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Paleotemperature reconstruction from mammalian phosphate δ^{18}O records - an alternative view on data processing

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The stable oxygen isotope composition of phosphates (δ^{18}O) extracted from mammalian bone and teeth material is commonly used as a proxy for paleotemperature. Historically, several different analytical and statistical procedures for determining air paleotemperatures from the measured δ^{18}O of phosphates have been applied. This inconsistency in both stable isotope data processing and the application of statistical procedures has led to large and unwanted differences between calculated results.

This study presents the uncertainty associated with two of the most commonly used regression methods: least squares inverted fit and transposed fit. We assessed the performance of these methods by designing and applying calculation experiments to multiple real-life data sets, calculating in reverse temperatures, and comparing them with true recorded values. Our calculations clearly show that the mean absolute errors are always substantially higher for the inverted fit (a causal model), with the transposed fit (a predictive model) returning mean values closer to the measured values (Skrzypek et al. 2015).

The predictive models always performed better than causal models, with 12–65% lower mean absolute errors. Moreover, the least-squares regression (LSM) model is more appropriate than Reduced Major Axis (RMA) regression for calculating the environmental water stable oxygen isotope composition from phosphate signatures, as well as for calculating air temperature from the δ^{18}O value of environmental water. The transposed fit introduces a lower overall error than the inverted fit for both the δ^{18}O of environmental water and T_{air} calculations; therefore, the predictive models are more statistically efficient than the causal models in this instance. The direct comparison of paleotemperature results from different laboratories and studies may only be achieved if a single method of calculation is applied.

Reference

Skrzypek G., Sadler R., Wiśniewski A., 2016. Reassessment of recommendations for processing mammal phosphate δ^{18}O data for paleotemperature reconstruction. Palaeogeography, Palaeoclimatology, Palaeoecology 446, 162-167.