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# The driving of the SAO by gravity waves derived from satellite data

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The dynamics in the tropical stratosphere and lower mesosphere is strongly influenced by an interplay of the quasi-biennial oscillation (QBO) and the semiannual oscillation (SAO) of the zonal wind. The tropical dynamics has significant influence on atmospheric dynamics over a large range of altitudes and latitudes. For example, QBO and SAO effects are seen in the MLT region, and there is a significant influence of the QBO on the surface weather and climate in the Northern Hemisphere during winter. Still, global models have large difficulties in reproducing a realistic QBO and SAO. One of the main reasons are uncertainties in the wave driving of these oscillations, in particular the driving by gravity waves (GWs) that are too small-scale to be resolved by the global models. Direct estimates of the GW driving of the QBO and SAO from global observations are still missing.
We derive GW temperature variances, GW momentum fluxes and GW drag from over three years of High Resolution Dynamics Limb Sounder (HIRDLS) satellite data. These observations are compared with the zonal wind tendencies and the drag that is still missing in the tropical momentum budget of the ECMWF ERA Interim (ERAI) reanalysis after considering zonal wind tendency, Coriolis force, advection terms and drag of resolved global-scale waves. In the stratopause region ERAI is no longer well-constrained by data assimilation. Nevertheless, the missing drag and its relative variations can be used as a proxy for GW drag. Qualitatively, we find good agreement between satellite observations and ERAI, however the missing drag in ERAI is likely too high by about a factor of two. Both HIRDLS satellite observations and ERAI support the general assumption that, due to the pre-filtering of the GW spectrum by the QBO in the stratosphere, GWs mainly contribute to the SAO momentum budget during SAO eastward wind shear. During SAO westward wind shear the GW contribution is usually smaller, and the wave driving is dominated by planetary waves, probably of extratropical origin. Still, we find indications in both satellite observations and ERAI that sometimes GW drag is also important in the tropical momentum budget during SAO westward wind shear.