2017 International SWAT Conference
Warsaw, Poland, June 28-30

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO — DIPARTIMENTO SCIENZE AGRO AMBIENTALI E TERRITORIALI

Comparison between SWAT and AnnAGNPS model simulations in a Mediterranean watershed

Abdelwahab O.M.M[1,2] ., Ricci G.F[1]., De Girolamo A.M[3] ., Gentile F[1].

Presenter: Giovanni Francesco Ricci, giovanni.ricci@uniba.it

1 University of Bari Aldo Moro, Department of Agricultural and Environmental Sciences, Bari, Italy.
2 Cairo University Faculty of Agriculture, Agricultural Engineering, Cairo, Egypt.
3 National Research Council, Water Research Institute (IRSA-CNR), Bari, Italy.

Corresponding Author: Abdelwahab, Ossama.M.M; osama.mahmoud@agr.cu.edu.eg

Introduction

Land degradation in its various forms is a common problem in Europe (Panagos et al., 2014) and in many parts of the world (Jones et al., 2012; Garcìa-Ruiz et al., 2016). Although the soil has a fundamental role in the ecosystem and economy (Tibebe & Bewket, 2011), it is perceived to be abundant, and as its degradation is generally a slow process, it passes unnoticed. At the basin scale, sediment yield is the result of several factors controlling runoff generation and erosion processes, and it is strongly related to factors controlling the sediment dynamics in a catchment, including sediment generation, transport and deposition (Parsons, 2012). In the last decades a large number of erosion models were developed among which the Soil Water and Assessment Tool (SWAT) (Arnold et al., 1998) and the Annualized Agricultural Non-Point Source (AnnAGNPS) (Bingner & Theurer, 2005) are two of the most used model as decision support tools identifying specific conservation measures and best management practices (BMPs). In this study the simulations of water yield and sediment load in a Mediterranean watershed were performed and the characteristics of the two models in terms of implementation of the project and calibration and validation phases were analyzed.

Study Area

The study area is the Carapelle watershed, a Mediterranean medium-size watershed (506.2 km^2) located in Apulia, Southern Italy (Figure 1, Table 1). The Carapelle torrent is one of the main streams that furrow the Tavoliere Plain, between the Ofanto River and the promontory of Gargano. The watershed areas with low slopes are used for cereal cultivation and olive orchards, while in the high steep slopes deciduous oaks, hardwoods (*Quercus pubescens* W. and *Quercus cerris* L.), and pasture conditions are present. The climate is typically Mediterranean, with rainfalls ranging from 450 to 800 mm·year^{-1} and average temperatures from 10 to 16°C.
For this study in particular the outlet is located at Ordona-Castelluccio dei Sauri Bridge where a monitoring station equipped with two gauging systems, one for measuring suspended sediment concentration (SSC), and the other one for streamflow measurement.is placed (Figure 2).

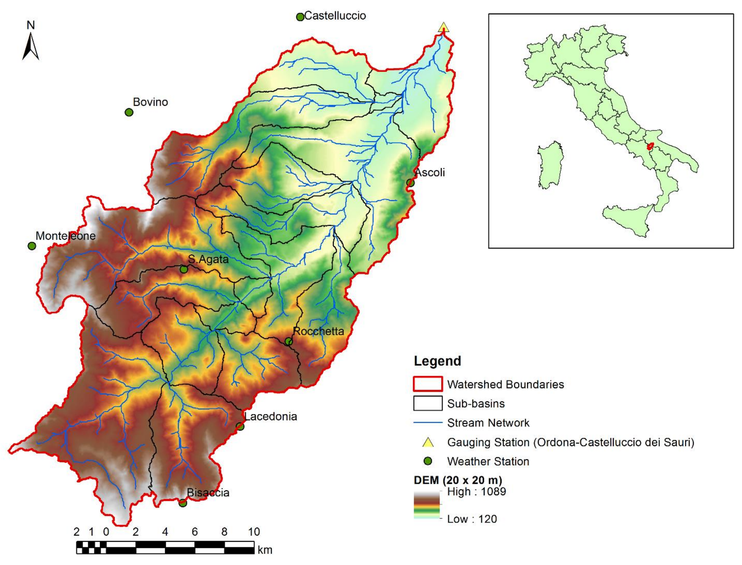


Figure 1 – The Carapelle watershed with outlet at Ordona-Castelluccio dei Sauri bridge.

