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Model performance in simulating the mid-Holocene Green Sahara

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The Green Sahara Period, spanning about 11,500 to 5,000 years ago, offers an opportunity to test the ability of climate models to simulate large-scale changes in northern African climate through the strengthening of the West African Monsoon. In this study, we evaluate the performance of four models in simulating the mid-Holocene (6,000 BP), namely – EC-Earth, iCESM, CCSM4-Toronto, and the GISS ModelE2.1-G. Two scenarios are considered for each model – a standard PMIP scenario simulated with the mid-Holocene orbital parameters and greenhouse gas concentrations with vegetation prescribed to pre-industrial conditions, as well as a Green-Sahara scenario which additionally considers factors such as enhanced vegetation, reduced dust, presence of lakes, and land and soil feedbacks. All mid-Holocene scenarios capture an increase in monsoonal precipitation in northern Africa. However, a comparison of the two mid-Holocene scenarios reveals significantly higher precipitation in northern Africa for all the Green-Sahara scenarios relative to the PMIP scenarios – an observation consistent across all models. Accompanied by a strengthened Saharan Heat Low, these changes in the West African Monsoon are also linked to polar amplification, a stronger Indian Summer Monsoon and alterations to the Walker circulation. Model results are in agreement with pollen-based SAT records, multi-proxy SST records and African lake level records. This comparison indicates that a realistic simulation of the mid-Holocene Green Sahara requires consideration of multiple factors in addition to orbital and greenhouse gas forcings.