Project: **1023**

Project title: **Tipping Points of Lake Systems in the Arid Environments of Central Asia (Q-TiP)**

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The project Q-TiP aims to investigate the controls on water resources in Central Asia in order to improve our understanding of the mechanisms involved in the development of arid environments and their relevance for present-day and potential future climate change. For model experiments ECHAM5-wiso is used which is the 5th version of the General circulation model ECHAM with stable oxygen isotopes implementation. Using of this climate model allows us conducting high-resolution simulations for different time slices corresponding to key periods through the Neogene. In combination with regional climate model (WRF) experiments (the nested WRF simulations are handled by collaborators) and records from deep boreholes from the Qaidam Basin and Gaxun Nur Basin together woth geomorphological work from Gaxun Nur and Orog-Nur Basin, the ECHAM5-wiso simulations will allow us to answer the questions on the ability of lakes to sustain themselves in arid environments over long periods of time and on the tipping points leading to their disappearance.

A present-day high resolution (T159L31, ca. 0.8°x0.8° and 31 vertical levels, 6 hour output frequency) ECHAM5-wiso control simulation has been conducted for years from 1989 to 2001 according to the AMIP protocol. This simulation has been validated by observational datasets including NCEP/NCAR and ERA40 re-analyses as well as by local observations of $\delta^{18}O$ from GNIP stations and published isotopic data (Fig. 1).

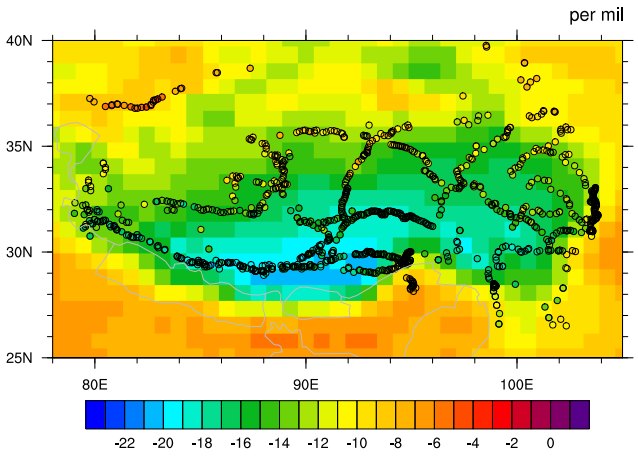

Fig. 1. Regional validation of ECHAM-wiso simulated precipitation $\delta^{18}O$ from present-day experiment (PD) against measured precipitation $\delta^{18}O$ (see the data compilation in Li and Garzione, 2017).

Furthermore, a high resolution (T159L31, 6 hour output frequency) simulation was conducted for boundary conditions of pre-industrial times and the Last Glacial Maximum. Pre-industrial (PI) ocean boundary conditions were taken from the AMIP2 data; boundary sea surface temperature and sea ice concentration were derived from a coupled atmosphere-ocean model ECHO-G (Lorenz and Lohmann, 2004) as described in Dietrich et al (2013).

Vegetation conditions for the LGM simulation has been constructed from PMIP (http://pmip2.lsce.ipsl.fr) data (Braconnot et al. 2007) and interpolated using vegetation model outputs (Arnold et al.2009). Green house gas concentrations and orbital parameter during LGM and pre-industrial times are based on Dietrich et al. (2013) and Otto-Bliesner et al. (2006). The pre-industrial simulation will be used as an additional

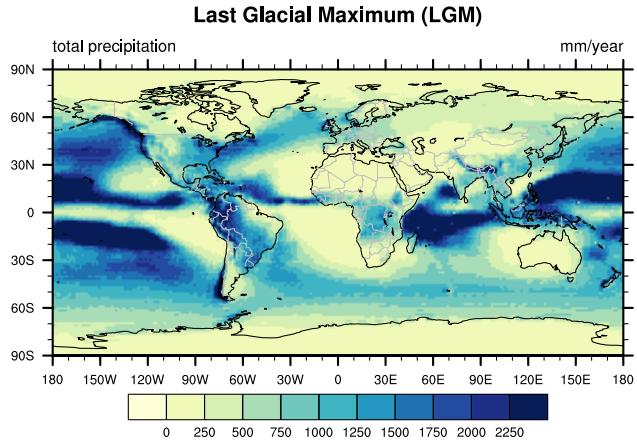

Fig.2. Annual mean precipitation of Last Glacial Maximum (LGM) time slices, mm/year

control experiment for all simulations to follow. Climate simulations for Pliocene and Miocene boundary conditions as well as sensitivity test simulations for different plausible vegetation and elevation scenarios for these time periods are currently prepared for running on DKRZ's Mistral. Results from the LGM simulation show significant differences atmospheric dynamic, precipitation patterns (Fig. 2) and other variables relevant for understanding the onset in large-scale aridity in the Asian regions (and therewith addressing major questions of the Q-Tip project).

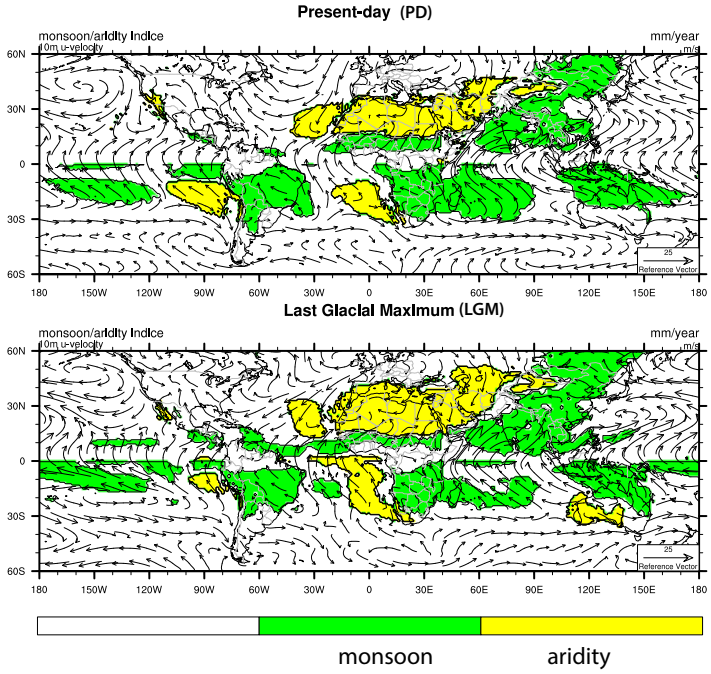

Fig.3. Global monsoon defined by the local summer-minus-winter precipitation rate exceeds 2 mm day^{-1}, and the local summer precipitation exceeds 55 % of the annual total (in green). Summer denotes May through September for the Northern Hemisphere and November through March for the Southern Hemisphere. The dry regions, where the local summer precipitation is less than 1 mm day^{-1}, are shown (yellow).

Global monsoon patterns have been analyzed for PD and LGM climates, based on commonly applied monsoon indexes (Wang et al., 2014). Fig. 3 shows an example of the monsoon seasonality index calculated for PD (top) and LGM (bottom) simulations. Despite lower annual precipitation over Asia for the LGM case, precipitation seasonality appears to be rather important. Study of the monsoon variability through time potentially can answer the questions on the changes of the hydrological budget in monsoon-neighbor regions such as Central Asia.