



An 8 ka record of drought and fire dynamics in the southern European Alps based on biomarker analyses

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The southern European Alps are currently suffering from serious drought conditions and wildfires due to climate change. For this reason, paleoenvironmental research is fundamental in this vulnerable region to better understand the interactions between climate, humans, and landscape in the past, which are still largely unknown. Therefore, we established an 8 ka sediment record from Lago di Pusiano in the Brianza region (northern Italy) to reconstruct previous drought and wildfire dynamics since the Neolithic period using biomarker analyses. Specifically, besides well-established geochemical analyses, we use compound-specific hydrogen isotope analyses ($\delta^2\text{H}$) of *n*-alkanes to reconstruct hydroclimatic conditions and polycyclic aromatic hydrocarbons (PAHs) to reconstruct fire activities.

Our results show that $\delta^2\text{H}$ of the terrestrial *n*- C_{29} and *n*- C_{31} , which both reflect the $\delta^2\text{H}$ signal of the growing season precipitation, is enriched during the Mid Holocene (~8 to 4.2 cal. ka BP), depleted from ~4.2 to 2.5 cal. ka BP and enriched from ~2.5 to 0.4 cal. ka BP. On longer timescales, we interpret our terrestrial $\delta^2\text{H}$ to reflect the isolation-driven temperature change due to northern hemispheric cooling, showing an ongoing depletion in $\delta^2\text{H}$ from the Mid to Late Holocene. However, on shorter timescales, especially during the Late Holocene, terrestrial $\delta^2\text{H}$ can be overprinted by changes in the moisture source of precipitation, which are mostly related to the North Atlantic Oscillation (NAO) and the position of the Westerlies. Compared to the terrestrial *n*-alkanes, $\delta^2\text{H}$ of the aquatic *n*- C_{25} , which reflects the $\delta^2\text{H}$ signal of lake water, is generally more enriched due to lake water evaporation. Consequently, the offset between aquatic and terrestrial $\delta^2\text{H}$ gives a valuable indication about evaporation at Lago di Pusiano and indicates wetter conditions during phases of enriched terrestrial $\delta^2\text{H}$ and dryer conditions during depleted terrestrial $\delta^2\text{H}$.

PAHs are abundant throughout the sediment core and increase during periods of higher regional human activity (e.g., Bronze Age pile dwellings ~4 cal. ka, Roman settlements ~2 cal. ka, and during Medieval times ~1 cal. ka), especially strongly during industrialization. The occurrence of PAHs in the Pusiano sediments, especially the large amount of high molecular PAHs, indicates significant local fire episodes with biomass combustion at high burning temperatures. The comparison of PAHs and $\delta^2\text{H}$ of *n*-alkanes suggests the presence of increased fire activities during wetter periods, possibly due to higher biomass availability as fuel for more extensive wildfires, and/or increased anthropogenic burning due to increased human presence during wetter periods.

