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Examining the response of larch needle carbohydrates to climate using compound-specific δ13C and concentration analyses

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Little is known about the dynamics of concentrations and carbon isotope ratios of individual carbohydrates in leaves in response to climatic and physiological factors. Improved knowledge of the isotopic ratio in sugars will enhance our understanding of the tree ring isotope ratio and will help to decipher environmental conditions in retrospect more reliably. Carbohydrate samples from larch (Larix gmelinii) needles of two sites in the continuous permafrost zone of Siberia with differing growth conditions were analysed with the Compound-Specific Isotope Analysis (CSIA). We compared concentrations and carbon isotope values (δ13C) of sucrose, fructose, glucose and pinitol combined with phenological data. The results for the variability of the needle carbohydrates show high dynamics with distinct seasonal characteristics between and within the studied years with a clear link to the climatic conditions, particularly vapour pressure deficit. Compound-specific differences in δ13C values as a response to climate were detected. The δ13C of pinitol, which contributes up to 50% of total soluble carbohydrates, was almost invariant during the whole growing season. Our study provides the first in-depth characterization of compound-specific needle carbohydrate isotope variability, identifies involved mechanisms and shows the potential of such results for linking tree physiological responses to different climatic conditions.