Kerstin Prömmel

Frank Kaspar, Ulrich Cubasch

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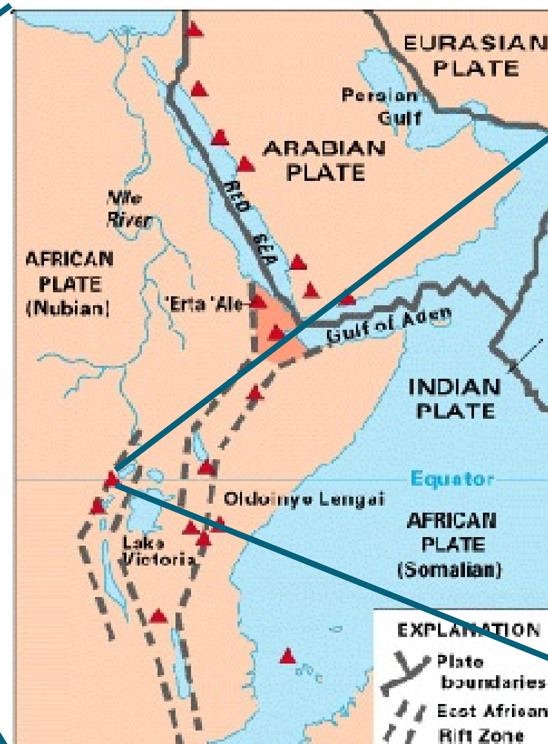
Regional Climate Model Study on the Impact of Tectonic and Orbital Forcing on East African Climate

RiftLink

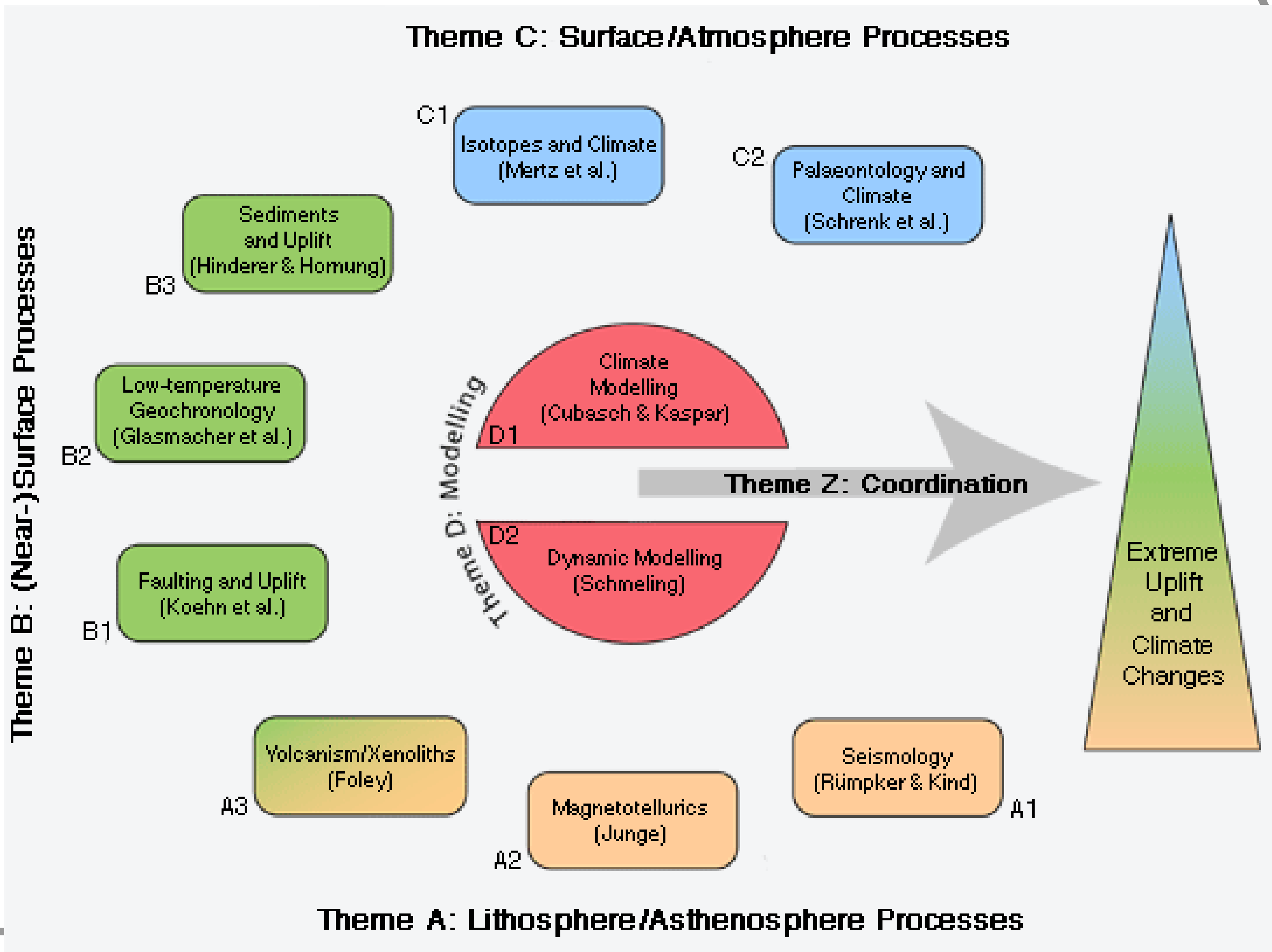
- DFG-Research Unit with 10 subprojects
- Rift dynamics, uplift and climate change in Equatorial Africa → development and evolution of the East African Rift System (EARS) and its impact on climate during the last 20 million years



Rwenzoris

5109 m

Subprojects in RiftLink



Climate modelling in RiftLink - Motivation

How strong is the impact of the development of the EARS (tectonic forcing) on regional climate (esp. precipitation) in East Africa?

