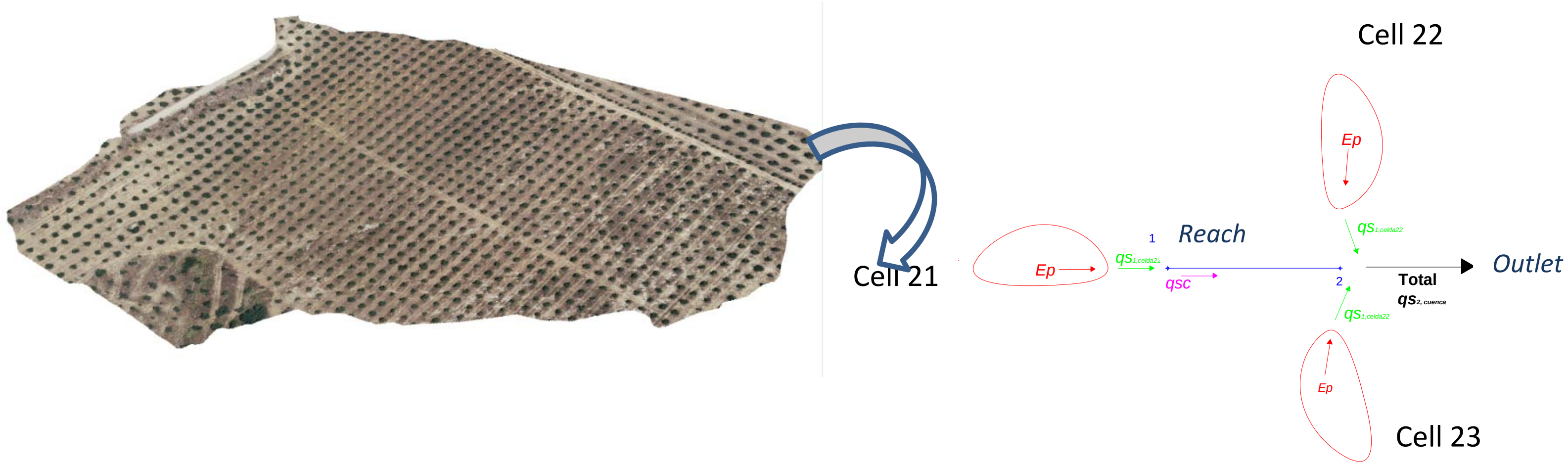
EGU General Assembly 2020

Online | 4–8 May 2020

Modelling scenarios of olive groves at the micro-catchment scale with the AnnAGNPS model to quantify organic carbon

Encarnación V. Taguas, Ronald L. Bingner, Henrique Momm, Robert Wells and Martin Locke



UNIVERSIDAD DE CÓRDOBA

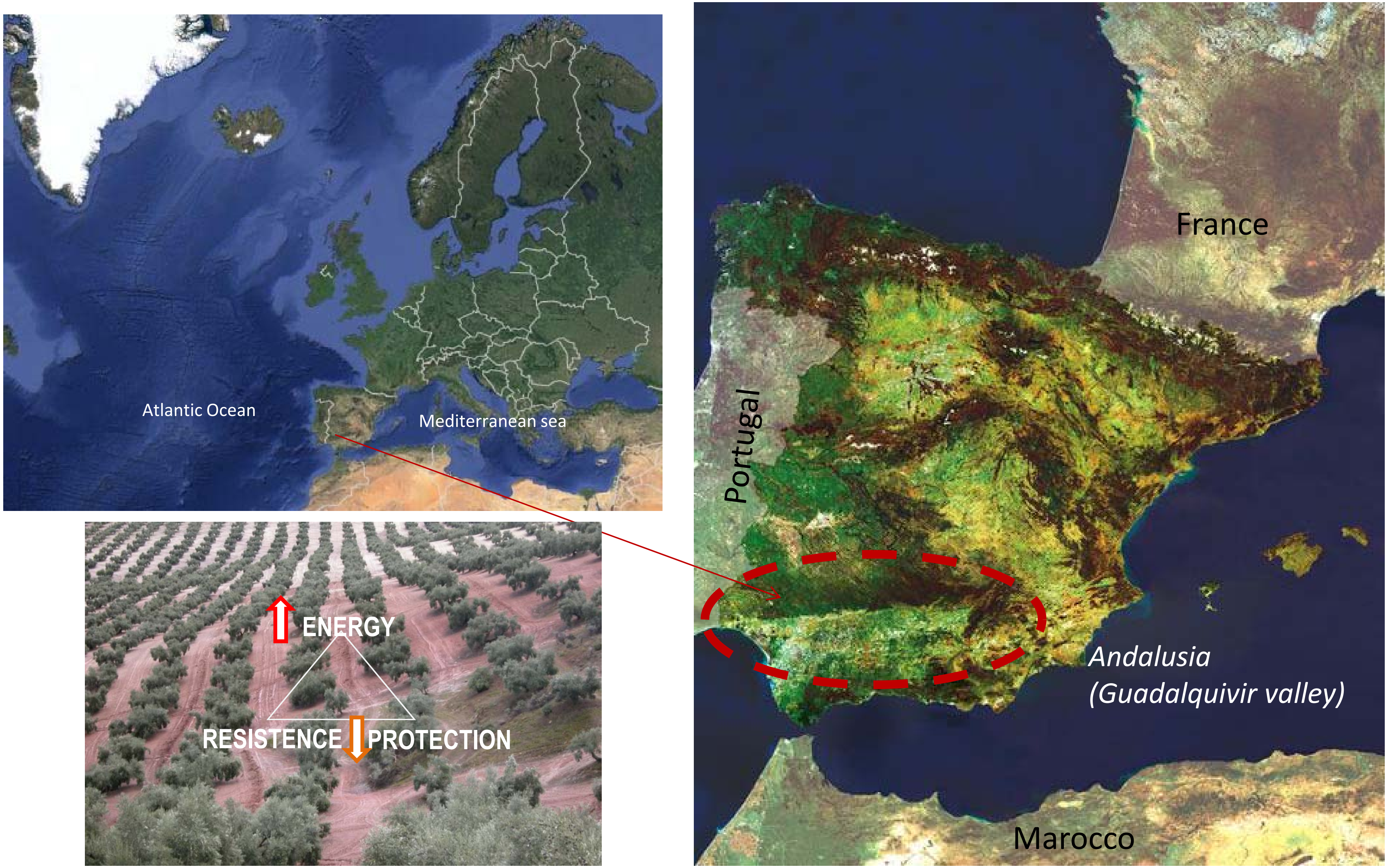
USDA United States Department of Agriculture
Agricultural Research Service

