MODELING SOIL RESPIRATION IN WHEAT FIELDS

Emilie Delogu[1], Valérie Le Dantec[1], Patrick Mordelet[1], Pauline Buysse[2], Marc Aubinet[2], E. Pattey[3] , Eric Ceschia[1], Tiphaine Tallec[1]
[1] Centre d'Etudes Spatiales de la BIOsphère, CESBIO, 18 Av. Édouard Belin bpi 2801, 31401 Toulouse Cedex 9, France. E-mail: emilie.delogu@cesbio.cnes.fr
[2] Unit of Biosystem Physics, Gembloux Agro Bio-Tech (GxABT), University of Liège, Belgium
[3]Agriculture and Agri-Food Canada · Eastern Cereal and Oilseed Research Centre, Ottawa (ON), Canada

Objectives

In the context of **climate change and changing agricultural practices, the aim of this study is to:**

- identify factors controlling variability of Soil Respiration (SR) over croplands
- assess contributions of Heterotrophic Respiration (HR) and Autotrophic Respiration (AR) in SR over croplands
- predict seasonal dynamics of SR over croplands using semi-mechanistic model

Dataset

		Texture [% sand; % silt; % clay]	Mean annual T [°C]	Annual rain [mm]	Soil C content on 15cm [kg/m²]
Lamothe	43°49'N, 01°23'E	12 ; 34 ; 54	13.1	615	2.4
Lonzée	50°33'N 4°44'E	5 ; 75 ; 20	9.1	772	2.3
Ottawa	45°22'N ,75°43'W	31 ; 49 ; 20	6.3	914	3.9

Inputs data / Parameterization

Soil and climatic data : soil moisture, soil temperature, texture, soil carbon content, soil hydrologic properties

Plant data: biomass, biochemistry

→ **available on each site**

Soil respiration fluxes to validate model :

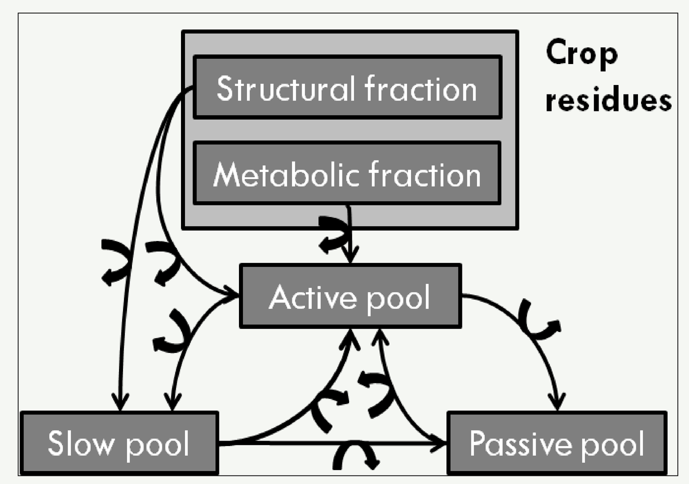
		Lamothe	Lonzée	Ottawa
HR dataset	***Bare soil***			
	Automated measurements	Eddy Correlation	-	Eddy Correlation
	Measurement frequency	Half hourly	-	Half hourly
	Root exclusion zones			
	Automated measurements	-	4automated chambers	-
	Measurement frequency	-	Half hourly	-
	Manual measurements	1 manual chamber	-	-
	Measurement frequency	About once a week	-	-
SR dataset	***Wheat planted Area***			
	Automated measurements	-	4automated chambers	1 automated chamber
	Measurement frequency	-	Half hourly	Half hourly
	Manual measurements	1 manual chamber	-	1 manual chamber
	Measurement frequency	About once a week	-	About once a week

Model

The soil heterotrophic respiration component (Parton et al., 1987)

- Semi-mechanistic formalism: parameterization based on processus
- Validated on numerous sites for soil C stocks
- Classical approach : Four layers (soil surface, top soil (0-15cm), subsoil (15-30cm) and undersoil (30-45cm)) containing 3 to 5 carbon pools each with different turnover and different décomposition rates.
- Assumption: produced CO_2 = outgoing CO_2 : no diffusion between the different layers

Inputs
Daily soil temperature
Daily soil moisture
Initial soil C content in each pool



Outputs
daily carbon flows among pools (Fig. 1) and respiration fluxes (thick arrows in Fig. 1).

Fig.1 – Carbon flows in a model layer.

