Soil loss prediction using SWAT in a small ungaged catchment with Mediterranean climate and vines as the main land use

Ramos MC & Martínez-Casasnovas JA

SWAT application to simulate the impact of soil conservation measurements on soil and nutrient losses in a small basin with mechanised vineyards

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SWAT 2013
Toulouse France

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Mediterranean areas

Climate, topography, soil characteristics, land use change , intensive agricultural practices

major cause of **soil erosion**

Objective

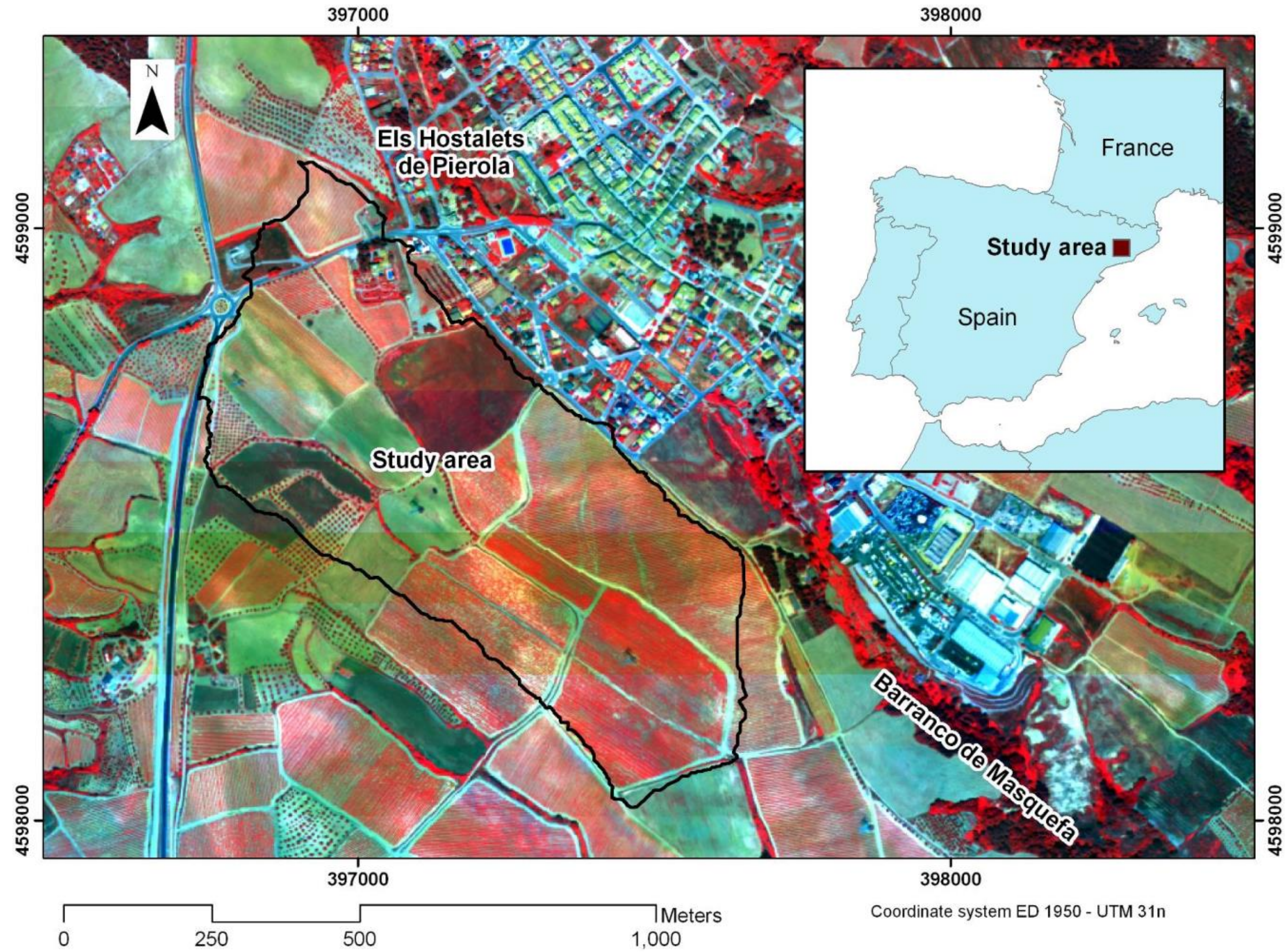
To analyse the suitability of SWAT to predict soil and water losses by erosion for a small ungaged agricultural basin in the Mediterranean area, with vines as the main land use.

To analyse the effects of the implementation of drainage terraces and filter-strips in the reduction of soil and nutrient losses

Material and methods

Study area:

Basin: 46 ha



ArcSWAT 2009.93.5 daily time scale

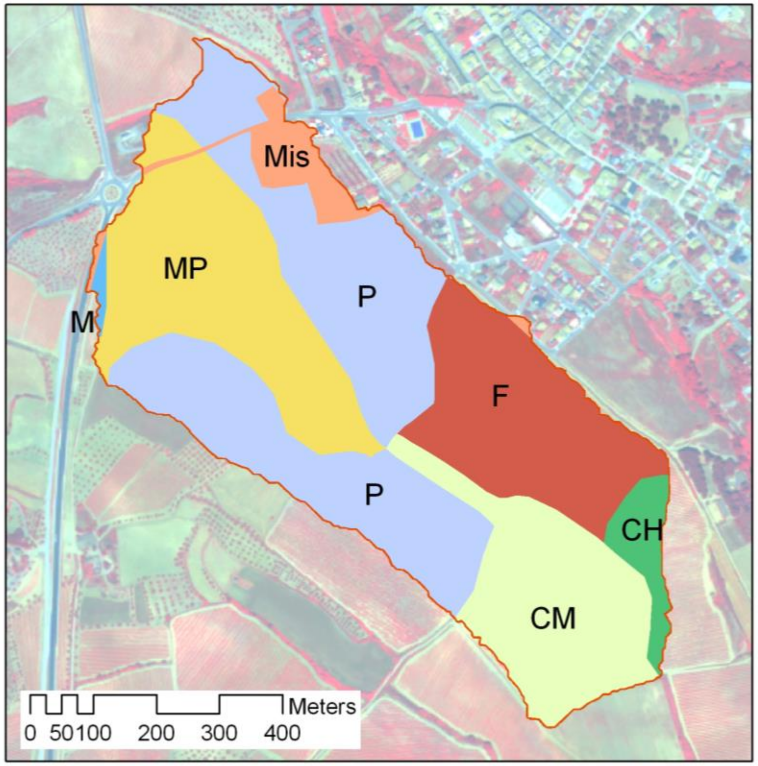
Input data

Soil data

Soil map (1:25,000) -Instituto Geológico de Cataluña

Soil survey: 40 additional points

- texture,
- bulk density,
- organic carbon content,
- steady infiltration rate,
- available water capacity
- K-erodibility factor

