Project: 965
Title: Regional Palaeoclimate Modelling and Palaeoenvironmental reconstructions
Report for allocation period 01.01.2023-31.12.2023

During the year 2023, different research questions have been addressed by using computing time in the granted project. Several publications (submitted, envisaged) benefit from resources in project bb0965. Collaborations with people from AWI as well as external partners (University of Cologne, University Koblenz, University Budapest, RWTH Aachen) are ongoing concerning different aspects of regional paleoclimate simulations with high resolution.

a) Changes in atmopheric dynamics over Dansgaard-Oeschger climate oscillations around 40 ka and its impact on Europe

During the last glaciation, multiple intervals of abrupt warming (interstadials) followed by slower cooling into a stadial climate state culminated in further temperature drops. This millenial scale climate variability is called a Dansgaard-Oeschger cycle. In this study, we investigated the atmospheric changes during Greenland interstadial (GI) and stadial (GS) phases based on regional climate model experiments with the WRF model. For this, we used coarse (2.5°) global simulations by colleagues from AWI with GI-10, and GS-9 both around 40 ka and PI boundary conditions for downscaling with the WRF model to much higher resolution (1°) over the North-Atlantic realm.
First, we compared the regional simulations with available proxy data reconstructions and found that our simulations accurately capture the changes in temperature (see Fig. 1a) and precipitation. Further, we investigated the large-scale atmospheric dynamics and regional circulation. Under stadial conditions, the eddy-driven jet stream is intensified and shifted southward during winter with a tilt towards the northeast (see Fig. 1b). In accordance with these jet stream changes, the near surface circulation in western Europe exhibits more southwesterly/cyclonic flow types, which is in turn in agreement with the colder and drier conditions indicated by higher $\delta^{13}C/\delta^{18}O$ values in the Villars Cave proxy record. These heavier $\delta^{18}O$ compositions can primarily be explained by temperature variations, but may at least partly be accounted for different, more southerly moisture sources.

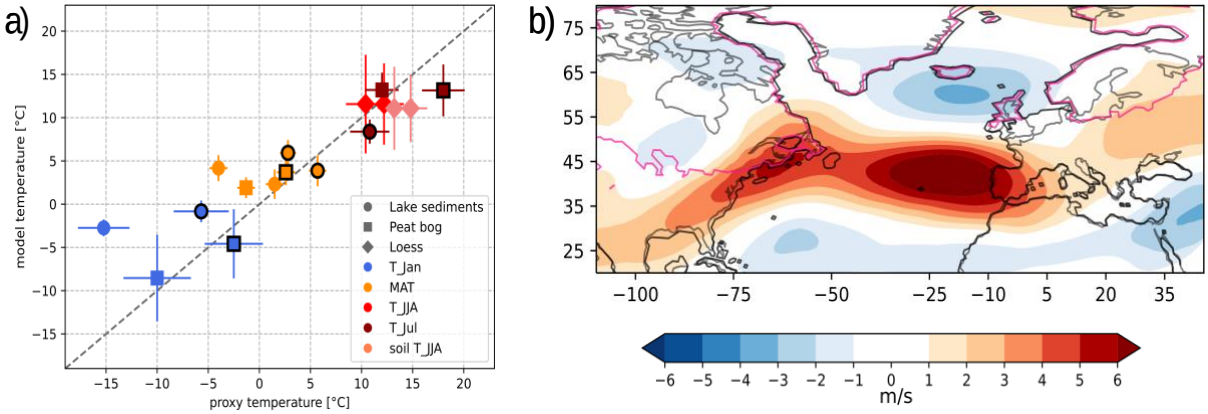

Figure 1: a) Comparison of modelled versus proxy-based temperature data. b) Differences of wind speed in 200 hPa in winter mean between the GS and GI regional simulations. Pink line denotes the GS ice sheet extent.

Stadelmaier, K. H., Ludwig, P., Pinto, J.G. and Ujvari, G. (2023): Changes in atmopheric dynamics over Dansgaard-Oeschger climate oscillations around 40 ka and its impact on Europe. JGR: Atmospheres (submitted).

***b*) Regional climate of the Caspian Sea region during the Last Glacial Maximum:**

The Caspian Sea is the world's largest inland water body and comprises several climate zones. It underwent multiple phases of regressions and transgressions with an amplitude of more than 100m during the last glacial cycle. Such different water levels lead to large variations in lake area and moisture availability in the atmosphere and thus also affect the regional climate. Loess-paleosol-sequences of the southern Caspian Sea show evidence of weakly developed paleosols that formed during MIS3/2 pointing towards a humid regional climate in contrast to an overall drier period of the climate of the Earth. The Caspian Sea in a transgression phase may have acted as a local moisture source.
This will be investigated with regional WRF simulations using PMIP4 output as forcing data. The first set of experiments was conducted this year, including MPI-ESM-LR driven PI and LGM simulations of the Pontocaspian region with 50 km and 12.5 km horizontal resolutions (see Fig. 2 for the simulated domain). Simulations under LGM conditions with two different water levels of the Caspian Sea are planned for 2024 (see application for 2024). Publications presenting the results of the simulations are envisaged for 2024.

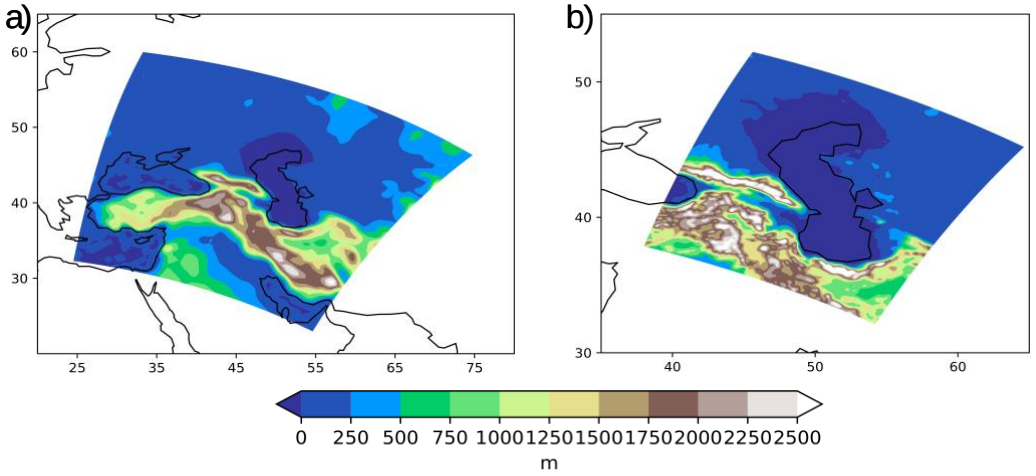

Fig. 2: Domain for regional PI and LGM simulations showing present day topography in the Pontocaspian region.