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Wave fluxes of equatorial Kelvin waves and QBO zonal wind forcing derived from SABER and ECMWF temperature space-time spectra

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Abstract. The quasi-biennial oscillation (QBO) of the zonal mean zonal wind is a dynamical phenomenon of the tropical middle atmosphere. Influences of the QBO can even be found at mid and high latitudes. It is widely accepted that the phase descent of alternating tropical easterlies and westerlies is driven by atmospheric waves of both global scale (equatorial wave modes like Kelvin, equatorial Rossby, Rossby-gravity, or inertia-gravity waves), as well as mesoscale gravity waves. However, the relative distribution of the different types of waves to the forcing of the QBO winds is highly uncertain. This is the case because until recently there were no high resolution long-term global measurements in the stratosphere. In our study we estimate Kelvin wave momentum flux and the contribution of zonal wind forcing by Kelvin waves based on space-time spectra determined from both Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) temperature measurements as well as temperatures from European Centre for Medium-Range Weather Forecasts (ECMWF) operational analyses. Peak values of total Kelvin wave zonal wind forcing found are about 0.2 m/s/day. There is good agreement between SABER and ECMWF results. Altitude-time cross sections are shown and the results are compared to the total wave forcing required to balance the background atmosphere. Sometimes Kelvin wave forcing is sufficient to explain almost the whole total wave forcing required for the momentum balance during the transition from QBO easterly to westerly winds. This is especially the case during the periods of strong westerly wind shear when the zonal wind is between −20 and 10 m/s at the equator in the altitude range 20 to 35 km. During other parts of the phases of strong westerly wind shear, however, the contribution of Kelvin waves can be comparably low and the missing wave forcing, which is often attributed to mesoscale gravity waves or intermediate scale waves, can be the by far dominant contribution of the QBO forcing. It is also found that seasonal variations of Kelvin wave accelerations could play an important role for the maintenance of the QBO westerly wind jets in the lower stratosphere.

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