An ~1500 year history of El Niño Southern Oscillation rainfall anomalies and land use for the Isthmus of Panama from speleothem calcite

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The history of the El Niño Southern Oscillation (ENSO) over the past two millennia remains poorly constrained. To document further the tropical paleoclimatic response to ENSO, we present a precisely-dated (180 B.C. to 1310 A.D.), high-resolution ~3 yr / sample), cave calcite isotopic time series from the Isthmus of Panama, a region that experiences ENSO-forced rainfall anomalies. We show evidence for rapid and dramatic rainfall variation in southern Central America, as inferred from stalagmite $\delta^{18}O$ isotope stratigraphy. Isthmian convective rainfall from 550 A.D. to 1300 A.D. was both less intense and more variable than the period 180 B.C. to 550 A.D. Speleothem growth spanned the interval of the Classic Maya Collapse (750 - 950 A.D.), and provides additional evidence for dry anomalies at this time. Carbon isotopes document changing vegetation from native rainforest to grasslands and/or maize, a period of soil erosion associated with pre-Colombian agriculture, and final forest recovery. We suggest that ENSO-forced sea surface temperature anomalies in the eastern equatorial Pacific Ocean resulted in isthmian rainfall anomalies over much of the past two millennia. Our data suggest that El Niño events are associated with decreased isthmian rainfall, and that increased ENSO activity results in generally drier and more variable conditions.