Influence of the representation of convection on the mid-Holocene West African Monsoon

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Global climate models have difficulties to simulate the northward extension of the monsoonal precipitation over north Africa during the mid-Holocene as revealed by proxy data. A common feature of these models is that they usually operate on too coarse grids to explicitly resolve convection, but convection is the most essential mechanism leading to precipitation in the west African monsoon region. Here, we investigate how the representation of tropical deep convection in the ICON climate model affects the meridional distribution of monsoonal precipitation during the mid-Holocene, by comparing regional simulations of the summer monsoon season (July to September, JAS) with parameterized (40km-P) and explicitly resolved convection (5km-E). The spatial distribution and intensity of precipitation, are more realistic in the explicitly resolved convection simulations than in the simulations with parameterized convection. However, in the JAS-mean the 40km-P simulation produces more precipitation and extents further north than the 5km-E simulation, especially between 12° N and 17° N. The higher precipitation rates in the 40km-P simulation are consistent with a stronger monsoonal circulation over land. Furthermore, the atmosphere in the 40km-P simulation is less stably stratified and notably moister. The differences in atmospheric water vapor are the result of substantial differences in the probability distribution function of precipitation and its resulting interactions with the land surface. The parametrization of convection produces light and large-scale precipitation, keeping the soils moist and supporting the development of convection. In contrast, less frequent but locally intense precipitation events lead to high amounts of runoff in explicitly resolved convection simulations. The stronger runoff inhibits the moistening of the soil during the monsoon season and limits the amount of water available to evaporation.