EPIC calibration and validation to predict crop yields and soil organic carbon dynamics among different management practices.

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Introduction

In the last years, there has been a focus on the positive and negative effects that agricultural activity has on the environment. Conservation agriculture and cover crops use are examples of measures which are considered capable of bringing environmental benefits.

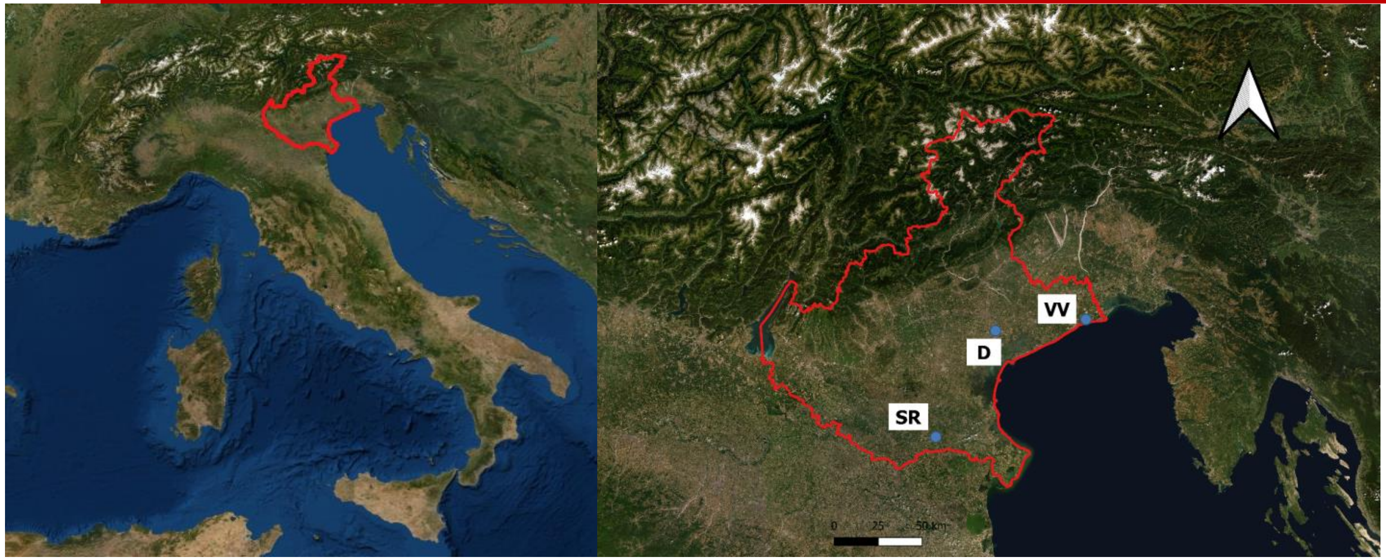
Conservation agriculture:

- ➢ Crop diversification
- ➢ No-tillage (NT) or minimun tillage (MT)
  - Decreased soil erosion
  - Decreased soil organic carbon (SOC) oxidation
- ➢ Cover crops and residues left on field

Cover crops:

- ➢ Decrease in nutrient loss, soil erosion, ETp
- ➢ Contribute to pest control: allelopathy, host for natural enemies

Study area and experimental sites



Field experiment started in 2010 in three farms in Veneto region, North –Eastern Italy : Diana (D), Sasse Rami (SR), ValleVecchia (VV). It is still ongoing; we used 2010-2017 data for this application.

Three managements systems:

- CV: conventional agriculture with ploughing
- CC: cover crops use with plughing
- CA: conservation agriculture (no-till)

Co-financed in the Veneto Region Rural Development Program - RDP (2007 – 2013 and 2014 – 2020)

Rotation:

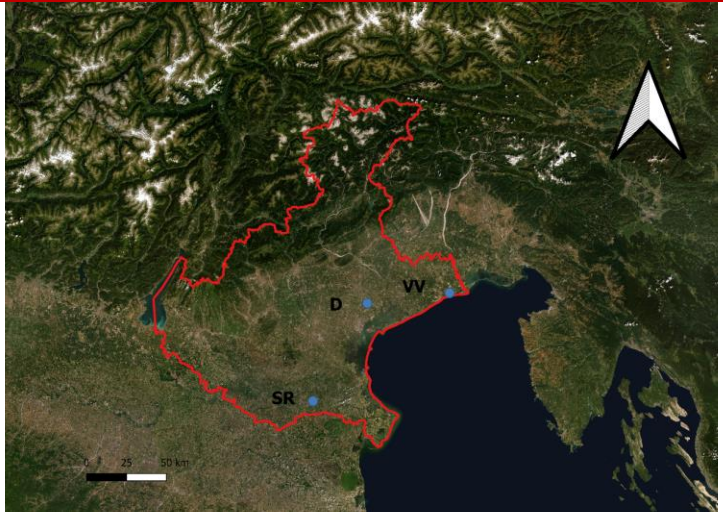
- Winter wheat
- Oilseed rape (until 2015)
- Soybean
- Corn

