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Simulation of the catchments hydrological processes in arid, semi-arid and semi-humid areas

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Abstract

Hydrological processes and their spatial distribution directly are relevant to climate, topography, geology, and land use in the watershed. Therefore, use of a model whit integrity and high performance for simulating the process in deferent watersheds is very important. In this study was assessment performance of semi-distributed SWAT model in simulating hydrology processes in three watersheds with different climate: Jazmurian basin with 1258 (km^2) in an arid climate, Khorramabad watershed white 2467 (km^2) in a semi-arid climate and Talar watershed white 2057 (km^2) climate in semi-humid climate. To this purpose, maps land use, soil, digital elevation model, and meteorological data in daily step collected from many stations for each region. After running the SWAT model, the calibration and validation model did whit SUFI2 algorithm. Performance models were assessed with statistical coefficients NS, R^2 and bR^2. The results showed that the values of these coefficients in Jazmurian basin is 0.56, 0.54 and 0.20, in Khorramabad watershed is 0.68, 0.72 and 0.32 respectively and in Talar watershed is 0.64 0.66 and 0.31 respectively. Overall, the results showed that the SWAT model performance in Talar watershed is higher than the other watersheds.

Keywords: Simulation; Jazmurian; Talar; Khorramabad; Climate

1. Introduction

Arid and semi-arid areas usually have a short term of floods and base flows are very low. Sometimes due to the characteristics of the catchment, several maximums are observed in flood hydrograph, which happens one after another and this reflects the pointed rainfalls in different parts of the catchment. Hence, evaluating the model's performance is very important in these areas. There are different methods to simulate the hydrological processes: pair catchment approach, which only used in small catchments with an area less than 100 km^2 due to the difficulty in finding large or medium pair catchments (Li *et al.*, 2009). A large percentage of the rainfall volume in different areas of the country transformed to surface runoff by factors such as the structure of geology, vegetation, land use, slope, and the catchment shape (Plesca *et al*., 2012). In addition, several advantages of SWAT model such as providing free access, ability to manipulate the information, simulating different variables due to land use changes, the insertion to GIS (Geographic Information System) are the reasons for choosing this model (Arnold *et al*., 2012).Using the statistical data of 2001-2004 for validation and statistic data of 1994-2000 for calibration by using the SWAT model in Doiraj catchment in West of Iran, after model calibration using SUFI2 algorithm, the coefficients of R^2, bR^2 and NS for the runoff calibration phase was 0.75, 0.74 and 0.65, respectively; and for the validation phase was 0.86, 0.50 and 0.24, respectively; the results indicated the high efficiency of SWAT model in this area. Simulated the river flow discharge of Haraz catchment using the SWAT model at Karesang hydrometer station (located at the outlet of the catchment), the R^2 and NS

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coefficients were 0.72 and 0.70, respectively, which indicated the acceptability of the simulated river flow discharge of Haraz catchment at this station. Simulated the runoff amount in the semi-arid catchment of Neishabor using the SWAT model and SUFI2 algorithm, the results showed that the model with P-factor = 0.67 and d-factor = 1.41 did not have a high uncertainty. Simulated the runoff in Kordan catchment in Qazvin using the SWAT model. To this end, the model was calibrated for 2002 to 2006 and validated for 2007 to 2008. The results showed that the model of SWAT 2009 was good at estimating runoff in this catchment (Bastani-Allahabadi *et al*., 2012). Therefore, the simulation of runoff in an area is influenced by several factors. The conceptual models are often preferred to other hydrologic models including models that based on physics. In addition to providing acceptable responses, conceptual models need less computational efforts and input data than physical models (Koch *et al*., 2013). Depending on the purpose of the model implementation, these models have several parameters, which represent the catchment's characteristics. Estimating runoff generated in a catchment as well as predicting numerous hydrological processes associated with certain complexity in some areas, is one the key issues in hydrological studies, which the required basis information for most of the water resources projects, watershed projects as well as many related projects is established by obtaining these data (Razavi and Coulibaly, 2013). Thus, estimating runoff and necessary predictions for hydrological issues as well as a proper management of natural resources are very important. In addition to the lack of rainfall, Iran has a variable rainfall regime due to its latitude and proximity to the subtropical high pressure (Hrachowitz *et al*., 2013). The statistical method is the simple approach, which statistical analysis is performed by using weather stations in the area, however, this method does not consider physical processes within the area (Wei *et al*., 2013). Therefore, hydrological models considered as the most appropriate methods because they consider the relationship between climate, land use and hydrological components (Khoi and Suetsugi, 2014). Soil and Water Assessment Tool (SWAT) has been global as an an effective tool in the hydrological study of catchments (Thampi *et al*., 2010; Ficklin *et al*., 2014). The efficiency of SWAT hydrological model has not been evaluated in arid and semi-arid areas in Iran and due to the increasing use of this model and importance of generated runoff in arid and semi-arid areas, the simulation of runoff is essential for a proper planning and management in these areas. According to this study could provide a better understanding of the impact of catchment on the water balance characteristics of the area and its influence on the performance of the model in simulating flow discharge of these areas.

