GSA Data Repository 2017130

Title: Millennial-scale hydroclimate variations in southwest China linked to tropical Indian Ocean since the last glacial maximum

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1. Study Site

Lake Tengchongqinghai (TCQH, 27°25′ N, 98°34′E; 1885m asl) is a crater (maar) lake located in Tengchong County, Yunan Province, southwest China (Fig. 1 in the main text). It has a surface area of ~0.25 km^2 and a catchment area of ~1.5 km^2. The average depth of the lake is ~5.2 m with a maximum depth of ~8.1 m (Fig. DR1A). This small closed lake is mainly recharged by direct precipitation, groundwater, and surface runoff from the catchment basin, with no visible outlet. The lake is located in the drainage basin of Ruili River, which flows south-westward to the Irrawaddy River and ultimately flows into the Andaman Sea (Fig. 1 in the main text).

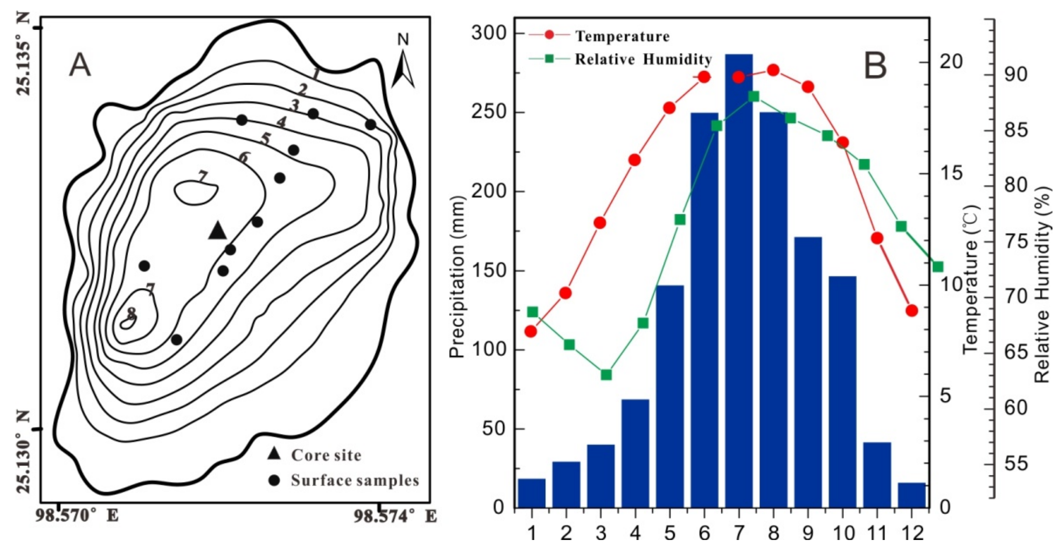

Fig. DR1. (A) Bathymetry map of Lake TCQH, southwest China. The coring location is shown as a triangle. Locations of surface samples for grain size analyses are shown as black dots. Water depths are shown in contour lines at 1-m intervals (E. Zhang et al., 2015). **(B)**. Monthly temperature, precipitation and relative humidity from 1951 to 2012 AD at nearby Tengchong meteorology station, ~30 km southwest of the lake.

This region is under the influences of the Indian summer monsoon with a strong precipitation seasonality. During the monsoon season from May to October, the region is hot and humid (Fig. DR1B). The mean annual air temperature is 14.7 °C, the mean annual precipitation is 1425 mm, and the mean annual relative humidity is 76.5% over the past 62 years (Fig. DR1B). The estimated annual evaporation is about ~1500 mm (E. Zhang et al., 2015).

The most common bedrock types in the catchment basin are andesite and basalt. Currently, the eutrophic lake is covered by submerged vegetation dominated by *Myriophyllum spicatum*, and *Trapa incisa* in the shallow part of the lake floor, and surrounded by forests in the catchment basin dominated by *Pinus*, *Castanopsis*, and *Quercus*.

