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# An isotopomer strategy to detect plant acclimation to increasing atmospheric CO2

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Abundances of deuterium (D) and 18O in precipitation carry climate signals. Both isotopes are incorporated into leaf photosynthate, and in a second step into tree rings. Strikingly, while D and 18O climate signals in precipitation are related, tree-ring records of both isotopes do not generally go in parallel. This contribution investigates this discrepancy, based on a comparison of the fractionation mechanisms for both isotopes. We present a strategy to detect plant acclimation on time scales of centuries from intramolecular deuterium distributions (D isotopomers).
We showed recently that specific C-H groups of glucose units exchange with water during cellulose synthesis in tree trunks, in agreement with the biochemistry of cellulose formation. Most importantly, this result allows separating influences of source water and of D fractionations in the plant, and hence to isolate climate signals and physiological signals.
NMR measurements of intramolecular D distributions of glucose demonstrate that each C-H group has a distinct abundance (each D isotopomer), corresponding to its unique biochemical history, and can serve as independent information channel. Therefore, isotopomers increase the information content of isotopes several-fold. Thus, using D isotopomers, a situation may be achieved where experimental quantities overdetermine the number of variables to be reconstructed. This increased information content can be retrieved along the following strategies.
Similar to C-O groups that exchange during cellulose synthesis, D isotopomers of C-H groups which heavily exchange should adopt the D abundance of source water and associated climate signals. We will present tree-ring results that support the feasibility of this approach.
C-H groups that are not affected by isotope exchange are passed from leaves to the trunk, and can therefore transmit leaf-level information to tree rings. On the leaf level, overall D abundance of photosynthate is influenced by transpiration, but individual D isotopomer abundances are ultimately set by enzyme isotope effects. In tree-ring cellulose, abundance differences between exchanging and non-exchanging isotopomers reflect evaporative enrichment and may be exploited to reconstruct humidity.
Finally, we have shown that abundance ratios of non-exchanging D isotopomers are wholly determined by biochemical isotope fractionations, independent of source water. Consequently, isotopomer ratios represent signals of leaf-level metabolic regulation, which are deposited in tree rings. For example, one isotopomer ratio responds to the CO2 concentration during photosynthesis. This effect reflects CO2-induced changes of the metabolic flux ratio of photosynthesis versus photorespiration. Photorespiration reduces the efficiency of photosynthesis, therefore this isotopomer ratio may reveal plant acclimation on time scales of decades, and associated trends in plant productivity.
Combining signals reflecting metabolic regulation with climate signals opens the possibility to study acclimation of plants to increasing atmospheric CO2 and concomitant climatic changes, on time scales of decades and centuries.