Paleohydrological evolution during the Late Glacial based on compound-specific δ^2H and δ^{18}O analyses from Bichlersee, Bavarian Alps

M. Prochnow[1], M. Bliedtner[1], P. Strobel[1], J. Struck[1], L. Bittner[2], H. Schneider[1], S. Acharya[1], M. Zech[2] & R. Zech[1]

[1] Physical Geography, Department of Geography, Friedrich Schiller University Jena, DE
[2] Heisenberg-Chair for Physical Geography, Department of Geography, Technical University Dresden, DE

Correspondence to: Maximilian Prochnow (e-Mail: maximilian.prochnow@uni-jena.de)

Introduction

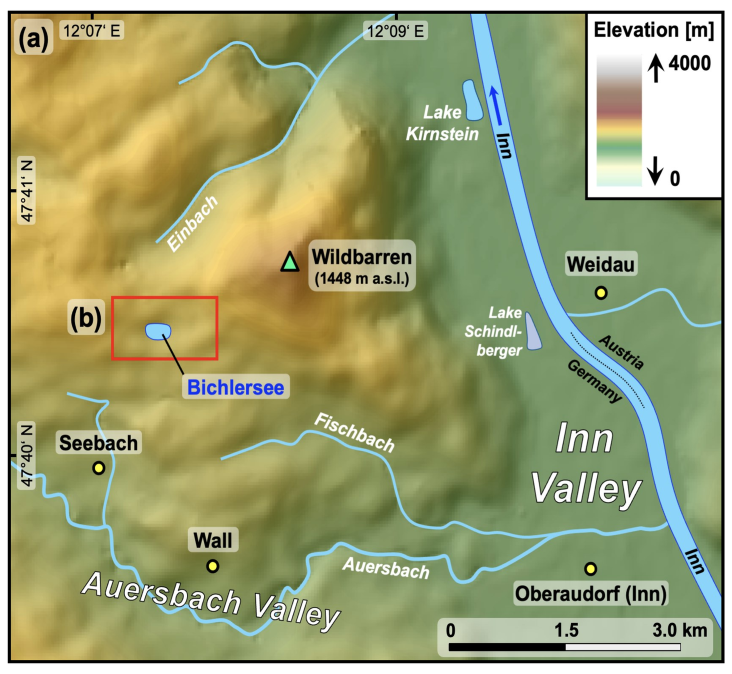
- The European Alps experienced major climatic and environmental changes during the Bølling-Allerød (BA) and the Younger Dryas (YD) (~14.7 until ~11.7 ka BP)
- Stable isotopes (i. e. δ^{18}O) from lake sediments and speleothems are mainly interpreted to reflect temperature due to similarities with Greenland δ^{18}O records, but disentangeling various effects on single isotope records is difficult

→ We test the potential of $\delta^2H_{n\text{-alkane}}$ and $\delta^{18}O_{sugar}$ analyses on lake sediments from Bichlersee for quantitative paleohydrological reconstructions