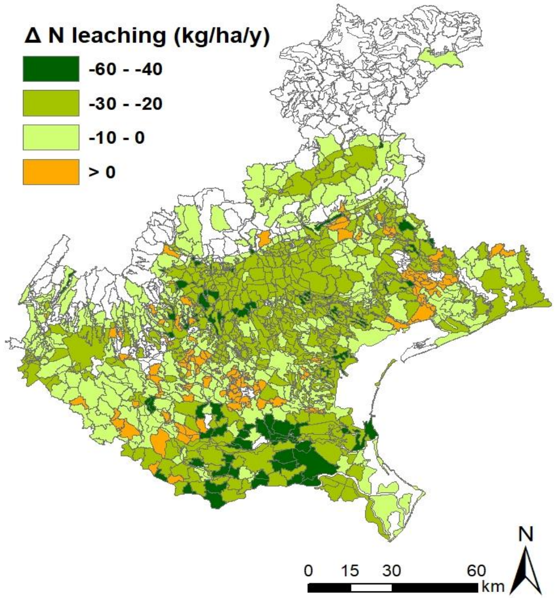
Cover crops (CC and CA):

- Sorghum (summer)
- Barley-vetch (winter,until 2014)
- Winter wheat (winter)

Purpose of the study

- Purpose of this particular study: calibrate and validate EPIC with data from the three farms.
- This way, we can find a model setup that reasonably reproduces the conditions of the low-lying Veneto plain.
- Future goal: extending model application to the entire Veneto region, to assess environmental impacts of measures financed in the RDP.
- We also compared different approaches incorporated in EPIC for simulating soil water content and soil organic carbon.





Model set up

- **44 plots** of about 1 ha surface were simulated for the 2010 – 2017 period;

- Before 2010, a 21 years spin-up run was added, to stabilize the organic carbon pools in the soil (Izaurralde *et al.*, 2017):
  - 3 years corn, 3 years meadow *(Bouteloua dactyloides*)
  - 170 kgN/ha from organic fertilizer during corn cultivation phase

PHU (Potential Heat Units):

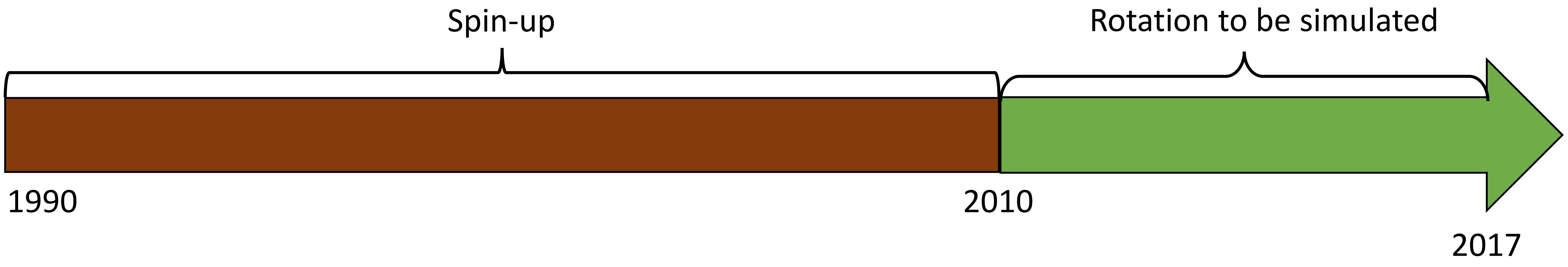
- Retrieved from Giardini *et al*. (1998) for winter wheat, maize and soybean
- Rapeseed and cover crops: calculated with:

$$\sum HU_k = \frac{Tmax,k+Tmin,k}{2} - T_{b,j}$$

Summation of daily HU for the period from sowing to harvest

Heat units for day-k

Base temperature for crop-j (°C)

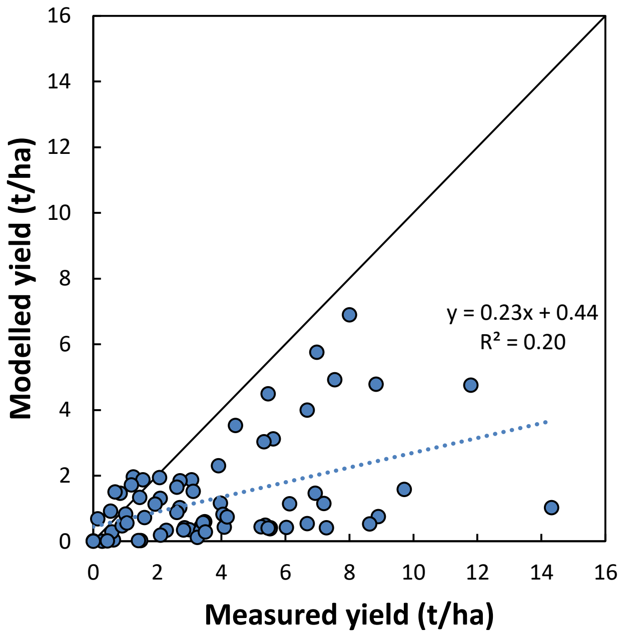


Model set up

- Addition of Johnsongrass (*Sorghum halepense* (L.) Pers.) as weed for CA managed fields (to account for important weed infestation episodes).