MIDDLE TENNESSEE STATE UNIVERSITY

0. CONTENTS

1. INTRODUCTION

1. INTRODUCTION



1. INTRODUCTION

Catchment
Simulated different olive grove systems

Modelling stages

Model consistency analysis

We are here

Sensitivity analysis

Calibration

Validation

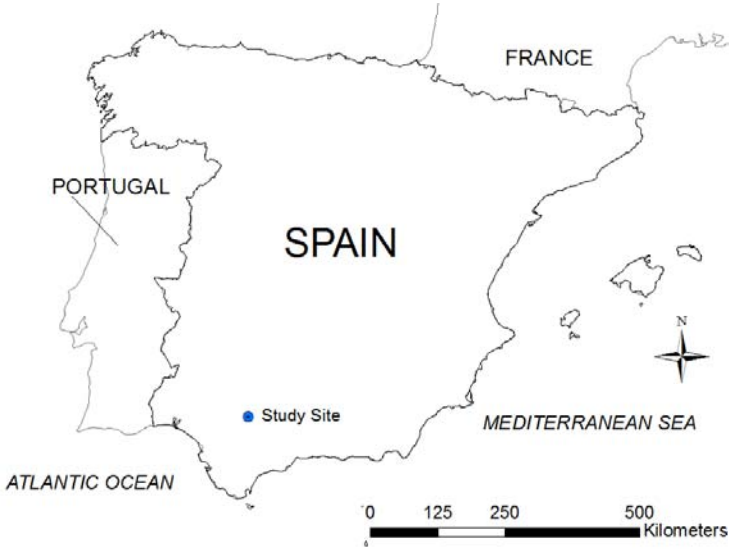
Prediction (RMSE)

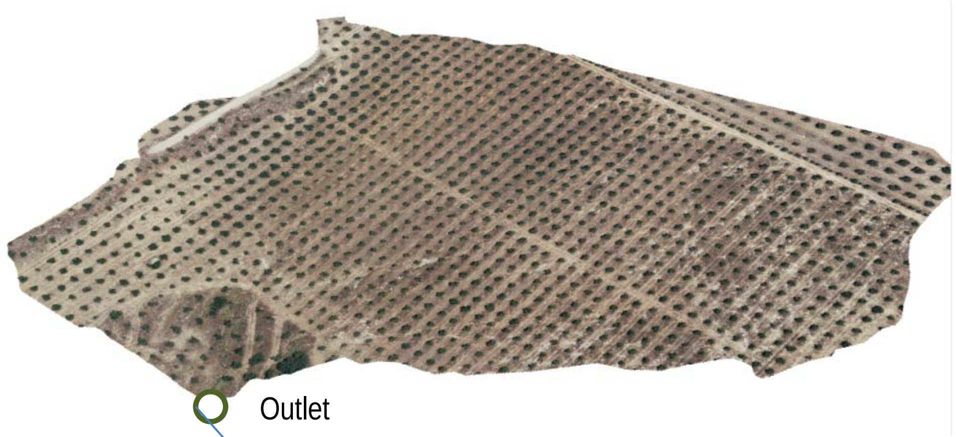
General objective: *to describe the new features of the model AnnAGNPS to simulate the organic carbon dynamics in catchments.*

1 . To present the basis of the model to quantify the organic carbon attached to sediments and the ground organic carbon variations on a small catchment of olive groves.
2. Carry out a descriptive sensitivity analysis to characterize the impact the different groups of parameters under different scenarios of extensive olive groves in Andalusia (Spain) on the algorithms of AnnAGNPS

