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Revisiting the ExTL: From tracer correlations to dynamical processes

Peter Hoor, Thorsten Kaluza, Daniel Kunkel, Hans-Christoph Lachnitt, Mayer Amelie, Vera Bense, Heiko Bozem, and Philipp Joppe
Johannes Gutenberg University, Institute for Atmospheric Physics, Physics, Mainz, Germany (hoor@uni-mainz.de)

The extratropical transition layer or ExTL has been recognized about 20 years ago as part of the upper troposphere / lower stratosphere (UTLS) of the extratropics. This region encompasses the tropopause and shows the chemical characteristics of both, the stratosphere and the troposphere. Tracer-tracer correlations show this ambiguous chemical character as the integral effect of numerous different processes contributing to transport and subsequent mixing. The ExTL exhibits a chemical composition which is remarkably distinct from the deeper lowermost stratosphere. The ExTL roughly extends 2 km (or 30K potential temperature) above the local (dynamical) tropopause. Notably the ExTL has been identified with only a weak seasonality (if at all) being a persistent feature at the extratropical tropopause all year round.

Various dynamical processes have been recognized to contribute to the chemical composition of the ExTL such as larger scale processes related to stirring and mixing at the jets as well as smaller scale processes such as overshooting convection, gravity wave induced turbulence and radiatively induced diabatics at the tropopause. The sum of these processes does not only affect the tropopause sharpness (i.e. the tropopause inversion layer TIL) but also contributes to the surprisingly distinct composition of the ExTL. This is a direct result of the short time scales of cross tropopause transport and mixing compared to the lowermost stratosphere beyond the ExTL where longer time scales prevail. However, a dynamical process based explanation for the upper bound of the ExTL is yet missing.

Most recent analysis of ERA5 reanalysis data provides strong indication that vertical shear is a key feature for maintaining the ExTL over the whole year. The results show that transient shear processes are a common feature of the tropopause region with a vertical extent of 2km (or 30 K in potential temperature units) around the tropopause. Here, they constitute a persistent potential cause of dynamical instability, which may lead to turbulence and mixing and thus the observed chemical distinctness and extent of the ExTL.