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Predicting cold pool strength as a function of rain duration and intensity

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Convective cold pools (CPs) have been recognised as an important ingredient in the organization of convective cloud fields and the formation of intense rain events (Feng et al. 2015, Torria and Kuang 2019). To understand the life cycle of CPs and their mutual interaction, idealised large-eddy simulations (LES) of isolated or colliding CPs have become an important tool to develop simple theories about the propagation speed, the dissipation rate and the moisture distribution within the CP and the surrounding environment (Rooney 2015; Langhans et al. 2015; Romps and Jeevanjee 2016; Grant et al. 2016, 2018). On the contrary, the formation of CPs and specifically their relation to their parent rain events has so far not gained much attention in idealised studies. This is surprising, as the relation between the generating rain event and the CP strength is relevant for the theoretical understanding of the 'rain – CP – rain' cycle and the parameterization of CPs, which aims at adjusting for the enhanced convective triggering under the presence of CPs, where the triggering scales with the CP strength.

In this study we thus examine the relation between rain intensity, duration and CP strength in an idealised setting. To this end, we include the temporal extent of the rain event that forms the CP through evaporative cooling by varying the duration, intensity and area of the air volume that is cooled and moistened to simulate the generation of a CP. This finite duration of the CP forcing has been neglected by most studies that initialise the CP by an instantaneous forcing alone (e.g., Rooney 2015, Grant 2016). Our simulations show that a continuous cooling, imitating persistent rainfall, affects the generated CP only over a period of approximately ten minutes. Shorter cooling leads to smaller and weaker CPs, while cooling occurring after 10mins does not substantially affect the CP properties, such as its radius and propagation speed, the internal circulation in the CP head. Consequently, the CP's effect on the environment as measured in terms of the updraft strength ahead of the CP, increases for cooling times up to 10mins and converges thereafter. To imitate a change in precipitation intensity, we vary the cooling amplitude. As expected, stronger cooling leads to stronger CPs. However, this effect is surprisingly small and does not substantially alter the CPs' internal structure.

To test the extent to which these results can be translated to 'real' CPs generated by evaporative cooling of rainfall, we study the relation between rain intensity and CP strength in comprehensive

LES of deep convection and observational data. Hereby, we hopefully can improve our understanding , how best to characterise rain events, e.g. by their instantaneous or time-integrated precipitation statistics, to determine the CP strength.