Coherent climate and vegetation changes in Indian and East Asian monsoon regions during the Quaternary: *Comparison of multi-proxy biomarker records from an east African lake and the Chinese Loess Plateau*

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Reference List & proxy calculations

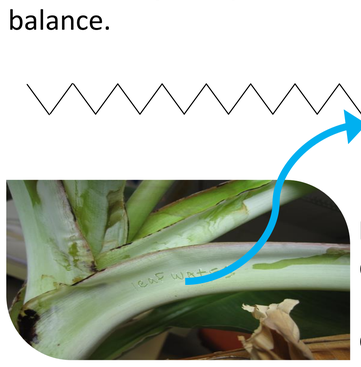
Background

Monsoons are a critical component of the global climate system, characterized by seasonal wind reversals and driven by the land-ocean temperature contrasts. The Indian and East Asian monsoons are two of the strongest monsoonal systems which control the water supply to over one-third of the world's population. Under ongoing anthropogenic global warming monsoon intensity is predicted to increase[1]. However, recent instrumental data indicates that the climate in certain areas affected by the Indian and East Asian is becoming drier or more erratic[2,3]. Paleoclimate studies can reveal important insights into the hydrological cycle in the past, help us better understand current trends, and predict future changes.

Here, we compare two long-term terrestrial records for monsoonal climate variability from Lake Chala (equatorial east Africa) and the Chinese Loess Plateau (CLP; central China) over the past 130 kyr.

Methods

BrGDGTs (branched Glycerol Dialkyl Glycerol Tetraether lipids) are temperature and pH-sensitive soil microbial membrane lipids. BrGDGT-based soil pH represents the net moisture (precipitation-evaporation) balance.



Plant wax *n*-alkanes are resistant to degradation. Hydrogen isotopic values of plant waxes (δ^2H_{wax}) reflect the isotopic composition of moisture used for lipid synthesis.

Study sites

Lake Chala is located just south of the equator at the base of Mt Kilimanjaro[4]. The region has a bimodal rainfall pattern because the Intertropical convergence zone passes overhead 2x per year driving the Northeasterly and Southeasterly Indian Monsoons.

Yuanbao is located at 2177m on the western CLP (with a mean annual temperature of 4 °C[5], and mean annual precipitation of 500 mm), under the influence of the East Asian Summer Monsoon (EASM) and the East Asian Winter Monsoon (EAWM)[6].

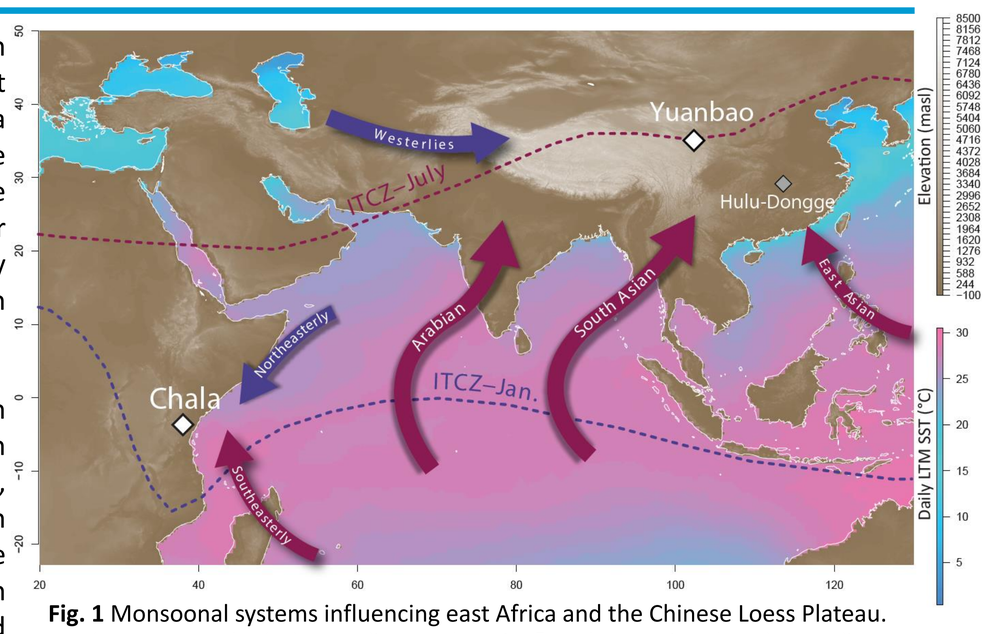


Fig. 1 Monsoonal systems influencing east Africa and the Chinese Loess Plateau. Landmasses are shaded according to elevation[7] and ocean is colored according to long term mean (LTM) daily sea surface temperature[8].

