A multi-proxy approach to understanding hydroclimate in the American Southwest

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Stalagmite stable isotope records ($\delta^{18}O_{cc}$) from across the southwestern United States show synchronous variability with high-latitude Northern Hemisphere temperature changes associated with the last deglaciation. Interpretations of regional $\delta^{18}O_{cc}$ records for the last deglaciation, however, point to likely variability in the drivers of regional hydroclimate. Here, we apply a multi-proxy approach to a stalagmite from the western Sierra Nevada for which calcite-based proxy time series were previously developed (Oster et al. 2015). We coupled high-resolution 3-dimensional neutron-computed tomography and x-ray-computed tomography to 3-dimensionally map fluid-filled inclusion distribution within the stalagmite. Using the map of fluid inclusion distribution, we analyzed fluid inclusion stable isotopes and noble gas concentrations. Noble gas concentration measurements from fluid inclusions in a Last Glacial Maximum sample indicate a temperature of 8.3 +/- 2.5 °C. This temperature indicates a LGM to modern temperature change similar to that of the global average. It is used to correct for temperature variability in $\delta^{18}O_{cc}$ and to evaluate the preservation quality of $\delta^{18}O_{FI}$ measurements. We observe synchronicity between periods in the stalagmite that have a high density of fluid-filled inclusions and the lowest $\delta^{18}O_{cc}$ values. This occurs during cool periods over the last deglaciation, i.e. the Last Glacial Maximum and Older Dryas, suggesting a common driver between $\delta^{18}O_{cc}$ and fluid inclusion distribution. Stable isotope compositions of fluid inclusions ($\delta^{18}O_{FI}$ and $\delta^{2}H_{FI}$) show low values during the same cool periods, however, during warm periods the $\delta^{18}O_{FI}$ and $\delta^{2}H_{FI}$ are consistent with the local meteoric water line. Thus, cool periods in the western Sierra Nevada indicate an increase in moisture and either 1) a shift in precipitation source from the North Pacific to the subtropical Pacific or 2) variability in humidity conditions over the North Pacific. Comparisons with isotope-enabled models suggest that LGM precipitation was sourced from the tropical Pacific, where relative humidity was lower during cold periods supporting scenario 1 as presented by the proxies. The opposite is true for warm periods that are similar to present-day in the $\delta^{18}O_{FI}$ and $\delta^{2}H_{FI}$ record.