Fourth International Conference on Earth System Modelling
4ICESM-95, 2017

Conceptual model of a shallow circulation induced by low-level radiative cooling

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Studies of radiative convective equilibrium in idealised domains have shown that low-level cooling is important in forcing the organisation of convection. This cooling, maximising at the top of the boundary layer (BL), is thought to drive a divergent low-level flow that enhances subsidence in the non-convective areas and transports moist static energy into convective areas. We use bulk concepts and idealised LES to show that heterogeneous radiative BL cooling causes a circulation induced by pressure deviations between regions of different radiative BL cooling. Including a feedback of the induced circulation on the BL in a dry two-column model, leads to a new equilibrium in which a weakened horizontal BL flow of about 1 m/s is maintained for a spatial difference in radiative BL cooling larger than 1 K/day. Such a circulation strength is comparable to a shallow circulation caused by surface temperature differences of a few Kelvins. First results of a moist convective two-column model indicate that the circulation is stronger when the effects of moisture and a simple convective mass flux are included. We conclude that spatial differences in radiative BL cooling should be considered as a first-order effect for the formation of shallow circulations.