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CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA AGROALIMENTARIA DE ARAGÓN

SWAT2012 model evaluation in semi-arid irrigated watershed

Dechmi Farida[1], Skhiri Ahmed[2], Javier Burguete [3] and Daniel Isidoro[1]

[1]Agrifood Research and Technology Centre of Aragón (CITA-DGA, Spain).
[2]School of Engineers of Medjez el Bab (ESIM, Tunisia).
[3]Aula Dei Experimental Station (EEAD-CSIC, Spain).

GOBIERNO DE ARAGON
Departamento de Innovación, Investigación y Universidad

Introduction

- The water balance (WB) is based on the principle that during a certain time interval the total input (mass of water) to a basin must be equal to the total output plus the net variation in the storage of the basin or water body.

- WB is an important tool for the planning and management of water resources, especially if it is considered in an integral way, both surface water and groundwater.

- The WB is an essential aid to Basin Authorities to help manage water in dry and hot conditions. Mainly in the case of irrigated agriculture: the major world's water consumer with 70% of all water consumption (FAO, 2016).

- In semi-arid irrigated areas, water is considered not only as a limited resource, but also as a production factor and a relevant economic input.

- Thus the importance to determine accurately the flow of water "in" and "out" of a system.

Introduction

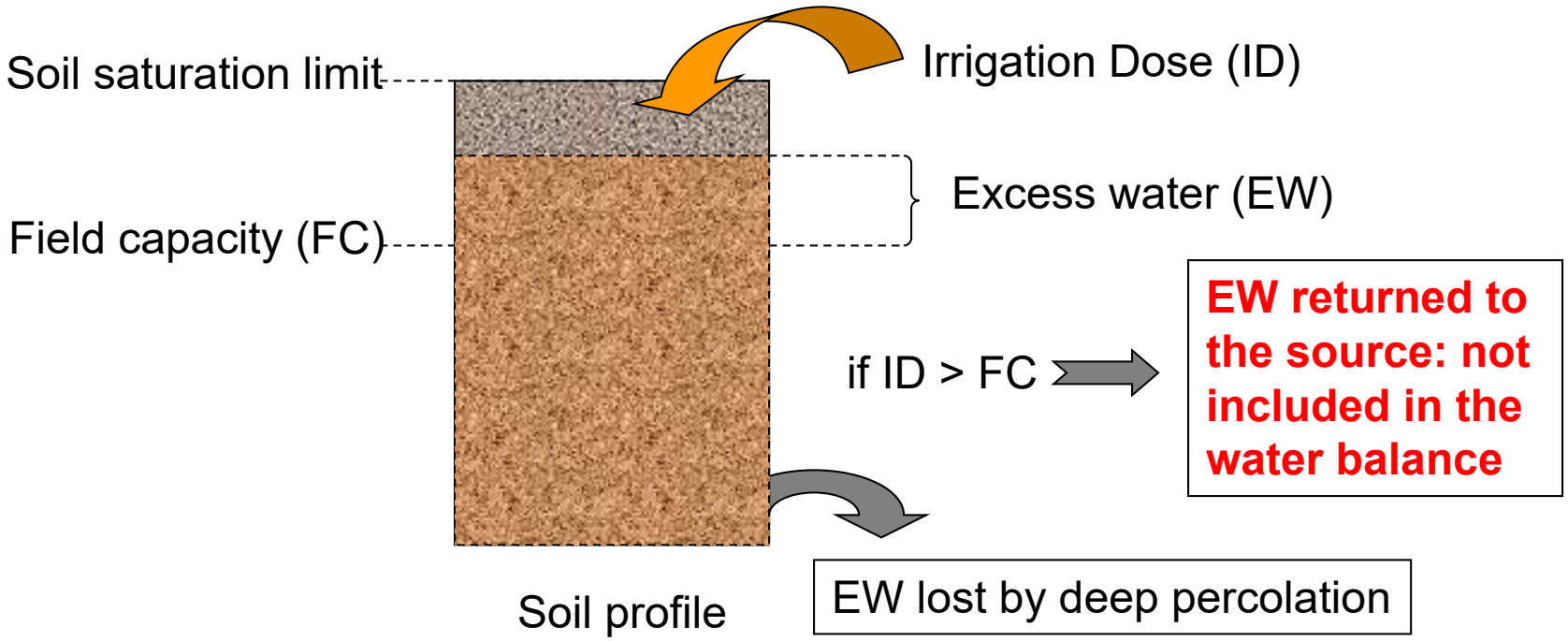
- Conducting fields experiments and collecting long-term data is very expensive (cost of instrumentation and operation) and time consuming. The application of hydrologic simulation models is an alternative for assessing the WB, for BMPs performance in reducing nutrients contamination from irrigated agricultural watersheds or for making management recommendations...