Figure 2 – The monitoring Station

Watershed area	A	506.2 km^2
Average altitude	H_m	466 m a.s.l.
Main channel length	L	52.16 km
Main channel slope	i_c	16.3%
Mean watershed slope	i_w	8.2%

Table 1 - Main characteristics of the Carapelle watershed with outlet at Ordona-Castelluccio dei Sauri bridge.

Materials and Methods

In this study, in order to compare the performance of SWAT and AnnAGNPS in a Mediterranean watershed, the same inputs for both models were used (Table 2).

Description	SWAT	AnnAGNPS
Digital Elevation Model (DEM)	Shuttle Radar Topography Mission (SRTM) resolution of 20 × 20 m	Shuttle Radar Topography Mission (SRTM) resolution of 20 × 20 m
Land use data	Merge between the Land Use Map (UDS) of Apulia and the Land Agricultural Use Map (CUAS) of Campania resolution of 100 m	Merge between the Land Use Map (UDS) of Apulia and the Land Agricultural Use Map (CUAS) of Campania resolution of 100 m
Soil database parameters	Agro-eco-logical Characterization of the Apulia Region named ACLA2 (scale 1:100,000).	Agro-eco-logical Characterization of the Apulia Region named ACLA2 (scale 1:100,000).
Watershed Delineation	17 Sub-basins with a threshold of 2000ha and homogenous area defined as Hydrologic Response Units (HRU) with a threshold of 200ha (72 HRU)	Homogeneous (in terms of soil type, land use and land management) drainage areas called cells are defined with a CSA of 200ha and a Minimum source channel length (MSCl) of 130m, creating a total number of 283 cells and 114 reaches.
Weather data	8 Gauging station Daily data of Temperature, Solar radiation, wind speed and relative humidity.	8 Gauging station Daily data of Temperature, Solar radiation, wind speed and relative humidity.
PET Method	Penman-Monteith	Penman-Monteith
Measured Data for calibration and validation	Four years of measured data of water yield and sediment load (2007/2008 - 2010/2011).	Four years of measured data of water yield and sediment load (2007/2008 - 2010/2011).
Infiltration/surface runoff algorithms	Modified SCS CN2	Modified SCS CN2
Sediment Yield	Sediment yield based on Modified Universal Soil Loss Equation (MUSLE) expressed in terms of runoff volume, peak flow, and USLE factors (Neitsch et al., 2005)	Uses RUSLE to generate sheet and rill erosion, HUSLE (Theurer and Clarke, 1991) for delivery ratio, and sediment deposition based on particle size distribution (Young et al., 1987) and particle fall velocity, ephemeral gully erosion model (Gordon et al., 2007)

Table 2 – Comparison of main input and characteristics of SWAT and AnnAGNPS.

