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Tree growth variability under environmental changes – identifying underlying physiological mechanisms by stable C and O isotopes

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Long-term variability of tree growth is a result of changing environmental factors and physiological response mechanisms. Information about these relationships can be retrieved from tree ring width, but also from tree ring isotopes as proxies of photosynthetic rates (13C), stomatal conductance (13C, 18O), and source water (18O) used by the tree.

With the interdisciplinary project iTREE, we aim to identify physiological mechanisms by relating time-series of tree ring isotopes from a network of sites to environmental factors, and compare resulting growth reponses with stand surveys and vegetation models. Linking these different scales – from individual trees to site and landscape - will contribute to reduce uncertainties in modeling large-scale variability of forest biomass production under current climate change.

At a high altitude site in Switzerland (Loetschental, 2100m asl), $\sim$400 yrs old larch (Larix dedicua) trees showed enhanced tree growth towards the end of the 20th century along with increasing CO_2 concentrations and temperature, but also increasing variability between individual trees. At this temperature limited site, both environmental factors seem to act as growth drivers by increasing photosynthesis and cell growth. Because δ18O and δ13C (after correction for atmospheric CO_2 increase and 13C decrease) remained rather unchanged over the past $\sim$100 yrs, the stomatal behavior did not change according to the dual isotope model, indicating relatively constant water supply over time.

At other sites throughout Central Europe, physiological responses to environmental changes may result in different carbon assimilation or allocation other than stem growth. First data of different sites and species along a temperature gradient in Central Europe show that year-to-year variability of tree ring δ13C and δ18O are positively correlated at most sites indicating pronounced responsiveness of stomatal conductance. A trend of increasing isotopic values across the past $\sim$100 yrs at many sites suggests an indirect effect of elevated CO_2 resulting in an increased water use efficiency.

Variability between sites and individual trees demonstrate the range of tree physiological responses to environmental changes that need to be considered when scaling up tree growth dynamics from site to landscape.

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