

Supplement of

**Enhanced production and methylation of bacterial branched tetraether lipids
responding to water content-mediated redox changes in Tibetan Plateau
permafrost soils**

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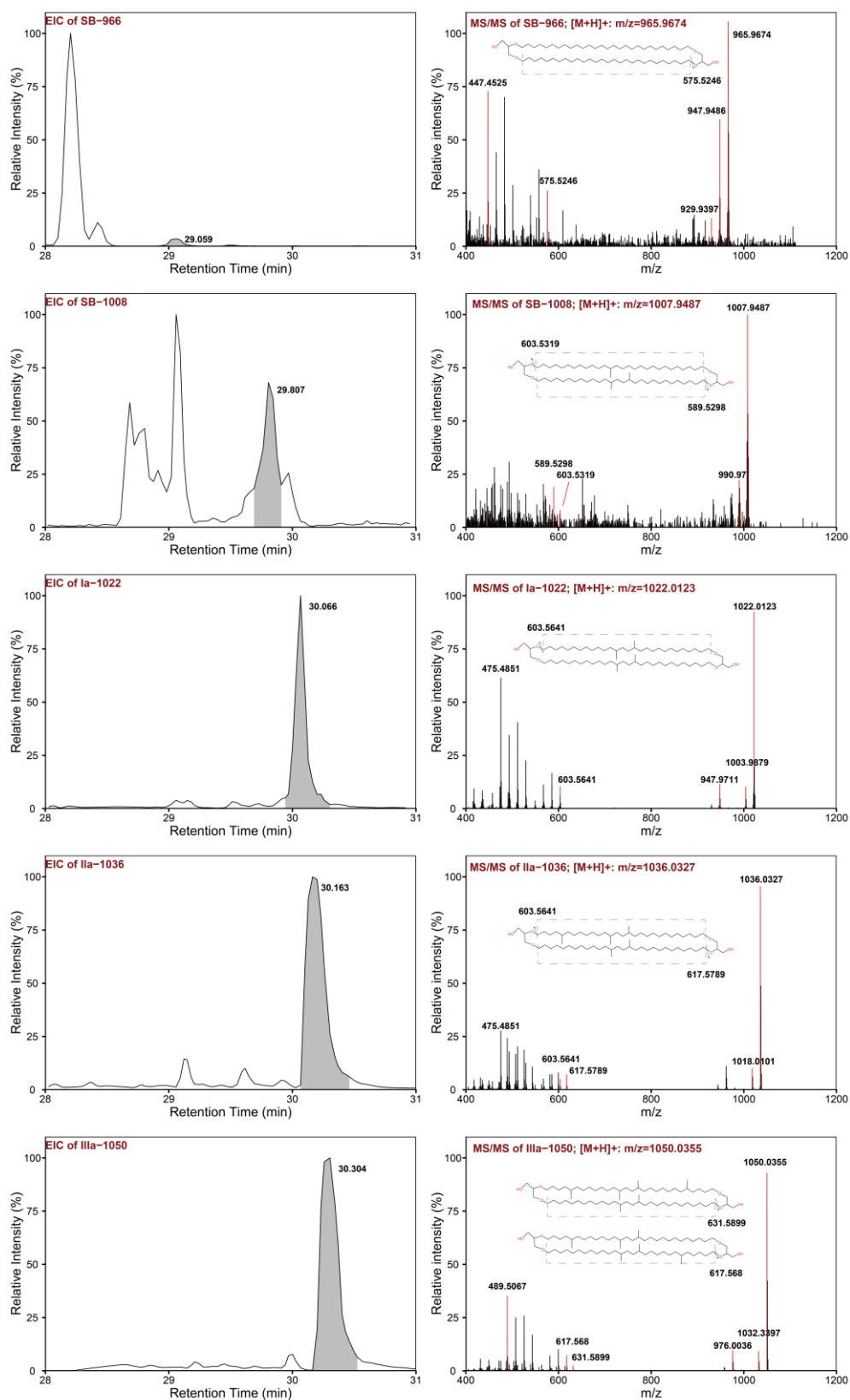


Fig. S1. Extracted Ion Chromatograms (EIC, $[M+H]^+$) and MS² spectra of detected sb-GDGTs and br-GDGTs in this study. The precursor ion $[M+H]^+$ and their characteristic product ions are highlighted in red.

