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How cold pool triggers deep convection?

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The cold pool in the boundary layer is often considered a major triggering mechanism of convection. Here, presented are basic theoretical considerations on this issue.

Observations suggest that cold pool-generated convective cells is available for shallow maritime convection (Warner et al. 1979; Zuidema et al. 2012), maritime deep convection (Barnes and Garstang 1982; Addis et al. 1984; Young et al. 1995) and continental deep convection (e.g., Lima and Wilson 2008; Flamant 2009; Lothon et al. 2011; Dione et al. 2013). Moreover, numerical studies appear to suggest that cold pools promote the organization of clouds into larger structures and thereby aid the transition from shallow to deep convection (Khairoutdinov and Randall 2006, Boing et al. 2012, Schlemmer and Hohenegger, 2014). Even a cold–pool parameterization coupled with convection is already proposed (Grandpeix and Lafore 2010: but see also Yano 2012). However, the suggested link between the cold pool and deep convection so far is phenomenological at the best. A specific process that the cold pool leads to a trigger of deep convection must still to be pinned down.

Naively, one may imagine that a cold pool lifts up the air at the front as it propagates. Such an uplifting leads to a trigger of convection. However, one must realize that a shift of air along with its propagation does not necessarily lead to an uplifting, and even if it may happen, it would not far exceed a depth of the cold pool itself. Thus, the uplifting can never be anything vigorous. Its thermodynamic characteristics do help much either for inducing convection. The cold-pool air is rather under rapid recovering process before it can induce convection under a simple parcel-lifting argument. The most likely reason that the cold pool may induce convection is its gust winds that may encounter an air mass from an opposite direction. This induces a strong convergence, also leading to a strong uplifting. This is an argument essentially developed by Moncrieff and Liu (1999). As a whole, in attempting a statistical description of boundary-layer processes, the cold pool is essentially nothing other than an additional contribution to a TKE (turbulent kinetic energy) budget.

Significance of trigger of convection by cold pool in context of convection parameterization must also be seen with much caution. Against a common misunderstanding, current convection parameterization is not designed to describe a trigger process of individual convection. In this respect, process studies on cold pool do not contribute to improvements of convection parameterization until a well-defined parameterization formulation for individual convection processes is developed. Even before then a question should also be posed whether such a development is necessary. Under a current mass-flux convection parameterization, a more important process to consider is re-evaporative cooling of detrained cloudy air, which may also be associated with downdraft, possibly further leading to a generation of a cold pool. Yano and Plant (2012) suggest, from a point of view of the convective-energy cycle, what follows would be far less important than the fact the re-evaporation induces a generation of convective kinetic energy (though it may initially be considered TKE). Both well-focused convective process studies as well as convection parameterization formulation would be much needed.