2. Materials and Methods

2.1. Case study

This research in order to assessment SWAT model performance in the simulation of hydrological cycle three case study selected. The Jazmurian basin with 1258 square kilometers area with 55° 37' to 57° 19' east longitude and 28° 52' to 29° 43' north latitude range in the southern part of the country is located in the Kerman province. This area the minimum elevation is 1912 and the maximum elevation is 3780 (m). This area with 160 (mm) average precipitation and 20 (ºC) temperature is located in the arid climate. The Khorramabad watershed with 2467 (km^2) area and 339 (km) perimeters is a sub-watershed of Karkheh watershed that located in the center of Lorestan province. This watershed has 48° 21' to 49° 8' east longitude and 33° 13' to 33° 44' north latitude geography range that located in the southern part of the country in the Kerman province. In this area minimum elevation is 1102 (m) and the maximum elevation is 2545 (m) and with 405 average precipitation and 15 (ºC) temperature have a semi-arid climate. The Talar watershed with 2057 (km^2) area and 369 (Km) perimeter is a sub-watershed of Haraz and Gharasou watersheds that are in Mazandaran province. This watershed located in 52° 35' to 53° 25' east longitude and 35° 45' to 36° 20' north latitude geography range. In this area minimum elevation is 61 (m) and the maximum elevation is 3890 (m) and with 610 (mm) average precipitation and 11 (ºC) temperature have semi-humid climate (Figure 1).

