DEPARTMENT OF GEOLOGY, RENARD CENTRE OF MARINE GEOLOGY (RCMG)

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# A 25-KYR RECORD OF EAST AFRICAN MONSOON VARIABILITY: INSIGHTS FROM GRAIN-SIZE DISTRIBUTIONS AND END-MEMBER MODELING OF SILICICLASTIC SEDIMENTS FROM LAKE CHALA

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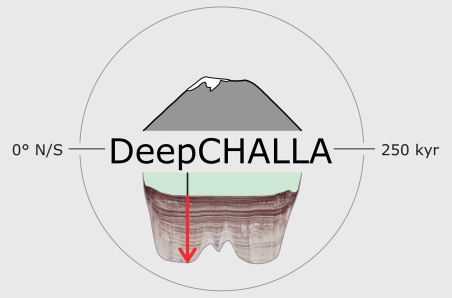
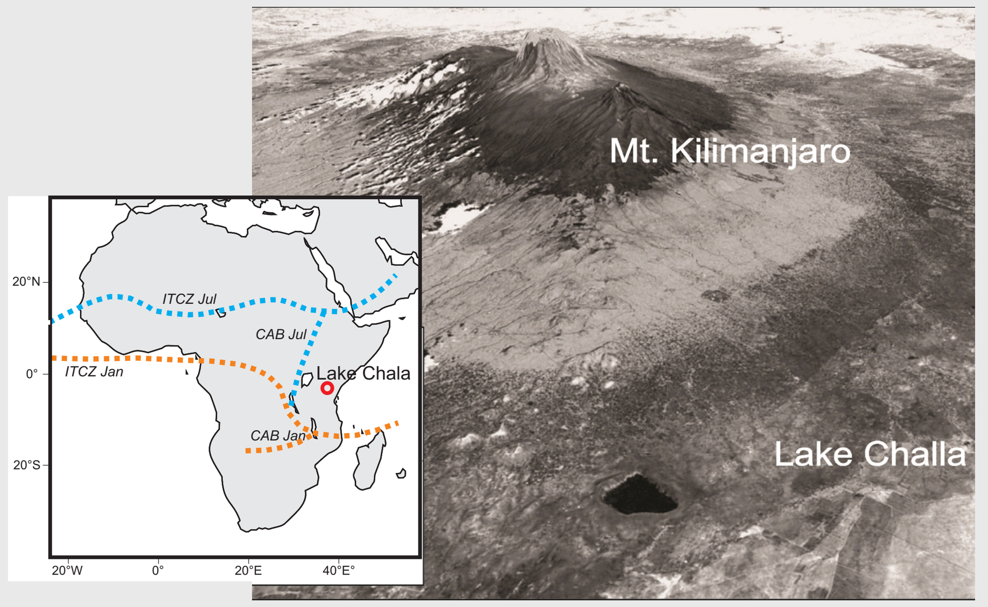



## Introduction

The clastic fraction of lacustrine sediments provide valuable information about the dynamics of sedimentation in lakes, and can be used to define distinct terrestrial source areas and transport mechanisms from source to sink.
However, terrigenous deposits typically represent a mixture of sediments with different provenances and supplied to the site by different processes, resulting in characteristic bi- or even polymodal grain-size distributions, which are challenging to interpret in terms of past climate or environmental conditions.
In this study we use grain-size analysis combined with end-member modeling of the clastic s fraction in the 25-kyr sediment sequence from Lake Chala, to reveal crucial aspects of climate-driven environmental change in equatorial East Africa since the Last Glacial Maximum.

