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High temporal resolution tracing of xylem CO_2 transport in oak trees

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Carbon (C) allocation defines the flows of C between plant organs and their storage pools and metabolic processes and is therefore considered as an important determinant of forest C budgets and their responses to climate change. In trees, assimilates derived from leaf photosynthesis are transported via the phloem to above- and belowground sink tissues, where partitioning between growth, storage, and respiration occurs. At the same time, root- and aboveground respired CO_2 can be dissolved in water and transported in the xylem tissue, thereby representing a C flux of large magnitude whose role in C allocation yet is unresolved.

In this study, we infused ^{13}C labeled water into the stem base of five year old potted oak (*Quercus rubra*) trees as a surrogate for respired CO_2 to investigate the role of respired CO_2 transport in trees in C allocation. We used high-resolution laser-based measurements of the isotopic composition of stem and soil CO_2 efflux combined with stem gas probes to monitor the transport of ^{13}C label. The high enrichment of the gas probes in the stem at the bottom of the canopy showed that the label was transported upwards from the base of the tree toward the top. During its ascent, the ^{13}C label was removed from the transpiration stream and lost to the atmosphere at stem level, as was observed using the stem CO_2 efflux laser-based measurements.

This study is the first to show results from tracing xylem CO_2 transport in trees at high temporal resolution using a ^{13}C labeling approach. Moreover, they extend results from previous studies on internal CO_2 transport in species with high transpiration rates like poplar to species with lower transpiration rates like oak. Internal transport of CO_2 indicates that the current concepts of the tree C allocation need to be revisited, as they show that current gas exchange approach to estimating above- and belowground autotrophic respiration is inadequate.