2. MATERIAL AND METHODS

2. MATERIAL AND METHODS
2.1. Study site

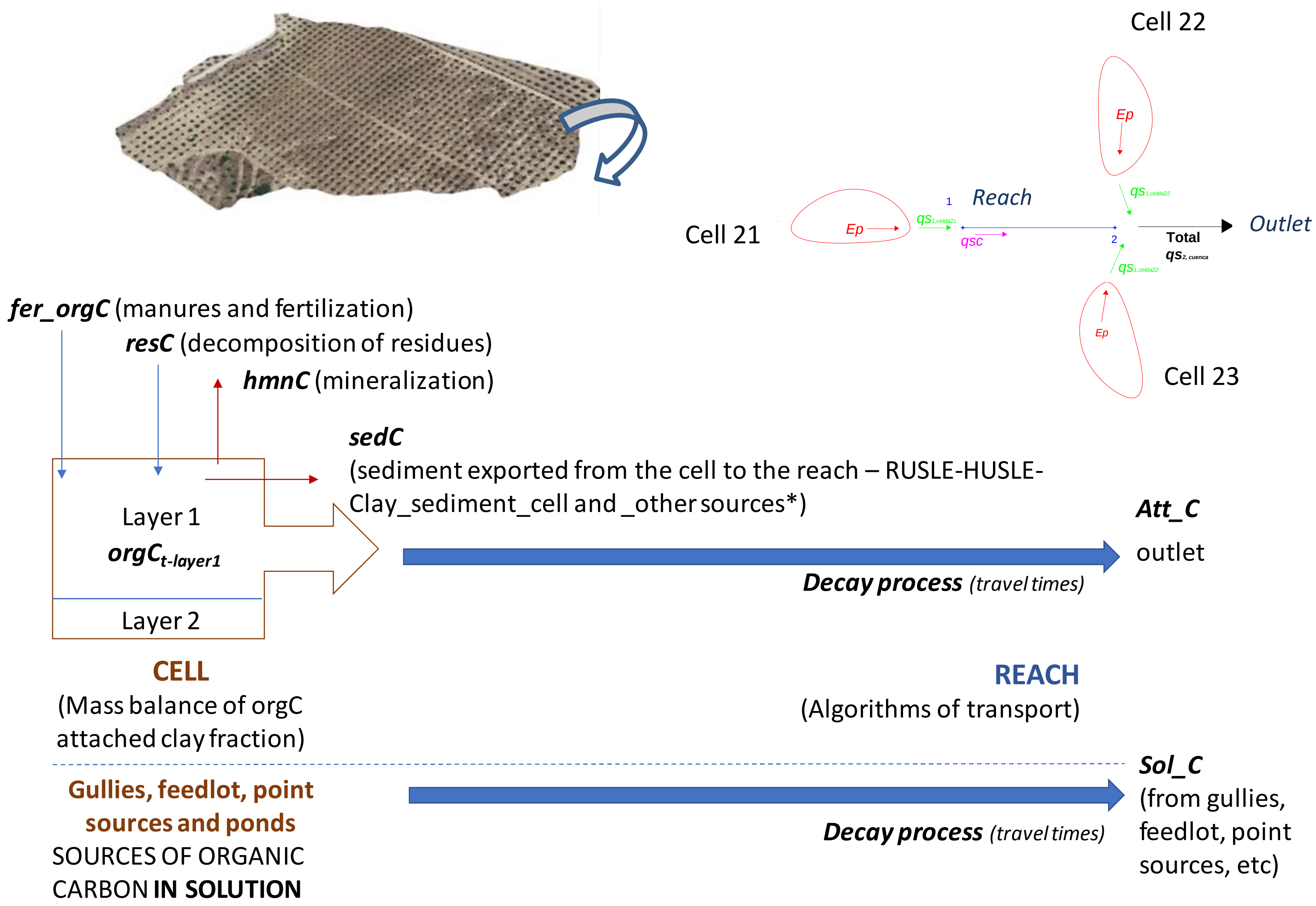




Puente Genil **(Taguas et al., 2012; Catena 98, 1-16)**
A=6.1 ha; **S=15%;** H=239 m
Pa=400 mm
Hilly olive orchard
3 cells –parameterisation described in Taguas et al. 2012.
Historical series of meteorological data
2005-2015 for simulation *(Mean precipitation 350 mm, between 233 and 774 mm)*

Figure 2. Equipment at the outlet to measure rainfall-tunoff-sediment load. (Measurements since April 2005-April-2016)

https://www.wcc.nrcs.usda.gov/ftpref/wntsc/H&H/AGNPS/downloads/AnnAGNPS_Technical_Documentation.pdf **-(Bingner et al., 2018)**



(*) point source, gully, pond, irrigation, bed & bank

Parameter group	Parameters
Dimensions	**D** = thickness for soil layer 1 (200 mm)
	ρ_b = bulk density of composite soil layer 1 (g/cc or Metric tons/ m^3)
Mineralization	**$(C/N)_{layer\text{-}1}$** =relation organic Carbon/Nitrogen in the computational layer 1
	hmnN $_{layer\text{-}l}$ = mineralization rate of N from the humus active organic N pool (kg/d) for the layer 1
Decomposition of residues	**$surf_{\_res}$** = surface residue for a cell which is computed from RUSLE module (kg/ha) - Check "added surface"
	surface-decomposition = is the surface residue coefficient (See Crop Data, 0.016 default)
	T_{soil} = the average cell temperature (^oC; cell_tmpr_avg= average air temperature)
	$CNR_{harvest}$ = ratio of carbon to nitrogen for crop at harvest (See Crop Data, Harvest C-N Ratio).
Manures and fertilisation	**fer_app** = the rate of fertilizer applied for current day operation (kg/ha); and
	frac_orgC = fertilizer fraction which is organic C, from fertilizer reference database (mass/mass).
Soil features	**Clay_soil**
	K-factor (texture, initial organic matter)
Hydrology and erosive dynamics	**C-factor** (Subfactor Roughness_management, subfactor residue was previously included)
	CN
	Storm type
	n Manning/concentration time
	Reach organic carbon half-life time (days) = time it takes half of the organic carbon to degrade while reach 0-730)