- It was added only in spring-summer periods for fields where the episodes happened. Example:

DATE	OPERATION
11/04/2014	Corn Sowing
10/05/2014	Johnsongrass sowing
20/07/2014	Kill Johnsongrass
24/09/2014	Harvest and kill Corn



Adding it in every field caused excessive underestimation; in fact, not all fields suffered from weed infestation.

Model performance evaluation

Measured *vs* simulated data:

- soil water content (2013 – 2017);
- Soil water content was measured only in three fields per farm;
- SOC (2011, 2014, 2017);
- crop yields (2010-2017).

Statistical indicators:

- NSE (Nash – Sutcliffe Efficiency) = 1 - $\frac{\sum_{i=1}^{n}(Yobs,i-Ysim,i)^2}{\sum_{i=1}^{n}(Yobs,i-Ymean)^2}$

  NSE > 0.0

- RMSE (Root Mean Square Error) = RMSE = $\sqrt{\frac{\sum_{i=1}^{n}(Yobs,i-Ysim,i)^2}{n}}$

  RMSE → 0

- coefficient of determination (r^2)

  $r^2 > 0.5$

Good model performance: NSE and r^2 both ≥ 0.5

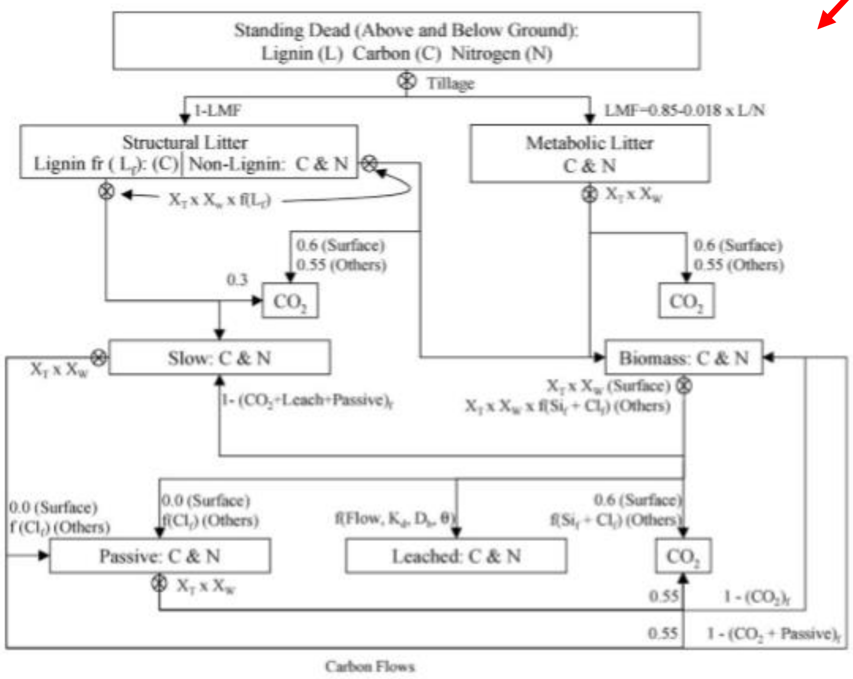
Subroutine comparison

1) For soil water content:

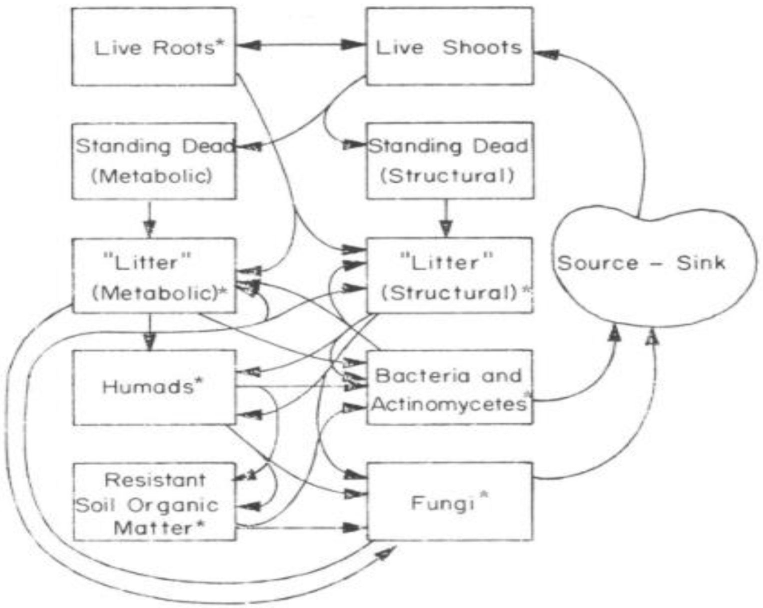
- Variable saturation Hydraulic Conductivity Method – VSHC (Doro *et al.*, 2018)
- Incorporation of Richards equation