## Lake Chala

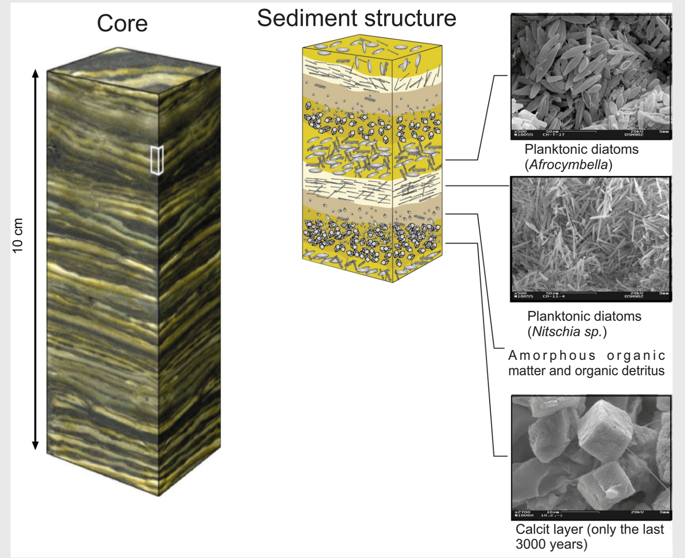
Lake Chala is a small freshwater lake (Kenya/Tanzania) filling a volcanic caldera basin on the lower eastern slope of Mt. Kilimanjaro. The lake spans a surface area of ~4.2 km² with water depth fluctuating between 92 and 98 m since 1999. The lake is surrounded by steep inner crater walls, reaching partly a height of 170 m above the modern lake surface, limiting the lake catchment area of the lake.




The proximity to the equator results in a bimodal rainfall distribution with rain seasons from October-December and from March to May
Due to its location east of the CAB, the influence of Atlantic-Ocean moisture is minimal in Lake Chala.

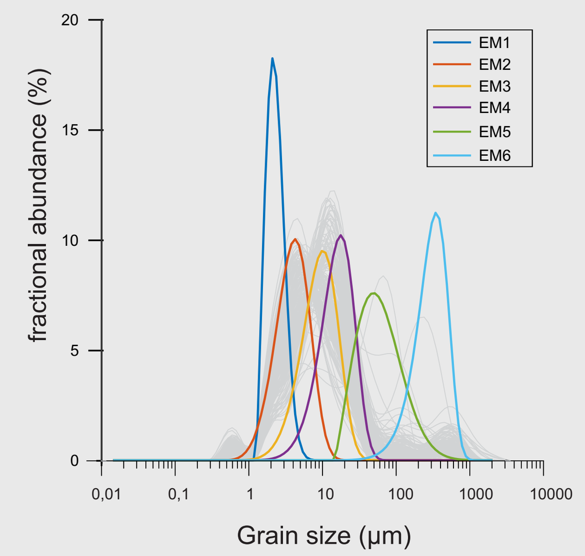
## Sediments

The Lake Chala sediment consists of varves, comprising a light-dark sediment couple.

