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600 yr High-Resolution Climate Reconstruction of the Atlantic Multidecadal Oscillation deduced from a Puerto Rican Speleothem

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A multi-proxy speleothem study tracks the regional hydrological variability in Puerto Rico and highlights its close relation to the Atlantic Multidecadal Oscillation (AMO) describing low-frequency sea-surface temperature (SST) variability in the North Atlantic ocean. Our proxy record extends instrumental observations 600 years into the past, and reveals the range of natural hydrologic variability for the region. A detailed interpretation and understanding of the speleothem climate record is achieved by the combination of multi-proxy measurements, thin section petrography, XRD analysis and cave monitoring results.

The speleothem was collected in Cueva Larga, a one mile-long cave system that has been monitored since 2012. MC-ICPMS ^{230}Th/U-dating reveals that the speleothem grew constantly over the last 600 years. Trace element ratios (Sr/Ca and Mg/Ca) as well as stable isotope ratios (δ^{18}O and δ^{13}C) elucidate significant changes in atmospheric precipitation at the site.

Monthly cave monitoring results demonstrate that the epikarst system responds to multi-annual changes in seepage water recharge. The drip water isotope and trace element composition lack short term or seasonal variability. This hydrological system creates favorable conditions to deduce decadal climate variability from Cueva Larga's climate record. The speleothem time series mimics the most recent AMO reconstruction over the last 200 years (Svendsen et al., 2014) with a time lag of 10-20 years. The lag seems to results from slow atmospheric signal transmission through the epikarst but the effect of dating uncertainties cannot be ruled out. Warm SSTs in the North Atlantic are related to drier conditions in Puerto Rico. During times of decreased rainfall a relative increase in prior calcite precipitation seems to be the main process causing increased Mg/Ca trace element ratios. High trace element ratios correlate to higher δ^{13}C values. The increase in both proxies indicates a shift towards time periods of decreased rainfall.

Before 1800 there were two intervals of increased Mg/Ca and δ^{13}C values (dryer conditions) lasting several decades in our speleothem record centered around 1680 CE and 1470 CE. The elevated ratios indicate that drier conditions than present may have occurred in the region during periods of warm Atlantic surface waters.