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Does convection select moist environments?

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It has previously been postulated that convection selects favorable environments. In particular, it is thought that entrainment of enhanced moisture above the boundary layer yields enhanced buoyancy in the convective updrafts. This impact of moisture in the environment has previously been demonstrated in observations of tropical convection (TOGA/COARE, Brown and Zhang 1997) and cloud resolving models of deep convection (Derbyshire et al 2004).

A large-eddy simulation (LES) of shallow convection with cloud tracking is used to answer the following question: Is the place where convection will decide to convect pre-moistened before convection starts? It is found that the answer depends strongly on cloud size. The stronger the pre-moistening, the larger the resulting convective cloud size. Additionally large convective clouds leave the largest moisture excess, as one would expect. All that is valid for moisture above cloud base. In contrast, no impact of sub-cloud moisture on resulting convective cloud size could be found.

A simple parameterization of this pre-moistening has been developed for the mass-flux framework. The entrainment of moisture is modified such that the environment represents not the mean grid-box but the top half of the moisture PDF. This represents the LES observation that all but the smallest convective clouds require a moisture perturbation in their direct environment. Note that this parameterization requires the knowledge (diagnostic or prognostic) of the variance of total water. For high resolution where the moisture variance goes to zero this parameterization will turn itself off naturally.

This parameterization of the effect of pre-moistening has been implemented in an experimental version of the ECMWF model that uses the eddy-diffusivity mass-flux (EDMF) approach with dual mass-fluxes (dualM). The results show an enhancement of mass-fluxes as well as an improvement of geopotential height, wind and cloud prediction.