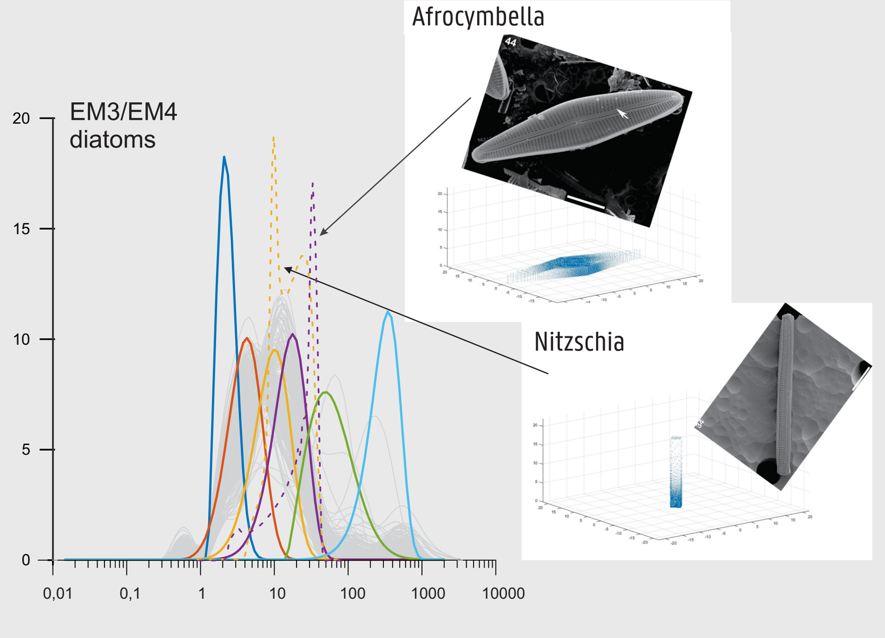



Microscopic examination revealed that dark layers consist of amorphous organic matter and fine-grained siliciclastics, with a minor occurrence of calcite crystals. Light layers are composed by diatom skeletons, which account for over 90% of the assemblage. Grain-size distributions of the isolated clastic sediment fraction was measured on a Malvern Mastersizer 3000.

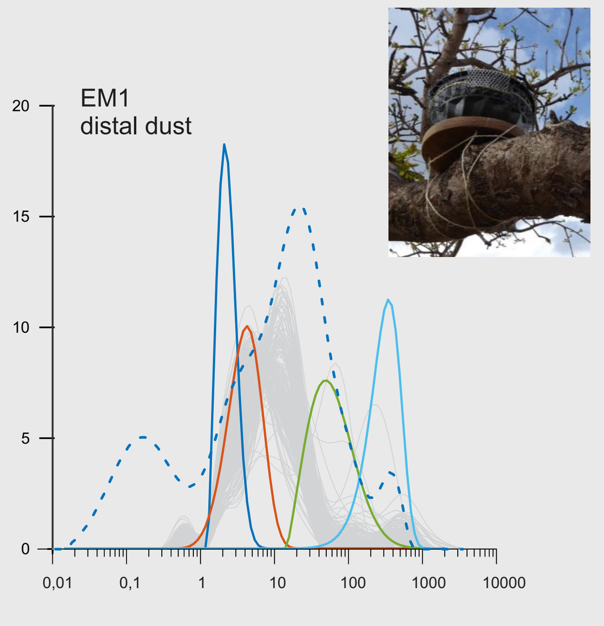
## Clastic end members



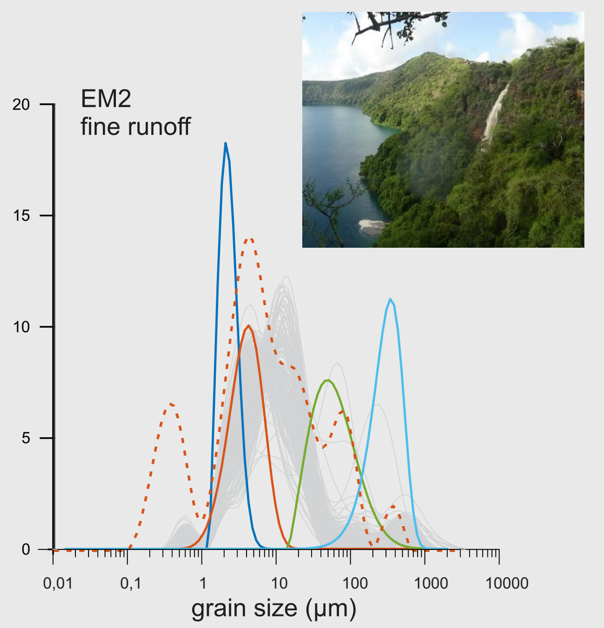

The polymodal grain-size distributions (grey background lines) were unmixed using the AnalySize model by Peterson and Heslop (2015). Six statistically independend end members were calculated.



