Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-558-RC2, 2016

Atmospheric Chemistry and Physics Discussions

Interactive comment on "How Does Downward Planetary Wave Coupling Affect Polar Stratospheric Ozone in the Arctic Winter Stratosphere?" *by* Sandro W. Lubis et al.

Anonymous Referee #3

Received and published: 8 September 2016

This manuscript investigates the effect of downward planetary wave coupling (DWC) events on Northern Hemisphere polar stratospheric ozone in MERRA-2 reanalysis data and WACCM simulations. The authors analyze the DWC modulation of O3 via a direct effect through changes in the residual circulation and transport, and an indirect effect, through changes in polar temperature and chemistry; and show that the direct effect dominates in explaining the changes in O3 during DWC events. Finally, the authors analyze the seasonal impact of DWC events (reflective Winters).

I find this study interesting and adequate for publication in ACP after some minor revisions. In particular, reorganization of Figures, improvement of the comparison of model and reanalysis results, and better description of the results linking them to the direct

and indirect effects as discussed in the Introduction. Detailed comments are listed below.

L. 104 and L. 108. Please explain a bit more what is the correcting tendency term.

L. 113. The period is not so clear as in line 91 it says 1980-2013 and in line 94, it says 1978 to 2004. I understand it is 1980-2013 but it would be better to clarify.

L. 135. Please add a bit more detail on the simulation of volcanic eruptions in CESM1 (WACCM), see for instance Marsh et al. (2013).

L. 155. Define total . Is this the climatology plus anomaly?

L. 157. How the results compare with DJF? I wonder if for the upward events, the coupling is larger in DJF than in JFM.

L. 164. It would be good to add a sentence on the comparison of the frequency of events, which is actually pretty similar between the reanalysis and the model.

L. 170. Can you please explain briefly the Monte Carlo test? , so that the reader does not neccesarily need to check the references?

L. 187. I notice Fig.S1c and d are the same as Fig.1a and d. In addition, I consider the results on v*T* and the divergence of the EP flux are important enough to be in the main figures (not in the supplementary material). Please include those panels in Fig.1 and then remove Fig.S1 from the supplementary material.

L. 198. Which levels are the authors referring to? For each day the gray areas in Fig. 1a and 1b?

L. 211-212. I don't see this transition in Fig. 2 a. I see the change from positive (day -5) to negative (day 0) but both maximum and minimum are at the same altitude (around 10hPa), so I don't see the change from the upper stratosphere to the lower stratosphere.

L. 220-223. Again, here changes in ozone tendency due to dynamics are discussed between the midlower stratosphere and the mid-upper stratosphere. I don′t see that .

L. 225-226.' . . . is evidente in the upper stratosphere'. This is actually only true in the days before the DWC.

L. 228. '. . .are relatively small. . .' They are actually not significant except for those around day -7. I think the description related to Fig. 2c needs to be improved.

L. 231 and L. 248 (and description of Figure 3c and 7c). L. 231 says that the same conclusion can be Dracn by assessing the instantaneous corrleation between for upward and downward heat flux events. I don′t see this conclusion from the 3 panels in Fig. 3. I think it is obvious that whatever relationship between w* and O3 is going to be associated to the dynamical term in equation [2] and not with the chemistry effects (which are related to production and loss). Am I missing something? So I do not see the point in showing panel c in Figures 3 and 7. I would keep these figures with 2 panels each.

L. 259 and others. I don′t fully understand what the authors mean by ′reversible or irreversible ′throughout the life cycle. Can you explain in hte manuscripts what are the consequences of having a reversible or irreversible impact? Reversible means that even though the impact is e.g. negative, it can become positive in the future? Please explain.

L. 264-265. I am not sure this sentence is right. I think it would be right if the time integration of ozone over the life cycle for DWC was negative , so it would balance the positive during upward events. But because Fig. 4 shows a time integration of ozone over the life cycle close to 0 for DWC and positive for upward events, I thikn what it means is maybe to 'minimize' or ' decrease' the increase in ozone, but not to 'prevent'.

L. 289. There are quite large differences in the values of Fig. 5c and 5d compared to 1c and 1d, with larger values in the model compared to MERRA. These differences are

not mentioned in the text. Please discuss them.

L. 325-334. Discussion of Fig. 8. I find interesting the differences in the evolution of total column ozone tendency the days previous to day 0 (significant blue lines in the figures), values about 1 DU/day in the model versus 5 in MERRA-2. Please discuss these differences and the possible reasons for them in the text.

L. 333. Again, I think 'prevent' is not the best Word here.

L. 343. How is m computed?

L. 345. Is sigma the sigma for JFM or which one?

L. 358. I see this tilt from 500hPa to about 100hPa but not up to the middle stratosphere.

L. 394 and discussion of Figure 12. I think it would help to add contour labels to the colors in the plots. It seems to me that the Dynamical and chemical terms cancel each other at the polar latitudes in Fig. 12b and c and 12e and f. Also the green contours mentioned in the caption seem black. Maybe better just to draw them in black.

Regarding Fig. 12, I wonder how symmetric or linear the response is between REF and ABS winters, otherwise it′s hard to know if the negative signal in Fig. 12a comes from positive anomalies in ABS or negative anomalies in REF. Can the authors discuss how the individual signals (ABS and REF) are to make sure the description of the differences make sense?

L. 400, should it be 'in the upper polar stratosphere? Also, L. 401 talks about the signal at 10hPa but neither fig. 12a nor 12 d show significant signal at 10hPa. Please focus the description on the significant signals.

Section 5. Conclusions. I think the first 4 points could be combined. My understanding is that the direct effect described in the Introduction is the one related to tranport and w*, while the indirect effect is that associated with the chemistry and their dependency

on temperature. If this is correct, then it would make more sense to arrange the first four conlsusions putting together these results on w* on one hand , and the results on chemistry on the other. I miss the link between the direct and indirect effect discussed in the introdution with the actual results of the paper.

L. 445. Shouldn′t be a positive divergence anomaly drawn in panel a of Figure 14, analogous to the negative anomaly in EP flux divergence in panel b?

L. 471. I think also a better understanding on stratospheric conditions , right? As it was shown here that the wave geometry in the stratosphere matters.

L. 481. Figures 1a and 1b should be Figures A1a and A1b.

L. 493. Figures A1c.

Figures: Please indicate in Fig captions 1 to 4 that those are with MERRA2 data.

Figure 9. Add in the caption which line is which (shaded or line plot).

Figure 10. What is the author referring with wave geometry in the caption of Figure 10?

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