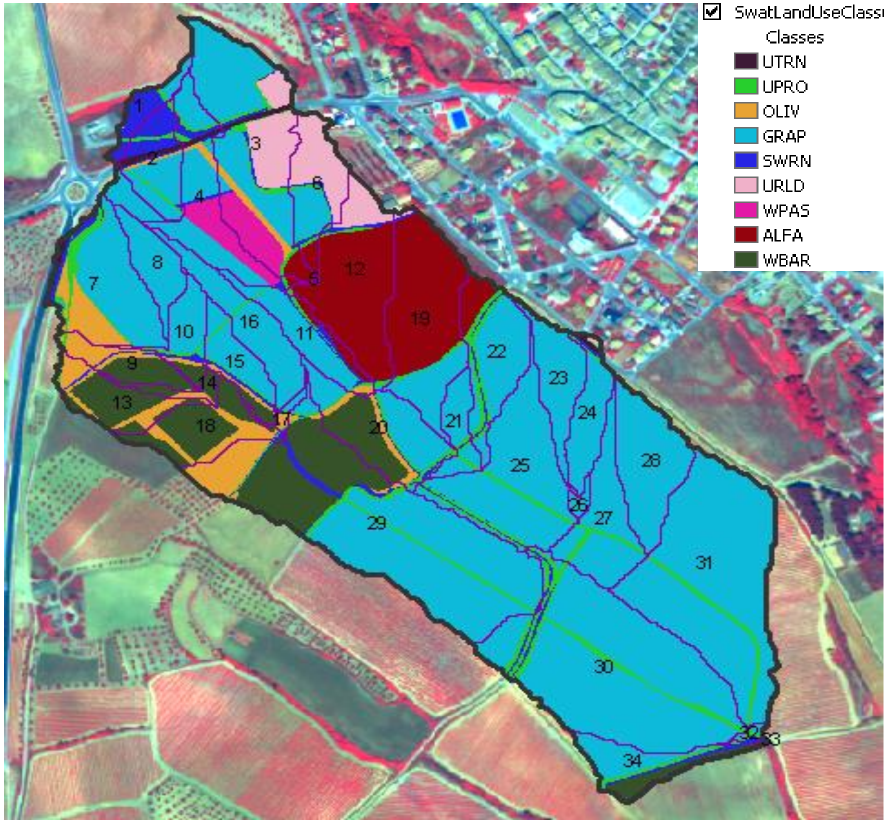


Soil Series and WRB (2006) Classification

- CH: CABANYES (Calcaric haplic regosols) and HOSTALETS (Fluvic cambisols)
- CM: CABANYES (Calcaric haplic regosols) and MARQUET (Skeletic haplic calcisols)
- F: FALGUERAR (Cutanic luvisols)
- M: MARQUET (Skeletic haplic calcisols)
- MP: MARQUET (Skeletic haplic calcisols) and PIEROLA (Skeletic fluvic cambisols)
- P: PIEROLA (Skeletic fluvic cambisols)
- Mis: MISCELLANEUS

Land Use

Visual interpretation of very detail aereal photogrpahs



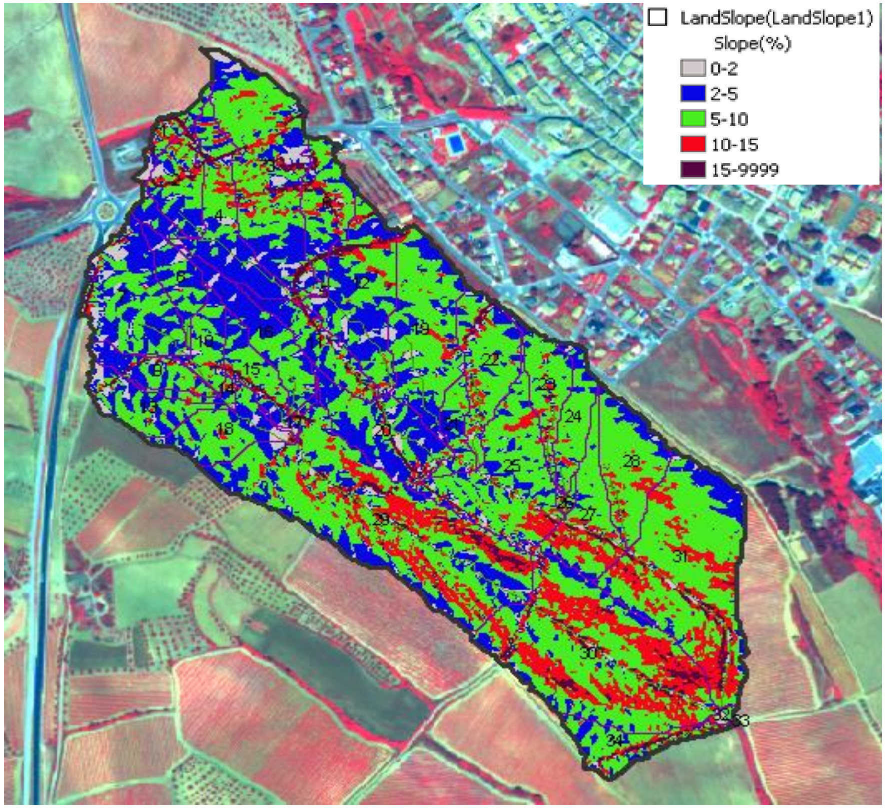
Land Use	%
vineyards	62.81
olive trees	4.70
alfalfa	8.47
winter barley	9.45
winter pasture	1.49
ranges	3.50

Management practices

Farmer information

Topography

A 1m-resolution digital elevation model: altitude photogrammetric aerial survey (2010)→slope



Sub-basins	34
HRU	1182

Climatic data

Els Hostalest de Pierola (1.809 E; 41.5328 N, 316 m.a.s.l.)
(Instituto Meteorológico de Cataluña)

16-year series (1996-2012) daily data:
temperatures (maximum and minimum),
precipitation,
solar radiation,
relative humidity
wind velocity

Mediterranean – Maritime influence

T m = 15 °C (9-25ºC)

Tmax = 20 ºC (10.3-29.7ºC)

Tmin = 9º C (2.5-19.5 ºC)

Pm = 520 mm

Sensitivity analysis

Parameter Description	value
1- CN2 _SCS runoff curve number for moisture condition II	72-79 agric. 92-96 urban
2- ESCO: Soil evaporation compensation factor	0.9
3- EPCO Plant evaporation compensation factor	0.9
4- GW_REVAP Groundwater 'revap' coefficient	0.15
5- GW_DELAY Groundwater delay (days)	14
6- REVAPMIN Threshold depth of water in the shallow aquifer required for "revap" to occur (mm)	10
7- Sol_K Soil conductivity (mm h^{-1})	10
8- Ch_K2 Effective hydraulic conductivity in main channel alluvium (mm h^{-1})	0.045
9- CH_N Manning coefficient for channel	0.020
10-GWQMN Threshold depth of water in shallow aquifer required for return flow to occur (mm)	1000
11- Alpha_Bf Baseflow Alpha factor (days)	0.05

SWAT application

Model calibration and validation

Soil moisture:

