Parameterization and initialization of a soil organic matter decomposition model in an agricultural soil.

P. Buysse[1], V. Le Dantec[2], P. Mordelet[2], M. Aubinet[1]
[1]Unit of Biosystem Physics, Gembloux Agro Bio-Tech (GxABT), University of Liège, Belgium
[2] Centre d'Etudes Spatiales de la Biosphère (CESBIO), Toulouse, France

1. Introduction

➔ Context of the study:

- Within the context of climate change, agricultural soils have been less investigated so far, despite their considerable importance through the world.
- Many Soil Organic Matter (SOM) decomposition models exist, which work at different spatial and temporal scales.
- But there is still a lack of a good understanding and description of the mechanisms which ultimately lead to SOM decomposition.

➔Objectives of the study:

- To model soil respiration in an agricultural soil:
  - at an annual timescale with a daily time resolution
  - at the ecosystem scale (field)
- The present work deals with the soil heterotrophic respiration component of the model, which will later be completed with a soil autotrophic respiration component.

2. Model description

The soil heterotrophic respiration model:

- 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.1).
- Daily meteorological inputs (soil temperature and soil moisture content).
- Outputs : daily carbon flows between pools (Fig. 1) and respiration fluxes (thick arrows in Fig. 1).

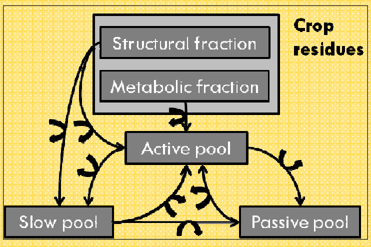


Fig.1 – Carbon flows in a model layer.

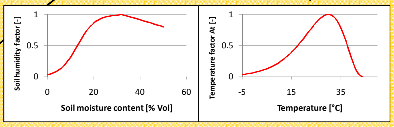
Carbon (C) flows in and out of each pool (x):

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

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)



The respiration fluxes are a part of Fx and are function of biochemical characteristics of residues and soil clay content.

3. Model parameterization

Site parameters:
The model was applied to the Carbo-Europe site of Lonzée, in Belgium. The soil is a Luvisol (FAO classification).

Parameter	Value	Unit
Soil fractions		
Silt	70	%
Clay	25	%
Sand	5	%
Soil moisture content (field capacity)	32.6	% vol.
Total soil carbon content	6.2	kg/m²

Soil temperature and soil moisture function parameters:
The soil temperature function was adjusted on a respiration flux-temperature relationship got from field soil respiration measurements. The soil moisture function was taken from Parton et al. (1987) and modified according to Ise and Moorcroft (2006) to take account of a linear decrease after field capacity.

Biochemical parameters:
Based on a literature survey, mean values (in % of dry matter) of wheat biochemical parameters at harvest were computed:

Parameter	Value
Wheat leaves and stems	
Nitrogen	0.5
Lignin	9.2
Cellulose	42.1
Hemicellulose	31.4
Wheat roots	
Nitrogen	0.45
Lignin	17.15
Cellulose	35.8
Hemicellulose	36.8

4. Initialization phase

Objective: To set the carbon pool contents, as their proportions are unknown.

Method: the model was run until equilibrium (constant total soil carbon) by means of the repetition (4000 times) of a mean climatic year. It was considered that wheat was cultivated each year, the residues being incorporated into the soil at harvest.

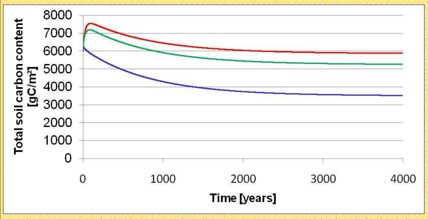


Fig. 2 : Evolution of the total soil carbon content with time during the initialization phase. Red line : 230gC/m² of AG residues and 200gC/m² of BG residues. Green line : 300gC/m² of AG residues and 150gC/m² of BG residues. Blue line : 200gC/m² of AG residues and 100gC/m² of BG residues.

- High sensitivity of the model (total soil carbon content) to the amount of residues.
- At the end of the equilibrium run, same carbon repartition between pools whatever the total soil carbon content.
- The measured total soil carbon content (6.2kg/m²) is reached for an amount of residues equal to 430gC/m² (230gC/m² above-ground and 200 gC/m² belowground residues) (red line in Fig. 2).
- The blue line in Fig. 2 represents what we get with our own residue estimates in Lonzée.

5. Comparison of model outputs with field data

Field measurements :

- ❖ Lonzée : Automatic dynamic closed chamber system on a bare area delimited in the field, from March 26, 2007 until July 16, 2007.
- ❖ Lamasquère (France): Manual flux measurements with a dynamic closed chamber system on a bare soil in the field.

The soil carbon pools were set according to two scenarios before starting the comparison:

- First scenario: all carbon pools were set at the values reached at equilibrium, considering 230gC/m² of AG residues and 200gC/m² of BG residues at harvest.
- Second scenario: Active, slow and passive pools at the equilibrium values. Surface carbon pools empty; their content brought to structural pools in both soil layers (like ploughing).

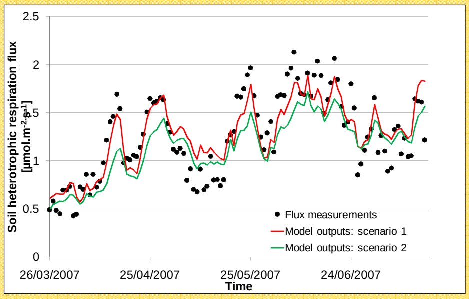


Fig. 3 : Comparison between modelled and measured fluxes for the experimental site of Lonzée.

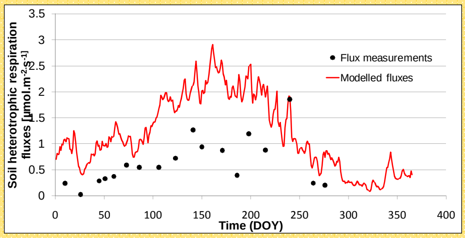


Fig. 4 : Comparison between modelled (red line – scenario 1) and measured (black dots) fluxes at the Lamasquère site (France) in 2007.

General comments:

- Overall good agreement between modelled and measured data at the Lonzée site (Fig. 3).
- The main driver is soil temperature.
- The first scenario seems less realistic for the fast carbon pools but provides results closer to the flux measurements.
- Lower modelled fluxes when the soil surface and metabolic pools are empty.
- In Lamasquère the important discrepancy between the modelled and measured fluxes is probably due to an overestimation of the total soil carbon content (Fig. 4).

6. To go further

- Calibration and validation on other sites (different soil and meteorological conditions).
- To reduce the uncertainties linked to the temperature equation parameters.
- To get better estimates of the amount of residues incorporated in the field at harvest, as this was seen to strongly influence the results.

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CONTACT PERSON: Pauline Buysse – FRS-FNRS Research fellow
Unit of Biosystem Physics – Gembloux ABT, University of Liège – Belgium
buysse.p@fsagx.ac.be