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Bacterial GDGTs in Holocene sediments and catchment soils of a high-alpine lake: application of the MBT/CBT-paleothermometer

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A novel proxy for continental mean annual air temperature (MAAT) and soil-pH, the MBT/CBT-paleothermometer, is based on the temperature (T) and pH-dependent distribution of specific bacterial membrane lipids (branched glycerol dialkyl glycerol tetraethers – GDGTs) in soil organic matter. Here, we tested the applicability of the MBT/CBT-paleothermometer to sediments from Lake Cadagno, a small high-alpine lake in southern Switzerland with a small catchment of 2.4 km2. We analysed the distribution of bacterial GDGTs in catchment soils and in a radiocarbon-dated sediment core, which covers the entire Holocene. The composition of bacterial GDGTs in soils are almost identical to that in the lake's surface sediments, indicating a common origin of the lipids. Consequently, the transfer of GDGTs from the soils into the sediment record seems undisturbed, probably without any significant alteration through in situ production or early diagenesis. This could be related to the euxinic conditions of Lake Cadagno, which persisted over the entire Holocene. The MBT/CBT-inferred MAAT-estimates from soils and surface sediments are in good agreement with instrumental values for the Lake Cadagno region ($\sim$ 0.5 °C). Moreover, downcore MBT/CBT-derived MAAT-estimates match in timing and magnitude other proxy-based T-reconstructions from nearby locations for the last two millennia. Major climate anomalies recorded by the MBT/CBT-paleothermometer are, for instance, the Little Ice Age ($\sim$14th to 19th century) and the Medieval Warm Period ($\sim$10th to14th century). Together, our observations indicate a high potential to use branched GDGTs in Lake Cadagno sediments for paleo-climate reconstructions. Consistent with other T-records from both the Alps and from the subpolar NE-Atlantic, our lacustrine paleotemperature record indicates Holocene MAAT-variations with T-highs at $\sim$1, 3, 5, 7, and 11 kyr BP. The good temporal match of the warm periods determined for the S-Alpine region with NW-European winter precipitation strength implies a strong and far-reaching influence of the North Atlantic Oscillation on continental European Holocene T-variations.