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Two millennia of seasonal rainfall predictability in the neotropics with repercussions for agricultural societies

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The reconstruction and analysis of palaeoseasonality from speleothem records remains a notoriously challenging task. Although the seasonal cycle is obscured by noise, dating uncertainties and irregular sampling, its extraction can identify regime transitions and enhance the understanding of long-term climate variability. Shifts in seasonal predictability of hydroclimatic conditions have immediate and serious repercussions for agricultural societies.

We present a highly resolved speleothem record (ca. 0.22 years temporal resolution with episodes twice as high) of palaeoseasonality from Yok Balum cave in Belize covering the Common Era (400-2006 CE) and demonstrate how seasonal-scale hydrological variability can be extracted from $\delta^{13}C$ and $\delta^{18}O$ isotope records. We employ a Monte-Carlo based framework in which dating uncertainties are transferred into magnitude uncertainty and propagated. Regional historical proxy data enable us to relate climate variability to agricultural disasters throughout the Little Ice Age and population size variability during the Terminal Classic Maya collapse.

Spectral analysis reveals the seasonal cycle as well as nonstationary ENSO- and multi-decadal-scale variability. Variations in both the subannual distribution of rainfall and mean average hydroclimate pose limitations on how reliably farmers can predict crop yield. A characterization of year-to-year predictability as well as the complexity of seasonal patterns unconver shifts in the seasonal-scale variability. These are discussed in the context of their implications for rainfall dependent agricultural societies.