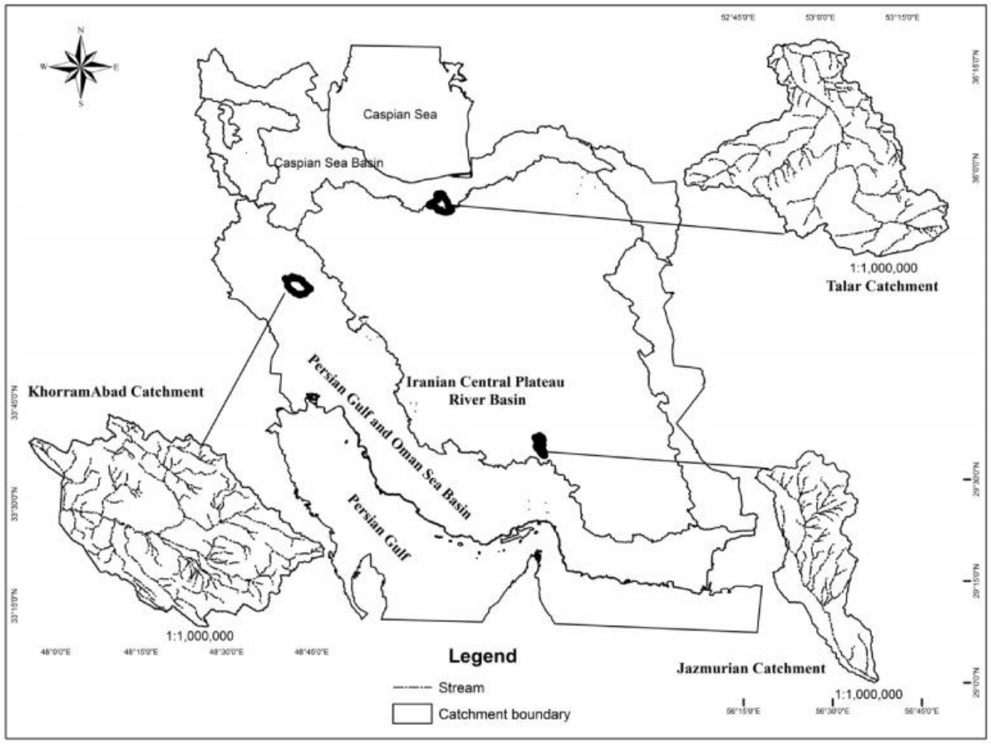

Fig. 1. Location of the Talar, Khorramabad and Jazmurian catchments

2.2. SWAT Model description

SWAT (Soil & Water Assessment Tool) is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. SWAT is a public domain software enabled model actively supported by the USDA Agricultural Research Service at the Backland in Temple, Texas, USA. It is a hydrology model with the following components: weather, surface runoff, return flow, percolation, evapotranspiration, transmission losses, pond and reservoir storage, crop growth and irrigation, groundwater flow, reach routing, nutrient and pesticide loading, and water transfer. SWAT could considered a watershed hydrological transport model. This model used worldwide and is continuously under development. As of July 2012, more than 1000 peer-reviewed articles published that document its various applications. SWAT Model has Extension programs to Arc Map as Arc SWAT 2012 (Neitsch *et al*., 2012). This model is set of different Mathematical equations and empirical formulas that designed for Simulation of different parameters as a daily, monthly, and annual step. SWAT model simulation the hydrological cycle based on water balance equation (Winchell *et al*., 2012).

$$SW_t = SW_0 + \sum_{i=1}^{t}(R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw})_i \quad (1)$$

Where SW_t is the final amount of soil water, SW_0 is the initial amount of soil water, R_{day} is the rain fall in day, Q_{surf} is the surface runoff amount in day i, E_a is the evapotranspiration amount in day i, W_{seep} is the water infiltration amount in upper soil layer in day i, Q_{gw} is the return flow on day i unit measurement of mentioned parameters based mm. In SWAT model for simulation surface runoff, exist to method A) Soil Conservation Service (SCS) Curve Number (CN) method and B) Green- Ampt infiltration (Neitsch *et al*., 2011). In this research based on SCS method, surface amount was calculated:

$$Q_{surf} = \frac{(R_{day} - 0.2\ S)^2}{(R_{day}\ 0.8S)} \quad (2)$$

In the equation Q_{surf} is surface runoff amount, R_{day} is Rainfall amount in day i, S is the soil surface maintain. Unit measurement in upper parameters is mm. For calculation evapotranspiration in SWAT three method are available, that is, Penman–Monteith, Priestley–Taylor, and Hargreaves methods (Neitsch *et al*., 2005a). In this research was use Hargreaves method. That general form is based on eqs.3 and 4.

$$ET_o = 0.0135 K_t R_a TD^{0.5} (T + 17.8) \tag{3}$$

$$K_t = 0.00185(TD)^2 - 0.0043TD + 0.4023 \tag{4}$$

In this relationships, ETo evapotranspiration (mm), TD average differences between maximum temperature and minimum temperature in T and I day is the average temperature in I day (ºC)

SWAT model for simulation undersurface flow using from reserve kinetic model. This model simulation subsurface flows in two-dimensional section and flows down the slope that calculation from below equation.

$$Q_{lat} = 0.024 \left(\frac{25\ SW_{ly,excess}\ K_{sat}\ slp}{\phi_d L_{hill}} \right) \tag{5}$$

Where Q_{lat} subsurface flow discharge (mm in day), $SW_{ly,excess}$ amount of Drainage water content in the regarded layer (mm), K_{sat} Saturated hydraulic conductivity (mm per hour), slp is the slope (elevation in distance unit), $Ø_d$ is the possible drainage soil porosity (mm in mm) and L_{hill} is the slope length (m/m).

2.3. Climate process in SWAT model

The climate of a catchment related to moisture and energy inputs that control the water balance and determine the relative importance of different components of the hydrological cycle. A- Snow: SWAT divides the precipitation as rain or snow on the daily average temperature. Snow melting is determined based on the air temperature and snow mass. B- Elevation bands: the sub-catchments can divide into elevation bands by the model that precipitation and snowmelt simulated separately for each band. C- Soil temperature: it is effective on the water movement and rotating speed of debris in the soil and it is determined by the snow cover, vegetation, and litter, temperature of the bare soil surface, soil surface temperature of the previous day and mean annual temperature.

2.4. Data collection and simulation

The used data in this study are including the spatial data, weather stations data, and hydrometers data. Weather data consist of Rainfall, minimum temperature, maximum temperature, wind speed and Ratio Humid that were collected based on the daily step of weather stations exist in the case study and were prepared with the SWAT2012 format to input the SWAT model. Discharge data were prepared from hygrometry stations in an output of tow watersheds. The three map consist of Digital Elevation Map (DEM) with 28-meter cell size, soil map (classified based on soil hydrology group, soil layer number, soil carbon and …) and Land use map input to SWAT model. For prevent from creating enormous of Hydrologic Response Unit, a threshold for each hydrological unit was selected 10 percent of the subbase area. These units should be similar from hydrological feature as far as possible (Neitsch *et al.*, 2011). The Collection of data that used as input model represented in Table 1.

