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Temperature structure of the tropical tropopause layer in radiative-convective equilibrium

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The tropical tropopause layer (TTL) shows a curious stratification structure: temperature continues to decrease beyond the level of main convective outflow (∼200 hPa) up to the cold point tropopause (∼100 hPa), but TTL lapse rates are smaller than in the upper troposphere. A cold point tropopause well separated from the level of main convective outflow has previously been shown to be consistent with the detailed radiative balance in the TTL even if dynamical effects were absent. More generally, the cold tropical tropopause is controlled by adiabatic cooling due to large-scale upwelling (forced by extratropical or tropical waves). TTL cooling can also come from the large-scale hydrostatic response aloft deep convective heating as well as from overshooting convection. Here, results based on idealized radiative-convective equilibrium model simulations are presented, contrasting single-column with cloud-resolving simulations. While all of the above processes are capable of producing a TTL-like region in isolation, their combination is found to produce crucial feedbacks. In particular, both water vapour and ozone are found to have strong radiative effects on TTL temperatures, highlighting important feedbacks between transport circulations setting temperatures and tracer structures and the resulting tracer structures in turn affecting temperatures.