Regional climate model study on the impact of tectonic and orbital forcing on East African climate

Kerstin Prömmel, Ulrich Cubasch
Institute for Meteorology, Freie Universität Berlin, Germany, kerstin.proemmel@met.fu-berlin.de

Regional climate model CLM

The non-hydrostatic regional model CLM is the climate version of the regional weather prediction model of the German Meteorological Service and is developed as a community effort of several universities and research centers (www.clm-community.eu). In this study it is applied with a horizontal resolution of 0.5° and 32 vertical layers. The simulation area covers nearly the whole of Southern and Eastern Africa.

Introduction

The DFG-funded research group RiftLink (www.riftlink.de) aims at clarifying the causes of rift-flank uplift in the East African Rift System (EARS) since the late Miocene, its impact on climate and the possible consequences for the evolution of hominids. The climate modelling part within RiftLink concentrates on climatic changes caused by different forcing factors. To analyse the impact of these factors, both global and regional climate models are applied. The global coupled atmosphere ocean general circulation model ECHO-G (ECHAM4 and HOPE-G) is used with a horizontal resolution of approx. 3.75°. Its simulations show the impact on larger scales and are used to drive the regional model CLM with a horizontal resolution of approx. 50 km. With this high resolution small-scale changes in forcing factors can be realised and their impact on regional to local climate can be analysed. Two forcing factors influencing East African climate are tectonic forcing represented by changes in the topography of East Africa and orbital forcing represented by changes in the Earth's orbital parameters. The impact of these forcing factors are analysed with ECHO-G (not shown) and CLM.

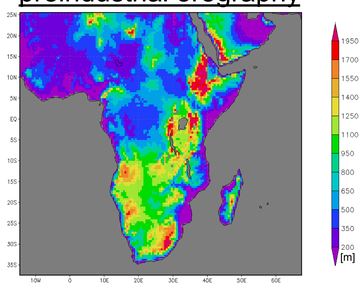
Tectonic forcing

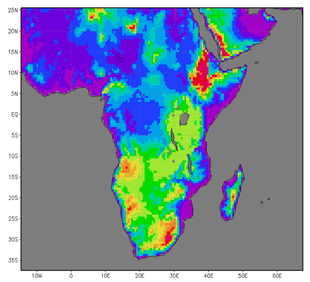
Spatial and temporal development of the EARS and topography in East Africa in the past is not yet sufficiently known
→ assumptions about topography
→ two possible configurations of topography in the past:

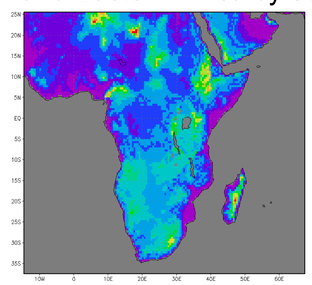
no peaks: lowering of the central EARS to a maximum of 1200 m

50%: reduction of the orography over Southern and Eastern Africa by 50%

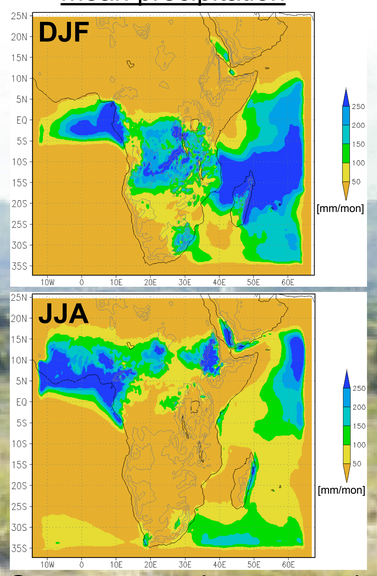
preindustrial orography



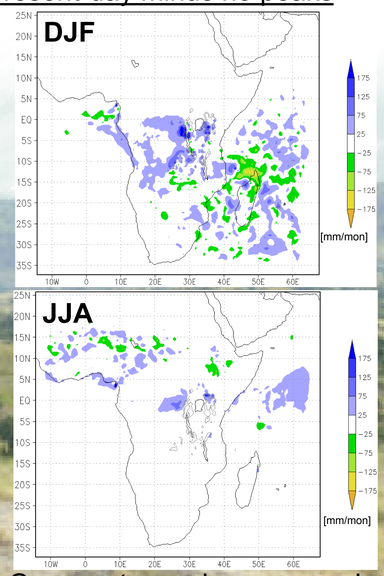




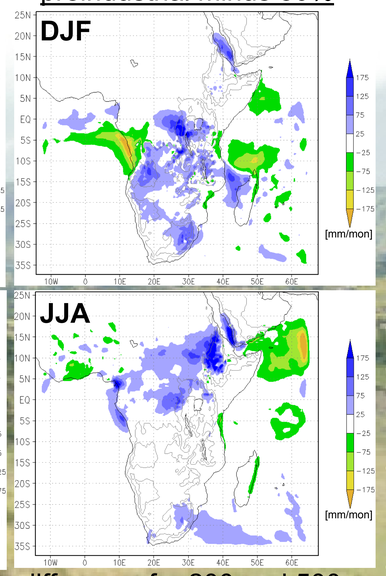
preindustrial seasonal mean precipitation



