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The winner takes it all - how long-lived raincells compete in cold pool-suppressed self-aggregation

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Under radiative convective equilibrium (RCE), cloud populations simulated by large-eddy simulations (LES) can spontaneously segregate into cloudy and cloud-free subregions. This process is well-known as convective self-aggregation (CSA) [4]. But how initially randomly distributed raincells compete and merge until only one prevails, is not well-understood. We remove cold pools (CPs) in LES by suppressing the re-evaporation of rain, which leads to qualitatively different dynamics. This extreme case helps to understand the role of CPs in the formation of CSA and further has relevance when humidity is very high in the boundary layer, so very little rainfall evaporates.

When convection starts, patterns of high and low moisture develop, which increase in scale over time. In contrast to CSA with CPs, individual rain events and convection cells persist up to tens of hours in the course of this modified CSA [1]. For the long lasting individual rain clusters, we observe interesting oscillations in rain intensity and spatial extent. We define an algorithm, that tracks the tree-like merging behavior of initially many individual small raincells to a final, single, raincell of large area and precipitation yield. We conceptualize the LES behavior in a simple model, that assumes different rain events to compete for buoyancy. This hypothesis is justified when viewing rain events as linked to local maxima of relative humidity around cloud base. The clusters' dynamics seem to be dominated by merging with other events and 'stealing' from smaller events, whereas splitting and emerging of new rain events seem neglectable after a build-up time. In each step, the conceptual model chooses two adjacent clusters. Initially, each cluster is attributed a 'mass' parameter of similar magnitude and a fraction (p) of the smaller 'mass' (m_2) is transferred to the bigger event (m_1).

$$m_1^{new} = m_1 + p(m_1 - m_2)$$
$$m_2^{new} = m_2 - p(m_1 - m_2)$$

An event is removed, when its mass parameter is diminished to zero. In contrast to field based approaches [3], this approach implements discrete rich gets richer dynamics, to capture how individual cells grow. This conceptual model could be combined with existing models, where CP suppress the rain cells, but trigger new updrafts through the CP gust fronts [2]. Bringing together these two limits could further elucidate how CP dynamics can be made compatible with convective self-aggregation.

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