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Field monitoring of carbon isotope composition and efflux rate of CO2 respired by tree trunks using tunable diode laser absorption spectrometry: methodological and analytical approaches

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The uncertainties of ecosystem response to global climate changes illustrate the need to improve knowledge of ecosystem functioning, in particular to explain the carbon (C) stock and fluxes variations and the abiotic and biotic factors driving such variations. Trunk CO_2 efflux (R_T) is a major component of total CO_2 forest ecosystem efflux, but in comparison with leaf photosynthesis, its determinism is still poorly understood. This CO_2 flux could originate from different carbon sources (respiration of newly assimilates or reserves; xylem sap flow dissolved CO_2). These potential CO_2 sources vary at both diurnal and seasonal time scales. They follow distinct metabolic pathways within the tree. To disentangle these pathways, stable C isotope composition ($\delta^{13}C$) can be used as metabolic tracer. However, technical steps, such as analytical preparation of samples and measurement frequency have highly limited the characterization of short term $\delta^{13}C$ variations of trunk CO_2 efflux ($\delta^{13}C_{RT}$).

During the last decade, new techniques such as tunable diode laser absorption spectroscopy (TDLAS) has enabled to track both the $\delta^{13}C$ and CO_2 efflux rate at a high temporal frequency compared to conventional isotope ratio mass spectroscopy. However there are still few published $\delta^{13}C$-based ecological studies using this technique, and obviously no standardized procedures for data quality check.

The present study (1) focuses on experimental data acquisition and processing of a TDLAS (TGA100A, Campbell Sci., UT) for quality check, and (2) assesses the influence of various meteorological variables on R_T and $\delta^{13}C_{RT}$, during summer and winter 2008. The TDLAS was installed in early July 2008 in a mature oak (*Quercus petraea*, L.) stand of the Barbeau forest (France, CarboEurope site). The system has been connected to three throughflow opened chambers placed on trunk of adult trees. For each chamber, absolute $^{12}CO_2$ and $^{13}CO_2$ concentrations were sequentially quantified in air pumped from the inlet's and outlet's chamber. Before each chamber measurement, the analyzer was calibrated with four calibration gas bottles with known CO_2 concentration (in air) and $\delta^{13}C$ values.

Data were flagged for mass flow deviation (relative to pre-set the values) as well for aberrant CO_2 concentrations values between chamber inlet and outlet. These flagged data represented less than 5% of the entire dataset. Measurements also showed that chambers inlets need to be buffered to dump very short-term (less than one minute) variations of CO_2 concentration. $\delta^{13}C_{RT}$ dramatically decreased between the two seasons. Hourly means of RT were positively and linearly linked to trunk temperature. The diurnal variations of $\delta^{13}C_{RT}$ were less obvious than for R_T, averaging around 1‰The results are discussed in light of those obtained with classical techniques.

Keywords: ^{13}C, carbon isotope composition, trunk CO_2 efflux, tunable diode laser spectroscopy