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Annual $^{18}O/^{16}O$ composition of authigenic calcite in varved lake sediments reflects regional air temperature

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The oxygen isotopic composition ($^{18}O/^{16}O$) of authigenic calcite in lake sediments reflects the temperature and the isotopic composition of the lake water from which the calcite is precipitated and thus contains information about the climatic conditions at the time of calcite formation. Varved lake sediments containing laminae of authigenically precipitated calcite provide the possibility to analyze the $^{18}O/^{16}O$ composition at an annual resolution, thus yielding high-resolution climatic information. Yet, despite this high potential the number of studies having used this approach is relatively low. Reasons for this are probably sampling challenges, the scarceness of suitable varved sediments, missing instrumental records to compare with, as well as uncertainties regarding the factors influencing the calcite isotopic composition (water/air temperature, precipitation, lake-internal factors).

Still, annually resolved data of the $^{18}O/^{16}O$ composition of calcite seems a promising climate proxy and we therefore investigated the $^{18}O/^{16}O$ pattern of the authigenic calcite in the varved sediments of Lake Zurich. Lake Zurich is a pre-alpine lake with a surface area of 88 km^2, a maximal water depth of 137 m and a theoretical water residence time of 1.4 years. Sediments are varved since the late 19^{th} century due to anthropogenic lake eutrophication. For this calibration study, we analyzed the $^{18}O/^{16}O$ composition of the authigenic calcite for the time period 1960-2010 at annual resolution. The $\delta^{18}O$ values range from -10.8 to -13.4 ‰; and the pattern is dominated by a conspicuous shift to more enriched values between 1985 and 1987. The same shift has been observed for local to large-scale climatic parameters such as lake, river, and groundwater temperatures throughout Switzerland, the mean air temperature for Switzerland, and the NAO index.

The consistency of the instrumental temperature data sets with the $^{18}O/^{16}O$ composition of the authigenic calcite emphasizes the high potential of this proxy, even in a setting that is strongly influenced by human activities and infrastructure such as Lake Zurich. Our results also indicate that the $^{18}O/^{16}O$ signal of a lake with the size and the hydrology of Lake Zurich potentially reflects climatic changes not only at a local but also at a regional scale.