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The mechanism limiting the northward extent of African monsoon in GCM and high resolution (4 Km) simulations of present and past climate

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It is known that GCMs that operate at coarse horizontal resolutions with convective parameterizations do not simulate some aspects of past and present African monsoons, especially the changes in the northward extent of precipitation on orbital time-scales. We investigate the mechanism limiting the northward extent of precipitation using a suit of simulations. We first use a coarse resolution Community Earth System Model (CESM) simulations to isolate the large-scale factors which influence the African monsoon precipitation. Then high resolution (4 Km) simulations from Weather Research and Forecast (WRF) model are used to associate these factors to the representation of convective processes in African region.

The CESM simulations indicate that in the present climate, the northward extent of precipitation is limited by the mid-level penetration of dry air from the Sahara desert. This penetration is driven by the shallow circulations active to the north of the precipitation. Additional idealized simulations with forced boundary layer heating shows that the shallow circulations change non-linearly in response to the linear forcing and hence enhance the northward precipitation non-linearly. This sensitivity points to the inaccurate simulation of radiative-convective processes in this region. The WRF simulations capture the diurnal cycle of convection and clouds in the main precipitation zone and reproduces the late evening peak in convective activity. These simulations are further used to investigate the association between the diurnal cycle of rainfall over Sahel-Sahara and simulated shallow circulations in past and present climate.