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Can climate variations be inferred from tree-ring parameters and stable isotopes from Larix decidua: budmoth outbreaks, juvenile effects and divergence problem.

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Larch wood has been used for centuries as a building material. It is therefore potentially very useful for reconstructing climate from tree-ring width, latewood maximal density and oxygen and carbon isotope composition of cellulose. We explored the usefulness and the limits of these parameters, focusing on a stand in the Névache valley (French Alps). The analysis of 15 trees showed that the intra-tree is small in comparison to the inter-tree variability of d13C and d18O and that 6 trees, at least, must be pooled to make a population-representative sample. The carbon and oxygen isotopic ratios of larch cellulose are suited to climate reconstruction in so far as: carbon is not affected by a juvenile effect, the isotopic ratios contrarily to tree- ring width and wood density are unaltered by budmoth outbreaks and linked to July-August temperature and relative humidity. The d18O of the larches cellulose is also strongly linked with the previous winter (December-March) oxygen isotopic composition of the precipitation. This is consistent with a winter water recharge of soil and ground. The past variations of July-August maximum temperature and relative humidity were reconstructed using two different combinations of the isotopic ratios. The uncertainties on the reconstructions are estimated respectively at $\pm$ 1.4°C and 3.6%. The inter-annual variations of temperature and relative humidity are well reproduced.
However, the reconstructed July-August temperature series diverges from the instrumental one, being lower, after ca. 1990. A shift of the growing season towards earlier dates in the later decades may account for the observed discrepancy. This 'divergence problem' strongly questions the ability of temperature reconstruction based on larch cellulose to capture earlier periods of putative warmth, such as the medieval times.
The relations between isotopes and the July-August relative humidity are more stationary than those with temperature. This may reflect the first order control of the relative humidity on d13C via the stomatal conductance and its influence on the evaporative enrichment of the oxygen of the leaf-water. Our study suggests that the variations of relative humidity in the French Alps through time can be truthfully reproduced using the stable isotope composition of larch cellulose.