Reply to the referee comments (gmd-2014-183-referee-report-#.1) on the revised paper "Vertical resolution dependence of gravity wave momentum flux simulated by an atmospheric general circulation model."

Dear referee,

We would like to thank you for re-reviewing our revised paper. We apology that we had not fully incorporated your comments in the revision of paper, taking your extra time to point it out. We have revised the paper following your suggestions as well as those provided by another referee. In the following your individual comments are quoted and our responses follow on.

Best regards,
Shingo Watanabe

The authors have addressed all of my concerns with the exception of two, which need to be addressed in the manuscript before I recommend acceptance.

(1) The first concerns one of my general comments:
"The authors consider the possibility that the different initial conditions have resulted in changes in the evolution of the tropospheric circulation, but the figure they show to demonstrate that this does not impact on the stratospheric GWs (Figure 2) is highly qualitative. Is it possible that the tropospheric circulation (or perhaps the region of deep convection) has changed so that the generation of the longer GWs generated by the convection is different?"
which they authors replied with:
"Indeed, the tropospheric circulation and locations of convection differ in the simulations with different vertical resolution, which can be seen in Figure 2c and 2d for precipitation, and Figure 3a and 3b for instantaneous background wind fields. It is difficult to argue that the observed differences in GWs are not affected by those differences. However, we believe that the systematic and global reduction of GWMF with increasing vertical resolution (Figures 1 and 5) cannot solely be explained by differences in the tropospheric circulation and convection."
but appear to have made no changes to the paper itself. The authors must discuss this in the paper, not to me, the reviewer. Their answer clearly indicates

that they cannot say with any certainty that the differences in the GWs in the two simulations are not due to differences in the troposphere. They must at least point that out in the paper by adding a statement like "Although differences in the tropospheric circulation in these two runs could account for the differences in the GWs, we believe this not the case...." and then provide a reason why they think this is so.

P.6 L. 8-10 - We have revised the text to add a sentence:
Although differences in the tropospheric circulation and locations of convection in these two runs could account for the differences in the GWMF, we believe that the systematic and global differences in the GWMF cannot solely be explained by them.

(2) My second point concerns their third comment:
"It was found that the longer vertical wavelength GWs observed in the summertime lower stratosphere were not excited well below 8 km. In this sense, it is difficult to say that GW excitation processes are similar in the runs with different vertical resolutions. Figure 4 (new) shows an example for orographic GWs. In that case phase structures of GWs in the troposphere are qualitatively similar to each other."
which was again in response to my general comment regarding differences in the tropospheric simulations resulting in differences in the upward propagating GWs. Again, their response ("it is difficult to say that ...") is very subjective and no change made to the paper. They need to add a statement in the paper to that effect, i.e. similar to what they need to say regarding my first point above.

P.6 L. 8-10 - We have revised the text to add a sub-sentence, 'Although ~ runs':
Although the tropospheric circulation, distribution of moist diabatic heating, and phase structures of GWs in the lower troposphere are not quite similar in the two runs, these circumstances may imply the existence of suppression effects of the thin GWs in the dz = 200 m run, which effectively suppress the high-frequency GWs with longer vertical wavelengths.

Reply to the referee comments (gmd-2014-183-referee-report-#.2) on the revised paper "Vertical resolution dependence of gravity wave momentum flux simulated by an atmospheric general circulation model."

Dear referee,

We would like to thank you for re-reviewing our revised paper. We have revised the paper following your suggestions as well as those provided by another referee. In the following your individual comments are quoted and our responses follow on.

Best regards,
Shingo Watanabe

Second review for 'Vertical resolution dependence of gravity wave momentum flux simulated by an atmospheric general circulation model'
by S Watanabe and co-authors.

The authors have addressed my concerns, and the addition of several subsections to discuss orographic waves and the latitudinal dependence of GWMF is very beneficial to the paper. I believe this makes the paper more complete and it now fully serves its role as a stimulating, concise paper describing an important and rather counter-intuitive result. I recommend publication, with very minor modifications.

Minor Points
For the figures: the vertical axis is generally pressure; for future publications, I would advise that the authors think of presenting altitude as the vertical axis. The difference between the wavelengths at different resolutions will probably be more apparent, and the extent of the atmospheric layers where significant differences arise will also appear clearer. For the present publication, it is fine to keep the figures as they are. I very much appreciated figure 5.

Thank you for your advice, which we promise to consider in our future papers.

p7 lines 18-20: rather than refer to details that are 'really hard to see' in the figure, please describe and explain, and indicate that the evidence for this is 'not shown'. In the present case, the evidence shown rather suggests that the parameterized turbulent mixing is not the more important process, but this is speculative.

The signature of turbulent mixing, i.e., Ri < 0.25, sometime appears, but our present feeling is that we cannot say if it would be a major mechanism or not. We have revised the text:
[One possible candidate of the suppression mechanisms is the *parameterized* turbulent diffusion, which is *not obviously seen in Figure 3 but* sometime induced by wave saturation of thin GWs.]

p8, line 1: 'below about 30 hPa': do the authors mean 'above about 30 hPa'?

Yes. Thank you. We have corrected the text.

p8, lines 5-6: the formulation 'not allowed to be shortened beyond the 2 km 5 limit' is confusing, please rephrase.

We have revised the text:
[On the other hand, *the minimum vertical wavelength of* orographic GWs in the dz = 1000 m run *is 2 km*, and *they* propagate higher than those seen in the dz = 200 m run.]

caption of Figure 2: the authors do not refer explicitly to panels c and d.

Thank you for pointing it out. We have added descriptions on those panels.

In the introduction or discussion, it may be useful to include a reference to the study of Lane and Knievel (2005), which revealed that the behavior of gravity waves as resolution is increased is not a straightforward monotonic behavior. The scales considered were not the same of course, but this publication serves as a useful cautionnary note to remind us that the behavior of GW may be complex as resolution is increased, with the interaction with the background flow (trapping in their case) playing an important role.

T.P. Lane and J.C. Knievel,

Some effects of model resolution on simulated gravity waves generated by deep, mesoscale convection, J. Atmos. Sci., 2005, 62, p3408-3419.

Thank you. This study is useful to us. We have incorporated that reference in the text P.7 L.31-:
[More statistical investigation are necessary to clarify the roles of thin GWs in the high-vertical resolution models. *One relevant study would be Lane and Knievel (2005), who investigated the vertical resolution dependence of convectively generated GWs by using a mesoscale model with much finer horizontal resolutions. Their study revealed that the behavior of gravity waves as resolution is increased is not a straightforward monotonic behavior*.]