Inflow and Sediment Simulation of Maroon Dam Catchment Using SWAT

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Abstract
Hydrological processes and their local scattering have always direct relation to weather, topography, geology and land use of watershed. The use of a universal model to simulate the basin would be very important. Thus, in this research SWAT was used to simulate the watershed basin sediment and inflow. This model has been focused on many investigations due to its widespread consideration of various effective parameters. The study is based on Maroon Dam Basin with an area of 2700 Km^2 which is one of the main sub-basins of Persian Gulf. The capability of model in simulation of runoff and sediment of the basin with collecting a large number of local information and considering the effective parameters in hydrological cycle was examined in this study. The model was calibrated from 1994-2002 period using sufi-2 algorithms and evaluated from 2002-2007 periods. The result showed relatively good fitness between measured and simulated discharge and sediment. The Nash Sutcliffe efficiency and R^2 were about 70% for discharge and 76% for sediment load. Overall, simulation of runoff and sediment is satisfactory by using the SWAT model.
Keywords: SWAT, Inflow, Sediment and Maroon Dam.

Introduction

Soil erosion is a worldwide environmental problem that degrades soil productivity and water quality, causes sedimentation in reservoirs, and increases the probability of floods (Ouyung, 2001).

Sediment transport rate is affected by hydrological as well as hydraulic characteristics. Since the former cannot be adequately taken into account quantitatively, a high degree of accuracy in sediment load computations cannot be expected (Garde and Rangaraju, 2000). Watershed management programs frequently fail to reduce sediment yield because either the physical nature of the problem is not properly diagnosed or the economic and cultural conditions leading to accelerated erosion are not addressed and erision control practices are abandoned as soon as government subsidies are removed (Gregory and Fan, 1998). Besides, the development of a comprehensive sediment yield model requires substantial funding, extensive time and expertise, which are often unavailable in developing countries (Mulengera, 1999).

The soil and water assessment tool (SWAT) is a physically based, continuous time model, developed by Dr. Jeff Arnold for the USDA-ARS (Agricultural Research Service) (Arnold et al., 2001), mostly used to predict the impact of land management practices on water, sediment,

and nutrient yields over long periods of time (Di Luzio et al., 2002). SWAT model has been used extensively to access water quality and quantity changes in the catchment responding to agricultural management across the US, Canada and other European countries (FitzHugh and Mackay, 2002; Abbaspour et al., 2004; Pandy et al., 2005; Plus et al., 2006; Abbaspour et al., 2007; Mehmet et al., 2009).

In previous studies, it was difficult to account for sediment yield deposition the catchment and to model the individual erosion processes. Therefore, this study aimed at assessing the suitability of SWAT2005 model (Neitsch, 2005) as one of the watershed erosion models in simulating inflow and sediment yield in Maroon Dam mountainous catchment. The model was used to assess its suitability in modeling sediment yield in the data scarce catchments, located in south western of IRAN.

Methods and Material

Study Area

The studied watershed, named Maroon Dam (Idanak station), is in south west of IRAN (Figure 1). The area of the watershed is about 2700 ha and located in a Semi- arid climatic region. Annual average precipitation is approximately 639.0 mm concentrated between November and May. Mean annual temperature is 23^{o}C.

