

Interactive comment on “PSCs initiated by mountain waves in a global chemistry-climate model: A missing piece in fully modelling polar stratospheric ozone depletion” by Andrew Orr et al.

Anonymous Referee #2

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Summary:

Orr et al. implement a mountain-wave parameterisation scheme within the UM-UKCA GCM, in its chemistry-climate mode. They use a 30-year run (perpetual 2000) to investigate the regional (over the Antarctic Peninsula) effects on PSC formation throughout the winter by quantifying the wave-induced negative temperature perturbations and evaluating against AIRS satellite and Rothera radiosondes. The authors demonstrate that inclusion of the parameterisation scheme enables substantially more PSC formation, especially for the ice class, whose formation potential is particularly sensitive to

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changes in temperature at these relatively northerly latitudes. Orr et al. then investigate the Antarctic-wide effects of inclusion of their parameterisation scheme and show the differences to the total column ozone distribution during October. The authors demonstrate the value of inclusion of this parameterisation in the UM-UKCA in their final sections (Sec 3.5 and 3.6), which quantify changes in NAT surface area density and the ClONO₂ + HCl flux (Fig 10) and the differences in October monthly mean column ozone, pressure, and temperature (Fig 11).

I have only a few minor comments (and a few technical points) for this manuscript and I recommend its publication once the authors have considered the below points.

Minor Comments:

Line 31, and at other locations throughout the manuscript: You use the phrase ‘ice frost point is rarely exceeded’ here. But really, you mean that temperatures rarely fall below the ice frost point temperature (without the additional wave-induced cooling phase). I suggest you rewrite these phrases throughout the manuscript to make this clear, and avoid the phrase ‘rarely exceeded’.

Line 222: Comments that the lowest temperatures (around -6K) are ‘perhaps the region of the distribution that is critical for decreasing below the threshold for PSC formation’. This would probably only be true early in the season and at the end, when synoptically the temperatures are warm. On the other hand, in mid-winter, you would be more likely to only need a small negative perturbation to form (ice) PSC. Relatedly, Figures 2 & 3 indicate that very few waves have large negative perturbations, but that is not of course saying these large amplitudes are unimportant especially at season start and end – perhaps this point could be made too.

Line 225: Comparison of parameterised perturbation and Rothera perturbations. A clear agreement. However, all observations are only seeing part of the wave spectrum, and in particular radiosondes are preferentially observing inertia-gravity waves. Moffat-Griffen et al. (JGR 2011, doi 10.1029/2010JD015349) concluded that winter & spring

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radiosonde observations of stratospheric waves at Rothera may also be in part due to non-orographic sources (e.g. vortex edge). You mention in the text that AIRS includes orographic & non-orographic wave sources. It seems to me that you should note that the Rothera radiosondes likely do so too.

Line 232: A 'hot-spot' within the Antarctic Peninsula 'hot-spot'?

Line 245: You write that the lower bound of the T-Tice distribution is around 0K in the control case, but it seems about -2K or even -3K to me (black line in Figure 5b). Please check. Maybe a better way (more quantitative way) of comparing is to say at what temperature the e.g. 1% limit is at?

Line 332: See comment from line 222 above.

Technical Comments:

Lines 26 & 27: I don't think 'AIRS-observations' and 'radiosonde-observations' need hyphens

Line 69: 'typically have horizontal wavelengths'

Line 112 & following: Subscript the '3' and '2' in HNO₃, H₂O

Line 136: suggest rewording to 'at pressure heights around 850 hPa'

Line 139: I think the reference for ERA5 is Hersbach et al, QJRM 2020, doi:10.1002/qj.3803

Line 139 & 140: You use 'shown' and 'not shown' in the same sentence, please reword

Line 236: Sentence seems incomplete.

Line 272 'high-altitude', not 'high-elevation'

Line 340. Phrase 'only during October (and to a lesser degree September)' doesn't make sense. Reword.

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