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Satellite observations of the QBO wave driving by Kelvin waves and gravity waves

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The quasi-biennial oscillation (QBO) of the zonal wind in the tropical stratosphere is an important process in atmospheric dynamics influencing a wide range of altitudes and latitudes. Effects of the QBO are found also in the mesosphere and in the extra-tropics. The QBO even has influence on the surface weather and climate, for example during winter in the northern hemisphere at midlatitudes. Still, climate models have large difficulties in reproducing a realistic QBO. One reason for this deficiency are uncertainties in the wave driving by planetary waves and, in particular, gravity waves that are usually too small-scale to be resolved in global models.
Different global equatorial wave modes (e.g., Kelvin waves) have been identified by longitude-time 2D spectral analysis in Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) satellite temperature data, as well as ECMWF temperatures. We find good agreement between SABER satellite observations and ECMWF wave variances in both QBO-related temporal variations and their magnitude. Slow phase speed waves are strongly modulated by the QBO, higher phase speed waves are almost unaffected by the QBO, and ultra-fast equatorial waves can even reach the MLT region.
Momentum fluxes and zonal wind drag due to Kelvin waves are derived, and the relative contribution of Kelvin waves to the QBO wind reversal from westward to eastward wind is estimated to be about 30% of the total wave driving. This is in good agreement with the general assumption that gravity waves (GWs) are probably more important for the QBO driving than global-scale waves.
This is further supported by SABER and High Resolution Dynamics Limb Sounder (HIRDLS) satellite observations of gravity wave drag in the equatorial region. These observations are compared with the drag still missing in the ECMWF ERA Interim (ERAI) tropical momentum budget after considering zonal wind tendency, Coriolis force, advection terms and drag of resolved global-scale waves. This missing drag can be attributed to gravity waves that are not resolved by the model. Good qualitative agreement between satellite observations and ERAI gravity wave drag is found. During QBO eastward wind shear even the magnitudes of gravity wave drag are in good agreement. During QBO westward wind shear satellite observations of gravity wave drag are however considerably lower than ERAI. This might hint at uncertainties of the advection terms in the ERAI momentum budget.