2) For SOC dynamics:

- EPIC approach (based on CENTURY model)
- PHOENIX model (McGill *et al.*, 1981)



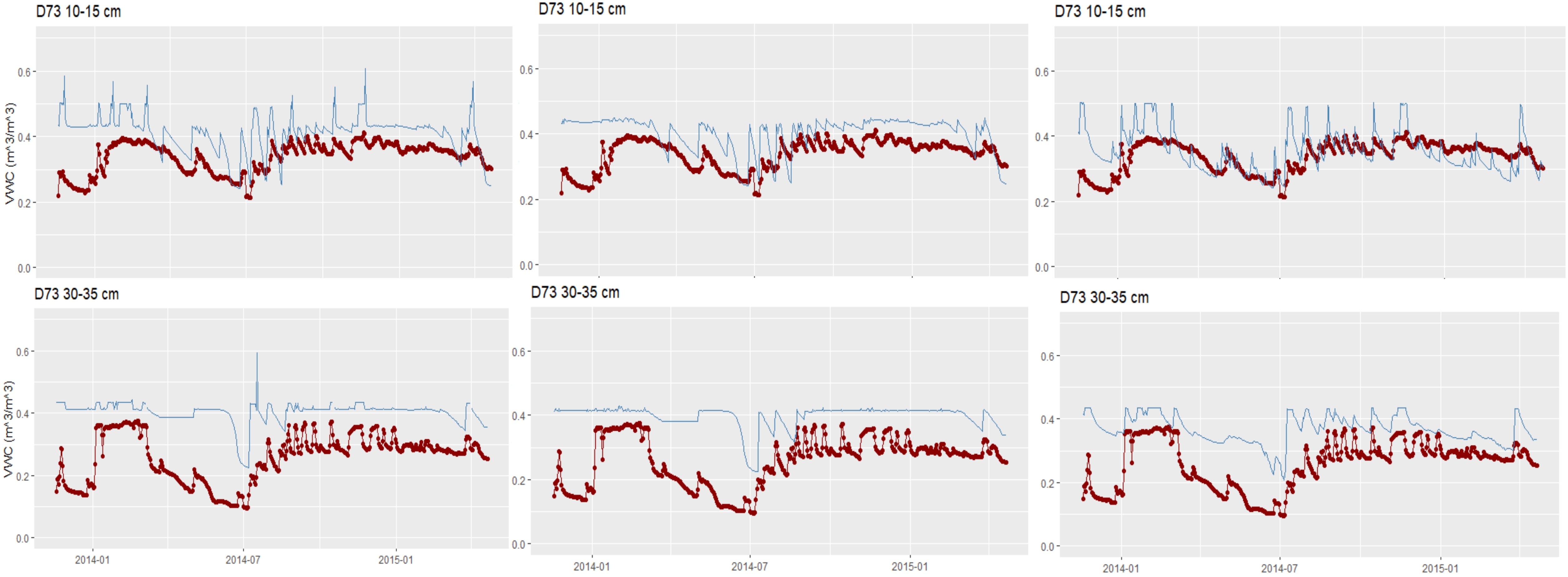
Izaurralde *et al*. (2006)



McGill *et al*. (1981)

Results: volumetric water content

Original EPIC method | **VSHC** | **Richards**



The curve for modelled data becomes flatter with depth, especially for VSHC and original EPIC models.