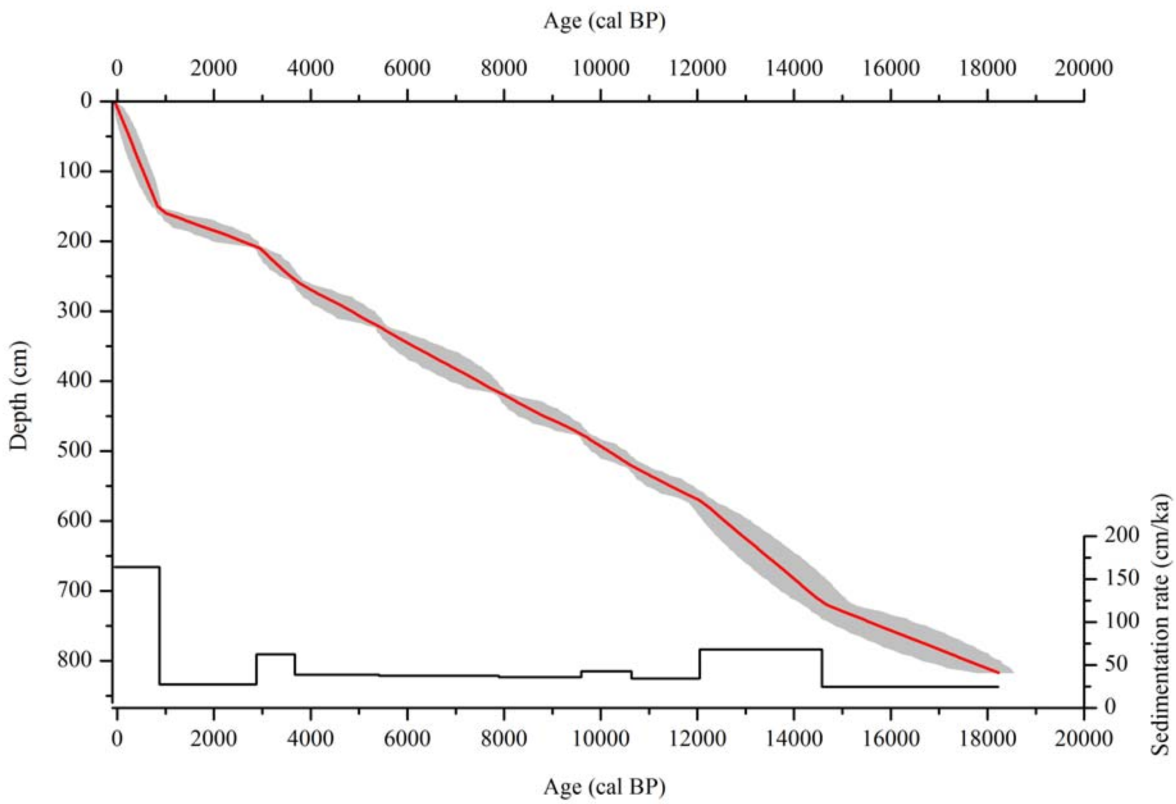

Fig. DR2. Age model and the sedimentary rate for core TCQH10-1 (E. Zhang et al., 2015). The age model is computed using the Bayesian approach taking sediment accumulation rates into account to construct the age-depth model (Blaauw and Christen, 2011). The shaded area indicates 2 sigma uncertainties.

2. **Chronology of Cores TCQH10-1 and TCQH10-2.**

Chronology of long core TCQH10-1 was controlled by AMS-^{14}C dating from terrestrial plant fragments at 10 intervals analysed by National Isotope Centre, Institute of Geological and Nuclear Sciences Ltd, New Zealand and Beta Analytic Radiocarbon Dating Laboratory. The ^{14}C dates were calibrated using IntCal09 dataset in R 3.1.0 program (Reimer et al., 2009; R Development Core Team, 2013). Age model was developed using a Bayesian approach with the Bacon program (Blaauw and Christen, 2011) (Fig. DR2). The age model has an averaged 2-sigma uncertainty of ±90 years for the Holocene (7 dates) and ±230 years for the last deglaciation (3 dates).

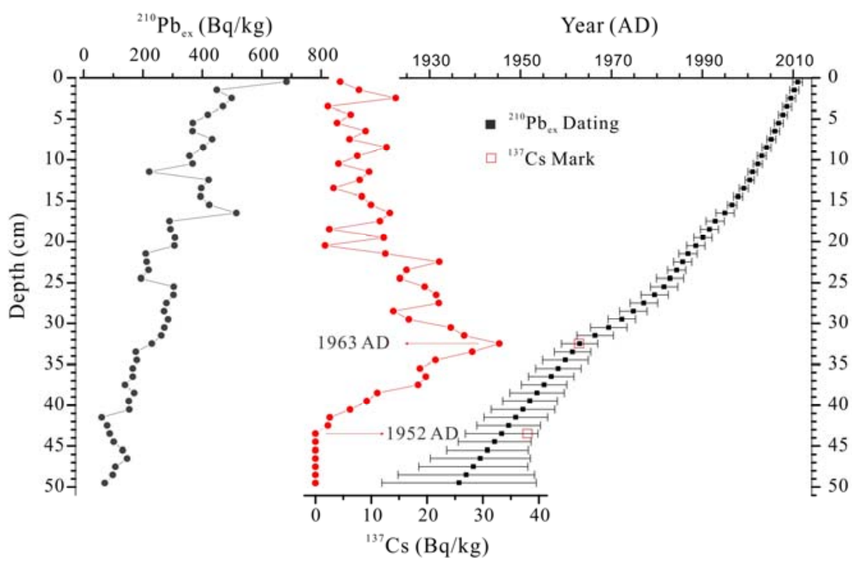

Fig. DR3. Age model and ^{210}Pb and ^{137}Cs results for core TCQH10-2.

