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Calibrating the alkenone paleothermometer for lakes

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Lake-based paleotemperature reconstructions are of particular importance in the Arctic, where other useful archives (e.g., tree rings, speleothems) for developing dense networks of quantitative climate records are absent or limited. Lacustrine alkenone paleothermometry offers a new avenue for investigating the evolution and variability of Arctic temperatures during the Holocene. Different calibration efforts for the lacustrine paleothermometer have involved spatial calibrations, laboratory culture-based calibrations, and calibrations developed by in situ monitoring. Here we synthesize these previous efforts and present the results of two new calibration studies from the Lofoten Islands and Svalbard. We find that the slopes of all existing UK37 calibrations are not statistically different. Combining all available data allows us to determine a common UK37 temperature sensitivity that can be used to quantify past temperature variability relative to a reference period.

Using the new temperature sensitivity, we generated a 5,000 year long, decadally-resolved record of summer water temperature from the annually-laminated sediments of Lower Murray Lake on Ellesmere Island in the Canadian High Arctic. The varved sediments of Lower Murray Lake allowed high-resolution sampling and excellent chronologic control of the sedimentary record. The record shows striking similarity on multi-decadal to centennial timescales to a 2,000 year Arctic paleotemperature synthesis as well as an IP25-based record of sea ice extent from the Canadian Archipelago. The previously published mass accumulation rate from Lower Murray Lake has been interpreted as a paleotemperature record and provides complimentary information to the new alkenone record. Melt percentage measurements from the nearby Agassiz Ice Cap provide another independent summer temperature reconstruction for comparison. Most notably, the alkenone record reveals warm lake water temperatures beginning $\sim$800 AD and persisting until $\sim$1200 AD, with temperatures up to 2-3 deg C warmer than the mean temperature for the past 100 years. This distinct warm period on Ellesmere Island interrupted a Neoglacial cooling trend that had begun approximately 2000 years earlier.