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Towards a 500 kyr record of tropical land temperature from fluid inclusion microthermometry in Borneo speleothems

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The advent of nucleation-assisted fluid inclusion microthermometry in speleothems (Krüger et al. 2011) opens new opportunities for accurate and precise reconstructions of land temperature in low latitudes. This physical approach, based on determination of liquid-vapor homogenization temperatures in fluid inclusions, does not need empirical calibration. Typical standard errors of the mean (2 SEM) resulting from measurements of 30-40 coeval fluid inclusions range between ~0.2 and 0.5 °C. In addition, the approach offers the rare opportunity to derive mean annual temperatures not affected by seasonal biases, due to year-round stable temperatures in the caves. However, the technique is limited to warm caves with temperatures above ~10°C and poses strict requirements on the samples in terms of calcite fabric and abundance and size of fluid inclusions.

Northern Borneo (4°N, 115°E) is situated in the heart of the Indo-Pacific Warm Pool, a major heat engine of the climate system. From this region, a set of well-dated speleothems covering the last half million years has previously been studied for hydroclimate reconstructions (Partin et al., 2007, Meckler et al., 2012, Carolin et al., 2013, Carolin et al. 2016). We are now revisiting these samples to generate a continuous land temperature record from this key area. Our data so far cover the last glacial termination (Løland et al., 2022) and several other terminations, interglacials, and glacials. We find glacial-interglacial changes in cave temperature of 4.4-5.4 °C, which reduce to 3.6-4.7 °C when correcting for sea-level induced changes in cave altitude. This amplitude is substantially larger than predicted by a transient Pleistocene simulation with CESM1.2 (Yun et al., 2023), suggesting either amplifying local factors not included in the model or a more general underestimation of the sensitivity of tropical temperatures to greenhouse and orbital forcing. The temporal evolution of Northern Borneo temperature for the most part follows the evolution of atmospheric CO_2, as previously observed with marine records, but with notable exceptions where insolation forcing appears to be the dominant factor. Our evolving temperature record thus sheds new light on the role and response of one of the major players in the climate system during glacial-interglacial cycles.

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