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Propagation of gravity waves across the tropopause

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The tropopause region is characterised by strong gradients in various atmospheric quantities that exhibit different properties in the troposphere compared to the stratosphere. The temperature lapse rate typically changes from negative to near-zero values resulting in a strong increase in stability. Accordingly, the buoyancy frequency often undergoes a jump at the tropopause. Analysis of radiosounding data also shows the existence of a strong inversion layer (tropopause inversion layer, TIL) characterised by a strong maximum in buoyancy frequency just above the tropopause, see e.g. Birner et al. (2002). Additionally, the magnitude of the vertical wind shear of the horizontal wind maximizes at the tropopause and the region also exhibits characteristical gradients of trace gases.

Vertically propagating gravity waves can be excited in the troposphere by several mechanisms, e.g. by flow over topography (e.g. Durran, 1990), by jets and fronts (for a recent review: Plougonven and Zhang, 1990) or by convection (e.g. Clark et al., 1986). When these waves enter the tropopause region, their properties can be changed drastically by the changing stratification and strong wind shear.

Within this work, the EULAG (Eulerian/semi-Lagrangian fluid solver, see e.g. Smolarkiewicz and Margolin, 1997) model is used to investigate the impact of the tropopause on vertically propagating gravity waves excited by flows over topography. The choice of topography (sine-shaped mountains, bell-shaped mountain) along with horizontal wind speed and tropospheric value of buoyancy frequency determine the spectrum of waves (horizontal and vertical wavelengths) that is excited in the tropsphere. In order to analyse how these spectra change for several topographies when a tropopause is present, we investigate different idealized cases in a two-dimensional domain. By varying the vertical profiles of buoyancy frequency (step-wise vs. continuos change, including TIL) and wind shear, the tropopause characteristics are changed and the impact on vertically propagating gravity waves, such as change in wavelength, partial reflection or wave trapping can be studied.

References

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