Study site

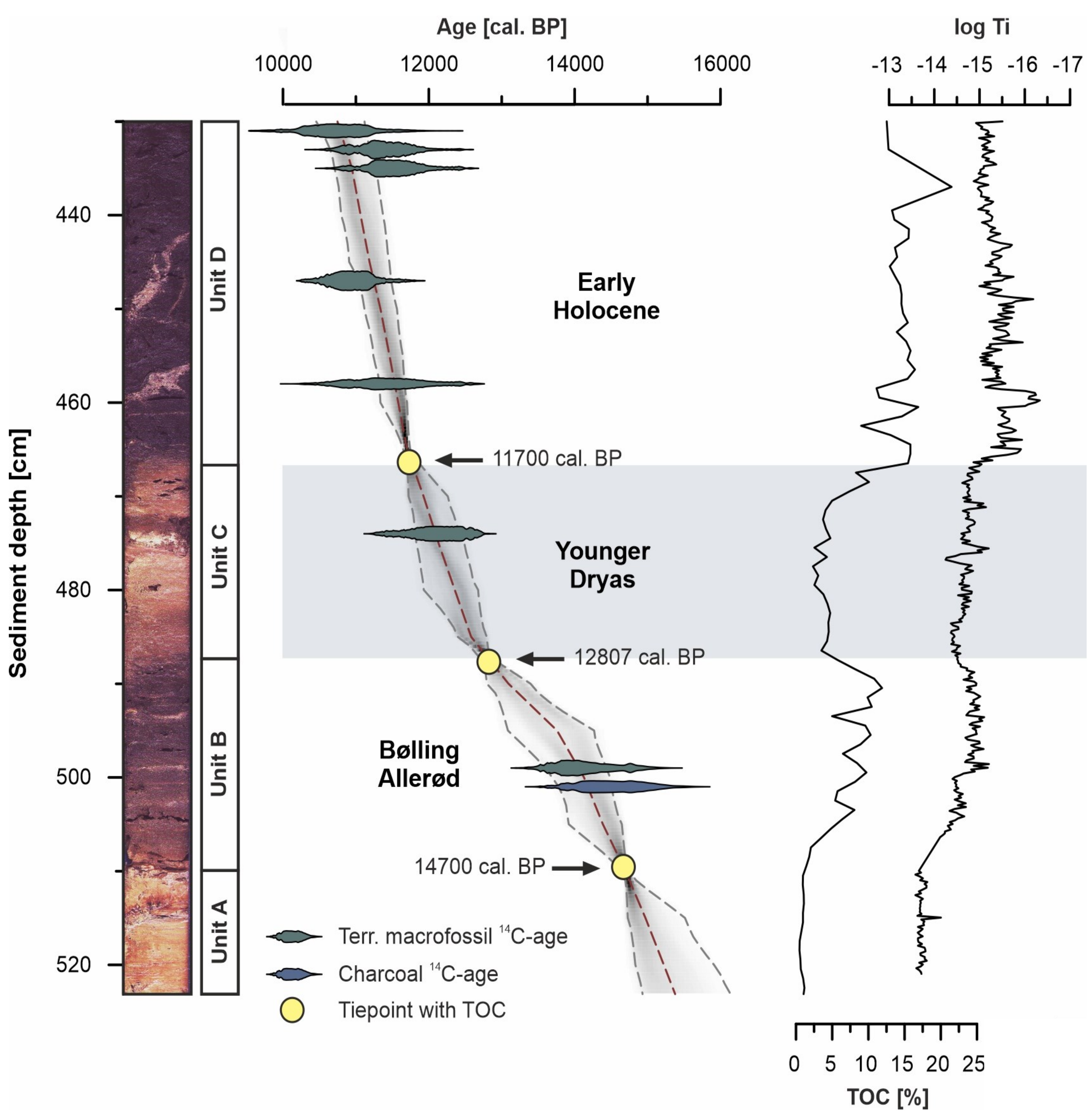
Bichlersee (960 m a.s.l.)

- Karst lake
- Size: 1.4 ha
- Depth: 11 m
- Catchment: 0.5 km^2 with three small creeks, no outflow



▲ **Figure 1**
(a) Topographic overview map of the study area (DEM: EuropeDEM v1.1). **(b)** Photograph of Bichlersee with the forested Wildbarren in the background.