The soil autotrophic respiration component

- Simulates carbon flow resulting from Maintenance Root Respiration and Growth Root Respiration using above-ground biomass

Growth respiration (Ryan 1991)

Inputs	Assumptions	Outputs
Aboveground biomass Growing degree day Growth respiratory quotient	Linked to energetic production cost to synthesize proteins to produce biomass	Growth respiration

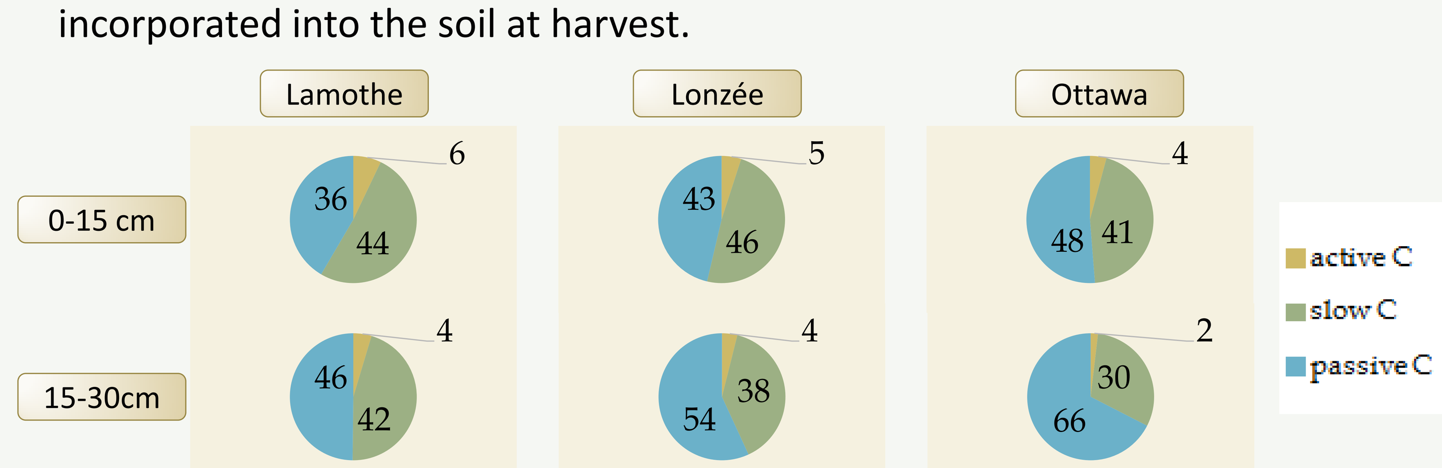
Maintenance respiration (McCree 1970)

Inputs	Assumptions	Outputs
Aboveground biomass -R/S Root N dynamic Soil temperature	Linked to maintenance cost to ensure enzyme survival (N = marker of enzyme quantity)	Maintenance respiration

Initialization phase

Objective: **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 (20 times) of one climatic year (2007). It was considered that wheat was cultivated each year, the residues being incorporated into the soil at harvest.