2. MATERIAL AND METHODS

2.3. Scenarios design and parameterisation

*Only data acquired at the plot scale and some data in PG catchment –No calibration, however, **guided** parameterisation*

Guided parameteristion for olive groves in Andalusia	Abbreviated reference
Soil features	Junta de Andalucía. 1984. Catálogo de suelos de Andalucía.
	Gómez et al. 1999; Soil Till. Res.. 52, 167-175.
	Gómez et al. 2009; Soil Till. Res. 102, 5-13.
CN and Hydrology	Romero et al., 2007; J. Soil Water Cons. 71(6), 1758–1769.
	Taguas et al., 2012; Catena 98, 1-16
	Taguas et al., 2009; ESPL 34 (5), 738-751
	Taguas et al., 2015; J. Irrig. Drain.Eng. 141 (11), 05015003
Managements	Taguas et al., 2012; Catena 98, 1-16
	Taguas et al., 2009; ESPL 34 (5), 738-751
	Gómez et al. 2003; Soil Use Manag.19, 127–134.
	Gómez et al. 2009; Soil Till. Res. 102, 5-13.
OC-Verification	Marquez, 2017. PhD thesis. University of Cordoba
Ground	Nieto, 2011. PhD thesis. University of Granada.
Sediment attached	Gómez et al.2017. Vadose Zone Journal 16(12)
	Data in PG catchment

→ *Catchment scale*

2.3. Scenarios design and parameterisation

108 SCENARIOS

SOIL SCENARIOS

(Initial soil parameters)

6 soil types conventional olive groves

Selected 6 soil types of olive orchards in Andalusia:

PCA – to identify the maximum variability

MANAGEMENT SCENARIOS

MANAGEMENT 1

(CN –C-RUSLE - nManning)

3 management types
NO TILL
TILLAGE
COVER CROP

CN,n = F(soil, management)
C=f(management) –
(Parameterisation: Taguas et al. 2012; 2015)

MANAGEMENT 2

(Fertilisation)

3 types of fertilizer

Inorganic NPK
Organic 1 (50% -OM)
Organic 2 (25%- OM)

Others

Reach organic carbon half-life time

2 contrasting times

(<0.1 d; >730 d)

2. MATERIAL AND METHODS
2.4. Analyses on the AnnAGNPS simuation

- Mean annual **OC exported in the catchment and its relationships with runoff and sediment loads** as well as their differences **based on soils and management. (***ANOVA and/or parametrical methods Turkey HSD test when assumptions were not acceptable).*

- Total **increase OC in the ground (depth=200 mm) in over 10 years** as well as their differences **based on soils and management.** *(ANOVA and/or parametrical methods, Turkey HSD test when assumptions were not acceptable).*

- **A sensitivity analysis** *based on regression method* was carried out on the simulated scenarios in order to explore the influence the most significant input parameters to represent the variability of SOC exported and stored.

6 soil types
3 managements
3 fertilisations
2 degradation times

Ground-OC (200 mm)
Total increase

Mean Annual Runoff and Sediment load
Mean Annual OC exported

3. RESULTS AND DISCUSSION

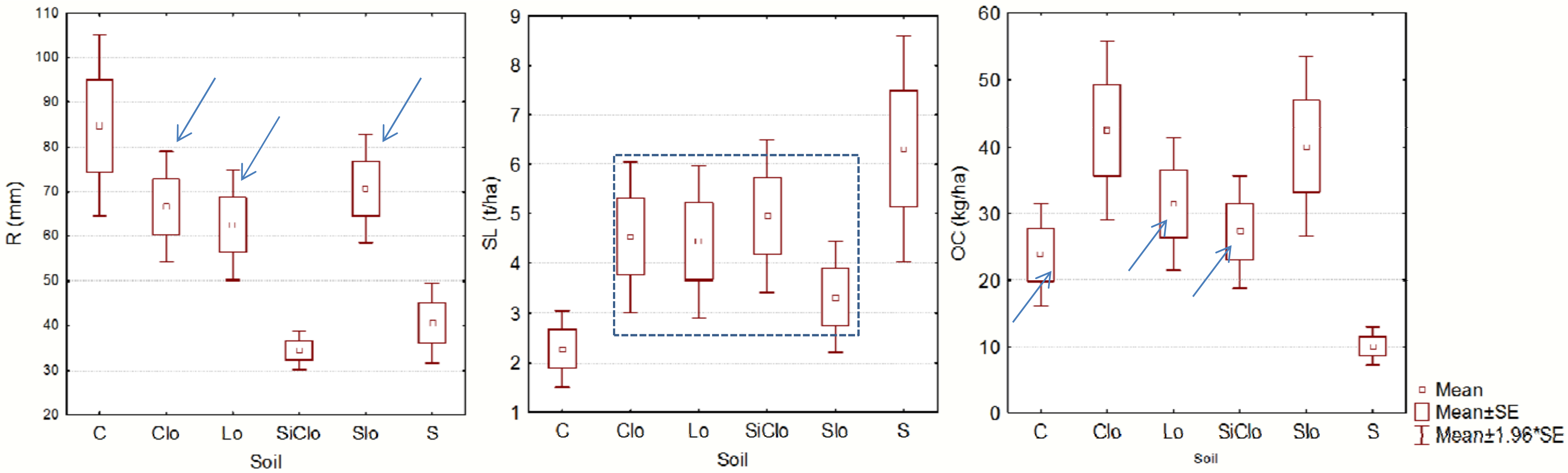
Mean Annual Runoff and Sediment load
Mean Annual OC exported