The 50-cm-long core TCQH10-2 was collected 2 metres away from the long core TCQH10-1.The chronology was established using 210Pb and 137Cs analyses for the entire core at every 1-cm interval with a gamma spectrometer (Hyperpure Ge detector) at

State Key Laboratory of Lake Science and Environment, Nanjing Institute of Geography and Limnology, Chinese Academy of Science. The total 210Pb activity decreased exponentially with the depth of each interval (Fig. DR3). However, the equilibrium between total 210Pb and 226Ra activities was not reached at the bottom of the sediment core (Fig. DR3). Therefore, it is not appropriate to use the CRS model for the chronology construction. The 137Cs peak at 32 cm depth in the core should correspond to 1963AD (Fig. DR3), the year having maximum atmospheric nuclear weapon testing (Appleby 2001). Thus, the chronology of the core between 0 and 33 cm depth was constructed with the composite model using the 137Cs date as a marker, while the chronology below 33 cm depth was constructed with the CIC model (Appleby, 2001).

3. Correlation of Grain-size Data with Water Depth and Local Climate

We analyzed 11 surface sediment samples along a water-depth transect in Lake TCQH. The result shows that small grain-size (SGS) fractions (<16 μm) of these samples show the best correlation with water depth (r^2=0.82), which increase with increasing water depths (Fig. DR4). We interpret this relation as the result of hydrological dynamics within the lake (Dearing, 1997), rather than the catchment processes. When the lake is larger and deeper, surface runoff from the catchment basin brings detrital materials into the lake, and most of the LGS particles would be trapped in the shallow part of the lake by aquatic plants, resulting in fine sediments delivered through a long distance to the coring location at a low energy environment. With lake-level getting lower, LGS particles brought by surface runoff would easily get to our coring location near the lake center because of a short transporting distance and higher environmental energy, which would effectively dilute the SGS fraction.

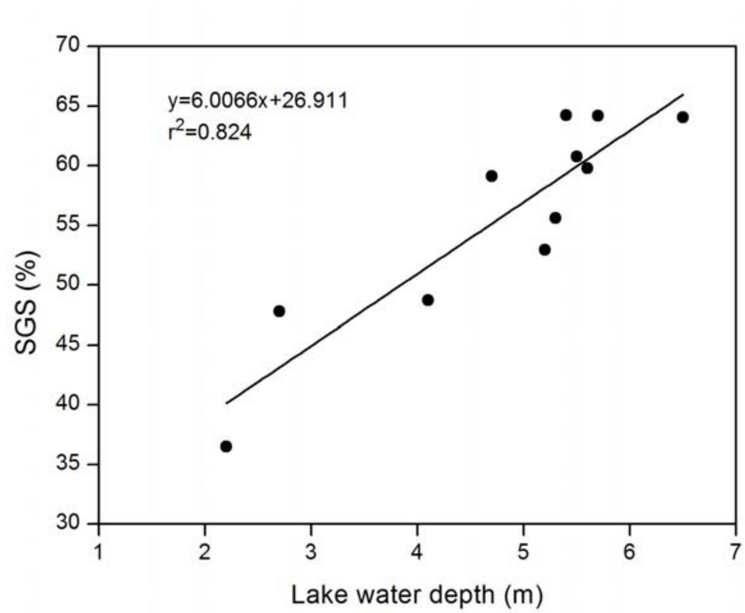

Fig. DR4. Relation between water depth and SGS of surface sediment samples. Analyses of 12 surface samples show that small grain-size fractions increase with water depth. The sampling locations for the 11 surface samples are shown in Fig. DR1B.

Grain-size analyses from the short core (TCQH10-2) show a decreasing trend in SGS and getting lower lake levels over the past 60 years at Lake TCQH (Fig. DR5A). This overall trend is consistent with the decreasing trend in relative humidity as indicated by the instrumental data at nearby Tengchong County (Fig. DR5B), but opposite with the increasing temperature (Fig. DR5C). Both lowering relative humidity and increasing temperature would effectively increase the evaporation, causing water loss from the surface of the lake and lower lake levels. Unfortunately, there is no historical lake level records available to confirm this relationship. There is no obvious relation between grain size data and local precipitations during this period (Fig. DR5D).

