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Modeling Surface Water δ18O Lapse Rates Across the U.S. Continental Interior

TARA K LONSDORF

University of Michigan

Though tectonic studies often rely on stable isotope (δ18O and δD) records of paleo-waters to reconstruct paleoaltitude, such estimates derived from surface water archives are complicated by outstanding questions regarding which catchment-wide elevations these lapse rates meaningfully reflect – and which watershed-wide climate processes exert control over the magnitudes of lapse rates across watershed gradients. In this study, we approach questions about the climatic and physiographic controls on isotopic lapse rates of surface waters by considering basin-scale variability of modern rivers in the intermontane Western USA, as this region has both sufficient physiographic and climatic complexity to serve as an ideal analog for a wide range of landscapes, and a high density of existing isotopic data. By pairing surface water isotopic values with topographic and climatic data, we use GIS to reconstruct the climatic and physiographic conditions of ~1,500 watersheds, and calculate regional lapse rates for maximum, average and minimum catchment elevations. To determine which atmospheric processes may exert the strongest controls on these local lapse rates, we then correlate lapse rates with average catchment-wide climatic conditions.

Distributions of calculated lapse rates for minimum- and average-basinwide elevations are more statistically significant than lapse rates calculated for maximum-basinwide elevations, suggesting that isotopic lapse rates likely reflect climatic processes altering the composition of waters following initial high-elevation precipitation or snowmelt. It is likely that the climate process controlling isotopic lapse rates is evaporation, as strong correlations between lapse rates and dew point temperatures indicate that evaporation and moisture recycling along the stream profile may "dampen" lapse rates from previously-published global estimates of lapse rates along windward sides of mountains. Overall, these results suggest that stable isotopes of surface waters preserved within the geologic record most likely record average regional elevations, rather than precipitation at the top of high-elevation mountains. Moreover, relative humidity along stream profiles is likely an important control on surface water isotopic lapse rates, and should be considered when interpreting stable isotope values for paleoaltitude.

