Modelling total soil respiration in agricultural soils.

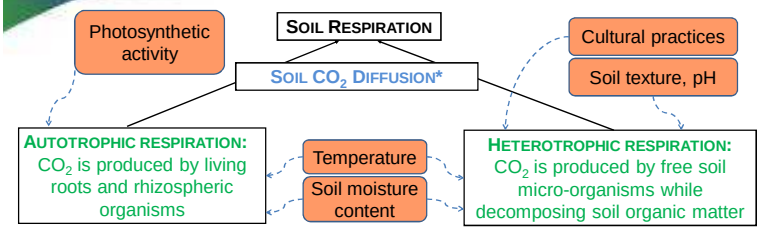
Buysse Pauline[1]*, Goffin Stéphanie[1], Carnol Monique[2], Le Dantec Valérie[3], Aubinet Marc[1].

[1] University of Liege – Gembloux Agro-Bio Tech – Unit of Biosystem Physics
8, Avenue de la Faculté – 5030 Gembloux – Belgium

[2] University of Liege – Laboratory of Plant and Microbial Ecology
Boulevard du Rectorat, 27, Building B22 – 4000 Liège 1 – Belgium

[3] Centre d'Etudes Spatiales de la Biosphère (CESBIO)
Avenue Edouard Belin, 18, bpi 2801, 31401 Toulouse Cedex 9, France

Introduction



* Is not dealt with in this study. See the poster by Goffin et al. (this session) for further information.

Fig. 1. Soil respiration components and the most important driving variables in the process.

➔Soil respiration is the second largest terrestrial CO_2 flux.

➔Crop soils have been less investigated so far.

➔Soil respiration comprises two components: heterotrophic and autotrophic respiration which are influenced by many different factors.

➔ **Objectives of the study**:

- ❑ To get to a better understanding of the variations of the heterotrophic and the autotrophic components of soil respiration in different agricultural soils.
- ❑ To model total (*, see Figure 1) soil respiration at an annual timescale, within a field spatial scale.
- ❑ To study short term temperature (= the most important driver) impacts on soil heterotrophic respiration.

The soil heterotrophic respiration component.

Adapting and developing the model.

Model description.

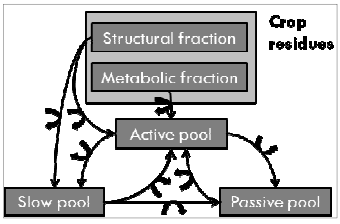


Fig.2 – Carbon flows in a model layer.

- Derived from the Century model (Parton et al., 1987).
- Three layers (soil surface, top soil (0-30cm) and subsoil (30-60cm)) containing 3 to 5 carbon pools each (Fig.2).
- Daily meteorological inputs (soil temperature and soil moisture content).
- Outputs : daily carbon flows between pools (Fig. 2) and respiration fluxes (thick arrows in Fig. 2).

Carbon (C) flows in and out of each pool (x):

$$\frac{dC_x}{dt} = F_{x,in} - F_{x,out}$$

The fluxes depend on several factors:

$$F_x = K_x \cdot Q_x \cdot Aw \cdot At \cdot C_x$$

- Decomposition constant (K_x)
- Soil texture factor (Q_x)
- Soil humidity factor (Aw)
- Soil temperature factor (At)
- Pool carbon content (C_x)

Model parameterization and initialization.

- Biochemical parameters (linked to crop type) were set based on a literature survey.
- Site parameters were set according to field data.
- The soil temperature and moisture functions were adjusted based on field measurements.
- The initialization phase was necessary to set the carbon pool contents.

Comparison of model outputs with field measurements.

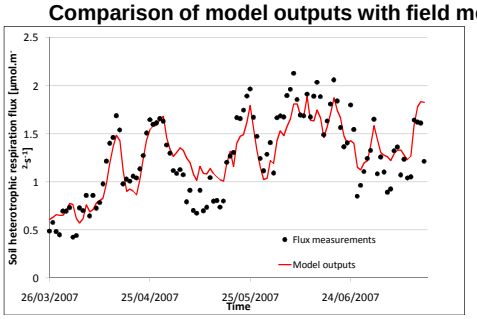


Fig.3 – Comparison between modeled and measured fluxes for the experimental site of Lonzée (Belgium). Measurements were performed with an automatic dynamic closed chamber system on a bare area delimited in the field, from March 26, 2007 until July 16, 2007.

