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Mountain wave trapping on the tropopause inversion layer reveald by idealized numerical simulations and evaluated by mid-latitude radiosonde measurements

Sonja Gisinger, Andreas Dörnbrack, and Markus Rapp
Deutsches Zentrum für Luft- und Raumfahrt e.V., Institut für Physik der Atmosphäre, Weßling, Germany
(sonja.gisinger@dlr.de)

Background conditions of wind and static stability in Earth's atmosphere are rarely constant, neither in time nor in space, which affects the propagation of atmospheric gravity waves. For temperature inversions at the top of the boundary layer in the troposphere, it is known that mountain waves can be trapped on such inversions. For the middle atmosphere numerical experiments revealed e.g., reflection and trapping of gravity waves in the vicinity of a mesosphere inversion layer. At mid-latitudes the tropopause inversion layer (TIL) is a common feature in the transition region from tropospheric to stratospheric static stability conditions. In the framework of the Deep Propagating Gravity Wave Experiment (DEEPWAVE) changes of WRF simulated vertical energy fluxes of mountain waves across the tropopause over New Zealand were found to correlate with the TIL characteristics.

By conducting idealized numerical simulations with the EULAG model, we found that mountain waves are not only reflected at the TIL but can also be trapped on the TIL. Thereby, in the case of vertically constant wind, the strength of the inversion ($\Delta\theta$) must be twice as large as for inversions in the troposphere due to the larger stability of the stratosphere above. Moreover, the horizontal wavelength of waves trapped on an inversion decreases with increasing stability above the inversion. Therefore, the wave generating mountain must trigger the respective wave scales. This was achieved in our simulations for trapping on the TIL with a mountain width being half the size of the idealized mountain used for trapping on a boundary layer inversion. For the reflected mountain waves, we found that the amplitudes are larger, if an inversion is present at the tropopause compared to the case with just a direct jump from tropospheric to stratospheric stability. Further, we analysed the strength of the TIL of the real atmosphere over New Zealand during DEEPWAVE using radiosonde data. While the radiosonde measurements do not allow to directly observe the wave reflection and wave trapping on the TIL, they indicate conditions allowing for trapping and reflection, i.e., $\Delta\theta$ around or even larger 30 K. Relating mountain wave activity in the stratosphere from soundings to the strength of the TIL reveals an impact of the tropopause on the observed wave activity in the stratosphere albeit the effect of the tropospheric forcing dominates.