Variability of ^{13}C-labeling in plant leaves
Implications for biogeochemical studies

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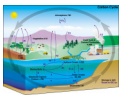
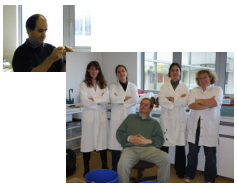
Introduction



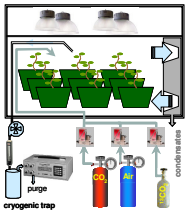
Incubation of artificially ^{13}C-enriched plant tissues is increasingly used to monitor the fate of organic matter in environmental studies

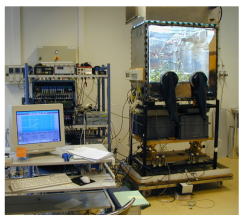
Variability of isotope labeling must be precisely documented to avoid bias when interpreting incubation patterns

AIM to quantify ^{13}C-variability in plant leaves after several months under continuously ^{13}C-enriched CO_2



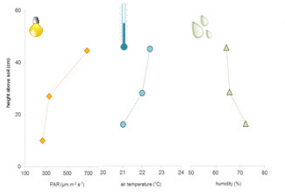
Labeling device





Fully controlled climatic chamber : "RUBIC 1" (Reactor Used for Continental Isotopic Biogeochemistry, Bariac et al. 1991)
- 0.5 m^3 entirely sealed volume
- 4 daylight bulbs (OSRAM HQI-BT) ⇨ ± 350 µmol.m^{-2}
- fans ⇨ good mixing of the air above the canopy
- cooling circulator + heat exchanger ⇨ t° & humidity regulation
- mass flow controllers ⇨ regulation of injection of gaz : CO_2-free air + normal CO_2 (-32‰) + ^{13}C-labeled CO_2 (10.7%)

Bariac *et al.* (1991) GCA 55 : 3391-3402.



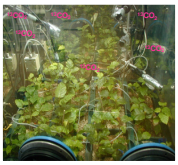
Vertical variability of climatic parameters from bottom to top of the chamber

European beech (*Fagus sylvatica* L.)

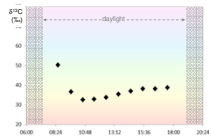
seed germination on **vermiculite** outside the chamber

planter **transfer to chamber at cotyledon** stage

4 months continuous $^{13}CO_2$-labeling
20°C day t° / 70% relative humidity
targeted values : 400ppmv CO_2 at **+40‰**

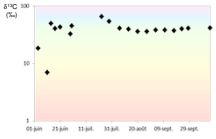


Daily kinetics of ^{13}C-signature of atmospheric CO_2



⇨ Night accumulation of **^{13}C-enriched CO_2 respired by plants**
⇨ Accumulated CO_2 is resorbed 2h after lamps are turned on

^{13}C-signature of atmospheric CO_2 inside the chamber throughout the labeling period



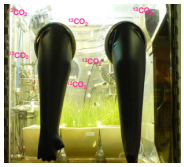
⇨ Regulation of $^{13}CO_2$ is difficult at the beginning of the growing period when plant biomass is limited

The obtained plant biomass was then dried and analysed through an isotope ratio mass spectrometer

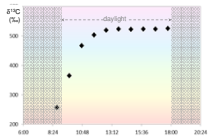
Italian ryegrass (*Lolium multiflorum* Lam.)

seed germination on **soil** directly **inside the chamber**

2 months continuous $^{13}CO_2$-labeling
22°C day t° / 70% relative humidity
targeted values : 450ppmv CO_2 at **+500‰**

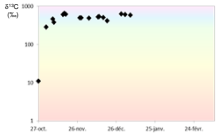


Daily kinetics of ^{13}C-signature of atmospheric CO_2



⇨ Night accumulation of **^{13}C-depleted CO_2 respired by soil** (+ minor ^{13}C-enriched CO_2 respired by plants ?)
⇨ Accumulated CO_2 is resorbed 2h after lamps are turned on

^{13}C-signature of atmospheric CO_2 inside the chamber throughout the labeling period

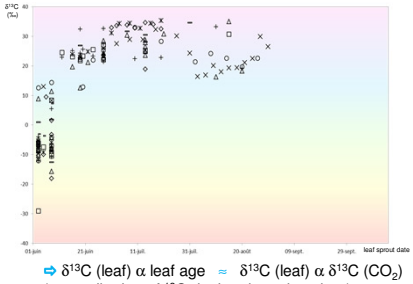


⇨ Regulation of $^{13}CO_2$ is difficult at the beginning of the growing period when plant biomass is limited