Other factors, such as human disturbance in the catchment basin and climate changes, would not affect the calibration between grain sizes and lake levels because of its closed-basin nature, a uniform lithology of the entire core, and the consistent patterns from multiple proxies from the entire long core TCQH10-1.

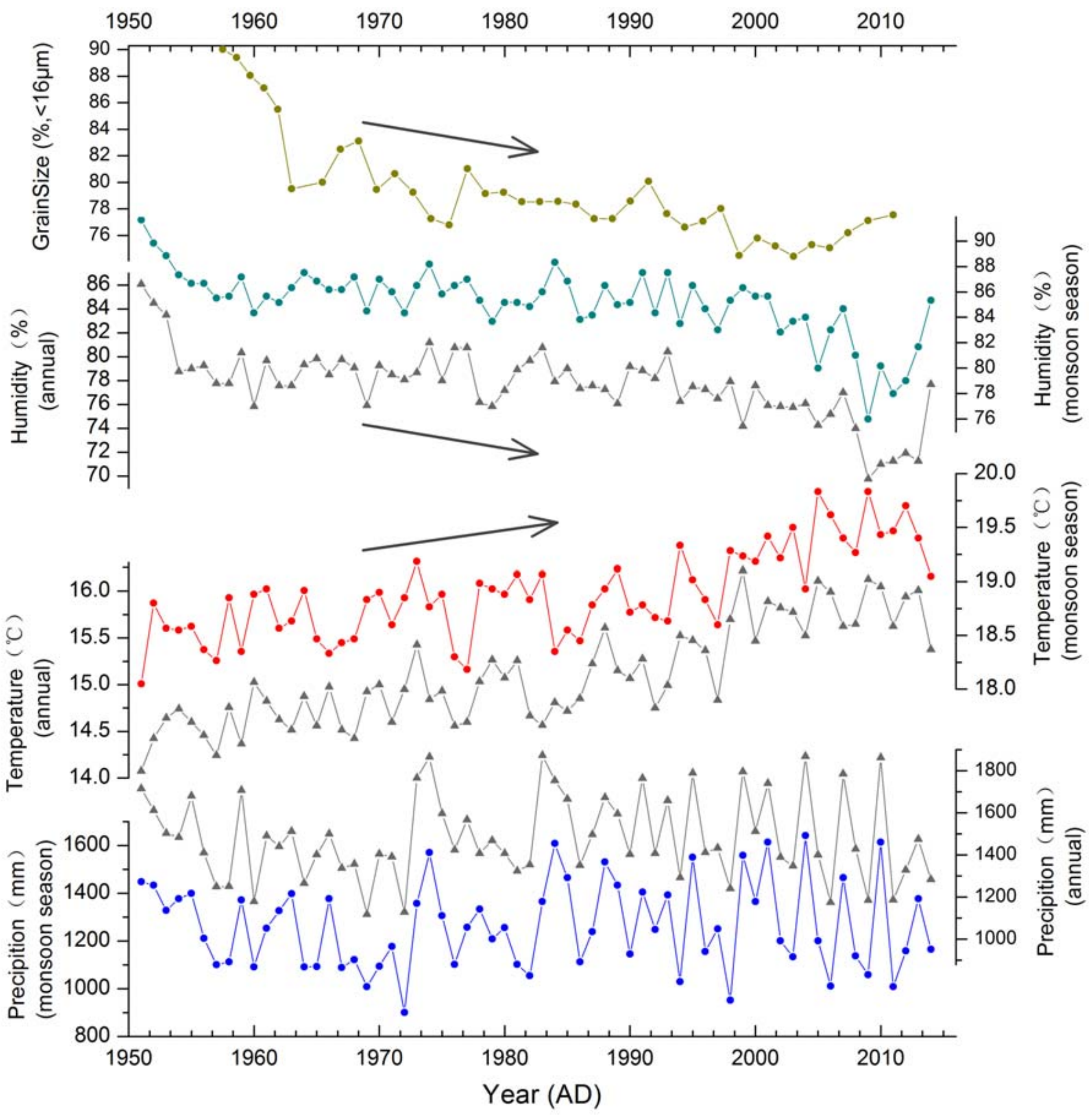

Fig. DR5. Relation between grain-size data from core TCQH10-2 and local instrumental data over the past 62 years, including SGS data (A) from core TCQH10-2, mean annual (grey) and monsoon season (green) relative humidity (B), mean annual (grey) and monsoon season (red) temperature (C), and mean annual (grey) and monsoon season (blue) precipitation (D) from nearby Tengchong meteorology station, ~30 km southwest of the lake.

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