Table 1. Input data to SWAT model

Data	Description	Source
Flow River	Talar Hydrometer station (output sub basin 1) Khorramabad Hydrometer station (output sub basin 10) Baft Hydrometer station (output sub basin 5)	Mazandaran Regional Water Company Lorestan Regional Water Company Kerman Regional Water Company
Meteorology	Talar: Stations Baladeh, Chamestan, Edareh Babol, Firozkoh, Gatkola, Kadir and Karesang Khorramabad: Stations Cham Angi, Dehno, Kakareza, Khorramabad, Srabsy and Sorkhab Jajmoreian: Bydkrdvyyh, Jamil Abad, Baft, swch, Kigan	Mazandaran Regional Water Company and Meteorological Department in Mazandaran
DEM	28 Meters	Geological Country
Land Use	Khorramabad watershed with 11 kind Talar watershed with 7 kind Jazmurian basin with 7 kind	Department of Natural resource and watershed management
Soil Map	2010	Natural Resource Office

2.5. Sensitivity analysis, calibration, and validation of the SWAT model

Calibration of distributed or semi-distributed model is a complex process (Pechlivanidis *et al.*, 2010; Pokhrel and Gupta, 2011; Lerat *et al.*, 2012). A large number of parameters, overlapping of parameters, uncertainty and the lack of ability to recognize the problem can have influences on this case (Beven, 1993, 1996, 2001; Kirchner, 2006; Götzinger and Bárdossy, 2007). The SWAT-CUP program developed by

(Abbaspoor *et al.*, 2007) used to analyze the sensitivity of parameters, calibration, and confidence. Information that is more detailed and the process to create SWAT-CUP program are available in the study of Abbaspoor 2012. Integrated algorithms consecutive uncertainty (SUFI2) was selected for simulation, which is a semi-automatic reverse modeling in SWAT-CUP program (Akhavan *et al*., 2010) because it has the potential to change and analyze many parameters with the lowest number of model repetitions (Yang *et al*., 2008). Global sensitivity analysis used in the SUFI2 program applied for sensitivity analysis. A SUFI2 algorithm in SWAT-CUP program tries to reduce the uncertainty of the model in successive steps in order to establish the two following conditions :

Most observational data is located at 95 PPU level (p-factor$\rightarrow$1).

The average distance between the upper and lower limit, in the range of 95% uncertainty divided by standard deviation of the measured data is as small as possible (R-factor $\rightarrow$ 0).

2.6. Evaluation of model efficiency

To evaluate the model efficiency and to limit answers to only one answer, sometimes it needed to use several statistical criteria (Santhi *et al.*, 2001; Gassman *et al*., 2007). In this research for assessment, the SWAT model performance used of NS, R^2, br^2, R factor, and p-factor (Table 2). R^2 Coefficient is (Determination Coefficient) indicated a correlation between observation and simulation variable that its ranges is between 0-1. The NS coefficient shows a relative differs between observation and simulation value and the value of this factor is between -∞-1 (Moriasi *et al*., 2007). In addition, P-factor is a percentage of observational data covered equal to estimating band of 95% uncertainty (95PPU) and R-factor is the percentage of observational data covered equal to estimating band of 95%. Since by increasing in P-factor, R-factor would also increase, then calculations continue until the equilibrium established between these two factors and this occurs when the majority of the observational data placed in estimating band of 95PPU.

Table 2. The coefficient for assessment the SWAT model performance

coefficient	equation	Range	Without Error
Determine coefficient	$R^2=\frac{\left[\sum_{i=1}^{n}(Q_i^{sim}-\bar{Q}_i^{sim})(Q_i^{obs}-\bar{Q}_i^{obs})\right]^2}{\sum_{i=1}^{n}(Q_i^{sim}-\bar{Q}_i^{sim})^2\sum_{i=1}^{n}(Q_i^{obs}-\bar{Q}_i^{obs})^2}$	[0, 1]	$R^2=1$
Nash-Sutcliffe coefficient	$NS=1-\frac{\sum_{i=1}^{n}(Q_i^{obs}-Q_i^{sim})^2}{\sum_{i=1}^{n}(Q_i^{obs}-\bar{Q}^{obs})^2}$	[-∞, 1]	NS=1
Regression coefficient	$br^2=\begin{cases}\lvert b\rvert R^2 & if\ \lvert b\rvert\le 1\\ \lvert b\rvert^{-1}R^2 & if\ \lvert b\rvert>1\end{cases}$	[0, 1]	$br^2=1$

n= observation number, Q_i^{obs}observation value, Q_i^{sim}Simulation value, $\bar{Q}_i^{obs}$average of observation value, $\bar{Q}_i^{sim}$average of simulation value and b is the regression line slop

3. Results and Discussion

The first step in the production of SWAT project for an area is to specify the catchment. The results of this phase were 8 sub- catchments for Jazmurian catchment, 33 sub- catchments for Khorramabad catchment and 23 sub- catchments for Talar catchment. Then, Hydrological Response Unit (HRU) was determined based on the input maps. As each HRU had a land use, a soil type and a common slope (Neitsch, 2005, Yang *et al*., 2008). After overlapping these layers, 96, 223, and 265 hydrological response units were create in Jazmurian, Khorramabad, and Talar catchments, respectively.

