Atmos. Chem. Phys. Discuss., 9, C3596–C3601, 2009
www.atmos-chem-phys-discuss.net/9/C3596/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Properties of the average distribution of equatorial Kelvin waves investigated by ray tracing techniques" *by* M. Ern et al.

M. Ern et al.

m.ern@fz-juelich.de

Received and published: 5 August 2009

The authors would like to thank Anonymous Referee #1 for the very helpful comments!

In the following we will address to the Reviewer's General and Specific Comments. The detailed discussion will be given in the revised manuscript.

Best regards,
Manfred Ern

General Comments:

General Comment #1: The authors should mention how much are the differences between the pseudo zonal wind spectra and original ECMWF zonal wind spectra!

Different from the ECMWF wind spectra ECMWF temperature spectra can directly be compared with SABER measurements (see Ern et al., 2008). Good agreement is found between the measurements and the model data. Therefore we concluded that ECMWF temperature spectra are very reliable, and in our study we therefore calculate Kelvin wave pseudo zonal wind spectra form both SABER and ECMWF temperature spectra. This means that our study is more or less based on measurements and validated model data.

Original ECMWF zonal wind spectra and pseudo zonal wind spectra derived from temperature spectra look almost the same in the altitude range of about 20–35 km. At altitudes above and below there are however some discrepancies. This can best be seen by comparing altitude-time cross sections of original ECMWF Kelvin wave zonal wind variances with the pseudo zonal wind variances presented in Fig. 4. (We will also show an altitude-time cross section for the original zonal wind variances in the revised manuscript.) Zonal wind variances and pseudo zonal wind variances both integrated over the same Kelvin wave band are almost the same in the altitude range 20–35 km. At higher altitudes the original ECMWF Kelvin wave zonal wind variances are however high biased with respect to the pseudo zonal wind variances (this can be over a factor of 2 at 45 km altitude). This hints at some imperfections of the model winds at higher altitudes where few (if any) observational wind data enter the ECMWF operational analyses.

Also at altitudes below the tropopause the original ECMWF Kelvin wave zonal wind variances are much higher than the Kelvin wave pseudo zonal wind variances derived from the temperature spectra. This is likely due to non-Kelvin wave contributions adding additional "noise" in the wind spectra so that we cannot separate the Kelvin wave signal from the overall noise. In the temperature spectra Kelvin waves are much more dominant than in the wind spectra. Therefore the Kelvin wave signal can be extracted much easier, and the calculation of pseudo zonal wind spectra should be favored.

Another reason why we chose to use ECMWF temperature spectra is that sometimes ECMWF zonal wind spectra contain artifacts. For example, sometimes there are enhanced spectral contributions at zonal wavenumber one, extending over all frequencies from 0–1 cpd. This effect is not seen in the temperature spectra.

Therefore we think that the original ECMWF zonal wind spectra are less reliable than the temperature spectra. In addition, the Kelvin wave signal can be better extracted from the temperature spectra (or pseudo wind spectra) than directly from the wind spectra.

Some explanation will be added in Sect. 2.3 in the revised manuscript.

General Comment #2: Westward propagating waves with eastward ground based phase speed could bias the Kelvin wave signal. Some explanations are needed in this paper!

This is another reason why we chose to calculate Kelvin wave pseudo zonal wind amplitudes from the temperature spectra: Since in the tropics Kelvin waves are the by far dominant wave mode in temperatures we expect only little bias. Westward propagating equatorial Rossby or Rossby-gravity waves have only small temperature amplitudes compared to Kelvin waves (for example, see Tindall et al. (2006a,b), or Ern et al. (2008)). We also use symmetric space-time spectra, which should strongly suppress anti-symmetric wave modes like Rossby-gravity waves and n=2 equatorial

Rossby waves.

In addition, at low altitudes the amplitudes of westward propagating waves with eastward ground based phase speed should be considerably lower than the amplitudes of the "standard" equatorial waves in the wave bands between 8 and 90 m equivalent depth, characteristic for the troposphere. For example, in Wheeler and Kiladis (1999) there are only little indications for those kind of waves. This could however change with altitude, but since the ground based phase speed of those waves should be likely low, it can be expected that part of them dissipates already at low altitudes.

Some explanation will be added in Sect. 2.3 in the revised manuscript.

General Comment #3: The authors set source levels with different altitudes and consider only vertical wave propagation. However, zonally non-uniform background zonal wind in the troposphere must affect the distribution of stratospheric Kelvin waves. This should be discussed or mentioned somewhere in the paper!

Yes, indeed! This point has only briefly been mentioned at the end of Sect. 2 and some more discussion should be given there.

Of course, there can be zonal variations in the global distribution of Kelvin waves. This can be seen not only in the troposphere, but also in the stratosphere (e.g., Wheeler and Kiladis (1999), Alexander et al. (2008), or Ern et al. (2008)). Also non-vertical propagation of Kelvin waves can play an important role (e.g., Suzuki and Shiotani (2008) or Kawatani et al. (2009)). These kind of effects are neglected in our study since we are only interested in the average distribution of Kelvin waves, its basic properties, as well as the dominant mechanisms. Of course, zonal variations in the source distribution or propagation conditions provided by the background atmosphere could introduce some bias in our results. These effects will however be likely small compared to the effects we are interested in and will not affect the key findings of our study.

Specific Comments:

Specific Comment #1: P13046: Equation 3 is not needed!

We will remove Eq. 3 and rewrite this part of Sect. 2.

Specific comment #2: P13048: Kelvin waves have meridional wind component in a sheared background wind. (see Imamura, JAS, 2006)

Yes indeed, this is another effect that is neglected in our study. But again, this will be a small effect not affecting our key findings. We will also state this at the end of Sect. 2 in the revised manuscript.

Specific comment #3: P13054 (Fig. 3): Why is the high bias above 45 km altitude removed if the source altitude is chosen higher than 20 km?

This is likely due to the fact that the higher the launch altitude is chosen the more "noise" in the launch spectra caused by non-Kelvin wave contributions is removed. If such "noise" is located at higher phase speeds it can grow considerably with altitude without being dissipated in our simulation. This can cause biases at higher altitudes. For launch altitudes above 20 km this "noise" is so small that the bias at high altitudes vanishes.

This will be mentioned in the revised manuscript in Sect. 3.5.

Specific comment #4: Figs. 10–15: Nearly same figures are shown continuously, but the authors did not mention much about these figures in the text. It is better to select some specific figures.

We will check whether some of the figures should be removed.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 13039, 2009.