QUANTIFICATION OF BIOCHAR IN ARABLE LAND:

A NEW APPROACH WITH ROCK-EVAL® THERMAL ANALYSIS

Marie-Liesse Aubertin, Oscar Pascal Malou, Frédéric Delarue, Priscia Oliva, David Houben, David Sebag

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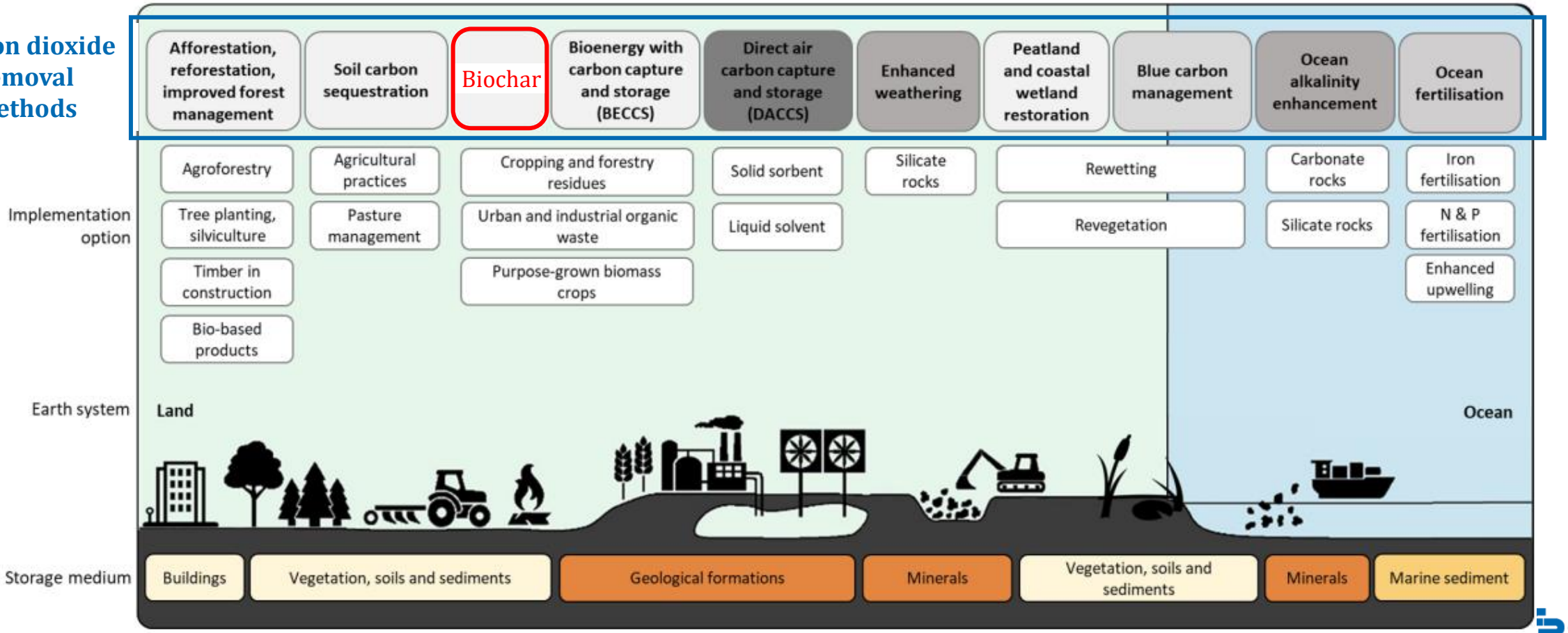
BIOCHAR: A CARBON DIOXYDE REMOVAL METHOD

Limit the warming at 1.5 °C → Net-zero anthropogenic CO_2 emissions by 2050 → Reduction of GHG emissions + Carbon dioxide removal



IPCC (2022)

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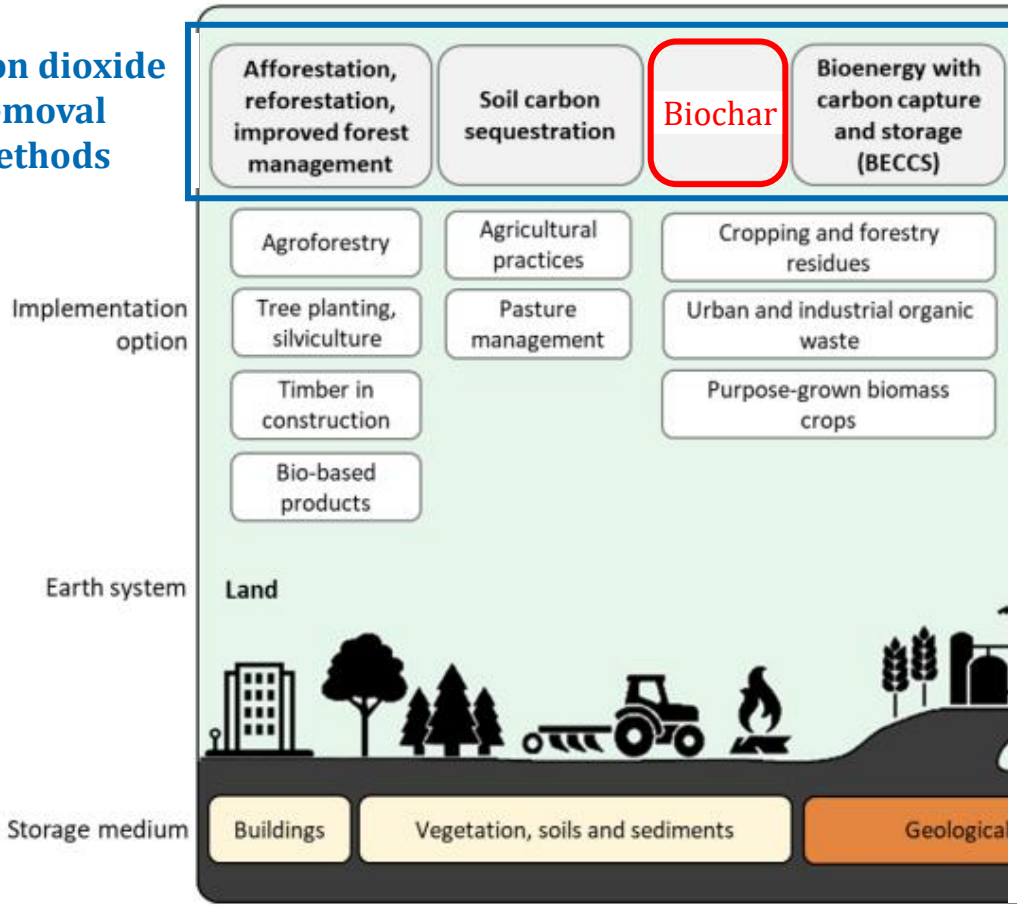
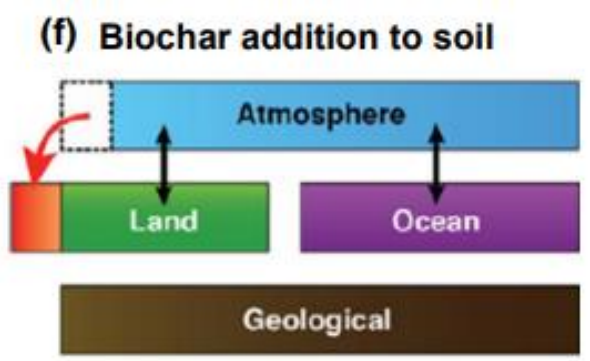
Carbon dioxide removal methods



IPCC (2022)

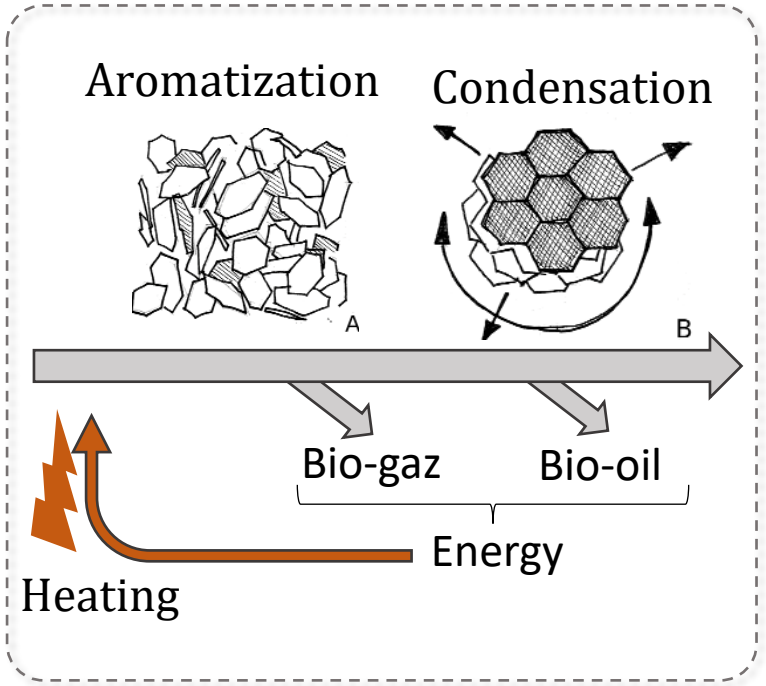


Smith (2016)