seasonal mean precipitation difference:
present-day minus no peaks



preindustrial minus 50%



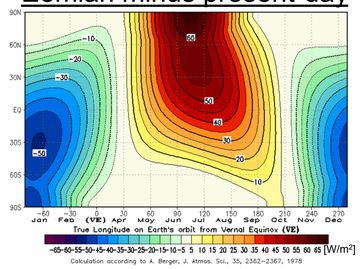
Grey contours show orography for 800, 1200 and 1600 m.

Grey contours show orography difference for 200 and 500 m.

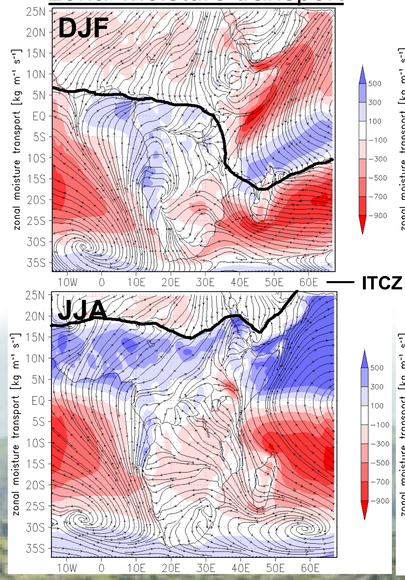
Orbital forcing

Earth's orbital parameters influence solar insolation at the top of the atmosphere.
As an example of a strong insolation change compared to today the last interglacial (Eemian) at 125 ka BP is chosen
→ change of orbital parameters in the climate model to Eemian values

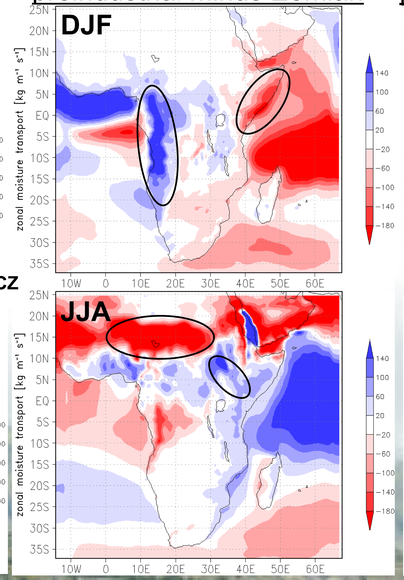
TOA insolation difference:
Eemian minus present-day



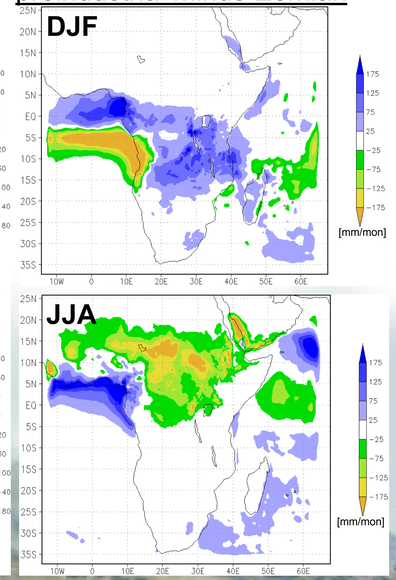
preindustrial seasonal mean zonal moisture transport



moisture transport difference:
preindustrial minus Eemian



precipitation difference:
preindustrial minus Eemian



Results

- **Tectonic forcing**: During preindustrial times more precipitation occurs windward of the mountains than during times of lower orography in the past. Along the East African coast around 5°S the higher orography leads to a slight aridification for the configuration with a 50% topography change.
- **Orbital forcing**: Precipitation has changed over large parts of Africa with more (less) precipitation during boreal winter (summer) compared to the Eemian. These changes are caused by altered zonal moisture transport (see circles), which is influenced by changes in insolation.
- These sensitivity studies show that both tectonic and orbital forcing have an equally strong impact on African climate, which is partly opposite to each other.