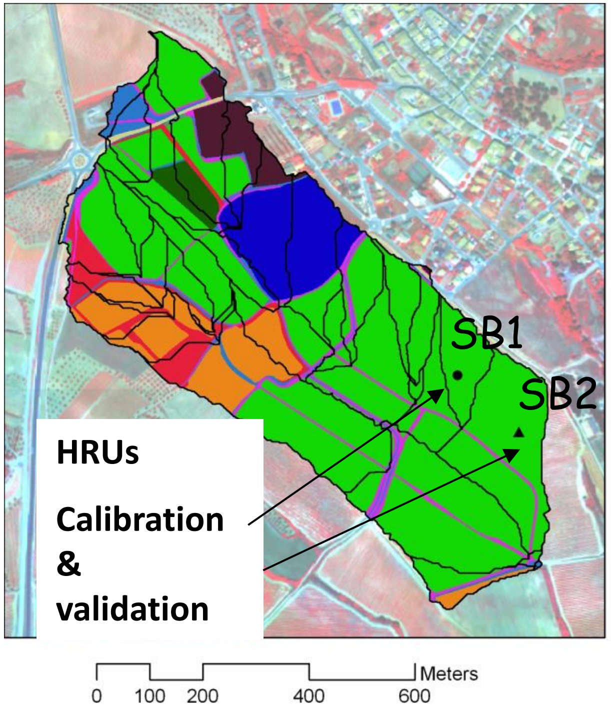
TFR probes (Decagon) at four depths:

10-30, 30-50, 50-70 and 70-90 cm

Sediment and nutrient concentration in runoff in 2 HRUs (total N and P)

2010-2011- calibration

2011-2012 validation



Model run

Years with different climatic characteristics
1998-1999
2000-2011

Soil conservation measures

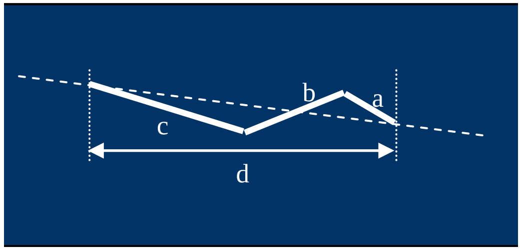
Drainage terraces " "rases"

1 terrace 24m (8 wine rows)

(Ramos and Porta, 1997)

Operations: terraces

P factor: 0.5
CN- 5% red



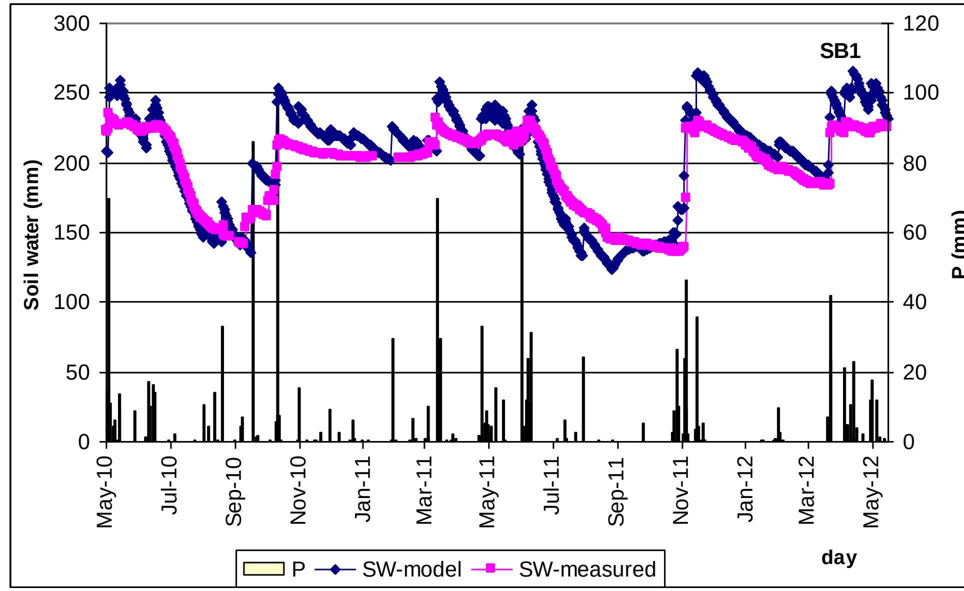
Filter strips

Separated 3 m
(between alternated vine rows)
Operations: filter strips
3 m width

Soil water

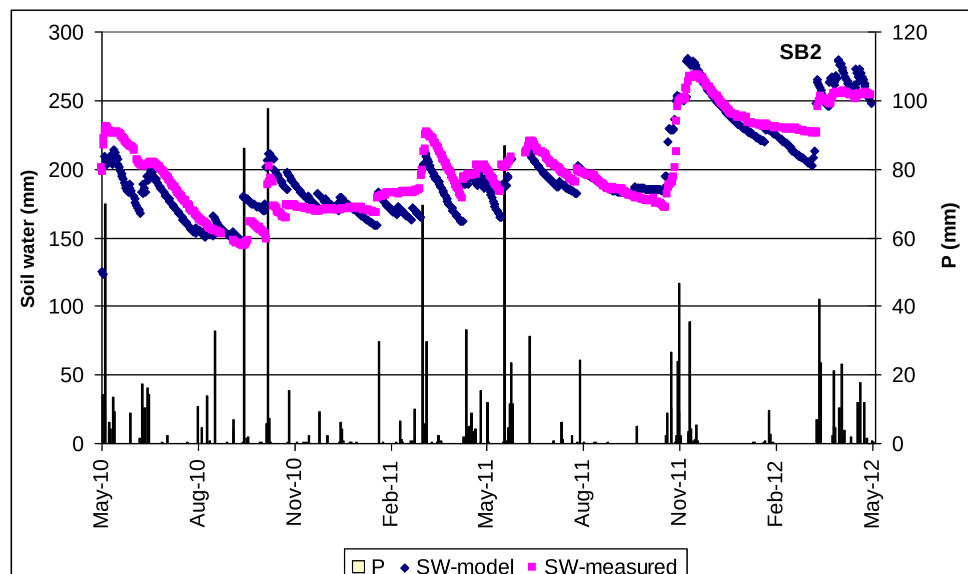
		RSR	PBIAS %	NSE
SB1 SB2	cal	0.49 0.67	-1.75 2.68	0.69 0.69
SB1 SB2	val	0.44 0.74	0.33 2.25	0.86 0.85