- The Soil and Water Assessment Tool (SWAT) is a well-established distributed hydrologic model. However, some studies reported that the SWAT irrigation function was unable to represent appropriately the hydrological processes in intensively irrigated areas.

- In Del Reguero watershed (Spain), the SWAT2005 version did not reproduce correctly the irrigation return flow generated under intensive sprinkler irrigation (Dechmi et al., 2012).

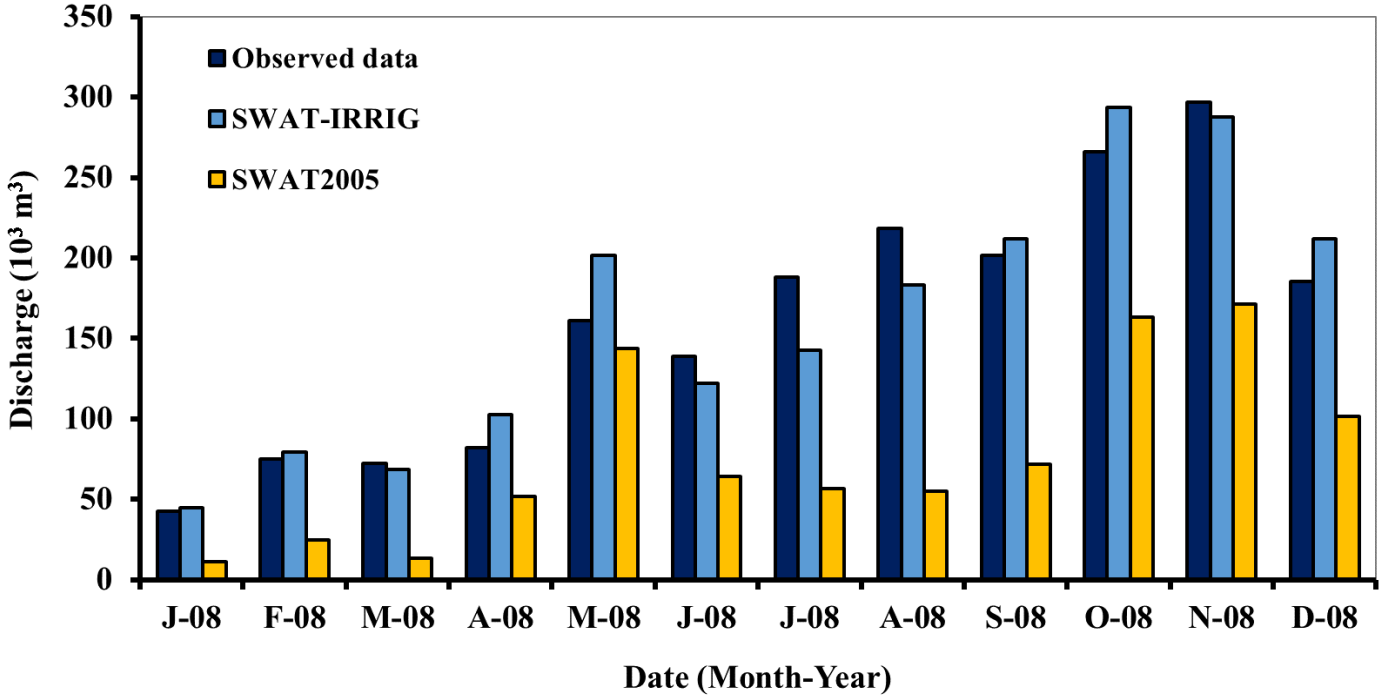
Introduction

❑ **Application of the original SWAT2005 using real farmer irrigation practices was not possible because of the model limitation on the maximum irrigation dose that could be applied as an irrigation event (when the source is external).**



