ASSESSMENT OF CLIMATE CHANGE IMPACTS ON SOC DYNAMIC IN RAINFED CEREAL CROPPING SYSTEMS MANAGED WITH CONTRASTING TILLAGE PRACTICES USING A MULTI MODEL APPROACH

I. Iocola[a], S. Bassu[a], R. Farina[b], D. Antichi[c], B. Basso[d], M. Bindi[e], A. Dallamarta[e], F. Danuso[f], L. Doro[g,h], R. Ferrise[e], L. Giglio[i], F. Ginaldi[j], M. Mazzoncini[c], L. Mula[a,g], R. Orsini[k], M. Pasqui[l], G. Seddaiu[a,g], R. Tomozeiu[m], D. Ventrella[i], G. Villani[m], P. P. Roggero[a,g]

[a]**NRD-UNISS**, University of Sassari, Italy; [b]CREA-AA, Rome, Italy; [c]DISAAA-a, University of Pisa, Italy; [d]Michigan State University, USA; [e]DISPAA, University of Florence, Italy; [f]DI4A, University of Udine, Italy; [g]Dipartimento di Agraria, University of Sassari, Italy; [h]Blackland Research & Extension, USA; [i]CREA-AA, Bari, Italy; [j]CREA, Bologna, Italy; [k]Dipartimento di Scienze Agrarie, Alimentari ed Ambientali, Marche Polytechnic University, Italy; [l]CNR-Ibimet, Roma, Italy; [m]Arpae-SIMC, Bologna, Italy.

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Introduction

- Sequestration of C in soil by **increasing SOC** is considered one way **to mitigate CC** (Maraccini *et al*., 2012; Wang *et al*., 2015)

- **Different tillage practices** affect organic C **sequestration capacity** in soil. There is still **uncertainty** of the merit of conservation tillage (i.e., RT, NT) to increasing SOC compared with CT (Gonzalez-Sanchez *et al*., 2012; Haddaway *et al*., 2016)

- **Simulation models** are **powerful tools** to explore CC mitigation strategies (Ewert et al., 2011; White et al., 2011)

Hypothesis

Using an **ensemble of models** to estimate SOC **improves simulation accuracy**

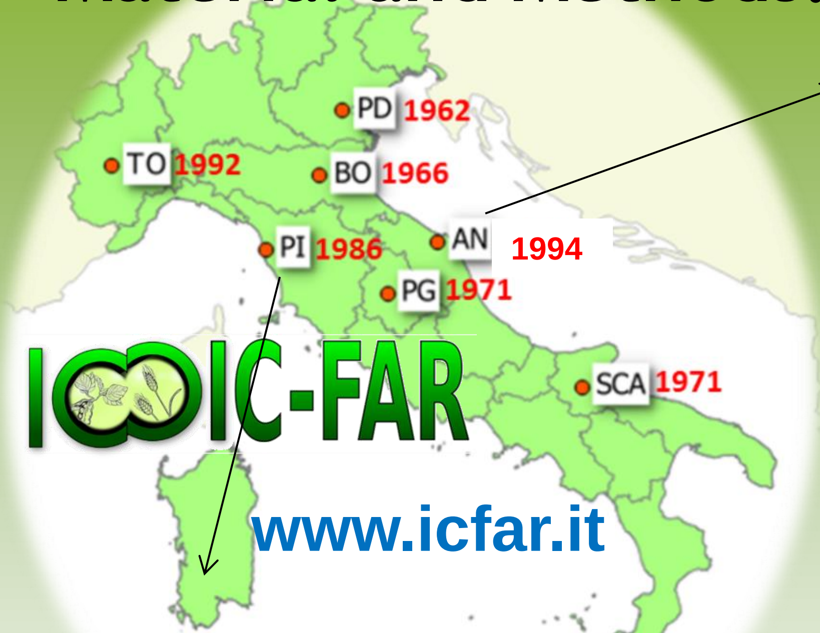
We **assumed** that the use of **crop models** for the **dynamic estimation of plant C inputs to soi**l can **improve the reliability of SOC simulations**

