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Variations of the tropical hydrological cycle during the last glacial-interglacial period: a model-data intercomparison

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The aim of the present study is to determine the mechanisms controlling past variations of the tropical hydrological cycle during the last glacial-interglacial period using climate model simulations and paleoreconstructions. To this end, results of Holocene and Eemian climate simulations with the Kiel Climate Model (KCM) together with PMIP3 simulations of the Last Glacial Maximum (LGM) are analyzed. For the model-data comparison we use paleoreconstructions of dD values of terrestrial plant leaf waxes preserved in a marine sediment core close to the mouth of the Zambezi over last 37,000 years. The estimated rainfall based on dD suggests a gradual increase in rainy season precipitation over the Zambezi basin from the early to late Holocene. This gradual increase in rainfall during the Holocene is very likely to be linked to increase in austral summer insolation over the southern tropical Africa. A similar trend is well reproduced by KCM simulations using orbital configuration changes as an external forcing. However, simulated LGM-preindustrial changes in precipitation vary substantially among the suite of PMIP3 models. Three models (MRI-CGCM3, IPSL-CM5A and CCSM4) demonstrate decreasing tendency towards the LGM while remaining models simulate an increasing amount of rainfall during the LGM. Nevertheless, the average of rainfall changes from these models suggests a minor intensification of southern African monsoon during the LGM. The latter estimate is in a qualitative agreement with the estimated rainfall based on our dD paleorecord.

Characteristics of the Asian summer monsoon (onset and withdrawal date, monsoon length, mean rainfall and its extremes) are analyzed using pentad precipitation from KCM simulations of the Holocene period. We found an overall increase in a length of the Asian summer monsoon which is primarily associated with earlier monsoon onset during the early Holocene.

Our model results show that a weakening of the Indian summer monsoon during the Holocene and Eemian (towards the present) is accompanied with a strengthening of its interannual variability. To understand a possible role of SST changes for the monsoon circulation, results of simulations with atmospheric model ECHAM5 (forced by early Holocene orbital configuration and preindustrial SST) are analyzed.