



MRV4SOC
PROJECT



Eddy covariance diverges from inventories and modelling on soil organic carbon stock evolution in a Belgian cropland over five rotations

Quentin Beauclaire, Bernard Longdoz, Laura Delhez, Neo Arquin, Marmar Sabetizade, Bruna Winck, Benjamin Loubet, Nicolas P.A Saby, Bernard Heinesch

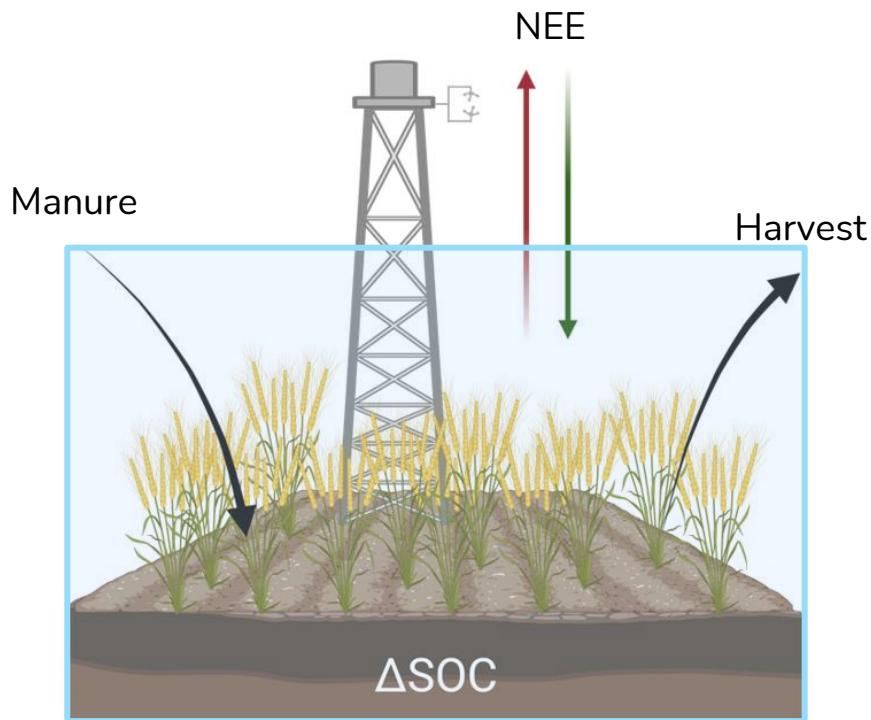


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SOC and eddy covariance

SOC stocks are commonly derived from the balance between net vertical and lateral C fluxes



Numerous studies using EC have reported **high SOC losses** in croplands ($\sim 100 \text{ gC/m}^2/\text{yr}$)

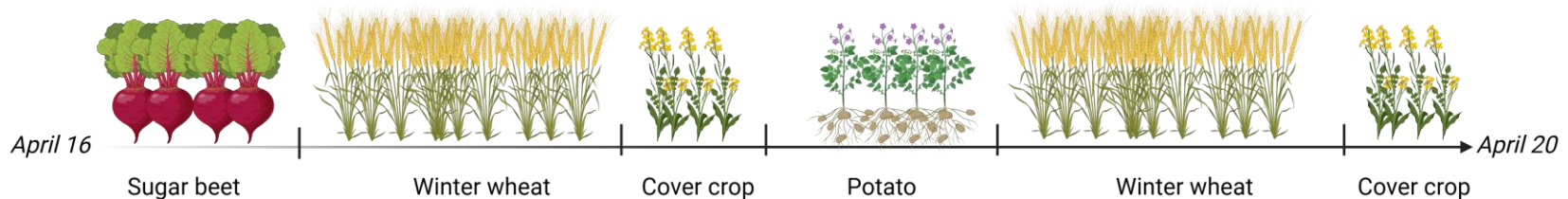
Need of comprehensive **uncertainty assessment**, **long study periods** and benchmarking with **other methods**

The Lonzée ICOS site

BE-Lon – class 2 since 2017



- Cropland cultivated for more than 80y
- Average temperature : 10.2 °C
- Mean annual precipitation : 742 mm
- EC since 2004
- This work focused on five crop rotations (2004-2024)
- SOC stocks in 2007 and 2017