Objectives

To calibrate and evaluate four crop models using **LTE datasets** on Mediterranean cereal systems **under conventional and conservation tillage management**

MME to assess the long-term effects of **contrasting tillage practices on SOC** stocks (0-40cm) in rainfed durum wheat-maize rotations under **current** and **future climate scenarios**

Material and Methods: LTEs



LTE AN

Hilly, silty-clay soil

1994-2014: Mean annual P: 820 mm; Tmean: 15.3° C

Crop system

- 1994-2001: durum wheat – sunflower
- 2002-2014: durum wheat – maize

Factors

- Conventional (**CT- 40cm**) vs. No tillage (**NT**)
- Mineral N: 90 kg N ha^{-1}

LTE PI

Lowland coastal area with loamy soil.

1994-2008: Mean annual P: 826 mm; Tmean: 14.6° C

Crop system

- 1994-1998: continuous maize
- 1999-2008: durum wheat – maize

Factors

- Conventional (**CT- 30 cm**) vs. Reduced tillage (**RT- 15 cm**)
- Mineral N: 180 kg N ha^{-1} - WHT; 300 kg N ha^{-1} - MZ

Material and Methods: Model Setup

Experimental and weather data harmonized in the **IC-FAR database** (Ginaldi *et al.*, 2016)

Crop models:

- **APSIM-Nwheat (Model1)**
- **DSSAT (Model2)**
- **EPIC (Model3)**
- **SALUS (Model4)**

Soil C initialization based on land use history (Basso *et al*., 2011):

- Wheat-Maize rotation 44 yr in AN, and 63 yr in PI
- Before then, the sites were grassland

Material and Methods: Evaluation

$$\boldsymbol{RRMSE} = \frac{100}{\bar{O}} \sqrt{\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{n}}$$

$$\boldsymbol{RRMSE_{95\%}} = \frac{100}{\bar{O}} \sqrt{\frac{\sum_{i=1}^{n}(t_{(n-2)95\%_i} * S_e(i))^2}{n}}$$

$$\boldsymbol{EF} = \frac{(\sum_{i=1}^{n}(O_i - \bar{O})^2 - \sum_{i=1}^{n}(P_i - O_i)^2)}{\sum_{i=1}^{n}(O_i - \bar{O})^2}$$

$$\boldsymbol{E} = \frac{100}{n} \sum_{i=1}^{n} \frac{(O_i - P_i)}{O_i}$$

$$\boldsymbol{E_{95\%}} = \frac{100}{n} \sum_{i=1}^{n} \frac{(t_{(n-2)95\%_i} * S_e(i))}{O_i}$$

$$\boldsymbol{r} = \frac{\sum_{i=1}^{n}(O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \bar{O})^2}\sqrt{\sum_{i=1}^{n}(P_i - \bar{P})^2}}$$

Observed SOC
AN (40cm): 1996, 2002, 2006, 2010
PI (30 cm): 1993, 1998, 2008

Mean of Ranks

Smith *et al*., 1997

Material and Methods: Climate Scenarios

Generated by setting up a **statistical model** (based on CCA, Tomozeiu *et al*., 2014) using predictors from **ERA40 reanalysis** and the **seasonal indices** of **T and P from E-OBS gridded data** network for the period 1958-2010.

The statistical downscaling model was applied to the **predictors of CMCC-CM global** model to obtain climate scenarios at local scale over:

CP - Present Climate (period 1971-2000, 360 ppm)

CF – Future Climate RCP4.5 (period 2021-2050, 460ppm)