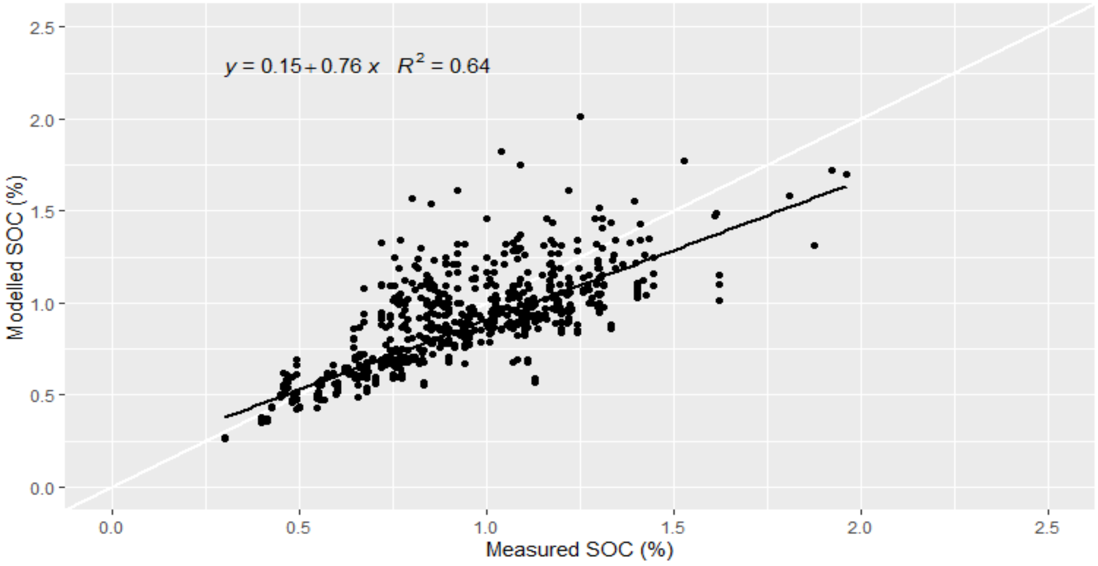
Results: SOC

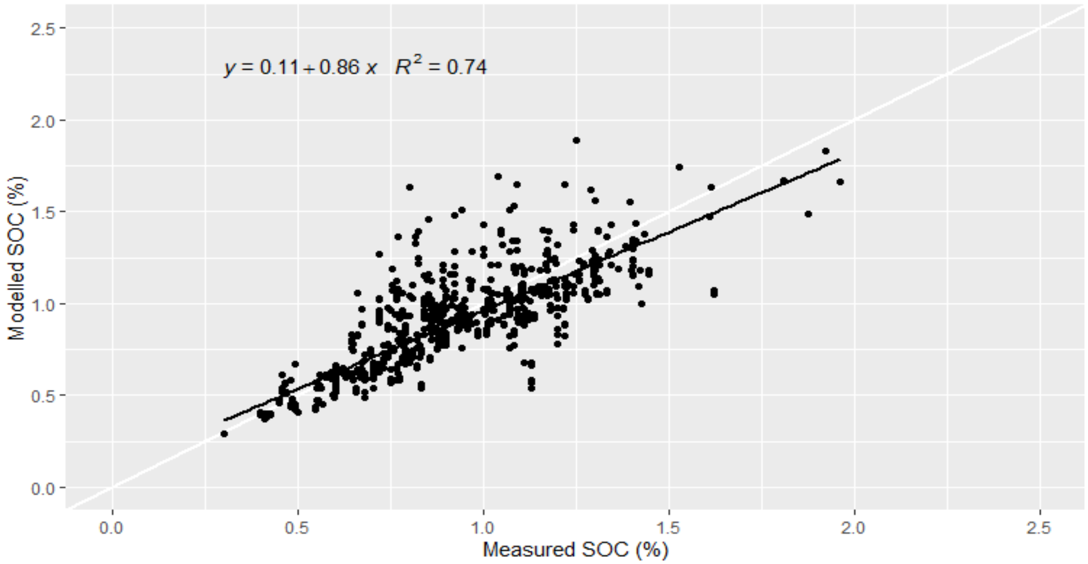
EPIC - Century

Management system	Average Measured SOC %	Average Predicted SOC %	NSE	RMSE (%)	r^2
CA	0.91	0.86	0.64	0.18	0.68
CC	0.88	0.83	0.61	0.20	0.67
CV	0.88	0.79	0.51	0.22	0.60
Total	0.89	0.82	0.57	0.20	0.64

