Development of a regional glycerol dialkyl glycerol tetraether (GDGT) temperature calibration for Antarctic and sub-Antarctic lakes

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Modern-day temperature calibration models based on the relative abundances of Glycerol dialkyl glycerol tetraethers (GDGTs – temperature-sensitive membrane lipids of Archaea and bacteria), in surface sediments have been used to reconstruct past temperatures from marine and terrestrial sedimentary records, but have not been widely applied in high latitude terrestrial lacustrine environments. This is mainly because the presence, type and provenance of GDGT compounds in remains uncertain or unknown in many lacustrine settings, while the performance of GDGT–temperature calibrations at lower temperatures is comparatively poorly understood. To address these issues, we examined surface sediments from 38 Antarctic, sub-Antarctic and Southern Chilean lakes (Foster et al., 2016). First, we quantified which GDGT compounds were present and then investigated modern-day environmental controls on GDGT composition. GDGTs were found in 37 of 38 lakes studied. Branched GDGTs (brGDGTs) were dominant in 36 lakes and multivariate statistical analyses showed that their composition was strongly correlated with mean summer air temperature (MSAT) rather than pH, conductivity or water depth. Second, we developed the first regional brGDGT–temperature calibration for Antarctic and sub-Antarctic lakes based on four brGDGT compounds (GDGT-Ib, GDGT-II, GDGT-III and GDGT-IIIb). The GDGT-IIIb compound had not been included in previous global calibrations, but proved particularly important in cold lacustrine environments. Compared to previous global calibrations (Pearson et al., 2011), our new brGDGT–Antarctic temperature calibration dataset exhibited an improved statistical performance at low temperatures (r^2=0.83, RMSE=1.45◦C, RMSEP-LOO=1.68◦C, n=36 samples). Third, as a proof of concept test for the new Antarctic calibration model, we applied the new Antarctic brGDGT–temperature calibration to strategically-located and well-dated lake sediment records from the Antarctic Peninsula and South Georgia. Downcore temperature reconstructions using the Antarctic brGDGT–temperature calibration proved to be more sensitive to even relatively minor temperature variations compared to existing global calibrations, and each record reproduced known periods of mid-late Holocene warmth. In conclusion, our study highlights the importance of basing palaeotemperature reconstructions on regional GDGT–temperature calibrations for the Polar Regions, where the inclusion of additional location-specific compounds leads to improved model performance.

References

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