Spatial and temporal development of the EARS and topography not yet sufficiently known → assumptions about topography → application of different topographies in the climate model

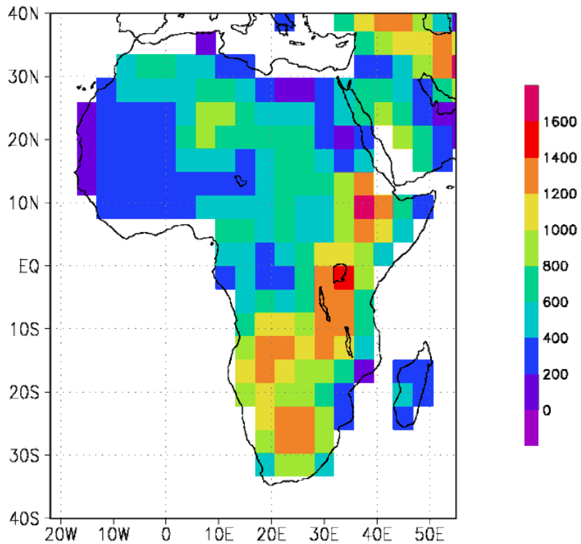
How strong is the impact of changes in insolation (orbital forcing) on regional climate in East Africa?

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

Models

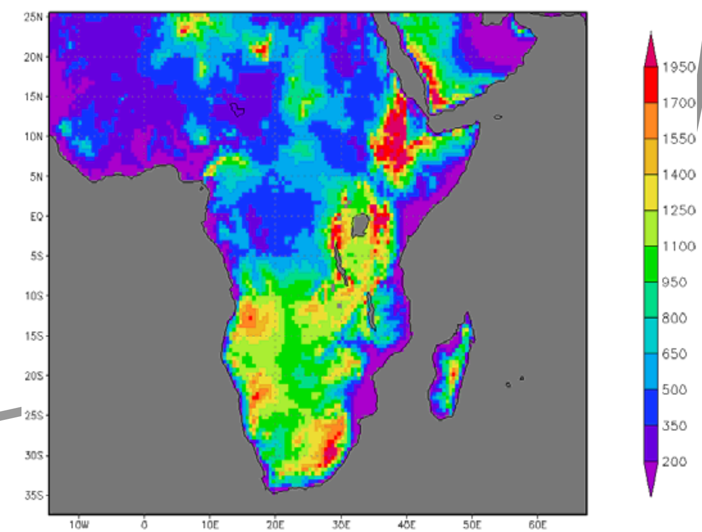
Global model: **ECHO-G**

•Coupled model
•Atmosphere: **EC**HAM4
T30 (3.75°) horizontal resolution, 19 vertical layers
•Ocean: **HO**PE-**G**
T42 (2.8°) horizontal resolution with equator refinement up to 0.5°, 20 vertical layers

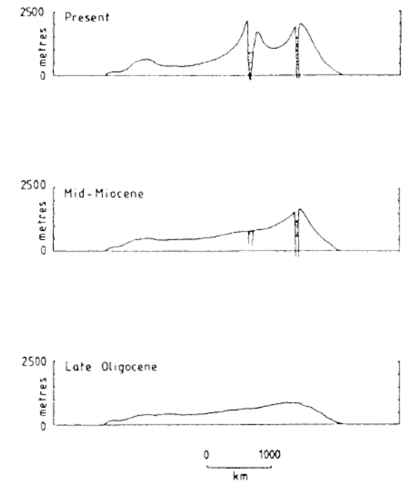


Regional model: **CLM**

•0.5° horizontal resolution, 32 vertical layers
•Tiedtke, two-category ice scheme
•Simulation area: 37°S to 25°N, 15°W to 67°E
•Forcing at the lateral boundaries with global simulations or ERA40 reanalysis



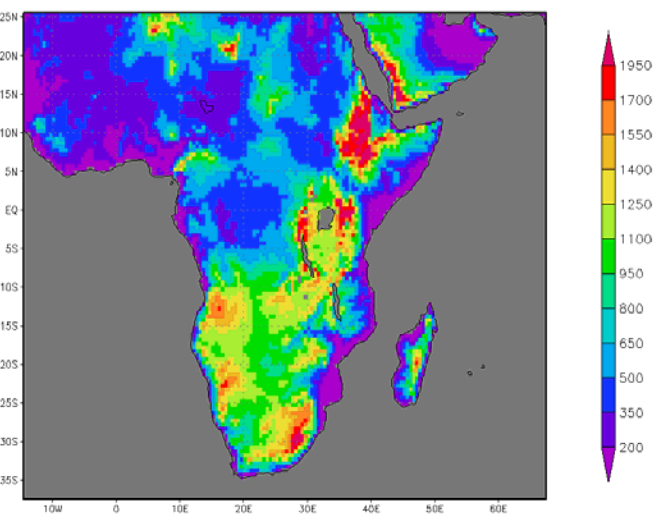
Tectonic forcing



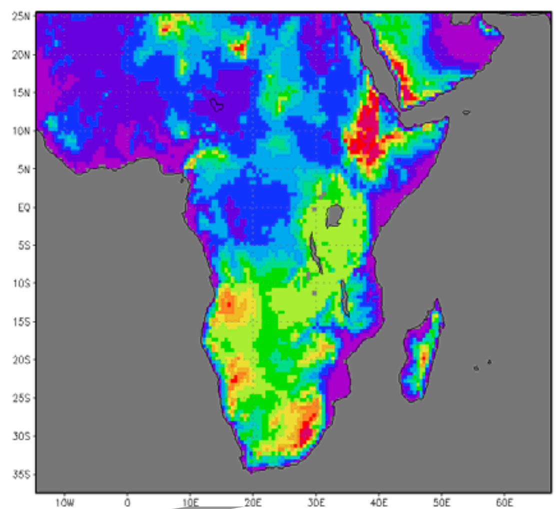
Two approaches:

1.„no peaks“: lowering of the western and eastern branches to a maximum of 1200 m, driven by ERA40 Reanalysis, based on Partridge (1997)