BIOCHAR: SOLID RESIDUE OF PYROLYZED BIOMASS USED AS ORGANIC AMENDMENT TO SEQUESTER CARBON IN SOIL

Biomass

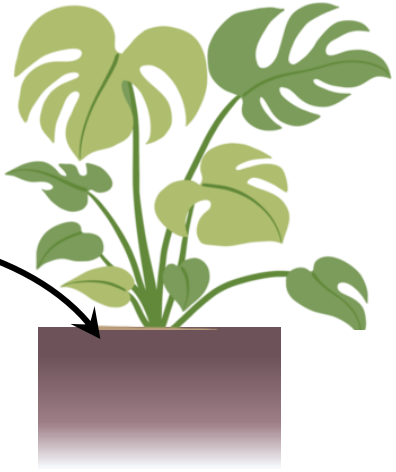
PYROLYSIS



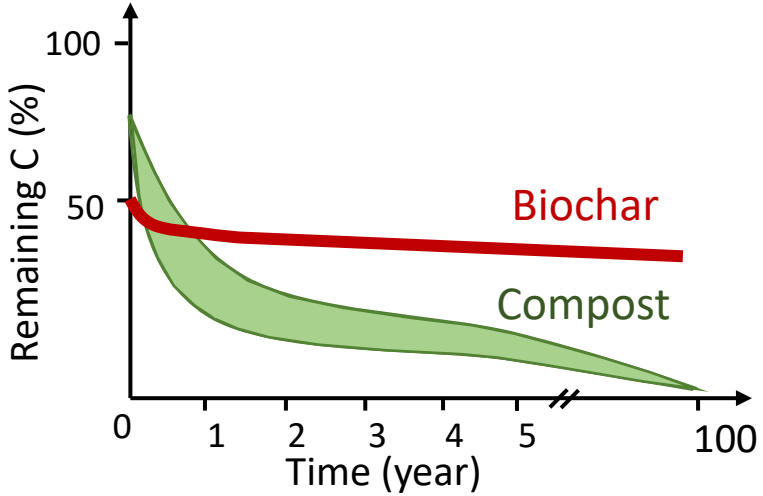
Biochar

- 40-90 % carbon
- Aromatic structure
- High porosity
- pH ≥7

Amendment



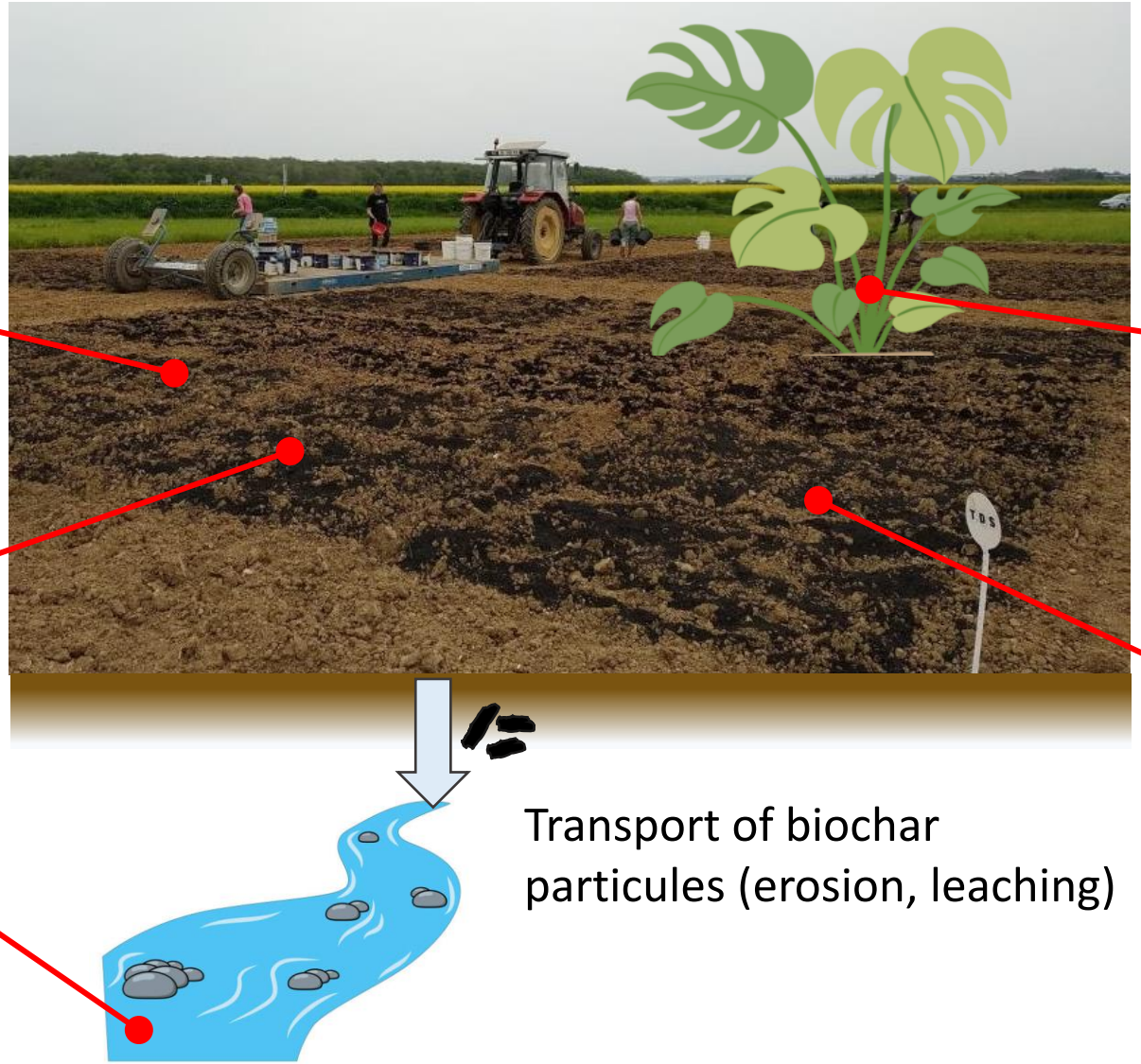
- **Agronomic effets** (water & nutrient retention, liming, etc.)
- **Long-term C storage**



e.g. Lehman & Joseph 2015

MULTIPLE INTERESTS TO QUANTIFY BIOCHAR IN SOIL

Monitor C stocks



Effect of biochar/soil ratio on agronomic responses

Homogeneous mixtures

Monitor biochar-C in the field

Monitor biochar-C in the environment (deposit areas)

Transport of biochar particules (erosion, leaching)

Effect on plants (e.g. crop yield)

Effects on soil fertility and quality (e.g. water retention, nutrients availability, earthworms)

CAN BIOCHAR BE QUANTIFIED USING ROCK-EVAL THERMAL METHOD ?

Limits of curent methods to quantify easily and rapidely biochar-C in soil
Molecular marker techniques (e.g. BPCA), physical, chemical, spectroscopic
→ limits : not direct, manipulator dependent, time-consuming

Specific thermal signature of char (more thermally stable), as compared to uncharred SOM

Limit of the DSC thermal method (overlapping of C from char and uncharred material)
→ The **Rock-Eval® method** has an additional pyrolysis stage

Objective: Developp a protocol to quantify biochar in soil, using the Rock-Eval® method

Hardy et al. 2012, 2022; Leifeld 2007, 2013; Plante et al. 2011, 2013

EXPERIMENTAL DESIGN

6 biochars industrials × **4 soils** from agricultural fields × **6 ratios (%)** biochar/soil

	Biomass	Pyrolysis T	Corg[1]
		°C	g kg^{-1}
	**Herbaceous**	400	855.1
	**Maize**	450	643.9
	**Compost**	450	606.2
	**Miscanthus**	550	764.9
	**Wood**	550	840.8
	**Rapeseed**	650	669.4

[1]RE analysis

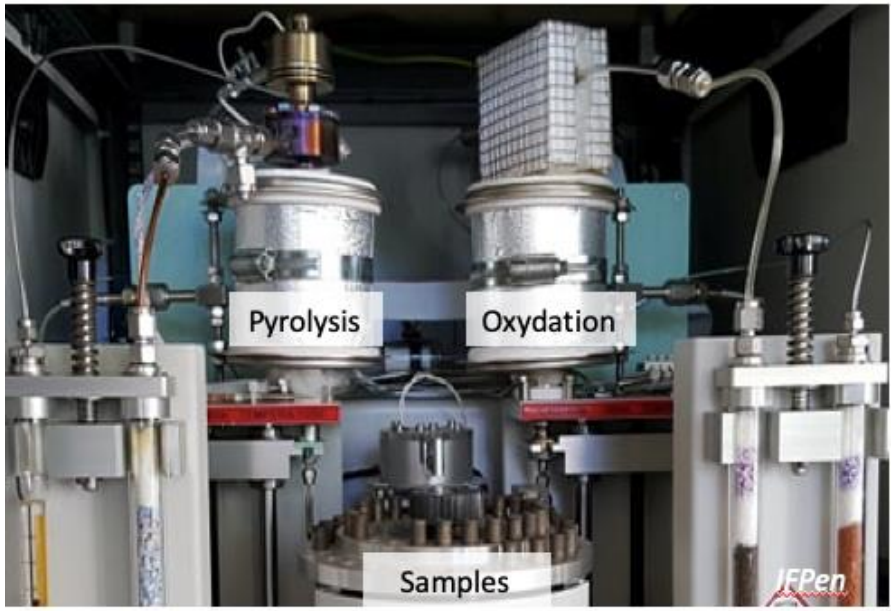
	Soil	Corg[1]	Cmin[1]	pH[2]	Clay[3]	Silt[3]	Sand[3]
		---- g kg^{-1} -----			------- g kg^{-1} ---------		
	**A**	6.8	0.1	6.6	125	587	288
	**B**	8.8	1.2	8.1	212	**736**	**52**
	**C**	8.0	**16.2**	8.3	334	314	352
	**D**	**60.7**	0.0	5.9	226	541	233

