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Volcanic forcing of the North Atlantic Oscillation over the last 2,000 years

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The North Atlantic Oscillation (NAO) is a principal mode of atmospheric circulation in the North Atlantic realm (Hurrell et al. 2003) and influences rainfall distribution over Europe, North Africa and North America. Although observational data inform us on multi-annual variability of the NAO, long and detailed paleoclimate datasets are required to understand the mechanisms and full range of its variability and the spatial extent of its influence. Chronologies of available proxy-based NAO reconstructions are often interdependent and cover only the last ∼1,100 years, while longer records are characterized by low sampling resolution and chronological constraints. This complicates the reconstruction of regional responses to NAO changes.

We present data from a 2,000 year long sub-annual carbon isotope record from speleothem YOK-I from Yok Balum Cave, Belize, Central America. YOK-I has been extensively dated using U-series (Kennett et al. 2012). Monitoring shows that stalagmite δ^{13}C in Yok Balum cave is governed by infiltration changes associated with tropical wet season rainfall. Higher (lower) δ^{13}C values reflect drier (wetter) conditions related to Intertropical Convergence Zone position and trade winds intensity.

Comparison with NAO reconstructions (Proctor et al. 2000, Trouet et al. 2009, Wassenburg et al. 2013) reveals that YOK-I δ^{13}C sensitively records NAO-related rainfall dynamics over Belize. The Median Absolute Deviation (MAD) of δ^{13}C extends NAO reconstructions to the last 2,000 years and indicates that high latitude volcanic aerosols force negative NAO phases.

We infer that volcanic aerosols modify inter-hemispheric temperature contrasts at multi-annual scale, resulting in meridional relocation of the ITCZ and the Bermuda-Azores High, altering NAO and tropical rainfall patterns. Decade-long dry periods in the 11th and the late 18th century relate to major high northern latitude eruptions and exemplify the climatic response to volcanic forcing by reorganization of atmospheric circulation over the North Atlantic.

References

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