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Large-eddy simulation of catchment-scale circulation: impact of soil moisture heterogeneity on the boundary layer development

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The impact of surface soil moisture heterogeneity on the convective boundary layer (CBL) development was studied. Applying soil moisture patterns along a synthetic river corridor and idealized atmospheric vertical profiles as initial conditions in large-eddy simulations (LES), this study provides insight in the influence of soil moisture heterogeneity on catchment-scale circulations (CCs) and the ensuing growth of the CBL. The simulation results show that organized circulations resulting from soil moisture heterogeneity are strong when the soil moisture gradient from the channel to the hillslope is large. In this case, the CCs also have a strong influence on the boundary layer structure and the entrainment layer. Differences in sensible heat fluxes among the heterogeneous cases are getting larger with the increase of height and reach a maximum at the top of CBL. The profiles of turbulent kinetic energy show two maxima, one close to the ground surface and the other one near the top of the CBL, which is in agreement with the divergence branch of the organized circulation in the lower part of the CBL and the convergence branch in the upper part of the CBL. It is particularly interesting to note that boundary layer heights of the heterogeneous cases are consistently smaller than the ones of homogeneous cases as a result of the organized circulation. Furthermore, boundary layer heights of the heterogeneous cases decrease with decreasing soil moisture gradients.