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Controls on Flood Event Frequencies Recorded in Stalagmites from Cave KNI-51, Australian Tropics

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Extreme rainfall events in the central Australia tropics are largely driven by tropical cyclones and the Australian summer monsoon, both of which are sensitive to external forcing. To better understand baseline variability in extreme rainfall, we produced a record of cave flooding events spanning the last two millennia from a suite of precisely-dated and fast-growing aragonite stalagmites from cave KNI-51 (Denniston et al., 2015, PNAS, 112, 4576). During cave flooding events, sediment deposited on stalagmite surfaces becomes preserved within the stalagmite when floodwaters recede and stalagmite growth resumes. Ages of individual flood events are determined using growth models constructed from linear interpolation of 230Th-dated intervals of stalagmite carbonate (2 s.d. errors of $\pm$1-30 yr in most cases). The robustness of this stalagmite flood record was tested, in part, by comparing accumulations of sediment layers in coeval stalagmites. Absolute values and temporal trends in flood recurrence rates were generally quite similar between stalagmites, arguing that each stalagmite was equally sensitive to flood events.

We have now extended this cave flooding record back to 3600 yr BP using three additional stalagmites, each of which contains multi-decadal to centennial variations in flood frequency. The longest duration (1000 yr) and tallest (1.1m) of these stalagmites, KNI-51-7, is marked by a secular trend toward reduced flood occurrence rates, with the 30 yr running mean of floods/yr reaching 0.0, a value lower than in any other of the other nine samples analyzed in this study. However, KNI-51-N, which overlaps with KNI-51-7 for 300 yr, contains nearly identical sub-centennial variations to KNI-51-7 but KNI-51-N does not trend toward lower values. We argue that the decreasing average number of flood events with time in KNI-51-7 is a result of the stalagmite having grown above average flood height, thereby restricting its ability to record more frequent, smaller events. These results suggest that the growth history of large stalagmites must be carefully considered when reconstructing cave flood activity.

Next, in order to assess the relationship between Australian summer monsoon activity and extreme rainfall, we compared temporal trends in stalagmite oxygen isotopic ratios with flood layer frequency. The oxygen isotopic composition of tropical stalagmites reflects that of regional precipitation which, in turn, is dominated by amount effects on rainfall. Consistent with the findings of Denniston et al. (2015), we find little covariance between flood event frequency and oxygen isotopic composition in most stalagmites, suggesting that the average strength of Australian summer monsoon precipitation is largely decoupled from extreme rainfall frequency at KNI-51. Thus, cave flooding may be related primarily to variations in the numbers and tracks of north-central Australian tropical cyclones, the primary source of the largest one, two, and three-day rainfall events in this region.