Method 1 : eddy covariance

Eddy covariance (2004-2024)

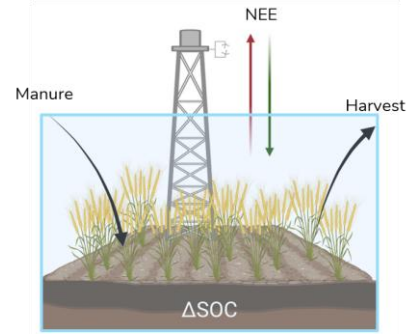
$$NBP = \sum_t^{t'} NEE - C_{imp} + C_{exp}$$

Net biome productivity

Net ecosystem exchange

Imports of C

Exports of C



Uncertainty assessment

$$\sigma_{NBP, hh} = \sqrt{(\sigma_{C_{imp}, hh})^2 + (\sigma_{NEE, hh})^2 + (\sigma_{C_{exp}, hh})^2}$$

Method 1 : eddy covariance

Uncertainty assessment

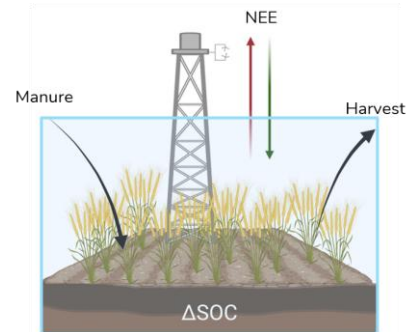
$\sigma_{Cimp,hh}$, $\sigma_{Cexp,hh}$ = Calculated from biomass samples

$$\sigma_{NEE,hh} = \sqrt{(\sigma_{NEE,meas,hh})^2 + (\sigma_{NEE,u*,hh})^2 + (\sigma_{NEE,spcorr,hh})^2}$$

calculated via mean sliding window (ONEFLUX)

calculated from the difference between NEE scenarios from u^* threshold distributions (ONEFLUX)

on spectral correction factors using FREQCOR



Faurès et al.
[preprint]

Uncertainty propagation

Random vs systematic = strong impact on cumulative uncertainty (quadrature vs linear)

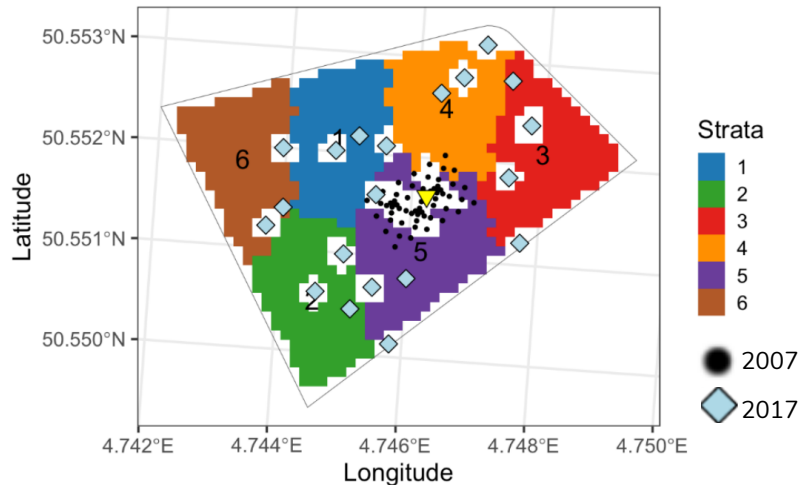
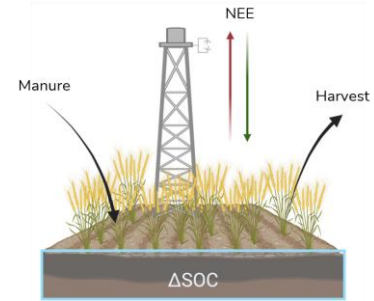
All uncertainties are assumed random except $\sigma_{NEE,u*,hh}$ and $\sigma_{NEE,spcorr,hh}$ = mixed approach used

Method 2 : soil C inventories

Soil C inventories (2007, 2017)

- Reduced dataset by selecting spatially co-located sampling points
- Equivalent soil mass
- Standardized mean difference (Hedges' g effect size)

