

## ***Interactive comment on “Interannual variability of the gravity wave drag – vertical coupling and possible climate links” by Petr Sacha et al.***

**Anonymous Referee #1**

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### General Comments

In this new study, Sacha et al. discuss variability in orographic gravity wave drag (OGWD) based on a 30-year Canadian Middle Atmosphere Model (CMAM) simulation. The CMAM-sd simulation used here has specified dynamics, by nudging it to the ERA-Interim reanalysis. The authors assess the correlations between the OGWD and climate indices such as the North Atlantic Oscillation (NAO), the Quasi Biennial Oscillation (QBO), and the El Niño Southern Oscillation (ENSO) based on multiple linear regression.

Overall, the study appears to be carefully conducted and the results seem to be sound and robust. The paper is mostly well written and concise.

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Before the paper can be accepted for publication in ESD, I would have two general comments, which perhaps could be addressed by expanding the introduction and discussion sections of the paper a bit:

1) The study is focusing on orographic gravity wave drag, which is directly provided by the OGWD parametrization of the CMAM model. However, non-orographic sources such as convection or jet and storm sources are another important source of gravity wave drag. It is pointed out that the OGWD parametrization of the CMAM-sd simulation was "tuned" to obtain more realistic circulation patterns. Does this "tuning" overemphasize the role of orographic gravity waves compared with non-orographic sources? If non-orographic sources are neglected (as I understand), how does this affect the analysis presented in this paper?

2) It would be good if this work could be put better into the context of related work. There is a number of studies discussing global climatologies of gravity wave activity in the stratosphere from observations and models, e.g.:

Gong, J., Wu, D. L., and Eckermann, S. D.: Gravity wave variances and propagation derived from AIRS radiances, *Atmos. Chem. Phys.*, 12, 1701–1720, <https://doi.org/10.5194/acp-12-1701-2012>, 2012.

Geller, M.A., M.J. Alexander, P.T. Love, J. Bacmeister, M. Ern, A. Hertzog, E. Manzini, P. Preusse, K. Sato, A.A. Scaife, and T. Zhou, 2013: A Comparison between Gravity Wave Momentum Fluxes in Observations and Climate Models. *J. Climate*, 26, 6383–6405, <https://doi.org/10.1175/JCLI-D-12-00545.1>

Hoffmann, L., X. Xue, and M. J. Alexander (2013), A global view of stratospheric gravity wave hotspots located with Atmospheric Infrared Sounder observations, *J. Geophys. Res. Atmos.*, 118, 416–434, doi:10.1029/2012JD018658.

Geller et al. (2013) showed that there are notable differences between momentum flux estimates from different models and observations. It might be good to provide more

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evidence that the results from the CMAM-sd simulation are realistic. Perhaps it might be helpful to also show gravity wave momentum flux distributions from the simulation, as this can be more easily compared to other studies.

#### Specific Comments

- p1, l7: Be more specific about what is meant by "lower tropospheric behaviour"?
- p1, l8-9: What is meant by "have a modified impact"? Do you mean "have a modifying impact on" or simply "have impact on"?
- p2, l2-5: This first sentence is quite long. The references to Plougonven and Zhang (2014) and Alexander et al. (2009) look a bit specific considering the broad statements made here.
- p3, l5-7: How strong was the nudging? Does the CMAM-sd simulation closely follow the ERA-Interim winds and temperatures? Are the results of this study sensitive to the specific details/parameters of the nudging procedure?
- p3, l21-27: It might be worthwhile to briefly repeat/recap the definitions of the different indices?
- p5, l6-7: Is this exception of the Antarctic Peninsula due to its SW-NE orientation?
- p7, l8-11: The degree of correlation seems to decrease with height? Is this due to the stratospheric background affecting the propagation of the waves?
- p7, l22-25: Reading this, I was wondering how well the CMAM-sd simulation itself captures the different climatological patterns (NAO, SO, QBO)?
- p8, l31-32: This also triggers the question of how well the CMAM-sd simulation reflects reality?
- Fig. 1: Recent studies showed that there might be notable gravity wave activity over remote islands in the Southern Ocean, e.g., South Georgia or Kerguelen Islands. Is

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the CMAM-sd simulation capable of capturing this?

Alexander, M. J., and A. W. Grimsdell (2013), Seasonal cycle of orographic gravity wave occurrence above small islands in the Southern Hemisphere: Implications for effects on the general circulation, *J. Geophys. Res. Atmos.*, 118, 11,589–11,599, doi:10.1002/2013JD020526.

Hoffmann, L., Grimsdell, A. W., and Alexander, M. J.: Stratospheric gravity waves at Southern Hemisphere orographic hotspots: 2003–2014 AIRS/Aqua observations, *Atmos. Chem. Phys.*, 16, 9381-9397, <https://doi.org/10.5194/acp-16-9381-2016>, 2016.

#### Technical Corrections

- The paper should be revised to fix English language issues.
- Check that acronyms are properly introduced at first occurrence (e.g. IGW or SSW).

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Interactive comment on *Earth Syst. Dynam. Discuss.*, <https://doi.org/10.5194/esd-2018-1>, 2018.

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