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Modeling convective clouds as a complex interacting system

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Two aspects of the convective cloud field highlight its departure from an equilibrium framework: the observation of unexpectedly strong temperature sensitivity of extreme precipitation intensities, i.e. an exceedance of the Clausius-Clapeyron rate of $\sim$ 7 percent/Kelvin (Lenderink v. Meijgaard, Nat. Geo. 2008, Berg et al., Nat. Geo., 2013); the effect of cloud-cloud interactions that may lead to intensified events (Moseley et al., Nat. Geo., 2016). Using a description in terms of *local* CAPE and CIN, we present a conceptual model, which breaks down the convective cloud field into four distinct states: (i) excitable, with sufficient CAPE but inhibitive CIN; (ii) excited, when CIN is overcome and CAPE is converted to precipitation at a fast rate τ; (iii) refractory, where CAPE is recovering at a slow rate ε and CIN is elevated; (iv) activated, where cold pools bring about spatial interaction between convective cells, leading to local enhancement of CAPE and reduction of CIN, thus causing extreme events. State (iv) hence provides the spatial process which allows for self-organization and the departure from conventional models that are often based on non-interacting clouds. We provide an analysis of the theoretical model and back this up by high-resolution large eddy simulations. Our results have implications for how the convective cloud field self-organizes and how this organization could be captured in large-scale models, such as GCMs.