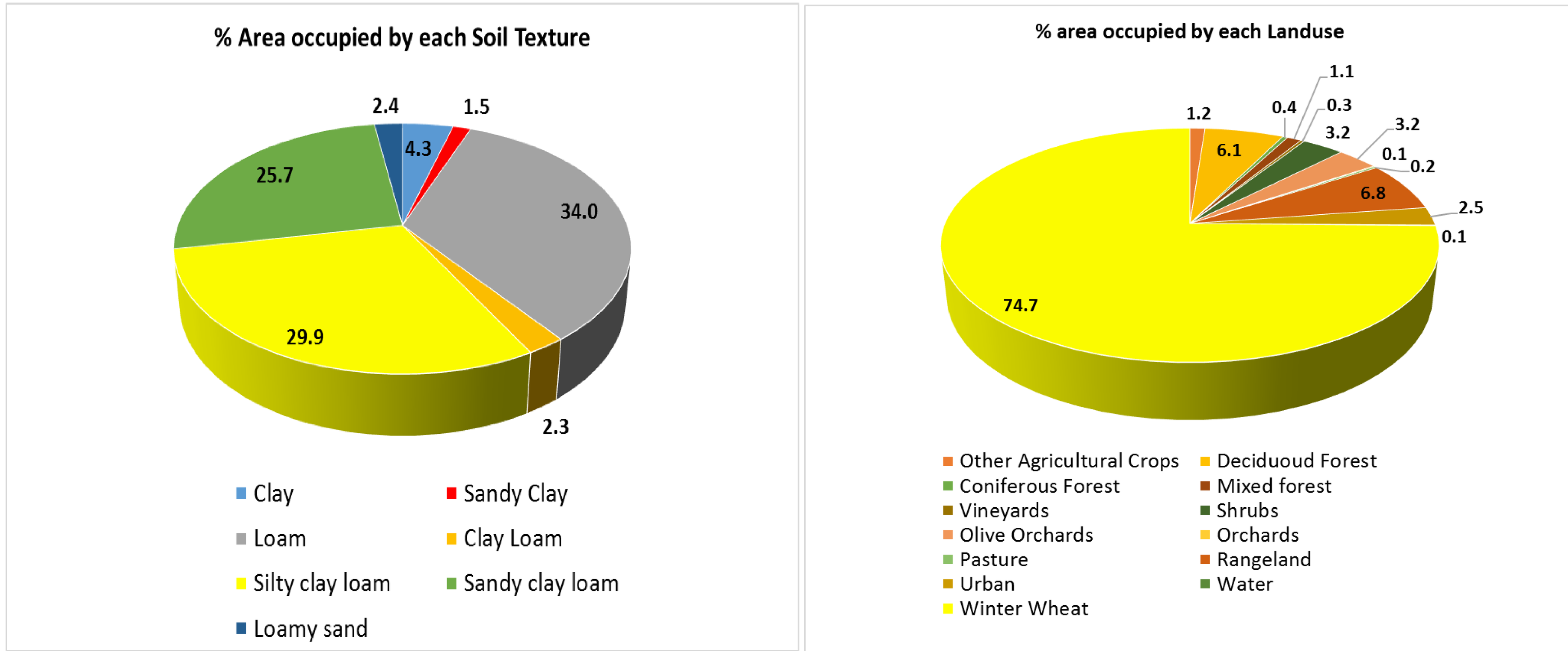
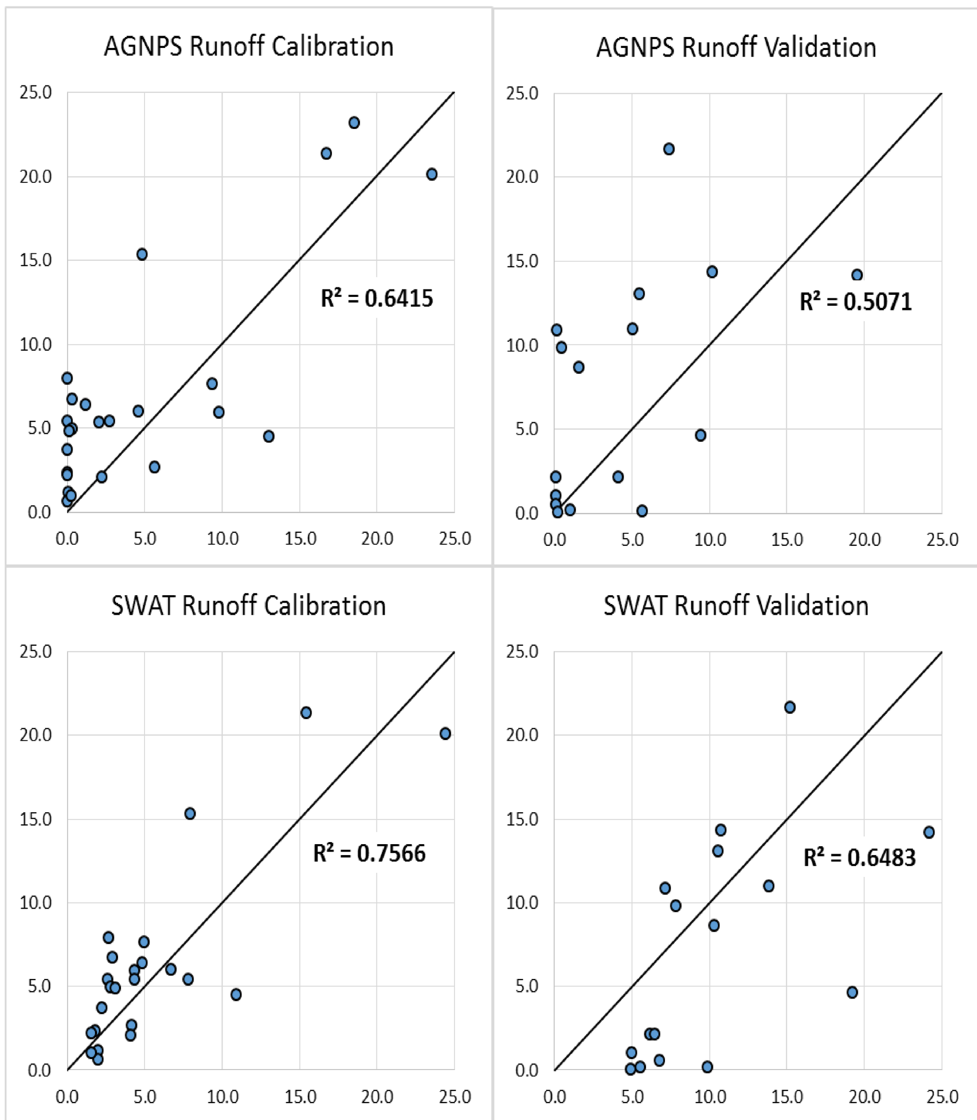