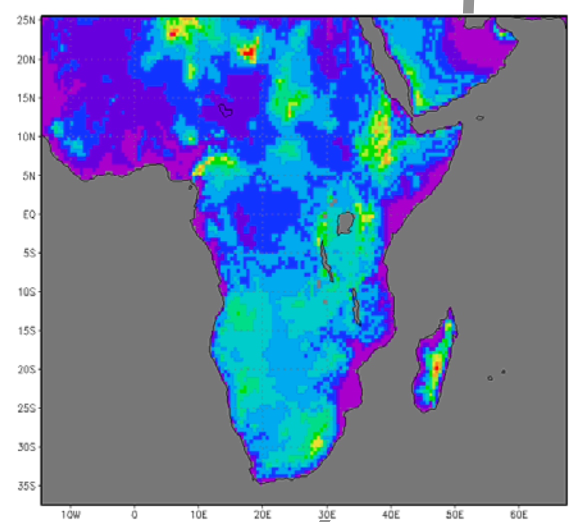
2.50%: topography of the whole Southern and Eastern Africa reduced by 50%, driven by corresponding ECHO-G simulation



present-day topography



„no peaks“

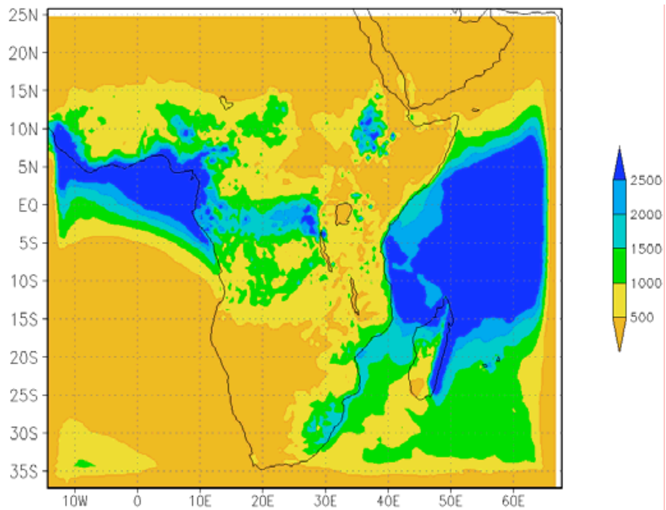


50%

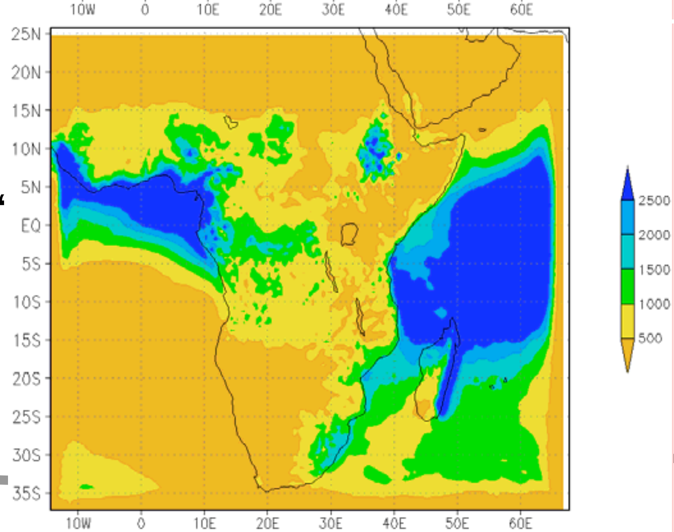
„no peaks“ (mean over 7 years)

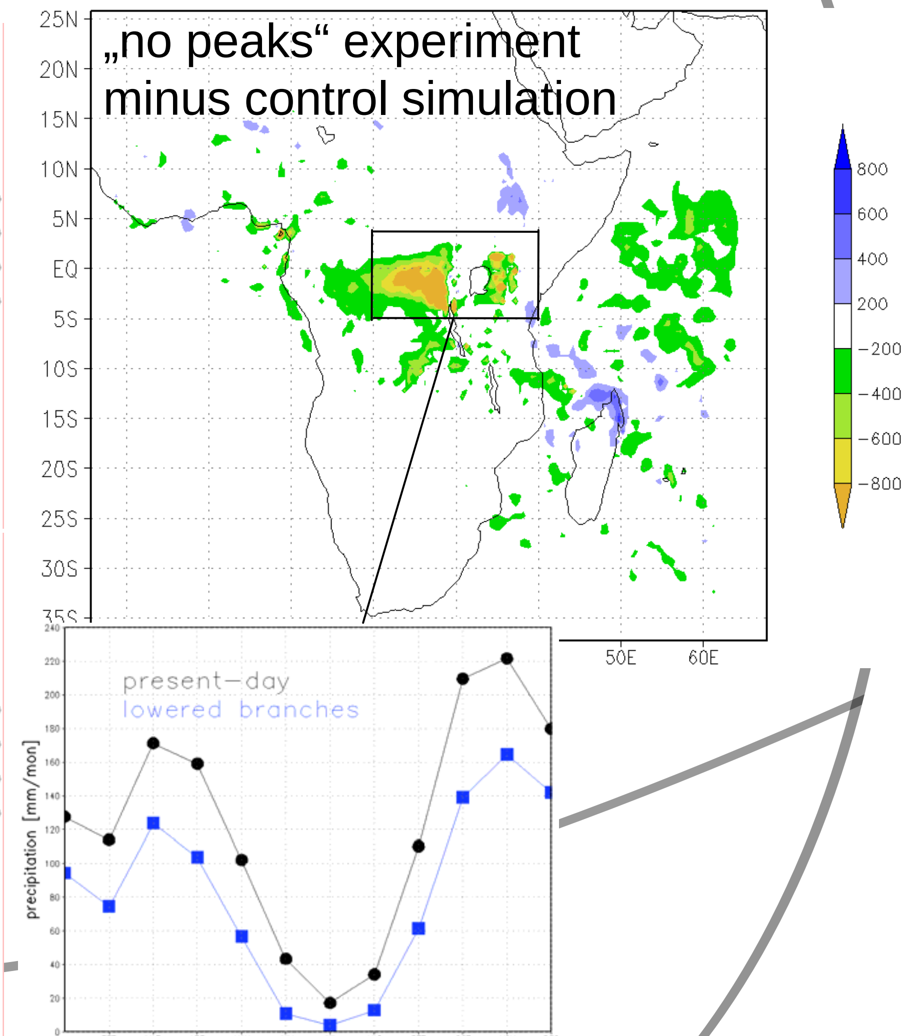
Decrease west (windward) of the lowered branches during the whole year