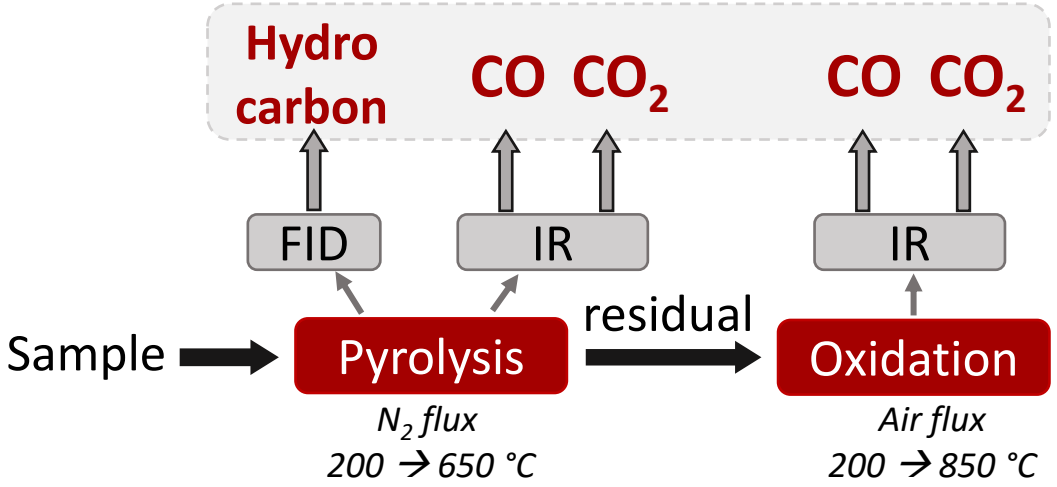
[1]RE analysis; [2] NF ISO 10390; [3] NF X 31-107

1,00
0,50
0,20
0,10
0,05
0,00

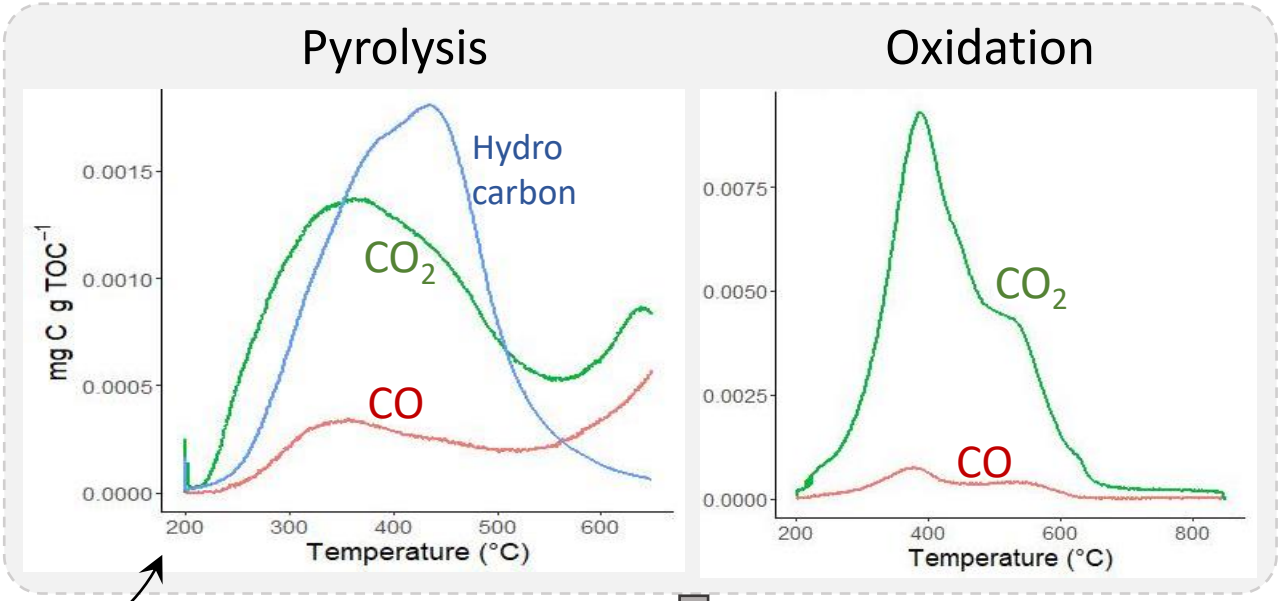
Rock-Eval® thermal analysis

THE ROCK-EVAL® THERMAL METHOD





Thermograms



Area integration & combination

Parameters

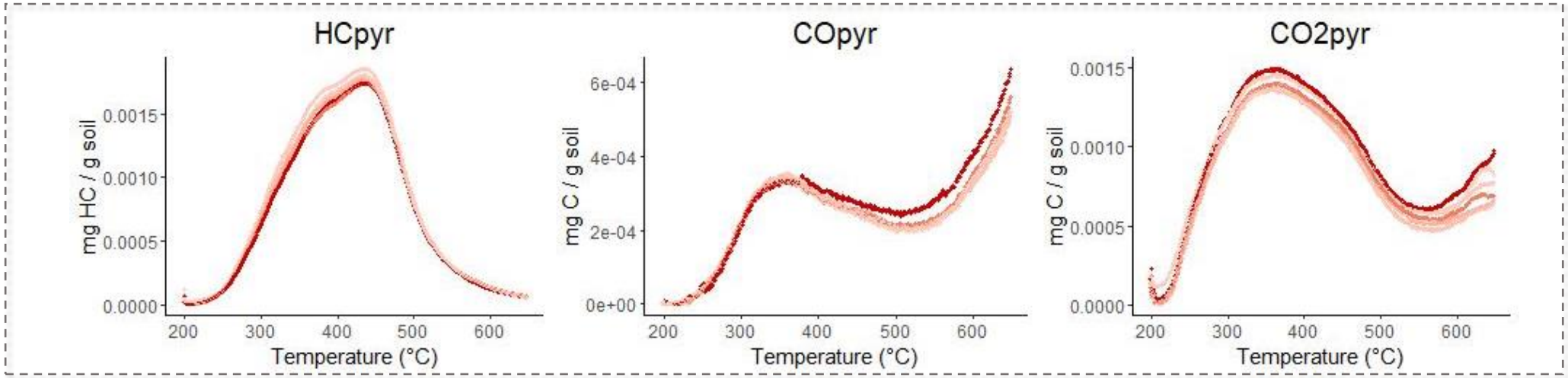
- Quantify organic & inorganic carbon : TOC, MinC, SOC, SIC
- Carbon stability: I & R, hydrogen (HI) & oxygen (OI) indexes

Espitalié et al. 1985, Lafargue et al. 1998 , Behar et al. 2001

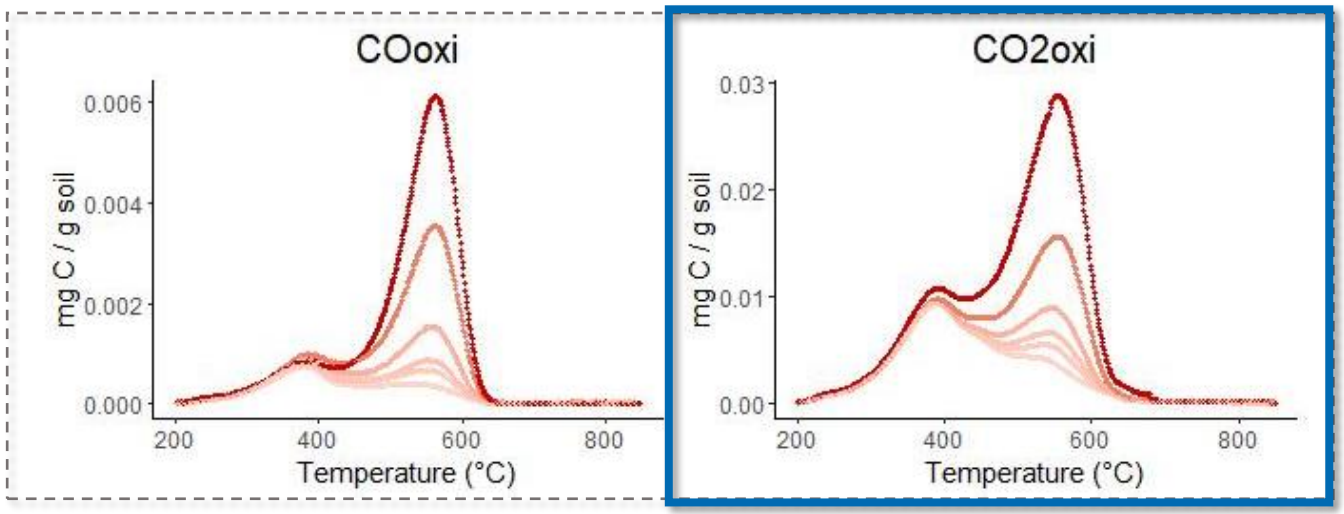
BIOCHAR IS EMITED AS CO2 DURING OXIDATION

Thermograms of one biochar-soil mixture (miscanthus biochar + soil A)

