Paleoclimate application of compound specific δD analyses in the Rocky Mountains: modern calibration and Holocene temperature trends

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Compound-specific δD values have proven to be powerful recorders of lake-water δD values and temperature in the eastern U.S.A., but their application has not been evaluated as extensively in other regions of the continent. Here, we investigate the use of δD analyses of sedimentary compounds derived from aquatic plants as recorders of temperature in the Rocky Mountains along an elevational transect in Jackson County, Colorado. Ongoing lake-water monitoring in the region shows that lakes share a regional lake-water input δD value, which is the weighted mean δD value of precipitation and thus reflects the mean temperature of precipitation. In lakes where evaporative enrichment occurs, lake-water values evolve from the regional input value along a coherent local evaporation line (LEL; r2 = 0.99). We selected American Lake (3400 m) as a study site because there is minimal evaporative enrichment of lake water, and therefore isotopic values record the mean temperature of precipitation. Calibration of compound-specific fatty acid δD (n=10, 2400-3400m) demonstrates that behenic acid δD values record lake-water δD values in this region (r = 0.88). Further, the fractionation factor between behenic acid and lake water is the same as that observed in the eastern U.S.A. The behenic acid δD record at American Lake shows a cold excursion (-7.89 ‰ δD anomaly from average late-Holocene values) at ca. 8200 years before present, which is consistent with Front Range evidence of glacier advances. During the mid-Holocene temperatures and δD values were ~1°C and 5.35 ‰ greater, respectively, than during the late-Holocene. Warm mid-Holocene temperatures are consistent with evidence of forest growing in modern tundra regions where it is presently too cold to support trees. Over the twentieth century temperatures in the region have increased by ~2.5° C, which is greater than mid-Holocene isotope-inferred temperatures. Our results show that behenic acid is a faithful recorder of lake-water isotopic values across a wide range of conditions and suggest that, if current warming continues, long-term trends will exceed mid-Holocene warming with important implications for water and ecosystem resources.