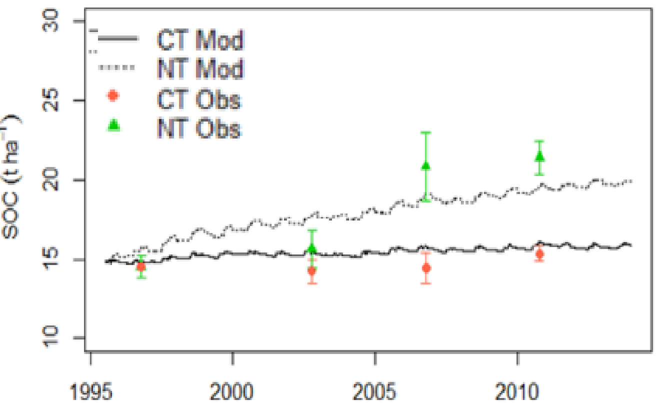
CF – Future Climate RCP8.5 (period 2021-2050, 490ppm)

Results: Model Evaluation

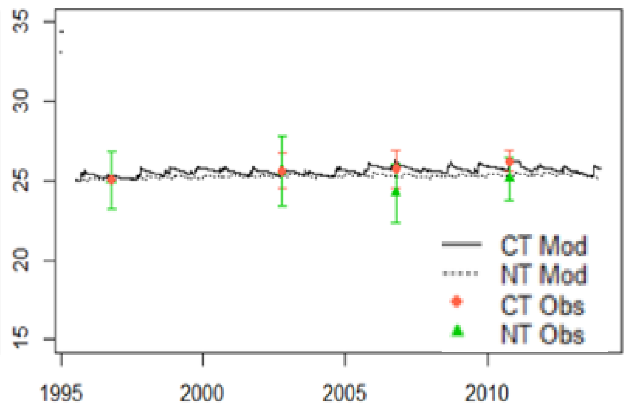
	RRMSE	EF	E	r	RankMean
Site AN	RRMSE95%=8.36		E95%= ±6.63		
Model1	5.85 *(4)*	0.01 *(4)*	2.26 *(3)*	0.63 *(5)*	*4.0*
Model2	4.60 *(3)*	0.39 *(3)*	0.31 *(1)*	0.83* *(4)*	*2.8*
Model3	7.44 *(5)*	-0.60 *(5)*	-6.57 *(5)*	0.86* *(3)*	*4.5*
Model4	3.77 *(2)*	0.59 *(2)*	-2.64 *(4)*	0.91* *(2)*	*2.5*
MM_MEAN	3.46 *(1)*	0.65 *(1)*	-1.66 *(2)*	0.95* *(1)*	*1.3*
Site PI	RRMSE95%=5.43		E95%=±5.35		
Model1	3.54 *(1)*	0.90 *(1)*	2.91 *(1)*	-	*1.0*
Model2	5.80 *(3)*	0.62 *(3)*	3.71 *(2)*	0.977* *(3)*	*2.8*
Model3	8.68 *(5)*	0.15 *(5)*	8.28 *(5)*	0.962* *(4)*	*4.8*
Model4	8.39 *(4)*	0.20 *(4)*	7.95 *(4)*	0.978* *(2)*	*3.5*
MM_MEAN	5.55 *(2)*	0.65 *(2)*	5.22 *(3)*	0.999* *(1)*	*2.0*

