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# Understanding the moisture source of orbitally controlled changes in northern Sahara rainfall: a multi-proxy speleothem approach

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The Sahara, the largest hot desert in the world, has witnessed green, humid phases in the past. It is clear that large areas of what is now arid/hyper-arid desert became vegetated, that currently fossil rivers flowed sufficiently to reach the Mediterranean, and that the African Monsoon is key in regulating this variance on the southern margin of the desert. However, what is happening on the northern margin, what regulates those changes and how the different northern and southern rainfall systems combine to affect the interior of the Saraha are poorly known. Closing this knowledge gap is an urgent priority, because climate models predict an enhanced drying under future global warming, but the IPCC give this forecast only "Medium" confidence and it contrasts strongly with those paleoclimatic records which indicate a greener Sahara during the warmer times through the Pleistocene. So, to understand what controlled the northern Sahara in the past, we use a multi-proxy approach using the longest absolute-dated speleothem records from Tunisia in central North Africa. This unique resource allows us to decipher periods of significant rainfall in this region through isotopic measurements and a direct indication of possible moisture sources through fluid inclusions.

The records indicate a strong orbital control on past hydroclimatic changes suggesting enhanced rainfall during MIS 3, 5, 7 and 9. The fluid inclusions are consistent with a Western Mediterranean source for most rainfall, with some derived from the Atlantic. For much of the record, deuterium excess is highest in the samples with the most depleted $d^{18}O$ and $d^{2}H$, which is consistent with some rainfall being derived from Mediterranean-derived high-intensity events, analogous to modern "medicanes". High deuterium excess is also found during MIS5e, which is the only time the fluid inclusions we report from Tunisia are similar in composition to those we have already published for Libya, indicating an enhanced Eastern Mediterranean source occurred during the Eemian which is not reflected during other times of MIS5.