3.1. Analysis of the OC attached to sediments

3. RESULTS AND DISCUSSION

3.1. Analysis of the OC attached to sediments: *soil types*

Sta.	*Mean*	*Desvest*	*Cv (%)*	*Min*	*Max*
Annual Rainfall (mm)	384.8	152.7	39.7	233.1	773.6



R = Runoff ; SL=Sediment Load; OC= Organic carbon attached to the sediment

Soil types: Sand (S), Sandy Loam (SLo), Loam (Lo), Clay loam (CLo), Silty loam clay (SiLoC), clay (C)

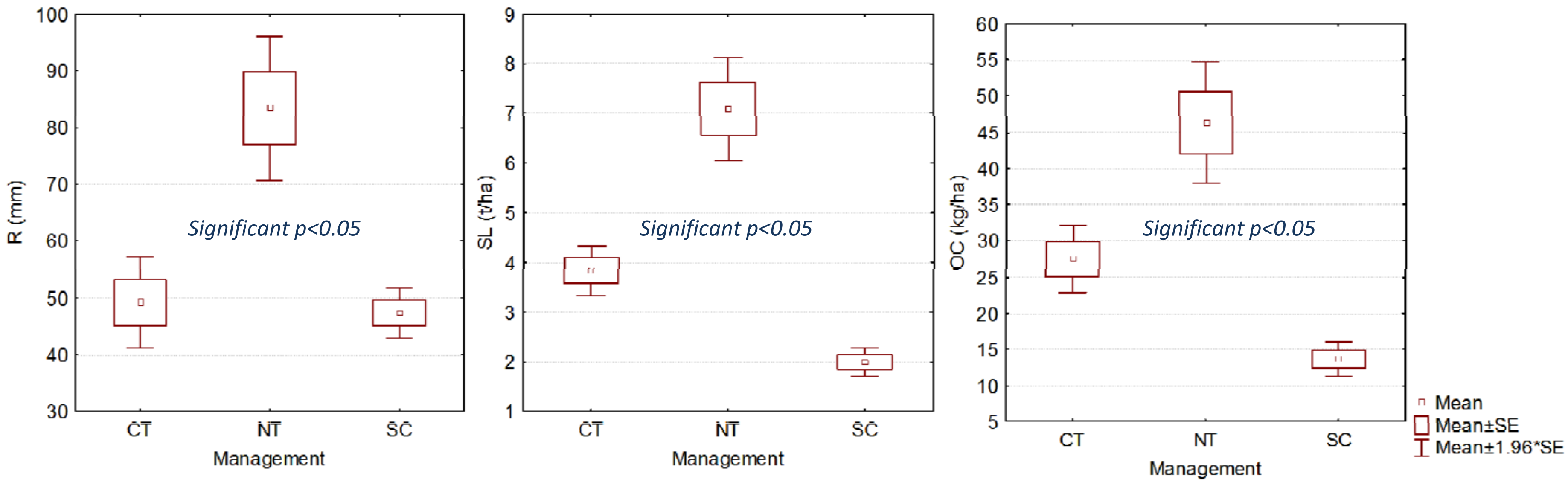
Indicated Turkey HSD gest

- The results of the simulation indicated that the mean annual runoff coefficient was of 16% (7-22), the sediment load for the different soil types varied between 2 and 6 t/ha whereas annual OC attached to the sediment was between 10 and 42 kg/ha.
- The statistical tests indicated significant differences among soil types. However, there were similar responses in clay loam, sandy loam and silty clay loam soils, also for sediment loads and organic carbon.

3. RESULTS AND DISCUSSION

3.1. Analysis of the OC attached to sediments: *managements*

Sta.	*Mean*	*Desvest*	*Cv (%)*	*Min*	*Max*
Annual Rainfall (mm)	384.8	152.7	39.7	233.1	773.6



Managements (no-tillage with spontaneous grass cover (SC), conventional tillage (CT), no-tillage with a bare soil (NT).
ANOVA one-way and Turkey HSD test

