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Alpine Holocene Tree Ring Isotope Records – A Synthesis of a Multi-Proxy Approach in Dendroclimatology

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High-resolution climate reconstructions based on tree-ring proxies are often limited by the individual segment length of living trees selected at the defined sampling sites, which mostly results in relatively short multi-centennial proxy series. A potential extension of living wood records comprise the addition of subfossil and archeological wood remains resulting in chronologies and associated climate reconstructions which are able to cover a few millennia in central Europe (e.g. Büntgen et al., 2011).
However, existing multi-millennial tree-ring width chronologies in central Europe rank among the longest continuous chronologies world-wide and span the entire Holocene (Becker et al., 1993; Nicolussi et al. 2009). So far, these chronologies have mainly been used for dating subfossil wood samples, floating chronologies and archeological artifacts, but only in parts for reconstructing climate.
Finds of Holocene wood remains in glacier forefields, peat bogs and small lakes allow us not only to establish such long-term tree-ring width records; further they offer the possibility to establish multi-millennial proxy records for the entire Holocene by using a multi-proxy approach which includes both tree-ring width and triple stable isotope ratios. As temperature limits tree growth at the Alpine upper tree line, the existing tree-ring width records are currently limited to reconstruct a single environmental variable.
In the framework of the project Alpine Holocene Tree Ring Isotope Records, we combine tree-ring width, cellulose content as well as carbon, oxygen and hydrogen isotope series in a multi-proxy approach which allows the reconstruction of past environments by combining both Holocene wood remains and recent tree samples from two Alpine tree-line species. For this purpose, α-cellulose is prepared from 5-year tree ring blocks following the procedure after Boettger et al. (2007) and subsequently crushed by ultrasonic homogenization (Laumer et al., 2009). The cellulose content is determined for each individual sample and carbon, oxygen and hydrogen isotopic ratios are measured simultaneously (Loader et al., 2015).
The isotope records of carbon, oxygen and hydrogen show distinct low-frequency trends for the Early- and Mid-Holocene, but the individual series per proxy are often offset in their isotopic signature. As the sampling sites in our study are distributed along a SW-NE transect, the influence of the site conditions (latitude, longitude, elevation, exposition) and the tree species is tested and subsequently a correction is applied to the individual series. In addition, the tree-ring width records operate as a helpful tool in detecting and attributing the influence of larch budmoth outbreaks on the cellulose content and isotope records.
We here present a synthesis of the applied multi-proxy approach and its ability to reconstruct Holocene climate variability for the time span from 9000 to 3500 years b2k covering the Early-Holocene (9000 to 7200 years b2k) and Mid-Holocene (7200 to 4200 years b2k) and the transition to the late Holocene (4200 to 3500 years b2k) as well as the recent 400 years including the modern warming.

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