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Exploring diurnal land-atmosphere coupling at small scales using large-eddy simulation

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Many processes and feedback mechanisms are involved in land-atmosphere interactions that play an important role in determining the boundary layer structure throughout the diurnal cycle. Here, the effect of soil moisture on the development of shallow cumulus convection is investigated using a coupled large-eddy simulation (LES)–land surface model (LSM) framework. Our results support the hypothesis that the response of shallow cumulus clouds due to a change of soil moisture severely depends on the thermal stability conditions. Furthermore, they also point out that the atmospheric moisture content is as important as the static stability in determining the boundary layer characteristics and in particular the fractional cloud cover. The results demonstrate that the soil moisture-cloud cover coupling is positive in most of the cases. However, we show that under specific conditions (a less stably stratified moist atmosphere) convective activity and cloud formation is stronger over dry soils, where the principle driving mechanism for cloud development is the boundary layer growth that tends to increase relative humidity by adiabatic cooling of the air at the top of the boundary layer. This leads to a soil moisture cloud cover relationship in which the cloud cover fraction decreases with an increase of soil moisture.