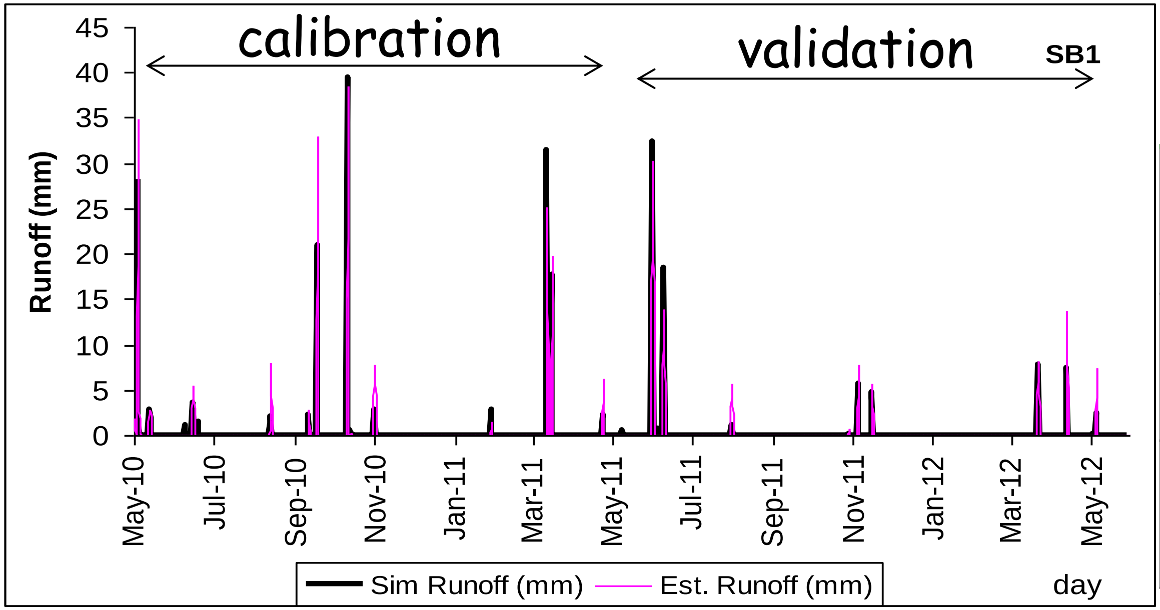
Comparisons between simulated and measured soil water during calibration and validation periods



Calibration period

Validation period

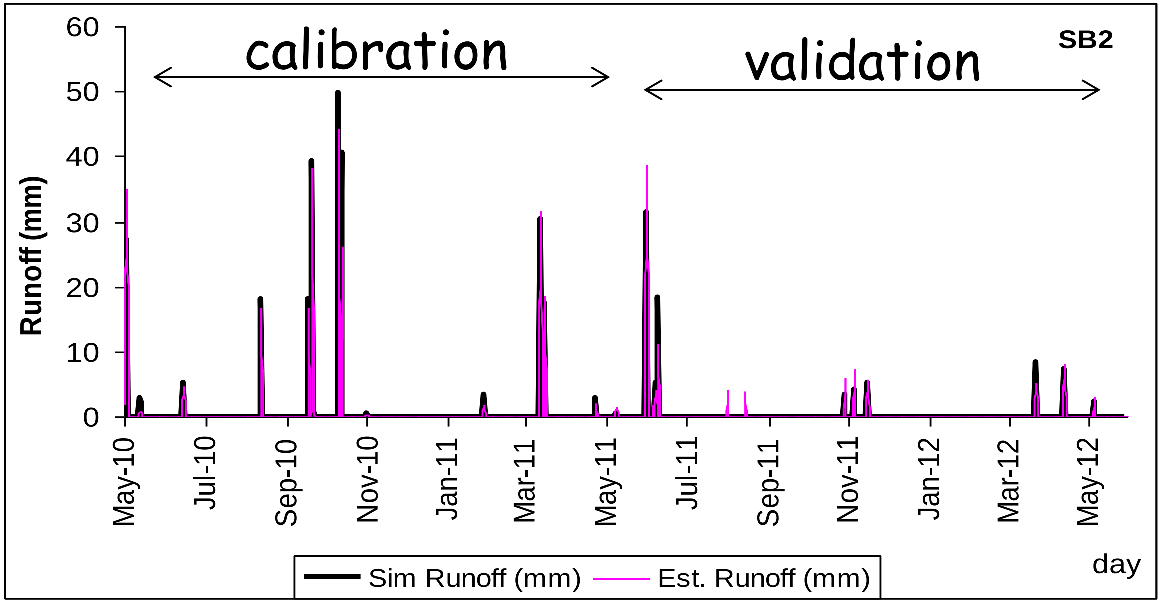




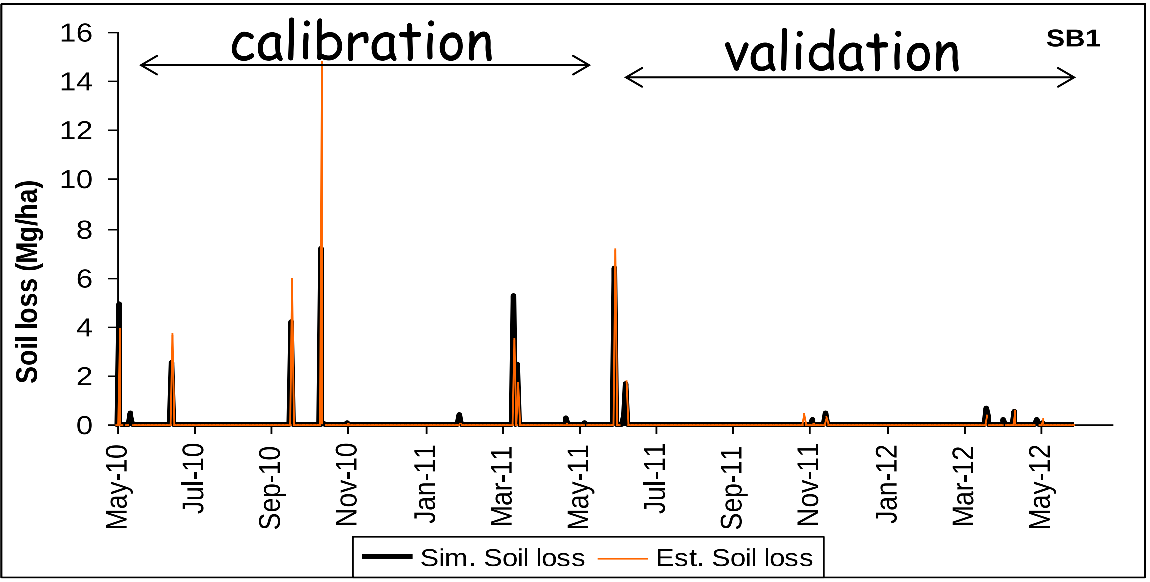
Runoff

	RSR	PBIAS %	NSE
SB1 cal	0.38	-16.3	0.89
SB2	0.42	-16.2	0.64
SB1 val	0.53	-13.82	0.82
SB2	0.38	-8.96	0.88

Comparisons between simulated and measured runoff during calibration and validation periods



