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Atmospheric Chemistry and Physics
Discussions

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.

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Author Comment

Reviewer #1

We are grateful for the Reviewers insightful comments. We are pleased that they found the results meaningful, the paper clearly written, and the figures precise and readable. We note that the Reviewer has only suggested some minor remarks, which we have answered below.

(1) line 57: The earliest paper stating the impact of mesoscale mountain waves on the PSC formation is by Ken Carslaw et al. and is worth mentioning here: Carslaw, Ken et al. (1998). Increased stratospheric ozone depletion due to mountain-induced atmospheric waves. Nature, v.391, 675-678 (1998). 391. 10.1038/35589.

Reply: This change has been made and we have added the Carslaw et al. (1998) reference.

(2) Comment - line 107-109: A very supporting paper about the blocking is the early GRL publication by Julio Bacmeister. I think, this contribution was the origin of all considerations using blocking heights in parametrizations. A paper also worth citing, especially, as it considers the same geographical region:

Bacmeister, J. et al., 1990: ER-2 mountain wave encounter over Antarctica: Evidence for blocking, GRL, https://doi.org/10.1029/GL017i001p00081

Reply: This suggestion has been followed. The description of the parameterisation scheme has been revised to include the text: 'The scheme also includes the effects of low-level flow blocking (Bacmeister et al., 1990), such that the initial wave amplitude is set equal to the "effective" mountain height . . ..'

(3) Comment - line 139: The Hersbach et al. ERA5 paper is now online published at the QJ web site: https://rmets.onlinelibrary.wiley.com/doi/10.1002/qj.3803

Reply: This change has been made and we have added the Hersbach et al. (2020) reference.

(4) Comment - line 147: replace "km" by "km2" twice

Reply: This change has not been made. The original description of the AIRS specification supplied by NASA (https://airs.jpl.nasa.gov/mission/instrument/specs/) refers to e.g. 41 × 21.4 km, so we have not implemented the suggestion to replace 'km' with 'km2'.

(5) Comment - line 154: Hoffmann with double "nn" at the end

Reply: This change has been made. There were a number of occasions where Hoffmann was wrongly spelt, i.e. Hoffman. These have all been corrected.

(6) Comment - line 224, 235: One dominant characteristics of the mountain wave propagation from the Antarctic peninsula is the frequent occurrence of oblique ray paths. This process might lead to a horizontal shift of mountain wave activity away from the actual sources towards the Drake Passage. I believe, the difference between the AIRS results and the simple, linear mountain wave parametrization as shown in Figure 4 can be easily explained by this process without referring to non-orographic sources. If you hesitate to investigate this aspect in more detail I would at least suggest adding suitable references that point to these well-known processes:

Preusse, P. et al., 2002: Space-based measurements of stratospheric mountain waves by CRISTA, 1. Sensitivity, analysis method, and a case study. J. Geophys. Res., 107(D23), 8178, doi:10.1029/2001JD000699.

Sato, K. et al. (2012). Gravity wave characteristics in the southern hemisphere revealed by a high-resolution middle-atmosphere general circulation model. Journal of the Atmospheric Sciences,69(4), 1378-1396. doi: 10.1175/JAS-D-11-0101.1

There are more papers that also document the oblique mountain wave propagation into the polar night jet that are based on recent results from the DEEPWAVE campaign, e.g.

Ehard, B., et al (2017). Horizontal propagation of large-amplitude mountain waves into the polar night jet. Journal of Geophysical Research: Atmospheres, 122(3), 1423-1436. doi: 10.1002/2016JD025621

Jiang, Q., et al. (2019). Stratospheric trailing gravity waves from New Zealand. Journal of the Atmospheric Sciences, 76(6), 1565-1586. doi: 10.1175/JAS-D-18-0290.1

Reply: This suggestion has been followed. The explanation for the disparity in Figure 4 in the revised manuscript has been revised to include the text '. . . (b) the (vertical-only

propagation) parameterisation scheme does not represent the horizontal propagation of waves (Preusse et al., 2002; Sato et al., 2012), which could be potentially important here and result in a horizontal shift of mountain wave activity away from the source region.'

(7) Comment - line 279: I would add " ... towards longer vertical wavelengths" before the parenthesis"(Wu ....)". Additionally, the shear calculation by Eq. 2 neglects recent results by the DEEPWAVE campaign about the existence of the "valve" layer:

Kruse, C. G. et al. 2016: The Midlatitude Lower-Stratospheric Mountain Wave "Valve Layer". J. Atmos. Sci., 73, 5081–5100, https://doi.org/10.1175/JAS-D-16-0173.1.

Indeed, how the waves propagate into the stratosphere (vertically as well as horizontally) depends largely and critically on the wind profile as nicely documented by

Bramberger, M., et al. (2017). Does Strong tropospheric forcing cause large-amplitude mesospheric gravity waves? A DEEPWAVE case study. Journal of Geophysical Research: Atmospheres, 122, 11,422–11,443. https://doi.org/10.1002/2017JD027371

Reply: These suggestions have been included. We have made two changes to the revised manuscript. Firstly, the suggested text and Bramberger et al citation have been added, and the manuscript now states 'causing wave refraction towards longer vertical wavelengths (Wu and Eckermann, 2008; Bramberger et al., 2017).' Secondly, the following sentence has been added to explain the limitations of Eq. 2: 'Note that this approach would not represent the impact of more local variations in α that also influence vertical propagation (Kruse et al., 2016).'

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