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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Momentum forcing of the QBO by equatorial waves in recent reanalyses" *by* Y.-H. Kim and H.-Y. Chun

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The authors thank the referee #3 for his/her valuable comments. In the final revised paper, we will clarify what the referee pointed out. The responses to each of the referee's comments are listed below.

Comment 1: *End of Sec 2: In Fig 1 you calculate EP fluxes for ERA-I at model-levels resolution. As I understand it, based on http://old.ecmwf.int/products/data/technical/model_levels/model_def_60.html, the ERA-I model levels are equivalent to pressure levels from 73 hPa upward. This would correspond to 18.3 km altitude for a log-pressure scale height of 7 km, just below the 19 km lower cutoff of your Fig 1. Based*

on this, it should be ok to apply the TEM equations for pressure coordinates to the ERA-I data on model levels, and I presume this is what you've done. But, please add a sentence or two here to clarify for the reader that this is the case. Or, if I've got it wrong, please explain what has been done.

Response: As the referee presumed, we used the TEM equations for pressure coordinates to the ERA-I_ml. We will clarify this in the revised paper.

Comment 2: *Temporal resolution of the data: if I recall correctly, MERRA data is available at 3-hourly frequency and the other reanalyses at 6-hourly frequency. I'm not sure about that, but at any rate, please state in Sec 2 what is the temporal resolution of the data. If it differs between reanalyses, did you use the same frequency for all of them when doing the spectral analysis? If not, does it affect the results?*

Response: As the referee mentioned, MERRA data is available at 3-hourly frequency, and we used the MERRA data at this frequency. We also calculated the wave forcing estimates using 6-hourly subsampled MERRA data, and confirmed that the difference between the estimates from 3- and 6-hourly data is negligible. We will include this information in the revised paper.

Comment 3: *MRG wave phase speeds: in Fig 1, I was surprised to see westward forcing by MRG waves occurring in both westerly shear (E-W transition phase) and easterly shear (W-E transition phase). E.g. in mid-2007, westward forcing is occurring simultaneously in the lower (18-21 km) easterly shear zone and the upper (28-35 km) westerly shear zone. Is this due to there being MRG waves of both westward and eastward phase speeds included in the MRG group? From Fig 9b,c of KC15 I see that both westward and eastward propagating MRG waves give westward forcing at the equator (at least, in HadGEM2), within the 5S-5N band that your Fig 1 covers. In that case, I presume the westward forcing in easterly shear would be due to westward*

propagating MRG waves, and the westward forcing in westerly shear would be due to eastward propagating MRG waves. Is this the correct interpretation? It would be helpful to add a brief comment to clarify this (or whatever is the explanation, if I've got it wrong) in the discussion of Fig 1, perhaps at line 21 on p 6.

Response: Figure 1 in this comment paper shows the westward (W) and eastward (E) propagating MRG wave forcing averaged over 5°N–5°S. As the referee mentioned, the forcing in the easterly shear is by the W-MRG wave. However, the W-MRG wave forcing dominates the E-MRG wave forcing in the westerly shear also. It implies that the W-MRG wave exists above the easterly jet core. The existence of the W-MRG wave above the easterly QBO wind was also reported by Maury and Lott (2014) using ERA-I. One possible explanation for this is the stratospheric generation of the W-MRG wave (Maury and Lott, 2014). Figure 2 shows the latitude–height cross section of the E–P flux and its divergence by the W-MRG wave in June 2007. It is shown in Fig. 2 that the E–P flux from the W-MRG wave is small around the easterly jet core (around z $\sim$ 28 km), and it suddenly increases above the jet core (cf. Fig. 9c in KC15). This may support the hypothesis of the stratospheric generation of W-MRG wave, which merits further study in the future. We will discuss this point in the revised paper.

Technical corrections: *p2, 2: suggest: "momentum forcing by equatorial waves to the QBO" –> "momentum forcing of the QBO by equatorial waves" p2, 5: suggest move "(3–11 m s^{-1} $month^{-1}$)" to right after "all equatorial wave modes", so as to be clear that this is the net forcing by all equatorial wave modes during the 30 hPa E-to-W transition. P2, 12: "easterly-to-westerly phase" –> "easterly-to-westerly transition phase" p3, 5: convections –> convection p6, 26: suggest add "at altitudes below 30 km" following "phases of the QBO". Strong Rossby wave forcing in Fig 1 does coincide with easterly onsets at very high altitudes. p12, 18-19: "The increase in forcing from other waves at 10 hPa is not large (see also Fig. 1).": I find this sentence a little unclear, suggest rephrase as: "For other waves, the forcing at 10 hPa not much larger than that at 30*

hPa (see also Fig. 1)." P12, 24-25: "due to the less constraints on" –> "due to fewer constraints acting on"

Response to the Technical corrections: We accept all of the corrections referee mentioned above. The corrections will be applied in the revised paper.