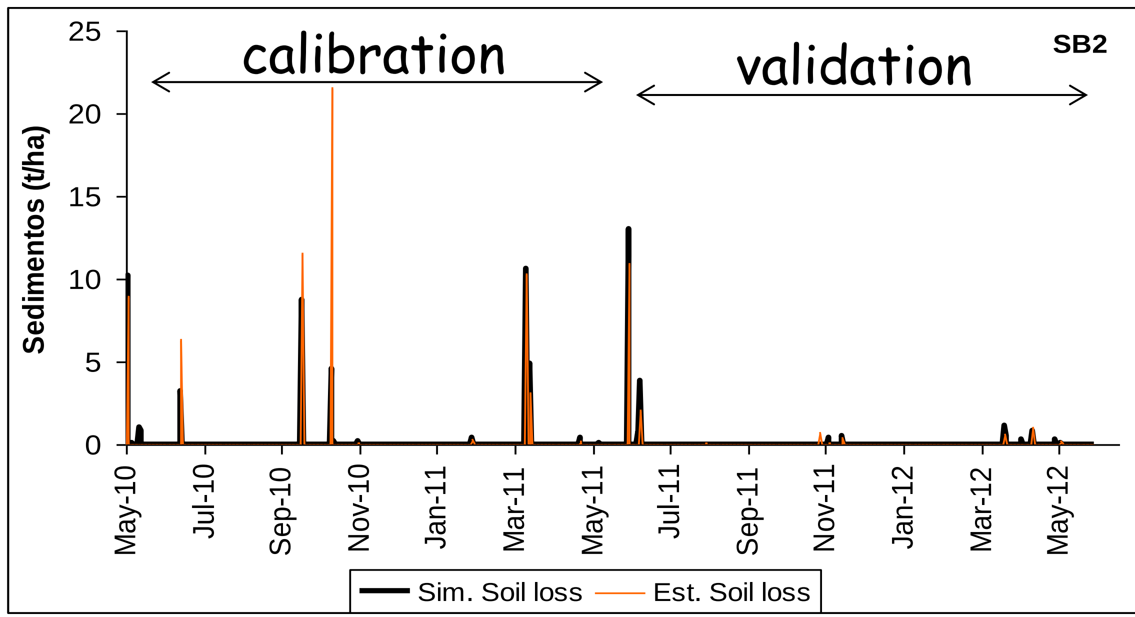
Soil loss prediction using SWAT in a small ungaged catchment with Mediterranean climate and vines as the main land use. Effects of soil conservation measures



Soil losses

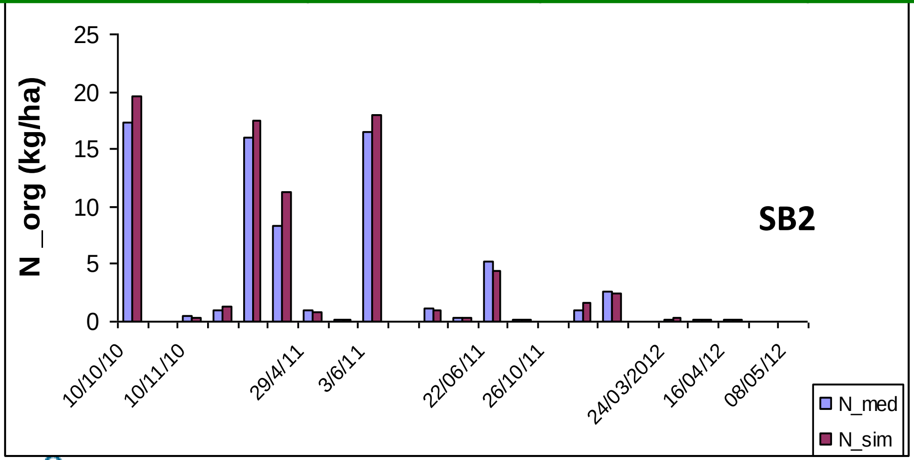
	RSR	PBIAS %	NSE
SB1 cal	0.52	-15.79	0.66
SB2	0.14	-28.70	0.33
SB1 val	0.71	8.63	0.71
SB2	0.28	23.12	0.91

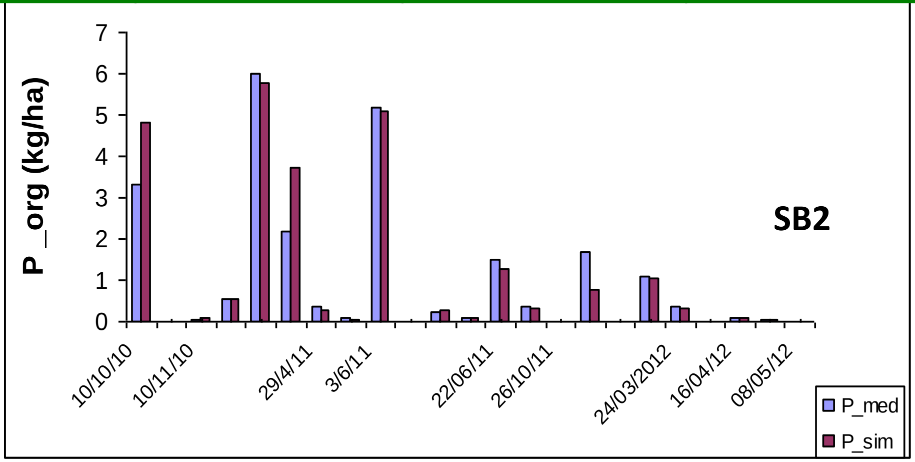
Comparisons between simulated and measured soil losses during calibration and validation periods



N and P losses

	RSR	PBIAS %	NSE	RSR	PBIAS %	NSE
	N			P		
SB1 cal SB2	0.34 0.36	15.30 7.800	0.95 0.95	0.72 0.80	23.43 18.25	0.83 0.85
SB1 val SB2	0.87 0.75	3.23 13.86	0.99 0.80	0.91 0.34	25.49 7.55	0.90 0.87





Comparisons between simulated and measured N and P losses in some events during calibration and validation periods

Results of simulations for the period 2000-2012

Year	P (mm)	SurQ (mm)	LatQ (mm)	GwQ (mm)	Percol (mm)	ET (mm)	Water yield (mm)	Sed yield (Mg ha^{-1})
2000	491.2	28.4	4.0	30.2	85.2	372.0	64.0	1.28
2001	447.8	28.3	5.1	93.9	99.5	353.7	124.7	1.37
2002	612.6	82.6	6.3	126.7	160.5	412.6	202.9	6.56
2003	496.0	67.7	5.4	114.7	126.9	354.7	174.2	5.99
2004	785.5	84.2	6.2	129.2	116.7	603.8	175.2	5.55
2005	365.0	15.1	3.3	44.0	67.7	323.5	61.5	0.19
2006	329.8	60.1	3.2	68.9	62.2	303.6	129.1	4.41
2007	548.0	37.7	5.5	74.7	107.6	386.8	127.5	1.63
2008	751.5	112.2	7.1	152.7	207.7	424.2	274.1	7.54
2009	541.9	93.5	5.4	108.7	83.0	432.9	196.6	7.33
2010	729.4	105.9	7.4	159.0	191.2	447.1	271.6	13.9
2011	655.7	119.3	7.4	184.4	207.1	384.9	288.6	9.8
aver	*562.9*	*69.6*	*5.5*	*107.3*	*126.3*	*400.0*	*174.2*	***5.46***