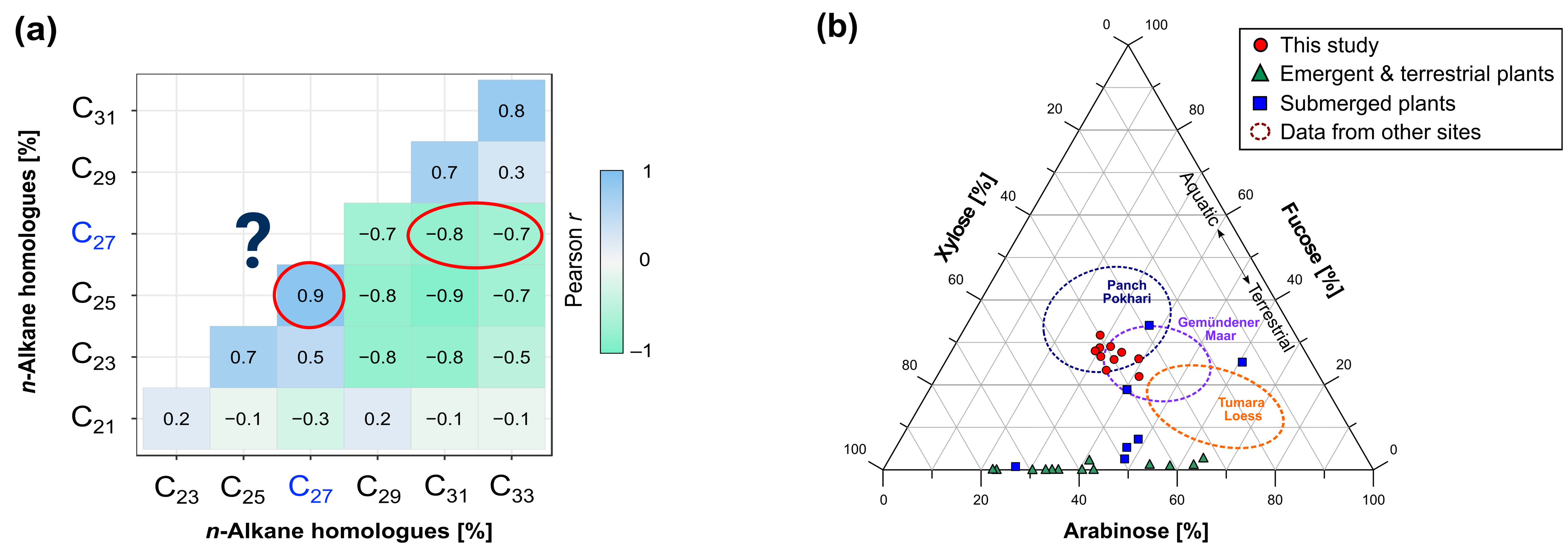
Lithology and chronology



▲ **Figure 2**
Core photograph, age depth model and results of geochemical analyses (TOC, log Ti) for the Late Glacial—Early Holocene part of our core from Bichlersee.

Biomarkers and their stable isotope signal

Sources of *n*-alkanes and hemicellulose sugars



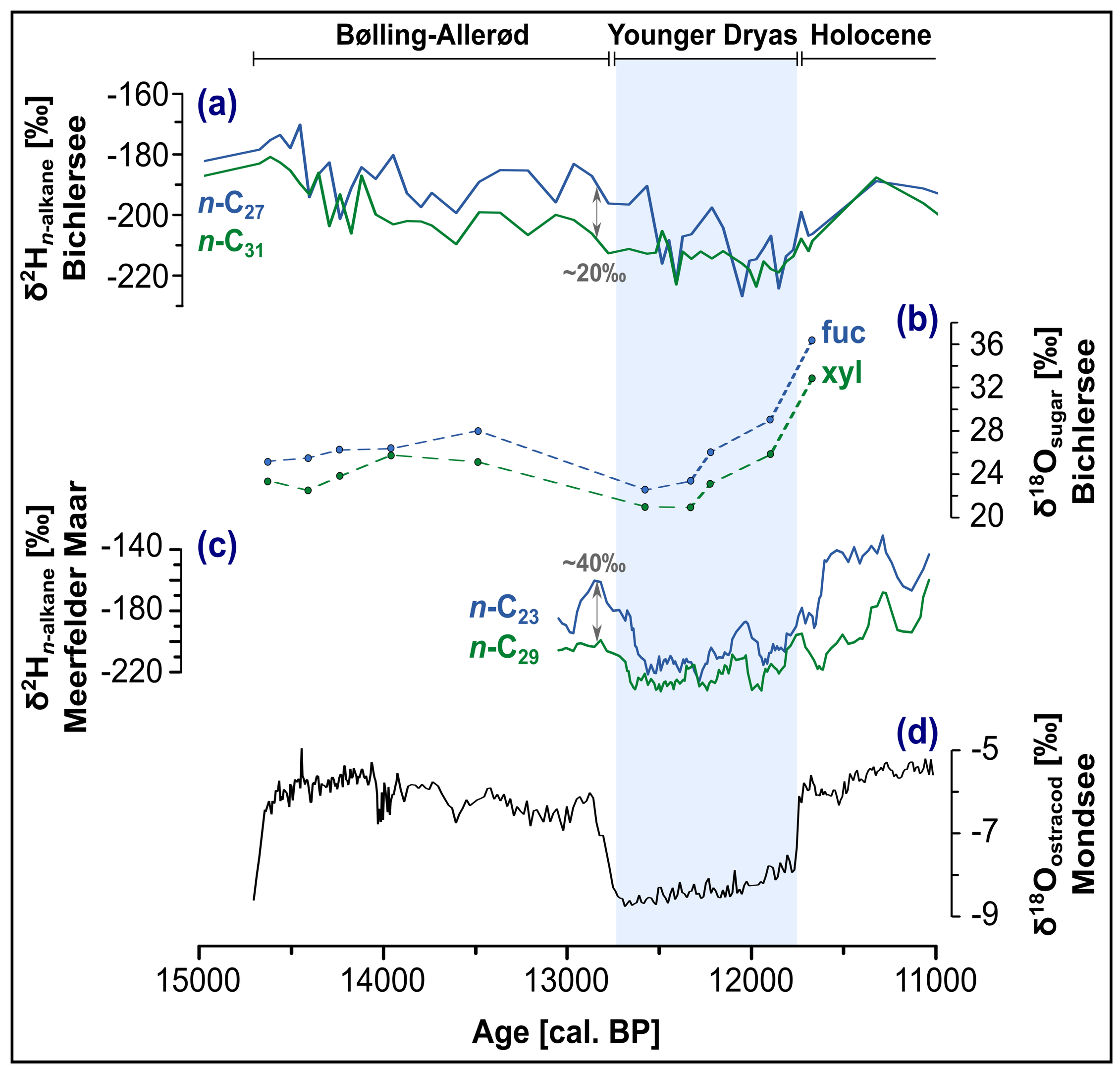
n-C_{31}: produced by grasses, reflects isotopic composition of precipitation
n-C_{27}: produced by trees (i. e. *Betula pendula*) → transpirative enrichment of leaf water – or a mixed terrestrial/aquatic compound → lake water?? (e. g. Andrae et al. 2020)