SWAT-2005 → **SWAT-IRRIG**

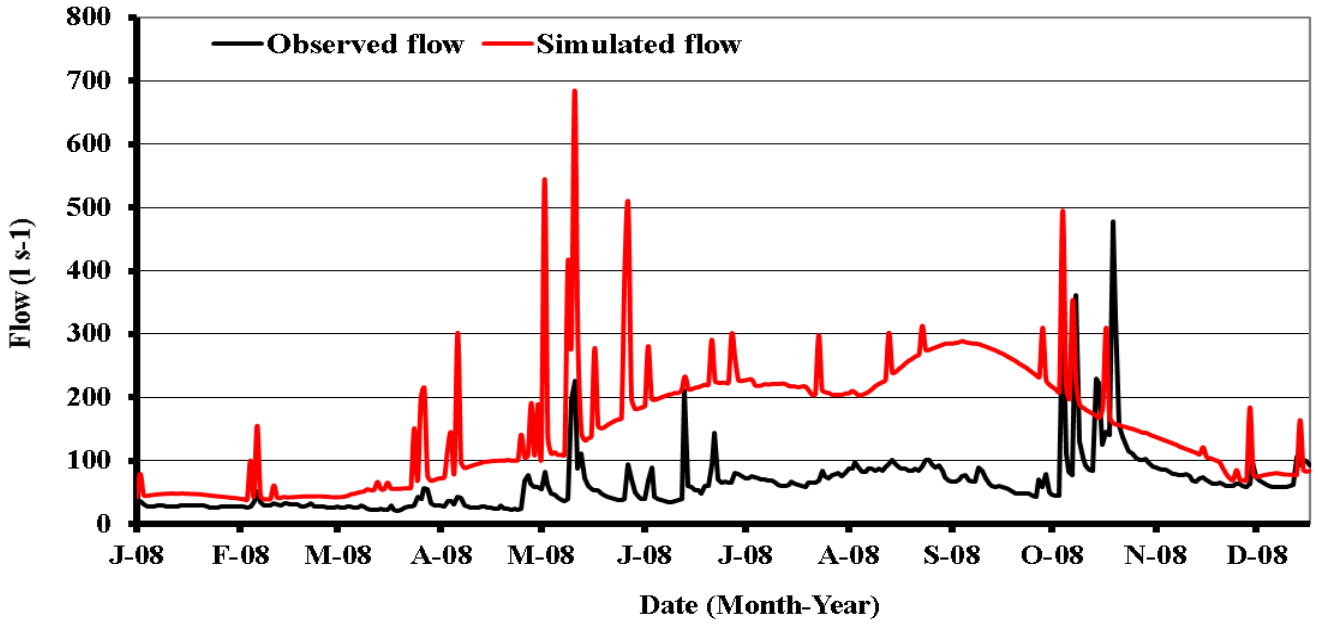
SWAT-IRRIG



Comparison between observed data of monthly discharge in Del Reguero Ditch and simulation results using SWAT2005 and SWAT-IRRIG (Dechmi et al., 2012).