3.1. Annual average of area hydrologic

After running, the model on the watershed, average runoff, soil water, and evapotranspiration obtained in study areas (Table 3). It is noteworthy that with an increase in the number of observation stations in the catchment areas the model performance in a simulation of these parameters be increased (Tampi *et al*., 2010; Rathhen and Oplet 2012; Solaymani and Gosain, 2014).

Table 3. Annual average of hydrological parameters in case studies

Talar	Khorramabad	Jazmurian	Parameters
Value in millimeter			
617.7	Precipitation	160	459.5
27	Snow Fall	47.31	14.56
21.86	Snow Melt	30.95	14.56
6.77	Sublimation	0.52	0
235.91	Surface Runoff	14.76	63.54
25.98	Aquafer Flow	6.95	187.86
344.4	Total water Yield	19.63	228.07
249.8	Evapotranspiration	226.9	135.3

3.2. Flow discharge at the outlet of the catchment

The result of relative Sensitivity analysis during the model calibration using algorithms SUFI2 showed that seven parameters had high sensitivity. These parameters selected for the calibration of the model (Table 4). Changes in these parameters during the replication of process had higher effects in the simulation of Flow discharge at the outlet of the catchment (Zuo *et al.,* 2014). After model calibration using sensitive parameters, minimum and maximum range for each parameter identified (Table 5). Sensitivity analysis of these parameters showed that the curve number (CN) had the highest sensitivity in both catchments and suggested that the range of these catchments was heavily influenced by changes in curve number and penetration rate, which correspond with previous studies in this area (Arnold *et al*., 2012; Khoi and Suetsugi., 2014).

Table 4. The sensitivity analysis results in case studies

Talar	Khorramabad	Jazmurian	Comments	Parameters
r_CN2	Initial SCS runoff curve number	1	1	1
v_ALPHA_BNK	Base flow alpha factor for bank storage (day)	-	2	-
r_SOL_K	Saturated hydraulic conductivity (mm/hr)	-	-	2
v_Rchrg_Dp	Deep aquifer percolation fraction	5	3	3
r_SOL_BD	Moist bulk density of soil layer (Mg/m^3)	-	4	4
v_SFTMP	Snowfall temperature (ºC)	2	5	5
v_CH_K2	Effective hydraulic conductivity (mm/hr)	4	6	-
v_SMFMX	Maximum melt rate for snow (mm /ºC/day)	-	7	6
v_SURLAG	Surface runoff lag time (days)	-	-	7
V__TLAPS	Temperature laps rate (ºC/km)	3	-	-
V__GW_DELAY	Groundwater delay (days)	6	-	-
R__SOL_ALB	Moist soil albedo	7	-	-

v- Means replacing exist value with obtained value and r- means multiply exist value with (+1) obtained value

Table 5. Fitted Value, Minimum value and Maximum value in Calibration SWAT model

Jazmurian		Talar		Khorramabad		
Fit value	Initial Range	Fit value	Initial Range	Fit value	Initial Range	Parameter
1	(-0.016, 0.016)	0.335	(-0.08, 0.019)	0.76	(-0.08, 0.8)	-0.76
2	(-0.495, 0.49)	0.094	(-0.42, 0.0112)	0.351	(-5, 5)	4.56
3	(0.495, 0.49)	0.056	(-0.065, 0.041)	0.015	(0, 50)	39.36
4	(-0.013, 0.013)	0.939	(-0.016, 0.26)	0.033	(0, 150)	29.8
5	(-0.005, 0.049)	4.581	(-0.089, 14.894)	13.23	(0, 1)	0.5
6	(-0.078, 0.07)	76.786	(-0.06, 0.1605)	0.121	(0, 500)	15
7	(-0.0088, 0.088)	0.717	(-0.136, 1.61)	1.147	(-5, 5)	0.44

v- Means replacing exist value with obtained value and r- means multiply exist value with (+1) obtained value

The simulated discharge in catchments for the simulation period of 2004 - 2008 at Khorramabad hydrometric station and for the period of 2003 – 2007 at Talar hydrometric station with the measured discharge shown in Figure 2 and 3. According to the proposal of (Binaman and Shoemaker 2005), the simulation of the model is satisfactory when the R^2 value is higher than 60% and NS is more than 0.5. The statistical coefficients obtained for the study catchments (Table 6) and comparison of charts indicated a very well conformity between simulated flow discharge and observations in both areas.