RESULTS

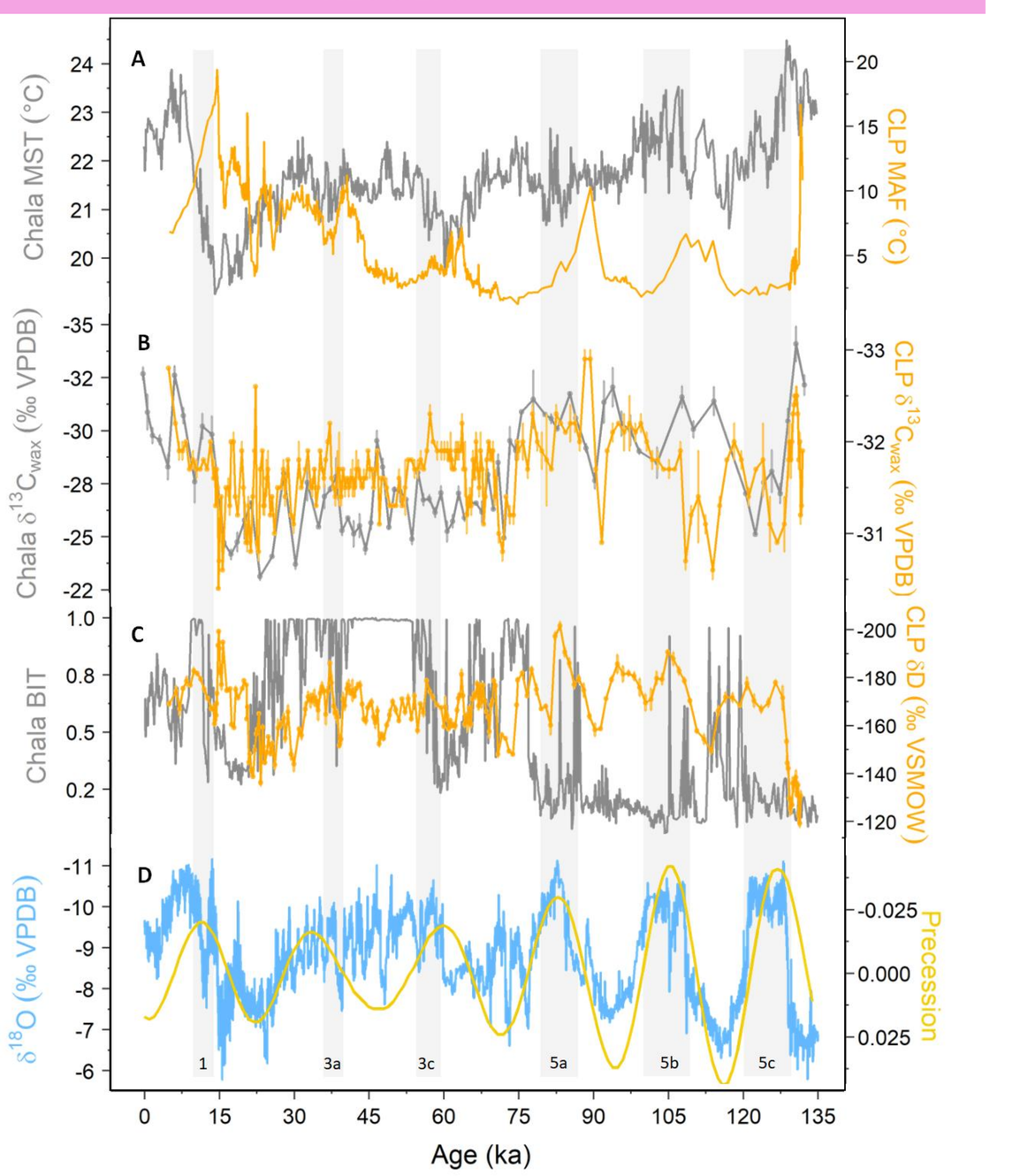


Fig. 2 (A) BrGDGT-based mean summer temperature (MST)[9] in Lake Chala sediment (gray line) and mean annual temperature above freezing (MAF)[10] from Yuanbao in the CLP (orange line). (B) Leaf wax $\delta^{13}C$ based on C_{31} *n*-alkane[11]. (C) The branched and isoprenoid tetraether (BIT) index[12] reflect the moisture balance in Lake Chala, δD of leaf waxes[13] reflect the precipitation in the CLP. (D) $\delta^{18}O$ of stacked speleothem records from Hulu/Sanbao/Dongge caves (blue line)[14] and precession (yellow line).