control simulation

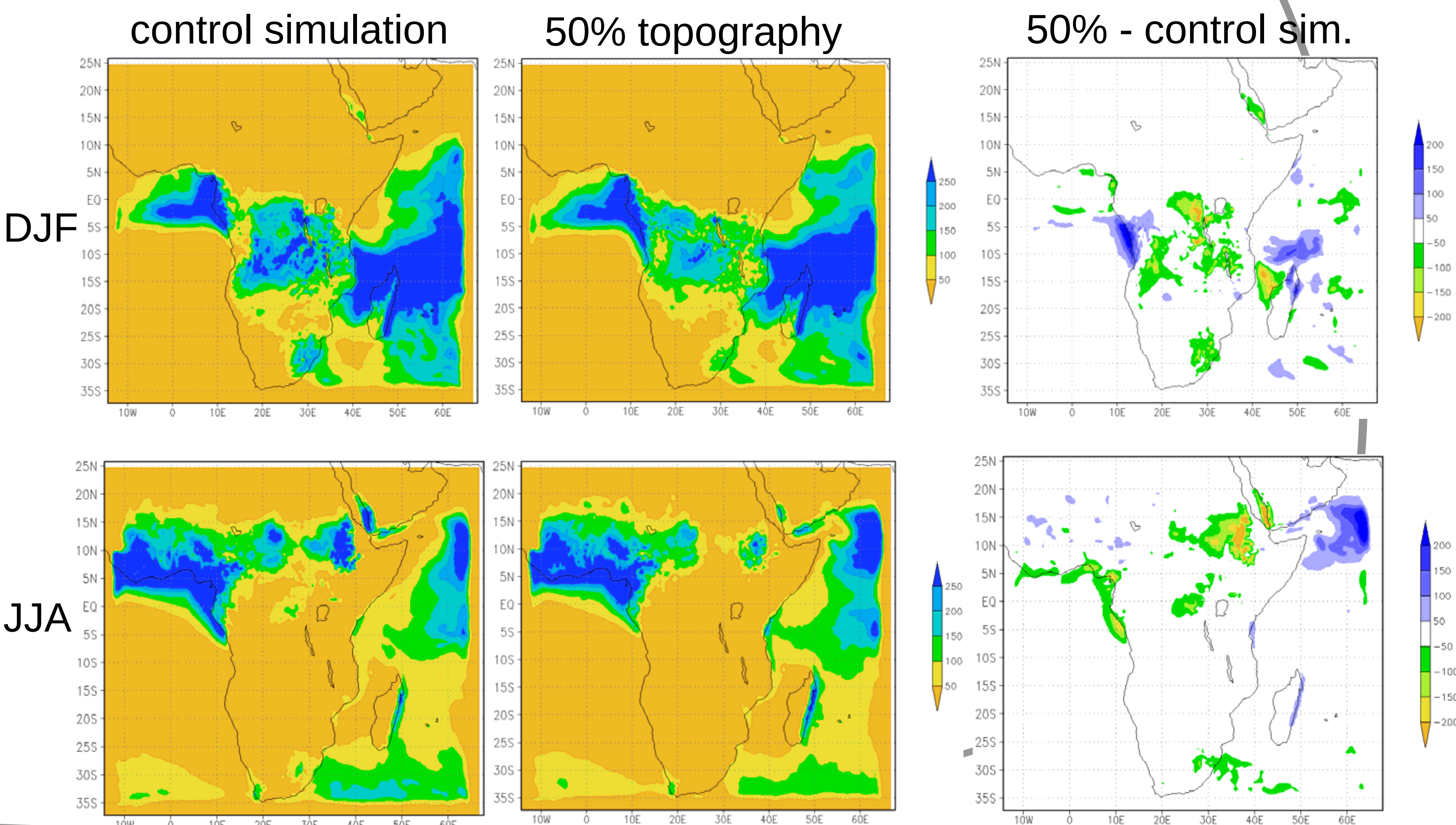


„no peaks“

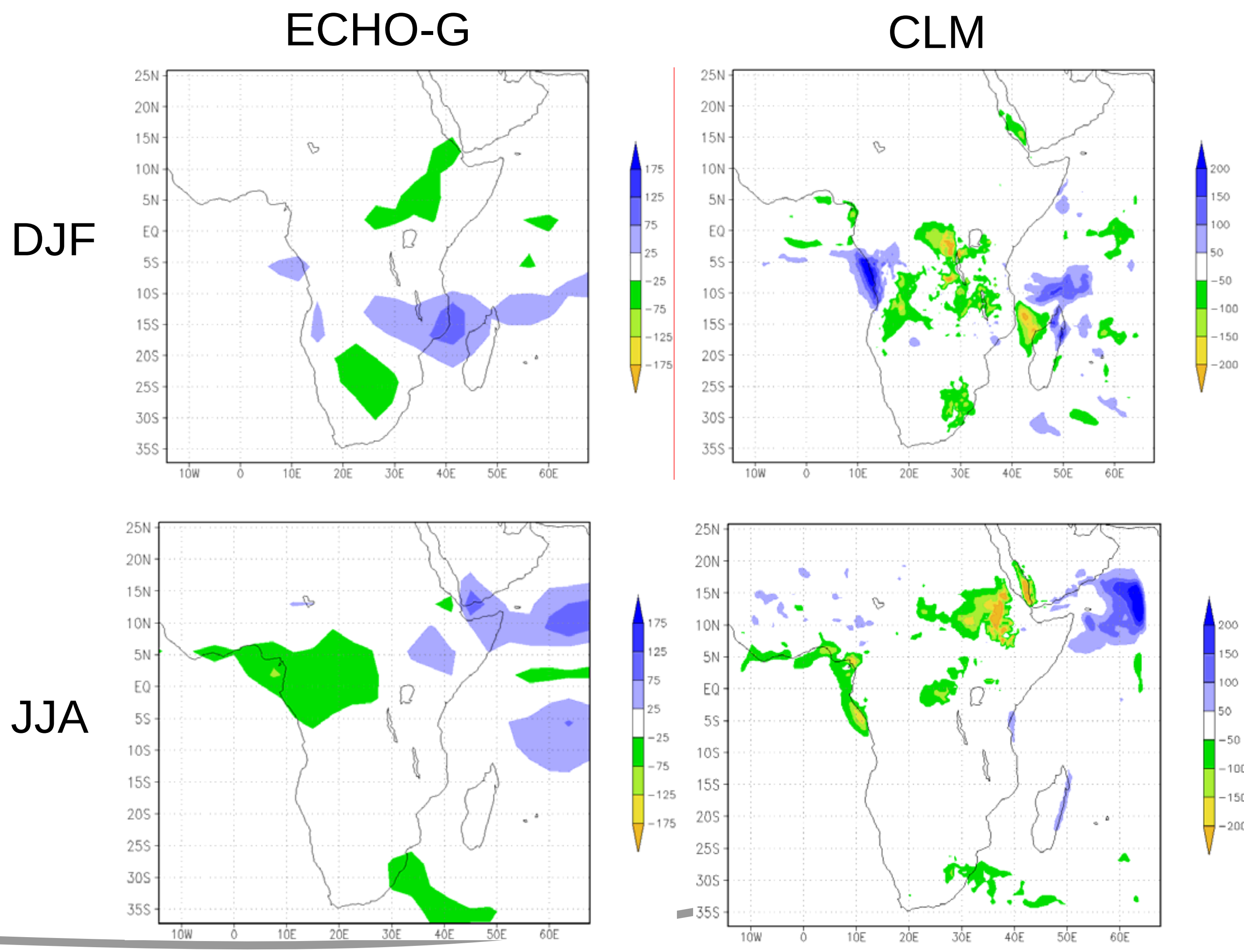




50% Topography (mean over 10 years)



Comparison to driving ECHO-G simulation

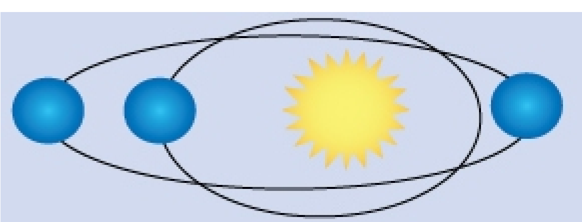


Orbital forcing

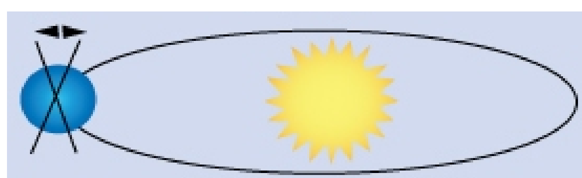
Implementation of an orbital routine in CLM (as in ECHO-G) by Frank Kaspar to adapt the orbital parameters to the desired time slice:

```
&PHYCTL
        ...
        lpalorb=.true.
           recc=0.040013,
           robld=23.7942,
           rlonp=127.274;
/END
end_input_phy
```