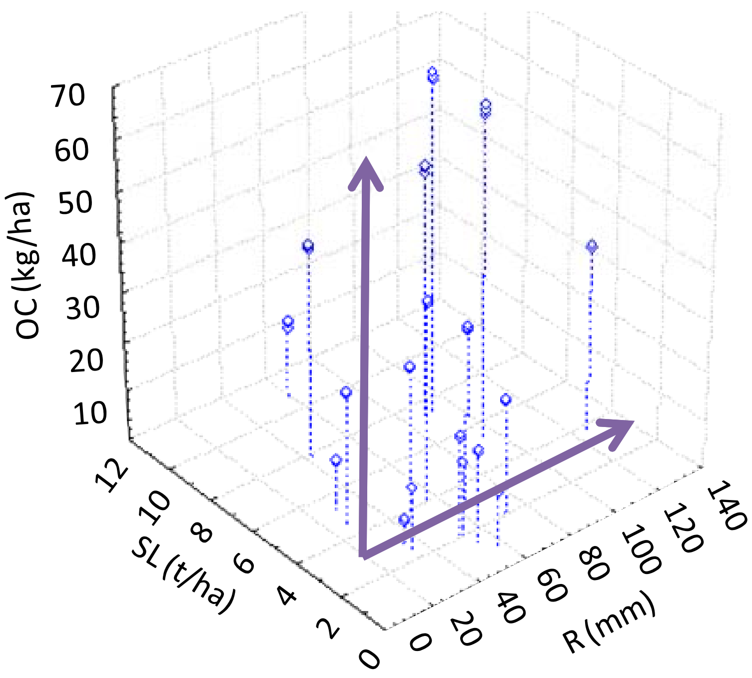
Significant differences for the management: the runoff coefficients varied between 14 and 24%. Cover crop and conventional tillage showed close runoff. For sediment loads and organic carbon, management with cover crops presented the lowest values and non-tillage presented the highest values.

Fertiliser types and degradation times were no significant!

3. RESULTS AND DISCUSSION

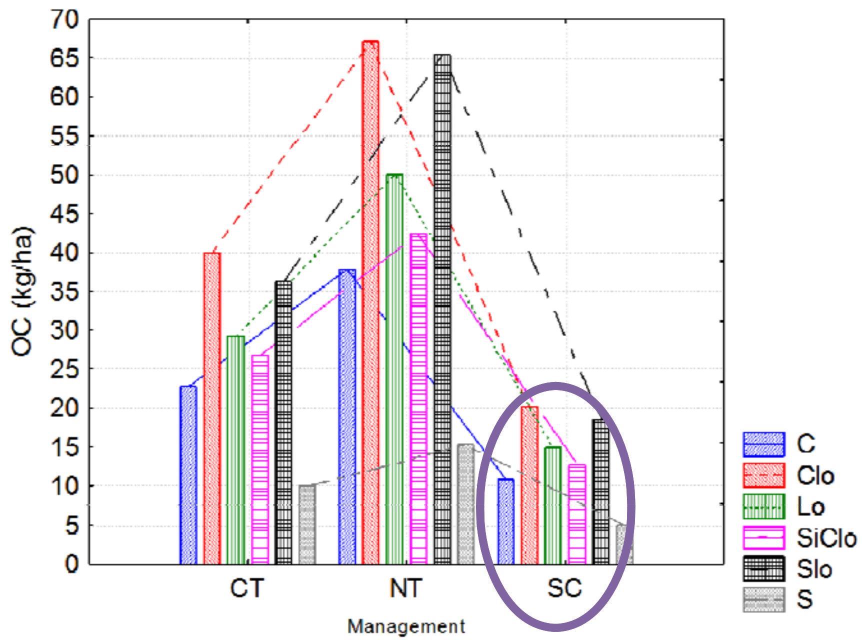
3.1. Analysis of the OC attached to sediments: *interactions*

Interactions Organic Carbon-Runoff- Sediment Load



r (OC-SL)= 0.44; r(OC-R)= 0.65 (p=0.000)

Interactions Management-Soil types



- Runoff explained better than sediment loads , the quantity of the exported organic carbon.
- Sandy soil showed the lowest variability on the exported OC.
- No-tillage presented the highest exported OC for all thesoil types. whereas cover crop the lowest range of variation.