➔ Overall good agreement between modeled and measured data at the Lonzée site (Fig. 3).

➔ The main driver is soil temperature.

➔ The model is highly sensitive to the carbon repartition between pools.

Studying short term temperature impacts on soil respiration.

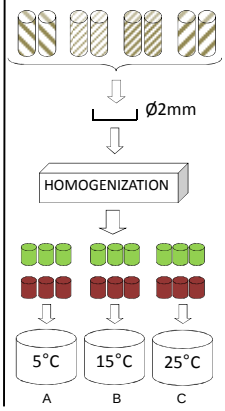
Site description

Crop site: Lonzée, Belgium.

Soil characteristics:

Parameter	Value
Soil type (FAO)	Luvisol
Soil texture: Silt / Sand / Clay	70% / 5% / 25%
Soil organic carbon content [kg/m²]	6.2
C:N ratio	9.40
Bulk density (0-30cm) [kg/m³]	1500
pH (H_2O)	7.9

Soil sampling



At two time periods (once in June and once in August), 2 auger samples (8cm Ø , 14cm height) were taken from each of 4 bare areas delimited in the field.

The samples were sieved at 2mm and homogenized. Their soil moisture content was kept constant.

Both times, 2 sets of 9 new samples (100g fresh soil) were prepared from the whole quantity of soil, put into 210 mL jars and slightly compacted.

3 jars of each set were placed into a water bath in each incubator. Incubator temperatures set at 5, 15 and 25°C. The jars were continuously ventilated with water-saturated air.

Experimental protocol

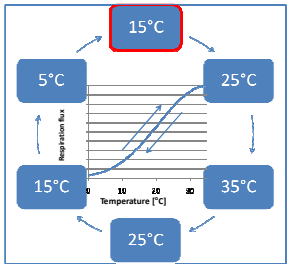


Fig.4 – Example of temperature cycle. After a 5-day pre-incubation period, the temperature was modified sequentially by 10°C-steps, starting from the incubation temperature. The same cycle was repeated two days later. Respiration flux measurements at each temperature step were performed with a dynamic closed chamber system (IRGA).

➔Clear increase of soil respiration with T°.
➔ Negative fluxes and hysteresis effect: probably due to physico-chemical processes
➔ Different pre-incubation temperature impacts at short and longer terms.

Main results

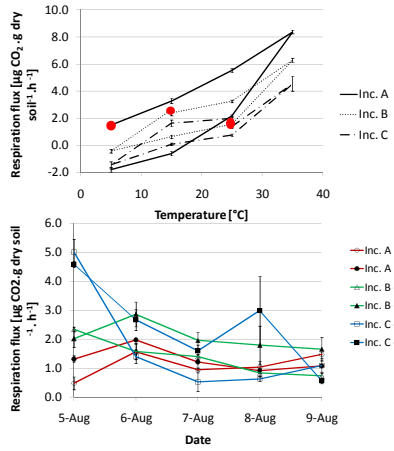


Fig. 5 – Evolution of measured soil respiration fluxes with temperature in June (above). Evolution of the fluxes during the pre-incubation period in August for two soil moisture treatments (%vol.) (below).

Further developments:

- **The soil heterotrophic respiration sub model:**
  - ➢ Calibration with long term (50 years) soil carbon content data taken at an agricultural site near Lonzée in Belgium.
  - ➢ Application to two other agricultural sites located in the South-West of France and model validation.
- **Short term temperature impacts on soil respiration:** set-up of complementary experiments to understand the present results (pre-incubation temperature impacts, physico-chemical processes influences).
- **The soil autotrophic respiration sub model:**
  - ➢ Development, parameterization and calibration of the sub model.
  - ➢ Validation of this sub model and of the global one with soil chamber and eddy-covariance measurements.

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CONTACT PERSON (*): Pauline Buysse
University of Liege – Gembloux Agro-Bio Tech – Unit of Biosystem Physics
8, Avenue de la Faculté – 5030 Gembloux – Belgium
e-mail : Pauline.Buysse@ulg.ac.be