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High temporal resolution tracing of up-and downward carbon 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 secondary C flux of large magnitude. The relative magnitude of both fluxes in a same set of trees and their concurrent role in C allocation remains unclear.

In this study, we ^{13}C pulse labeled five year old potted oak (*Quercus rubra*) trees to investigate both the role of C transport via the phloem and xylem in C allocation. To this end trees were randomly assigned to two ^{13}C labeling experiments: 1) a canopy labeling experiment using transparent canopy chambers and 2) a stem labeling experiment based on the infusion of ^{13}C labeled water in the stem base. We used high-resolution laser-based measurements of the isotopic composition of stem and soil CO_2 efflux to monitor both the down-and upward transport of ^{13}C label. Additional tissue samples at stem, canopy and root level were analyzed to validate the assimilation of the label in tree tissues during transport. Overall, after both labeling experiments enrichment was observed in both stem and soil CO_2 efflux, showing that the ^{13}C label was removed from both xylem and phloem transport during up- and downward transport, respectively. Higher enrichments of CO_2 efflux were observed after stem labeling as compared to canopy labeling, which implies that xylem transport strongly contributes to C lost to the atmosphere.

This study is the first to show combined results from tracing of xylem and phloem transport of C for a same set of trees at high temporal resolution using a ^{13}C labeling approach. Moreover, they extend results from previous studies on the tracing of phloem transport in trees to a tracing of both xylem and canopy transport as well as results from studies on the internal CO_2 transport in species with high transpiration rates like poplar to species with lower transpiration rates like oak. The results further demonstrate the complex interplay of phloem and xylem transport of carbon and its role for the emission of respired CO_2 from trees into the atmosphere.