EGU24-4596, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-4596
EGU General Assembly 2024
© Author(s) 2024. This work is distributed under
the Creative Commons Attribution 4.0 License.

A precipitation dipole between central Nepal and eastern India during the 4.2 ka event

Rhawn Denniston[1], Benjamin Tiger[2], Ethan Wimmer[1], Caroline Ummenhofer[3], Yemane Asmerom[4], Alan Wanamaker[5], Victor Polyak[4], Diana Thatcher[5], Ashok Gurung[6], and Surya Thapa Magar[7]

[1]Cornell College, Geology, Mount Vernon, United States of America (rdenniston@cornellcollege.edu)
[2]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, United States of America (tigerb@mit.edu)
[3]Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, United States of America
[4]Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico USA
[5]Department of Geological and Atmospheric Sciences, Iowa State University, Ames, Iowa USA
[6]Community Support Group, Pokhara, Nepal
[7]Tanahun District Government, Nepal

Over the late Holocene, a variety of hydroclimate-sensitive proxies have identified substantial, multidecadal changes in Indian summer monsoon (ISM) precipitation, the most prominent of which is the “4.2 ka event”. This interval, dated to ~4.2-3.9 ka, is associated with severe droughts across South Asia that are linked to societal change. Given the absence of the 4.2 ka event in polar records, the 4.2 ka event is generally associated with low latitude forcings, but no clear consensus on its origins has been reached.
We investigated the ISM response to the 4.2 ka event through analysis of aragonite stalagmites from Siddha cave, formed in the lower Paleozoic Dhading dolomite in the Pokhara Valley of central Nepal (28.0˚N, 84.1˚E; ~850 m.a.s.l.). The climate of this region is dominated by small monthly variations in air temperature (21±5˚C) but strong precipitation seasonality associated with the ISM: ~80% of the annual 3900 mm of rainfall occurs between June and September. High uranium and low detrital thorium abundances in these stalagmites yield precise U/Th ages that all fall within stratigraphic order. These dates reveal continuous growth from 4.30-2.26 ka, interrupted only by a hiatus from 3.27-3.10 ka. Overlap with coeval aragonite stalagmites reveals generally consistent trends in carbon and oxygen isotope ratios, suggesting that these stalagmites reflect environmental variability and not secondary (e.g., kinetic) effects.
Many stalagmite-based paleomonsoon reconstructions rely on oxygen isotope ratios, which track amount effects in regional rainfall. However, our on-going rainwater collection and analysis program, as well as a previous study conducted in Kathmandu, 120 km the east of Siddha cave, reveals that amount effects in precipitation are weak in this region, particularly during the monsoon season, and thus we rely instead on carbon isotope ratios, which have been demonstrated to track site-specific effective precipitation. Siddha cave stalagmite carbon isotopes, in contrast to other South Asian proxy records, indicate that ISM rainfall increased at Siddha cave

from 4.13-3.91 ka. As a further test of this result, we analyzed uranium abundances in the section spanning 4.3-3.4 ka. Uranium serves as an indicator of prior aragonite precipitation and thus of hydroclimate, and like carbon isotopes, suggests increased ISM rainfall coincident with the 4.2 ka event.

This precipitation anomaly is nearly identical in timing and structure but anti-phased with stalagmites from Mawmluh cave, northeastern India. We investigated the climatic origins of this precipitation dipole using observational data from the Global Precipitation Climatology Centre (GPCC) and Hadley Center Sea Ice and Sea Surface Temperature (HadISST) products. Preliminary spatial composites suggest that large precipitation differences between Mawmluh and Siddha caves are associated with SST anomalies in the equatorial Pacific. Additionally, superposed Epoch Analysis shows relatively rapid eastern Indian Ocean cooling during the summer monsoon season coeval with large precipitation differences between these sites. Our findings lend support to a tropical Indo-Pacific origin of the 4.2 ka event.