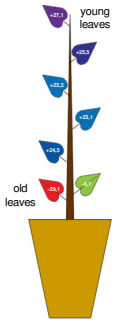
The obtained plant biomass was then dried and analysed through an isotope ratio mass spectrometer

Inter-leaf variability of ^{13}C-labeling

	CO_2	leaves		
		mean	σ	range
$\delta^{13}C$	+40.0	+15.8	15.0	65.9

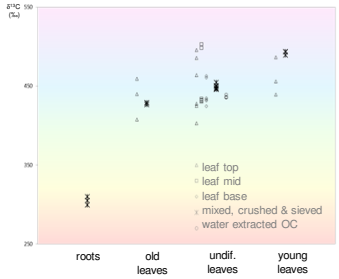


⇨ Significant variability of $\delta^{13}C$ among leaves (> natural leaves)



⇨ $\delta^{13}C$ (leaf) α leaf age ≈ $\delta^{13}C$ (leaf) α $\delta^{13}C$ (CO_2)
(+ contribution of ^{13}C-depleted seed carbon)

	CO_2	leaves		
		mean	σ	range
$\delta^{13}C$	+500.0	+448.9	27.2	92.9



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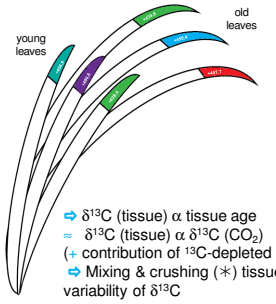
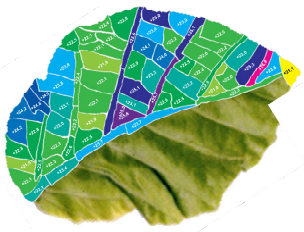
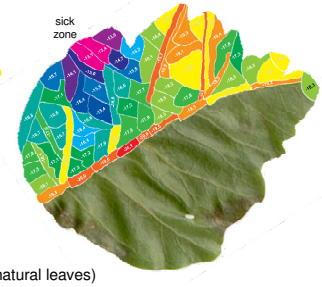


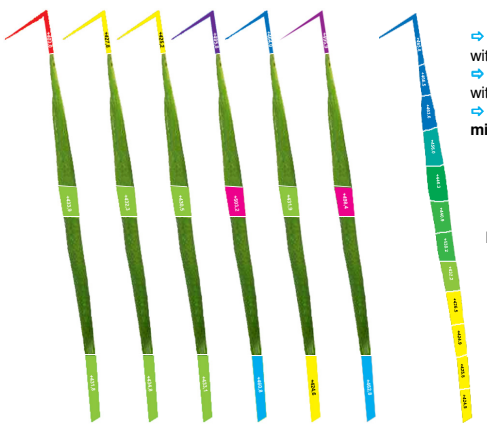
⇨ $\delta^{13}C$ (tissue) α tissue age
≈ $\delta^{13}C$ (tissue) α $\delta^{13}C$ (CO_2)
(+ contribution of ^{13}C-depleted seed C)
⇨ Mixing & crushing (✳) tissues limits variability of $\delta^{13}C$

Intra-leaf variability of ^{13}C-labeling





⇨ Significant variability of $\delta^{13}C$ within leaves (> natural leaves)
⇨ No systematic ^{13}C pattern within leaves (e.g. vein/intercoastal ltissues, apex/base, etc)



⇨ Significant variability of $\delta^{13}C$ within leaves (> natural leaves)
⇨ No systematic ^{13}C pattern within leaves (base/mid/apex)
⇨ ⇨ $\delta^{13}C$ are also inlfluenced by **microenvironmental** parameters

Even water extracted ⇦ OC exhibit some variability of $\delta^{13}C$, although extracted on pooled leaves
Influence of ⇦ ⇦ microenvironmental parameters

Conclusions

- Significant inter- and intra-leaf variability of ^{13}C-labeling
  - ↕ variations in $\delta^{13}C(CO_2)$ and in microenvironmental parameters
    - ➡ Caution is required when interpreting small variations in $\delta^{13}C$
- Mixing & crushing tissues limits variability of $\delta^{13}C$

Thanks to André Mariotti, Sylvie Derenne, Jean Broutin and FNS-ACIJC 10051 (partial funding)