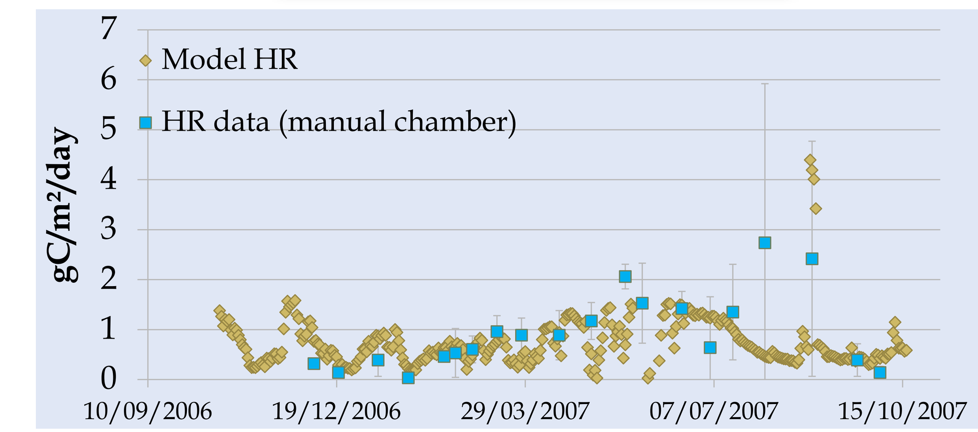


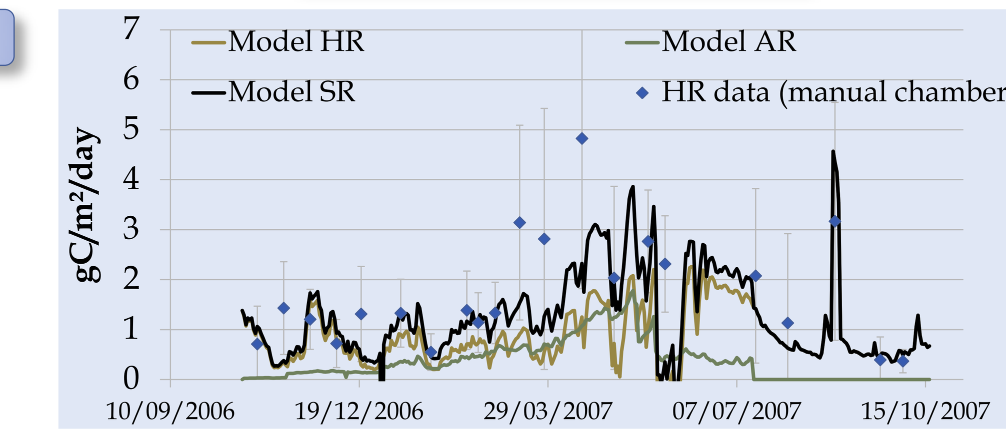
C proportions after 20 years [%] for each site

