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The impact of cold pools on the transition from shallow to deep convection over land

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Large-eddy simulation is used to investigate the effects of cold pools driven by rain evaporation on the shallow-to-deep convection transition over land. The applied methodology allows for obtaining a time-dependent reference ensemble without cold pools for interactive surface fluxes. The reference ensemble, in the spirit of one-dimensional single-column models, eliminates cold pools by horizontally homogenizing negative buoyancy production due to rain evaporation. Two additional ensembles complement the reference cold-pool-free ensemble by including cold pools and by applying either interactive or prescribed surface fluxes. Contrasting these ensembles suggests possible improvements of convection parameterization in large-scale models of weather and climate. Without cold pools, the reference ensemble preserves key features of buoyancy-driven cellular convection associated with a field of convective plumes, as assumed in a typical convection parameterization. With cold pools, a significant enhancement of surface heat and moisture fluxes and about an hour delay of their daily maxima is simulated. Cold pools enhance near-surface temperature and moisture standard deviations as well as maxima of the near-surface updraft velocity. They also lead to the reduction of cloud lateral entrainment, deeper vertical development of the cloud layer, and a few-times-larger accumulated surface precipitation. Interactive surface fluxes provide a damping mechanism that noticeably suppresses all these effects. The most important effects are incorporated in the multi-plume Eddy-Diffusivity/Mass-Flux convection parameterization and shown to improve its representation of the transition from shallow to deep convection over land.

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