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Plants in changing climate: Linking isotope effects, manipulation experiments, plant archives and modelling to derive long-term ecophysiological signals

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Conventional isotope applications in plant ecophysiology measure isotope ratios (e.g. $\delta^2\text{H}$, $\delta^{13}\text{C}$) of whole molecules. However, it is well established that isotope abundance varies AMONG the CH groups of metabolites (isotopomers), because they are biochemically distinct. This variation reflects enzyme isotope fractionations and encodes metabolic information, but it is unclear how these fractionations get transferred into signals that can be recovered from archives of plant material.

Here, we will describe physical and biochemical mechanisms of hydrogen isotope fractionation in plants and compare their magnitudes. Based on observations for hydrogen isotope transfer in plants, we present a model for the extraction of H isotope signals from plant archives.

Plant responses to increasing CO_2 are critical for plant productivity and as climate feedbacks. As CO_2 is the substrate for photosynthesis, plants should benefit from increasing CO_2 , but the magnitude of this “ CO_2 fertilization” disagrees with biomass estimates. Photorespiration is a side reaction of photosynthesis that reduces C assimilation in most vegetation, therefore its response under climate change is critical for the future C cycle. Photorespiration should be reduced by increasing CO_2 yet exacerbated by rising T, but its response is not well captured in models, adding large uncertainty to C cycle predictions.

To retrieve ecophysiological signals from plant archives, we use manipulation experiments to develop *proxies* for plant C fluxes, based on intramolecular abundance variation of ^2H and ^{13}C , detected by NMR. We then retrieve these *proxies* from archives such as tree-ring series, to derive metabolic responses over long time scales, and to improve global

vegetation models.

Here we will describe progress in tracking isotopomer signals from controlled experiments to plant archives, and results on long-term trends of photorespiration in response to increasing atmospheric CO₂ for two globally important ecosystems. In *Sphagnum* species, we link trends in photorespiration to the C sink of boreal peatlands. In the tropical tree species *Toona ciliata*, we describe long-term trends in photosynthetic efficiency.

As intrinsic quantities, isotope data are well suited to report on metabolic shifts, but not about fluxes in absolute numbers. Therefore we use isotopomer data as input for the LPJ-GUESS Ecosystem Model, to translate isotopomer-derived changes in photorespiration into trends in ecosystem C fluxes.

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