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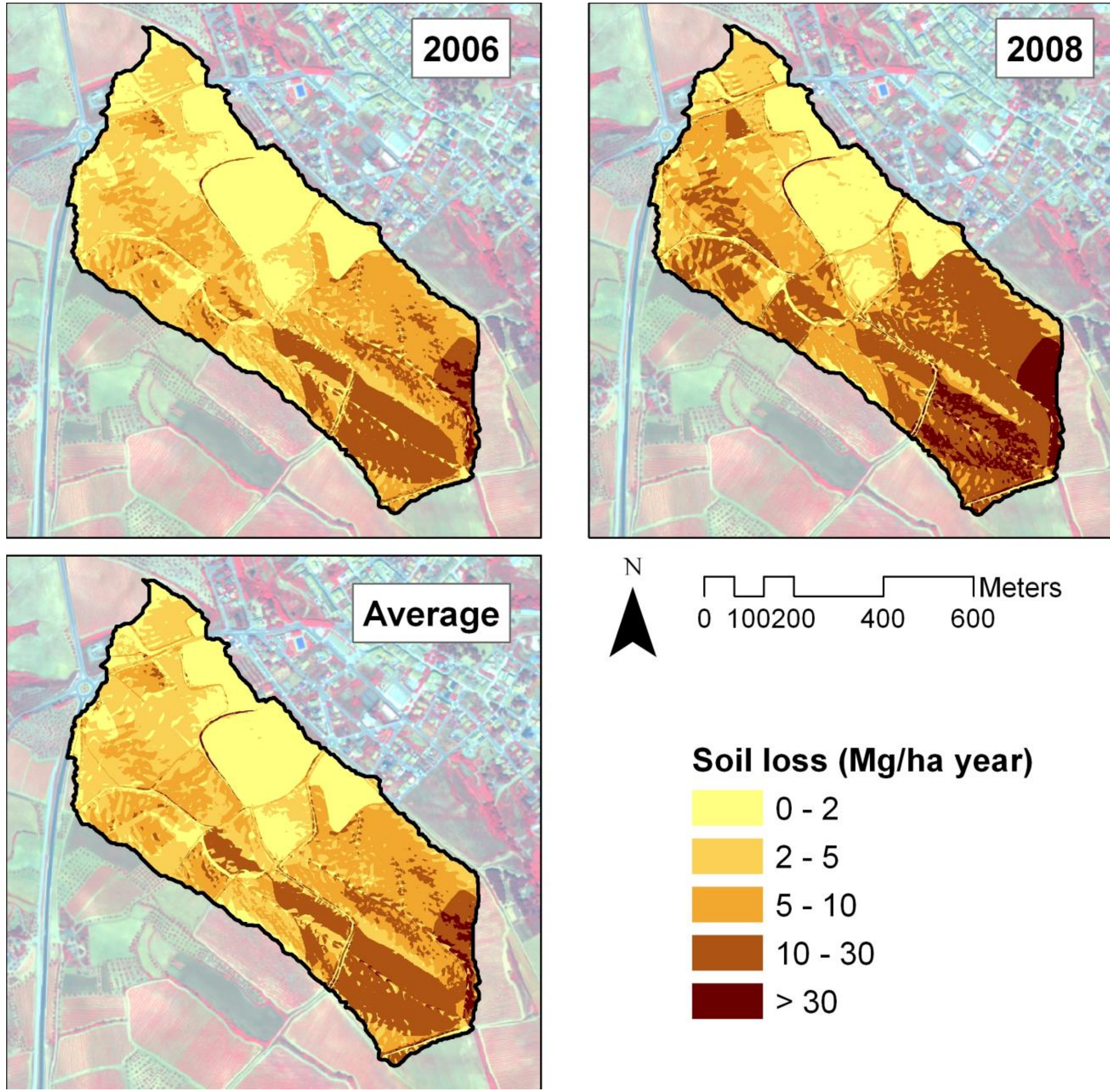
Soil losses for:
2008 (very wet year)
and
2006 (dry year)

Average annual soil losses (2002-2011)



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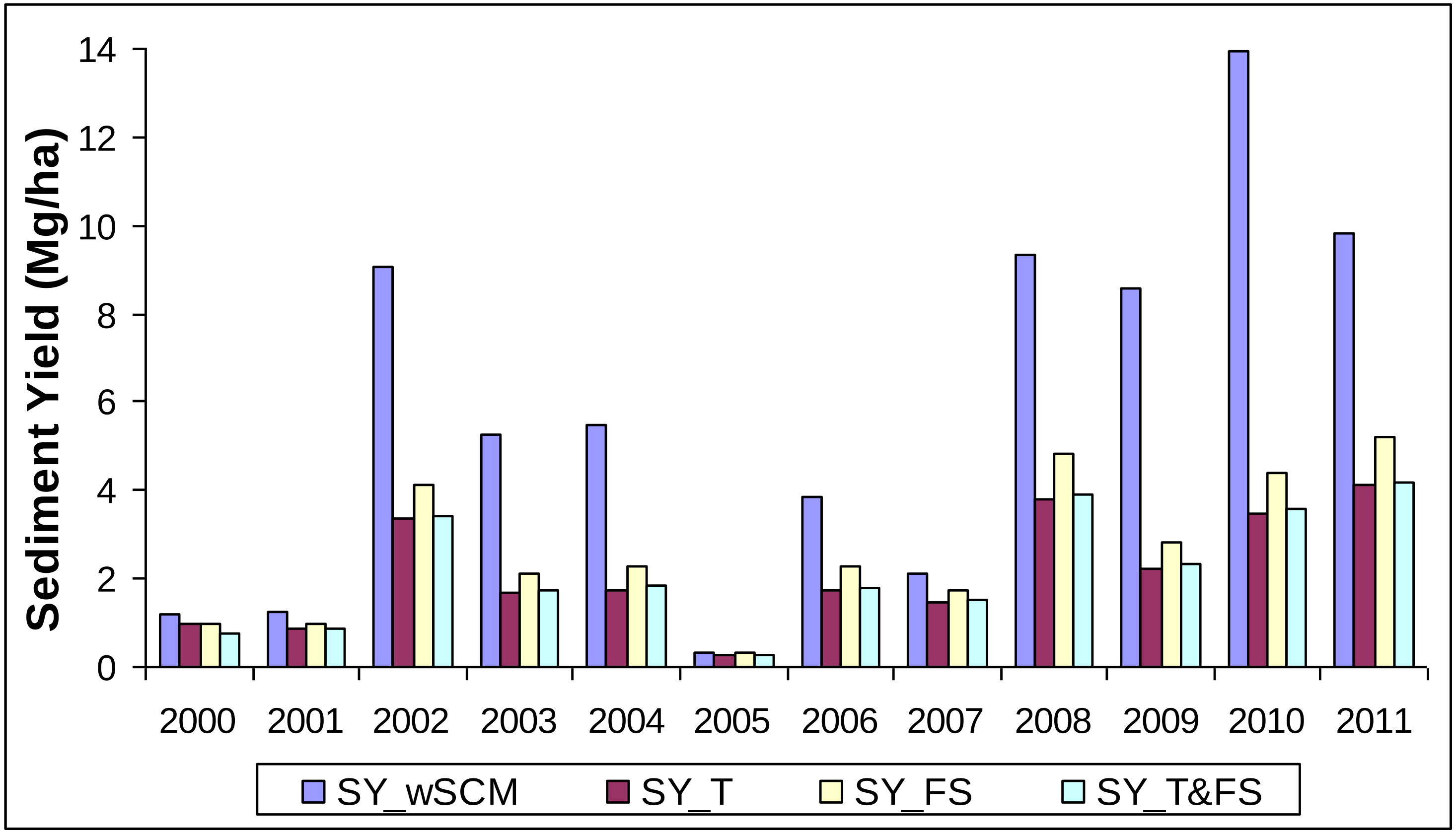
Annual soil and nutrient losses in the basin for the analysed period