=> Winck et al. "Soil organic carbon stock changes at European ICOS croplands: a harmonized multi-site assessment" poster 286



Uncertainty assessment

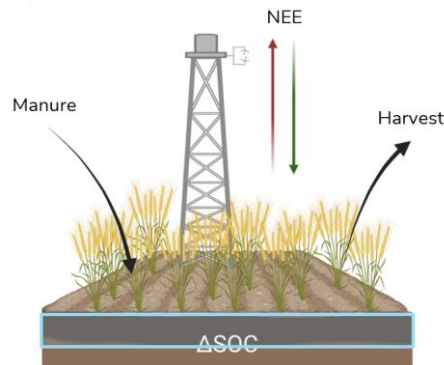
Confidence intervals on Hedges' g via 10,000 nonparametric bootstrap resamples

Method 3 : RothC



RothC (2004-2024)

- requires C inputs and meteorological data
- Initial C stock set to 2007 inventory
- C inputs : aboveground C inputs measured (ICOS protocols) + estimated belowground C inputs via allometric equations from C_{exp}

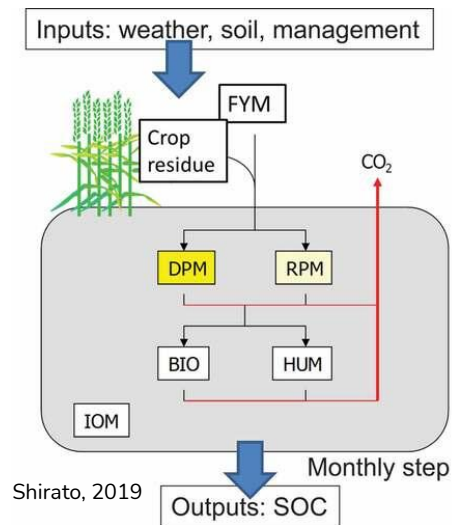


Uncertainty assessment

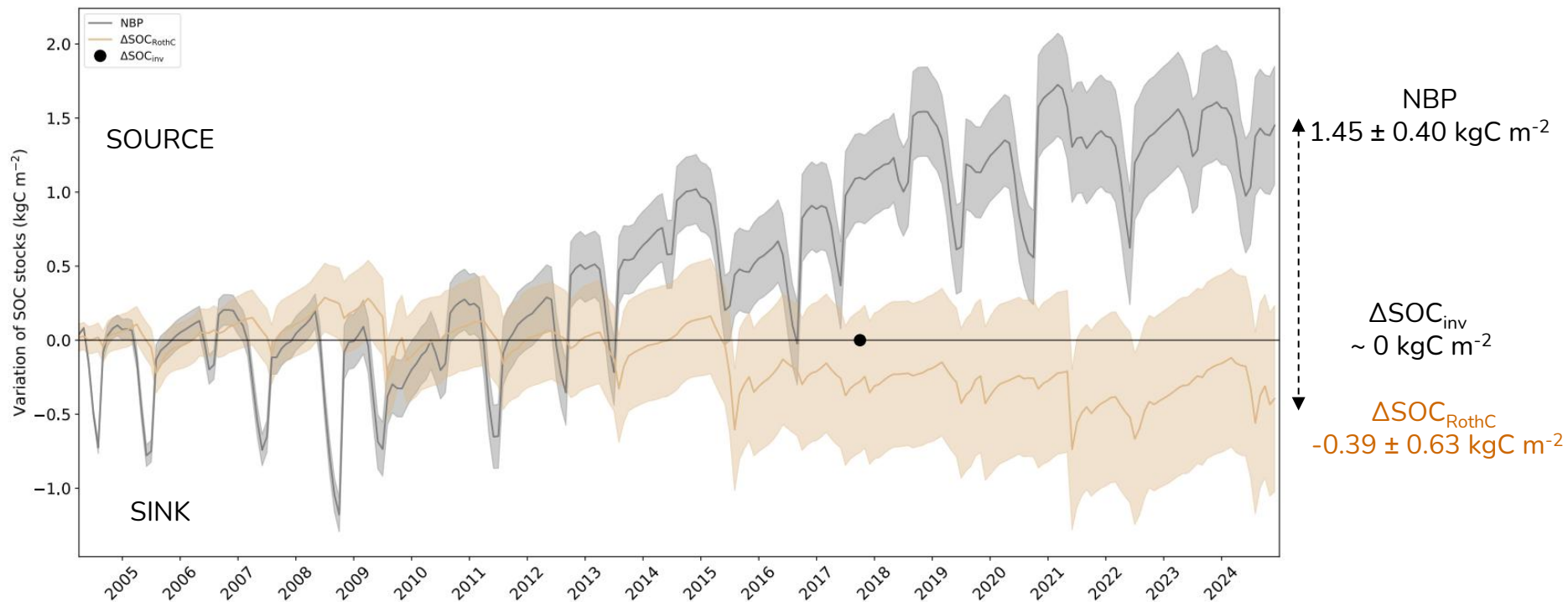
Monte-Carlo n simulations based on:

