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The first multi-proxy speleothem paleoclimate record from Georgia and calculations of temperature variations during the last ~ 13500 years

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The study of glacial to interglacial climate transitions is extremely important for understanding the full scale of climate variability from global to local scale. Unfortunately, there are large areas where multimillennial paleoclimate timeseries are unavailable. Southern Caucasus, is such a region as currently only a few continental climate time series extend beyond the short instrumental records. Importantly, temperature-related proxies are virtually absent here, thus impeding to evaluate how global-scale rapid climate instabilities propagate and impact this area. This work provides the first paleoclimate reconstruction from Georgia (Southern Caucasus) spanning approximately the last 13500 years. Four stalagmites named Zak-1, Zak-3, Zak-4 and Zak-6, measuring 46, 50, 55 and 102 cm respectively, were collected from the Zakariasklde Cave (42°10' N; 43°20' E). Dated by the U-Th method, Zak-1 was deposited between $3.1^{+0.04}/_{-0.03}$ to $0.32^{+0.46}/_{-0.44}$ ka (ka = kiloyears before 1950 AD); Zak-3 between $13.48^{+0.07}/_{-0.08}$ to $10.11^{+0.05}/_{-0.09}$ ka; Zak-4 between $12.01^{+0.08}/_{-0.09}$ to $9.73^{+0.53}/_{-0.61}$ ka; and Zak-6 between $8.77^{+0.07}/_{-0.08}$ to $0.71^{+0.16}/_{-0.13}$ ka, with a possible hiatus between $4.45^{+0.19}/_{-1.49}$ and $3.27^{+1.35}/_{-0.34}$ ka. Timeseries of $\delta^{18}O$-$\delta^{13}C$ from calcite show the main patterns of temperature variations during the last glacial-interglacial shift as well as throughout the Holocene, which mostly agree in pace and tempo with global records (i.e., Greenland ice and Atlantic/Mediterranean sediment cores). Then, $\delta^{18}O$-$\delta^{2}H$ from speleothem fluid inclusions (FI) are preliminarily applied to quantitatively calculate temperatures. Conveniently, FI resulted well aligned with the modern meteoric water line in Georgia, thus indicating that isotopic fractionation occurred during the karst flow-path and calcite precipitation was negligible. FI-derived temperatures document the effects of climate warming in Southern Caucasus related to the last deglaciation, with a ca. 4.5ºC increase of average temperatures from ~12 to ~10 ka. Paleotemperatures during the Holocene instead presents a gradual decrease of around 2ºC from ~10 ka to ~3 ka. This potentially supports the existence of a Holocene thermal maximum during the Early Holocene, which is still a matter of debate. However, calculation uncertainties make this finding debatable. The interpretation of the record is refined by considering changes of rainfall (e.g., amount, provenance/source and

seasonality) as well as soils (e.g., vegetation bioactivity). To comprehend the climate mechanisms of South Caucasus climate during rapid global instabilities, the Zak-timeseries is compared to the others from different climate regimes to advance the current characterization of regional climate shifts. Therefore, the results of this study certainly help to further investigate possible climatic teleconnections on a regional to global scale.