Compound-specific labelling: a tool to access the mechanisms underlying rapid dynamics in respired $\delta^{13}CO_2$

Christiane Werner[1], Frederik Wegener[1], Stephan Unger[1], Cristina Maguas[2], Pierrick Priault[3]

[1]Exp. and Systems Ecology, University of Bielefeld, Germany
[2]Centro de Biologia Ambiental/FCUL, University Lisbon, Portugal
[3]Université Henri Poincaré Nancy I, Faculté des Sciences, Vandoeuvre-lès-nancy cedex, France

There is increasing evidence of marked diurnal dynamics in respired δ13CO2 (δ13Cres) of up to 10% in different plant organs (leaf, stem, roots), ecosystem compounds (foliage, trunk, heterotrophic and autotrophic soil respiration), and nocturnal ecosystem respiration (δ13CR). Nevertheless, the underlying mechanisms are still largely unknown. We combined compound specific labelling (13C-pyruvate) with a rapid in-tube incubation technique and on-line gas exchange measurements to investigate the causes of diurnal patterns and short-term changes in δ13Cres. Positional labelled pyruvate revealed that apparent fractionation processes in respiratory pathways resulted in marked differences in δ13CR dynamics between plant functional groups. Large diurnal enrichment of δ13Cres occurred in evergreen, slow growing and aromatic species due to increasing investment of pyruvate derived Acetyl-CoA into secondary metabolism (e.g. defence or aromatic compounds) while the Krebs-cycle activity remained constant. In contrast, fast growing herbs with a high respiratory energy demand exhibited no diurnal changes in δ13Cres or in the carbon flow through the respiratory pathways. Hence, allocation of carbon between respiratory pathways due to different metabolic demands for growth, maintenance or storage can induce large diurnal variations in δ13Cres. No distinct diurnal patterns were found in δ13C of water soluble organic matter in either leaves or roots. On a short-term scale (>30 min) very rapid post-illumination changes in δ13Cres ranging from 2 to 5‰ were not entirely attributable to partitioning between respiratory pathways. Theoretical calculations of potential fractionation effects revealed that a transient decarboxylation of an enriched substrate pool (e.g. malate) or, more probably, Rayleigh fractionation processes of enzymatic reactions in the respiratory pathways could explain these initial post-illumination δ13Cres dynamics. At the ecosystem scale, changes in environmental pattern such as increasing drought markedly influenced the diurnal dynamics of δ13Cres in different ecosystem components. Large variations in δ13Cres of foliage and roots were in accordance with the above described pattern of post-photosynthetic fractionation. Root δ13Cres reflected changes in allocation pattern with increasing. Marked diurnal dynamics in δ13Cres may therefore provide valuable information on both the physiological mechanisms and allocation patterns and may help to give further insights on species and ecosystem scale responses to changes in environmental conditions.