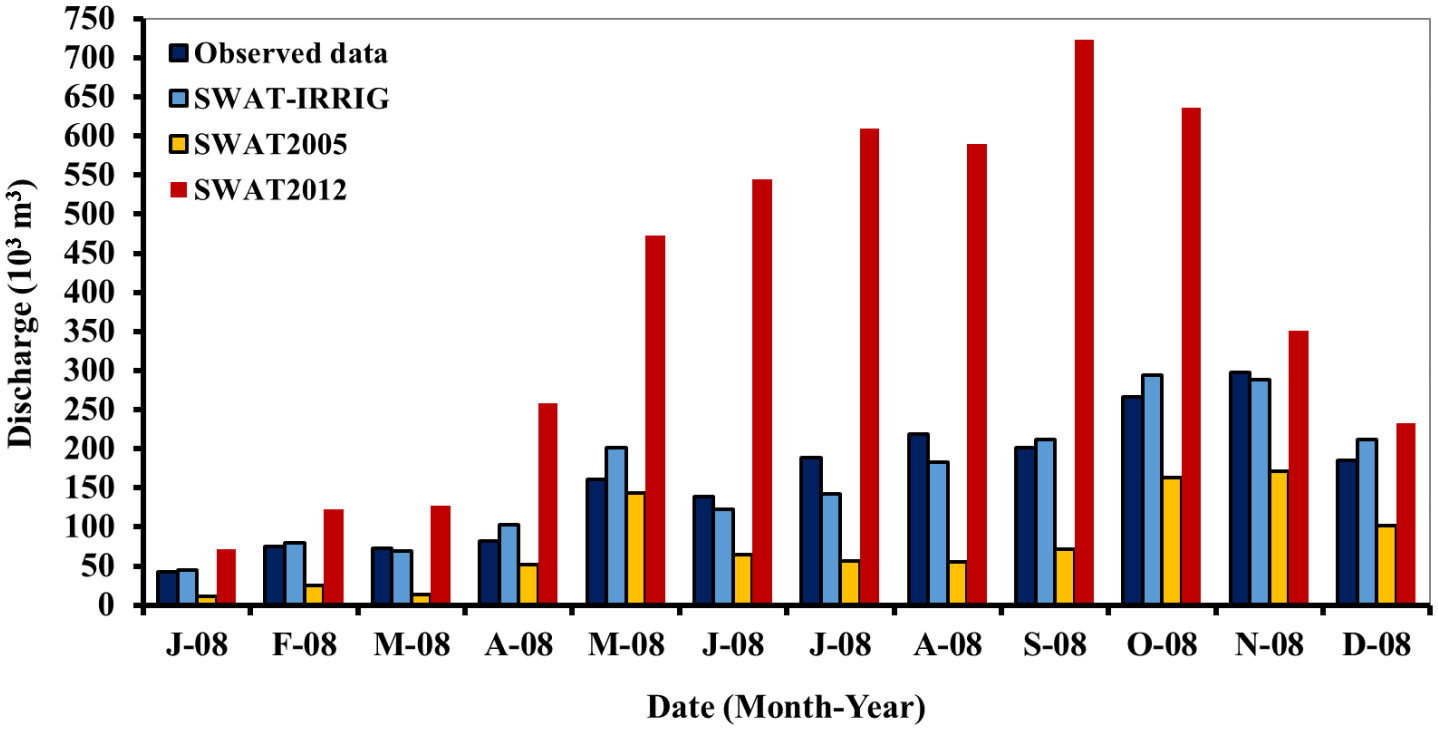
SWAT2012

- Irrigation return flows were unreasonably higher than observed values, mainly during the irrigation season (April-October): 63 Ls^{-1} vs. 202 Ls^{-1}, in average



Comparison between observed and SWAT2012-simulated daily water flows

SWAT2012



Comparison between the monthly water flows simulated with modified SWAT2005 (SWAT-IRRIG), SWAT2012 and the SWAT2005 original version.

Objectives

To evaluate the last SWAT version (SWAT2012 revision 664) in the same study area (Del Reguero watershed, Spain) and to correct the identified deficiency in the irrigation algorithms in the case of manual irrigation and water resource originating from outside the watershed.

Modifications introduced in current SWAT2012

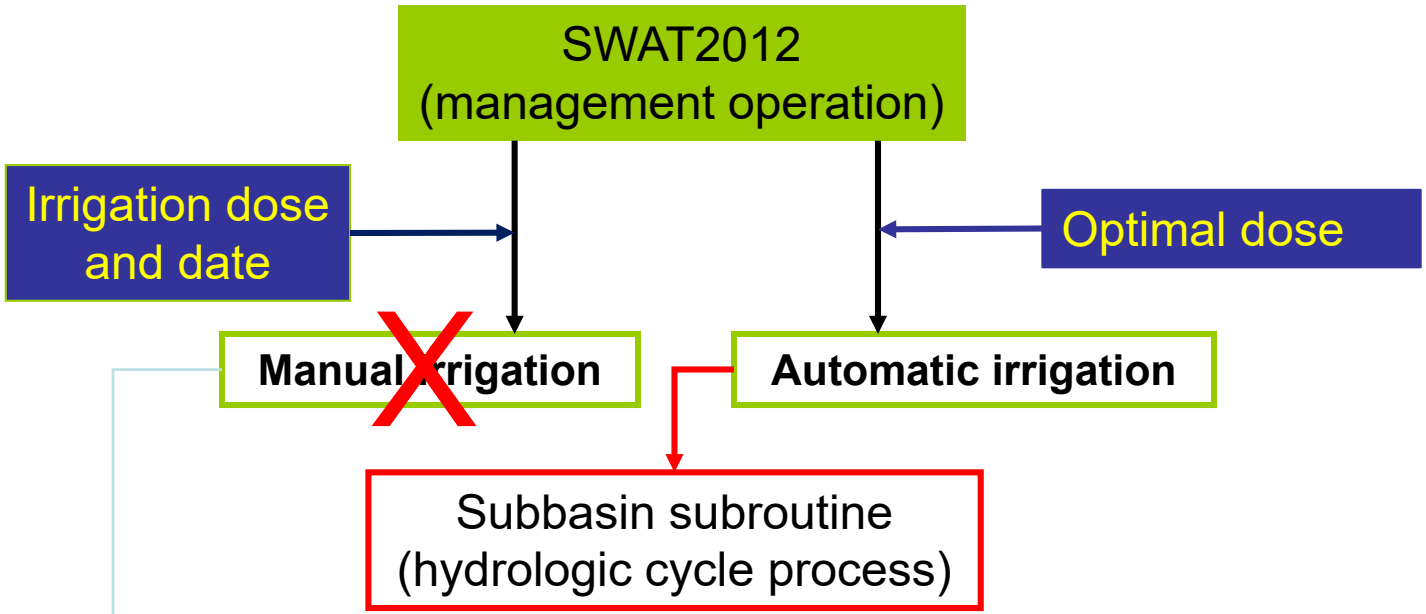
- **First modification was introduced in the "percmain" subroutine:**

```
1     subroutine percmain
2
3   !!    ~ ~ ~ PURPOSE ~ ~ ~
4   !!    this subroutine is the master soil percolation component.
5
6   !!    ~ ~ ~ INCOMING VARIABLES ~ ~ ~
7   !!    name        |units         |definition
8   !!    ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
9   !!    drai
10  !!      de
11  !!    drai
12
104
105         if (icrk == 1) then
106           sepday = Max(0., inflpcp - voltot)
107         else
108           sepday = inflpcp
109         end if
110
111 !!  add irrigation water
112           if (aird(j)>0) then
113             j=j
114           end if
115         sepday = inflpcp + aird(j) + pot_seep(j)
116         pot_seep(j) = 0.
117
```