- Measured uncertainty on C inputs
- Assumed uncertainty on model parameters (20%)

Calculation of the monthly mean / std across n simulations



EC vs soil C inventories vs RothC

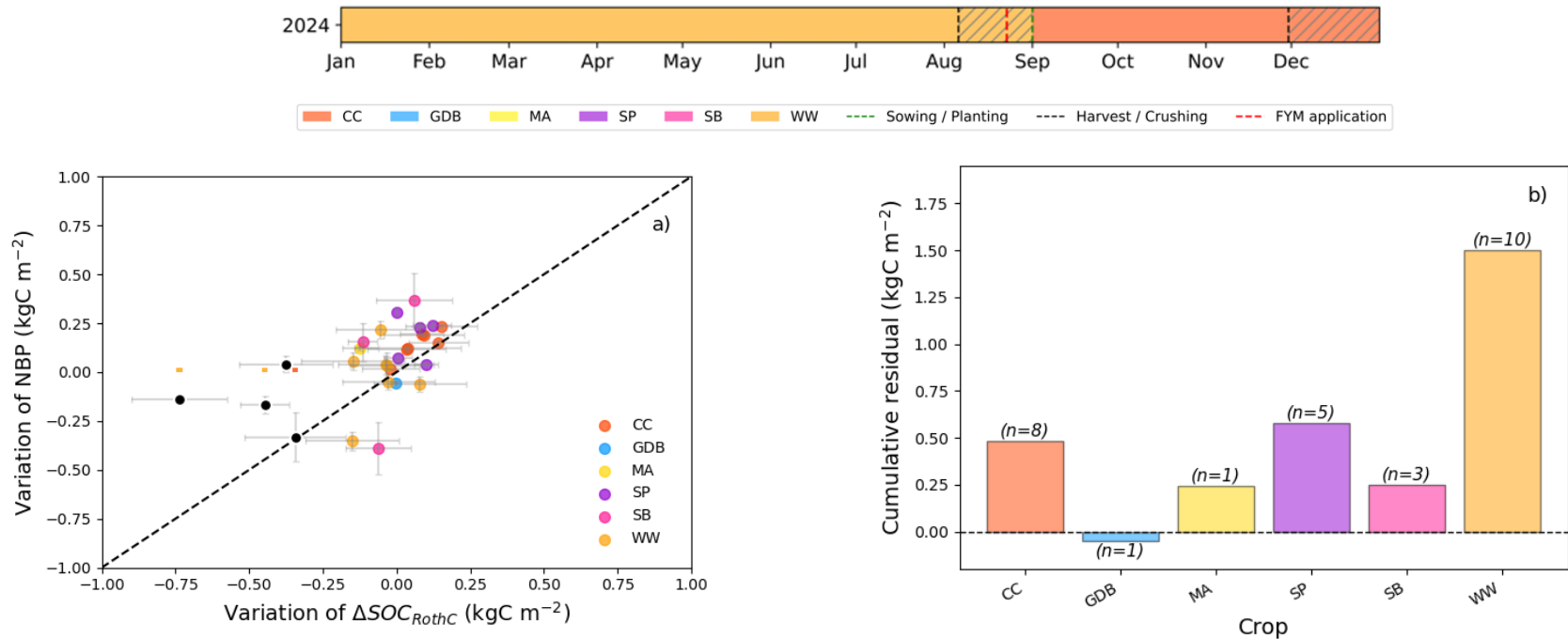


No overlapping between NBP and ΔSOC_{RothC}

ΔSOC_{RothC} and ΔSOC_{inv} support equilibrium

Where does the discrepancy between EC and RothC come from ?