Phoenix

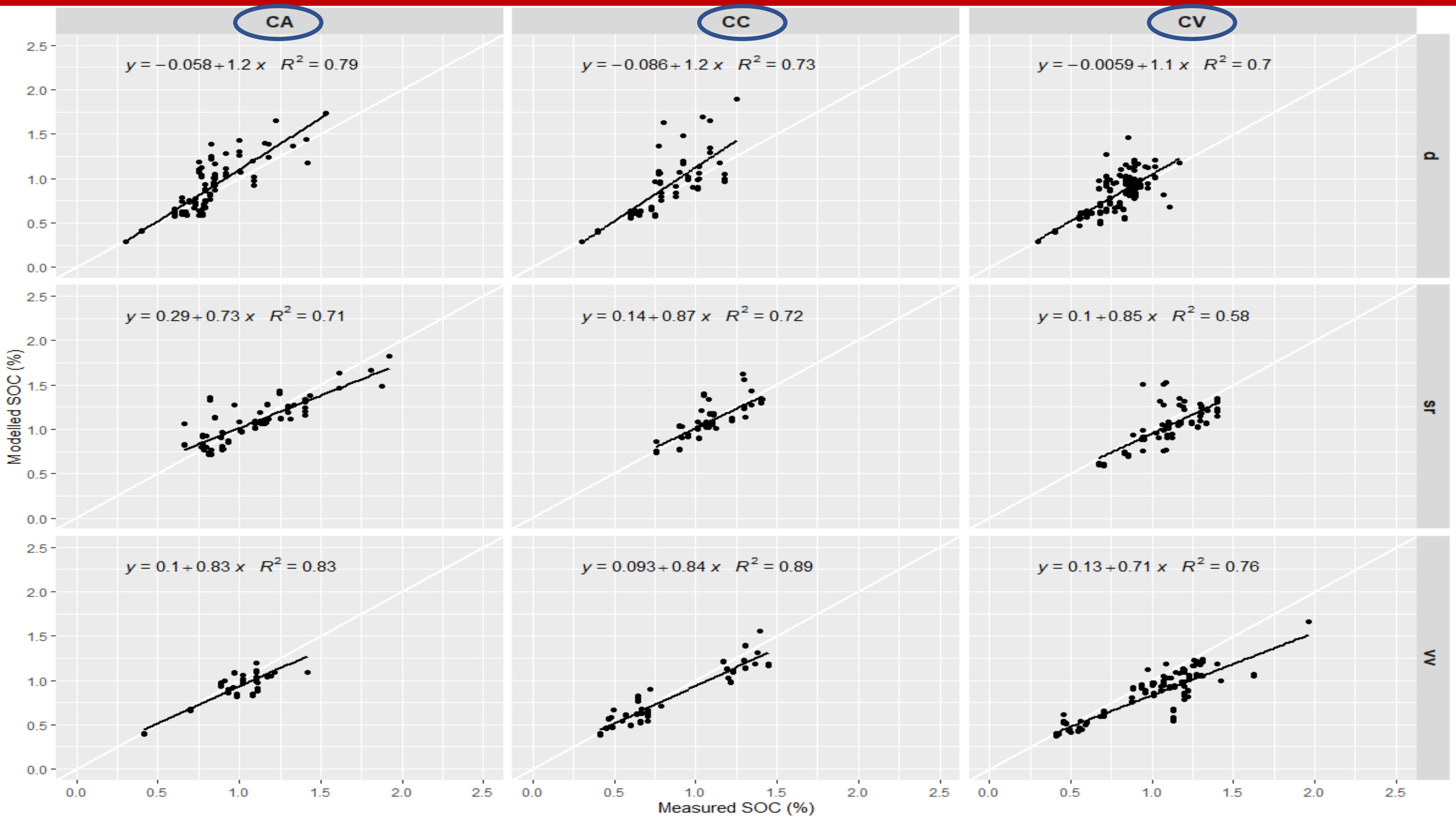
Management system	Average Measured SOC %	Average Predicted SOC %	NSE	RMSE (%)	r^2
CA	0.91	0.92	0.76	0.15	0.78
CC	0.88	0.89	0.77	0.15	0.80
CV	0.88	0.82	0.67	0.18	0.70
Total	0.89	0.86	0.72	0.17	0.74





Results: SOC (Phoenix Method)

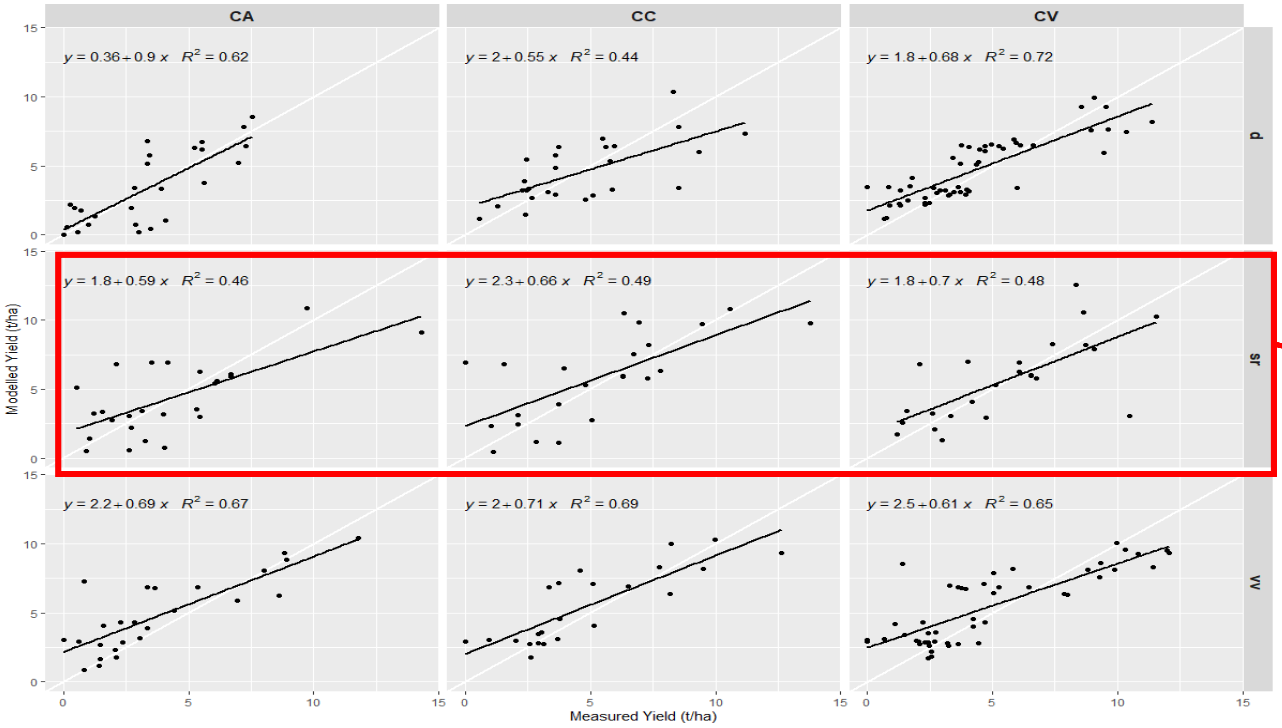
General good model performance considering management systems.