PYROLYSIS



OXIDATION

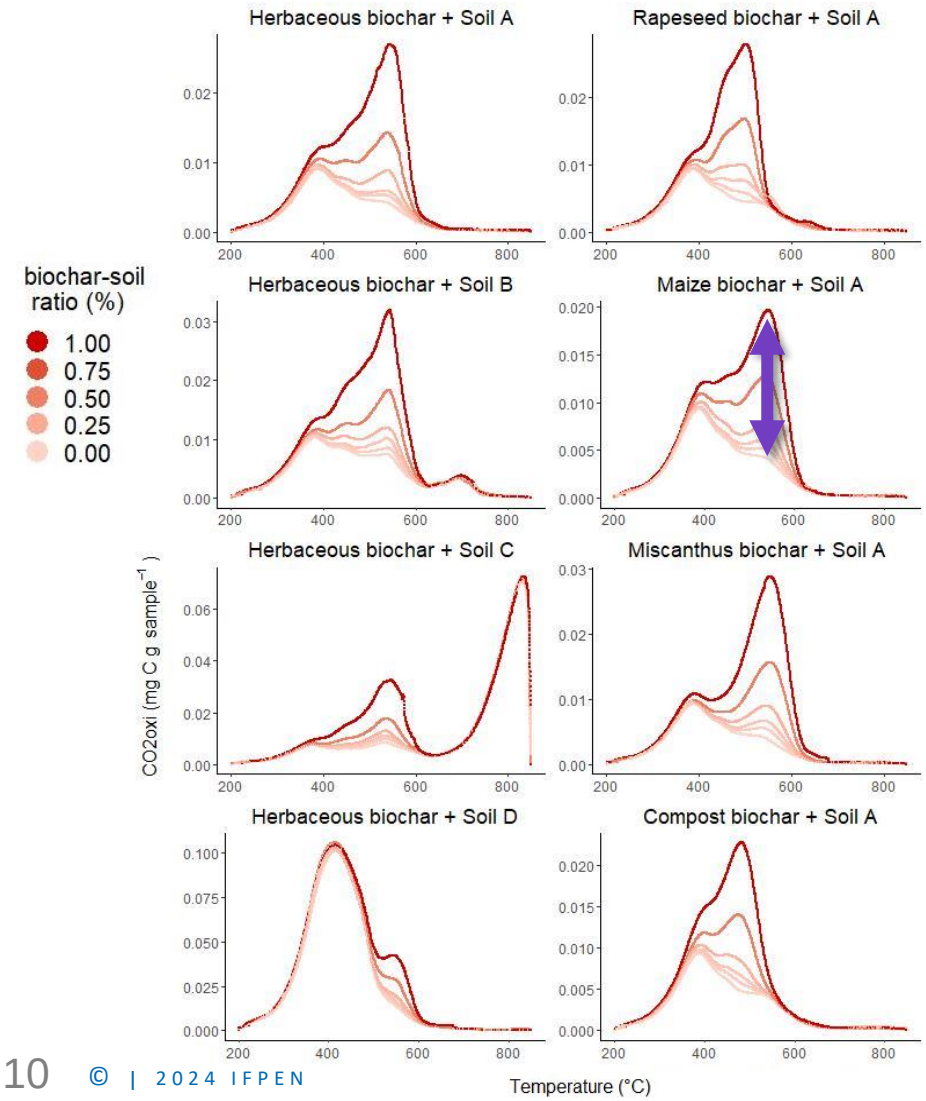


Ratio (%)
1.00
0.75
0.50
0.25
0.00

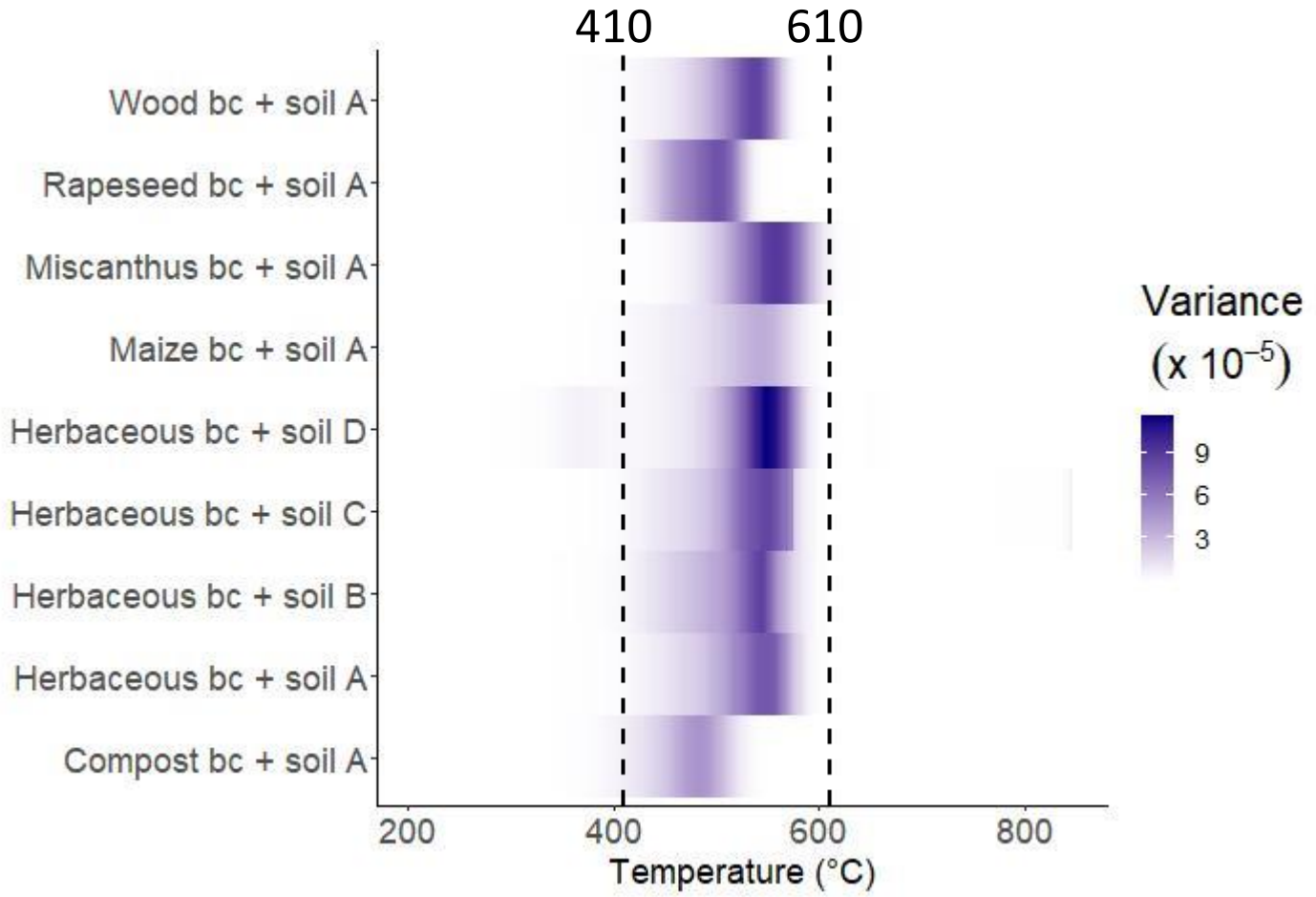
= 80 % C emissions

BIOCHAR-$CO2_{OXI}$ IS MAINLY EMITTED AT 410-610 °C

CO_2 oxydation thermogram of all mixtures

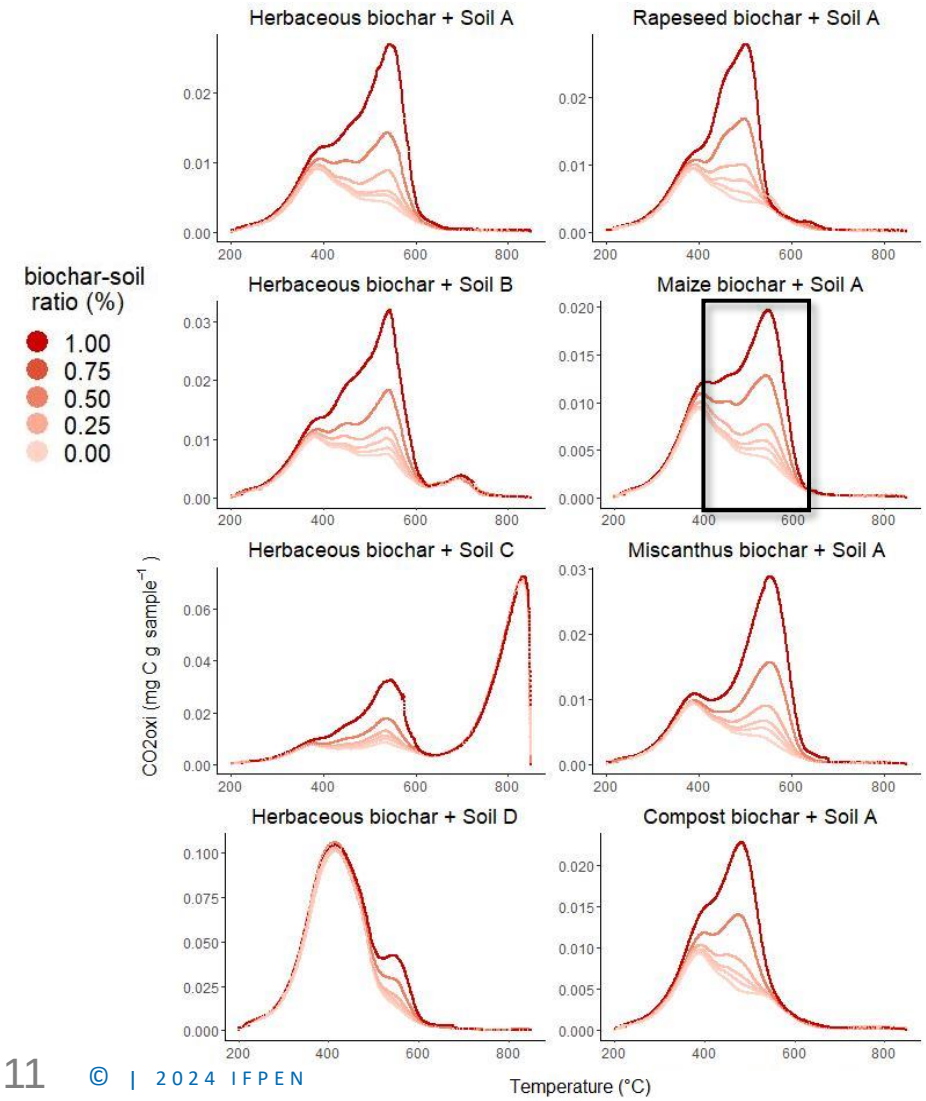


Variance of the CO2oxi thermograms

