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Input of 12CO2 and 13CO2 soil concentration measurements to understand trends in soil carbon production and emission.

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In the context of the climatic change and global carbon cycle, knowledge about soil forest CO_2 efflux (Fs) has to be improved as it is the largest respiratory flux (60% to 80% of the total forest ecosystem respiration) and the second largest carbon flux after the gross primary productivity under temperate latitudes. A better knowledge of the origin of soil CO_2 is needed to feed mechanistic models of soil carbon dynamics and then, to better estimate continental CO_2 effluxes.

Carbon isotope studies are an efficient tool to understand ecosystem functioning (carbon transfer through tree and soil) and identify the CO_2 sources in the soil (layer-depth, organism emitting). But, despite the development of $^{12}CO_2$ & $^{13}CO_2$ measurements at high frequency, Marron and co-authors (2009) have shown that the correlation between isotope composition of CO2 efflux (δFs) and fluctuation in environmental parameters are difficult to analyse. This is due to the conjugation of two processes: (i) temporal fluctuations of $^{12}CO_2$ & $^{13}CO_2$ production intensity and/or (ii) variable isotopic fractionation of CO_2 during its transport (diffusion and advection) from source to soil/atm interface. Our objective is to go beyond uncertainties due to this last process and be able to determine the influences of both environmental conditions and tree phenology on the $^{12}CO_2$ & $^{13}CO_2$ production intensity. In this optic, we have set up a device to measure simultaneously Fs, δFs, $^{12}CO_2$ & $^{13}CO_2$ concentrations at key depths (5 depths from 0 to -80 cm). This experimental device has been successfully tested (Parent et al. abstract, same session) and the data provided allow the estimation of the soil CO_2 production and its δ^{13}C-signature.

We will present results from a field campaign performed during September 2010 in a Scot pine forest located at Hartheim in the southwest of Germany. For $^{12}CO_2$ and $^{13}CO_2$, the comparison between efflux, soil concentration and soil production shows that the impact of transport depends of the time scale. When period of few days are considered, the integrated efflux is equivalent to the total amount of CO_2 produced and their integratedgδ^{13}C-signatures are similar. For shorter time scale, large hourly and daily variations in Fs and δFs (4μmol.m^{-2}s^{-1} and 2‰ respectively) are not sustained by the production evolution and prove the large impact of environmental conditions (temperature, soil water content, atmospheric turbulence…) on the CO_2 transport and its apparent fractionation.

In view of our results, studies about diel evolution of soil respiration (links between autotrophic production and solar radiation, litter decomposition and temperature…) necessitate $^{12}CO_2$ and $^{13}CO_2$ soil concentration data in complement to efflux measurements whereas these last are sufficient to estimate seasonal trend.

Marron N, Plain C, Longdoz B, Epron D. 2009. Seasonal and daily time course of the ^{13}C composition in soil CO_2 efflux recorded with a tunable diode laser spectrophotometer (TDLS). *Plant and Soil* 318: 137-151.