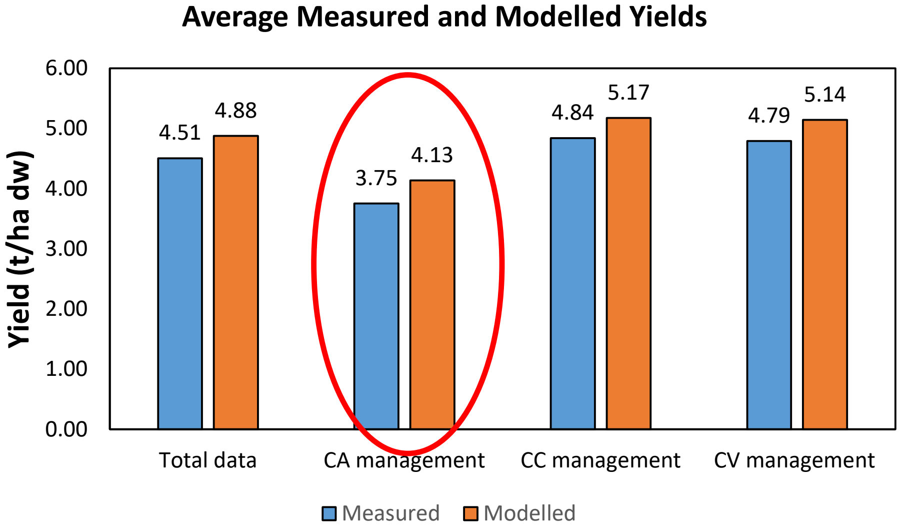


The three experimental sites

Results: crop yields

Management system	NSE	RMSE (t/ha dw)	r^2
CA	0.52	2.00	0.57
CC	0.56	1.86	0.61
CV	0.62	1.94	0.64
Total	0.59	1.99	0.62