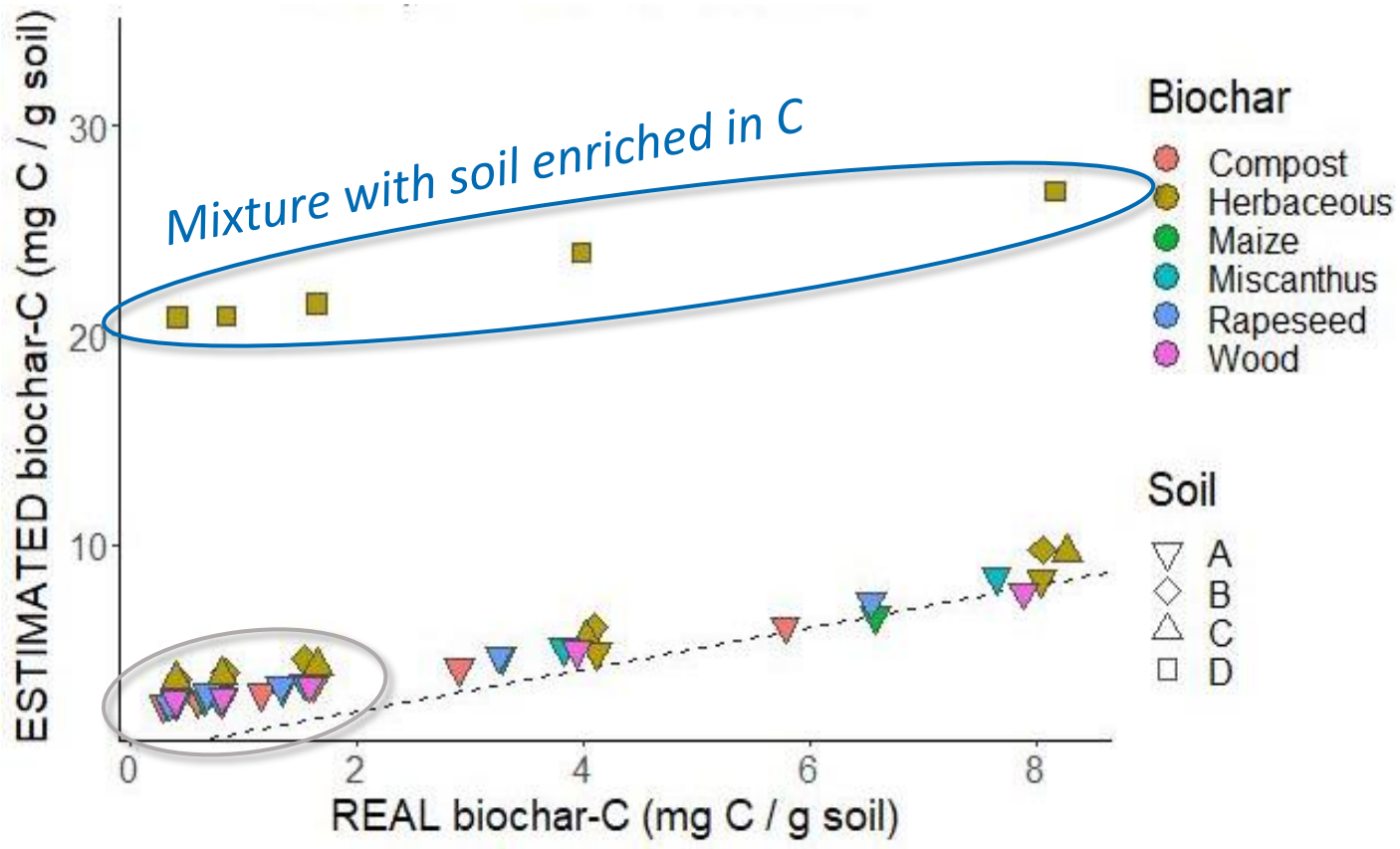


BIOCHAR-C IS OVERESTIMATED FOR SOIL ENRICHED IN C

CO_2 oxydation thermogram of all mixtures



Correlation between real and estimated biochar-C
(AUC emitted at 410 - 610 °C)



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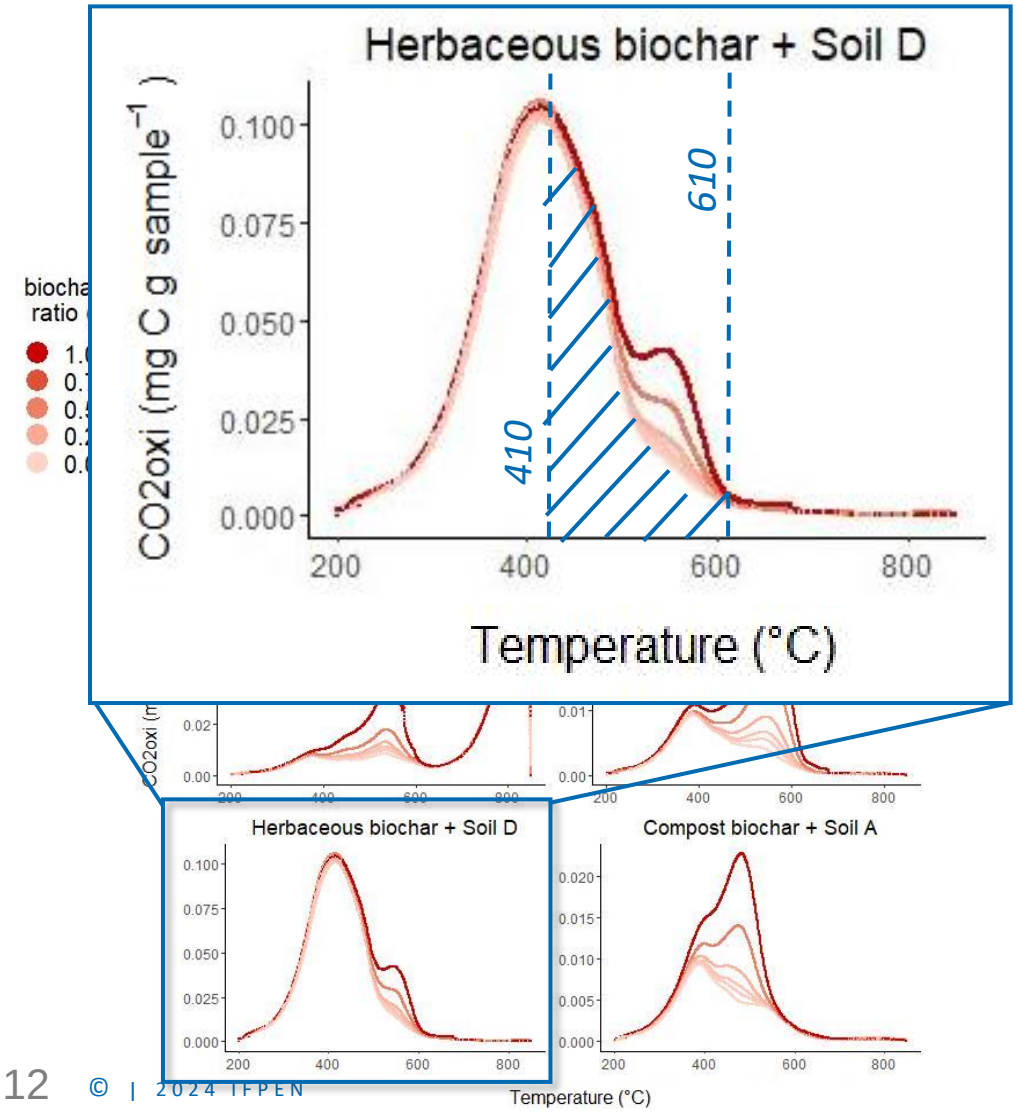