Table 6. Assessment of SWAT model performance in calibration period

p-factor	r-factor	bR^2	NS	R^2	Period	watershed
0.43	2.45	0.20	0.54	0.56	60 month	Jazmurian
0.98	3.35	0.32	0.72	0.68	60 month	Khorramabad
0.63	5.62	0.31	0.66	0.64	60 month	Talar

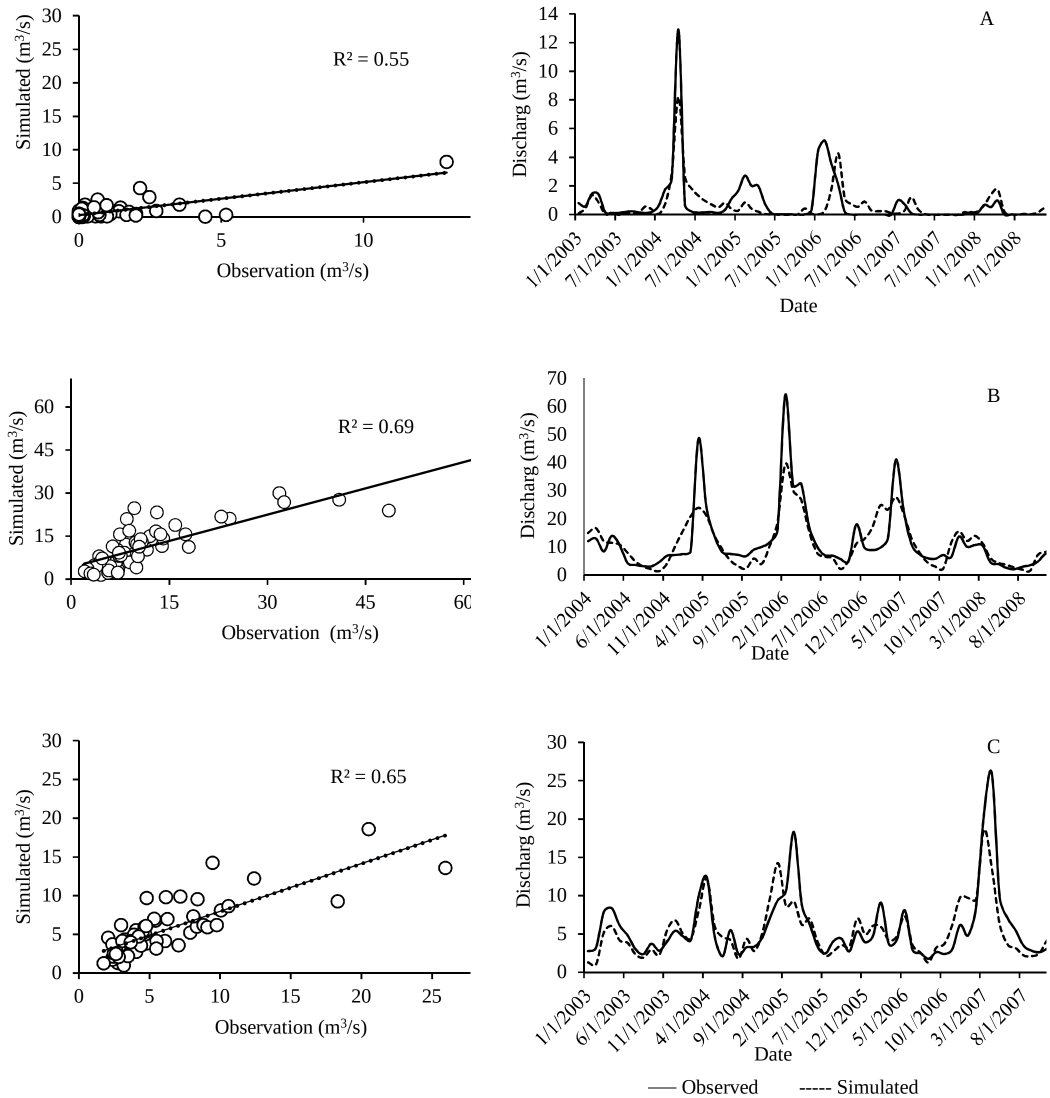

Fig. 2. Observation and simulated discharge and correlation between observation and simulated discharge using SWAT model in calibration period A) Jazmurian B) Khorramabad C) Talar

