Climate model studies on the impact of tectonics and Earth's orbital changes on African climate

Kerstin Prömmel (1*); Ulrich Cubasch (1); Frank Kaspar (2)

(1) Institute of Meteorology, Freie Universität Berlin, Germany

(2) Deutscher Wetterdienst, Germany

*Corresponding author: kerstin.proemmel@met.fu-berlin.de

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The development of the East African Rift System (EARS) during the last 20 million years caused by tectonic forcing is supposed to influence the regional climate in Africa. However, on these timescales also changes in the Earth's orbital parameters have an influence on climate. The analysis of these impacts is one topic within the research group RiftLink (www.riftlink.de). To analyse the influence of both tectonic and orbital forcing on African climate, first, the global coupled ocean-atmosphere climate model ECHO-G is applied. These simulations have a coarse horizontal resolution of roughly 350 km meaning the EARS is poorly represented in the global model. Therefore, in a second step, the non-hydrostatic regional climate model COSMO model in CLimate Mode (CCLM) is applied with a horizontal resolution of roughly 50 km. The regional simulations are forced at the lateral boundaries with the simulations performed with ECHO-G.

Tectonic forcing is represented in the climate models by changes in model topography. The different topographies can be considered as possible past stages during the development of the EARS. The results indicate that tectonic forcing has a strong impact on precipitation in Africa caused by changes in the circulation. For example, the forcing helps explaining East African aridification during the Neogene. However, additional rather global forcing factors like changes in greenhouse gas concentrations or orbital forcing are necessary to fully explain the aridification.

To analyze the impact of orbital forcing, Earth's orbital parameters are changed in the model in a way that top of atmosphere insolation results in significantly different patterns compared to today. Here, the orbital configuration of the last interglacial at 125000 years before present is chosen, when the seasonality of insolation on the northern hemisphere was strongly enhanced, whereas on the southern hemisphere it was strongly weakened. The simulations of this timeslice show a strong impact of orbital forcing on precipitation over large parts of Africa caused by altered moisture transport.

Both tectonic and orbital forcing can have an equally strong impact on African climate. Therefore, at least these two factors have to be considered when interpreting proxy data and also setting up paleo climate model simulations.