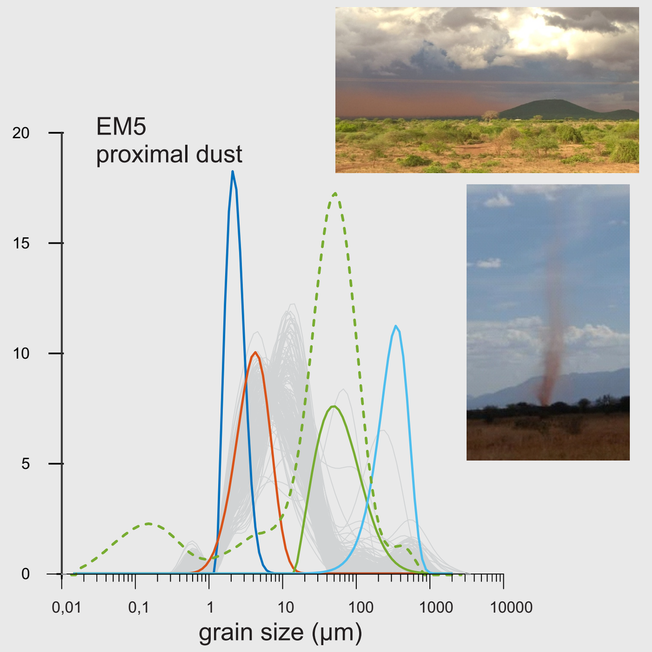

Despite chemical treatments microscopic investigations revealed the existence of high amounts diatom sceletons in the sediments. Simulated size distributions of both species (dashed lines) show an overlap with two modeled end members (EM3 & 4), which are therefore excluded from the following interpretations.



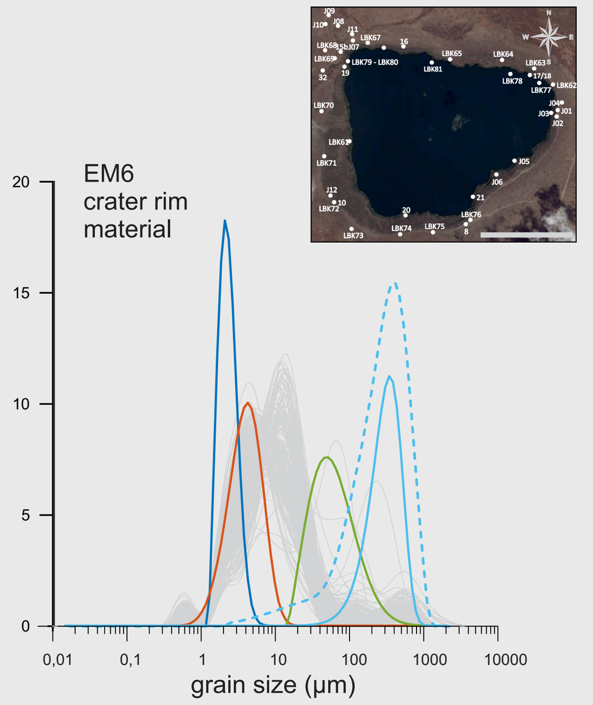

Em1 (blue solid line) is matching a robust shoulder at 2-3 µm, visible in present day dust samples collected in November 2016 (dark red dashed line). Therefore, EM1 is suggested to represent fine aelian dust from distal sources, i.e. the Horn of Africa.




EM2 (red solid line) represents fine soil run-off from the crater slopes. Short cores taken in front of a creek revealed high amounts of clay sized material. During periods of strong rain fall (already twice in 2020, see picture) the creek supplies fine sediments to the lake.