Validation of the results is necessary to increase user's confidence in the capability of model simulation. Therefore, the model validated by observational runoff data at Khorramabad hydrometric station for the period of 2009 - 2010 and at Shirgah hydrometric station for the period of 2008-2009 in Talar catchment. The results of this validation presented in Figure 3. Whatever presented in the previous section about the acceptable performance of model to simulate the timing and discharge amount is true for validation period. As in the model validation period in Khorramabad catchment, the average observational and simulated discharges were 5.862 and 4.816 m^3/s, respectively; and in Talar catchment, the average observational and simulated discharges were 4.712 and 3.919 m^3/s, respectively. Statistical coefficient values of model validation at validation phase for the catchments shown in Table 7.

Table 7. SWAT model performance Assessment in validation period

p-factor	r-factor	bR_2	NS	R^2	Period	Study area
0.54	12.63	0.18	0.48	0.52	24 month	Jazmurian
1	11.26	0.44	0.63	0.66	24 month	Khorramabad
0.46	9.07	0.17	0.51	0.63	24 month	Talar

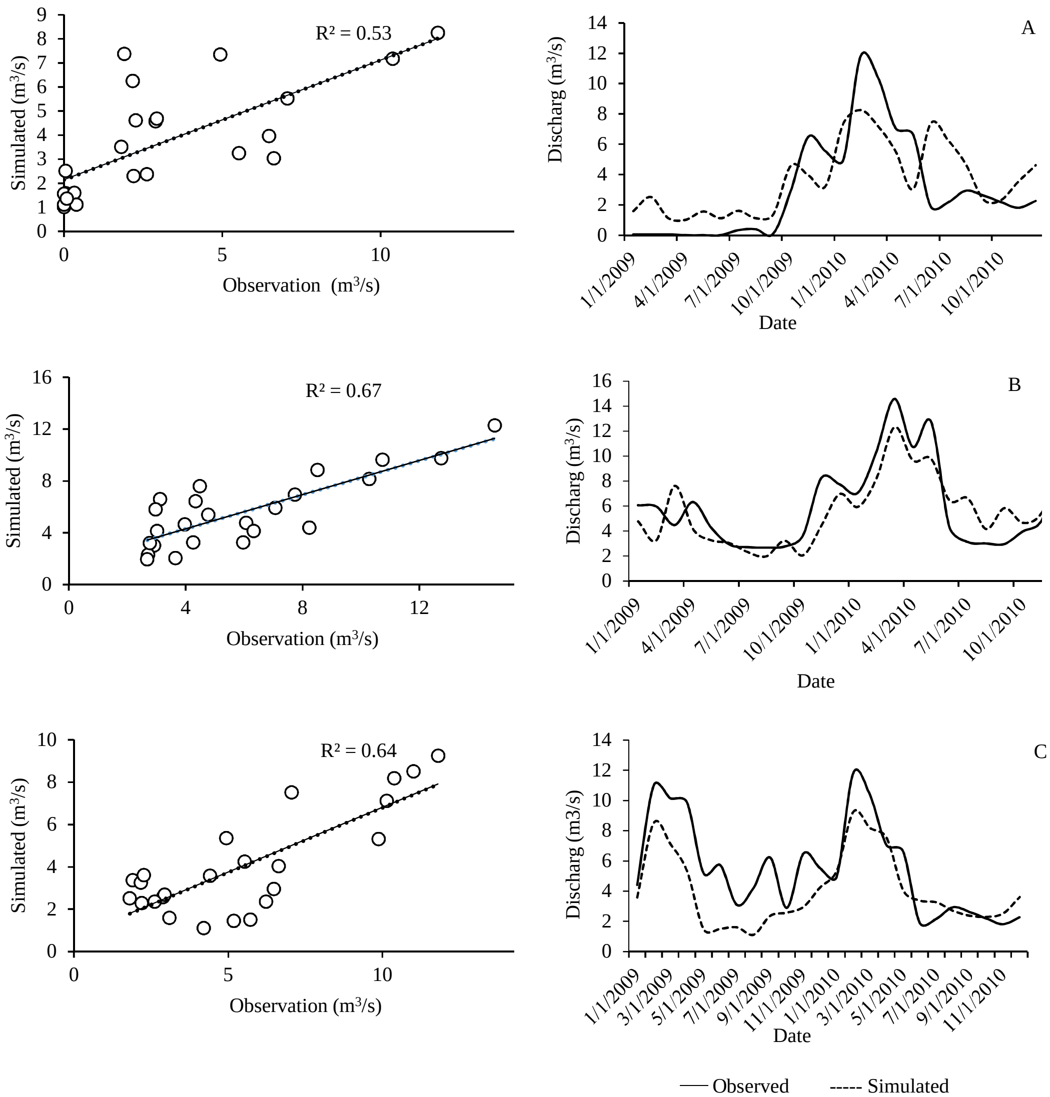

Fig. 3. Observation and simulated discharge and correlation between observation and simulated discharge using SWAT model in validation period A) Jazmurian B) Khorramabad C) Talar