Results

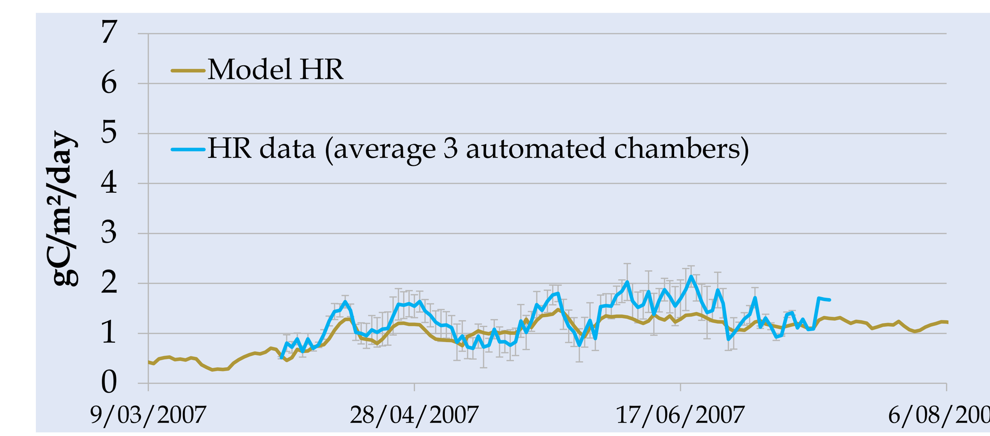
HR modeling | SR modeling

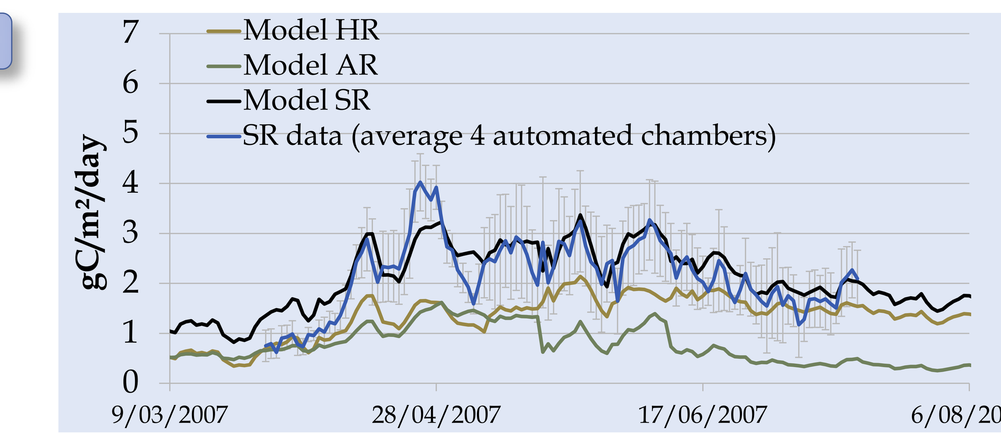
Lamothe



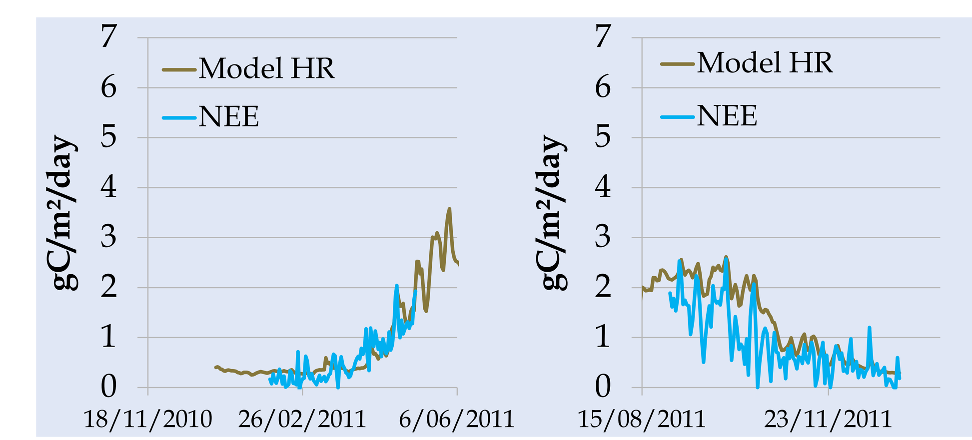


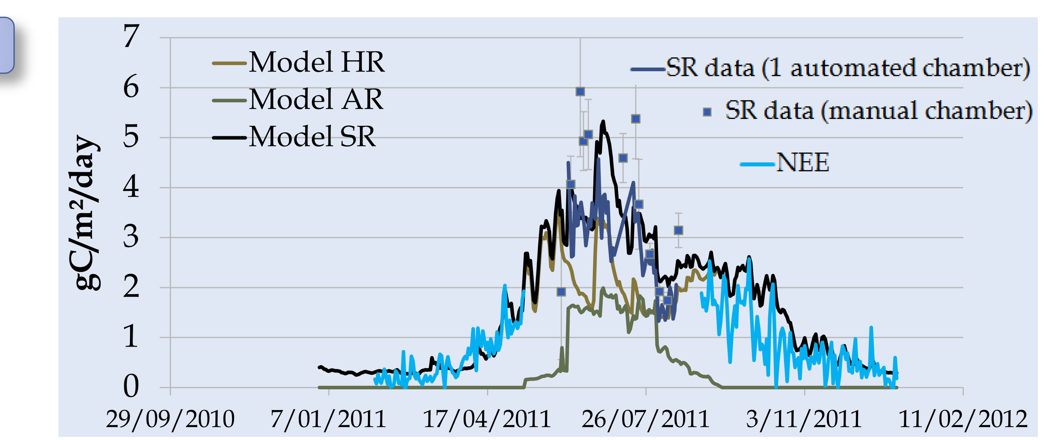
Lonzée





Ottawa





- Great modeling of HR : level of carbon well-predicted, seasonal dynamic well-reproduced for different soils, and different climatic conditions
- Only some particular points with high standard deviation are not reproduced
- Great reproducibility of total SR on multiple different sites - Root/Shoot dynamics parameterization is a crucial issue

Partitioning SR components

	Period (seedbed to harvest)	HR [gC/m²]	AR [gC/m²]	SR [gC/m²]	TER [gC/m²]	% HR/SR	% SR / TER
Lamothe	18/10/2006 to 15/07/2007	239	131	370	902	64.5	41
Lonzée	13/10/2006 to 05/08/2007	291	152	443	1055	65.6	42
Ottawa	20/05/2007 to 03/09/2007	187	89	276	*Missing data*	67.7	*Missing data*
Ottawa	11/05/2011 to 29/08/2011	240	111	351	*Missing data*	68.3	*Missing data*

- High HR contribution in SR(~65%) among sites during crop periods
- HR contribution not higher on Ottawa whereas highest soil C content (3.9kg C/m² but mostly passive C = protected organic matter) → importance of C proportions in modeling
- SR / TER ~40% (during crop periods!)→ important contribution in TER→ importance of agricultural soil in GES balance → scenarii, management need to be study

Prospects

- Addition of cultural management process
- Scenarii survey (crop rotation, irrigation, ploughing)
- Comparison between empirical and mechanistic modeling : partitioning and understanding SR/TER, AR and HR / SR **(see poster session BG2.11 Green Poster area, board G44)**