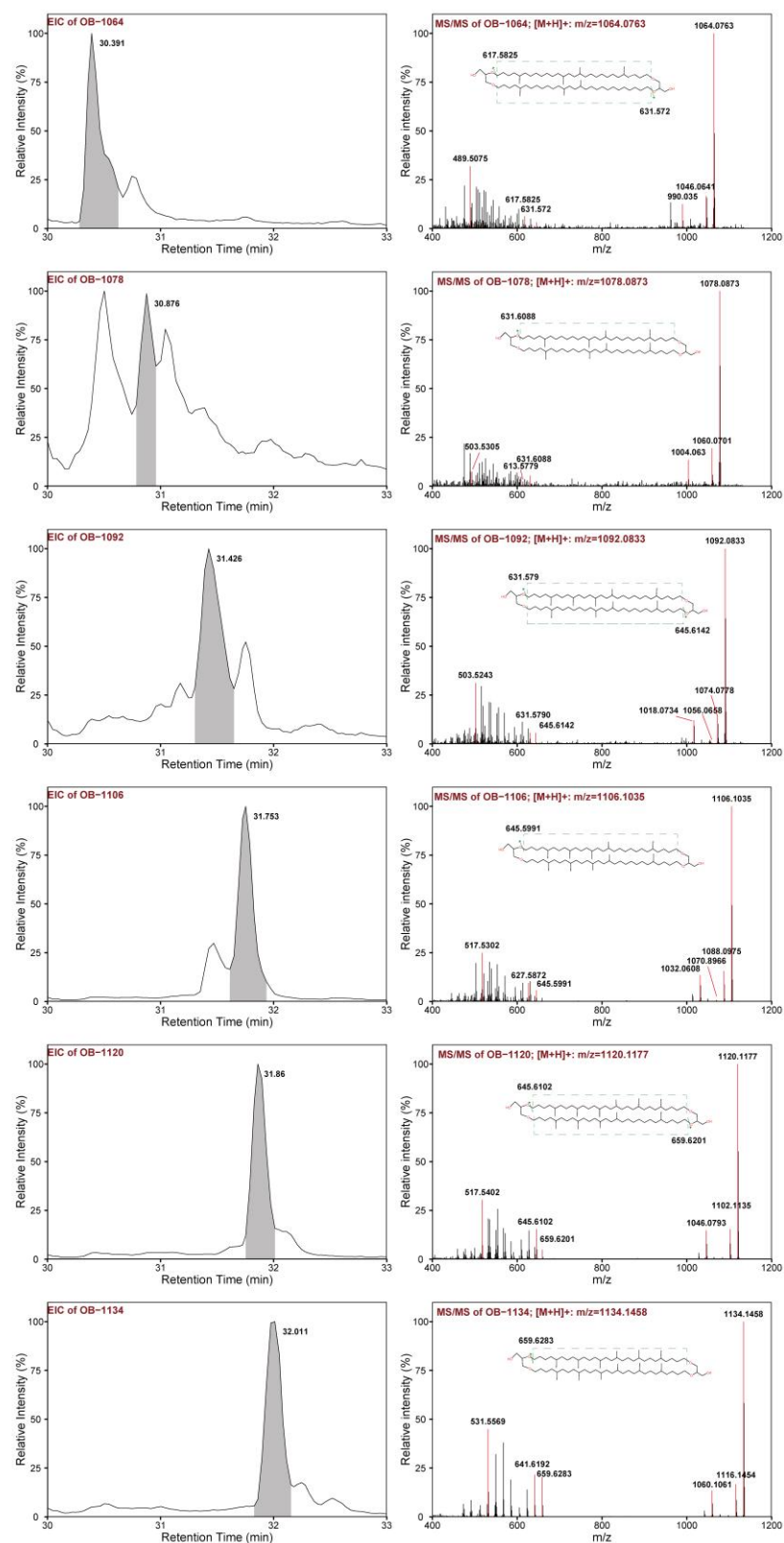


Fig. S2. Extracted Ion Chromatograms (EIC, $[M+H]^+$) and MS² spectra of detected ob-GDGTs in this study. The precursor ion $[M+H]^+$ and their characteristic product ions are highlighted in red.

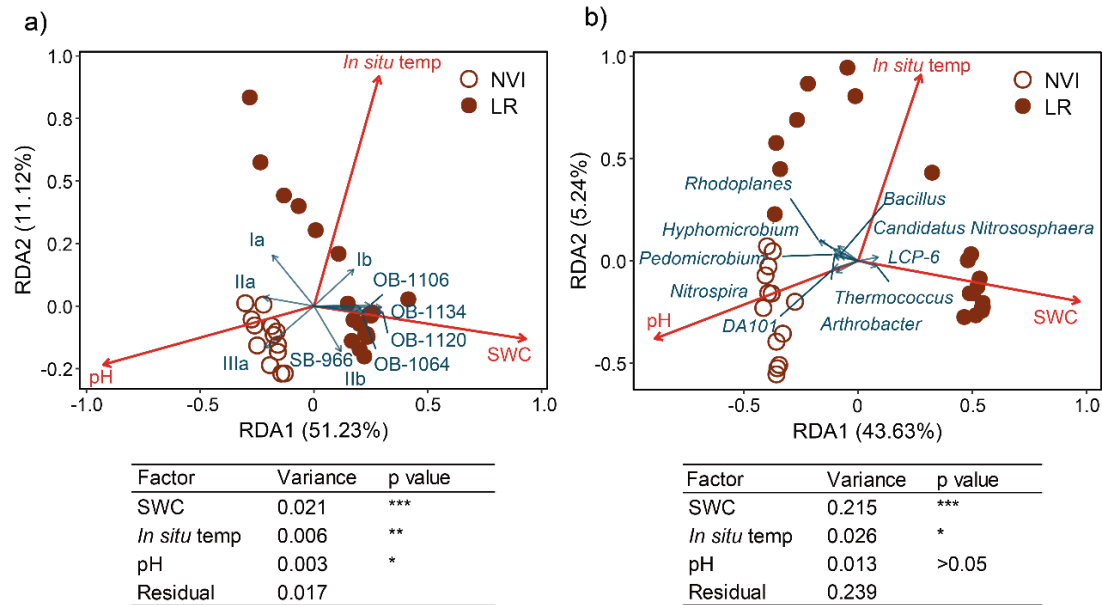


Fig. S3. Redundancy analysis (RDA) of (a) lipid compositions and (b) microbial communities associated with environmental factors. Red arrows represent environmental variables (*in situ* temperature, pH, and SWC). Blue arrows represent specific lipid compounds in (a) and microbial genera in (b). Open and solid circles indicate NVI and LR samples, respectively.