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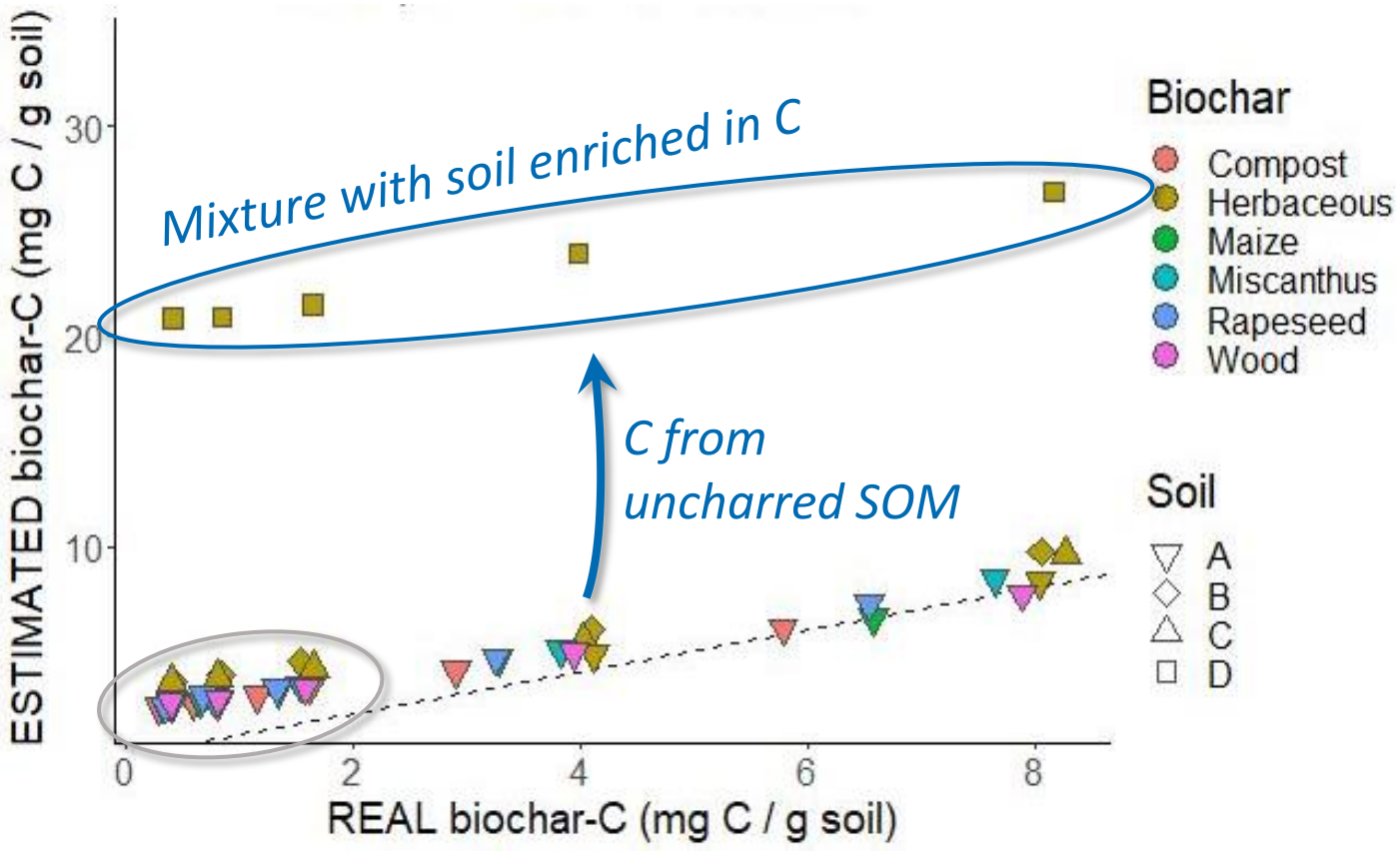

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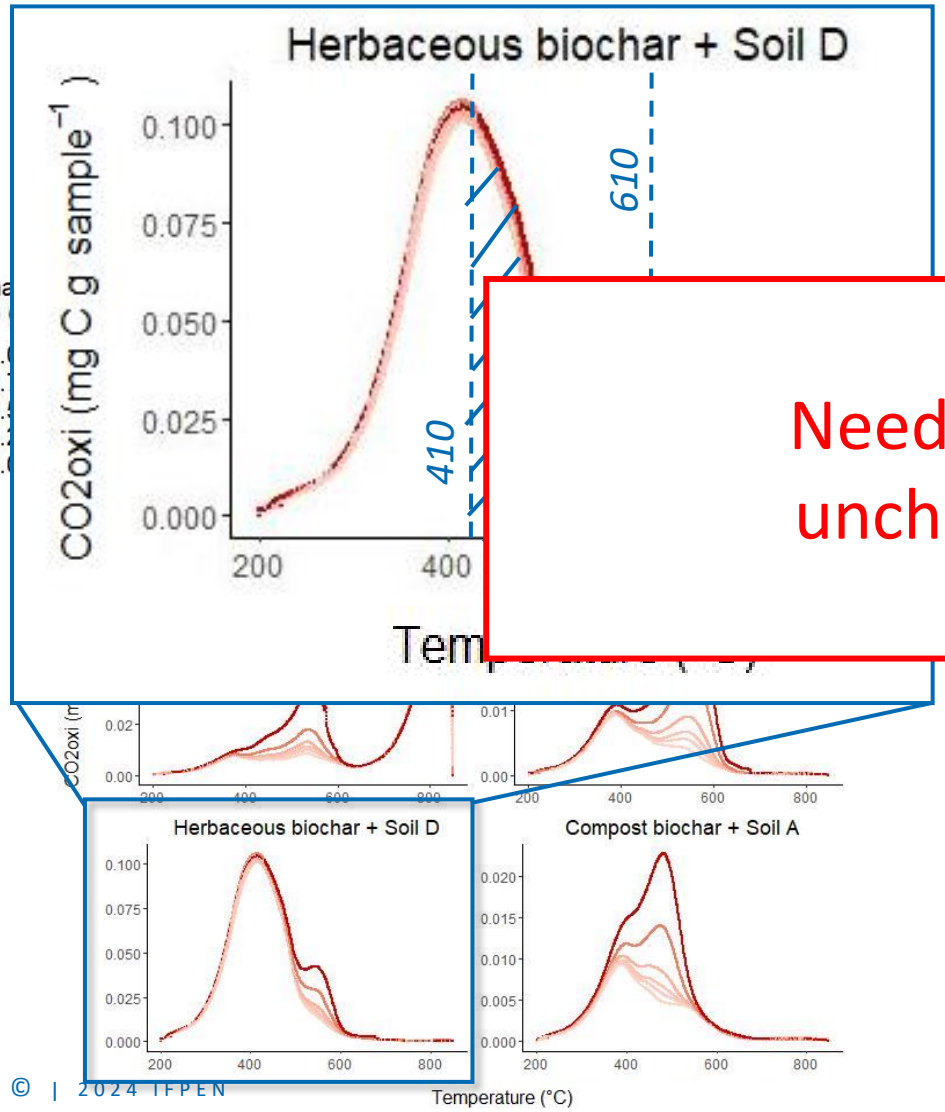
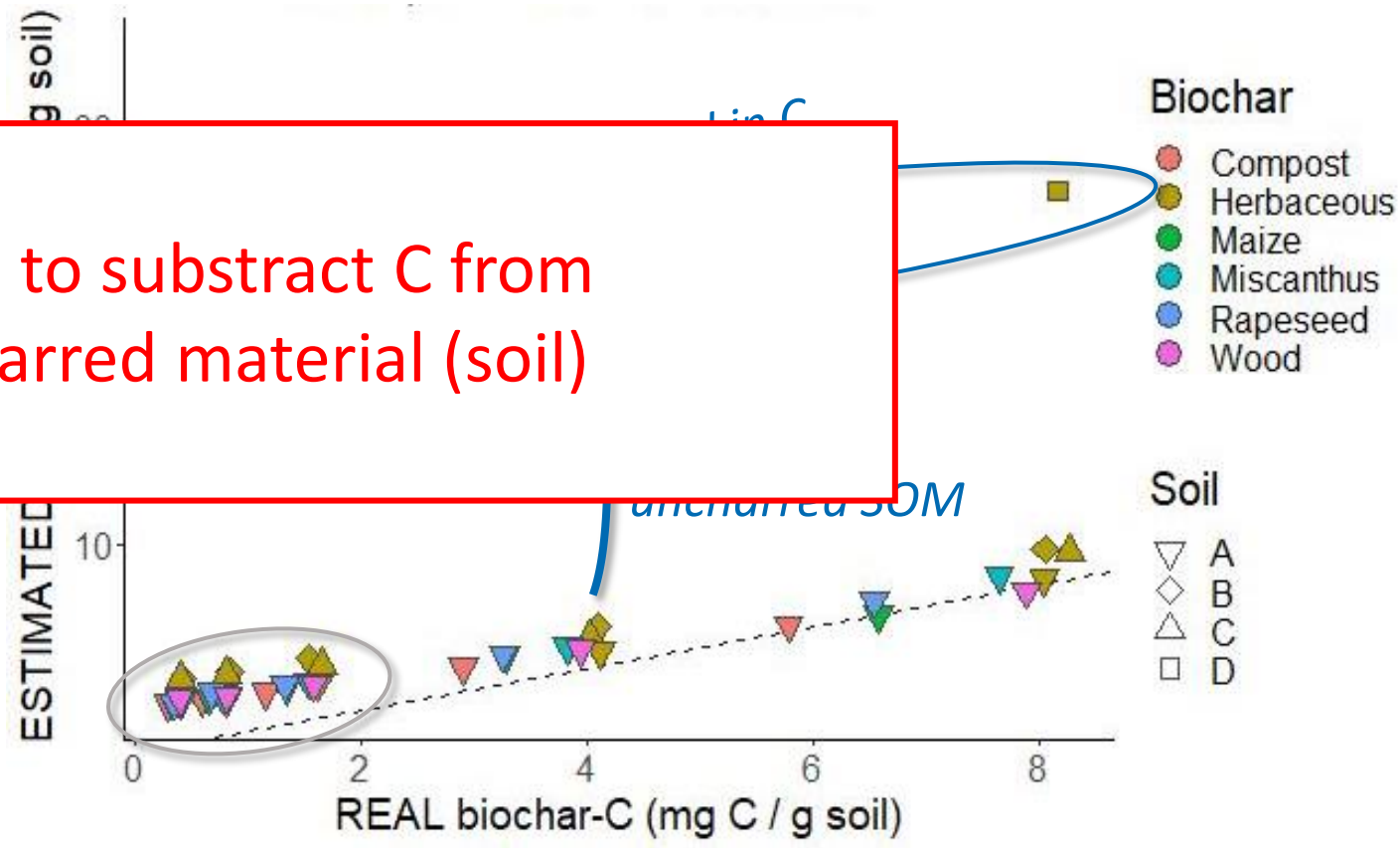
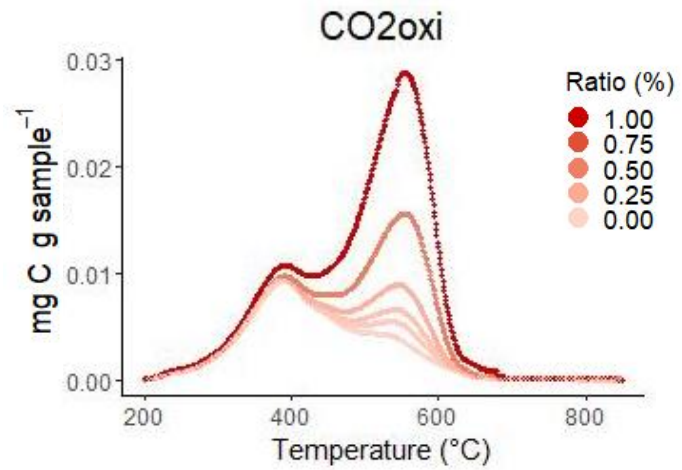