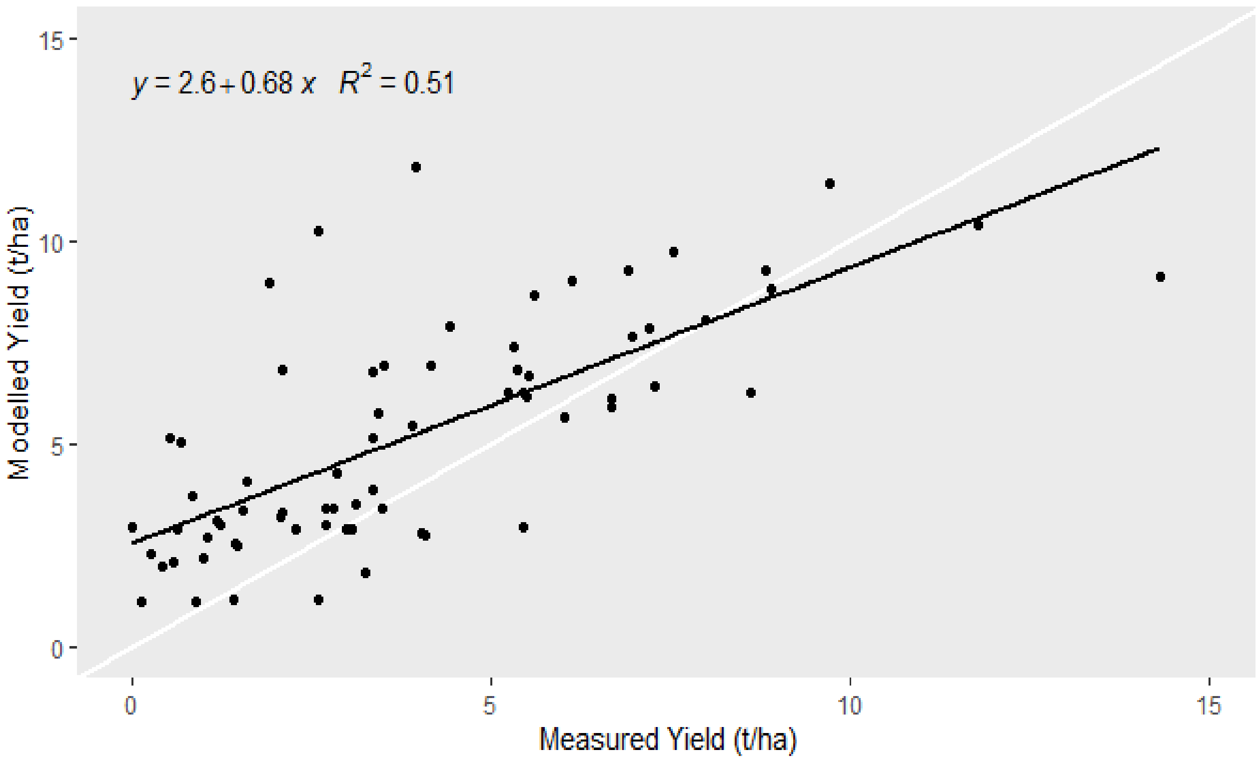




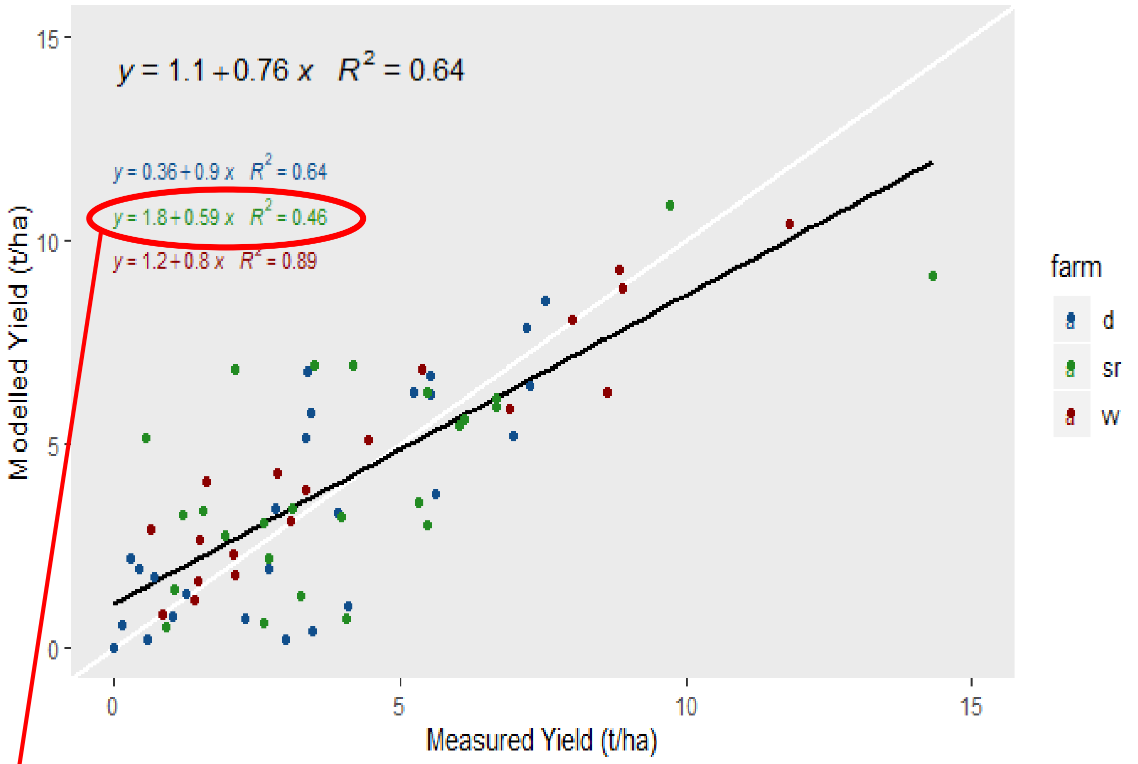
- Yield reduction in CA system relative to CV and CC.
- Mixed performance in simulating the different management systems because of the high variability between the three farms.
- Simulations are problematic mostly in SR farm.

Results:crop yields in CA – managed fields

Without johnsongrass



With johnsongrass



SR farm remains the «weak link»

Summary

Variable	NSE	RMSE
Soil water content	< 0.5	< 0.5
SOC	> 0.5	> 0.5
Crop yields	> 0.5	> 0.5

Soil water content:

- All the subroutines considered followed measured data better in the first 10-15 cm of soil.
- Improvements with VSHC and Richards method with respect to original EPIC approach.
- Richards method is less subject to the curve flattening in deeper layers.

SOC:

- Further investigations needed to understand the better performance of Phoenix approach; a possible explanation is the fact that the EPIC - Century configuration relies on soil N data, which were not available in this case.

Crop yields:

- EPIC offered good simulations, considering the high variability in this parameter both between different farms and among different fields in the same farm.
- Possible improvements could be obtained by refining the approach used to simulate weeds (e.g. using various plants instead of only Johnsongrass.

Thank you for the attention!

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