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Triple Oxygen Isotope Record from Goethite-Rich Deposits Shows Holocene Moisture Source Shift in the Rocky Mountains

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Holocene (~11.7 ka to present) hydroclimate changes in the western US are poorly constrained, in part because the region's complex topography and seasonally distinct circulation patterns can generate heterogenous responses over small spatial scales. To better understand regional precipitation patterns over the Holocene, we measured the triple oxygen isotopes of goethite from high elevation ferricrete deposits across a latitudinal gradient in the Rocky Mountains. Additionally, we modified a 1-dimensional vapor transport model to simulate $\Delta'^{17}O$ of precipitation along a hypothetical storm track given various amounts of moisture recycling and differing proportions of evaporation and transpiration contribution to evapotranspiration fluxes. Both northern (central Montana) and southern (southwest Colorado) Rocky Mountain sites exhibit similar increases in $\delta^{18}O$ over time, accompanied by a decline in $\Delta'^{17}O$. $\Delta'^{17}O$ is largely insensitive to temperature, and our model shows that changes in water balance along the storm track cannot account for the observed $\Delta'^{17}O$ decreases. Instead, we conclude that the isotopic trends primarily reflect an increased contribution of southerly sourced precipitation, since moisture from the Gulf of Mexico—the dominant source of summer precipitation in the interior western US—is characterized by high $\delta^{18}O$ and comparatively low $\Delta'^{17}O$. More generally, this work demonstrates how triple oxygen isotopes of terrestrial paleoclimate archives can be used to disentangle changes in moisture source, temperature, and humidity in semi-arid to arid regions.