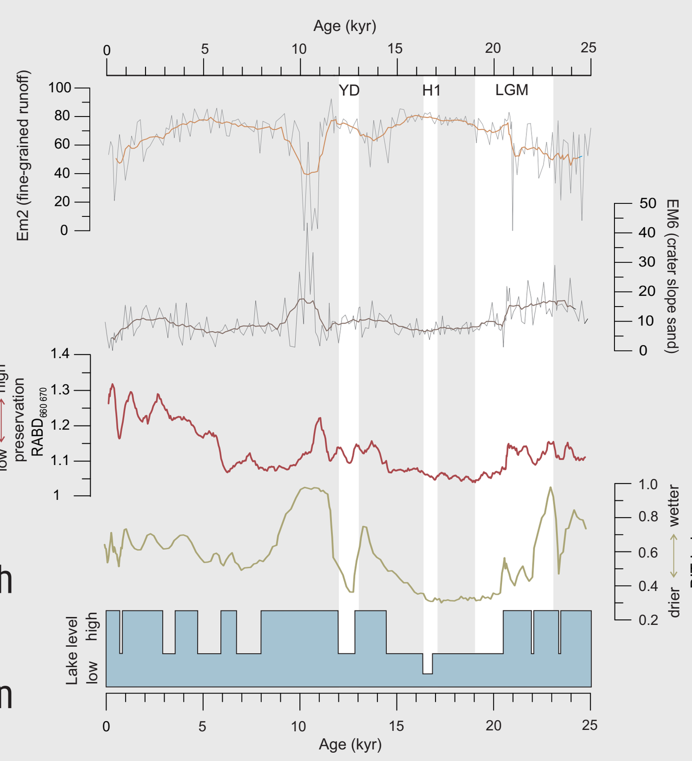



Similar to EM1 also EM5 is represented in the modern dust samples, with a peak at 60 µm. We suggest that EM5 pictures coarse aeolian dust transorted to the lake from proximal sources. Aeolian activity is a frequent process in the Lake Chala area.

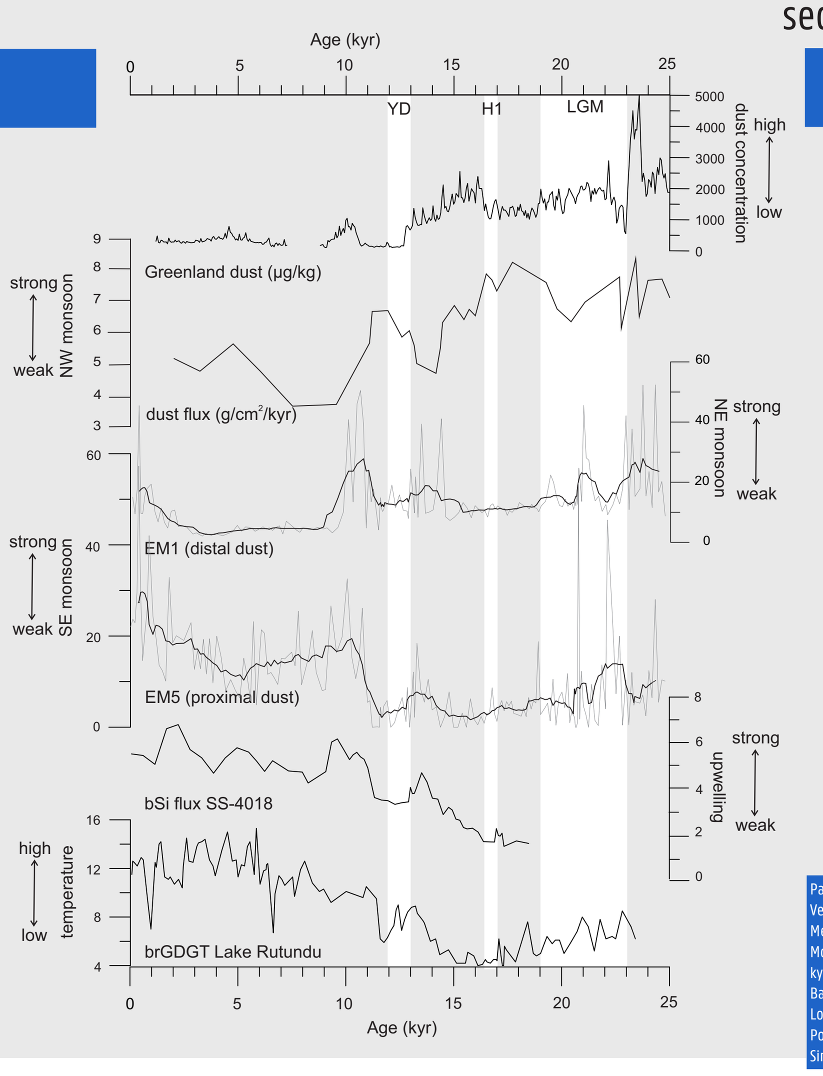



EM6 is the coarsest end member and is suggested to represent material originating from the steep crater rim surrounding the lake. Onshore samples from various sites of the rim show the occurance of similar grain sizes.