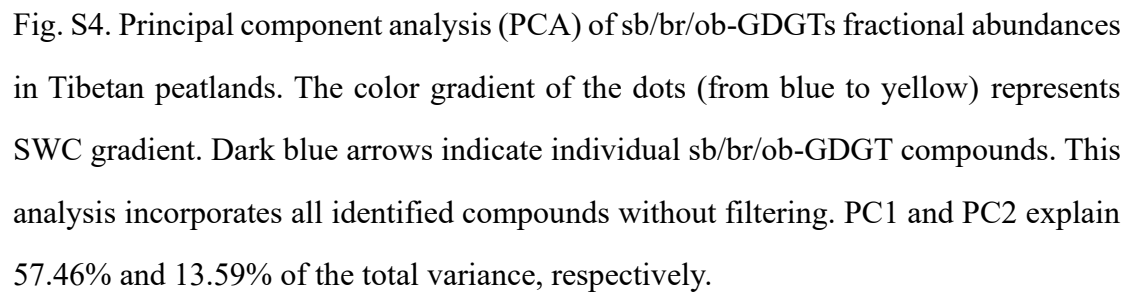


Fig. S4. Principal component analysis (PCA) of sb/br/ob-GDGTs fractional abundances in Tibetan peatlands. The color gradient of the dots (from blue to yellow) represents SWC gradient. Dark blue arrows indicate individual sb/br/ob-GDGT compounds. This analysis incorporates all identified compounds without filtering. PC1 and PC2 explain 57.46% and 13.59% of the total variance, respectively.

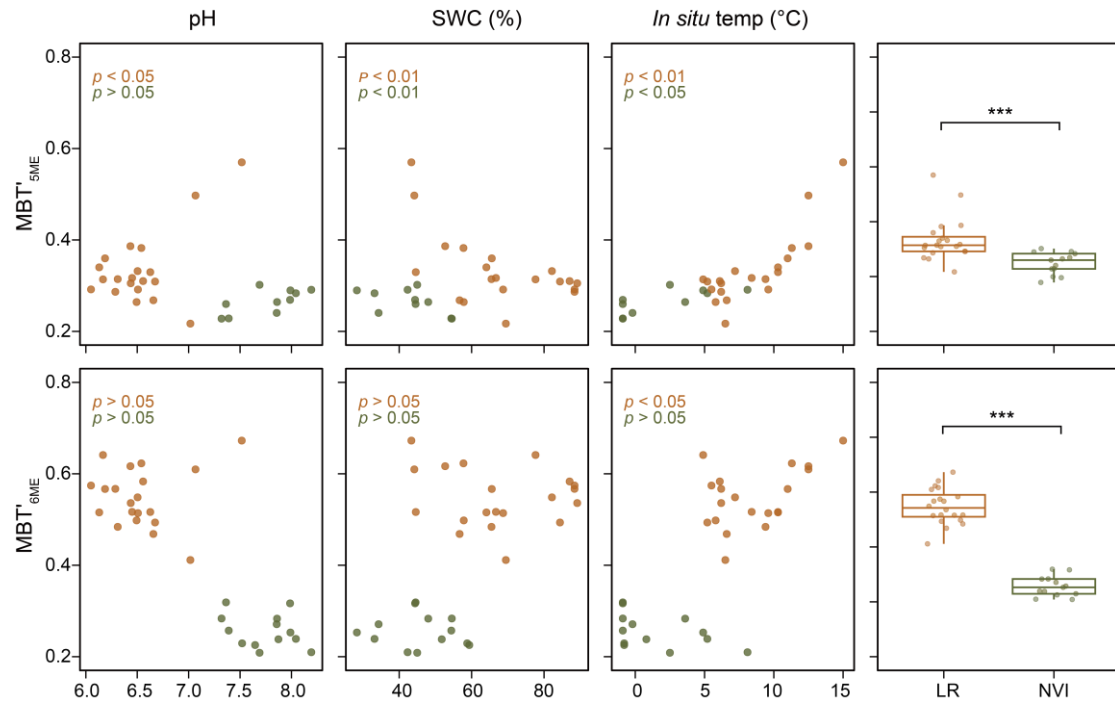


Fig. S5. Correlations of MBT'_{5ME} and MBT'_{6ME} with soil pH, SWC (%), and *in situ* temperature (°C). Scatter plots show site-specific responses (LR: orange; NVI: green), with p -values indicating the significance of each correlation. Rightmost panels compare proxy value distributions between LR and NVI. Statistical significance is indicated by *** $p < 0.001$.