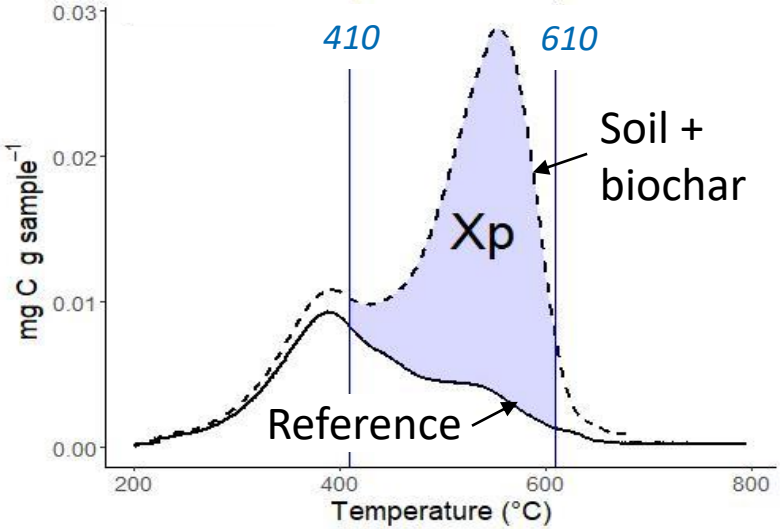
Correlation between real and estimated biochar-C
(AUC emitted at 410 - 610 °C)

Need to substract C from uncharred material (soil)



RELATIVE BIOCHAR QUANTIFICATION USING A REFERENCE

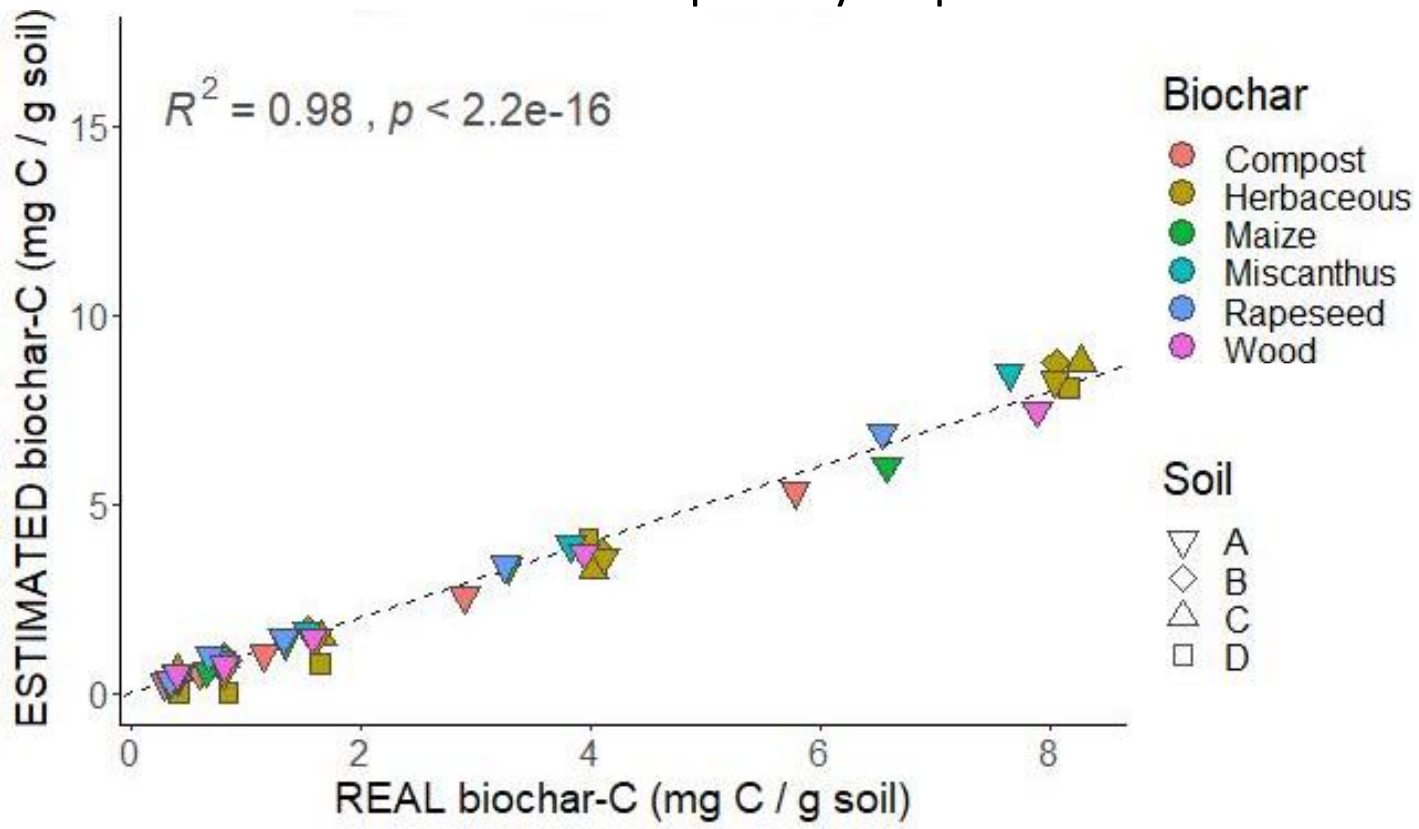




Reference = thermogram with the lowest value of AUC at 410-610 °C

Aubertin et al. (in prep)