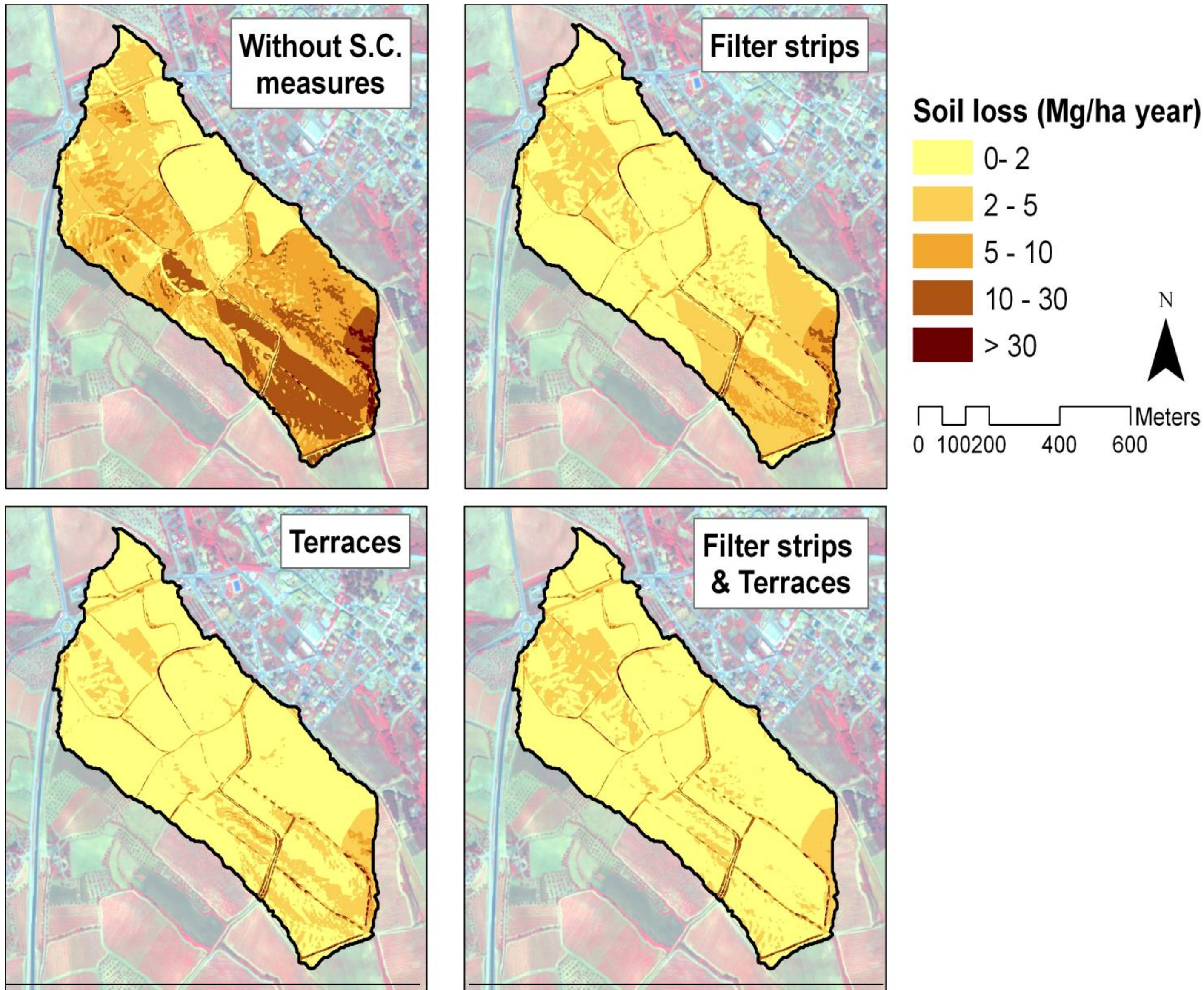
Year	Sediment Yield Mg ha^{-1}	SurfN_NO$_3$ kg ha^{-1}	Org N kg ha^{-1}	P sol kg ha^{-1}	P Org kg ha^{-1}
2000	1.28	0.07	0.19	0.02	0.09
2001	1.37	0.34	4.72	0.21	1.35
2002	6.56	1.18	27.34	0.59	8.38
2003	5.99	0.61	13.02	0.37	3.82
2004	5.55	1.30	18.93	0.59	6.58
2005	0.19	0.23	1.46	0.14	0.56
2006	4.41	1.05	21.64	0.63	7.31
2007	1.63	0.62	10.08	0.29	3.04
2008	7.54	2.66	38.11	1.18	13.18
2009	7.33	2.72	17.79	0.64	5.88
2010	13.9	0.80	27.42	0.67	8.28
2011	9.80	1.03	20.81	0.76	7.86

