Reply to Reviewer#2

We greatly appreciate your helpful suggestions, which have great benefit for improving the presentation of this manuscript. We have tried our best to revise our manuscript according to your valuable and helpful comments. In what follows, we shall detail the changes we have made to the manuscript.

Review

This work investigated the anomalous tidal amplitudes in association with the anomaly in QBO. The causes of the tidal anomaly, contributed to anomalous ozone transport and gravity wave filtering, are well explained and demonstrated through observations and modeling. The findings provide new insights of a coupling process between lower and middle/upper atmosphere on the interannual scale. This manuscript is of high scientific merit and high presentation quality.

There is one issue that I like to bring to the authors' attention, which is the calculation of GW forcing on tides. The current method, comparing the phase offset between the tidal tendency and GW forcing to determine whether GW forcing is enhancing or decreasing tidal amplitude is appropriate only when the GW forcing is small relative to the frequency of the tides (1/24 hr). When the GW forcing is large, it changes the resulting tides significantly, both in amplitude and phase. For example, adding a GW forcing that has 90 deg phase offset with a tide will not change the tide's amplitude but shift its phase. The resultant tide is then not in 90-deg phase offset with the GW forcing. If one uses the GW-modified tide to compare with the GW forcing, one would find that the GW forcing should change the tidal amplitude (because they are not in 90-deg phase offset) which is incorrect. This issue was described in McLandres (2002) and a correction was described in Liu et al. (2013). Please consider using equation (10) in that paper to obtain a more accurate GW forcing effect on tides.

Response: We are grateful for your valuable comment and suggestion. After using the method in the paper by Liu et al. (2013), the more accurate GW forcing effect on tides is obtained. Thank you for providing us with this methodology, which helped us to obtain reliable tidal response results as shown in Figure R1.

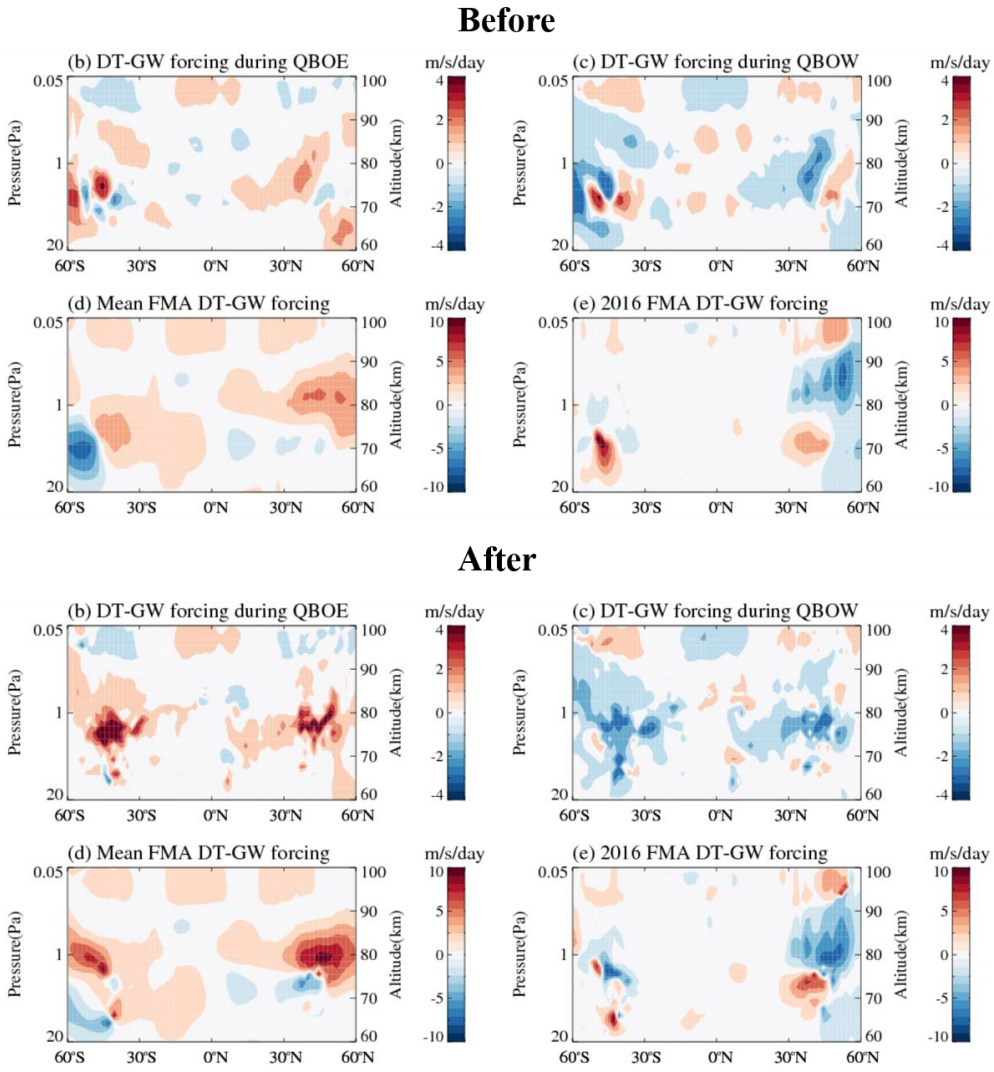

Figure R4: Comparison of GW forcing effect on tides before and after the correction.

Minor:

While figures 2,3,5 show meridional tidal amplitudes, Fig.4 shows correlation with zonal diurnal tidal amplitude. Why switching between zonal and meridional amplitudes?

Response: Thank you for your underlining this deficiency. In the original manuscript, Figures 2,3,5 only show meridional tidal amplitudes because the response of QBO to tidal amplitudes in meridional wind component are stronger than in zonal wind component. According to your comment, the zonal tidal amplitudes are shown in Figures A1 and A2 in the revised manuscript.

322: 'mounts' -> 'amounts' ?

Response: Thank you for your suggestion. This inaccuracy is corrected in the revised manuscript.

323: 'relatively increases' -> 'increases' ('relatively' can be associated with 'larger' as used in line 322 but not with 'increase')

Response: Changed.

324,325: why give units in the parenthesis? They are not associated with any numbers.

Response: Thank you for your valuable comment. The ozone data used in this study is

mass mixing ratio (kg/kg) rather than volume mixing ratio (mol/mol). If you suggests that it is not necessary to show the units, we will remove them in the revised manuscript.

622: (A2) is missing Omega as a coefficient (after taking derivative of A1).

Response: Thank you for your underlining this deficiency. This mistake is corrected in the revised manuscript.

625: The meanings of GW_forcing and GW_drag are not described clearly. It seems GW_drag is the diurnal amplitude of GW forcing, but it's not stated.

Response: Thank you for your helpful comment. In this study, GW_drag is the amplitude of the diurnal variation of the GW forcing on the background zonal wind. GW_forcing is the effects of GW forcing on the diurnal tide. According to your comment, the meanings of GW_forcing and GW_drag have been further explained in the revised manuscript.

References

McLandress, C. (2002), The seasonal variation of the propagating diurnal tide in the mesosphere and lower thermosphere. Part I: The role of gravity waves and planetary waves, *J. Atmos. Sci.*, *59*, 893-906,

Liu, A. Z., X. Lu, S. J. Franke (2013), Diurnal variation of gravity wave momentum flux and its forcing on the diurnal tide, *J. Geophys. Res. Atmos.*, *118*, 1668-1678, doi:10.1029/2012JD018653.