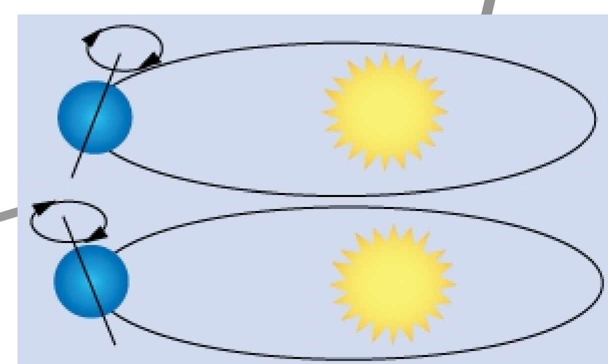
Eccentricity



Obliquity

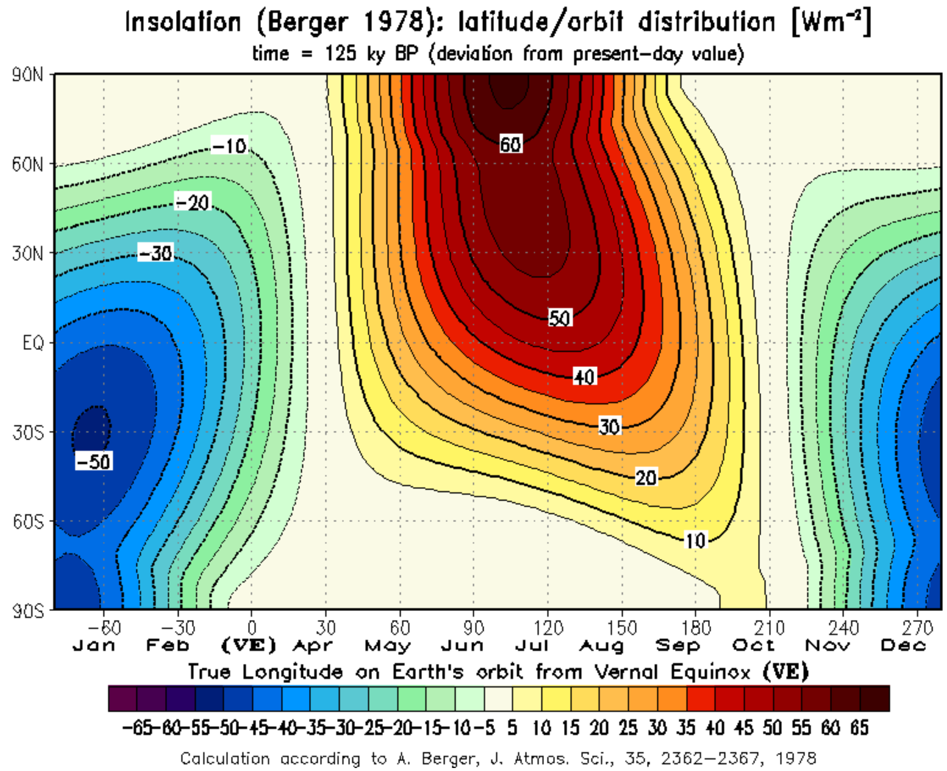


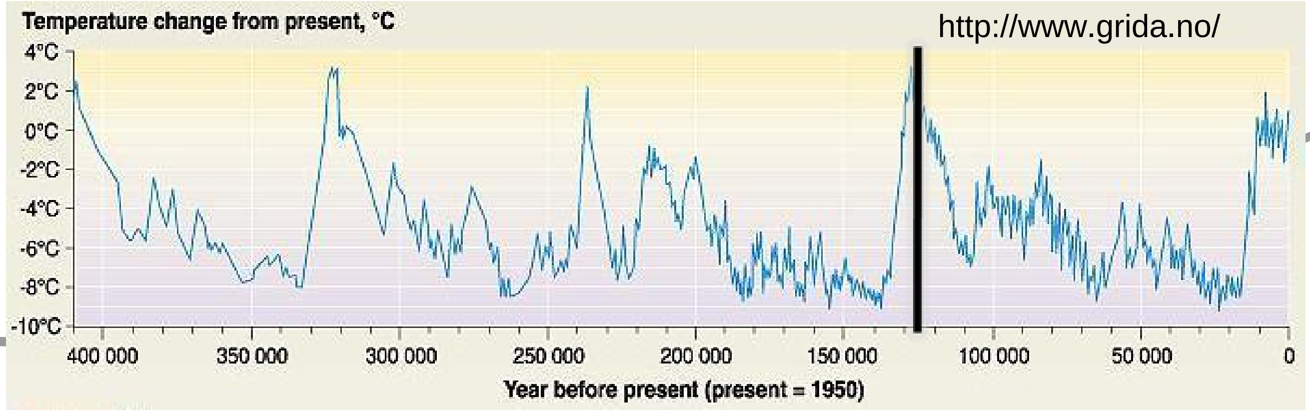
Precession