Comparison of NBP and ΔSOC_{RothC} over cultivation periods (sowing to sowing = residue integration into the crop-related period)

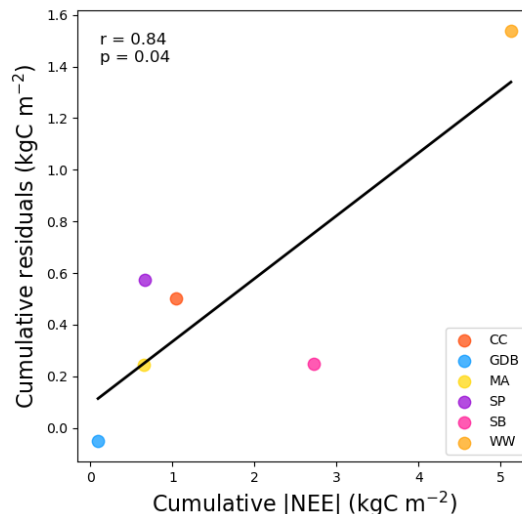
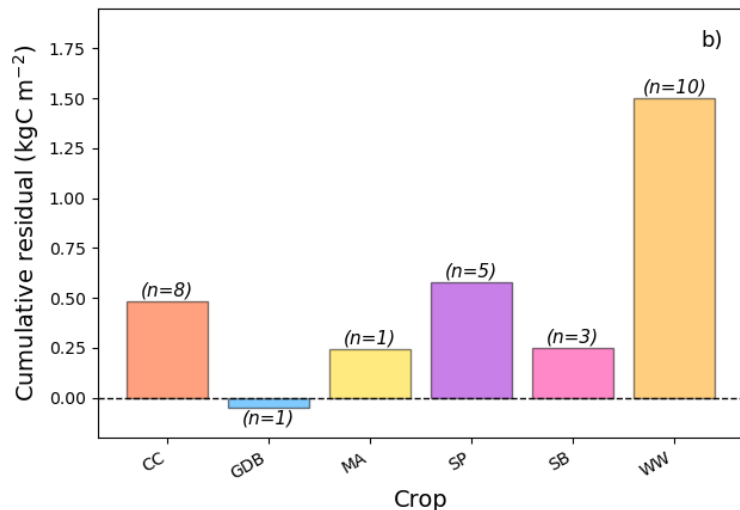
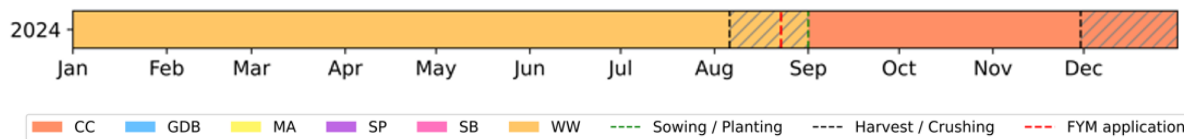


Most of the crops are above the 1:1 line

Winter wheat is a key driver of the discrepancy

Where does the discrepancy between EC and RothC come from ?

Comparison of NBP and $\Delta\text{SOC}_{\text{RothC}}$ over cultivation periods (sowing to sowing = residue integration into the crop-related period)



The cumulative residuals are correlated to the cumulative NEE

The more C sequestration, the larger the discrepancy between RothC and NBP

Winter wheat is a key driver of the discrepancy

Take-home message

- **Uncertainty matters:** essential when benchmarking EC against other methods.
- **EC–RothC bias remains significant**, and is amplified with NEE
 - possible **systematic NEE bias?**
 - possible link with **energy balance non-closure?**

Arquin et al. “Revisiting Energy Balance Non-Closure through Multivariate Atmospheric Regime Analysis” Parallel session 29, 17/09 (AGROFLUX project)
- **Second ICOS soil C sampling (start 2027)** will help resolve SOC stock changes on ICOS sites
- **Multi-site studies are needed** to assess robustness and generality.





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Thank you for listening!



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Beauclaire et al. [preprint]



Faurès et al. [preprint]