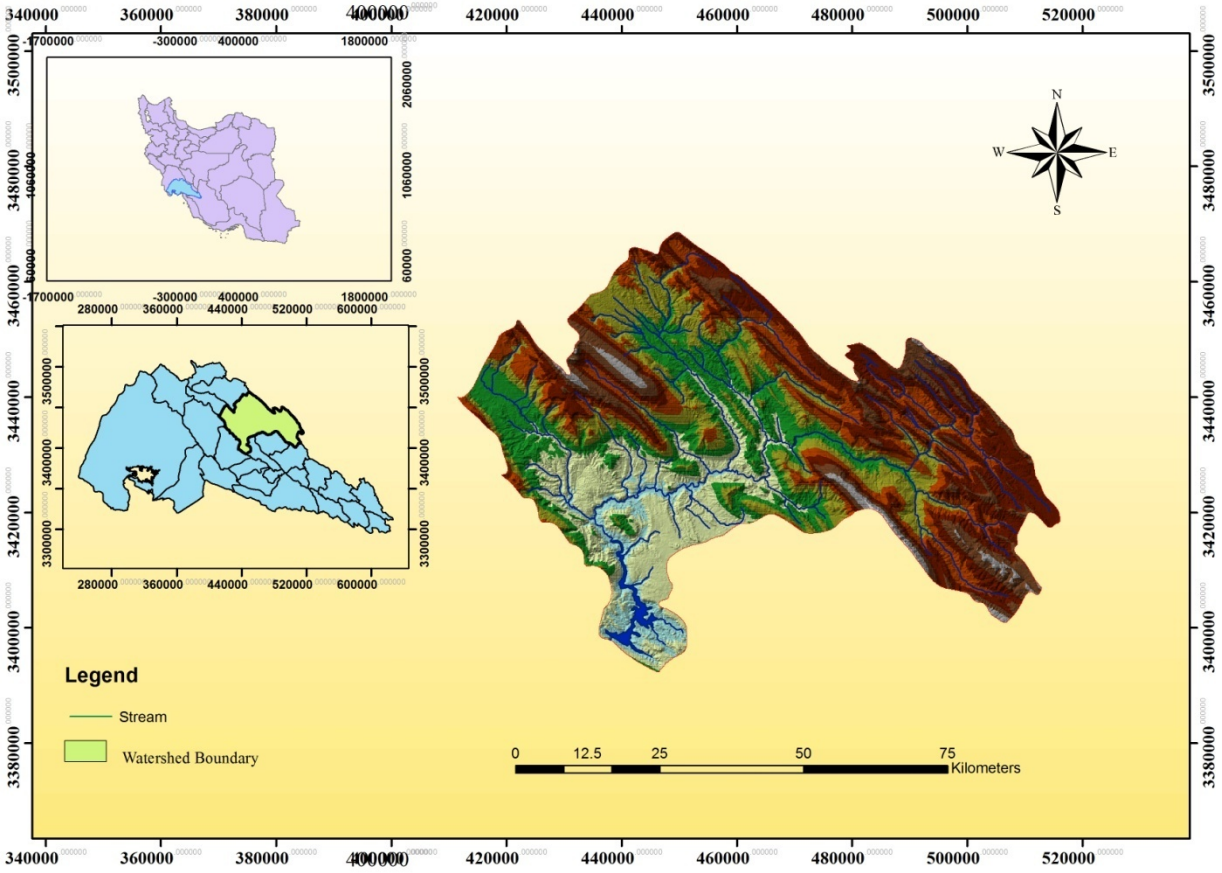

Figure1. Research site: Dam Maroon watershed

SWAT input data

The basic input data included the digital elevation model (DEM), land use, soil maps and climate data. Data has been collected and processed for daily rainfall, runoff and sediment discharge, and maximum and minimum temperature for the watershed during 1987 to 2006.
The SWAT2005 was used to delineate the boundaries of the entire study area and its sub-basins. The model was calibrated using data in the catchment of Maroon Dam. During the simulation process the inflow and sediment yield was calibrated and then validated.

Results and Discussion

Model calibration and validation are indispensable for simulation process, which are used to assess model prediction results. Calibration was performed by comparing the simulated and observed surface runoff. After achieving a reasonable runoff data, the same parameters were used for calibration of the sediment and further for validation.
River sediment yields were estimated primarily by quantifying soil losses from HRU"s with the Modified Universal Soil Loss Equation (MUSLE) (Neitsch et al, 2005). K_{USLE} is the USLE soil erodibility factor, C_{USLE} is the USLE cover and management factor, P_{USLE} is the USLE support practice factor and CFRG is the coarse fragment factor (Neitsch et al, 2005).
The available measurements of flows and sediments were used for comparison with the predicted results in order to test the SWAT simulation efficiency. Calibration took place in monthly basis at Idanak Station, where inflow data is existed from 1994 to 2006 and sediment measurement data from 1995 to 2006. Figures 2 and 3 represents the graphical comparison between predicted and observed flows and sediment yields in Idanak during calibration and validation periods.