  - The irrigation dose applied in management input data was added in the soil percolation depth calculation

Modifications introduced in current SWAT2012

❑ **Another modification was included in the "subbasin" subroutine:**



"percmain" subroutine

➢ **WB calibration process**
Satisfactory results with some model parameter combinations

➢ Yes for small part of irrigation water input

➢ No when irrigation is the main input in the WB:
- Farmer not using optimal irrigation dose
- High irrigation water excess
- Available water resource less than irrigation requirement
- Climate change assessment…

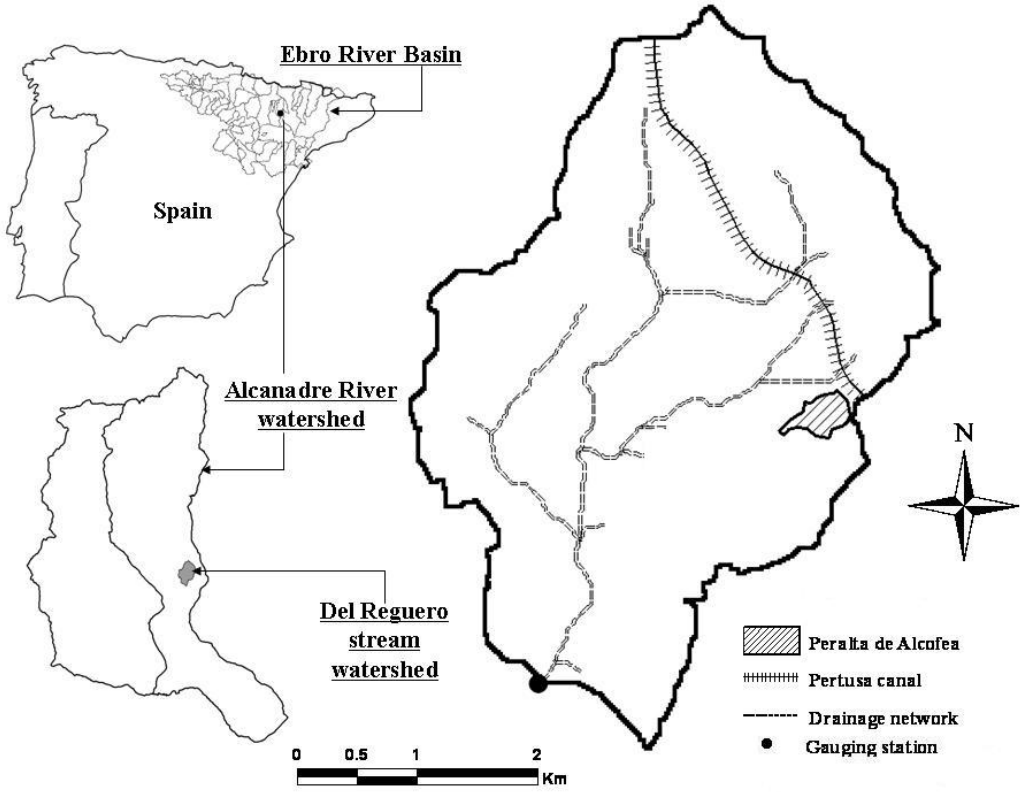
Modifications introduced in current SWAT2012 by our group

