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Intra-seasonal pathway of oxygen isotopes from soil to wood - A case study along an altitudinal transect in the Loetschental/Switzerland

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Oxygen isotopes in tree-rings are seen as a powerful tool for reconstructing past climate conditions, namely precipitation and temperature. There exist, however, still uncertainties about the spatial and temporal stability of the climate signal and particularly about how to disentangle between regions and periods with source water or processes at the leave level respectively, being the main drivers of isotope fixation. These open questions call for a deepened investigation of the interaction between tree physiological processes and varying environmental impacts. We study the intra-seasonal and diurnal pathway of oxygen isotopes from precipitation and soil water to the tree-rings of Larix decidua Mill (4 trees per site) at two sites in the Loetschental, an inner-alpine dry valley in the Swiss Alps. Sites are located at the upper tree line (2100 m asl) of a south-facing slope and at the valley bottom (1300 m asl). The air temperature difference of approx. 3°C between the tree line and the valley bottom, which roughly coincides with the predicted deviation from current temperatures over the next 100 years makes this region an ideal place to monitor the effects of climate change on tree physiological processes.
Sampling took place on a weekly basis covering the full vegetation period 2008 (beginning of April to mid of November). Here we present first results of highly resolved intra-seasonal oxygen isotope variations in precipitation, soil, needle and xylem water, phloem sugars and wood. As expected, the diurnal cycle (investigated at two days) of needle water enrichment is rather pronounced. In contrast, no trend is to be seen in both xylem water and phloem sugar records, an important finding for the interpretation of intra-seasonal variations. Over the full vegetation period, individual needle and xylem water records respectively, nicely correlate between trees per site, pointing to a common signal contained. Correlations between phloem records are lower, but still significant. Overall, mean isotope values per parameter and particularly values of needle water show an offset with generally higher values at the lower site. The isotope variations of precipitation are fingerprinted in xylem water records at both sites. Isotope variations of soil water, however, correlate only weakly, pointing to the fact that the source water up-taken by the trees might originate from lower depth than covered by the soil water sampling. Needle and xylem water per site show similar trends, meaning that despite of strong leaf water enrichment, the source water signal is still contained. It can, however, not be identified any longer in the phloem sugars suggesting strong (post-)photosynthetic fractionation processes. Compared to the other parameters, the amplitude of needle water variations is of much broader range, and it strongly correlates with external factors such as relative air humidity, amount of precipitation, temperature and irradiation. Surprisingly, correlations are weaker at the lower, seemingly dryer site. Wood sample measurements are still in progress, but will be finished soon, so that we will be able in our talk to draw the full picture of the oxygen isotope pathway and its dependency on varying environmental conditions with altitude.