EGU24-11799, updated on 10 May 2024
https://doi.org/10.5194/egusphere-egu24-11799
EGU General Assembly 2024

Exploring the mechanisms controlling dryland hydroclimate in past 'warmer worlds'

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Drylands cover almost half of Earth’s land surfaces, supporting ~30% of the world’s population. The International Panel on Climate Change predicts increasing aridification and expansion of drylands over the course of this century. As we approach new climate states without societal precedent, Earth’s geological past may offer the best tool to understand hydroclimate change under previously, allowing us to elucidate responses to external forcing. Paleo-records from previously warm and high-CO_2 periods in Earth’s past, such as the mid-Pliocene (~3 Ma), point towards higher humidity in many dryland regions.

Here, we examine desert speleothems from the hyper-arid desert in central Arabia, part of the largest near-continuous chain of drylands in the world, stretching from north-western Africa to the northern China, to elucidate substantial and recurrent humid phases over the past 8 million years. Independent quantitative paleo-thermometers suggest that mean annual air temperatures in central Arabia were approximately between 1 to 5 °C warmer than today. The analyses of the isotopic composition ($\delta^{18}O$ and δ^2H) of speleothem fluid inclusion waters, representing ‘fossil rainwater’, reveal an aridification trend in Arabia from the Late Miocene to Late Pleistocene during Earth’s transition from a largely ‘ice-free’ northern hemisphere to an ‘ice-age’ world. Together, our data provide evidence for recurrent discrete wetter intervals during past warmer periods, such as the Pliocene. Data-model comparisons allow us to assess the agreement between our paleoclimate data and climate model output using the HadCM3 isotope-enabled model simulations during past ‘warmer worlds’ – namely the mid-Piacenzian warm period (3.264 to 3.025

Ma). To assess the hydroclimate response to external forcing, we examine model output from a series of sensitivity experiments with different orbital configurations allowing us to postulate the mechanisms responsible for the occurrence of humid episodes in the Arabian desert, with potential implications for other dryland regions at similar latitudes. Together, our approach unveils the long-term controls on Arabian hydroclimate and may provide crucial insights into the future variability.