Estimated biochar-C quantity = Xp × 1.45

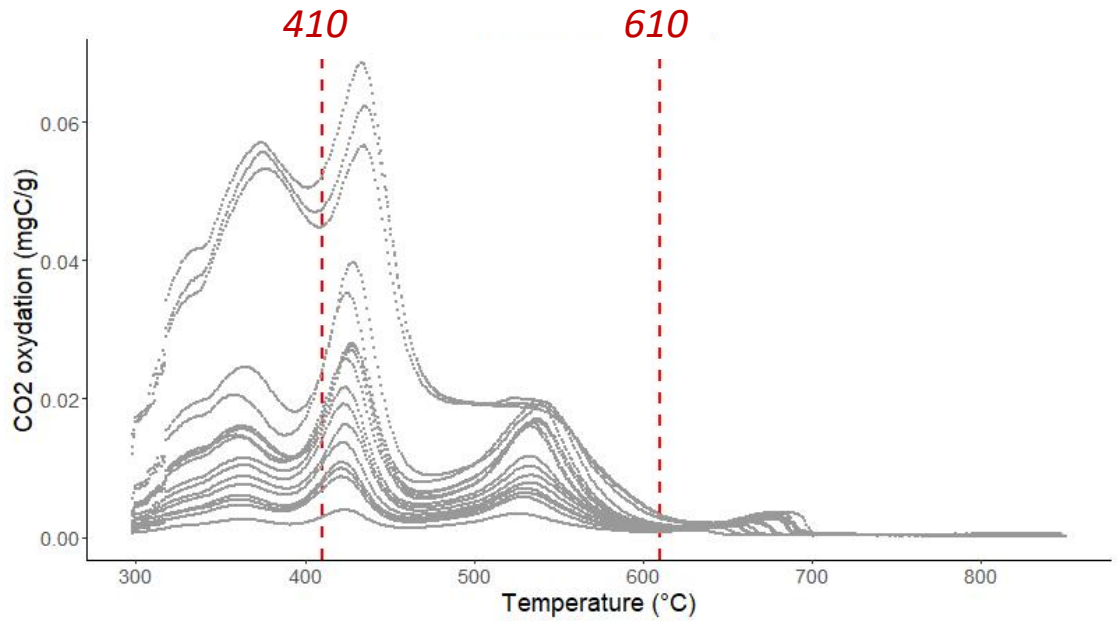


APPLICATIONS ON ANTHROPIC SOILS

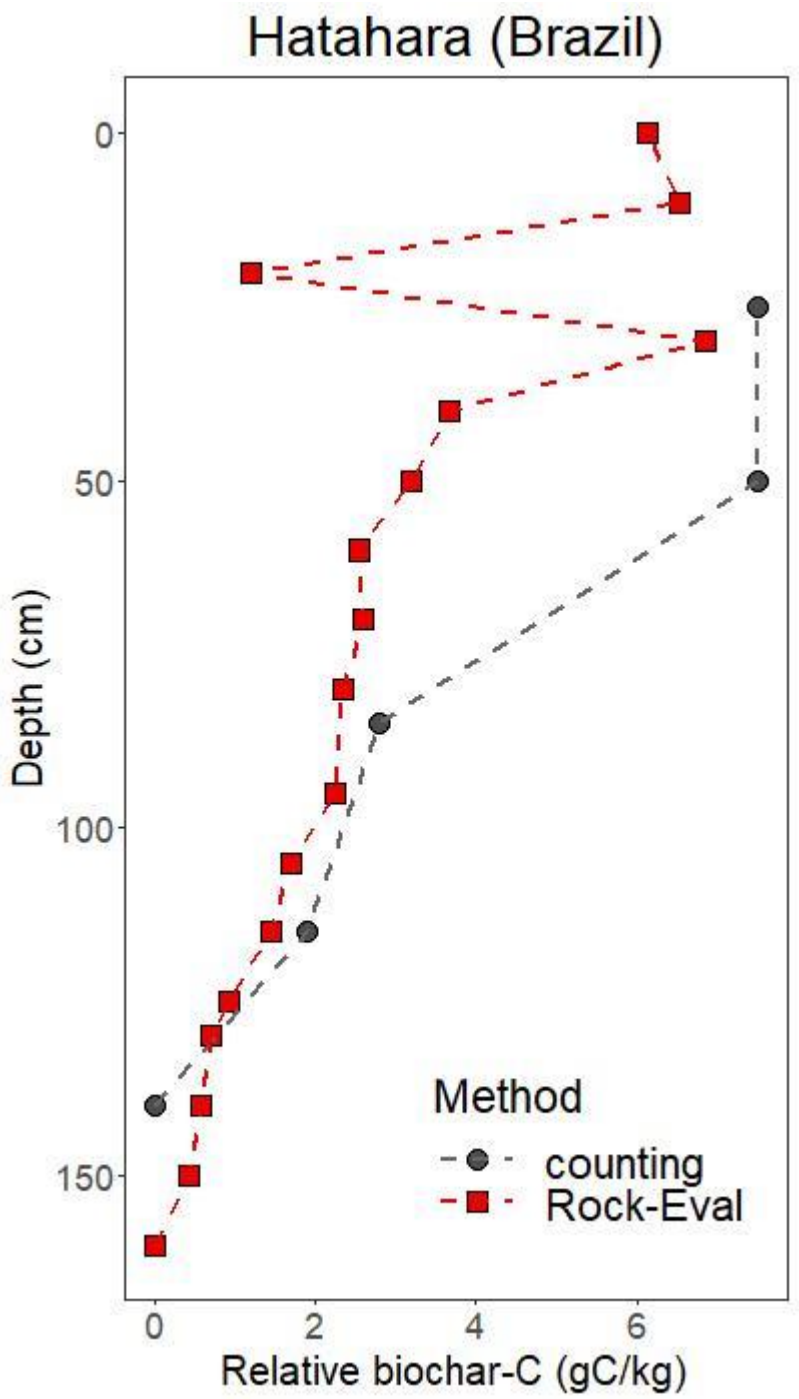
+ COMPARISON TO OTHER METHODS

ANTHROPIC SOILS IN BRAZIL

Compared method:
Counting under binocular loupe

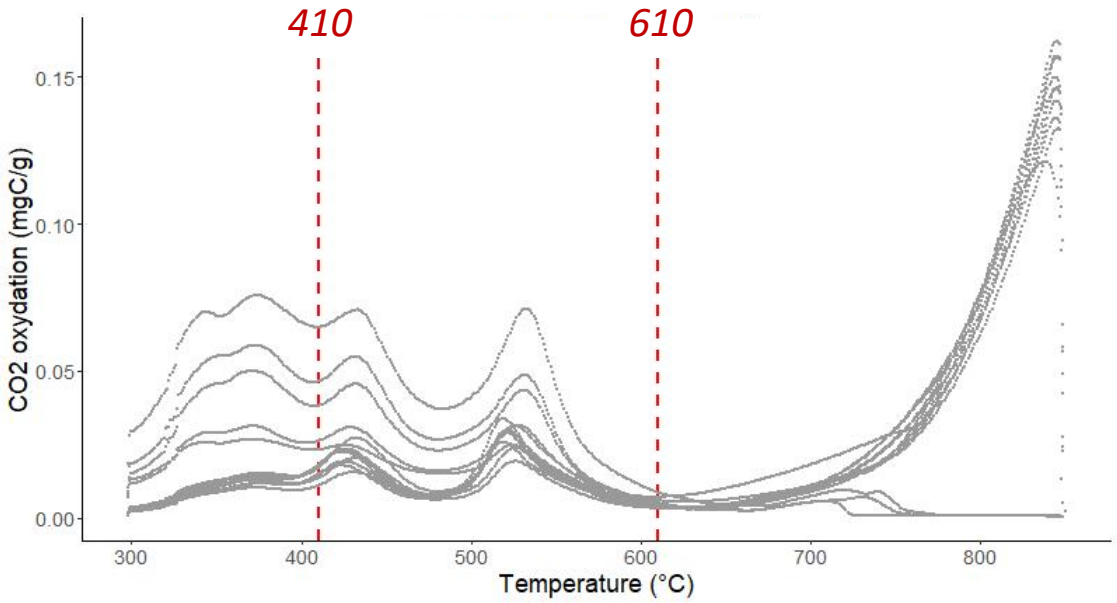


Arroyo-Kalin 2008

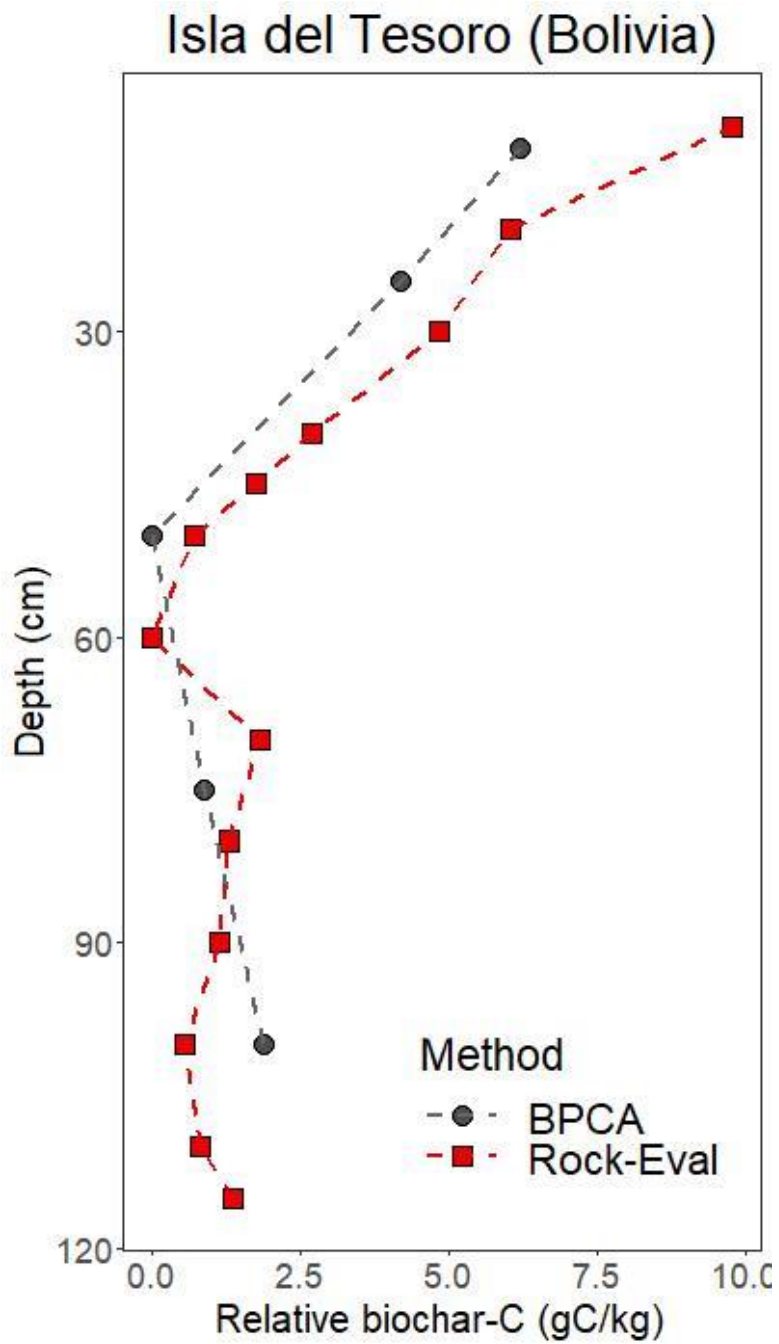


ANTHROPIC SOIL IN BOLIVIA

Compared method:
benzene polycarboxylic acids (BPCA)



Lombardo et al. 2013



CONCLUSIONS

Rock-Eval method using the CO_2 emissions from the oxidation stage

- **Quantification of biochar-C in agricutural fields** when no previous biochar amendment
- **Relative quantification of biochar-C in the other cases**
  → **Need for a reference sample**

Perspectives

- **Variation of the reference** over a profile ?
- **Effect of ageing** on biochar thermal characteristics ?

MANY THANKS !

David Sebag[1]
Oscar Pascal Malou[1]
Frédéric Delarue[2]
Priscia Oliva[3]
David Houben[4]

[1] *IFP Energies Nouvelles, Rueil-Malmaison (France)*
[2] *UMR 7619 METIS, Sorbonne University, Paris (France)*
[3] *Géosciences Environnement Toulouse (GET), Université de Toulouse (France)*
[4] *UniLaSalle, AGHYLE UP 2018.C101, Beauvais (France)*

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