3.2. Analysis of the increase of ground OC (depth 200 mm):

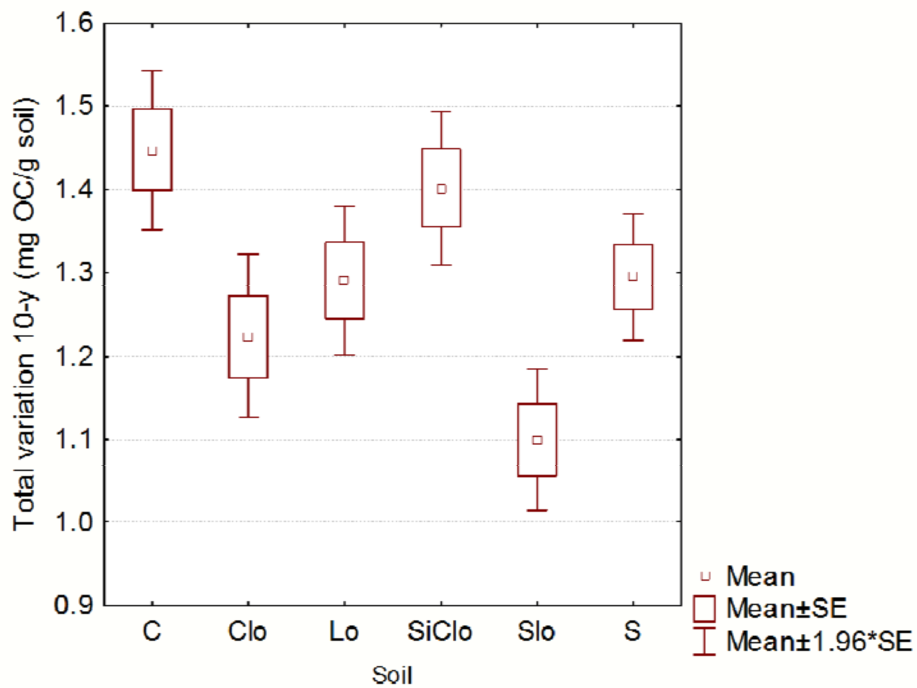
3. RESULTS AND DISCUSSION

3.2. Analysis of the increase of ground OC (depth 200 mm): *soil types*

Sta.	*Mean*	*Desvest*	*Cv (%)*	*Min*	*Max*
Annual Rainfall (mm)	384.8	152.7	39.7	233.1	773.6
Max daily temperatures (Cº)	25.3	8.6	33.9	6.0	44.9
Min daily temperatures (Cº)	11.6	6.2	53.6	-8.9	27.3
Annual ETP (mm)	365.0	36.6	10.0	298.2	410.1

ANOVA one-way – p=0.000;