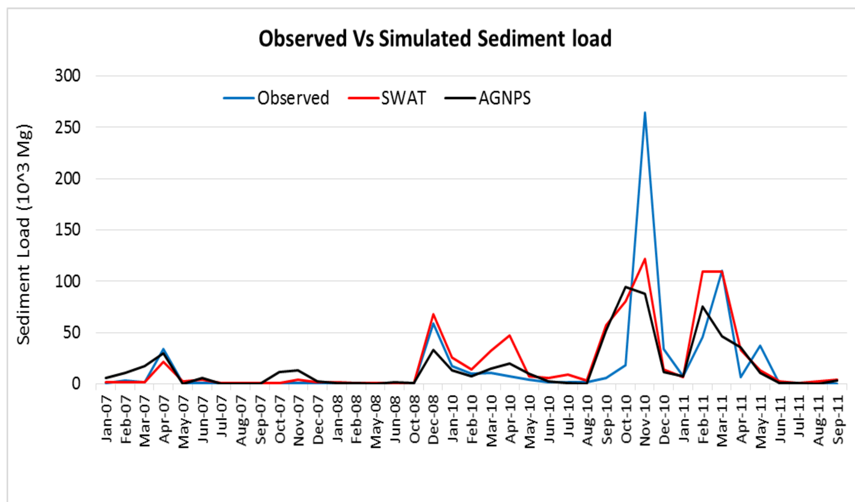
Figure 3. Landuse and Soil Texture in the study Area

A four year measured data (2007-2008, 2010-2011) were used to run the models at monthly time step. These data sets were divided into two-year pairs and used for the calibration and validation phase.
SWAT divides the watershed into sub-basins and further into homogenous slope, land use, management, and soil characteristics hydrologic response units (HRU). In AnnAGNPS, the analyzed watershed can be divided into many small, homogeneous (in terms of soil type, land use and land management) drainage areas called cells. They are connected to each other defining a network of channels and reaches, where water, sediment and nutrients are transported. According to Parajuli et al., 2009 flow and sediment calibration were performed by considering the parameters that resulted most sensitive from previous researches (Abdelwahab et al., 2014; Ricci et al., 2017 (submitted)). In particular, the Curve Number (CN) was considered for the runoff and the Manning's coefficient for overland flow for the sediment load.

