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Tropopause inversion layer formation and stratosphere-troposphere exchange during idealized baroclinic wave life cycle experiments

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Recent simulations of baroclinic wave life cycles revealed that the tropopause inversion layer (TIL), commonly situated just above the thermal tropopause, is evident in such experiments and emerges after the onset of wave breaking. Furthermore, bidirectional stratosphere-troposphere exchange (STE) occurs during this non-linear stage of the wave evolution and might be affected by the appearance of the TIL.
We study the evolution and the impact of the TIL on STE by using the COSMO model in an idealized mid-latitude channel geometry configuration without physical sub-grid scale parameterizations. We initialize the model with a geostrophically balanced upper level jet stream which is disturbed by an anomaly of potential vorticity to trigger the evolution of the baroclinic waves. Moreover, we use passive tracers of tropospheric or stratospheric origin to identify regions of potential STE.
Our results show that the static stability is low in regions of stratosphere to troposphere exchange (STT), while it is high in regions dominated by exchange in the opposite direction (TST). Furthermore, inertia gravity waves, originating from regions with strong ageostrophic wind components, modulate the static stability as well as the vertical shear of the horizontal wind near and above the tropopause. While propagating away from their source, the inertia gravity waves lead to large values of the squared Brunt Vaisala frequency in regions which are simultaneously characterized by low bulk Richardson numbers. Thus, these regions are statically stable and turbulent at the same time and might be crucial for TST, thereby explaining tropospheric mixing ratio changes of e.g. CO across the tropopause which commonly change from tropospheric to stratospheric values a few hundred meters above the local thermal tropopause.