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On the importance of atmospheric water vapour on the oxygen isotopic composition of water and assimilates in plants

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The atmospheric water vapour and its oxygen isotopic composition (δ18OV) can strongly influence the δ18O of leaf water (δ18OLW) and thus the δ18O of freshly produced photosynthetic assimilates that shape to a certain extent the δ18O of biomarkers (e.g. tree-ring cellulose). Seasonal and daily changes in weather conditions can cause that δ18OV differs from the δ18O of source water that is taken up from the soil via the xylem stream. The relative contribution of δ18OV on δ18OLW is known to increase with increasing relative humidity of the air. At very high humidity conditions δ18OV can be the sole source determining δ18OLW. However, the importance of δ18OV on δ18O of water and assimilates is still neglected in many ecophysiological studies.
To understand how changes in δ18OV are imprinted on water and assimilates we performed several greenhouse and field experiments with 18O-labelled water vapour at high humidity (i.e. a fog event) with different tree species, but also with plants of other growth forms. Additionally, we investigated the δ18OV incorporation into sugars and followed the label allocation in the sugars from leaves towards the twig phloem in trees under dry and wet soil moisture conditions (i.e. trees of different water status).
Across all experiments, we observed that a change in δ18OV immediately affects δ18OLW within minutes, reaching full equilibration between δ18OV and δ18OLW after about 4 hours in most plant species. The incorporation velocity of δ18OV into sugars was observed to depend on the photosynthetic assimilation rate in oak saplings and to be different among growth forms (e.g. broadleaf trees, conifers, aquatic plants, grasses, succulents). Moreover, we observed that the tree water status influences the incorporation of the 18O-label and its allocation from leaves towards twigs.
We demonstrate that changes in δ18OV are immediately influencing δ18O of water and fresh assimilates in plants, which is particularly important (but not only) for the interpretation of biomarkers from plants that regularly experience high humidity conditions (e.g. trees in cloud forests, tropics, coastal regions). We show that water vapour labelling reflects an easy-to-apply tool that can be combined with $13CO_2$-labelling to investigate and compare the allocation of different elements (O, H, C) in plants.