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Climatic predictors of speleothem deposition in SW Asia

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Speleothems (stalagmites, stalactites and flowstones) are a powerful archive for reconstructing past climate conditions. These are secondary calcium-carbonate deposits that form in caves from the adequate supply of rainwater, soil CO_2 and dissolved bicarbonate. They have been used extensively in arid regions, such as SW Asia, to reconstruct and benchmark past hydroclimatic conditions. Analysis of the distribution of active and inactive speleothem deposition across the Negev desert suggested a precipitation threshold of ~300-350 mm yr^{-1} is required for speleothems to deposit. This threshold has been applied to the broader SW Asia region to understand the minimum rainfall during periods of climate amelioration but has lacked specific region-wide analysis. Here, we apply logistic regression techniques and machine-learning methods to understand the climatic parameters which predict speleothem deposition across SW Asia. We show a gradual, rather than threshold response between speleothem deposition and rainfall amount, suggesting 1) precipitation over 300-350 mm yr is not a simple predictor of speleothem deposition across SW Asia, and 2) sites specific climates/environments and processes play an important role. We then apply a Random Forest machine-learning algorithm to our dataset to create a prediction of speleothem deposition. We show that minimum and maximum monthly rainfall, elevation, and a terrain roughness index are the most important variables, suggesting that water availability and topography are important predictors of speleothem deposition. Climate indices associated with temperature and evaporation contribute but play a less important role in the prediction. We emphasise the need for additional monitoring of external and internal cave environments to refine the climatic predictors of speleothem deposition in SW Asia and understand the site-specific processes that lead to the activation or cessation of speleothem growth. Importantly, our prediction provides a model which includes a range of climate-environmental data and may be used by researchers to locate new speleothem-bearing cave sites for study.