Samples show high contributions of fucose and xylose, but low amounts of arabinose → sugars mostly of aquatic origin
$\delta^{18}O_{sugar}$ reflects the δ^{18}O signal of lake water → evaporative enrichment

▲ **Figure 3**
(a) Correlation matrix (Pearson *r*) for the relative abundance of *n*-alkanes. **(b)** Ternary diagram of relative abundances of arabinose, fucose and xylose in the Bichlersee samples (red dots) and data from the literature: emergent/terrestrial plants from Bichlersee (Hepp et al., 2016), Panch Pokhari (Zech et al., 2014), Tumara Loess (Zech et al., 2013) and Gemündener Maar (Hepp et al., 2019).

$\delta^2H_{n\text{-alkane}}$ and $\delta^{18}O_{sugar}$ and their paleoclimatic implications

- $\delta^2H_{n\text{-}C31}$: decreasing during BA and YD, increasing during the Younger Dryas-Holocene transition
  → Likely reflects changes in isotopic composition of precipitation
- $\delta^2H_{n\text{-}C27}$: somewhat enriched compared to $\delta^2H_{n\text{-}C31}$
  → leaf and/or lake water enrichment
- $\delta^2H_{n\text{-alkane}}$ from Bichlersee is similar with Meerfelder Maar (Rach et al., 2014)
- $\delta^2H_{n\text{-alkane}}$ roughly follows the pattern of $\delta^{18}O_{ostracod}$ from Mondsee (Lauterbach et al., 2011)
- $\delta^{18}O_{sugar}$ enriched during the BA, depleted at the onset of YD, then increasingly and strongly enriched
  → Variable lake water enrichment, probably related to summer temperature



▲ **Figure 4**
(a) $\delta^2H_{n\text{-alkane}}$ of *n*-C_{27} and *n*-C_{31} from Bichlersee and **(b)** $\delta^{18}O_{sugar}$ data illustrating lake water enrichment during the Late Glacial. **(c)** $\delta^2H_{n\text{-alkane}}$ data from Meerfelder Maar with *n*-C_{23} as an aquatic and *n*-C_{29} as an terrestrial compound (Rach et al., 2014). Grey arrows indicate amplitude of enrichment. **(d)** $\delta^{18}O_{ostracod}$ data from Mondsee (Lauterbach et al., 2011). This signal is interpreted to reflect the isotopic composition of precipitation (modulated by temperature effects).

Take-Home-Messages

- The effect of lake water enrichment should be considered when reconstructing paleohydrology using stable isotopes from lake sediments
- δ^{18}O is much more sensitive to evaporative enrichment than δ^2H, so more $\delta^{18}O_{sugar}$ analyses are recommended

References
Andrae et al. (2020): Carbon isotope systematics of leaf wax *n*-alkanes in a temperate lacustrine depositional environment. *Org. Geochem.* 150; Hepp et al. (2016): A sugar biomarker proxy for assessing terrestrial versus aquatic sedimentary input. *Org. Geochem.* 98; Hepp et al. (2019): How dry was the Younger Dryas? Evidence from a coupled δ^2H–δ^{18}O biomarker paleohygrometer applied to the Gemündener Maar sediments, Western Eifel, Germany. *Clim. Past* 15 . Lauterbach et al. (2011): Environmental responses to Lateglacial climatic fluctuations recorded in the sediments of pre-Alpine Lake Mondsee (northeastern Alps). *JQS* 26 . Rach et al. (2014): Delayed hydrological response to Greenland cooling at the onset of the Younger Dryas in western Europe. *Nature Geosci.* 7; Zech et al. (2013): A 220ka terrestrial δ^{18}O and deuterium excess biomarker record from an eolian permafrost paleosol sequence, NE-Siberia. *Chem. Geol.* 360-361; Zech et al. (2014): A 16-ka δ^{18}O record of lacustrine sugar biomarkers from the High Himalaya reflects Indian Summer Monsoon variability. *Journ. Paleolimn.* 51.

FRIEDRICH-SCHILLER-UNIVERSITÄT JENA

TECHNISCHE UNIVERSITÄT DRESDEN