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Interactive Comment

Interactive comment on "Modelling water-harvesting systems in the arid south of Tunisia using SWAT" *by* M. Ouessar et al.

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Interactive comment on 8220;Modelling water-harvesting systems in the arid south of Tunisia using SWAT8221; by M. Ouessar et al. Anonymous Referee 2 Received and published: 7 August 2008 General comments The objective of this paper is to adapt and evaluate the wellňknown distributed model SWAT for simulating the hydrologic processes in arid Mediterranean environments takňing into account waterňharvesting systems. The methodology consists on developing a methodology to represent water harvesting in SWAT and to adjust the crop parameters to the speci64257;cities of Mediterranean arid zone. The wadi Koutine watershed (270 km2) Southern Tunisia was selected as a study case. The objective of the paper is of international interest for modeling the impact of man-made management such as embankments and dikes, called jessours and tabias in Tunisia, constructed for water harvesting in arid zones. The bibliography is complete and of international broad. In the literature, very few models enable to take into acňcount jessours and tabias, and the development of a model which takes into account hydrological processes through these two structures is fully justi64257;ed. The paper is well structured and well written, and the study case well adapted to the objectives. The modi64257;ed version of SWAT (called SWATňWH) was applied in order to calculate at the whole watershed scale, the water budget at the 64258;ood event scale and for a set of 38 64258;ood events (from 1973 to 1985). However, the paper did not present a clear analysis of the main hydrological processes through jessours and tabias, lacks of hydrologic analysis of the hydrological, meteorological and cartographic data on the study site, and lacks of soundness in discussion. My major comments concern:

1. The hydrologic processes through jessours and tabias: The study of hydrologic processes through jessours and tabias is one of the main originality of this paper. However, it is not clear from the presentation of jessours (page 1868, lines 22ň29) and tabias (page 1869, lines 1ň7) what are the similarities (from hydrologic point of view) and what are the differences between these two structures. Figure 2 is not clear enough to present the main differences: for example in the scheme of the Jessr component (b), there is a tabia! A clear scheme should be added to compare jessours and tabias, showing for each structure the hydrologic processes, the main geometric parameters, and how to represent the hydrologic processes in the model. If I understand well, both jessours and tabias are represented in SWATňWH using the same approach; if this is the case, why to distinguish two types (jessours and tabias)? SWATňWH and SWAT should be applied and compared at the scale of one Hydrologic Response Unit (HRU) corresponding to a jessour or a tabia, in order to show the shortcomings of SWAT, the improvements obtained using SWATňWH and the main hydrological processes at the local scale.

AC.

It is true that there are a lot of similarities between the two systems: Jessour and tabias. However, the main difference is that the first one receives the runoff from the impluvium while the second one can receive in addition floodwater from a diversion channel (represented in SWAT as DIVMAX). On another side, the height of the pounding area (represented as FLOWFRACTION) is also slightly different. We do agree that a clearer scheme should be added by improved Fig 2 to illustrate the differences between the two systems.

The differences in the hydrologic functioning of these systems, as implemented in SWAT-WH (cf. 2.3) is that, if located within one subbasin, jessour capture the runoff water first and the tabias receive the remainder. Also, the model parameters that describe these systems, i.e., the fraction of runoff captured by these systems (FLOWFR) and the average height of the ponded water (DIVMAX), have different values.

Jessour and tabias can only function when there is more than 1 HRU: a rocky rangeland area that generates runoff, and a cultivated area with a dike (tabia or jessour) that captures this runoff. SWAT can not be used to simulate this two-HRU system, because SWAT will route the runoff from the rocky rangeland area directly out of the subwatershed.

2. The hydrologic processes on the study site: The paper lacks of a hydrologic analysis of 64258;ood events. Few hydrologic characteristics, such as total rainfall, runoff, and rainfall intensity, are given at the end of the paper (for example page 1882, lines 1ň17 and 27ň30; page 1883, lines 1ň9). First, the paper must be strengthen by presenting a complete analysis of the available data (rainfall, runoff, potential evapoňtranspiration) by presenting an estimation of the annual water budget using the measured data. A similar analysis must be conducted at the event scale by presenting the characteristics of rainfall events such as duration, total rainfall, total runoff, peak 64258;ow, etc. (present for example the classical graphics showing the relationships between these characteristics for calibration and validation events). Are there any missing data? What is the accuracy of data? What are the terms of the observed water budget? Second,

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the paper must analyze the geographic characteristics of the watershed, especially the exact location on a map and the dimension of jessours and tabias. A discussion must analyze the geometric characteristics of these structures, in order to justify the adequate range of parameters.

