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# Northern Borneo stalagmite records reveal West Pacific hydroclimate across MIS 5 and 6

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ABSTRACT

Over the past decades, tropical stalagmite $\delta^{18}O$ records have provided valuable insight on glacial and interglacial hydrological variability and its relationship to a variety of natural climate forcings. The transition out of the penultimate glaciation (MIS 6) represents an important target for tropical hydroclimate reconstructions, yet relatively few such reconstructions resolve this transition. Particularly, comparisons between Termination 1 and 2 provide critical insight on the extent and influence of proposed climate mechanisms determined from paleorecords and model experiments spanning the recent deglaciation. Here we present a new compilation of western tropical Pacific hydrology spanning 0–160 ky BP, constructed from eleven different U/Th-dated stalagmite $\delta^{18}O$ records from Gunung Mulu National Park in northern Borneo. The reconstruction exhibits significant precessional power in phase with boreal fall insolation strength over the 0–160 ky BP period, identifying precessional insolation forcing as the dominant driver of hydroclimate variability in northern Borneo on orbital timescales. A comparison with a network of paleoclimate records from the circum-Pacific suggests the insolation sensitivity may arise from changes in the Walker circulation system. Distinct millennial-scale increases in stalagmite $\delta^{18}O$, indicative of reduced regional convection, occur within glacial terminations and may reflect a response to shifts in inter-hemispheric temperature gradients. Our results imply that hydroclimate in this region is sensitive to external forcing, with a response dominated by large-scale temperature gradients.



## 1. Introduction

The hydrologic response to anthropogenic $CO_2$ forcing in the Indo-Pacific Warm Pool, a densely populated region, remains highly uncertain. Ambiguity persists due to a combination of high natural variability in hydroclimate, the limitations of short instrumental records of precipitation, and climate model biases in the simulation of present-day rainfall distributions (e.g. IPCC AR5, 2013). Hydroclimate reconstructions spanning the middle and late Pleistocene provide an opportunity to test the influence of several different climate forcings on tropical hydrology, with implications for hydroclimate sensitivity to past, present, and future greenhouse forcing.

Several long, tropical paleo-hydrology records from across the globe reveal the strong influence of precessional (23 ky) insolation on tropical monsoon strength, with some of the earliest evidence coming from the Indian Ocean (Prell and Kutzbach, 1987). More recently, stalagmite oxygen isotopic records with excellent absolute age control from the tropical–subtropical regions of Indo-China and South America (e.g. Cruz et al., 2005; Wang et al., 2008; Cheng et al., 2013) have demonstrated strong precessional (23 ky) signals closely in phase with local summer insolation. These signals are likely related to large-scale, coherent shifts in regional

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