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Interactive comment

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

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Reviewer #2,

The authors greatly appreciate the reviewer's critical reading of our manuscript and constructive comments. We have revised the manuscript as much as possible following the reviewer's comments. Responses to each comment are described in the following. The pdf version is also attached as the supplement pdf.

Response to major comments: NICAM validation: NICAM-derived gravity wave ampli-

Printer-friendly version

Discussion paper

tudes are found to be too large in comparison with PANSY (discussed at P15-16). The explanation you give at page 16 / line 2 is counterintuitive. Either you explain in depth how a diffusive process, which dissipates energy, leads to stronger waves, or you give another argument or hypothesis... May be related to this issue is the too-strong polar vortex in NICAM as shown in Figure 6b in comparison with MERRA (Figure 6a). Possibly, there are breaking too few gravity waves in the stratosphere which appear then too strong in the mesosphere? A good place for such a discussion could be the end of section 5 at page 30.

Rane and Knievel (2005, JAS) showed that gravity waves that were vertically propagating in simulations with coarse resolutions becomes vertically trapped in those with fine resolutions. A similar discussion was also given by Watanabe et al. (2015, Geosci. Model Dev.), although they focused on a vertical resolution in a numerical model. Thus, it is inferred that some of simulated gravity waves which propagated to the mesosphere in NICAM are trapped or breaking in lower altitudes in the actual atmosphere, leading to the overestimation of the wave energy in NICAM compared with the observation. The discussion has been added to the end of Section 5.

Flat vertical-velocity spectrum: Perhaps it could help the explanation of the flat vertical-velocity spectrum when you include dispersion relations. These imply that the vertical velocity is proportional to the frequency w _ nhat{nomega} / N b where b is the buoyancy. Consequently, its variance is proportional to nhat{nomega}ËĘ2. Given a buoyancy / temperature spectrum with an frequency exponent between -1 and -5/3, an exponent between 1 and 1/3 could be expected for the verical velocity spectrum.

Thank you very much for your fruitful comment. The quantitative discussion based on the linear theory of gravity waves has been added below the description of the spectral shape of P_w (ω) (P21, L.14-19).

3) Doppler shift: An important element of your study is the consideration of critical latitudes where the intrinsic frequency nhat{nomega} equals the Coriolis frequency f. Your

radar and model data are analysed, at the other hand, for the ground-based frequency nomega. The missing information on the intrinsic frequency is also critical for the identification in long-periodic and mid-periodic waves. One consequence is the population of lower-than-f frequencies by gravity waves which is seen in some figures. Although your physical interpretation is basically correct, the issue of Doppler shift deserves a more detailed discussion.

In Section 4, we have added notes that the analysis in this study is based on the ground-based frequency and not the intrinsic frequency (P22, L5-6). In addition, the volume of the discussion about the Doppler shift has been increased (P30, L3-23). In particular, we have mentioned the difference of the spectra between the meridional wind and the temperature as: “In addition, according to the dispersion relation of gravity waves, |k|/m becomes small at latitudes where ω ÌĆ$\sim$f. As a result, the ratio of the kinetic and potential energies shifts toward the kinetic energies, and then a parcel motion on the gravity waves becomes horizontal. Thus, it is suggested that the isolated peak at frequencies slightly smaller than the inertial frequency is more evident in the spectra of the meridional wind than that of the temperature, which is consistent with the result in Fig. 9.” This is also one of the consequences that gravity waves with frequencies of ω ÌĆ$\sim$f stalls poleward of a latitude where "ω" $\sim$ f.

Response to minor comments: 1) Arrangement of formulae: Please, introduce Doppler shift and dispersion relation earlier, for example right after equations (3) where nbar{nomega} appears first.

The equation about ω ÌĆ has been replaced right after the Eq. (3).

2) Notation of temperature spectrum as P_{tem} - why dont you use the more common P_{T}? But this is a matter of taste, your notation is mathematically correct.

The notation for the temperature spectrum has been changed to P_t (ω) (Section 4.2 and Fig. 8).

P9L11: For my taste, you do not need ", respectively," here. P9L12: Again, ", respectively," might be deleted. P10L9: "which IS a global" P10L24: targeted –> target P12L8: "one IS produced..." P12L10: "pertaining" –> "pertains" P12L17: Suggest to substitute the sentence "included. The vertical... zero." with "included, and thus have been set to zero." P14L13: You might delete "with a vertical phase velocity V_1" without loss of information. P15L19: The imaginary number "i" is twice too much in the argument of cosine. P14L21: You might delete "via the factor of 2.0 introduced on the right hand side of the equation" because if you are exactly on a phase line you have exactly A = a provided you sample enough waves. P17L3: I suggest to write "as strong" instead of "strongly" because the jets tilt equatorward in both datasets, more or less. P17L19: May be, you replace "that assumes.. form" with "as noted in the form" makes this long sentence slightly better to read. P17E2: The imagaginary number "i" is missing in the exponential function. P26L19: Please specify you mean the austral summer. Inhabitants of the Northern hemisphere could think of JJA when they read "summer"...

The sentences have been revised. We sincerely apologize for many careless mistakes and thank you very much for your pointing out.

P28L11: Please, give a proper reference for the WKB theory. In order to reduce the number of formulae I suggest not to use the frequency function nOmega because it is not used in any formulae.

The reference (Bu ÌĹhler and McIntyre, 2005) has been added.

P29L14: Please, add a "hat" to the frequency –> nhat{nomega}.

In this case, ω without hat is correct. This is because the poleward propagation of gravity waves stalls “at” a latitude where ω ÌĆ$\sim$f, which is “poleward of” a latitude where "ω" $\sim$ f. To clarify this point, the sentences have been revised (P30, L14-15).

P32L20: Please, change "tsutsumi" to "Tsutsumi". P34L23: The year of publication appears after the author and not at the end of the record, as with the others. P42L20:

The year of publication appears after the author and not at the end of the record, as with the others.

The sentences have been revised. Thank you very much for your pointing out such careless mistakes.

P51F6: There seems to be a minus sign in front of 30 _S at the lower axis of Fig. 6b which does not belong there. P57F12: Please add "Latitude [S]" to the lower axes. P58F13: Please, add an information on the height (25 km?) to the caption. P59F14: Please add "Period [h]" to the lower axes.

The figures and figure captions have been revised.

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-1023/acp-2018-1023-AC2-supplement.pdf

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