AC.

A section dealing with the analysis (annual and event based) of the available hydrologic data could be added.

According to Fersi (1985), all runoff events for the study period (1973/74-1984/85) have been recorded except one (cf. p1878-9). However, for the daily rainfall data, there were some missing records in one or more stations. It is important to highlight also the variability in the rainfall especially the Jessour and Tabias are found in different locations of the watershed that receive different rainfall events and patterns some of which are not captured in the rainfall data. A summary table with characteristics for the events could be added.

For the observed water budget, we have only runoff at the outlet. The annual water budget is: P (area-weighted over the watershed 8211; we have computed this), total observed runoff, remainder = ETa + recharge.

Figure 1 provides the geographical position of the study watershed and shows also the location of jessour (olive of the mountains) and tabias (olives on the plain) within the watershed.

The choice of the geometric parameters was mainly based on previous studies conducted by the authors (Ouessar De Graaff, 2002; Ben Mechlia Ouessar, 2004; Ouessar et al., 2004;, 2005) and other researchers (El Amami, 1984; Snane Mechergui, 1990; Chahbani, 1990; etc). in the same region.

3. Justi64257;cation of the choice of the model: The justi64257;cation of the model to be used is not clear in the introduction. The authors say that few of the available

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watershed models can be easily applied to simulate the high spatiotemporal variability processes in arid watersheds (page 1866, lines 2ň4). This assumption is not true, because a large number of models are adapted to the arid region, probably not to take into account the role of jessours and tabias. However, the authors justify the choice of SWAT (page 1866, lines 4ň9), not because it is well adapted to arid regions, but for technical reaňsons. The authors should 64257;rst justify the constraints of modeling jessours and tabias (see above in 1), and then choose a model well adapted to take into account these structures. When reading the conclusion of the paper, one may ask if a global model is not adapted to calculate the terms of the water budget. Why do we need a distributed model? Justify also the adequacy of the daily time step (64257;xed in SWAT) for simulating hydrological processes during shortň duration high ňintensity events?

AC

The specificity of the jessour and tabias is that their hydrologic functioning is based on water harvesting (collection of runoff from the impluviums and/or flood water from the streams (wadis)). We want to be able to see water uses at different location in watershed. In addition, there is no model that captures these hydraulic features. SWAT is distributed and widely used and allows for sufficient flexibility to capture various hydrologic processes that can represent these structures.

The time step was chosen to be as short as possible but also to accommodate to the availability of data (only daily). Our constraint is the data, SWAT can also simulate intensities, for the future when we have the suitable data.

4. The parameterization strategy: The paramaterisation strategy is well conducted in order to give a range of variation for the main model parameters as shown in section 2.4. However, the section 2.4 lacks of a synthetic conclusion showing a list of the whole parameters of the model, the parameters to be 64257;xed, and the parameters to be caliňbrated. The paper should present maps showing the spatial variabil-

ity of Hydrologic Response Units (HRU), jessours and tabias location, soil, and land use. Particularly, the two parameters DIVMAX and FLOWFR need to be addressed speci64257;cally because they represent the speci64257;c role jessours and tabias. How to spatialize these two pařrameters, and can they be considered identical for all jessours and tabias? A second point concerns the comparison between SWAT and SWATňWH at the catchment scale. The paper does not demonstrate that SWATňWH gives better results than SWAT beňcause no comparison was established. A comparison between SWATňWH and SWAT at both the local and catchment scales enables to demonstrate the advantages (or not) when introducing jessours and tabias. I think it is one of the main points to be adňdressed in a revised version because it enables to better understand the hydrological processes through jessours and tabias, and enable to discuss the domains and limits of applications of SWATňWH.

AC

By performing the sensitivity analysis (cf. 2.5.1.) that we could determine the parameters to be changed and the remaining will be kept fixed. The results are shown in table 4 (p.1896). The calibrated parameters were: CN, DIVMAX and FLOWFR.

The HRUs could be added as layer to existing map or displayed on a separate map. For Fig 1 we could use the soil map (colors) and add the land uses (we have only 4) as different stripes and dots on top. Make it full page size.

We adopted only average values for DIVMAX and FLOWFR for both jessour and tabias based on field knowledge and literature revue.

For our application, we only have runoff data at the watershed-level (270- km2). Thus, we can not calibrate/validate all these different parameter values throughout the watershed. Therefore, it was recommended to monitor small watersheds in future and perform refinement of jessour and tabia dimensions.

