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Cloud resolving modelling of the life cycle of a MCS: Sensitivity to soil conditions over West Africa

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In the African Sahelian (12°N-18°N) and Sudanian climate zone (9°N-11°N) convective systems contribute about 80-90% and about 50%, respectively, to the annual rainfall. Thus, they play a key role in the water cycle of West Africa. Their rainfall, however, is highly variable in space as well as in time. The initiation and modification of rain-producing convective systems in West Africa are still not well understood. The development of moist convection requires any kind of instability like potential and/or conditional instability and a trigger mechanism like vertical motion. The latter process is needed to release the available energy for convection. The type of convection, i.e. shallow or deep convection, then depends on atmospheric stratification above the condensation level, the presence of lids which may inhibit convection, and the height of the equilibrium level. In addition to mid- and upper-tropospheric forcing, the influence of surface and convective boundary layer (CBL) processes on the initiation of convection is often emphasised. Major factors are the spatial distribution and temporal development of water vapour in the CBL. Besides advective processes, water vapour is made available in the atmosphere locally through evapotranspiration from soil and vegetation; the latter is an important component of the earth's surface energy balance. Soil moisture affects the energy balance via the albedo and emissivity of the surface, the conduction of heat in the soil and the stomata resistance of vegetation. Research findings show that the soil moisture exerts greater influence on the CBL than vegetation

Cloud resolving real-case simulations initialized with ECMWF analysis data were performed to investigate the sensitivity of a mesoscale convective system (MCS) to soil properties. Several scenarios with different content of soil moisture and distribution of soil conditions were investigated.

Initiation of convection was observed in all experiments. The initiation area was characterised by very low convective inhibition (CIN) and high convective available potential energy. The simulations showed some evidence that convection was initiated in the vicinity of orography and along soil moisture inhomogeneities. In a moist case precipitating cells were weak and disappeared when entering a region with higher CIN. In the other experiments MCSs developed. In the control run a weakening of the system was observed when approaching an area with reduced total water content and enhanced CIN. In the run with a dry band of soil moisture, convection developed almost simultaneously in the original initiation area and inside the dry band, where convergence, generated by thermally-induced circulation and supported by downward mixing of momentum from AEJ, triggered convection. When the mature MCS approached the band from the east it weakened, caused by increasing convective inhibition ahead of the band. This case study showed that a negative feedback between soil moisture and convection existed during the initiation and organization of convection, but in the mature stage of the MCS a positive feedback was observed.