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Turbulent troposphere stratosphere exchange across regions of enhanced static stability in baroclinic lifecycles

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During the HALO-mission WISE (Wave driven ISentropic Exchange) several research flights over the North Atlantic were performed to study the variability and development of the tropopause inversion layer (TIL) during baroclinic developments and their effect on the local tropopause structure.

We present the analysis of one flight performed during WISE, which was dedicated to regions of enhanced static stability above the tropopause during a strong baroclinic wave development.
We analyzed this case study on the basis of operational ECMWF data with high spatial and temporal resolution and found an excellent agreement between the analysis and the observations. The results confirm recent findings of Kunkel et al. from idealized simulations, which indicate regions of low Richardson number favorable for the occurrence of turbulence above the region of ascending air masses probably associated with the warm conveyor belt. Perturbations of the temperature stratification which modify the TIL are often accompanied by local strong and very narrow maxima of the horizontal wind and thus a strong vertical shear.
Trajectories are used to identify regions which are subject to STE and exhibit a strong TIL. The trajectory analysis of such regions show indicators for turbulent STE, forced by a combination of strong tropospheric updraft and high vertical gradients of the horizontal wind.
The analysis hints toward the existence of turbulent STE across regions of enhanced static stability.
While we cannot estimate the overall relevance of this STE process, it appears to be rather efficient
for our case studies because it counter-intuitively takes place in regions of enhanced static stability
and strong PV-gradients.

Our results further confirm the findings of Kunkel et al. from idealized simulations of baroclinic lifecycles, which indicate STE in the region of TIL-formation colocated with enhanced turbulent kinetic energy (TKE) above strong updrafts such as warm conveyor belts.