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A 25,000 years climate record from the East African equator: Half-precessional climate forcing and the history of temperature and hydrological change

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Particularly in tropical and subtropical regions, high-resolution climate records have demonstrated major variability in the hydrological cycle at orbital, millennial and sub-millennial time scales in the last 25,000 years. Geographical patterns of past climate change (from the equator to both poles, and among continents and ocean basins at similar latitude) at these various time scales hold the key to understanding the climate-dynamical processes governing them, and to resolution of longstanding questions about the relative importance of tropical and high-latitude climate dynamics in translating external climate-forcing mechanisms into regional climate variability. Currently, dynamical analysis of past tropical climate variability is being hampered by the fragmentary or poorly dated nature of available records from key continental regions, debate to what extent marine records are representative for climate history on the continents, and uncertainty about whether traditional isotopic tracers applied to tropical continental records mainly reflect temperature or hydrological change. What has been missing is a continuous, high-resolution climate record from the tropics that adequately separates the evolution of temperature and hydrological change, and covers

the period from the Last Glacial Maximum until the present with sufficient age control to establish supra-regional phase relationships in past climate anomalies at millennial and century time scales.

In this context, the EuroCLIMATE project CHALLACEA here presents a reconstruction of climate history on the East African equator, based on multiple proxy-indicator analyses in the sediment record of a permanently stratified crater lake (Lake Challa, a 4.2 km^2, 92 m deep crater lake on the lower East slope of Mt. Kilimanjaro, Tanzania) with stable physical limnology and sedimentation dynamics over the past 25,000 years. This has resulted in a unique combination of high temporal resolution, excellent radiometric (^{210}Pb, ^{14}C) age control, and confidence that the recording parameters of the climatic proxies (i.e. the relationship between climate change and its proxy signals extracted from the sediment record) have remained constant through time. The equatorial (3° S) location of our study site in East Africa, where seasonal migration of the Intertropical Convergence Zone spans the widest latitude range, provides unique information on how varying rainfall contributions from the Indian Ocean monsoons have shaped the region's climate history. The detailed reconstruction of the temperature and moisture-balance history of equatorial East Africa from before the Last Glacial Maximum to the present uniquely weaves together tropical climate variability at orbital, millennial and century time scales. The temporal pattern of reconstructed climate changes bears the clear signature of half-precessional insolation forcing of tropical monsoon dynamics on the East African equator, modified by high southern latitude influence on the timing of post-glacial temperature rise, and by high northern latitude influence on tropical hydrological variability at millennial and century time scales.