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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A study of the dynamical characteristics of inertia–gravity waves in the Antarctic mesosphere combining the PANSY radar and a non-hydrostatic general circulation model" *by* Ryosuke Shibuya and Kaoru Sato

Anonymous Referee #3

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The study presented is a very interesting characterization of long-period GWs in the SH polar mesosphere. The tools used are inspired by the radar findings focusing mostly on ground-based frequency. This is also the quantity directly accessible in model data whereas intrinsic frequency would require a full wave-analysis (with associated uncertainties) beforehand. Given that this is the first study setting these kind of oscillations into a hemispheric context, I am for this paper satisfied with the directly accessible quantities. Follow-up studies e.g. including intrinsic frequency and ray-tracing can and should be made, but in my eyes they are beyond the scope of this paper. In general,

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Discussion paper

the paper is well written and the figures of good quality. There are a number of minor comments (including suggestions for references) and technical corrections given below.

Minor comments and technical corrections:

Start your abstract with one sentence about the general purpose of this study.

P2L11 than those from the radar observations.

P3L20 physically-based

P3L24 to show that this is a general problem quote also one Korean paper, e.g. Choi et al., JAS, 2011

P4L5 also McLandress et al., JAS, 2012 and Garcia et al., JAS 2017

P4L20 It is not the mesosphere which is the harsh environment. Revert order Due to the harsh environment in the Antarctic it is still challenging there to perform observations of the mesosphere.

P5L19 Mesosphere data for CRISTA would be Preusse et al., JASTP, 2006 (omit Preusse et al 1999, and Eckermann and Preusse 1999)

P5L20 There is a new reference for climatological data of GWMF in Ern et al., ESSD, 2018. The inferred GW climatology is freely available.

P5L24 Observational filter: Alexander, GRL, 1998 is the first, Alexander et al, QJRMS, 2010 the most comprehensive discussion of the observational filter. The observational filter for MLS is first introduced by Wu and Waters, GRL, 1996 and the one for infrared limb sounders (CRISTA, SABER) by Preusse et al., JGR, 2002. Anyway, if you want one reference, probably Alexander et al, QJRMS, 2010 is best.

P7L8 There are comparisons between modeled and observed GWs in the MLT in the frame of DeepWave, e.g. Eckermann et al., JAS, 2016. Please be more precise what is really not existing.

P7L28 2 sentences: Pansy is capable ... when ... . This high resolution is unique in ....

P8L1 Just as a comment (no change requested): Provided you can resolve spatial and temporal scales related to non-hydrostatic waves. Otherwise the feature also may cause problems.

P9L18 that we use (present tense for the innvestigation, cf. L21)

P10L9 which is

P10L15 resolution

P11L5 In order to adequately simulate ... (omit finely)

P11L20 As a result the ... or Accordingly

P13L4 gaps -> jumps ?

F2 line-of-sight or perhaps here an abbreviation LOS might be easier to read, actually

P13L15 () to the end of sentence

P13L22 Really? A very crude check for the order of magnitude. The overall residence time in the MLT is half a year, hemsiphere-to-hemisphere, which corresponds to 1m/s. In addition, you are close to the pole, south of the acceleration region which should lessen the value. Please give an expected value with reference for comparison.

P14L6 Using again a simplified argumentation: wavelengths there are 10km, so you are some 7 cycles above ground (likely more because of varying wind speeds). This means that you need to know your background atmosphere to an accuracy better than 5-10%. Deviating phases seem not that unexpected after all.

P14L12 this method -> the method

P14L13 Start with introducing that you use a variational approach and that you illustrate

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this first with a well-matching example.

P14L15/16 Please clarify the difference between the two L

P16L1 shorter -> longer

P16L3 and shift the energy from shorter, unresolved scales to the shortest resolved scales. A reference for that, though in different context, would be Lane and Knievel, JAS, 2005. I have seen things like this also occur in other models. For instance, the high-resolution WACCM and also some Canadian simulations show very pronounced ring-like convective GWs over the whole tropics. In principle such features are known from storms like the Hector (Darwin, Australia), but the scales in case of the model are several 100km and for that we have no experimental evidence. Still, why waves with wavelengths longer than 1000km should be overestimated, remains a bit puzzling. Anyway, that you see similar waves in radar and model is encouraging for the further investigation of the waves.

F5 slightly increase the distance between the two panels

P16L10 gap -> jump

P16LL20 Which data are assimilated into MERRA? Likely there is very little guidance by observations above 50km, so you cannot use MERRA as truth either (though it is some confirmation that both show the same basic features), i.e. you know that you have the general features right, but which of the two actually comes closer to reality in the details you do not know.

P17L19 Linear gravity wave theory is based on the ansatz [equation]

P17L20 relationship -> relation

P18L2 since you have both I think being precise would be better: vertical flux of horizontal momentum and horizontal flux ...

Please check that all variables(frequency omega, intrinsic frequency \hat{\omega} are defined in the text.

P19L5 and superpressure balloon and satellite observations.

F7 contour lines versus coast lines The coast lines are very weak the contour lines are bold. By that it is very difficult to make out the geographic features. In particular for the lower three rows contour lines do not make sense as the structures are much too fine scale to follow them uphill and hence get additional quantitive information. Better omit them. It may also be worthwhile not to use a contour filling algorithm but plot for each grid point a little area with the color code of that value (tile-like).

P19L17 also Hertog et al 2008

P20LL2 Please use a few lines to explain, why this is consistent (consistent with a westward-poleward and westward-equatorward horizontal flux of horizontal momentum at low / high latitudes) This is qualitative, though.

4.2 Spectral analysis

F8 to one day and half a day

P21L3 -5/3 is steeper than -1

What puzzled/intrigued me in these figures: I think it would be good to give a general guidance: At the left edge one finds signatures of what apparently are planetary waves (Rossby waves). On he right side there is the GW branch. However, GWs may have ground-based frequencies lower than f because of Doppler shift, i.e. peaks on the left side of the red line might still be associated with GWs. A few sentences for orientation would probably be helpful for the reader.

P24L14 also Kalisch et al., JGR, 2014

P25L5 topographic -> orographic ; also follow-on sentences: topographies -> orography

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P25L20 Geller et al makes kind of the destinction that models resolving scales substantially smaller than 1000km are what we now call GW allowing models, but that are definitely not small-scale GWs. Maybeone could use a terminology like <100km small scale (not contained here) 100km<Lh<1000km mesoscale and Lh>1000km large scale

P29L13 stops -> stalls

P28LL1 If you approach a critical level than as you say the group velocities tend to zero. What kind of simultaneously happens is that the vertical wavelength decreases, that the ratio of kinetic and potential energy shifts towards kinetic energy (rotational-part of the GW wind increases) and that the satuartion limit decreases (the saturation limit of GWMF is proportional to the third power of the vertical wavelength). In addition, knowing that the horizontal wavelength is very long, i.e. m»k, you can do a simple estimate for c_gh/c_gz. Assuming that k is changing its value much less than m, one can argue that the propagation would be more and more oblique as the critical level is approached.

I think all this is in favor of your argumentation of accumulating GWs from the north in a region where omega approaces f. The peak is much more evident in the wind than in the temperature and momentum flux spectra. The propagation direction would become very oblique (very horizontal) before the wave than stalls in that horizontal direction and would thus not be dissipated before it becomes visible in the spectra.

P30L18 I think that reads a bit wrong: It is the first simulation with that model but not the first long term simulation for this altitude range.

P31L4 Also, the or In addition, ... at the beginning of sentence

P31L11 Here in the summary clarify again: ... peaks at ground-based frequencies ...

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