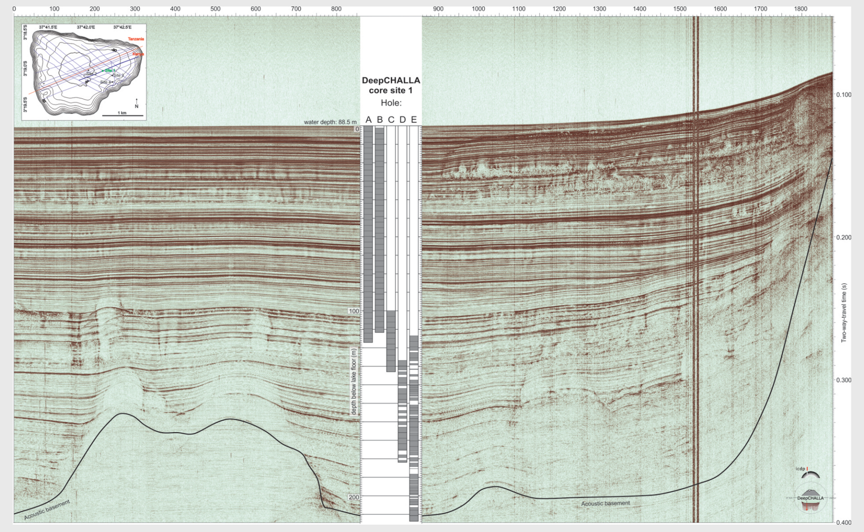
## Paleo-environmental interpretation




Temporal variations in the relative abundance of EMs 2&6 represent catchment erosion and run-off, is proven to be valuable tracers of changes in sedimentation dynamics, thereby assisting the interpretation of diverse other paleoenvironmental proxies extracted from Lake Chala sediments such as the reconstruction of organic matter preservation (Meyer et al., 2018). The BIT index/moisture reconsrtuction (Verschuren et al., 2009) and lake level reconstructions (Moernaut et al., 2010).
Temporal variation of EMs 1&5 representing distal and proximal dust, is shown to be a valuable indicator for past changes in monsoon circulation over equatorial East Africa, with EM1 representing NE monsoon strenght and EM6 representing the SE monsoon. During NH cold periods, such as the LGM, YD and H1, the ITCZ and associated wind systems were pushed southward, increasing the influence of NE monsoon winds in the Lake Chala area and advecting more fine dust from the Horn of Africa region. This is in line with increased dust fluxes, globally (Simonsen et al., 2019) and offshore Somalia (Pourmand et al., 2004). At the same time SE monsoon circulation was diminished due to a reduced pressure gradient between the East African land mass and the adjacent Indian Ocean. A EA warming trend (Loomis et al., 2017) and abrupt intensification of the SE monsoon at the onset of the Holocene is recorded by an abrupt increase in the amount of coarse dust delivered to Lake Chala, fitting with increased upwelling offshore Somalia (Balaji et a., 2018).




## ICDP DeepCHALLA



Given the exquisite combination of length, continuity and temporal resolution of the Lake Chala climate record, a follow-up project – the ICDP DeepCHALLA project - was successfully initiated. The ICDP field expedition took place in Nov 2016. During core opening in LacCore (University of Minneapolis) in March/April 2017 a composite core was established. Most parts of the sediment sequence show a continuous fine lamination. Currently the results of this study are applied on the 215-meter long ICDP DeepCHALLA core in the framework of a recently funded project by the Research Foundation Flanders (FWO).

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