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Use of $\delta^{13}\text{C}$ for soil CO_2 efflux partitioning in a beech temperate forest and a rain tropical forest

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1. Objectives

Soil CO_2 efflux is the main respiration flux in the terrestrial ecosystems. Because of its high dependence on temperature and water content and important carbon stock in the soil, it plays an important role in the perturbations of the global carbon cycle due to climatic change. ^{13}C (stable isotope of the carbon) can be used as a tracer to achieve a better understanding and modelling of the processes involve in soil respiration (identification and quantification of these processes, determination of the relative importance of the different soil CO_2 sources). In this context, the aim of this study was first to measure the $\delta^{13}\text{C}$ (ratio $^{13}\text{C}/^{12}\text{C}$) at different stages of soil respiration to evaluate the discriminations (modification of $\delta^{13}\text{C}$ value during a carbon transformation or transfer) and then to compare $\delta^{13}\text{C}$ of soil CO_2 efflux coming from trenched (zone without living roots) and control plots to separate the heterotrophic and autotrophic components of Rs.

2. Sites

HESSE, France (CarboEurope & Fluxnet site)



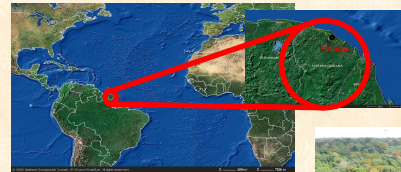
Temperate oceanic climate
Mean annual air Temp.: 9.2°C
Mean annual Precip.: 820 mm
Soil type: luvisol/stagnic luvisol (FAO)

Hesse 1 (H1):
Species: 90% Beech
Age: 37 years
LAI: 7-4 m² m⁻² Height: 18m



Hesse 2 (H2):
Species: Beech, Hornbeam, Oak
Age: 14 years
LAI: 8-5 m² m⁻² Height: 8m

PARACOU, French Guyana



Tropical climate
Mean annual air Temp.: 25.8°C
Mean annual Precip.: 2875 mm

Soil type:
ferralitic (FAO)



Mixed forest:
180 species ha⁻¹
LAI: 7 m² m⁻²
Height: 35 m

3. Material and Methods

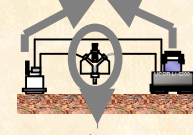
- Measurement of $\delta^{13}\text{C}$ for dry matter of fine roots, soil organic matter (SOM) and litter: Core sampling, soil components (roots-SOM-litter separation), passage of dry samples in the mass spectrometer
- Measurement of $\delta^{13}\text{C}$ for CO_2 coming from fine roots, SOM and litter : Core sampling, soil components separation, air sampling during incubation (use of gas sampling chamber, Fig. 3.1.), passage of the samples in the mass spectrometer
- Measurement of $\delta^{13}\text{C}$ for soil air CO_2 Tubes (closed at the top and pierced at the bottom) inserted permanently in the soil (Fig. 3.2.), sampling of gas in these tubes (use of gas sampling chamber), passage of the samples in the mass spectrometer

- Measurement of $\delta^{13}\text{C}$ for CO_2 efflux (soil Keeling plot): accumulation of CO_2 coming from soil in the soil respiration system (Fig. 3.1.), air sampling in the system at different CO_2 concentration, passage of the gas samples in the mass spectrometer, Keeling plot (Fig 3.3.)



Fig. 3.2.

Soil respiration system



Gas sampling chamber
Fig. 3.1.

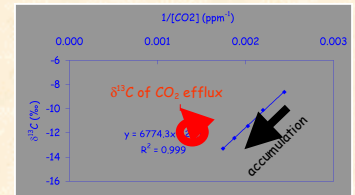
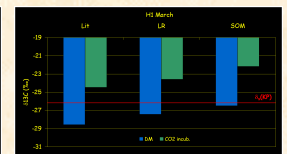
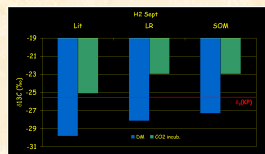
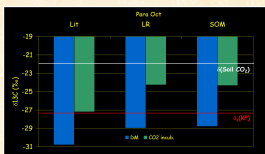
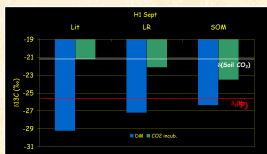


Fig. 3.3.

4. Results and discussion

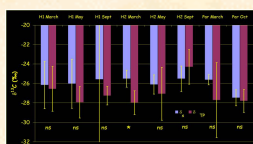
A. Control plots: Results of $\delta^{13}\text{C}$ for different sites (H1, H2, Paracou) and different campaigns (March, May, September, October) with Blue = dry matter; Green = CO_2 from incubation; White $\delta^{13}\text{C}(\text{soil } \text{CO}_2) = \text{CO}_2$ from soil air; Red $\delta^{13}\text{C}(\text{KP}) = \text{soil Keeling plot}$

Lit = litter; LR = living roots; SOM = soil organic matter



Systematic (all campaigns, all soil components) positive **discrimination** during the CO_2 production ($\delta^{13}\text{C}$ incubation - $\delta^{13}\text{C}$ dry matter, 3‰ in mean)
Systematic (all campaigns, all soil components) negative **discrimination** during the CO_2 diffusion toward surface (CO_2 efflux - incubation, -5‰ in mean)
Logically the value of soil air $\delta^{13}\text{C}$ is quasi-systematically between the incubation $\delta^{13}\text{C}$ of the different soil components

A. Trenched plots: Comparison between soil air $\delta^{13}\text{C}$ measured on trenched plots (δ_{TP} , no living roots) and control plots (δ_{S})



Except in one case, no significant difference between δ_{TP} and δ_{S}

Possible causes: • $\delta^{13}\text{C}$ of living root and SOM are too close

• The discriminations during respiration process (that are not well quantified) seem to be larger than the difference studied ($\delta_{\text{TP}} - \delta_{\text{S}}$)

5. Conclusion

Better quantification of discrimination is needed to improve the results of soil respiration process studies using ^{13}C
Use of ^{13}C don't give significant results for soil CO_2 efflux partitioning between potential sources (roots, SOM, litter)