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Extending a dry turbulence scheme towards all moist aspects – main challenges, guidelines for maintaining consistency and practical solutions

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Provided the 'fully dry' (without water vapour) solution ensures consistency between its own particular aspects, extending as simply as possible a turbulence scheme to the moist case looks like the mere juxtaposition of four problems. First, one should filter out the role of condensation/evaporation for the heat and moisture diffusion solver (Betts' old proposal is here still the solution). Second, one should provide a closure assumption for the shallow-convection parameterisation. Third, one should define the right equivalent to the TPE (proportional to $<\theta'^2>$ in the fully dry case) so that both contributions of the conversion term cancel out in the budget of TTE=TKE+TPE. Fourth, one should translate the cross-correlation aspects of moisture and heat sub-grid transport into a unique definition for their vertical exchange coefficient K_h.

However, this vision is partly misleading since it relies on finding a convenient equivalent to θ for each particular algorithm. Yet, as soon as moisture appears (even without clouds), the buoyancy and conservation roles of θ, condensed in $N^2=(g/\theta)d\theta/dz$, cannot anymore be played by a unique quantity (Marquet and Geleyn, 2013). Hence a careful analysis of the respective roles of moist equivalent variables (θ_l and q_t), specific moist entropy θ_s (Marquet, 2011), buoyancy term contributions as function of partial cloud cover and energy budget terms is needed for a fully consistent moist extension. On the basis of a newly developed dry case framework (Bašták Ďurán et al., 2014) we propose here a possible solution for the transversal above challenges. It relies on three concepts: (i) the shallow-convection closure must mimic how nature seems privileging q_t transport for the TPE↔TKE conversion; (ii) the TTE and buoyancy flux formulations must be each other's mirrors; (iii) the K_h derivation should combine the stability effects traced by θ_s and the maintenance of the TTE conservation rule.