significance differences among soils

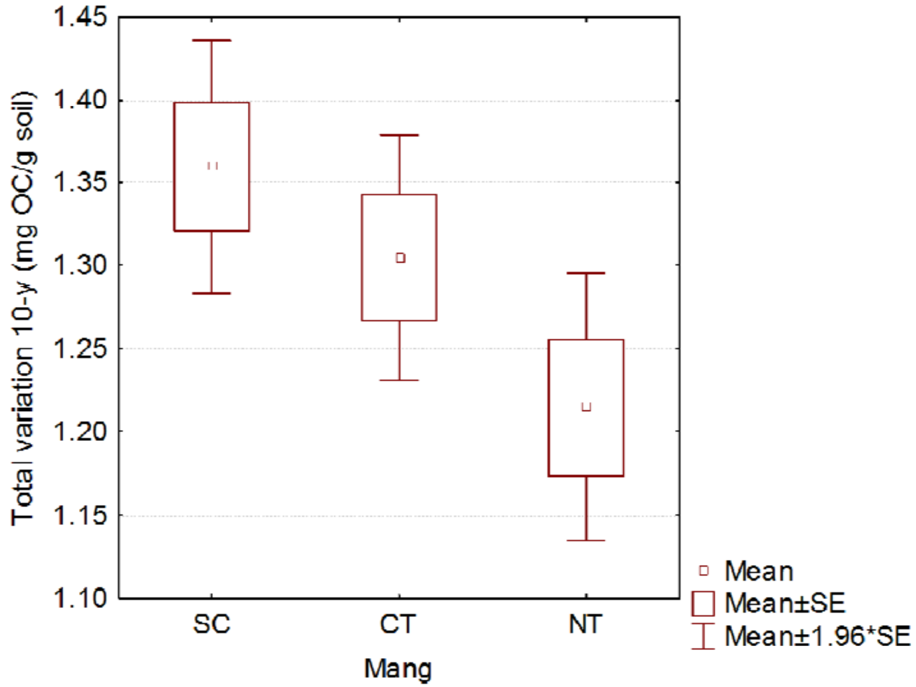


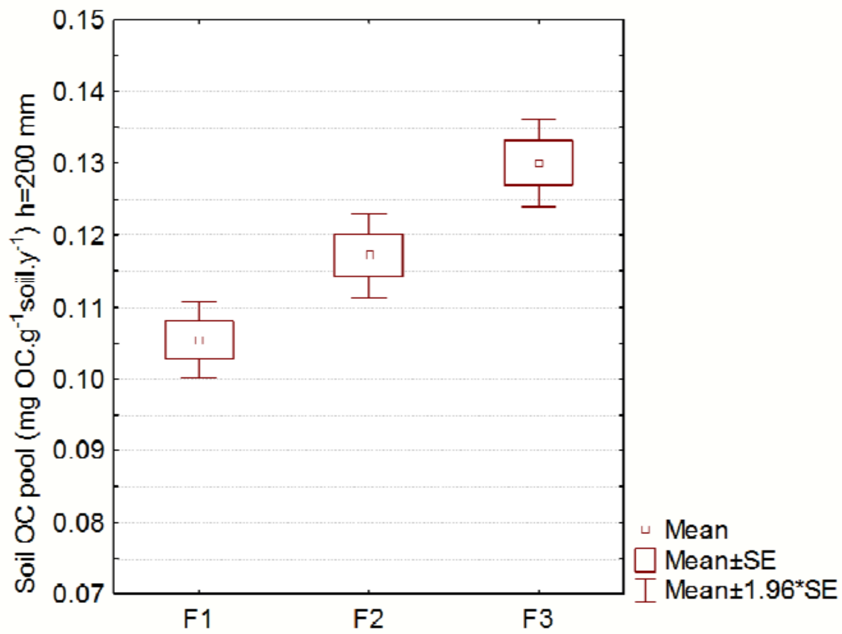
3. RESULTS AND DISCUSSION

3.2. Analysis of the increase of ground OC (depth 200 mm): *managements and fertilisers*

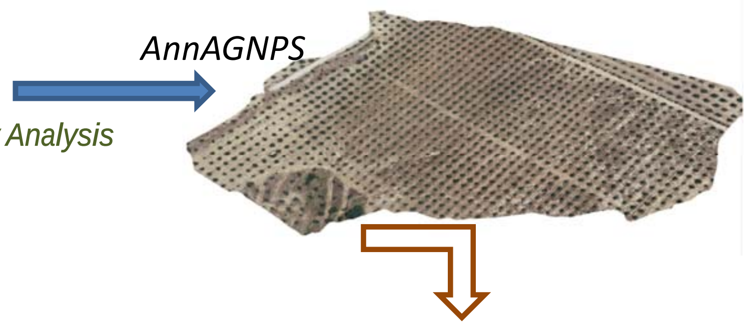
Sta.	*Mean*	*Desvest*	*Cv (%)*	*Min*	*Max*
Annual Rainfall (mm)	384.8	152.7	39.7	233.1	773.6
Max daily temperatures (Cº)	25.3	8.6	33.9	6.0	44.9
Min daily temperatures (Cº)	11.6	6.2	53.6	-8.9	27.3
Annual ETP (mm)	365.0	36.6	10.0	298.2	410.1

ANOVA one-way – p=0.000;
significance differences among managements and fertilisation types
> 4000 t/ha – Increase 0.13% in 10 y





F1=inorganic fertilizer; F2= organic fertilizer with a rate of 40 kg.ha-1; F3= organic fertilizer with a rate of 80 kg.ha-1)



3.3. Sensitivity Analysis

3. RESULTS AND DISCUSSION

3.3. Sensitivity Analysis

Summary of the stepwise linear regression with non-correlated inputs to quantify the most sensitive variables to the OC attached to the sediment (left) and soil OC pool (right) simulated with AnnAGNPS.

Variables	*Beta*	*Std.Err.*	*p-level*
Intercept			**0.000000**
P (mm)	**0.624681**	**0.022187**	**0.000000**
Root_Mass (kg.ha^{-1})	0.118095	0.104124	0.257189
Silt_Ratio	**3.157129**	**0.702895**	**0.000009**
CN4	0.058767	0.047355	0.215111
Clay_Ratio	**3.452499**	**0.897565**	**0.000133**
CN2	**0.927472**	**0.362589**	**0.010782**
Sand_Ratio	**5.891177**	**1.390520**	**0.000026**
Saturated_Conductivity	**0.330067**	**0.120441**	**0.006323**
CN1	0.463151	0.316725	0.144195
CN3	-0.436116	0.375499	0.245943
Coefficient surface decomposition	-0.075486	0.089760	0.400707
F =131.77, p<0.0000			
R^2=0.714; *adjusted* R^2=0.708			

Variables	*Beta*	*Std.Err.*	*p-level*
Intercept			**0.000000**
Inorganic_N	**-0.504196**	**0.025414**	**0.000000**
P (mm)	**-0.418330**	**0.025414**	**0.000000**
CN2	**-0.513556**	**0.043691**	**0.000000**
Clay_Ratio	0.108088	0.060663	0.075304
CN4	**-0.159447**	**0.032696**	**0.000001**
Organic_N_Ratio	**-0.185577**	**0.039465**	**0.000003**
CN5	**0.346749**	**0.075699**	**0.000006**
Surface_Decomp	**0.091011**	**0.035294**	**0.010161**
F = 120.42 p<0.0000			
R^2=0.622; *adjusted* R^2=0.617			

"Beta" are the regression coefficients; F and p-level (statistical significance) were calculated to evaluate the adjustment; RMSE is the root mean square error of the observed and predicted values; R^2 is the coefficients of determination; adjusted R^2 is the adjusted coefficient of determination.

- For sediment-OC, after 8 iterations, only 6 variables resulted found to be statistically significant in the group of the best 11 in explaining the variability of the annual sediment OC (see Table 6). They were annual precipitation, silt ratio, clay ratio, sand ratio, saturated hydraulic conductivity, CN2 (March-April) (p>0.05)
- For soil OC pool, after 6 iterations, the significant variables were: the content of inorganic N of the fertilizer, the content of organic N the fertilizers, annual precipitation, coefficient of surface residue decomposition and CN2, CN4 and CN5

4. CONCLUSIONS

4. CONCLUSIONS

- There were significant differences of annual values of the sediment OC for the scenarios of soil and management. *Sandy* soil and *Cover crop* showed the lowest variability intervals of sediment OC while *Clay loam* soil and *No-tillage* had the highest values and variation ranges.
- For the SOC pools, the effects of soil and fertilization types were more evident than the impact of the management. The combination Clay-Cover-F3 (organic fertiliser 80kg.ha^{-1}) presented the maximum increase of SOC while the combination Sandy loam-NoTill-F1 (inorganic fertilizer) presented the minimum.
- The knowledge of Curve Numbers, soil properties and the aspects related to residue decomposition rates and organic matter richness associated to the fertilization, are crucial to application of the model for evaluation of management impacts on SOC and for calibration and validation approaches. In addition to olive groves, the extensive experimental work to parameterize the Curve Number approach and RUSLE soil and management factors enable the use of AnnAGNPS to evaluate SOC balance in agricultural catchments where the intra-annual variability of soil conditions are very high.

EGU General Assembly 2020

Online | 4–8 May 2020

Modelling scenarios of olive groves at the micro-catchment scale with the AnnAGNPS model to quantify organic carbon

Encarnación V. Taguas, Ronald L. Bingner, Henrique Momm, Robert Wells and Martin Locke

UNIVERSIDAD D CÓRDOBA

USDA United States Department of Agriculture
Agricultural Research Service

MIDDLE TENNESSEE STATE UNIVERSITY