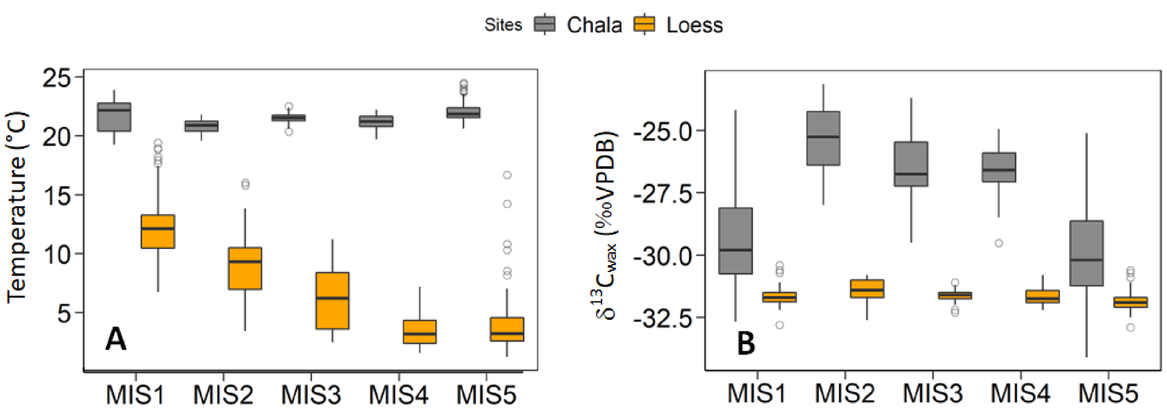


Fig. 3 Box plot of (A) brGDGT-based temperature and (B) Leaf wax $\delta^{13}C$ based on C_{31} *n*-alkane from the sediment core in Lake Chala and loess-paleosol sequence at Yuanbao in the CLP.

Astronomical cyclicities

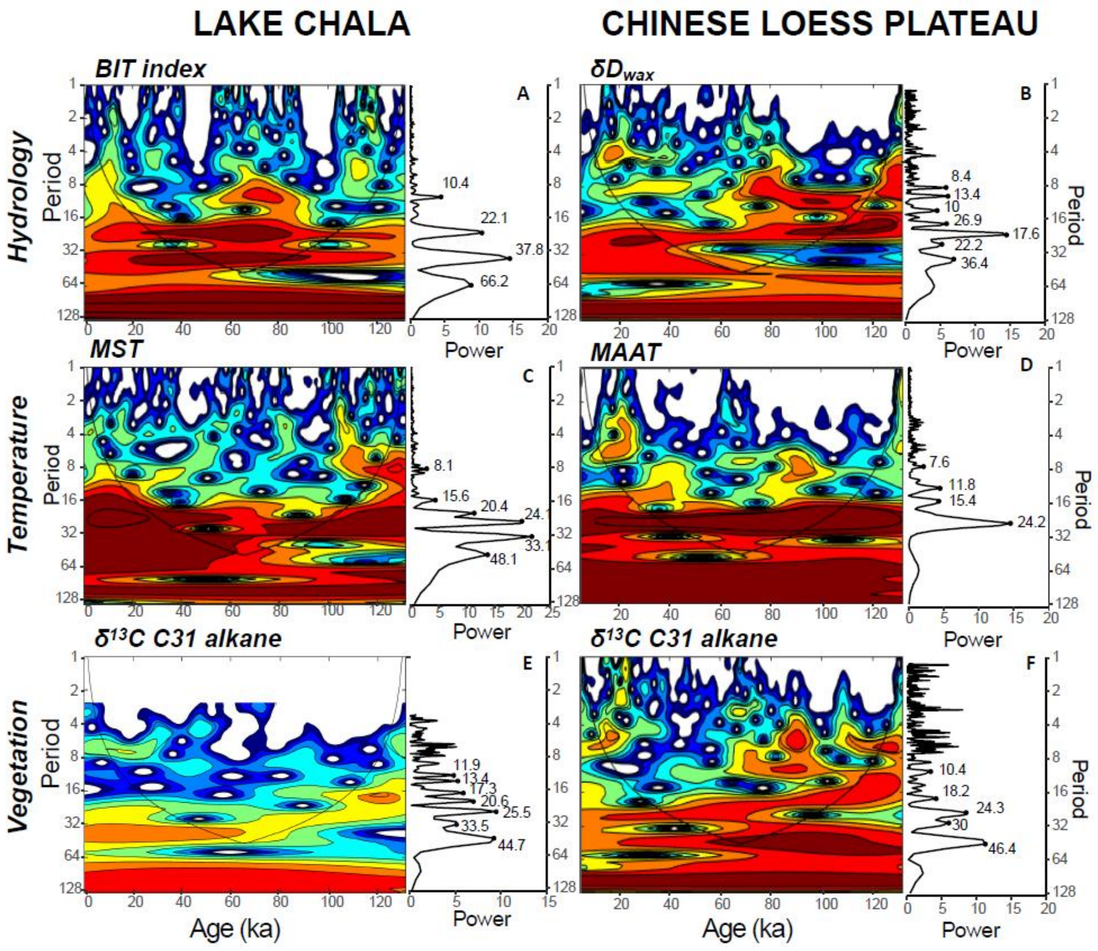


Fig. 4 Wavelets and Lomb-Scargle spectra of biomarker proxies at Lake Chala (left) and Yuanbao (right).

Key points

- Low-latitude insolation forcing has a strong influence on hydrology in both regions, resulting in the presence of both precession and half-precessional cycles, typical of (sub-) tropical regions.
- The influence of Northern Hemisphere climate events (e.g., Heinrich events) is reflected at both sites.
- The direct influence of orbital parameters on vegetation change is less clear, and likely vegetation type is controlled by several interacting factors, including water availability and atmospheric CO_2 concentrations.
- The moisture balance and vegetation proxies show a major transition around 75 ka for both sites which may correspond to differential behavior of monsoonal systems under interglacial versus glacial climate conditions and indicate coherent behavior of regional monsoons.

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