Effects of terraces and filter strips application on sediment yield



SYred: T:3-20.9% FS:10-42% T+FS:10-52%

Effects of terraces and filter strips application on sediment yield



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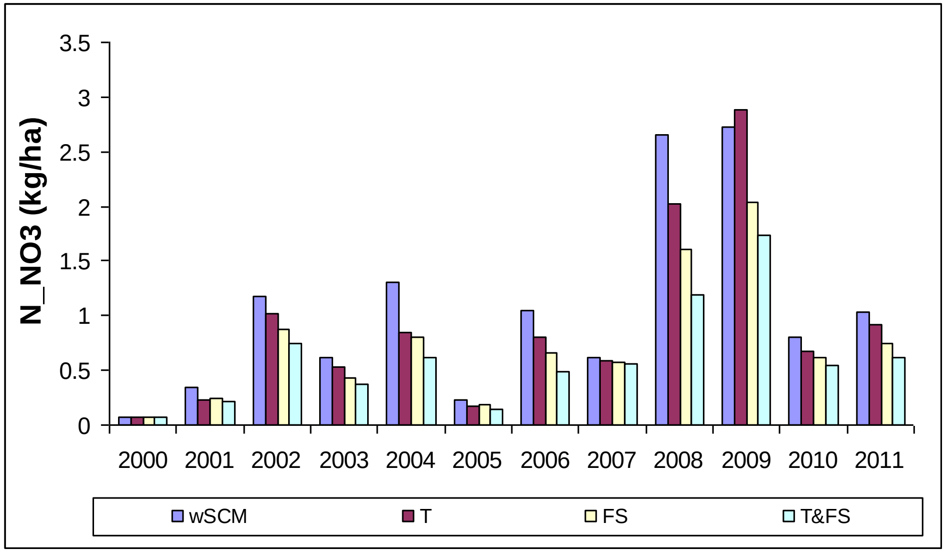
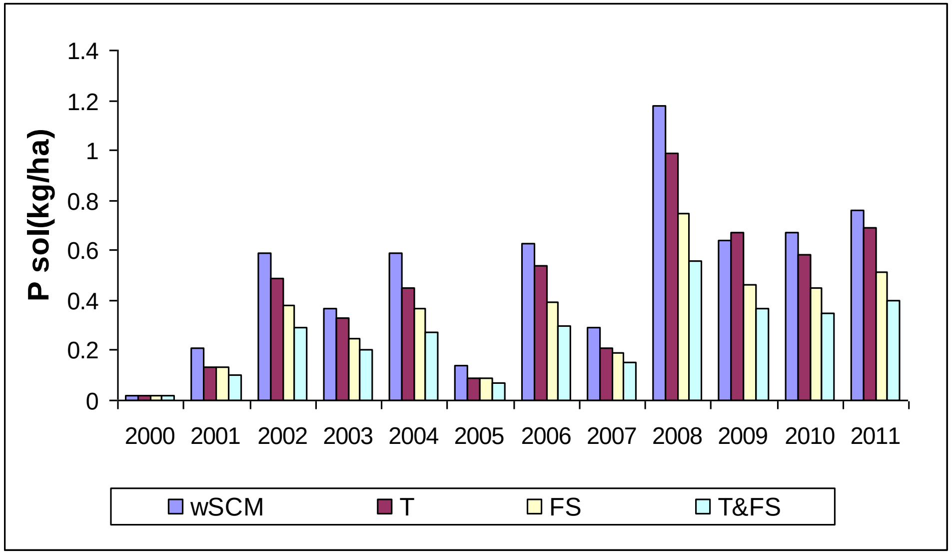
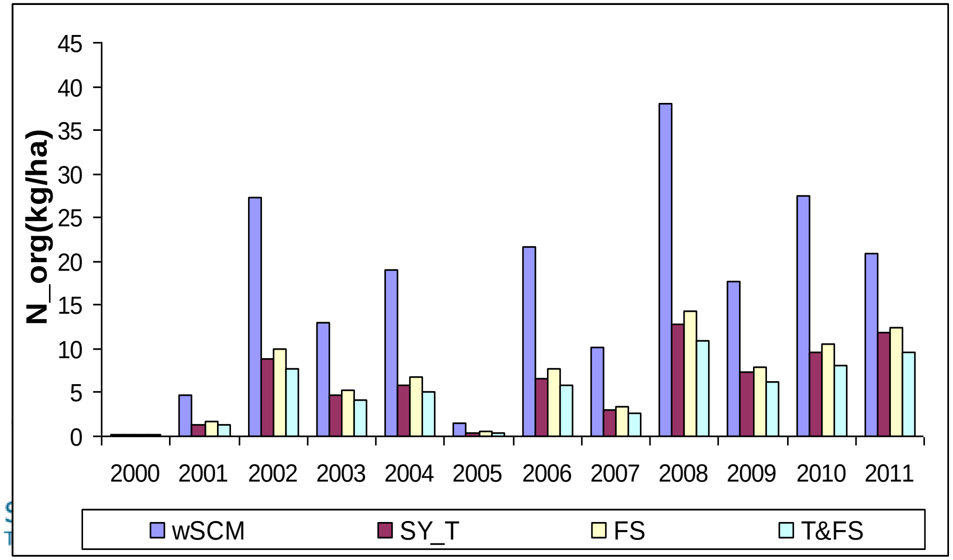
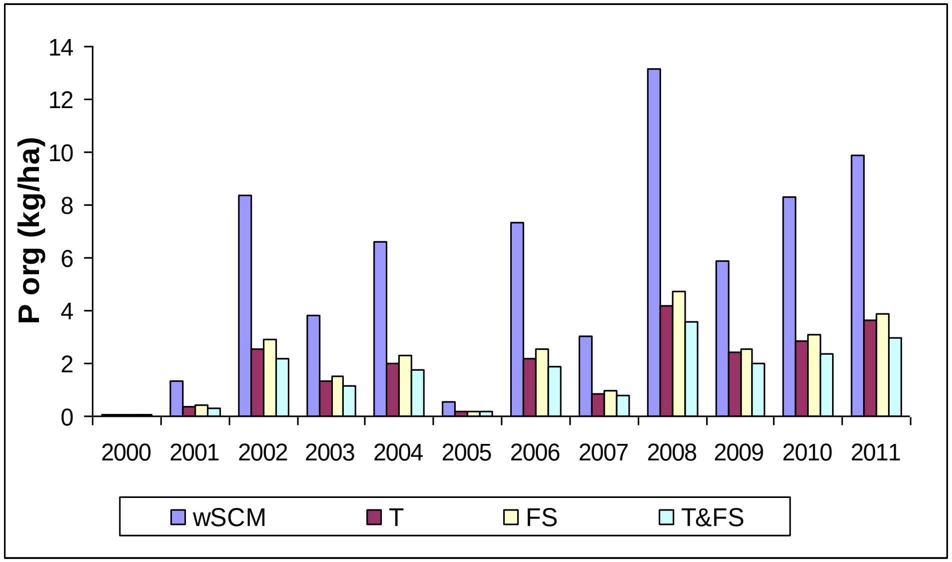
Effects of terraces and filter strips on N and P losses









Conclusions

The use of soil moisture data and runoff and samples collected at different points within the basin allowed to adjust and calibrate the model to the study conditions.

The detail information of soil allowed a better understanding of the processes occurring in the basin.

Conclusions

At the analysis scale, SWAT showed an agreement between measured and simulated **soil water content**.

Runoff rates and soil losses predicted by the model were in agreement with the soil loss estimated by combining runoff rates and sediment concentration in runoff on average conditions (PBIAS 16 - 23%)

Nutrient losses: N was relatively well fitted, while for total P the statistics showed a poorer fit. Nevertheless, the simulated results were in agreement with data observed in the area measured at plot scale.

Conclusions

High variability was observed in the annual runoff and soil depending on climate characteristics. However, the average soil losses of about 5.5 Mg/ha (ranging between <1 and about 13.9 Mg/ha) overpasses the soil loss tolerance, which point out the need of establishing soil conservation measures in the basin.

High variability is observed within the basin, with the highest values near the outlet.

Conclusions

The implementation of drainage terraces, with a separation of 24 m, equivalent to eight vine rows would allows a soil loss reduction estimated in about 17%, on average.

The implementation of filter strips 3m width could also produce a soil loss reduction estimated in about 33%.

If both measures were combined the reduction was estimated in about 40% on average.

These SCM could produce an average reduction of nutrient losses, particularly org- N and P, up to 60% for N and up to 70% for P.

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