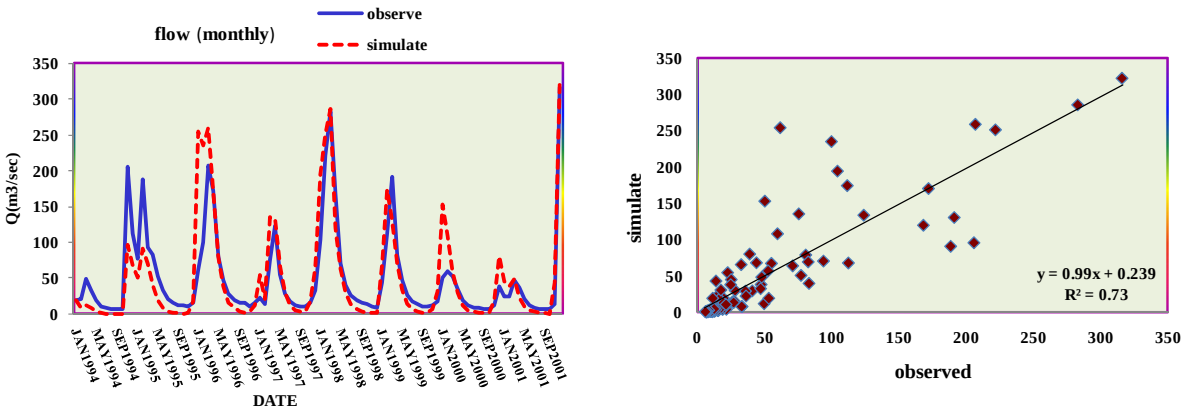

Figure 2: observed and predicted flows in Idanak Station during calibration period

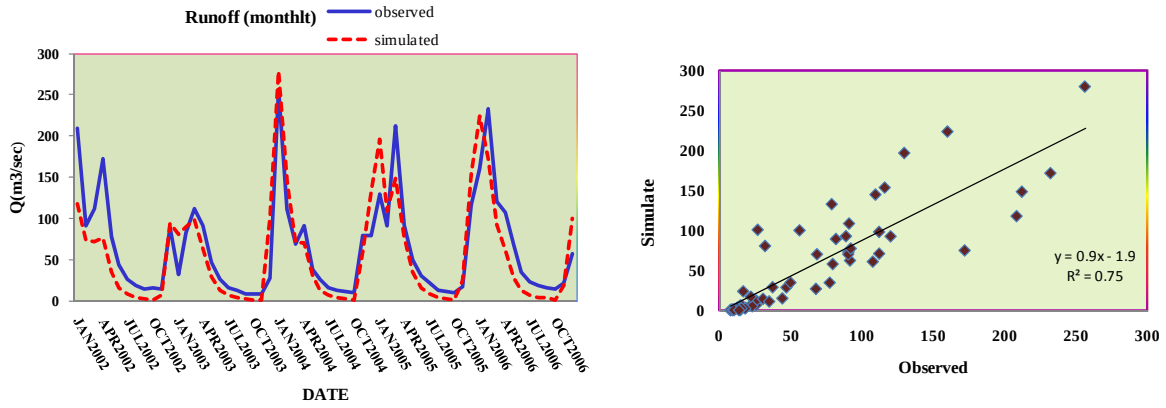

Figure 3: observed and predicted flows in Idanak Station during validation period

