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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Wave fluxes of equatorial Kelvin waves and QBO zonal wind forcing derived from SABER and ECMWF temperature space-time spectra" *by* M. Ern and P. Preusse

Anonymous Referee #2

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The paper is investigates the contribution of Kelvin waves to the dynamics of the QBO, based on data from SABER and the operational ECMWF analysis for a period of 5 years, covering a bit more than 2 QBO cycles. The paper is generally well structured. The English is sufficient, but would deserve some polishing by a native speaker. Overall this is an interesting paper, which should be published after minor modifications.

General comments

Please explain the major properties of the operational ECMWF system (model, assimilation system, and observing system) and its changes during the period of interest, i.e. from 2002 to 2006. Do such changes matter for your analysis?

After the discussion of Figure 9 vs. Fig 7 it is unclear why the unsmoothed SABER data are used as basis of the paper. The problem requiring the vertical smoothing could be discussed in the data section, before starting the proper discussion and comparison of the results of SABER and ECMWF (cf. specific comment for P.5650).

Maybe it is worth to have a separate section on these data issues before current section 2.2?

Uncertainties with respect to the vertical advection should be discussed more thoroughly. Westerly jets of the QBO sometimes remain nearly stationary near 70 hPa, and at other times end quickly. This is probably the result of changes in nearly equal, though opposite effects of vertical advection and Kelvin wave – mean flow interaction. Even though the vertical velocity is small near 70 hPa, it may play an important role for the westerly jets of the QBO. This should be discussed more in depth in the discussion on the uncertainties in vertical advection. What are the resulting uncertainties for the necessary wave forcing and hence the role of Kelvin waves (cf. specific comment for P.5645, L.28)?

Estimated momentum fluxes for Kelvin waves in SABER data may also include uncertainties related to the temperature retrieval. How big are these uncertainties? (This point is related also to your discussion of Fig.9)

Please allow for fairly large figures. Details are otherwise very hard to see in printed versions.

Specific comments

Abstract P.5624, L.2 The QBO is rather a 'dynamical phenomenon of the tropical middle atmosphere' than a 'process in the dynamics of the middle atmosphere in the tropics'

P.5624, L.21 (and later) 'the later parts of the period of the westerly wind shear' is difficult to understand. Please discribe this in a better way. Maybe you can refer to the zonal wind velocity, within the westerly shear, at which the Kelvin wave – mean flow

interaction typically explains the highest fraction of the necessary forcing.

Introduction P.5625, L.17 'about 15 km to 40 km': 15 km is generally too low for the QBO. Though QBO related signals can be detected in U, there wouldn't be a closed jet of westely wind around the globe. The lower end of the QBO is generally close to 18 km.

P.5626, L.23/24 '... of single measurements station ...' → '... of single station measurements ...'

P.5627, L.3 '... of the whole atmosphere ...' is a bit exaggerated. The QBO is certainly an important mode of internal variability of the middle atmosphere, and the QBO is important for chemistry and transport in the whole middle atmosphere. But the tropospheric climate or weather can be simulated "reasonably well" in models that do not simulate the QBO.

P.5630, L.14 '... due to its lower buoyancy frequency N.' → '... due to the lower buoyancy frequency N there.'

P.5634, L.12, Eq.8 and later The authors should not use the letter "F" for force and flux. Please choose two different letters, or at least different styles.

P.5636, L.25 It should be mentioned that the QBO wind profile in the equatorial stratosphere exposes at any time zonal winds and vertical wind shears of zonal winds that will filter Kelvin waves of low phase speeds.

P.5641, L.4 Fig.4 shows some cases, where the momentum flux increases with height, e.g. in October 2003 or August 2005 in the analysis for SABER, or October 2005 for ECMWF. What happens here? How should this be interpreted?

P.5644, L16 onwards How do assimilation increments enter your momentum equation Eq.6? Can they project on the waves you are interested in? What is the effect of these increments on your estimates for the advection terms, especially the vertical advection?

P.5645, L.28 If the minimum equatorial vertical velocity of the ECMWF analysis near 21 km were twice the correct vertical velocity, what would be the implications for your analysis? Please include this uncertainty in your discussion. The vertical velocity near 20 km seems to be quite important in the maintenance of the westerly jets at low levels. When the westerly jets remain nearly stationary close to 70 hPa, before its end, there exists an approximate balance between dissipating Kelvin waves, maintaining the westerly jet, and upward advection, hindering its downward progression. Uncertainty in vertical wind should be important for the estimation of the Kelvin wave forcing of the QBO at these levels.

P.5647, beginning Fig.7 seems to show colours for negative values. Please refer to the later discussion on this issue.

P.5650 Here you discuss Figure 9 and it seems you have good reason to assume that the vertical smoothing is necessary, and these results seem of better quality than those of Fig.7. If you think that this smoothing procedure is necessary to deal with the vertical oscillation in SABER data, I would suggest that you discuss this problem in the data section and focus the analysis thereafter on the smoothed SABER data. Alternatively you should explain better why most of the discussion is based on the unsmoothed SABER data, though this section suggests that there are problems.

P.5653, L.9, Fig.10 Please show zonal wind contour lines in Fig.10, as in Figures 3-9.

P.5653, L.22 'During QBO east periods ...' What do you mean, easterly or eastward wind? Which is the reference level? (Generally you find all phases of the QBO in the equatorial stratosphere.)

P.5653, Section 4.3 Here you should also consider uncertainties in the advection terms, especially in the vertical advection terms near 70 hPa, where sometimes westerly jets are maintained for an extended period, and at other times terminate quickly.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 5623, 2009.