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Convective organization from the interaction between cold pools and thermally induced mesoscale circulations

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Land surface conditions can influence the onset and strength of convective systems. This is because sharp gradients in land surface properties result in differential latent and sensible heat fluxes, which leads to the development of mesoscale atmospheric circulations similar to the circulations present in land-sea breezes. These mesoscale circulations play an important roll in controlling the location of the initiation of deep convection in various ways. Studies have shown how different land surface heterogeneities may influence afternoon convective cloud sizes (and thus timing of initiation), precipitation duration and amount and cold pool modification. Cold pools may thus be altered to be more efficient at triggering further convective events. However, to synthesize all these effects that arise from land surface gradients and its control on rainfall distributions has been neglected.

Motivated by the modeling framework from previous studies (e.g. Huang and Margulis, 2012; Rieck et al., 2015; Schneider et al., 2019) we employ a checkerboard of alternating extremely dry vs. wet soil moisture patches in an idealized cloud resolving model coupled to a land surface model. The checkerboard approach has previously been used to show how the PBL, cloud size, precipitation duration and amount are all influenced by different strength and length scales of the land-surface gradients. Using this setup, mesoscale circulations induced by surface heterogeneities are therefore overlaid with cold pool circulations from subsequent afternoon convection. Our aim is to understand the complex of interactions between the land surface (e.g soil moisture), cold pools and thermal mesoscale circulations to organize diurnal moist convection. In particular, we aim to determine how these phenomena interact to 1) bring rain to conditionally unstable regions 2) organize convection into more localized extremes of rainfall and 3) allow the upscale growth of scattered convection in an environment where background wind is absent. These questions may give insight into the mechanisms that allow land use changes, such as deforestation and urban environments, to alter rainfall patterns that become locally more extreme.

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