Results: Model Evaluation

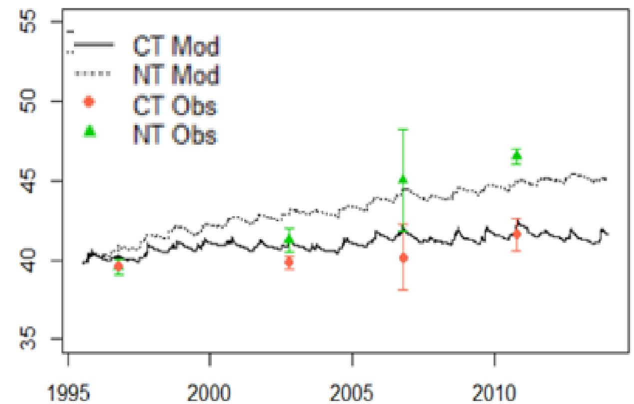
AN 0-15 cm



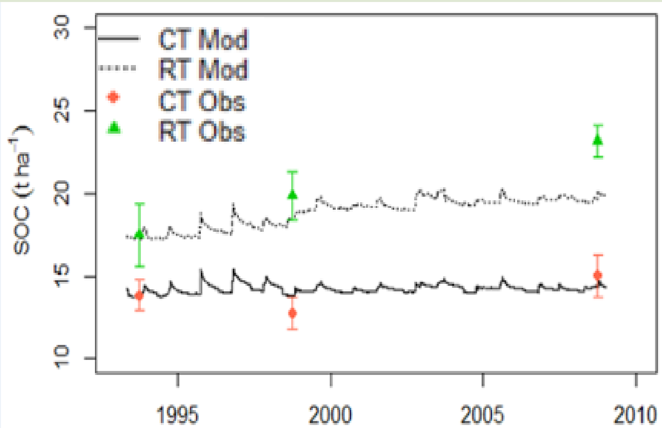
AN 15-40 cm



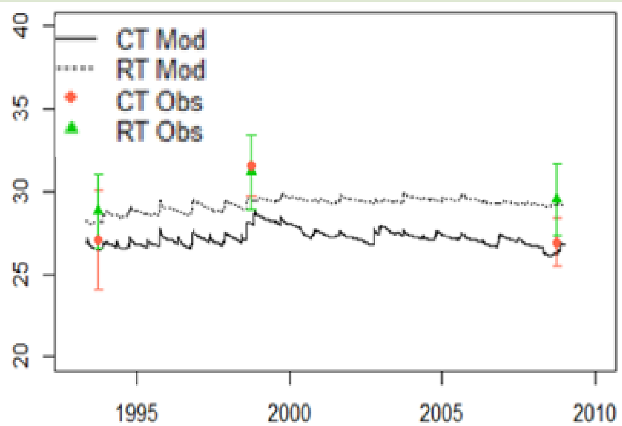
AN 0-40 cm



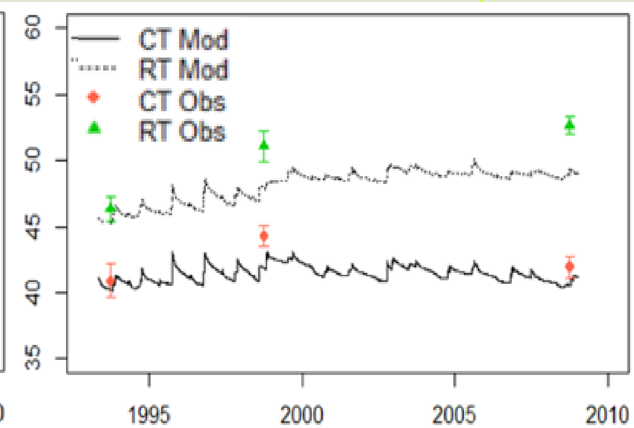
PI 0-10 cm



PI 10-30 cm

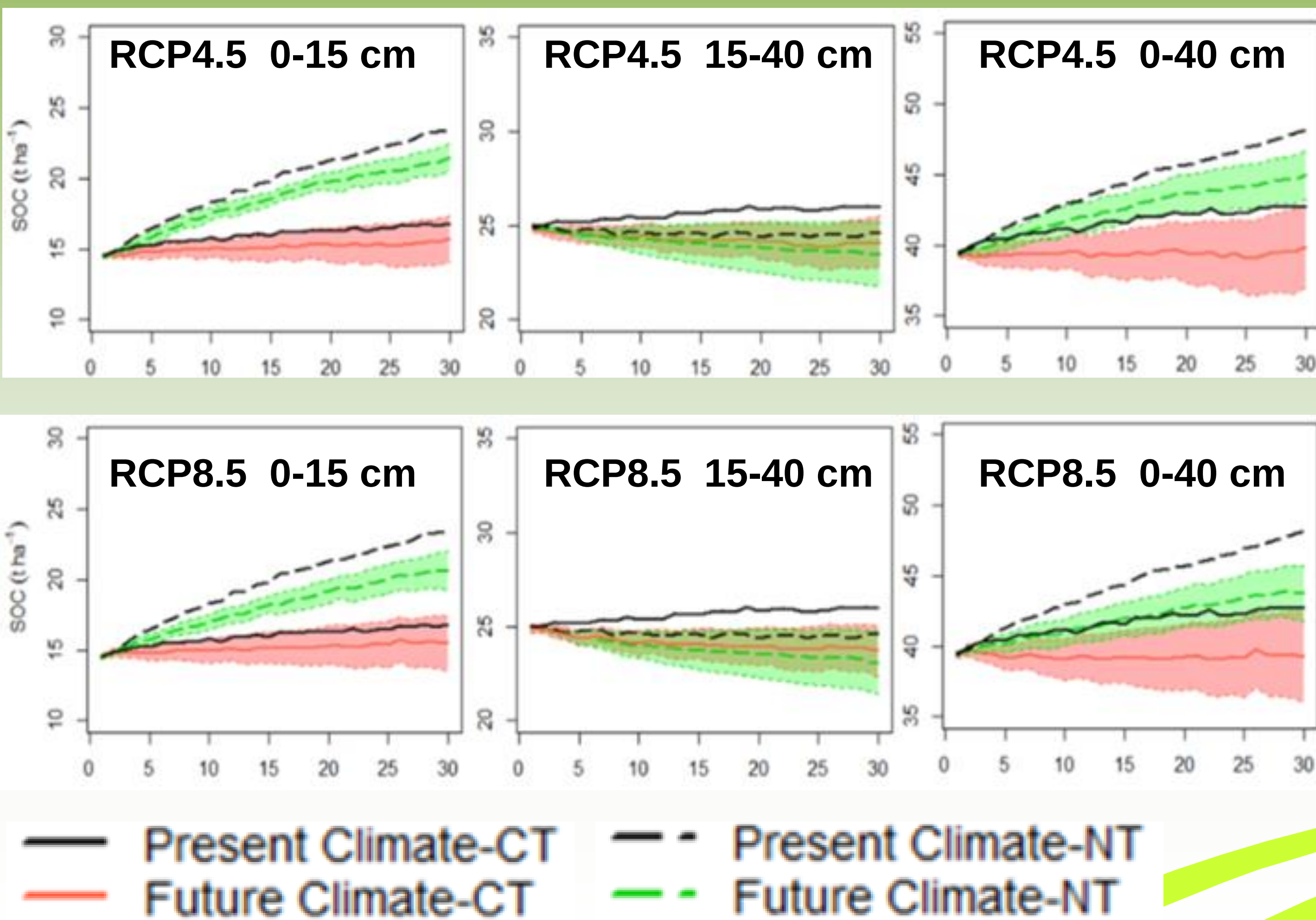


PI 0-30 cm



Results: Climate Scenarios - AN

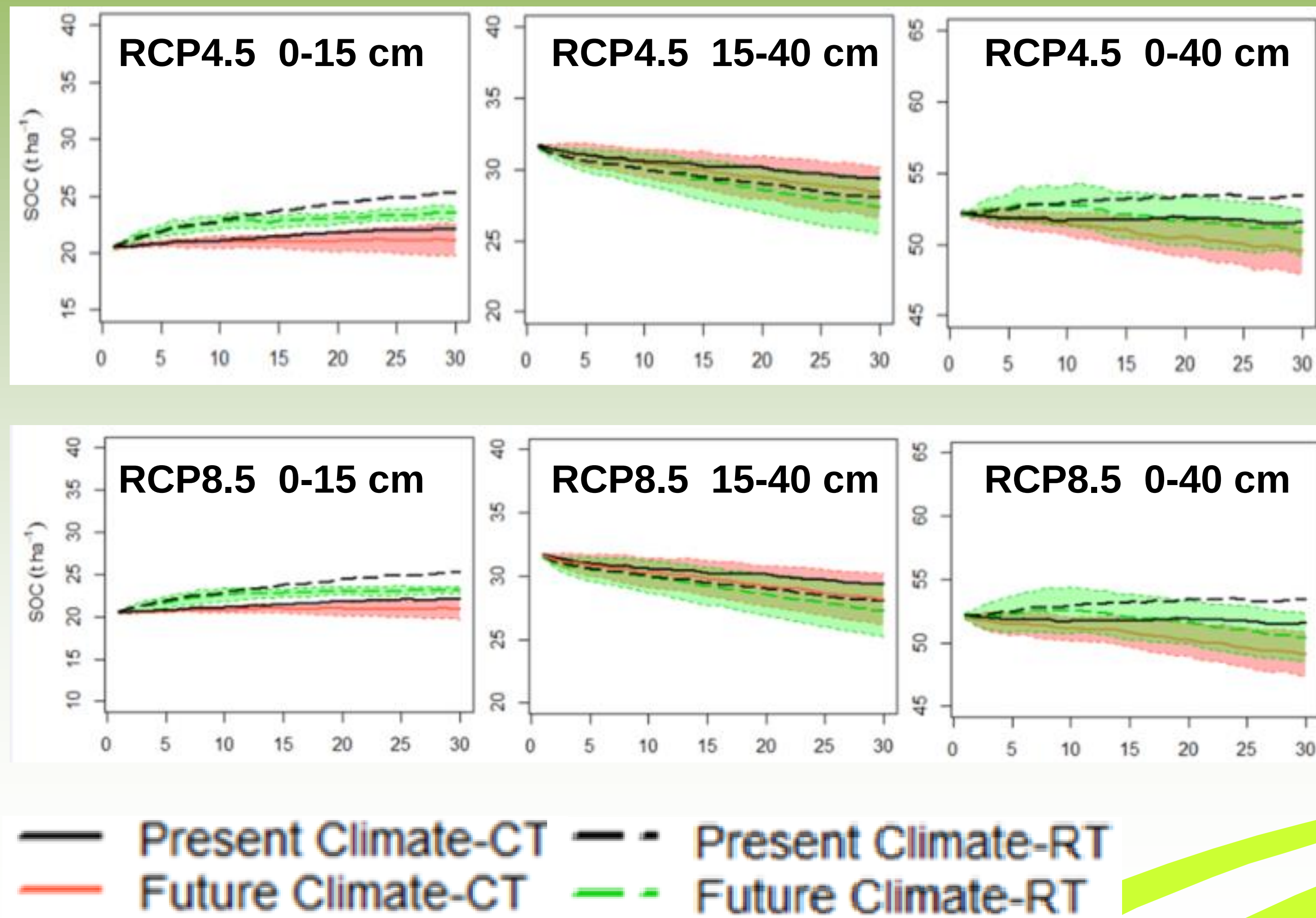
Annual mean T : **+1.8° C** in RCP4.5 and **+2.1° C** in RCP8.5
Mean annual Rain: **-22.5%** in RCP4.5 and **-23.0%** in RCP8.5



SOC annual rate
Present Climate:
CT +0.28%
NT +0.73%
Future climate:
CT no change
NT +0.4%

Results: Climate Scenarios - PI

Annual mean T : **+1.9° C** in RCP4.5 and **+2.1° C** in RCP8.5
Mean annual Rain: **+2.1%** in RCP4.5 and **+4.9%** in RCP8.5



SOC annual rate
Present Climate:
CT -0.04%
RT +0.07%
Future climate:
CT -0.19%
RT -0.11%

Conclusions

- Better accuracy using the **MME**
- **Conservation tillage systems** significantly increase C stock
- **NT** effects were consistent to the annual SOC increase target of **0.4% set by 4PT** under changed climate
- **Other complementary studies needed** (GHG emissions including N_20, soil C saturation capacity)

THANK YOU!

For further information:

iiocola@uniss.it, pproggero@uniss.it

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