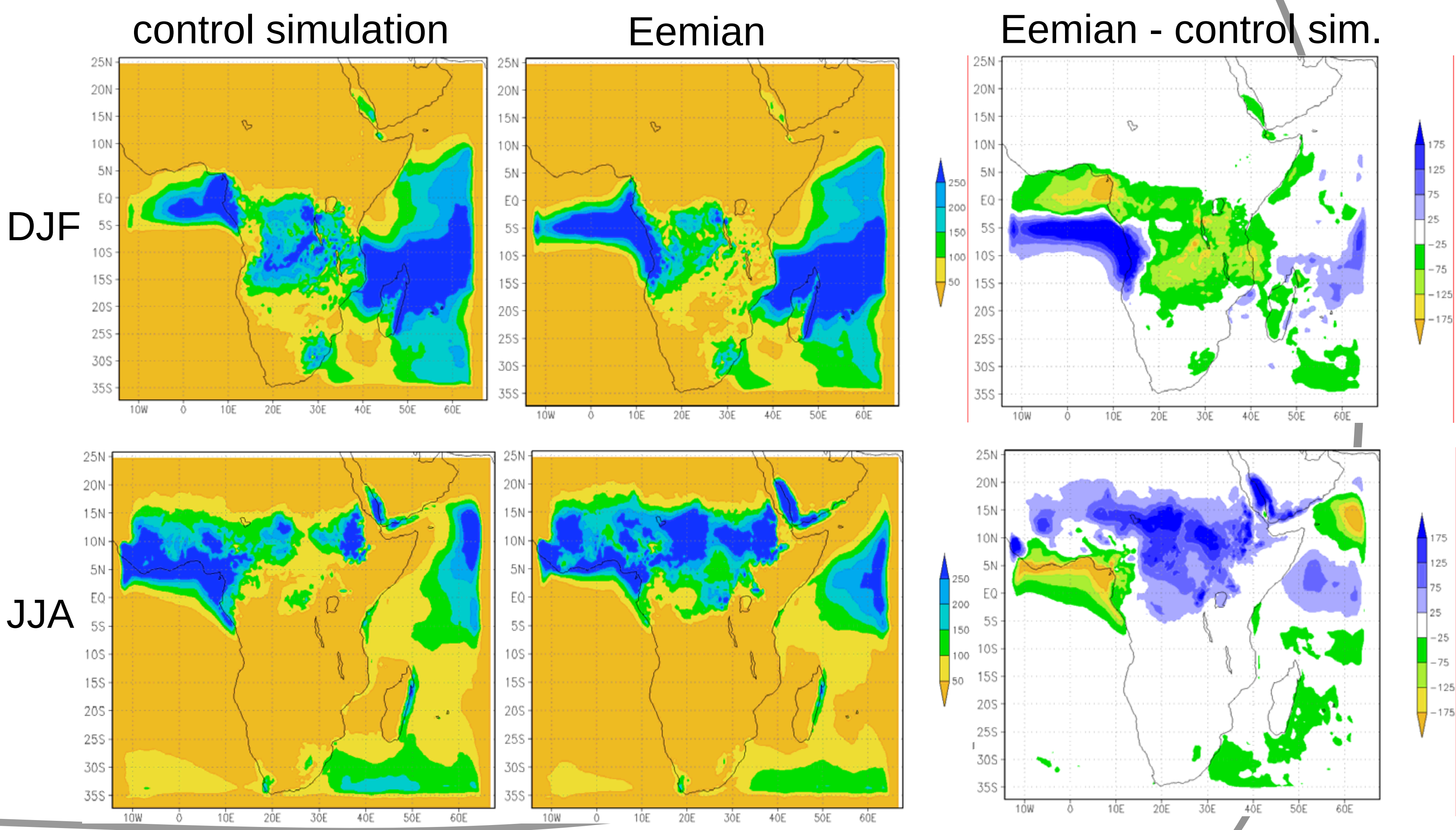
Eemian interglacial at 125 ka BP

insolation compared to present-day

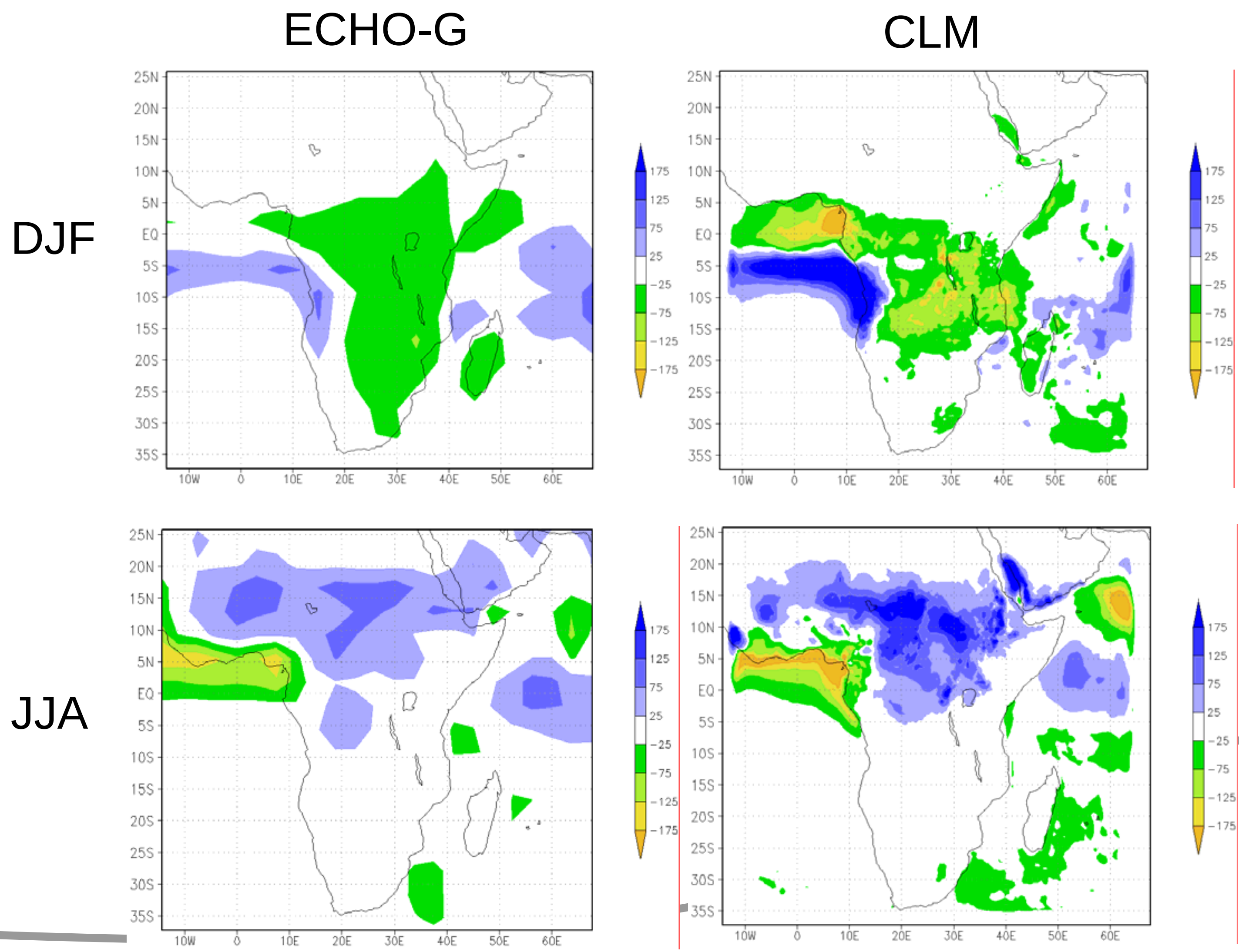




Eemian (mean over 30 years)