The results of the model calibration and validation at the studied stations indicated that SWAT model had an appropriate accuracy for runoff simulation in the study period, which is in accordance with some researchers (Setegn *et al*., 2010; Hwa *et al.,* 2012) about the efficiency of the SUFI2 program with target function of NS. The average observational and simulated discharges during the calibration at Khorramabad hydrometric station were 11.625 and 11.423 m^3/s, respectively; and at Talar hydrometric station were 5.78 and 5.462 m^3/s, respectively. The difference between simulated and observational average discharges was under-simulated by 0.202 m^3/s in Khorramabad catchment and 0.318 m^3/s in Talar catchment, which represents the acceptable accuracy of the model in simulating average discharge in semi-arid and semi-humid catchments in Iran (Azari *et al*., 2013; Vaghefi *et al*., 2014). The difference of average simulated discharge in study catchments related to the impact of precipitation storage as snow as well as the effect of groundwater flow and evapotranspiration. Soil water percolation was 173.61 and 26.05 mm per year in Khorramabad and Talar catchments, respectively, which the soil percolation was better in Khorramabad regarding the average discharge of both catchments that would increase the groundwater flow. In addition, the actual and potential evapotranspiration were simulated 135.3 and 950.8 mm in Khorramabad catchment, respectively; and 249.8 and 969.3 mm in Talar catchment, respectively; certainly, higher evaporation in Talar catchment would reduce the flow discharge rate.

The highest observational discharge in March 2005, February 2006, and April 2007 was 48.51, 64.14, and 40.96 m^3/s, respectively at Khorramabad hydrometric station. SWAT model simulated the flow 23.95, 39.47 and 27.72 m^3/s, respectively for these months. In addition, the flow in April 2004, March 2005, and April 2007 was 12.13, 18.33, and 25.95 m^3/s, respectively at Talar hydrometric station. The simulated flow was 12.23, 9.27, and 13.57 m^3/s, respectively in Talar catchment. The model simulated the time of flow earlier for observational data in Talar catchment, so the occurred flow in March 2005 simulated in January 2005 and occurred flow in April 2007 simulated in March 2007. This not been observed in Khorramabad catchment. In general, except the two mentioned months it can be said that the model accuracy was high in simulating occurrence time and amount of flow (Wang *et al*., 2012; Panhalker, 2014) Talar catchment has high elevations up to 3890 m, which could cause the occurrence of precipitation as snow and its accumulation in solid form at high altitudes. The average annual snowfall and snowmelt were simulated 14.56 mm in Khorramabad catchment; however, 21.86 mm snow melted from 27 mm average annual snowfall and 5.14 mm considered as storage in Talar catchment that melted by increasing in temperature and increased the discharge in the catchment. Despite the SWAT model determined the parameters of SMTP (base temperature of melting snow) and SMFMX (snowmelt factor in June) as sensitive parameters for Talar catchment, it did not simulate snow melting process very well (Abbaspor *et al*., 2007; Wang *et al*., 2012).

4. Conclusion

In the current study, the distributed model of SWAT in ArcGIS, as well as uncertainty analysis algorithms of SUFI2 in SWAT-CUP program successfully used to simulate runoff and water resources components in semi-arid and semi-humid catchments. The main purpose of this study was to evaluate the efficiency of a semi-distributed model of SWAT in simulating runoff in study catchments. R^2 coefficient values in the calibration period (2004 - 2008) were 0.68 and 0.63 for Khorramabad and Talar hydrometric stations, respectively; and NS coefficient values were 0.72 and 0.66 for these stations, respectively. Comparison of obtained statistical coefficients showed that the model accuracy in simulating flow discharge for Khorramabad catchment was higher than Talar catchment. Overall, the results indicated the acceptable ability of SWAT model in simulating river flow discharge in both semi-arid and semi-humid areas in Iran. In addition to representing hydrological processes in study catchments, the results also examined the impact of catchment characteristics on the simulation process. Using this model or other computer models considered as possible solutions in order to improve water resource management and environmental protection because of lower costs of field operations and especially reducing the time needed to analyze problems.

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