- **Incorporation of an algorithm that allow the performance of the manual irrigation operations in the subroutine "subbasin" (separate automatic from manual irrigation)**

- **Change the maximum amount of water applied as an irrigation event in the "irrsub" subroutine to the depth of irrigation water applied to each HRU as specified by the user (instead of the amount of water held in the soil profile at field capacity considered in the current version).**

SWAT-2012 → **SWAT-IRRIG2**

Study zone



- **Surface**: 1,865.5 ha (**71%** under irrigation)
- **Climate**: semiarid
- **Average Precipitation**: 391 mm
- **Average PET**: 1294 mm
- **Irrigation systems**: solid-set sprinkler
- **Crops**: corn, alfalfa, sunflower, barley

Location of the Del Reguero watershed

Methodology

Model calibration and validation

Simulation periods:

a) **Warm-up**: January 1st, 2007 to January 14th, 2008

b) **Calibration**: January 15th, 2008 to December 31st, 2008

c) **Validation**: January 1st, 2009 to December 31st, 2009

Observed data:

a) **Streamflow**: using daily observed data

b) **NO_3**: using daily observed data

Methodology

Model performance evaluation

a) Nash-Sutcliffe Efficiency (NSE)

b) Root Mean Square Error (RMSE)

c) Percent Bias (PBIAS)

d) RMSE-observation standard deviation ratio (RSR)

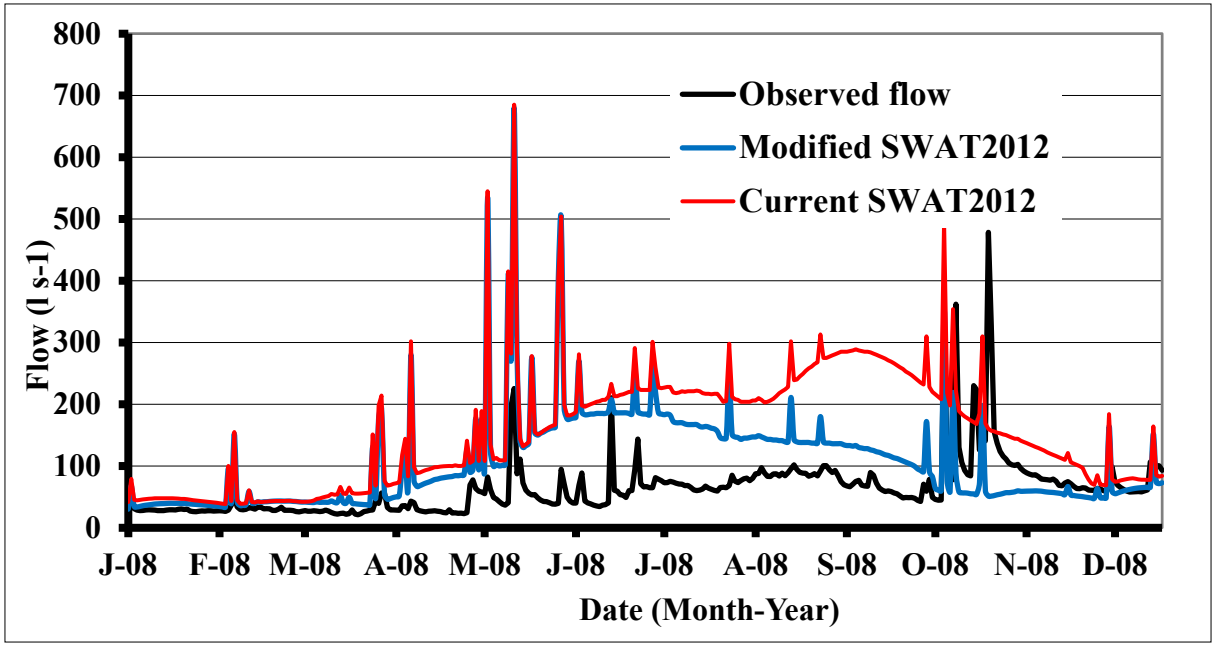
e) Coefficient of Determination (R^2)

