and Figure 6)? Is it related to the vertical structure of

ozone after the SSW?

Line 198-199: so is it weaker SSWs (which doesn't seem true, see next comment below) than in DJF or weaker stratosphere-troposphere coupling or both? This seems easy enough to check. Another possibility is that the surface response in spring is just not as strong/significant as the NAO evolves to a summer state.

Line 215: True, but it's worth noting that the magnitude of the dynamical heating for March SSWs and DJF SSWs is about the same (at least on visual comparison). Does this imply that the March SSWs are not dynamically weaker than the DJF SSWs? (this seems to be stated on line 256). The minimum zonal wind reversal in Figure 7 and Figure 11 looks roughly equivalent, but the DJF SSWs start from a stronger westerly climatology. Again, it might be nice to show a dynamical metric here as well.

Line 246-247: I'm not sure it was ever explained clearly why the interactive chemistry simulation has a stronger basic state of the polar vortex.

Appendix A: just wanted to comment that this is a useful recipe.

Technical Corrections

Line 36: change "stratosphere" to "polar stratosphere"

Line 206: I'd remove "As for the surface plots,"

Line 242: change to "maximum absolute anomaly"

Line 263: change to "are important for accurately capturing the response"

Figure 1: can you make tick marks match up with the start of months, as it's difficult to infer where, for example, January starts.

Figure 2, 3, 8: Use CHEM and NOCHEM for consistency with text, rather than WACCM and SC-WACCM

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