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Initiation of deep convection over an idealized mesoscale convergence line

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This study performs cloud-resolving simulations of cumulus convection over an idealized surface-based convergence zone, to investigate the mechanisms and sensitivities of deep-convection initiation forced by mesoscale ascent. The surface convergence forms in response to a localized diurnal heating anomaly over an otherwise homogeneous and unheated surface, producing a strong boundary-layer updraft over the center of the heat source. This updraft gives rise to a line of cumuli that gradually deepen and, in some cases, transition into deep convection. To statistically investigate the factors controlling this transition, a new thermal-tracking algorithm is developed to follow incipient cumulus cores as they ascend through the troposphere. This tool is used to isolate the impacts of key environmental parameters (cloud-layer lapse rate, mid-level humidity, etc.) and initial core parameters near cloud base (horizontal area, vertical velocity, etc.) on the ultimate cloud-top height. In general, the initial core size determines which thermals in a given cloud field will undergo the deepest ascent, and the sensitivity of cloud depth to initial core parameters increases in environments that are more hostile to deep convection. Diurnal midlevel moistening from detraining cumuli above the convergence line produces a small but robust enhancement in cloud-top height, particularly for smaller cores.