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Revisiting the radiative vertical velocity paradigm in the TTL

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We demonstrate that uplift rates in the TTL (tropical tropopause layer) may be commonly overestimated. The mass balance of any tracer in the TTL depends on the vertical speed of large-scale uplift and the rate of convective detrainment from overshoots. Generally, uplift velocity is retrieved from the conservation of energy, assuming that the only significant factor is radiative heating.[1,2] The detrainment rate is then computed from the convergence of the uplift flux, with the assumption that detrainment dominates over entrainment in the TTL. We show that this commonly calculated "radiative vertical velocity" and the associated rate of detrainment are necessarily flawed for either of two mutually exclusive reasons. If radiative heating is the sole diabatic term in the energy budget, then significant convective entrainment must occur at TTL levels. If detrainment dominates over entrainment, then the heat budget must include the cooling rate from the export of sensible heat deficit in overshooting convection. We illustrate the calculations using tropical values of radiative heating rates and large-scale divergence fluxes from ERA-Interim reanalysis. For undilute convection, the export of heat deficit in detrained overshoots would substantially offset radiative heating, lowering the resulting assumed vertical velocity at 16 km by a factor of three. The computed detrainment rate at this altitude also increases significantly, by a factor of five. Because these changes would alter interpretation of tracer profiles, it is important to include all terms in the heat budget in tracer studies. Conversely, tracer transport properties can be used to help constrain the impact of convection on the TTL heat budget.[3]

[1] Folkins, I. et al., *J. Geophys. Res.*, **111**, D23304, (2006).

[2] Read, W. G. et al., *Atmos. Chem. Phys.*, **8**, 6051-6067, (2008).

[3] Kuang, Z. and Bretherton, C. S., *J. Atmos. Sci.*, **61**, 2919-2927, (2004)