Reference:

Maury, P., and Lott, F.: On the presence of equatorial waves in the lower stratosphere of a general circulation model, Atmos. Phys. Chem., 14, 1869–1880, doi:10.5194/acp-14-1869-2014, 2014.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 5175, 2015.

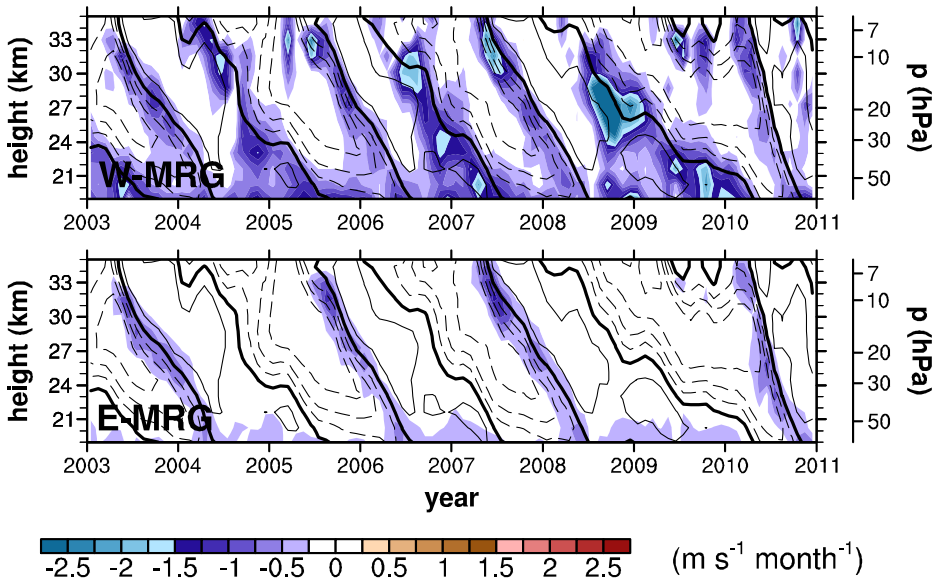

Fig. 1. Zonal momentum forcing by the (upper) westward and (lower) eastward propagating MRG waves over 5N–5S, obtained using the ERA-I model-level data (shading).

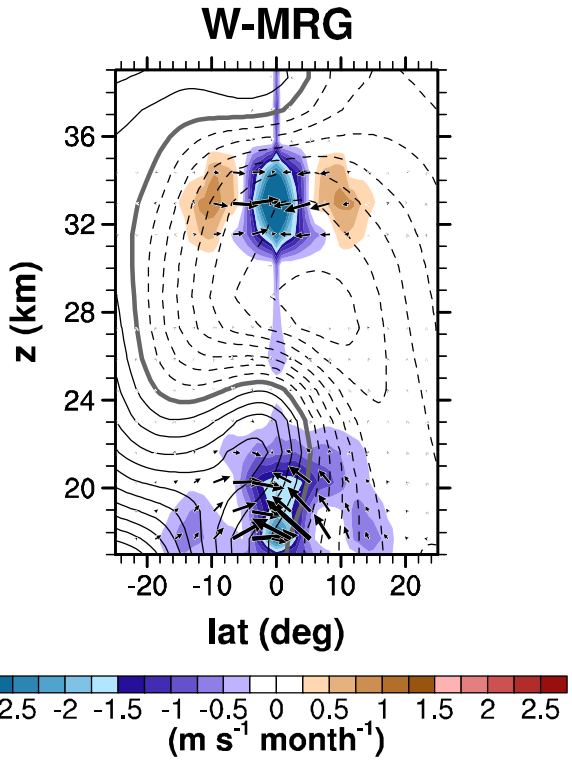

Fig. 2. E–P flux (arrow) and its divergence forcing (shading) for the W-MRG wave from the ERA-I model-level data in June 2007. The E–P flux is multiplied by exp(z/2H) for display purposes (H = 6.6 km).