Model performance criteria (satisfactory)

a) Water flow: NSE > 0.5; RSR ≤ 0.7; PBIAS ± 50%

b) NO_3: NSE > 0.5; RSR ≤ 0.7; PBIAS ± 70%

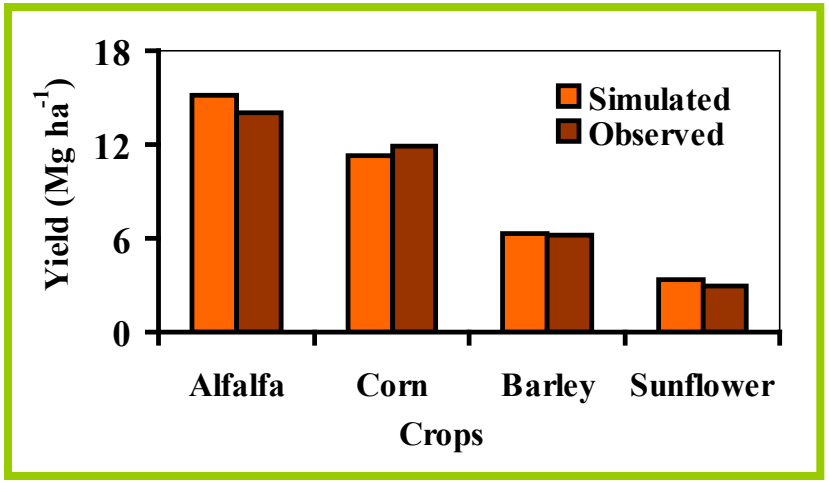
Model modification



Comparison between observed daily water flows and daily water flows simulated with the current SWAT2012 and with the modified SWAT2012

