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Tropopause Sharpness in Baroclinic Life Cycle Experiments

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The Tropopause Inversion Layer (TIL) is a region of enhanced static stability just above the WMO-defined thermal tropopause. It is an ubiquitous feature in mid–latitudes and is well characterized by observations. However, it is still lacking a satisfying theoretical explanation.

This study considers adiabatic baroclinic life–cycle experiments to investigate dynamical mechanisms that lead to the formation of a TIL. As soon as the baroclinic wave grows, a strong TIL forms above anti–cyclonic anomalies, while no TIL is found above cyclonic anomalies. This is consistent with previous results. However, in the global or zonal average there is no TIL during the early growth phase. This refutes an earlier hypothesis, which suggested that the TIL may be a net effect from averaging over synoptic-scale variability owing to the nonlinearity of the dynamics. Rather, the TIL emerges only during the mature stage of the life cycle after the onset of wave–breaking. Life-cycles without significant wave breaking do not feature a global mean TIL nor a zonal mean TIL. In addition, no global or zonal mean TIL is found in any life-cycle if the dynamical definition for the tropopause is used.

A new explanation of dynamical TIL formation is provided, drawing on the concepts from earlier work about cyclone anticyclone asymmetry and nonlinear effects in PV inversion. The analysis suggests that the TIL (as a global mean feature) is linked to a strongly skewed distribution of relative vorticity after the wave breaking, which implies that ancicylonic anomalies cover a much larger area than cyclonic anomalies.