Publication

Validation and calibration of soil delta H-2 and brGDGTs along (E-W) and strike (N-S) of the Himalayan climatic gradient

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Reconstructing the timing of mountain range uplift and the evolution of high-altitude plateaus is important when attempting to understand potential feedbacks between tectonics and climate at geological timescales. This requires proxies that are able to accurately reconstruct elevation during different time periods in the past. Often, the sensitivity of climatic parameters to elevation gradients, recorded in geological archives such as soils, is used to estimate paleoelevations. However, most proxies reflect an indirect response to elevation change, adding uncertainties to reconstructions. In this study, we aim to identify those sources of uncertainty with respect to elevation reconstructions and test if the combined application of two such proxies, i.e., stable isotopes (delta H-2) of plant waxes in modern soils and surface waters and bacterial membrane lipids (brGDGTs) in soils, which can potentially reduce uncertainties in the estimation of (paleo-) elevation. We performed this study in four Himalayan catchments (from west to east: Sutlej, Alaknanda, Khudi, and Arun), of which each individual catchment is subject to a unique precipitation regime, relative influences of moisture sources, and vegetation cover. In total, we analyzed 275 surface water samples, 9 precipitation samples, 131 xylem water samples, and 60 soil samples, which were collected between 2009 and 2014.The following key observations were made: Soil nC(31)-alkane H values (delta H-2(wax)) in the Sutlej, Alaknanda, Khudi, and Arun generally record surface water delta H-2 values, confirming that the first-order control on the plant wax isotopic signature is precipitation delta H-2 and, therefore, the elevation in orogenic settings. We identified aridity as the factor that introduces scatter to this relationship. BrGDGT-derived Mean Annual Temperature (MAT) correlates in a statistically significant manner with sample site elevation and a 14-year annual average of remotely sensed land-surface temperature, showing that the main process influencing the brGDGT distribution is the adiabatic cooling of air.In an effort to combine these proxies to improve uncertainties in elevation reconstruction, elevations were inferred from both the delta H-2(wax) and brGDGT distributions. Arid, high elevation sites appear to underestimate actual sample site elevations using delta H-2 values while sites subject to high (>23-25 degrees C) annual temperatures overestimate the actual sample site elevation using brGDGT distributions. Elevations inferred from both proxies under such paleoclimatic conditions should be interpreted with caution. Elevations derived from the brGDGT distribution appear to most accurately reconstruct elevation. However, we show that the difference in elevation between

the two proxies, described by the proposed Delta(Elevation) parameter, can provide information on the hydrological conditions of the soil's depositional environment. In conclusion, we emphasize that knowledge of the sample site's climatic conditions are essential to reconstruct elevation from paleoarchives. In particular, knowledge of moisture availability and annual air temperatures are important, as these have been found to cause the largest scatter in the observed data.

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