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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Enhanced internal gravity wave activity and breaking over the Northeastern Pacific/Eastern Asian region" *by* P. Sacha et al.

Anonymous Referee #1

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General comment:

In their paper, the authors investigate a region in the Northeastern Pacific/Eastern Asia coastal region that stands out because of its anomalous annual cycle in temperature, geopotential height, ozone and zonal wind, as identified in the MERRA and JRA-55 reanalyses for the 1979-2013 time interval. It is suggested that this anomaly is caused by longitudinal variations of the residual circulation. To further support this theory, the authors investigate whether an anomaly of enhanced gravity wave activity and breaking could contribute to this circulation anomaly. For this purpose, four years (2007-2010) of GPS radio occultations of the FORMOSAT-3/COSMIC constellation of GPS receivers

are analyzed. Different from previous studies, the authors use relative density perturbations to derive gravity wave potential energies. This method is better than analyzing temperature fluctuations because density fluctuations are more directly related to fluctuations of the refractivity index, and fewer assumptions are required. The authors find that, indeed, gravity wave activity is enhanced in the region of interest. It is also found that atmospheric conditions and gravity wave amplitudes are favorable for gravity breaking. The anomalous gravity wave activity, reduced stability, and possibly gravity wave breaking in the region of interest could be an important contribution to the circulation anomaly.

Overall, the paper presents an interesting, nice and comprehensive overview of the different evidence that supports the existence of the circulation anomaly and gives possible explanations.

Publication in ACP is therefore recommended after addressing the few remaining minor and technical comments.

Main comments are:

(1) The time intervals of gravity wave analysis (2007-2010) and of the analysis of annual cycles in reanalysis data (1979-2013) are very different, and there is considerable interannual variability at high northern latitudes during autumn and winter. For consistency, it should therefore be checked whether the anomalies of the annual cycles are also found for the shorter time interval 2007-2010.

(2) Effects of the observational filter on the wave amplitudes should also be mentioned when discussing the possibility of below-threshold IGW breaking.

For details see the specific comments below.

Specific comments:

(1) p18289, l.9-13 shorter horizontal and shorter vertical wavelength with same amplitude as in other regions... This is not necessarily an effect of higher buoyancy fre-

quency. It should be mentioned that this effect could also be related to IGW sources or background winds.

(2) p18289, l.14-19: Having a look at Faber et al. (2013), I had the impression that the findings mentioned in your manuscript are supported for horizontal and vertical wavelength, as well as for momentum flux. For Epot, however, this is not so clear. During summer Epot seems to be about average, and during DJF2006/7 Epot over the region of interest is lower than over the Asian continent. Suggest to just omit Epot in p18289, l.18.

(3) p18296, l.11-13: About instability criteria... The probability of observing IGW at the exact time of breaking is not the only effect why IGW breaking could occur although criteria are below threshold. It should also be mentioned that the IGW wave amplitude of GPS RO will usually be low-biased due to the observational filter of the instrument. Therefore it should be self-understood that IGW breaking should happen, even if IGW amplitudes observed by GPS are below threshold.

A sensitivity function for squared amplitudes, applicable to limb observing geometries like GPS RO, is given, for example, in Trinh et al. (2015), their Fig.7b.

(Trinh, Q. T., Kalisch, S., Preusse, P., Chun, H.-Y., Eckermann, S. D., Ern, M., and Riese, M.: A comprehensive observational filter for satellite infrared limb sounding of gravity waves, Atmos. Meas. Tech., 8, 1491–1517, doi:10.5194/amt-8-1491-2015, 2015.)

(4) p18298, end of Sect.3.1: For consistency, it should be mentioned whether this climatological pattern (determined from the years 1979-2013) is also found for the four years (2007-2010) used for IGW analysis in Sect.3.2.

(5) p18306, around l.23: waves over the Himalayas / over the Andes This discussion addresses the question whether Epot is a good measure of the average IGW wave energy. This uncertainty, however, is not explicitly mentioned there, reference should

be made to the previous discussion related to Eq.(2) in Sect.2.

Technical comments:

(1) p18286, l.5: internal gravity wave -> internal gravity wave (IGW)

(2) p18286, l.16: phenomena -> phenomenon

(3) p18288, l.19: E_p s -> E_p

(4) p18290, l.1: temperature bias. -> temperature variance bias.

(5) p18291, l.26: ration -> ratio

(6) p18293, l.13: extend -> extent

(7) p18296, l.18: start new paragraph after "...in a region."

(8) p18297, l.18/19: the area of interest the area of interest -> the area of interest

(9) p18297, l.22: a eastward -> an eastward

(10) p18298, l.8: mean -> the mean

(11) p18303, l.6: lover -> lower

(12) p18314, l.23: journal in reference Marquardt and Healy is missing

(13) caption of Fig.7: not only secondary maxima are shown, suggested rewording: selected (secondary) sigma maxima -> primary and selected secondary (i.e., higher order) sigma maxima

(14) similar problem in caption of Fig.S13

(15) caption of Fig.8: in (left) -> (left)

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 18285, 2015.