As mentioned above (AC to 1), SWAT calculates the runoff for each subabsin and

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routes it directly to the reach. Nevertheless, a comparison between SWAT and SWATWH is an interesting idea that will be addressed in the revised version.

Speci64257;c comments: . Page 1866, lines 2-4: Please explain why we cannot use the available models?

AC. Most of the models are based on the concept of soil and water conservation while our systems (jessour and tabias) function on the basis of water/runoff harvesting.

. The introduction must introduce the waterňharvesting systems (jessours and tabias) and the dif64257;culties to represent them in hydrological models.

AC The water harvesting systems are introduced in section 2.1 but need to add their hydrologic representation difficulties. For example, most models do not route between different HRUs.

. Page 1867, line 15: indicate what hydrological processes will be modi64257;ed by the water-harvesting system.

A.C. The water harvesting systems affect runoff, infiltration/percolation, transmission losses, and evapotranspiration.

. Page 1867, lines 21ň-25: Indicate on a map the location of Jeffara, Médenine, Matň-mata, Sebkha Oum Zessar, Hallouf, etc.

AC. OK. Map to be updated with those locations.

. Page 1869, line 25: Please explain WXGEN. AC SWAT includes the WXGEN weather generator model (Sharpley, A.N. and J.R. Williams, 1990) to generate climatic data or to fill in gaps in measured records.

. Page 1870, line 2: Please give a list of the available data on the study site which justify the choice of the Hargreaves method. A.C. Min and Max daily temperature. . Page 1872, line 25: Please give a map showing the 35 subňbasins or HRU.

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A.C. OK for adding a layer or a map with the 35 subbasins.

. Page 1873, lines 12ň-18: Please check the name of all locations which differ between the text and the map on 64257;gure 1: Allamet and Alamat, Toujène Dkhilet and Toujène Edkhila, Ksar and Kasr, Béni Khédache and Béni Kedhache, etc.

AC. OK for harmonizing the used local names.

. Page 1874, line 7: Is it TABS or STAB? A.C. Yes. It will be changed to STAB.

. Page 1874, line 20: Please comment Table 1. AC. Table 1 provides a summary of the soil characteristics.

. Page 1875, line 5: Please explain to what corresponds the group D?

AC. According to the SCS (1972), the group D soils are those having very shallow depth and thus present a high infiltration rate. Footnote could be added to Table 1.

. Page 1876, lines 10ň-16: The new parameters DIVMAX and FLOWFR added in the application worth a detailed discussion function of observations on the study site. AC. The DIVMAX and FLOWFR are explained in section 2.3 (p. 1871). However, we used average vales based on the literature and field knowledge.

. Page 1877, lines 6ň-25: Please explain how was established the reference scenario. Is there any calibration function of measured data?

AC. The reference scenario was obtained by running the model using the observed/measured input parameters and/or by making the best estimates (expert and field knowledge) of the lacking ones. They are explained in section2.4.

. Page 1879, line 1879: What is the value of n? AC. n: number of observed (recorded) runoff events at the outlet. That is 38.

. Page 1880, lines 15ň-25: Please explain the signi64257;cance of the relative sensitivity RSI values.

AC. According to Lenhart et al. (2002), the following classes are used (absolute values): less than 0.05: small to negligible 0.05-0.2: medium 0.2-1.0: high More than 1: very high.

. Page 1882, lines 2ň-3: Data analysis shows that 50

AC. This is one of the features of the dry areas that need to be produced by any used model in those conditions. Although the high intense rainfall events are the most destructive but they are the most efficient in producing runoff and recharging the aquifers .

. Page 1893, Table 2: Please explain HYDGRP. AC. Hydrological group used by the SCS (1972).

. Page 1895, Table 3: Please justify why the same interval variation is not used for all parameters (for some parameters the variation is 5

AC.

Not the same interval was used in order to keep the values in the logic intervals of each parameter.

The absolute values of Ksoil, AWC are found in Table1 and those of the CN are found in Table 2.

. Page 1898, Figure 1: Please indicate the location of sites on the map of Tunisia.

AC. The site is indicate in red color on the map of Tunisia (the frame on the right up corner) but may need to be clearer.

. Page 1899, Figure 2: The Figure is not clear and does not enable to compare jessours and tabias. Also, the character size is small.

AC. OK. The font to be enlarged.

. Page 19052, Figure 5: The yňaxis of runoff does not enable to compare measured and calculated values. Please enlarge the scale of the axis, and enlarge the size of characters.

AC. OK. Font and scale to be enlarged.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 1863, 2008.

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