Comparison to driving ECHO-G simulation

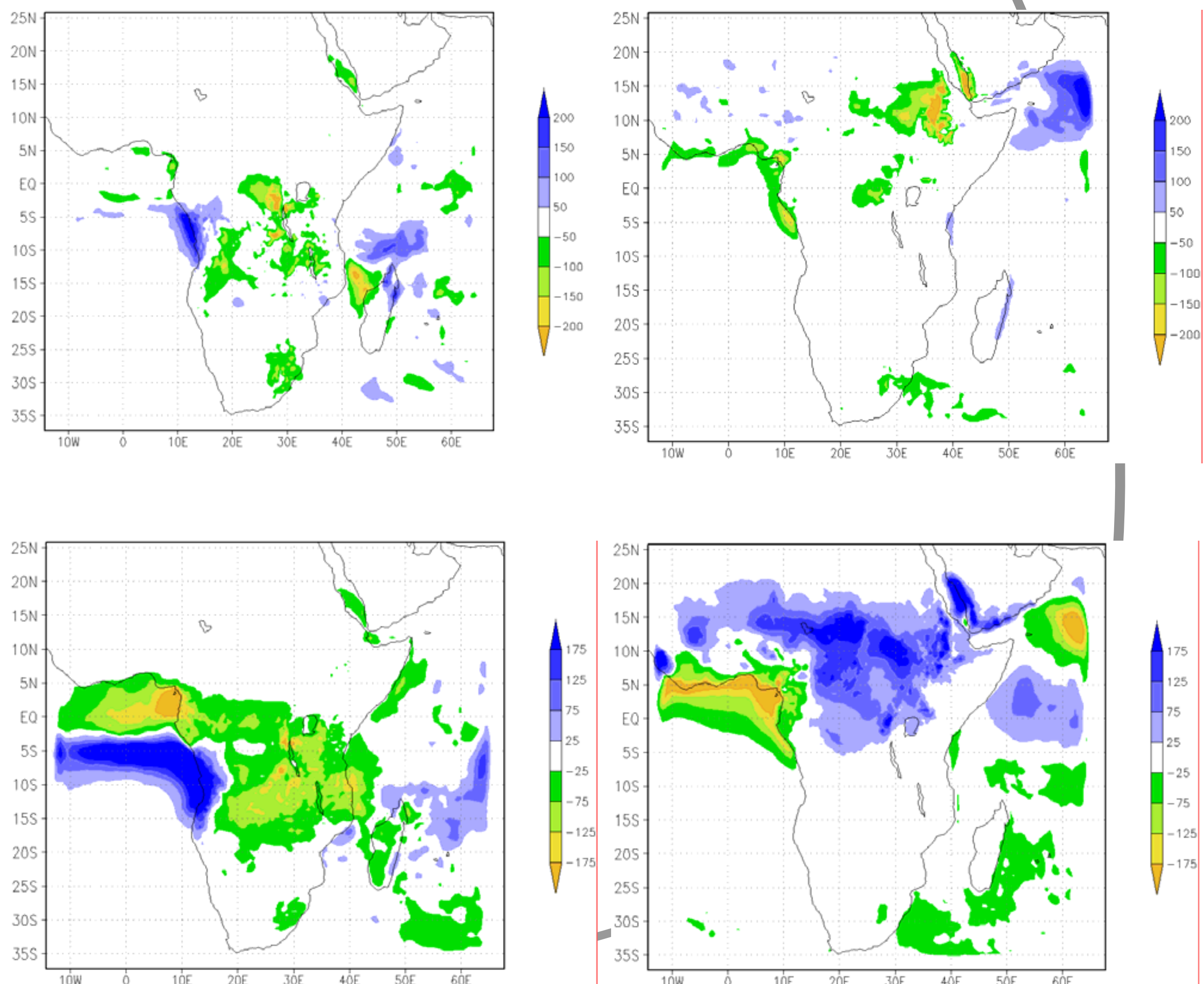


Comparison between tectonic and orbital forcing

DJF JJA

tectonic focing
50% topography minus
control simulation

orbital forcing
Eemian minus
control simulation



Summary

The tectonic forcing represented in the model by changes in topography has an impact on precipitation in (Eastern) Africa windward of the mountains, mainly caused by the too strong orographic precipitation in CLM.

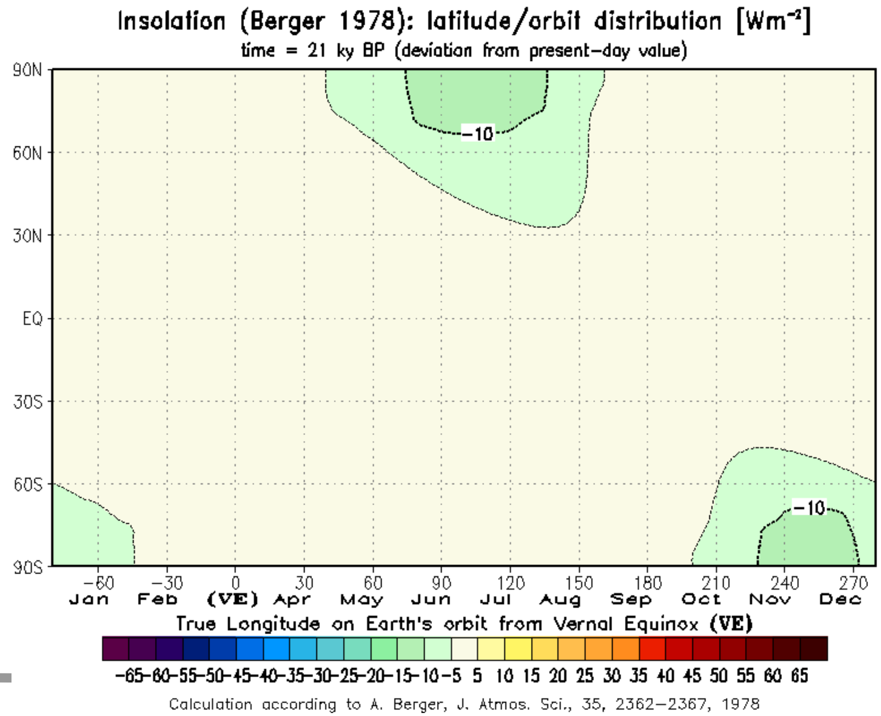
The implementation of an orbital routine allows paleo applications with CLM.

Using the example of the last interglacial (Eemian) the orbital forcing shows a strong impact on precipitation over large parts of Africa.

Both tectonic and orbital forcing have an impact on African climate, which is partly opposite to each other, and therefore needs to be taken into account for following time slice simulations.

Further steps

Sensitivity test of the impact of global ice volume:
21 ka BP (Last Glacial Maximum) with maximum extension of glaciation, orbital parameters very similar to present-day → analysis only of the impact of changing global ice volume



Further steps

Time slice experiments for different points in time:
Combination of different forcing factors (topography, ice cover, orbital parameters, land sea mask, vegetation, greenhouse gas concentration). Comparison to proxy data from project partners.
Time slice experiments = equilibrium simulations
Forcing factors are held constant, simulation runs until an equilibrium is reached (no trend)

3 Ma BP (middle Pliocene)
A lot of proxy data show a change in vegetation in Africa between 4 and 2 Ma BP indicating an aridification.

Different time slices during the Miocene (23 - 5.3 Ma BP)
Choice of time slices:
For which time slices do proxy data (from project partners) exist?
For which time slices do forcing data or global simulations exist?

Thank you for your attention