Results

The figures below (Figure 4) show the performance of each model in simulating runoff and sediment load. Both models show fair to good performances in runoff and sediment simulation.





	R2	NSE	PBIAS
Runoff Calibration			
SWAT	0.76	0.65	6.12
AGNPS	0.64	0.45	31.29
Runoff Validation			
SWAT	0.65	0.65	-1.75
AGNPS	0.51	0.32	41.14
Sediment Calibration			
SWAT	0.94	0.93	-5.49
AGNPS	0.72	0.67	-23.74
Sediment Validation			
SWAT	0.53	0.51	-19.58
AGNPS	0.37	0.36	15.50

Figure 4. Landuse and Soil Texture in the study Area

Discussion and Conclusions

The objective of this research was to compare AnnAGNPS and SWAT model simulation results for runoff and sediment load using 4 years (2007/2008 for calibration, and 2010/2011 for validation) of measured data. It is important to choose appropriate model to prioritize critical areas in the watershed. According to the classifications of Parajuli (2007), this study concluded that both AnnAGNPS and SWAT models performed with fair to good correlation (R2 from 0.51 to 0.76) and fair to good agreement (NSE from 0.3 to 0.65) for runoff when comparing model predictions with measured data during calibration and validation. As for sediment load, SWAT and AnnAGNPS performed fairly in simulating sediment load either during calibration or validation. The fact that SWAT uses SWAT-CUP tool in model calibration can be considered a strength point of SWAT.

Further developments

To improve the model performances in calibration and validation, the entire dataset could be split in two periods, the dry (May to September) and the wet (October to April). Both model will be used also to study Nutrients, pesticides dynamics in the watershed to asses water quality in the river system.

References
Abdelwahab, O. M. M., Bingner, R., Milillo, F., & Gentile, F. (2014). Effectiveness of alternative management scenarios on the sediment load in a Mediterranean agricultural watershed. *Journal of Agricultural Engineering, 45*(3), 125-136.
Arnold, J. G., Srinivasan, R., Muttiah, R. S., & Williams, J. R. (1998). Large area hydrologic modeling and assessment - Part 1: Model development. *Journal of the American Water Resources Association, 34*(1), 73-89.
Bingner, R. L., & Theurer, F. D. (2005). AnnAGNPS technical processes documentation,version 3.2. Oxford, MS, USA: USDA-ARS National Sedimentation Laboratory.
García-Ruiz, J. M., Beguería, S., Lana-Renault, N., Nadal-Romero, E., & Cerdà, A. (2016). Ongoing and Emerging Questions in Water Erosion Studies. *Land Degrad. Develop.*, 28: 5–21. doi: 10.1002/ldr.2641.
Jones, D. L., Rousk, J., Edwards-Jones, G., DeLuca, T. H., & Murphy, D. V. (2012). Biochar-mediated changes in soil quality and plant growth in a three year field trial. *Soil Biology & Biochemistry, 45*, 113-124. DOI: 10.1016/j.soilbio.2011.10.012
Panagos, P., Meusburger, K., Van Liedekerke, M., Alewell, C., Hiederer, R., & Montanarella, L. (2014). Assessing soil erosion in Europe based on data collected through a European network. *Soil Science and Plant Nutrition, 60*(1), 15-29.
Parsons AJ. 2012. How useful are catchment sediment budgets? *Progress in Physical Geography,* 36,(1), pp. (60 – 71). DOI: 10.1177/0309133311424591.
Ricci GF, De Girolamo AM, Abdelwahab OMM, Gentile F. 2017. Identifying sediment source areas in a Mediterranean watershed using the SWAT model, Land Degradation & Development, under review.
Tibebe, D., & Bewket, W. (2011). Surface runoff and soil erosion estimation using the swat model in the keleta watershed, Ethiopia. *Land Degradation & Development, 22*(6), 551-564. DOI: 10.1002/ldr.1034.