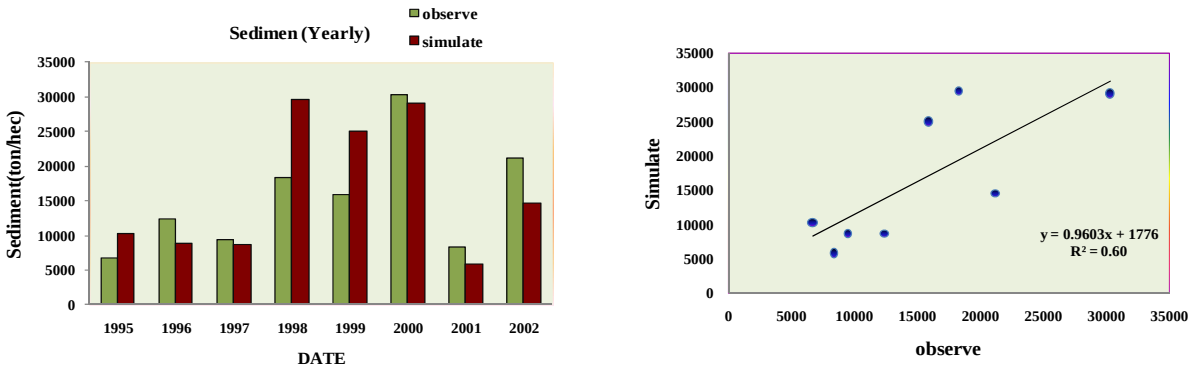

Figure 4: observed and predicted sediment yields in Idanak Station during calibration period

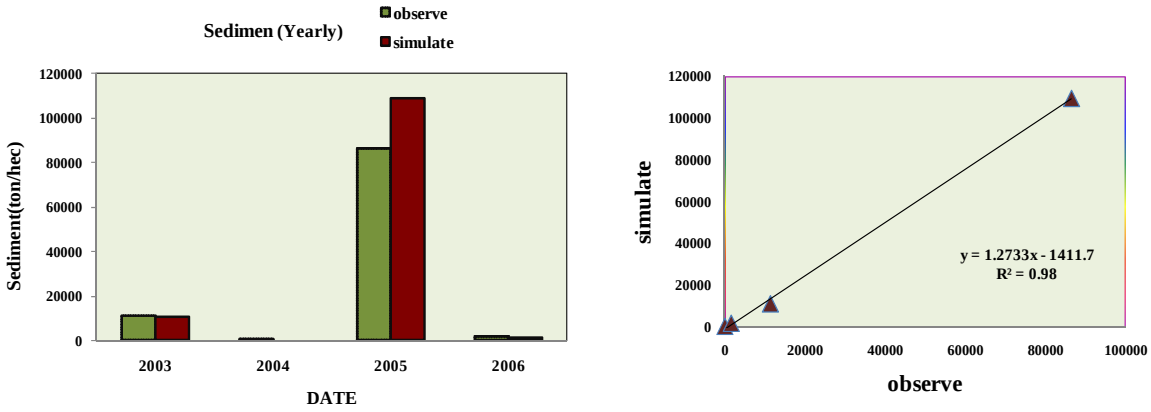

Figure 5: observed and predicted sediment yields in Idanak Station during validation period

Different values appeared between the simulated and observed monthly-runoff during the simulation for 1994–2001. The difference might be explained by the measured errors in runoff data, and system errors of SWAT. After reasonable parameter calibration, in validation process, simulated monthly-runoff was in the range of the observed values (Figure.3).
The correlation coefficient and Nash-Sutcliffe coefficient reached 0.75 and 0.70 respectively, which showed the validity of the simulation (Figure.4). Also the correlation coefficient in

calibration and validation process during sediment load simulation reached to 0.60 and 0.98 respectively (Figure.5).

Conclusion

In this study SWAT was used to simulate inflow and sediment yield in the Maroon Dam watershed in south west of Iran. Simulated flow and sediment yields were generally in agreement with measured data.

The Auto-calibration Tool in ArcSWAT provides a user-friendly method for specifying various inputs including calibration parameters and desired widths of uncertainty confidence intervals. It also facilitates specification of measured data sets and the desired output parameters and objective functions. The text-based summaries from the three components of the Tool can be used to determine the optimal parameter set for calibration purposes, parameter sensitivity ranges and corresponding objective function ranges. Time series graphs, with or without parameter and model uncertainty bounds, can be created from additional output files to facilitate comparison between the amount of variation in the model results and the measured data.

Acknowledgements

We gratefully appreciate Research and Standards Office of irrigation and drainage networks of Khuzestan Water and Power Authority for financial support and science assessments.

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