Geophysical Research Abstracts
Vol. 20, EGU2018-11679-1, 2018
EGU General Assembly 2018

A Quantitative framework for understanding past environmental change using meteoric ^{10}Be in lake sediments

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Meteoric ^{10}Be in lake archives offers potential insights into paleoenvironmental change and long-term variations of erosion and climate. The delivery of ^{10}Be to the surface varies with precipitation, and its strong adsorption to sediment has already proven useful in studies of erosion. While several studies have used meteoric ^{10}Be concentrations in lake cores to understand past environmental change, empirical correlations are often used to derive insights, and a quantitative framework to assess controls on nuclide abundance is needed. We present a simple model to predict the concentration profiles of ^{10}Be in lake archives as a function of changing climate, upland erosion, and in-lake sedimentation. We apply the model to two published ^{10}Be datasets from sediment archives of Lake Baikal, Russia, and former Lake Lisan, Israel. We assess the sensitivity of individual model controls on ^{10}Be concentrations in these systems. In our quantitative reanalysis of both data sets, sedimentation rate is the primary control on the pattern of changing meteoric ^{10}Be concentrations, due to the dilution of ^{10}Be by in-situ produced lake sediments. Smaller changes to ^{10}Be concentrations reflect delivery to the lake from upland sources or wind-delivered dust, while precipitation-driven changes in atmospheric flux have little influence on ^{10}Be concentrations. A variety of environmental processes likely influence ^{10}Be concentrations in lake sediments, however, these can be modeled with simple parameters. Furthermore, nuclide profiles may vary widely due to intrinsic variables (e.g., authigenic lake sedimentation), with surprisingly little external controls on the system (e.g., changes in paleoerosion). This work provides a quantitative framework to assess the sensitivity of paleoarchives to environmental change, and highlights limitations and potential for meteoric ^{10}Be to quantify past critical zone processes.