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Predicting drip-water $\delta^{18}O$ using machine learning methods

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Reconstructing past climate is a crucial step to better predicting anthropogenic climate change. Using cave calcite deposits as archives of regional and local paleoclimate variability (temperature, precipitation amount and source, evaporation) is a rapidly growing field. One drawback of using cave calcite is the necessity for in-depth understanding of the cave environment, including cave drip-water, in which the calcite was precipitated from. Although some researchers create and maintain intensive cave monitoring programs to better understand a specific cave environment, others are unable to perform these types of environmental monitoring programs because of budgetary constraints and limited accessibility. Here we use supervised machine learning techniques that are trained on a global dataset of cave monitoring data from the literature to predict cave drip-water $\delta^{18}O$ at five sites in the western United States. The predictions of drip-water $\delta^{18}O$ use precipitation $\delta^{18}O$, temperature, and evaporation data that is available to all researchers through open sources. Additionally, we demonstrate that these techniques can be adapted to a site that has isotope enabled climate modeling data available or that has raw observations of surface conditions. We find that the drip-water $\delta^{18}O$ predicted from these techniques agree with modern measurements of cave drip-water $\delta^{18}O$ at four of the five western United States sites, within uncertainty. Additionally, the results replicate those from proxy system modeling. We posit that the supervised machine learning techniques will be a straight-forward approach for researchers to predict drip-water $\delta^{18}O$ at a given site in the absence of cave monitoring programs, enhancing the climatological interpretations of paleoclimate records from cave calcite.