End of Green Sahara Responsible for Monsoon Failure and Societal Shifts in Mainland Southeast Asia

MICHAEL L. GRIFFITHS[1*], KATHLEEN R. JOHNSON[2], FRANCESCO S.R. PAUSATA[3], JOYCE WHITE[4], HONGYING YANG[2], GIDEON HENDERSON[5], CYLER CONRAD[6]

[1]Department of Environmental Science, William Paterson University, Wayne, New Jersey, 07470, USA (*correspondence: griffithsm@wpunj.edu)

[2]Department of Earth System Science, University of California, Irvine, 92697-3100, USA

[3]Department of Earth and Atmospheric Sciences, University of Quebec in Montreal, Montreal, Quebec, Canada H3C 3P8

[4]Institute for Southeast Asian Archaeology

[5]Department of Earth Sciences, University of Oxford, Oxford, OX1 3 PR, UK

[6]Department of Anthropology, University of New Mexico, Albuquerque, NM

The mid-to-late Holocene in eastern Africa and Eurasia was characterized by one of, if not the, largest climate anomalies of the past ~10,000 years (the '4.2 ka event'), yet the nature and geographical extent of this event, especially in mainland southeast Asia (MSEA), remains elusive. This is somewhat surprising given that this period also coincides with what has been termed the 'missing millennia' in MSEA, which refers to the dearth of archeological evidence that may have some link with the broader Asian monsoon failure during this time. Here we have compiled three new speleothem oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$) isotope records from Tham Doun Mai cave in northern Laos for the Holocene. The $\delta^{18}O$ profiles show a general increasing trend through much of the Holocene, which is interpreted to reflect an overall weakening of the Southeast Asian monsoon (SEAM). This general trend is punctuated by a marked positive $\delta^{18}O$ shift at ~4-5 ka, signifying an overall reduction in monsoon strength. Interestingly, it is also coeval with a cessation in speleothem growth for two speleothems and a ~5 per mil $\delta^{13}C$ increase for the speleothem that continued to grow, interpreted to reflect a marked reduction in cave recharge.

The onset of this abrupt 'megadrought' in northern Laos is consistent with abrupt cooling in the Indo-Pacific Warm Pool, and matches the timing of African monsoon failure during the termination of the Green Sahara. Using fully coupled ocean-atmosphere model simulations, we show that reduced vegetation and increased dust emissions (such as the case during the Green Sahara demise) cool the Indian Ocean and shift eastward the Walker circulation, causing a weakening of the Indian and southeast Asian summer monsoon systems.