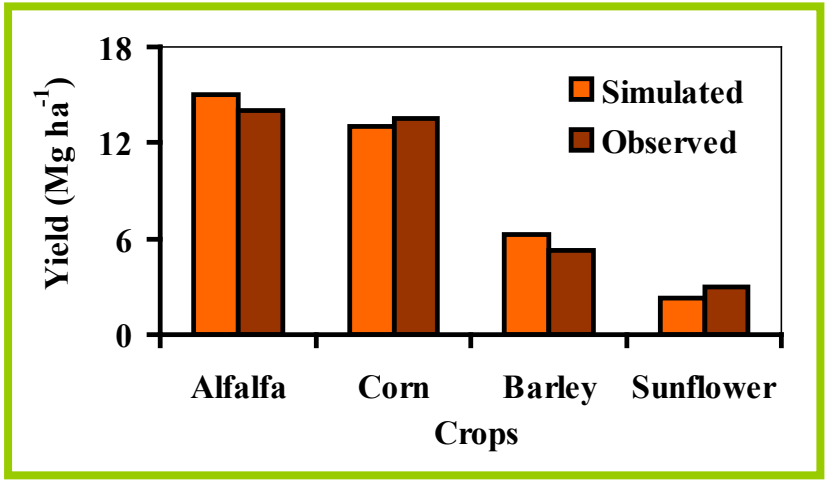
Results

Crop model calibration and validation



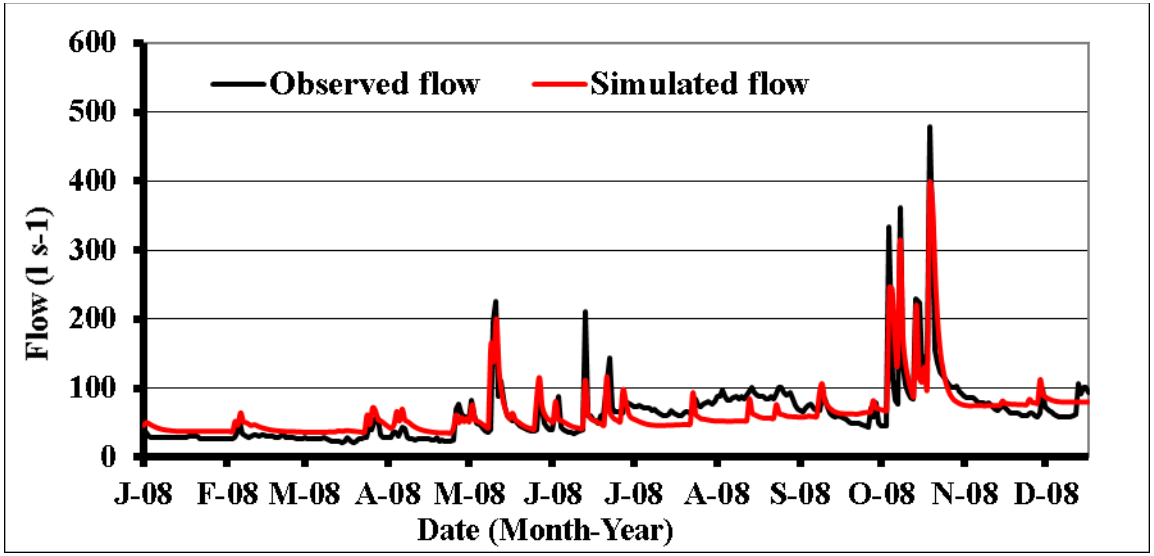
Calibration (2008)

Validation (2009)



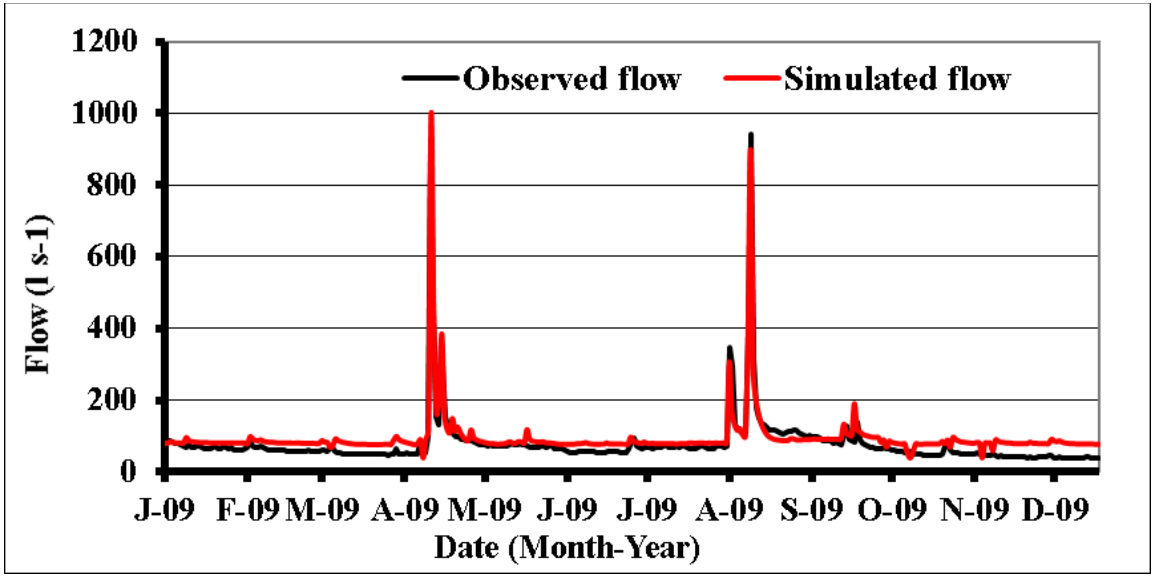
Results: Streamflow calibration and validation

Calibration (2008)



NSE=0.70

Validation (2009)



NSE=0.88

Conclusions

1. SWAT2012 doesn't reproduce the irrigation return flow at the outlet of intensive irrigated systems.
2. Alternatively, the modified version (SWAT-IRRIG2) showed better model performance under sprinkler irrigated systems.
3. Daily and monthly model calibration and validation indicated a "very good" SWAT-IRRIG2 performance in describing stream discharge at the outlet of the study area.
4. SWAT-IRRIG2 (as well as the other SWAT versions) was able to predict adequately the yield of the main crops in Del Reguero Basin under sprinkler irrigation.


THANK YOU VERY MUCH

Results

Statistic parameter	Calibration (A)		Validation (B)	
	Daily	Monthly	Daily	Monthly
NSE	0.73	0.81	0.88	0.88
PBIAS (%)	3.44	3.44	2.33	2..3
RSR	0.52	0.45	0.25	0.26
Predictive criteria	Very Good	Very Good	Very Good	Very Good